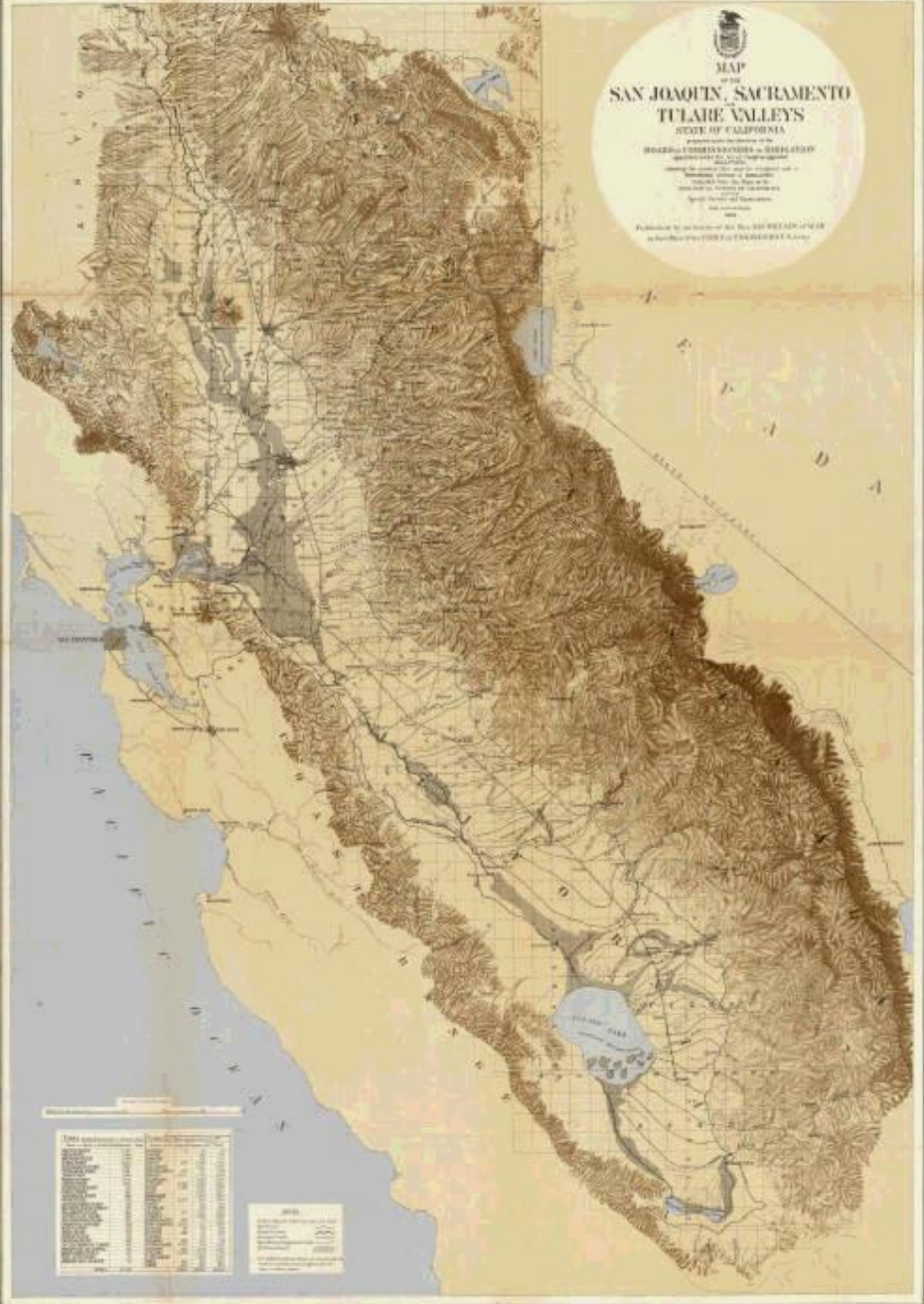





 MAP
 OF THE
**SAN JOAQUIN, SACRAMENTO
 TULARE VALLEYS**
 STATE OF CALIFORNIA
 prepared under the authority of the
 BOARD OF SUPERVISORS of CALIFORNIA
 approved July 27, 1892
 drawn by contract by JOHN W. BAKER and
 published under the direction of
 JOHN W. BAKER, State Engineer
 State of California
 April 20, 1893
 and corrected
 1905
 Published by the Order of the BOARD OF SUPERVISORS
 at San Francisco by THE CALIFORNIA MAP CO.



Vertical Scale

0	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	3100	3200	3300	3400	3500	3600	3700	3800	3900	4000	4100	4200	4300	4400	4500	4600	4700	4800	4900	5000
---	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

Horizontal Scale

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
---	---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Notes

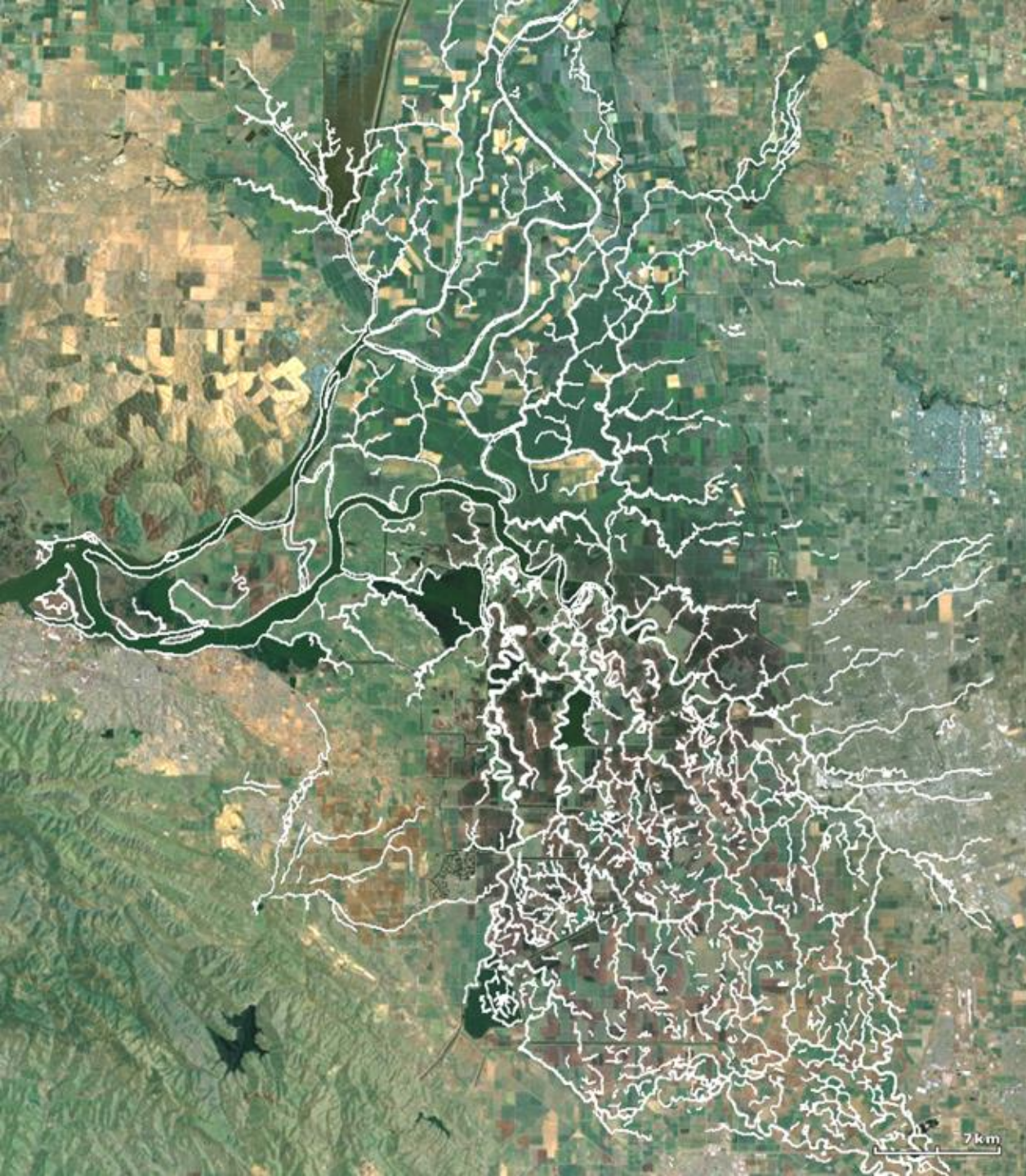
1. The map is based on the original survey data.

2. The map is published by the California Map Co.

Select from the following Map Views

-  Major Rivers
-  State Projects
-  Federal Projects
-  Local Projects
-  All Water Projects





1873 Delta:

Long residence time

Marsh connections

Two rivers connect
to bay

Waterways dendritic



Modern delta

Short residence times

Rip-rapped

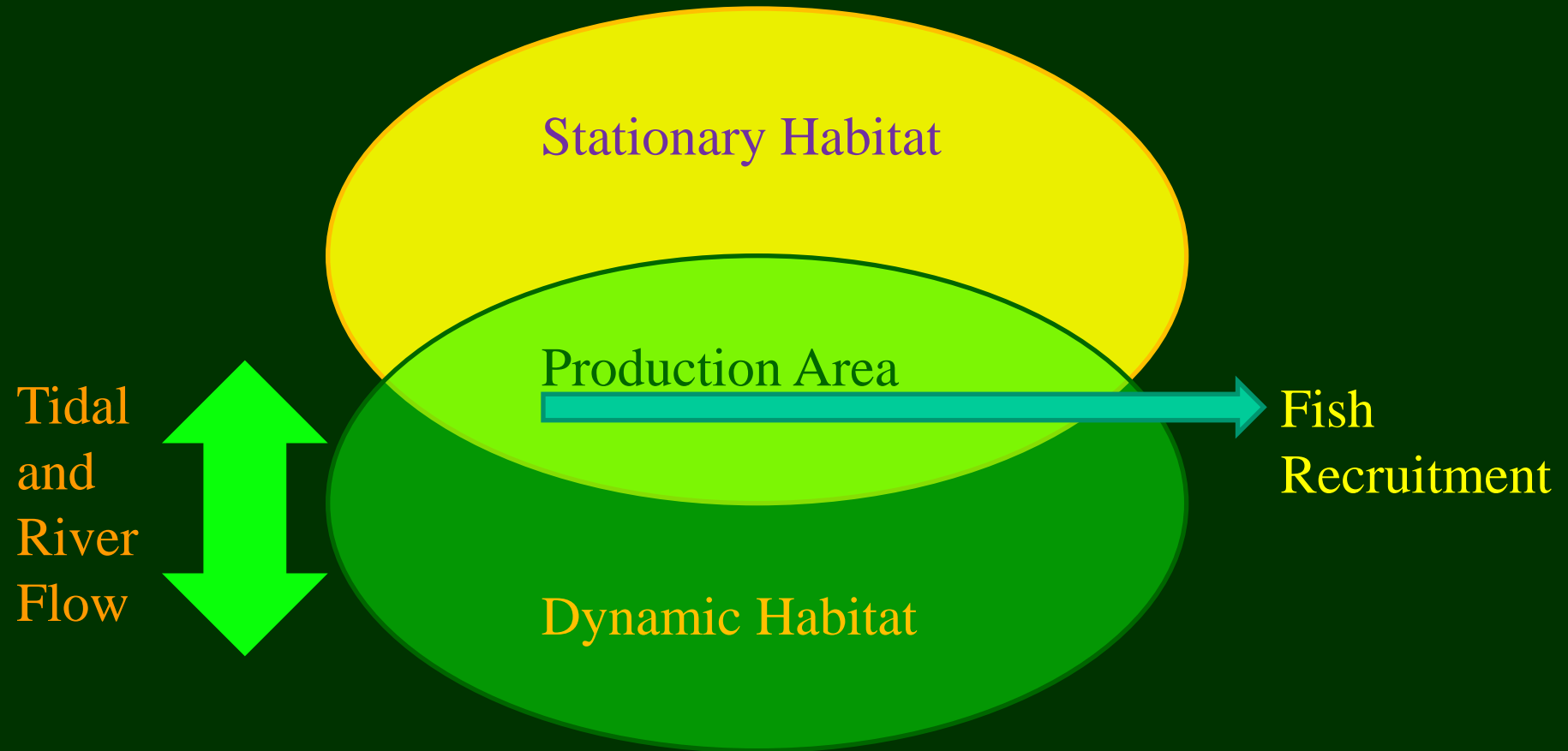
Cross Delta flows

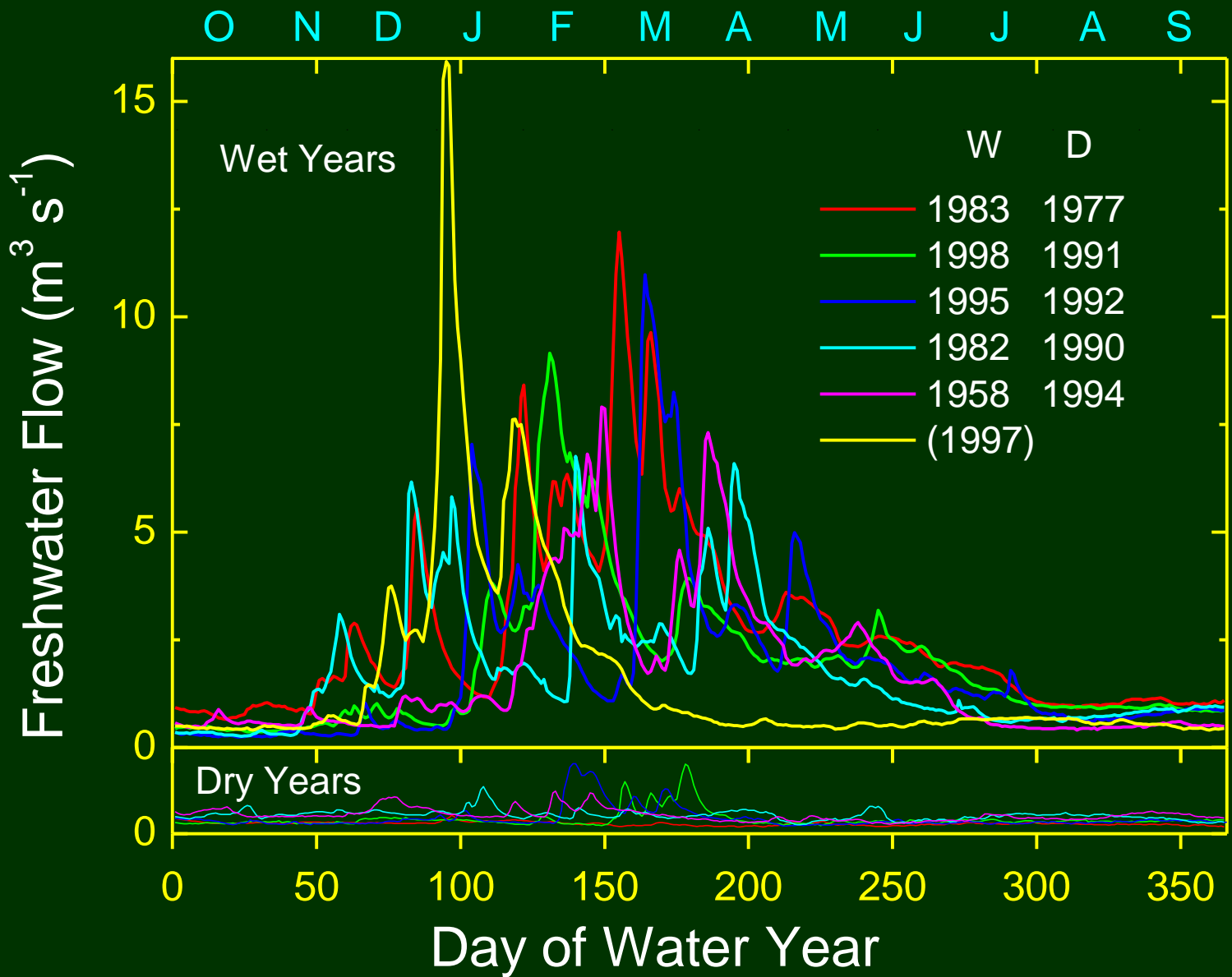
**Rare San Joaquin
connection to bay**

Waterways web-like

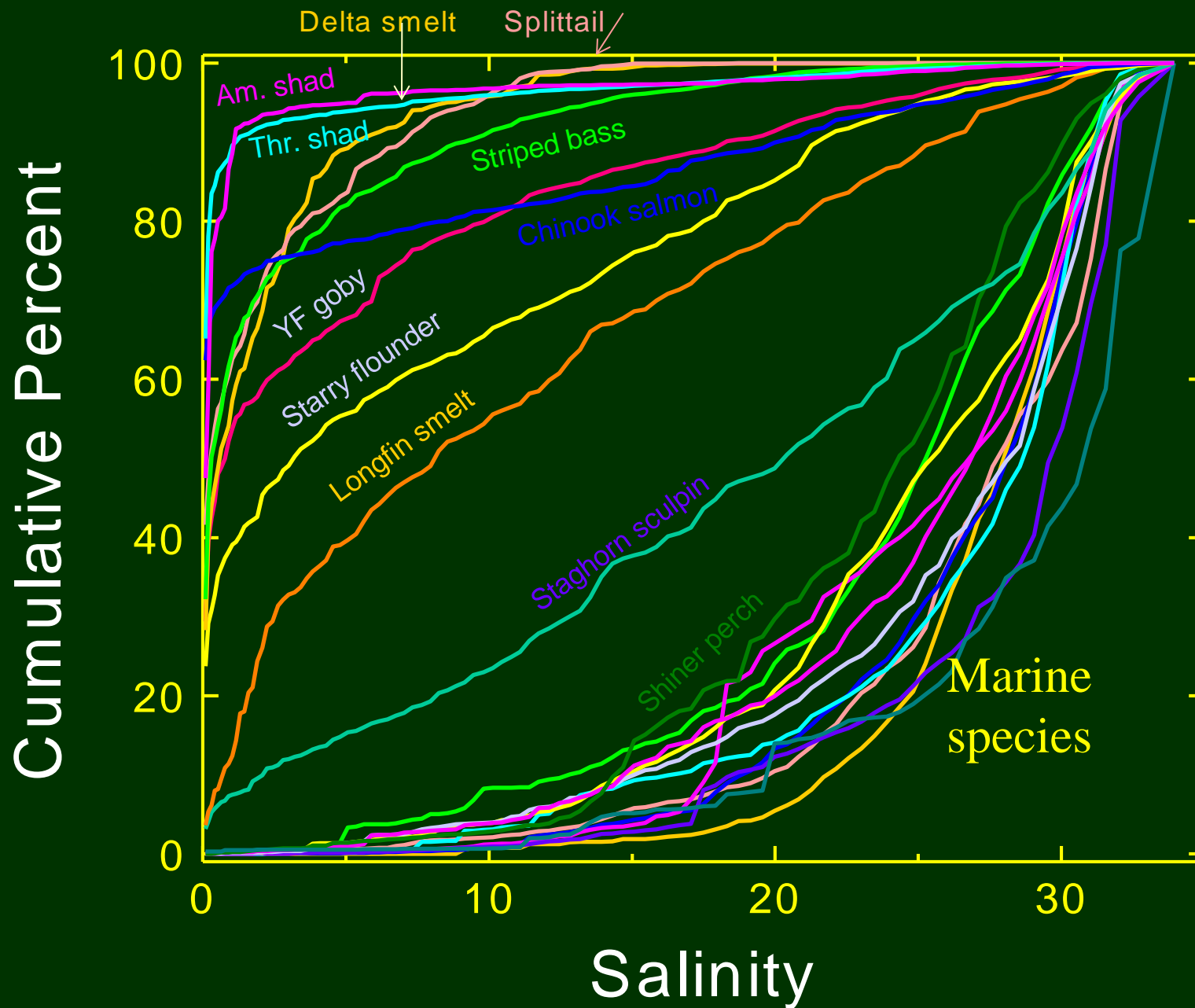
Estuarine habitat conceptual model

(Peterson 2003)





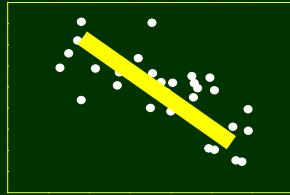
Most fishes follow salinities



[Kimmerer 2004](#)

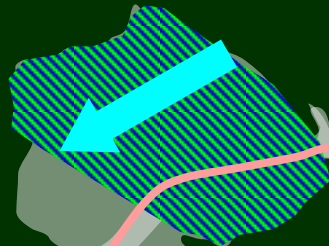
What Changes As Flow Increases?

Salinity
and X2



FLOW

Location of
Any Salinity
Range

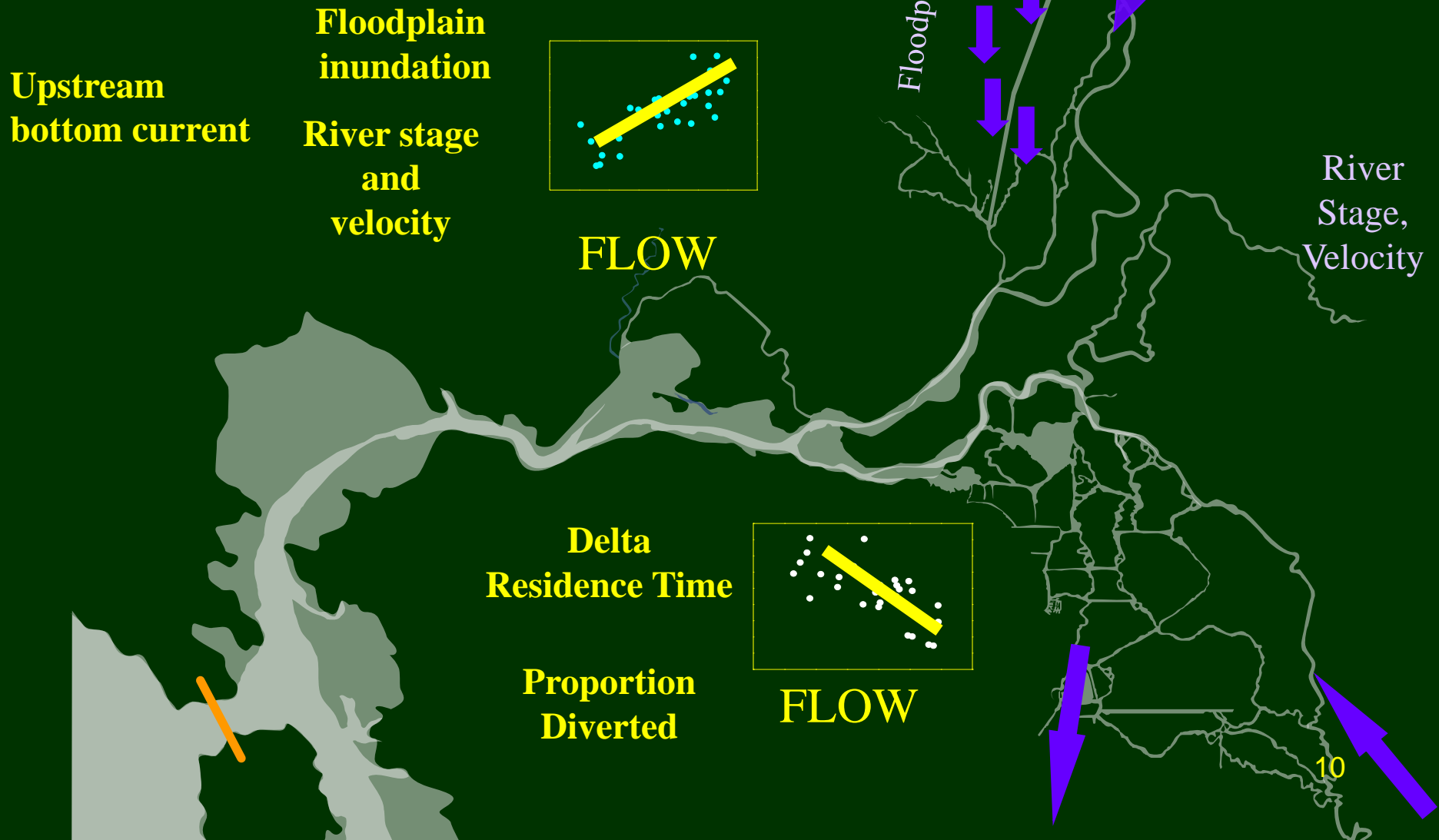


L
S
Z

stratification

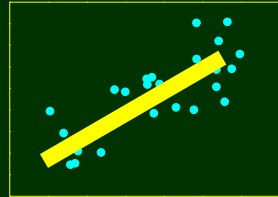


What Physically Changes As Flow Increases?



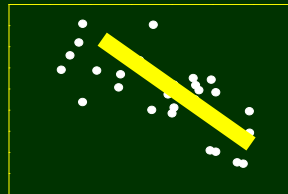
What chemically changes?

Loadings



FLOW

Concentrations



FLOW

**Nutrients
Contaminants
Organic matter
Sediment**

What Biologically Changes As Flow Increases?

Adult spawners move up:

Salmon

Green and White Sturgeon

Longfin smelt

Delta smelt

Splittail

American shad

Pacific herring

Young fish move down:

Salmon

Longfin smelt

Delta smelt

Splittail

American shad

Striped bass

Young Marine fish move up:

Starry flounder

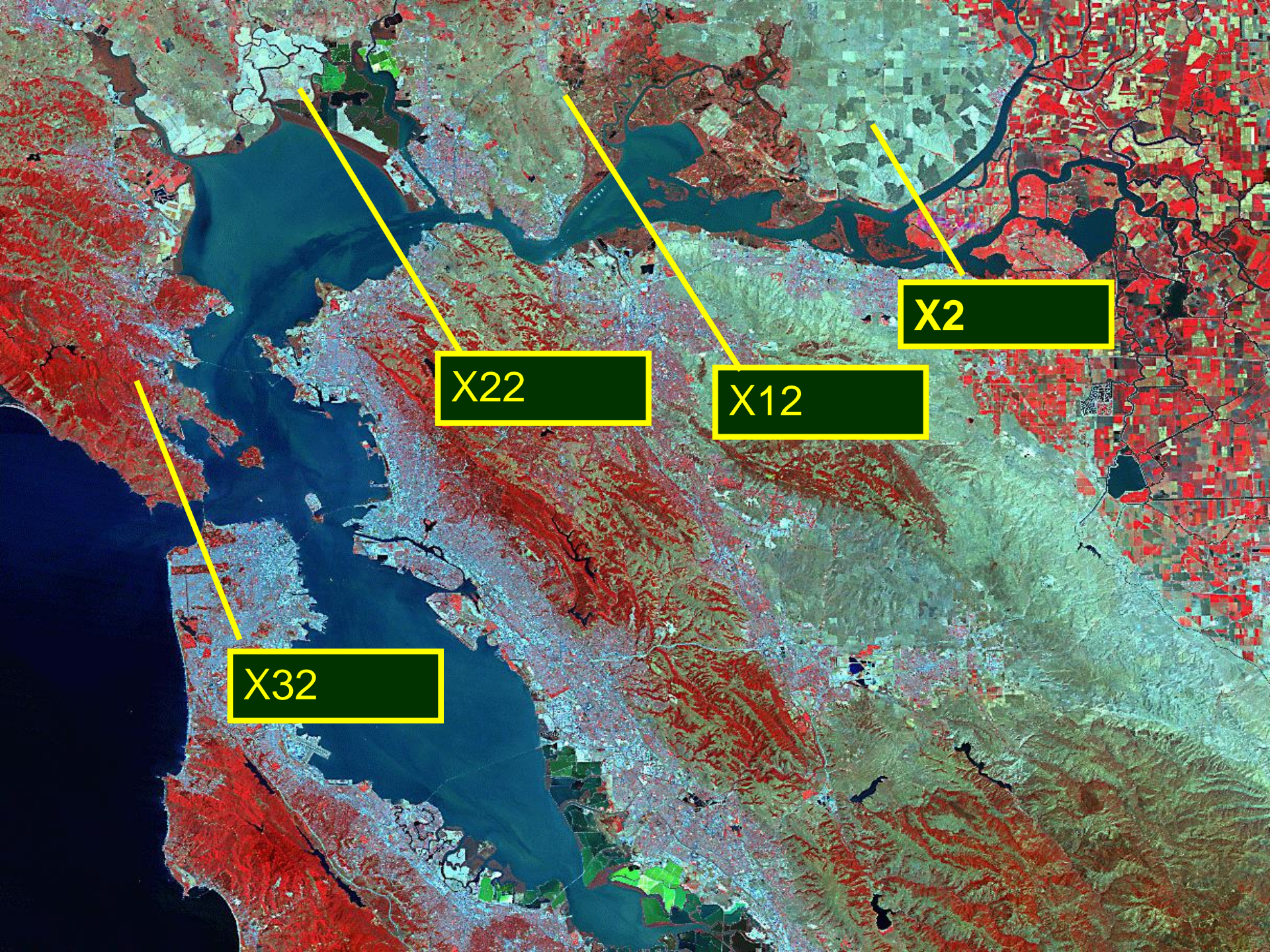
White croaker

Pacific halibut

How much water do fish need?



X2

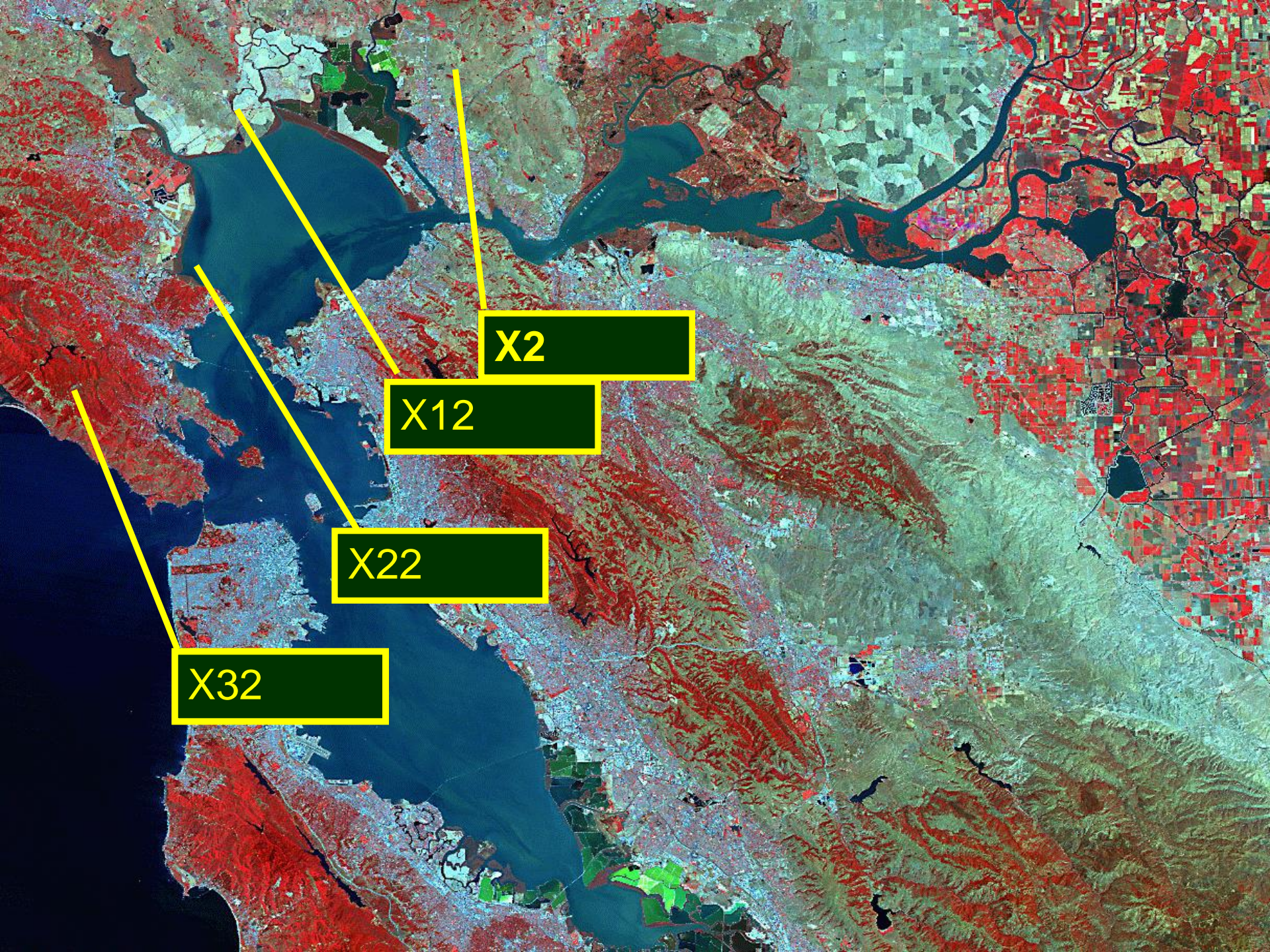


X2

X12

X22

X32

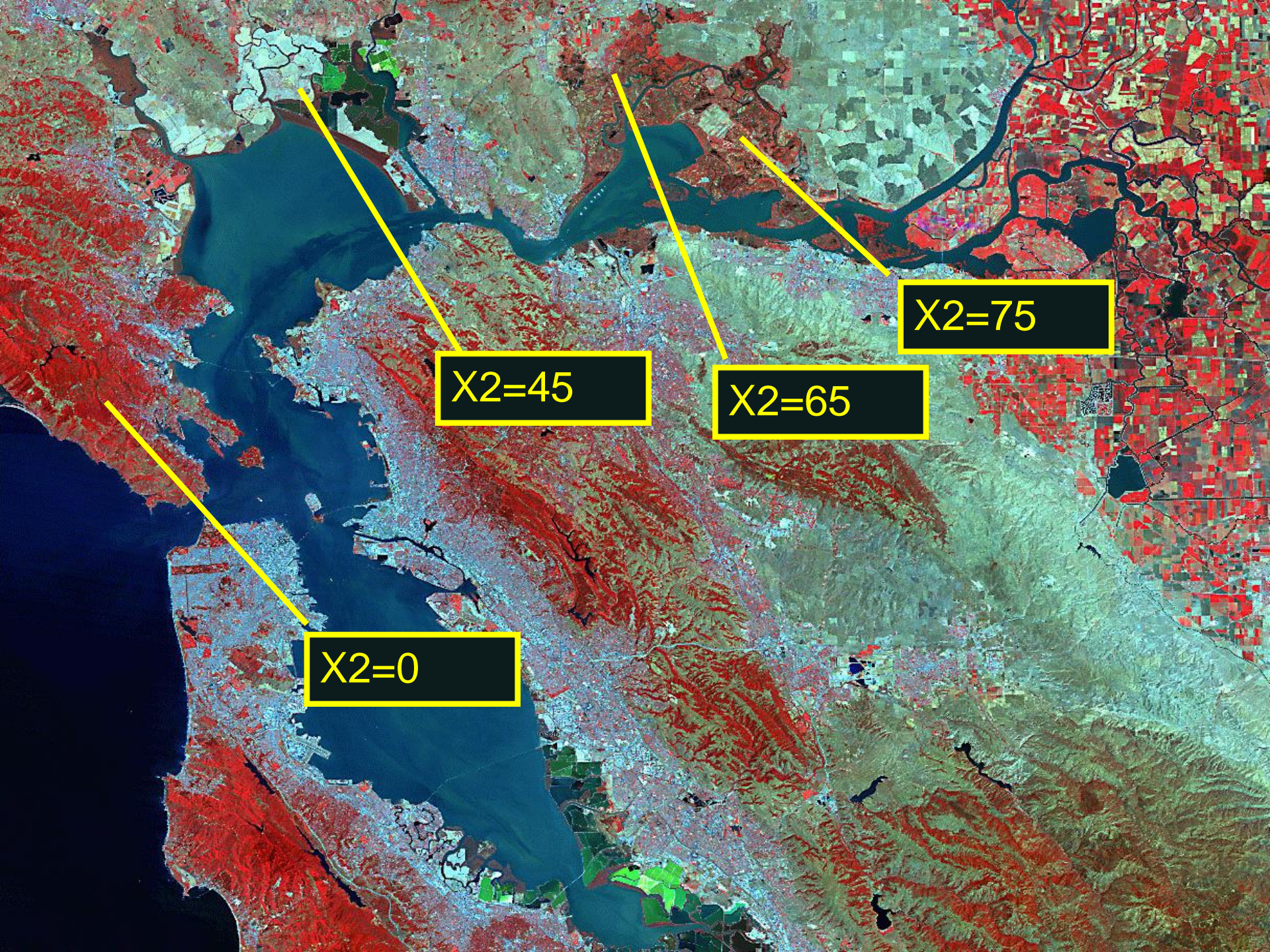


X2

X12

X22

X32



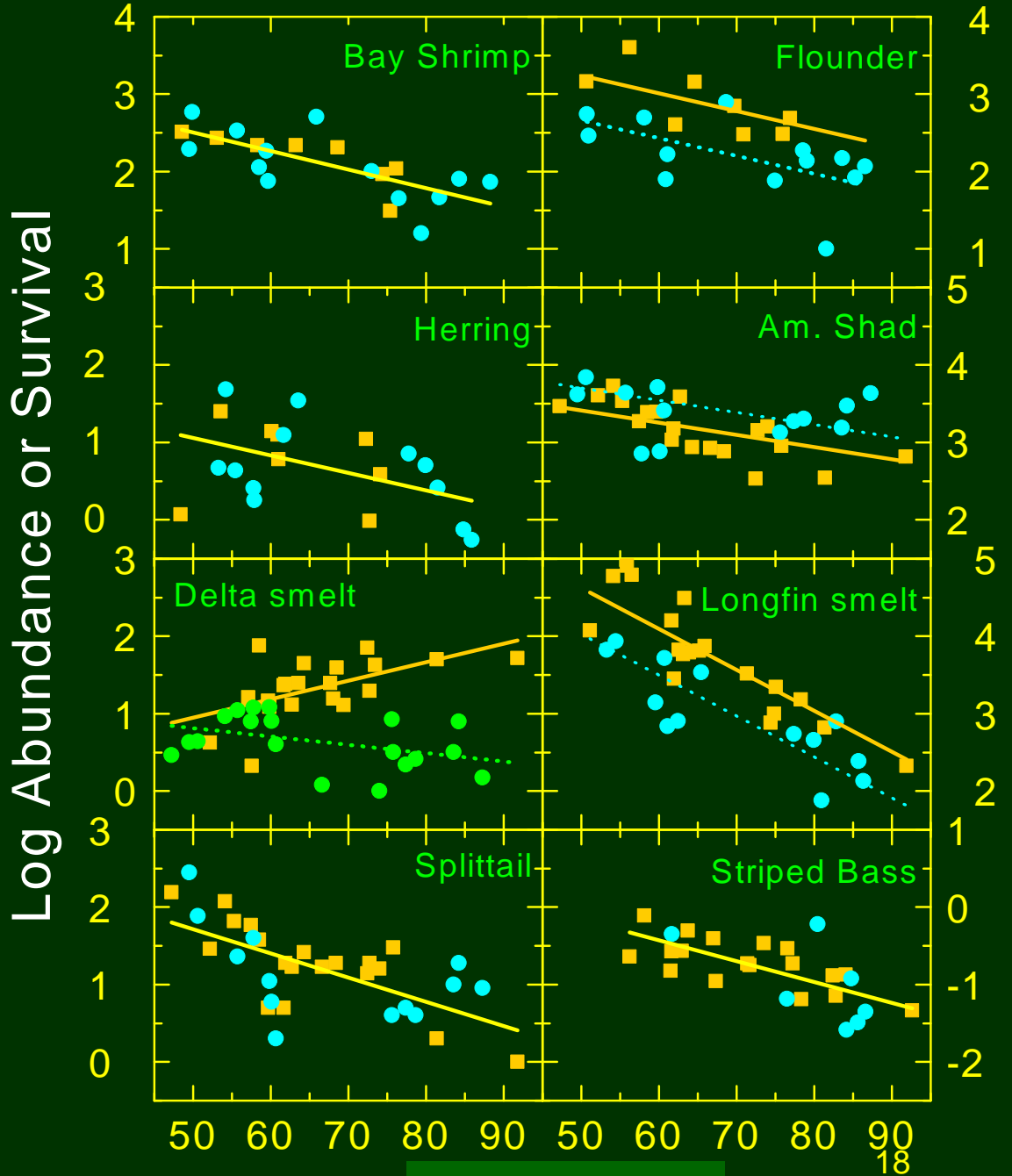
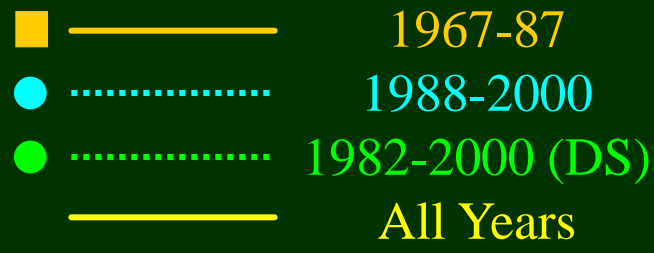
X2=0

X2=45

X2=65

X2=75

Higher trophic levels show many relationships of abundance to X2

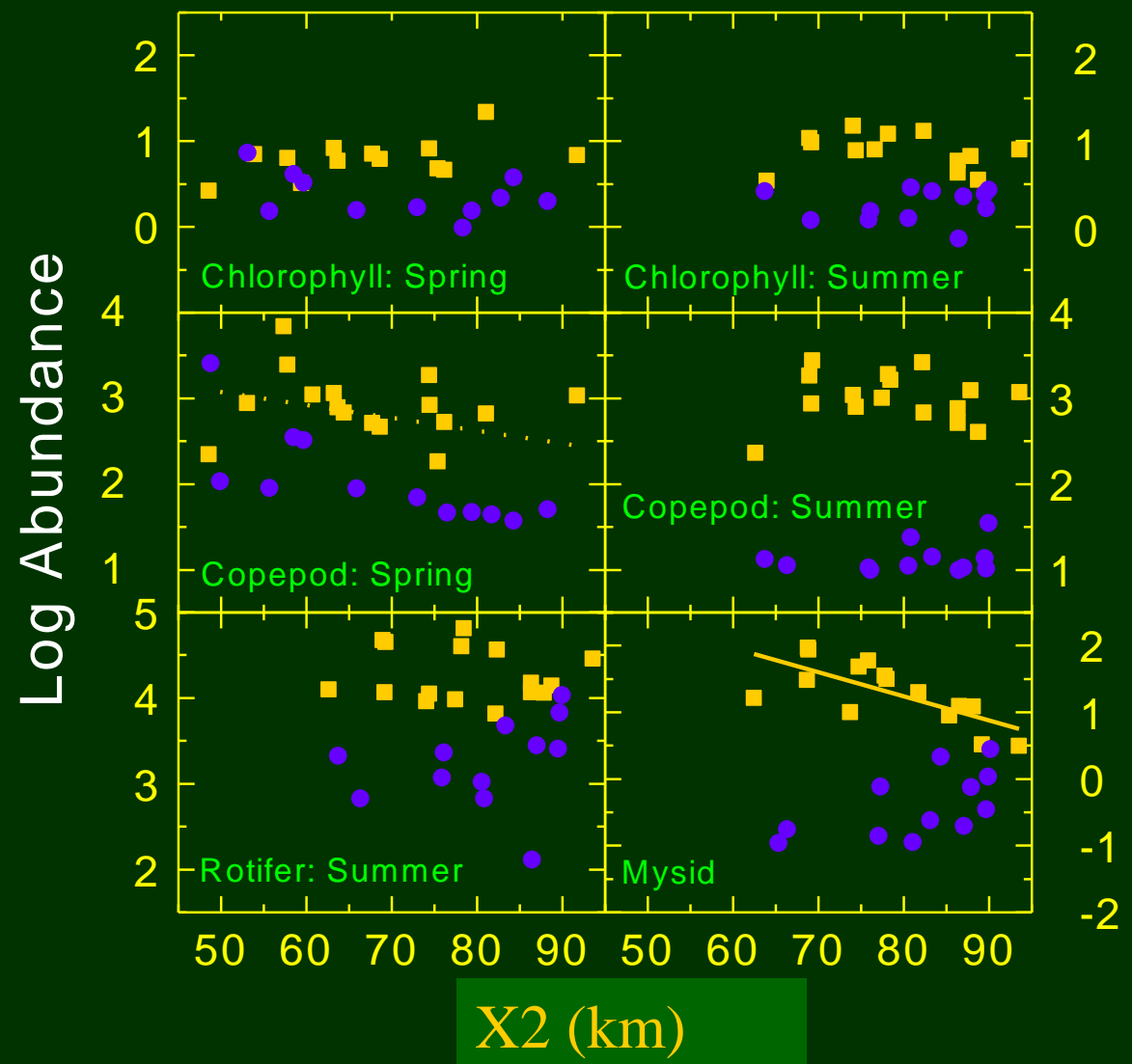


Source: Kimmerer 2002MEPS



Lower trophic levels show few relationships of abundance to X2

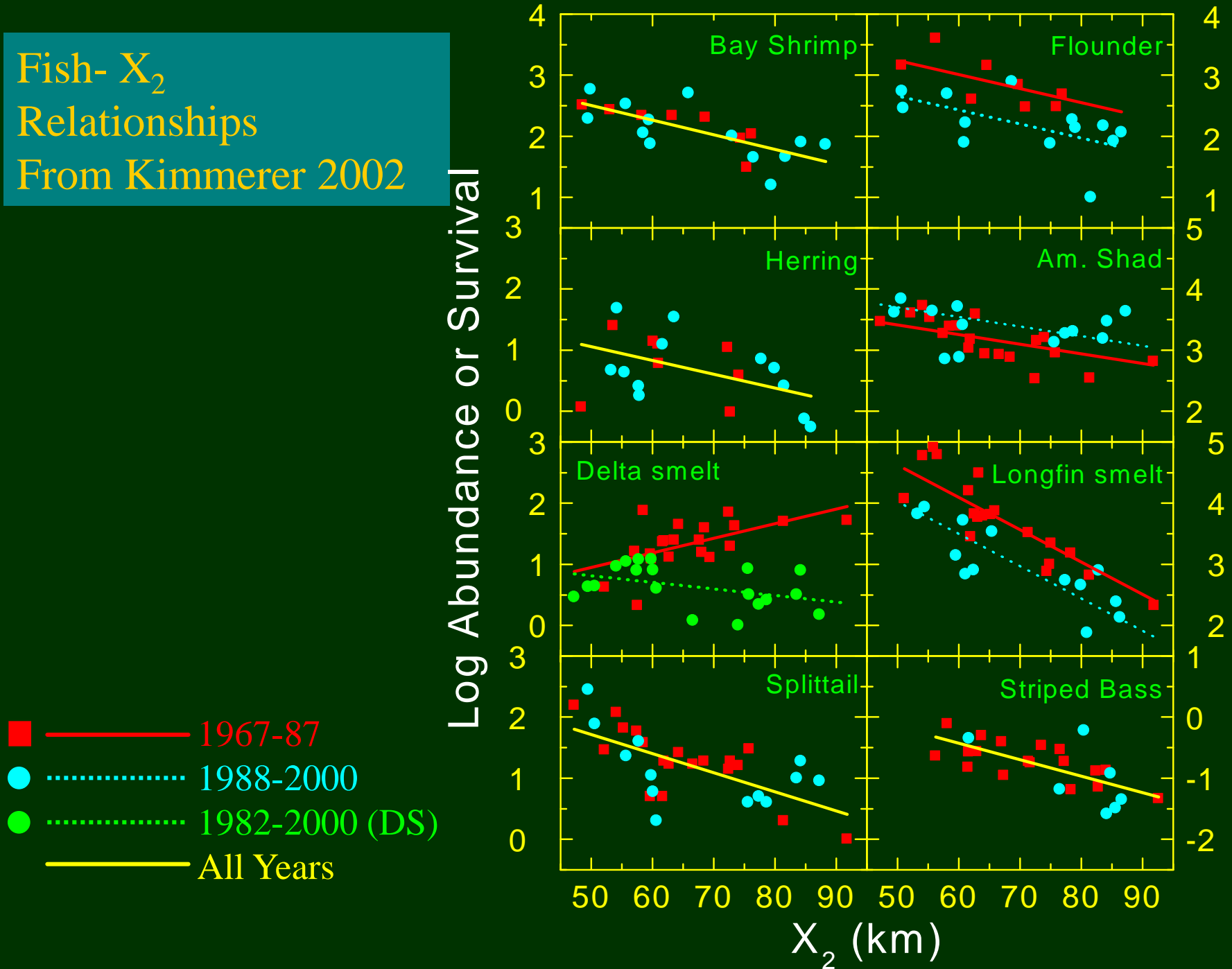
■ ————— 1972-1987
● 1988-2000



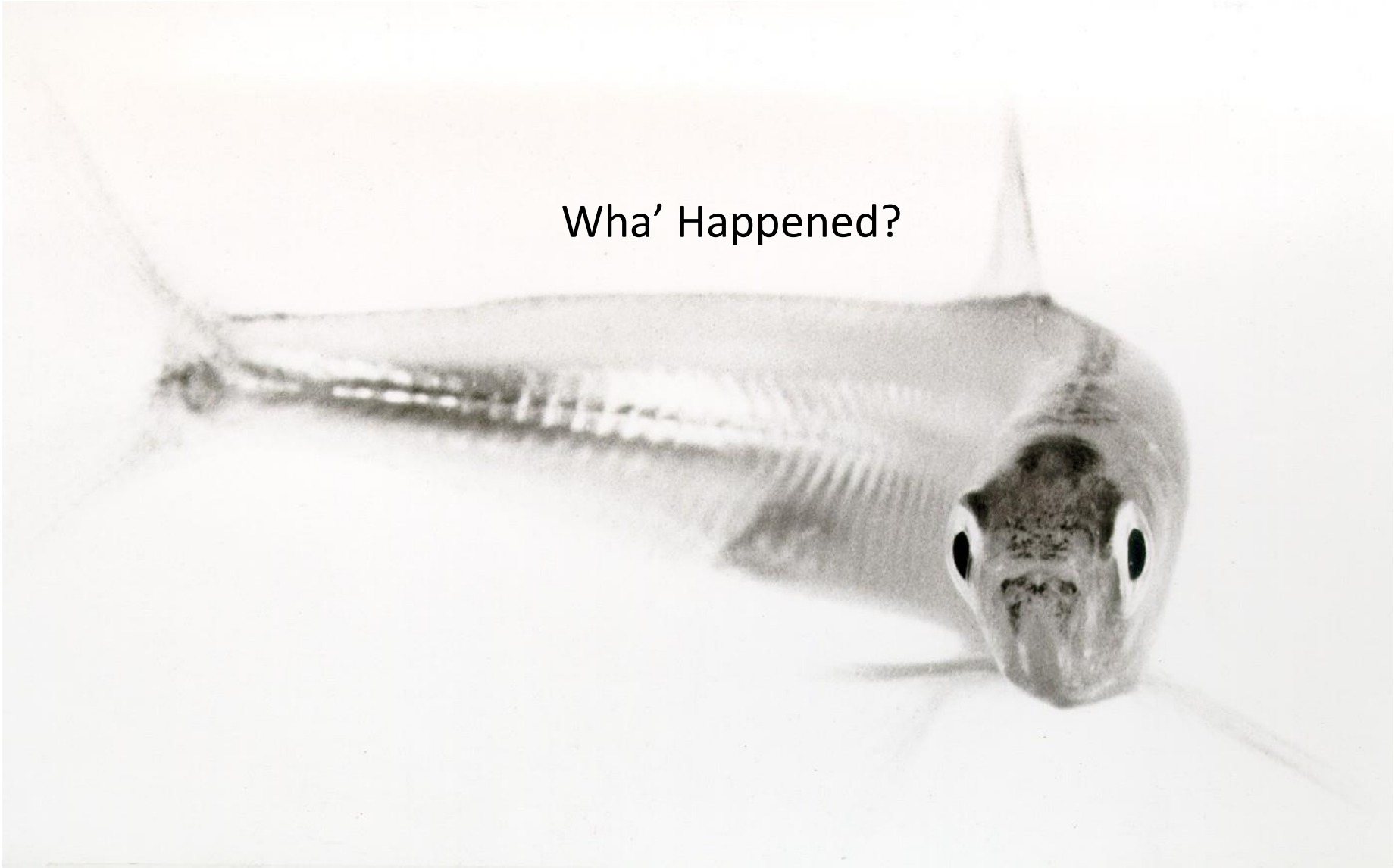
Source: Kimmerer 2002 MEPS

High Flow
20
Low Flow

Fish- X_2
 Relationships
 From Kimmerer 2002



Wha' Happened?



POD---

Pelagic

Organism

Decline

Delta smelt

Longfin smelt

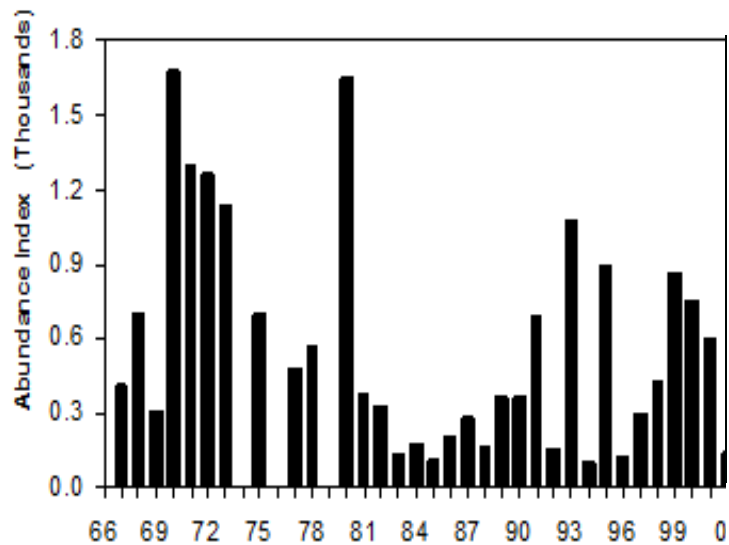


Threadfin shad

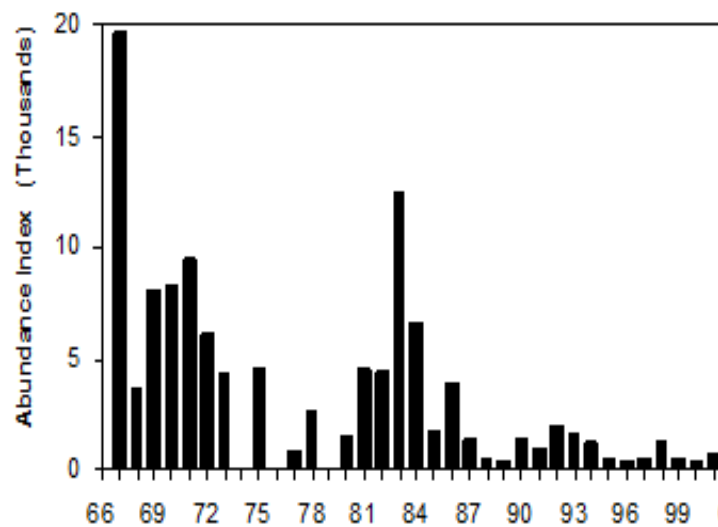


Striped bass

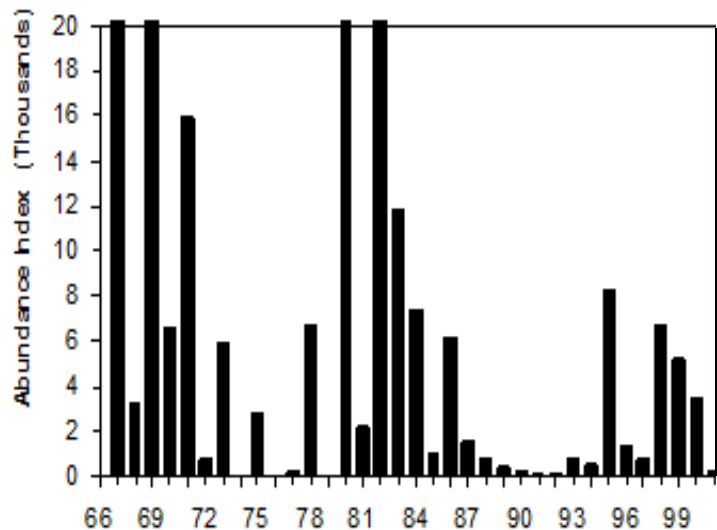
Delta Smelt



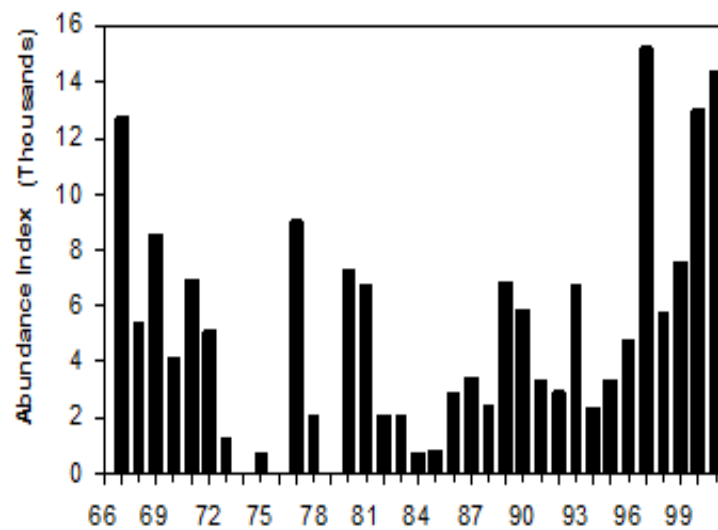
Striped Bass



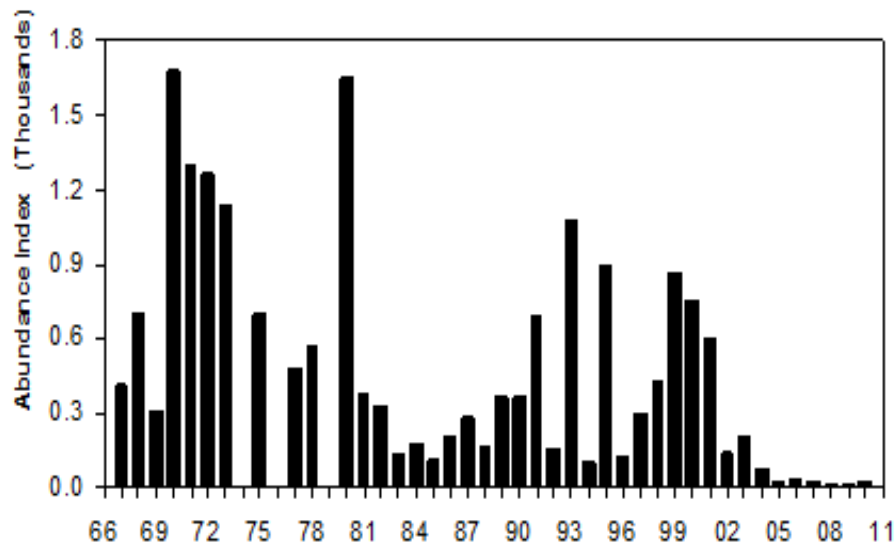
Longfin Smelt



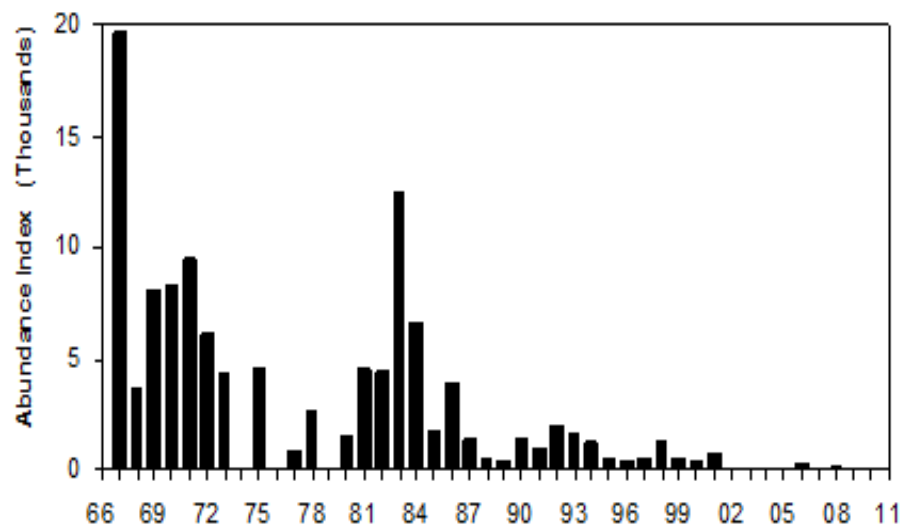
Threadfin Shad



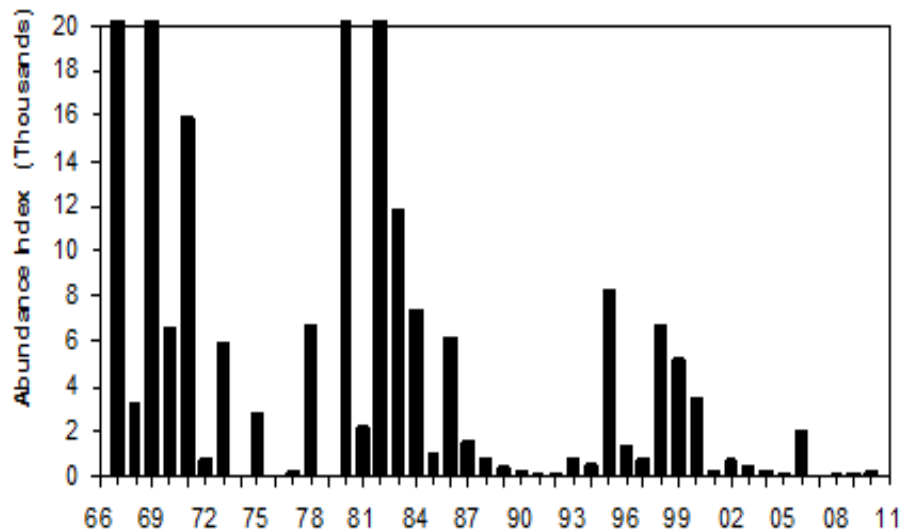
Delta Smelt



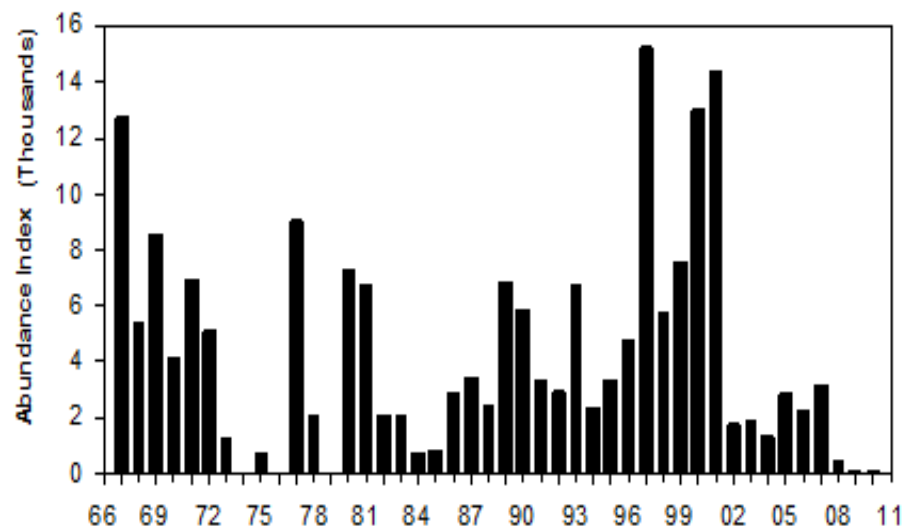
Striped Bass

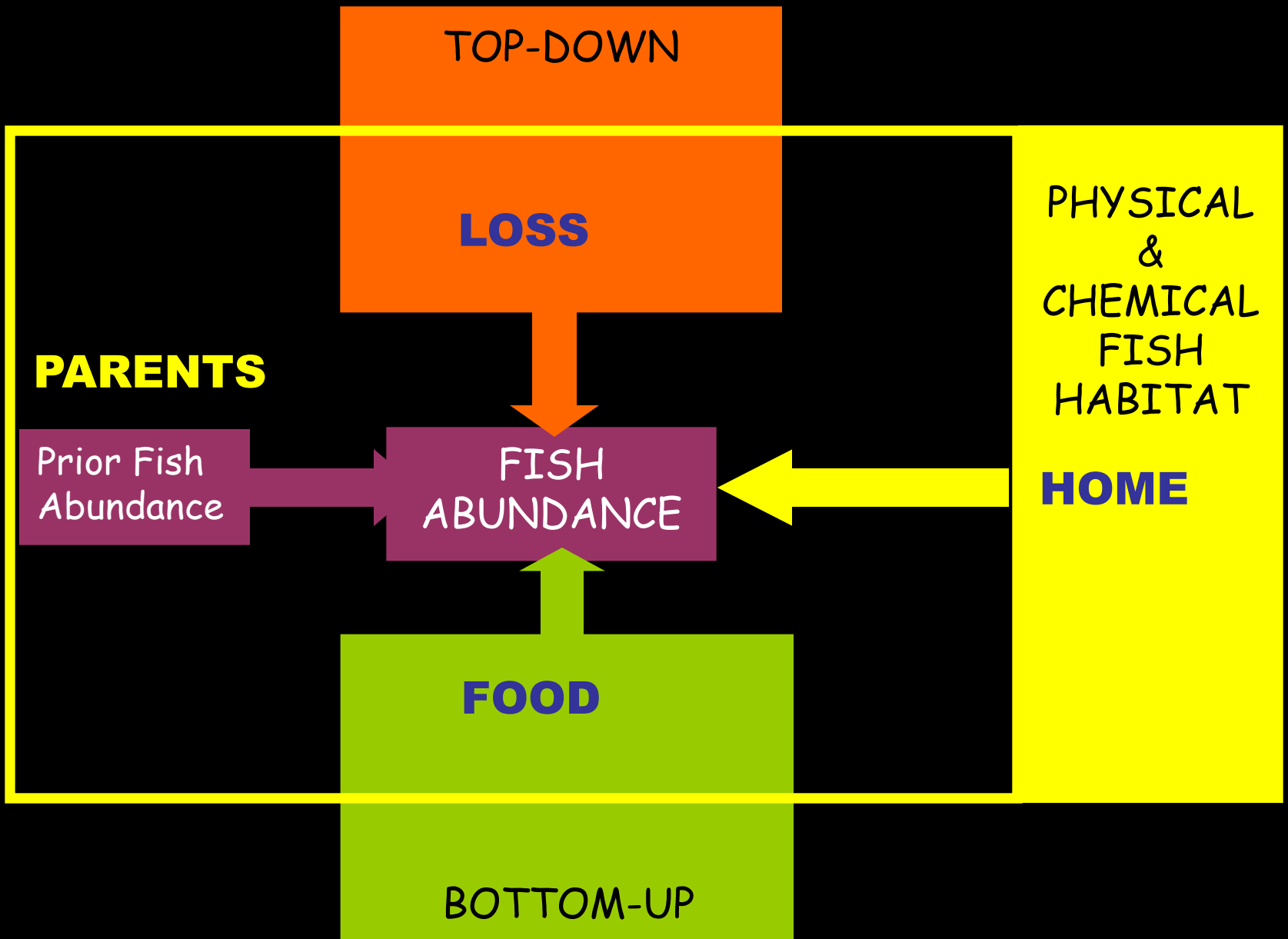


Longfin Smelt



Threadfin Shad







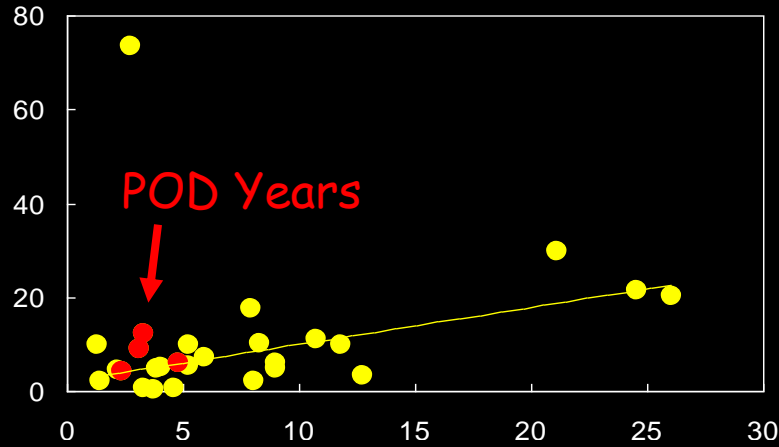
Prior
Abundance



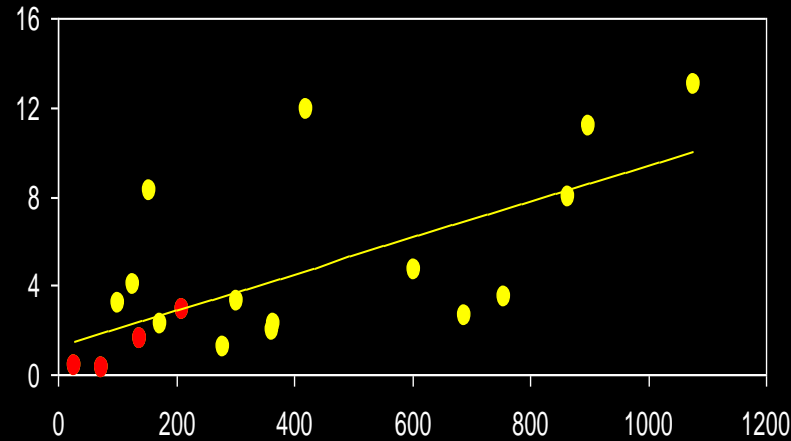
PRESENT
ABUNDANCE

Stock - Recruitment Effects

Juvenile Production



Threadfin shad

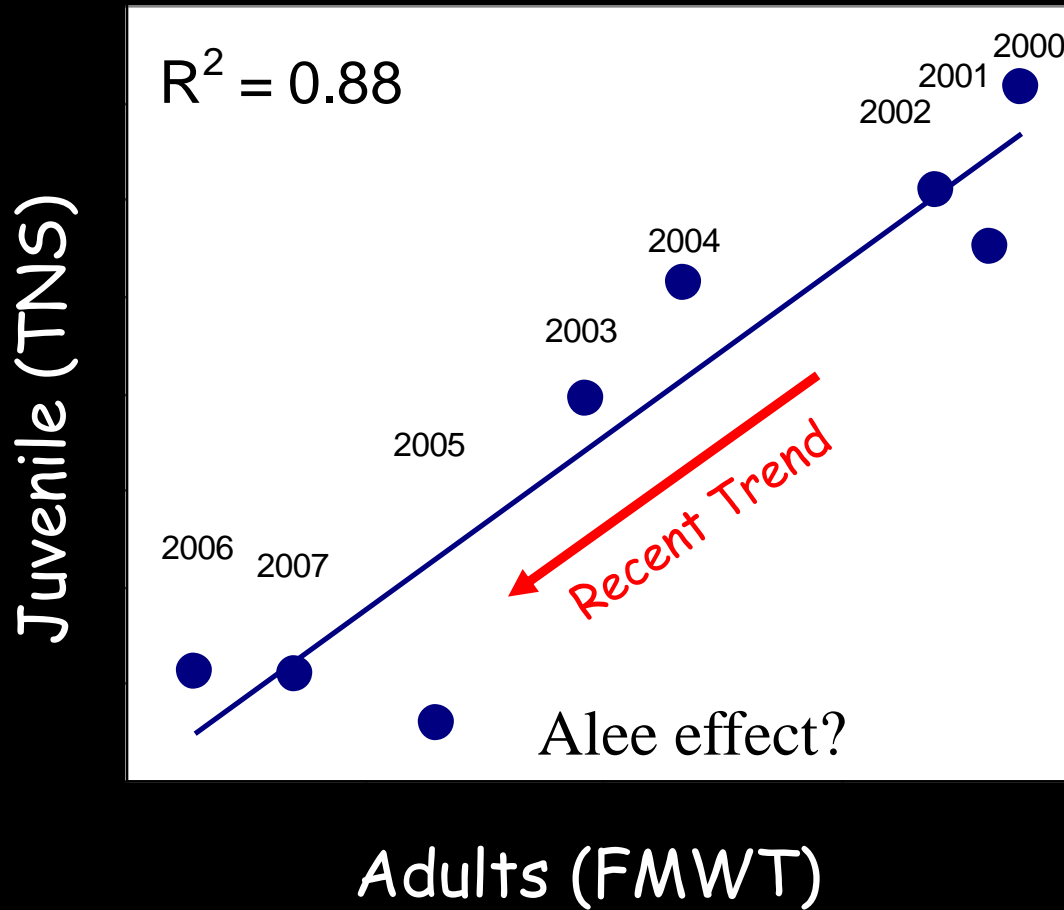


Delta smelt

Fall Midwater Trawl (Adults)



Have Delta Smelt Dropped Below Critical Population Levels?



Source: Anke Mueller-Solger (DWR)

FISH
ABUNDANCE

PHYSICAL
&
CHEMICAL
FISH
HABITAT



PHYSICAL & CHEMICAL FISH HABITAT

FISH
ABUNDANCE

Temperature
Turbidity
Salinity
Nutrients

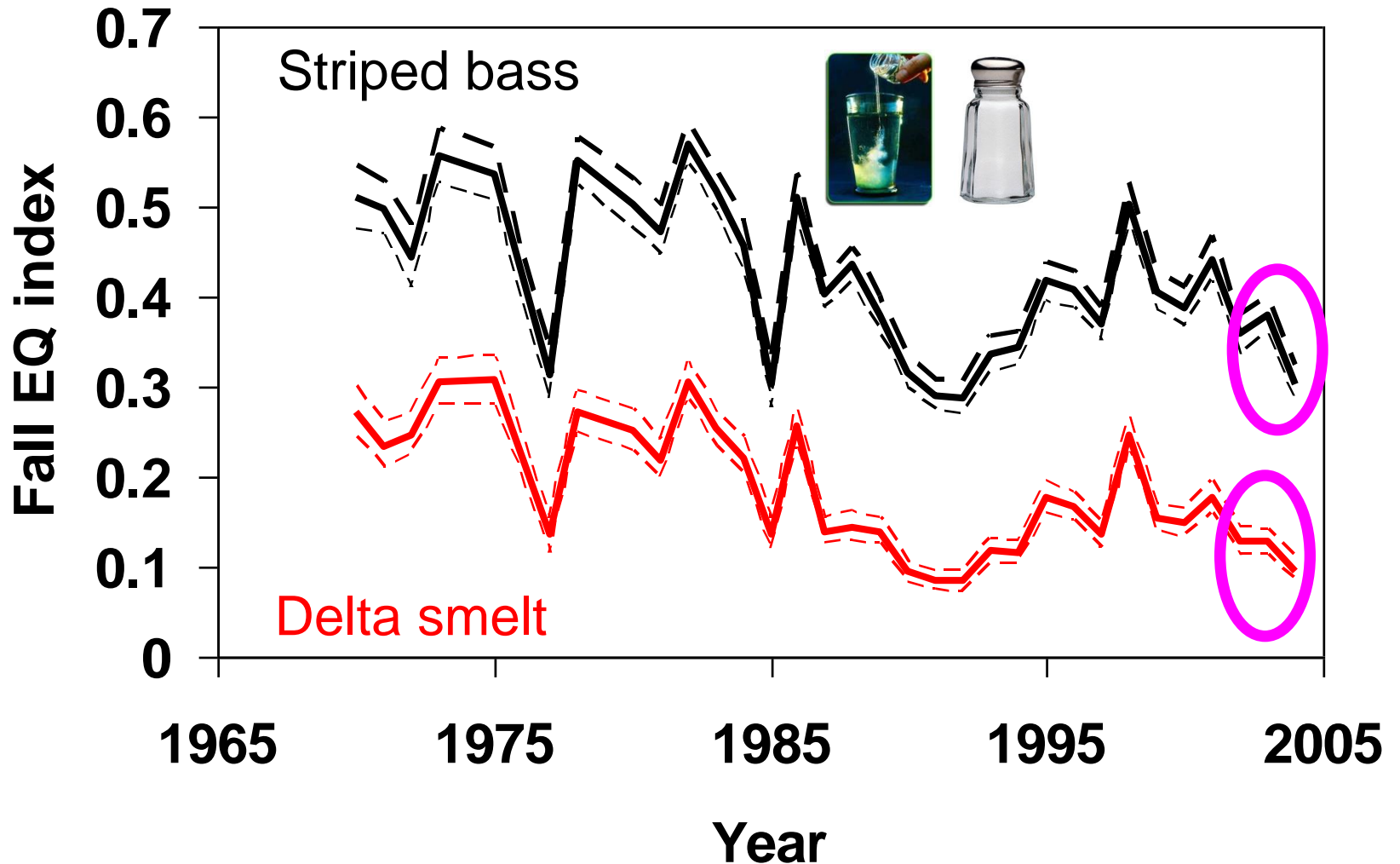
Contaminants

Disease

Toxic algae



Fall "habitat quality" deteriorated



Contaminants and Disease?

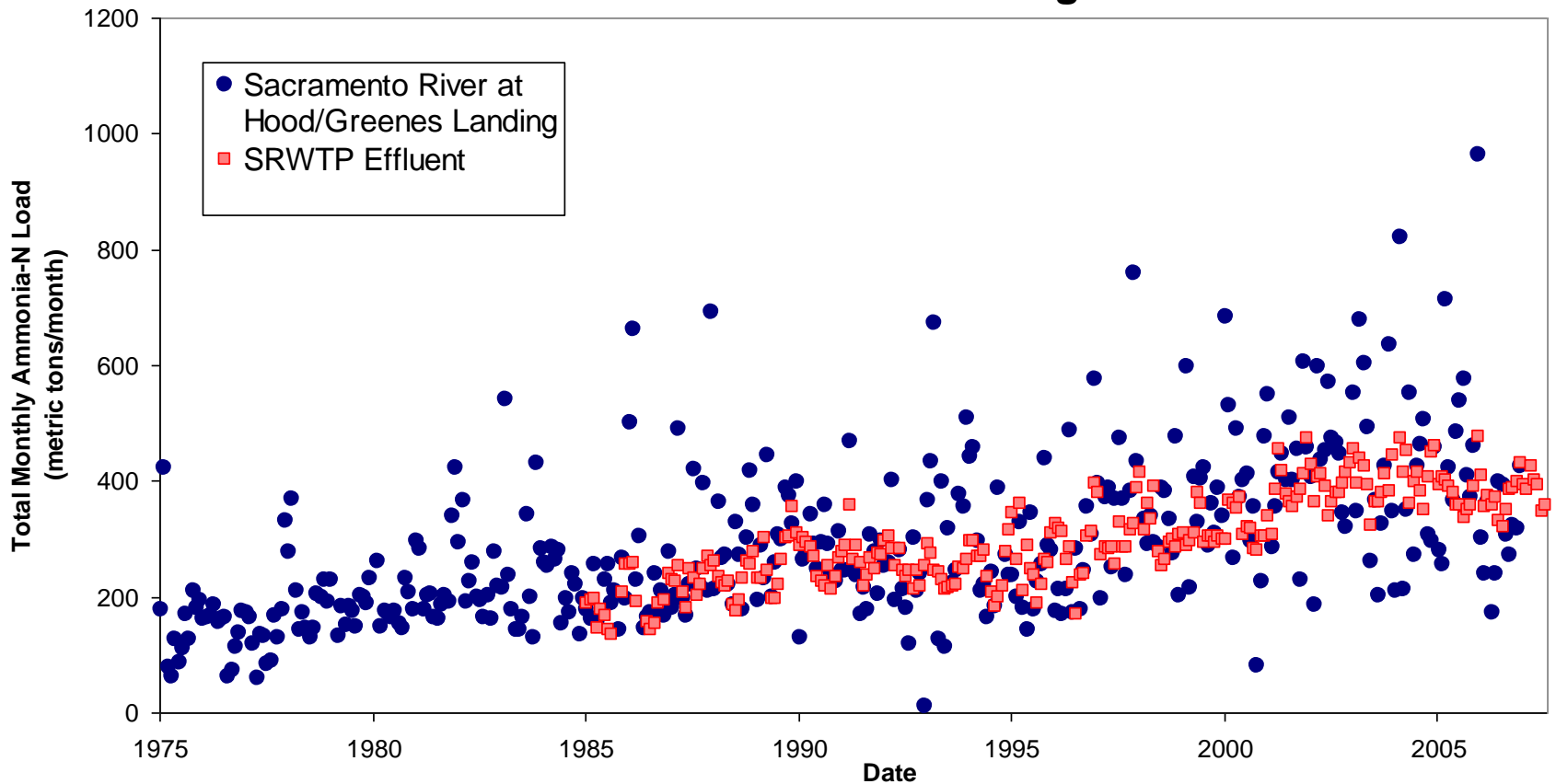
- Bioassays showed little effect (<5 %) in 2005 or 2006.
- <15% adult delta smelt impaired
- 100 % of young striped bass show multiple infections



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

Ammonia?

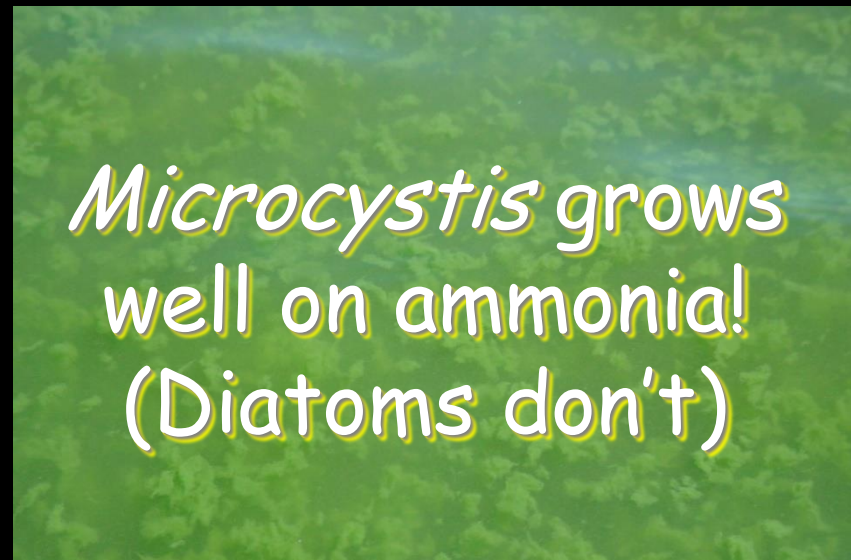
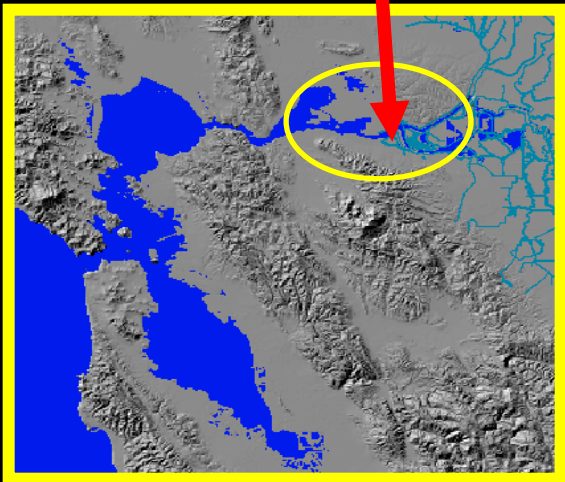
**Monthly Ammonia Loads in the Sacramento River at Hood
and in Effluent from the Sacramento Regional WWTP**



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

Widespread blooms of the toxic alga *Microcystis* in 2007

August Levels: 1.3 million cells/mL



Core Habitat of Delta Smelt

Source: Peggy Lehman (DWR)



TOP-DOWN

*Water
Divisions*

Predation

FISH
ABUNDANCE

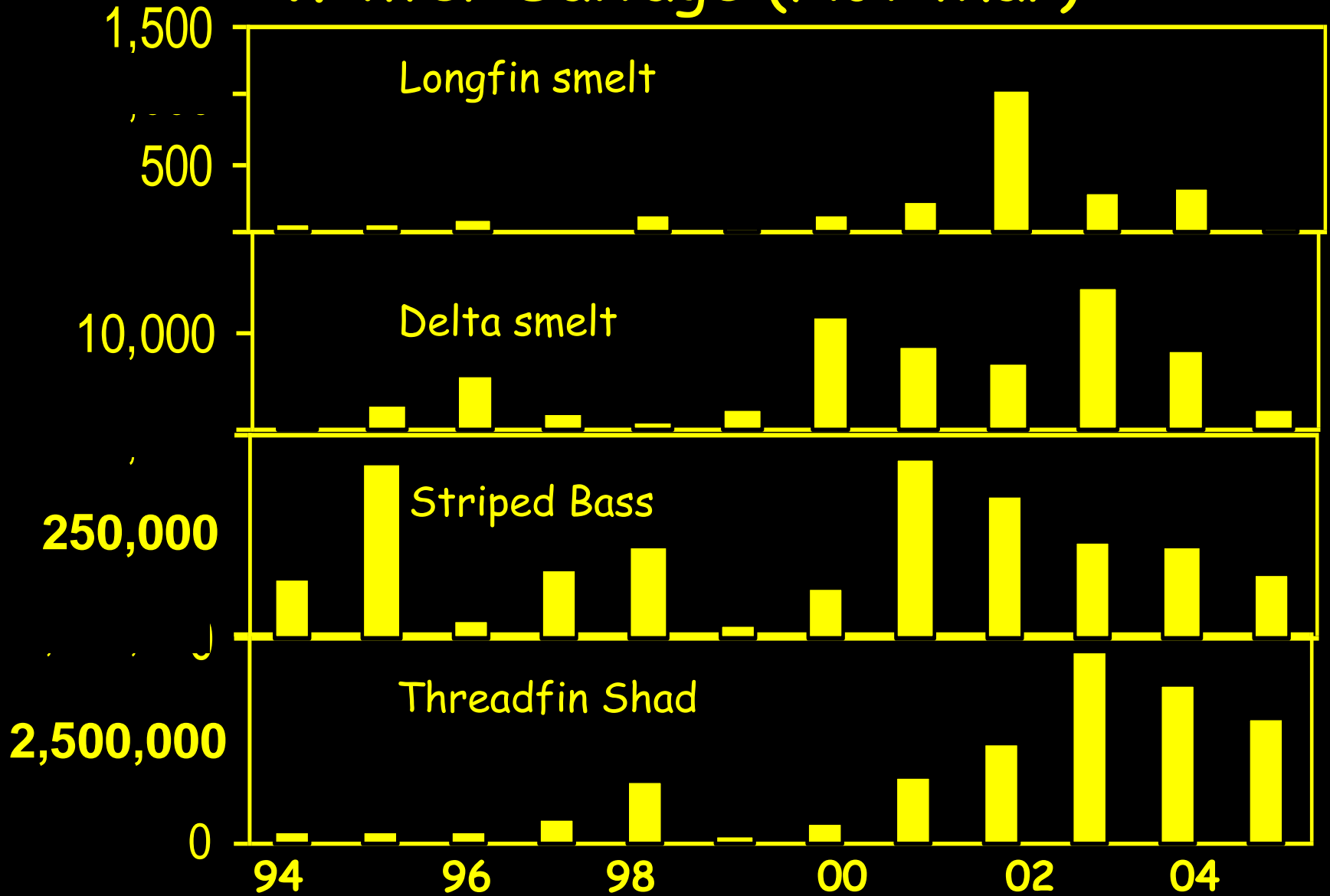


Water Project Losses



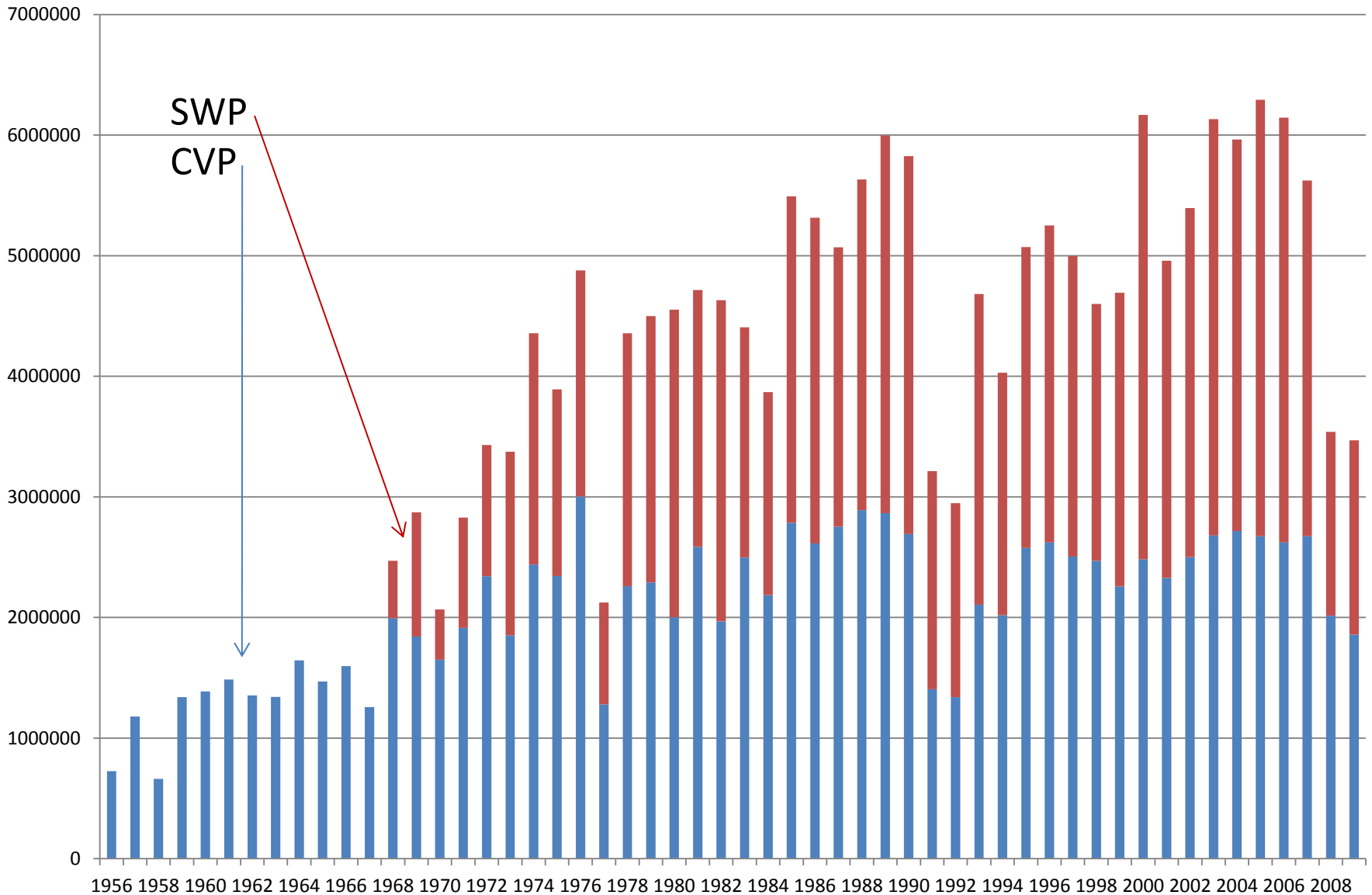
Fish Facilities Provide Data on Numbers "Salvaged"

Winter Salvage (Nov-Mar)

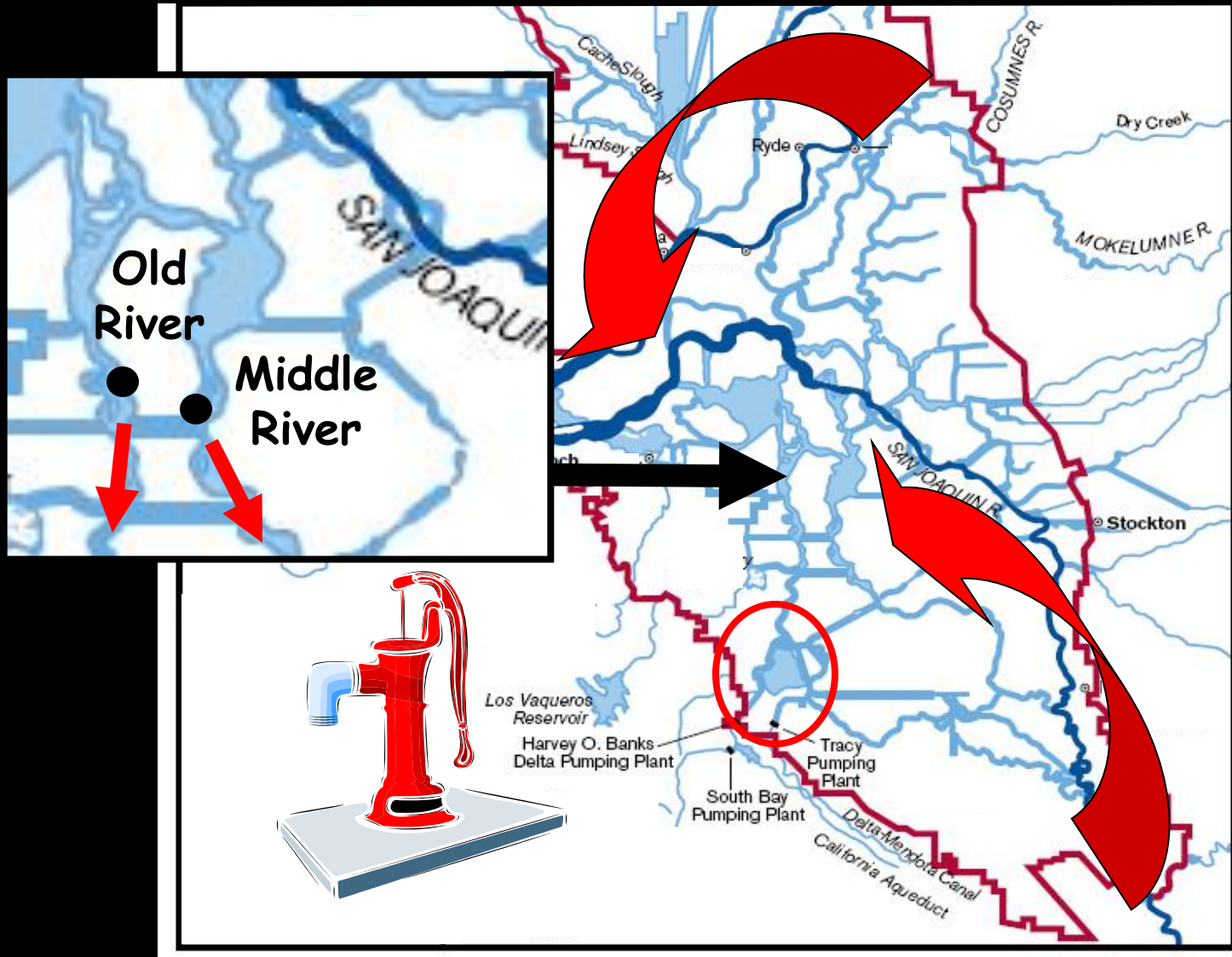


Exports in acre-feet

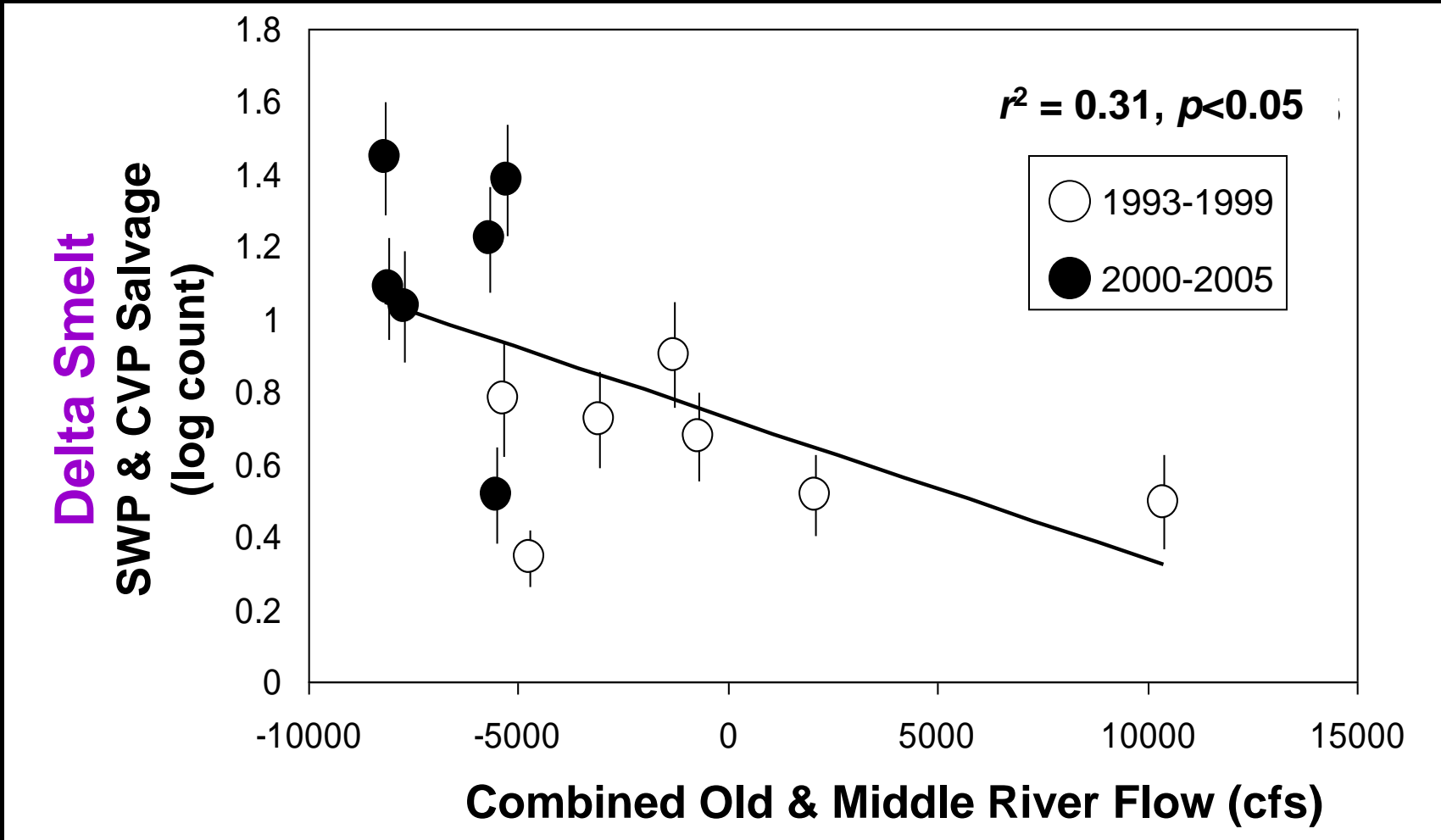
1 acre-foot = 325,851 gallons = 1233 kiloliters



OMR = Old and Middle River flows



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



Mean Values for December-March
1993-2005

Source: Lenny Grimaldo



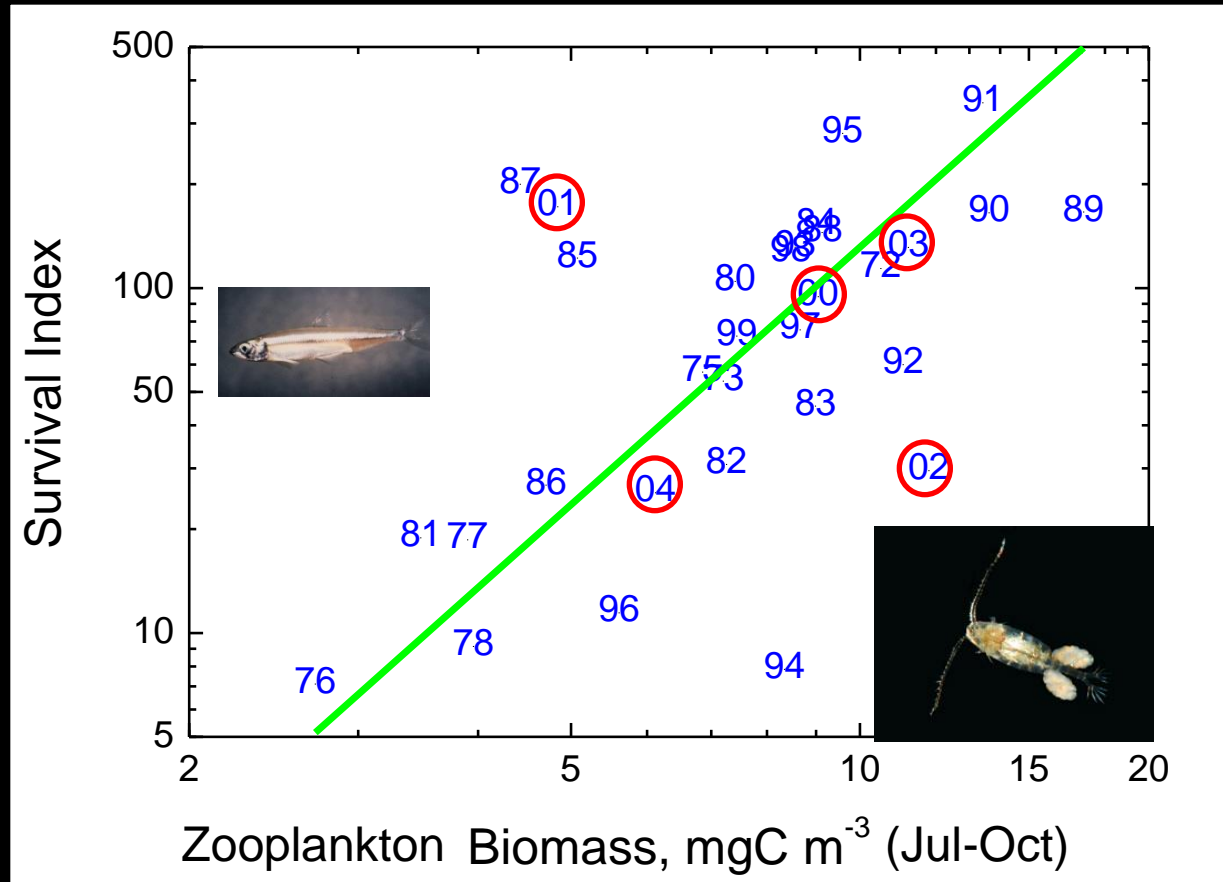
FISH
ABUNDANCE



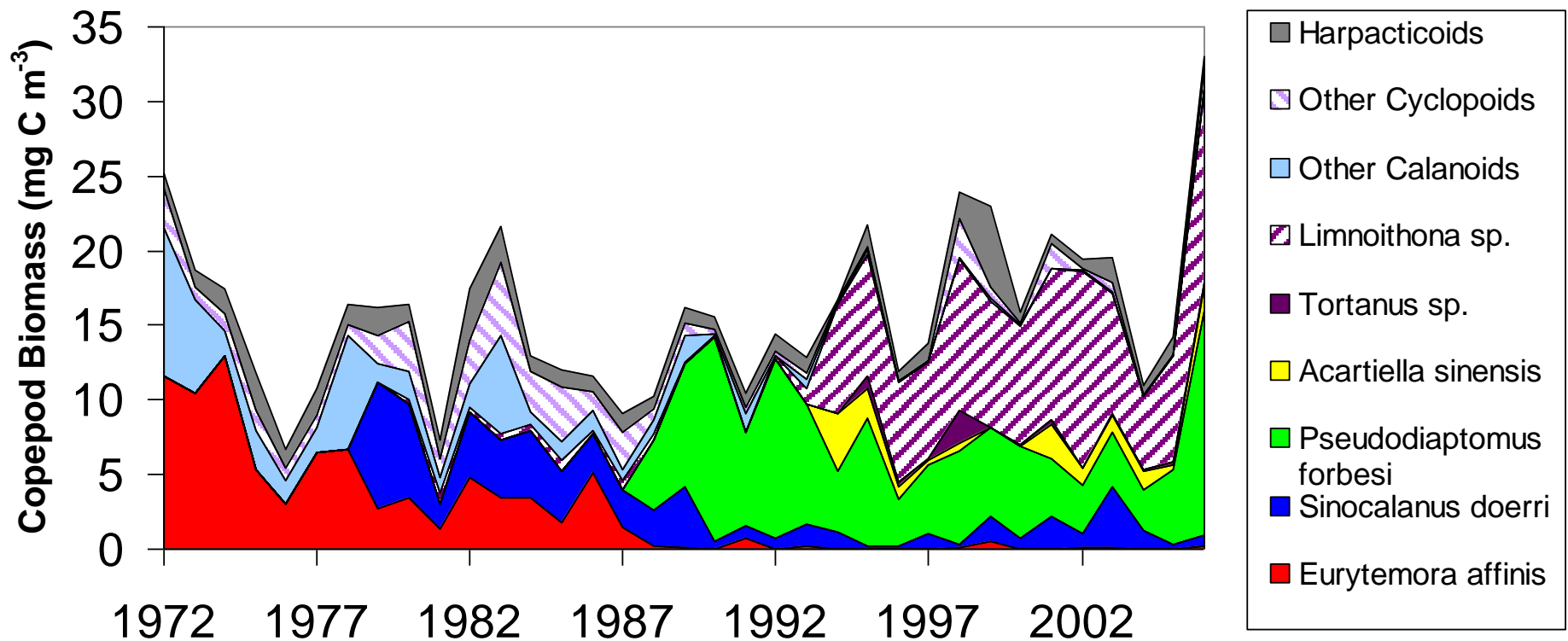
BOTTOM-UP



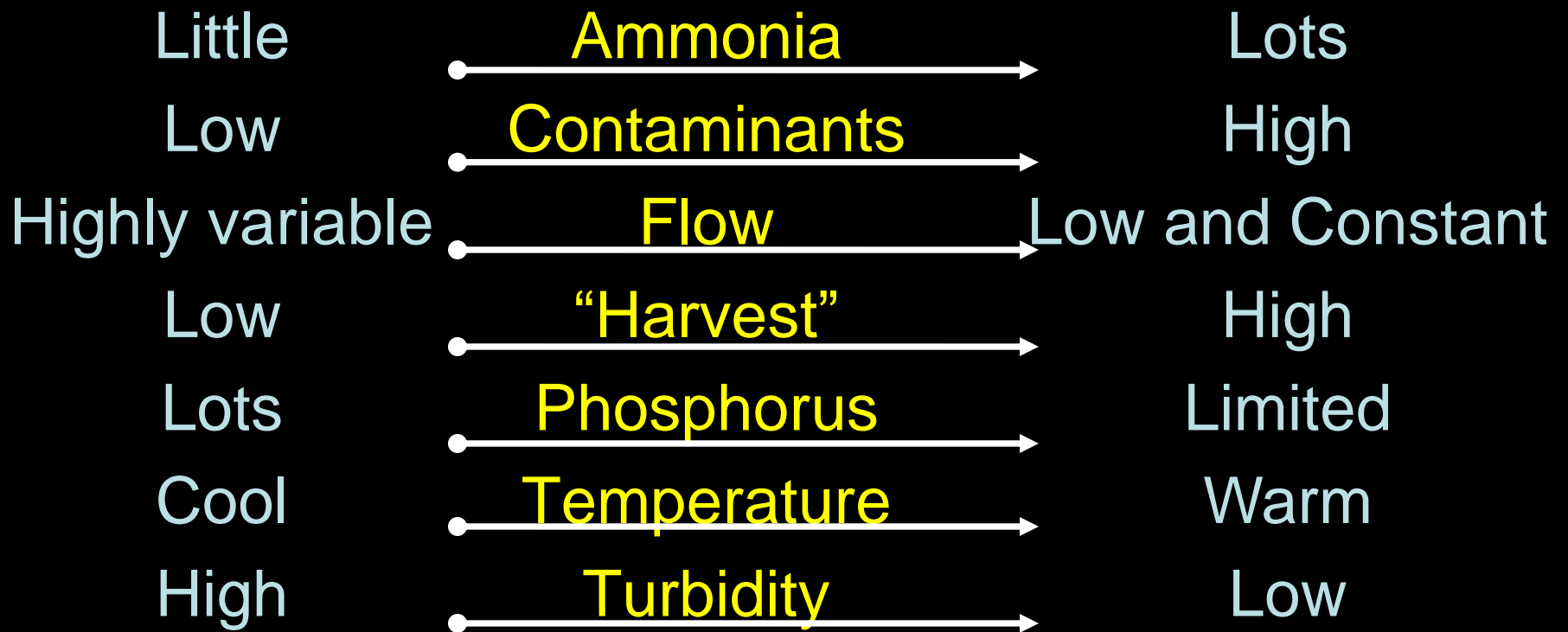
Food Affects Summer Smelt Survival But Recent Levels Were Not Remarkable



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

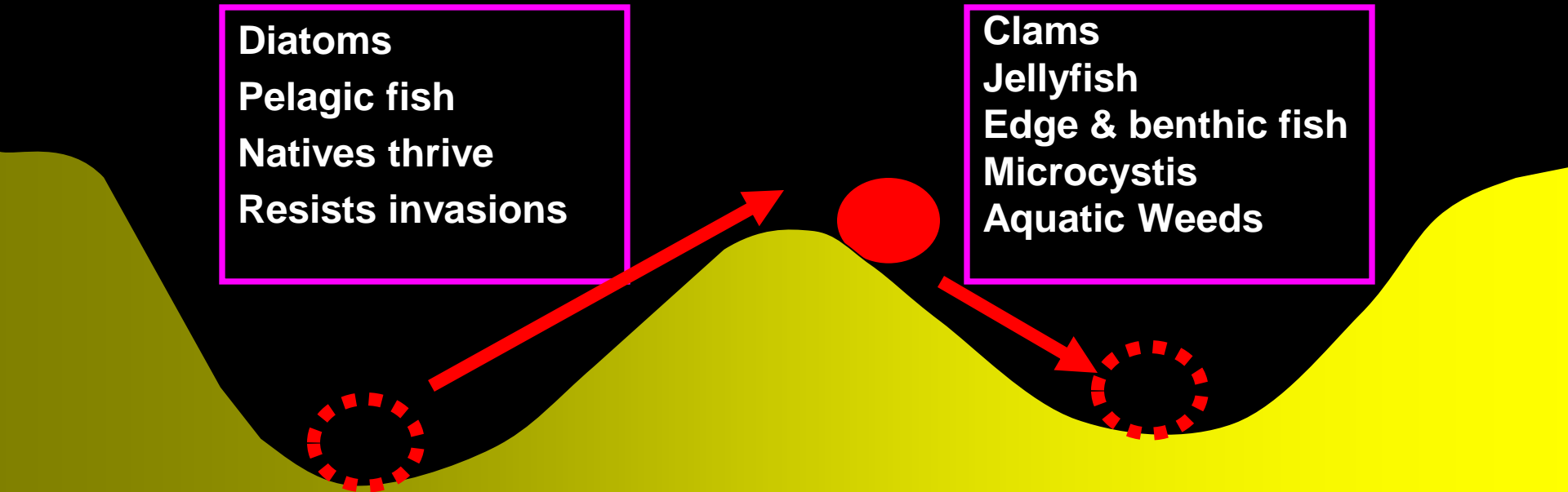


Source: Anke Mueller-Solger (DWR); IEP (2007)

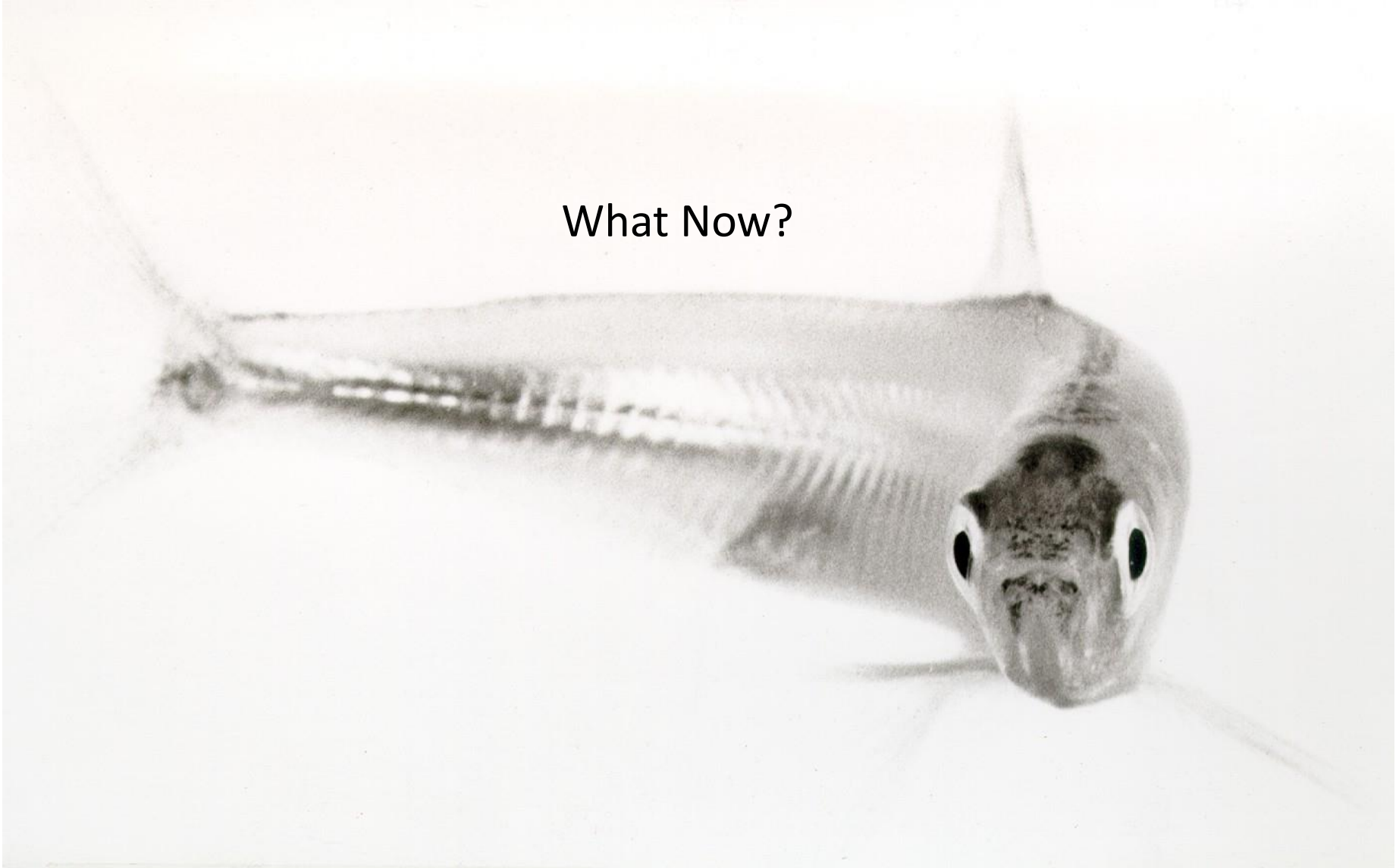


Diatoms
Pelagic fish
Natives thrive
Resists invasions

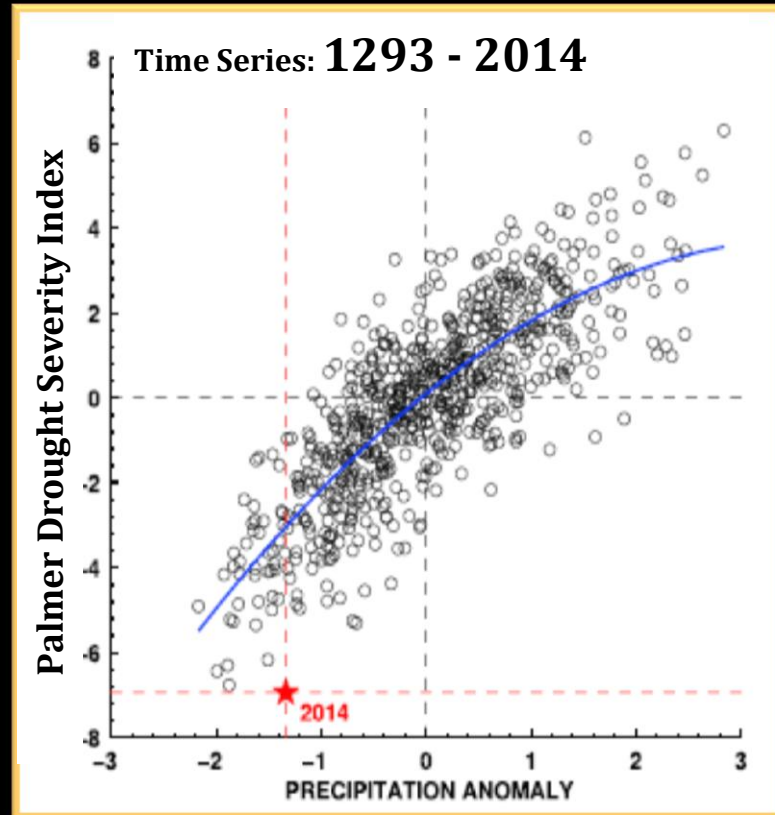
Clams
Jellyfish
Edge & benthic fish
Microcystis
Aquatic Weeds



What Now?



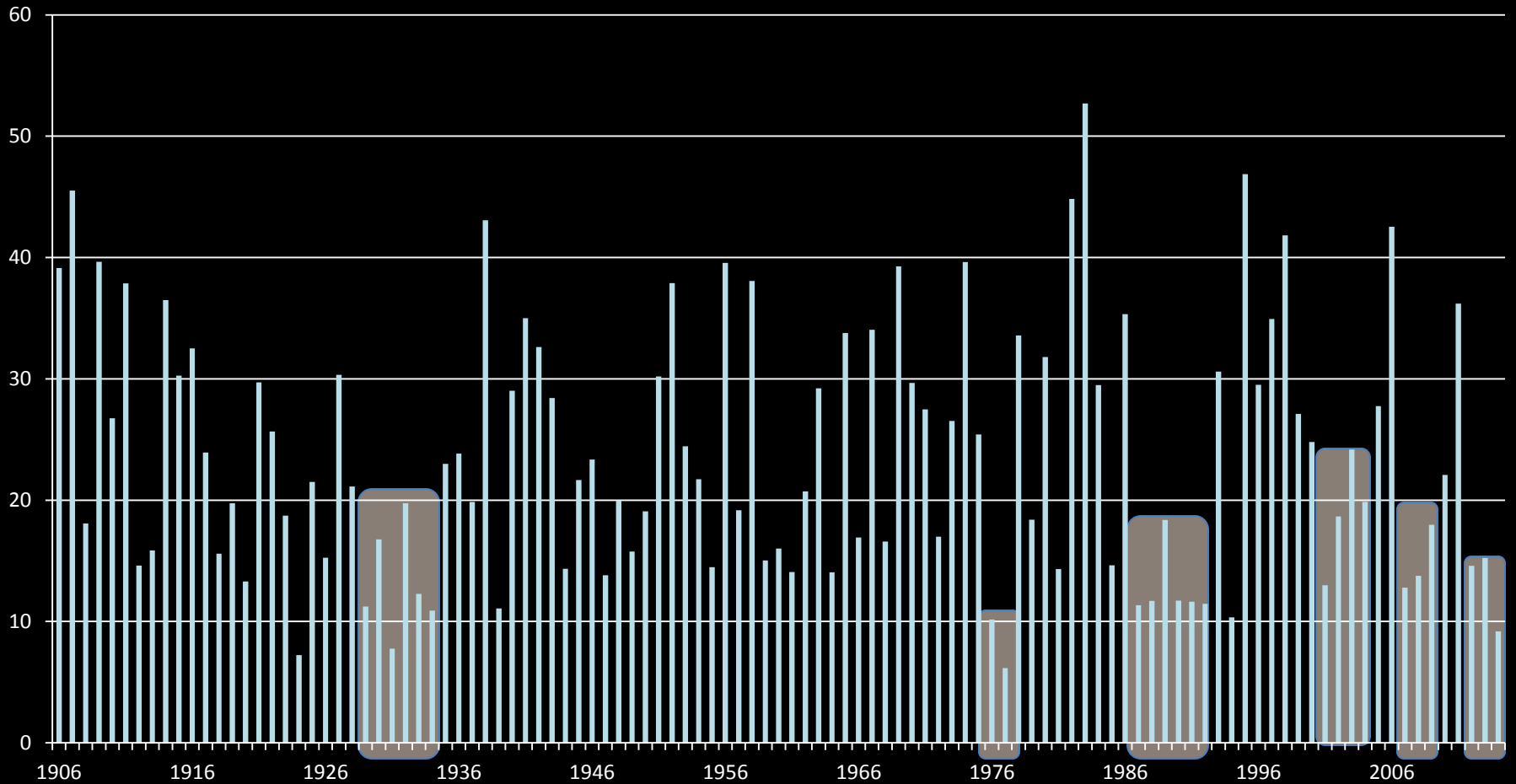
Drought Effects on Delta Smelt Application of a Conceptual Model



Griffin & Anchukaitis, 2014
Geophysical Research Letters, 41: 1-7.

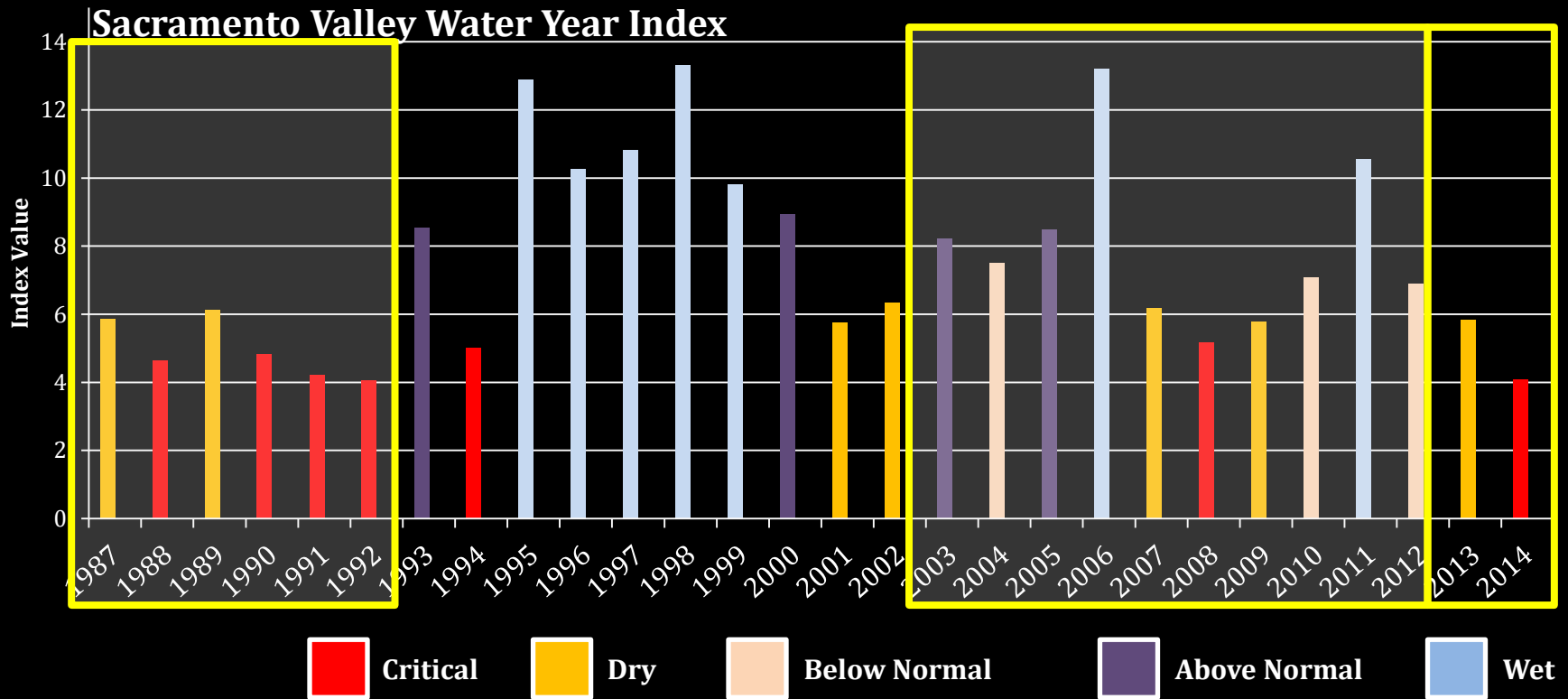
Thanks to Louise Conrad, DWR

Central Valley Runoff MAF



➤ 2013-2014 Drought compared to Previous Decade

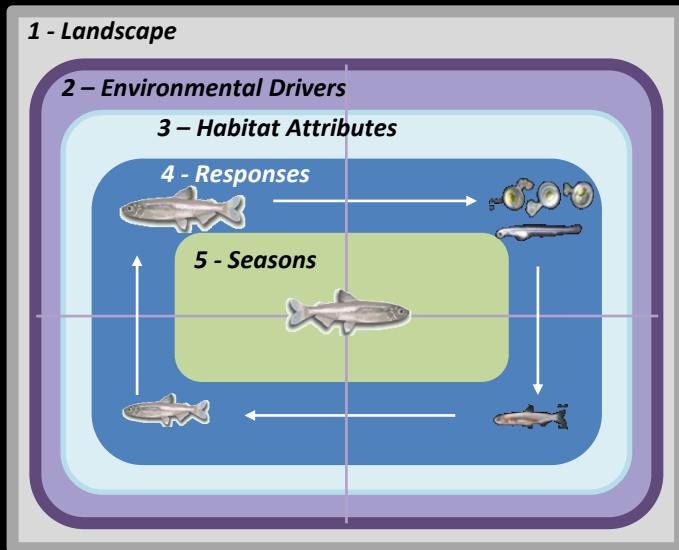
➤ 2013-2014 Drought compared to 1987-1992 Drought



Delta Smelt MAST Report: Completed January 2015

INTERAGENCY ECOLOGICAL PROGRAM, MANAGEMENT, ANALYSIS, AND SYNTHESIS TEAM

An updated conceptual model
of Delta Smelt biology:
our evolving understanding of an estuarine fish



**Technical Report 90
January, 2015**

Interagency Ecological Program
for the
San Francisco Bay/Delta Estuary

A Cooperative Program of:

California Department of Water Resources
California Department of Fish and Wildlife
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers

State Water Resource Control Board
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Environmental Protection Agency
National Marine Fisheries Service

www.water.ca.gov/iep

Tier 1 - Landscape Attributes

Erodible Sediment Supply, Proximity to Ocean, Proximity to Discharges,
Proximity to Diversions, Bathymetry (Proximity to and Extent of Shallow Areas)

Tier 2 - Environmental Drivers

Air Temperature, Flows, Turbidity,
Contaminant Loading, Water Diversions

Weather, Exports, Hydrology,
Turbidity, Contaminants

Tier 3 - Habitat Attributes

Food, Predation, Temperature,
Entrainment, Toxicity

Food, Predation, Temperature,
Transport, Entrainment, Toxicity

Tier 4 - Delta Smelt Responses

Adults

Spawning

**Eggs &
Larvae**

Survival

Tier 5 - Life Stage Seasons

December-May
(Winter)

March-June
(Spring)

Growth

September-December
(Fall)

June-September
(Summer)

Survival

Subadults

Survival

Growth

Juveniles

Food, Predation, Size and
Location of LSZ, Toxicity

Food, Predation, Temperature
Harmful Algal Blooms, Toxicity

Weather, Outflow, Turbidity, Clam Grazing,
Nutrients, Contaminants

Weather, Hydrology, Turbidity, Clam Grazing,
Nutrients, Contaminants



Seasonally Clearer Water...

Jan - Mar

Apr - Jun

July - Aug

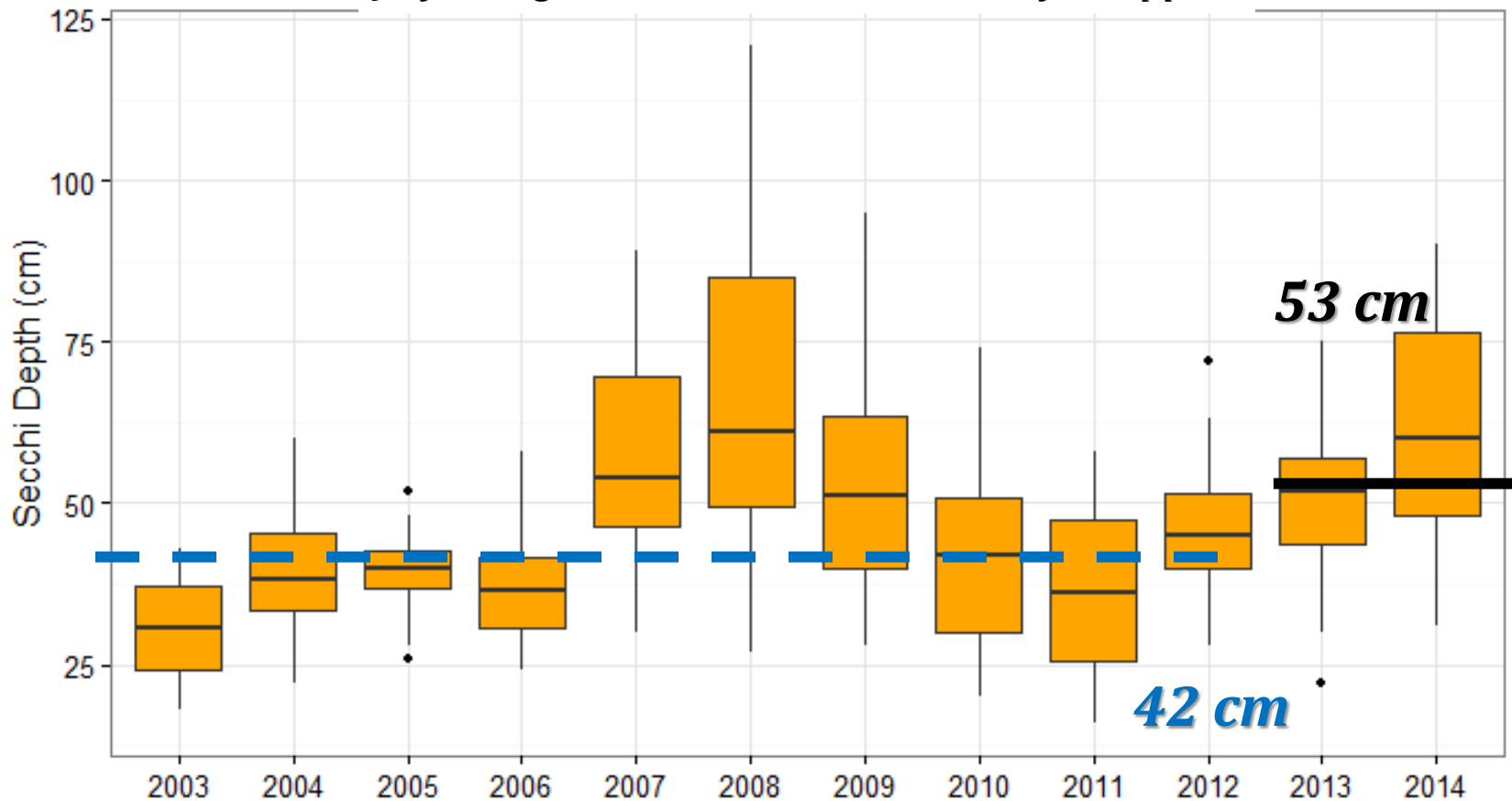
Sept - Dec

Results

Water Clarity



July - August, Summer Towntnet Survey, 1-6ppt



CDFW Summer Towntnet Survey

Sharp Increase in Mississippi Silverside Abundance

Jan - Mar

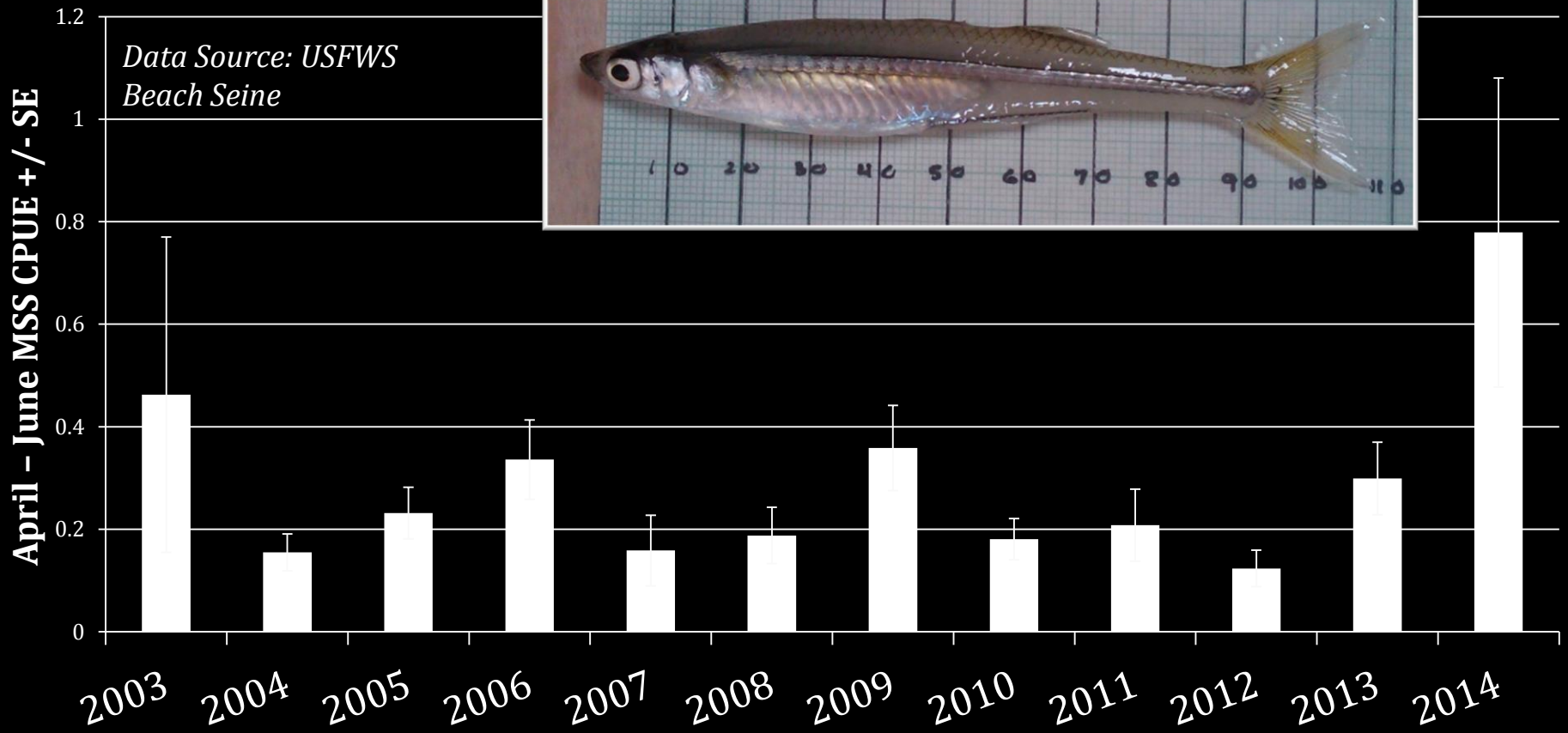
Apr - Jun

July - Aug

Sept - Dec

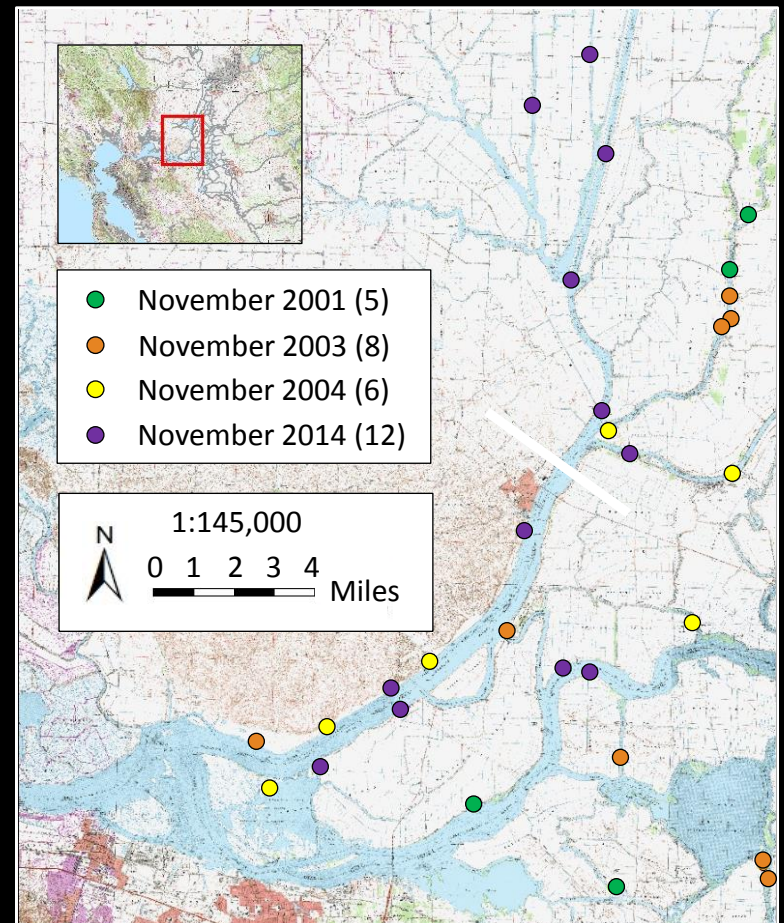
Results

Mississippi Silverside



November 2014: Boat Electrofishing Drought Survey

- Western and northern Delta



Black bass densities increased in 2014

Jan - Mar

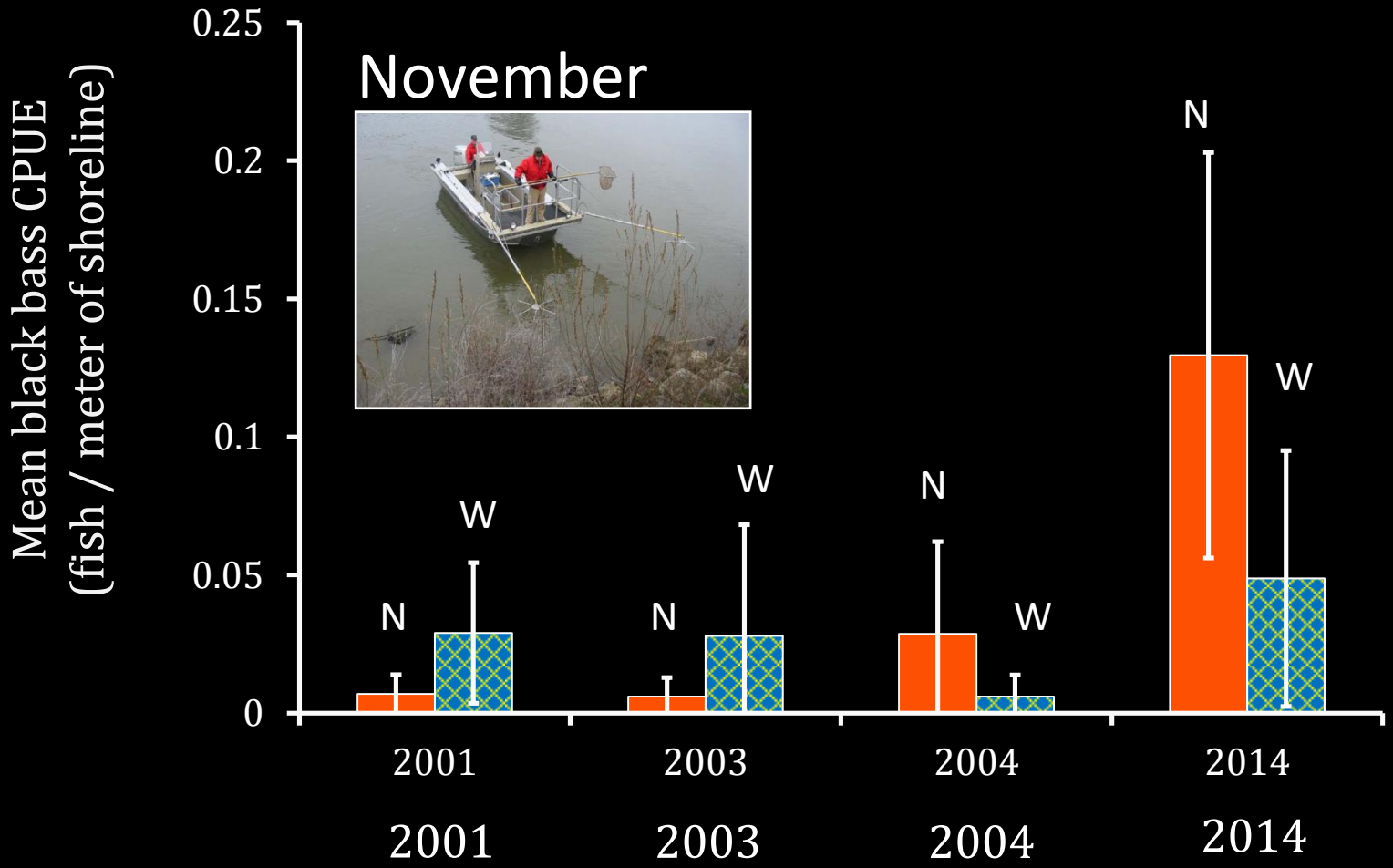
Apr - Jun

July - Aug

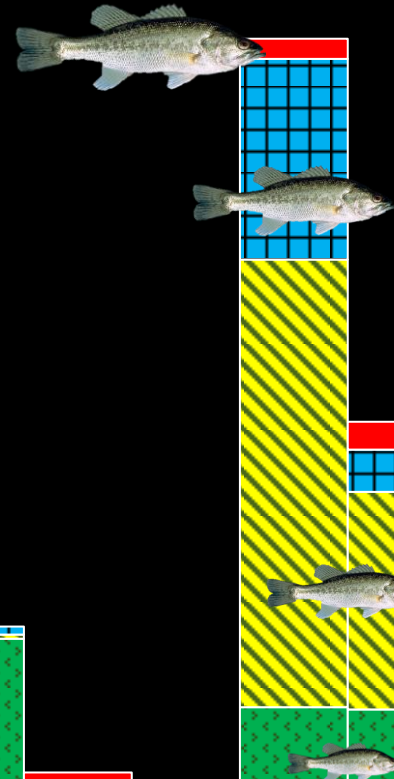
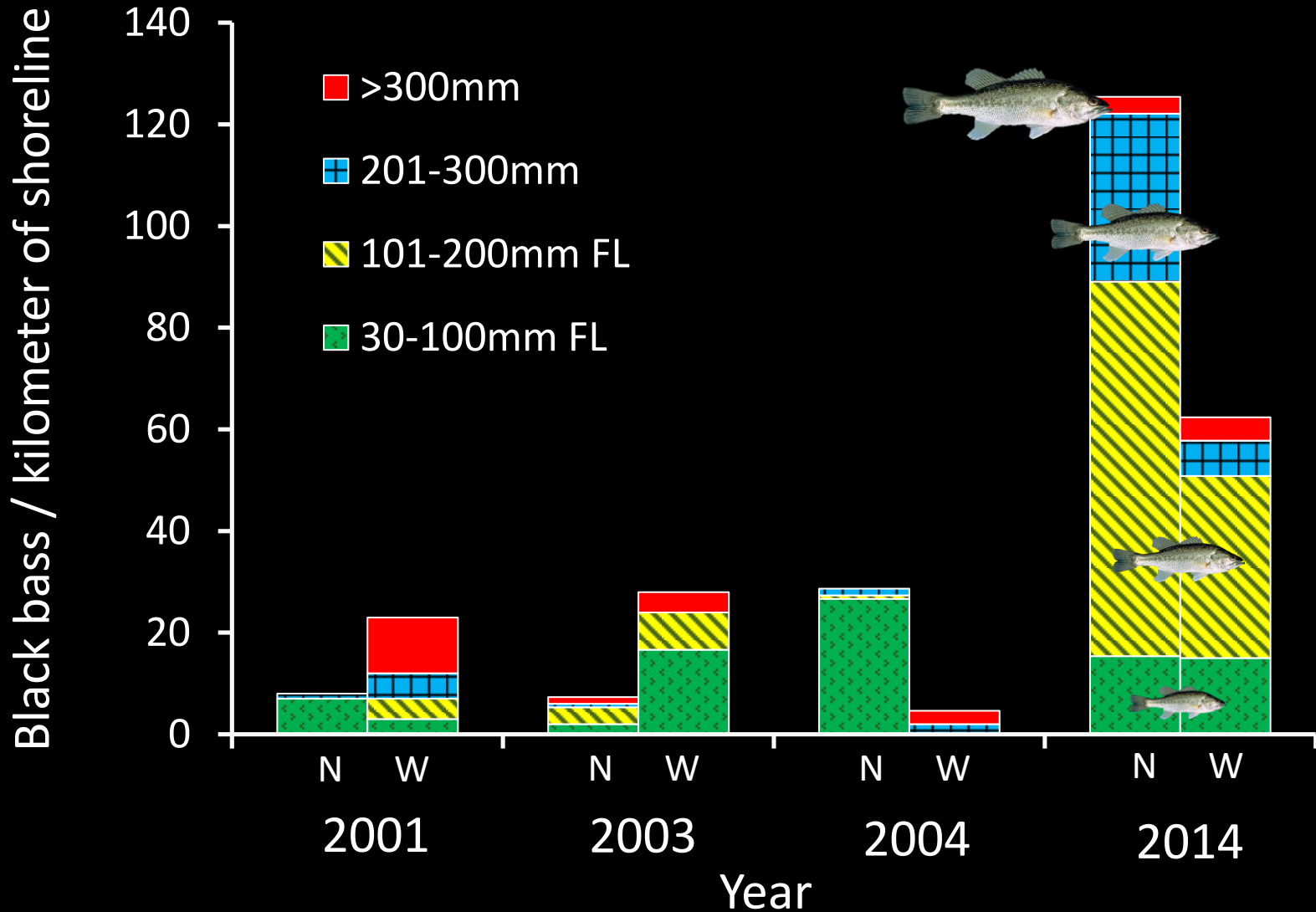
Sept - Dec

Results

Black Bass



More Black Bass in Larger Size Classes



Water Temperatures Warmer All Year Long

Jan - Mar

Apr - Jun

Jul - Aug

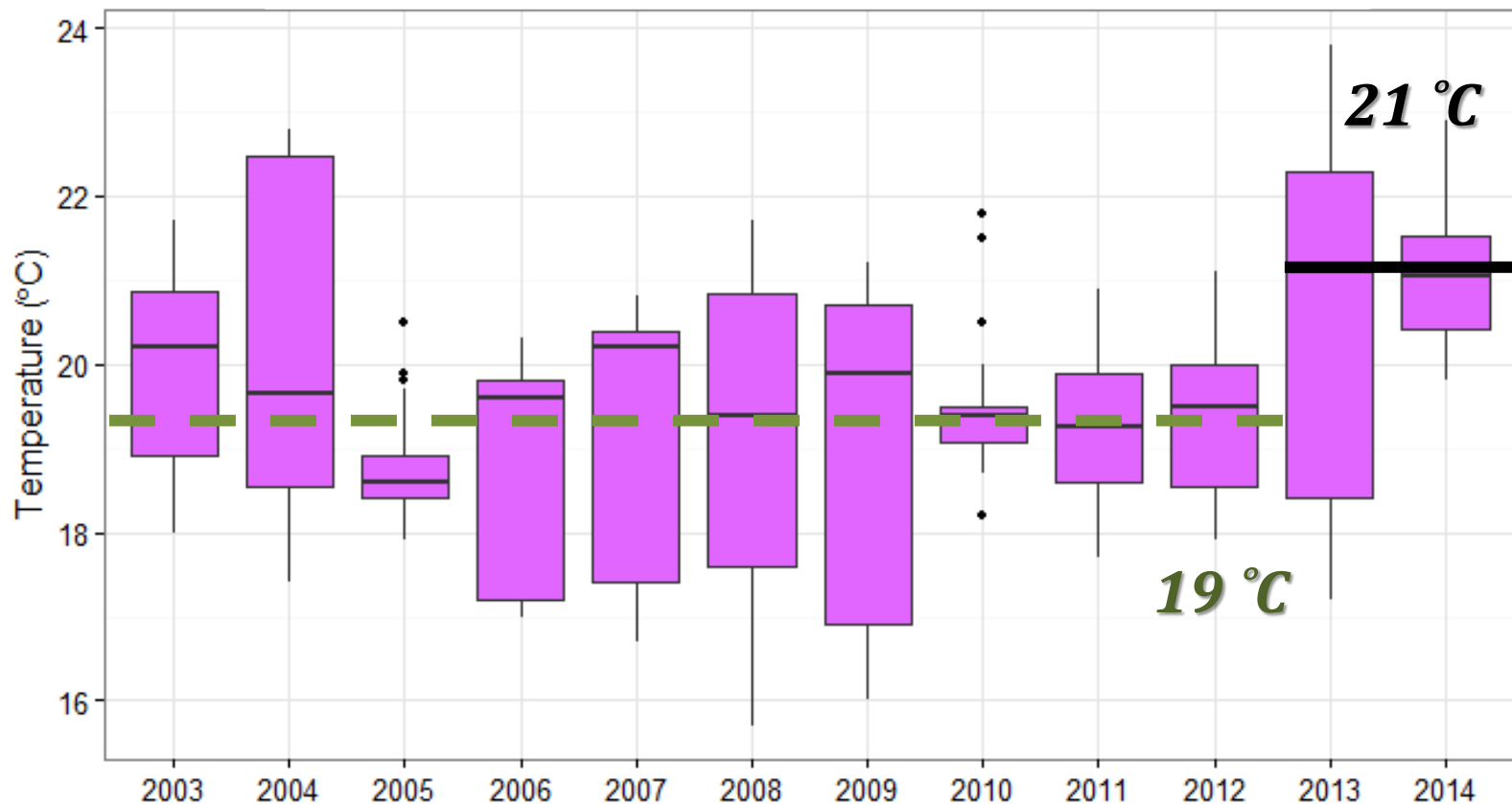
Sept - Dec

Results

Water Temp

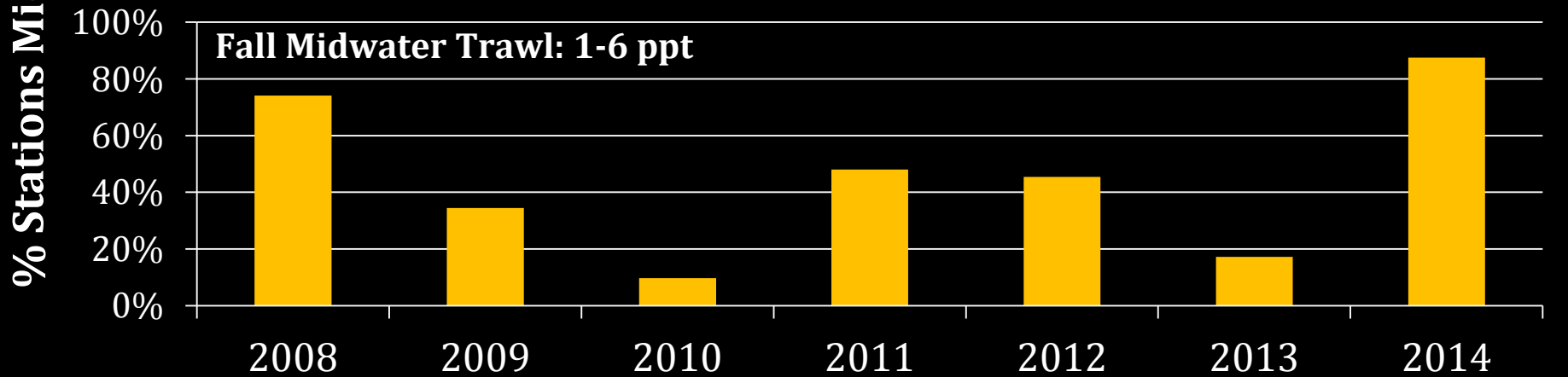
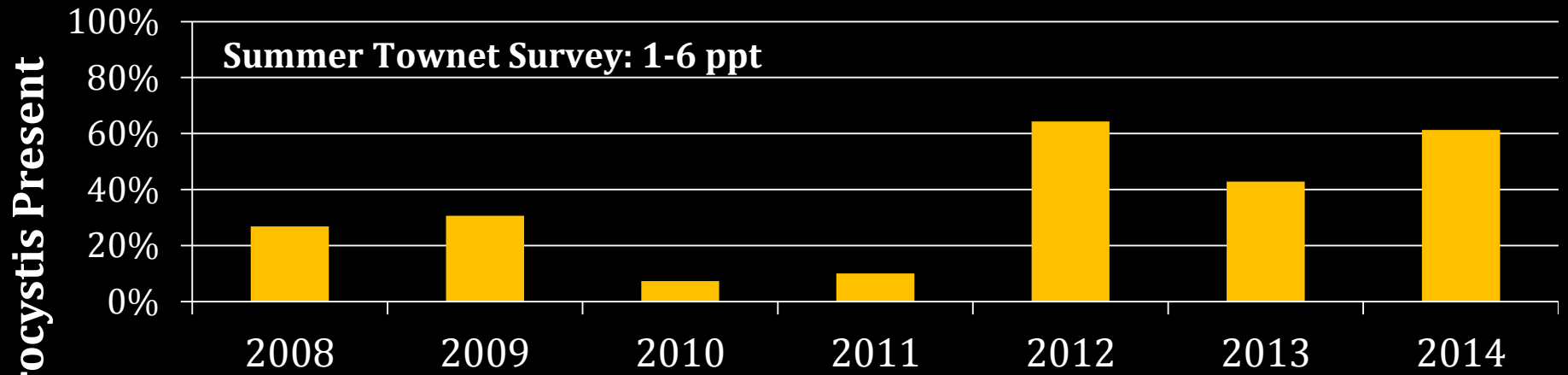


September - October only, Fall Midwater Trawl, 1-6 ppt

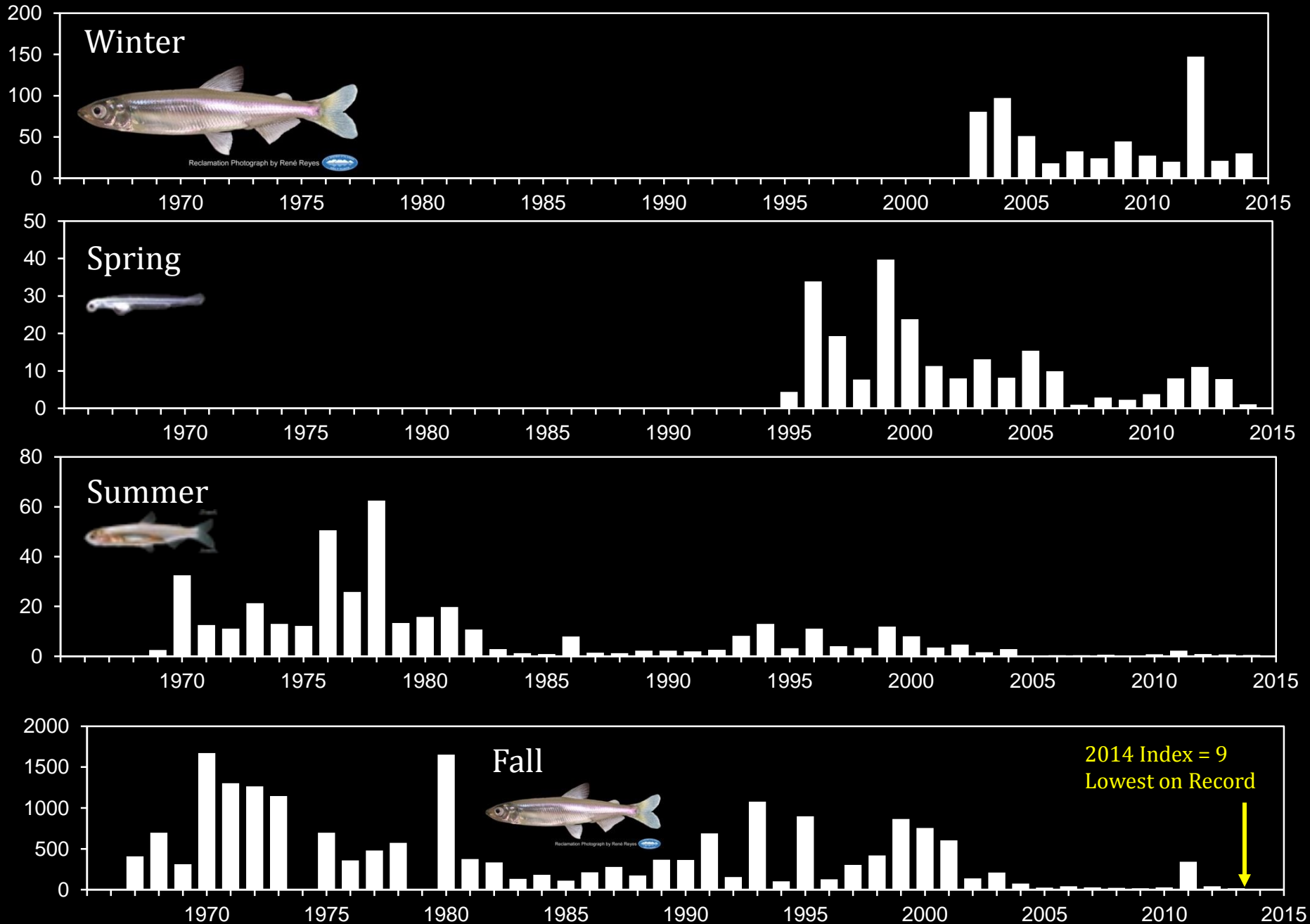


Microcystis More Prevalent

	Jan - Mar	Apr - Jun	Jul - Aug	Sept - Dec
Results				
<i>Harmful Algae Bloom</i>			↑	↑



Abundance Indices at Historic Lows



Warmer Air Temperatures During Drought

Jan - Mar

Apr - Jun

July - Aug

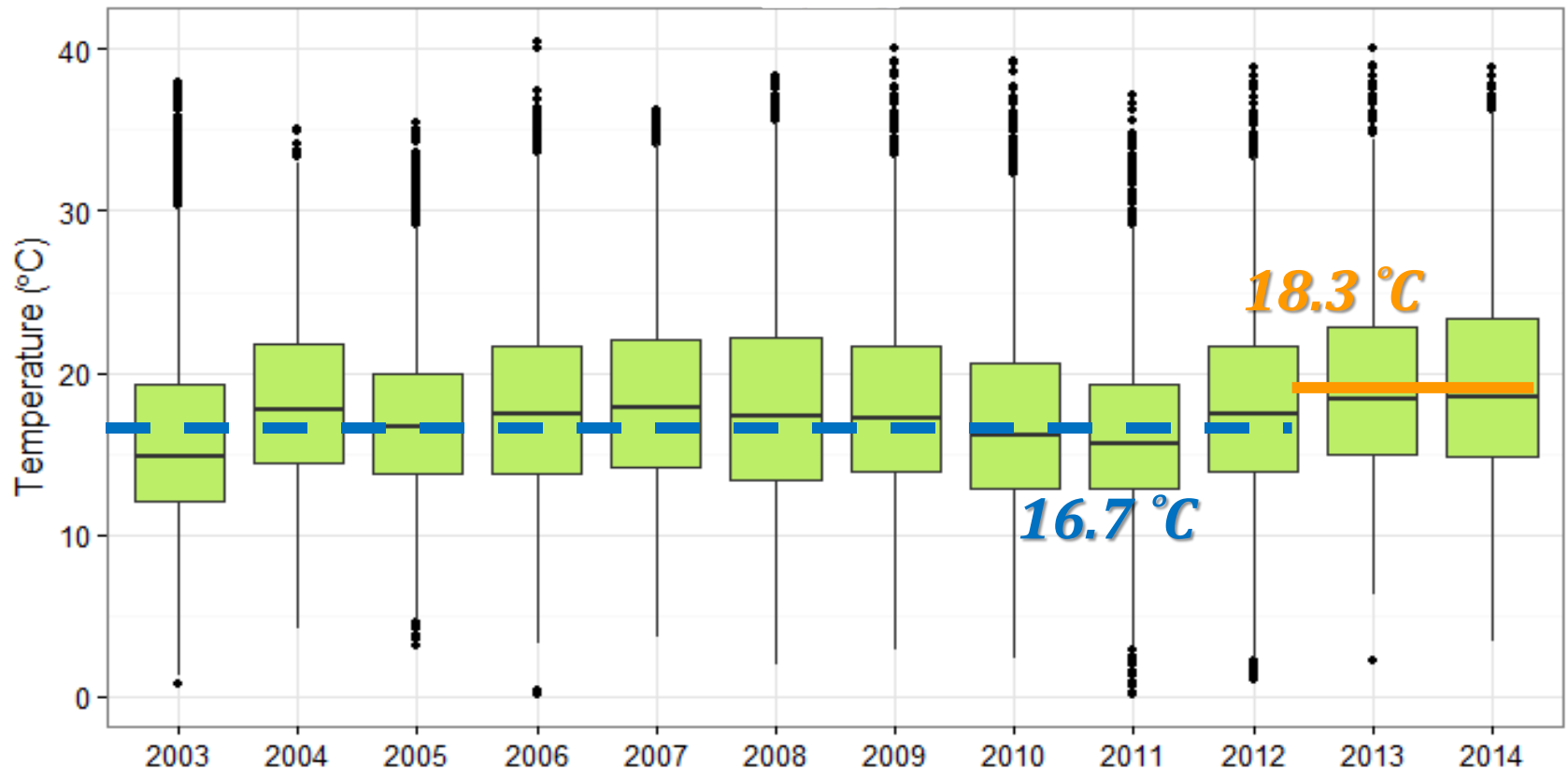
Sept - Dec

Results

Air Temperature

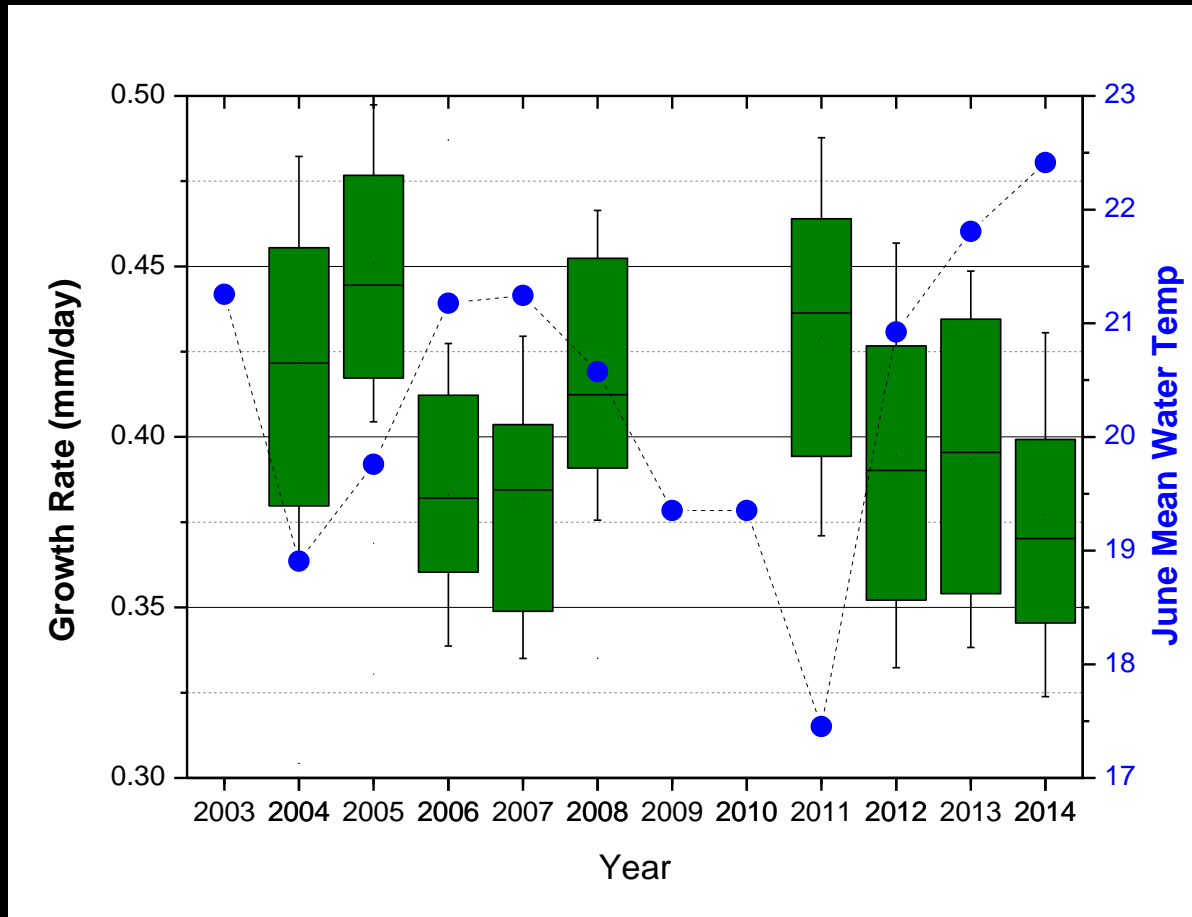


April - June

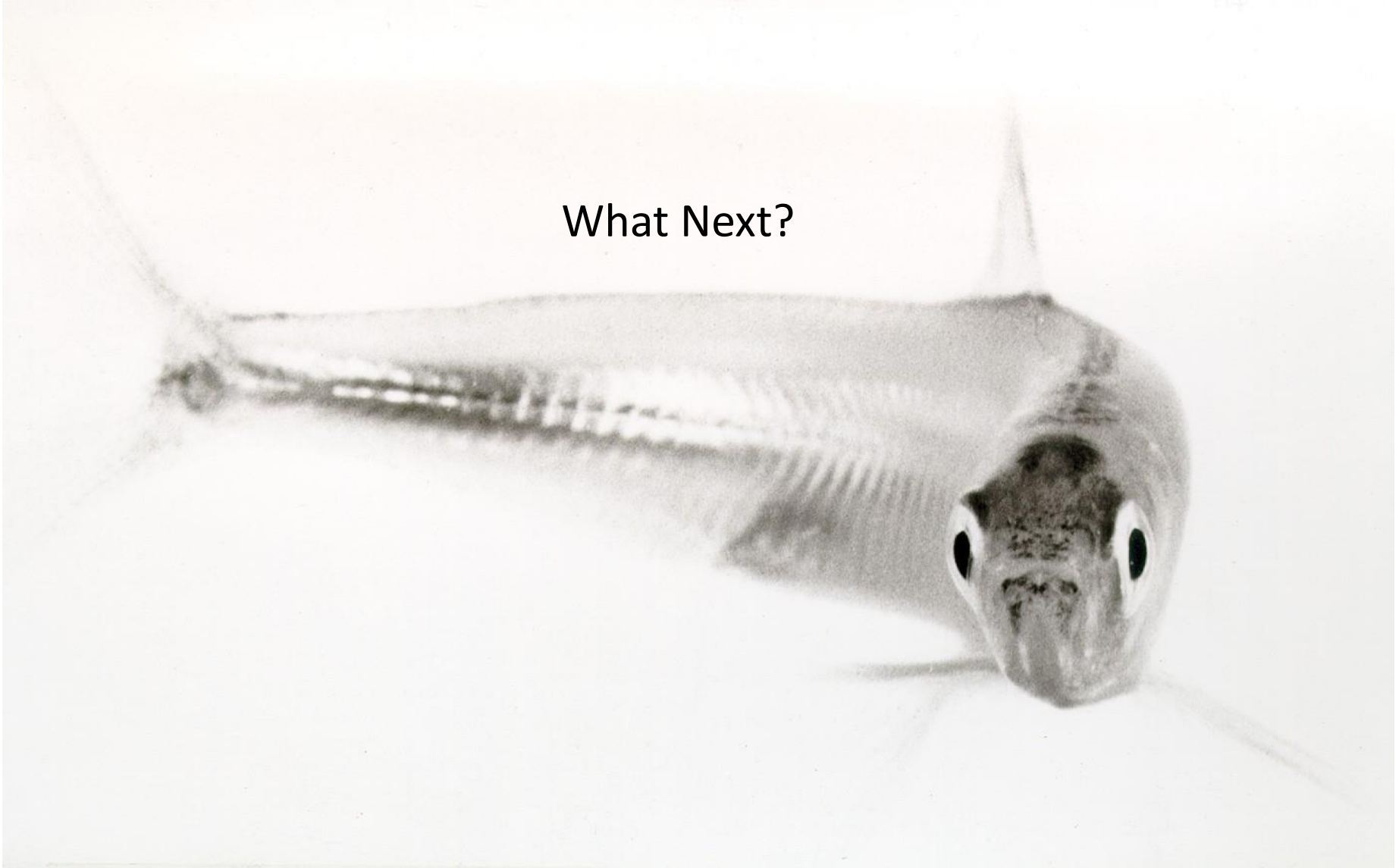


Air temperature station data pooled from: *Lodi, Mossdale Bridge, Mallard, Rio Vista*

Summer Growth Reduced



What Next?





**Water Hyacinth, San Joaquin River @
Connection Slough; December 2014.**

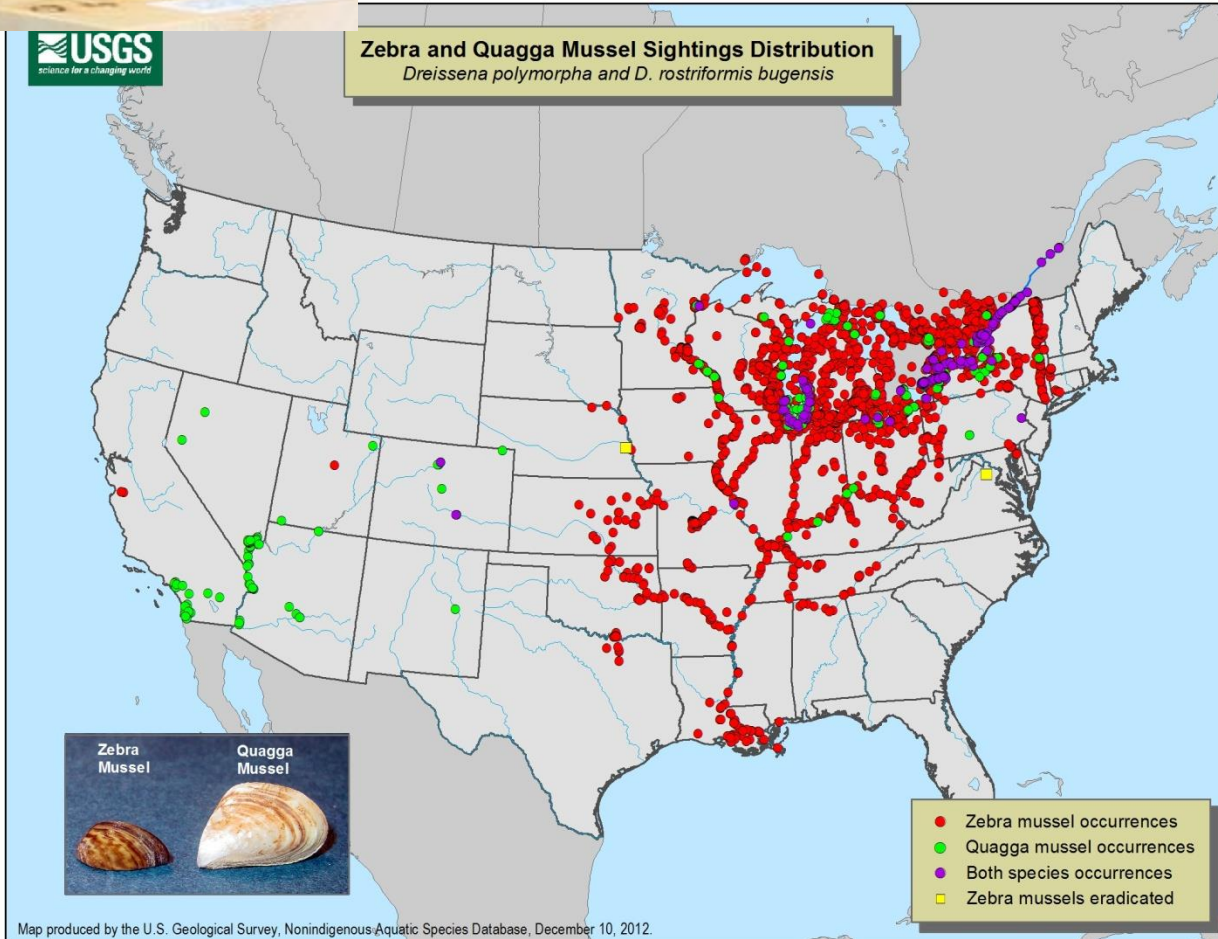
Photo: Roger Kelly for Bay Nature Magazine

**South American Sponge Plant@ Brannon Island
2011 Lars Anderson**

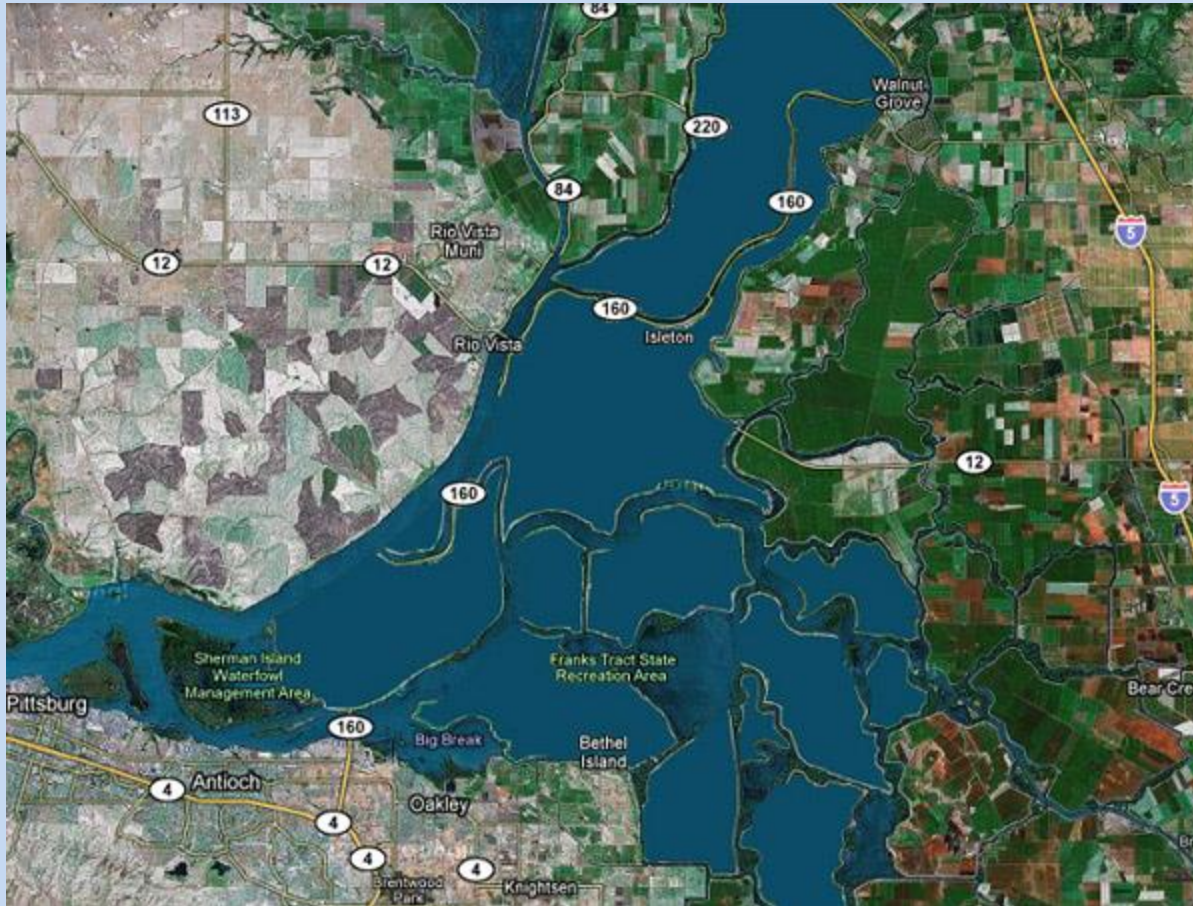


**Loach: San Joaquin River near
Fresno, Fall 2014.**

Today?



Earthquake or flood 64% chance in 50 years



1 M sea level rise (2100?)

