



2 adults return to spawn

4,000
eggs
are laid

Salmon life cycle

800 fry
hatch

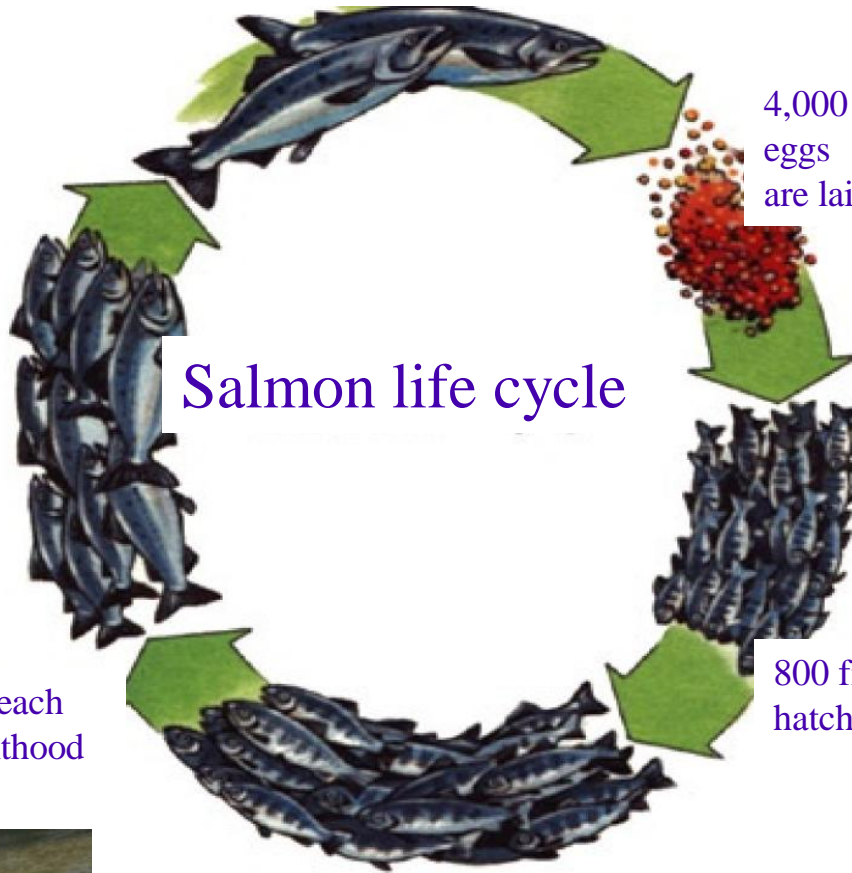
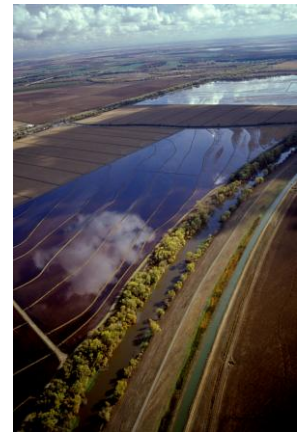
200 smolts go to sea

10 reach
adulthood

Ocean

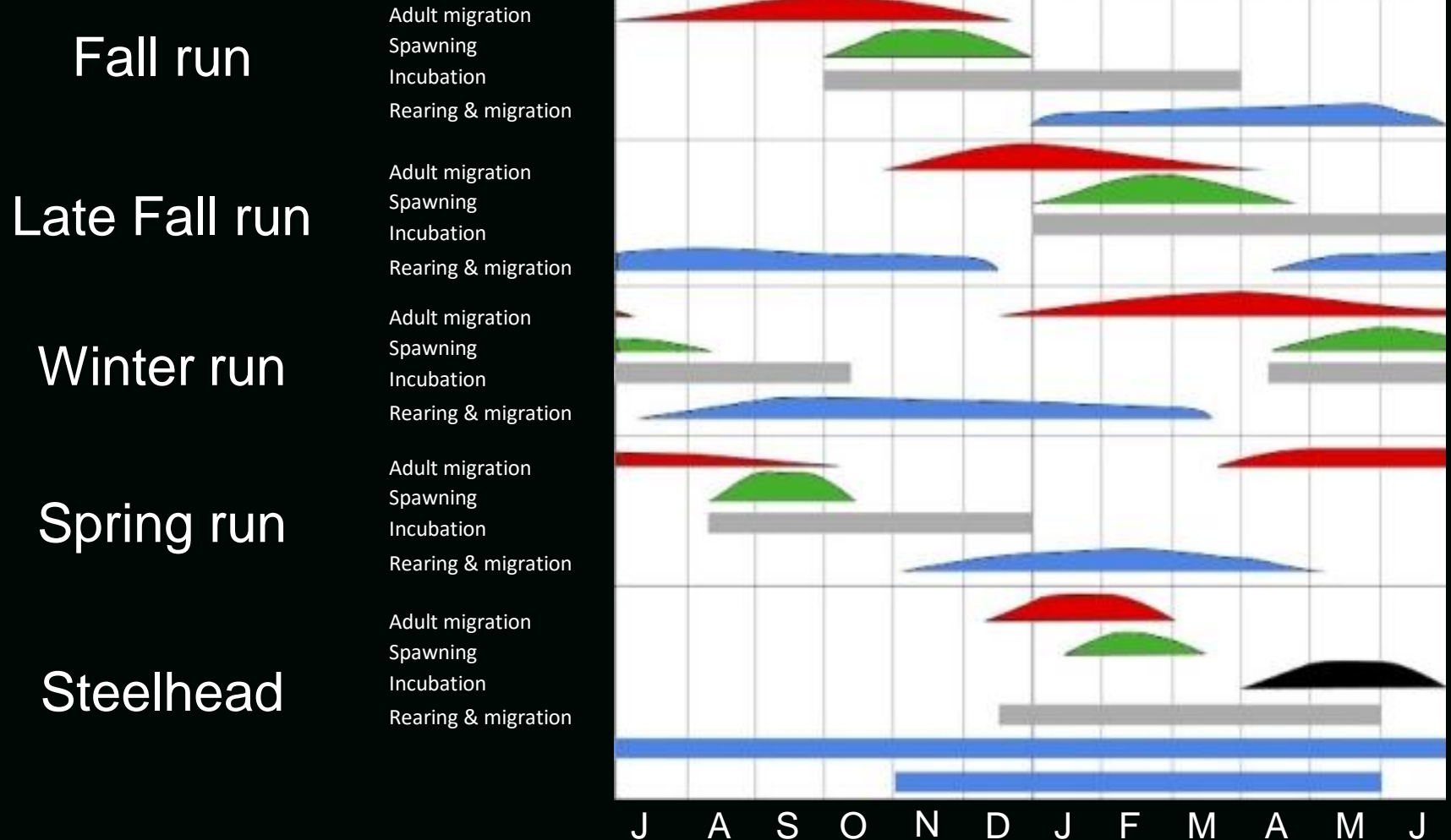
Freshwater

Estuary



Salmon

Diversity spreads risk in space & time



Data sources: Vogel and Marine, 1991; Hallock, 1983; CDFG, 1993

Modified from California Rice Promotion Board by CH2MHill

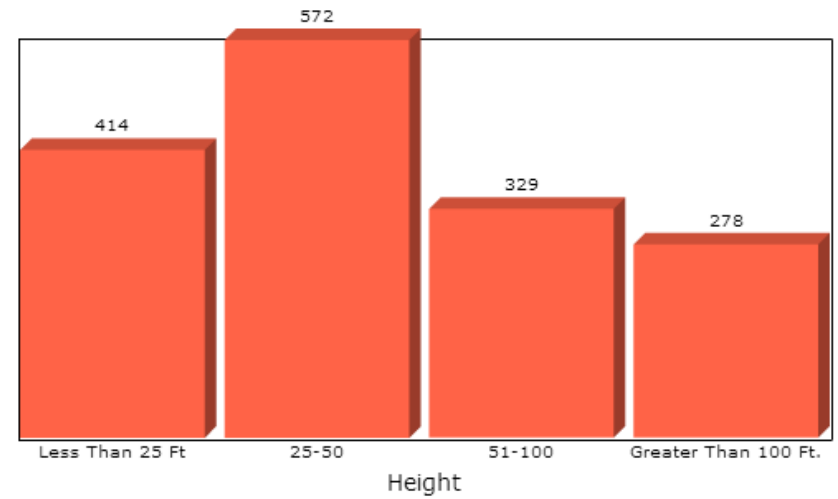
Select from the following Map Views

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

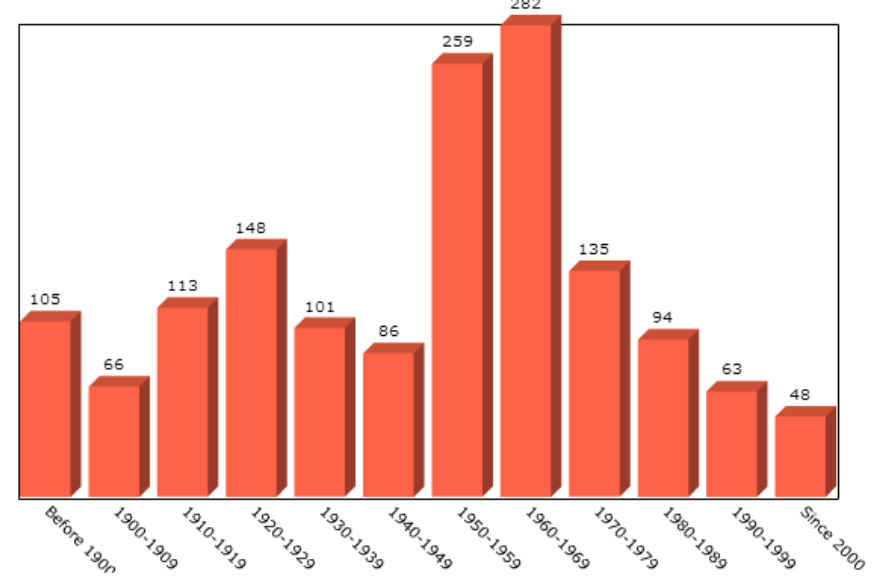




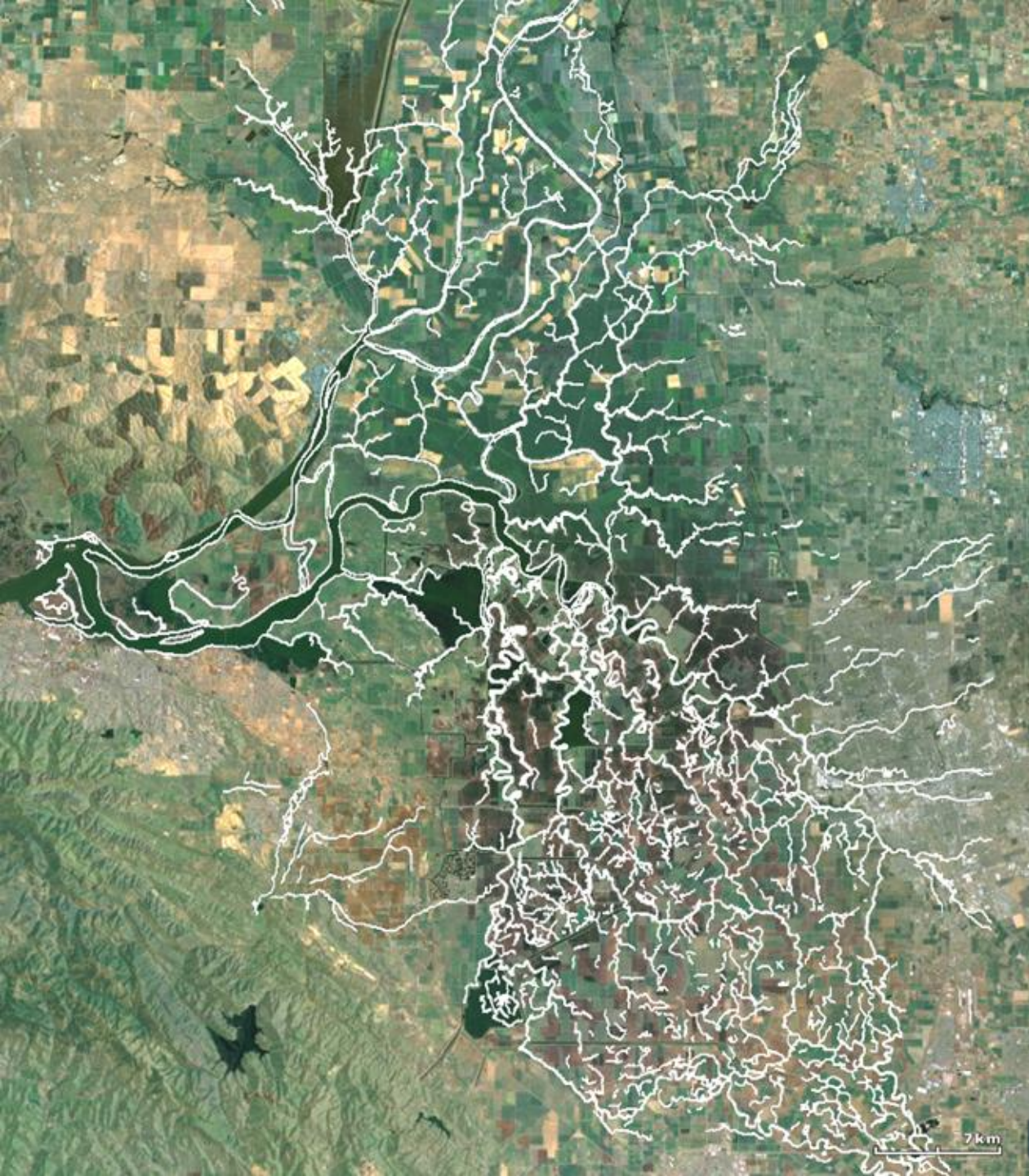
Dams by Height



Dams By Completion Date



1594 Dams in California
 National Inventory of Dams, Army Corps



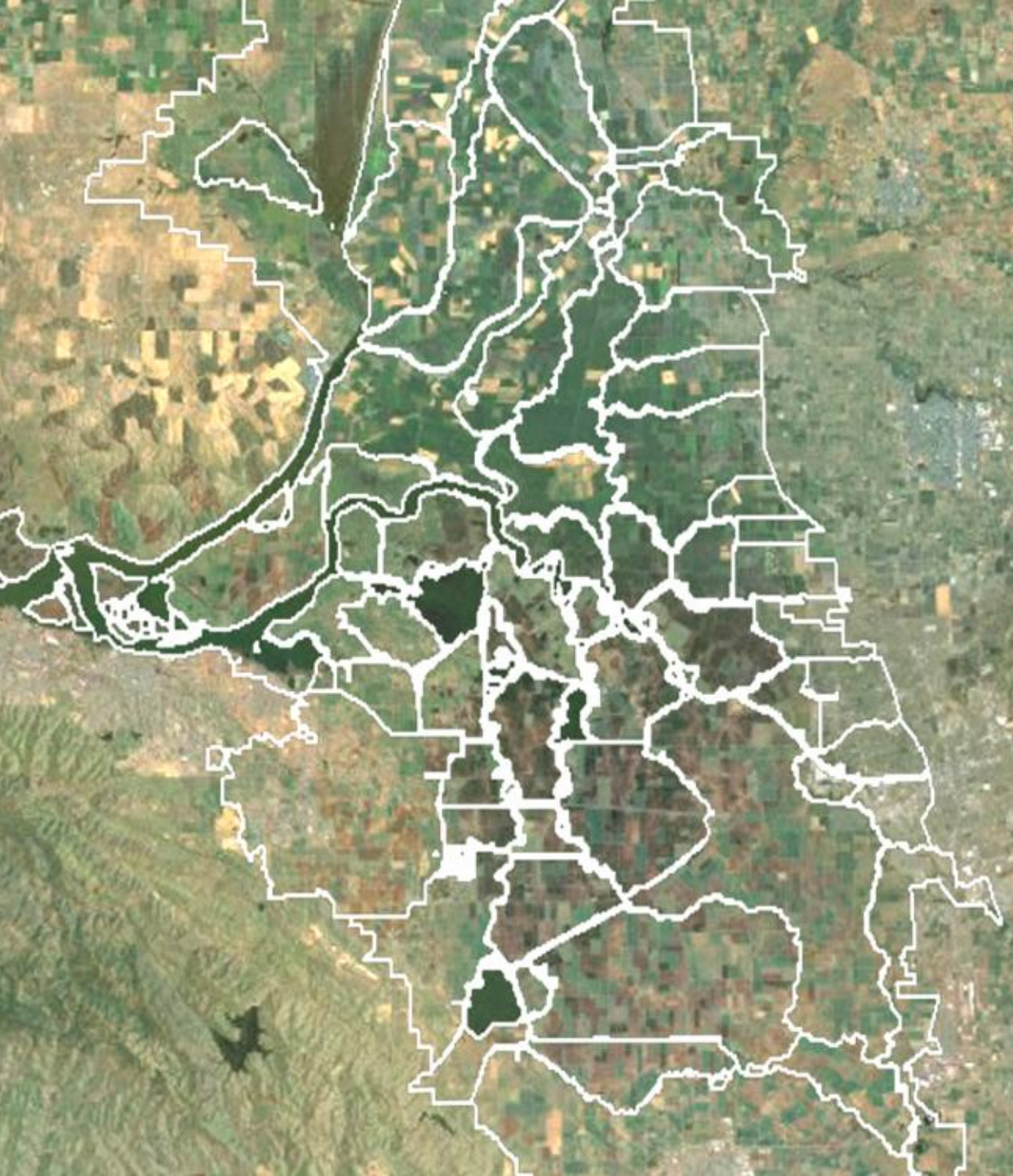
1873 Delta:

Long residence time

Marsh connections

Two rivers connect
to bay

Waterways dendritic



Modern delta

Short residence times

Rip-rapped

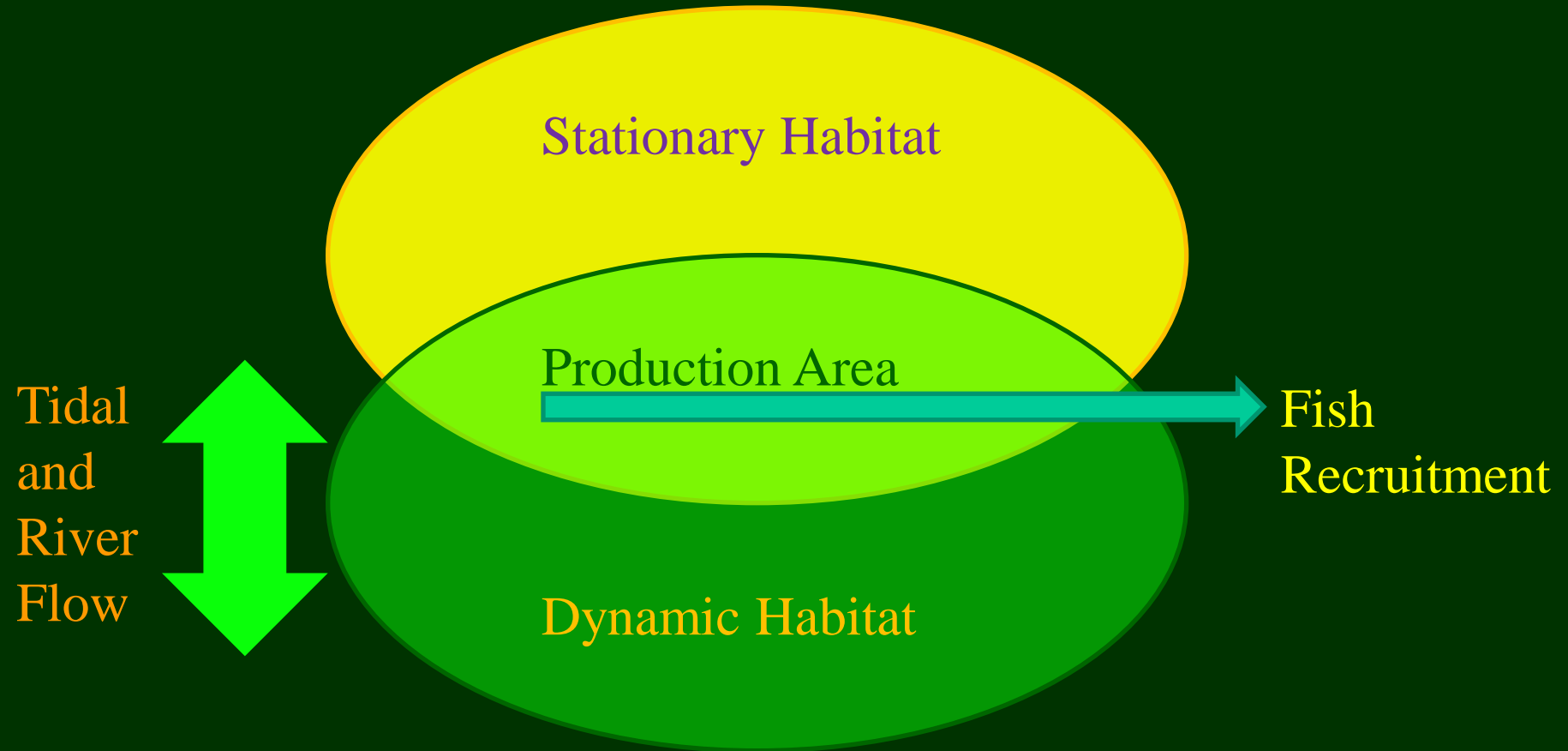
Cross Delta flows

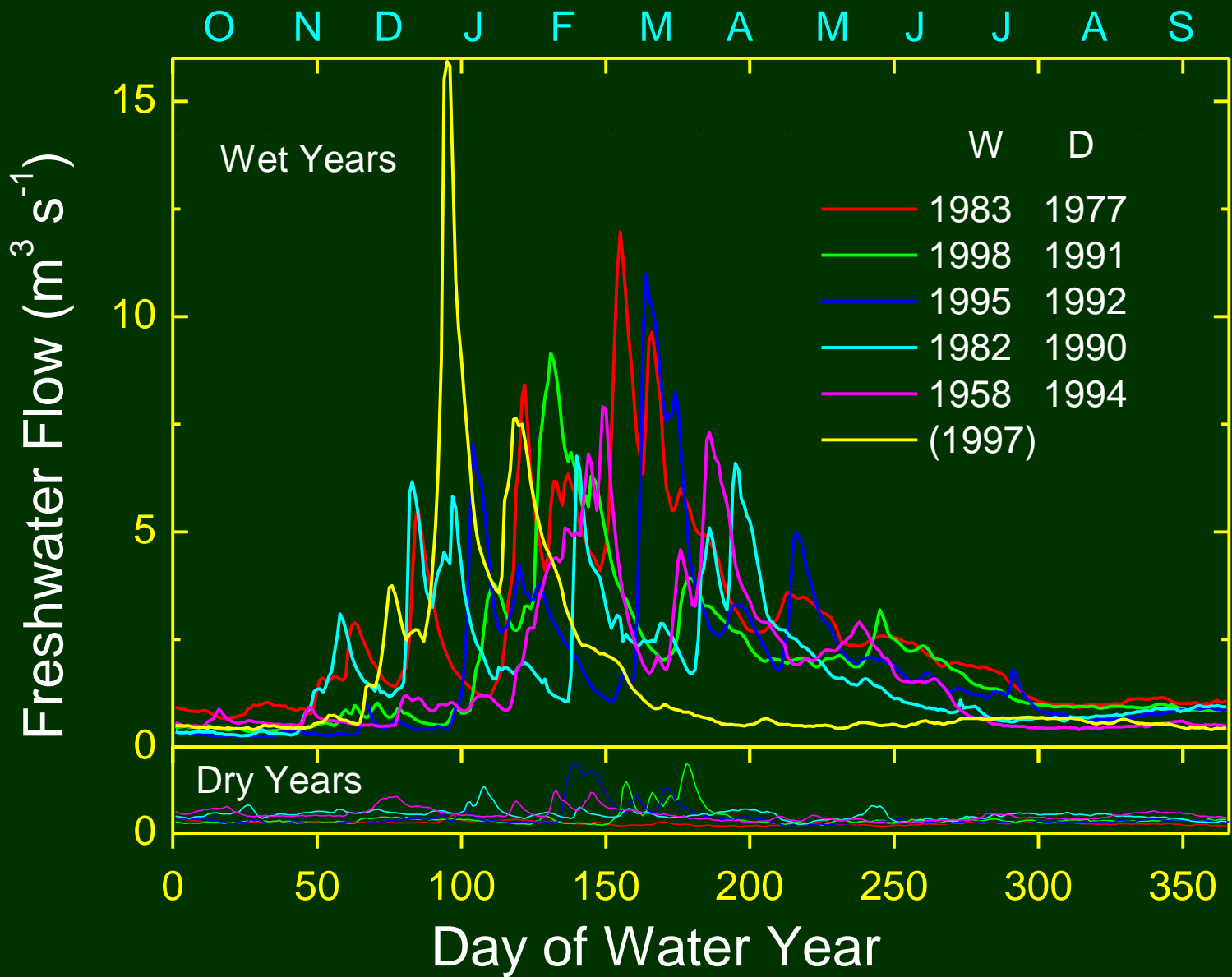
**Rare San Joaquin
connection to bay**

Waterways web-like

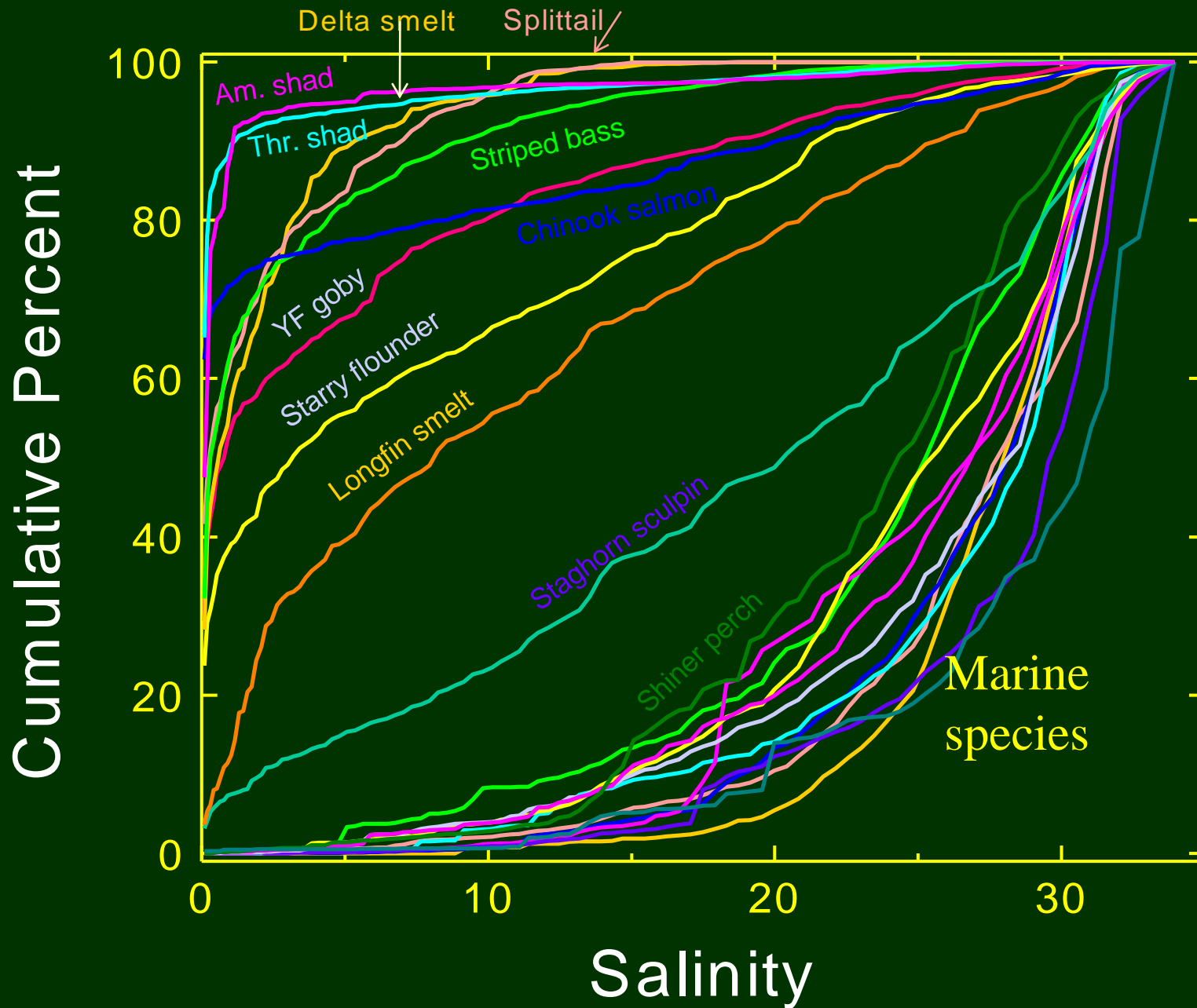
Estuarine habitat conceptual model

(Peterson 2003)





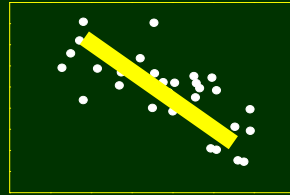
Most fishes follow salinities



[Kimmerer 2004](#)

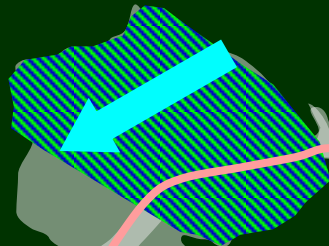
What Changes As Flow Increases?

Salinity
and X2



FLOW

Location of
Any Salinity
Range

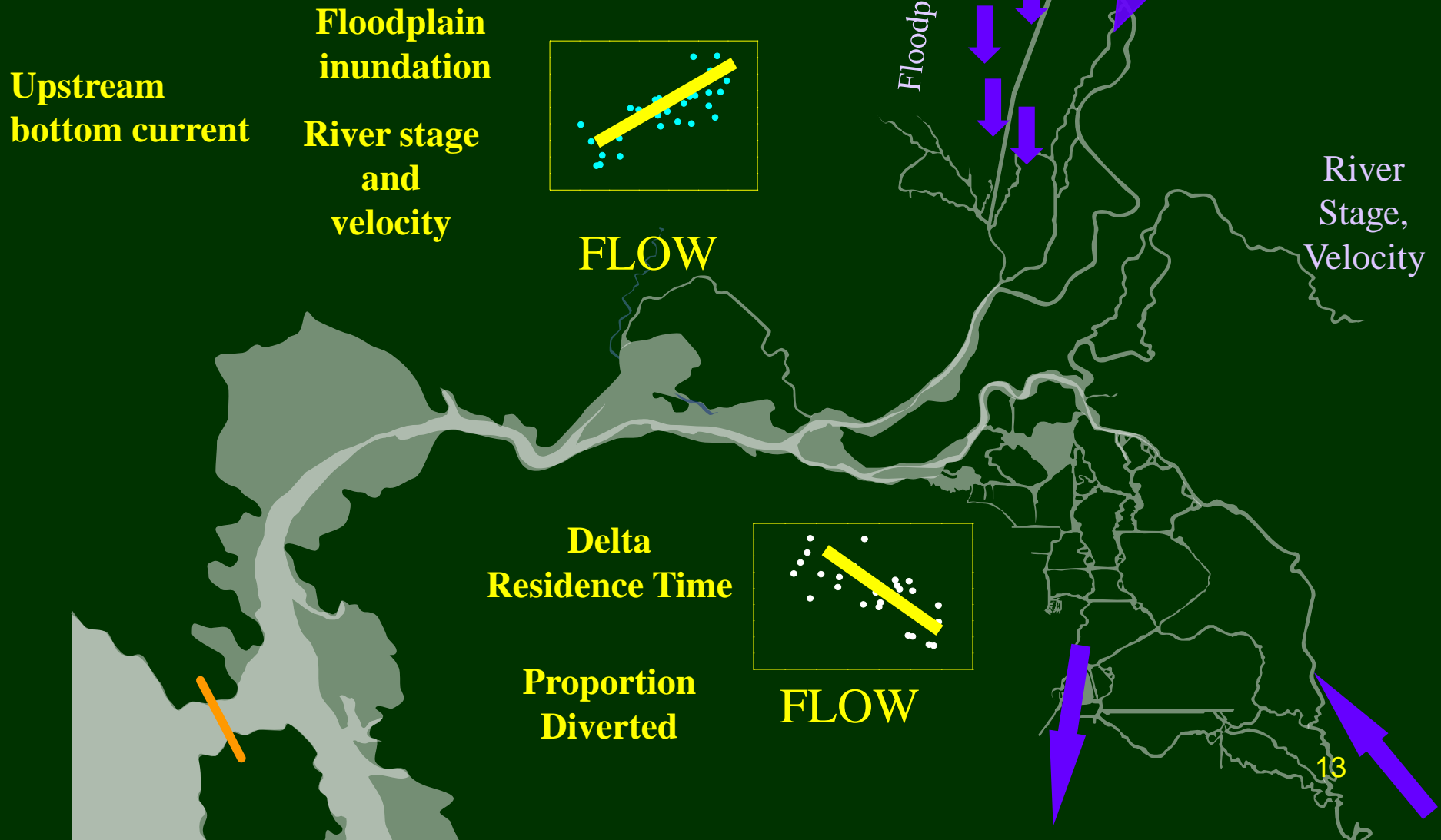


stratification

L
S
Z

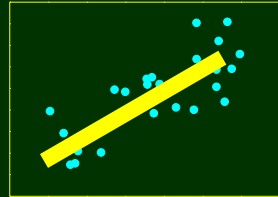


What Physically Changes As Flow Increases?



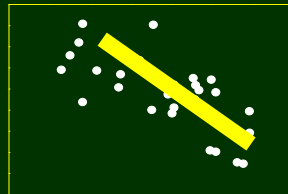
What chemically changes?

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

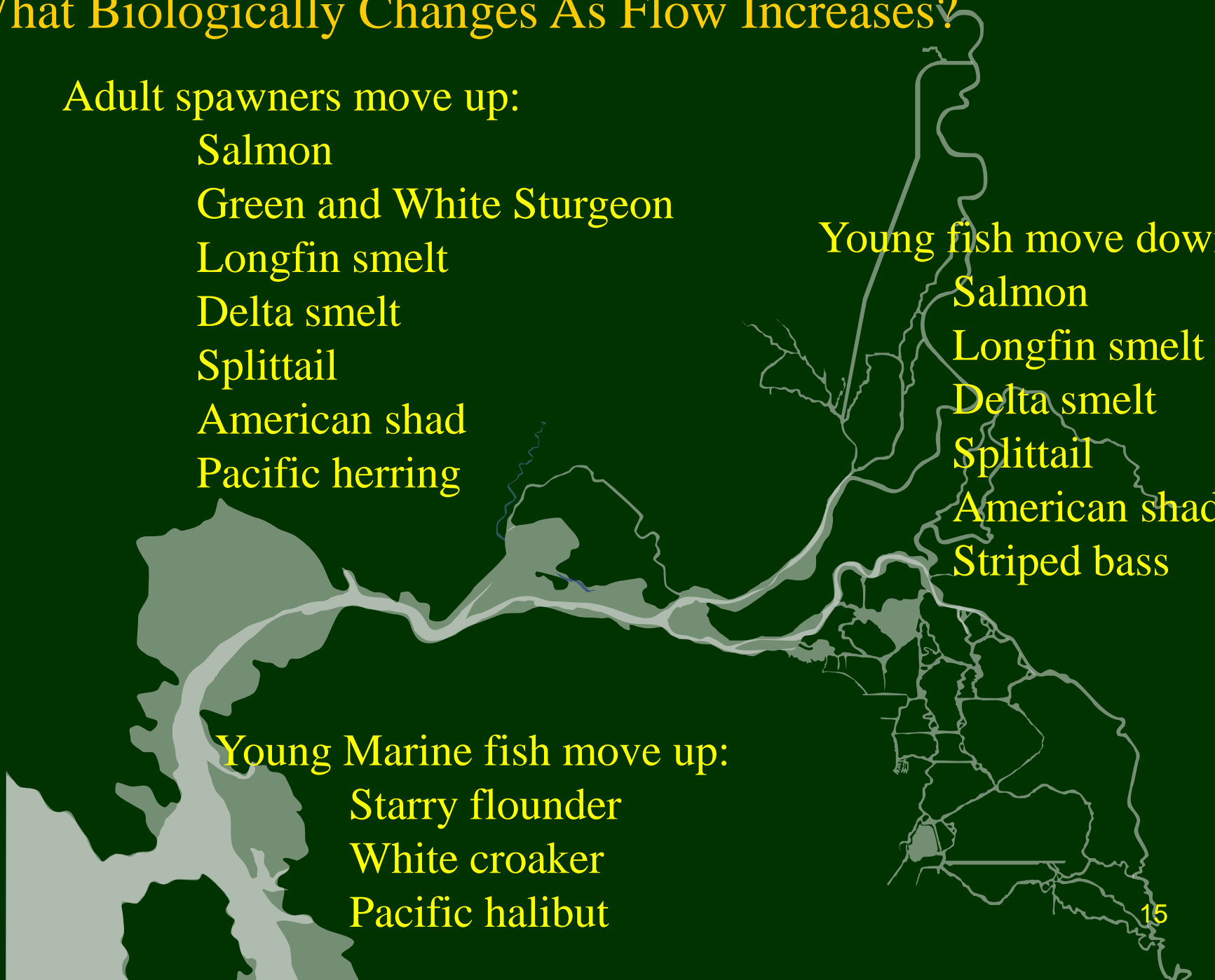
Striped bass

Young Marine fish move up:

Starry flounder

White croaker

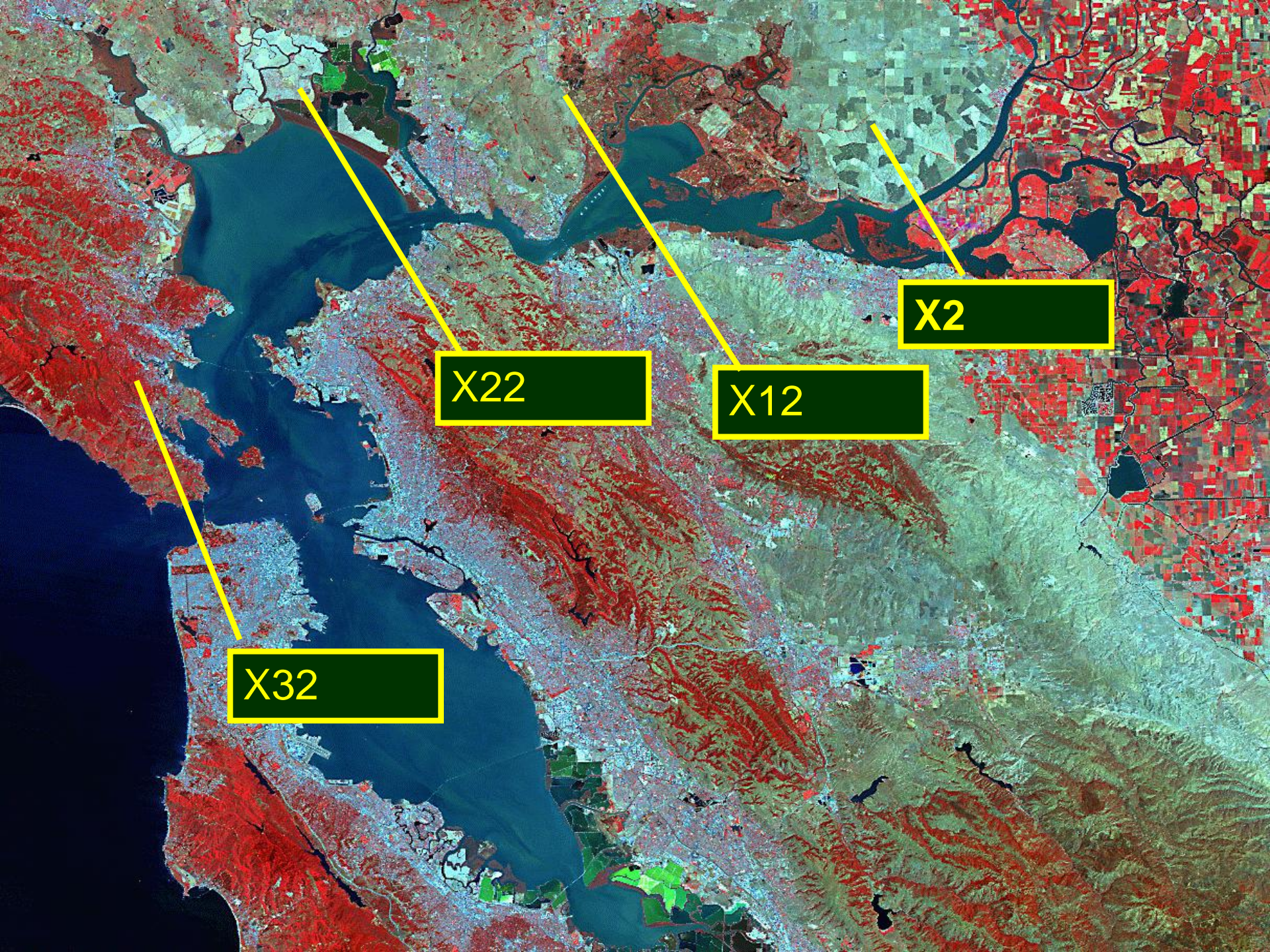
Pacific halibut



How much water do fish need?



X2

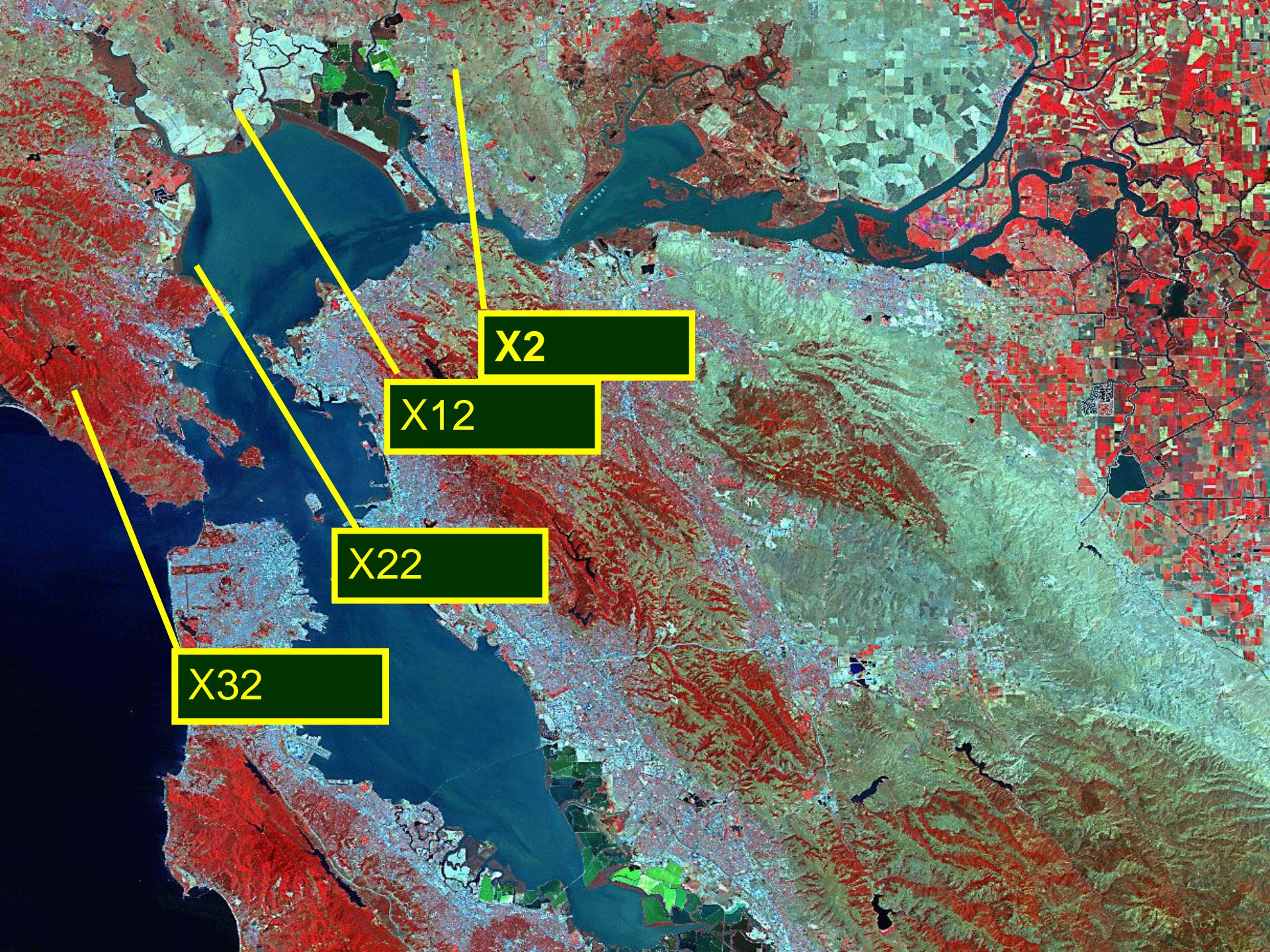


X2

X12

X22

X32

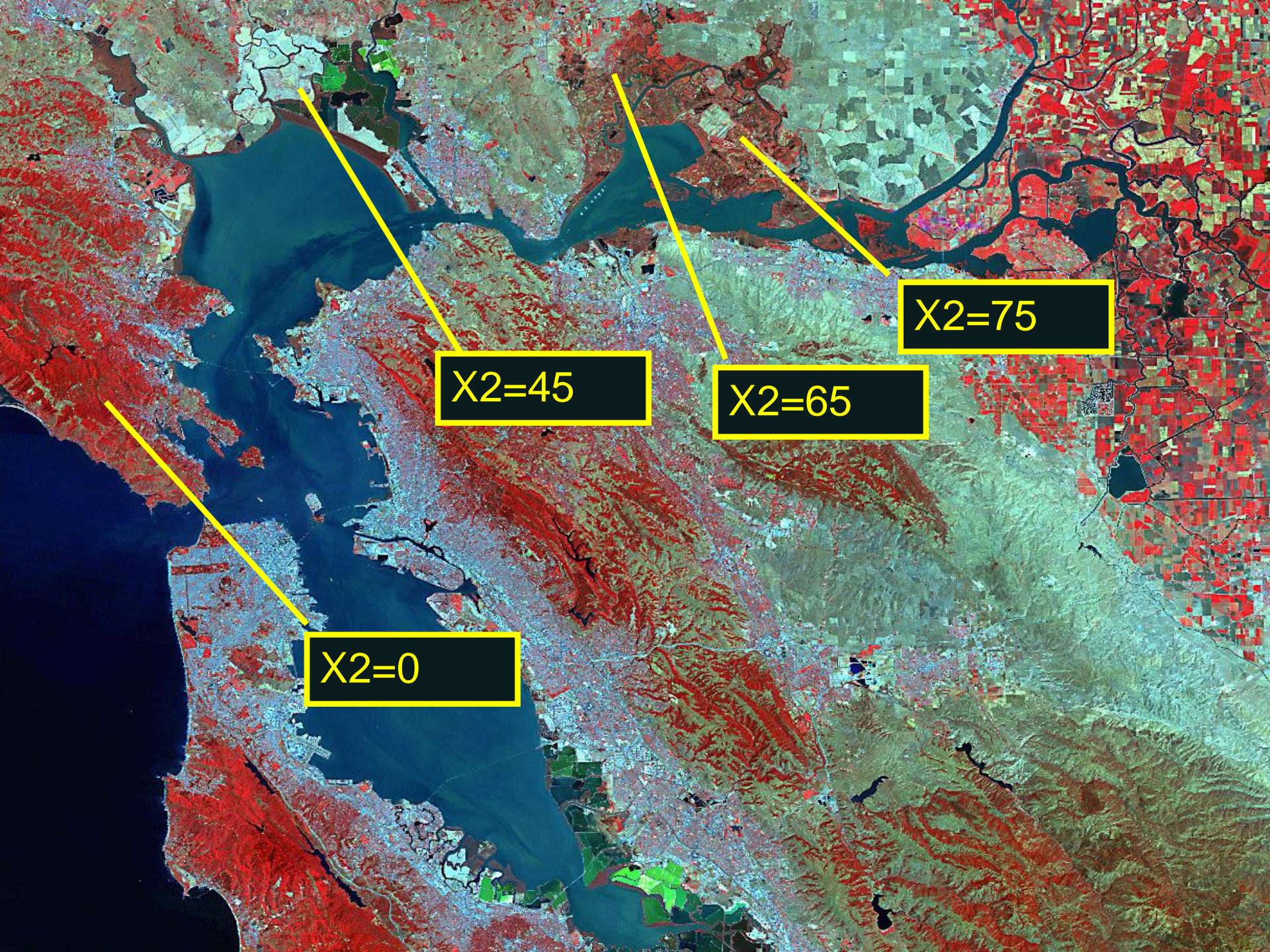


X2

X12

X22

X32



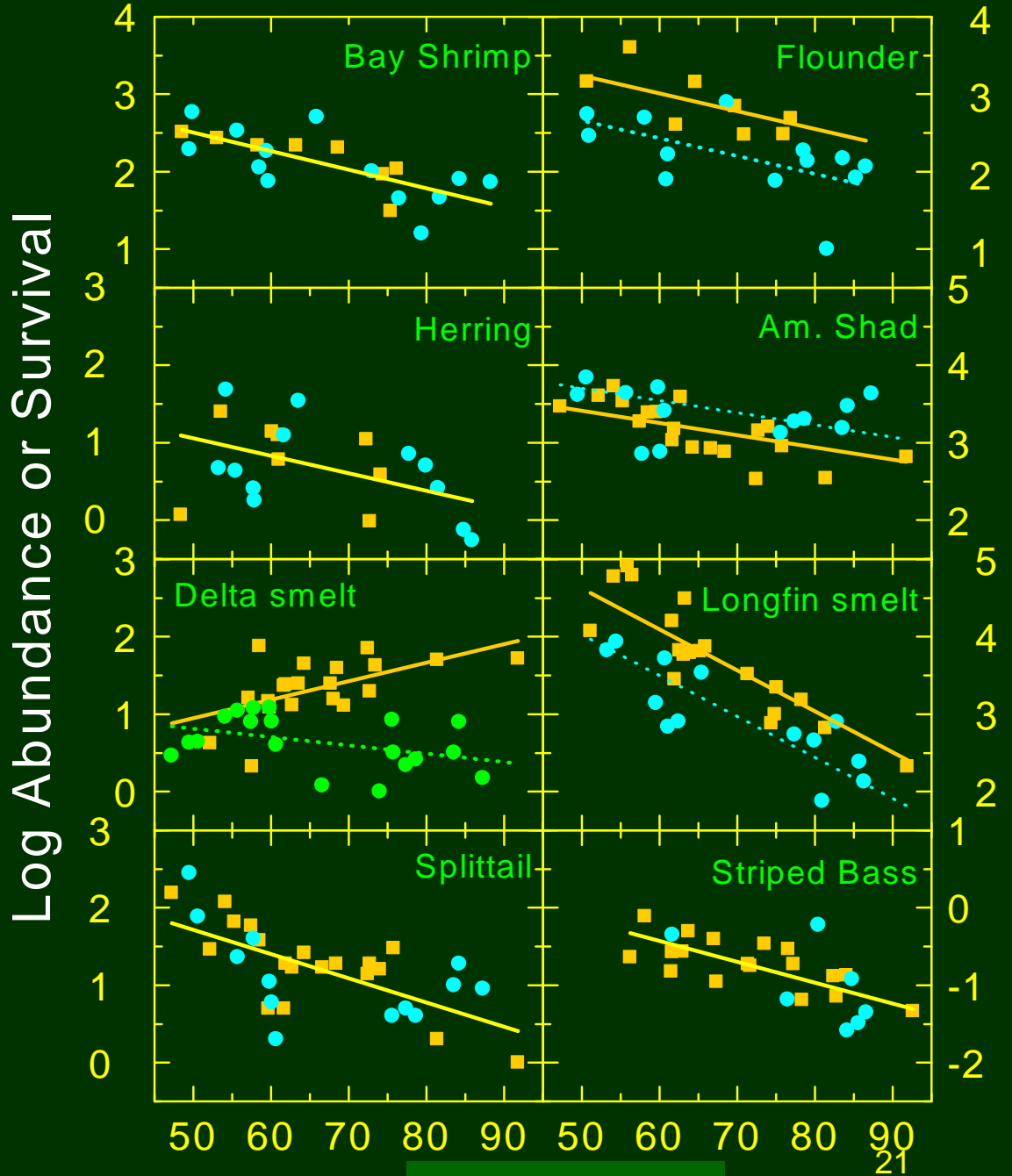
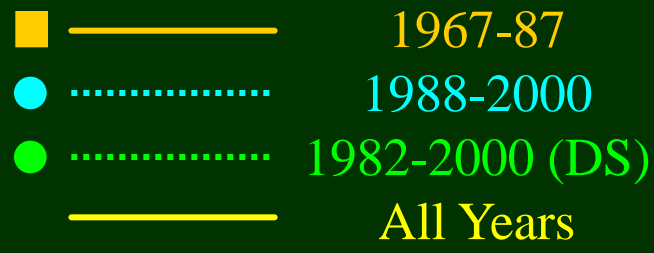
X2=0

X2=45

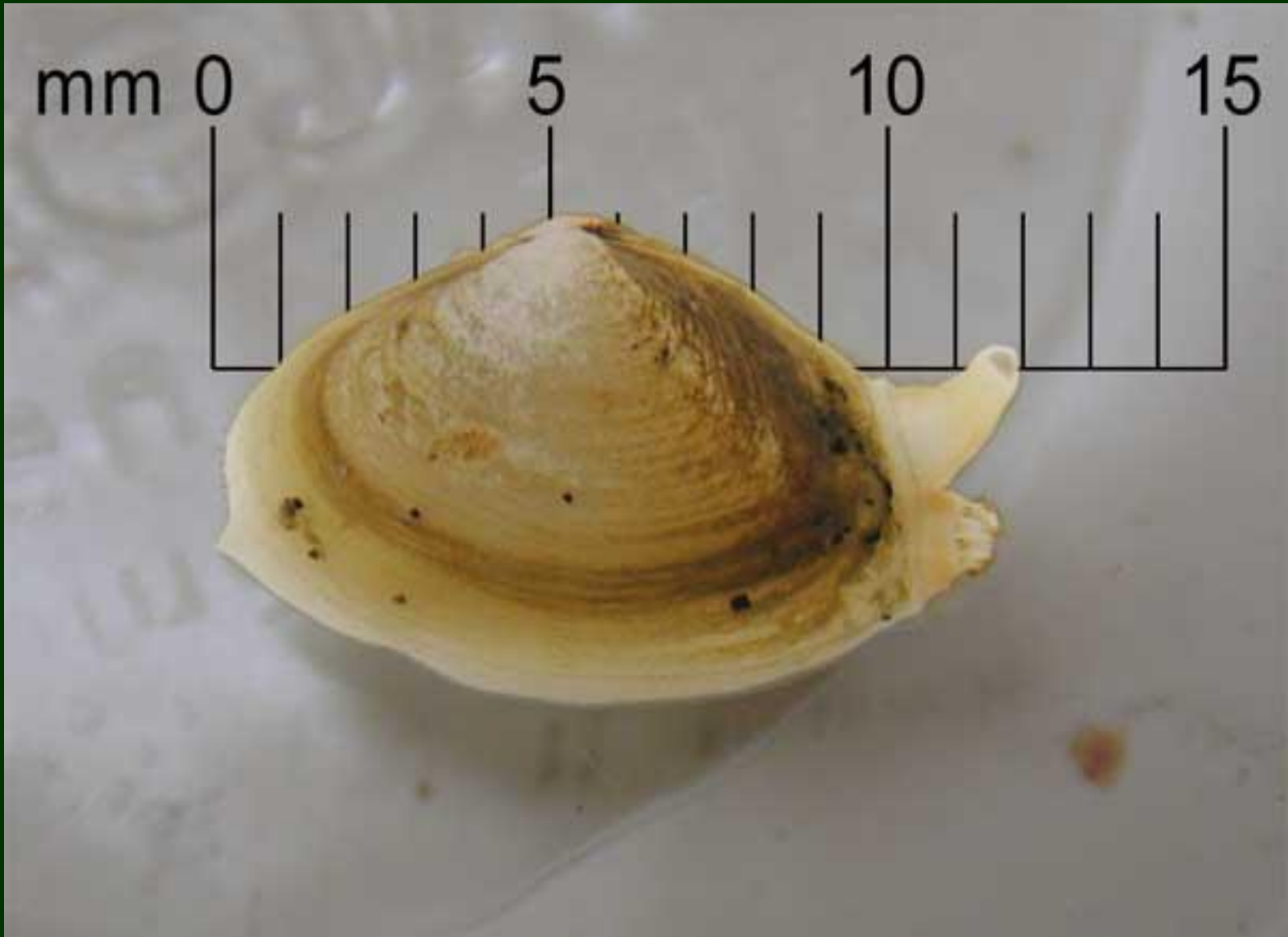
X2=65

X2=75

Higher trophic levels show many relationships of abundance to X2

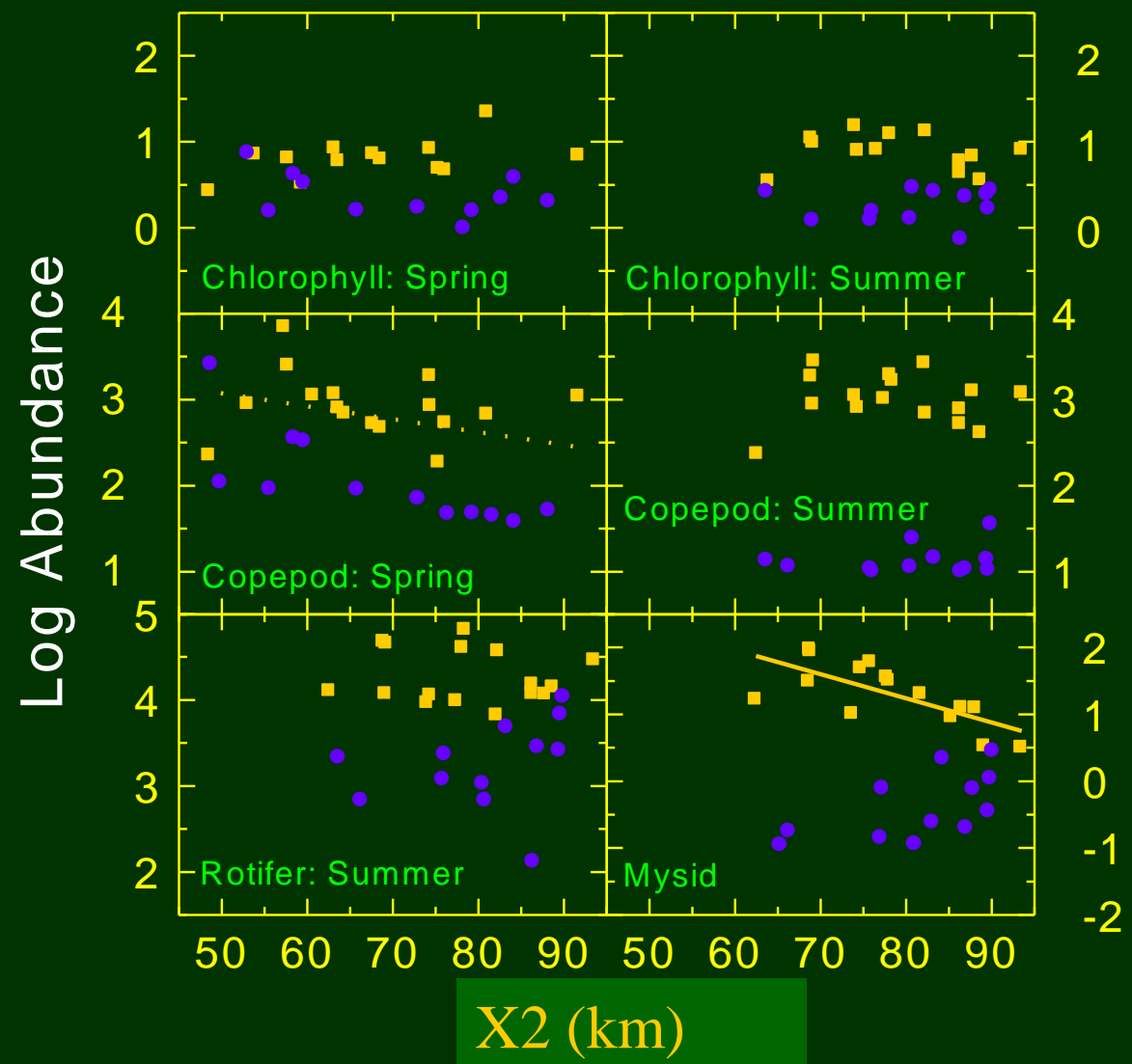


Source: Kimmerer 2002MEPS



Lower trophic levels show few relationships of abundance to X2

■ ——— 1972-1987
 ● 1988-2000

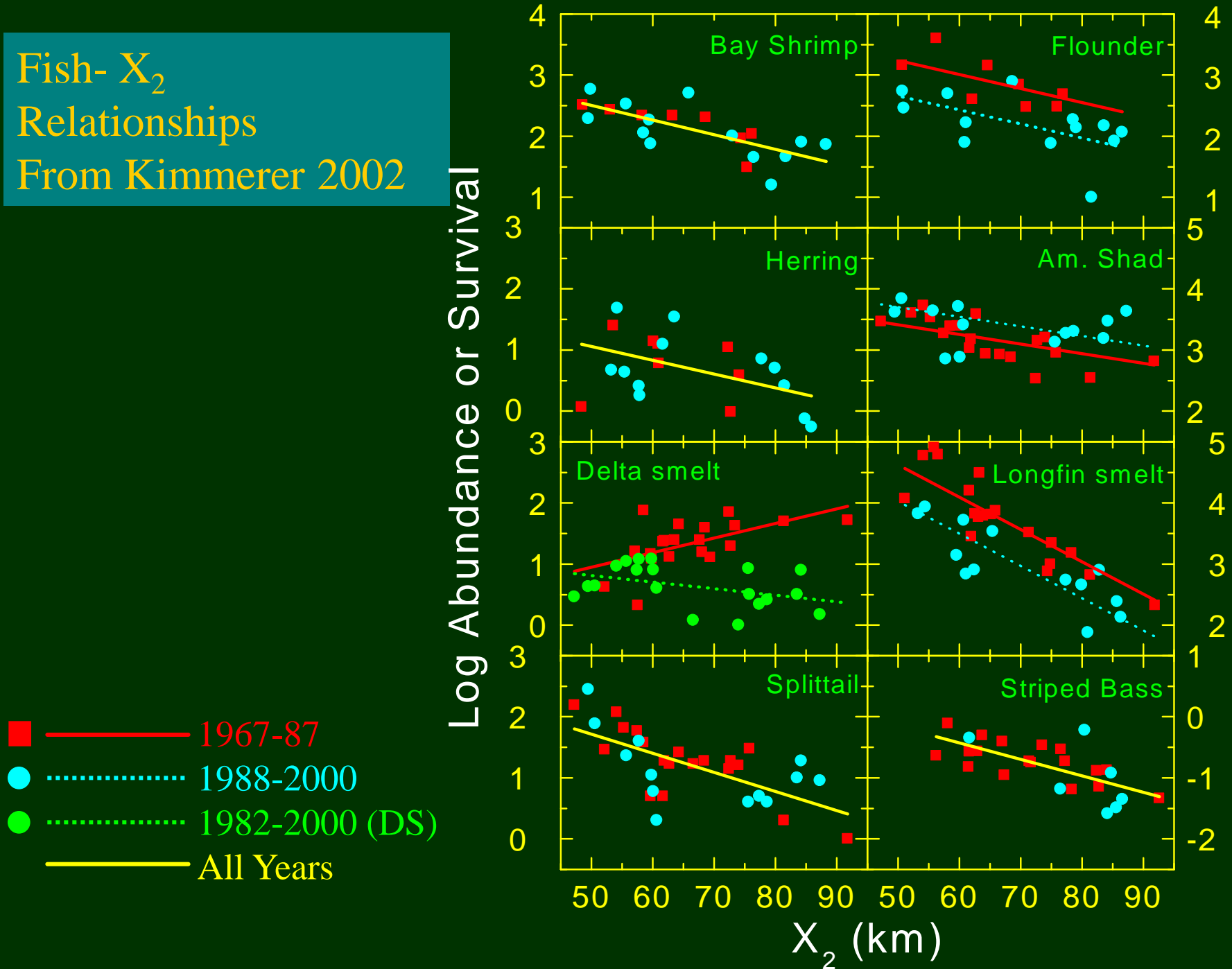


Source:
 Kimmerer 2002 MEPS

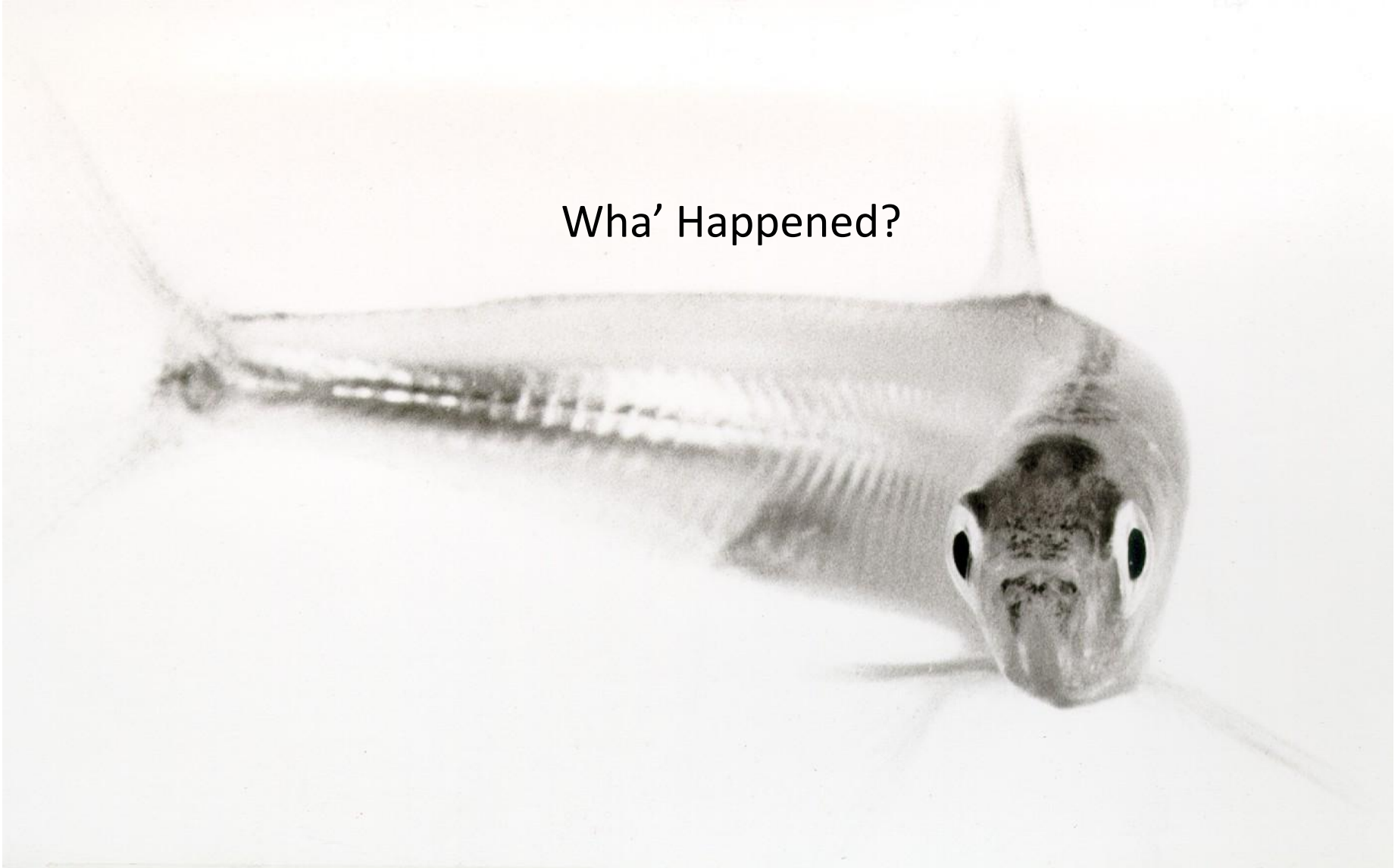
High Flow

23
 Low Flow

Fish- X_2 Relationships From Kimmerer 2002



Wha' Happened?



POD---

Pelagic

Organism

Decline

Delta smelt

Longfin smelt

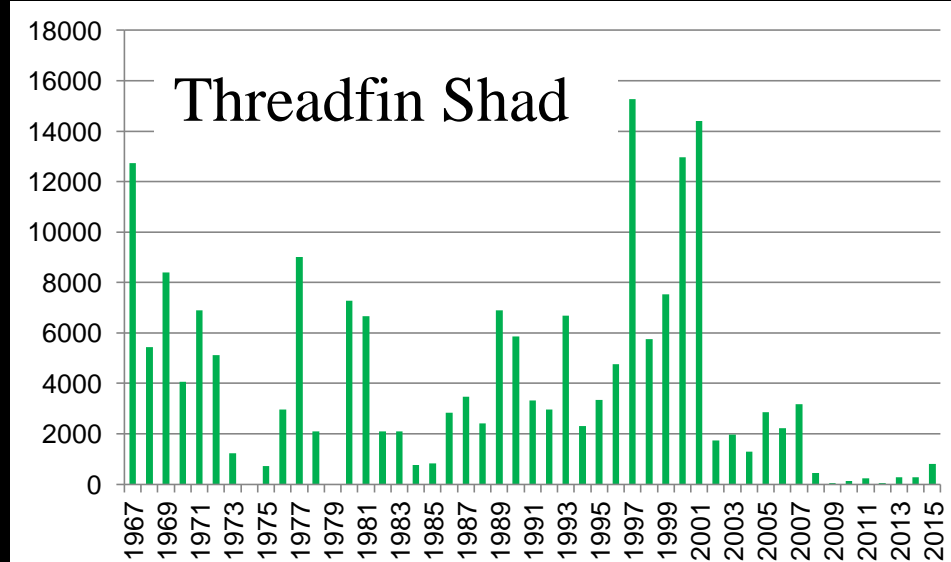
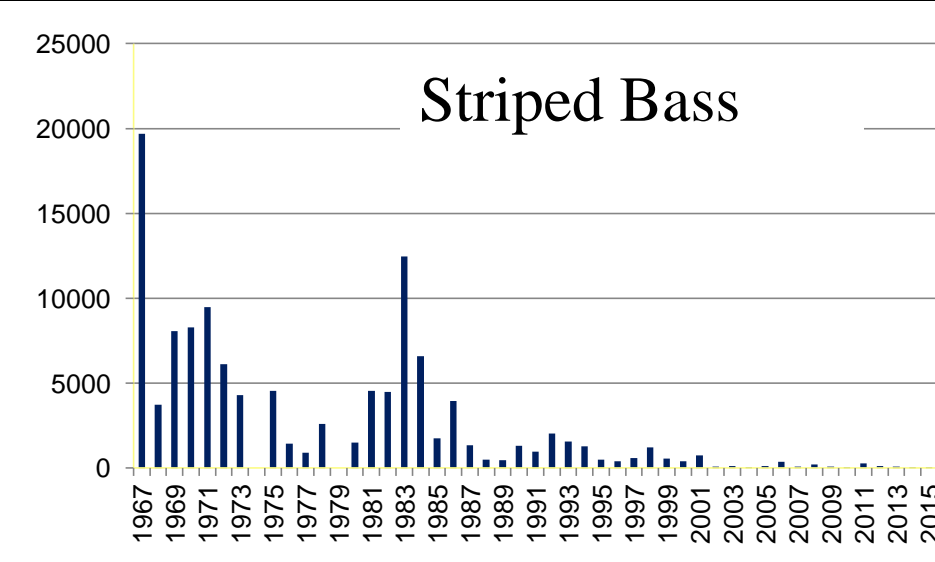
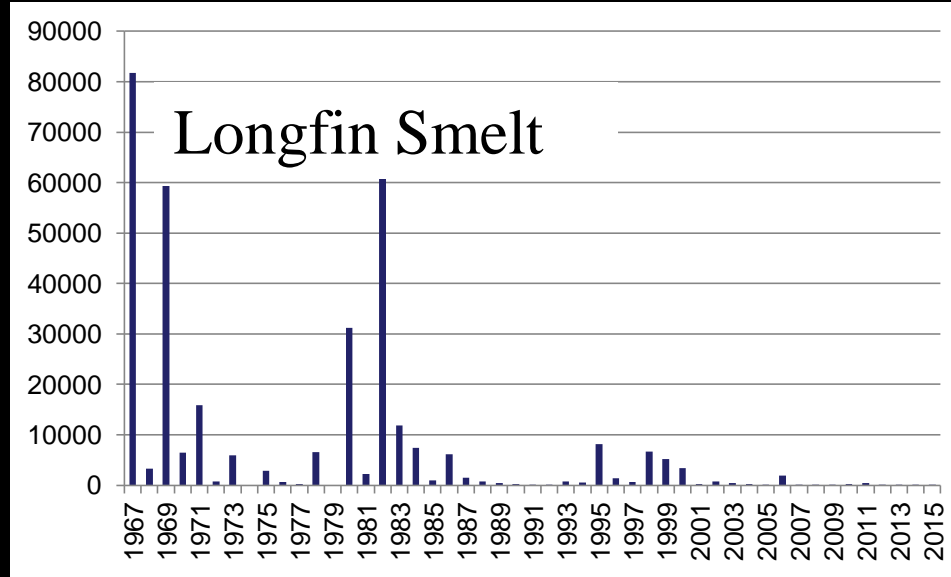
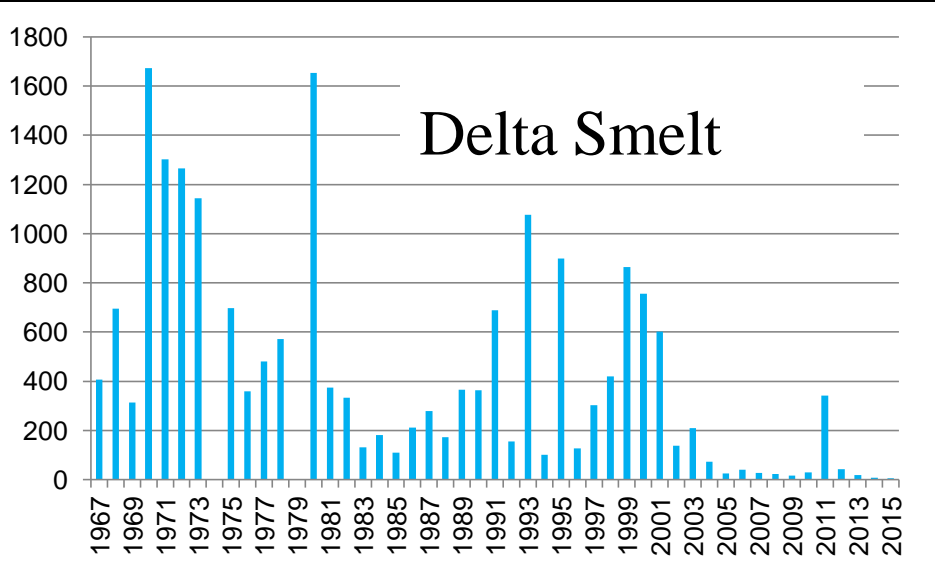


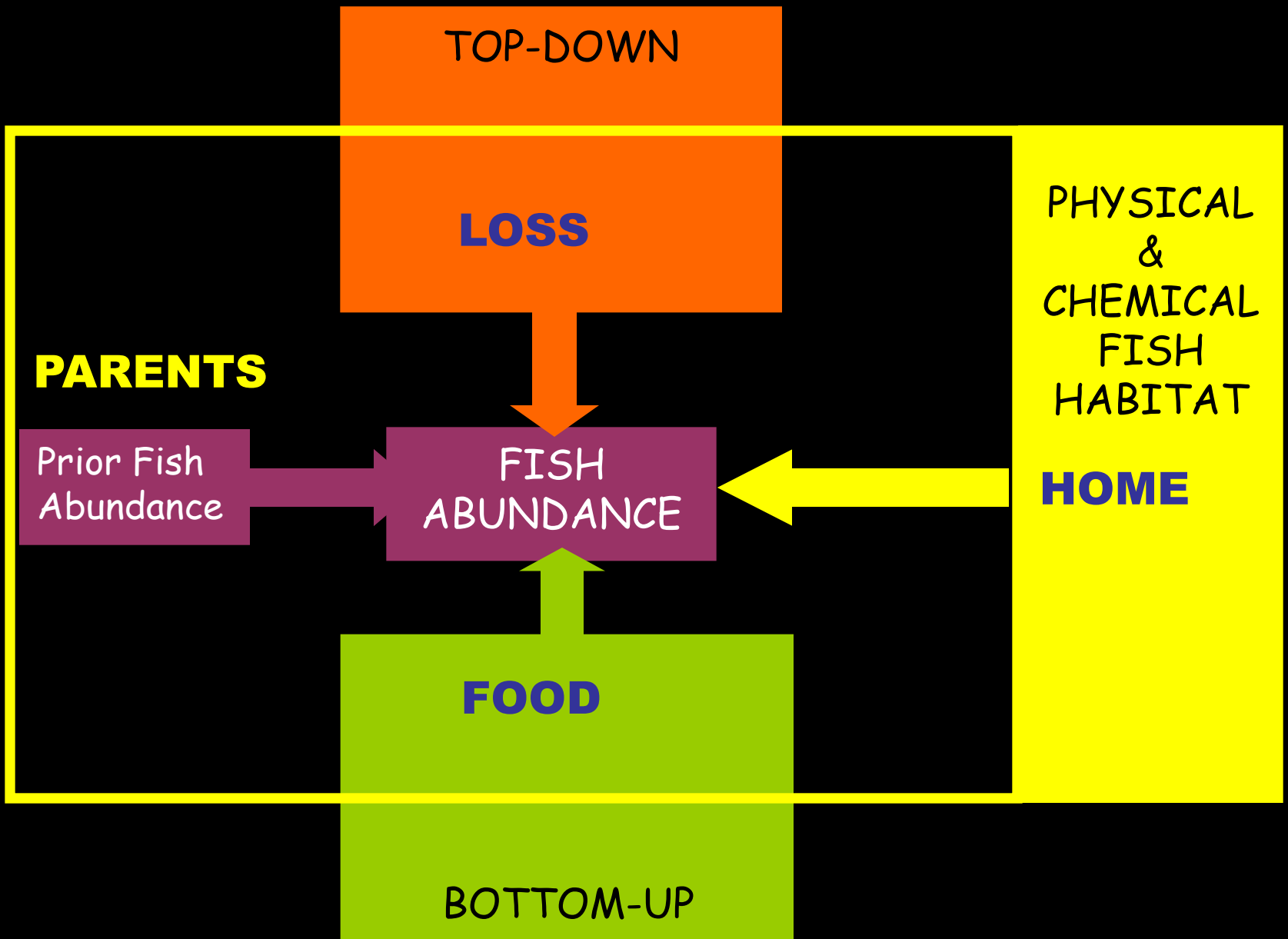
Striped bass



Threadfin shad

Fall Abundance Indices 1967-2015

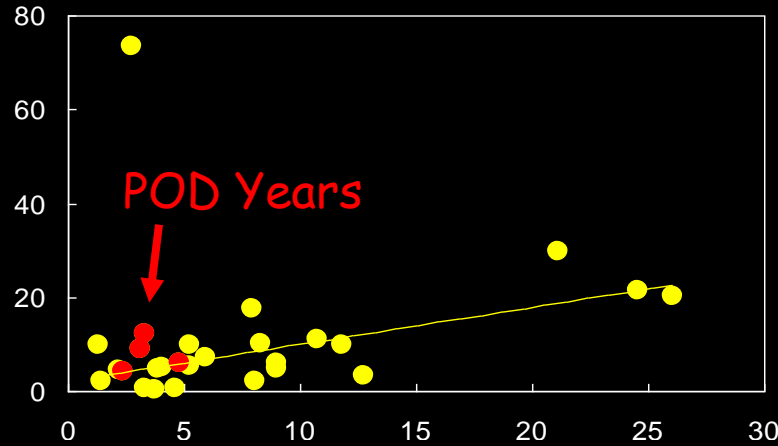




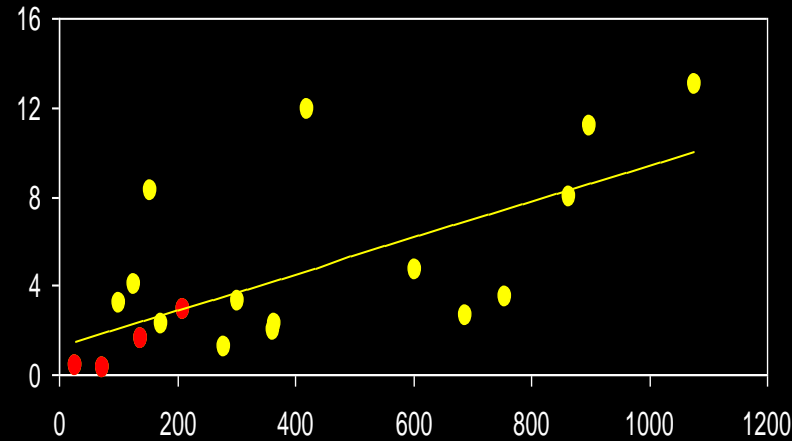
Stock - Recruitment Effects



Juvenile Production



Threadfin shad



Delta smelt

Fall Midwater Trawl (Adults)

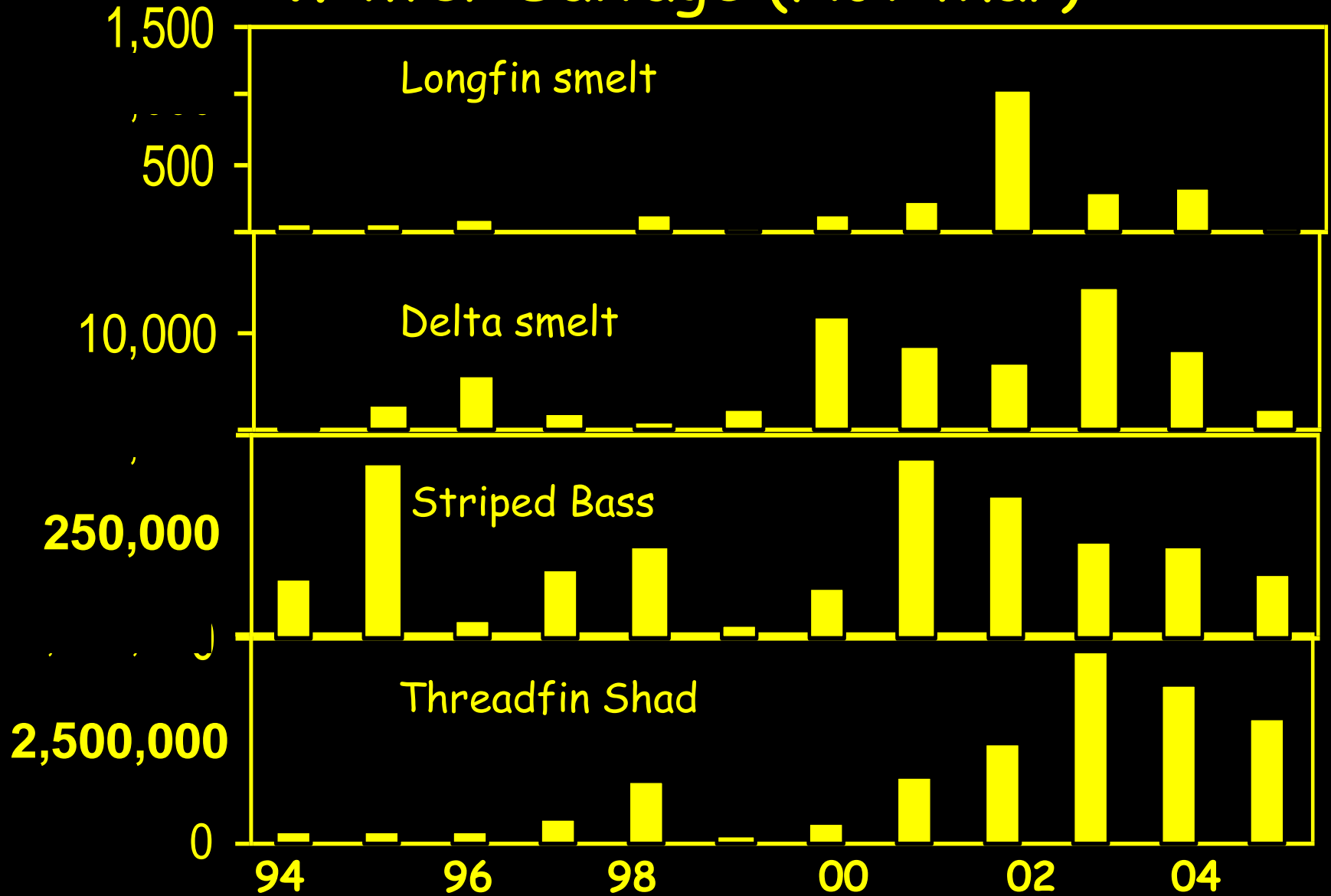


Water Project Losses



Fish Facilities Provide Data on Numbers "Salvaged"

Winter Salvage (Nov-Mar)



Exports in acre-feet

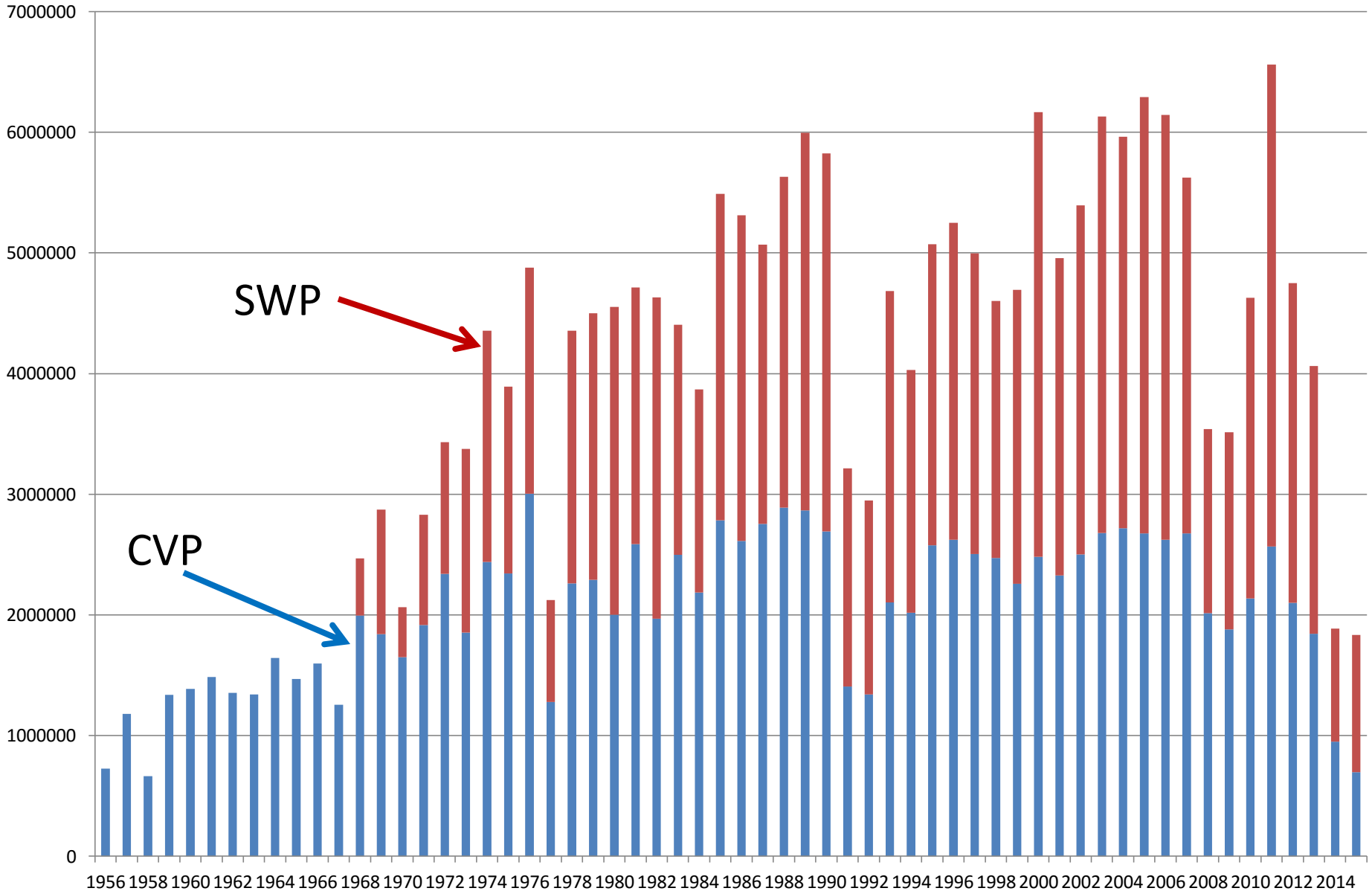
1 acre-foot = 325,851 gallons

OR

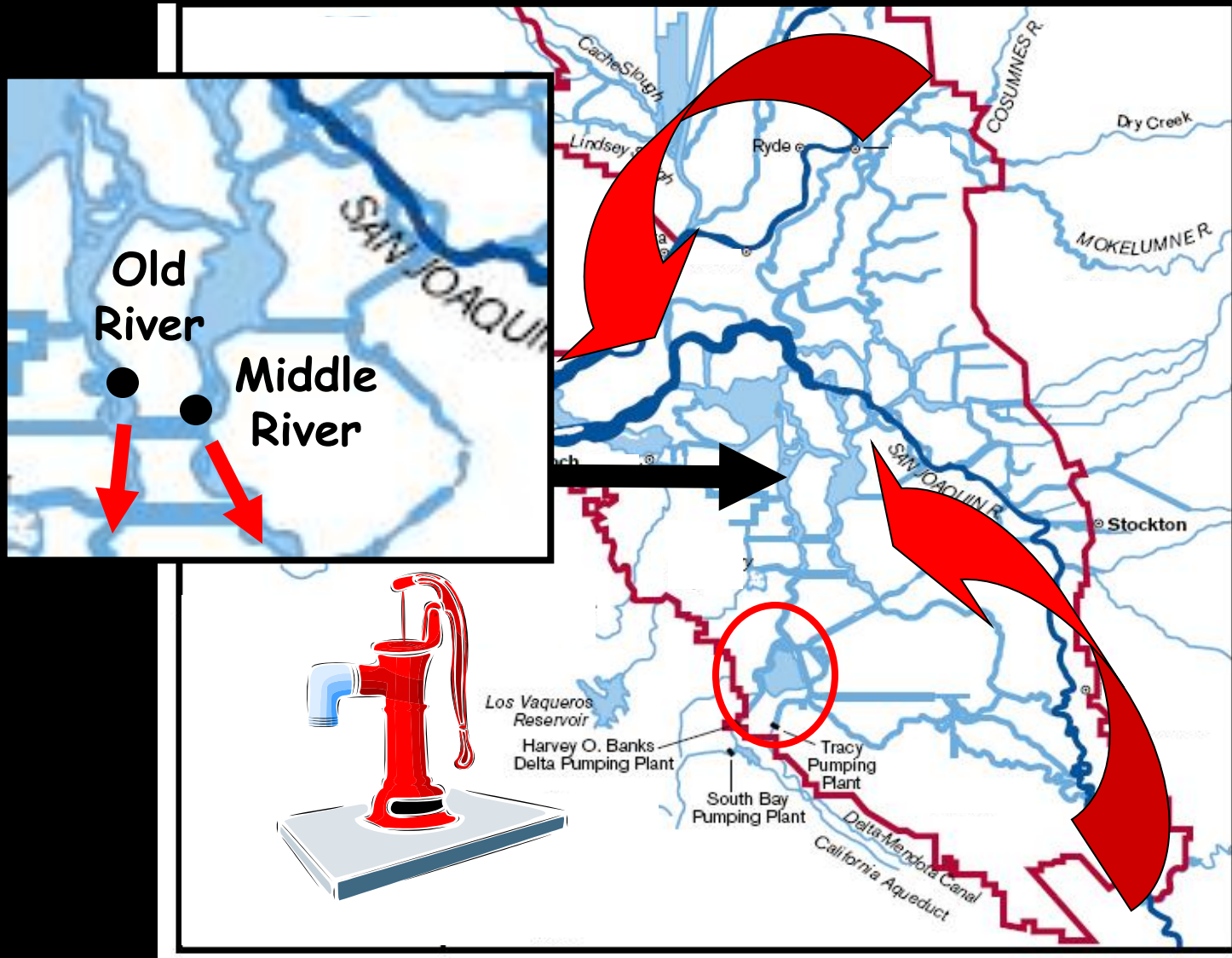
1233 kiloliters

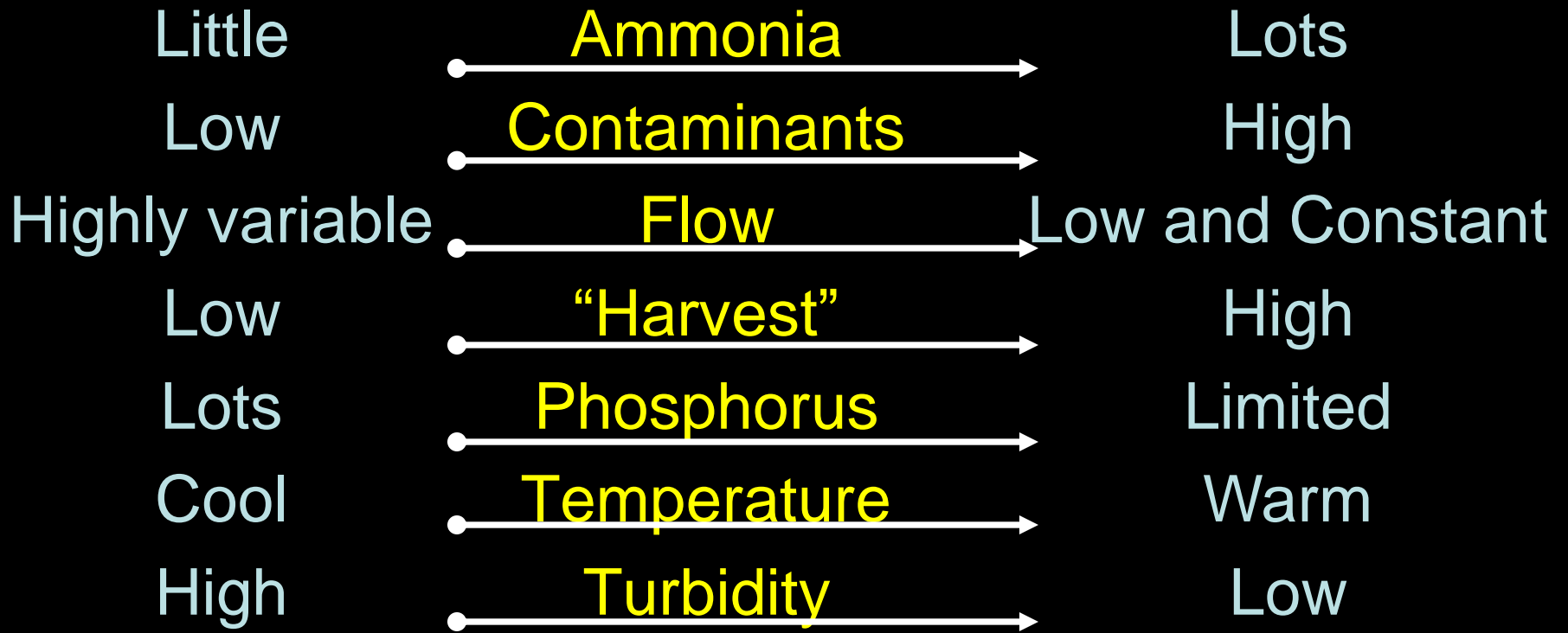
OR

1 cfs for 12 hours



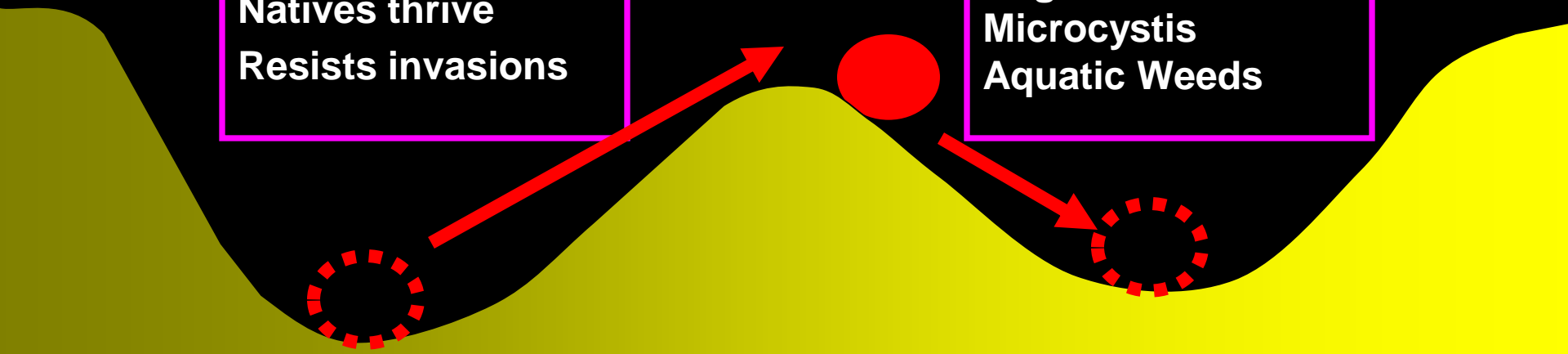
OMR = Old and Middle River flows



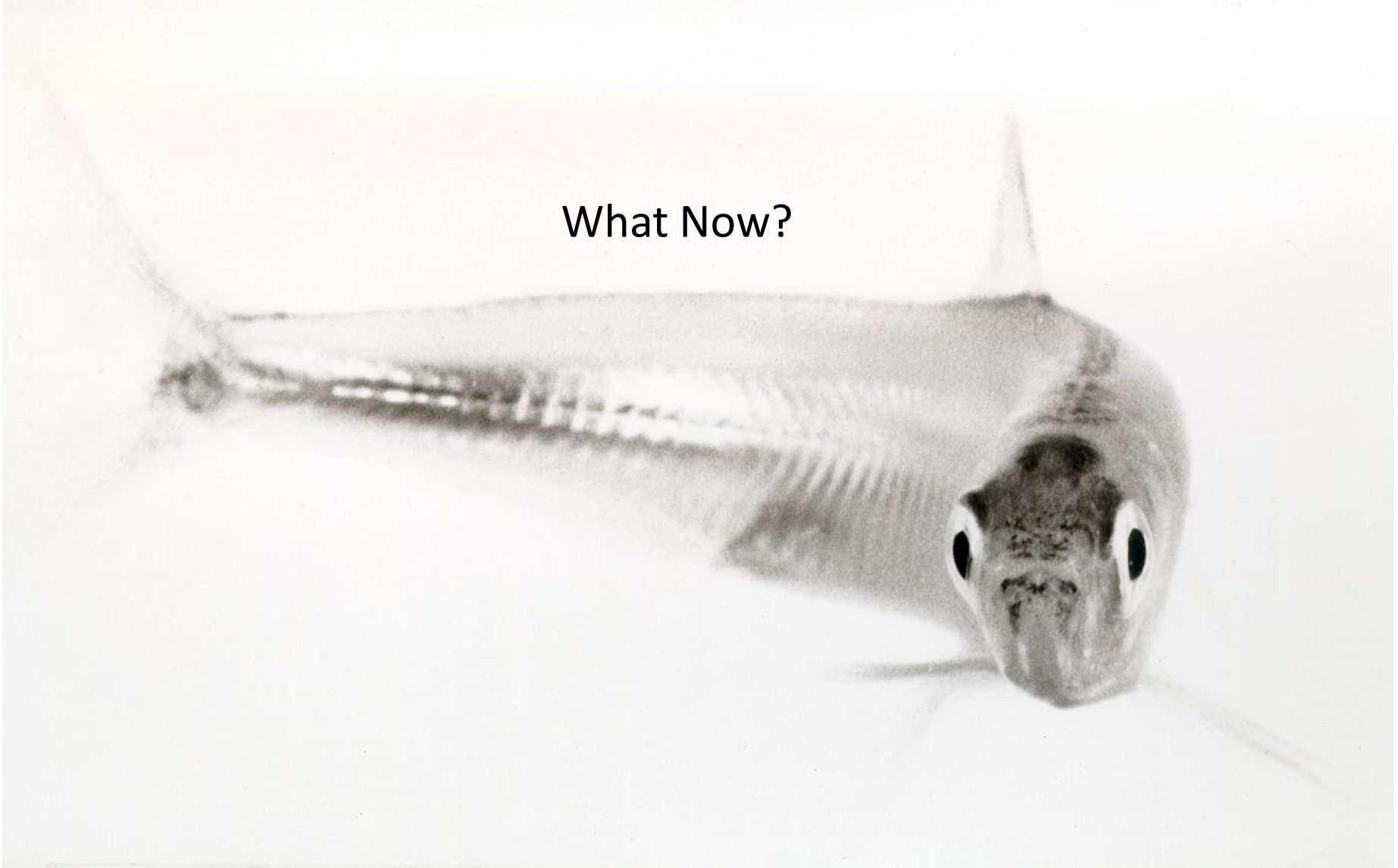


Diatoms
Pelagic fish
Natives thrive
Resists invasions

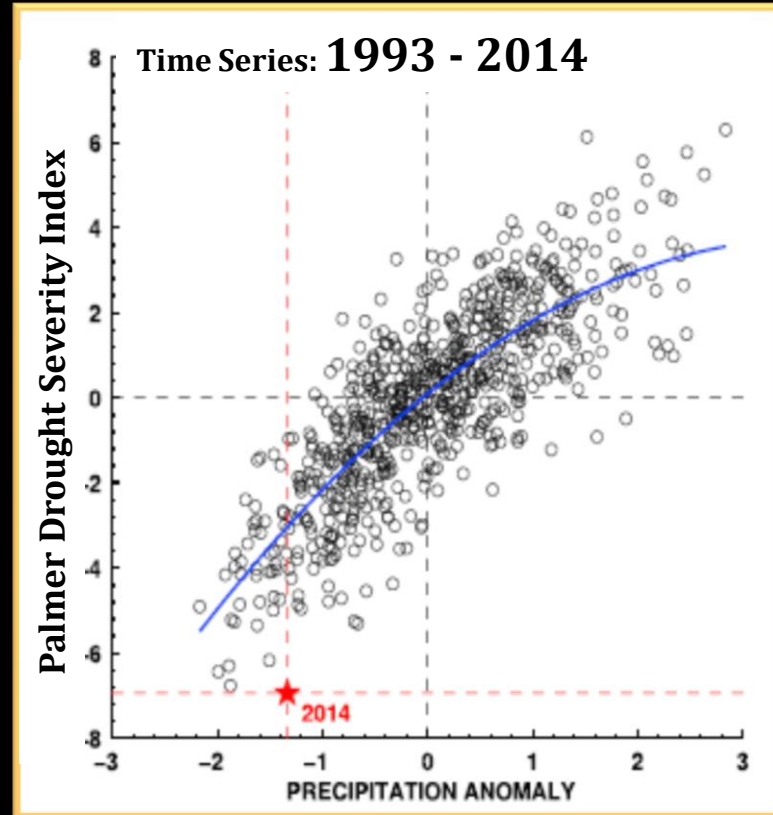
Clams
Jellyfish
Edge & benthic fish
Microcystis
Aquatic Weeds



What Now?



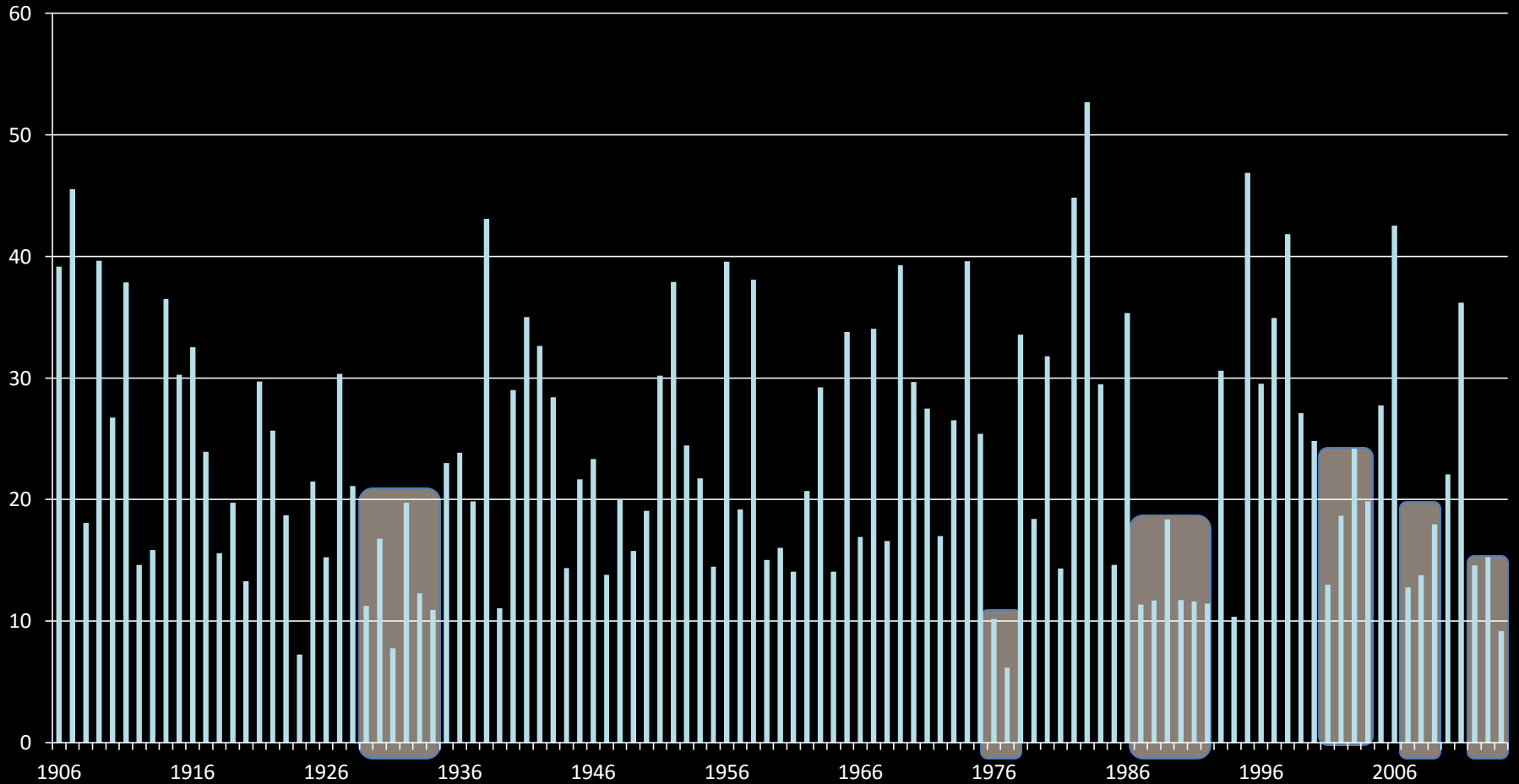
Drought Effects on Delta Smelt Application of a Conceptual Model



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

Thanks to Louise Conrad, DWR

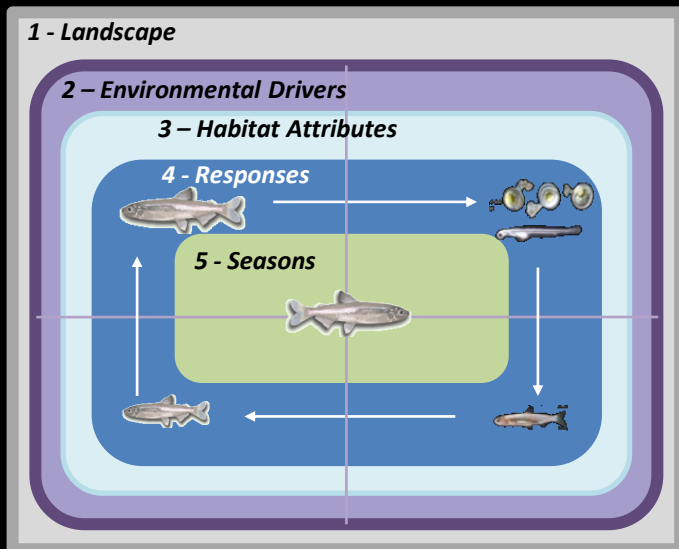
Central Valley Runoff MAF



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

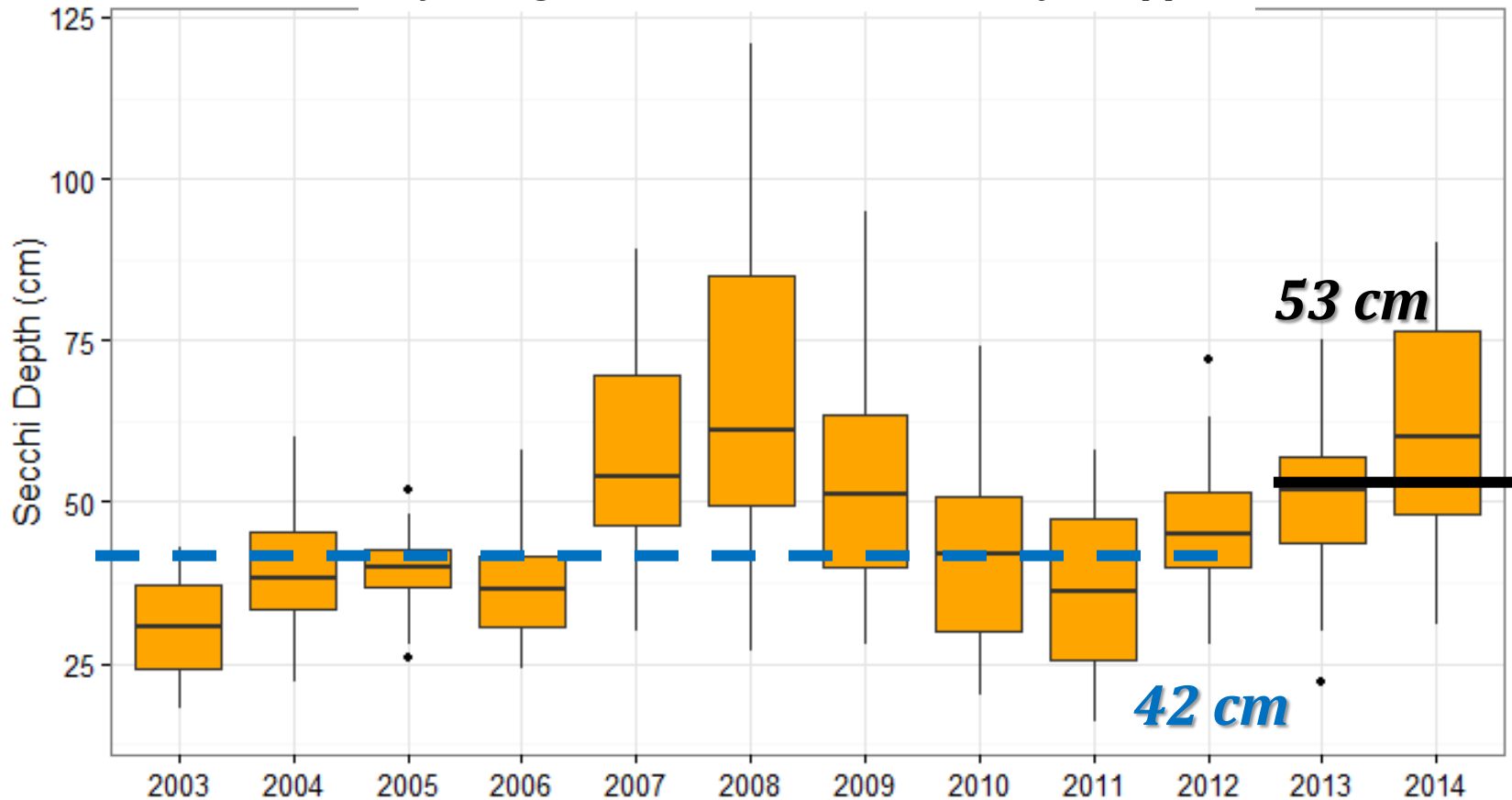
Sept - Dec

Results

Water Clarity



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



CDFW Summer Towntet Survey

Sharp Increase in Mississippi Silverside Abundance

Jan - Mar

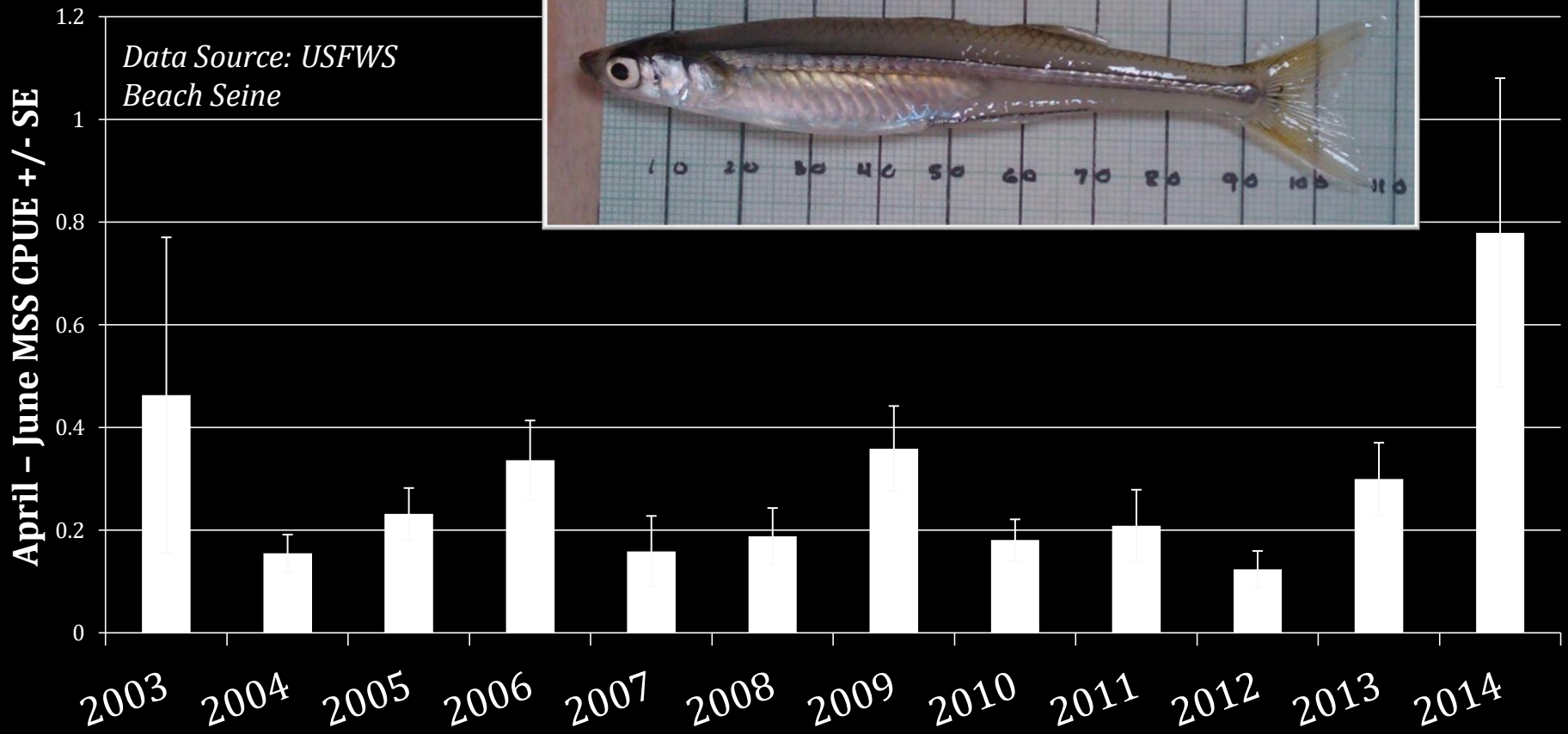
Apr - Jun

July - Aug

Sept - Dec

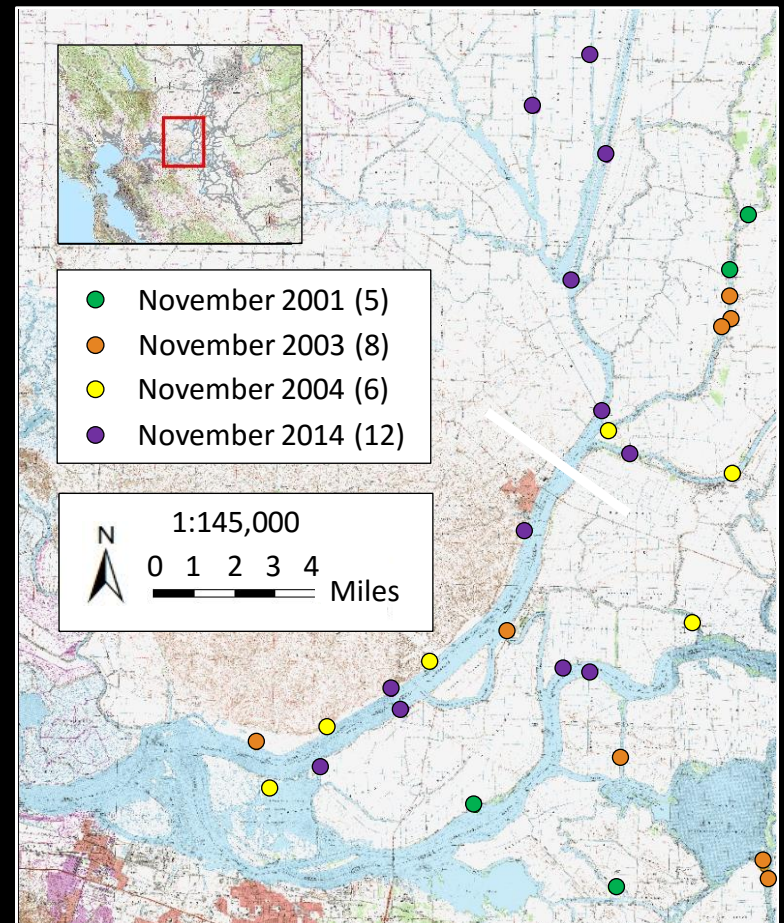
Results

Mississippi Silverside



November 2014: Boat Electrofishing Drought Survey

- Western and northern Delta

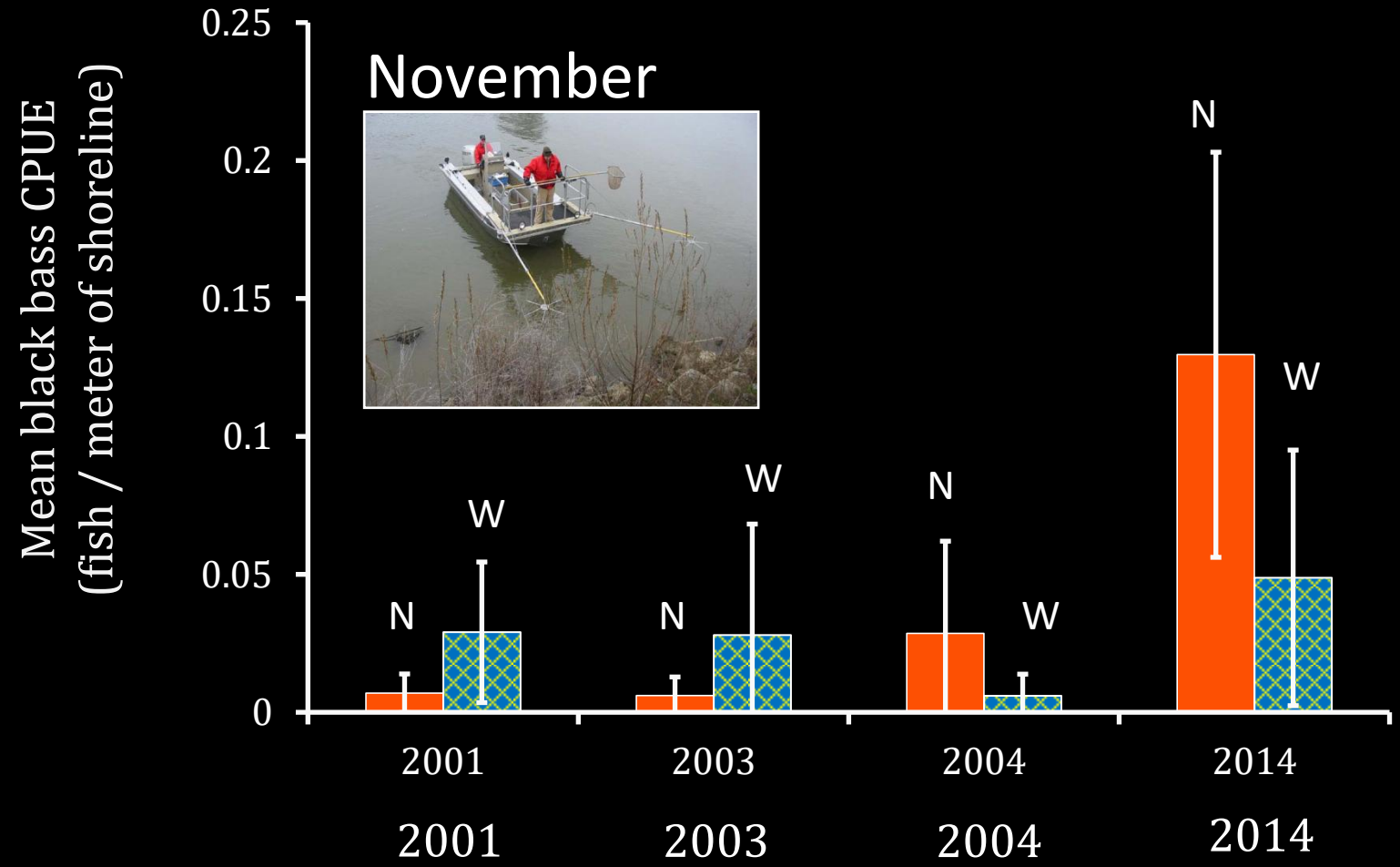


Black bass densities increased in 2014

Jan - Mar Apr - Jun July - Aug Sept - Dec

Results

Black Bass ↓ ↓ ↓ ↑



Water Temperatures Warmer All Year Long

Jan - Mar

Apr - Jun

Jul - Aug

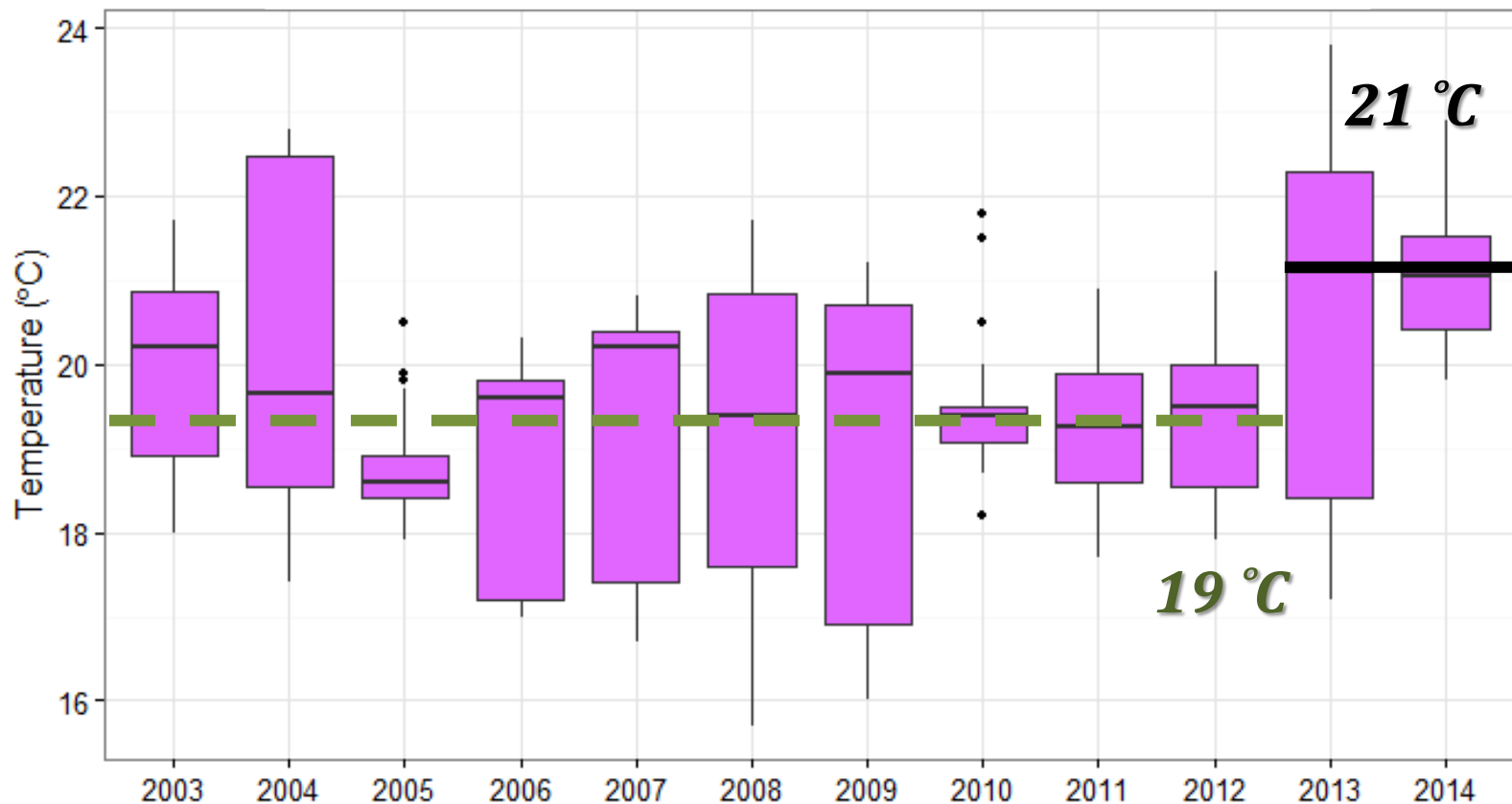
Sept - Dec

Results

Water Temp



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

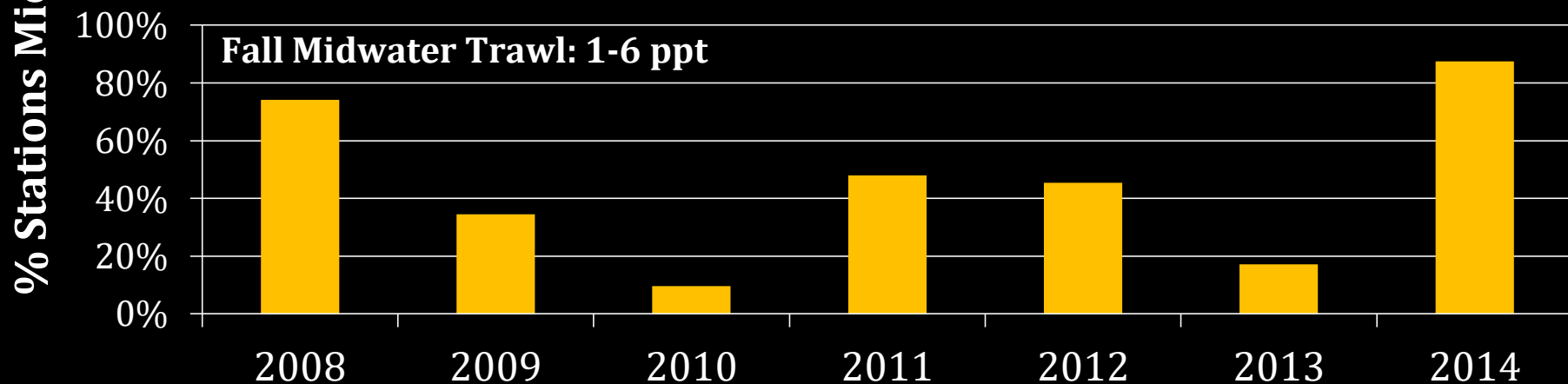
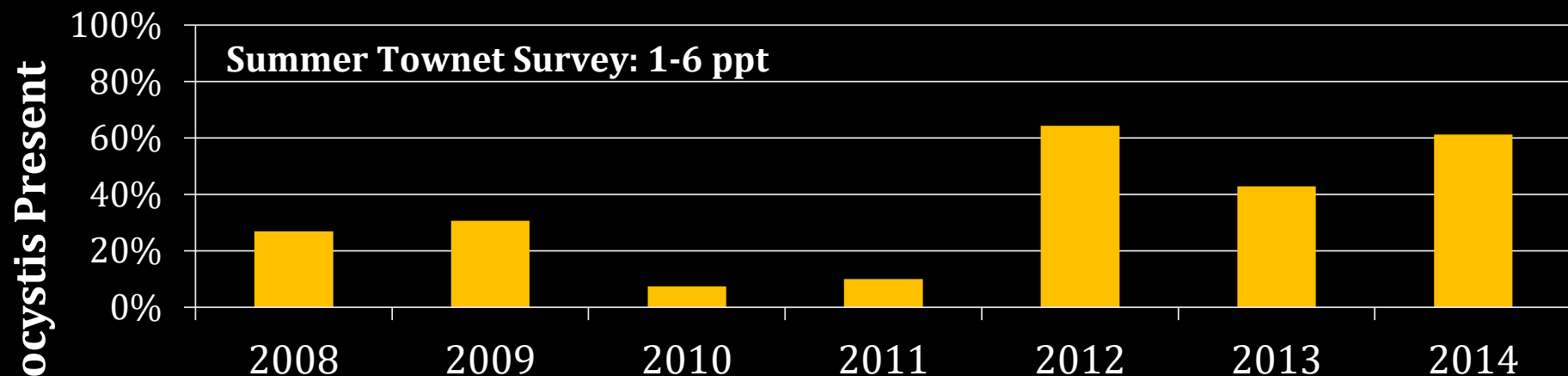


21 °C

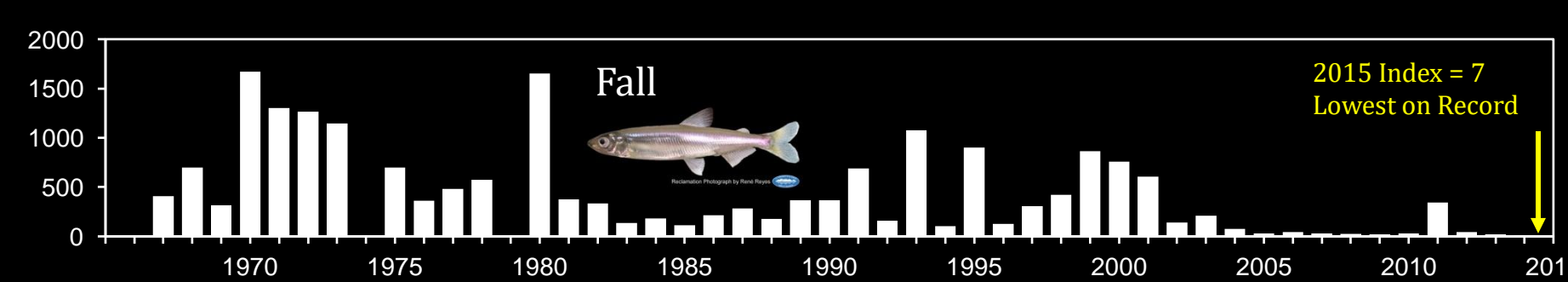
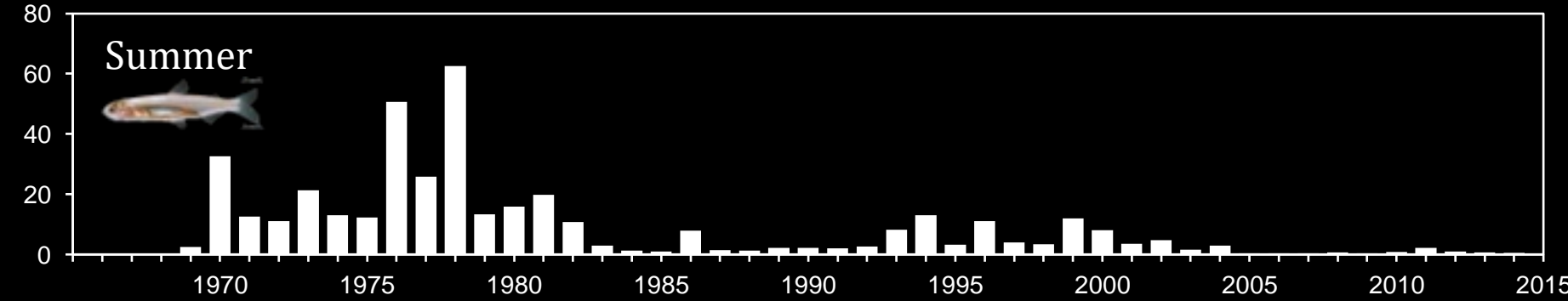
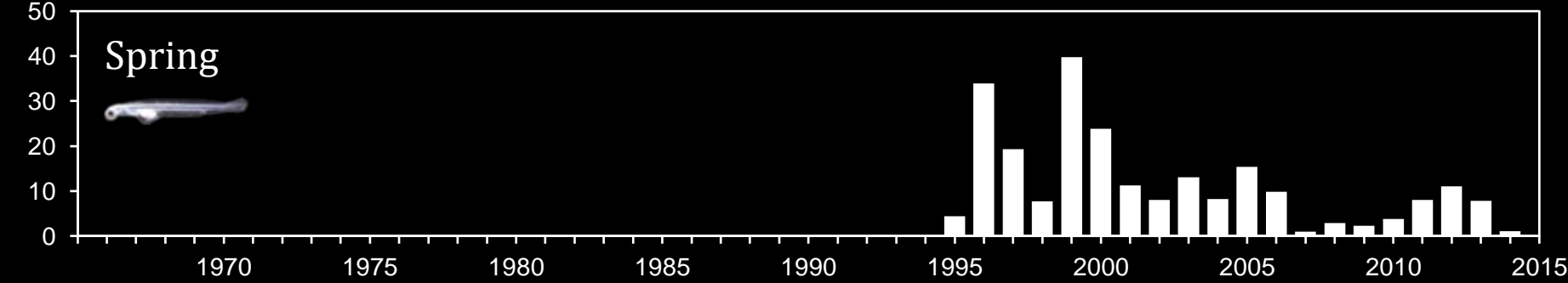
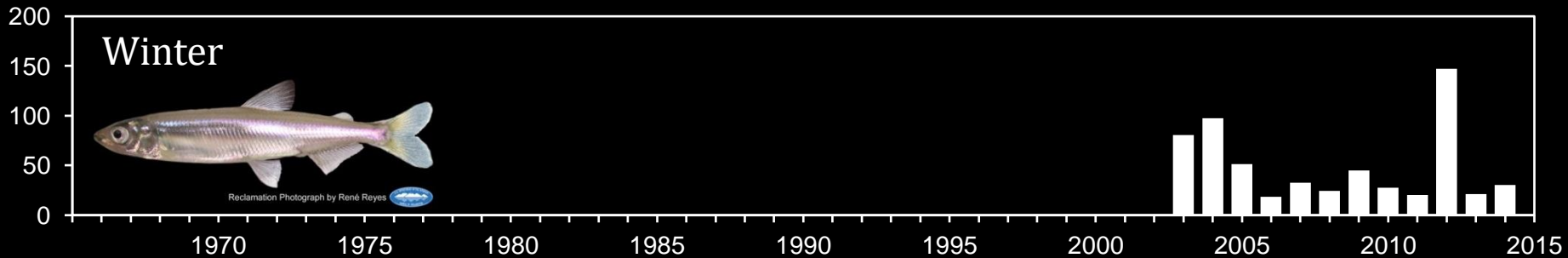
19 °C

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

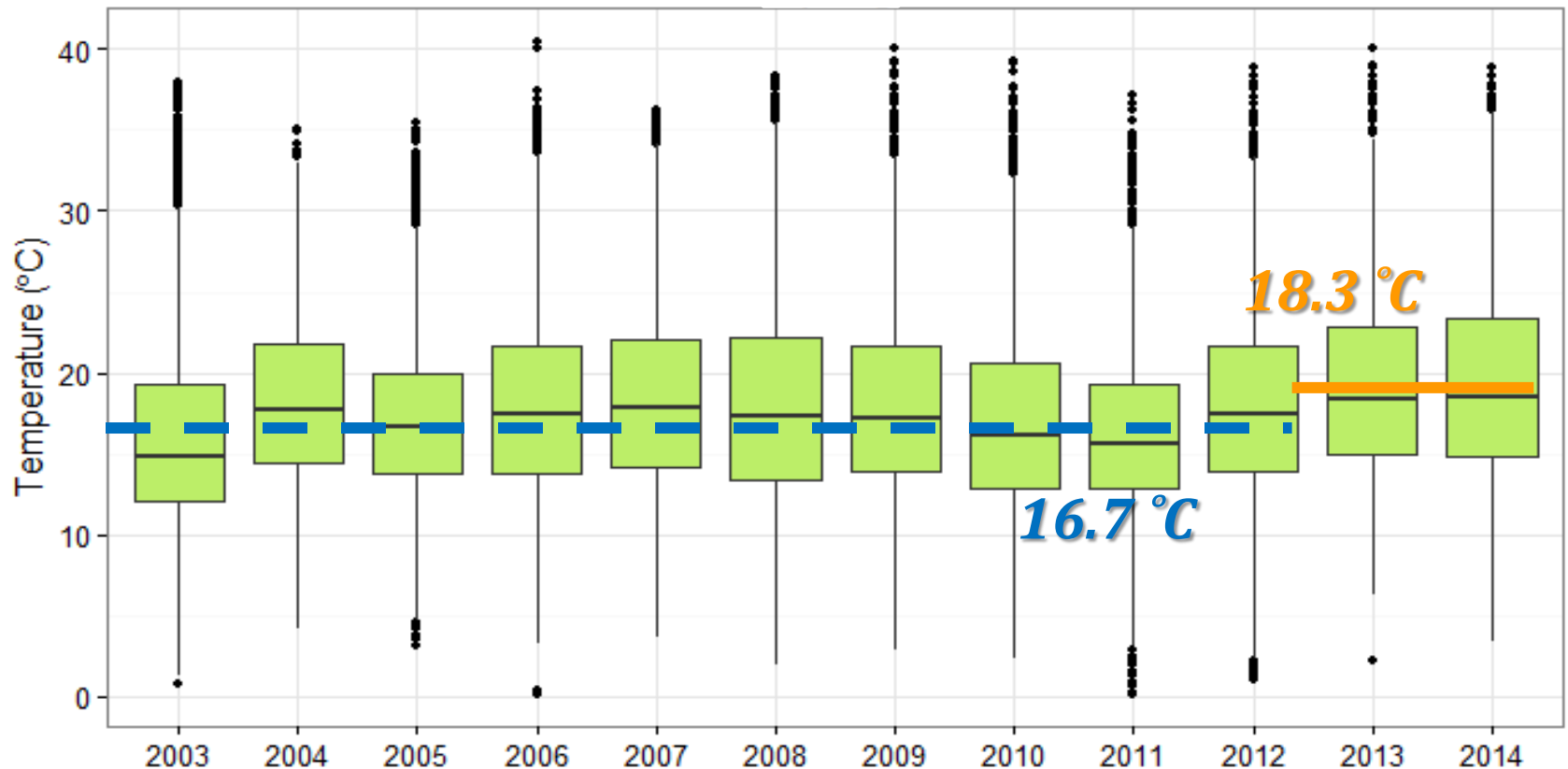
Sept - Dec

Results

Air Temperature

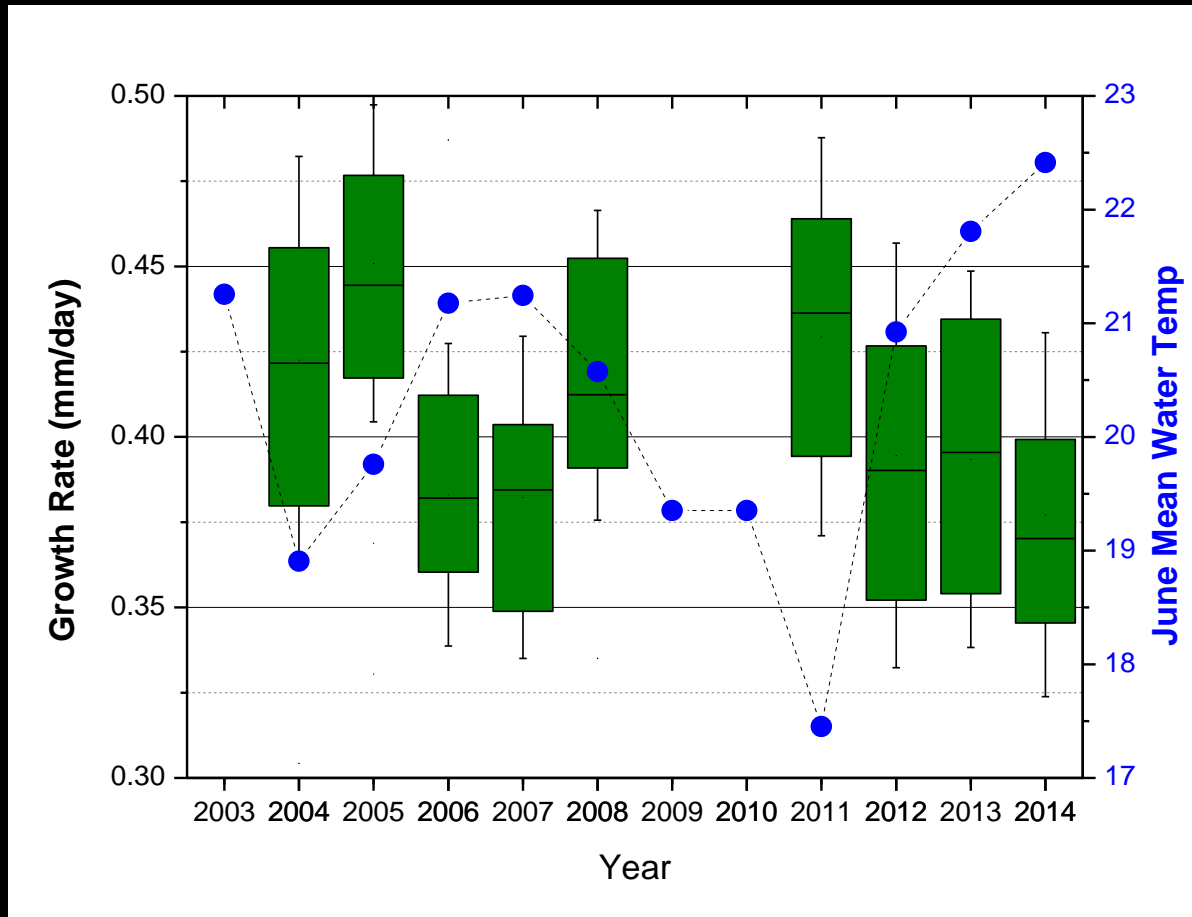


April - June

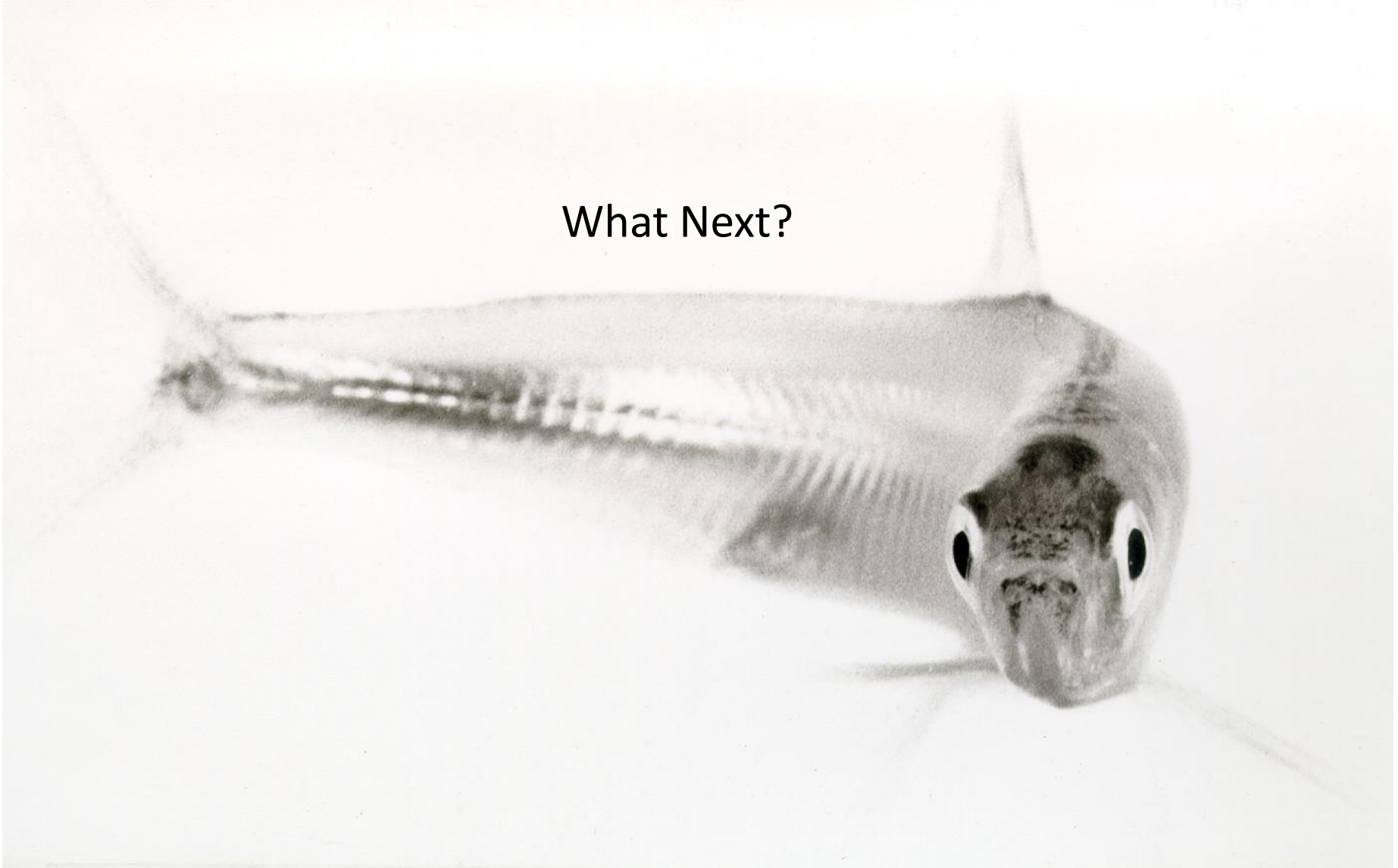


Air temperature station data pooled from: *Lodi, Mossdale Bridge, Mallard, Rio Vista*

Summer Growth Reduced



What Next?





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

Photo: Roger Kelly for Bay Nature Magazine

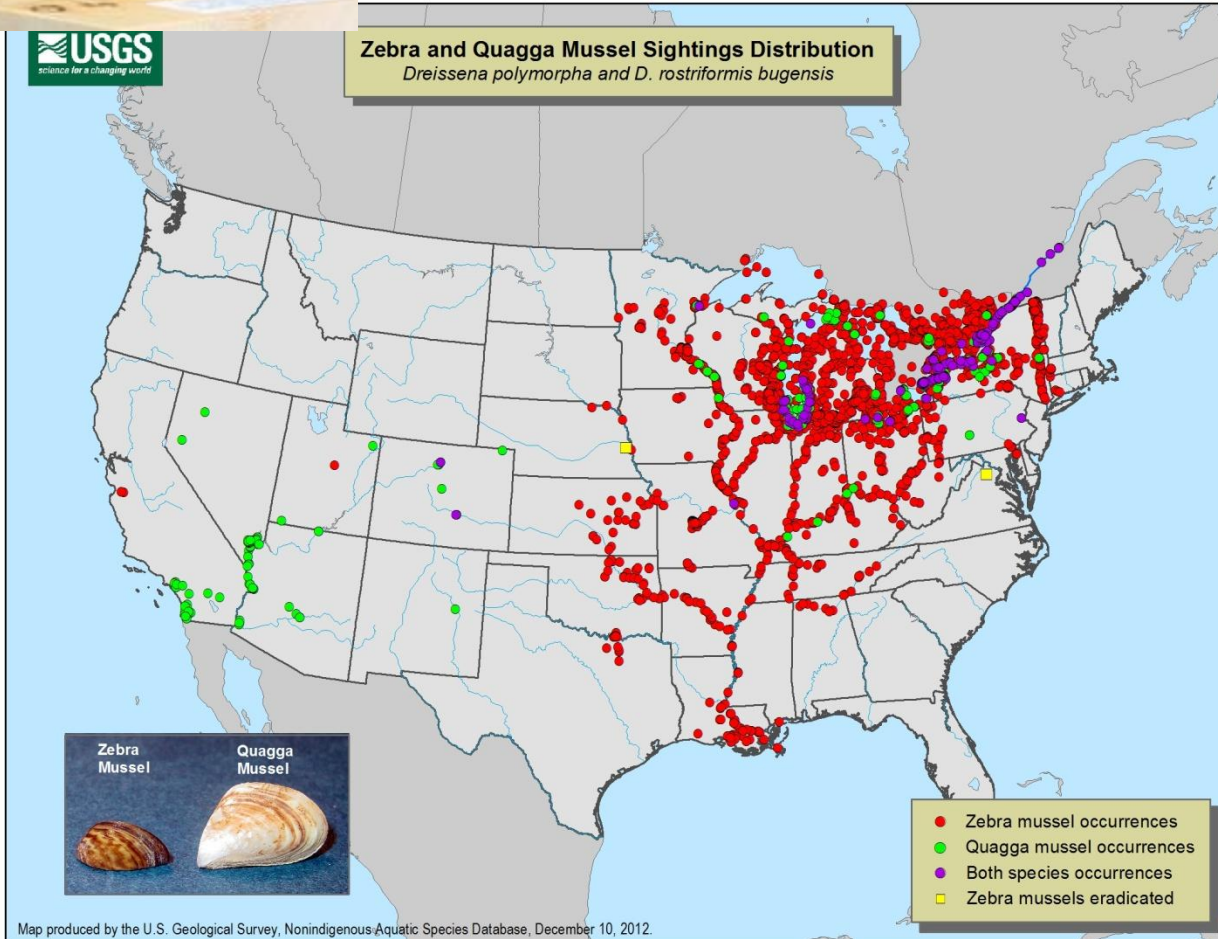


**South American Sponge Plant @ Brannon Island
2011 Lars Anderson**

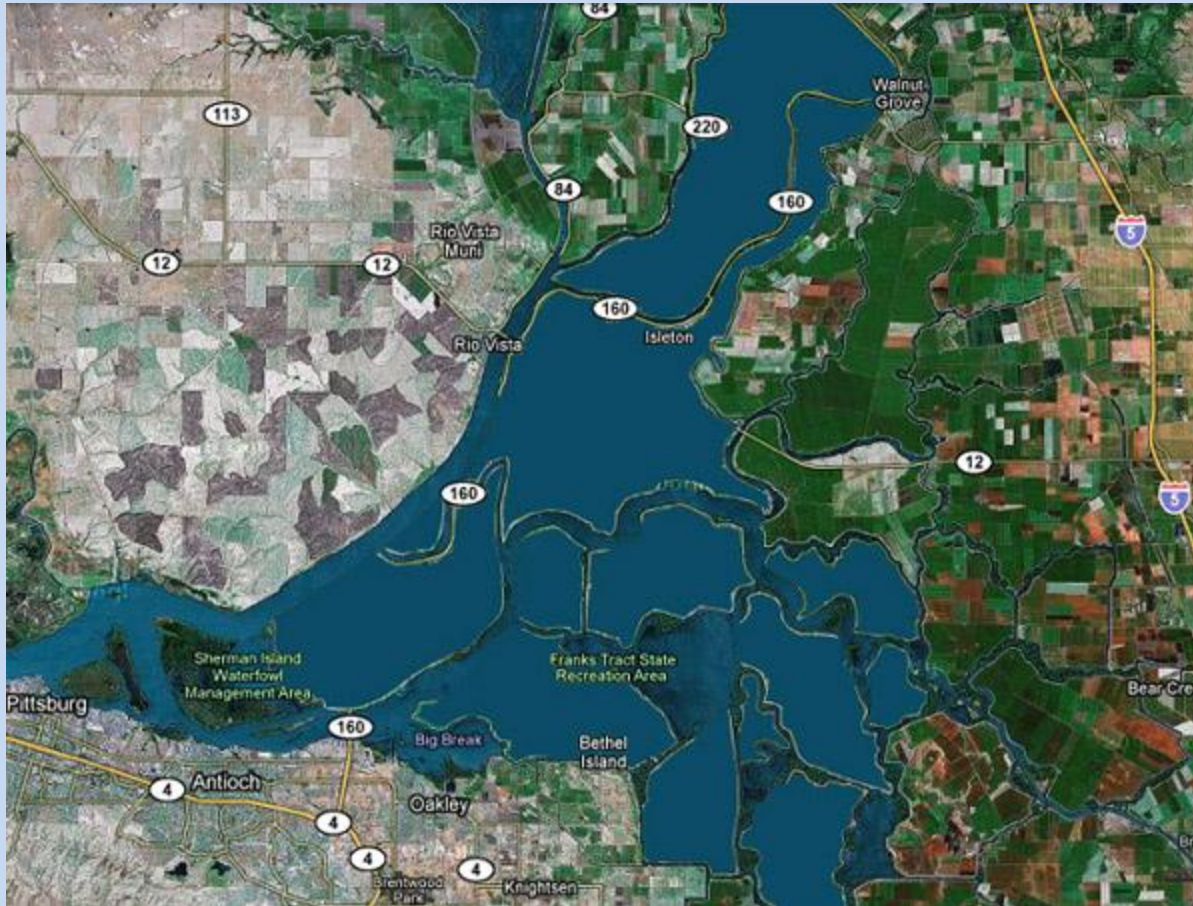


**Loach: San Joaquin River near
Fresno, Fall 2014.**

Today?



Earthquake or flood 64% chance in 50 years



1 M sea level rise (2100?)

