

**NOAA
FISHERIES
SERVICE**



SWFSC

California Central Valley Survival Studies

(Section 5.1 Sacramento Survival Studies)

SWFSC, WCRO, NWFSC, UCSC, UC Davis, UW-SAFS, USFWS,
USBR, USGS, Cramer Fish Sciences, CA DWR, CA DFW

Cinco de Mayo, 2015



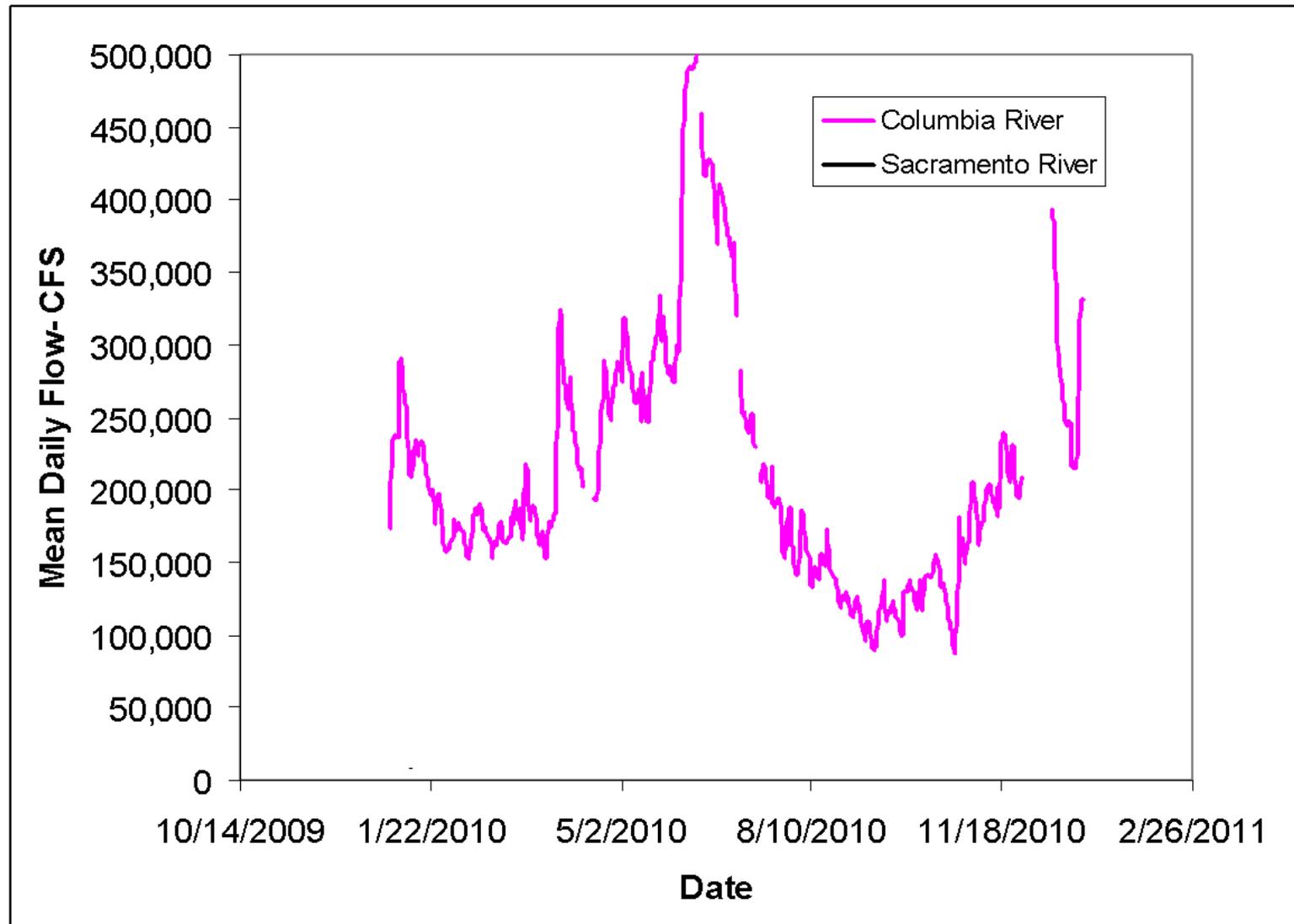
California Aqueducts



65 million acres
15% unchanged.....



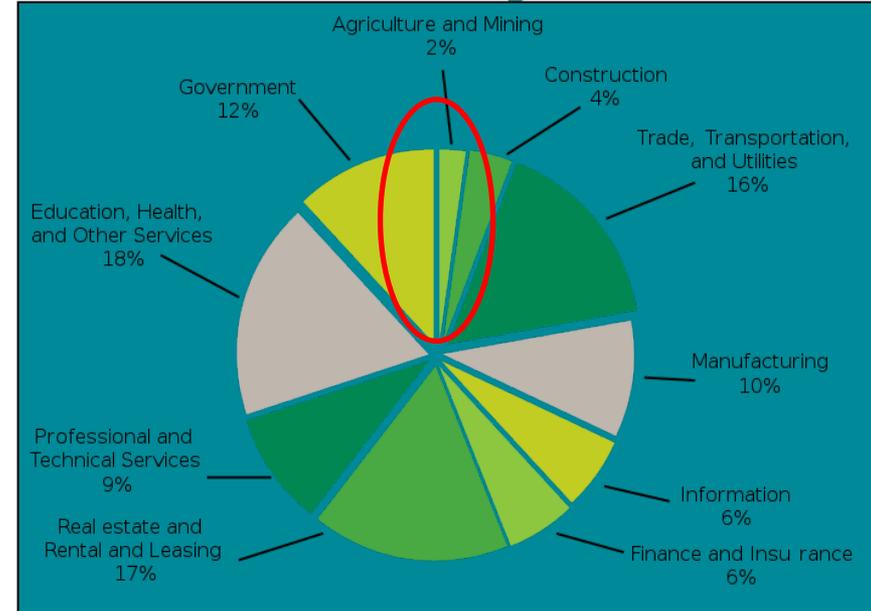
California ain't like the Pacific Northwest.....



California..... a \$1.85 Trillion economy

Resource competition:

- 37 million people
- Introduced fisheries
- Mediterranean climate
- Agriculture worth \$40 Billion/ 13% of US production
(uses >80% of the water)

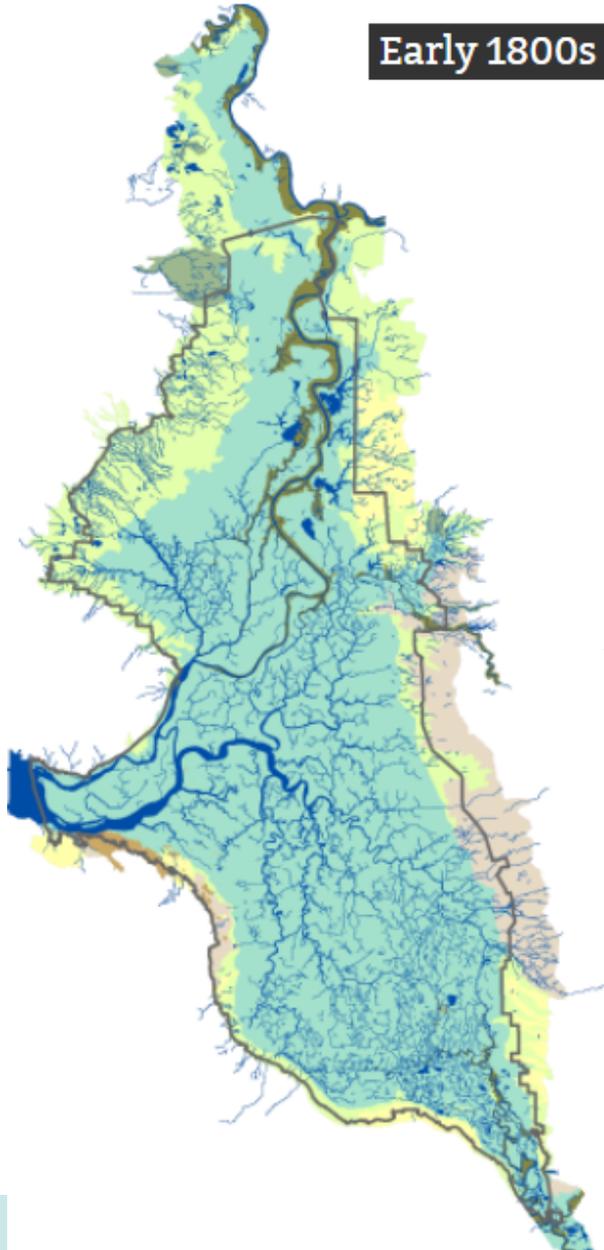


Water- 2 problems- transport and storage



The Delta- The heart of California's Circulatory System

Early 1800s

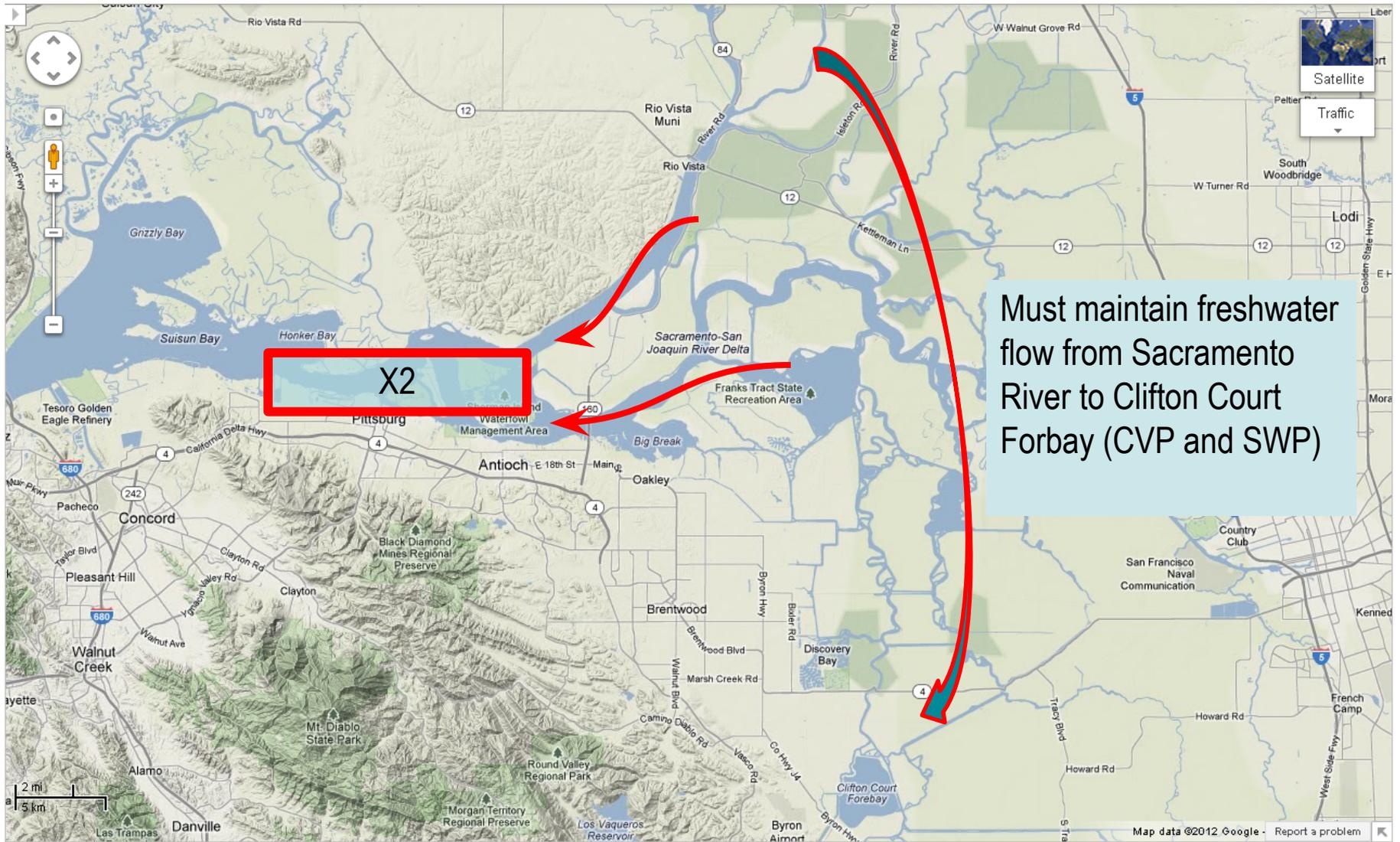


Show All

-  Agriculture
-  Urban
-  Water
-  Freshwater Wetland
-  Willow Thicket
-  Riparian Forest
-  Seasonal Wetland
-  Dune Scrub
-  Grassland
-  Oak Woodland

Note:

The outline on the map at left indicates the mutually mapped area. The outline on the map at right indicates the boundary of the SFEI-ASC study.



SUBSIDENCE

The Delta

- 1100 km of River Channel
- 1800 km of levees
- earth and stone 3-15m+ high
- 2000 km² land below 3-9m < sea level

Sensitivity to Storms and Earthquakes?



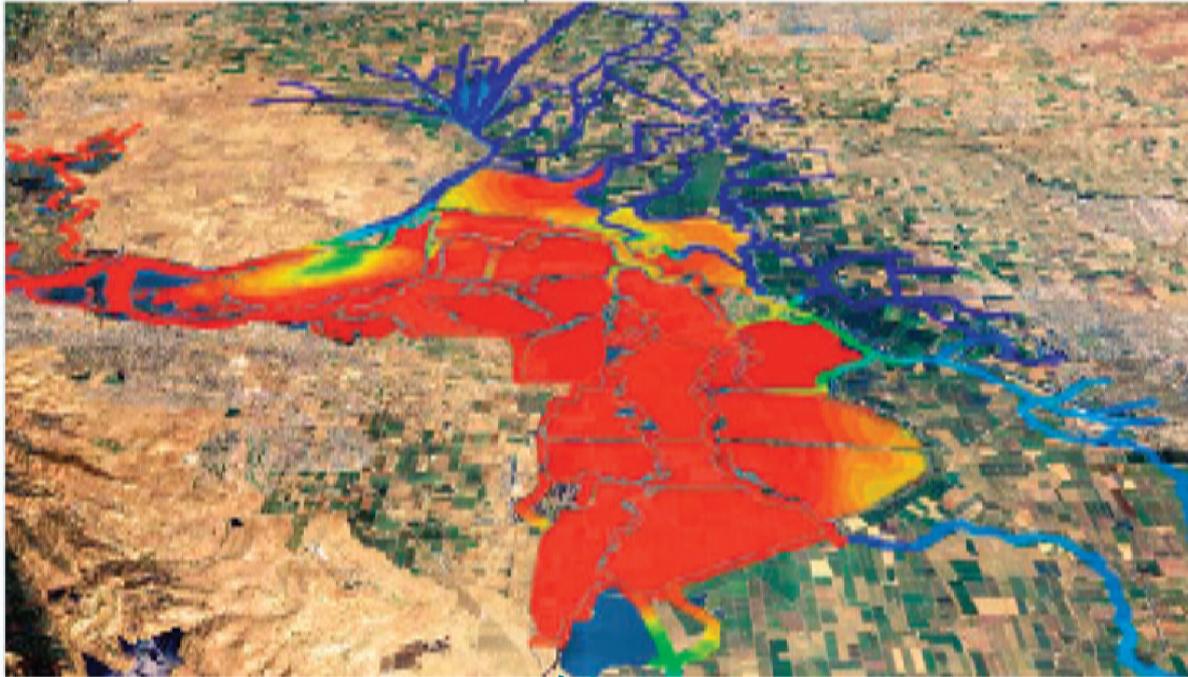
Earthquake simulation (only a 6.5)

....a **62 percent** probability of occurring
sometime between 2003 and 2032....(DWR 2009)

Electrical Conductivity ($\mu\text{mhos/cm}$)



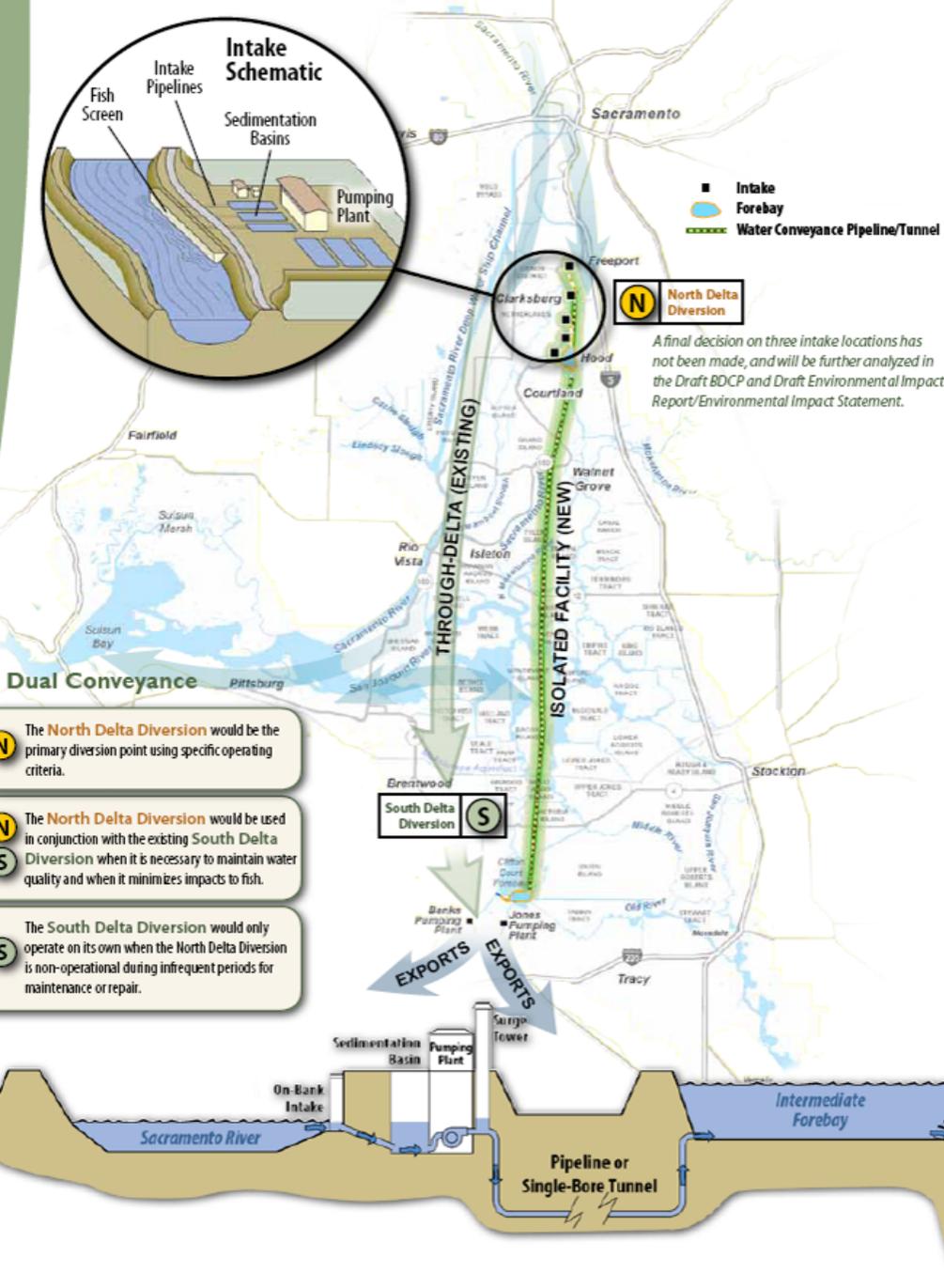
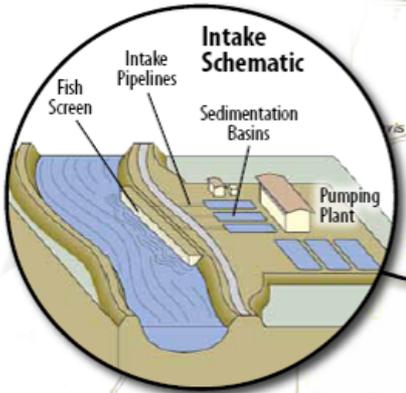
30 days: A saline estuary



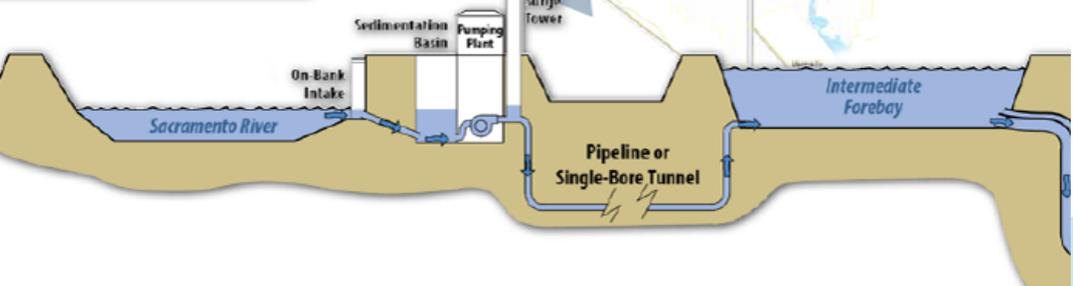
Transport Solutions Bay Delta Cons. Plan -

Dual Conveyance (Tunnels)

- 2 diversions= 6000 CFS
- \$20 Billion+ project
- Concern to juvenile salmonids?
- Ya think?

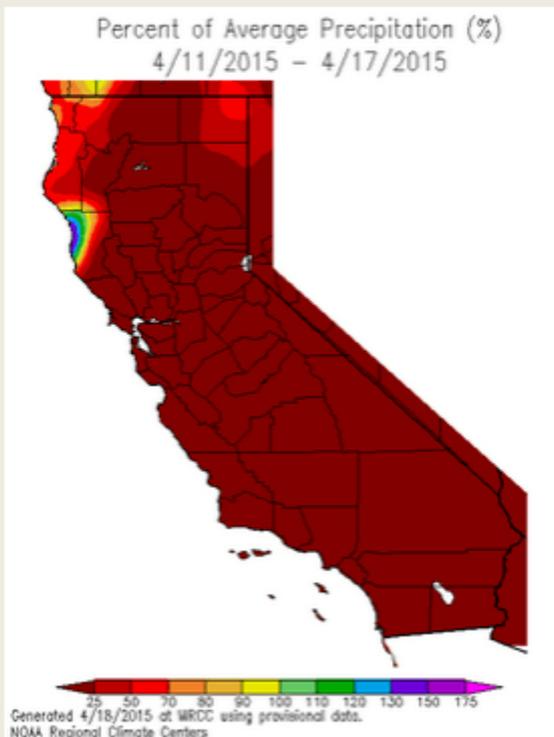


- N** The North Delta Diversion would be the primary diversion point using specific operating criteria.
- N** The North Delta Diversion would be used in conjunction with the existing South Delta Diversion when it is necessary to maintain water quality and when it minimizes impacts to fish.
- S** The South Delta Diversion would only operate on its own when the North Delta Diversion is non-operational during infrequent periods for maintenance or repair.

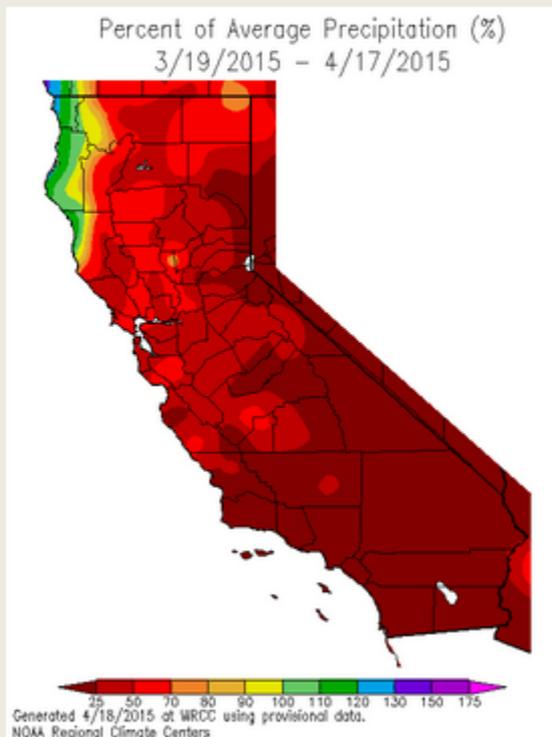


Drought? (storage issue)

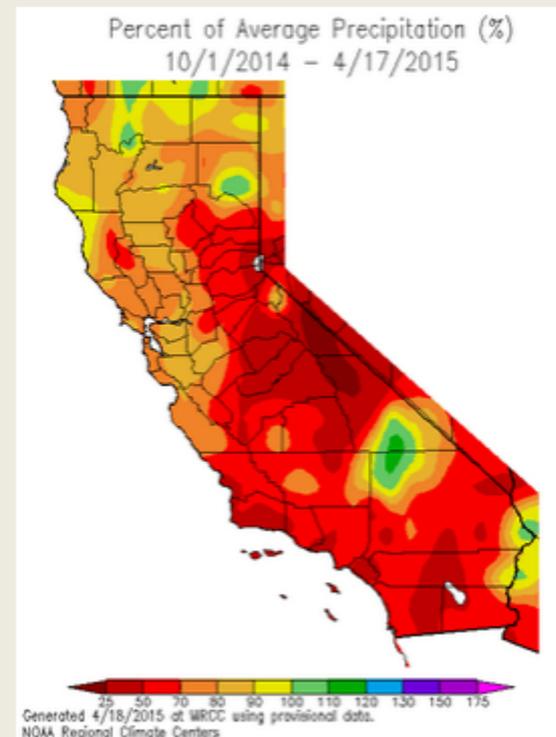
Last 7 Days % of Average Precipitation



Last 30 Days % of Average Precipitation



Oct 1 to Date % of Average Precipitation



Risks of Inaction

- ~\$250,000,000 salmon economy
- Flood safety and livelihood for 500,000 people
- \$40,000,000,000 agriculture (~13-45% of all US Ag)
- Fresh water supply for 25,000,000 people

- Stake holders all blame each other or the Ocean

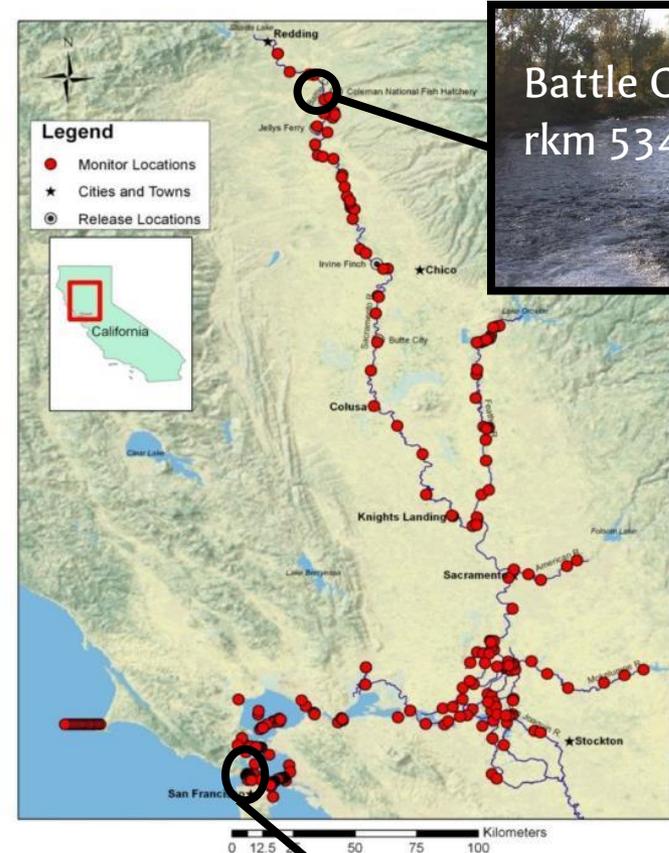
Any solution requires approval by NMFS

Need more data.....

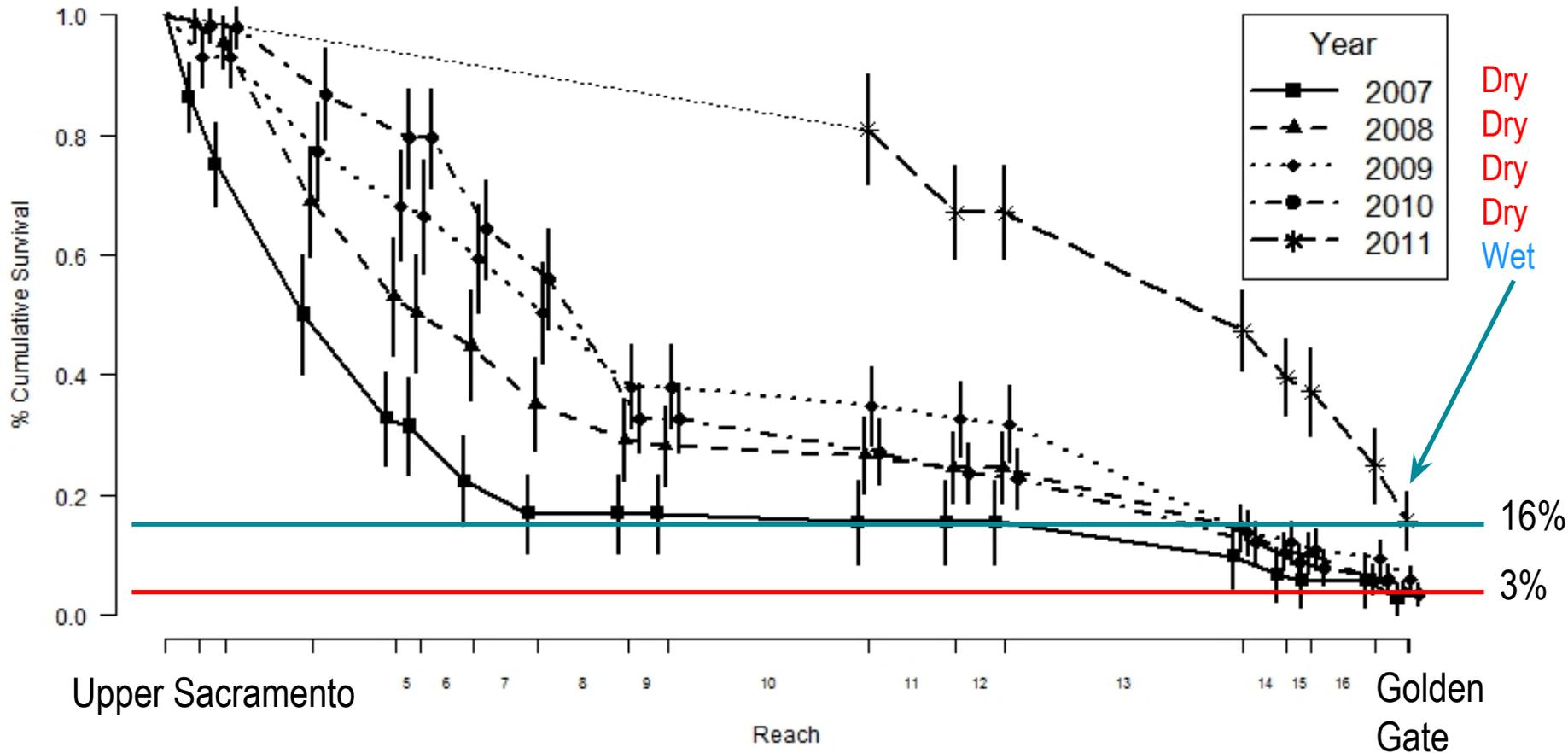
Empirical studies

- Juvenile outmigration survival
- Predation studies
 - Impact of water diversion
 - Habitat-Density interactions

Integrated Life Cycle Modeling Efforts



Late Fall Chinook Survival to Golden Gate 2007-2011 (5 years)



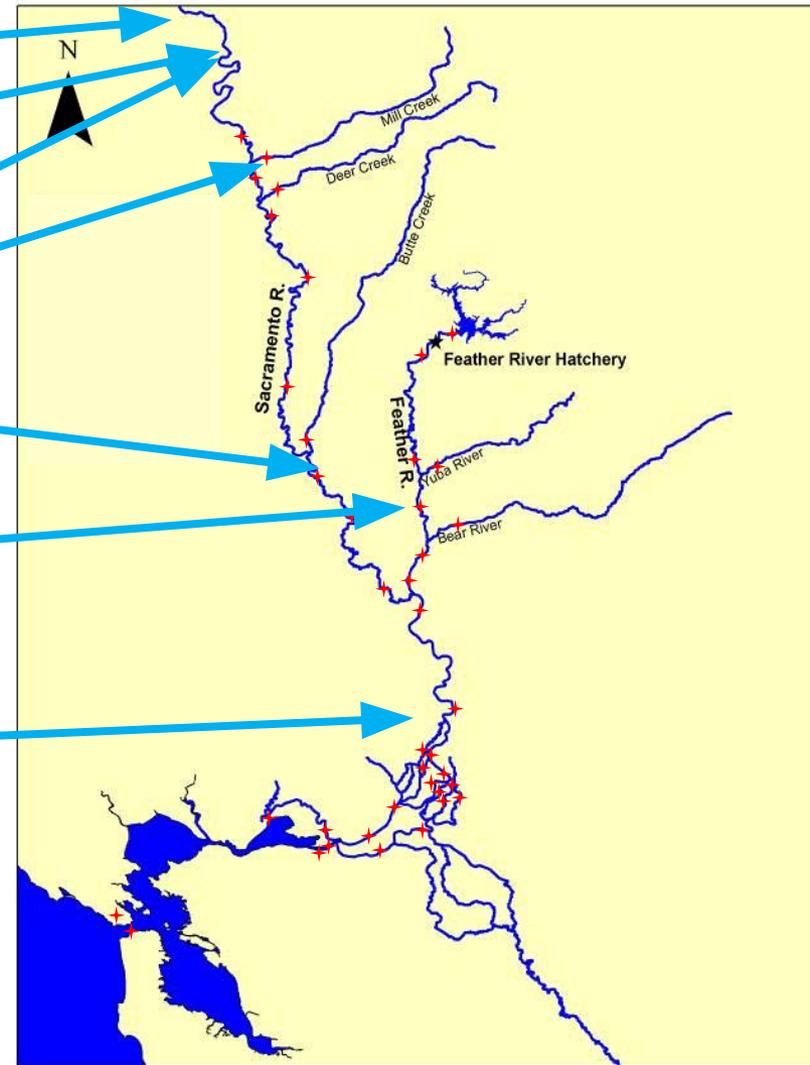
- Most effective life history strategy- SWIM FAST, get the hell out...
- 84-97% mortality occurs in 2-3 weeks post hatchery release
- More water appears to = More fish...



Tagging Schedule 2012-2015

Tagging goals

- Winter run- LSNFS
 - 200-400 Jan
- Fall run- CNFH
 - 150 x 2 early/late Apr
- **Wild** tagging Spring and Fall
 - Mill, Battle, Butte-Sutter
 - 200-400 Nov-May
- Spring run from FRFH
 - 150 x2 Apr- upper/lower river
- Fall and Spring run releases into Delta
 - 100 f/100s x2 (repeat Perry et al 2010)



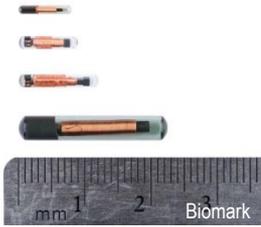
Comparative stock results

Run	Years	Survival	Transit time (days)	Area of Peak Mortality
Late Fall	2007-2011	3-16%	15-28	SF Bay
Fall	2012-2013	3-5%	8-17	SF Bay
* Spring	2012-2014	0-2%	9-17	Feather River
* Winter	2013-2014	4-5%	<20-54	Middle Sac
* Wild Fall/Spring	2013-2014	0-2%	~10-20	Tributaries and Middle Sac

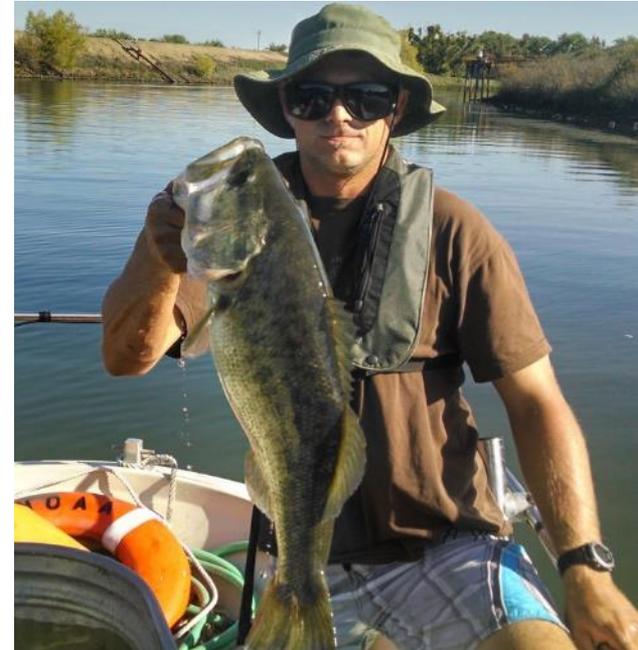
* Despite continued drought in 2015- several stocks were released on large pulse flows and preliminary observations from new real-time receivers suggest higher survival.

What about PIT tags?

- Two year feasibility study (2015-16)
- NOAA (SWFSC and NWFSC), USBR and CA DFW
- Deploy existing small-channel antennas a
- Engineer and deploy prototype large-channel detection arrays at two locations
- Develop/test boat -trawl antennas in the estuary
- Tag and release juvenile salmonids to estimate detection efficiency
- Identify additional sites



Mortality Causes?



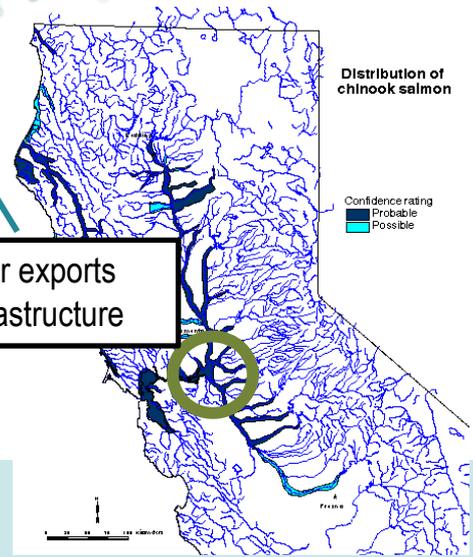
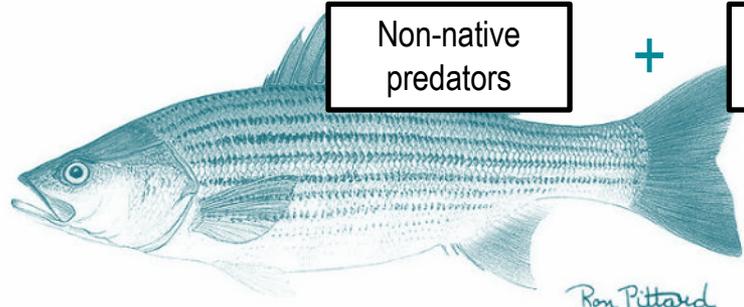
ESA-listed salmon and steelhead

?

Non-native predators

+

Water exports & infrastructure



Distribution of chinook salmon

Confidence rating
Probable
Possible

Bass present for 130+ years, why a problem now?

- Constant introductions of Invasive Species

- Asian Clams

- *Corbicula fluminea*
 - *Potamocorbula amurensis*,

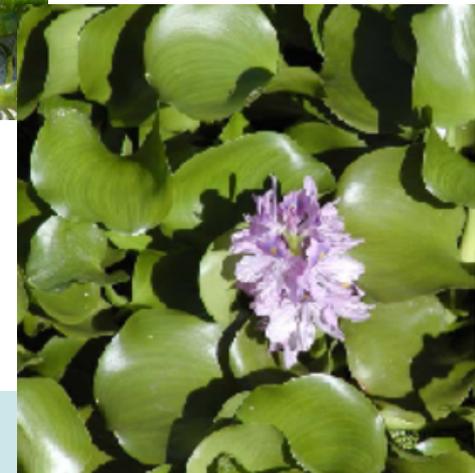


- Aquatic Plants

- *Egeria densa*

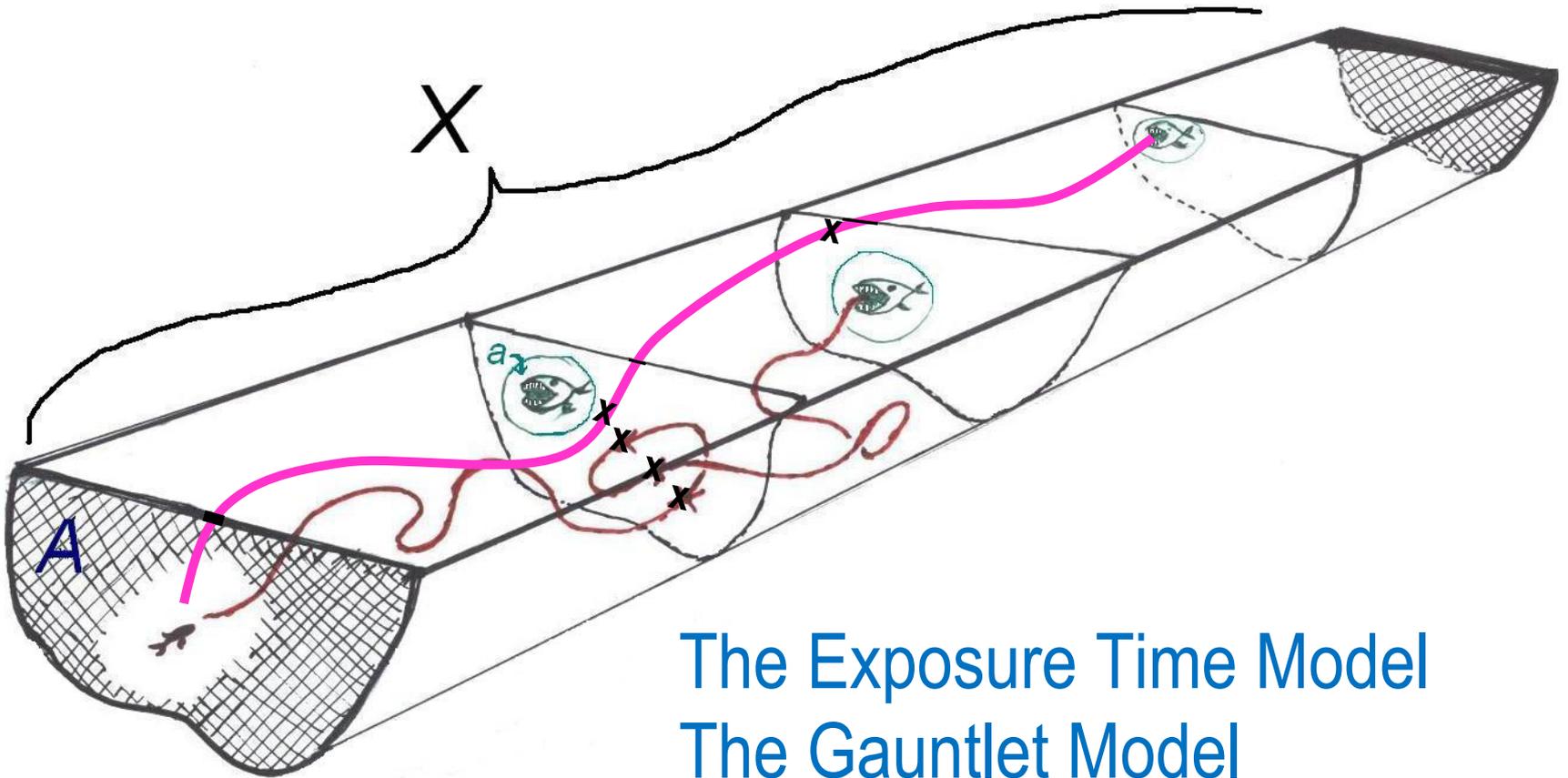


- Water Hyacinth



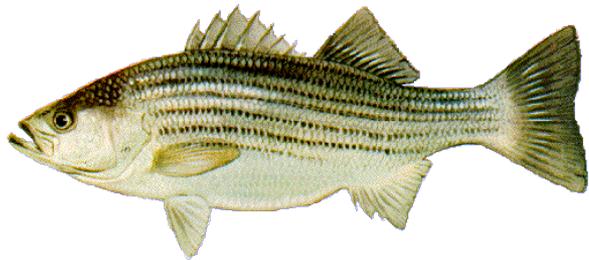
The XT Model Cartoon

Gurarie (2008) Anderson et al. (2005)



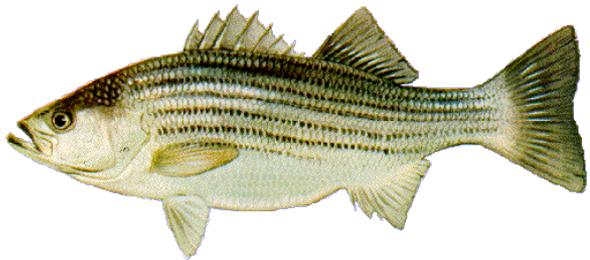
The Exposure Time Model
The Gauntlet Model

Effect of habitat on predation rate?



Diet in lower river = 80% crayfish, 0 salmon

- Habitat alterations matter!



Diet at Dam = 80% salmon

The Predator Issue..... Just how bad is it?

Loboschefsky, E., Benigno, G., Sommer, T., Rose, K., Ginn, T., Massoudieh, A., and Loge, F. 2012. Individual-level and Population-level Historical Prey Demand of San Francisco Estuary Striped Bass Using a Bioenergetics Model. San Francisco Estuary and Watershed Science 10(1).

- Sacramento Bay/Delta populations of striped bass consume.....

~25,000,000 kg of fish per year

All CV juv salmon

~240,000 kg

~1% of bass diet?



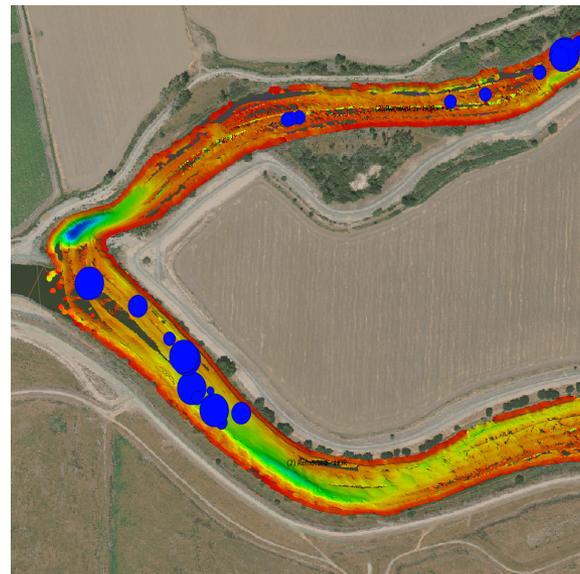
Delta Predation Studies

- ***Objective 1*** - Determine representative densities and local spatial distributions of predator fish
- ***Objective 2*** - Quantify the magnitude of predation through genetic analysis of predator stomach contents
- ***Objective 3*** - Conduct a controlled large-scale experiment that manipulates the density of predators
- ***Objective 4*** - Determine how predation on salmon smolts may be influenced by physical habitat, water chemistry, and other environmental features



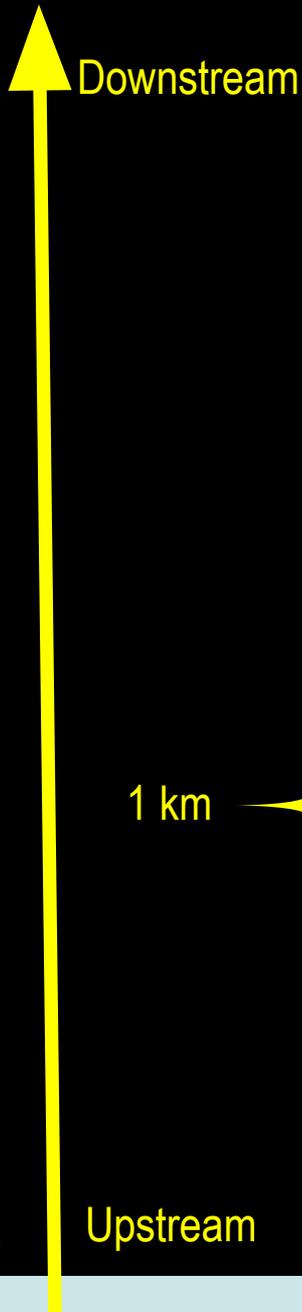
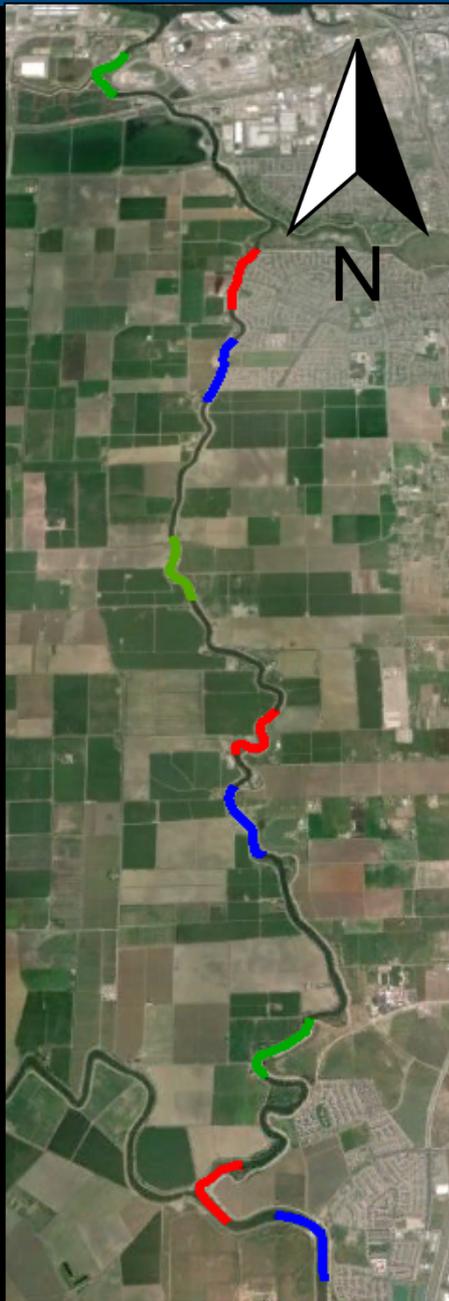
Objective 1 - Densities and local spatial distributions of predator fish

- Map river bathymetry, fishes, and flora with multi-frequency sonars and echosounders
- Improve estimates of fish densities with high-resolution riverbed bathymetry
- Fish abundance appears to be patchy and variable with time
- Frequently repeated surveys needed to characterize fish behaviors and identify causes.



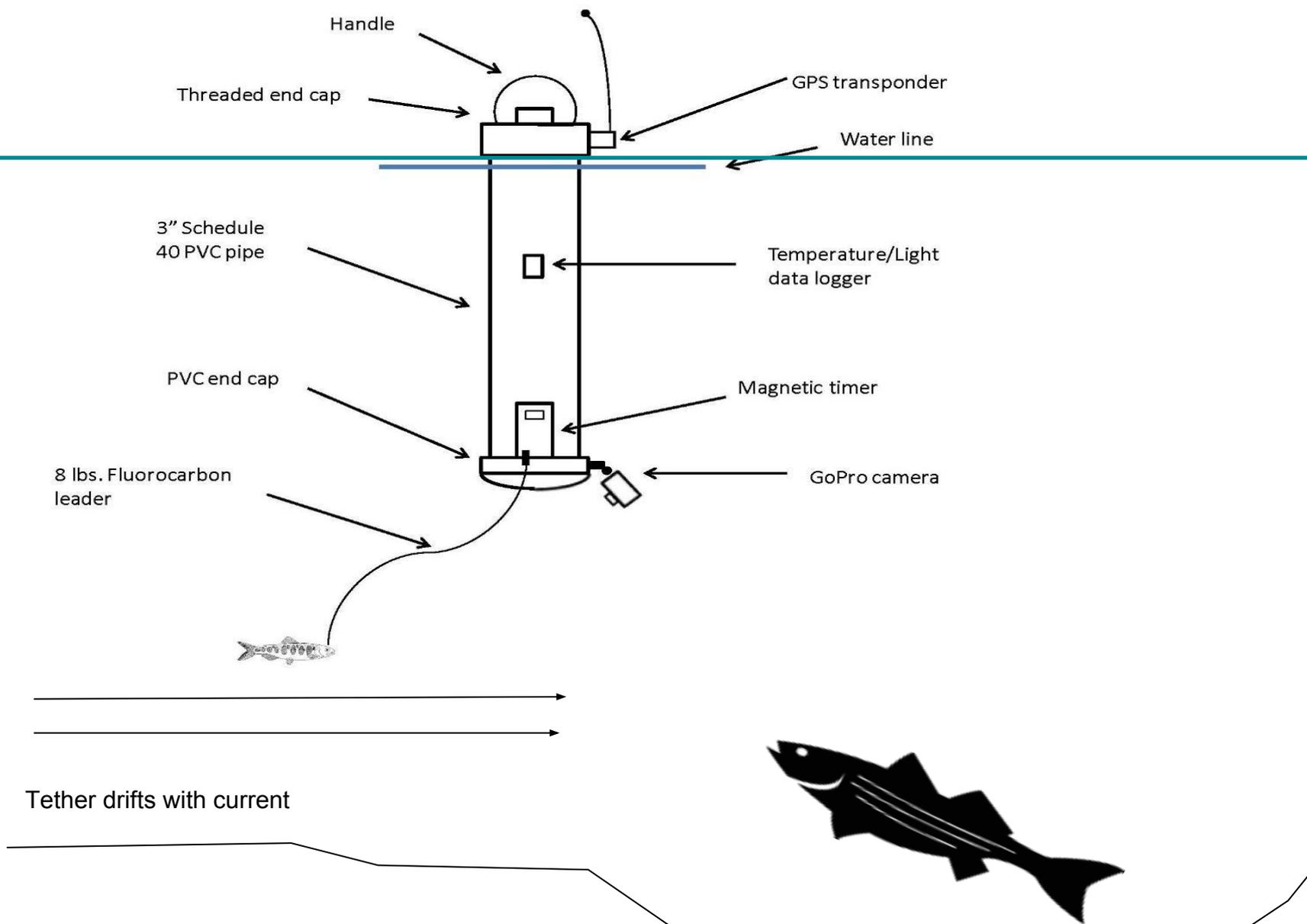
Objective 3 - Experiment that manipulates the density of predators

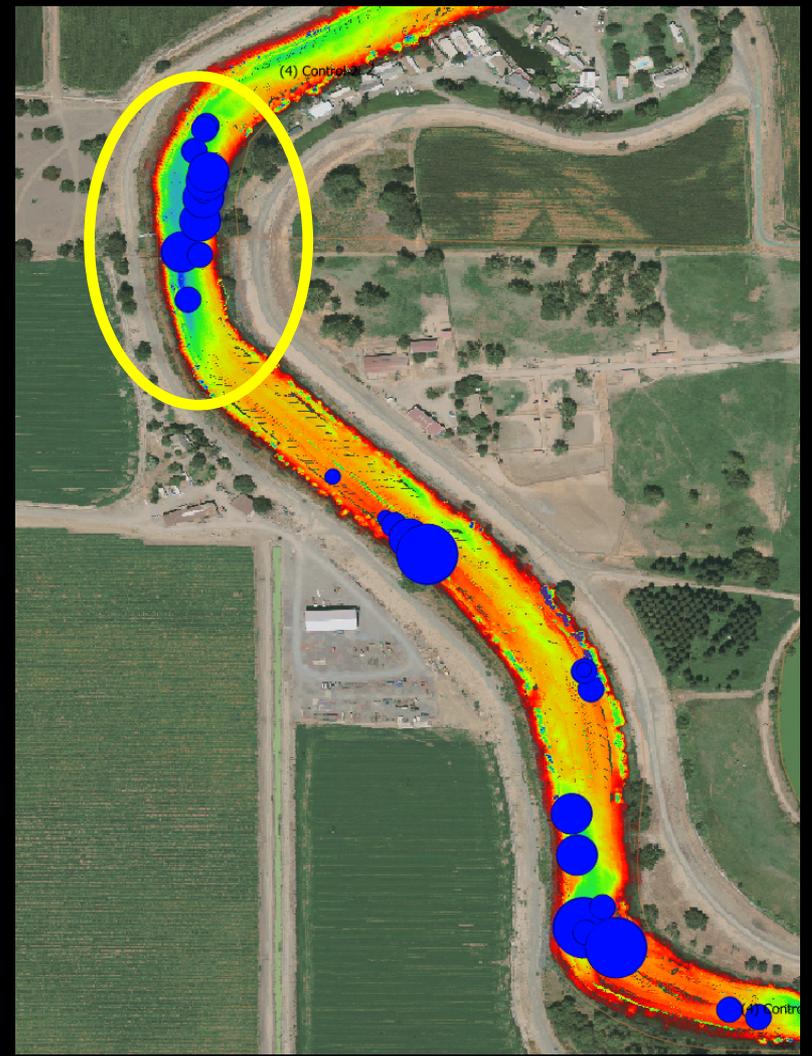
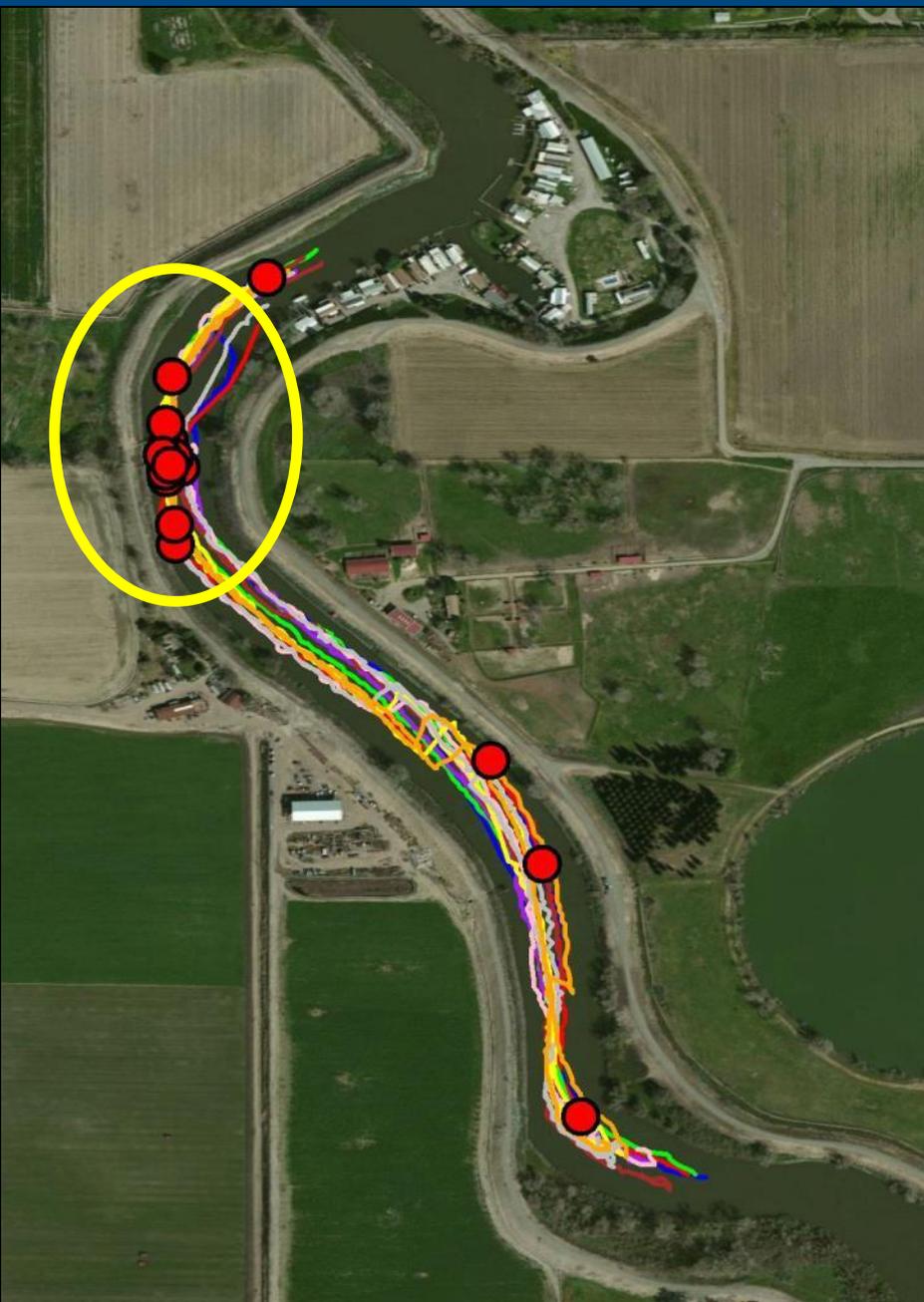




- A3 Addition 3
- R3 Removal 3
- C3 Control 3
- A2 Addition 2
- R2 Removal 2
- 1 km  C2 Control 2
- A1 Addition 1
- R1 Removal 1 - HOR
- C1 Control 1

Objective 4 - Determine how predation on salmon smolts influenced by environment

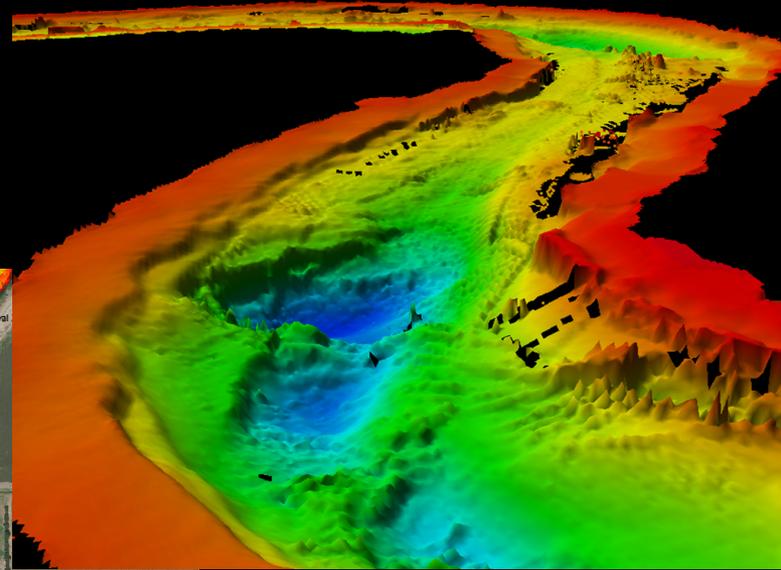
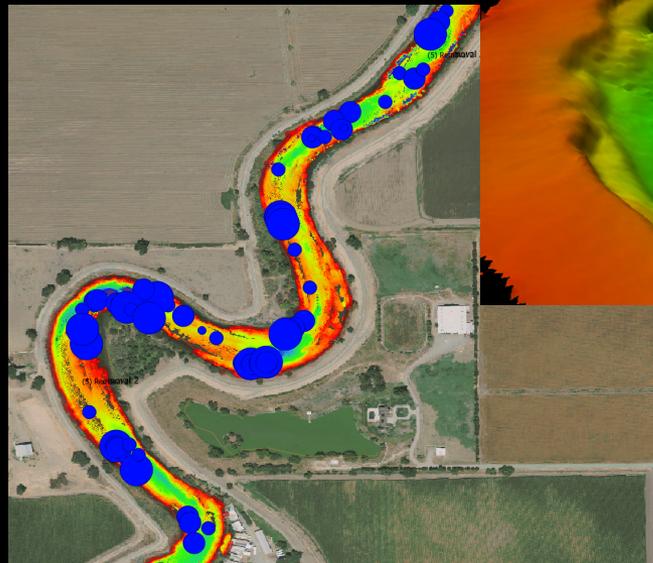




Objective 4 - Determine how predation on salmon smolts influenced by environment

- Habitat features- sinuosity, depth, channel location
- Temperature/ Dissolved oxygen
- Water velocity/direction (tide, pumping and flow)
- Prey transit time (as influenced by water velocity above)
- Turbidity/Light intensity
- Predator density
- Diel period

Model selection

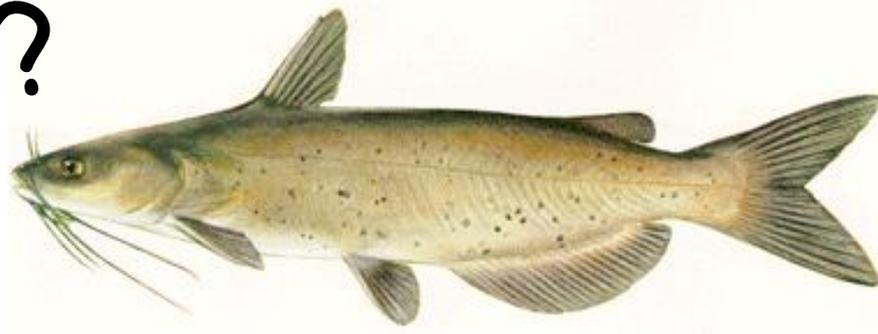


What if its not ^{just} predation?

2015 →

Temperature (°C)

???



Date 2014



Physiology ?

Physical Structure

Water Quality

Predator Density

Smolt Stress

Temp ?

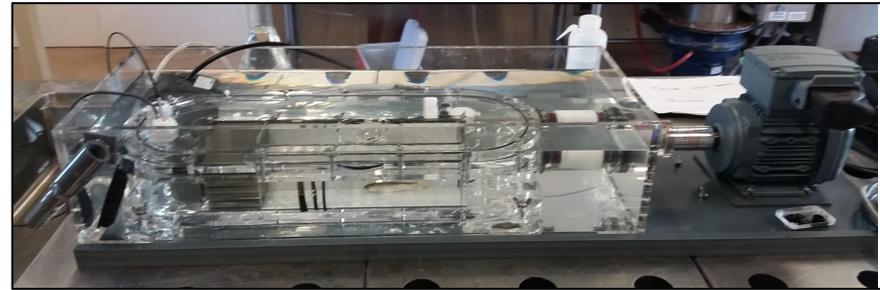
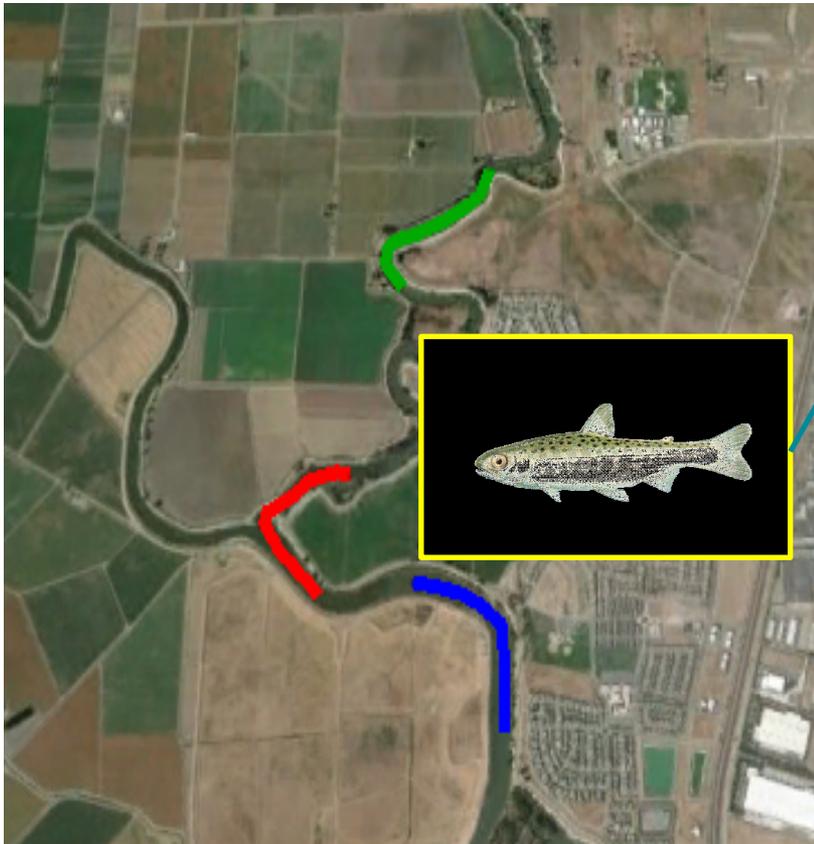
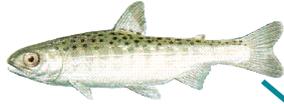
Tag effect ?

Mortality due to
predation



Comparative Survival/Swim Capacity

Hatchery



Challenges, Successes and Opportunities

Challenges

- Project stability challenged by soft \$ and 80% contractor load
- Balancing Fish + Agriculture + Human safety
- Refocus metric of success from 'smolts out' to 'adults back'

Successes

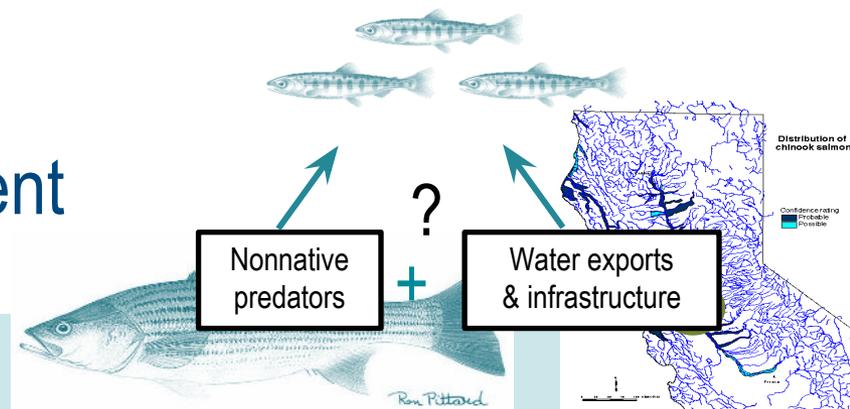
Filling data gaps

Ambiguity shrinking

Stake holders accepting responsibility.....

Solutions?

- Focused adaptive management



Fish die... get over it....

We can r

Options?

A.) a cha

B.) an im
growth p

C.) high (they

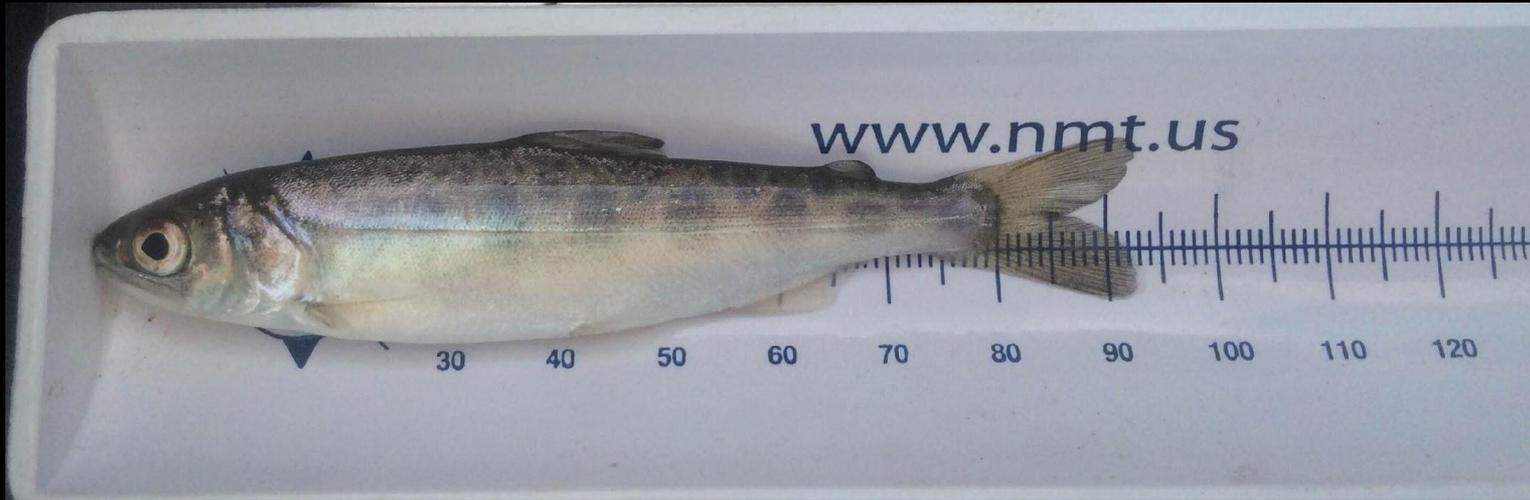
(hint- on



..

risk AND high

Creative opportunities...



River or the Rice Ditch?





TNC and Drew Kelly



TNC

Funded by



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