



# Salmonid Predation Evaluation

## Sacramento and San Joaquin River Delta

Workshop on the State of the Science on  
Fish Predation on Salmonids in the Bay-Delta

Presented by:

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# Outline

- Introduction/Researchers
- Acoustic Telemetry
  - Salmonid Smolts
  - Predatory Fish
- Acoustic Imaging
  - Mobile Hydroacoustic Surveys
  - Fixed Hydroacoustic Monitoring
- Predatory Fish Sampling
- Clifton Court Forebay Predation Studies
- Future Research Directions



# Introduction

## Recent and On-going Research

- Clifton Court Forebay Studies
- Head of Old River BAFF
- Head of Old River Rock Barrier
- Head of Old River Synthesis
- Temporary Agricultural Barriers
- Georgiana Slough 2011, 2012, and 2014

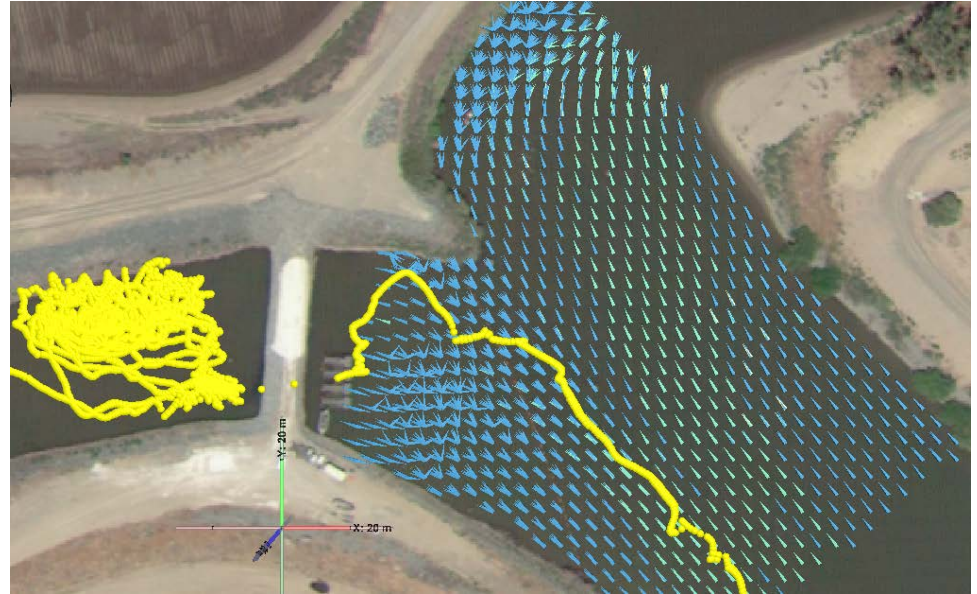
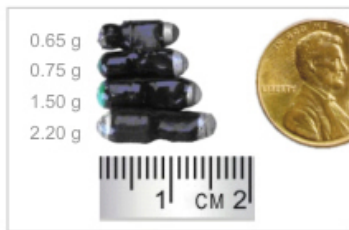
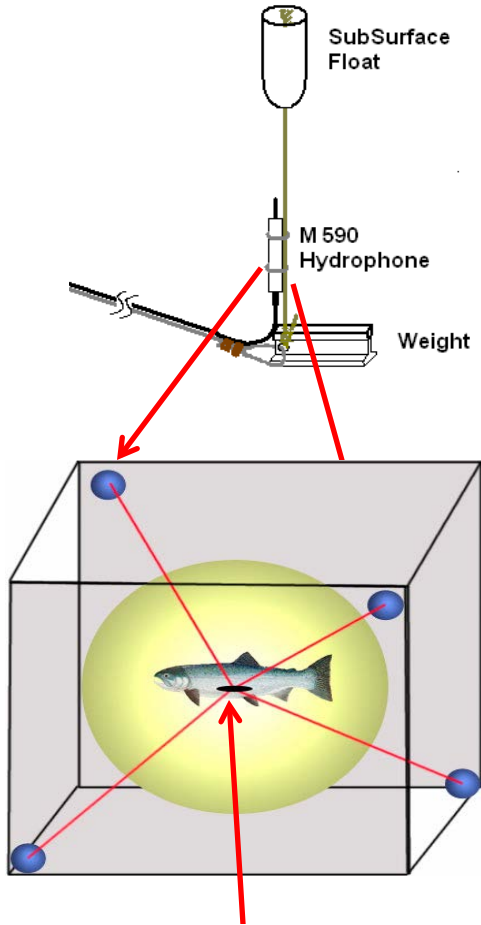


# The Researchers/Lead Investigators

- Dr. Romine & Dr. Perry, USGS
- Dr. Horn, Reclamation
- Dr. UK Phantom, THA
- Dr. Greenwood, ICF
- Clark, Cane, Wunderlich & Yip, DWR
- Johnston & Kumagai, HTI
- Pagliughi & Fitzner, AECOM
- Kennedy, Fisheries Foundation



# Acoustic Telemetry





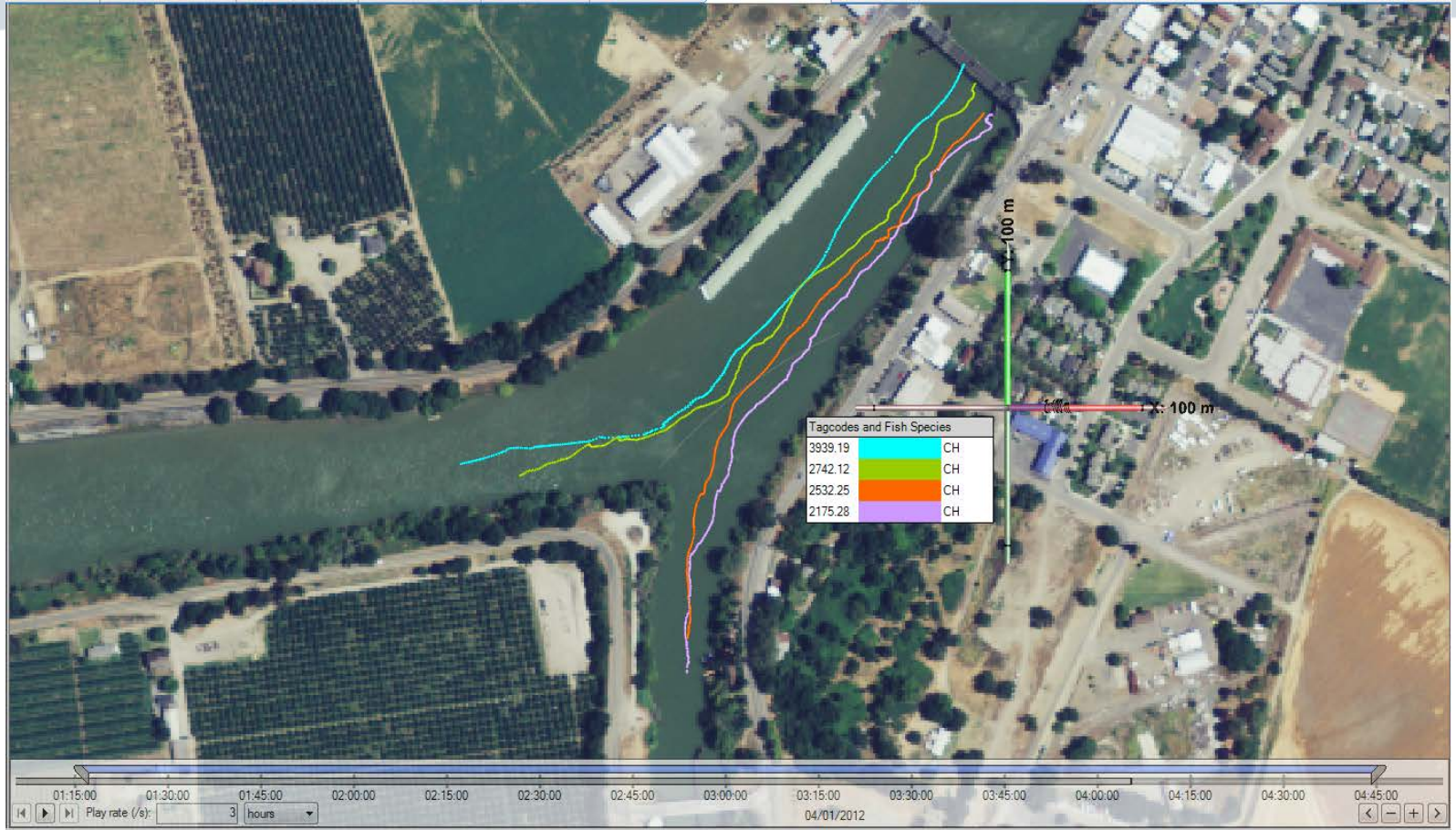
# Detecting Predation Events Using Acoustic Telemetry

- Track Salmonid Smolts
- Track Predatory Fish
- Qualitative Predation Determination- Visually compare 2-D track characteristics to determine if a salmonid has been predated on
- Quantitative Predation Determination- Mathematical and probabilistic determination of predation





# 2-D Salmonid Smolt Tracking

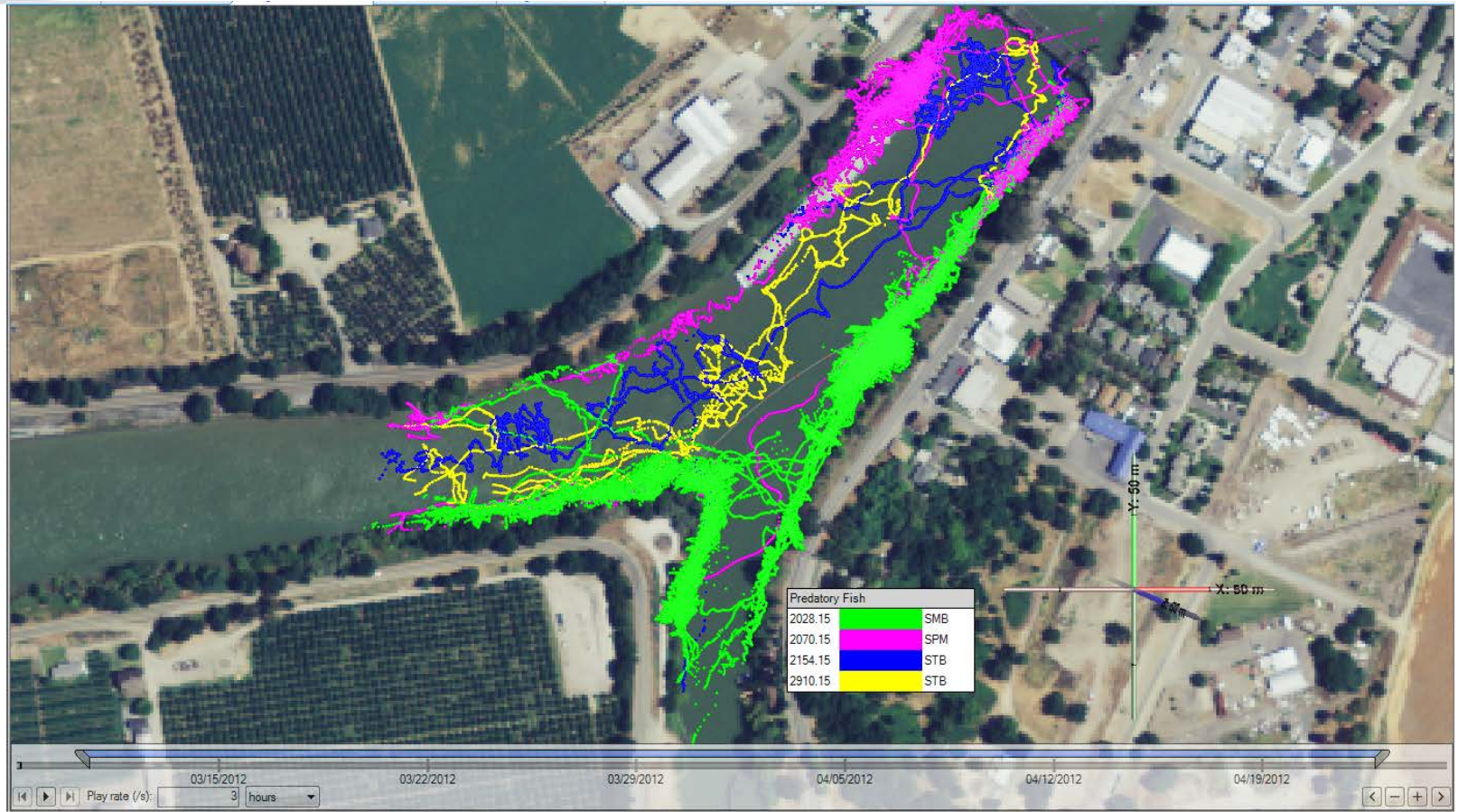


**Tracks of acoustically tagged Chinook salmon smolts, Georgiana Slough, Spring, 2012.**

Chinook tags (tag codes 3939.19 and 2742.12, turquoise and lime spheres, respectively) travel down the Sacramento River while (tag codes 2532.25 and 2175.28, orange and lavender spheres, respectively) move down Georgiana Slough.



# 2-D Predatory Fish Tracking



**Tracks of acoustically tagged predatory fish, Georgiana Slough, Spring, 2012.**

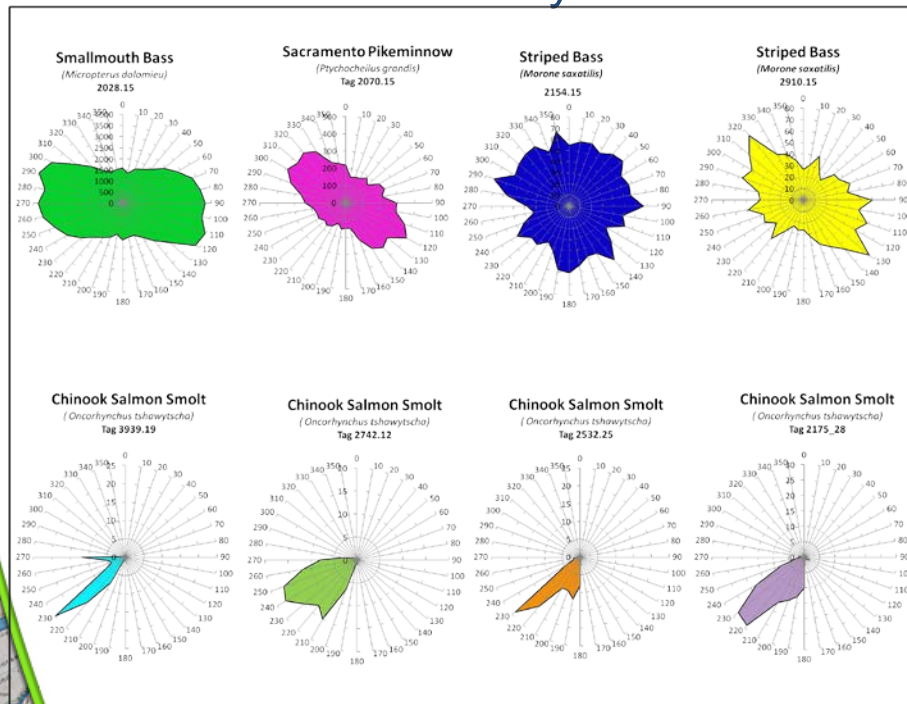
Smallmouth bass (tag code 2028.15, green spheres) and Sacramento pikeminnow (tag code 2070.15, pink spheres) were margin oriented while striped bass (tag codes 2154.15 and 2910.15, blue and yellow spheres) associated with the open water.



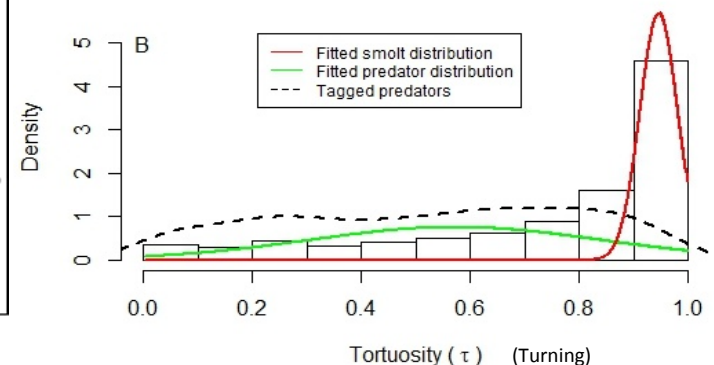
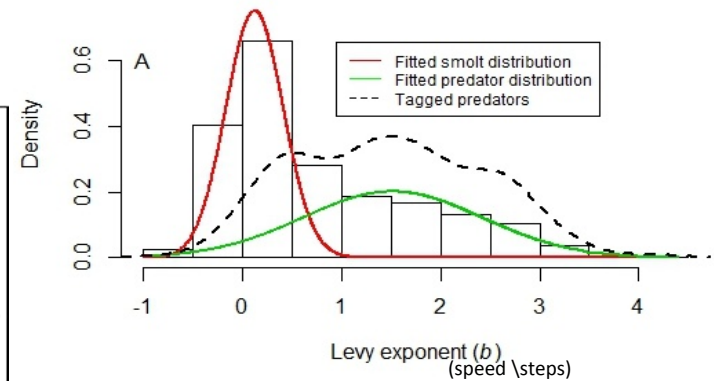


# Obtaining Predation Event information

- Qualitative Analysis
  - Expert evaluation of swimming speed, direction, location and movement rates
- Quantitative Analysis



Radar Plots



Mixture Model



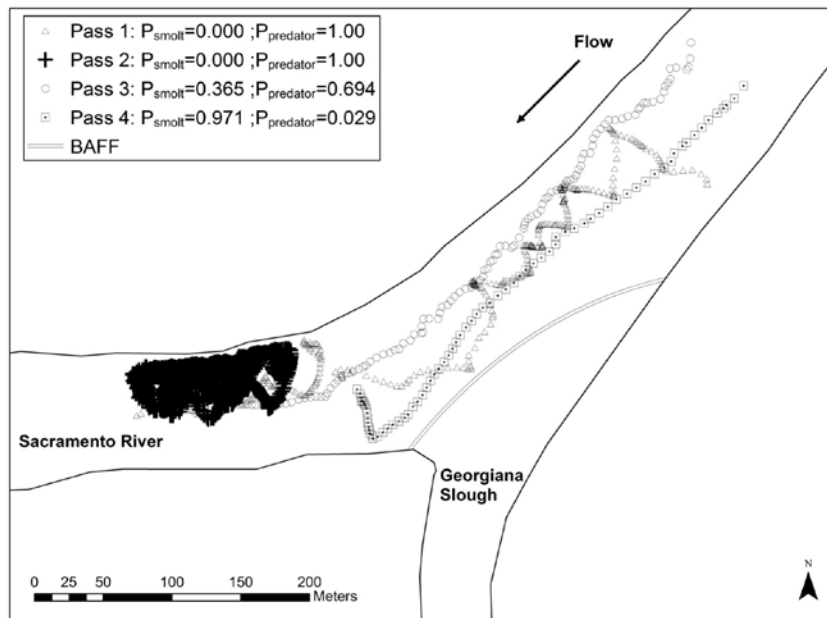
# Comparisons between Qualitative and Quantitative Analyses

- Both Qualitative and Quantitative Analyses yielded similar results in smolt predation estimates at GSNPB 2012.
  - 24.6% predation vs. 23.9% predation
- Not all predation determinations were the same between the analyses
  - 75% of the smolts that were classified as predated on were the same between analyses
- Quantitative Analysis was highly successful at correctly identifying tagged predatory fish as predators
  - 100% of the tagged spotted and smallmouth bass
  - 80% of the tagged striped bass.

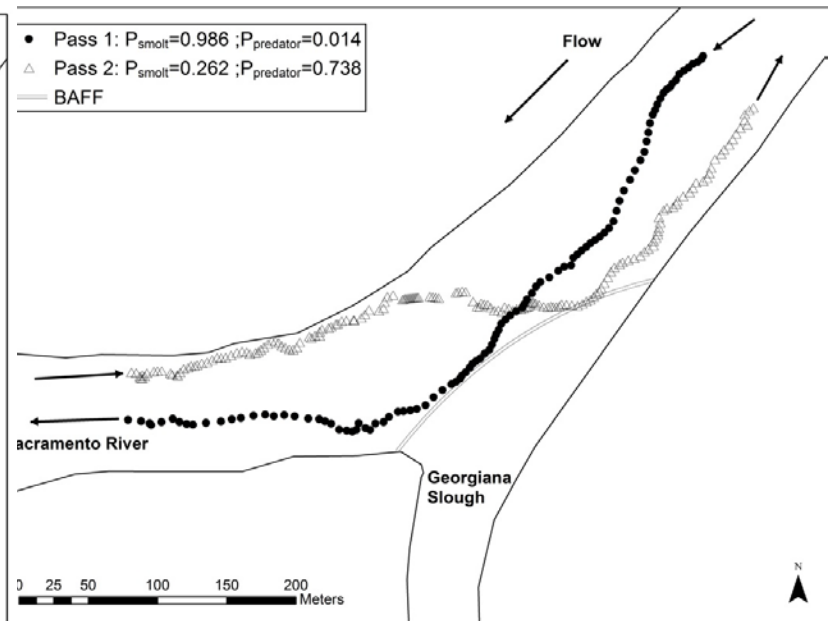


# Quantitative Mixture Model

- Can show probability of being in a predator or remaining a smolt
- Shows that predatory fish can exhibit smolt-like behavior



Tagged striped bass that exhibits smolt-like behavior on 4<sup>th</sup> pass through the study area



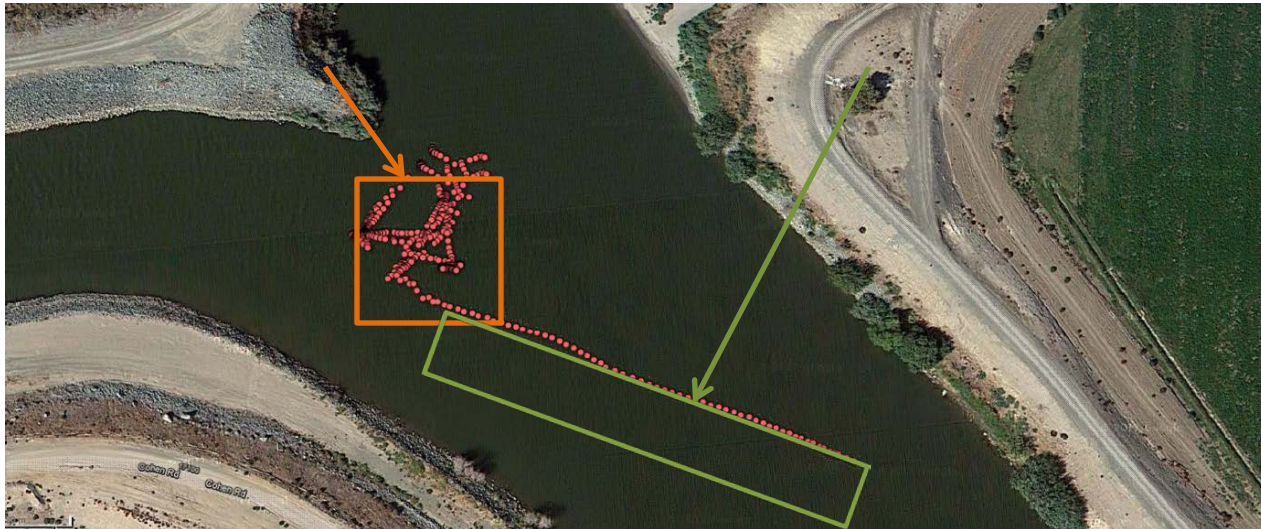
Tagged Chinook salmon smolt that returns to the study area and appears to have been consumed by a predator



# Confirmed Smolts

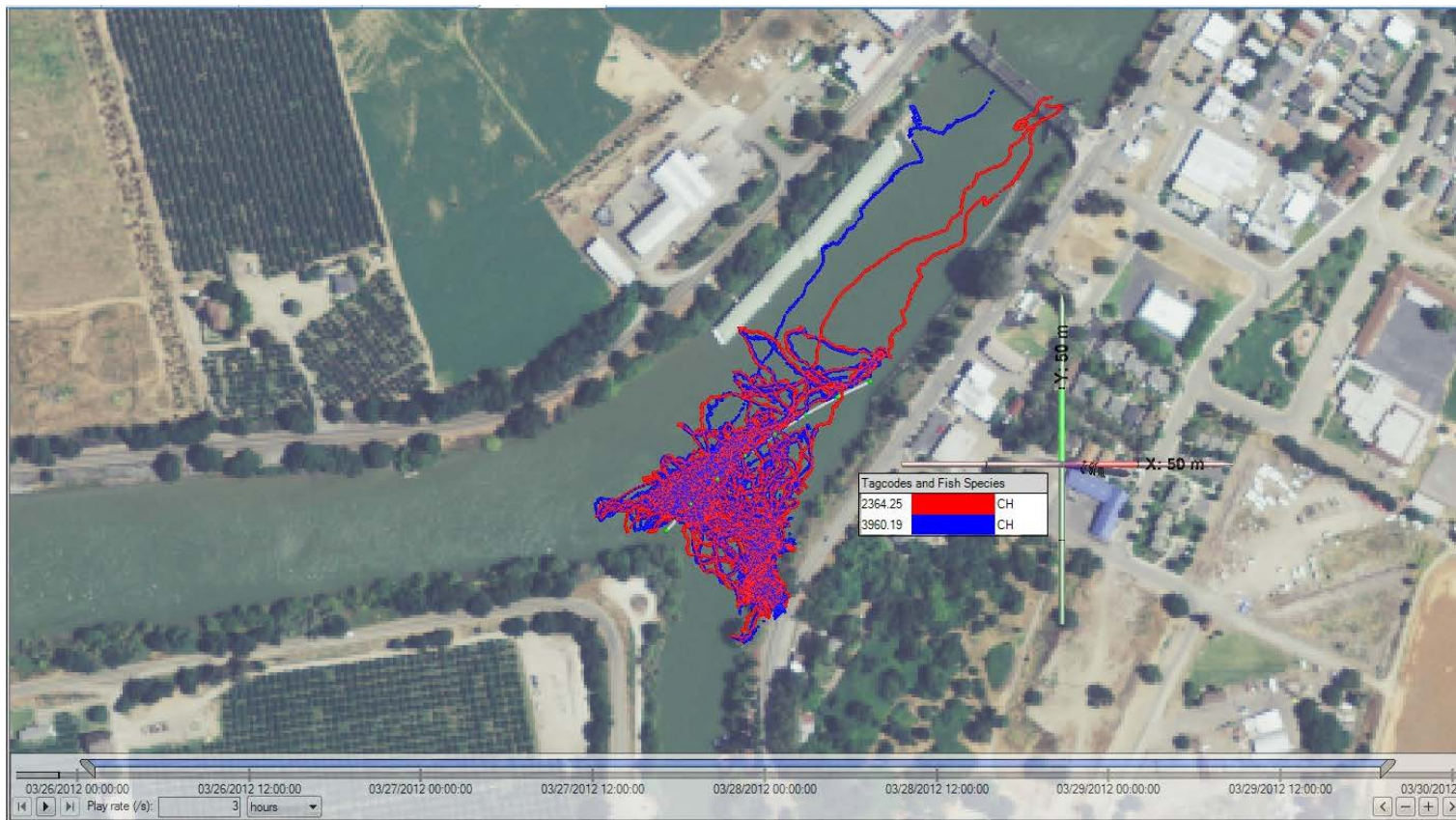
- By confirming that tagged smolt tracks are still smolts (recovery at salvage facility), DWR has been able to compare these with tagged predatory fish tracks to discern similarities and differences.
- Confirmed smolts from 2011 6-Year Study Steelhead and a single Chinook salmon smolt from Georgiana Slough NPB 2012.
- Data suggests that larger steelhead can display both smolt-like and predator-like behaviors

11" Confirmed Steelhead Track  
with predator-like movements and smolt-like movements





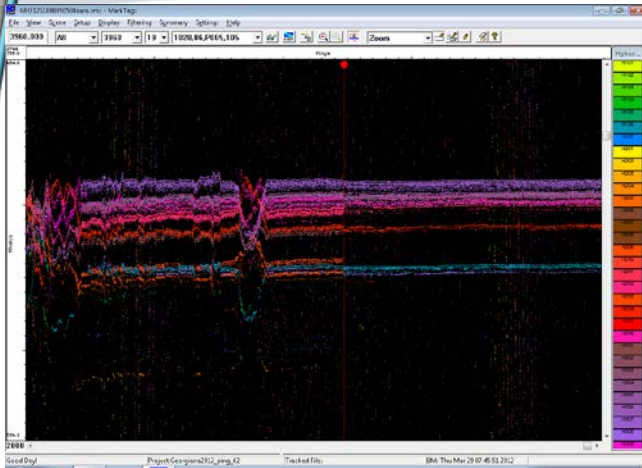
# Other Ways to Determine Predation Events



**Two simultaneous tags.** Two Chinook tags (2364.25, red spheres, and 3690.19, blue spheres) enter array individually from upstream. Tags begin swimming simultaneously at 3:19:40 on March 26 continuing for three plus days. Tag 3960.19 defecated at 7:45:51 on March 29. Tag 2364.25 leaves array back upstream.

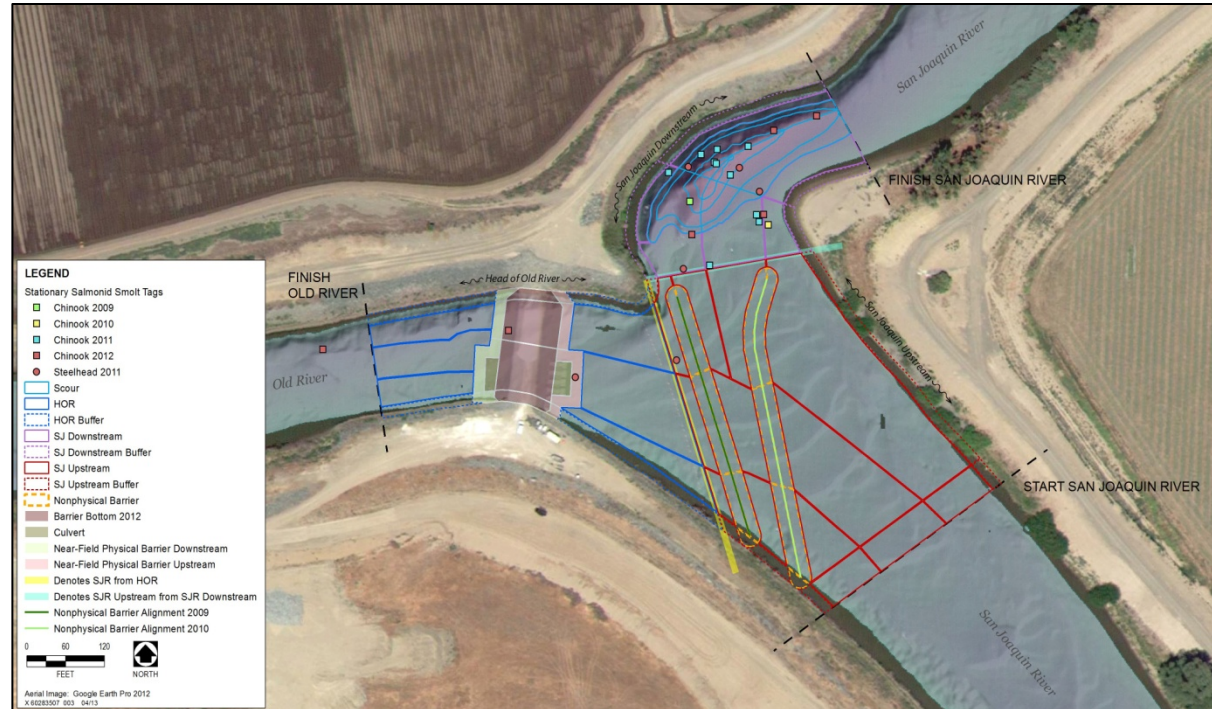


# Tag Defecation



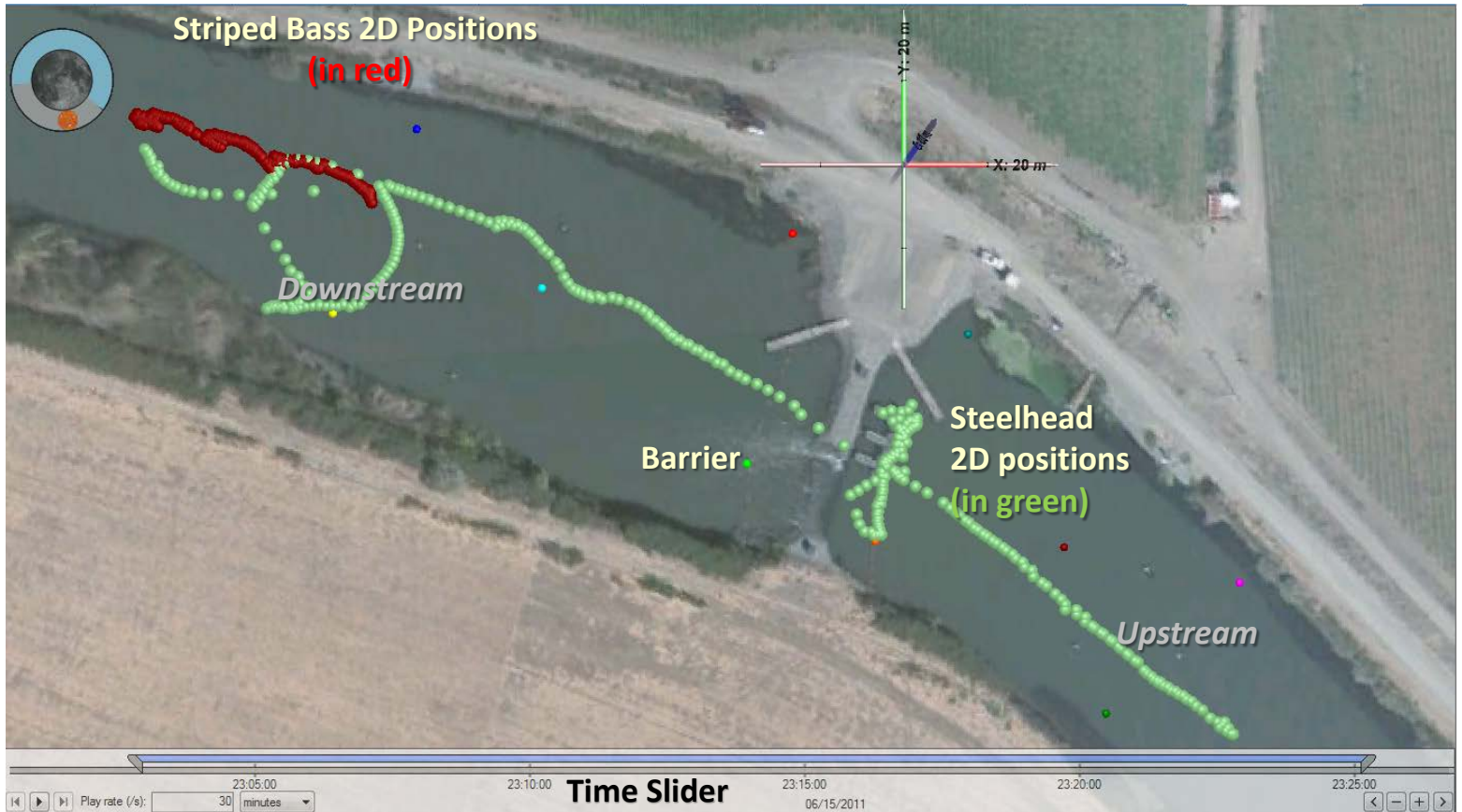
**Tag defecated within hydrophone array.** Raw detection data from Tag 3690.19, originally implanted into a Chinook smolt, spans 5 hours from 05:00 to 10:00. The tag suddenly stops all movement within the hydrophone array at Georgiana Slough on March 29, 7:45:51. Each colored line represents data from one individual hydrophone.

**Tags defecated within hydrophone array at HOR.** Locations of defecated tags provides information on where predatory fish reside.





# Predator Avoidance

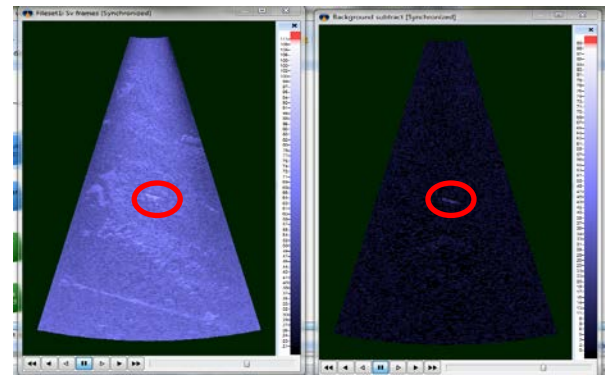
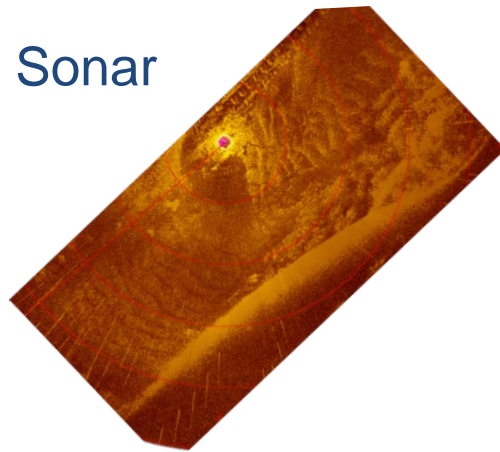
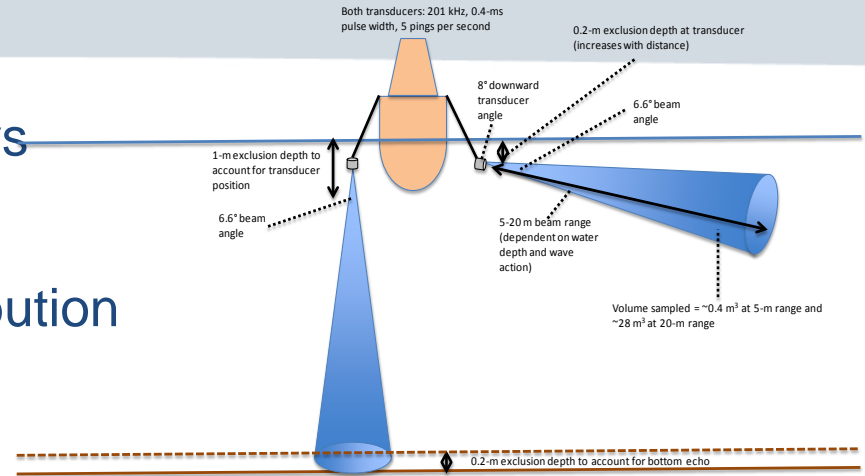


**Predator Avoidance.** As steelhead tag passes over striped bass, steelhead tag appears to avoid bass looping counter-clockwise. Striped bass also moves downstream.



# Acoustic Imaging

- Mobile Hydroacoustic Surveys
  - Split-beam system
  - provide information distribution and fluxes in fish density
- Fixed Hydroacoustic Monitoring
  - Didson
  - Scanning Sonar

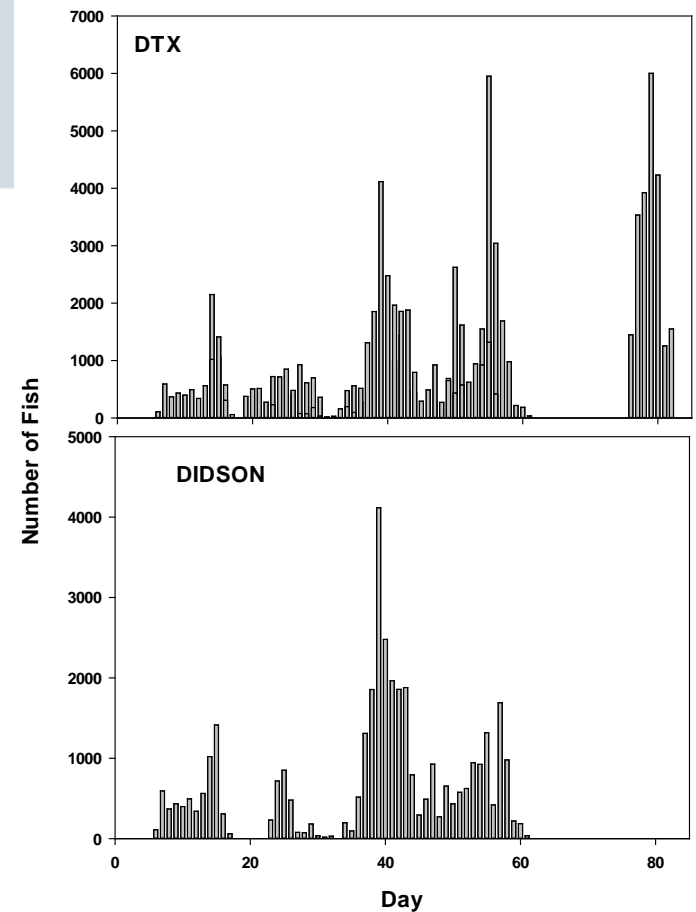






# Mobile Hydroacoustics

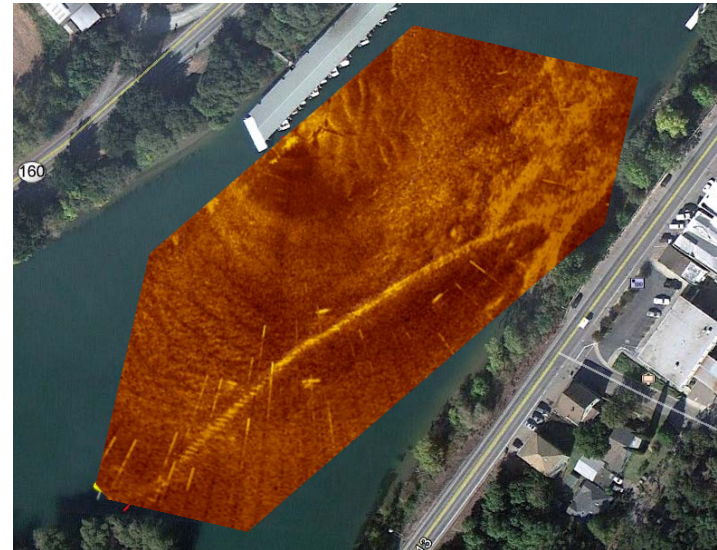
- Can provide a systematic approach for determining fish abundance and size
- Ability to sample large areas of habitat and provide information on large numbers of targets.
- Provides detailed fish location data for areas and can show how fish densities change over time
- Cannot determine fish species





# Fixed Hydroacoustic Monitoring

- DIDSON
  - Species identification may be possible
  - Provides high quality imagery in turbid water
  - Processing is difficult and time consuming
- Scanning Sonar
  - Can give detailed views of habitat
  - Gives Bathymetry





# Predatory Fish Sampling

- Many Techniques
  - Hook and Line Sampling
  - Electrofishing
  - Fyke Trapping
  - Seine Netting

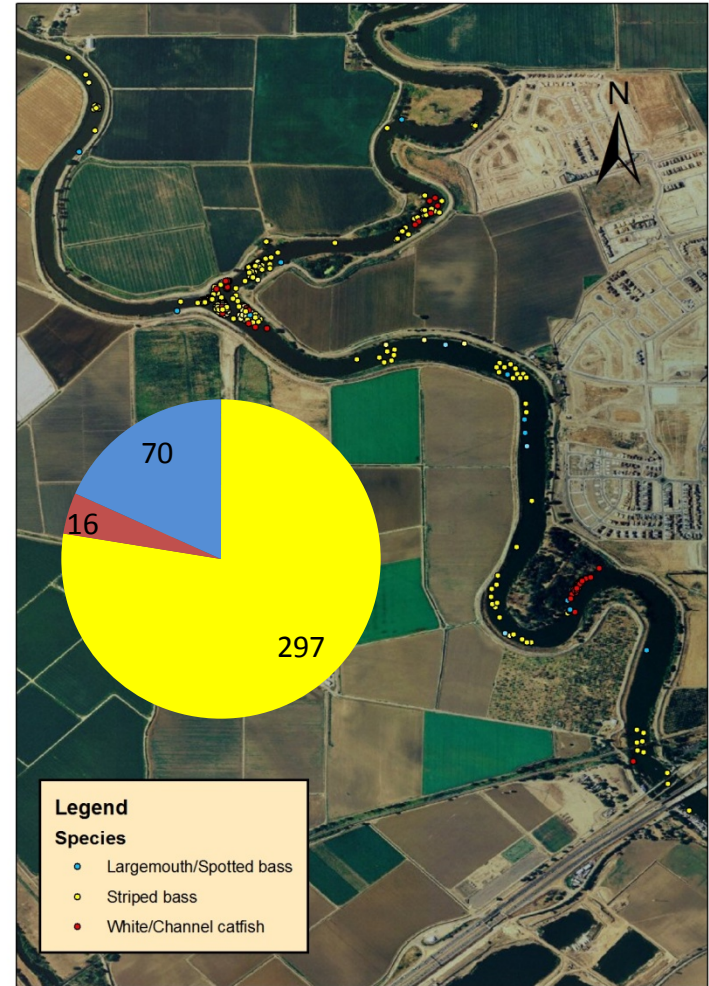


- DWR has mainly used hook and line sampling in the past due to regulatory concerns



# Hook and Line Sampling

- Can be used to show predator hotspots
- Species composition, distribution and habitat utilization can be determined
- There is a potential to extrapolate with hydroacoustic data
- May favor capture of certain predatory fish species due to fishing techniques used

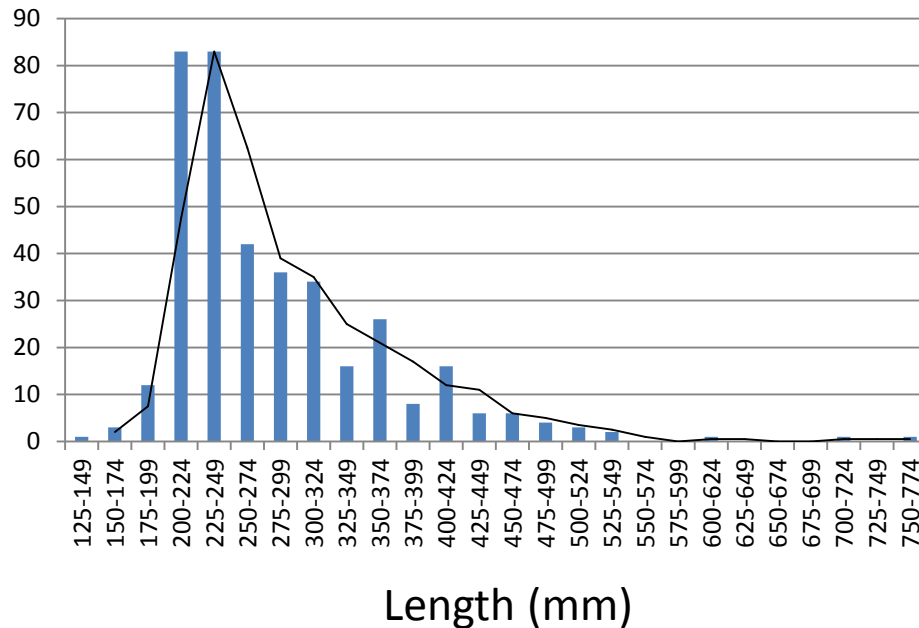




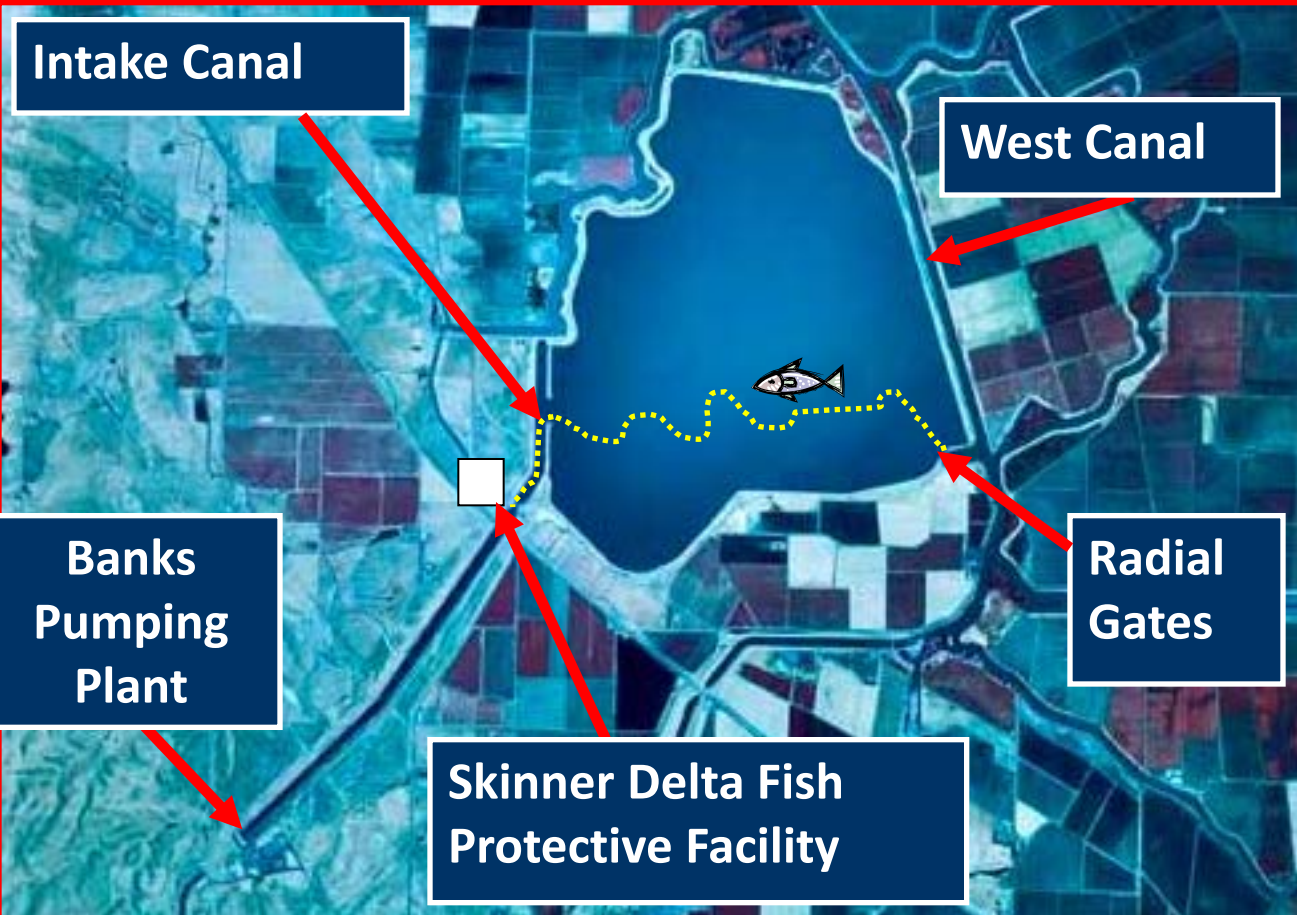
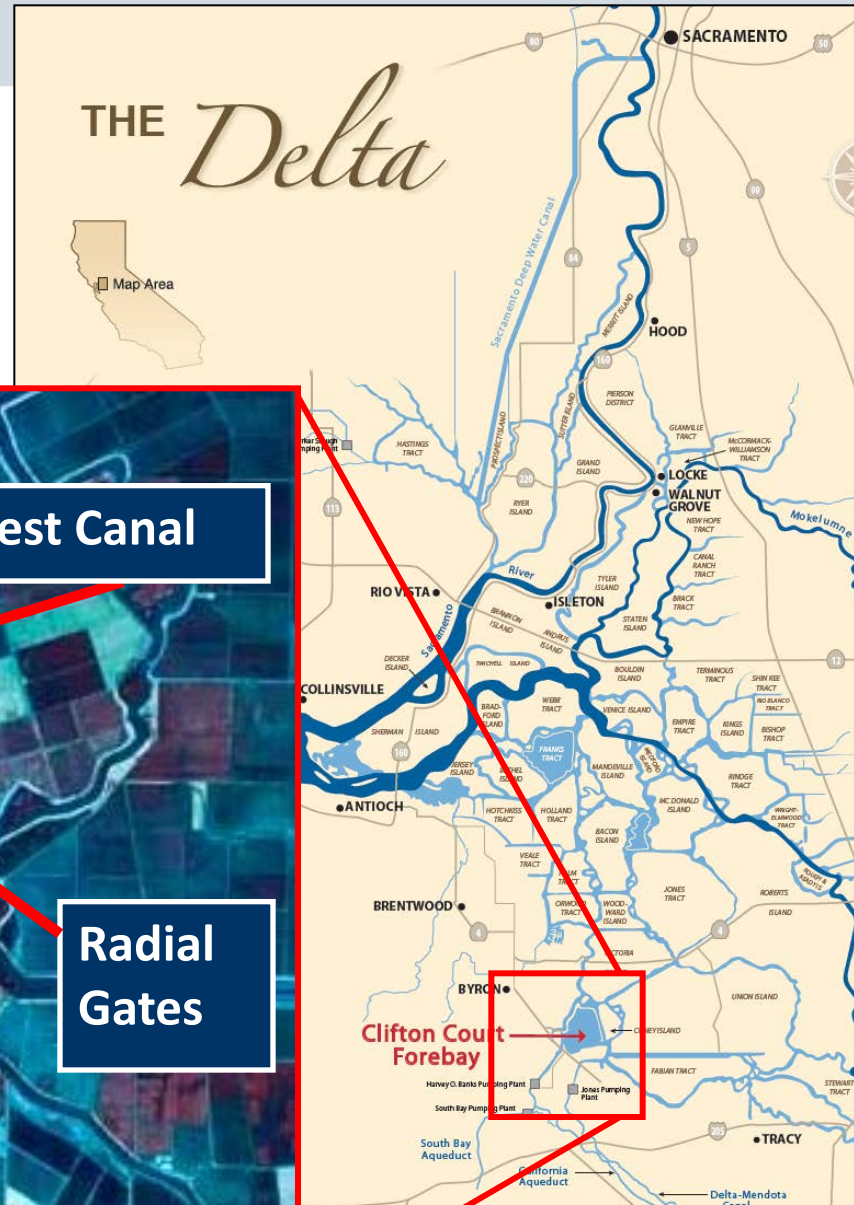
# 2013 Predator Sampling Effort

- 42 days of effort
- 383 predatory fish were captured
- 30 predators were acoustically tagged
- 82 predators were Floy tagged

# of  
Individuals



# Clifton Court Forebay Predation Studies





# Pre-screen Loss Studies

<b>Year/Month</b>	<b>Species</b>	<b>Pre-Screen Loss</b>	<b>Fork Length (mm)</b>
1976/OCT	Salmon	97%	114
1978/OCT	Salmon	88%	87
1984/APR	Salmon	63%	79
1984/JUL	Striped Bass	94%	52
1985/APR	Salmon	75%	44
1986/AUG	Striped Bass	70%	55
1992/MAY	Salmon	99%	77
1992/DEC	Salmon	78%	121
1993/APR	Salmon	95%	66
1993/NOV	Salmon	99%	117
2007/JAN-APR	Steelhead	82 ±3%	217



# Fishing Facility Project

- DWR proposed fishing pier installation in CCF to provide improved public fishing access to a known predatory fish hotspot
- Benefits of the pier could include a decrease in the loss rate of salmonids
- Ancillary benefits of the pier may include increased survival in CCF of other fishes such as delta smelt







# Current CCF Predation Study Elements

- Salmonid Mark Recapture
- Predatory Fish Mark Recapture
- Creel Surveys
- Avian Surveys
- Genetic Gut Content Analysis
- Bioenergetics Modeling



# Future Research Directions

- Predator Manipulation Study
  - Remove predatory fish from a study reach
  - Determine if smolt survival can be improved
  - Understand recolonization of manipulated study reach by predatory fish
  - Determine where predation is occurring within the study area.
- Clifton Court Forebay Fishing Pier
  - DWR proposed fishing pier installation in CCF to provide improved public fishing access to a known predatory fish hotspot
  - Benefits of the pier could include a decrease in the loss rate of salmonids and other listed fish species
- Continued Support of Survival Studies and Build Statistics of Known Predatory Fish Behavior