Do Barriers for Deterring Juvenile Salmonids Away from High-risk Migration Pathways Affect Survival at Important Channel Junctions in the Sacramento-San Joaquin Delta, California?

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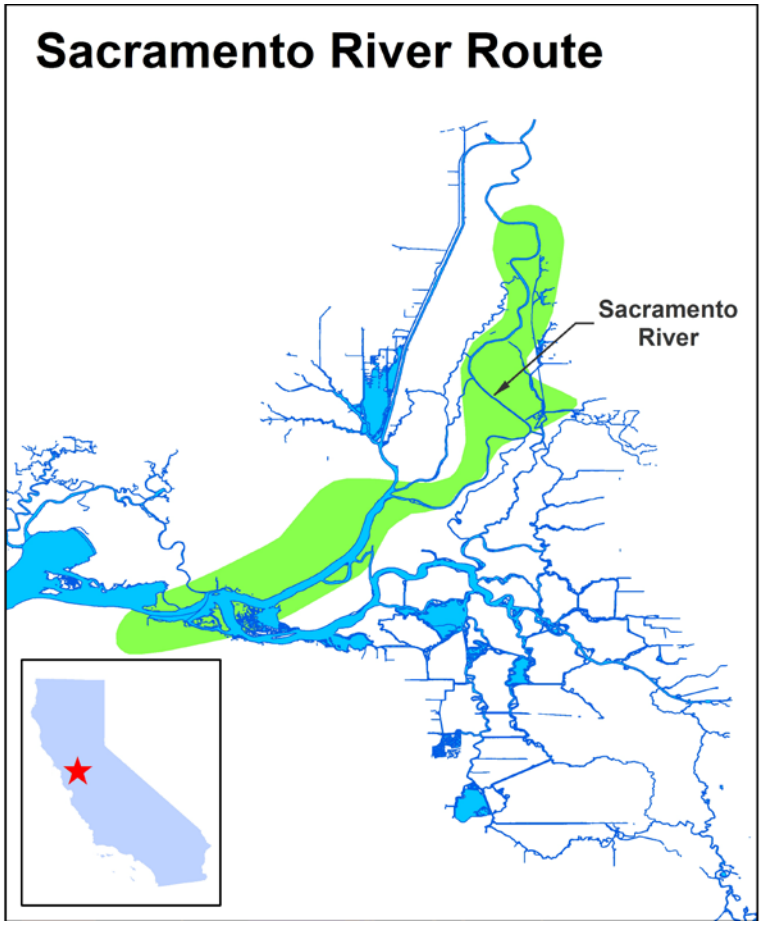
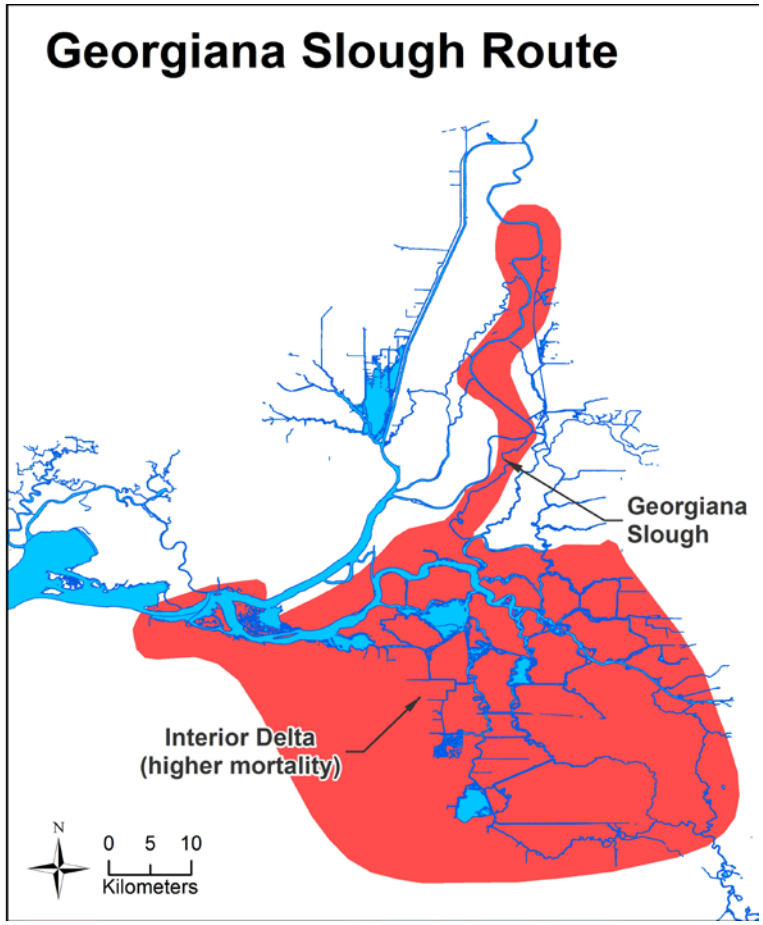
- Joe Smith (Univ. of Washington) – session organization & PER results

Background

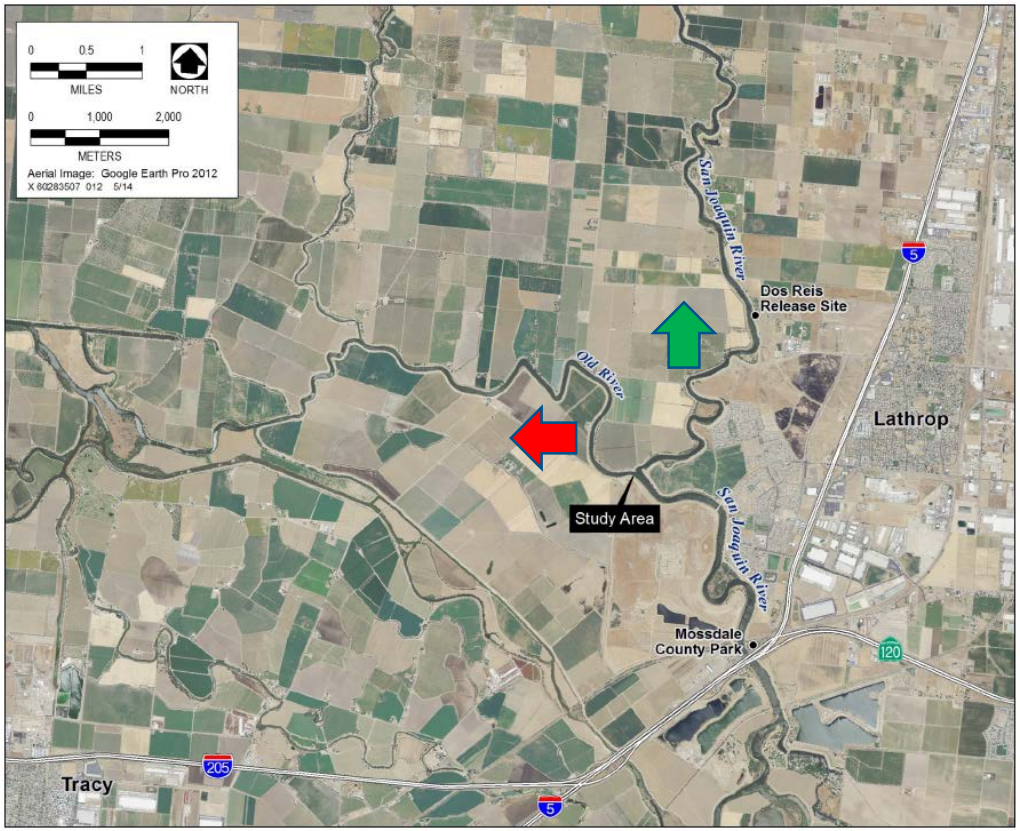
- **Different through-Delta migration routes give different survival…**





Background

- **Different migration routes give different chances of survival…**



DWR (2015) An Evaluation of Juvenile Salmonid Routing and Barrier Effectiveness, Predation, and Predatory Fishes at the Head of Old River, 2009–2012

Background

- **DWR is mandated to investigate ways of reducing interior and south Delta entry**

National Marine Fisheries Service
Southwest Region

June 4, 2009

BIOLOGICAL OPINION
and CONFERENCE OPINION

on the

LONG-TERM OPERATIONS OF THE CENTRAL VALLEY PROJECT AND STATE WATER PROJECT

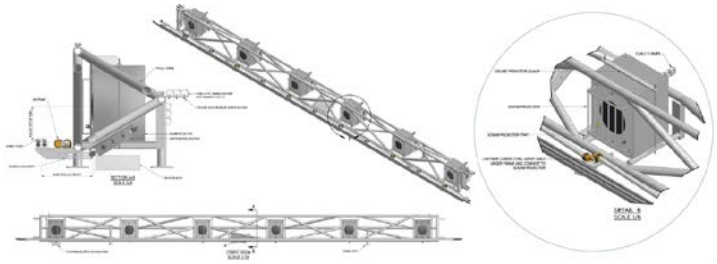
Action IV.1.3 Consider Engineering Solutions to Further Reduce Diversion of Emigrating Juvenile Salmonids to the Interior and Southern Delta, and Reduce Exposure to CVP and SWP Export Facilities

NMFS (2009)

Background

- **Various barrier types (“engineering solutions”) have been tested**
  - Rock barrier (many years, including 2012): Head of Old River

  - Bioacoustic Fish Fence (BAFF)
    - Head of Old River (2009 and 2010)
    - Georgiana Slough (2011 and 2012)



  - Floating Fish Guidance Structure (FFGS)
    - Georgiana Slough (2014)

Background

- **Concern: Barriers could affect predation risk**
  - In-water structure (predator ambush habitat)
  - Disorient/startle/delay juvenile salmonids
- **Study Objective**
  - Assess whether the ***probability of predation*** is related to:
    - **Barrier operations (barrier on vs. off; rock barrier)**
    - Flow: more flow ➔ faster transit time ➔ lower predation
    - Temperature: lower temperature ➔ lower predator metabolism ➔ lower predation
    - Turbidity: higher turbidity ➔ lower visibility ➔ lower predation
    - Light level: less light ➔ lower visibility ➔ lower predation
    - Small-prey density (“predator swamping”): more alternative prey➔ lower visibility ➔ lower predation
    - [Predator density: less predators ➔ lower predation]

Methods

- **Juvenile Chinook Salmon fitted with acoustic tags, released upstream**
- **BAFF and FFGS switched between on and off every ~25 hours**
- **Hydrophone array at each junction**
  - Predation: Change in 2D track from straight, “smolt-like” to looping, “predator-like”

- **Statistical analysis**
  - Generalized linear modeling (model-averaging, information-theoretic approach: glmulti package in R)
  - Head of Old River: Probability of predation ~ BAFF on/BAFF off/Rock + other variables
  - Georgiana Slough: Probability of predation ~ FFGS on/off + other variables

Results: Environmental Conditions (Head of Old River)

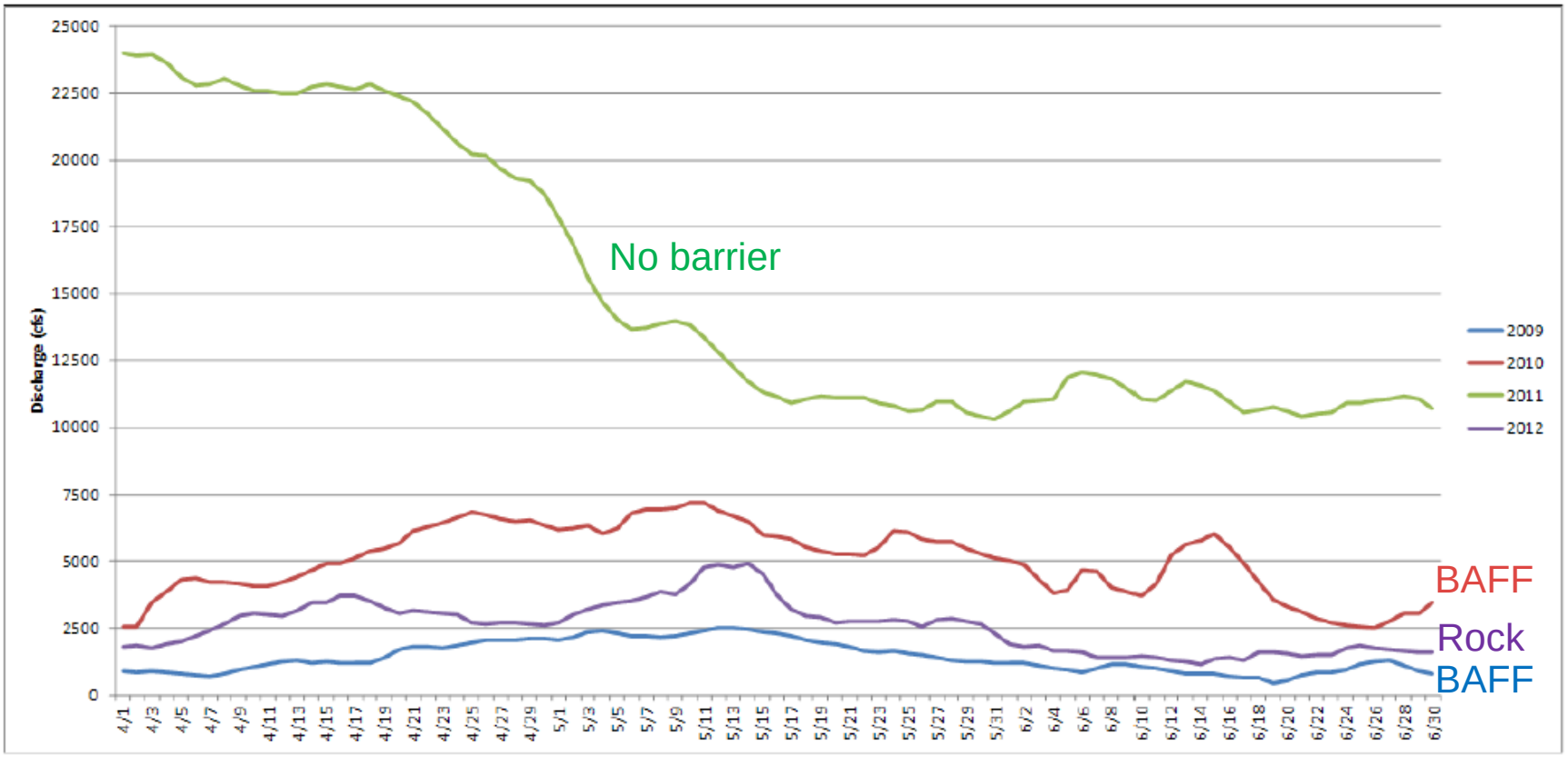


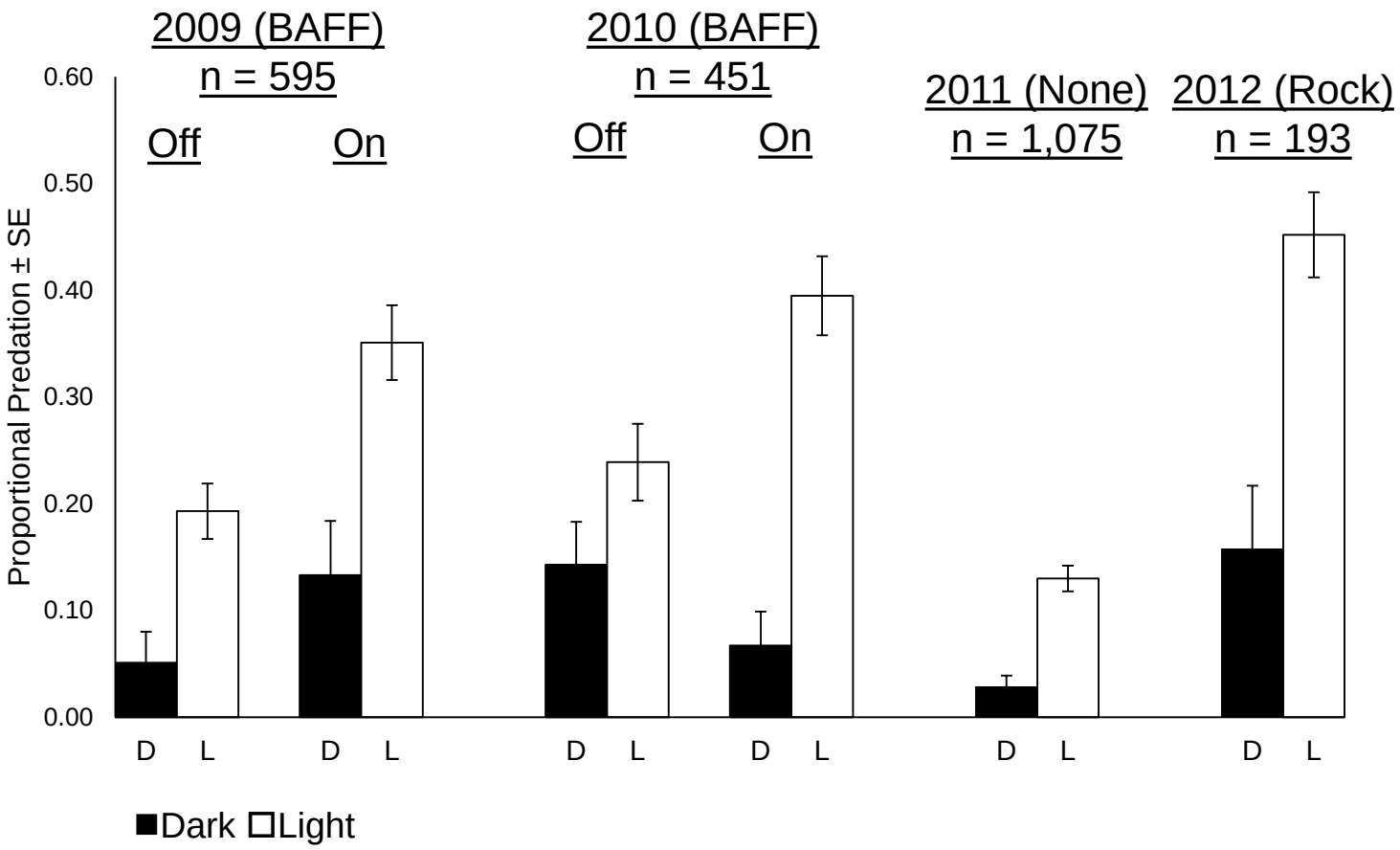
Figure ES-1 **Mean Daily River Discharge (cubic feet per second) of the San Joaquin River at Mossdale (MSD), during the study period - April 1 to June 30, 2009–2012**

DWR (2015) An Evaluation of Juvenile Salmonid Routing and Barrier Effectiveness, Predation, and Predatory Fishes at the Head of Old River, 2009–2012

ICF

Results: Head of Old River

- **Predation relatively high with BAFF on and rock barrier; in light**



Results: Head of Old River

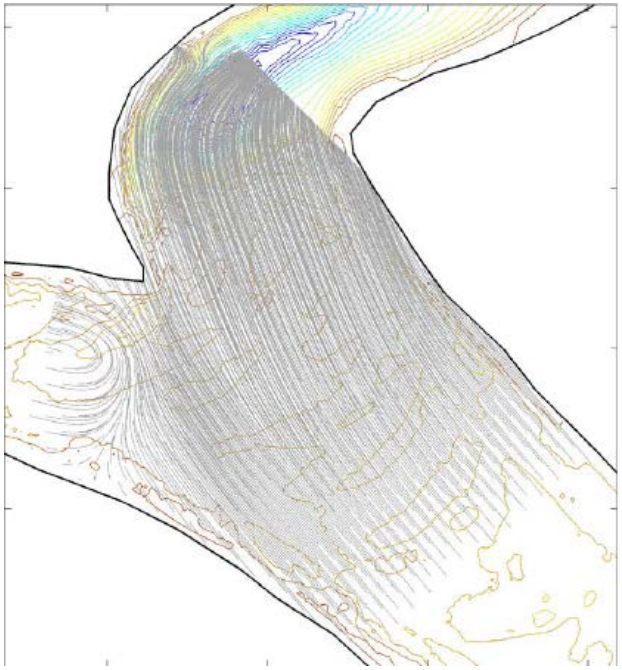
- **Statistical results (model-averaged coefficients)**

Variable	Coefficient	Lower 95%	Upper 95%	Importance	
Light	0.108	0.072	0.144	1.00	☑
BAFF On	0.605	0.285	0.924	1.00	**> BAFF Off**
Rock barrier	0.853	0.310	1.396	1.00	
Small-fish density	0.222	0.049	0.394	0.96	☒
Turbidity	0.035	-0.005	0.076	0.86	☒
Chinook size	0.015	-0.011	0.041	0.72	☒
Temperature	0.078	-0.059	0.215	0.71	☒
Flow	0.002	-0.003	0.007	0.44	☒

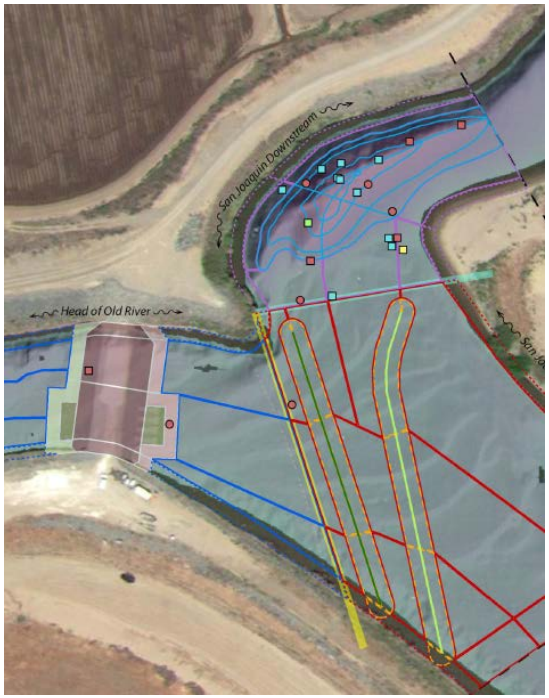
Results: Head of Old River

- **Importance of hydrodynamics and the scour hole**

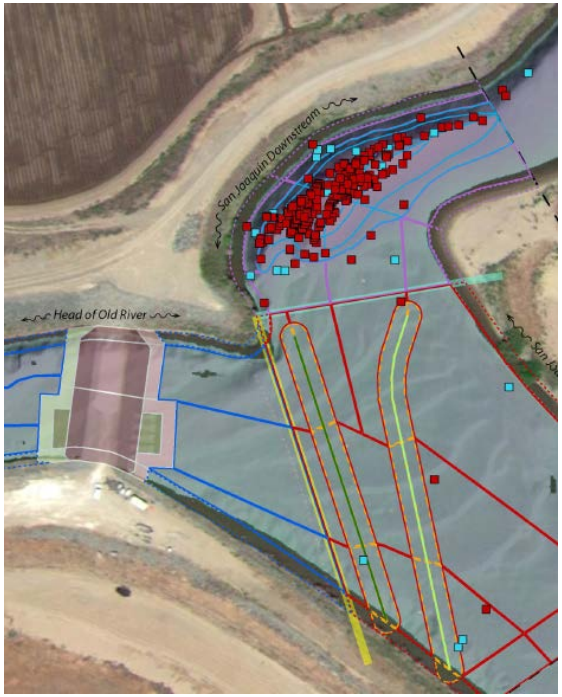
Eddies next to rock barrier



Stationary defecated tags



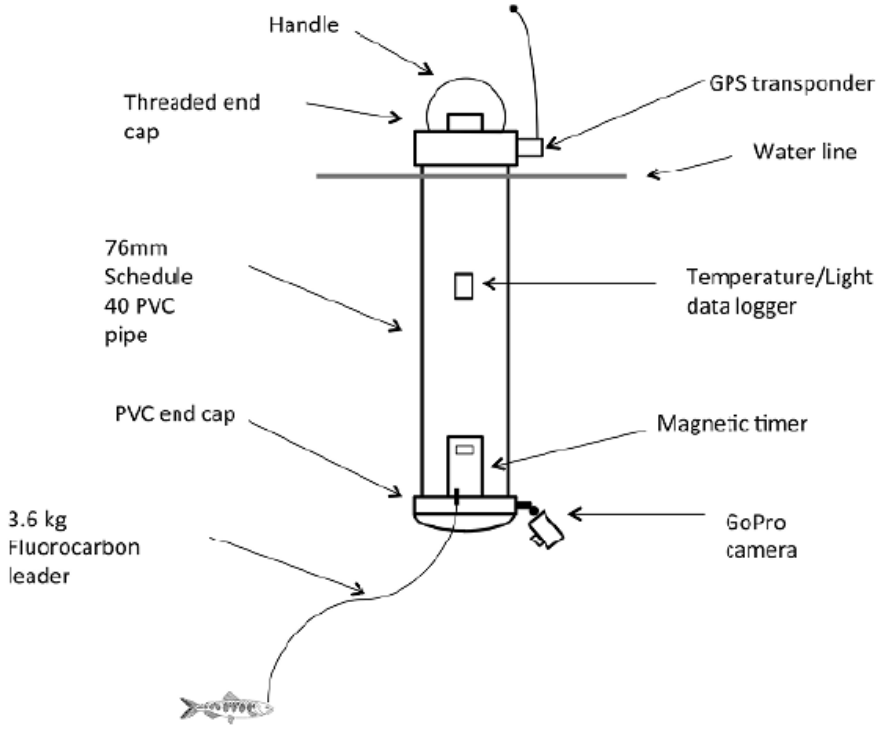
Hydroacoustics: Large (>30 cm) fish - possible predators



DWR (2015) An Evaluation of Juvenile Salmonid Routing and Barrier Effectiveness, Predation, and Predatory Fishes at the Head of Old River, 2009–2012

Perspective on Head of Old River estimates

- **215 Predation Event Recorder deployments (2014-2015) in 1-km reach including Head of Old River: 42% (0.42) predation**



Demetras et al. (2016) Fish. Bull. 114:179–185.

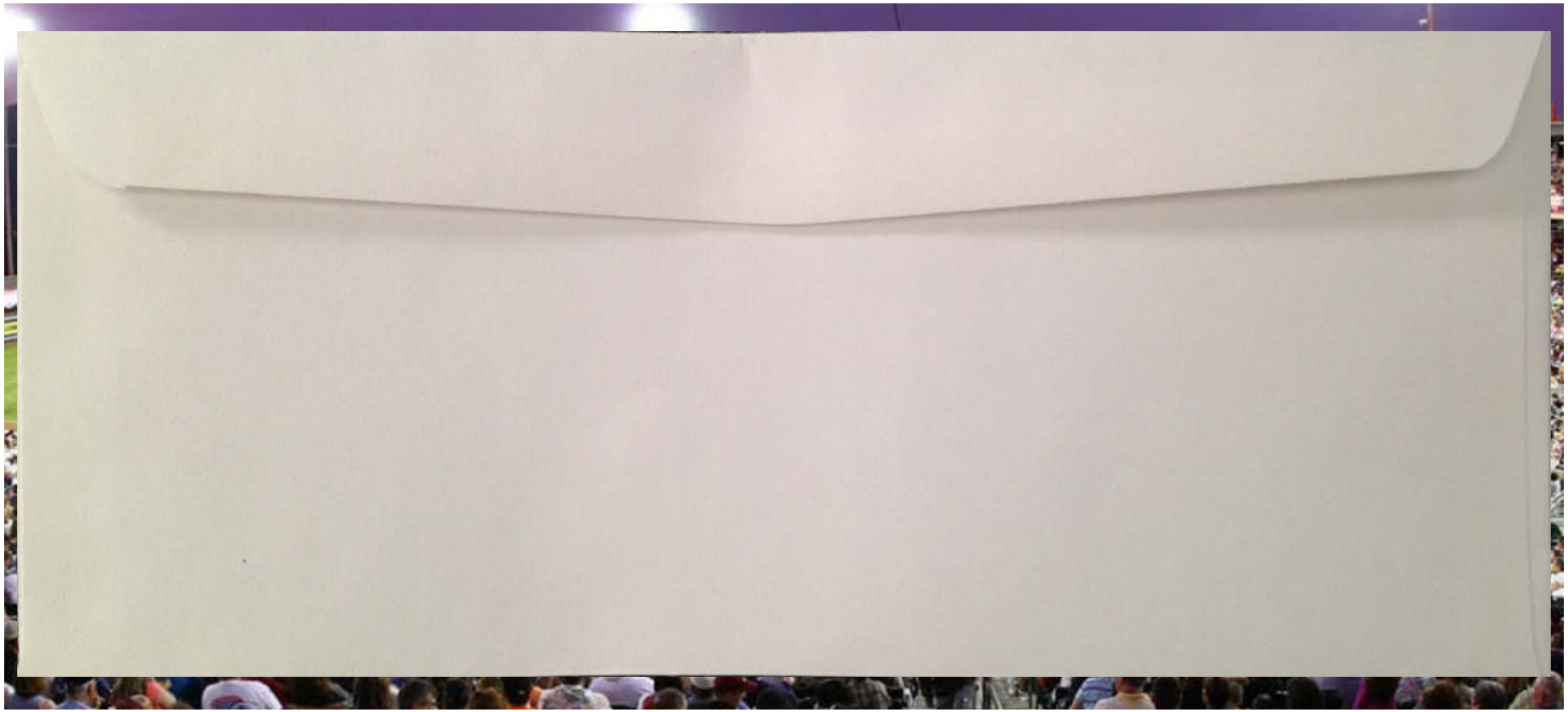
Perspective on Head of Old River estimates

- **Bioenergetics modeling: Striped Bass**

http://www.westsacliving.com/west-sac-blog/sacramento-river-cats/

Perspective on Head of Old River estimates

- **Bioenergetics modeling: Striped Bass**



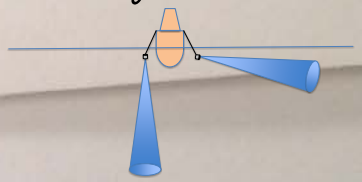
Perspective on Head of Old River estimates

- **Bioenergetics modeling: Striped Bass**

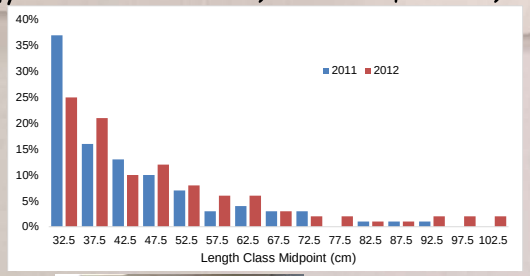
"Demand"

1. Fish > 30cm density (per 10,000 m^3): 1.7 (2011), 8.8 (2012)

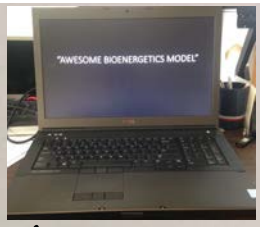
Mobile hydroacoustics

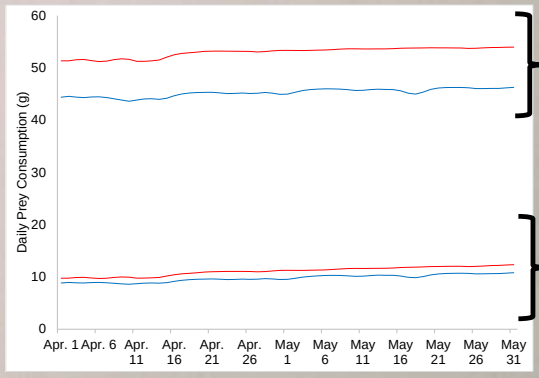


2. Size distribution



3. Bioenergetics needs





4. Daily consumption (g per day per 10,000 m^3): 36.6 (2011), 264.5 (2012)

Perspective on Head of Old River estimates

- **Bioenergetics modeling: Striped Bass**

"Supply"

Mossdale trawl

1. Chinook Salmon < 15cm biomass density (g per 10,000 m^3): 20.3 (2011), 11.6 (2012)
2. River flow: 10,973 cfs/311 m^3s^{-1} (2011); 3,337 cfs/95 m^3s^{-1} (2012)
3. Daily biomass entering Head of Old River (density × flow): 55 kg (2011), 9.6 kg (2012)

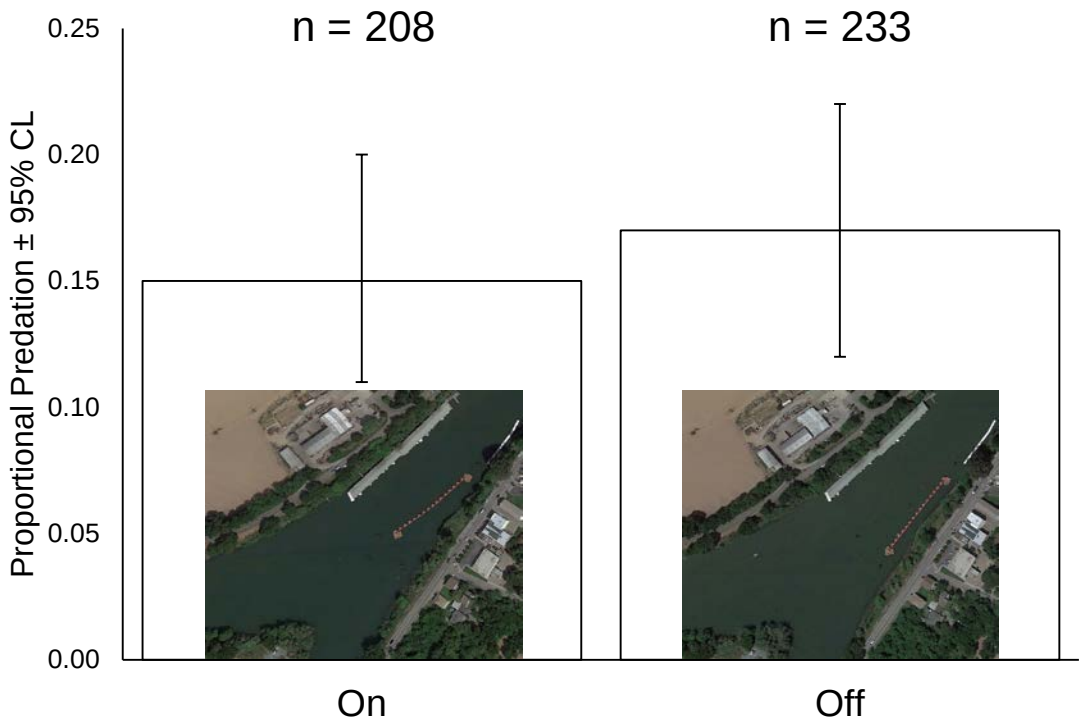
Predation Rate (Daily Demand/Daily Supply)

- Bioenergetics: 0.4% (2011), 17% (2012)
- Acoustic telemetry: 10% (2011), 39% (2012)

Mossdale trawl picture by Steve Tsao

Results: Georgiana Slough

- **FFGS operation (on vs. off) did not influence predation**
- **Turbidity was the only significant variable (more turbidity = less predation)**



DWR unpublished FFGS study; Google Earth

Conclusions and Recommendations

- **Evidence for negative barrier effects at Head of Old River**
  - Relatively high predation with rock barrier or BAFF on – importance of scour hole
    - Habitat reconfiguration feasibility (“fill the scour hole”)?
    - Predator relocation feasibility?
  - Strong importance of light level
  - Physical barrier is best for keeping fish in main stem
    - Far-field effect: keeps flow in main stem – some benefits (work by Pat Brandes et al.)
    - Consider other potential physical barriers (e.g., gate closer to the junction)
  - Consider non-barrier alternatives (e.g., habitat improvement)
- **No evidence for negative barrier effects at Georgiana Slough**
  - Environmental factors more important (turbidity)
- **Further study**
  - True control (no barrier, similar flows)
  - Through-Delta survival using tags that detect predation

Final

An Evaluation of Juvenile Salmonid Routing and Barrier Effectiveness, Predation, and Predatory Fishes at the Head of Old River, 2009–2012

Prepared by:

http://baydeltaoffice.water.ca.gov/sdb/tbp/web_pg/tempbar/horbereport.cfm

California Department of Water Resources