Early Warning of Delta Smelt Movement During an Extreme Drought: Intensive Springtime Kodiak Trawling at Jersey Point

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Jan 2014- Drought and Impending Doom?

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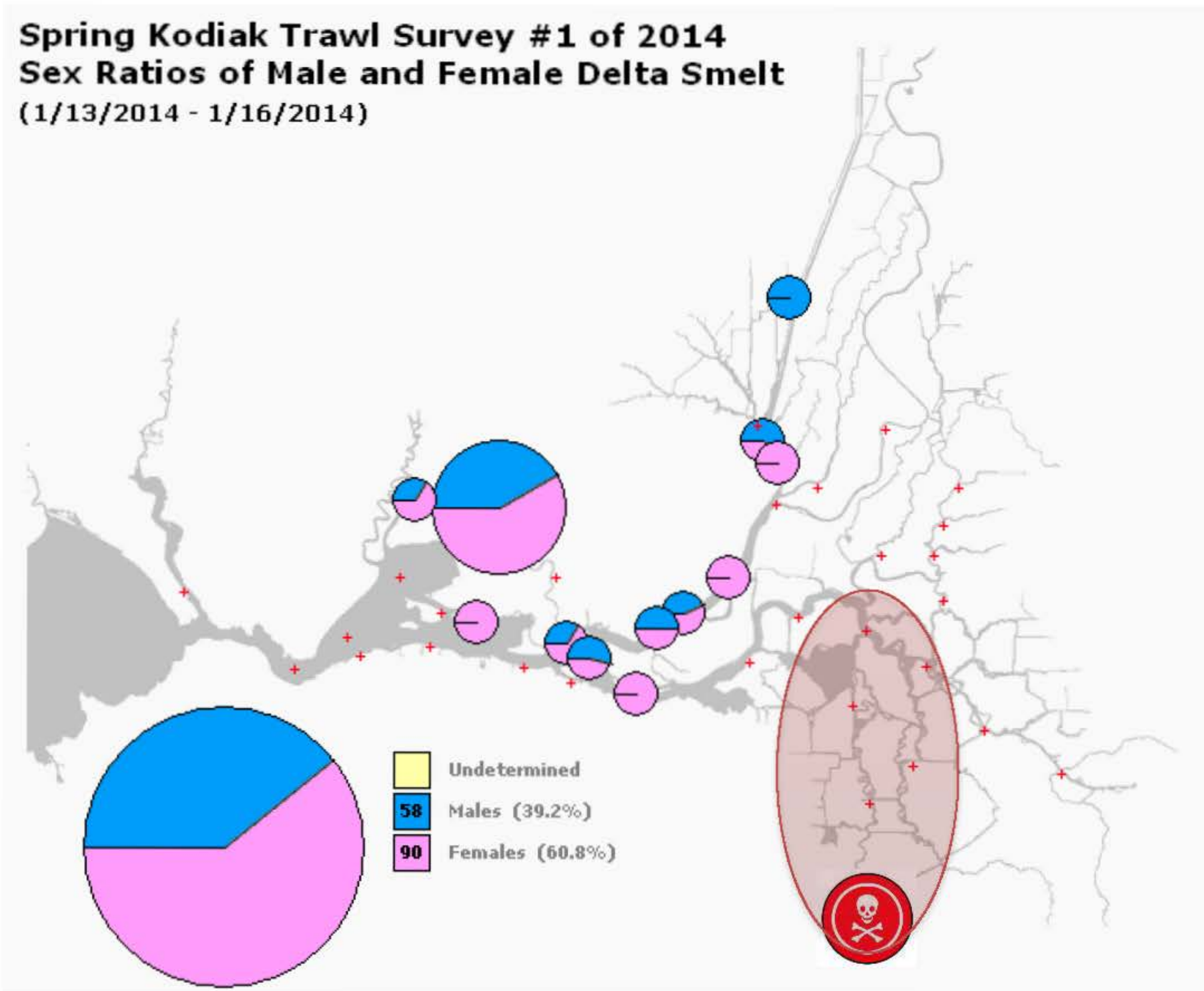
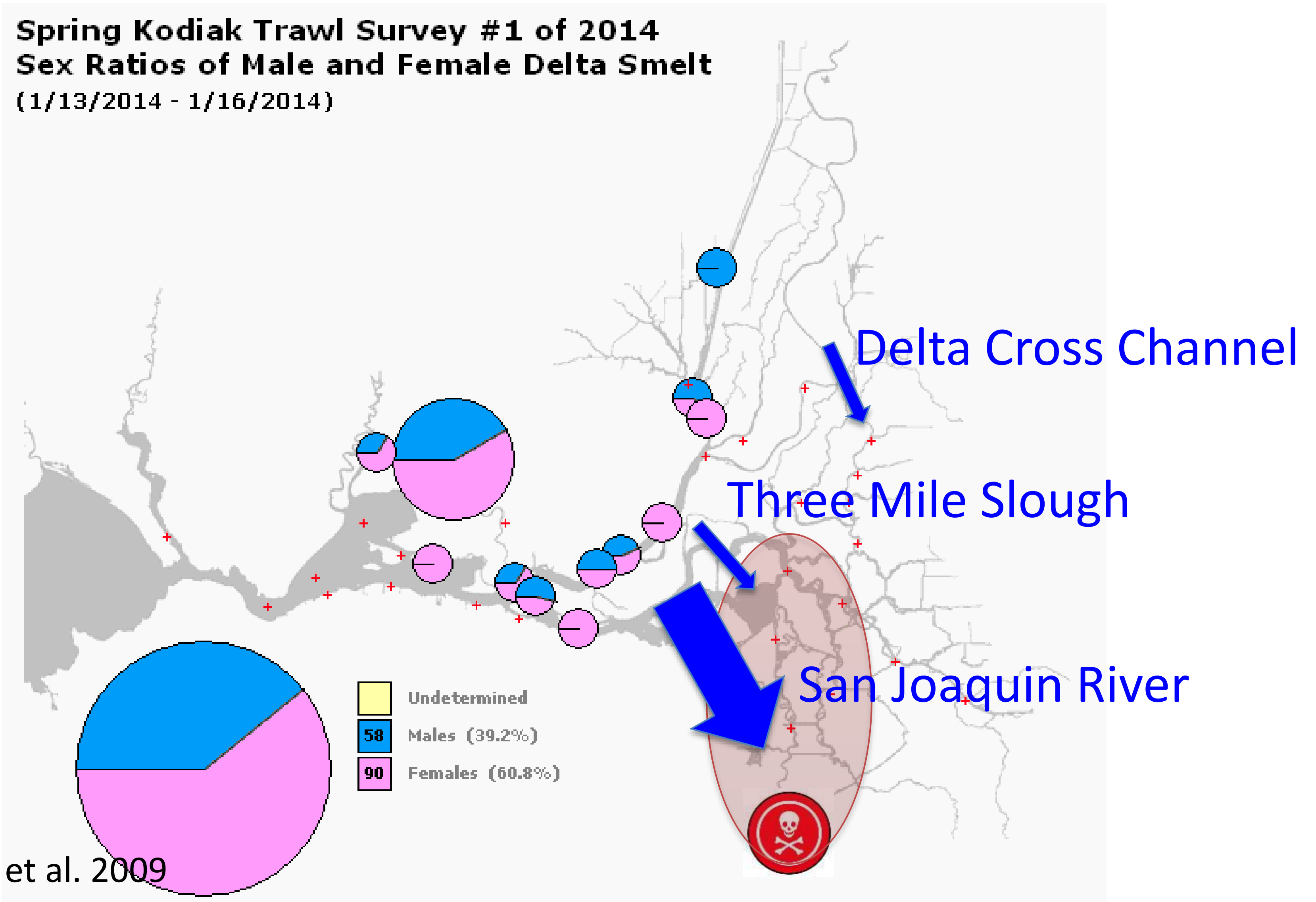


Jan 2014- Drought and Impending Doom?

- As storms begin to come, can we predict "pumpward" migration of smelt to inform when entrainment risk is high[1]?



(1) Grimaldo et al. 2009

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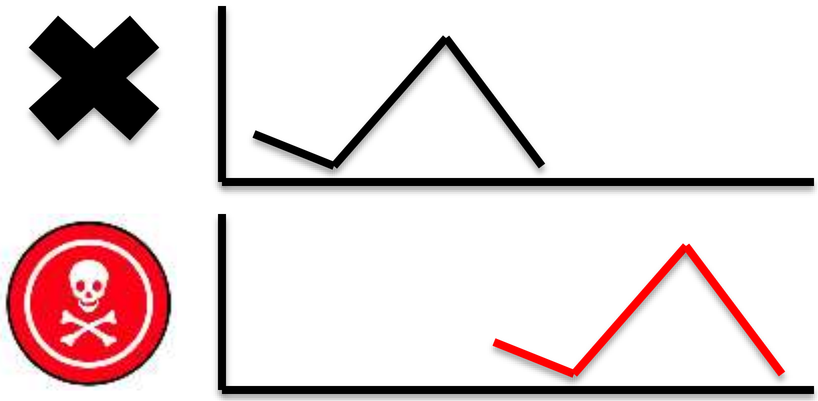
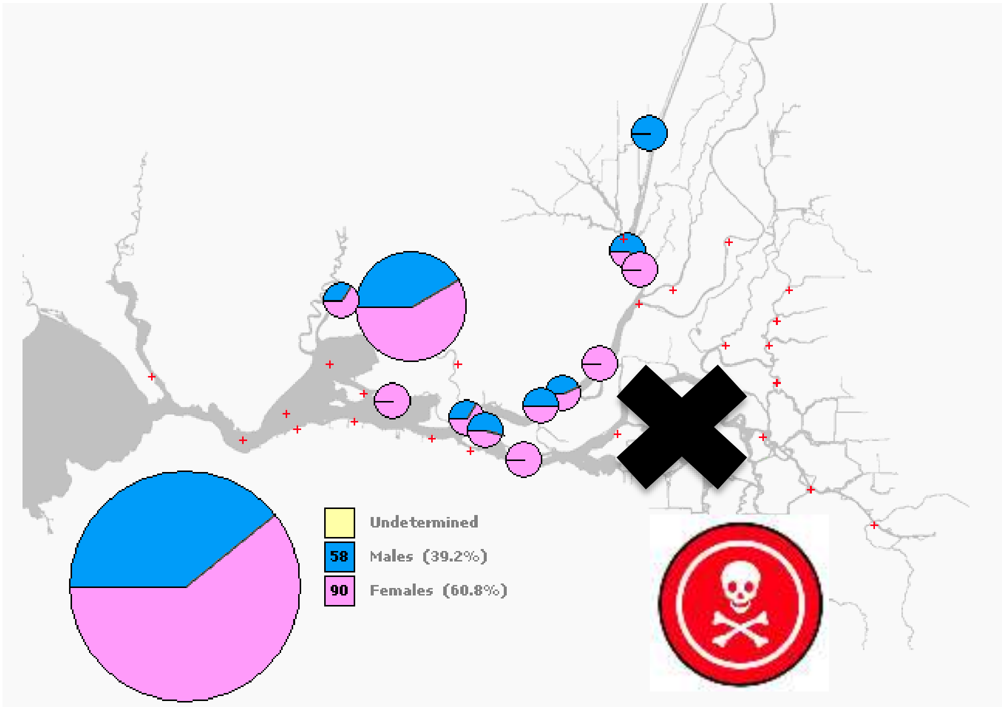
- Analysis Strategy: Correlate density changes at a location on the route to entrainment with salvage data





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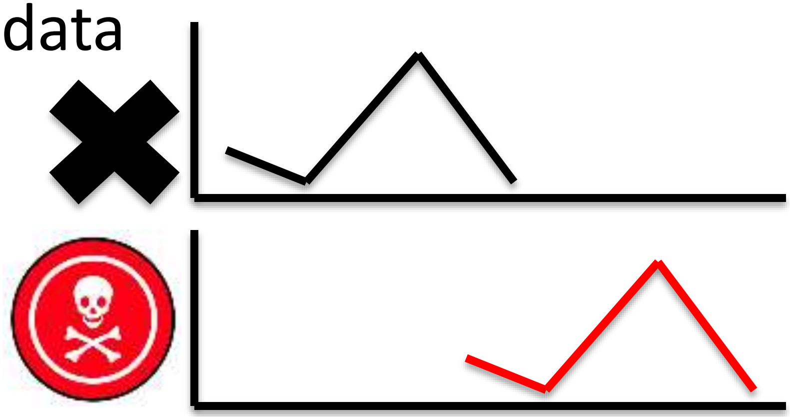


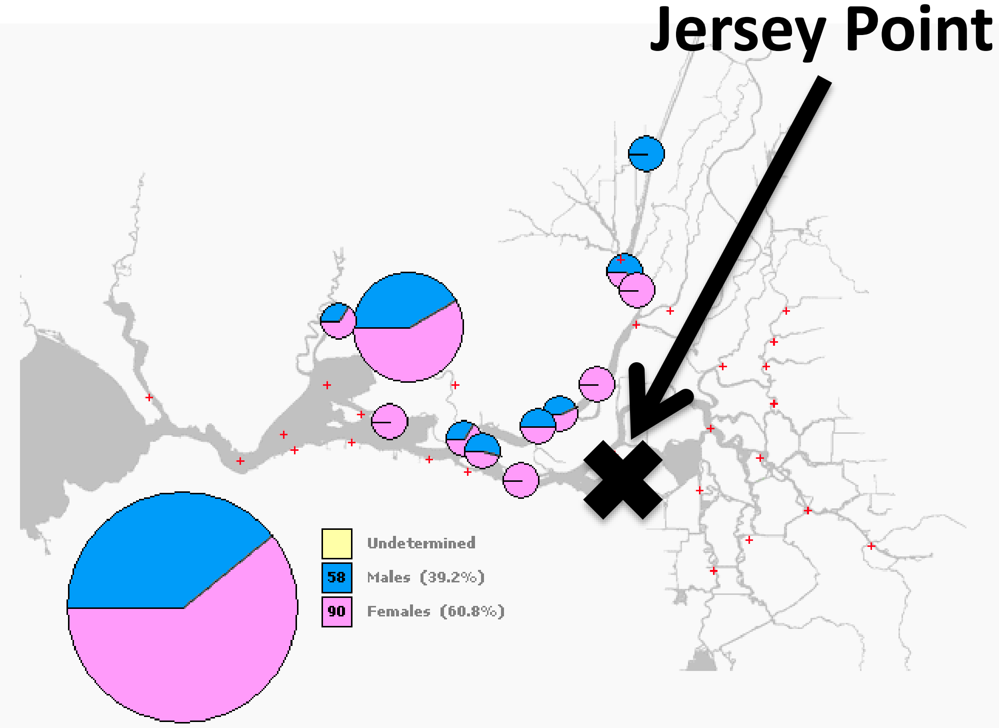
- Migration events can be rapid, on order of days after a storm event[1, 2]

Implement Intensive Sampling

(1) Grimaldo et al. 2009; Sommer et al. 2011

Intensive Sampling at Jersey Point

- Use Kodiak Trawl gear type
- Sample nearly every day from Feb 6 to April 10
- Approximately 15 tows per day
- Usually 10 min per tow (~4000m^3 of water sampled per tow)
- Three lanes: North (tule marsh), Middle, and South (rip rap)



Water Year 2014- No storms, No salvage

- No enticement to move towards pumps?
  - -Not very strong reverse flows (OMR not very negative)
  - -Low turbidity at Jersey Point (>11 NTU only a few days)
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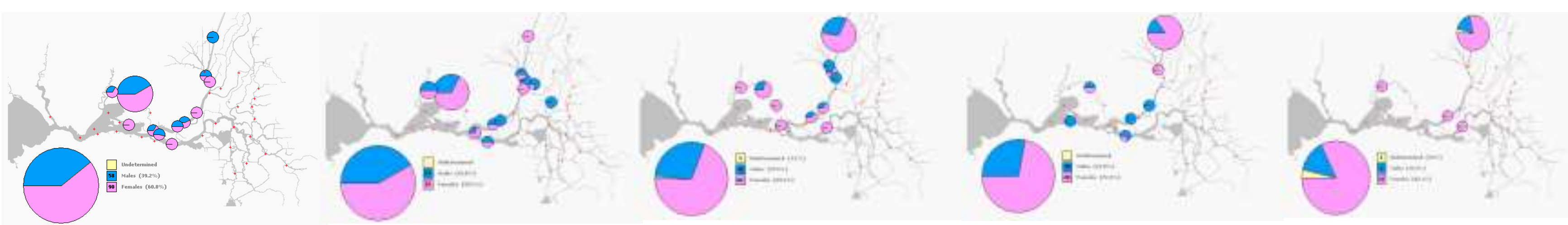
- Smelt caught at Jersey Point (as we shall see), but…
  - -Generally no catch in South Delta by “regular” SKT
  - -No salvage at the pump facilities

“Early Warning System” of entrainment via correlation of density changes at Jersey Point and salvage not possible



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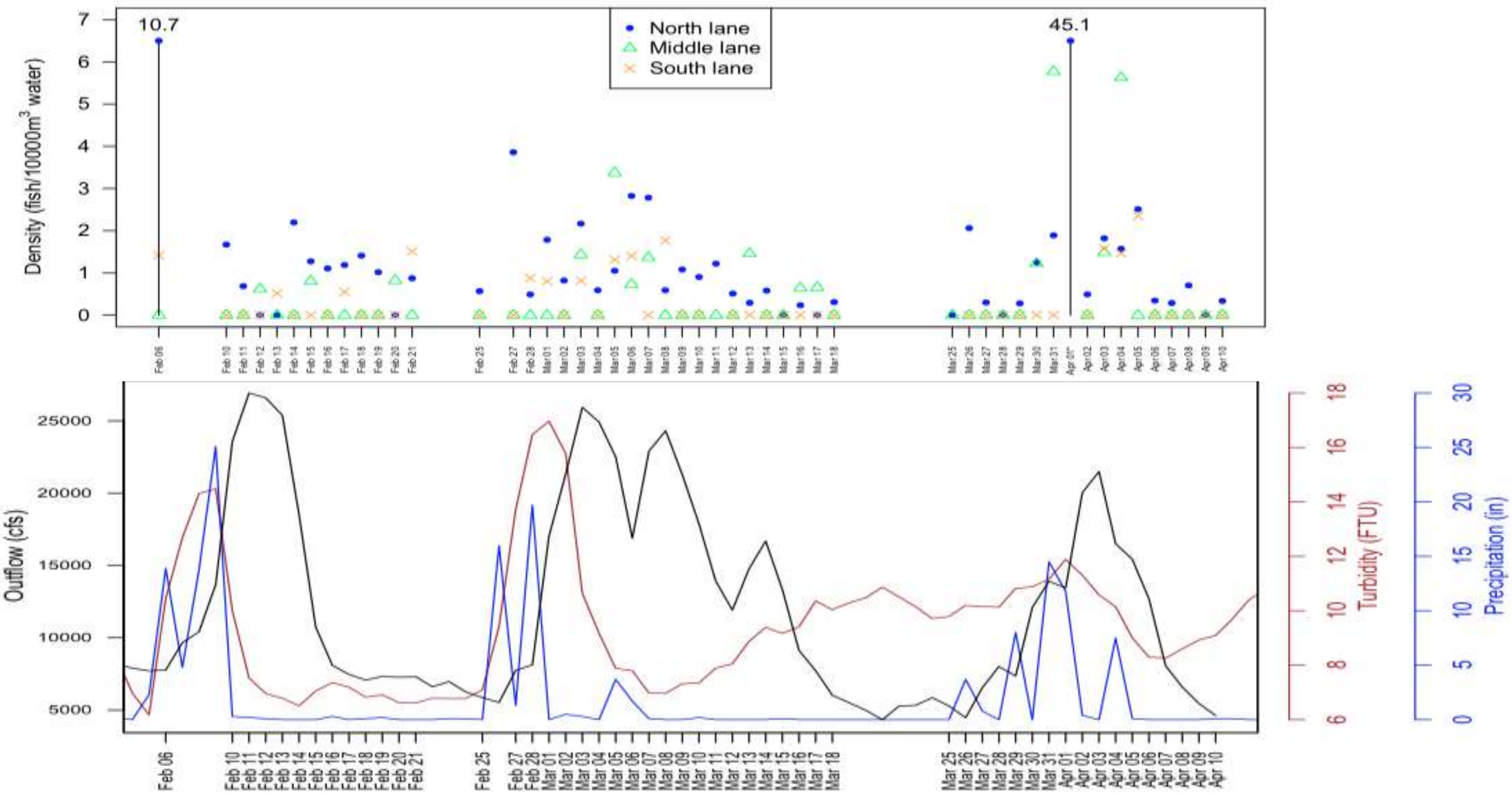
1) **How rapid and ephemeral are changes in catch density given "obvious" changes in turbidity and outflow?**

(3) Polansky et al. 2014.

Data overview

- At least one fish caught most days, most (78%) tows got no fish
- Density around 0 to 7 fish per 10000m^3, some "extremely" high days
- A few minor storm events during study period



Results

1) How do environmental covariates influence catch densities at JP?

Model: GLM, Negative binomial error distribution, $\log_e$ link

catch size~offset(log(sample volume))+covariates [(4-6)]

Covariate	Estimate	Std. Error	z value	P-value
Intercept	-12.82	0.50	-25.45	<0.01*
Lane (north)	**0.69**	**0.25**	**2.74**	**<0.01***
Lane (south)	-0.46	0.35	-1.31	0.19
Turbidity	0.10	0.02	4.35	<0.01*
Conductivity	<0.01	<0.01	3.35	<0.01*
Water Velocity	**0.03**	**0.06**	**0.50**	**0.62**
Precipitation	0.07	0.02	3.59	<0.01*
Outflow	<0.01	<0.01	2.79	0.01*

North Lane has more fish, water velocity not important

(4) Nobriga et al. 2008; (5) Feyrer et al. 2011; (6) Feyrer et al. 2013

Results

2) What are the chances of getting at least one smelt on one tow?

General observations:
371 tows on 51 days
4 days no smelt caught
78% of tows did not catch a single smelt

Model: GLM, logistic regression, North lane data only
catch indicator~offset($\log_e$(sample volume))+daily density

Probability of catching at least one fish

Sample effort	Density: Low	Median	High
1 tow	0.16	0.23	0.35
15 tows	0.74	0.81	0.89

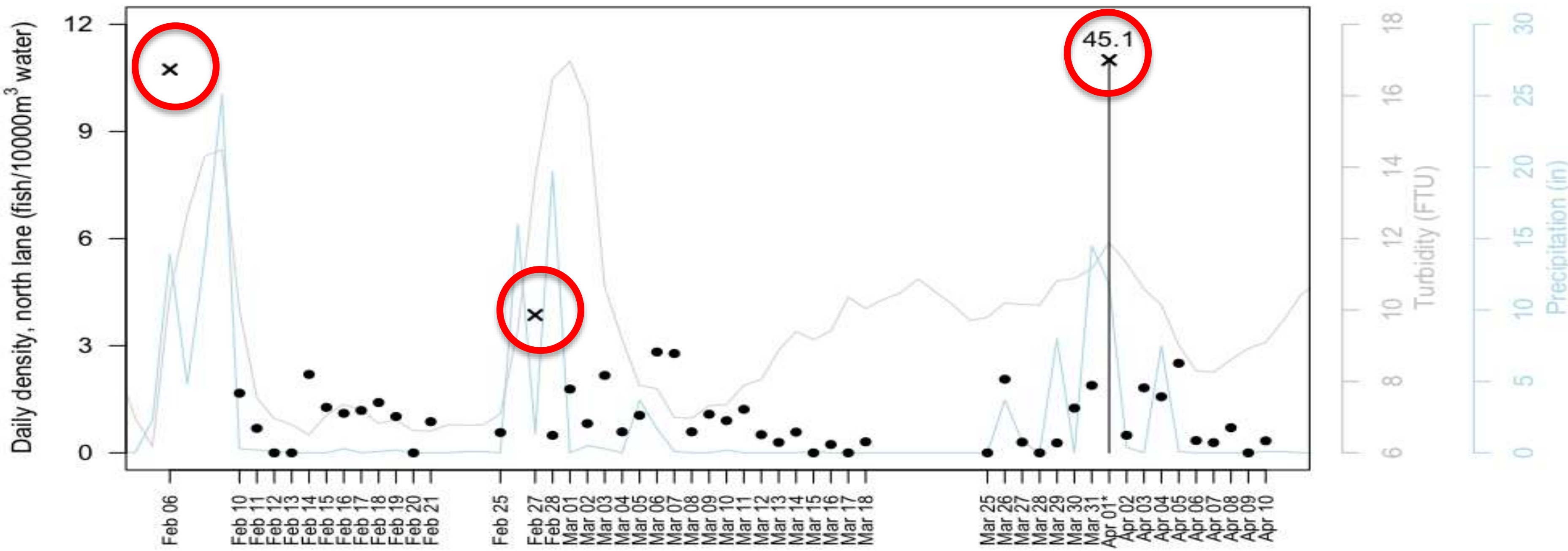
Results

3) How rapid and ephemeral are changes in catch density given "obvious" changes in turbidity and outflow?

Model: Hidden Markov model of north lane densities

Two latent states: "low" density and "high" density

Three days with "high" densities, roughly corresponding to increases in precipitation, outflow, and turbidity



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- **Chances of getting at least one fish on any give tow are low**, even when smelt are in the local area
- **Tow location important** for reliably catching fish
- **Catch size and probability of catching a fish increase temporarily with storm events**
- Detecting fish and measuring density changes across days reliably: **more than one tow per day needed**

Discussion

- Regular monthly SKT surveys
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- Frequency of zero catches (78%) in special study in line with regular survey (71% over 2002-2010)

Percentage of zero catches by year			
Year	%	Year	%
2002	45	2007	79
2003	58	2008	79
2004	60	2009	85
2005	64	2010	81
2006	69		

- **Replace regular sampling with intensive sampling in key locations?**

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  Really want to know:
  What are the demographic consequences of entrainment?

(7) Bennett and Burau 2014.

Discussion

- Early Warning System
  Intensive sampling at multiple locations needed to detect movement towards pumps in the absence of salvage.

- Assuming we have an Early Warning System "sampling grid"
  Really want to know:
  What are the demographic consequences of entrainment?

- What is the relative proportion of the population moving towards pumps vs up the Sacramento River?
  Would require fish being caught in both watersheds[7].

(7) Bennett and Burau 2014.

Literature

(1) Grimaldo et al. 2009. North American Journal of Fisheries Management, 29.

(2) Sommer et al. 2011. San Francisco Estuary and Watershed Science, 9(2).

(3) Polansky et al. 2014. IEP Newsletter and references therein.

(4) Nobriga et al. 2008. San Francisco Estuary and Watershed Science, 6(1).

(5) Feyrer et al. 2011. Estuaries and Coasts, 34.

(6) Feyrer et al. 2013. PLoS ONE, 8(7).

(7) Bennett WA and JR Baraughs 2014. Estuaries and Coasts.

Acknowledgements

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