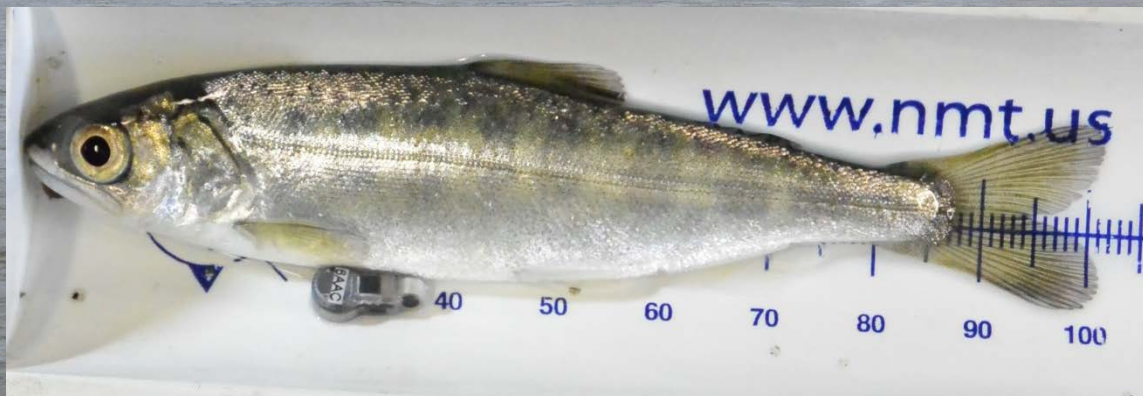


# Predator swamping and movement under high flows: comparing winter-run Chinook juveniles released only days apart.

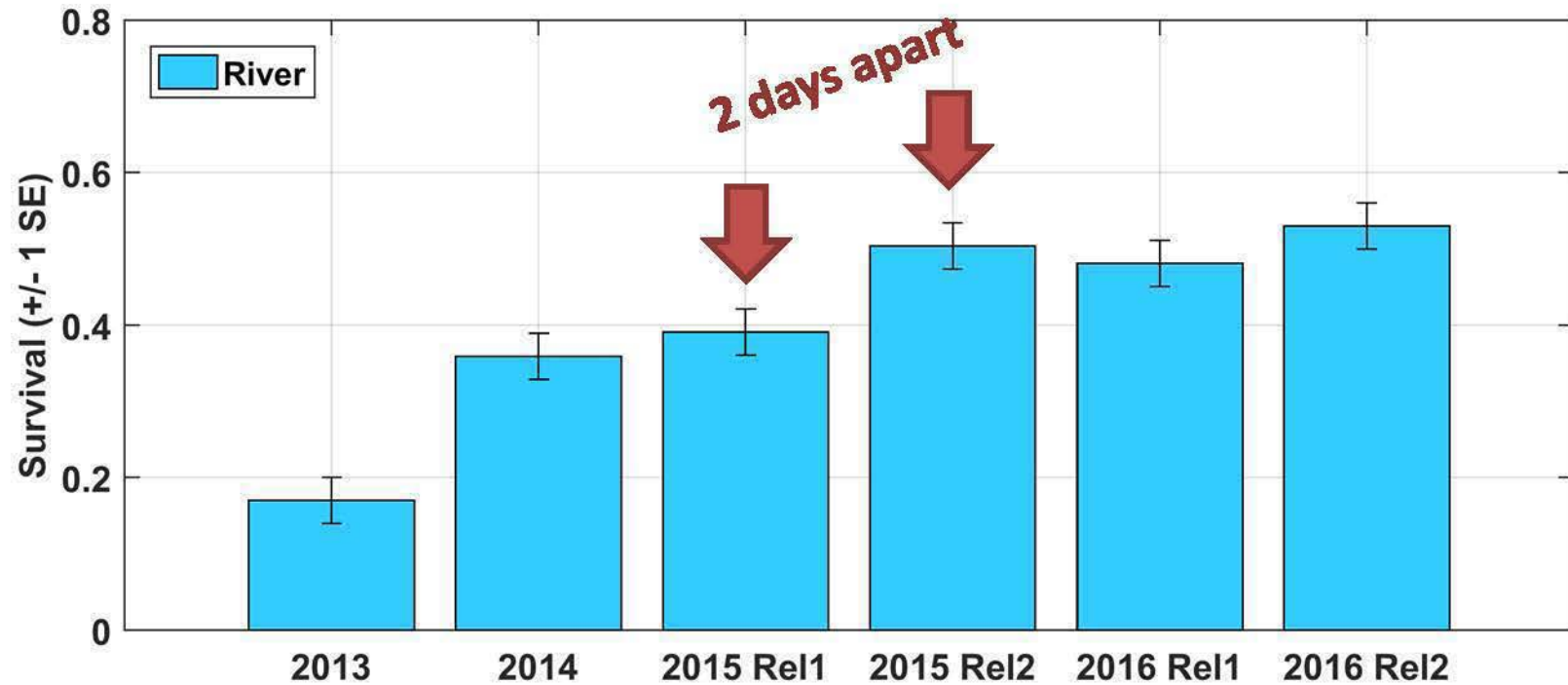
Arnold J. Ammann

National Marine Fisheries Service, Santa Cruz



# Hatchery Winter-run

## River survival among years and release groups



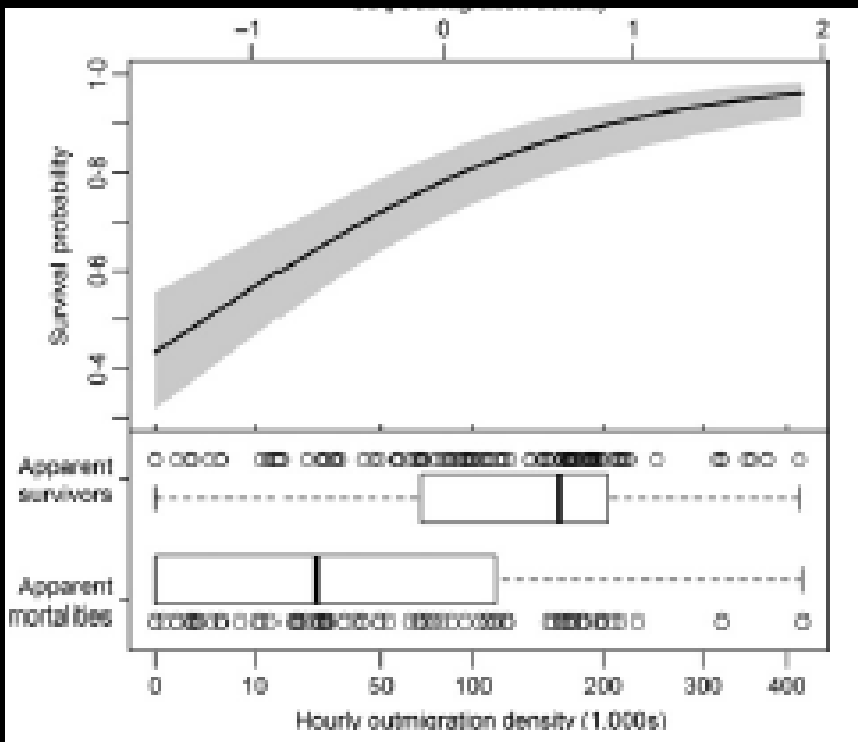
**Predator swamping** = since there is always a limit to the number of prey a predator can catch and handle per unit of time, a sudden mass appearance of prey in the vulnerable stage may *swamp* or *satiated* the predator population, thereby reducing the fraction of prey taken by the predator (Darling 1938)



## Predator swamping reduces predation risk during nocturnal migration of juvenile salmon in a high-mortality landscape

Nathan B. Furey\*, Scott G. Hinch, Arthur L. Bass, Collin T. Middleton, Vanessa Minke-Martin and Andrew G. Lotto

*Department of Forest and Conservation Sciences, University of British Columbia, 2424 Main Mall, Vancouver, BC V6T 1Z4, Canada*



- High risk landscape
- Discrete groups with varying density and ability to measure density
- Estimate survival of groups with acoustic telemetry

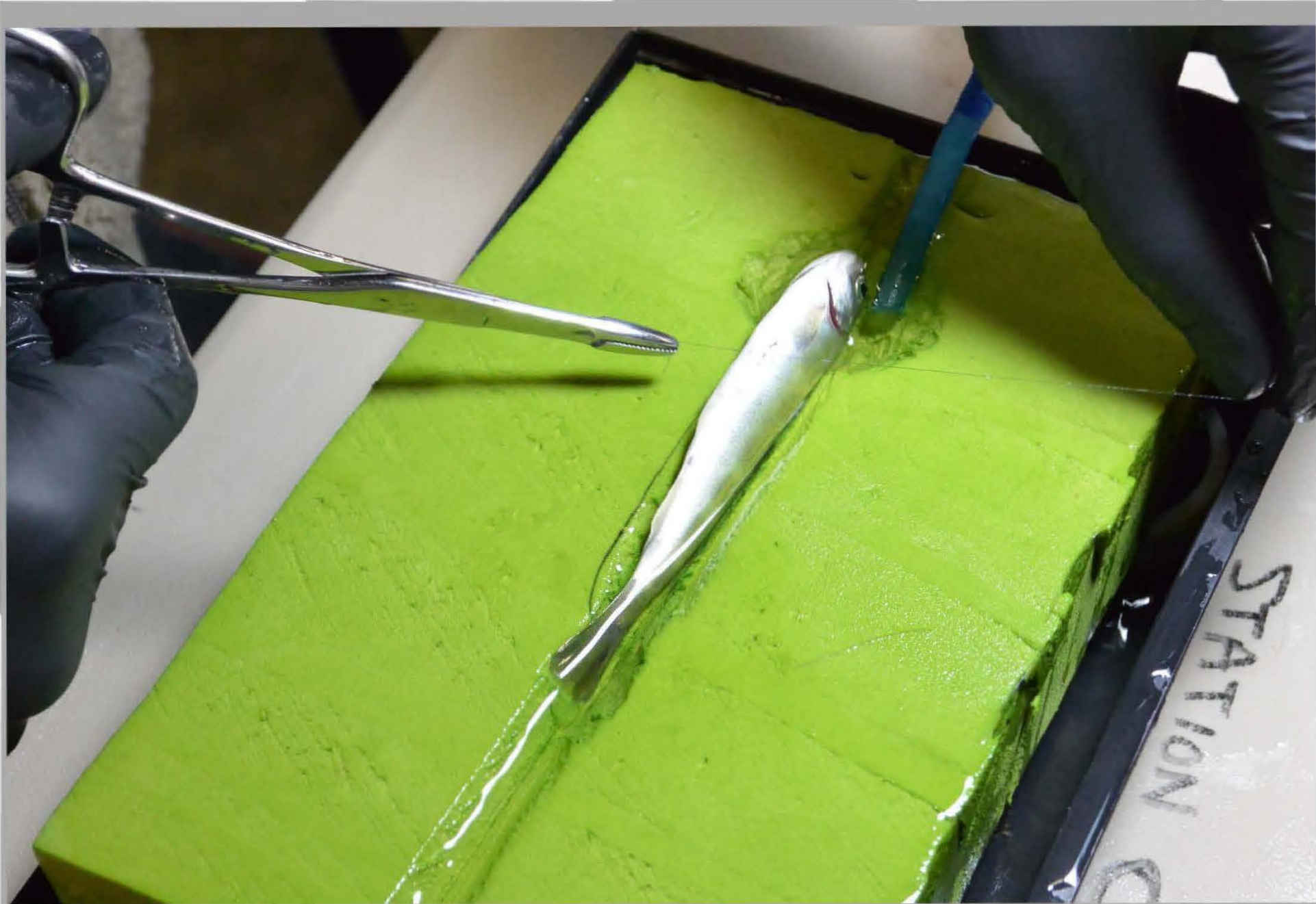
# **Is predator swamping happening with hatchery fish in the Sacramento River?**

- Predation pressure thought to be high for outmigrating smolts**
- Multiple releases of large groups of fish (unique for 2015 and 2016)**
- Groups have some acoustic tagged fish, so survival can be estimated.**

## Livingston Stone National Fish Hatchery Winter Run Acoustic Telemetry

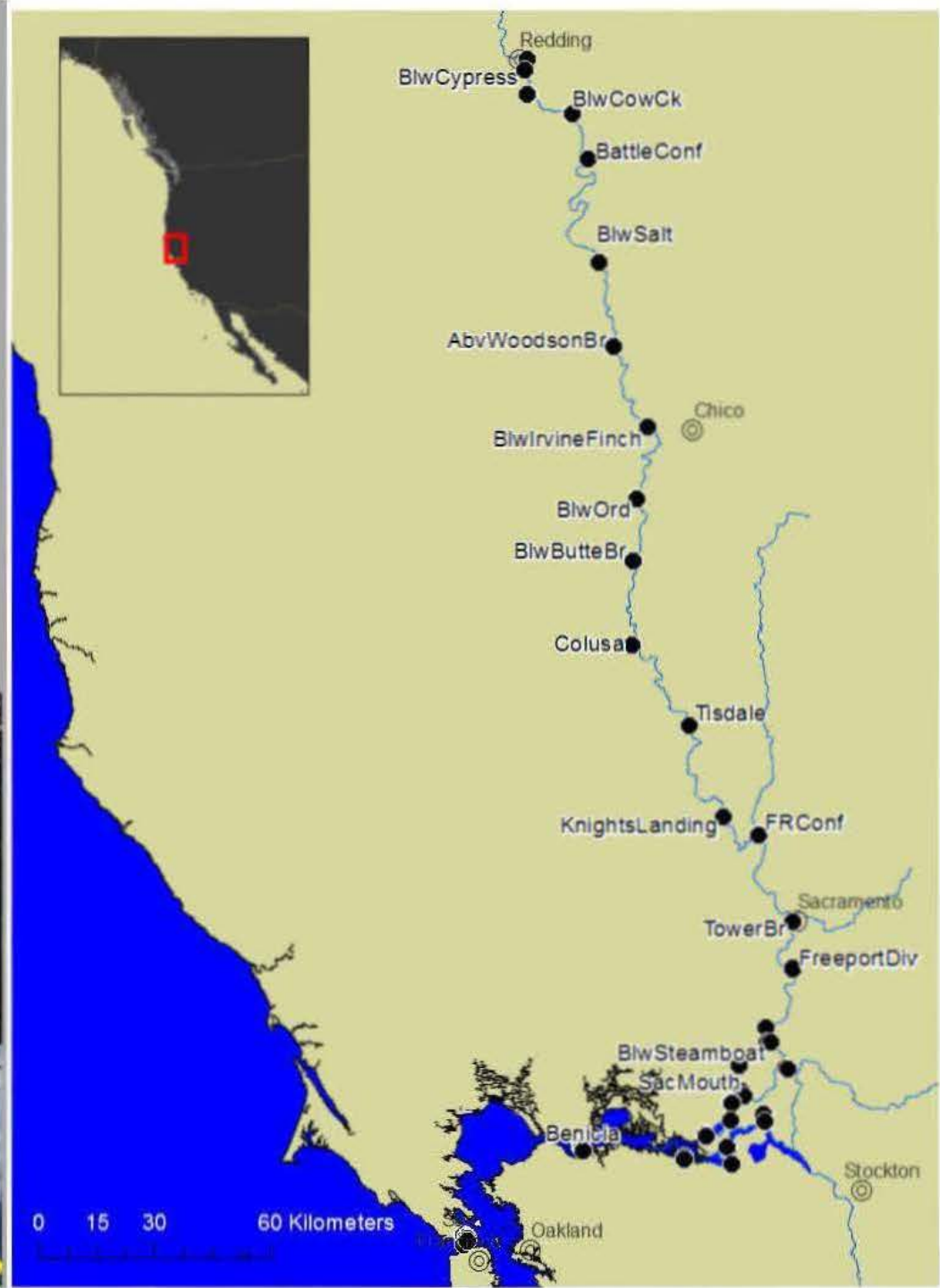
Year	N	Date Released	Ave Weight (g)	Ave FL (mm)
2013	148	07-Feb-13	10.3	98
2014	358	10-Feb-14	9.4	95
2015	251	04-Feb-15	10.6	100
2015	321	06-Feb-15	10.5	100
2016	285	17-Feb-16	9.4	95
2016	285	18-Feb-16	9.2	95





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# Receiver Locations



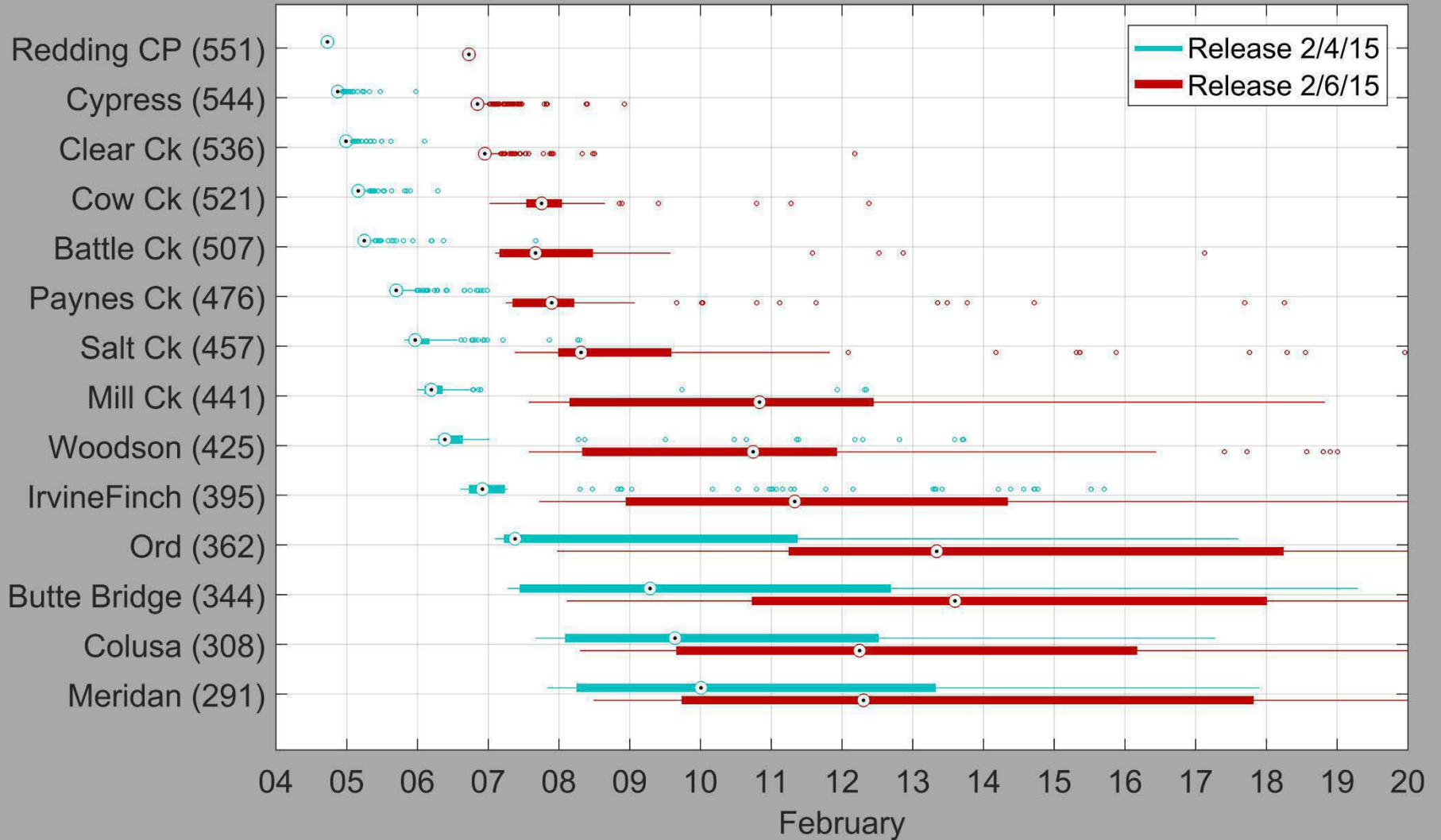


# Hatchery releases 2015 Feb 4,5,6

- Hatchery released 200K fish each day for three days
- Acoustic tagged fish in first and third day
- Assumption: Density of fish migrating past a given location is higher for third release group
- *Hypothesis: Reach survival will be higher for third release group compared to first release group*

# Distribution of arrival time by release group

Winter Run 2015 Arrival Times



# Migration behaviors

- **Fast migrators – steady and rapid movement downstream “migrators”**

# 2015 JSATS Movement Plot: TagID = 21155(52A3)

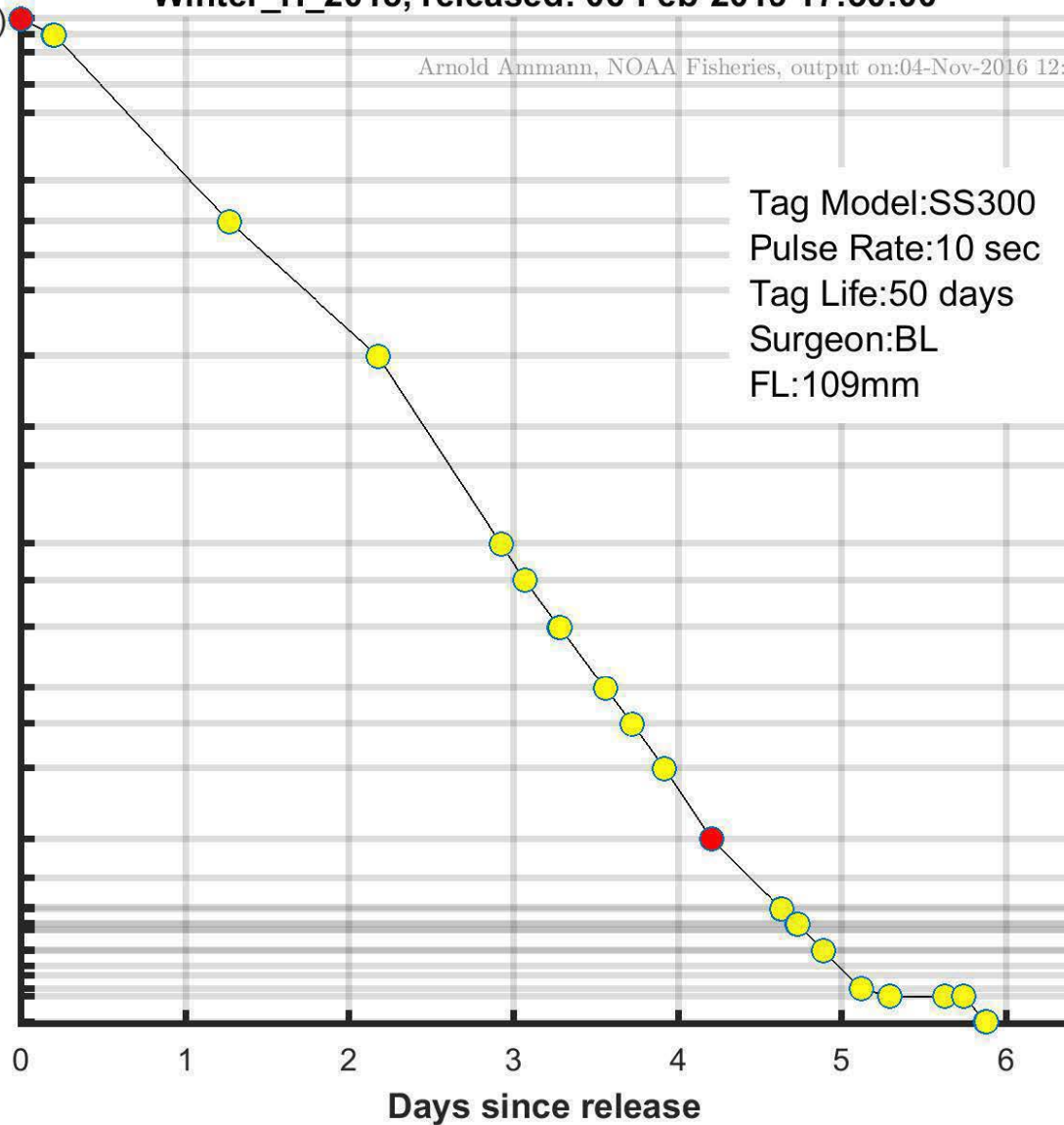
Winter\_H\_2015, released: 06-Feb-2015 17:30:00

Arnold Ammann, NOAA Fisheries, output on:04-Nov-2016 12:33:58

River kilometer

- SR Caldwell Park Rel (551)
- Blw Cypress (544)
- Blw ClearCr (536)
- BlwCowCr (521)
- Battle Conf (507)
- Blw Paynes Ck (476)
- Blw Salt (457)
- Mill Ck Conf (441)
- Abv WoodsonBr (425)
- Blw IrvineFinch (395)
- BlwOrd (362)
- ButteBr (344)
- AbvColusaBr (308)
- MeridanBr (291)
- AbvTisdale (269)
- BlwChinaBend (241)
- Knights (224)
- Blw FRConf (203)
- 180 Br (171)
- Freeport (152)
- AbvWoodsonBr (139)
- SR Pine Bluff (128)
- Blw George Spohn (119)
- Base of Ferry (108)
- SR VistaBr (98)
- DeckerIsland (86)

Tag Model:SS300  
 Pulse Rate:10 sec  
 Tag Life:50 days  
 Surgeon:BL  
 FL:109mm



# Migration behaviors

- **Fast migrators – steady and rapid movement downstream “migrators”**
- **Stop and hold – at some point in migration, slow down or stop for several days “holders”**

# 2015 JSATS Movement Plot: TagID = 11097(2B59)

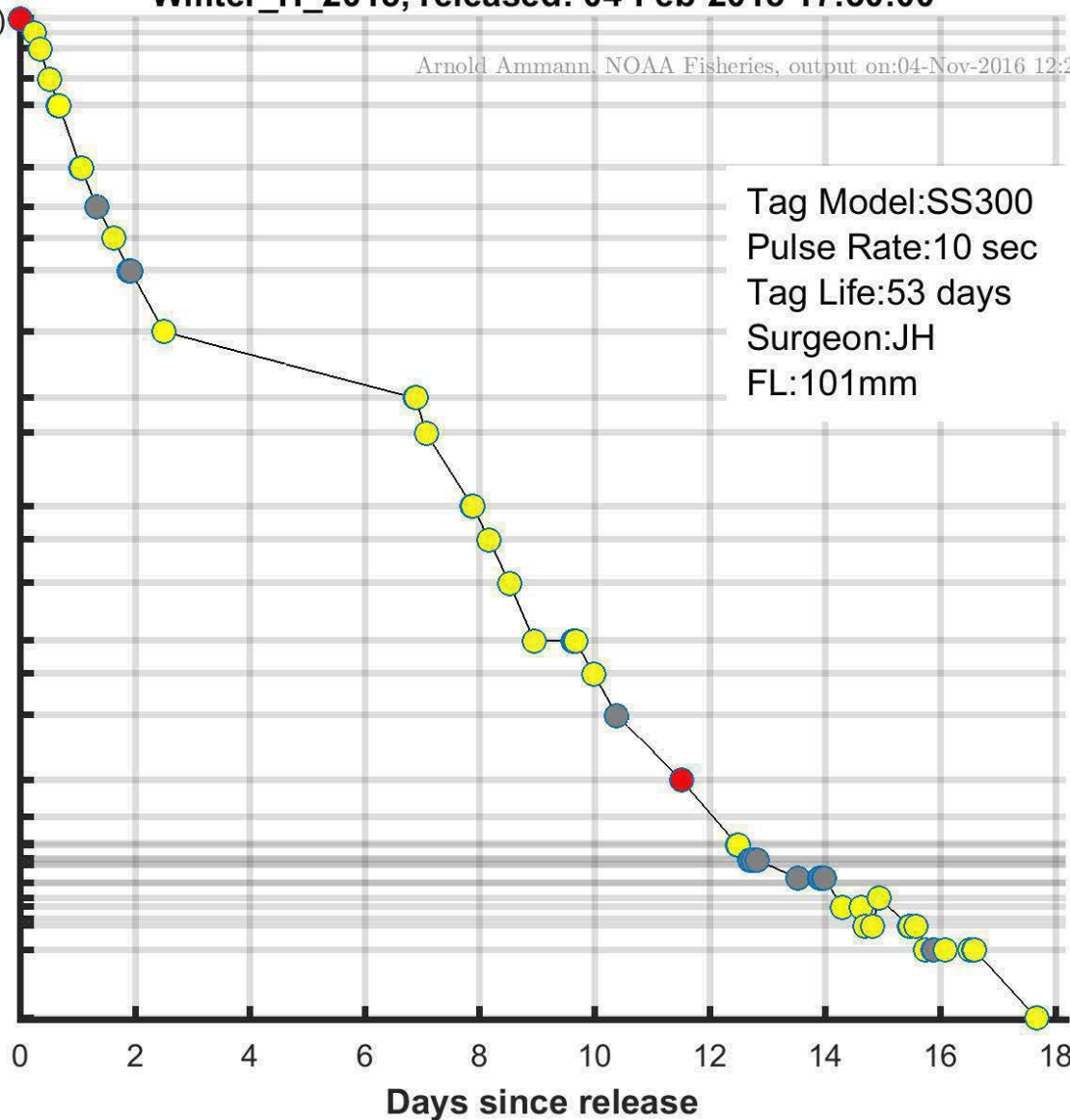
Winter\_H\_2015, released: 04-Feb-2015 17:30:00

Arnold Ammann, NOAA Fisheries, output on:04-Nov-2016 12:21:50

River kilometer

- SR Caldwell Park\_Rel (551)
- Blw Cypress (544)
- Blw ClearCr (536)
- Blw CowCr (521)
- Battle Conf (507)
- Blw Paynes Ck (476)
- Blw Salt (457)
- Mill Ck Conf (441)
- Abv WoodsonBr (425)
- Blw IrvineFinch (395)
- Blw Ord (362)
- ButteBr (344)
- Abv ColusaBr (308)
- MeridanBr (291)
- Abv Tisdale (269)
- Blw ChinaBend (241)
- Knights (224)
- Blw FRConf (203)
- I80 Br (171)
- Freeport (152)
- Abv WoodsonBr (139)
- SR Suisun (130)
- SR Suisun (128)
- Blw Grays Pond (119)
- Base of Ferry (112)
- SR WoodsonBr (98)
- DeckerIsland (86)
- Benicia (52)

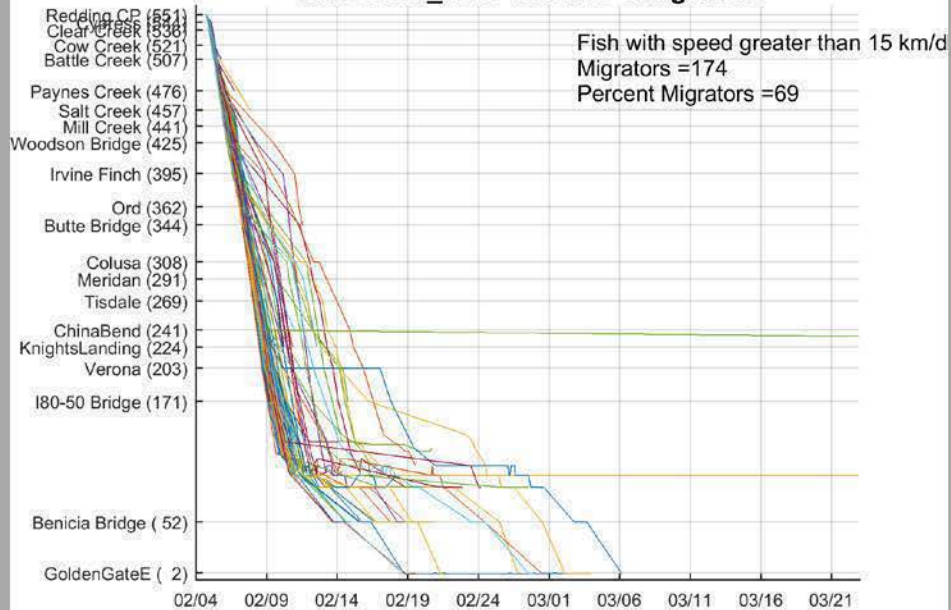
Tag Model:SS300  
Pulse Rate:10 sec  
Tag Life:53 days  
Surgeon:JH  
FL:101mm



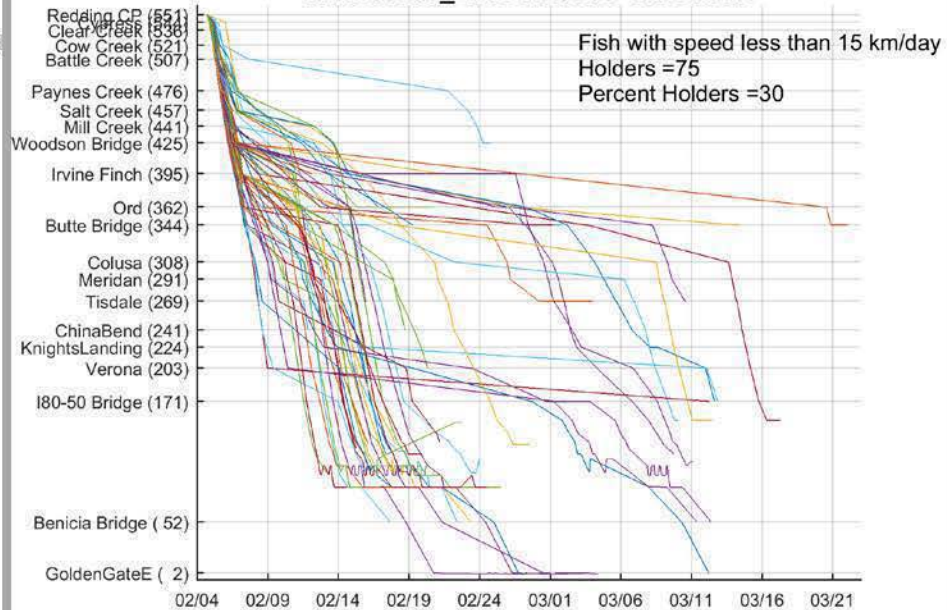
# Migration behaviors

- **Fast migrators – steady and rapid movement downstream = “migrators”**
- **Stop and hold – at some point in migration, slow down or stop for several days = “holders”**
- **Only migrators would be affected by predator swamping if effect exists – because swamping is time dependent**

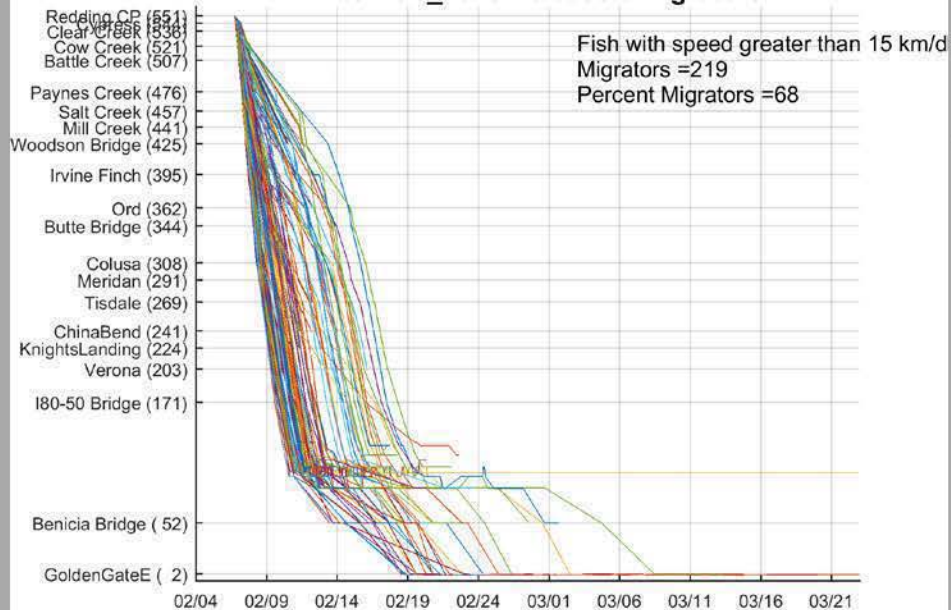
### WinterRun\_2015 Release 1 Migrators



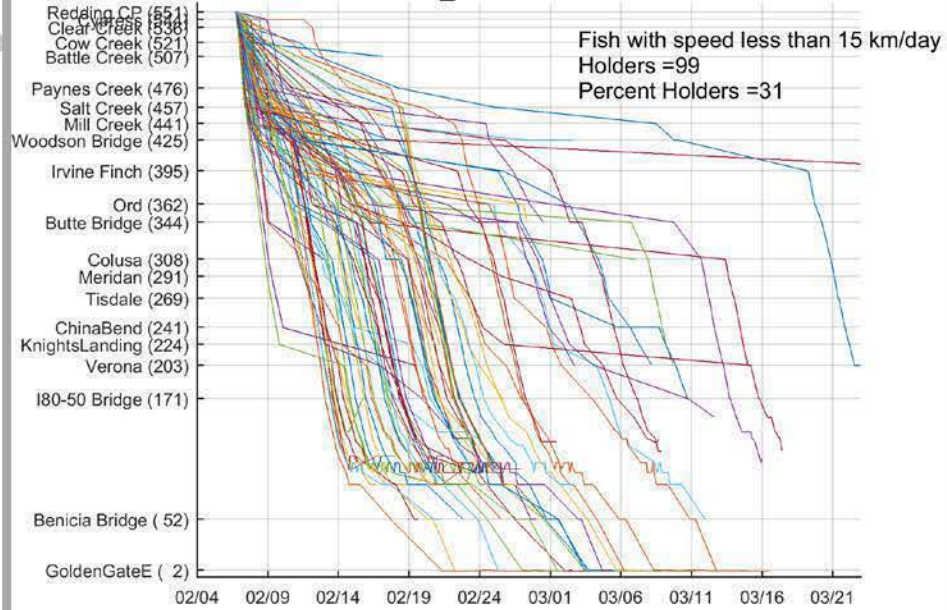
### WinterRun\_2015 Release 1 Holders



### WinterRun\_2015 Release 3 Migrators

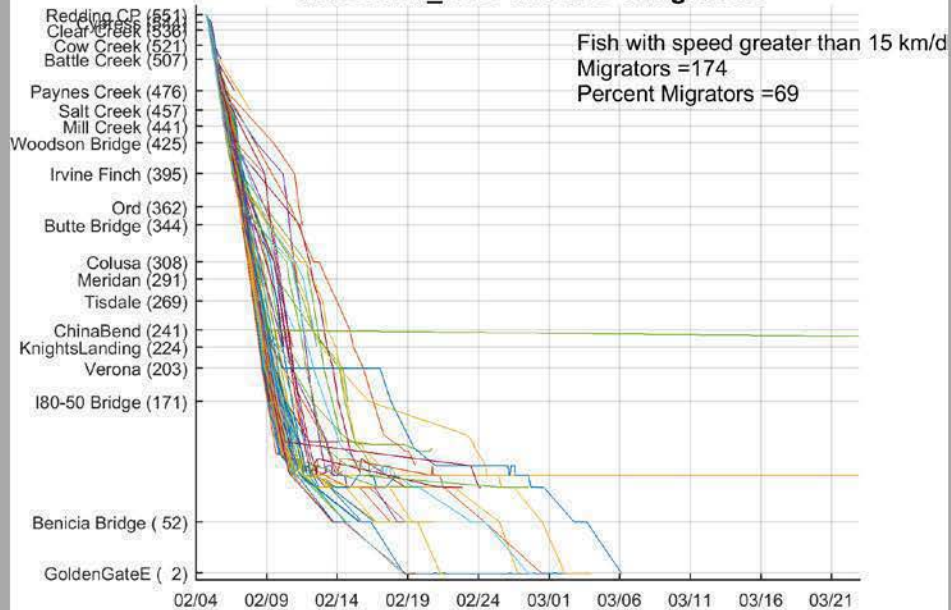


### WinterRun\_2015 Release 3 Holders

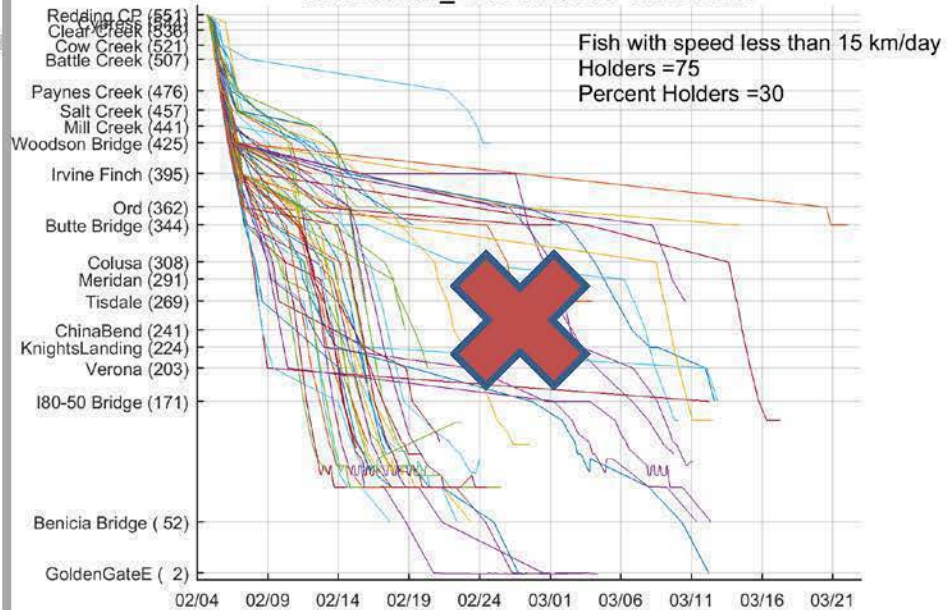




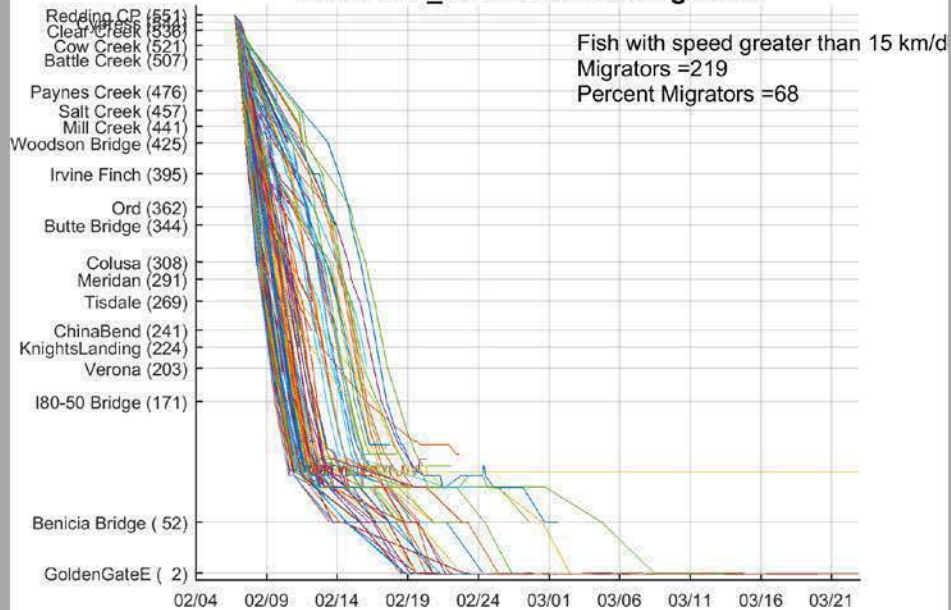
### WinterRun\_2015 Release 1 Migrators



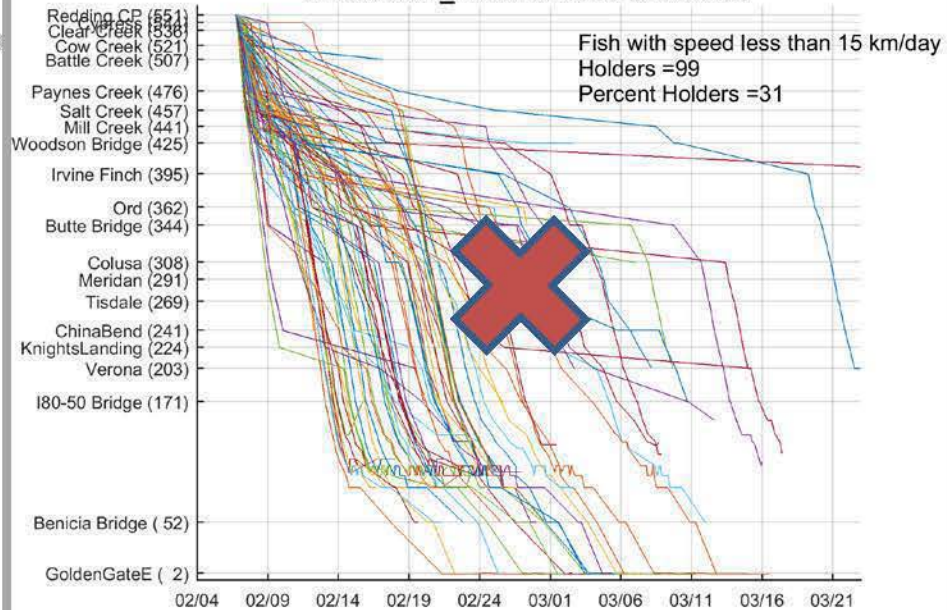
### WinterRun\_2015 Release 1 Holders



### WinterRun\_2015 Release 3 Migrators



### WinterRun\_2015 Release 3 Holders



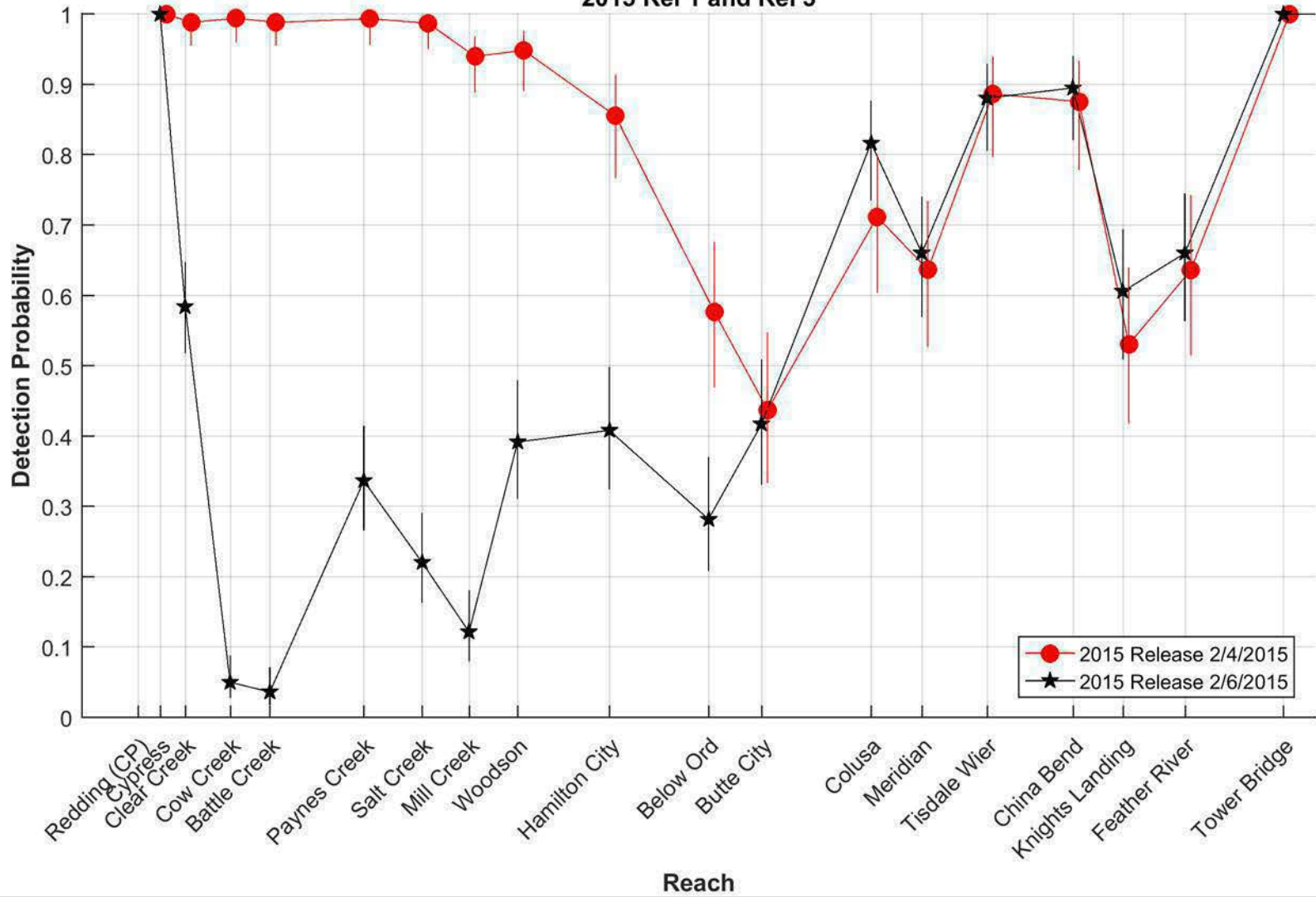
# Cormack-Jolly-Seber modeling using program Mark

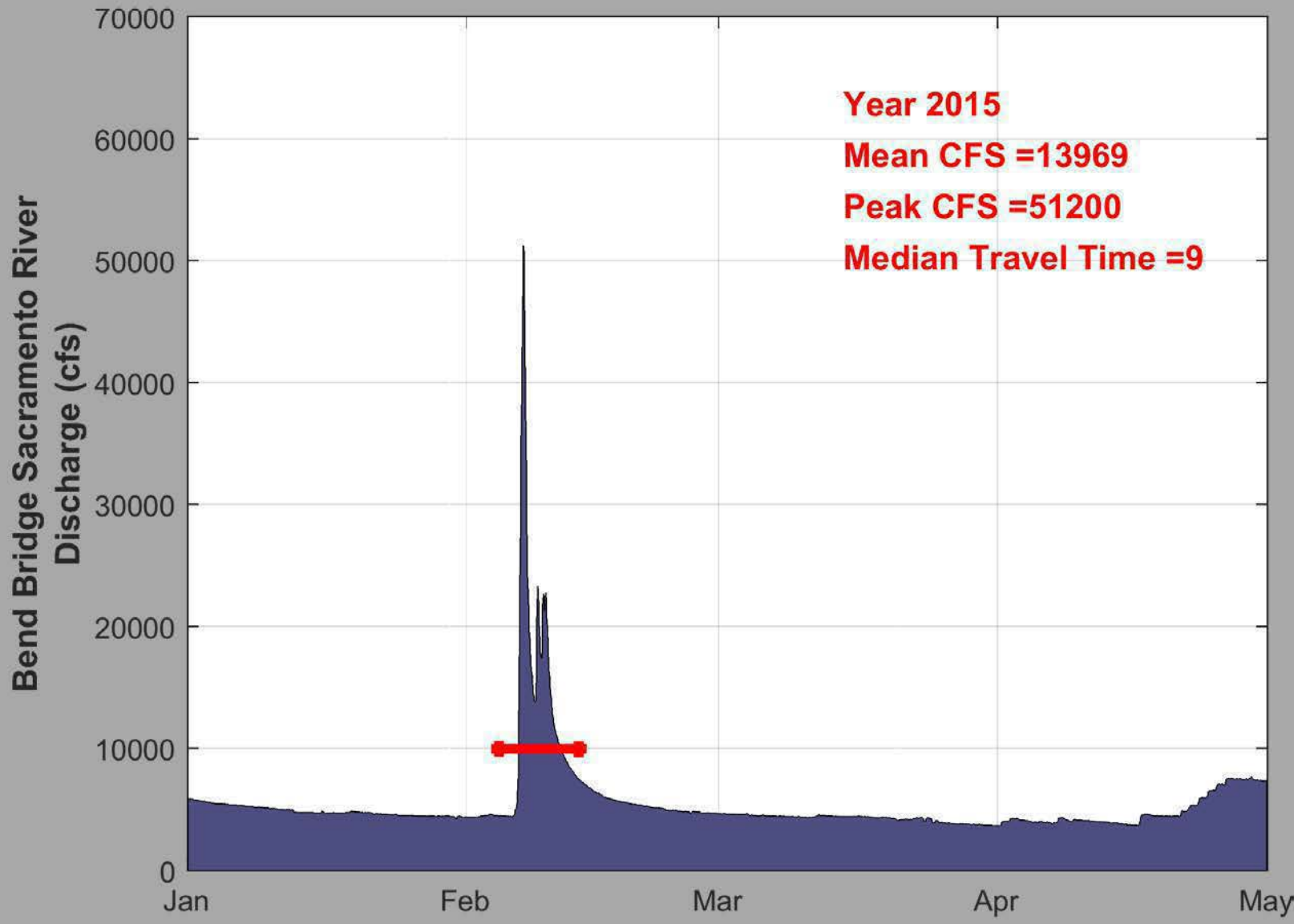
Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance
Surv(reach) Detect Prob(grp + reach)	5097.479	0	0.62688	1	62	4971.315
Surv(grp + reach) Detect Prob(grp + reach)	5098.517	1.0377	0.37312	0.5952	82	4930.7251
Surv(.) Detect Prob(grp + reach)	5252.947	155.4682	0	0	43	5165.9045
Surv(grp) Detect Prob(grp + reach)	5254.761	157.2819	0	0	44	5165.6694
Surv(grp + reach) Detect Prob(grp)	6715.922	1618.4432	0	0	44	6626.8307

# Cormack-Jolly-Seber modeling using program Mark

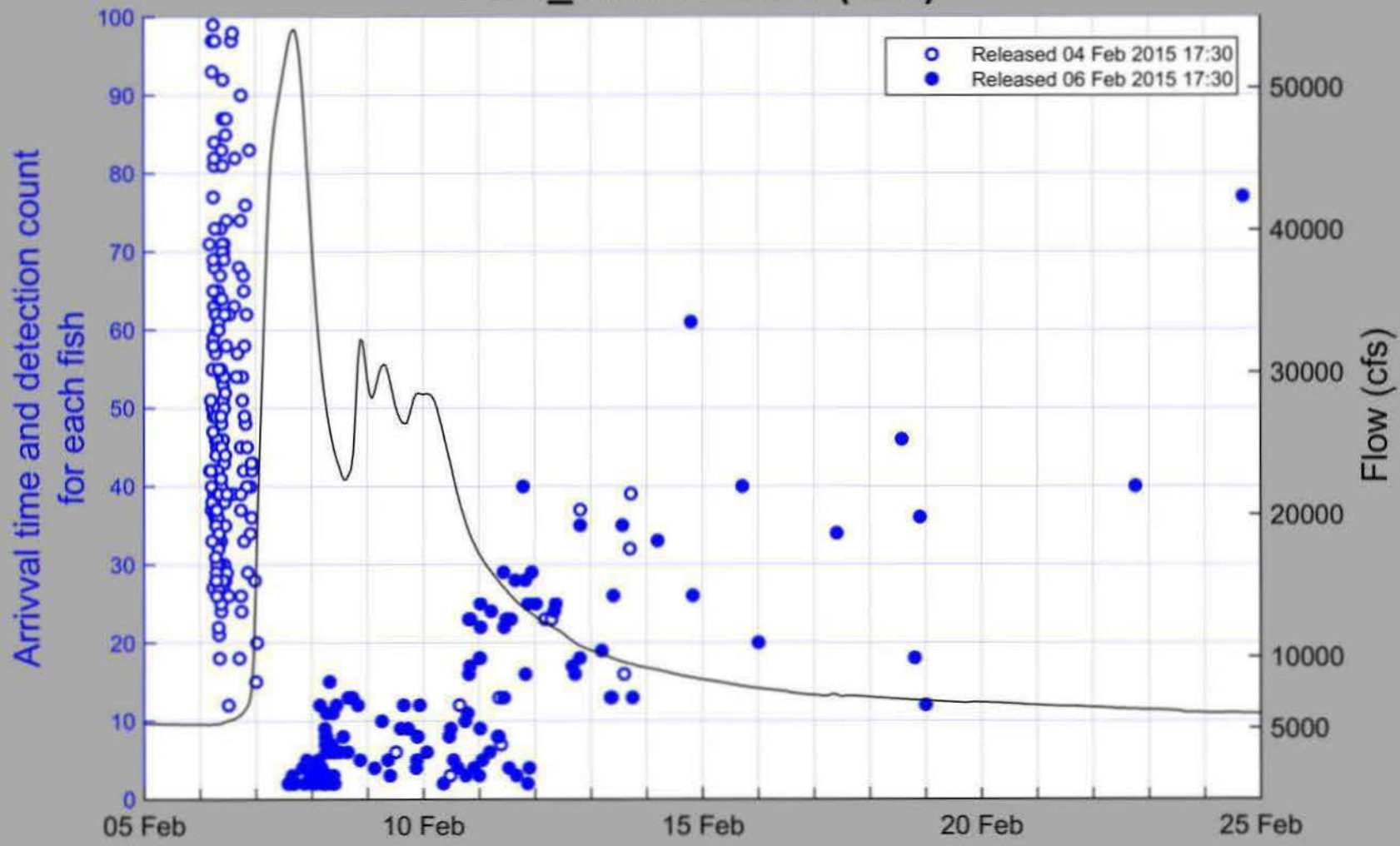
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Detection Probability: Winter-run Chinook Migrators  
2015 Rel 1 and Rel 3

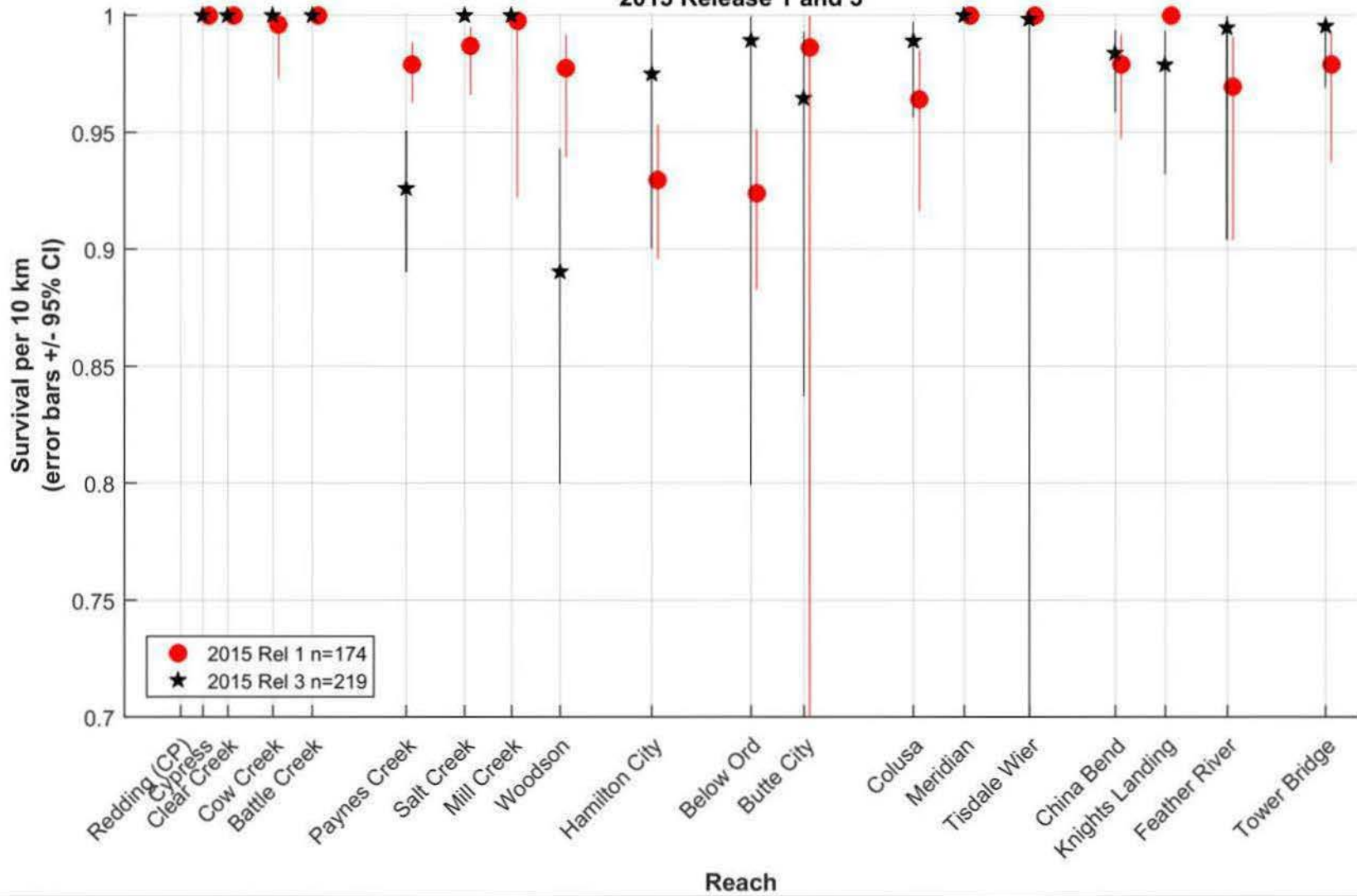




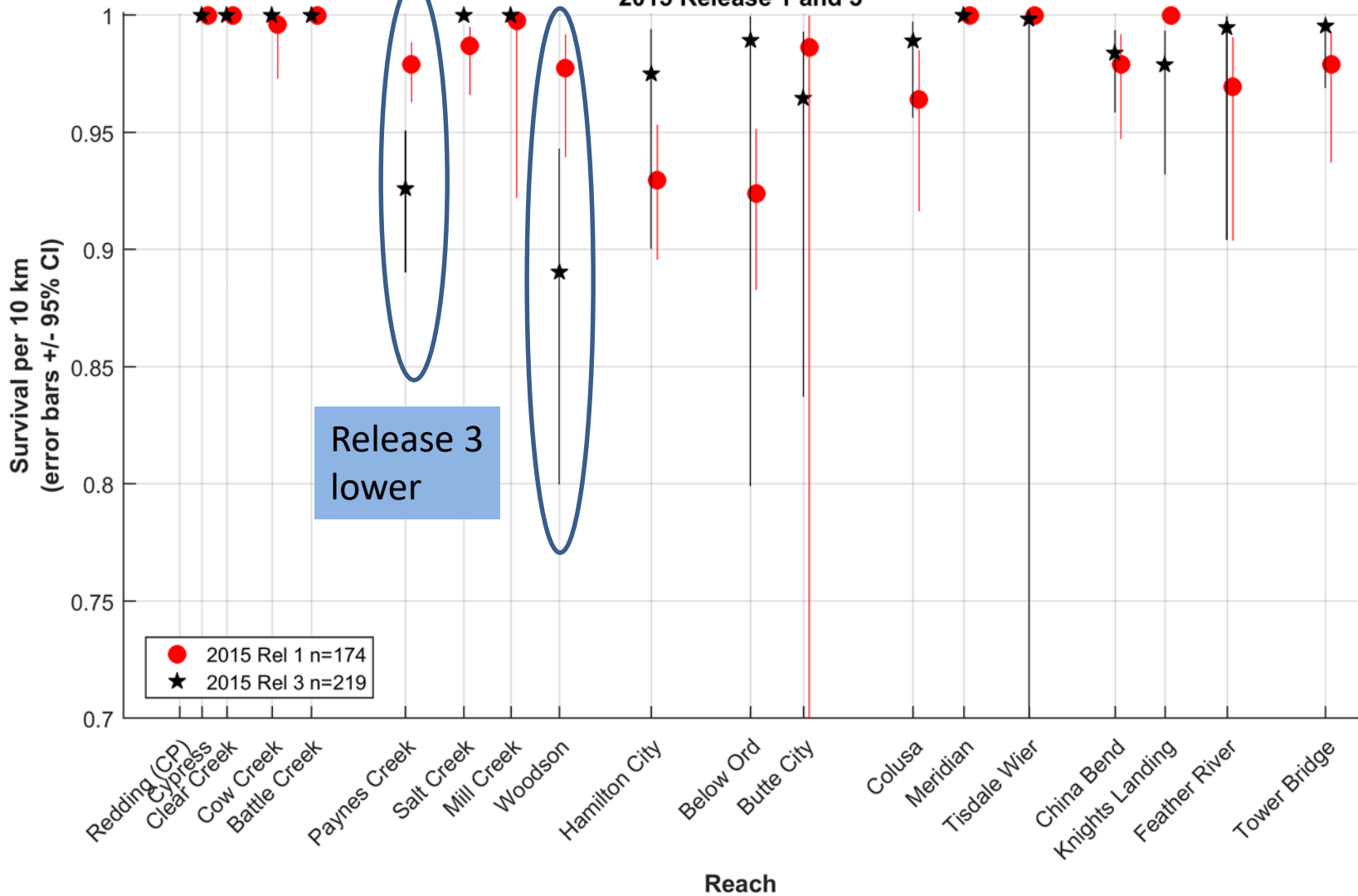
# Abv\_WoodsonBr (425)



### Survival: Winter-run Chinook Migrators 2015 Release 1 and 3



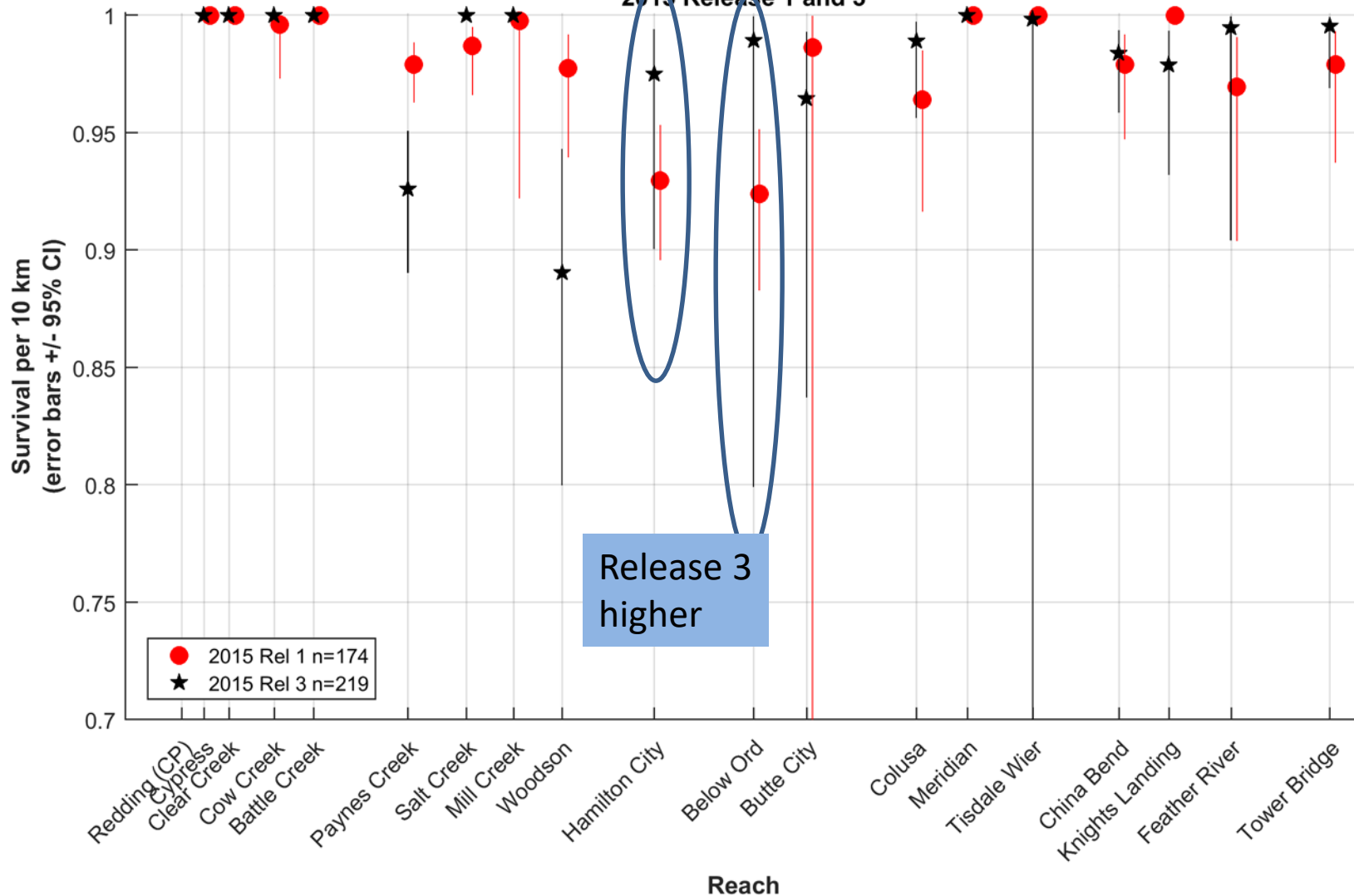
### Survival: Winter-run Chinook Migrants 2015 Release 1 and 3





# Survival: Winter-run Chinook Migrators

## 2015 Release 1 and 3



# Summary

## Predator Swamping

- **Not supported**
- **Preliminary analysis**
- **Assumptions incorrect**
  - **Density of conspecifics**
  - **Predation relatively low**

# Summary

## Movement patterns

- **Migrators 70% and Holders 30%**
  - **Ratio same for both releases**
- **Movement during low flow**
  - **Less variation in arrival times**
- **Movement during high flow**
  - **More variation in arrival times**

# Future Work

## Look at 2016

- Also had two releases
- Flows more moderate

## Different method to estimate density

- Use acoustic data to estimate density of fish entering reaches instead of release group as proxy for density

# THANKS

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