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NWFSC

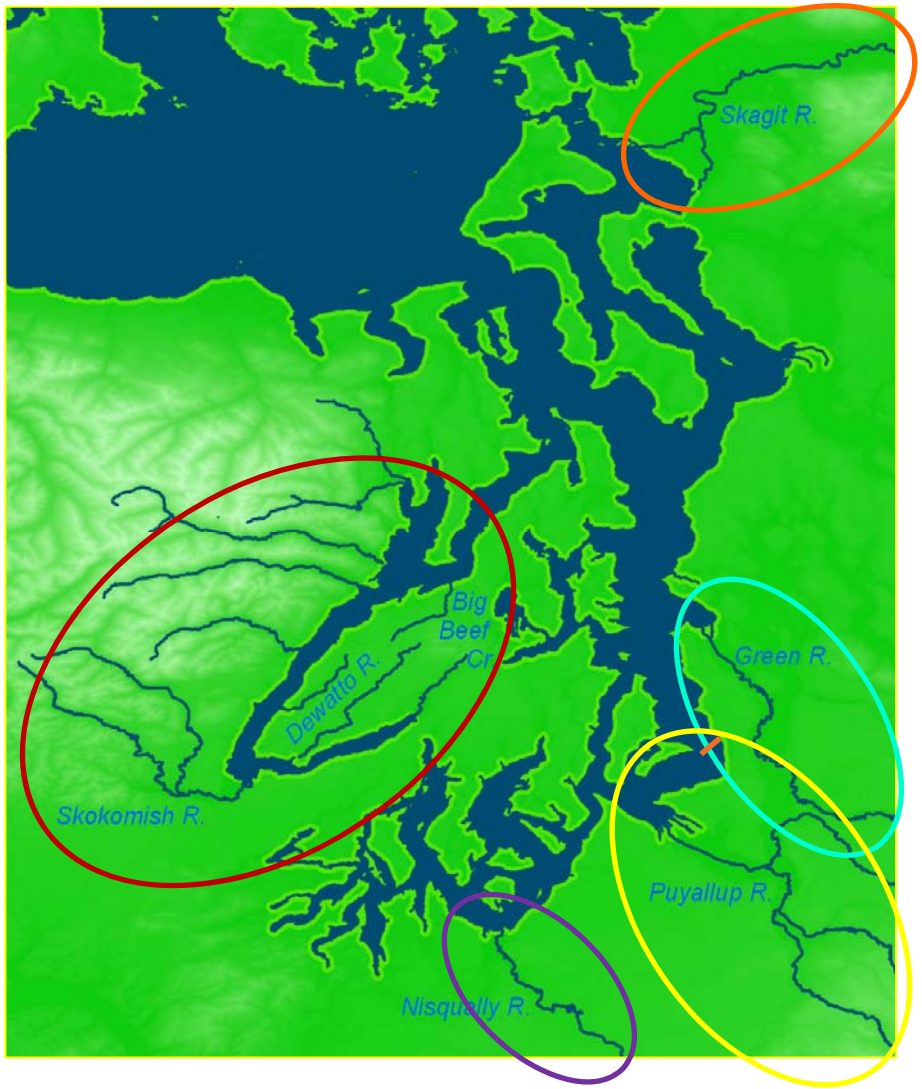
Decoupling freshwater and marine effects on the early marine survival of steelhead smolts through Puget Sound

Megan Moore
Barry Berejikian

Manchester Laboratory, NOAA Fisheries

SALISH SEA MARINE SURVIVAL PROJECT
www.marinesurvivalproject.com

Previous Puget Sound Telemetry Studies



Hood Canal Rivers: 2006-2010
Moore, Berejikian, et al. (NWFSC)

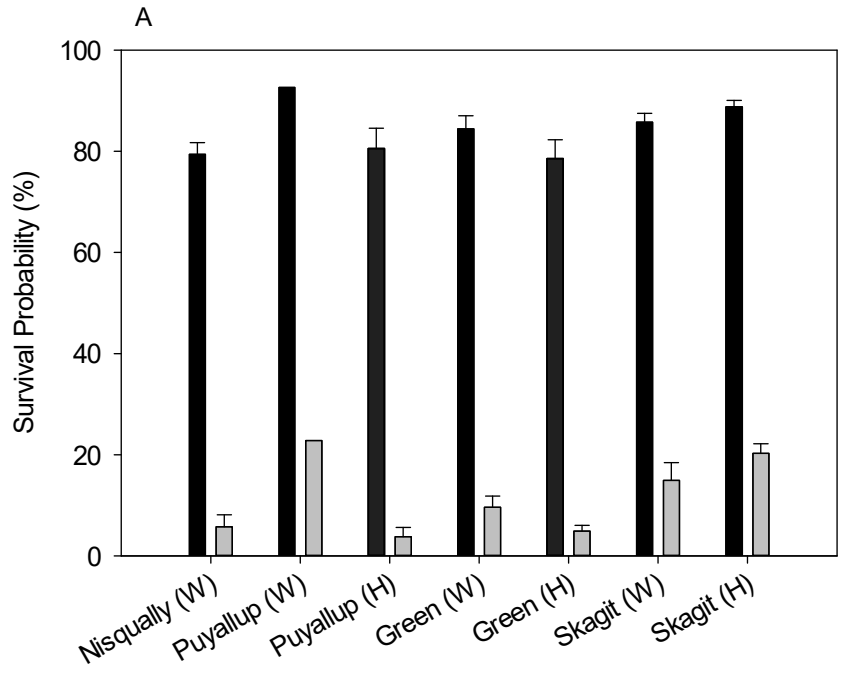
Green River: 2006-2009
Fred Goetz, Tom Quinn et al (UW, ACOE)

Puyallup River: 2006, 2008-2009
Andrew Berger et al. (Puyallup Tribe)

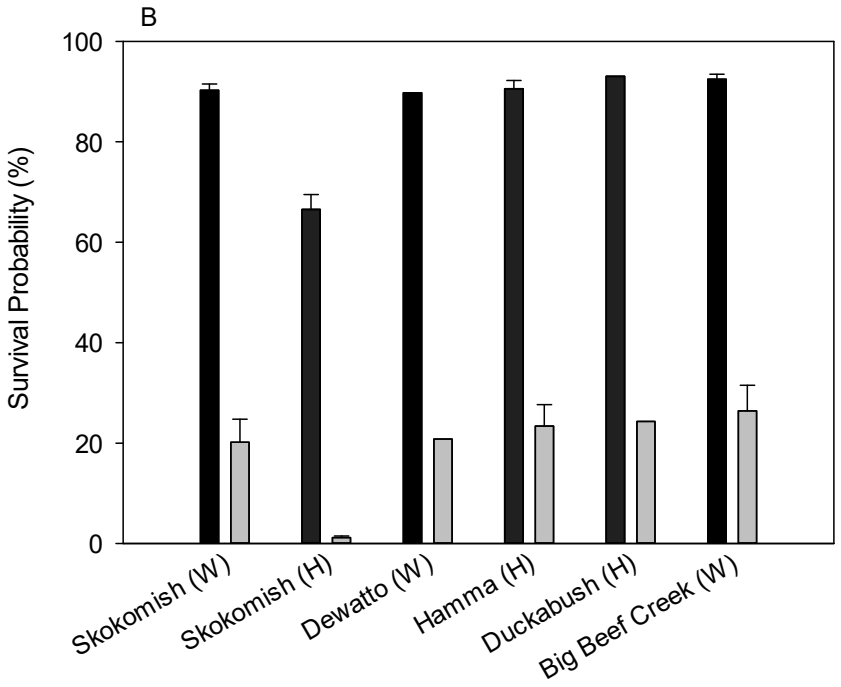
Nisqually River: 2006-2009
Sayre Hodgson et al. (Nisqually Tribe)

Skagit River: 2006-2009
Ed Conner et al. (Seattle City Light)

- Low marine survival rates
- Hatchery fish generally had lower survival
- Lower survival for longer migration distances



Puget Sound



Hood Canal

river
marine

NOAA FISHERIES

Salish Sea Marine Survival Project

SALISH SEA
MARINE SURVIVAL PROJECT
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2013 Steelhead Technical Team convened to determine causes of declines in marine survival

What we know:

- Steelhead marine survival through Puget Sound is LOW, likely limiting recovery

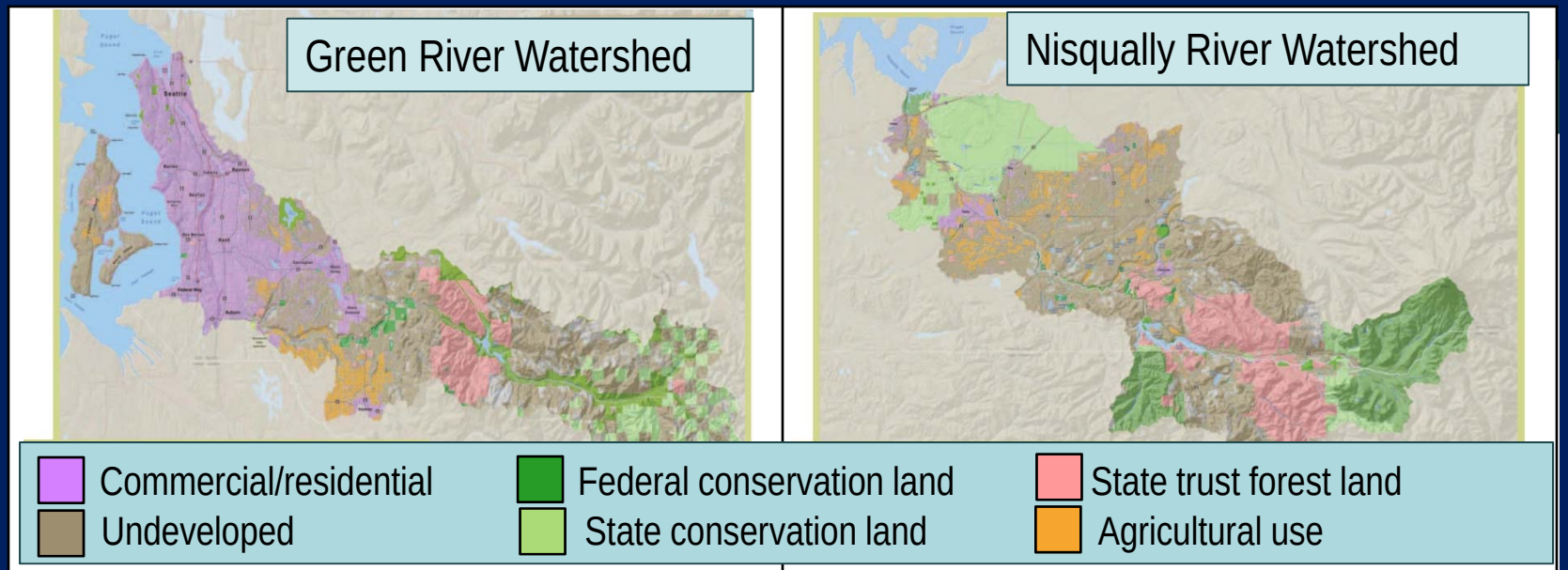
What we don't know:

- Mechanisms of mortality: what is it about the Puget Sound migration that is causing fish to die?

2014 Telemetry efforts began with the following objectives:

- Separate **freshwater** effects (habitat conditions and hatchery influence) from **marine** effects on marine survival
- Identify areas of low survival ('hot spots')
- Investigate effects of body size, outmigration timing, marine entry point

Treatment vs. control



Green River Watershed	Nisqually River Watershed
• Lower watershed 75% industrial/residential	• Lower watershed 5% industrial/residential
• Degraded riparian zone (lower river 95% armored)	• Healthy riparian zone
• 2% of historic estuary/mudflats remains	• Largest undeveloped delta in Puget Sound
• Steelhead hatchery since 1964	• No steelhead released since 1994

The Experiment

- Smolts collected at Nisqually R. and Green R. smolt traps
- Surgically implanted with Vemco V7 acoustic transmitters
- Held overnight in flow-through tanks at trap/tagging location
- Released at RKM 19 the following morning at either home or away location

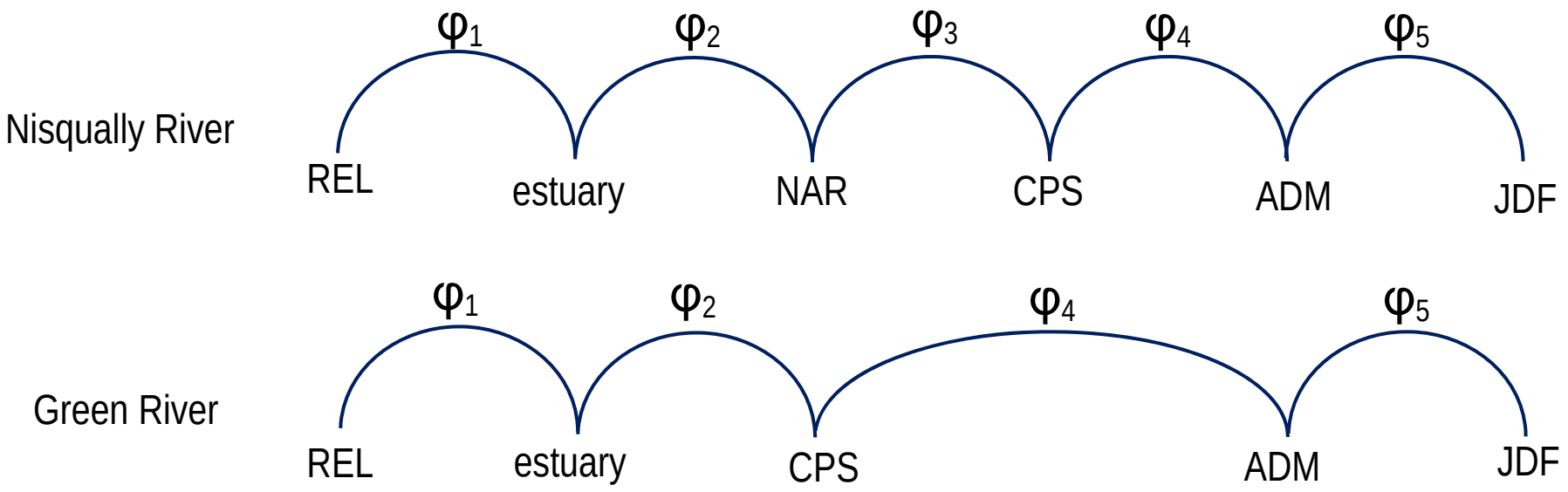
	GREEN POPULATION		NISQUALLY POPULATION			
Release Week	Away	Home	Away	Home	**Delay**	**TOTAL**
1 (4/27-5/3)	12	13	12	12	10	59
2 (5/4-5/10)	13	12	13	13	10	61
3 (5/11-5/17)	12	18	13	12	11	66
4 (5/18-5/24)	13	10	12	13	12	60
TOTAL	**50**	**53**	**50**	**50**	**43**	**246**

Photos by Matt Klungle


JDF
EST
REL

Survival Analysis

mark-recapture (Program MARK)



FIXED DETECTION PROBABILITY

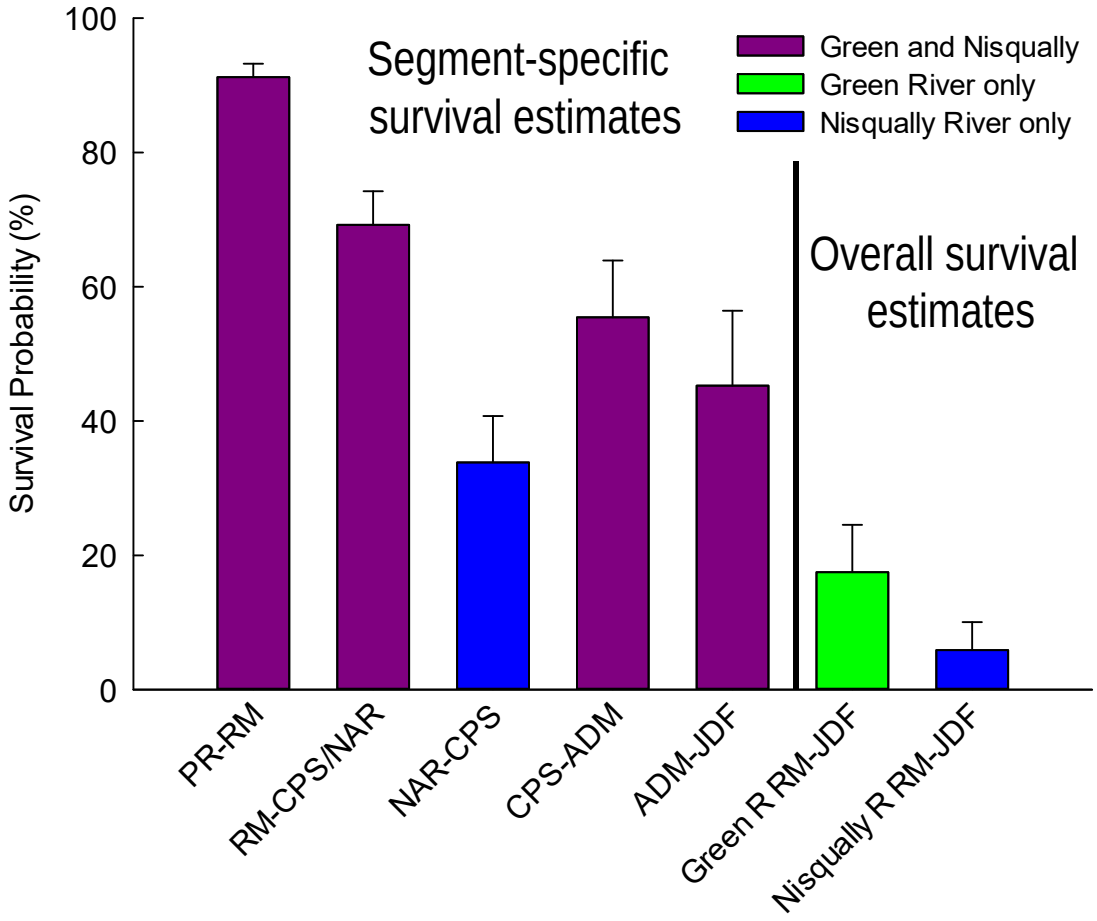
JDF = 68.5 % (Melnychuk)
(V7/V9 comparison = 66.67%)

MODEL VARIABLES

- Population (genetic or habitat)
- River (release location)
- translocation (home or away)
- fork length
- release date

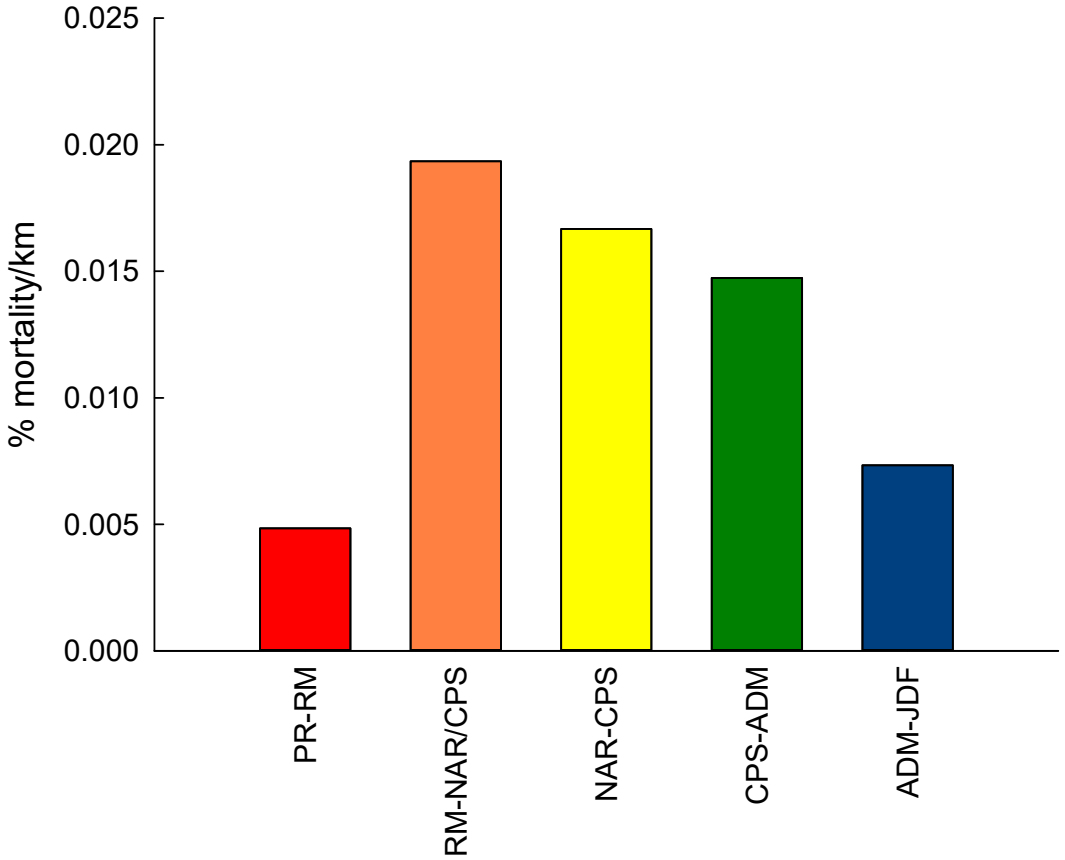
Survival Analysis - results

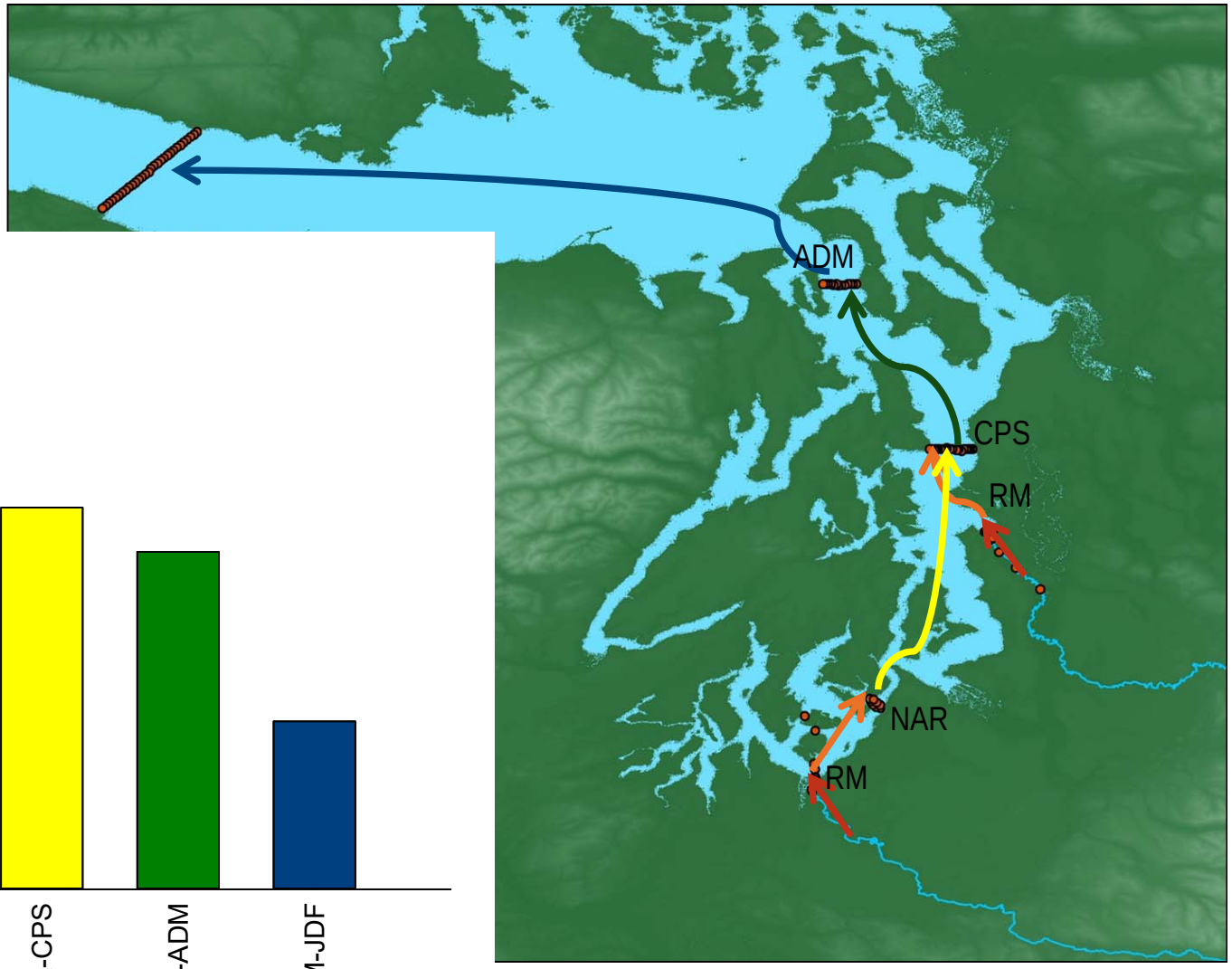
Lowest AICc = migration segment x release date



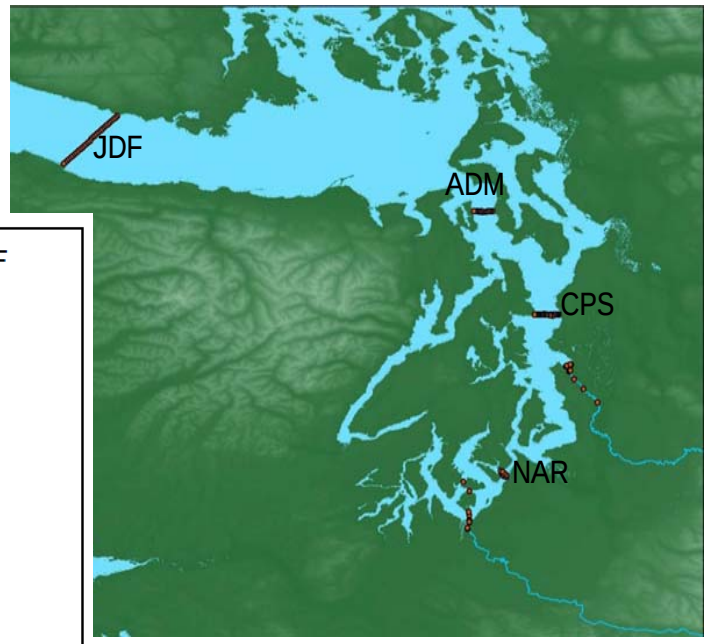
parameter	relative weight
release	0.64
pop	0.26
length	0.23
translocation	0.22
river	0.22

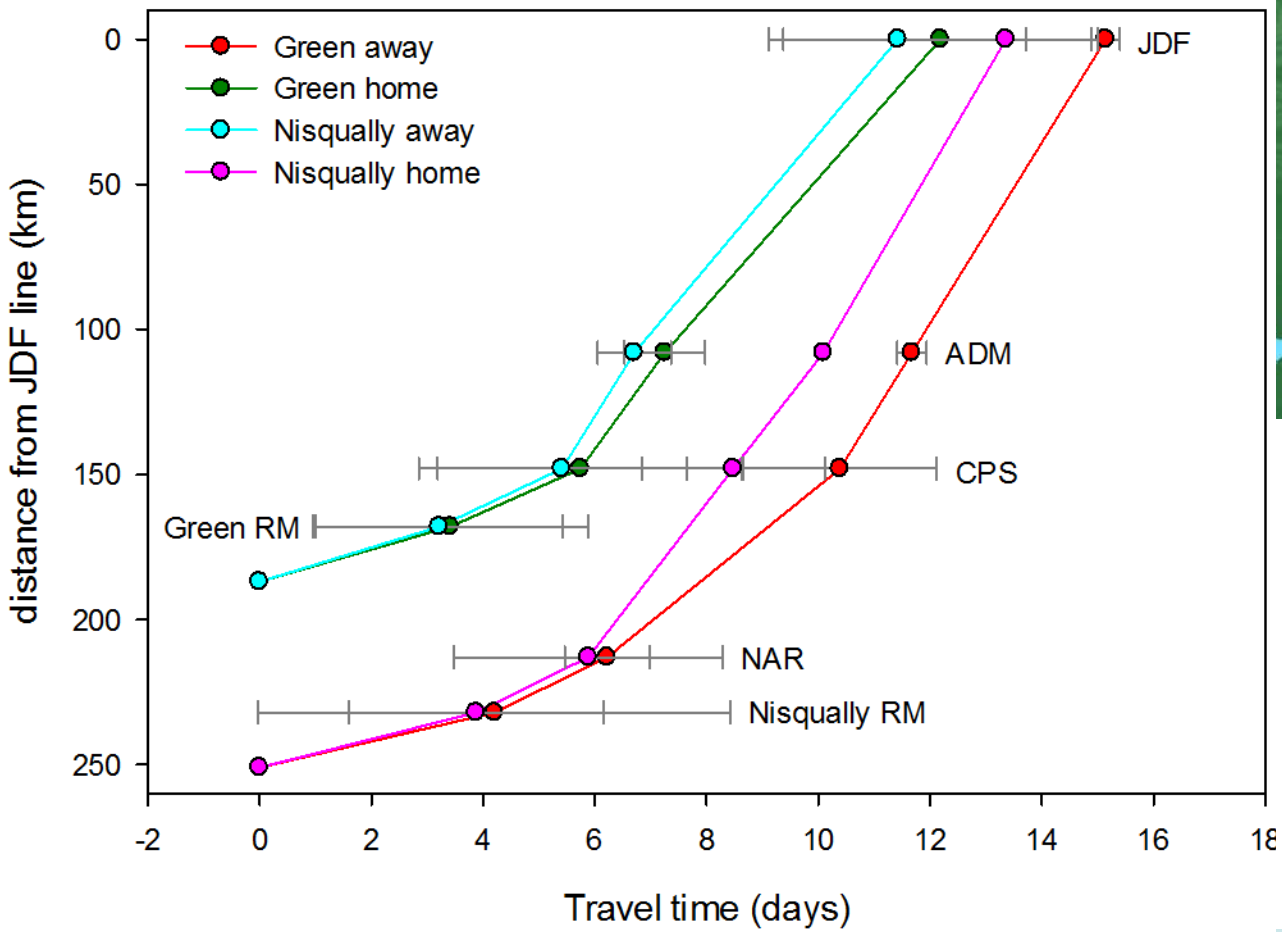
Where is mortality most acute?



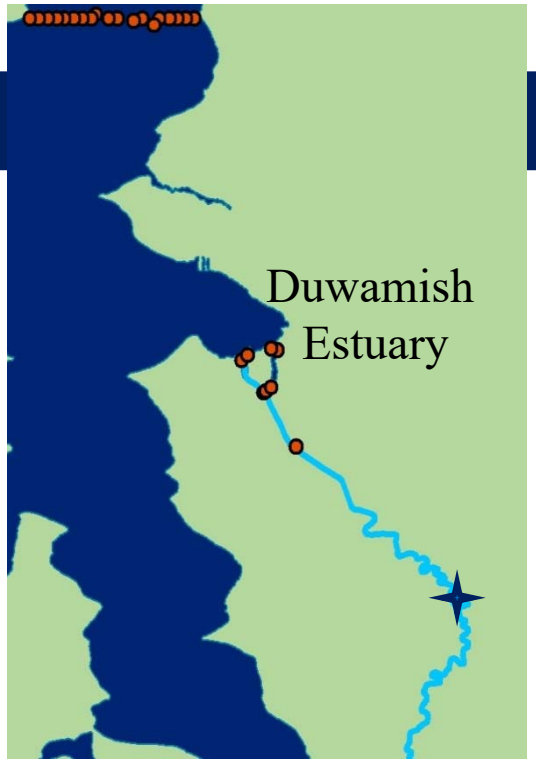


Steelhead smolt travel time



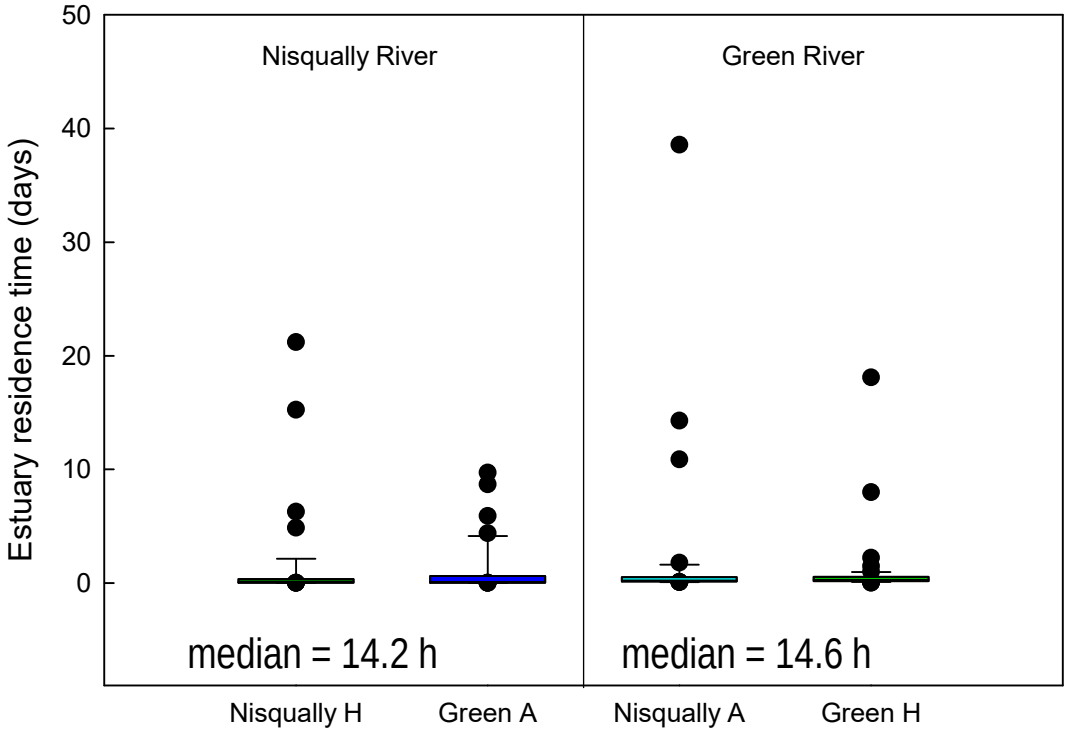


ESTUARY BEHAVIOR

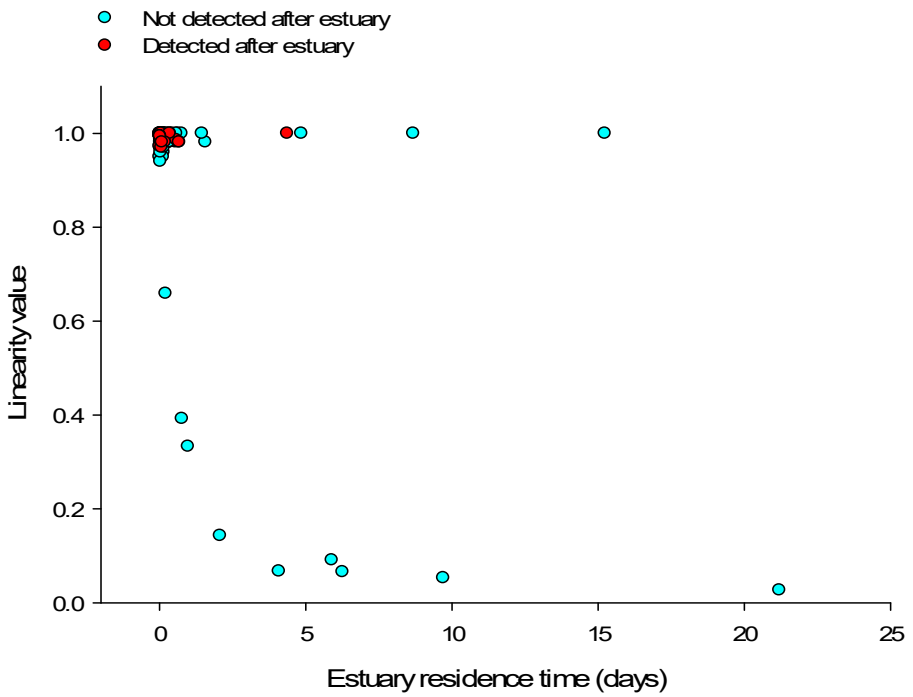


	NISQUALLY	GREEN
Release to RM distance	19 km	19 km
First - last estuary receiver distance	4 km	5 km
Number of Estuary receivers	6	8
Detection rate of lower receivers	100%	100%
Distance to first marine line	19 km	19 km
Degree of urbanization	Low	High

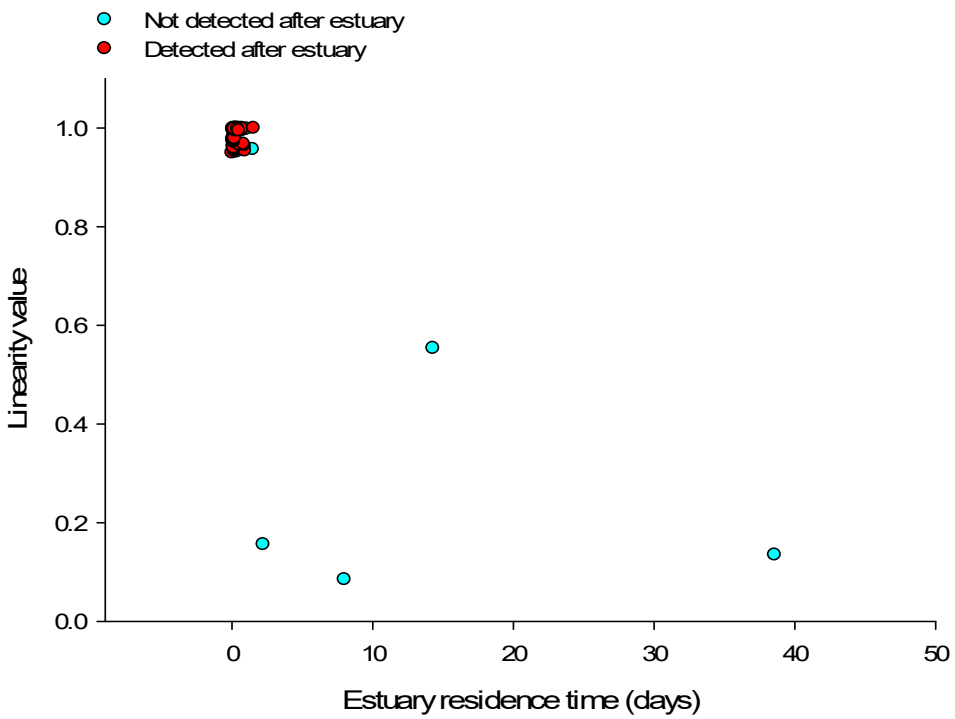
ESTUARY RESIDENCE TIME



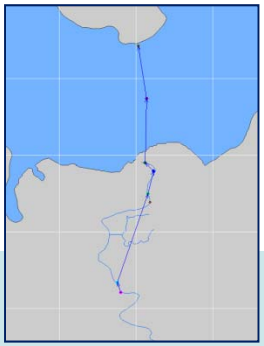
Nisqually River

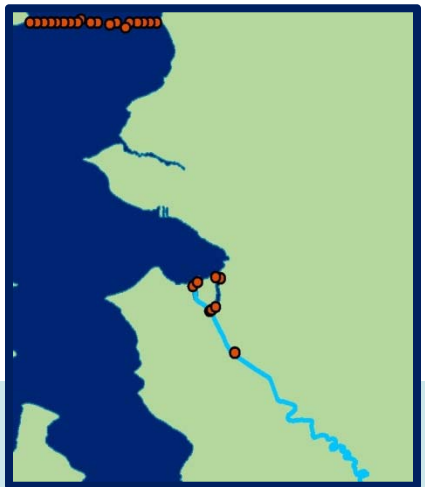


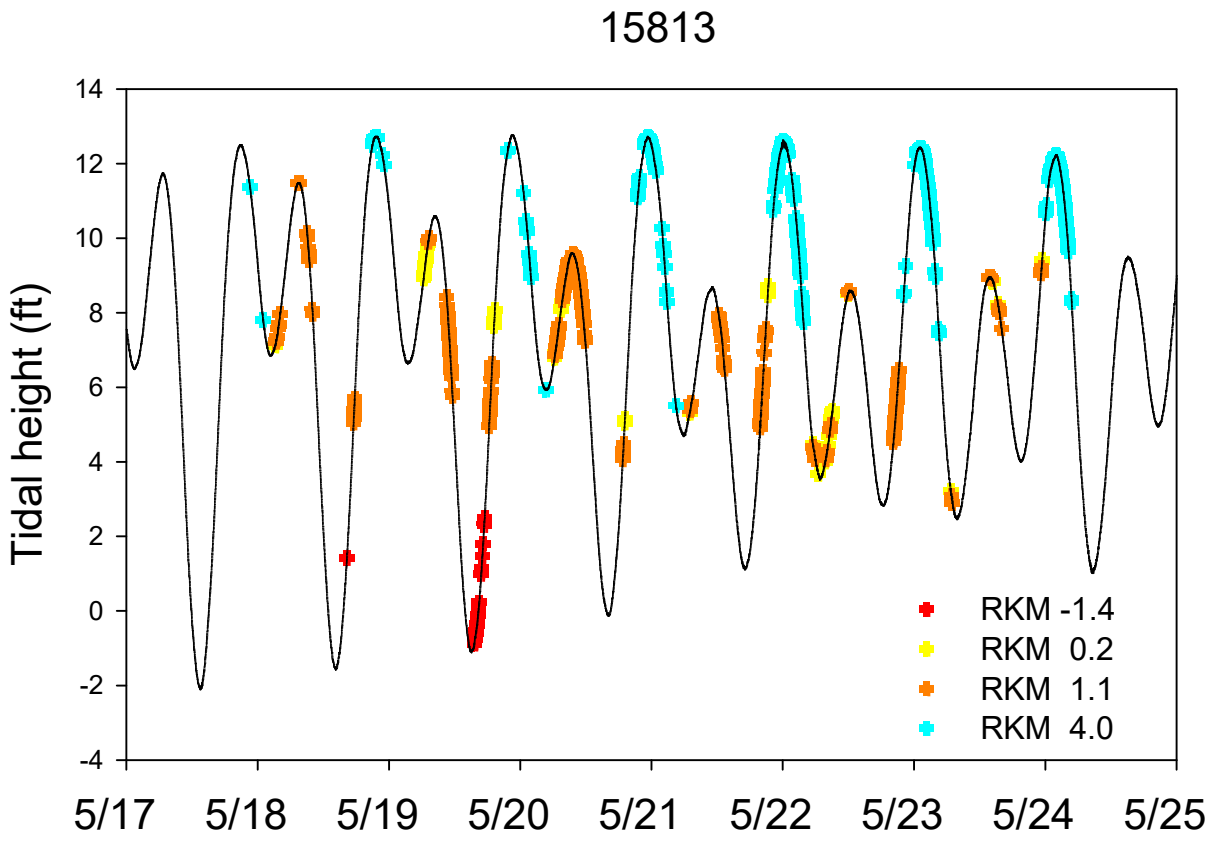
Green River

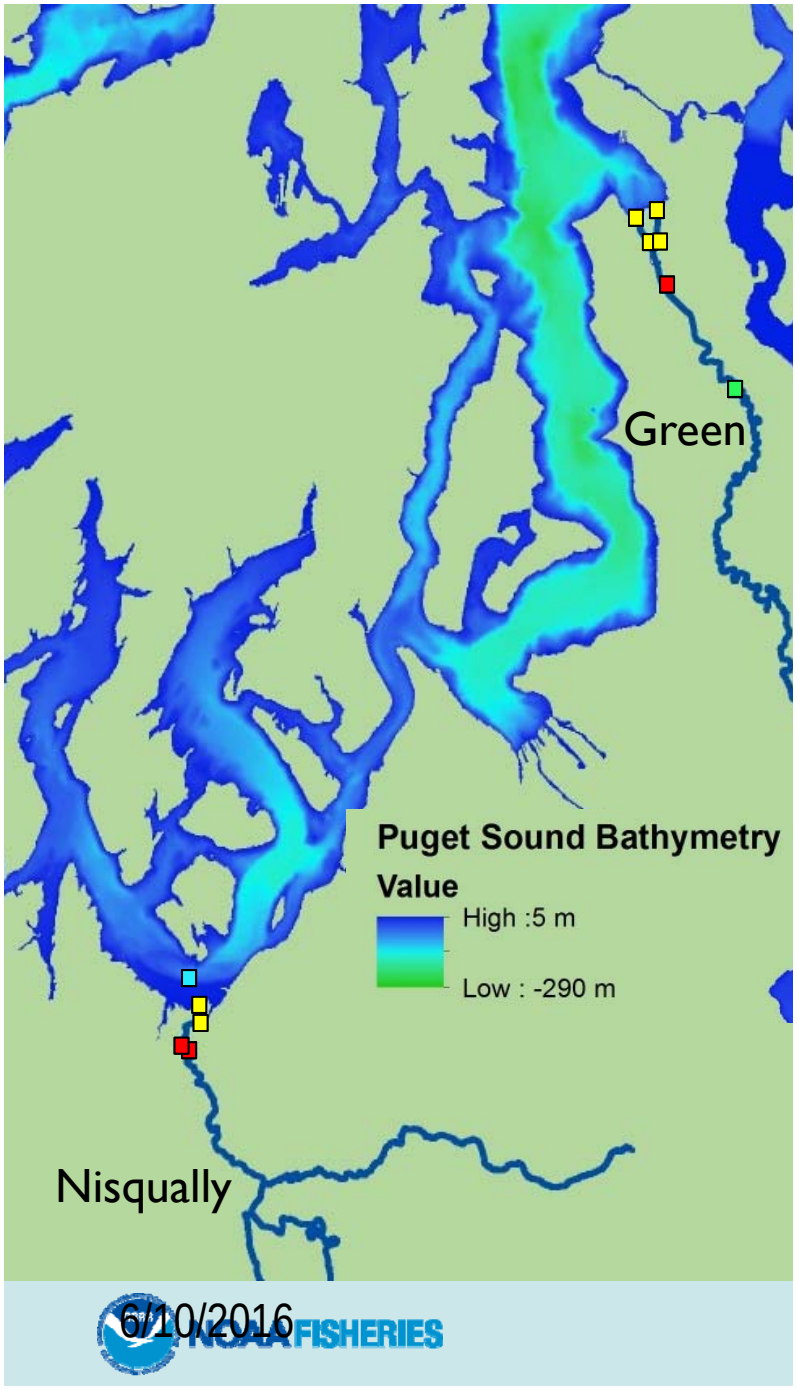


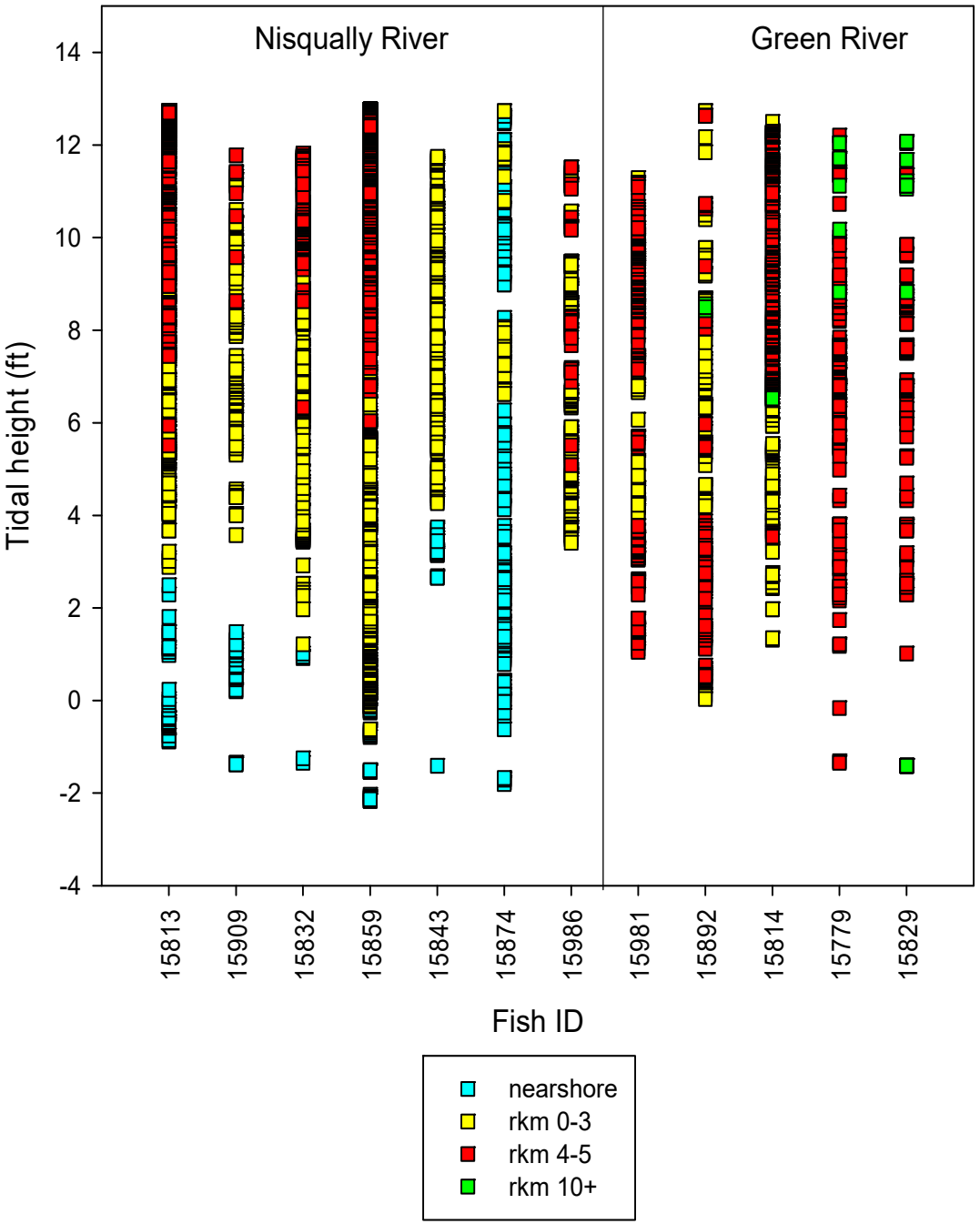
Linearity = $\frac{\text{max track range}}{\text{distance travelled}}$






15813
Tidal height (ft)
14
12
10
8
6
4
2
0
-2
-4
5/17
5/18
5/19
5/20
5/21
5/22
5/23
5/24
5/25
RKM -1.4
RKM 0.2
RKM 1.1
RKM 4.0

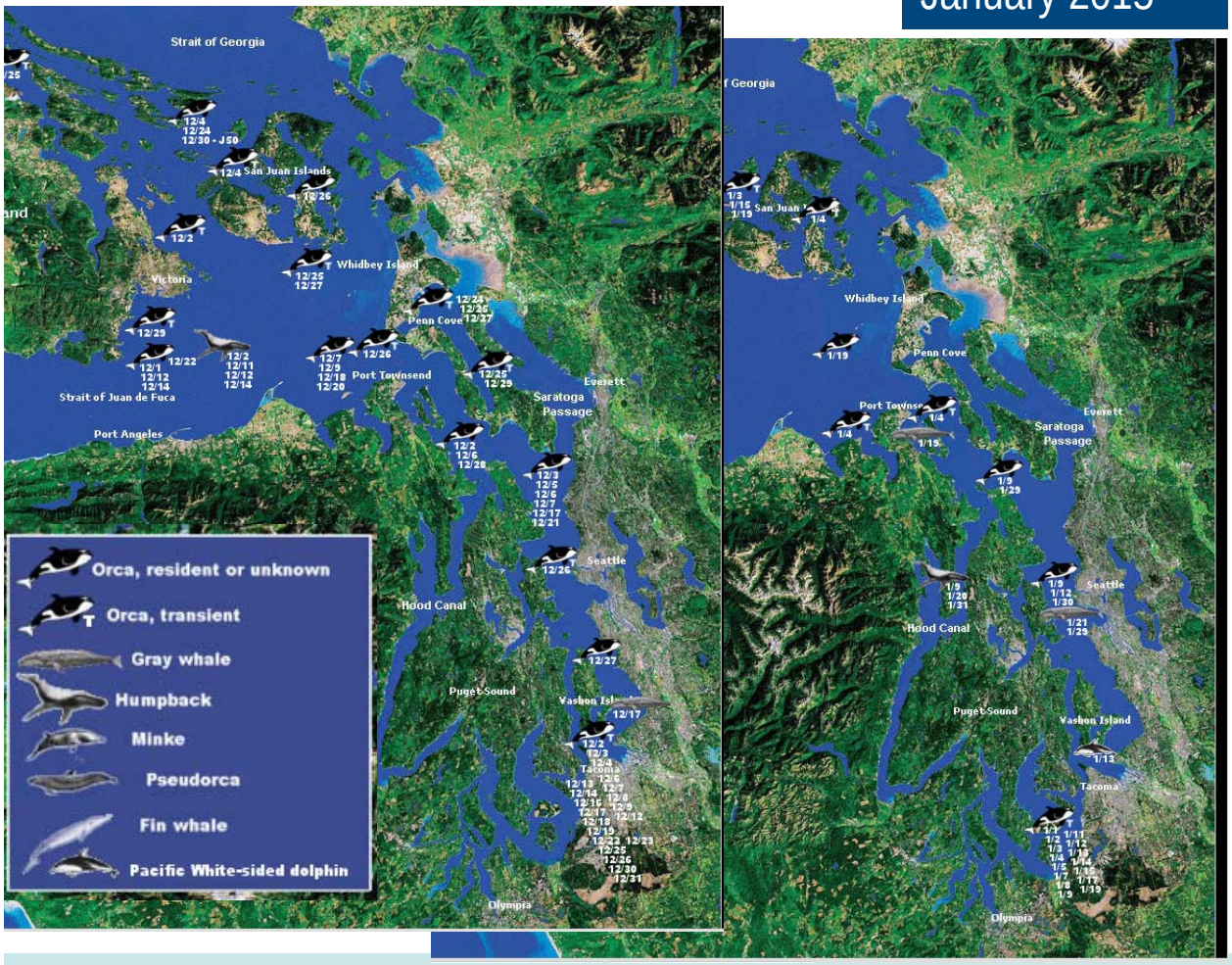

Green
Puget Sound Bathymetry
Value
High :5 m
Low : -290 m
Nisqually


Nisqually River
Green River
Tidal height (ft)
14
12
10
8
6
4
2
0
-2
-4
15813
15909
15832
15859
15843
15874
15986
15981
15892
15814
15779
15829
Fish ID
nearshore
rkm 0-3
rkm 4-5
rkm 10+

Orca network sightings - 2015

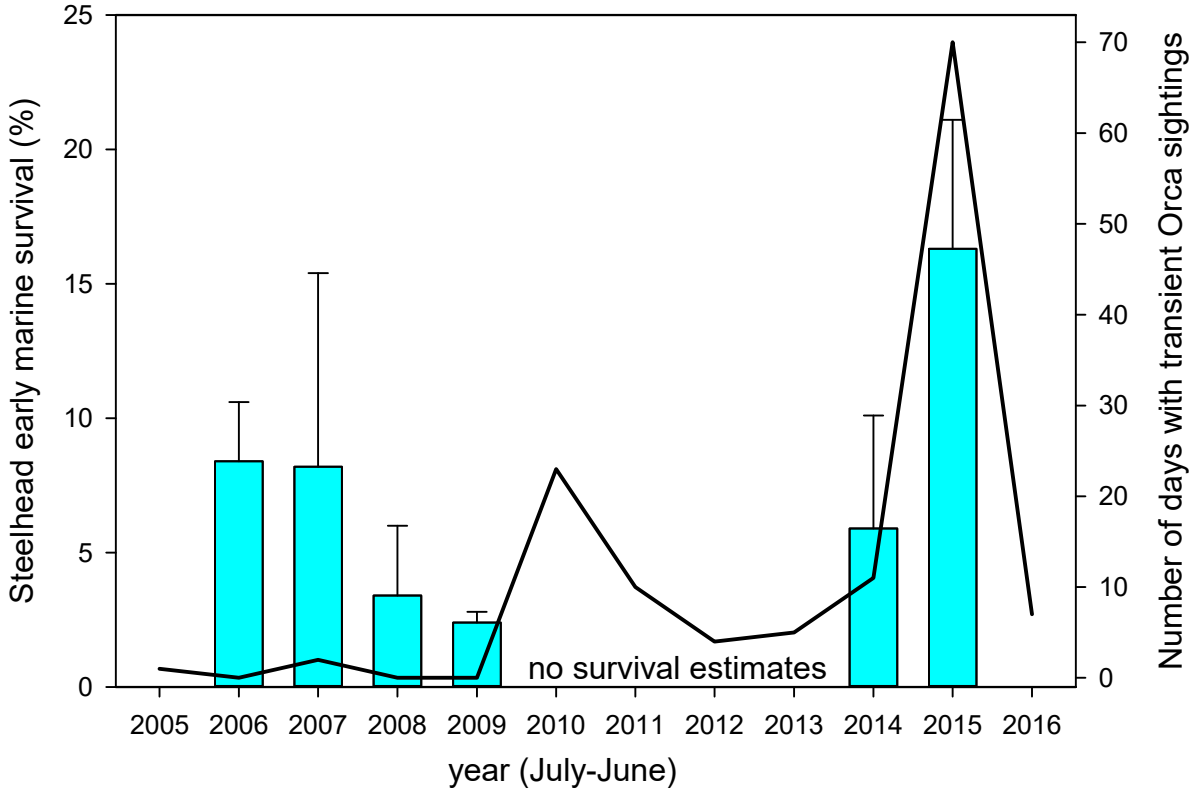
December 2014

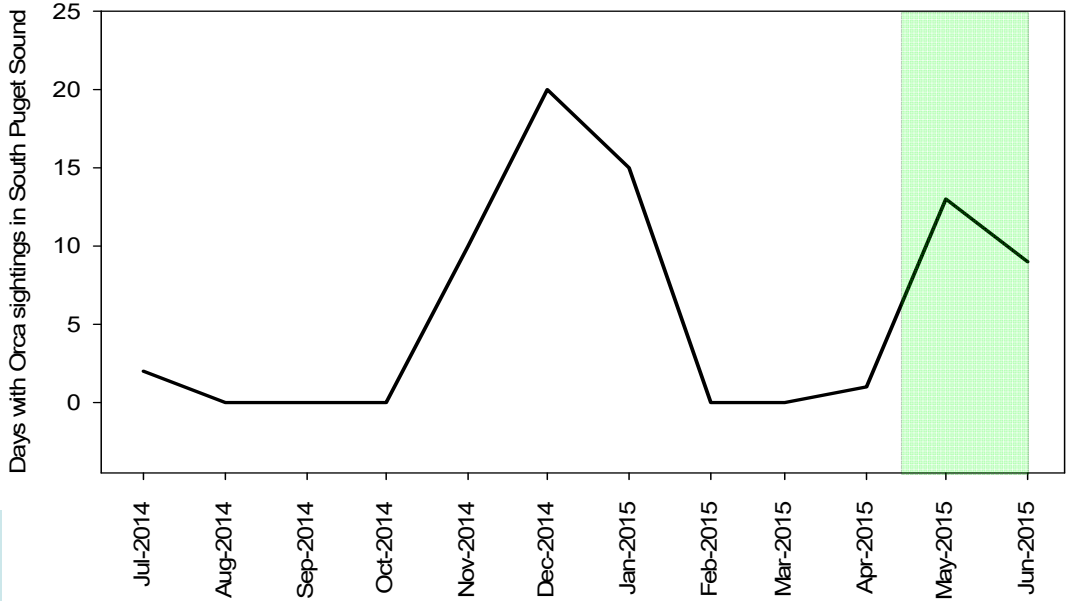
January 2015



(Relevant) ORCA FACTS

- Resident Orcas eat salmon
- Transient Orcas eat marine mammals
- Transient orcas rarely come into Puget Sound
- 2015 anomalous behavior brought them into the sound for 3 months in the winter and 3 months in the spring


Steelhead early marine survival (%)
Number of days with transient Orca sightings
no survival estimates
year (July-June)
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016


Days with Orca sightings in South Puget Sound
Jul-2014
Aug-2014
Sep-2014
Oct-2014
Nov-2014
Dec-2014
Jan-2015
Feb-2015
Mar-2015
Apr-2015
May-2015
Jun-2015

Conclusions

- Puget Sound (RM-JDF) survival probabilities are low (Green – 17%, Nisqually – 6%) – similar to previously calculated Puget Sound estimates
- Release date was the only important model variable; distance was the most important factor affecting early marine survival
- Smolts from both rivers took a similar amount of time from release to the JDF Strait (< 2 weeks)
- Highest mortality rates occurred in the first marine segment for both populations
- Measures of behavior in the estuary may help identify some causes of mortality
- Patterns in survival over multiple years can help us understand predator-prey interactions and the impact of anomalies

Acknowledgements

Steelhead Advisory Group to the SSMSP

LLTK: Michael Schmidt, Iris Kemp

WDFW: Joe Anderson, Pete Topping, Matt Klungle, Chris Frazier

Green River Trap Crew (Bob Green & Matt Pollack)

Nisqually Trap Crew (Devin West, Justin Miller, & Lars Swartling)

Nisqually Tribe: Chris Ellings, Sayre Hodgson, Jed Moore, Walker Duvall

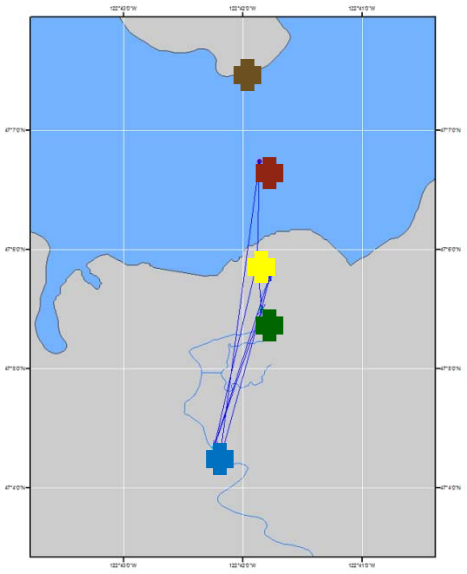
Muckleshoot Tribe: Ava Fuller, Eric Warner, Sean Hildebrandt

Squaxin Tribe: Scott Steltzner

NWFSC: Anna Kagley, Heather Jackson, Rob Endicott, Jose Reyes- Tomassini, Jeff Atkins

Port of Seattle: George Blomberg, Mick Schultz



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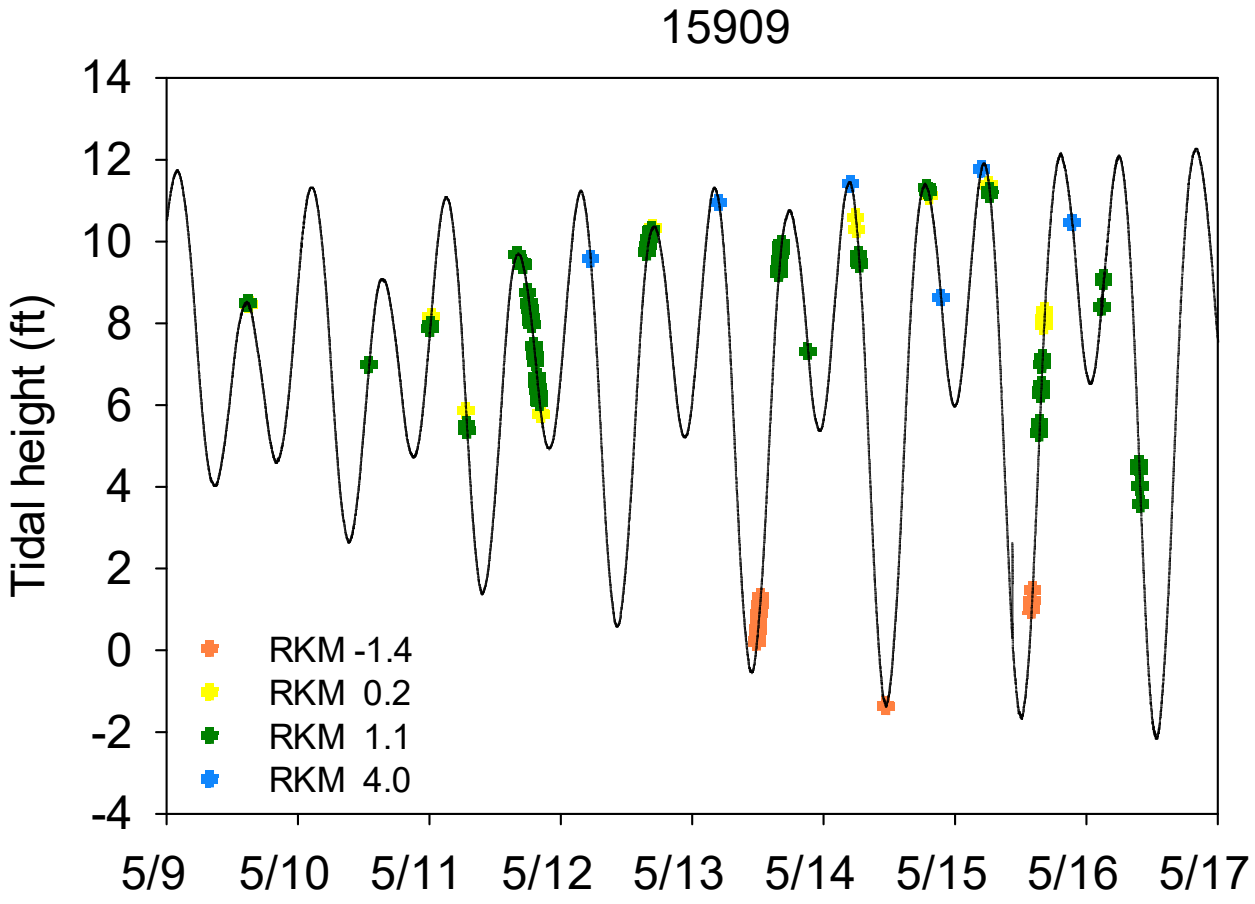

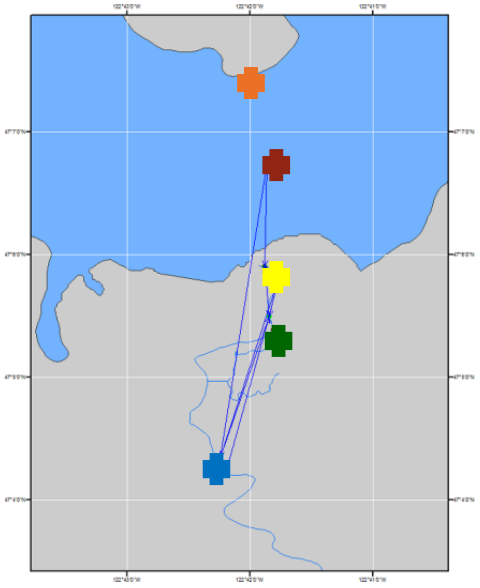

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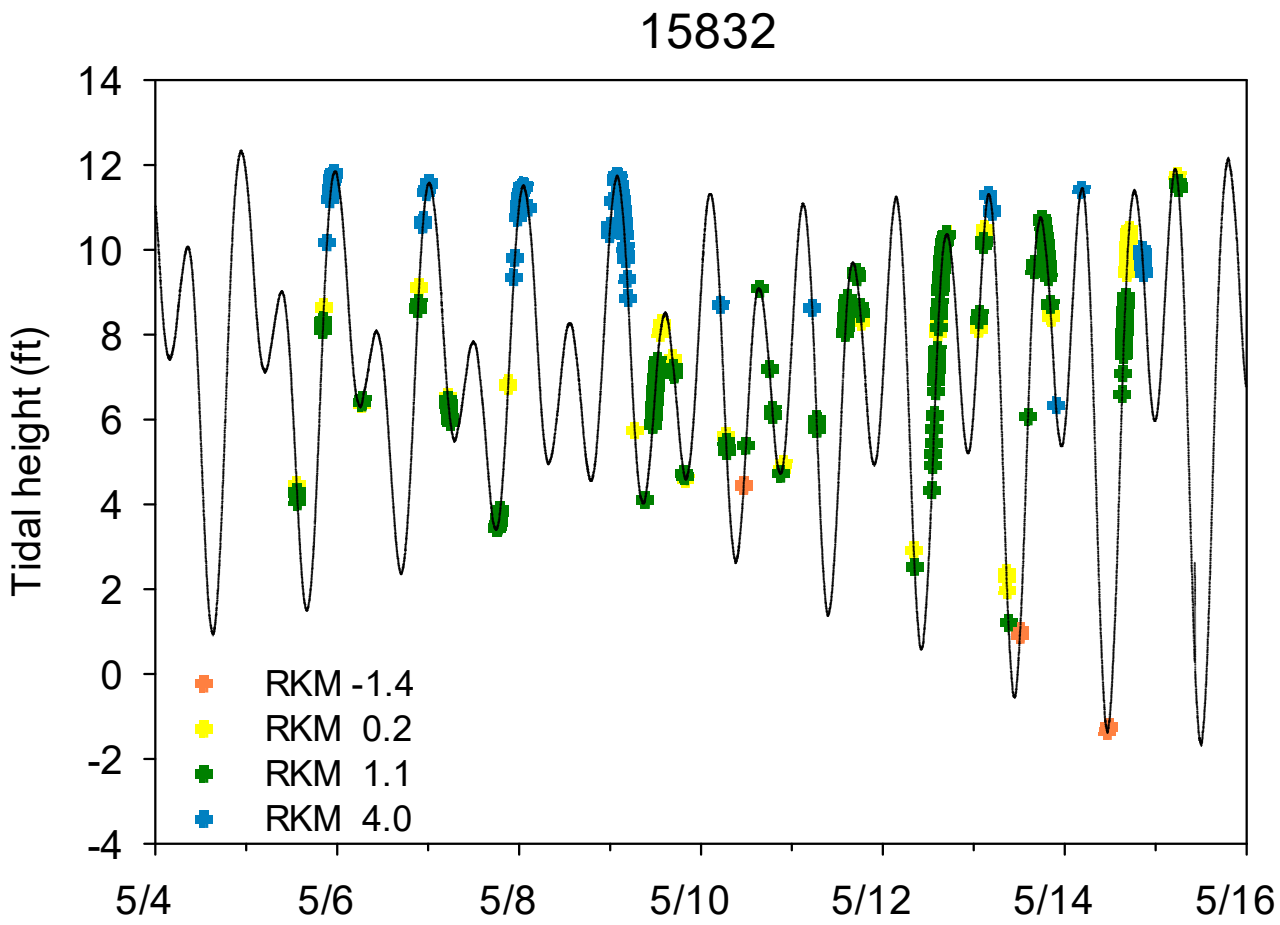

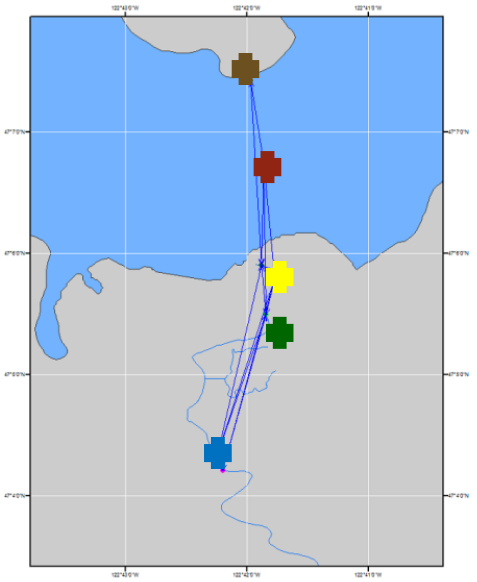

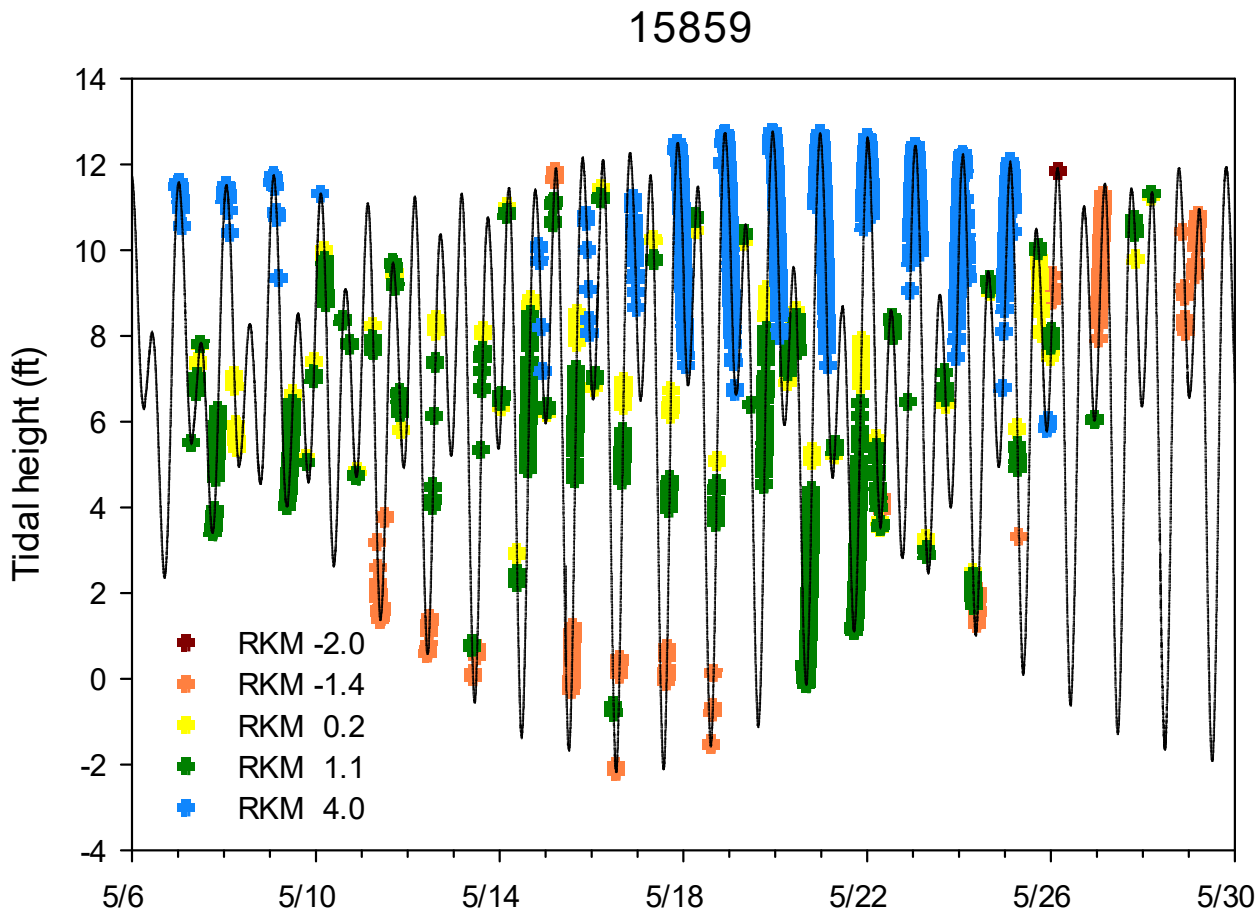

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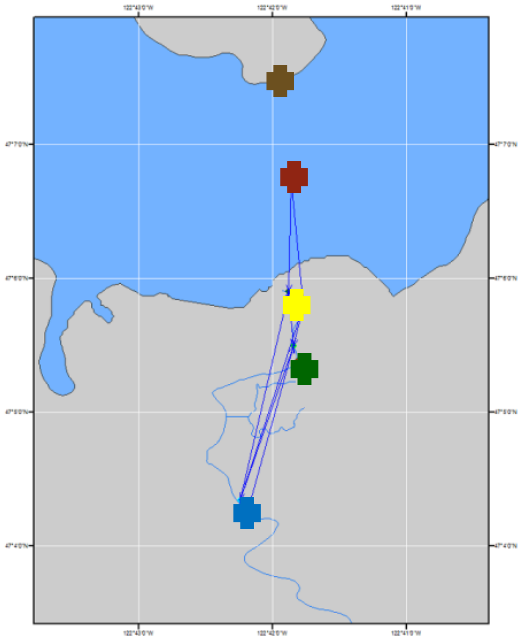
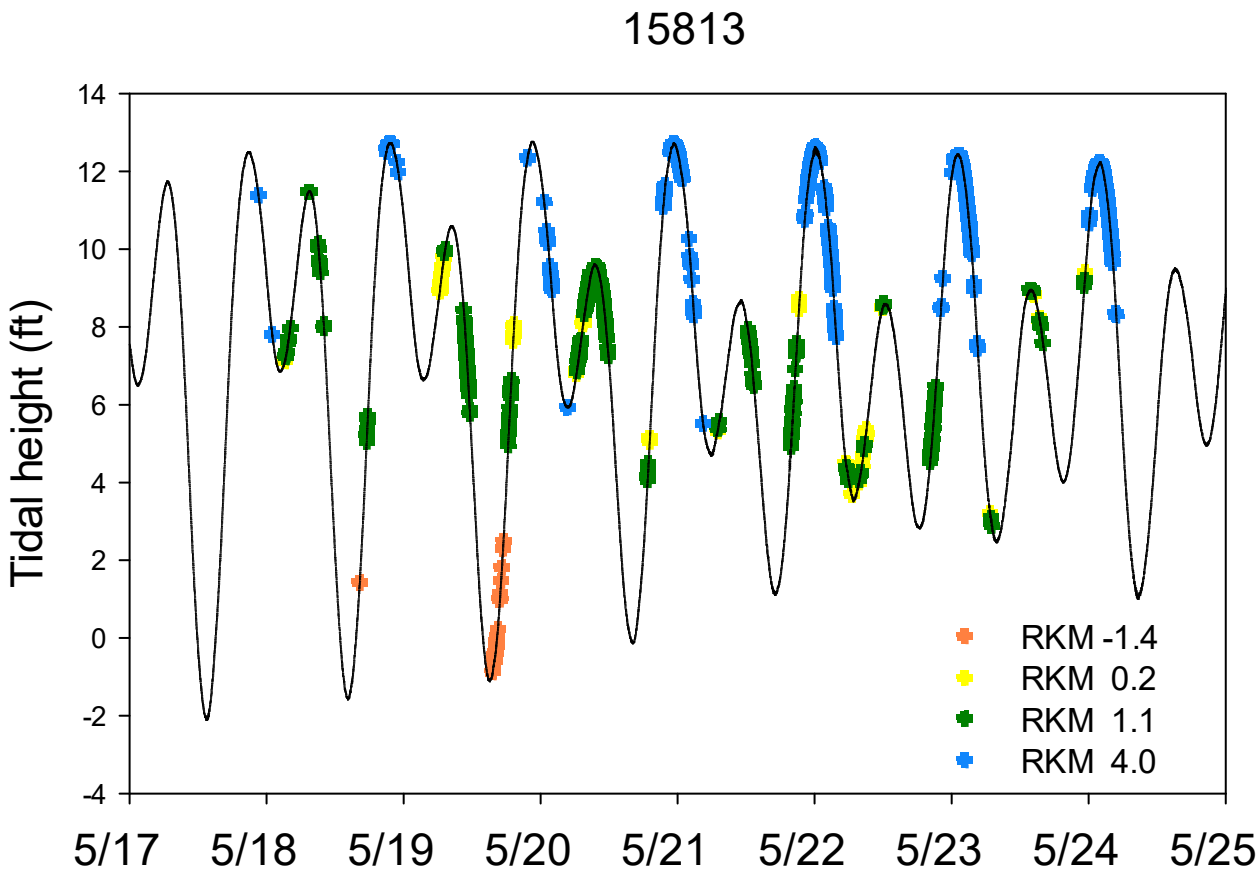
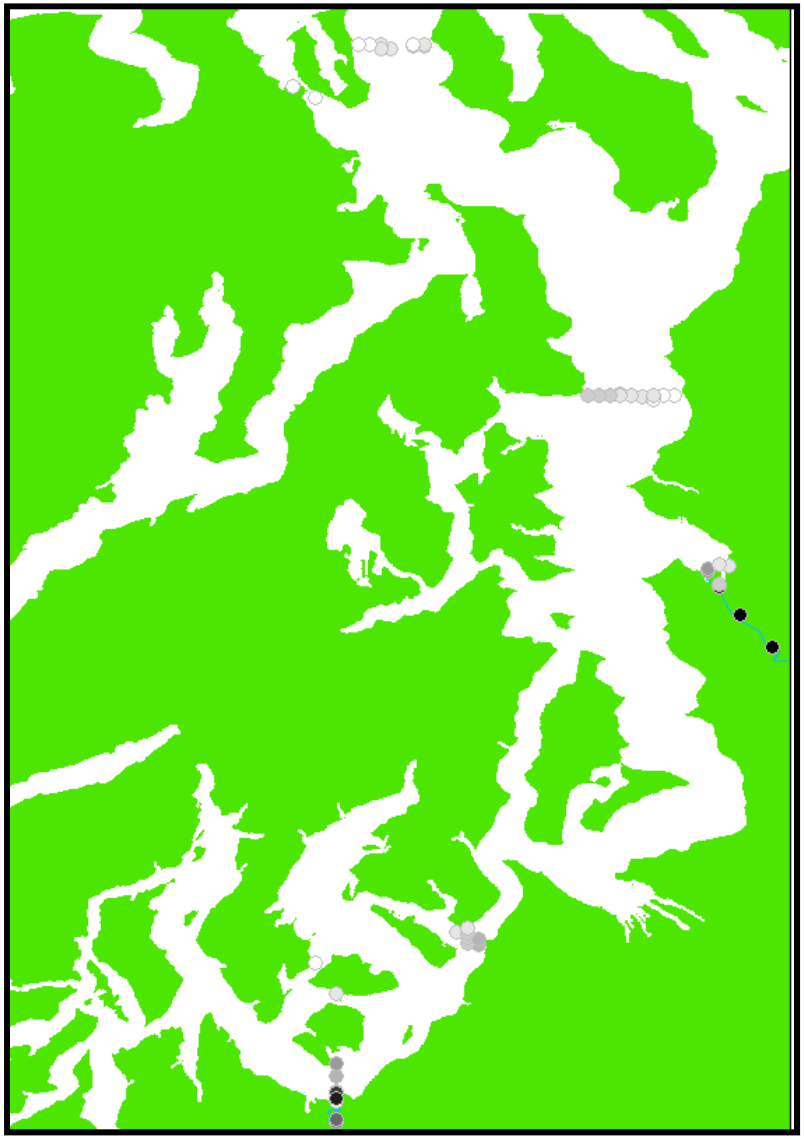


5 Upper --> I5 Lower --> Distrib Lower --> Animal Upper --> Animal Lower --> Nisqually --> Animal Lower --> Animal Upper --> I5 Lower --> I5 Upper --> I5 Lower --> Distrib Lower --> Animal Upper --> Animal Lower --> Nisqually --> Animal Lower --> Animal Upper --> Distrib Lower --> I5 Lower --> I5 Upper --> I5 Lower --> Distrib Lower --> Animal Upper --> Distrib Lower --> Animal Upper --> Distrib Lower --> Animal Upper --> Animal Lower --> Animal Upper --> Distrib Lower --> I5 Lower --> I5 Upper --> I5 Lower --> Distrib Lower --> Animal Upper --> Animal Lower --> Animal Upper --> Animal Lower --> Animal Upper --> Distrib Lower --> I5 Lower --> Distrib Lower --> Animal Upper --> Animal Lower --> Animal Upper --> Distrib Lower --> Animal Upper --> Distrib Lower --> Animal Upper --> Distrib Lower --> Animal Upper --> Animal Lower --> Animal Upper --> I5 Lower --> I5 Upper --> I5 Lower --> Distrib Lower --> Animal Upper --> Animal Lower --> Animal Upper --> Animal Lower --> Animal Upper --> Animal Lower --> Animal Upper --> Distrib Lower --> Animal Upper --> Animal Lower --> Animal Upper --> Distrib Lower --> I5 Lower --> Animal Lower

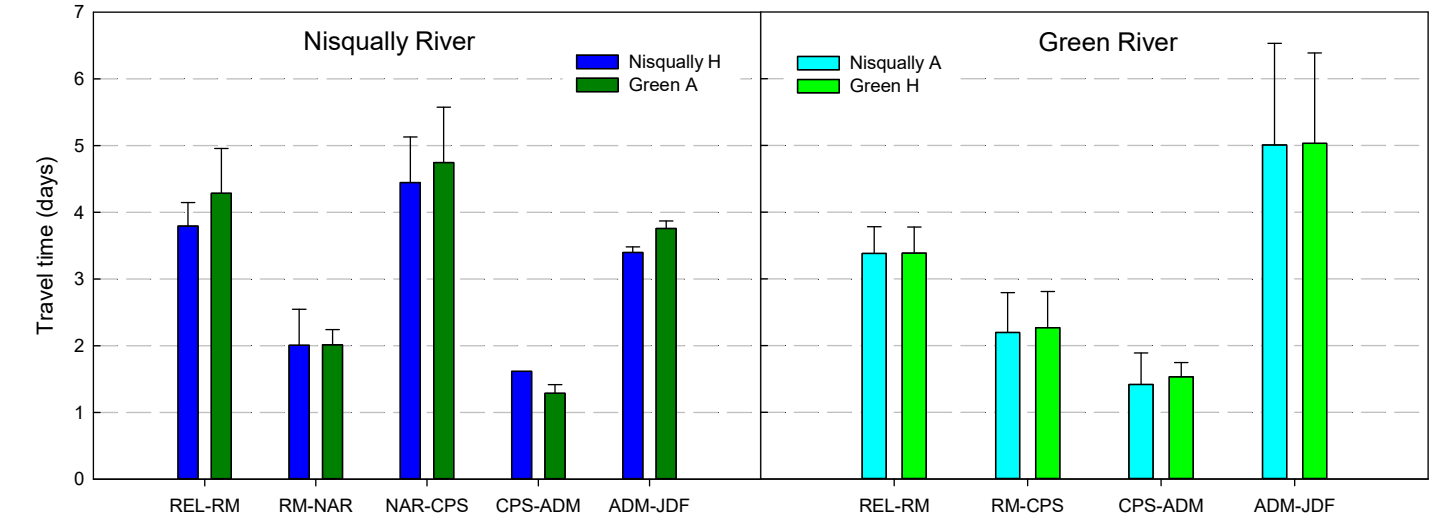


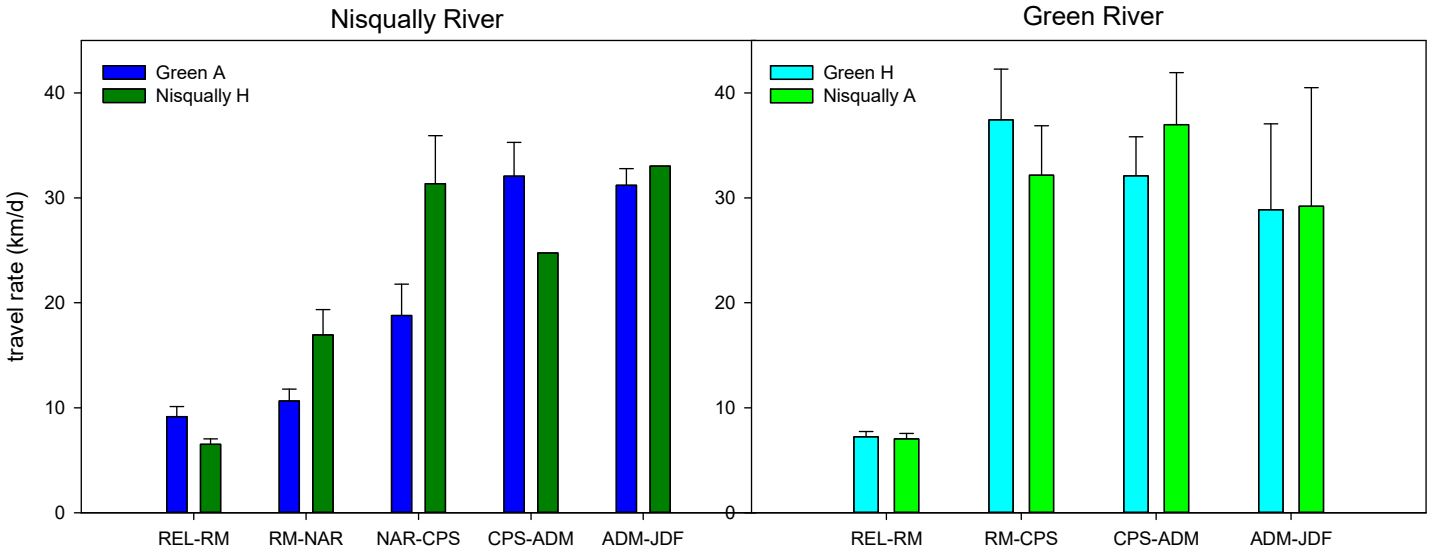
Size and age at tagging

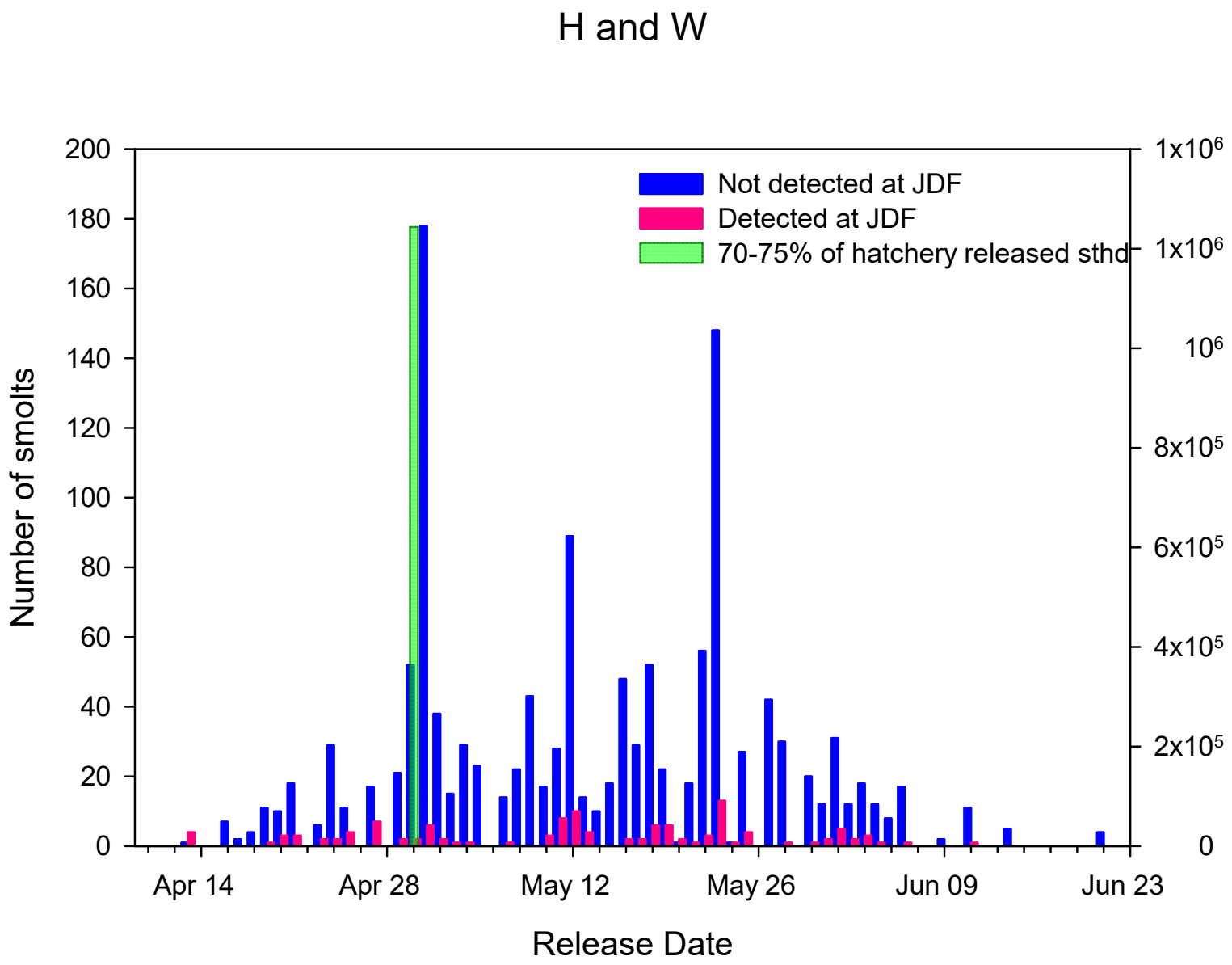
	Length (mm)	Weight (g)	age (% age-1)	age (% age-2)
Green Home	182.0 ± 2.0	56.3 ± 2.0	49%	51%
Green Away	178.8 ± 1.8	52.6 ± 1.7	40%	53%
Nisqually Home	207.2 ± 2.8	84.8 ± 3.8	18%	72%
Nisqually Away	207.7 ± 3.6	86.9 ± 4.7	18%	77%


0
24
48
72
96
12
36
60
84

Migration timing (by segment)






H and W
Not detected at JDF
Detected at JDF
70-75% of hatchery released sthd
Number of smolts
200
180
160
140
120
100
80
60
40
20
0
1x10^6
1x10^6
10^6
8x10^5
6x10^5
4x10^5
2x10^5
0
Apr 14
Apr 28
May 12
May 26
Jun 09
Jun 23
Release Date