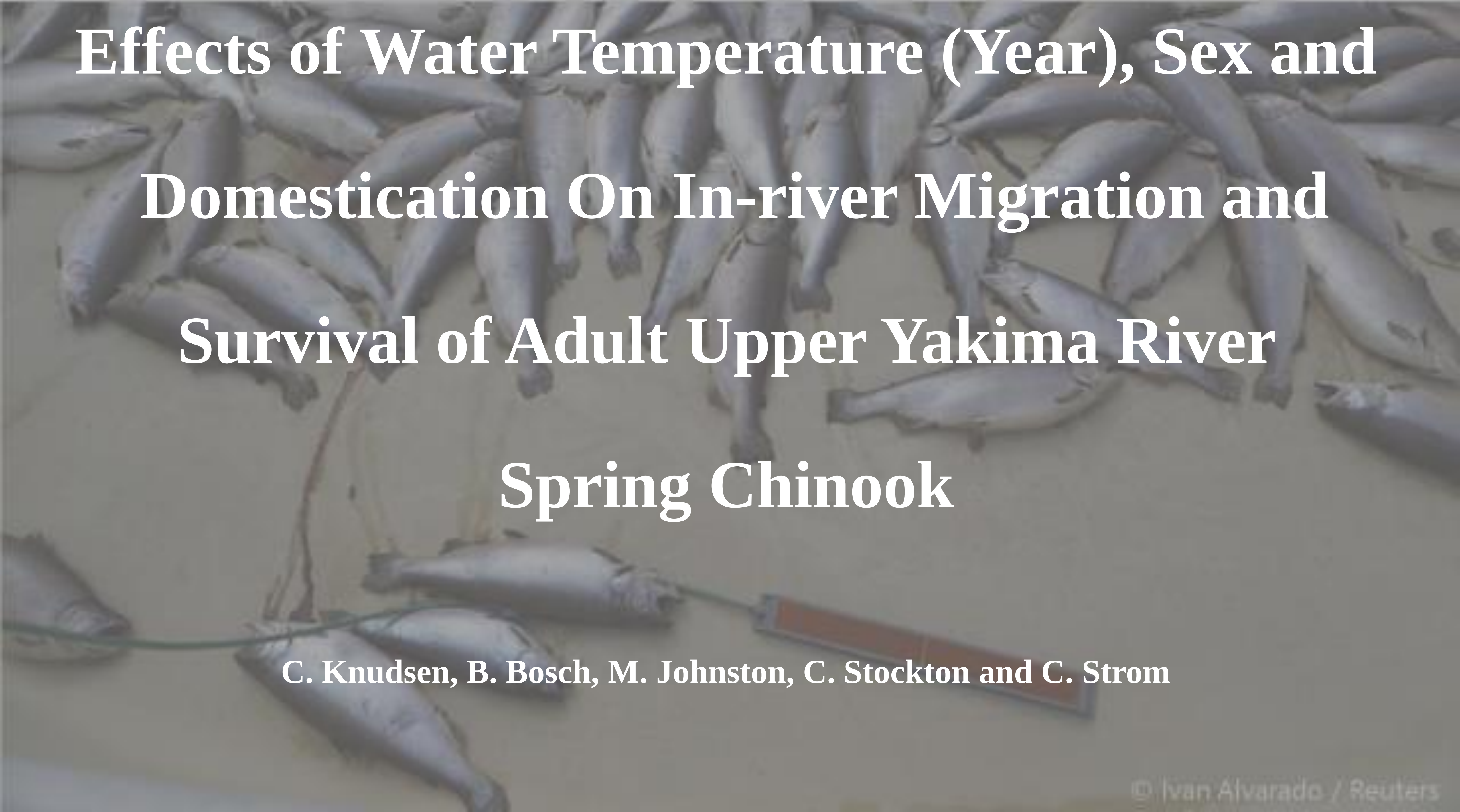
Effects of Water Temperature (Year), Sex and Domestication On In-river Migration and Survival of Adult Upper Yakima River Spring Chinook

C. Knudsen, B. Bosch, M. Johnston, C. Stockton and C. Strom



Objectives: RY’s 2011 to 2015

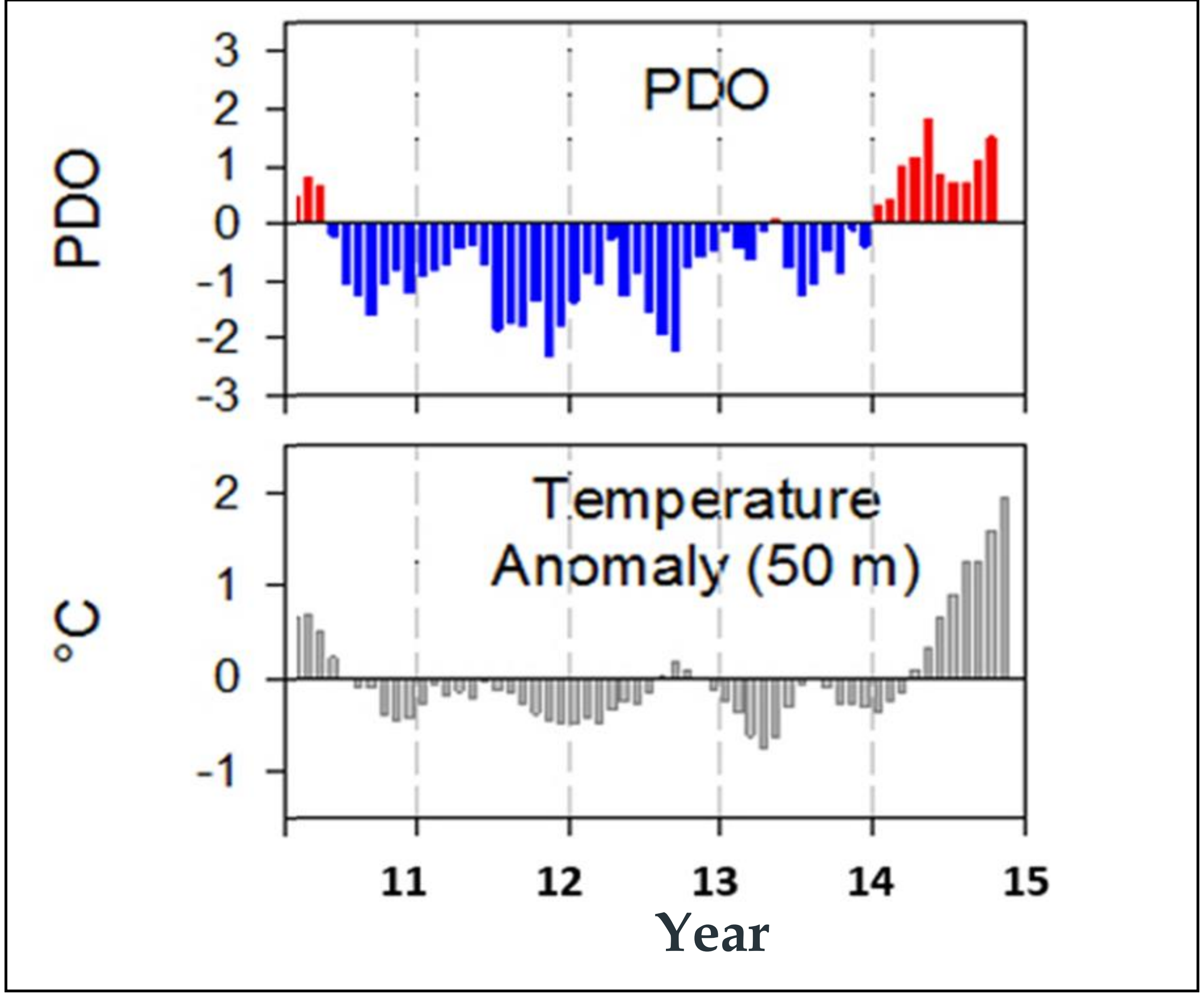
- NOAA Ocean Predictors, and Bonneville and Prosser (Kiona) water temperatures

Part 1 - PIT tagged Fish

- Trends in arrival timing at Bonneville, McNary and Prosser
- Trends in migration rates from Bonneville to McNary and Prosser dams
- Bonneville to Prosser Survival Rates

Part 2 – Pre-spawning Mortality

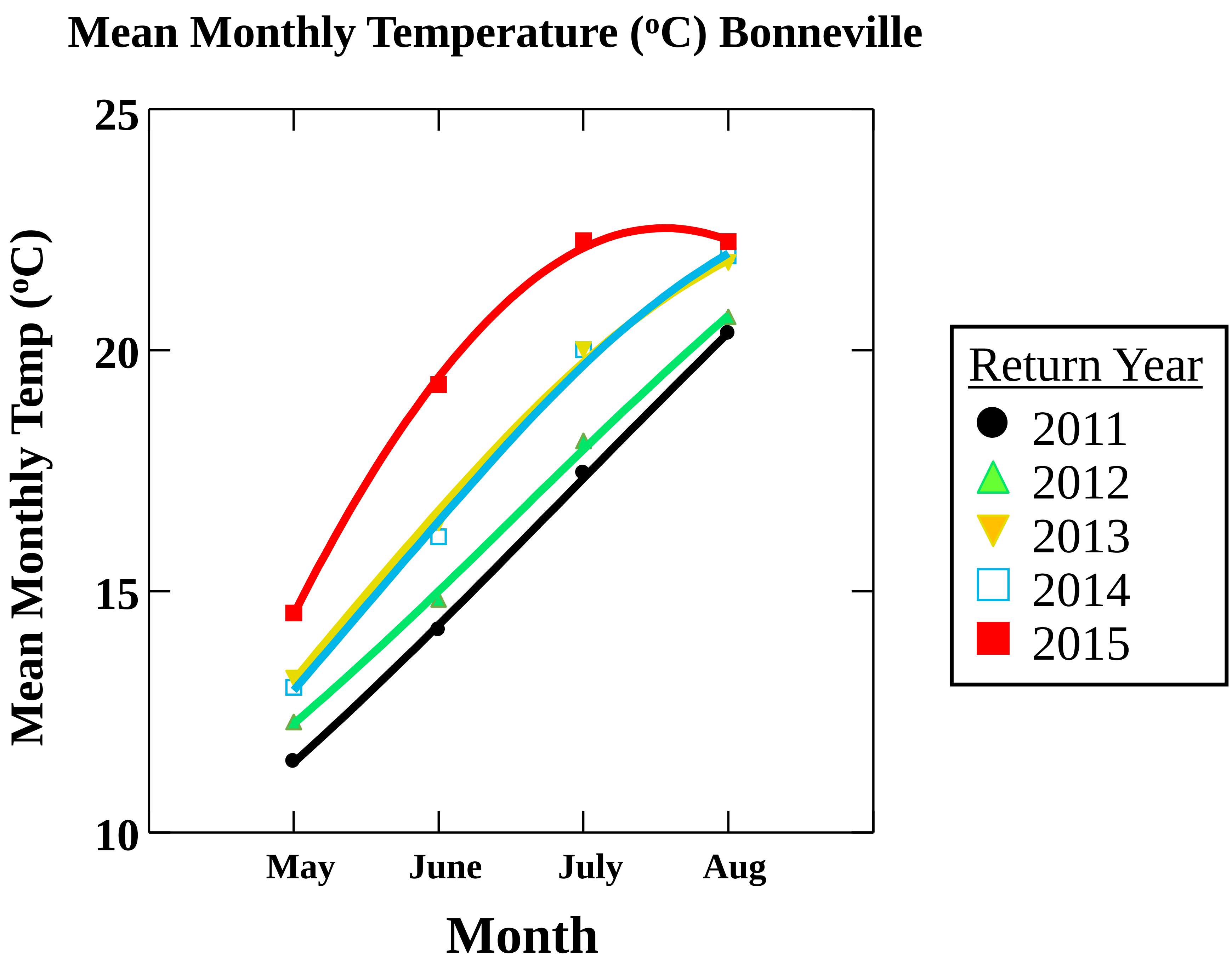
- Logistic Regression to estimate effects of Year, Origin, Sex, and Roza Passage Date on pre-spawning mortality at CESRF



NOAA time series plots of large-scale atmospheric forcing and local physical and biological indicators from 2011 - 2015. (Taken from: https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/time-series-plots.cfm.)

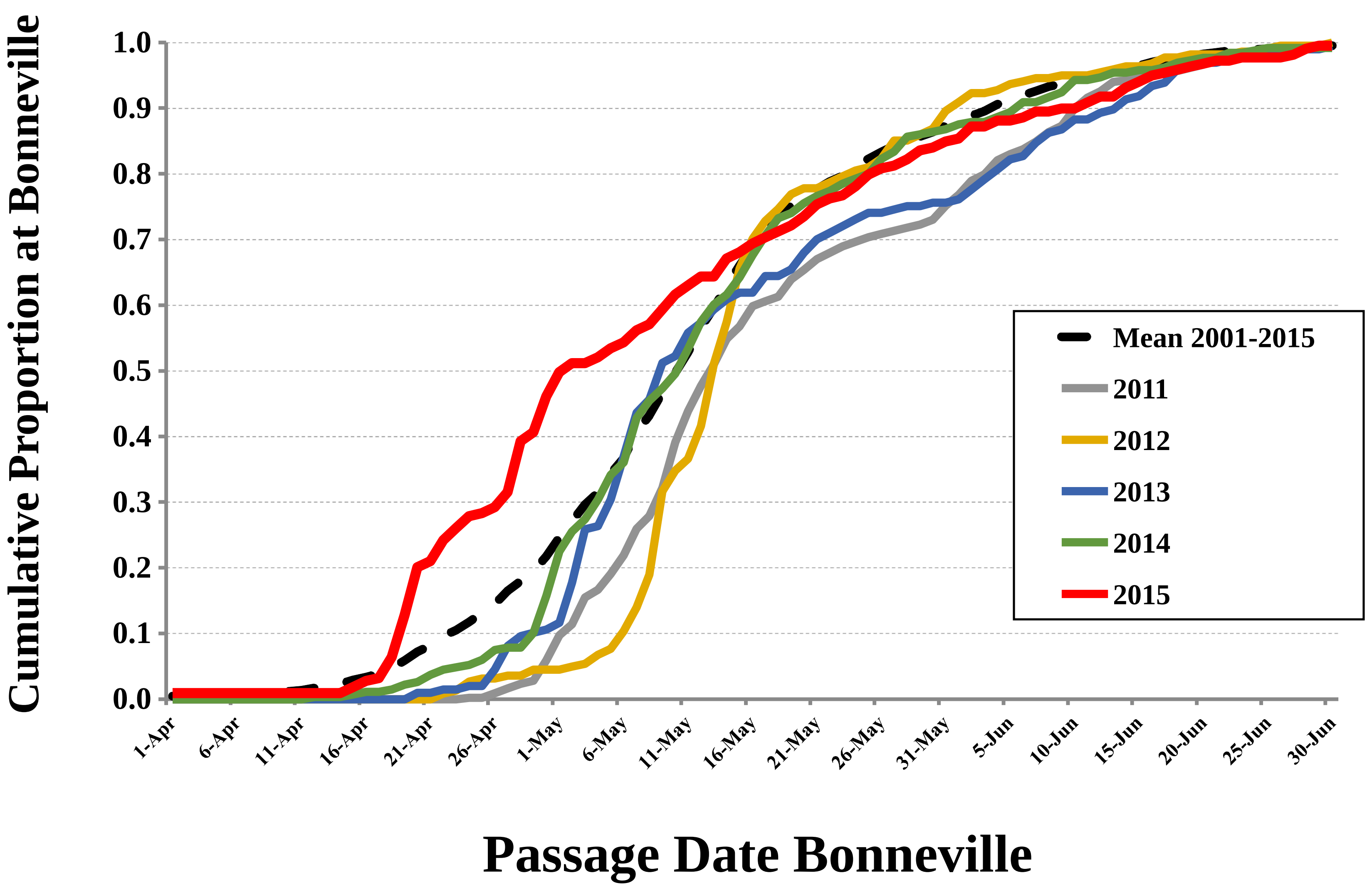
Ecosystem Indicators	2011	2012	2013	2014	2015
PDO (Sum Dec-March)	4	2	8	10	18
PDO (Sum May-Sept)	3	1	8	17	18
ONI (Average Jan-June)	4	5	7	9	17
46050 SST (°C; May-Sept)	10	11	12	13	17
Upper 20 m T (°C; Nov-Mar)	4	3	7	2	18
Upper 20 m T (°C; May-Sept)	10	6	15	17	9
Deep temperature (°C; May-Sept)	11	3	17	16	15
Deep salinity (May-Sept)	10	9	13	17	12
Copepod richness anom. (no. species; May-Sept)	4	5	2	9	18
N. copepod biomass anom. (mg C m^{-3}; May-Sept)	1	2	4	5	16
S. copepod biomass anom. (mg C m^{-3}; May-Sept)	9	8	6	11	16
Biological transition (day of year)	4	9	5	13	18
Ichthyoplankton biomass (mg C 1000 m^{-3}; Jan-Mar)	12	8	6	17	4
Chinook salmon juvenile catches (no. km^{-1}; June)	14	3	2	9	13
Coho salmon juvenile catches (no. km^{-1}; June)	13	16	1	11	8
Mean of ranks	7.5	6.1	7.5	11.7	14.5
Rank of the mean rank	7	4	7	13	16

Roza Dam
Prosser Dam
McNary Dam
Bonneville Dam

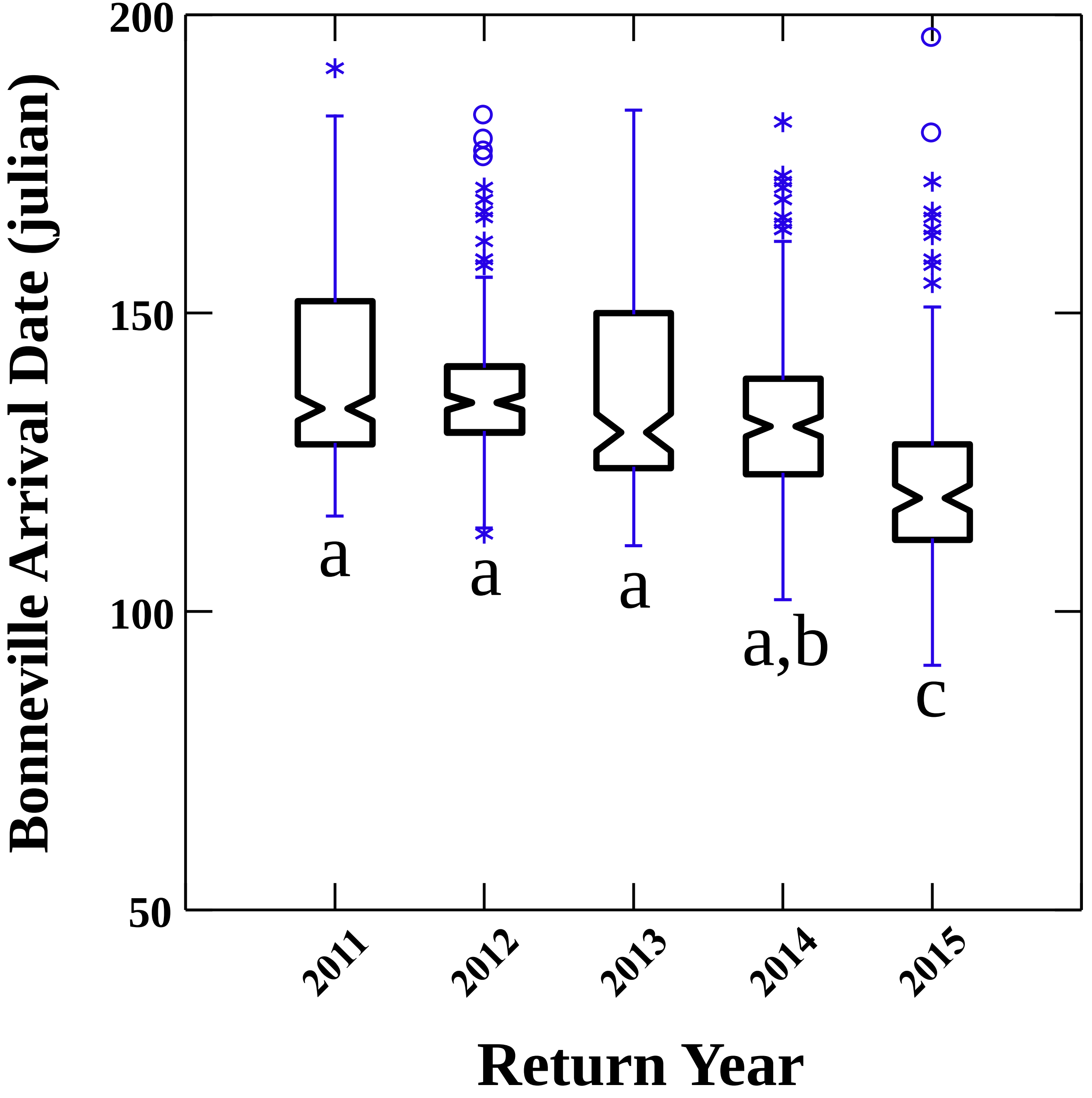


Mean Monthly Temperature (ºC) Bonneville
Mean Monthly Temp (ºC)
25
20
15
10
May
June
July
Aug
Month
Return Year
2011
2012
2013
2014
2015

Cumulative Proportion of CESRF PIT tags Passing Bonneville By Return Year

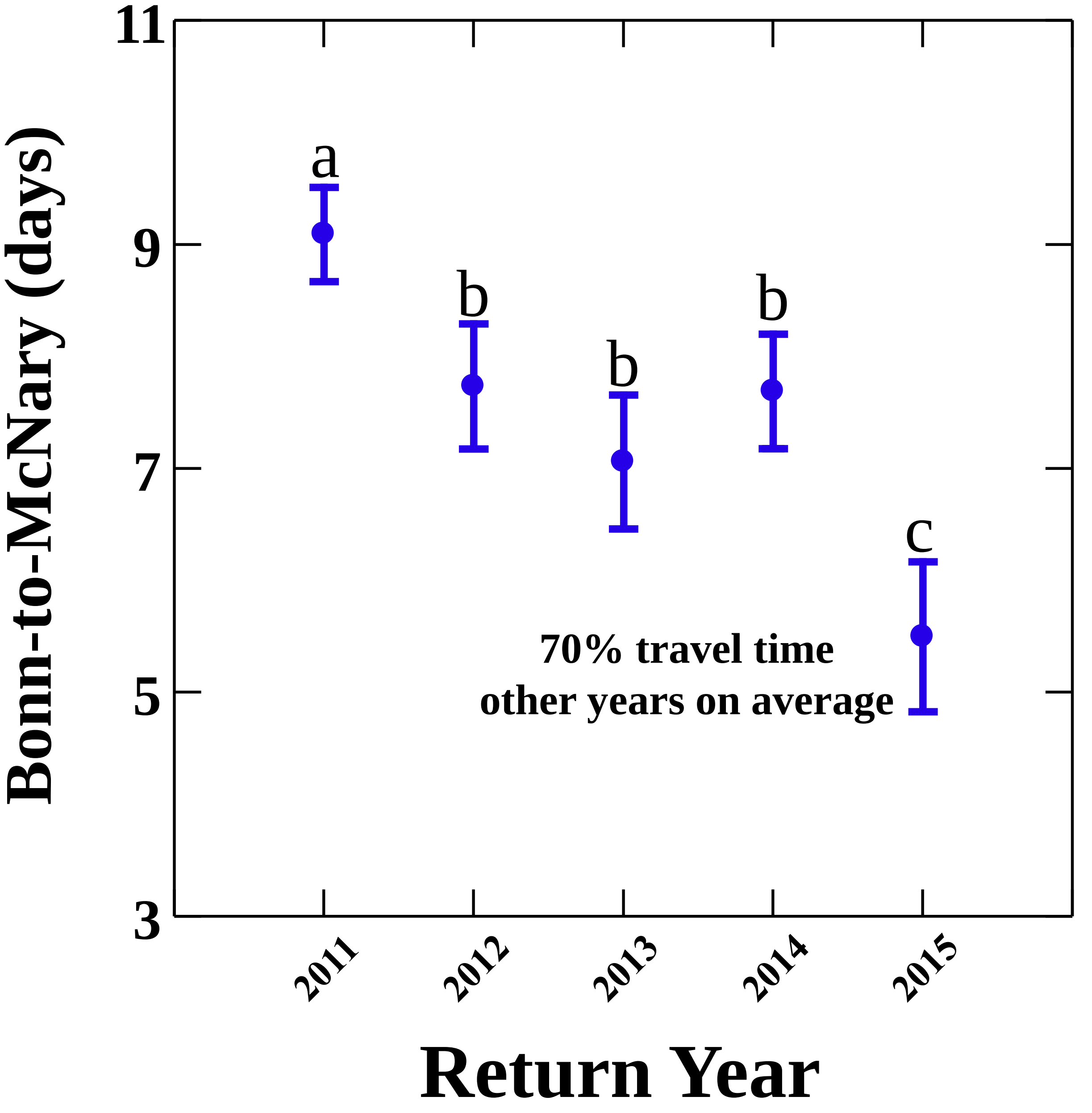


Bonneville Arrival By Return Year



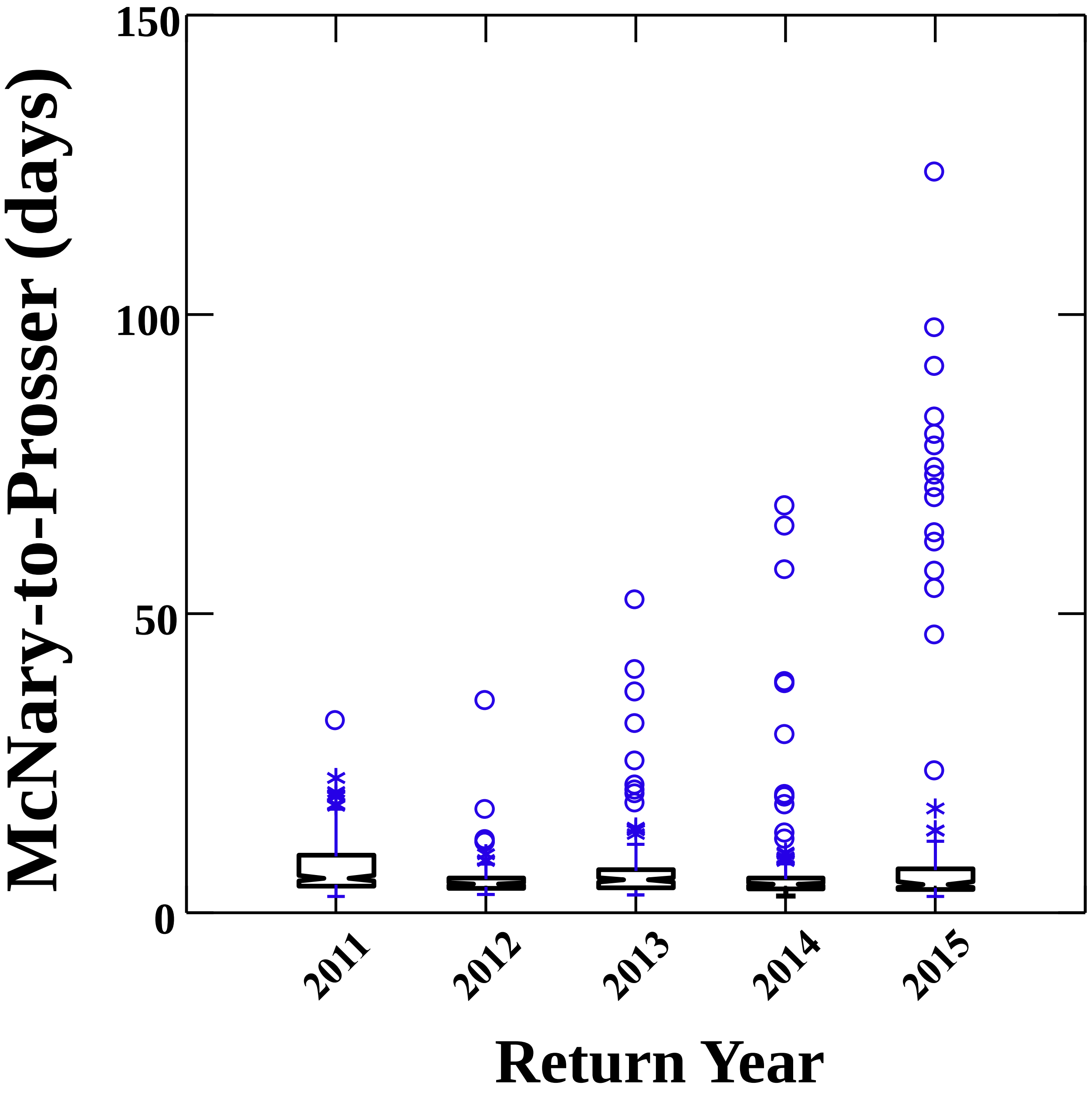
Lower case letters indicate means significantly different at p<0.01 in ANOVA assuming unequal variances.

Mean Travel Time (+1 SE) Bonneville-to-McNary (days)

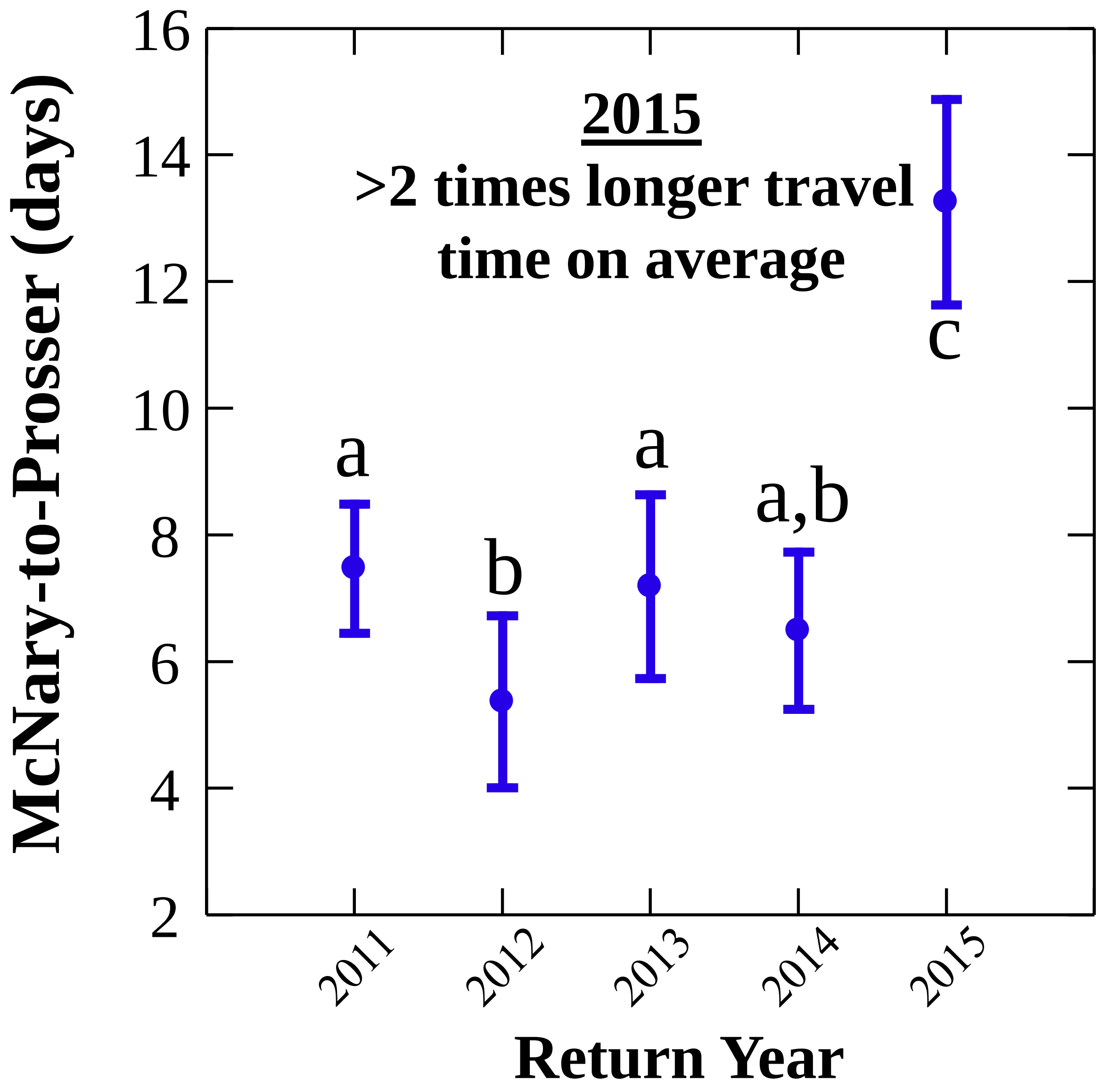


Lower case letters indicate means significantly different at p<0.001in ANOVA assuming unequal variances.

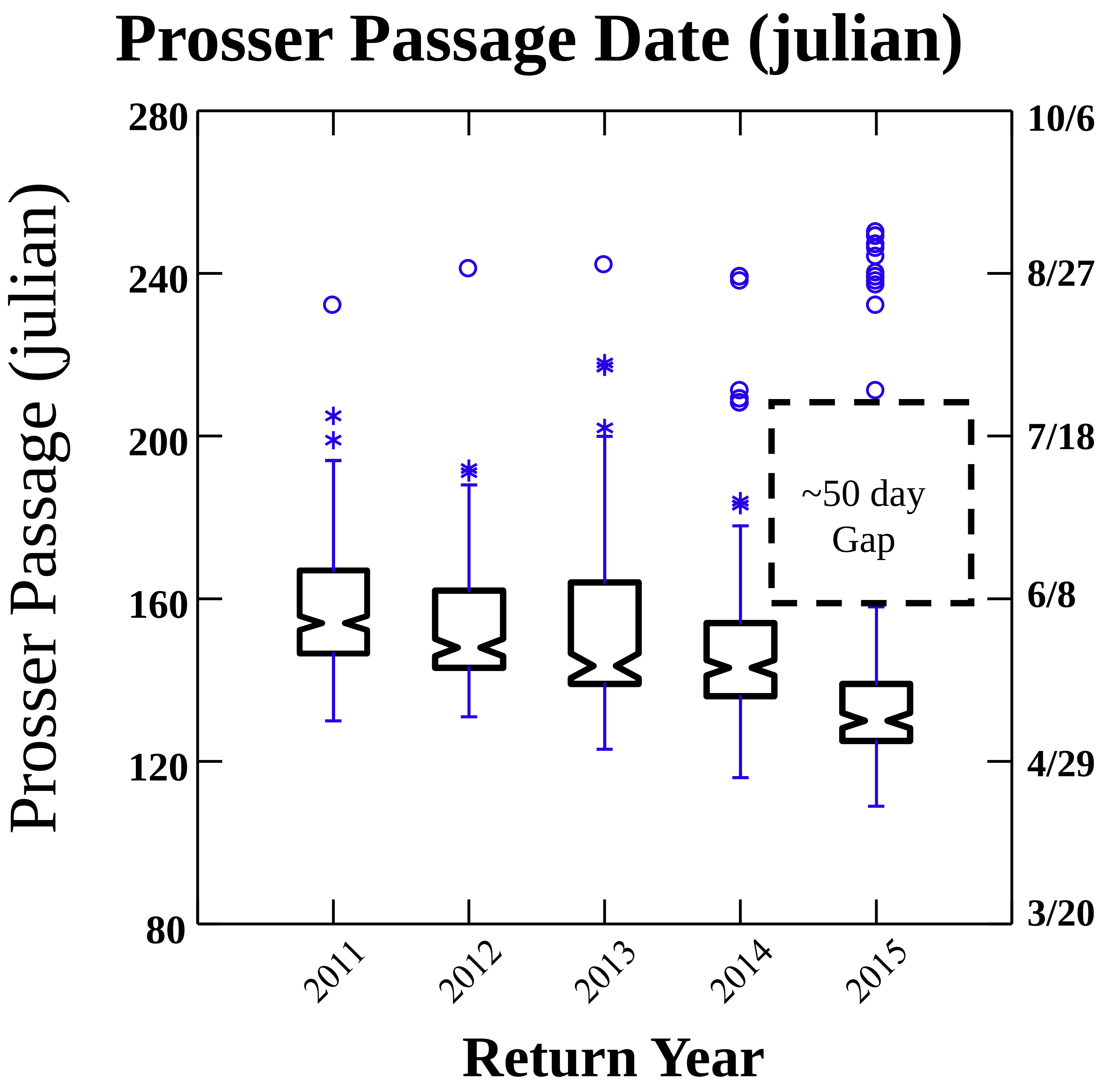
Travel Time McNary-to-Prosser Distributions

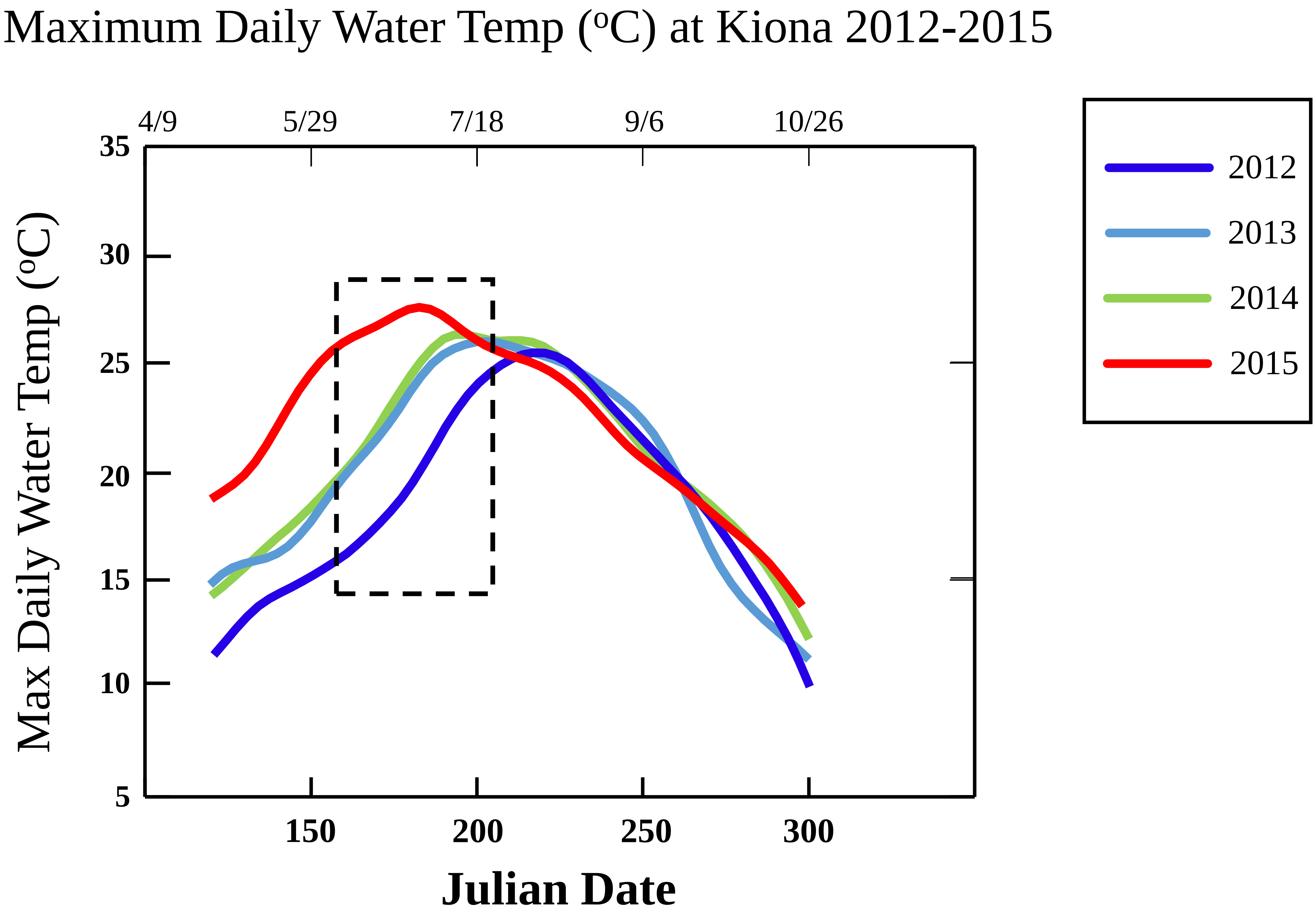


Mean McNary-to-Prosser Travel Time (±1 se)



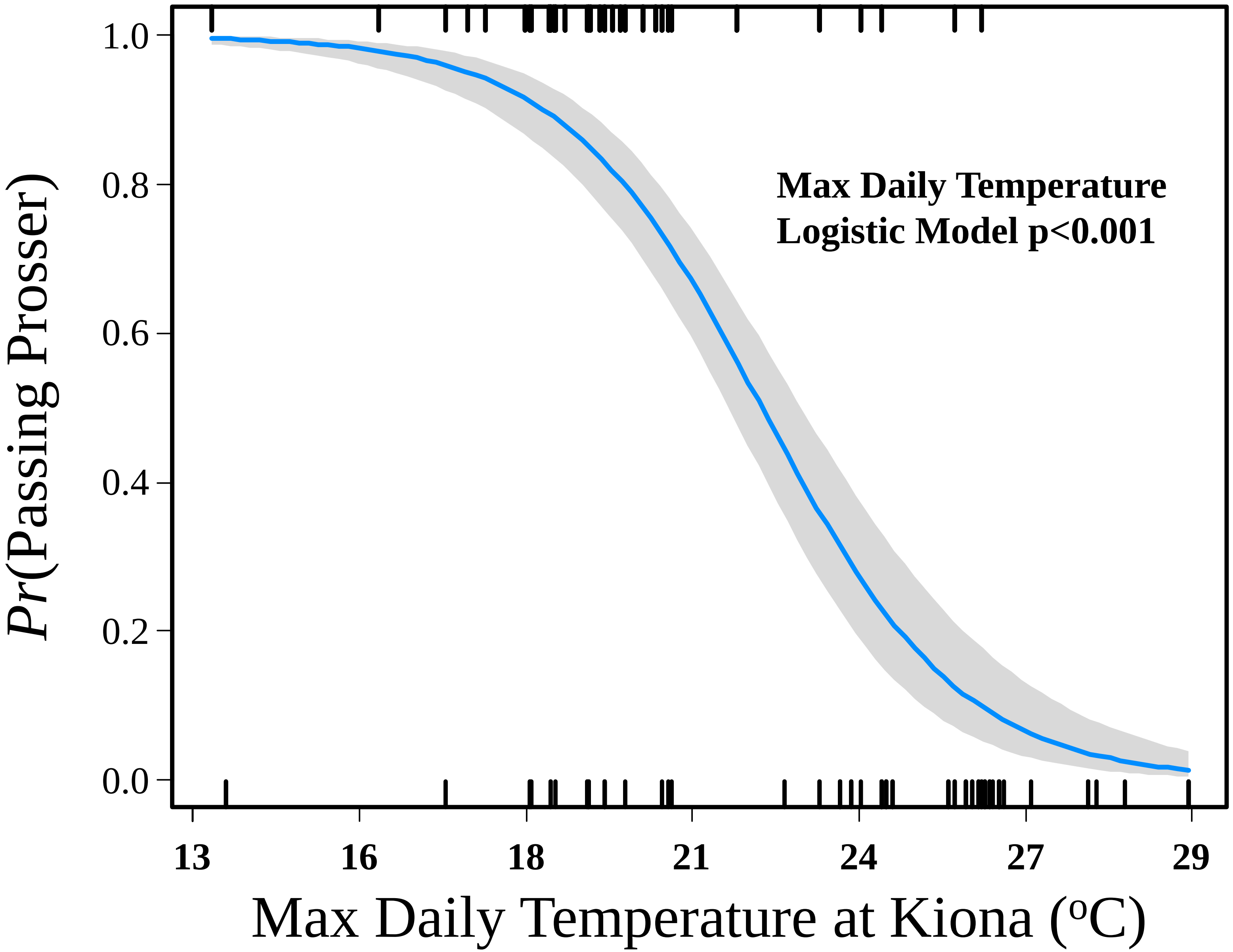
Lower case letters indicate means significantly different at $p<0.05$ in ANOVA assuming unequal variances.


Prosser Passage Date (julian)
Prosser Passage (julian)
280
240
200
160
120
80
10/6
8/27
7/18
6/8
4/29
3/20
~50 day
Gap
2011
2012
2013
2014
2015
Return Year



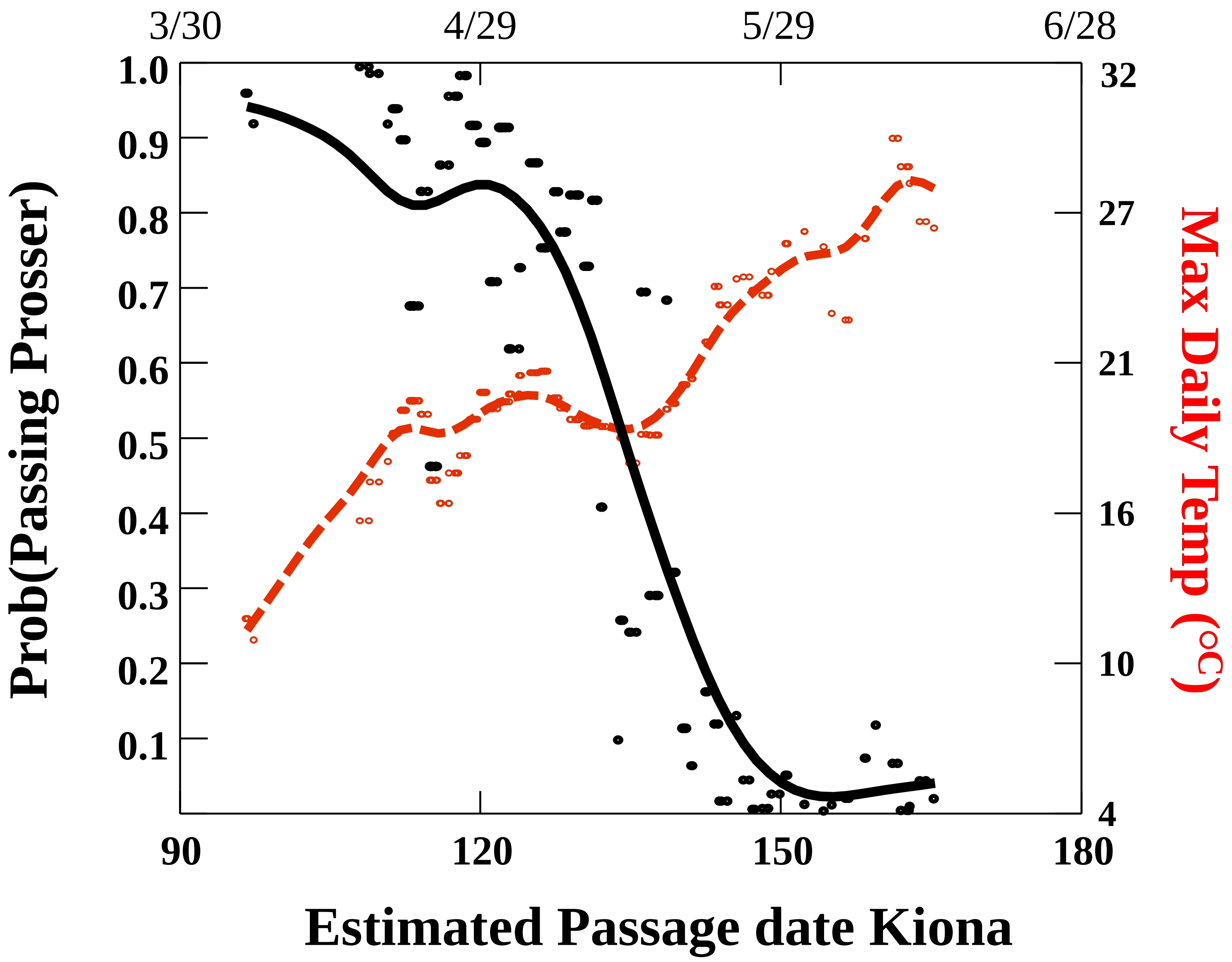
Maximum Daily Water Temp (ºC) at Kiona 2012-2015
4/9
5/29
7/18
9/6
10/26
35
30
25
20
15
10
5
150
200
250
300
Max Daily Water Temp (ºC)
Julian Date
2012
2013
2014
2015


Yakima
Prosser Dam
Kiona
Thermal Block
Terrace Heights
Union Gap
Moxee
Parker
Wapato
Buena
Zillah
Harrah
Ashue
Toppenish
Granger
Sunnyside
Grandview
Satus
Mabton
Byron
North Prosser
Whitstran
Pearl
Willa
Edna
Geneva Junction
Columbia River
Mathews Corner
Basin Ci
West Richland
Richland
West Pasco
Badger
Kenn
City
ser



Max Daily Temperature
Logistic Model p<0.001
Pr(Passing Prosser)
1.0
0.8
0.6
0.4
0.2
0.0
13
16
18
21
24
27
29
Max Daily Temperature at Kiona (oC)

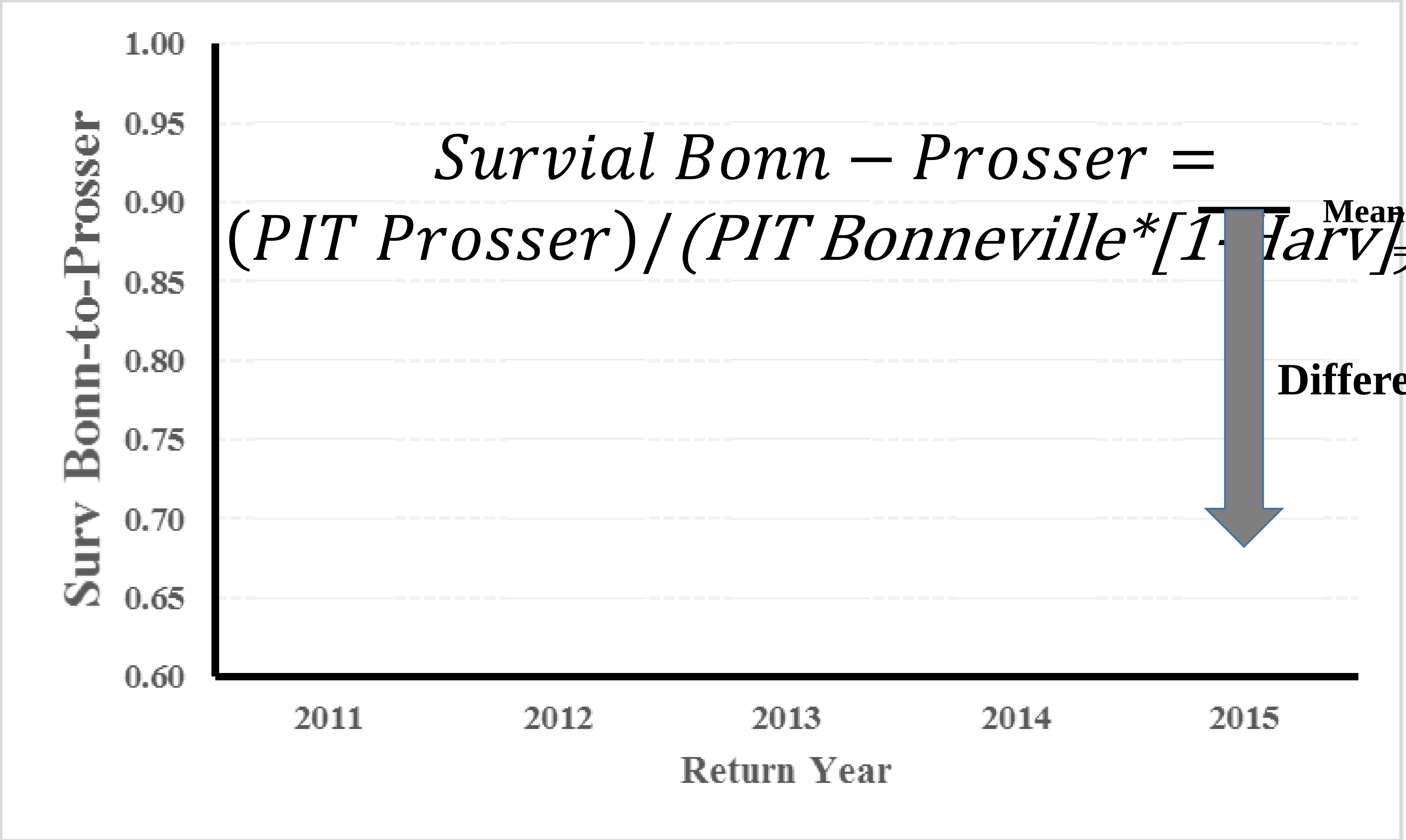
Estimated Probabilities of Passing Prosser Based on Max Daily Temp When Passing Kiona



$$Survial\ Bonn - Prosser =$$
$$(PIT\ Prosser)/(PIT\ Bonneville*[1-Harv])$$

Mean 2011-2014 = 0.890

Difference=0.209



Sockeye Salmon Survival from Bonneville to McNary

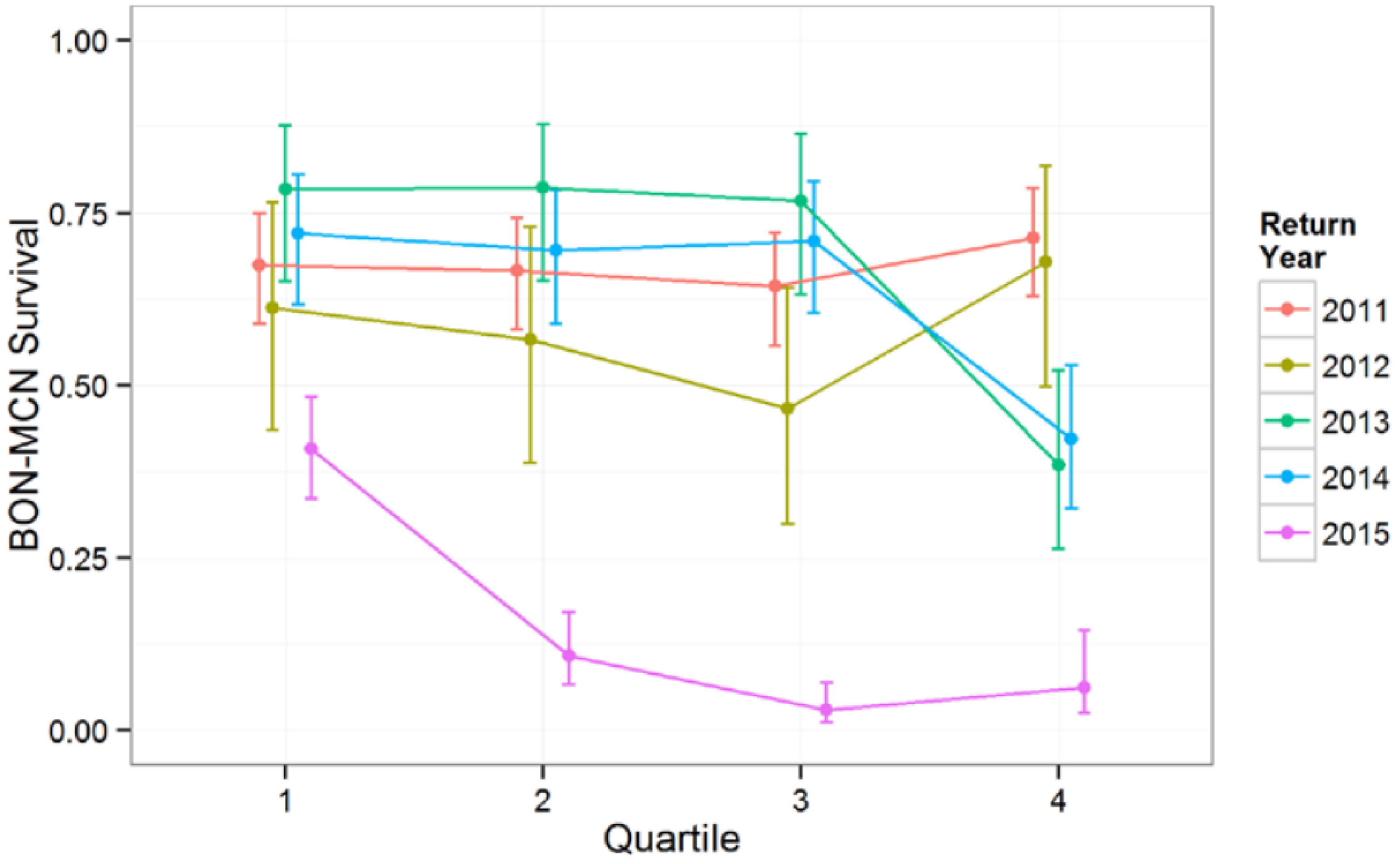
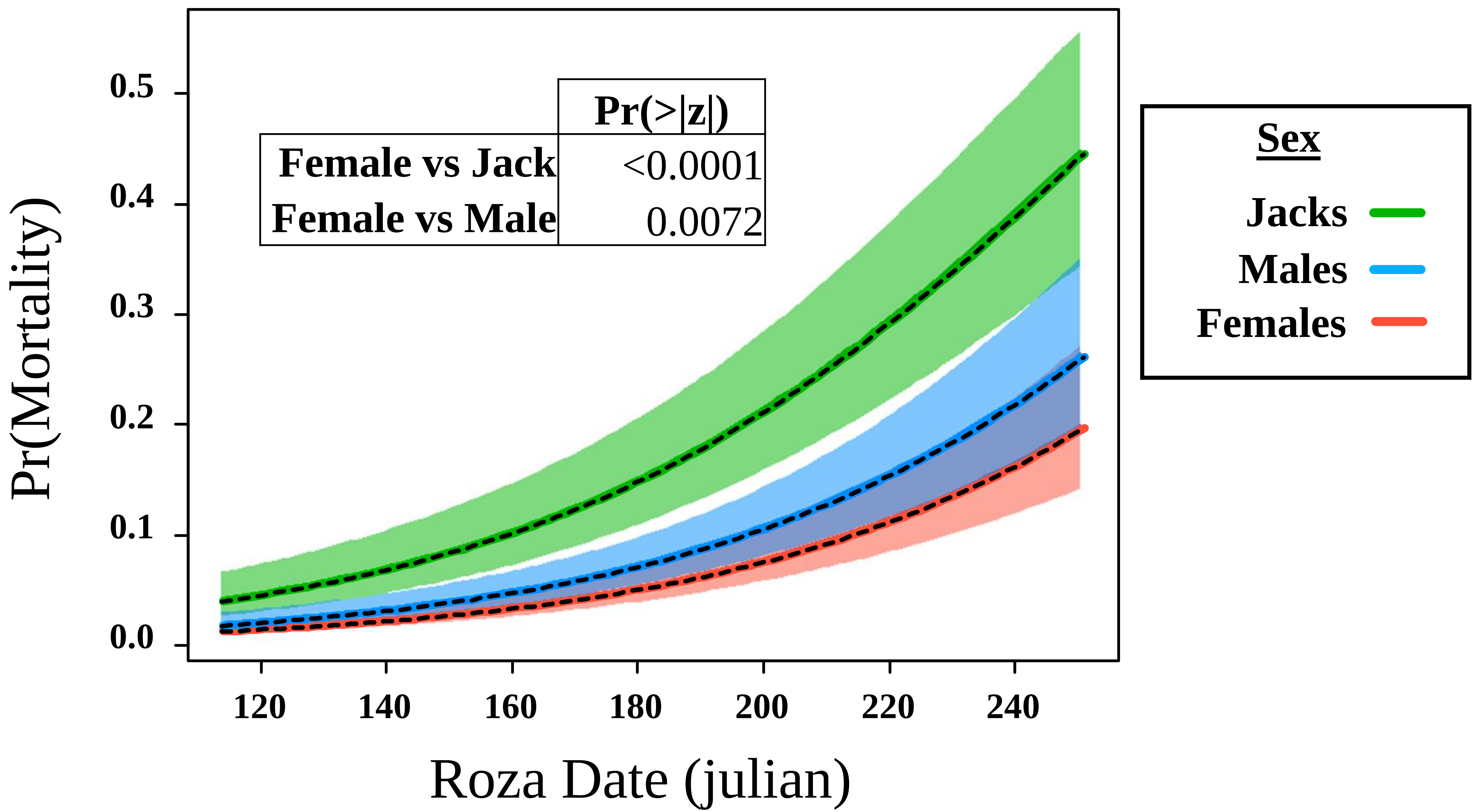


Figure 7. Sockeye salmon survival from Bonneville to McNary Dam by run grouping determined by quartiles (i.e., first 25% of the run (1), 26%–50% of the run (2), etc.). (Taken from DeHart. 2015. *Fish Passage Center Memo 159-15*)

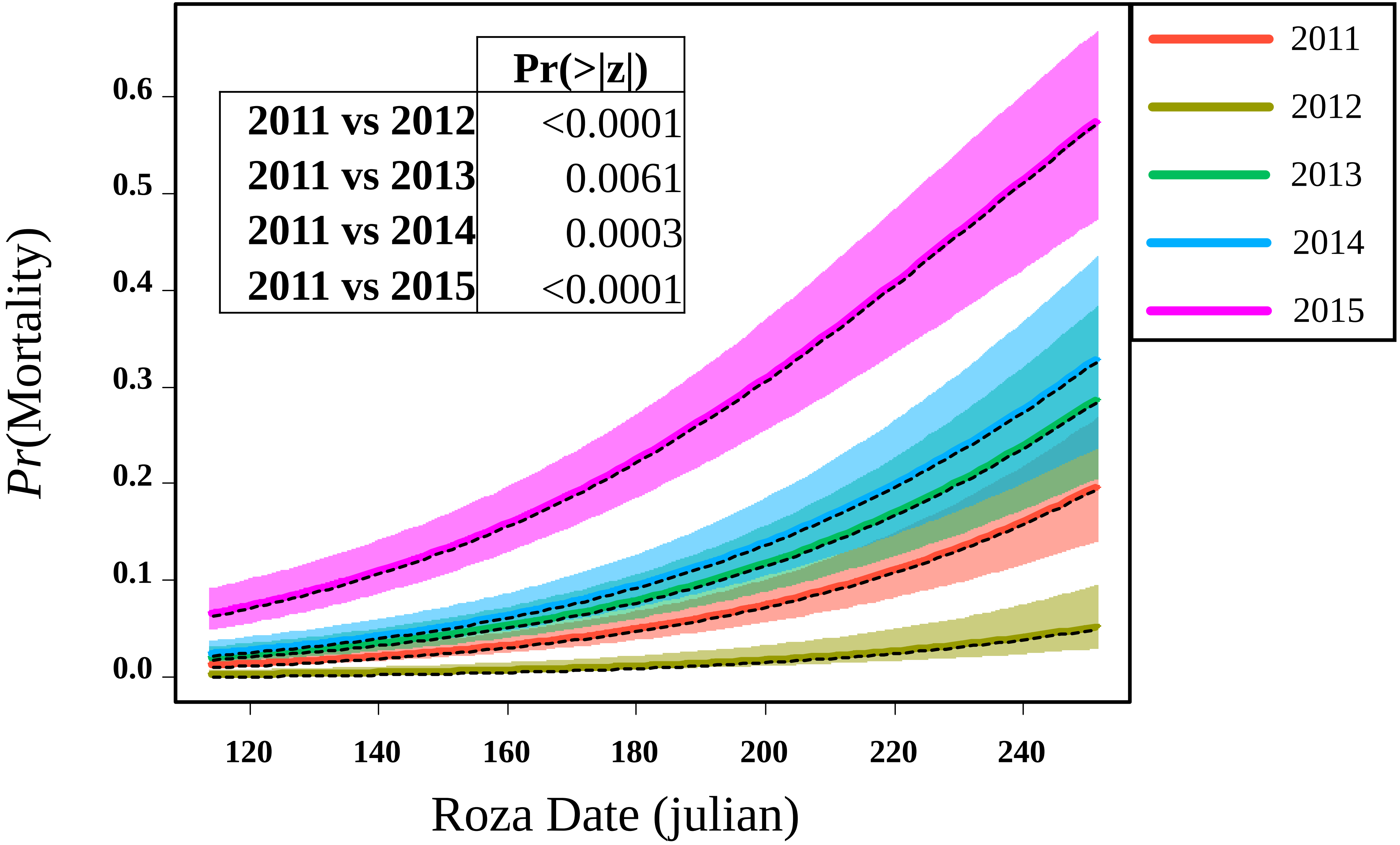
Logistic Regression Model

Mortality ~ Roza Collection Date + Sex + Origin + Return Year

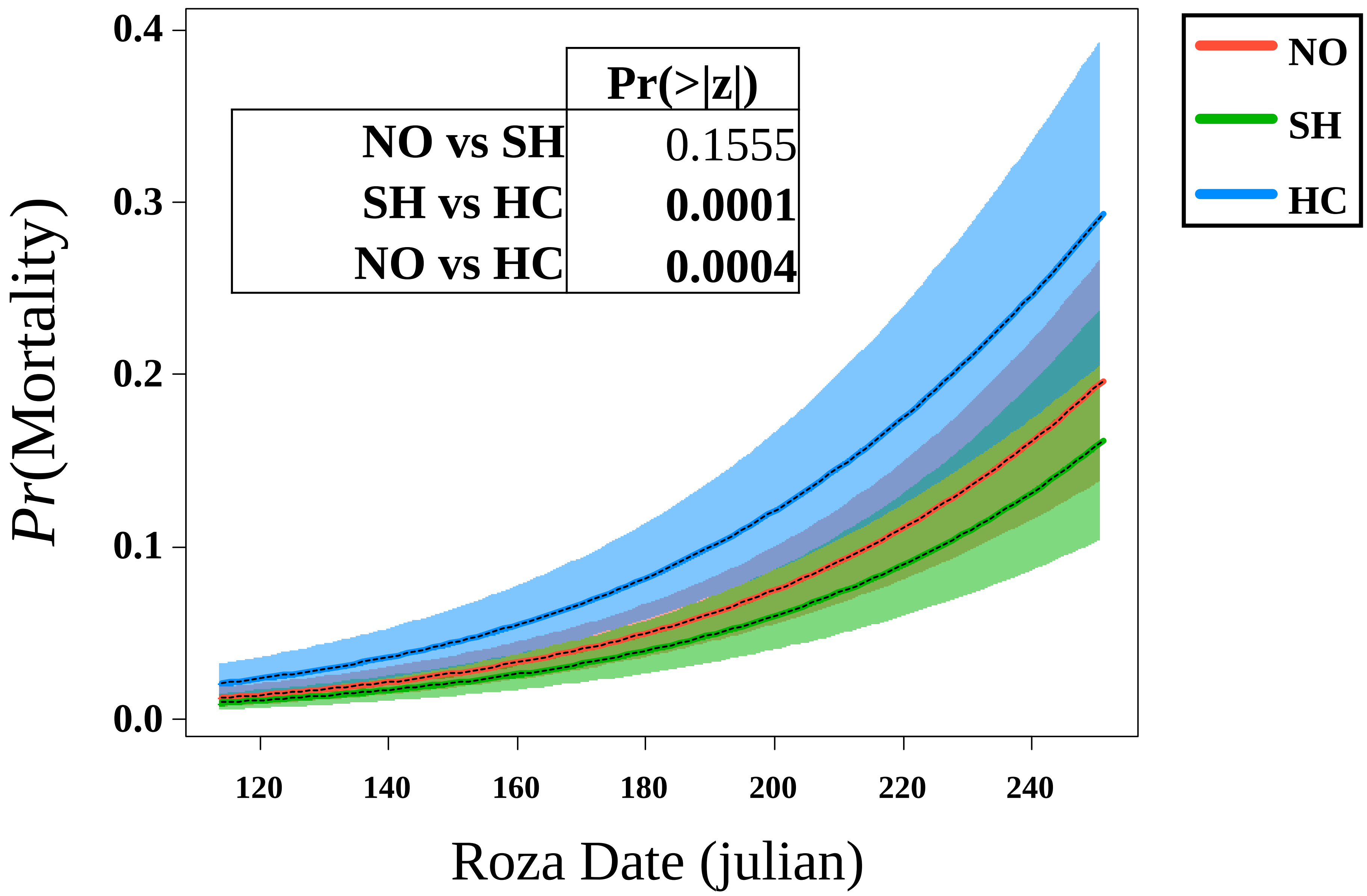
	Estimate	Std. Err	z value	Pr(>|z|)
(Intercept)	-6.2956	0.4274	-14.7307	**<0.0001**
Roza Collec. Date	0.0216	0.0021	10.2545	**<0.0001**
Female vs Jack	1.1889	0.1595	7.4520	**<0.0001**
Female vs Male	0.3676	0.1367	2.6898	**0.0072**
2011 vs 2012	-1.4915	0.3115	-4.7886	**<0.0001**
2011 vs 2013	0.4966	0.1812	2.7411	**0.0061**
2011 vs 2014	0.6928	0.1898	3.6494	**0.0003**
2011 vs 2015	1.7091	0.1743	9.8033	**<0.0001**
NO vs SH	-0.2370	0.1669	-1.4203	0.1555
SH vs HC	-0.7660	0.1885	-4.0630	**0.0001**
NO vs HC	0.5290	0.1494	3.5412	**0.0004**



Pr(>|z|)
Female vs Jack <0.0001
Female vs Male 0.0072
Sex
Jacks
Males
Females
0.5
0.4
0.3
0.2
0.1
0.0
Pr(Mortality)
120
140
160
180
200
220
240
Roza Date (julian)



Pr(>|z|)
2011 vs 2012 <0.0001
2011 vs 2013 0.0061
2011 vs 2014 0.0003
2011 vs 2015 <0.0001
2011
2012
2013
2014
2015
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Pr(Mortality)
120
140
160
180
200
220
240
Roza Date (julian)


Pr(>|z|)
NO vs SH 0.1555
SH vs HC 0.0001
NO vs HC 0.0004
NO
SH
HC
0.4
0.3
0.2
0.1
0.0
Pr(Mortality)
120
140
160
180
200
220
240
Roza Date (julian)

Summary: PIT tagged fish

- 2015 was an anomalous year in many ways due in large part to higher ocean and freshwater temperatures, but was also likely flow related issues (not looked at here).
- Adult returns in 2015:
  - Arrived significantly earlier at Bonneville
  - Migrated from Bonneville to McNary at significantly faster rates
  - Were then blocked by a thermal barrier at the mouth of the Yakima R. which delayed fish passage and appeared to stop passage completely from mid-May to August
  - Showed significantly longer McNary-to-Prosser Travel Times
  - Experienced 21% higher mortality from Bonneville to Prosser

Summary: Fish held at CESRF

- Examining the Pre-Spawning Mortality rates of fish held at CESRF using logistic regression analysis we found that:
  - Sex: Jacks had the highest mortality rates followed by Males and then Females
  - Return Year: RY 2015 had the highest mortality rates and 2012 the lowest with the order of RY's following closely the overall temperature profiles for each RY
  - Origin: HC fish had the highest mortality rates followed by NO and then SH fish. HC fish were significantly higher than NO and, more importantly, SH fish demonstrating a significant domestication effect across the 5 RY's.

Summary: Fish held at CESRF

- Origin:
  - If fish held at CESRF reflect the rates of pre-spawning mortality on the spawning grounds, then the supplemented fish (SH) are likely experiencing survival rates similar to NO fish in the wild.

Questions?