If you build it will they come? A look at the spawning movements of Kootenai River White Sturgeon

Kevin N. McDonnell – Idaho Department of Fish and Game

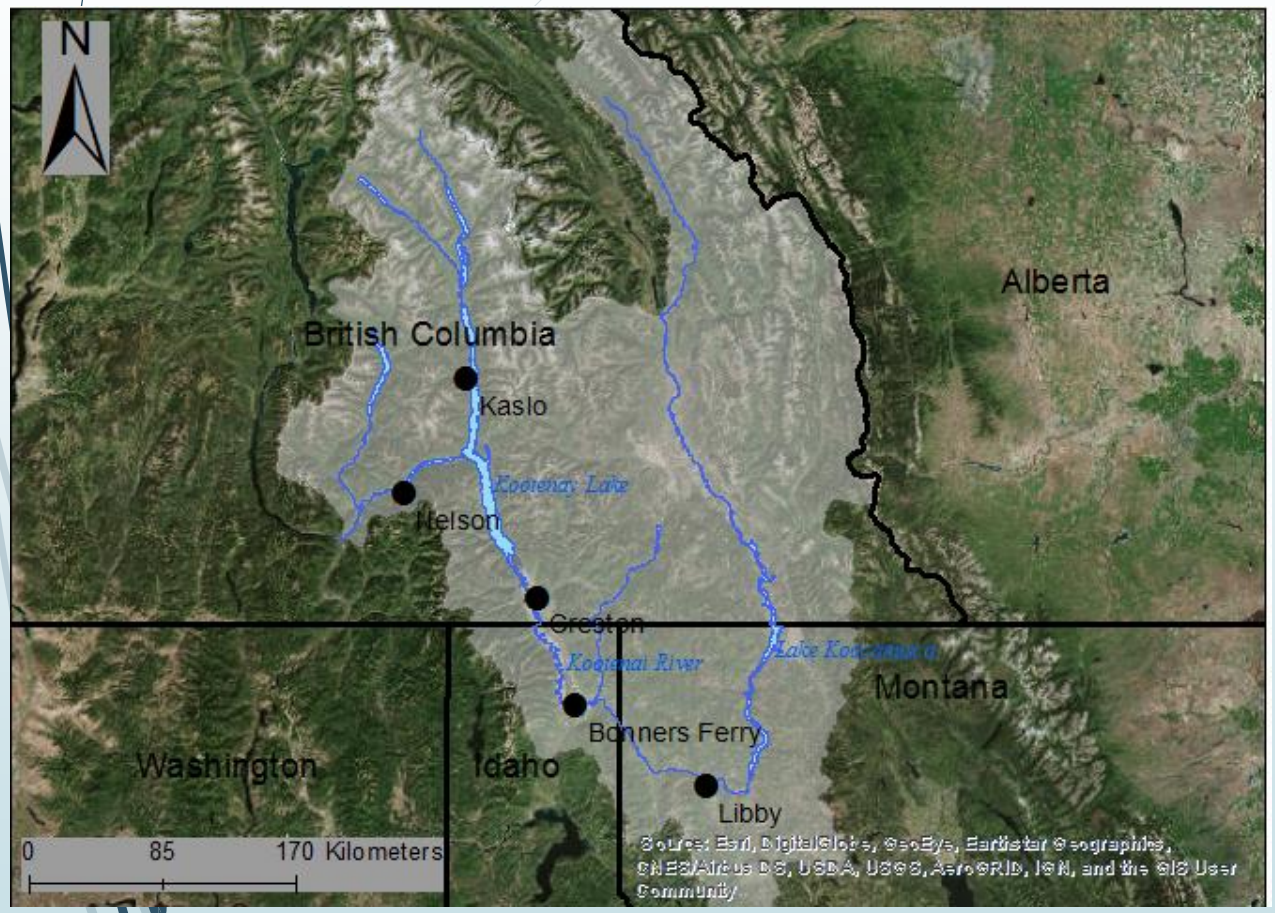
Ryan S. Hardy – Idaho Department of Fish and Game

Sarah M. Stephenson - British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development

Shawn P. Young – Kootenai Tribe of Idaho

Ministry of Forests, Lands and Natural Resource Operations

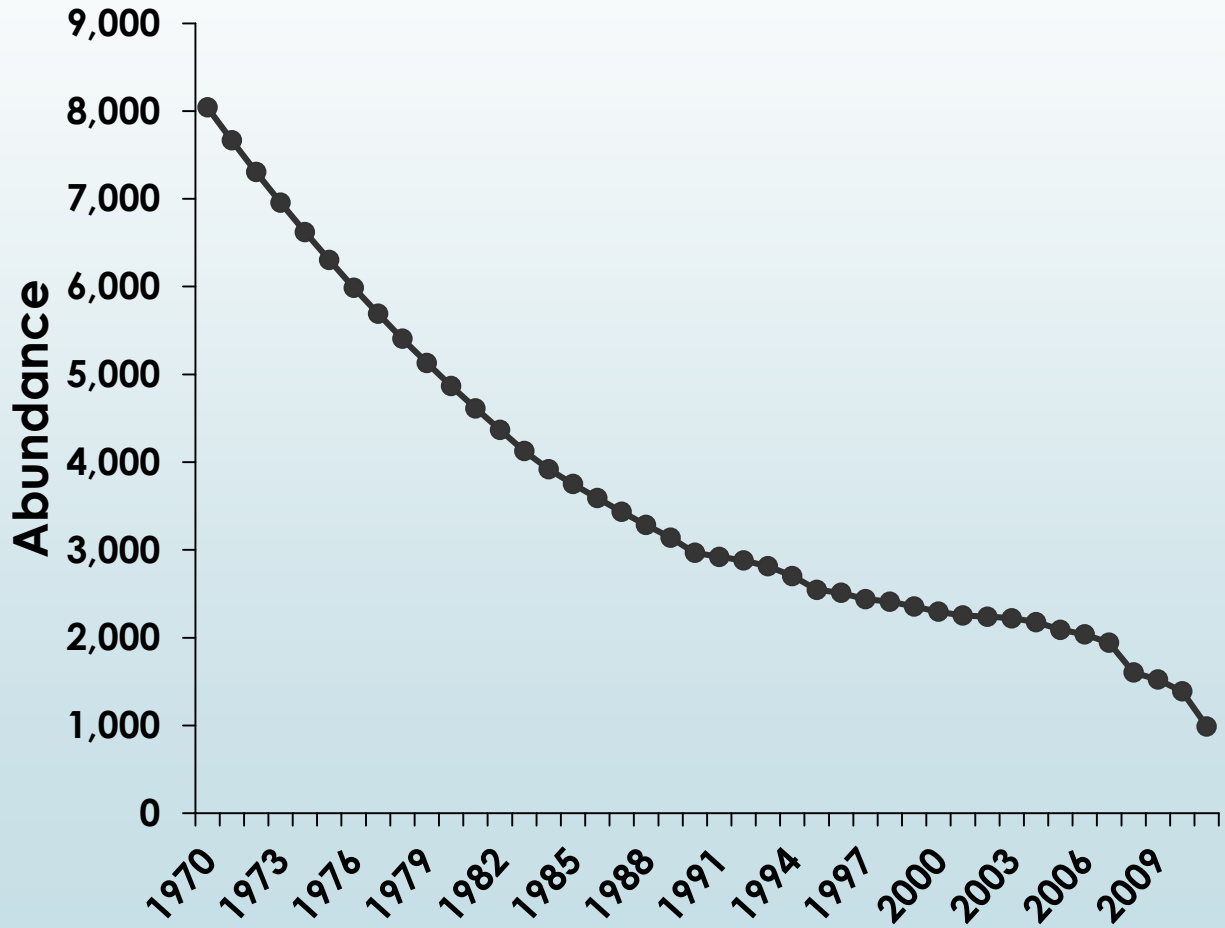
Kootenai River



- Basin covers B.C., MT, and ID
- White Sturgeon are found between Kootenai Falls (MT) and Bonnington Falls (BC).
- A large stretch of ID river is recognized as critical spawning habitat.

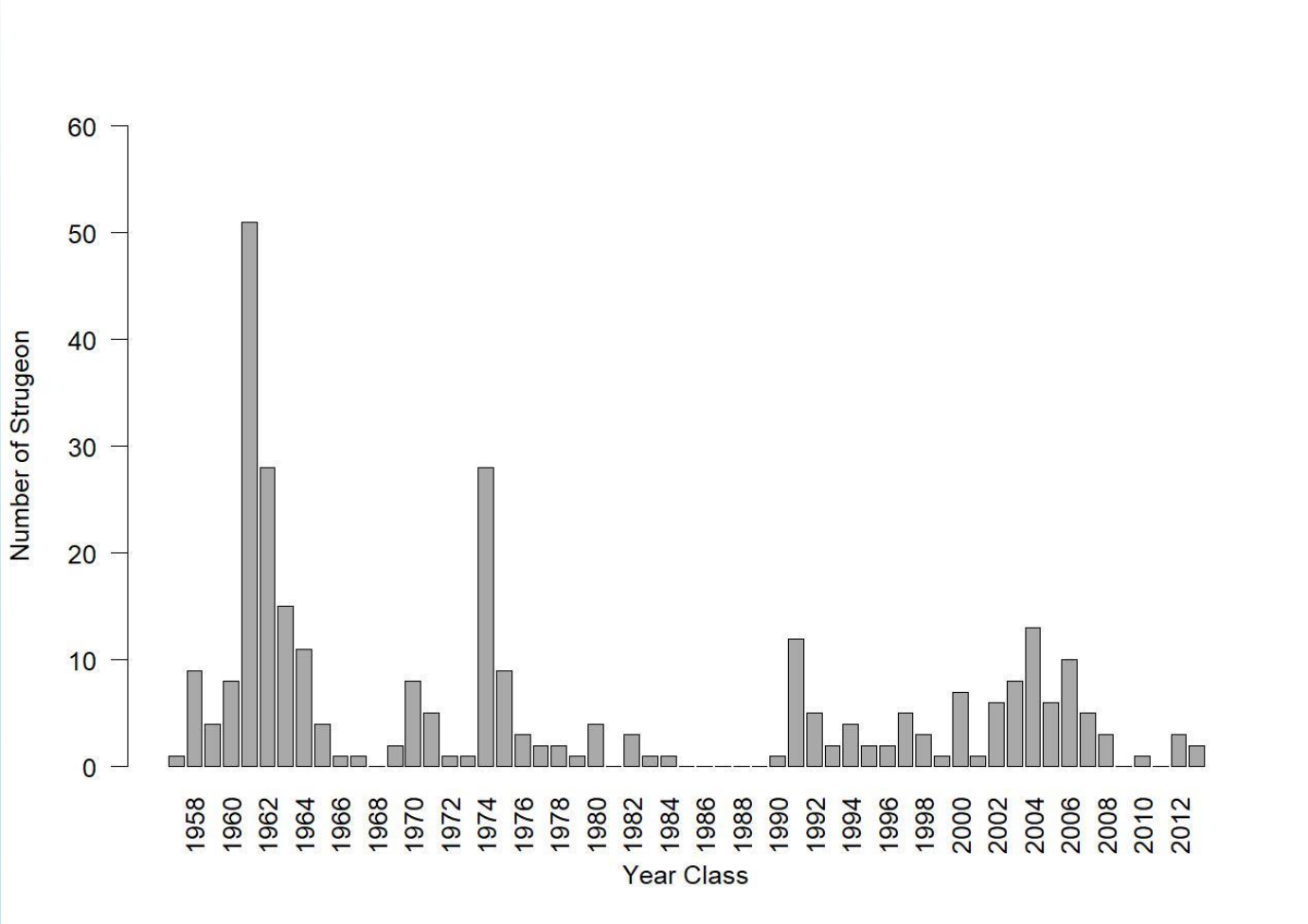
Kootenai River Sturgeon

- Population has steadily declined since 1970
  - Libby Dam installation 1972



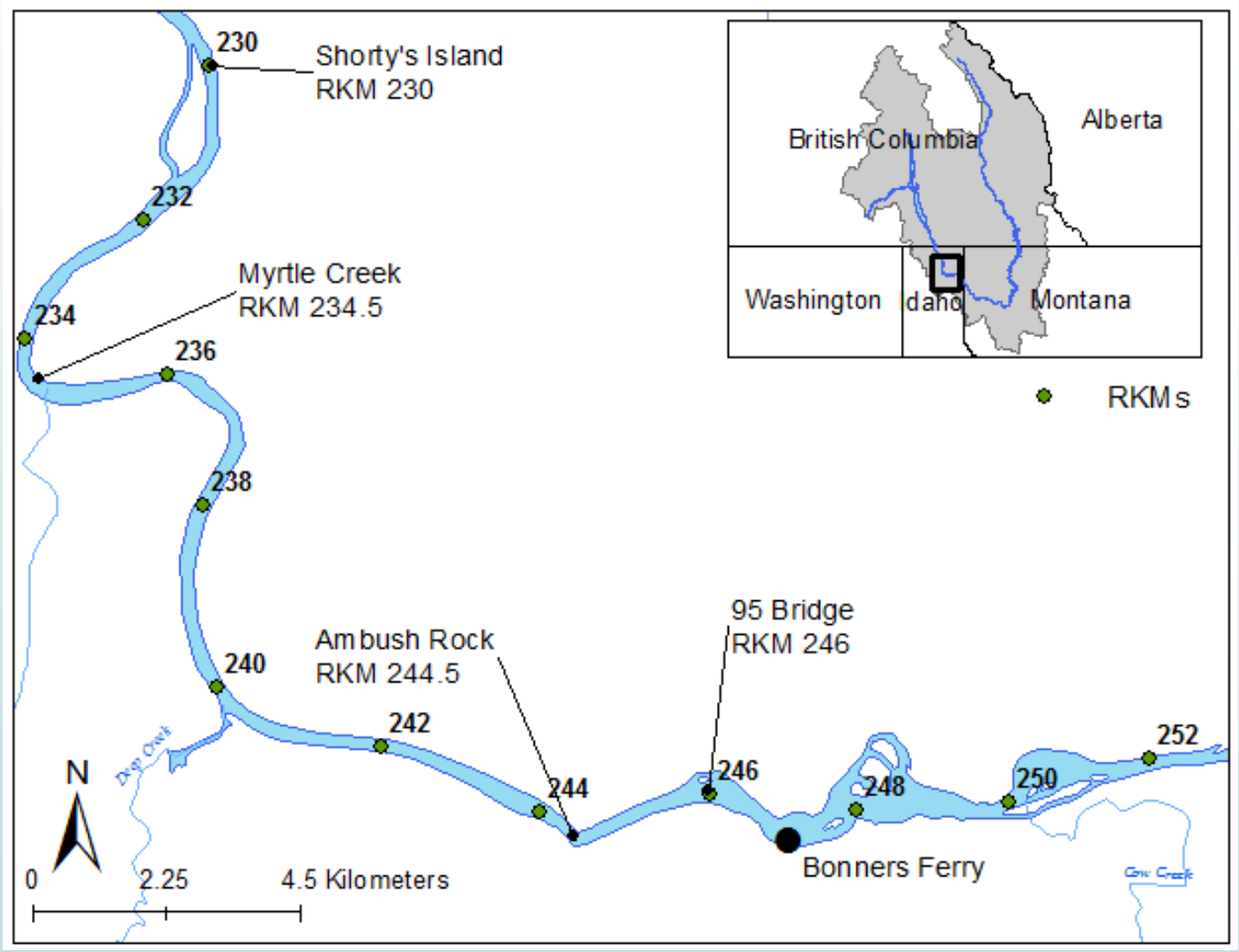
Kootenai River Sturgeon

- Population has steadily declined since 1970
  - Libby Dam installation 1972
- No consistent recruitment
- Population is currently supported by a conservation aquaculture program



Kootenai River Sturgeon

- Population has steadily declined since 1970
  - Libby Dam installation 1972
- No consistent recruitment
- Population is currently supported by a conservation aquaculture program
- Spawning currently occurs over clay shelves instead of suitable gravels
- Adults that make it rkm 230 (shortys land) are considered part of the spawning population



Kootenai River Sturgeon

- Population has steadily declined since 1970
  - Libby Dam installation 1972
- No consistent recruitment
- Population is currently supported by a conservation aquaculture program
- Spawning currently occurs over clay shelves instead of suitable gravels
- Adults that make it rkm 230 (shortys land) are considered part of the spawning population

Kootenai River Sturgeon

- Population has steadily declined since 1970
  - Libby Dam installation 1972
- No consistent recruitment
- Population is currently supported by a conservation aquaculture program
- Spawning currently occurs over clay shelves instead of suitable gravels
- Adults that make it rkm 230 (shortys land) are considered part of the spawning population

Kootenai River Sturgeon

- Spawning Staging begins in April
  - Adults come out of the Lake and move into Lower River
- Spawning typically occurs in June and into July
  - After River temperatures > 9 C°

If you build it they will come…

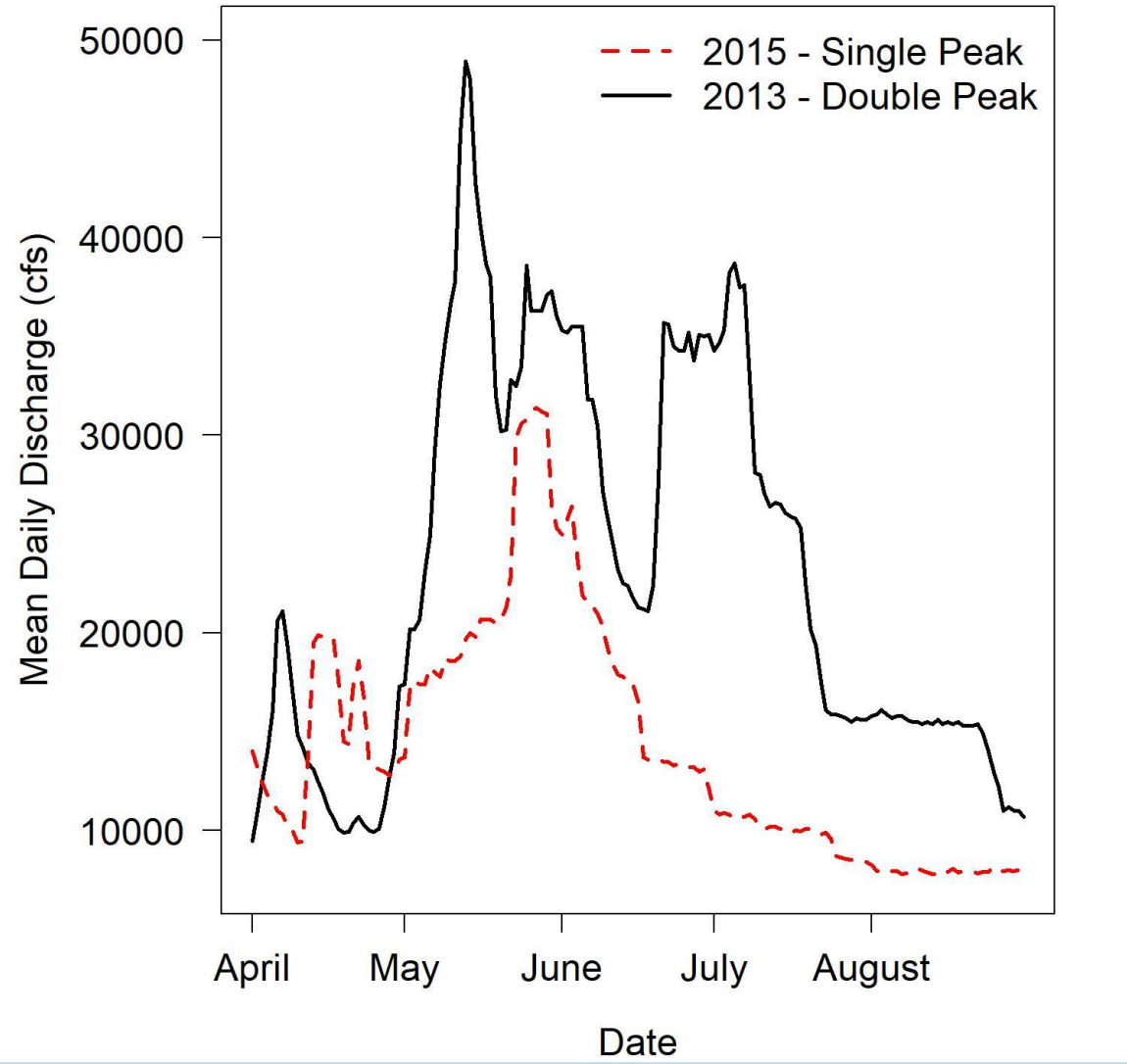
- Can we build habitat and/or design hydrographs to entice spawning white sturgeon to move further upstream to more suitable spawning habitat?

Management Actions

- Only a few management alternatives are available to try to get Sturgeon upstream
  - Flow Manipulations
  - Habitat Restoration

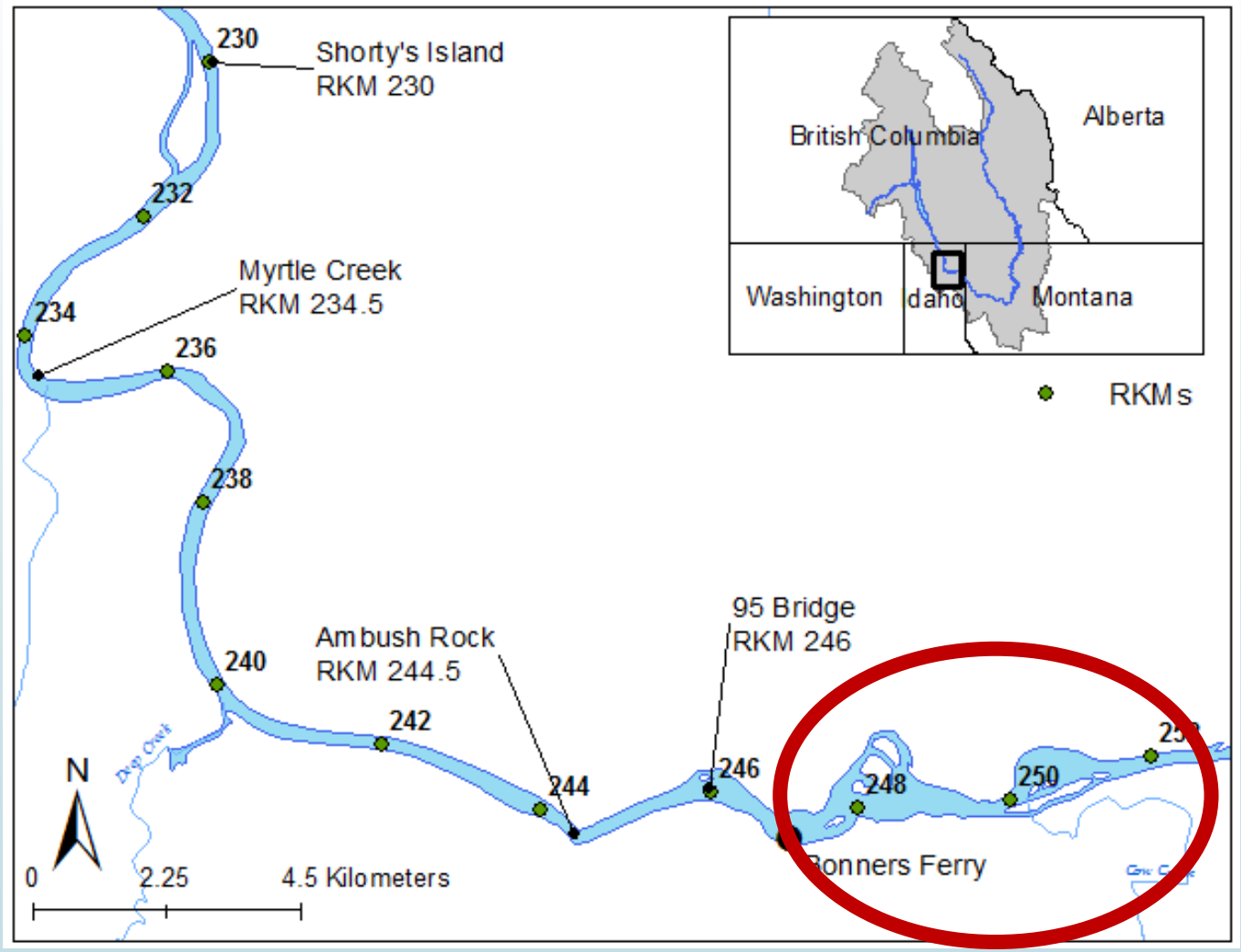
Management Actions

- Stream Flow Alterations
  - Shaping Hydrograph During spawning period
  - Number of Distinct Peaks



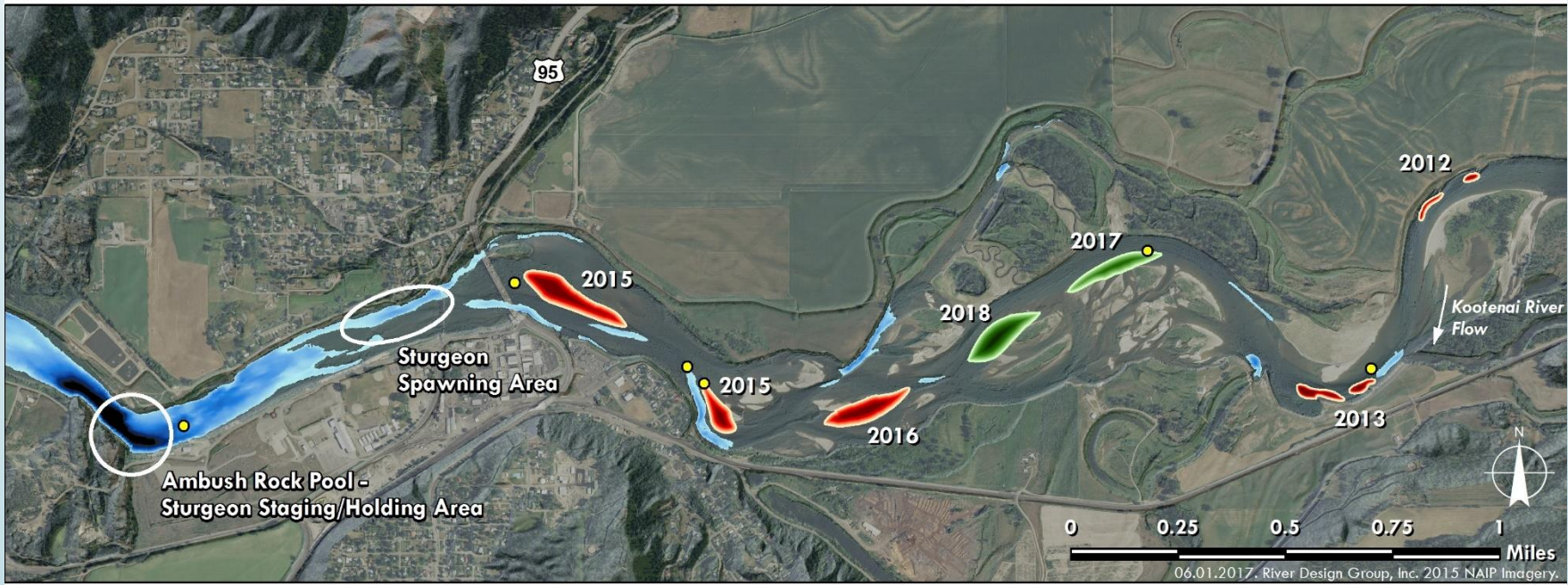
Management Actions

- Stream Flow Alterations
  - Shaping Hydrograph During spawning period
  - Number of Distinct Peaks
- Habitat Restoration Projects
  - Pool – Ladder Concept



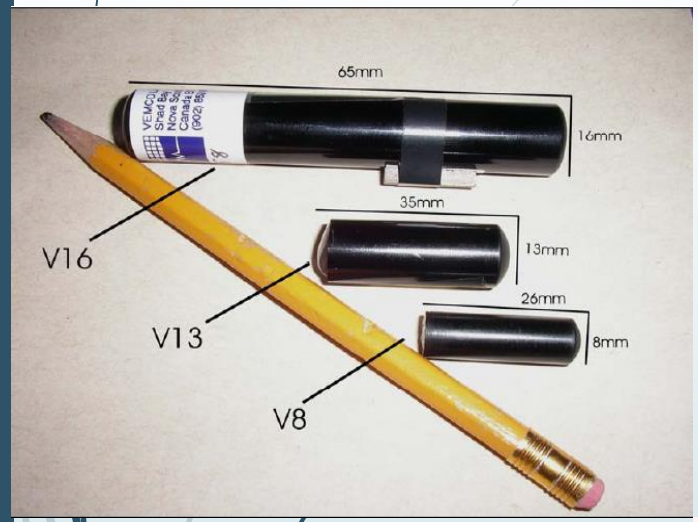
Management Actions

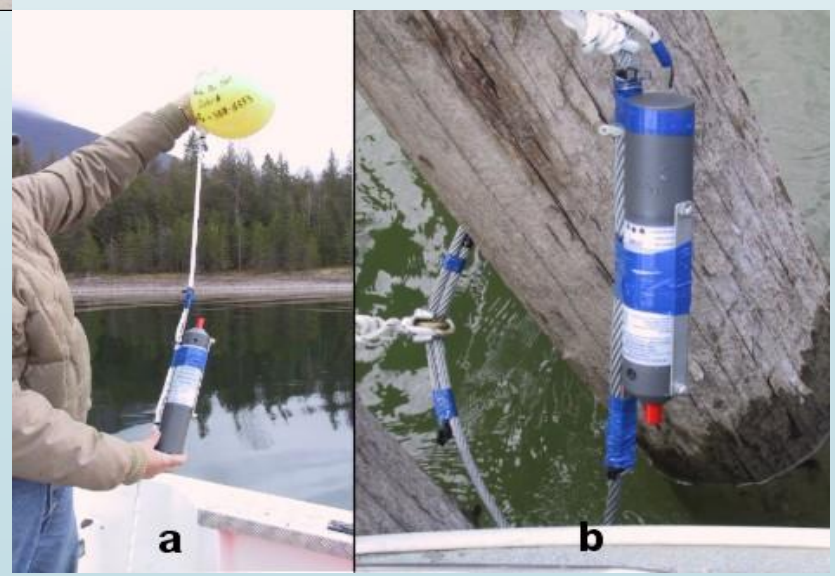
- Stream Flow Alterations
  - Shaping Hydrograph During spawning period
  - Number of Distinct Peaks
- Habitat Restoration Projects
  - Pool – Ladder Concept



Habitat Restoration

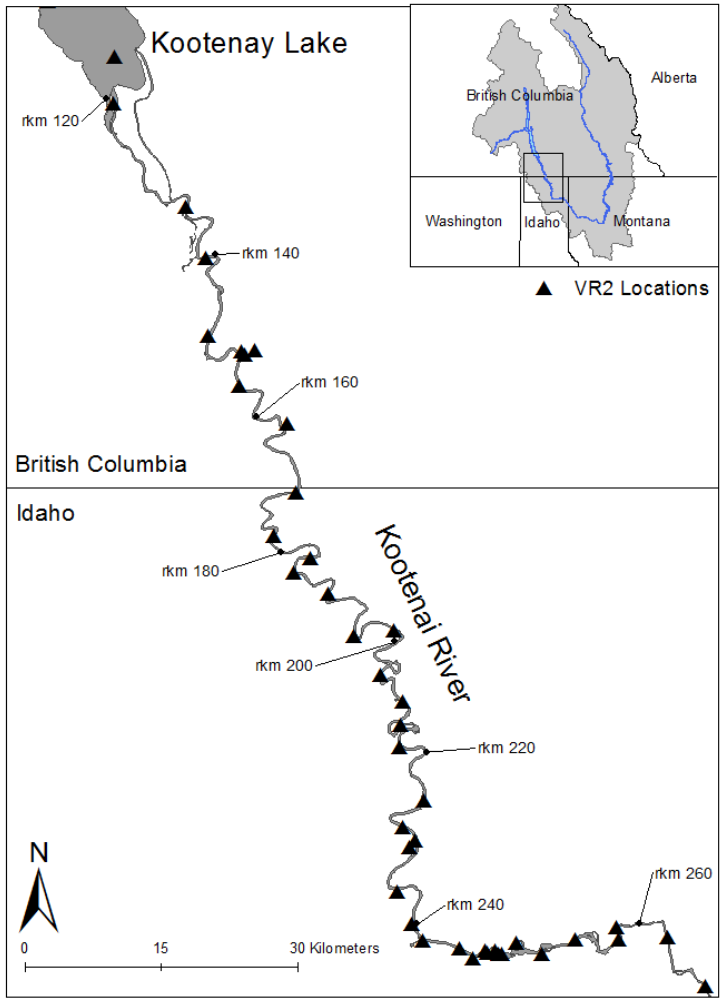
Evaluation





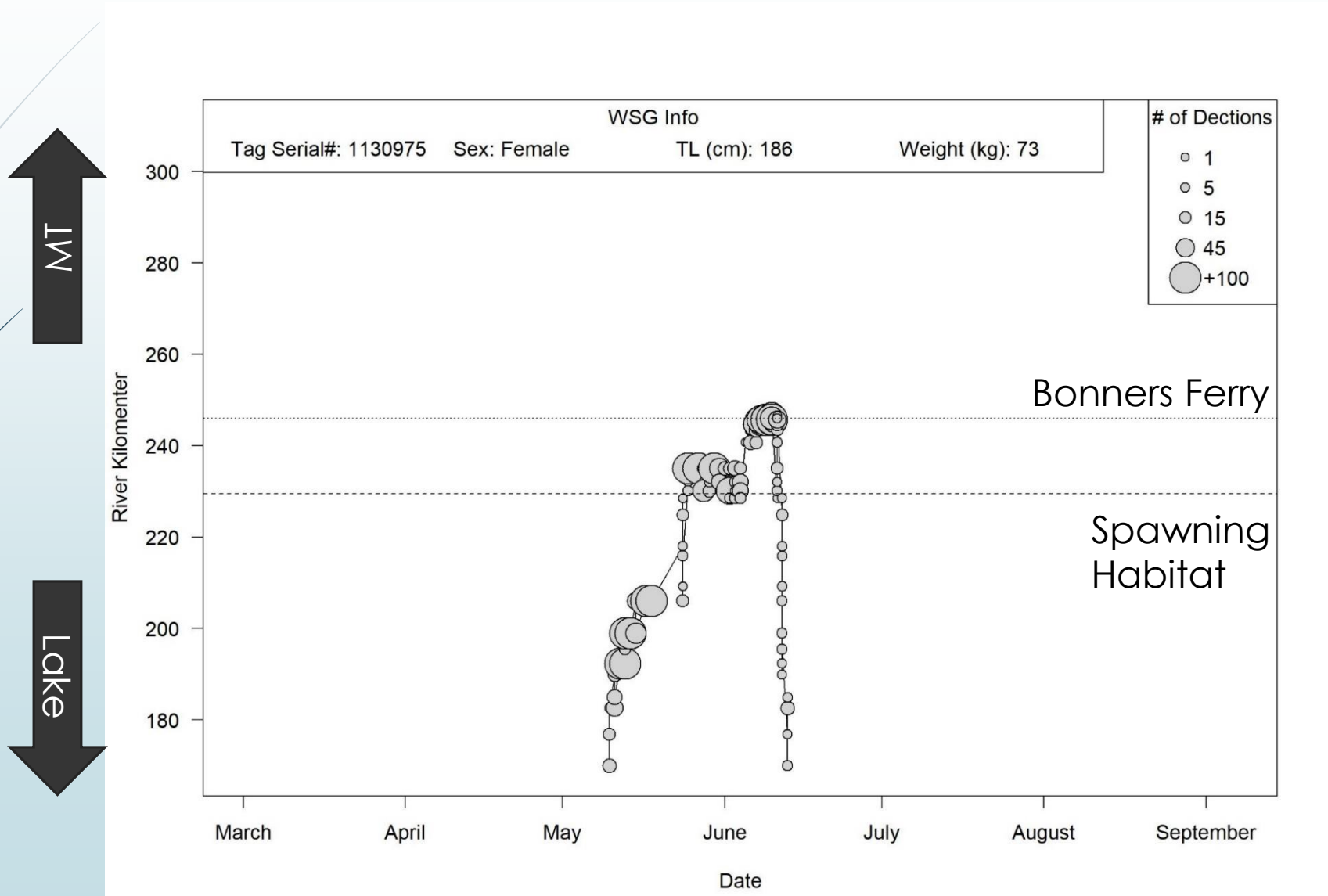
- Spawner information from our acoustic array
- Tagging began in 2005
- Approximately100 fish tagged in most years (almost all females)
- Allows us to track a individual fish and monitor it's spawning movement behaviors

Evaluation

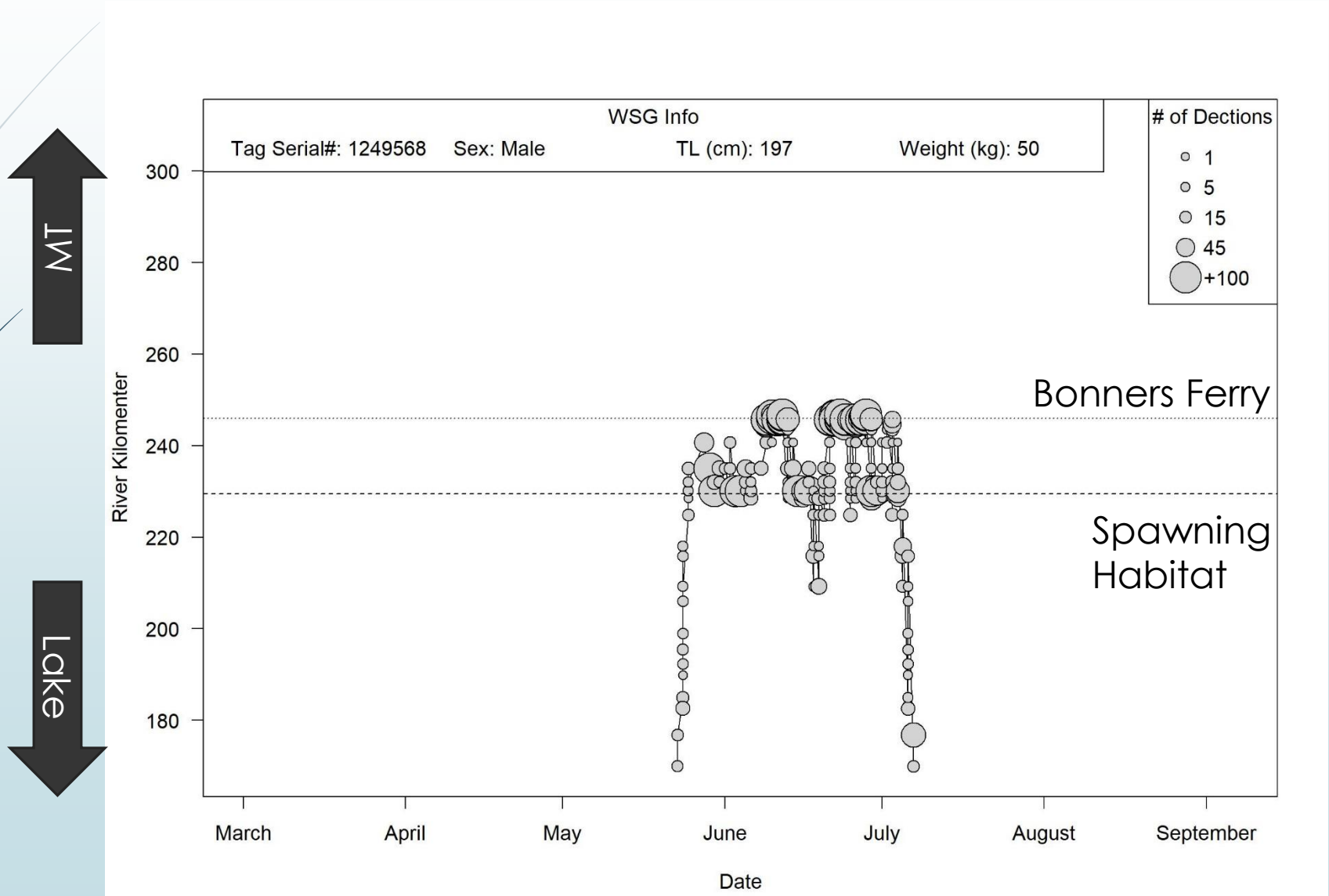


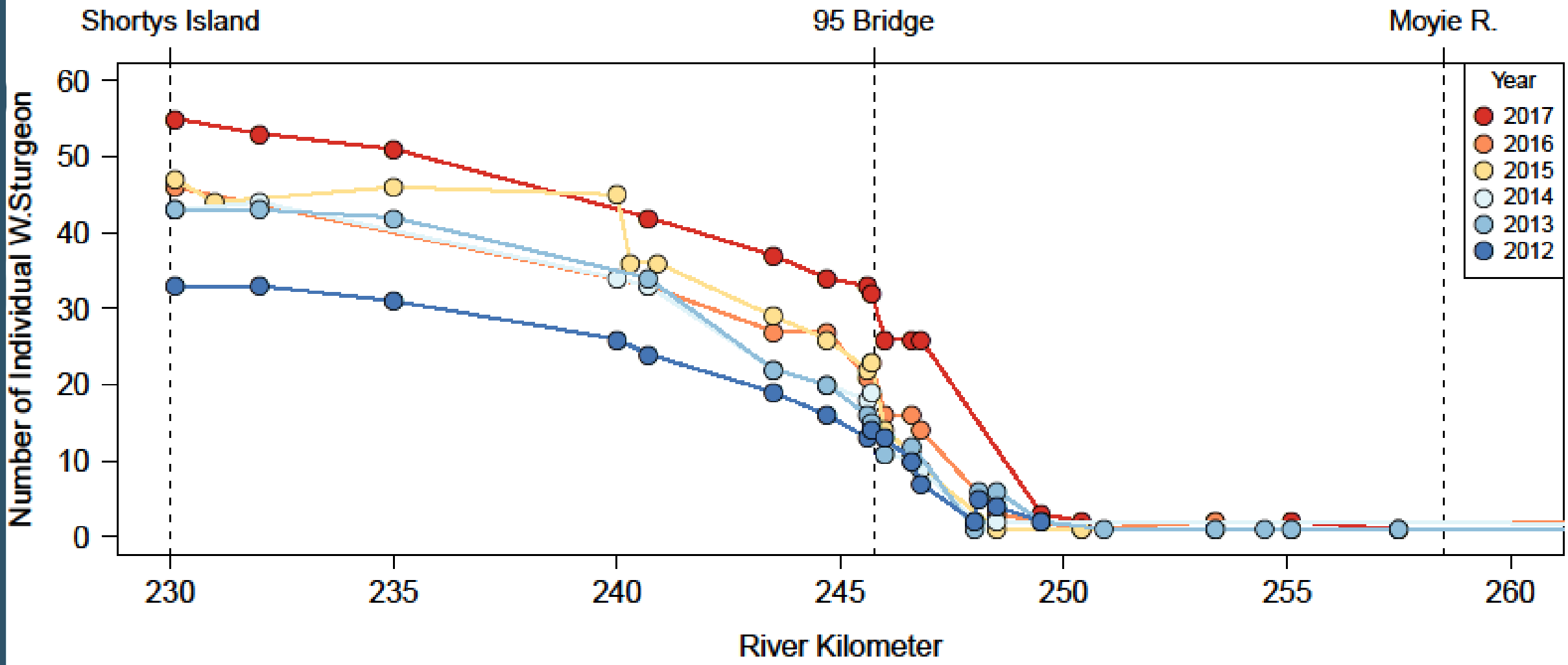
- Spawner information from our acoustic array
- Tagging began in 2005
- Approximately100 fish tagged in most years (almost all females)
- Allows us to track individual fish and monitor spawning movements

Example Spawning Movement



Example Spawning Movement




Shortys Island
95 Bridge
Moyie R.
Number of Individual W.Sturgeon
0
10
20
30
40
50
60
230
235
240
245
250
255
260
River Kilometer
Year
2017
2016
2015
2014
2013
2012

Modeling

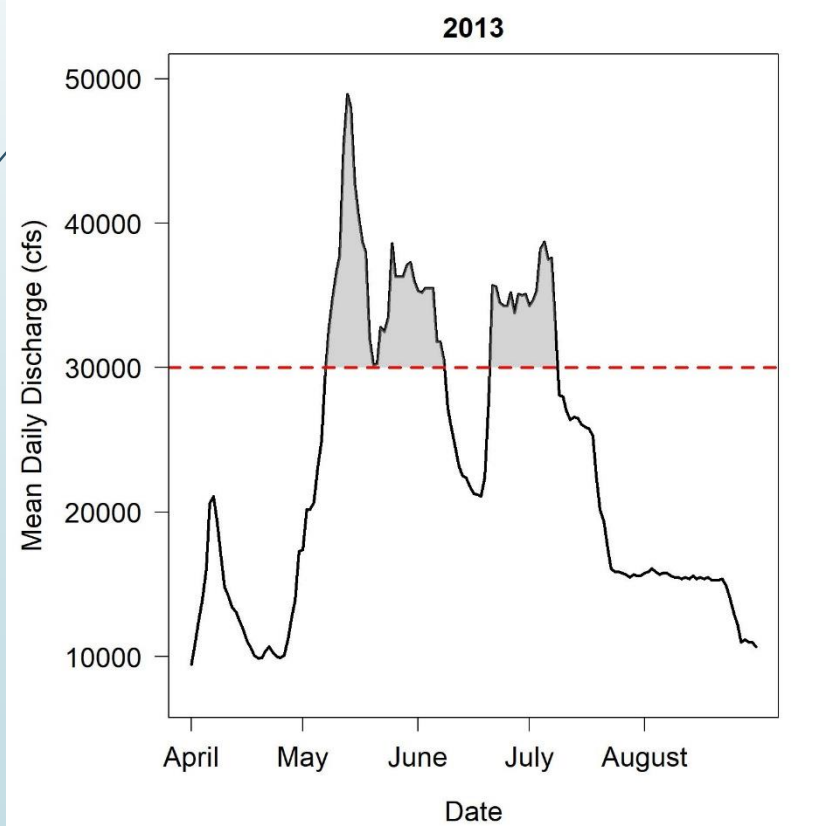
- Logistic Regression to determine what factors influenced the probability of a spawner migrating beyond Bonners Ferry in a given year.

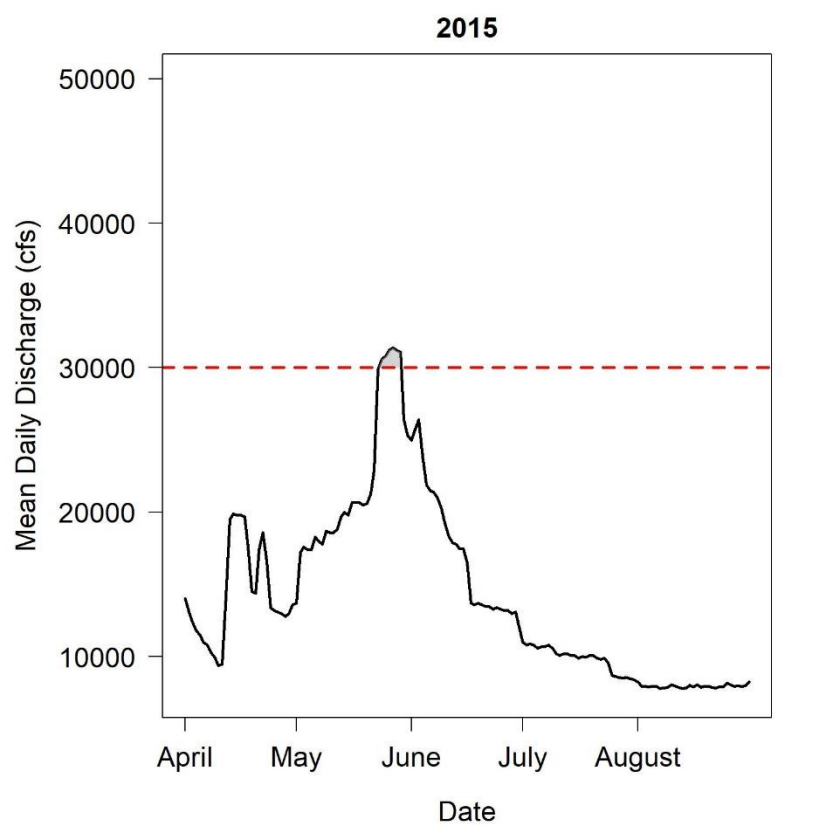
- Number Tagged Adults Above BF ~ Binomial (n, p)
  - n = Total number of spawners (# adults at Shortys Island)
  - p = probability of an individual moving above BF
  - Logit(p) = $\mathbf{X\beta}$ + RE

- Modeled probabilities from 2005 - 2017

Covariates Considered

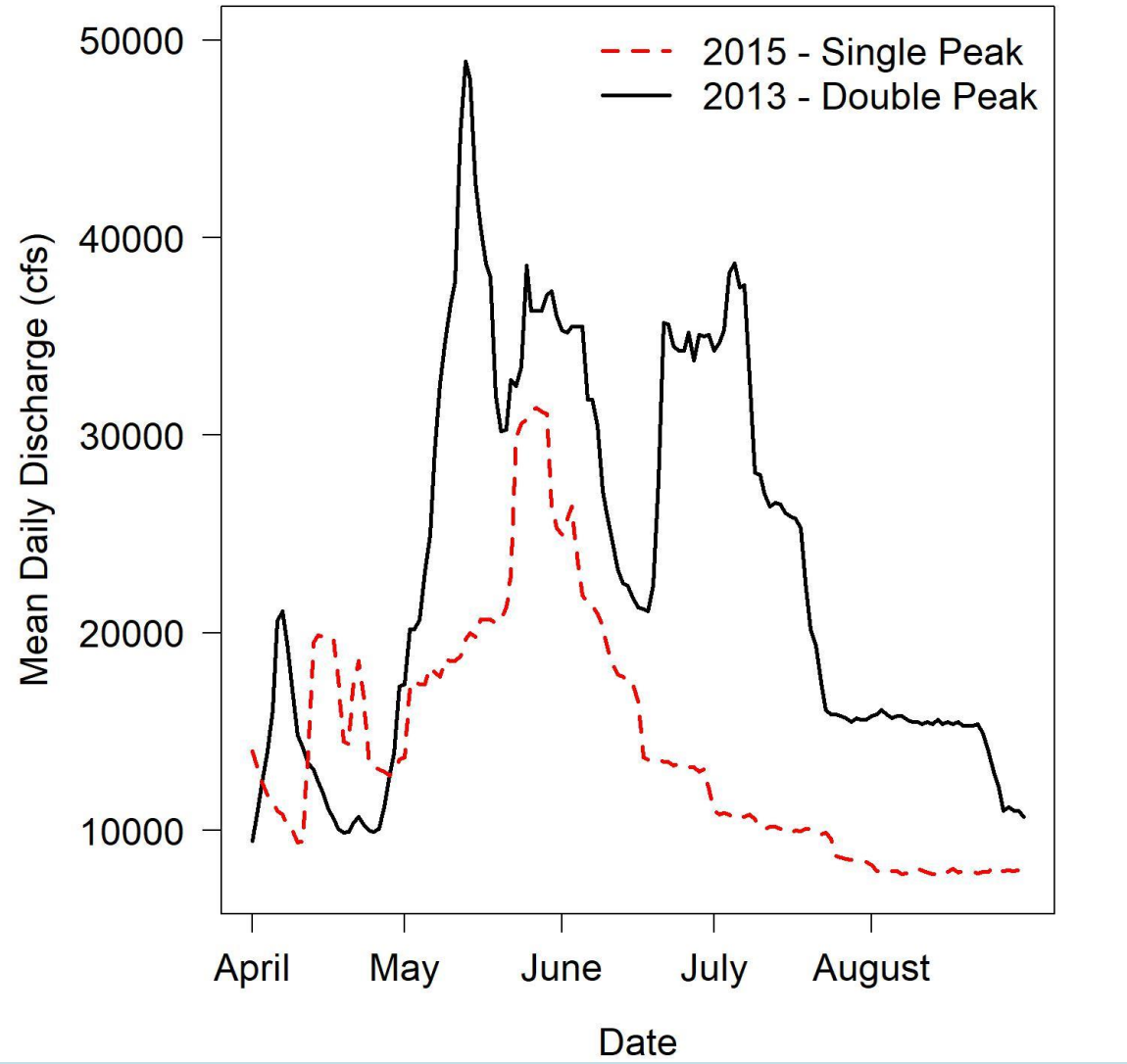
- High Flow Duration – Total Magnitude
  - Total Number of days in spawning period where daily mean discharge > 30k cfs
  - Full spill from Libby Dam = 25k cfs



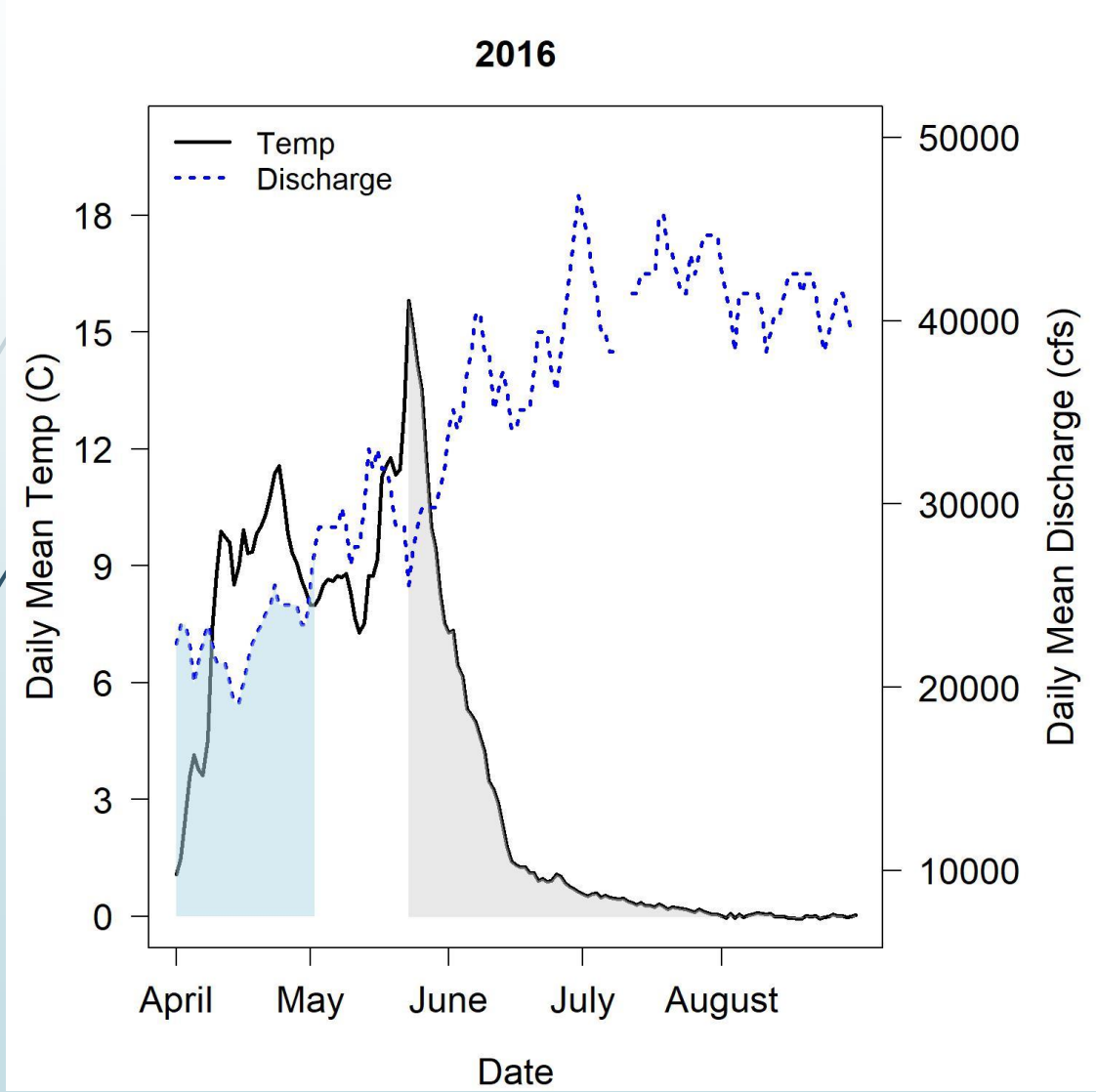


Covariates Considered

- Discharge Shape
  - 1 vs 2 peak
  - 1 Peak
  - 2 Peaks - Staging and Spawning



Covariates Considered



- Peak flow and temperature
  - We know spawn timing is related to temperature: 9°C seems to be the key
  - Does temperature influence spawning movement?
  - Calculated difference (days) between peak flow and when 9°C is reached

Covariates Considered

- Adult Density
- How many tagged spawners are present on lower spawning grounds?

Covariates Considered

- Project Completed?
- Simple indicator variable to represent that the habitat projects were complete and available for use.
- Considered complete starting in 2015

Modeling

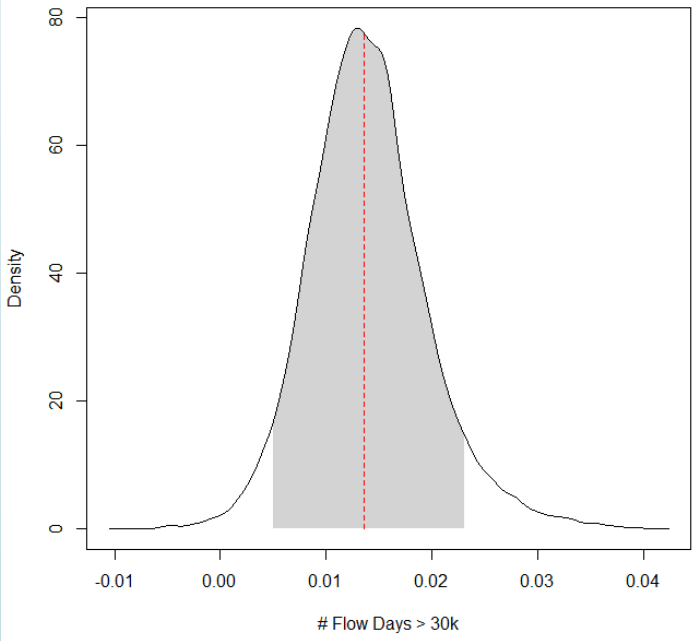
- Model fit in Bayesian frame work in STAN using *brms*() package in R
  - 10,000 samples taken from posterior (burn-in = 5,000)
  - 4 Chains
  - Converge was checked for using traceplots and Gelman-Rubrick Metric
- Random effect for year was included
- All priors were uninformative
- Model selection was done using WAIC
  - Determine which of these covariates can best predict adult movement

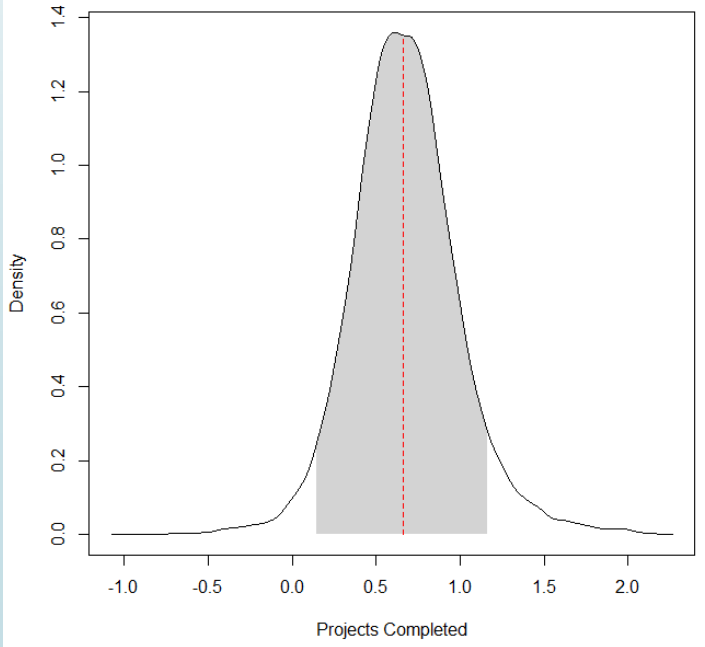
Model Selection Results

Model	WAIC	Δ WAIC
#Days > 30k + Habitat Project	68.33762	0
#Days > 30k + Spawner Density	69.2671	0.929482
#Days > 30k + Flow/Temp Lag + Habitat Project	69.53596	1.198343
#Days > 30k + flow_peaks_80 + Habitat Project	69.95532	1.617707
#Days > 30k + Habitat Project + Spawner Density	69.97529	1.637672
#Days > 30k + flow_peaks_80 + Flow/Temp Lag + Habitat Project	70.19539	1.857769

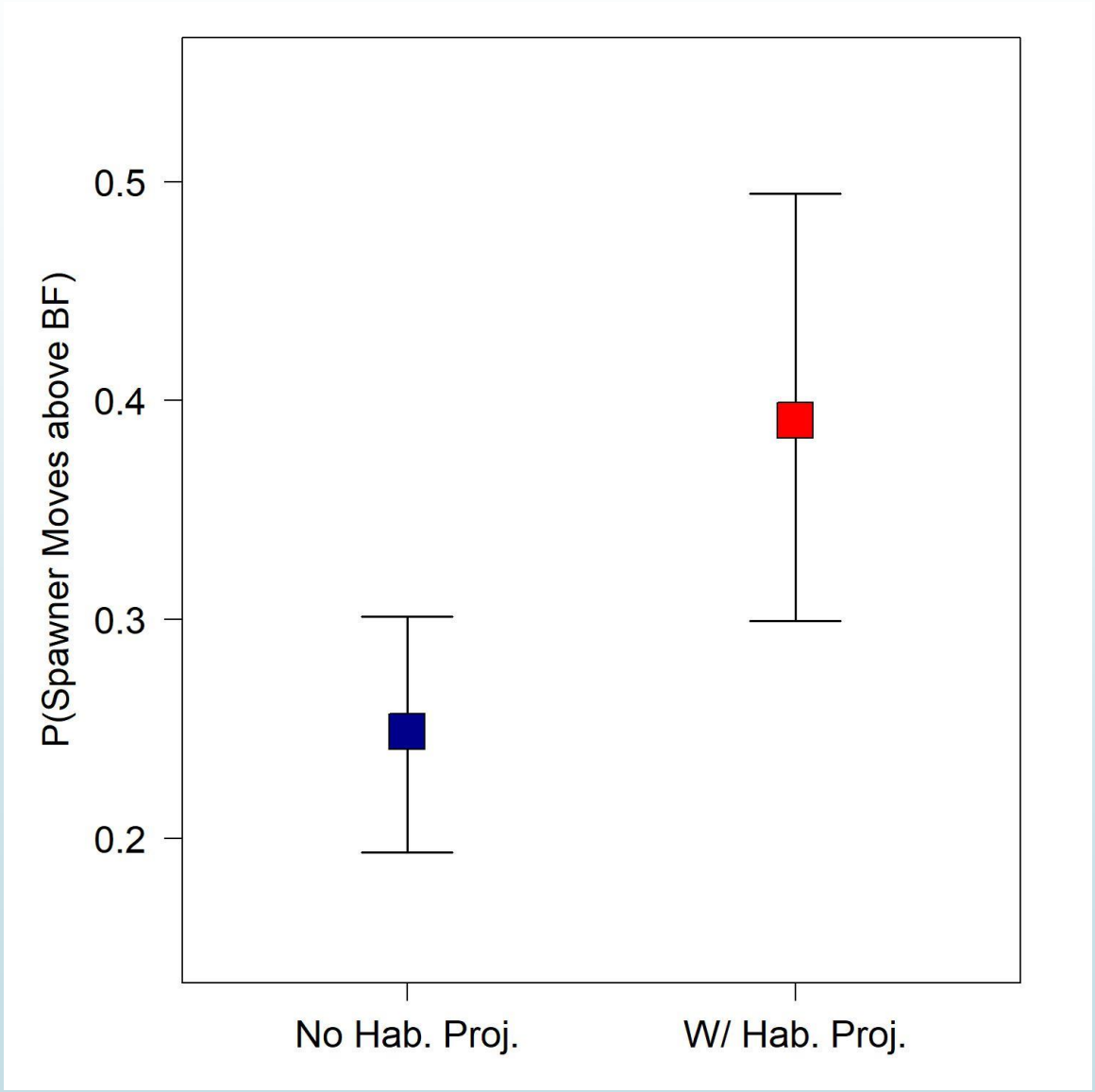
Top Model

Parameter	Mean	Lower 90% CI	Upper 90% CI	Rhat
Intercept	-1.65	-2.36	-1.09	1.00
#Days > 30k	0.01	0	0.03	1.00
Habitat Project	0.67	0.07	1.37	1.00
RE(Year)	0.28	0.01	0.81	1.00

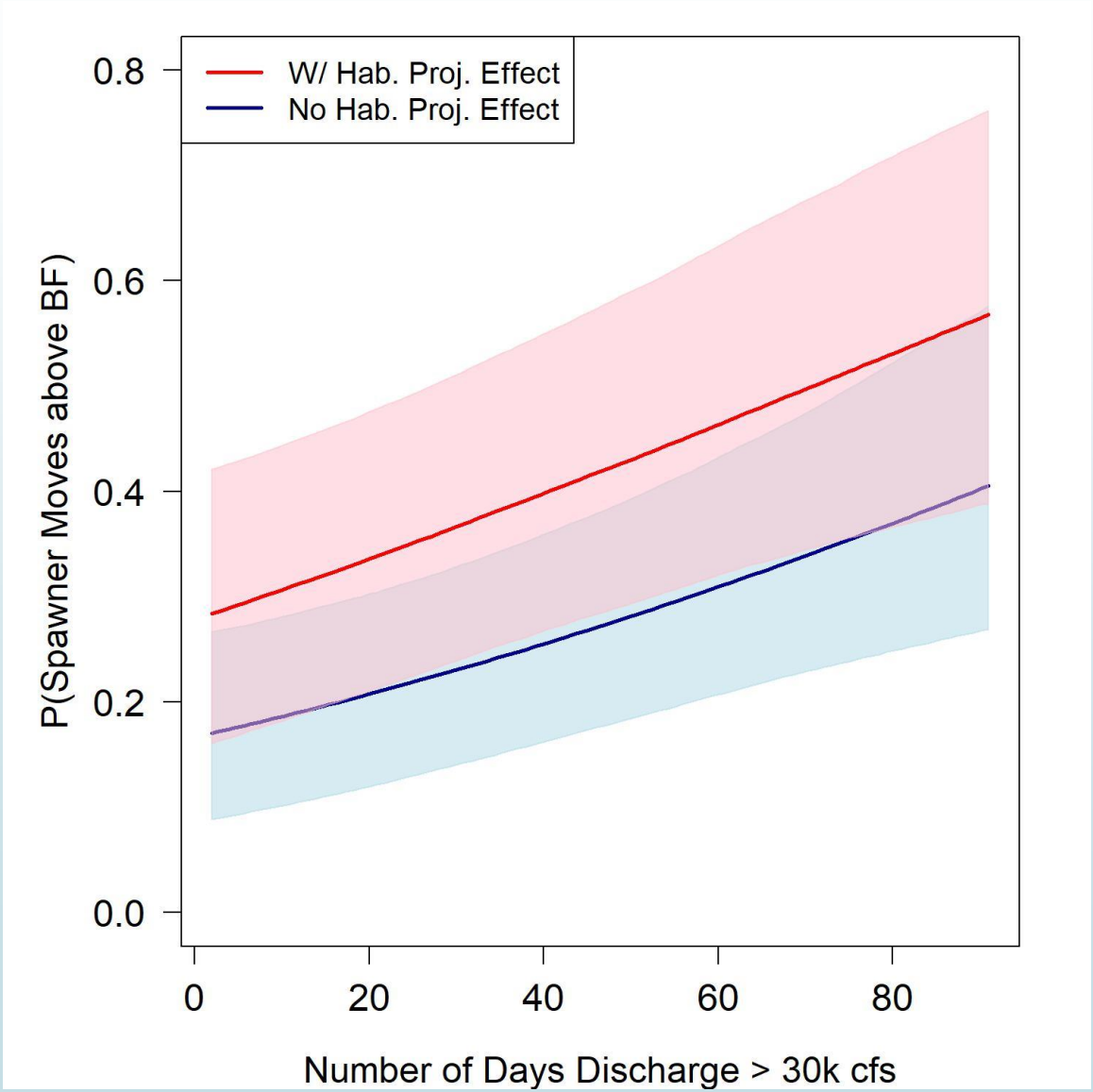




Marginal Effects



Marginal Effects

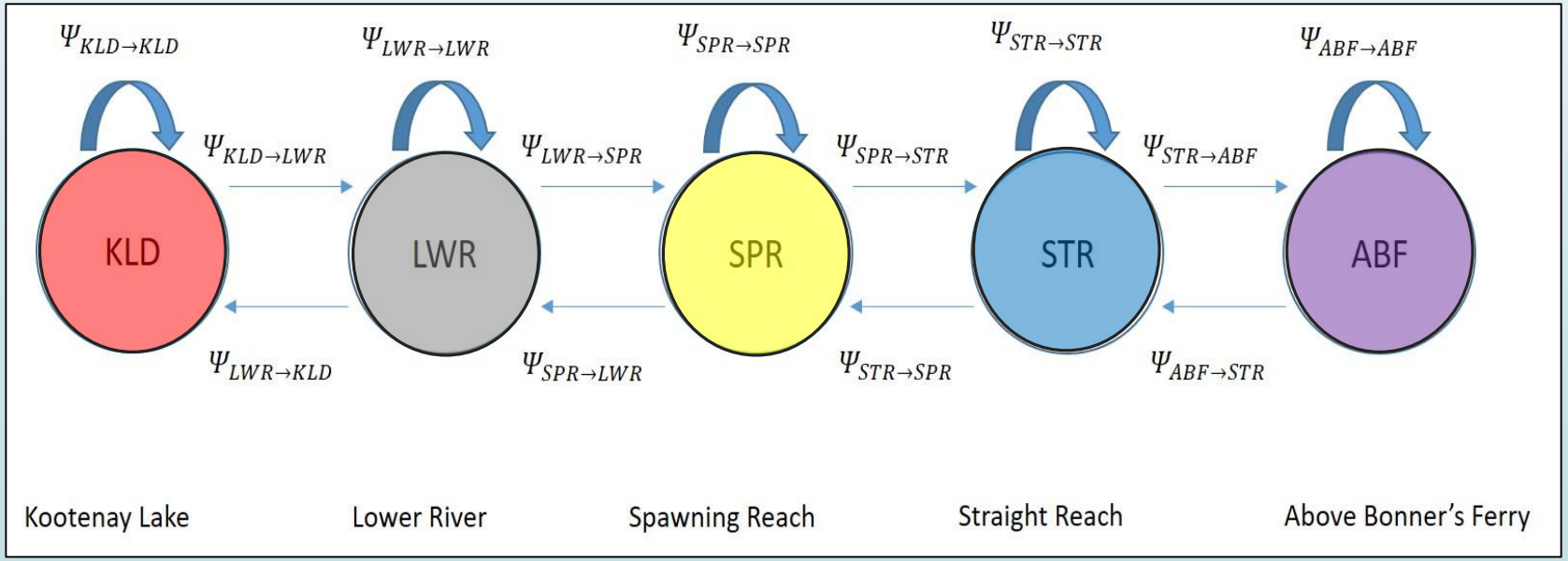


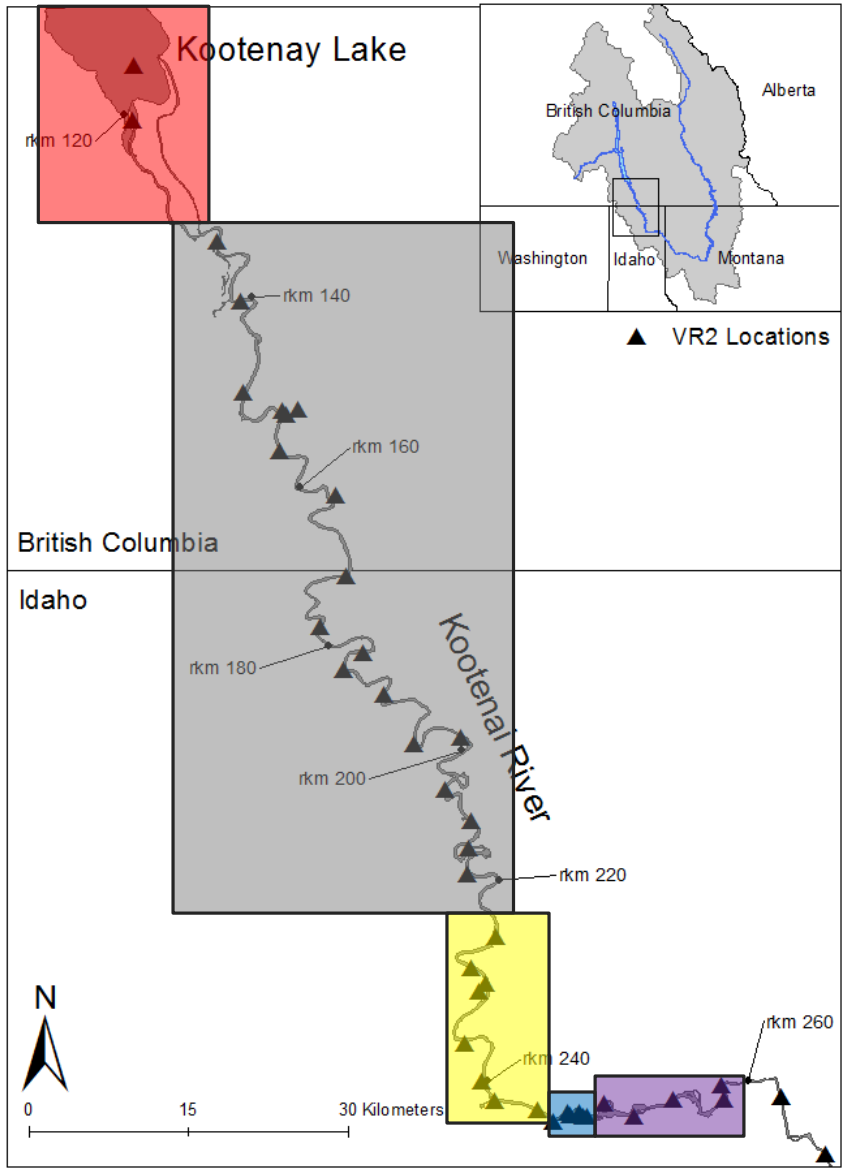
Model Result Summary

- The presence of new habitat additions resulted in a ~15% increase in the probability a tagged spawner would migrate above Bonners Ferry.
- The # of days discharge > 30k was a large predictor of whether or not a tagged spawning adult would move above Bonners Ferry into more suitable spawning habitats
- Number of peaks was not have a lot of support in the model.
- This suggests that it isn't the peak of the hydrograph, but rather the duration of high water events

Fine scale movement

- Used a multi-state model to estimate daily movement probabilities between 5 different strata




Kootenay Lake
rkm 120
rkm 140
rkm 160
rkm 180
rkm 200
rkm 220
rkm 240
rkm 260
British Columbia
Idaho
Kootenai River
Alberta
British Columbia
Washington
Idaho
Montana
VR2 Locations
N
0
15
30 Kilometers

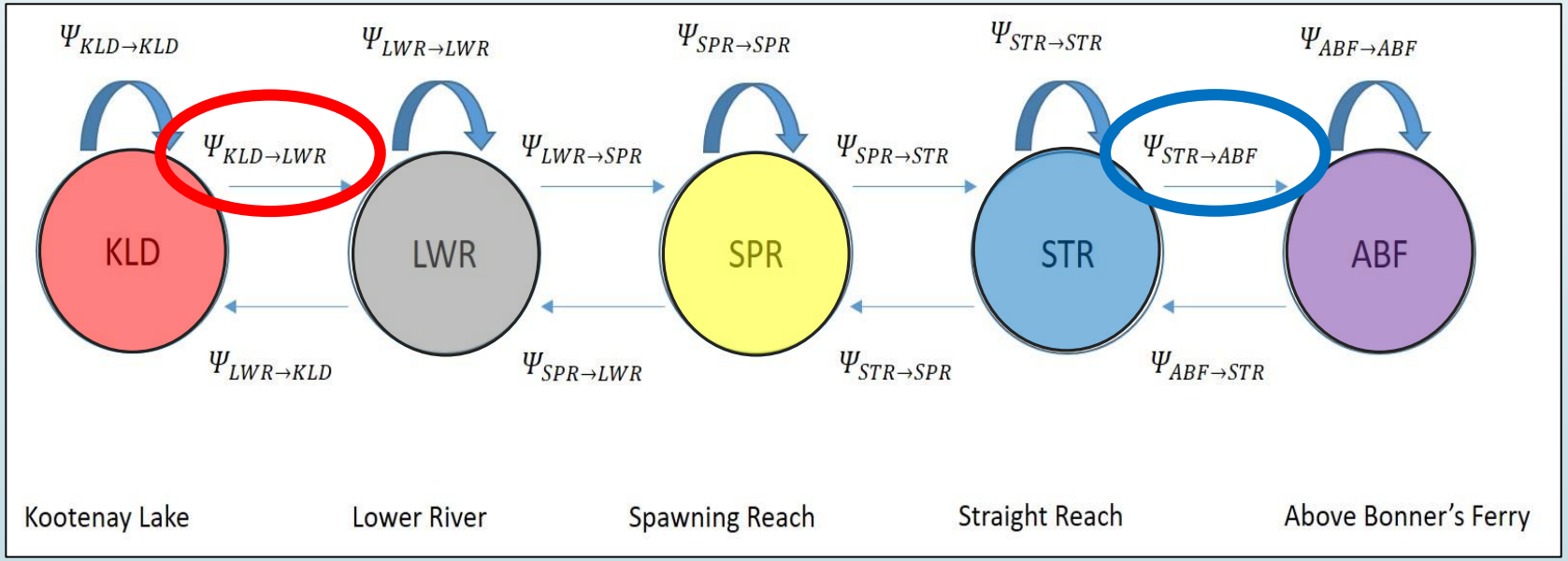
Fine scale movement

- A multi-state model was used to estimate daily movement probabilities between 5 different strata during spawning season
  - Used data from 2005 – 2012 (no habitat additions)
- How do these different transition probabilities influence the number of spawners that move above Bonners Ferry

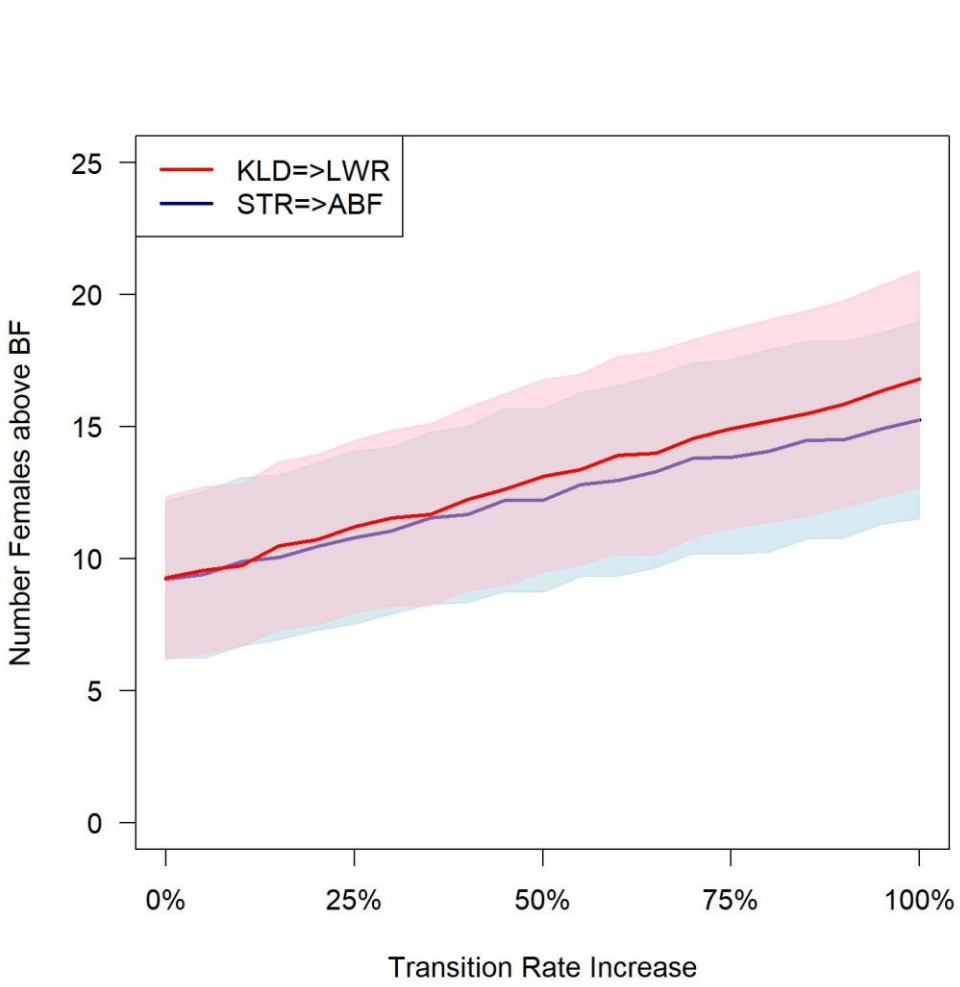
- IBM to simulate how these probabilities can influence broad scale movement behaviors
  - Starts with 500 fish in the lake
  - Last the entirety of the spawning season
  - Calculated the number of simulated individuals that made it to Bonners Ferry

Fine scale movement

- Manipulated two transition rates to see how they affected spawning movements above town.
  - Kootenai Lake to Lower River
  - Straight reach to Above B.F.



Which transition probability is the most important?



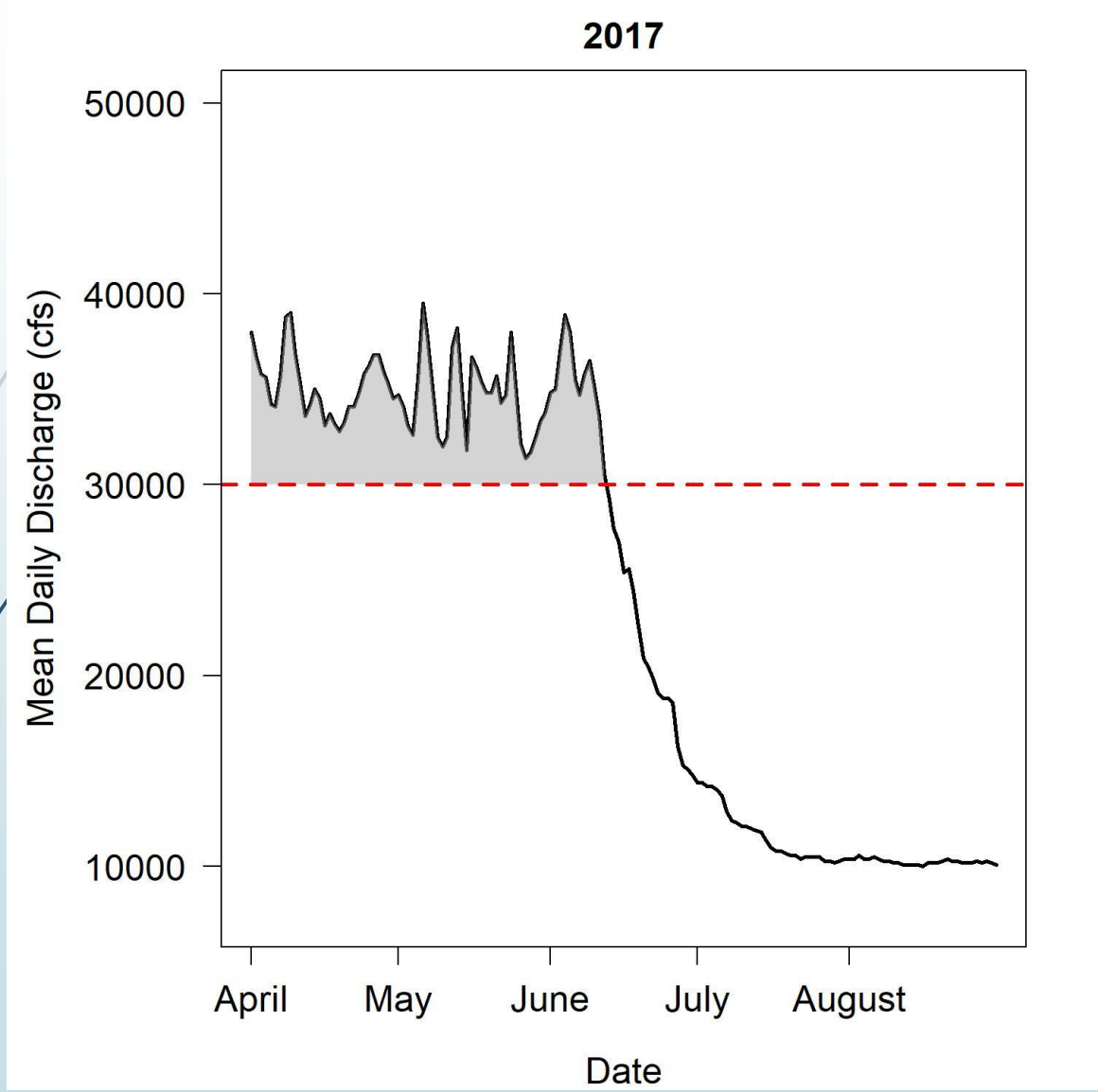
- Both parameters appear to be equally sensitive
- Increasing the probability an adult would leave the Lake has the same effect as increasing the probability that a adult would move from the straight reach to above BF
- May provide options for future

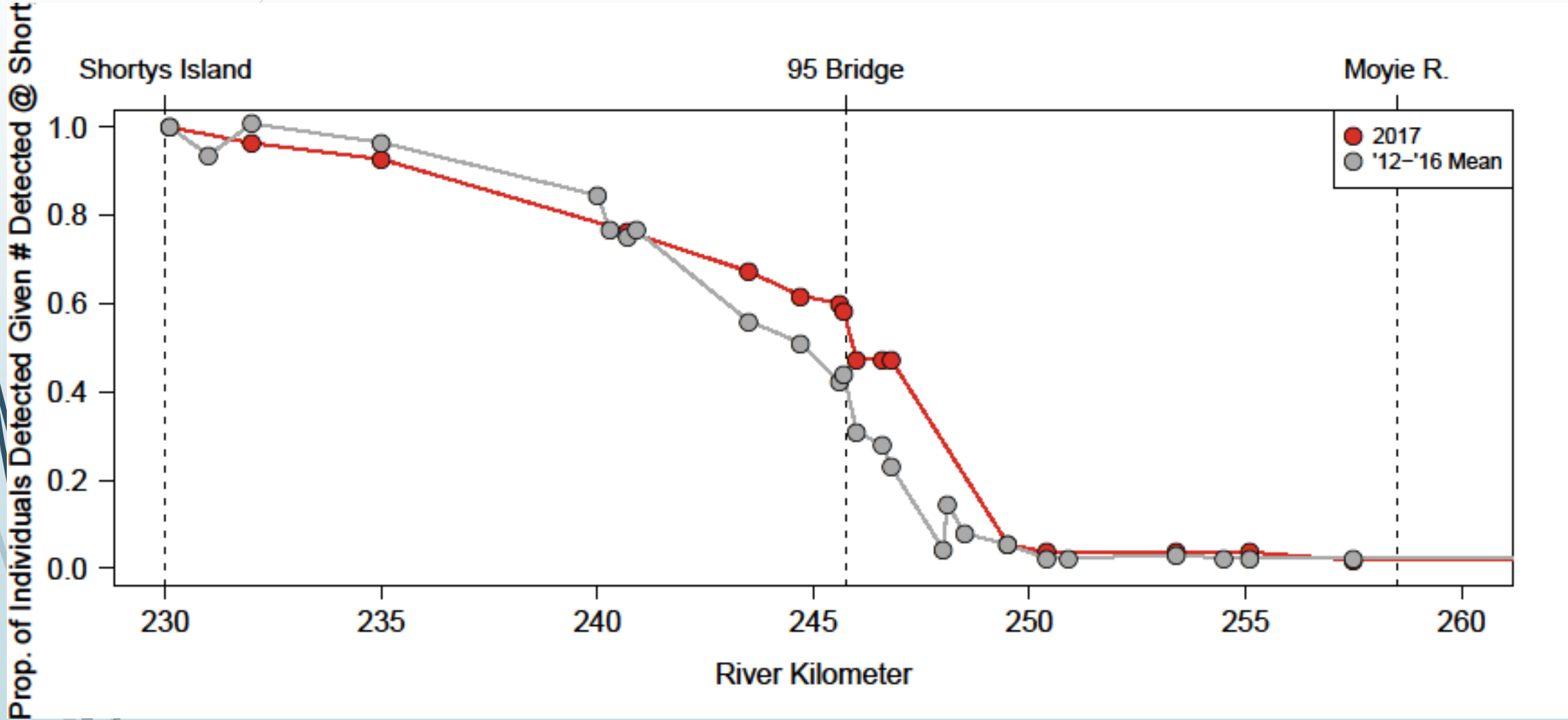
Summary

- Appears to be a lot of support to suggest that upstream habitat work has caused an increase in the likelihood that a tagged adult sturgeon would move above BF.
  - Empirical estimates of the amount of habitat are needed.
- Magnitude of flow seems to be the best predictor of whether a tagged adult sturgeon will move above BF.
  - Single vs double peaks didn't seem to be as important.
  - Duration of high water is key
- There may be opportunities else where in the system

Questions

E-mail: kevin.mcdonnell@idfg.Idaho.gov


2017
50000
40000
30000
20000
10000
Mean Daily Discharge (cfs)
April
May
June
July
August
Date


Shortys Island
95 Bridge
Moyie R.
2017
'12–'16 Mean
Prop. of Individuals Detected Given # Detected @ Short
1.0
0.8
0.6
0.4
0.2
0.0
230
235
240
245
250
255
260
River Kilometer