Steelhead Overshoot Update

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1/13/2022

Workflow - John Day River Wild Steelhead - 05/06 to 14/15

- Query PTAGIS
  - Selected individuals marked/released in John Day River
  - All fish seen at BON adult ladders
  - Sorted into run years
- Generate detection history
- Fit multistate model
  - Fit in R - did not use USER or Branch
  - MLE

Columbia River Basin

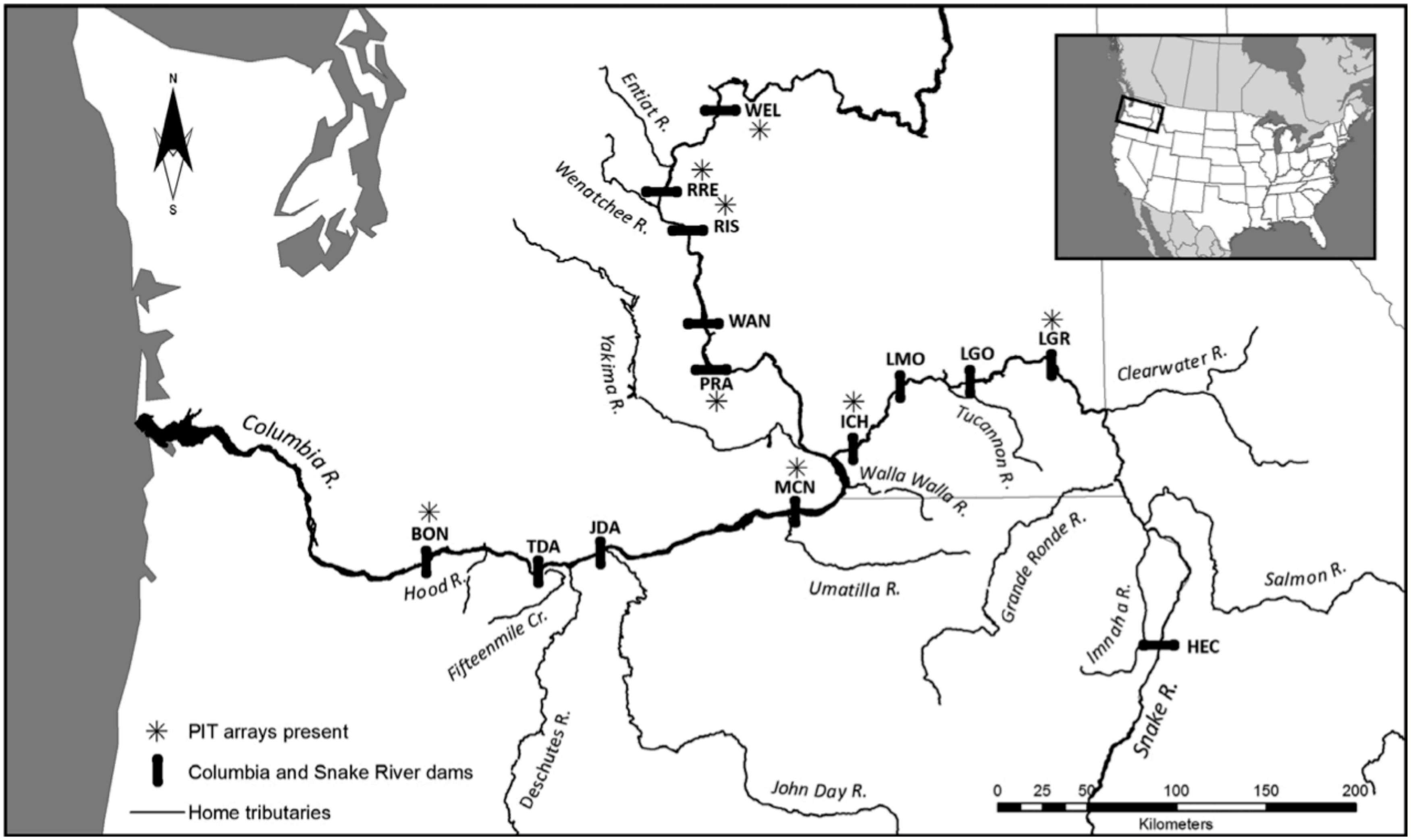


FIGURE 1. Map of the Columbia River basin, with natal tributaries of PIT-tagged steelhead used in this study (BON = Bonneville Dam; TDA = The Dalles Dam; JDA = John Day Dam; MCN = McNary Dam; PRA = Priest Rapids Dam; WAN = Wanapum Dam; RIS = Rock Island Dam; RRE = Rocky Reach Dam; WEL = Wells Dam; ICH = Ice Harbor Dam; LMO = Lower Monumental Dam; LGO = Little Goose Dam; LGR = Lower Granite Dam; HEC = Hells Canyon Dam).

Pseudocode for individual detection histories - MCN example

```
# Get names of all McNary adult fishway detectors
site_metadata$event_site_name[grep("McNary", site_metadata$event_site_name)]
MCN_adult_fishways <- c("MC1 - McNary Oregon Shore Ladder",
                        "MC2 - McNary Washington Shore Ladder")

# For each of the unique tags
for (i in 1:length(unique_tags)){
  tag_ID <- unique_tags[i]
  tag_hist <- subset(JDR_CTH, tag_code == tag_ID)
# Record if seen at MCN
  tag_hist_adult$event_site_name %in% MCN_adult_fishways -> MCN_TF
  if (TRUE %in% MCN_TF){
    detection_df[i,5] <- TRUE
  }
  else{
    detection_df[i,5] <- FALSE
  }
```

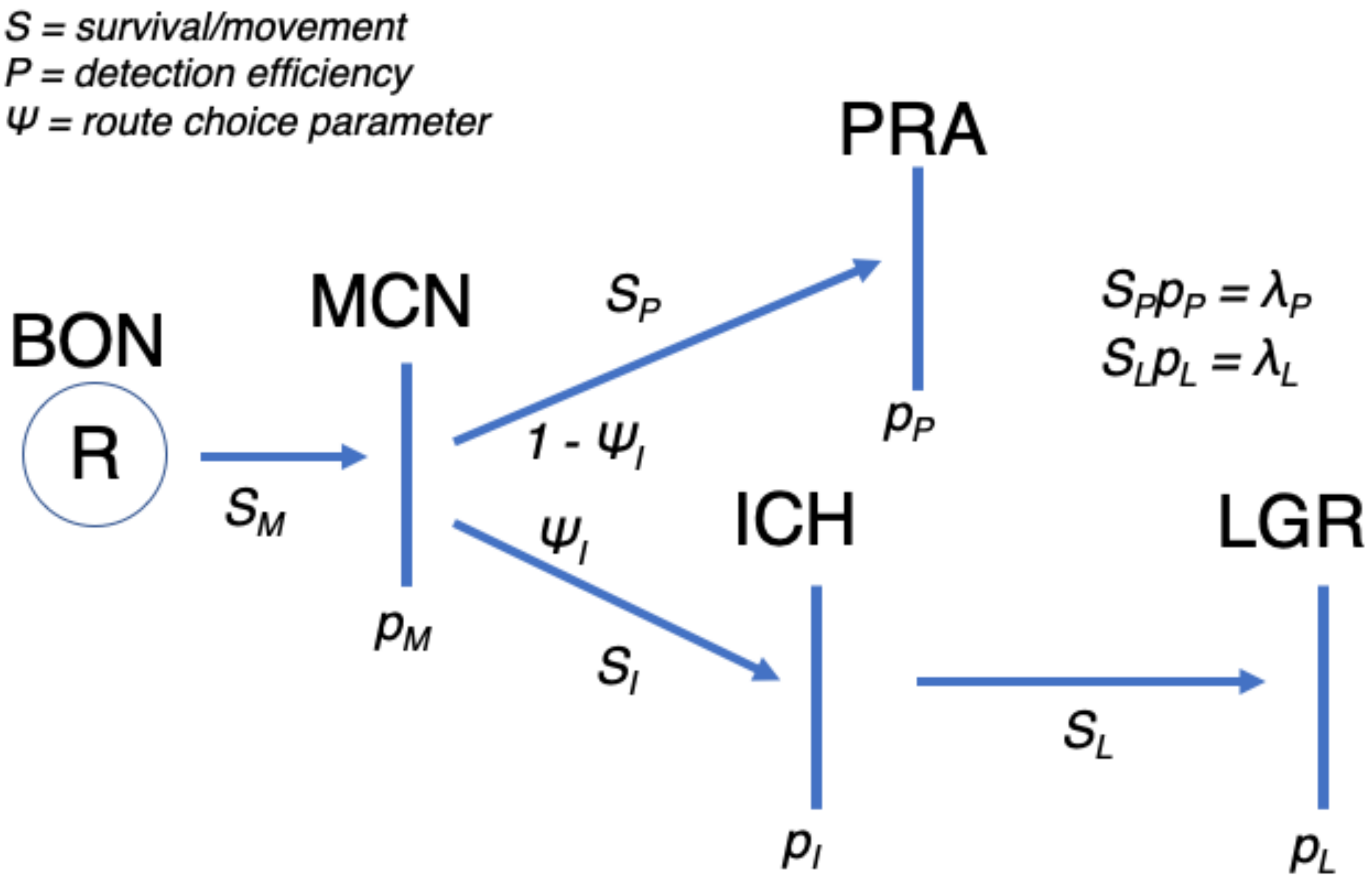
Detection histories for model

```
# Release at BON
detection_df %>%
  mutate(det_hist = ifelse(MCN == TRUE, "M", 0)) %>%
  mutate(det_hist = paste0(det_hist, ifelse(ICH == TRUE, "I", 0))) %>%
  mutate(det_hist = paste0(det_hist, ifelse(LGR == TRUE, "L", 0))) %>%
  mutate(det_hist = paste0(det_hist, ifelse(PRA == TRUE, "P", 0)))-> det_df
```

```
head(det_df)
```

```
##              tag run_year  BON  TDA   MCN   ICH   LGR   PRA det_hist
## 1 384.3B23983360    14/15 TRUE TRUE FALSE FALSE FALSE FALSE     0000
## 2 384.3B2399307E    14/15 TRUE TRUE FALSE FALSE FALSE FALSE     0000
## 3 3D6.000AC9D32D    14/15 TRUE TRUE FALSE FALSE FALSE FALSE     0000
## 4 3D6.000AC9D33B    14/15 TRUE TRUE FALSE FALSE FALSE FALSE     0000
## 5 3D6.000AC9D579    14/15 TRUE TRUE  TRUE FALSE FALSE FALSE     M000
## 6 3D6.000AC9EA4D    13/14 TRUE TRUE  TRUE FALSE FALSE FALSE     M000
```

Model structure



Probabilities for multinomial likelihood

```
# Zero probability detection histories (in one-directional model):
# MILP, MI0P, M0LP, 0ILP, 0I0P, 00LP

# MIL0
nMIL0 <- sM * pM * psiI * sI * pI * lambdaL
# MI00
nMI00 <- sM * pM * psiI * sI * pI * (1 - lambdaL)
# M0L0
nM0L0 <- sM * pM * sI * (1 - pI) * lambdaL
# M00P
nM00P <- sM * pM * (1 - psiI) * lambdaP
# M000
nM000 <- sM * pM * psiI * (1 - sI) + # Chose ICH route, died on way
  # Chose ICH route, made it undetected, not seen at LGR
  sM * pM * psiI * sI * (1 - pI) * (1 - lambdaL)+
   # Chose PRA route, not seen at PRA
  sM * pM * (1 - psiI) * (1 - lambdaP)
```

Probabilities for multinomial likelihood

```
# 0IL0
n0IL0 <- sM * (1 - pM) * sI * pI * lambdaL
# 0I00
n0I00 <- sM * (1 - pM) * sI * pI * (1 - lambdaL)
# 00L0
n00L0 <- sM * (1 - pM) * sI * (1 - pI) * lambdaL
# 000P
n000P <- sM * (1 - pM) * lambdaP

# 0000
n0000 <- (1 - sM) + # died before MCN
  # survived undetected to MCN, chose ICH route, died on way
  (sM * (1 - pM) * psiI * (1 - sI)) +
  # survived undetected to MCN, chose ICH route, survived ICH
  # undetected, not seen at LGR
  (sM * (1 - pM) * psiI * sI * (1 - pI)) * (1 - lambdaL) +
  # survived undetected to MCN, chose PRA route, not seen at PRA
  (sM * (1 - pM) * (1 - psiI) * (1 - lambdaP))
```

Fit model - maximum likelihood

```
negLL = function(params, data){
  # Get parameters from params vector
  sM <- params[1]; pM <- params[2]; sI <- params[3]; pI <- params[4];
  lambdaL <- params[5]; lambdaP <- params[6]; psiI <- params[7]

  # Calculated the probabilities of the 16 different detection
  # histories from the 7 parameters above

  p <- c(nMILP, nMIL0, nMI0P, nMI00, nM0LP, nM0L0, nM00P, nM000,
         n0ILP, n0IL0, n0I0P, n0I00, n00LP, n00L0, n000P, n0000)
  negLL <- -1* dmultinom(x = data$count, prob = p, log = TRUE)
}
# Use optim
# Order of parameters: sM, pM, sI, pI, lambdaL, lambdaP, psiI
optim_results <- optim(par = c(0.5, 0.99, 0.5, 0.99, 0.2, 0.2, 0.8),
                       data = data, fn = negLL, method = 'L-BFGS-B',
                       hessian = FALSE, lower = 0.0001, upper = 0.9999)
```

Comparison w/ Shelby's results for JDR

```
kable(JDR_table)
```

	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	mean
BON -> MCN	0.589	0.550	0.624	NA	NA	0.524	0.365	0.524	NA	0.542	0.531
MCN -> ICH	0.324	0.227	0.187	NA	NA	0.404	0.269	0.085	NA	0.331	0.261
ICH -> LGR lambda	0.692	0.533	0.000	NA	NA	0.488	0.750	0.750	NA	0.308	0.503
MCN -> PRA lambda	0.000	0.000	0.121	NA	NA	0.187	0.000	0.065	NA	0.087	0.066

```
kable(Richins_table_E1)
```

	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	mean
BON -> MCN	0.536	0.552	0.603	0.454	0.611	0.525	0.364	0.532	0.607	0.543	0.533
MCN -> ICH	0.337	0.227	0.134	0.416	0.295	0.296	0.271	0.075	0.129	0.261	0.244
ICH -> LGR	0.692	0.555	0.000	0.391	0.525	0.489	0.753	0.833	0.302	0.294	0.483
MCN -> PRA	0.000	0.000	0.029	0.090	0.014	0.048	0.000	0.025	0.019	0.015	0.016

Issues with current model formulation

Model is set up to be unidirectional?

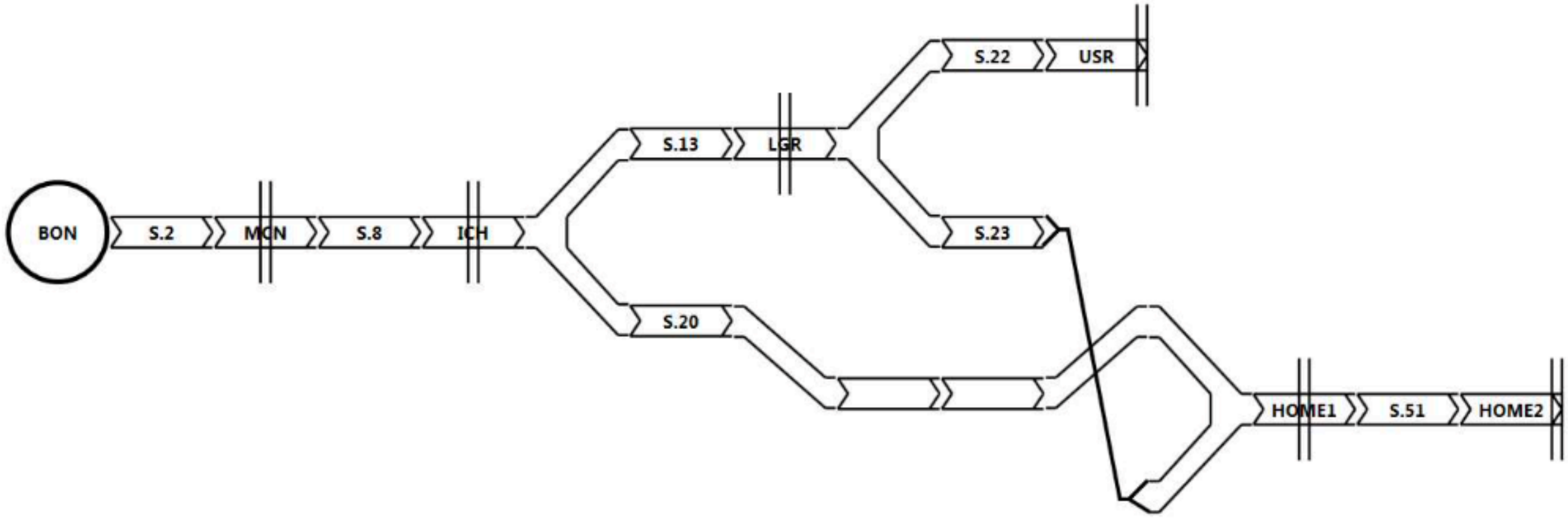


FIGURE 2.3.—Schematic drawn in the program Branch model the adult migration behavior of Tucannon River steelhead. BON = Bonneville, MCN = McNary, ICH = Ice Harbor, LGR = Lower Granite, USR = upper Snake River, HOME1 = Lower Tucannon River, HOME2 = upper Tucannon River.

3/2121 fish violated unidirectional assumptions

```
subset(funky_fish, tag_code ==  "3D9.1C2C84343A") %>%
  remove_rownames() %>%
  dplyr::select(tag_code, event_site_name, event_date)
```

```
##         tag_code                          event_site_name event_date
## 1 3D9.1C2C84343A  JDARMF - Middle Fork John Day River 2008-04-17
## 2 3D9.1C2C84343A BO1 - Bonneville Bradford Is. Ladder 2009-07-20
## 3 3D9.1C2C84343A BO1 - Bonneville Bradford Is. Ladder 2009-07-21
## 4 3D9.1C2C84343A     MC1 - McNary Oregon Shore Ladder 2009-08-03
## 5 3D9.1C2C84343A            PRA - Priest Rapids Adult 2009-08-18
## 6 3D9.1C2C84343A            PRA - Priest Rapids Adult 2009-09-03
## 7 3D9.1C2C84343A              RIA - Rock Island Adult 2009-09-09
## 8 3D9.1C2C84343A      ICH - Ice Harbor Dam (Combined) 2010-05-01
## 9 3D9.1C2C84343A        GRA - Lower Granite Dam Adult 2010-05-05
```

63/2121 ascended at least one dam multiple times

```
subset(JDR_CTH, tag_code ==  "3D9.1BF1CF04A0") %>%
  remove_rownames() %>%
  dplyr::select(tag_code, event_site_name, event_date)
```

```
##         tag_code                        event_site_name event_date
## 1 3D9.1BF1CF04A0   JDARSF - South Fork John Day River 2004-04-30
## 2 3D9.1BF1CF04A0          JDJ - John Day Dam Juvenile 2004-05-09
## 3 3D9.1BF1CF04A0 BO3 - Bonneville WA Shore Ladder/AFF 2006-07-15
## 4 3D9.1BF1CF04A0     BO4 - Bonneville WA Ladder Slots 2006-07-15
## 5 3D9.1BF1CF04A0     MC1 - McNary Oregon Shore Ladder 2006-07-21
## 6 3D9.1BF1CF04A0     MC1 - McNary Oregon Shore Ladder 2006-07-22
## 7 3D9.1BF1CF04A0      ICH - Ice Harbor Dam (Combined) 2006-07-25
## 8 3D9.1BF1CF04A0        GRA - Lower Granite Dam Adult 2006-09-01
## 9 3D9.1BF1CF04A0        GRA - Lower Granite Dam Adult 2006-09-02
```

63/2121 ascended at least one dam multiple times

```
subset(JDR_CTH, tag_code ==  "3D9.1C2C31825B") %>%
  remove_rownames() %>%
  dplyr::select(tag_code, event_site_name, event_date)
```

```
##          tag_code                                  event_site_name event_date
## 1  3D9.1C2C31825B BRIDGC - Bridge Creek, John Day River Basin 2007-12-03
## 2  3D9.1C2C31825B        BO2 - Bonneville Cascades Is. Ladder 2009-07-22
## 3  3D9.1C2C31825B            BO4 - Bonneville WA Ladder Slots 2009-07-22
## 4  3D9.1C2C31825B            MC1 - McNary Oregon Shore Ladder 2009-07-30
## 5  3D9.1C2C31825B            MC1 - McNary Oregon Shore Ladder 2009-08-03
## 6  3D9.1C2C31825B            MC1 - McNary Oregon Shore Ladder 2009-08-14
## 7  3D9.1C2C31825B             ICH - Ice Harbor Dam (Combined) 2009-10-16
## 8  3D9.1C2C31825B               GRA - Lower Granite Dam Adult 2009-10-21
## 9  3D9.1C2C31825B        MC2 - McNary Washington Shore Ladder 2010-04-14
## 10 3D9.1C2C31825B        JD1 - John Day River, McDonald Ferry 2010-04-17
```

Calculating detection efficiency

APPENDIX A.—Detection efficiencies

TABLE A.1.—PIT-tag detection efficiencies in the adult fish ladders of McNary, Priest Rapids, Rock Island, Rocky Reach, Wells, Ice Harbor, and Lower Granite dams for the run years 2005/2006—2014/2015. Standard errors are in parentheses.

	Run Year										
Dam	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	**Mean**
					Lower Columbia						
McNary	98.9% (0.4%)	98.9% (0.4%)	99.0% (0.3%)	99.5% (0.2%)	99.2% (0.1%)	99.2% (0.1%)	99.4% (0.1%)	99.6% (0.1%)	99.1% (0.2%)	99.3% (0.2%)	**99.2%**
					Upper Columbia						
Priest Rapids	94.8% (1.4%)	99.3% (0.5%)	100%	99.7% (0.3%)	99.3% (0.3%)	98.9% (0.4%)	99.1% (0.5%)	99.5% (0.4%)	100%	100%	**99.1%**
Rock Island	78.3% (3.5%)	85.4% (2.2%)	92.0% (1.9%)	81.8% (2.1%)	97.7% (0.6%)	97.0% (0.8%)	93.2% (1.2%)	73.3% (2.3%)	88.9% (2.1%)	60.3% (3.1%)	**84.8%**
Rocky Reach	--	98.5% (1.0%)	100%	100%	99.6% (0.3%)	99.7% (0.3%)	98.7% (0.7%)	98.4% (0.9%)	99.1% (0.9%)	100%	**99.3%**
Wells	100%	100%	100%	95.2% (4.6%)	100%	100%	100%	100%	96.3% (3.6%)	100%	**99.2%**
					Snake						
Ice Harbor	98.9% (0.6%)	100%	98.7% (0.4%)	98.7% (0.4%)	99.5% (0.1%)	99.6% (0.1%)	99.3% (0.2%)	99.6% (0.1%)	99.0% (0.2%)	99.5% (0.1%)	**99.3%**
Lower Granite	100%	96.2% (3.8%)	100%	100%	99.8% (0.2%)	99.8% (0.2%)	99.6% (0.2%)	100%	99.5% (0.3%)	99.9% (0.1%)	**99.5%**

Expanding model formulation to more arrays

- Mainstem instream arrays?
  - Could be used for detection efficiencies at terminal dams
- Getting information from steelhead from other rivers to get bigger sample sizes for detection efficiencies
- Dual arrays?

Ideas for next steps

- Higher resolution model
  - Allow for movement in both directions?
  - Incorporate more detection sites
- Generalize workflow to work for any system (automate)
  - Generate multistate estimates for key populations affected by recent improvements in detection ability
- Bayesian? R/JAGS?

https://github.com/markusmin/steelhead