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Case Studies IV: Adaptive Management of Fish Passage at a Pool and Weir Fishway

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Massachusetts Division of Marine Fisheries

Scott Elzey
Massachusetts Division of Marine Fisheries

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ADAPTIVE MANAGEMENT OF FISH PASSAGE AT A POOL AND WEIR FISHWAY

MarineFisheries
Commonwealth of Massachusetts

BEN GAHAGAN AND SCOTT ELZEY

MASSACHUSETTS DIVISION OF MARINE FISHERIES

2016 INTERNATIONAL CONFERENCE ON RIVER CONNECTIVITY

6/21/2016

THE PARKER RIVER

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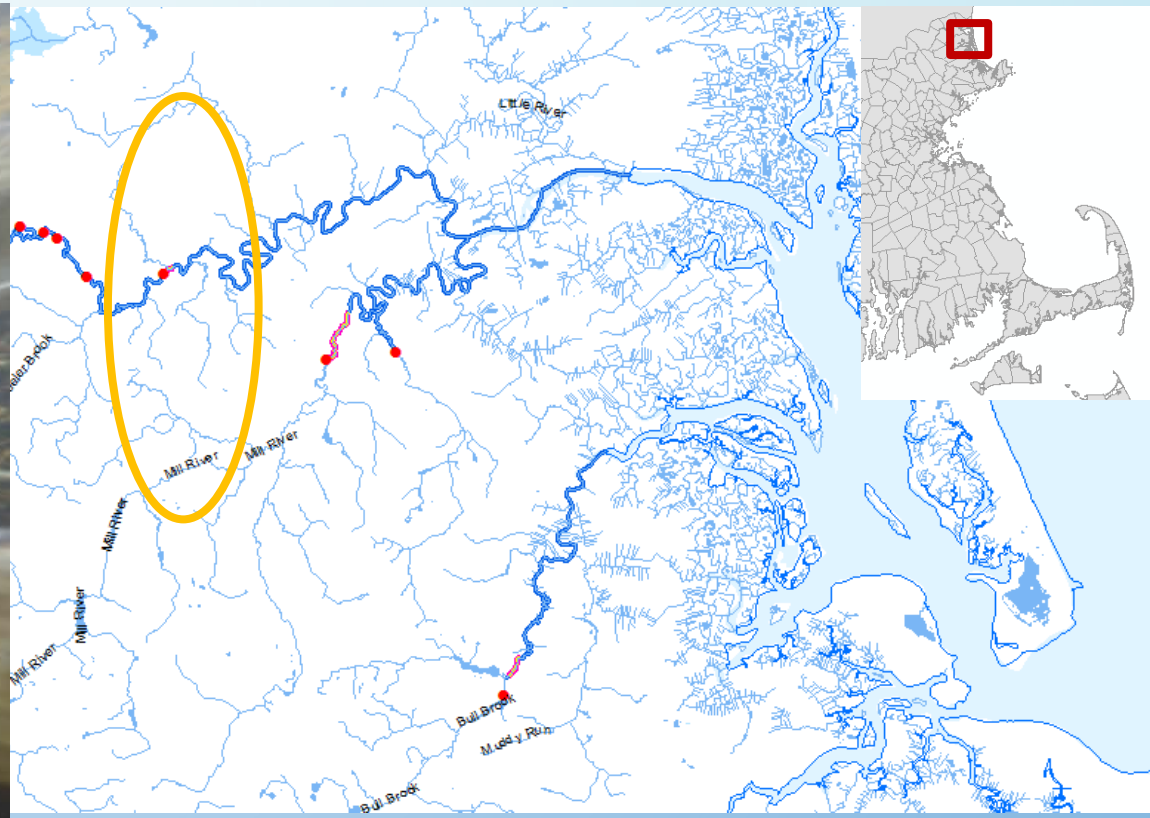

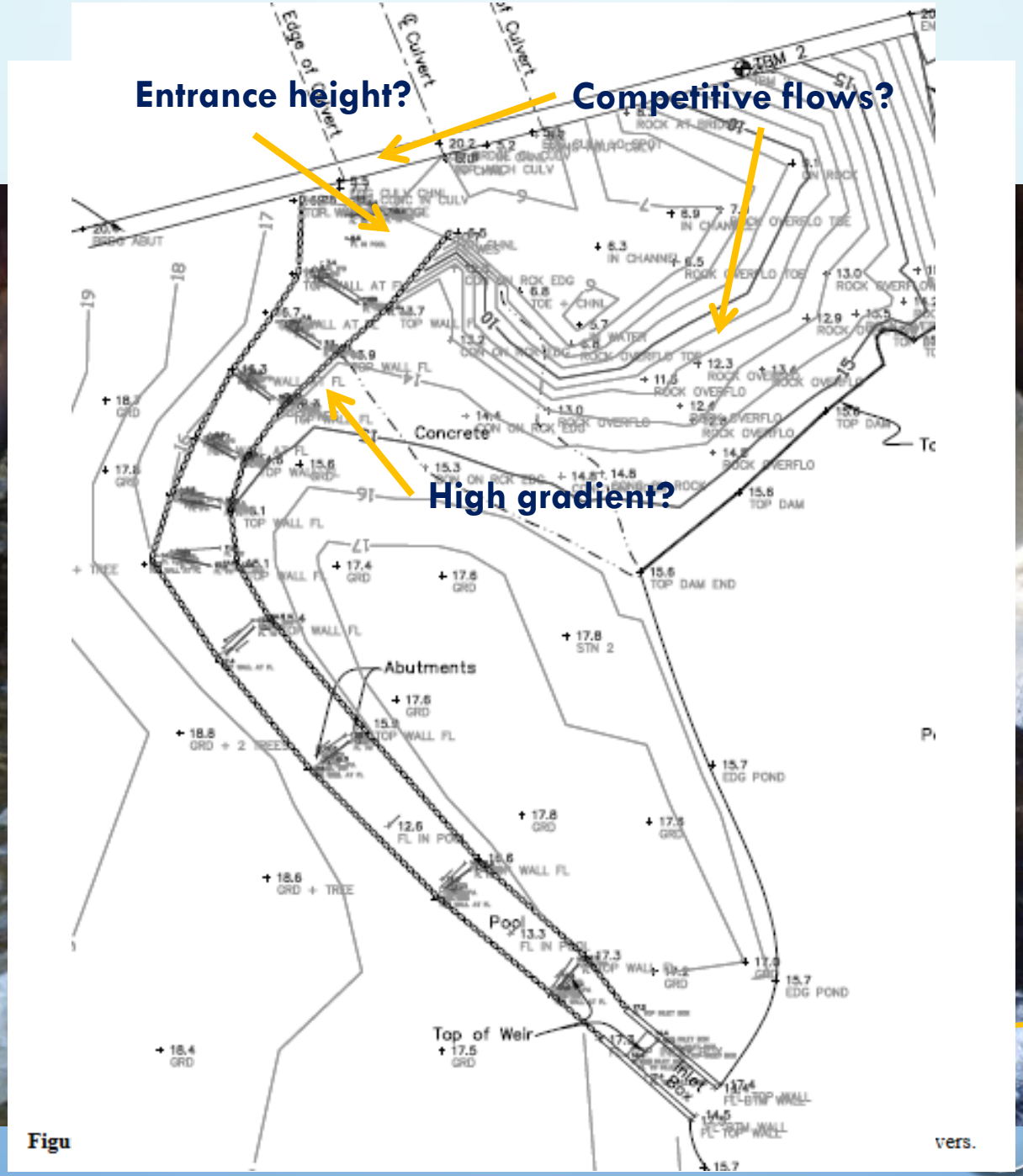
Entrance height?
Competitive flows?
High gradient?
Concrete
Abutments
Pool
Top of Weir
Inlet Box
Edge of Culvert
℄ Culvert
of Culvert
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Figu
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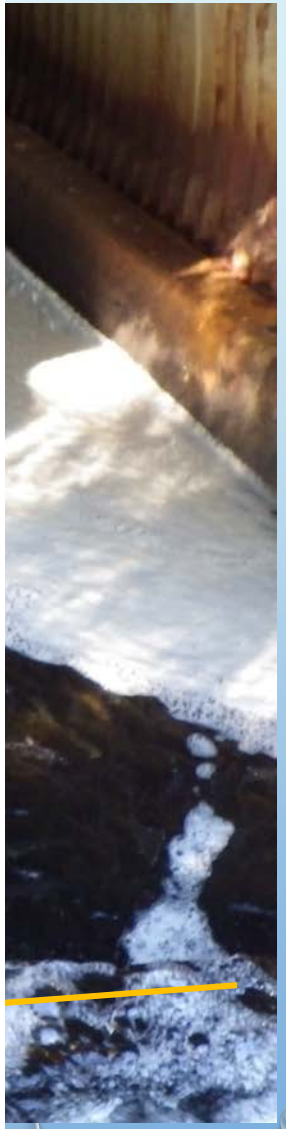


ADAPTIVE MANAGEMENT

- PROPOSED AND DEVELOPED BY HOLLING (1978), WALTERS (1986)
  - ITERATIVE
  - MONITORING TO PROVIDE NEW INFORMATION
  - ADJUSTMENTS BASED ON MONITORING

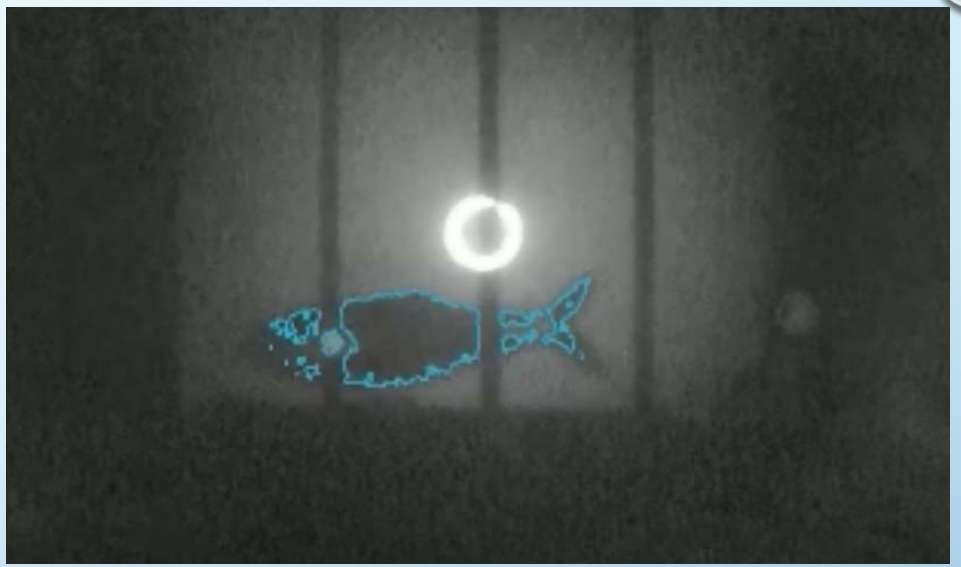
TIMELINE

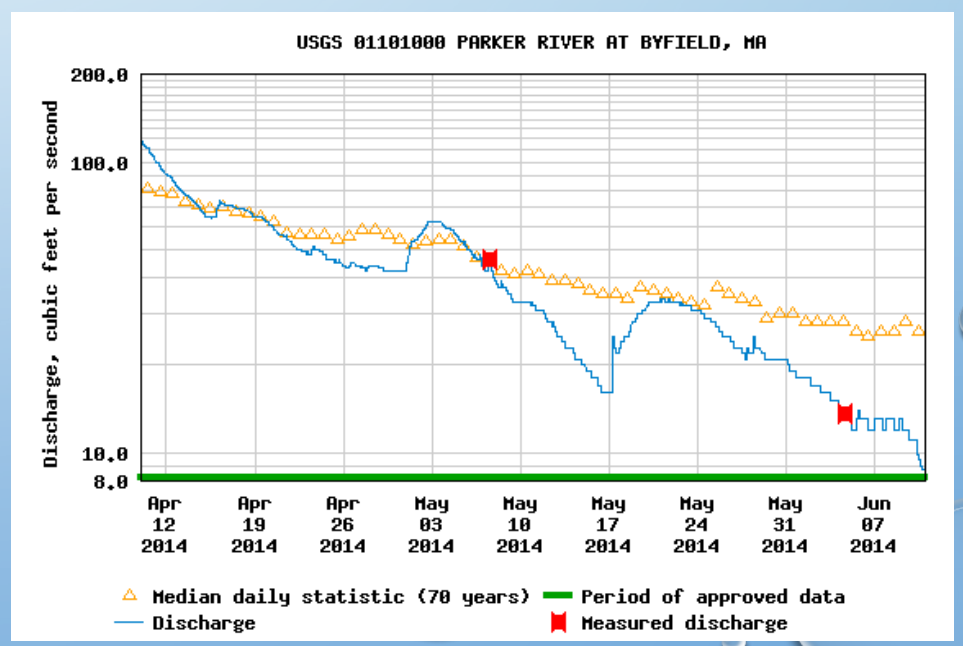
- **SPRING 2013:** NO IMPROVEMENTS, NAÏVE TO FISHWAY PERFORMANCE AT FLOWS, TAGGED
- **FALL 2013:** CONSTRUCTION TO REPAIR AND REINFORCE CULVERT WEIRS
  - ADD BOARD SLOT ABOVE FISHWAY ENTRANCE
- **SPRING 2014:** ADVERSE HYDRAULIC CONDITIONS FROM "FIX", TAGGED
  - ALLEVIATED ON 5/1 WITH STONE WEIR BELOW DOWNSTREAM WEIR
- **FALL 2014:** ADDED FLASHBOARDS TO WEIRS
  - ALLOWED FOR RAISED BOARD AT SLOT ABOVE ENTRANCE
- **SPRING 2015:** IMPROVED ENTRANCE CONDITIONS (?), 2 YEARS OF EXPERIENCE WITH FISHWAY OPERATION, TAGGED

DATA COLLECTION

DAILY RESOLUTION

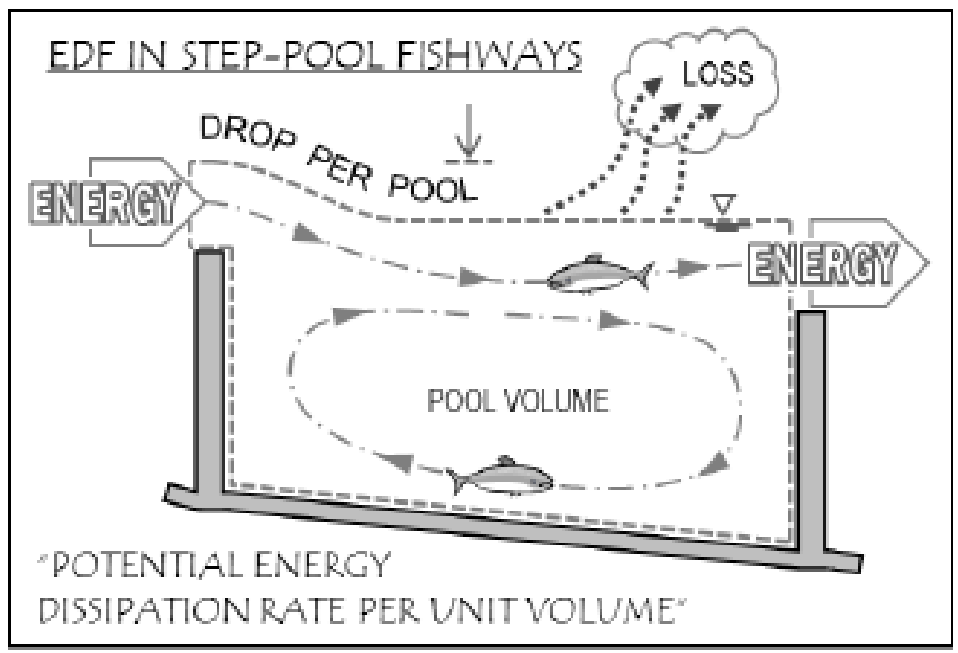
- POOL DEPTHS AND ENTRANCE HEIGHT
- TEMPERATURE
- FLOW FROM USGS GAGE
- PASSAGE NUMBERS
  - 2013: SMITH-ROOT 1601
  - 2014 & 2015: INFRA-RED LIGHTED VIDEO





IN FISHWAY FLOWS

- CALCULATED ENERGY DISSIPATION FACTOR AT LOW, MEDIUM, AND HIGH FLOWS
  - LOW: $M^3 * SEC^{-1} < 1.0$
  - MEDIUM: $1.0 < M^3 * SEC^{-1} < 1.5$
  - HIGH: $M^3 * SEC^{-1} > 1.5$
- X^2 TO TEST DIFFERENCES AMONG YEARS



DESIGN $\forall = \frac{\gamma Q D}{EDF}$

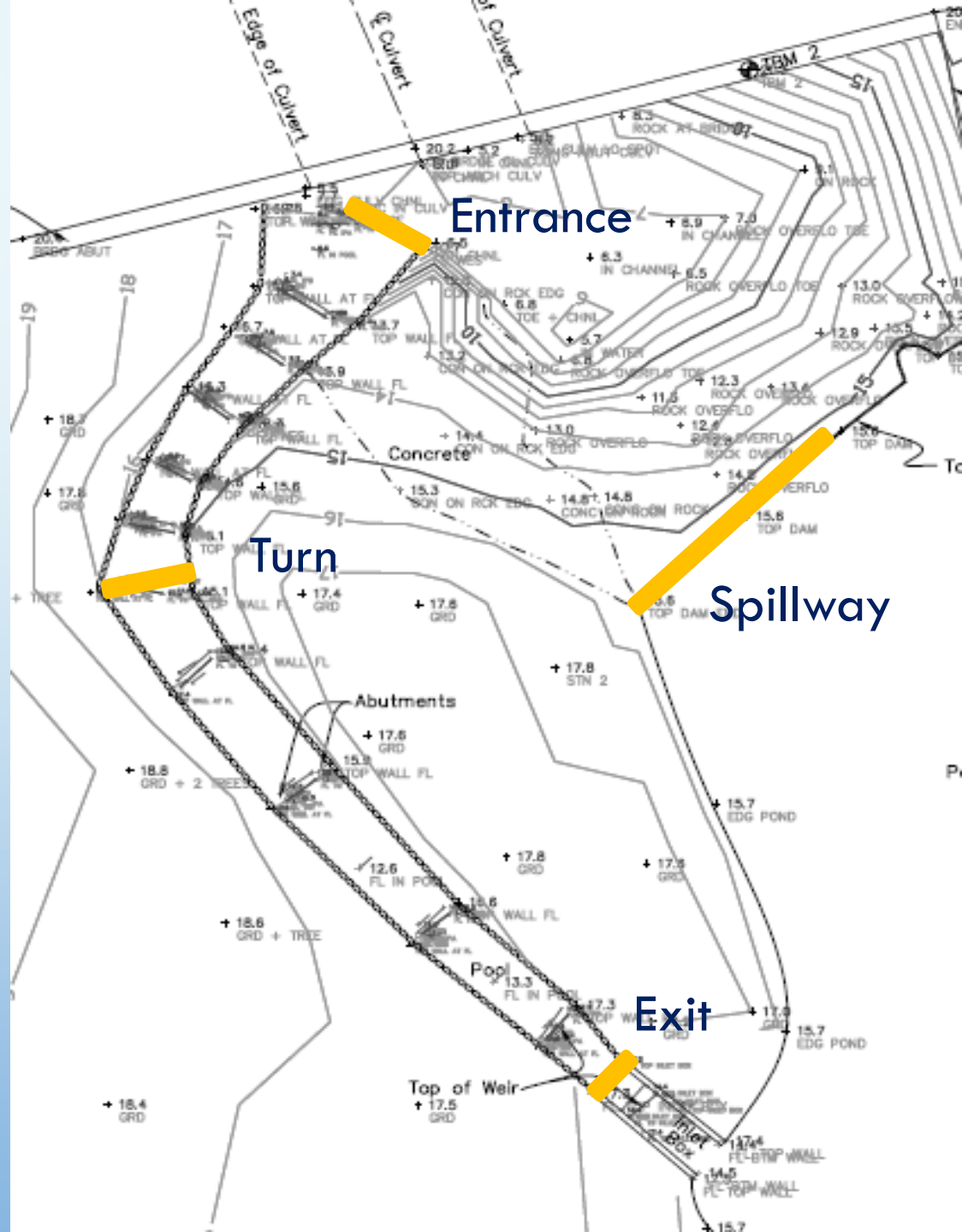
EVALUATE $EDF = \frac{\gamma Q D}{\forall}$

where:

EDF is the volumetric energy dissipation rate in ft-lb/s/ft^3
$\forall$ is the water volume in the fishway step pool in ft^3
D is the hydraulic drop from one pool to the next in ft
Q is the flow over the weir crests, through the fishway, in cfs
γ is the unit weight of water (62.4 lbs/ft^3)

PIT ARRAY

- MULTIREADER SYSTEM
  3 ANTENNAS IN FISHWAY
  - ENTRANCE
  - TURN
  - EXIT
- FOURTH ANTENNA ON SPILLWAY
  WITH LOW FLOW CHANNEL



TAGGING

- FISH COLLECTED DOWNSTREAM OF ENTRANCE USING DIP NETS
- 23MM HALF-DUPLEX TAG, FOLLOWED THE INTRAPERITONEAL METHOD DESCRIBED IN CASTRO-SANTOS AND VONO (2013)
- FOR EACH FISH THE SPECIES, SEX, TOTAL LENGTH (TL), AND AN ESTIMATION OF SCALE LOSS WAS RECORDED
- HANDLING TIME, OR TIME OUT OF WATER, WAS KEPT TO A MINIMUM (MEAN = 18.65 SEC, SD = 1.51)

MULTIPLE LOGISTIC REGRESSION

- BINARY RESPONSE: PASS (0), FAIL (1)
- INDEPENDENT VARIABLES:

  ENVIRONMENTAL

  RIVER FLOW, TEMPERATURE, IN FISHWAY

  FLOWS (CAT), ENTRANCE HEIGHT, *JULIAN DATE

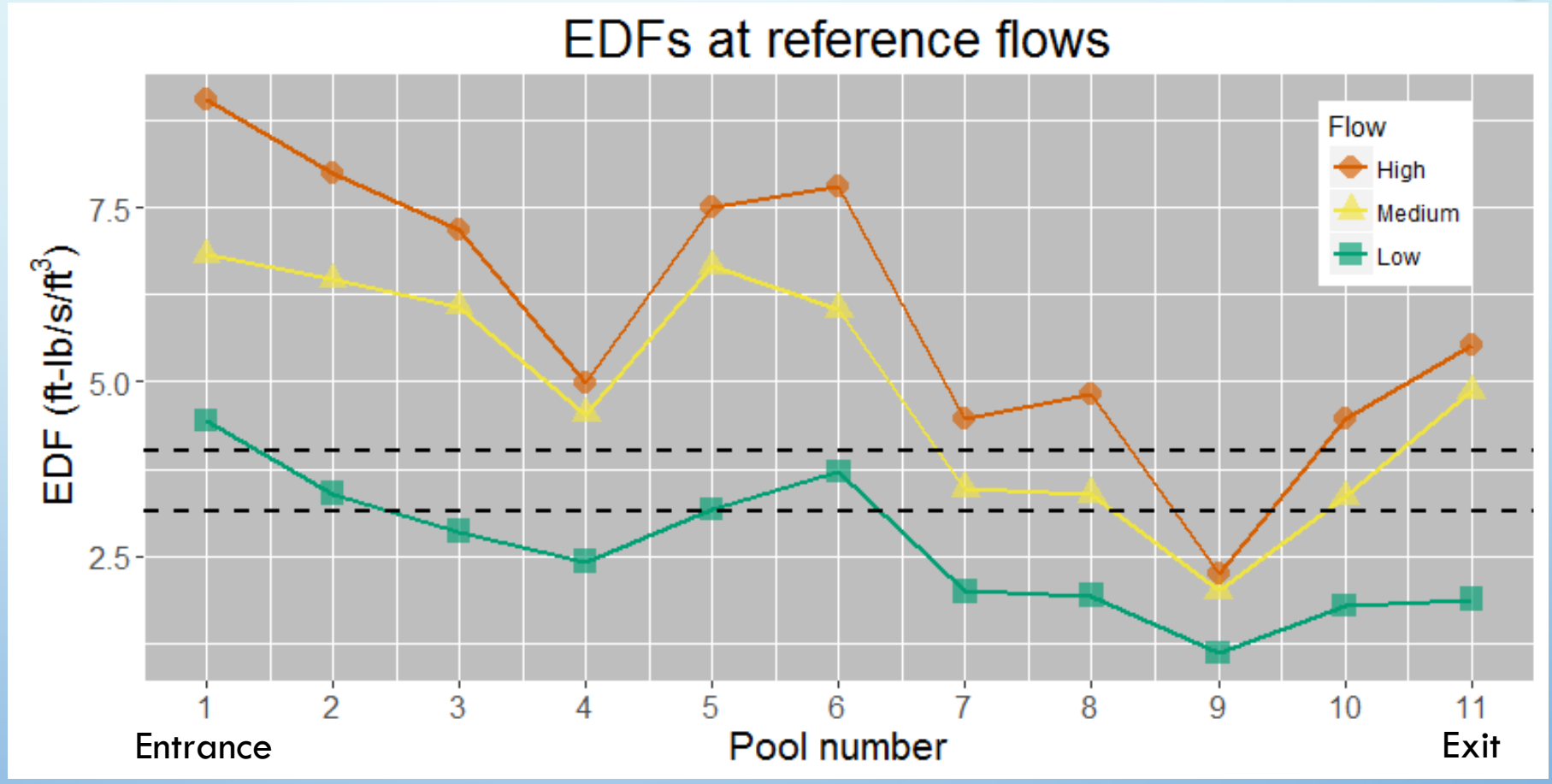
  BIOLOGICAL

  TOTAL LENGTH, SEX, SPECIES, SCALE LOSS,

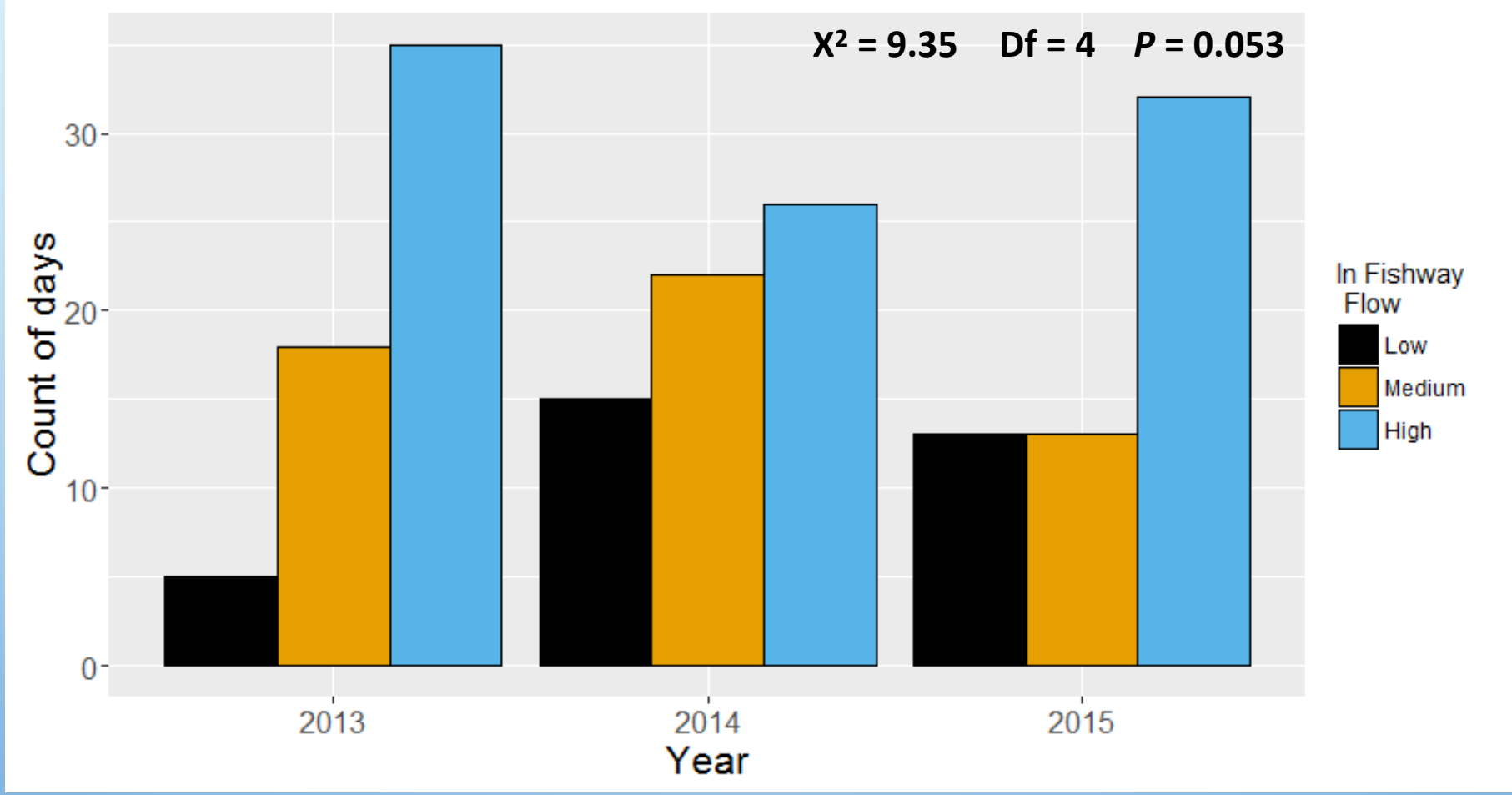
  YEAR TAGGED (2014, 2015, ALL)

- FOR EACH YEAR: STEPWISE MODEL SELECTION
  - LOG LIKELIHOOD TEST AND AIC; WALD TEST, HOSMER-LEMESHOW GOODNESS OF FIT
  - *INDIVIDUAL YEAR MODELS FOR ALEWIFE ONLY*
- ALL YEARS
  - MIXED EFFECT FOR FISH, ADDED ENTRANCE CONFIGURATION
  - *BOTH SPECIES INCLUDED*

IN FISHWAY FLOWS

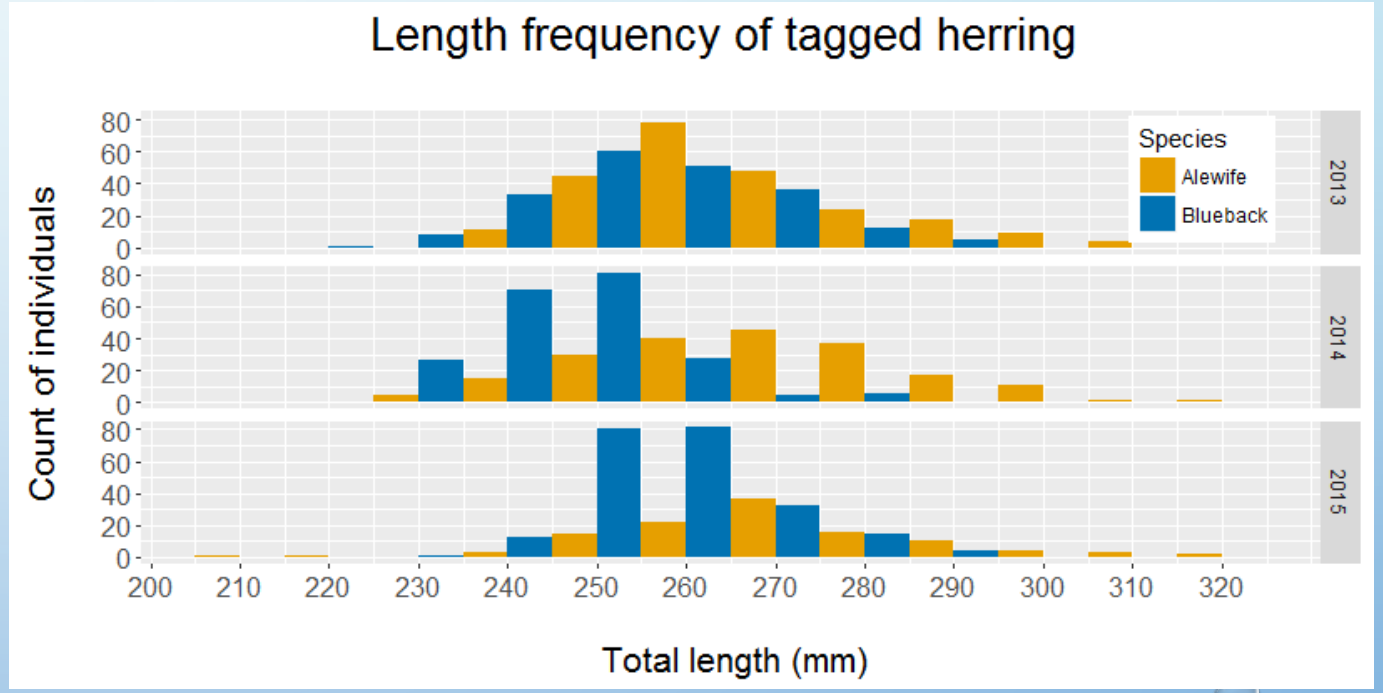


IN FISHWAY FLOWS

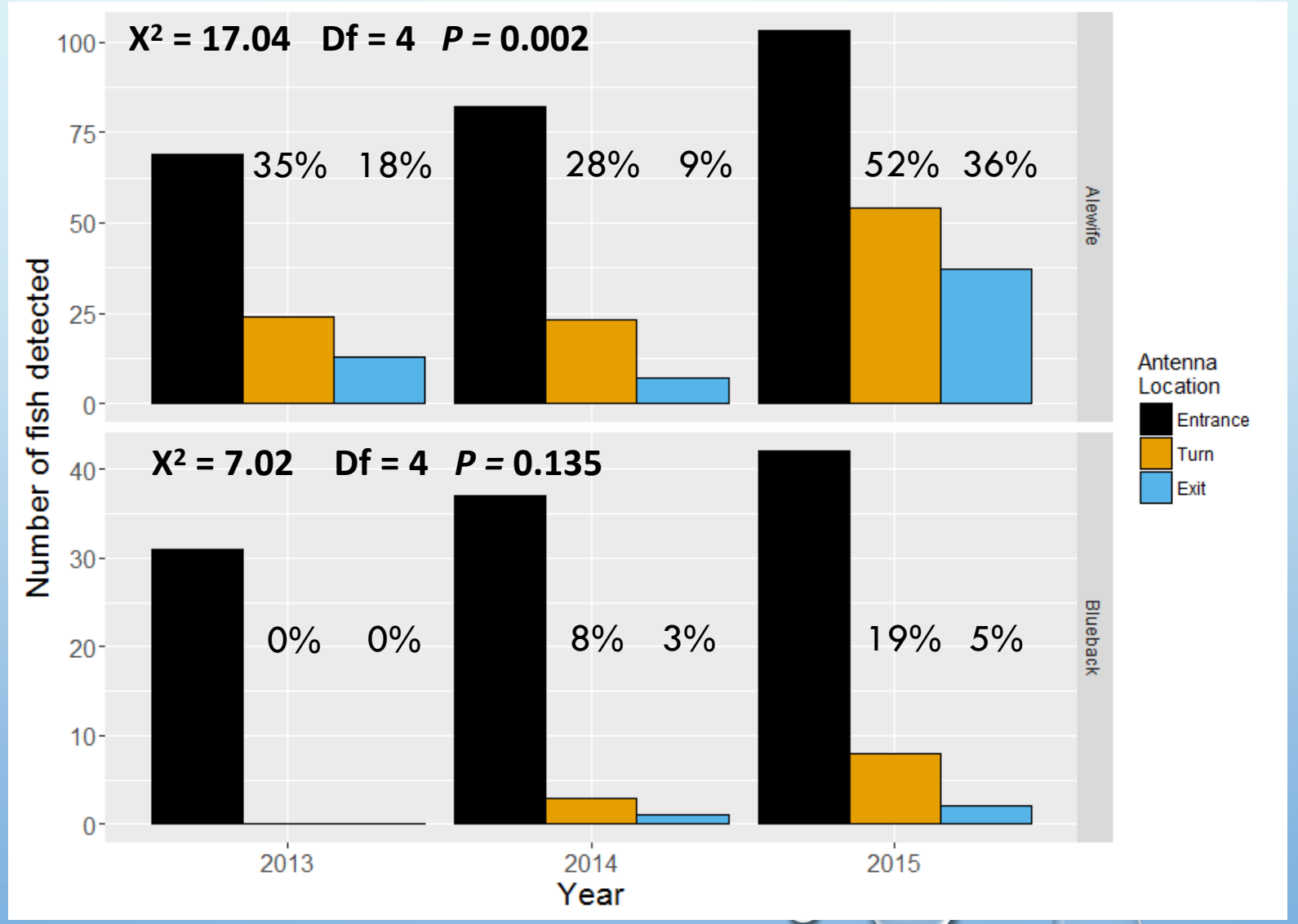


TAGGING

RIVER HERRING DETECTED			
YEAR	ALEWIFE	BLUEBACK	*TOTAL*
2013	114 (.48)	45 (22)	***156 (.35)***
2014	66 (.33)	28 (.15)	***94 (.22)***
2015	63 (.55)	42 (.19)	***105 (.31)***
TOTAL	***243 (.44)***	***115 (.18)***	***355 (.30)***



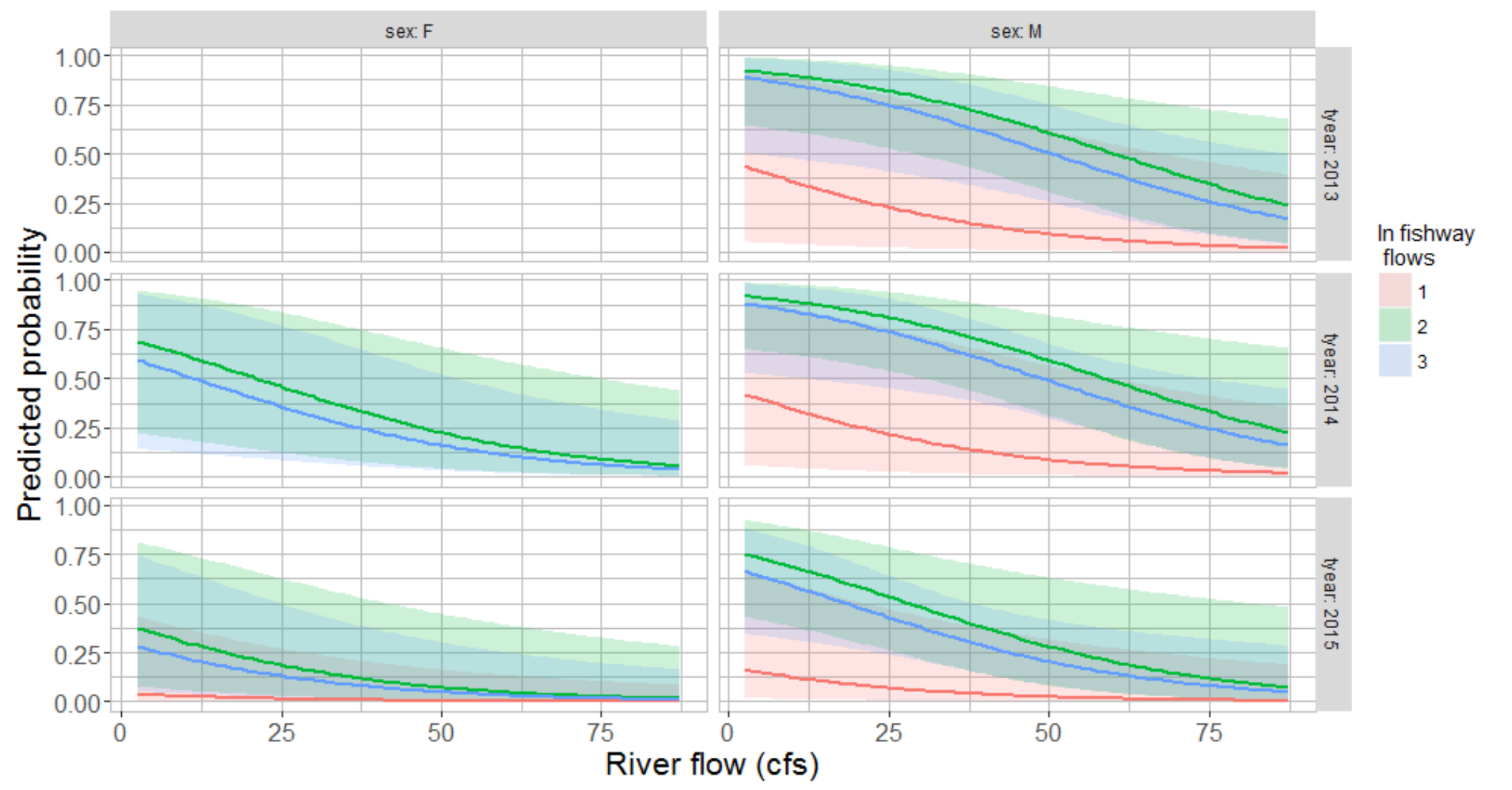
PASSAGE RATES



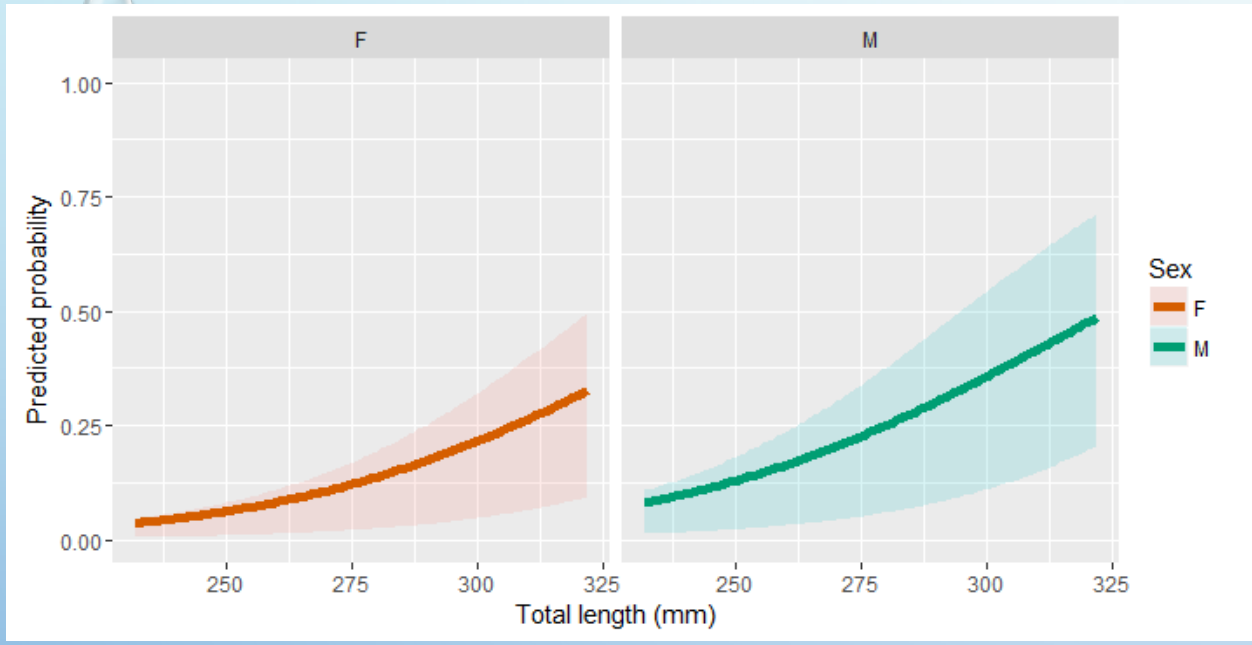
LOGISTIC REGRESSION MODELS

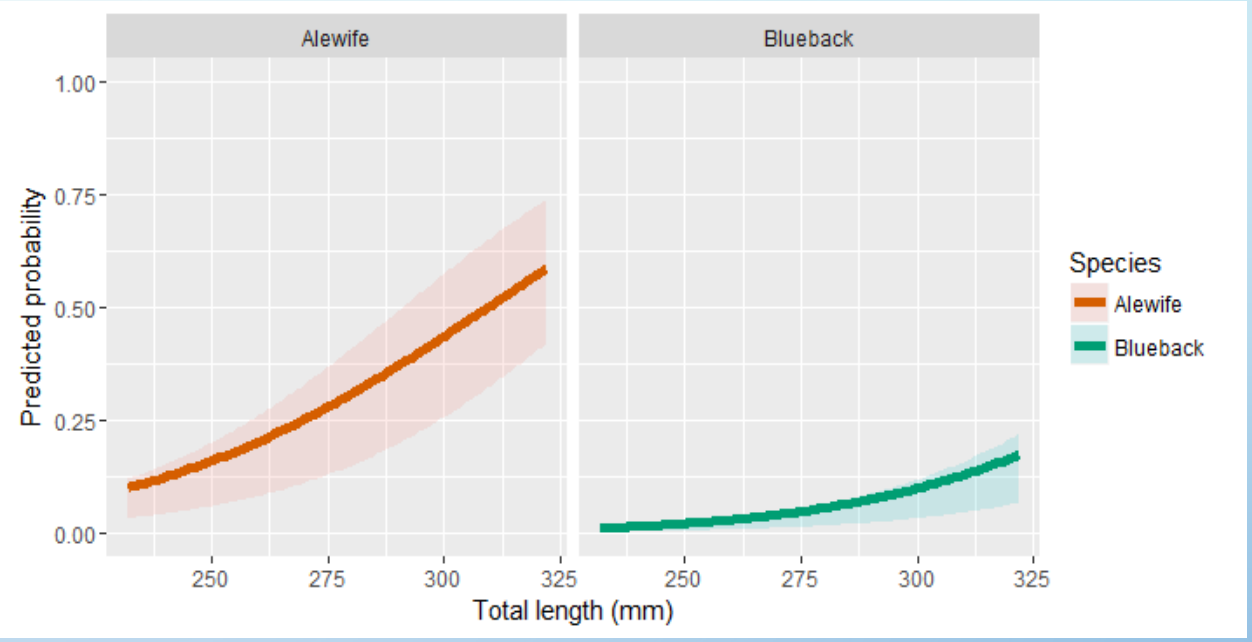
	Terms	n	AIC	ΔAIC	H-L GOF χ^2	H-L GOF df	H-L GOF *P*	Likelihood Ratio
2013	TL, Temperature, In Fishway Flows	59	55.57	1.597	16.026	8	0.042	*P* = 0.002
2014	River Flow, Entrance Height	66	42.07	0.63	7.176	6	0.305	*P* = 0.014
2015	In Fishway Flows, Sex, River Flow, Year Tagged	87	118	0.03	9.529	8	0.3209	*P* = 0.019
All	TL, River Flow, Entrance Height, Sex, Species, Years since tagging	354	248.1	1.35			*NA*	

2015: IN FISHWAY FLOWS, SEX, RIVER FLOW, YEAR TAGGED



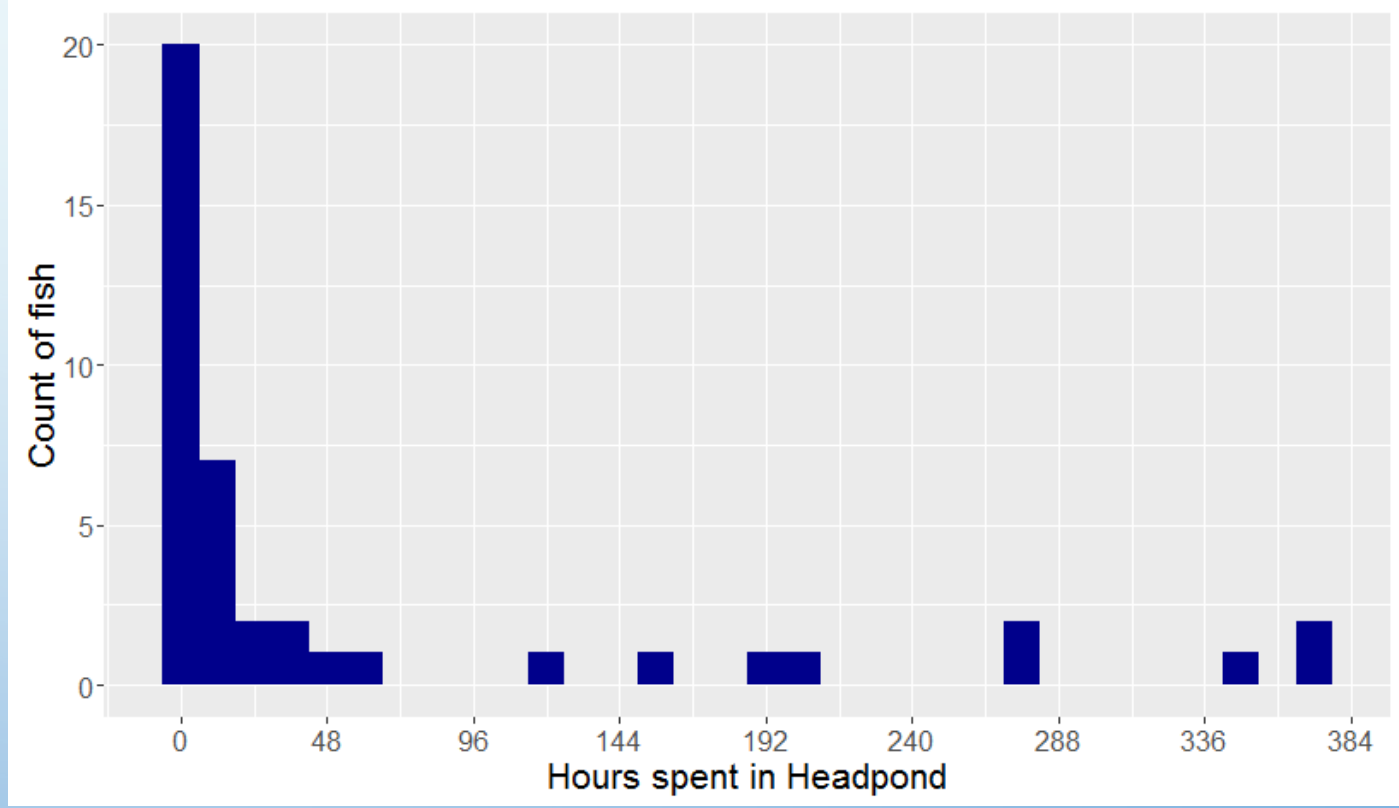
ALL YEARS:TOTAL LENGTH, RIVER FLOW, ENTRANCE HEIGHT, SEX, SPECIES, YEARS SINCE TAGGING





CONCLUSIONS

- PASSAGE RATES HAVE IMPROVED, BUT REMAIN LOW
- BLUEBACKS DO NOT PASS WELL
- POSSIBLE WITHIN YEAR EFFECT OF TAGGING
- PATTERN OF PASSAGE OF TAGGED FISH MATCHES FISH COUNTED
- MOTIVATION OF THIS POPULATION?



ACKNOWLEDGEMENTS

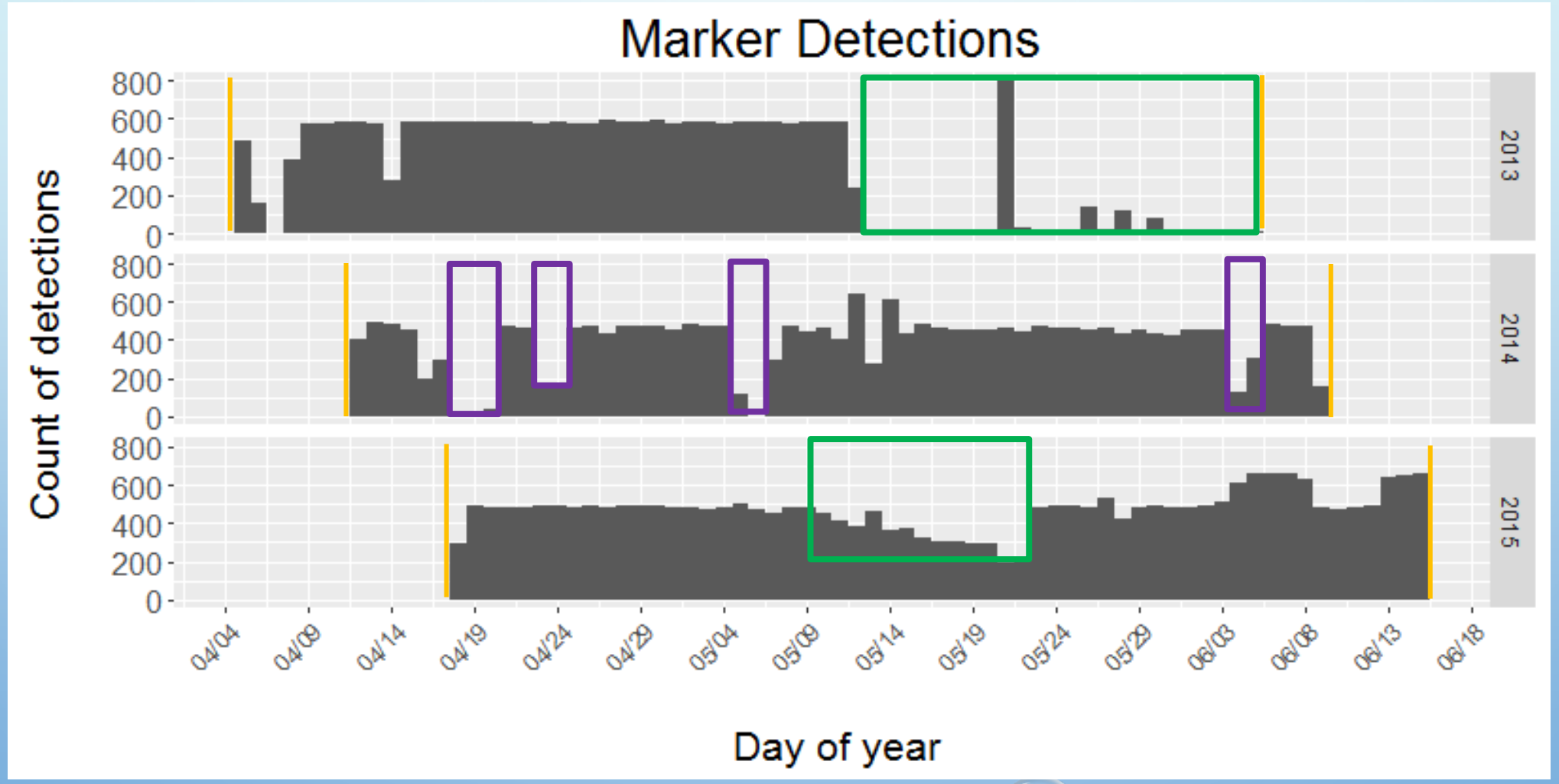
- DAVE ANDREWS, NICOLE WARD, RYAN JOYCE, ED, CLARK, KATIE ROGERS, KIM TRULL, KEVIN SULLIVAN, ANDREW JONES, ALEX HARO, TED CASTRO-SANTOS, BRIAN WAZ, MICAH DEAN, GARY NELSON, SCOTT AND KARIN LEPANNEN, BILL AND DIANE LORD, PARKER RIVER CLEAN WATER ASSOCIATION, USFWS, LUCY

SPORT FISH RESTORATION

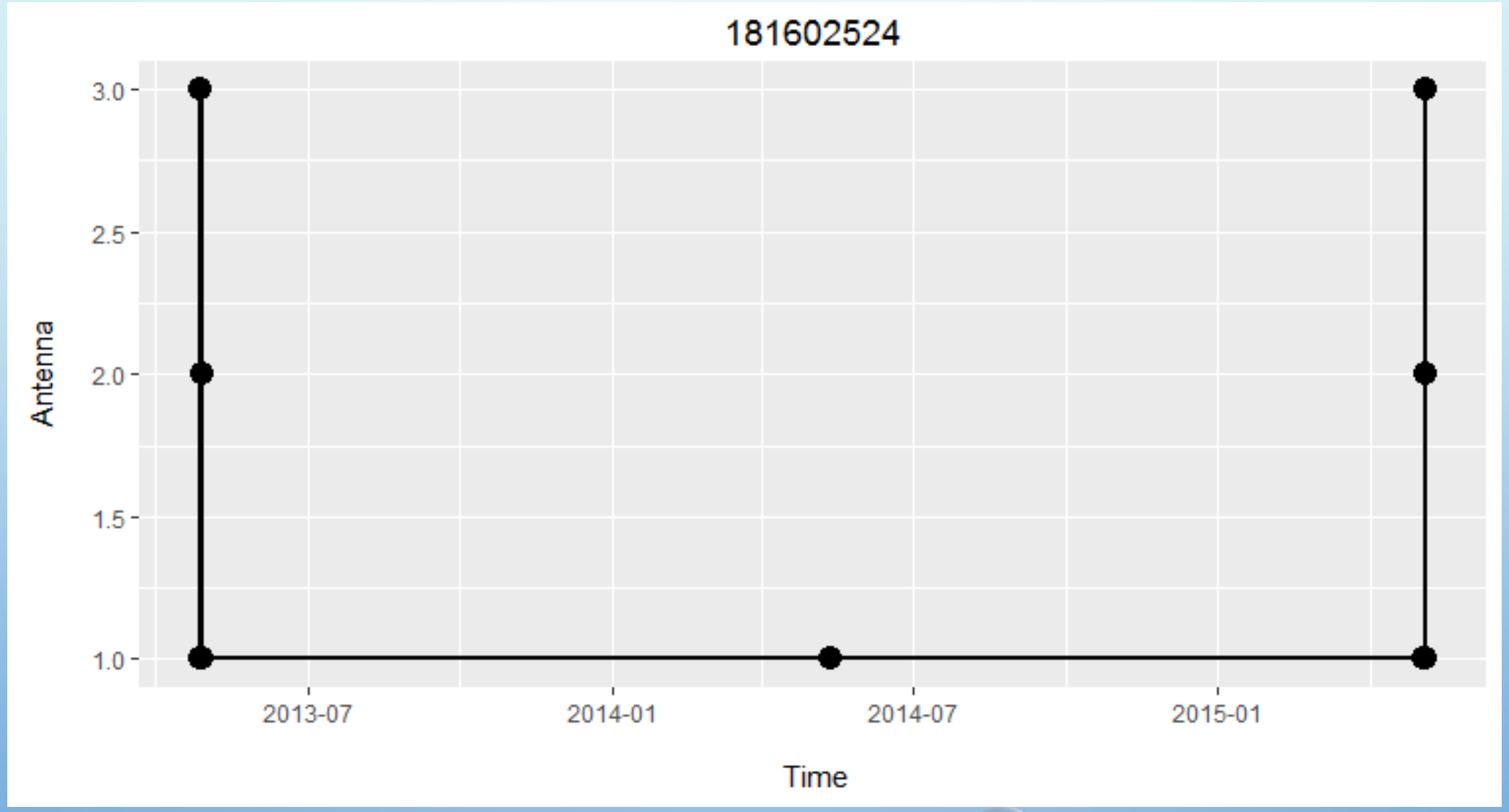
NEXT STEPS

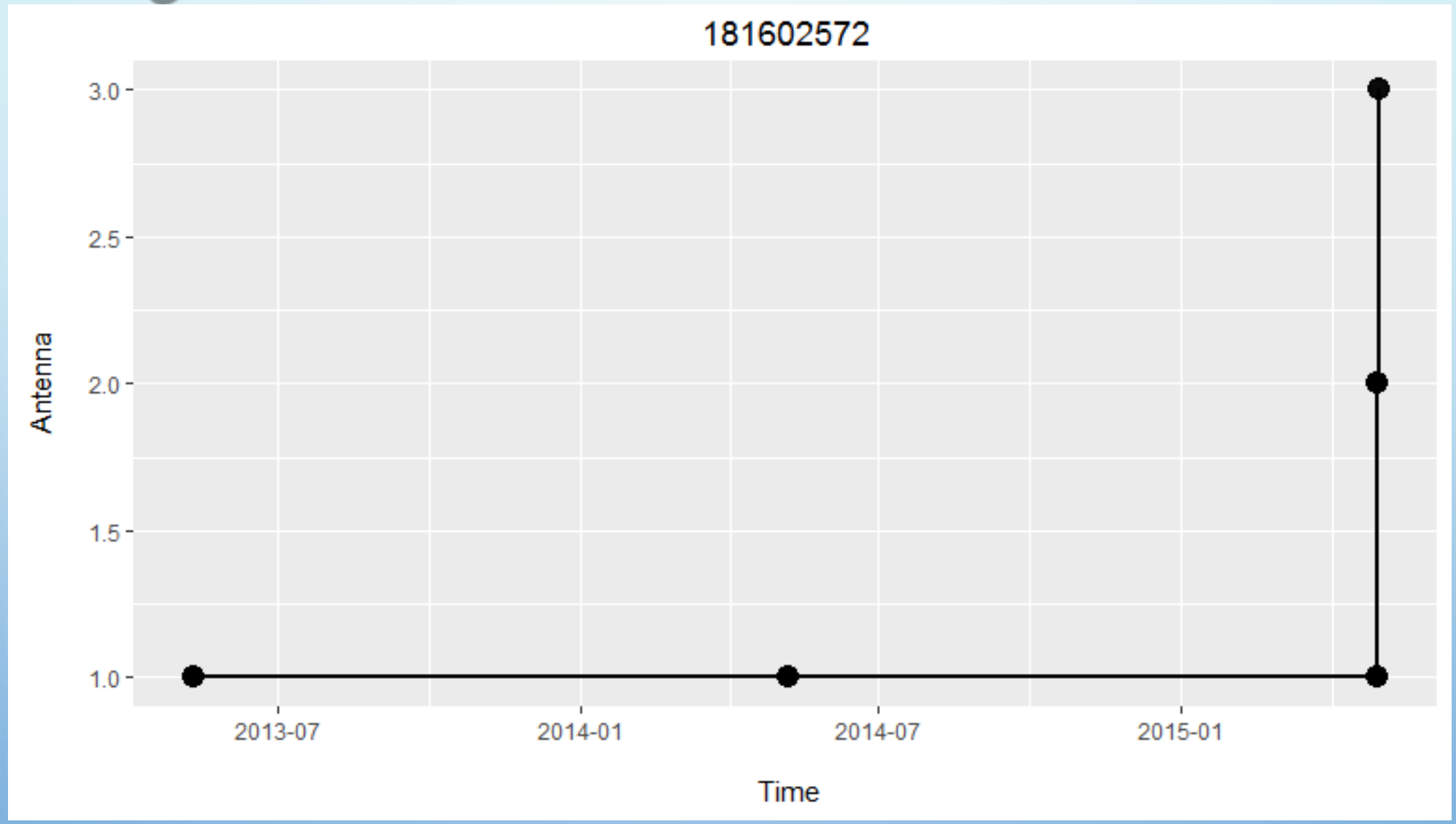
- ADD 2016 DATA
- INCORPORATE APPROACH ANTENNA FROM 2015 AND 2016
- FURTHER QUANTIFY INDIVIDUAL PASSAGE METRICS SUCH AS # OF ATTEMPTS, DELAY, ETC.
- CONDUCT TIME TO EVENT ANALYSES
- BY SPECIES ANALYSES

ANTENNA PERFORMANCE

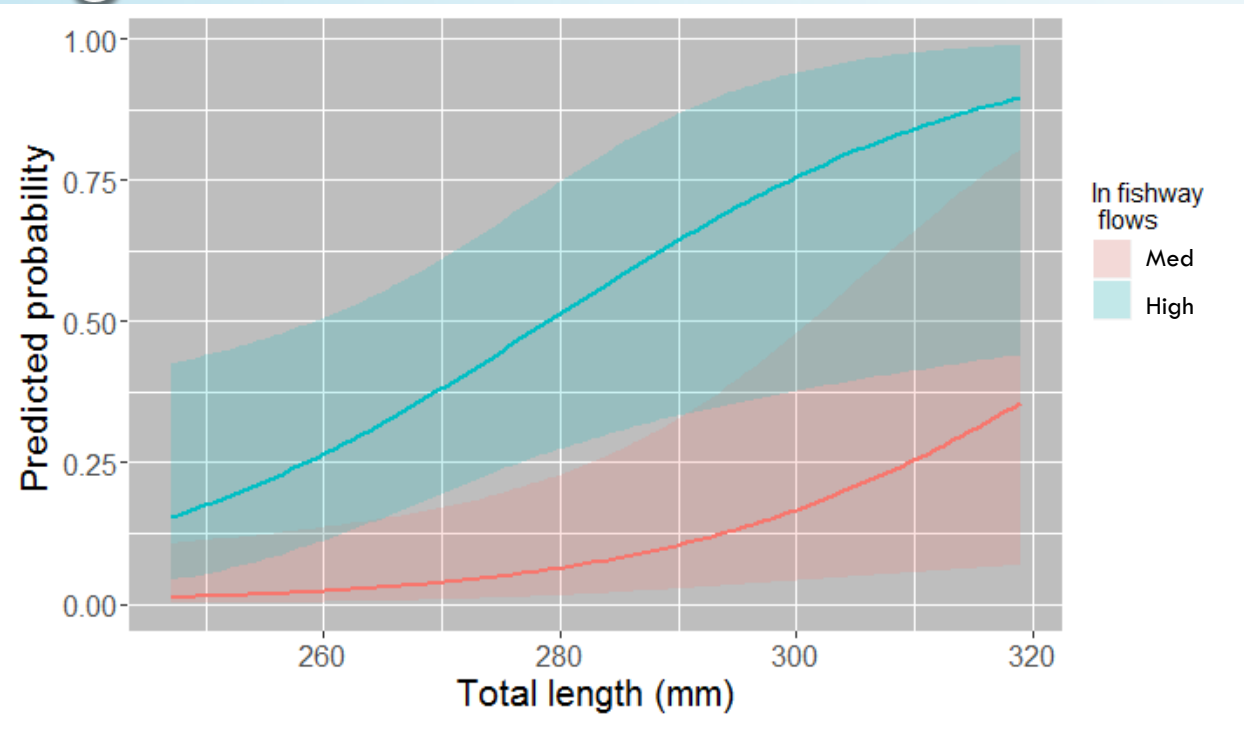


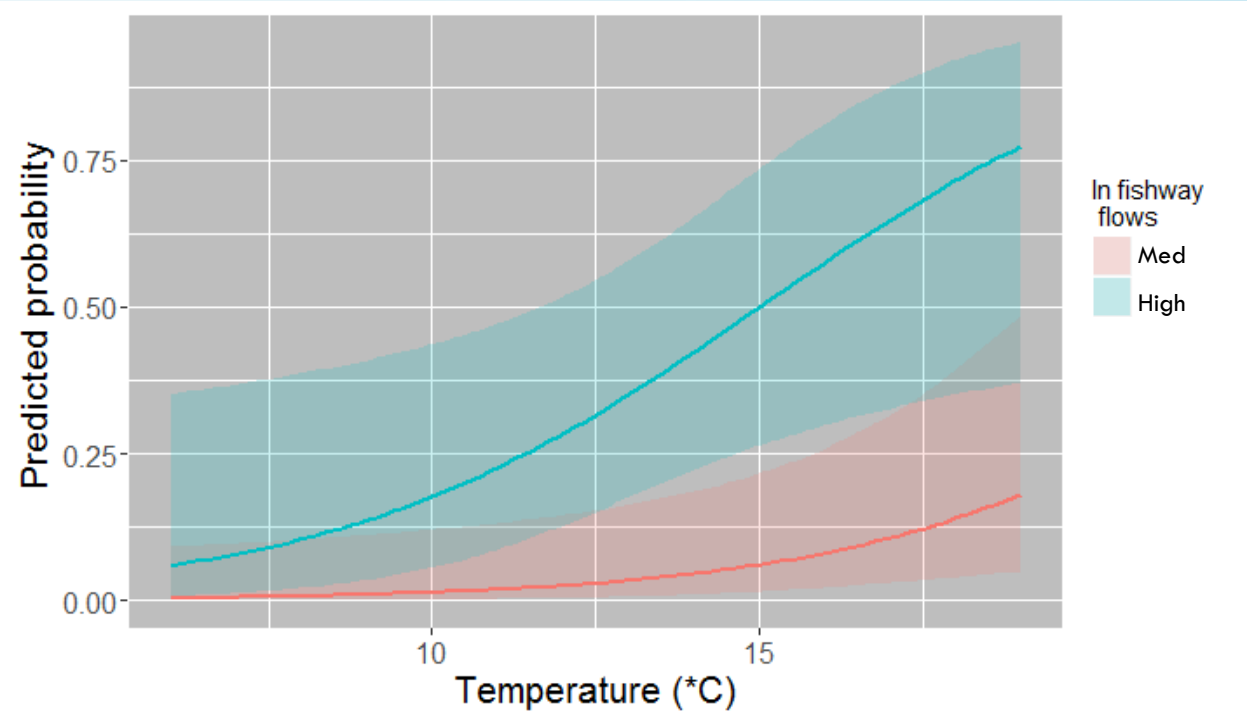
```
> table(Y15$loc,Y15$tyear)

           2013 2014 2015
  Approach   33   47  235
  Entrance   29   46   70
  Turn       19   22   21
  Exit       11   16   12
  Spillway    3   13    6
> table(Y14$loc,Y14$tyear)

           2013 2014
  Approach    0    0
  Entrance   62   55
  Turn       10   13
  Exit        1    7
  Spillway    2    7
>
```


181602524
3.0
2.5
2.0
1.5
1.0
Antenna
2013-07
2014-01
2014-07
2015-01
Time

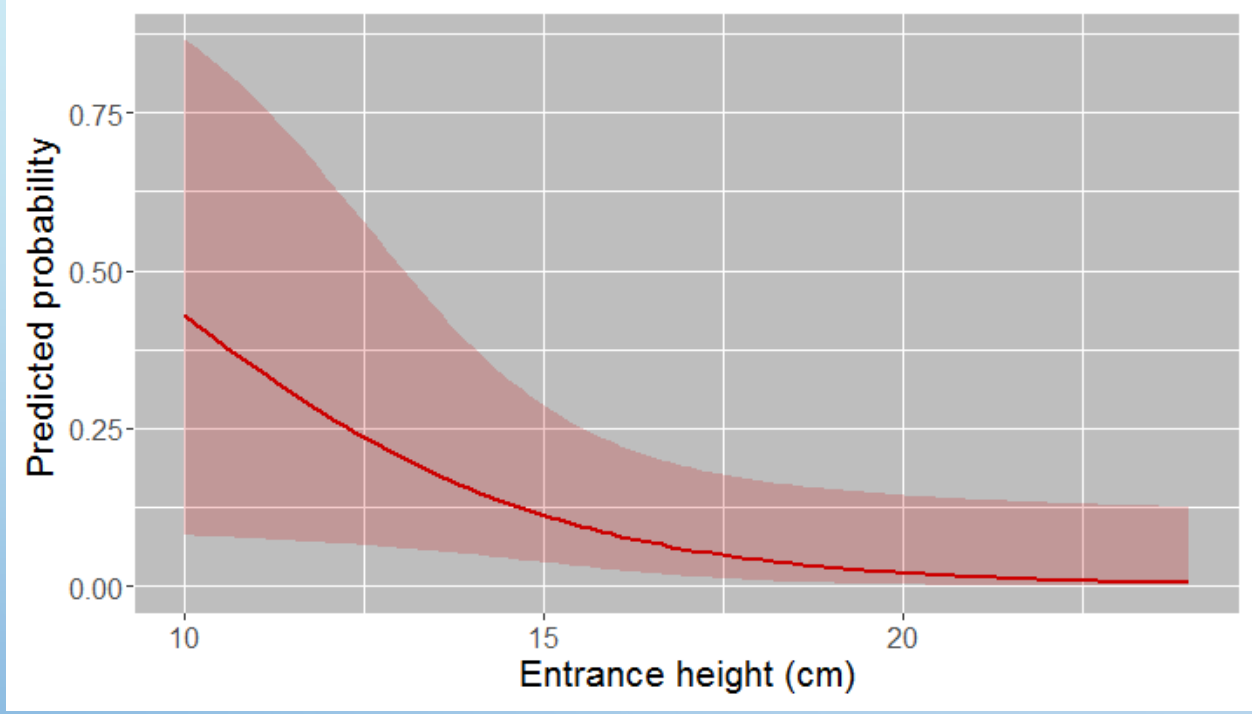

181602572
3.0
2.5
2.0
1.5
1.0
Antenna
2013-07
2014-01
2014-07
2015-01
Time

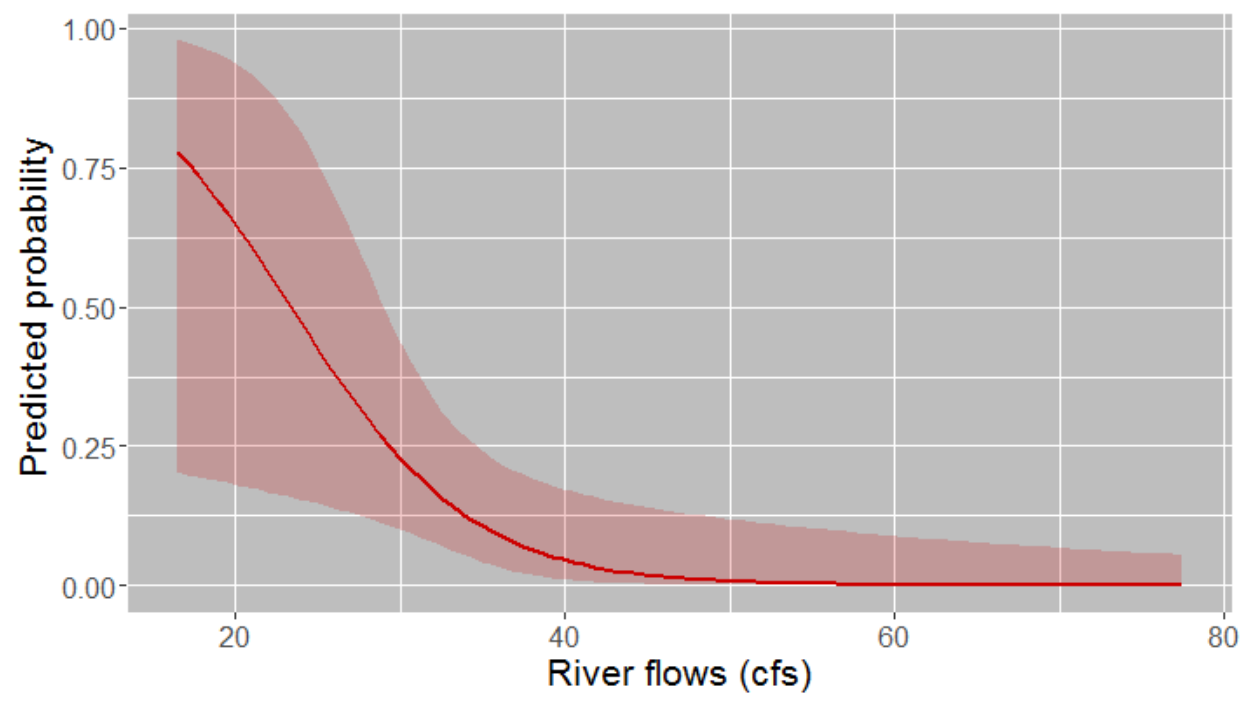
2013: TOTAL LENGTH AND CFS AT IN FISHWAY FLOWS

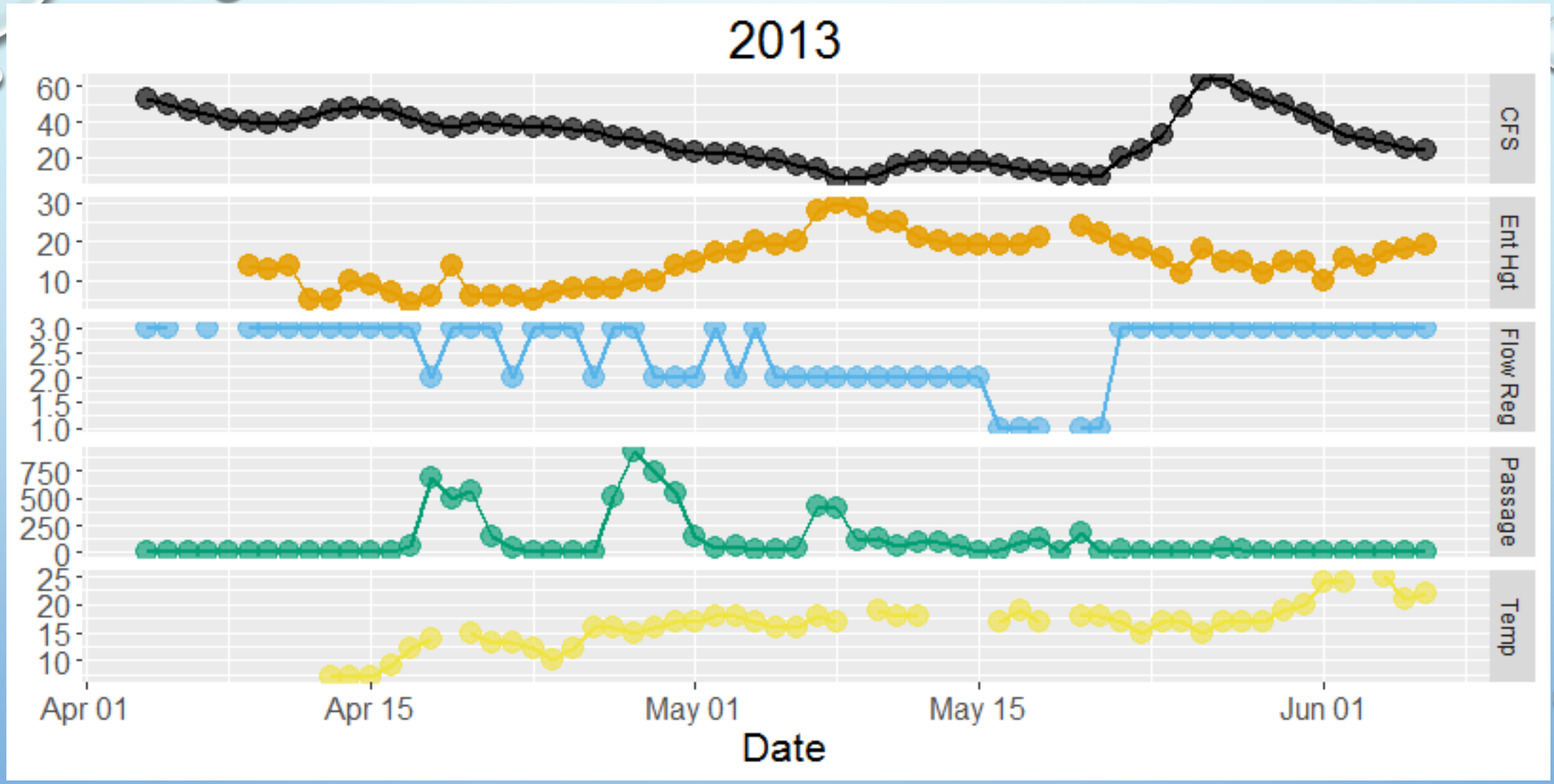




2014: RIVER FLOW AND ENTRANCE HEIGHT






2013
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CFS
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Flow Reg
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Passage
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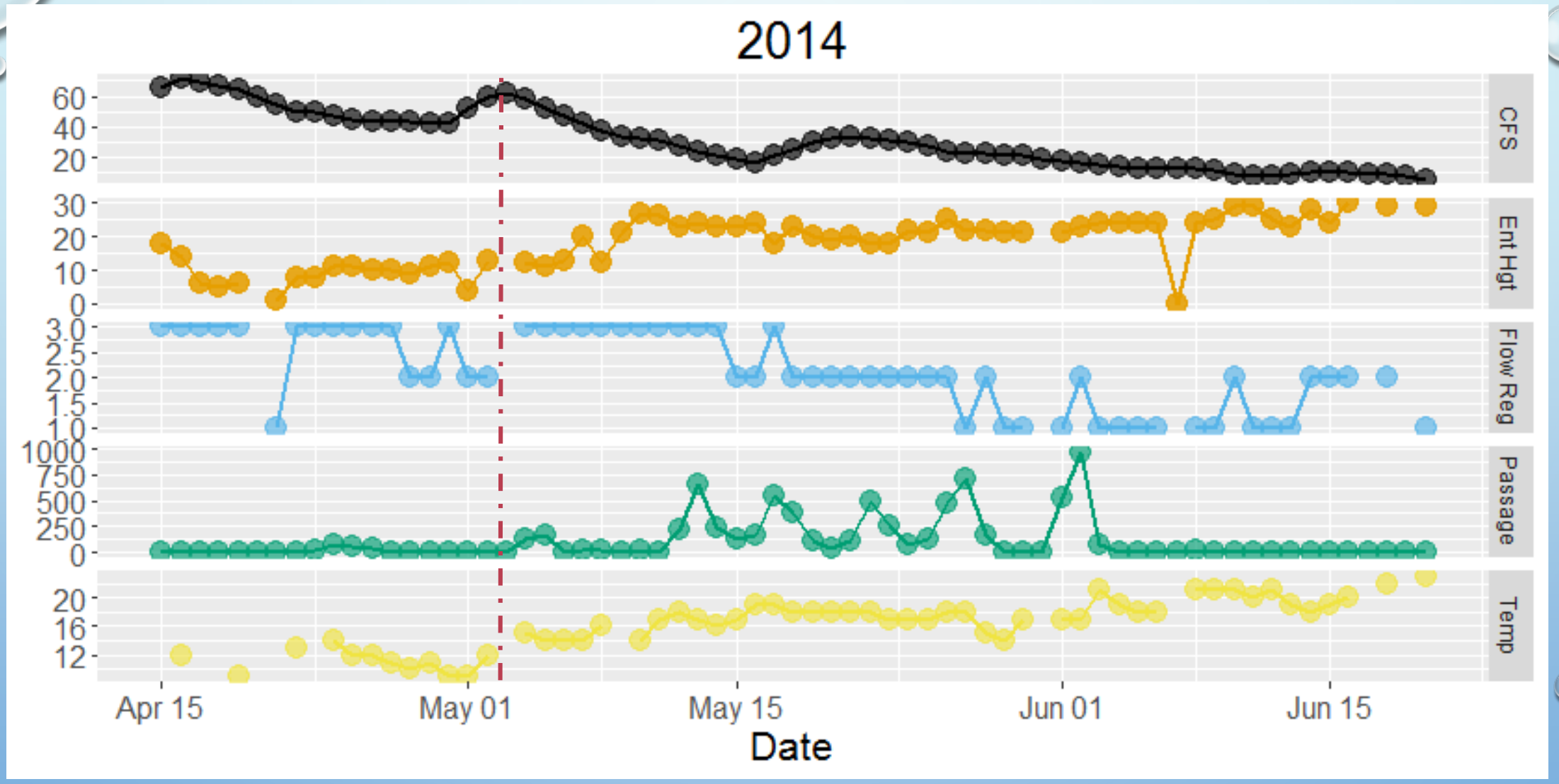
Temp
Apr 01
Apr 15
May 01
May 15
Jun 01
Date


2014
CFS
Ent Hgt
Flow Reg
Passage
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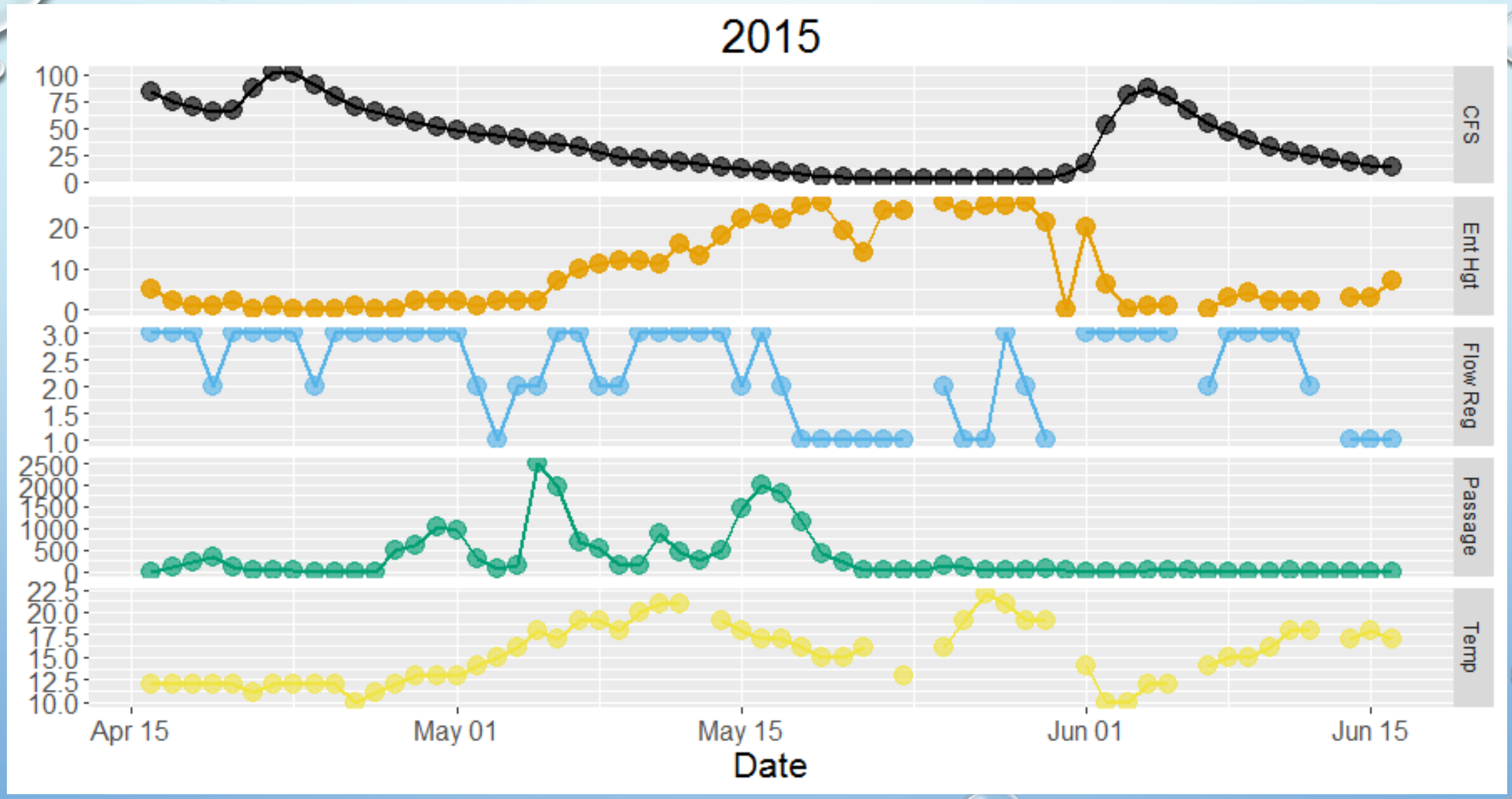
2015
CFS
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Flow Reg
Passage
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Jun 01
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Date

TIMELINE

- SPRING 2
- FALL 201 RD SLOT ABOVE FI

TIMELINE

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TIMELINE

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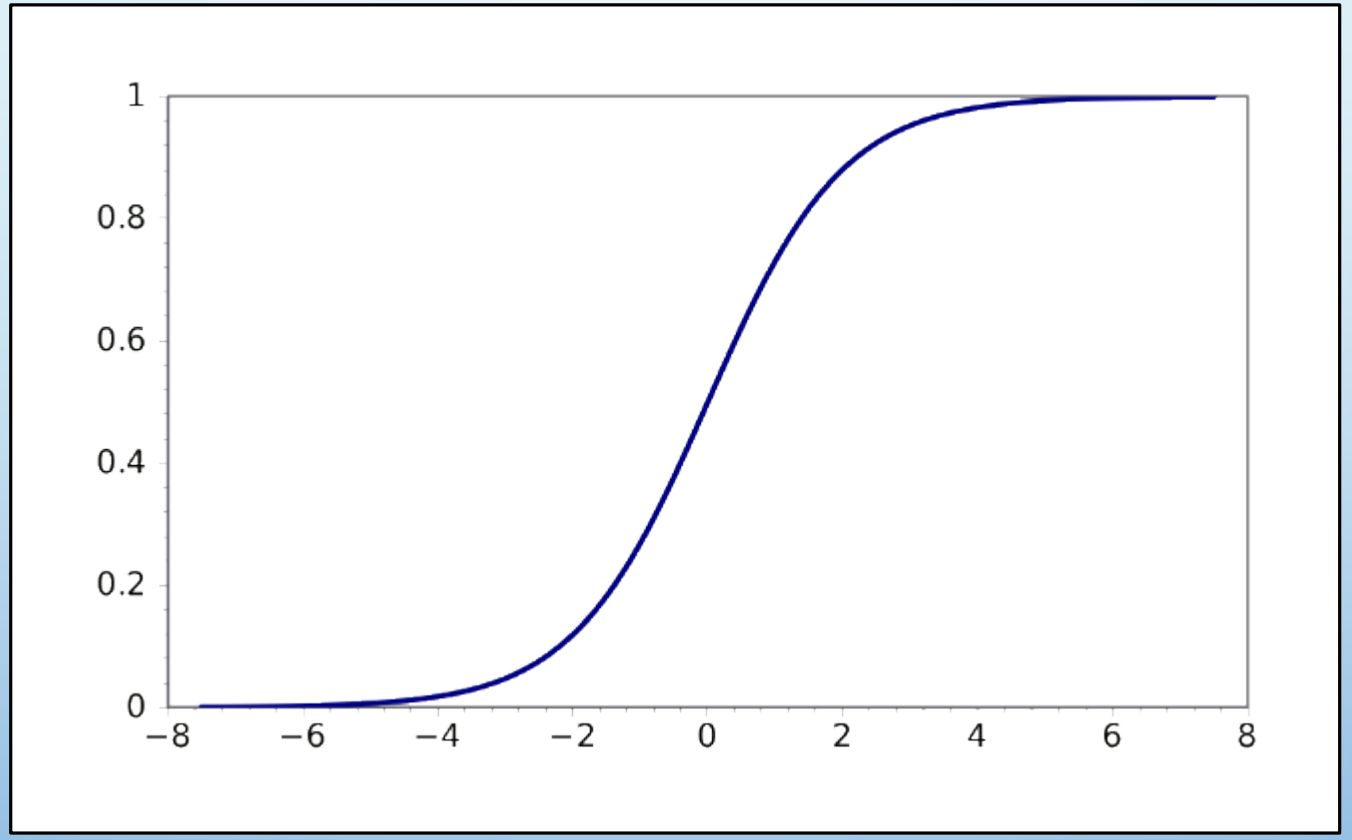
  -
- SPR
  FIS

LOGISTIC REGRESSION RESULTS



MOTIVATION

- TIME DISTRIBUTION OF EXIT TO SPILLWAY
- SPAWNING STAGE AT ARRIVAL
- MULTIPLE TRIPS UP AND DOWN