Accounting for Capture Efficiency in Abundance and Run-Timing Estimation of Snake River Fall Chinook Salmon

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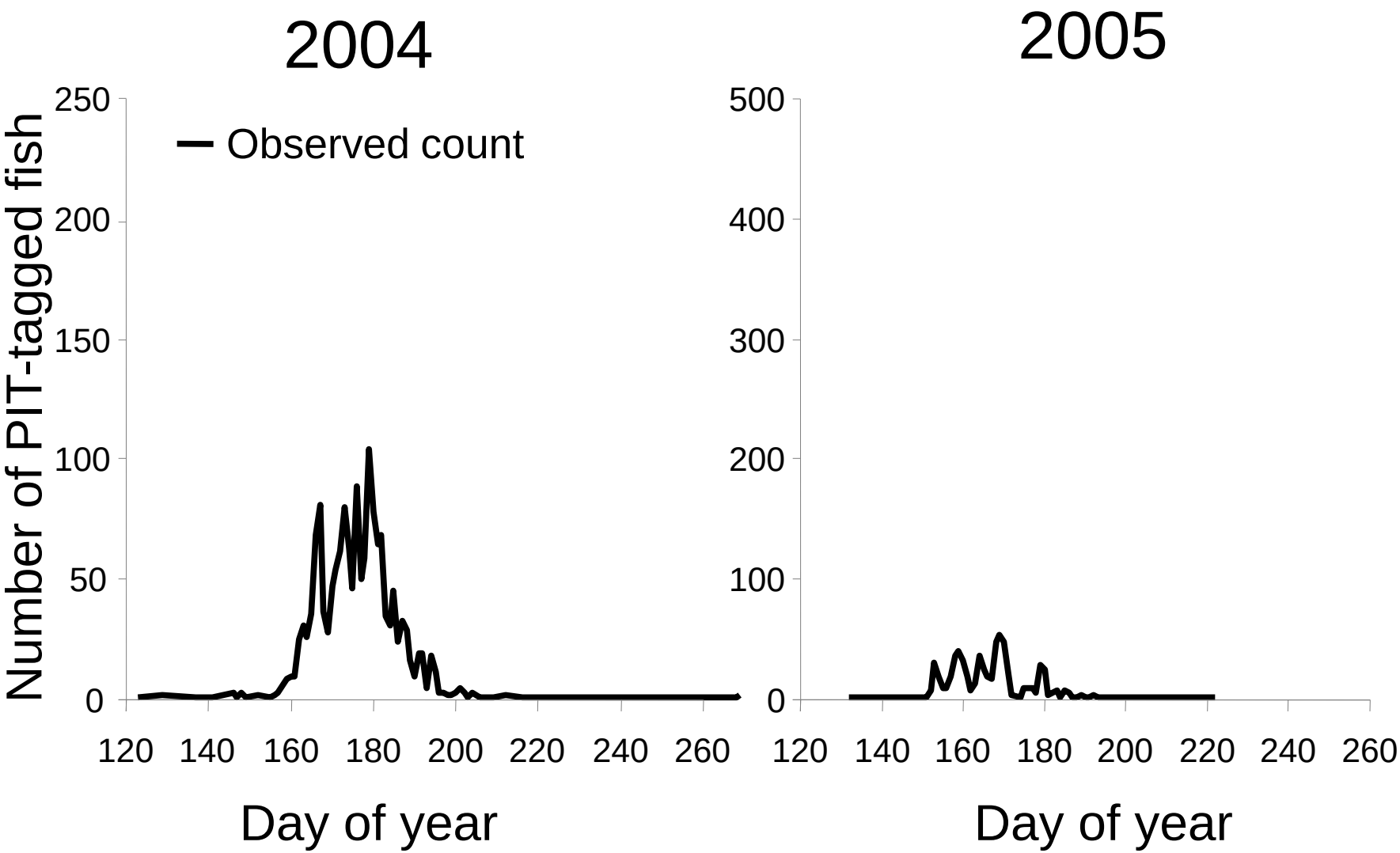
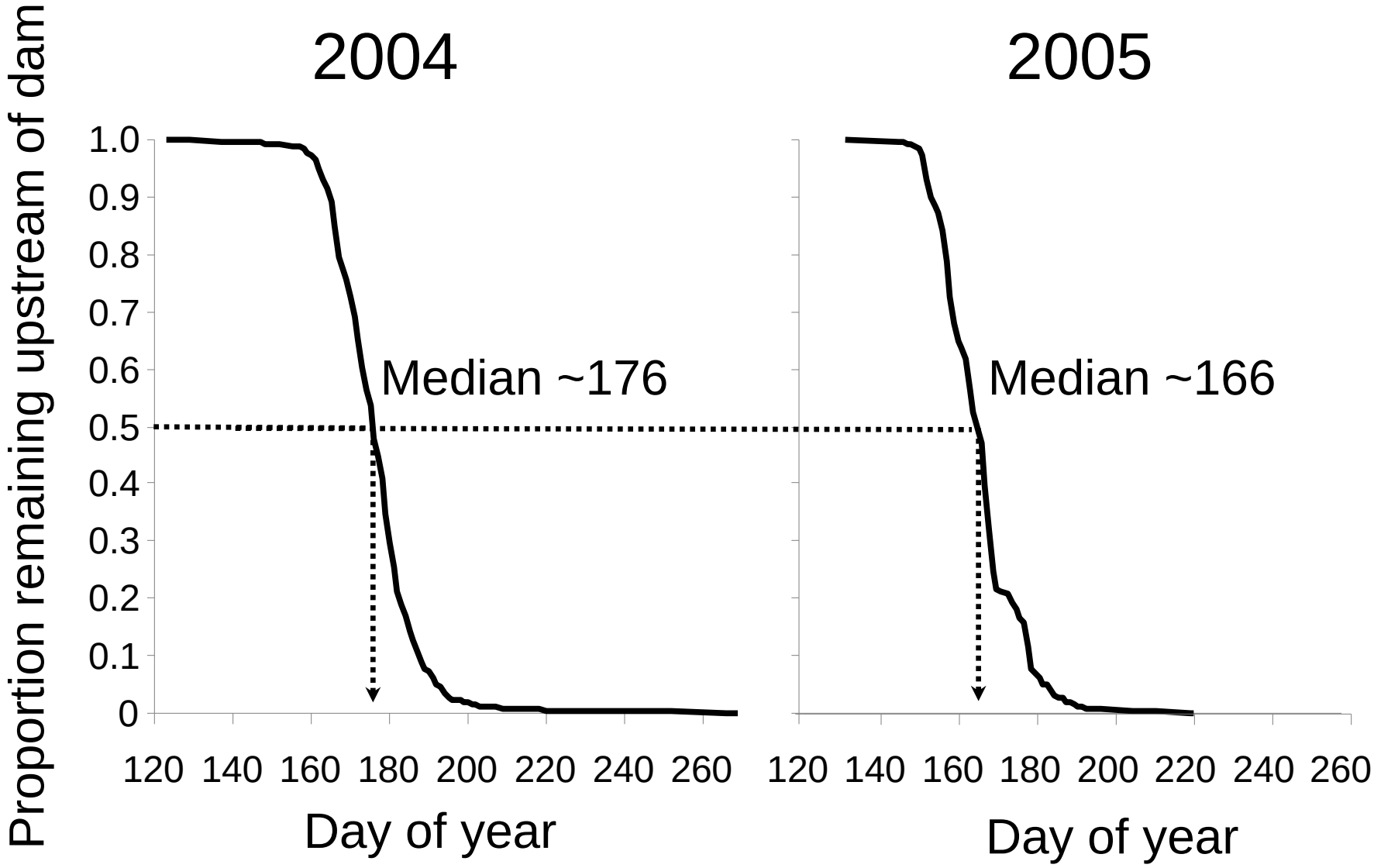
Daily Counts & Abundances



Migration Timing



Objectives

1) Use mark-recapture methods to understand daily passage abundances and annual migration timing at Lower Granite Dam

2) Apply models to multiple years of data from both radio- and PIT-tagged juvenile SR fall Chinook salmon

3) Determine if changes in dam operations may account for variation in abundance and migration timing of the wild population

Rationale
Bypass (Capture) Probability ($\hat{B}_t$)

- **Dam operations can affect counts of PIT-tagged fish at dams**
  - Daily passage counts may need adjustment

$$\hat{N}_t = c_t / \hat{B}_t$$

'Sampling effort' or the fraction of the population sampled

- **Analysis seeks to quantify and test for effects of dam operations and river flows on $\hat{B}_t$**
- **Develop quantitative models that can then be applied at other locations**

Analysis Outline

- Two tagging technologies (Radio and PIT)
- Two novel uses of multistate M-R models
- Evaluate radio and PIT tag model performances
- Express $\hat{B}_t$ as a linear function of dam operations

  - Used logit link function and the following predictors:
    - Total discharge (**TQ**),
    - Turbine allocation (**PT** - Proportion of total flow)
    - Surface passage operations (radio-tag only)
      - Use surface spill index (**SSI**)

  SSI = Prop. of time X Prop. of total flow

  - Used AIC model selection
  - Compare model subsets
  - Used USER 4.5.2 software and Powell's optimization

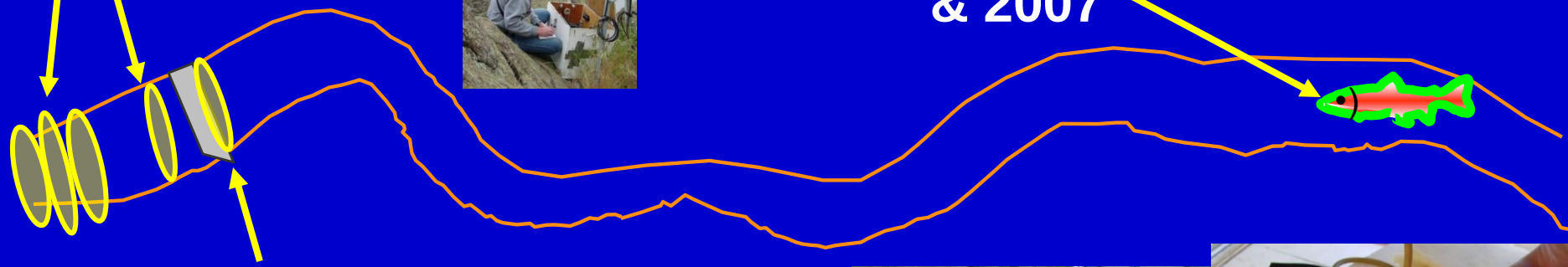
Data Collection and Sources

- **USGS radio telemetry**
  - Subyearling Chinook salmon
  - 1997, 1998, 2005, 2006, and 2007
  - Passage information on all routes
  - Provides estimates of $\hat{B}$ at the dam
- **PTAGIS database**
  - Wild & hatchery PIT-tag detections at dams
  - 1995 to Present
  - Provides passage information on one route
- **Environmental data**
  - Daily river flows from CR DART web page
    - Used with PIT tag data (SBC & RSW were NA)
  - 5 min flow data
    - Used with radio tag data (information on all routes)

Radio Tagging & Fish Detection

Tailrace exit antenna ~ 1 km
+ 3 other downstream arrays

<u>Release site</u>
Blyton Landing ~ 20 km
3,852 radio-tagged fish
1997, 1998, 2005, 2006, & 2007



<u>Lower Granite Dam</u>
~ 53 aerial antennas
~ 107 underwater antennas

Also, <u>PIT-tag detections</u> at downstream dams

A total of 1,677,379 fish from 1995 – 2008

Model Selection – Hypothesis tests

Use Akaike's Information Criterion (AICc)

Based on the Principle of Parsimony

- **Model with the lowest AICc value**
- **Fewest parameters**

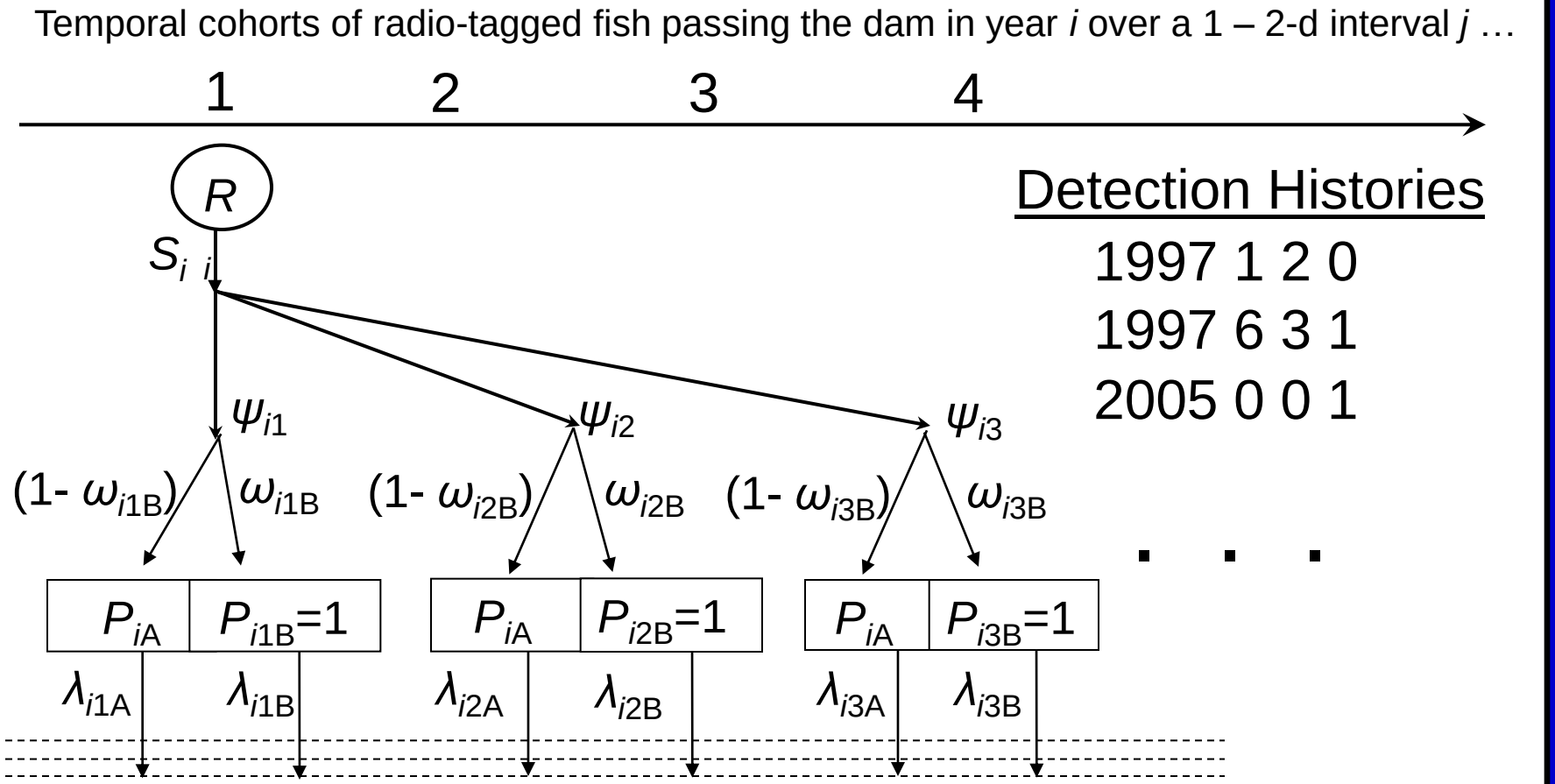
Most plausible model given…

- **The data**
- **The candidate model set**

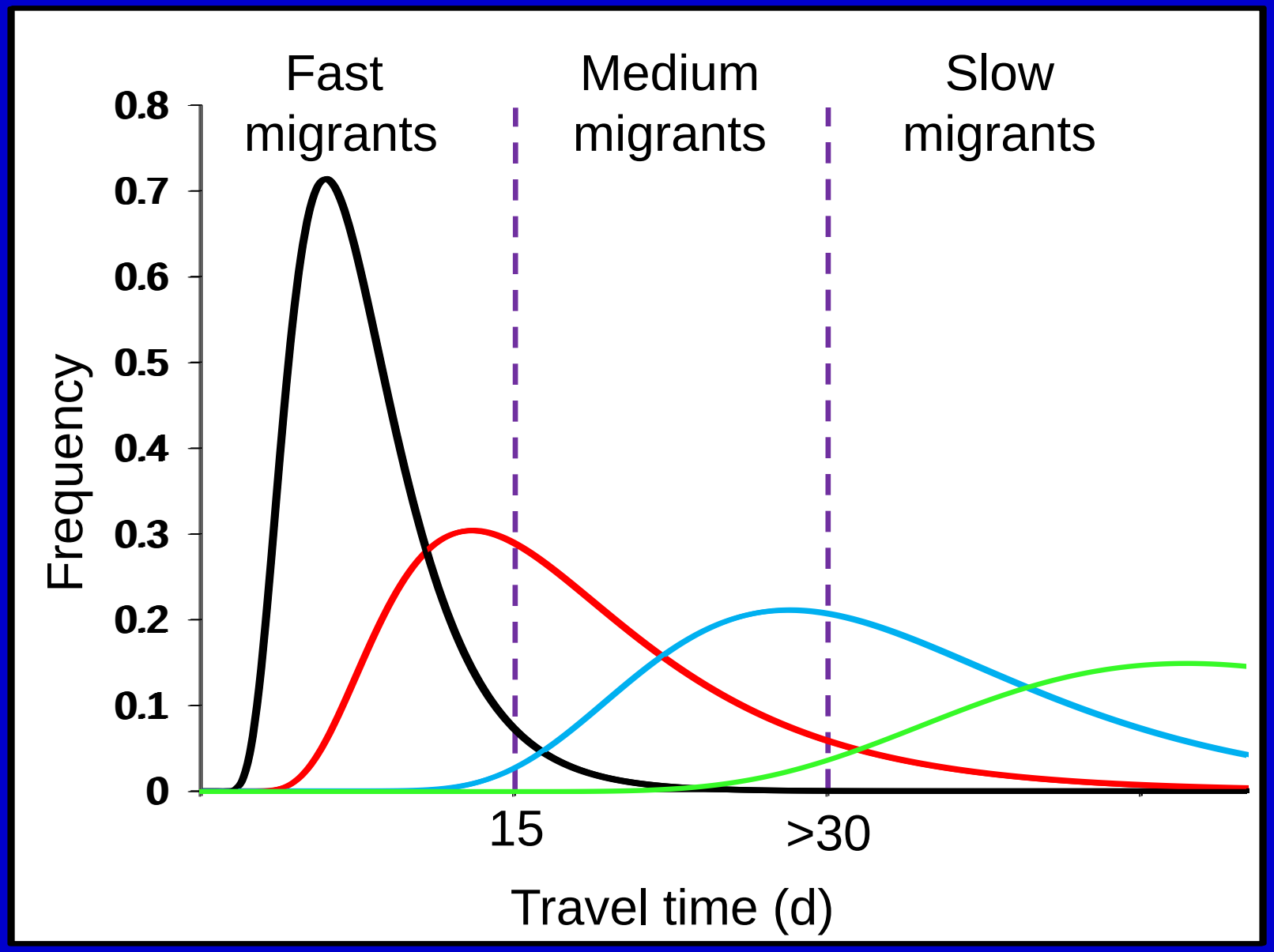
Compare different model subsets of full model based on the *a priori* chosen predictors

- **Turbine allocation (PT)**
- **Mean total discharge (TQ)**
- **Surface passage index (SPI)**

Mark-Recapture Model of Radio-Tagged Fish
'Full passage model'

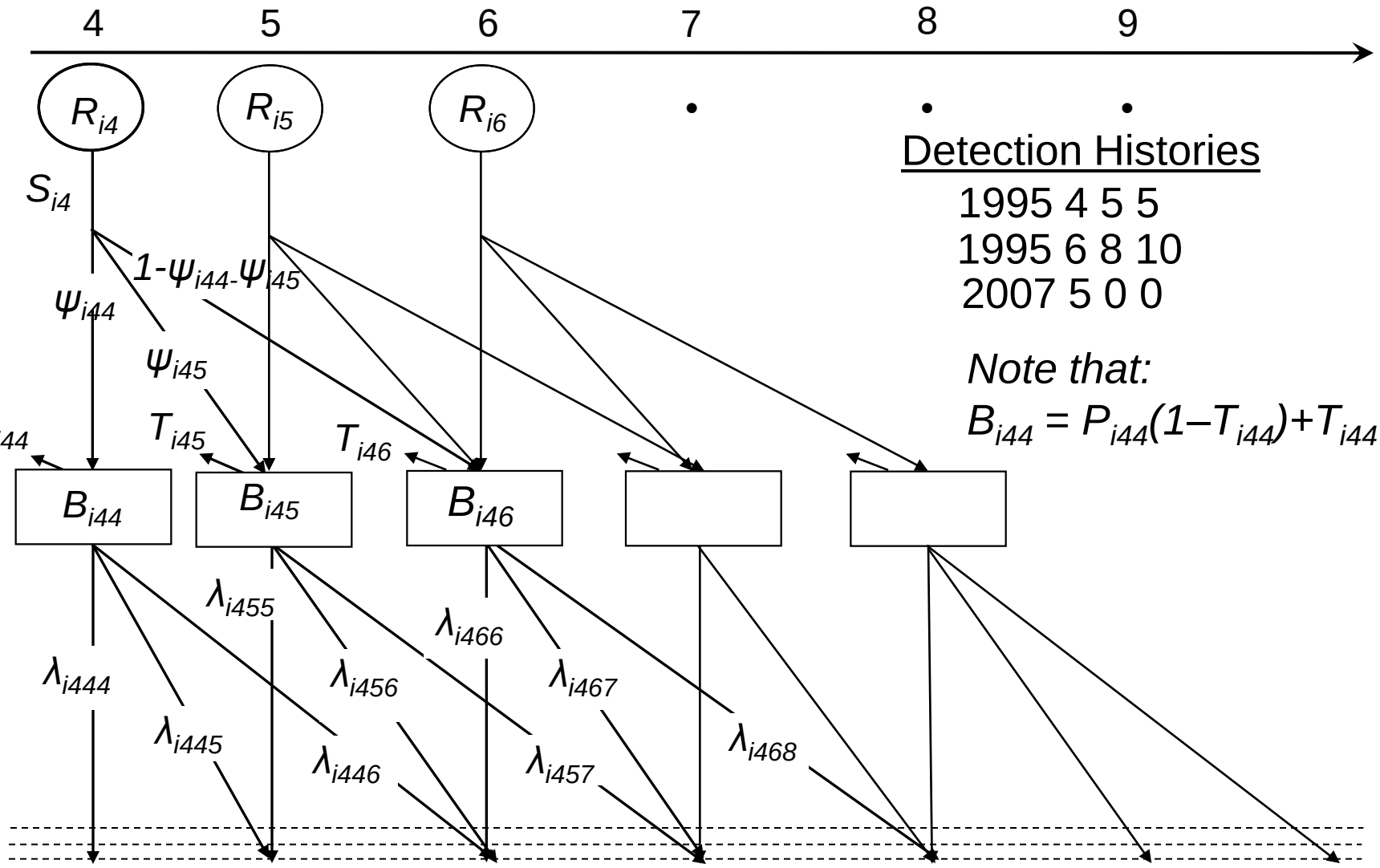


Fish Migration (PIT-tag model)



Mark-Recapture – PIT-Tagged Fish
'Full migration model'

Temporal cohorts of PIT-tagged fish released and passing the dam in year *i* over 30-d interval *j*…



Detection Histories

1995 4 5 5
1995 6 8 10
2007 5 0 0

Note that:

$B_{i44} = P_{i44}(1-T_{i44})+T_{i44}$

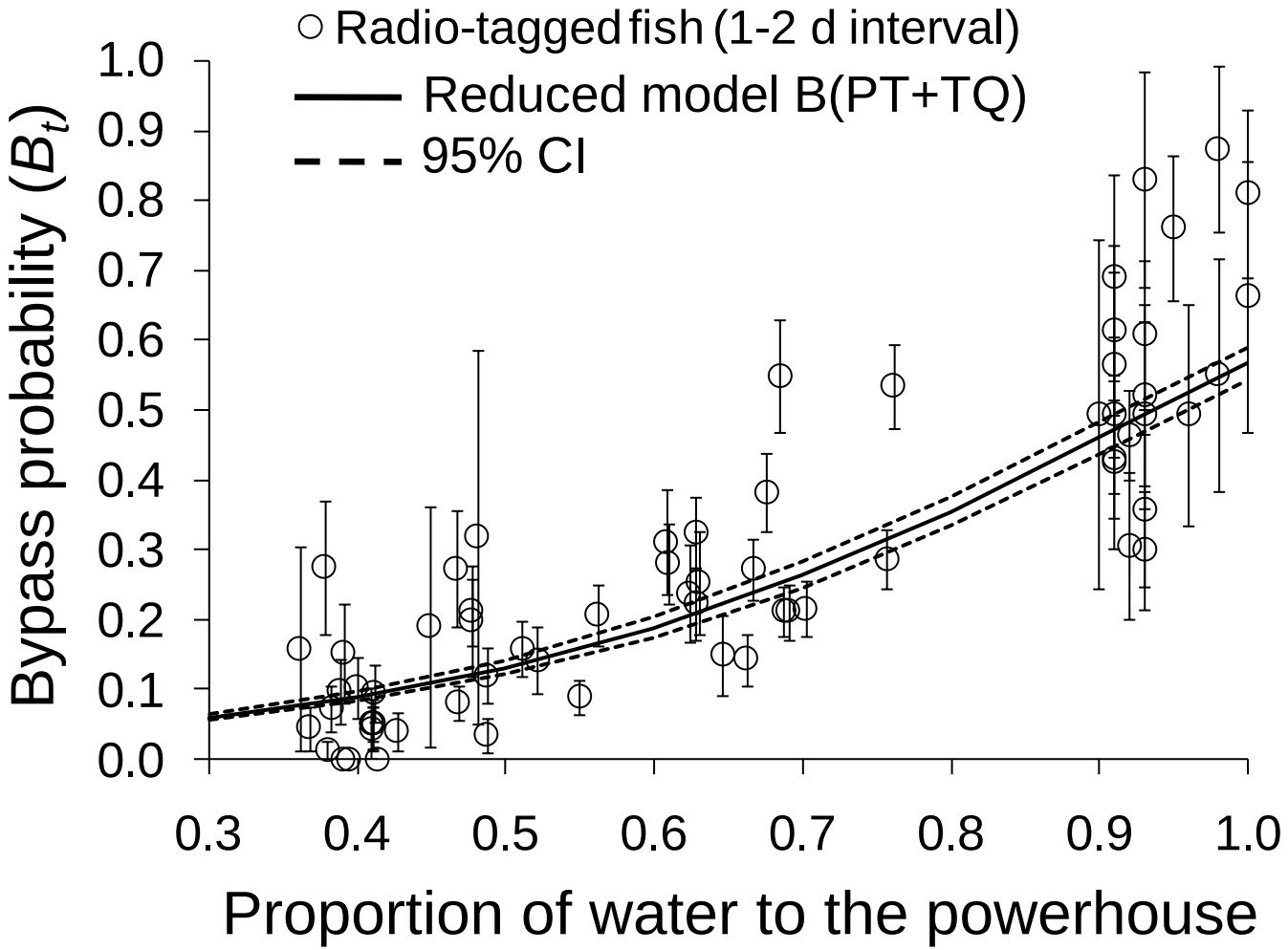
Results

- Model goodness-of-fit
  - Full Models based on…
    - Radio-tagged fish
    - PIT-tagged fish
- AIC model selection
  - Full model
  - Candidate linear expressions of $\hat{B}_t$
  - Intercept only model
  - Both M-R models based on RT and PIT-tagged fish
- Model application
  - Adjust PIT-tag counts of wild fall Chinook juveniles
  - During annual spill scenarios
    - 2004 (no spill) and 2005 (court-ordered spill)

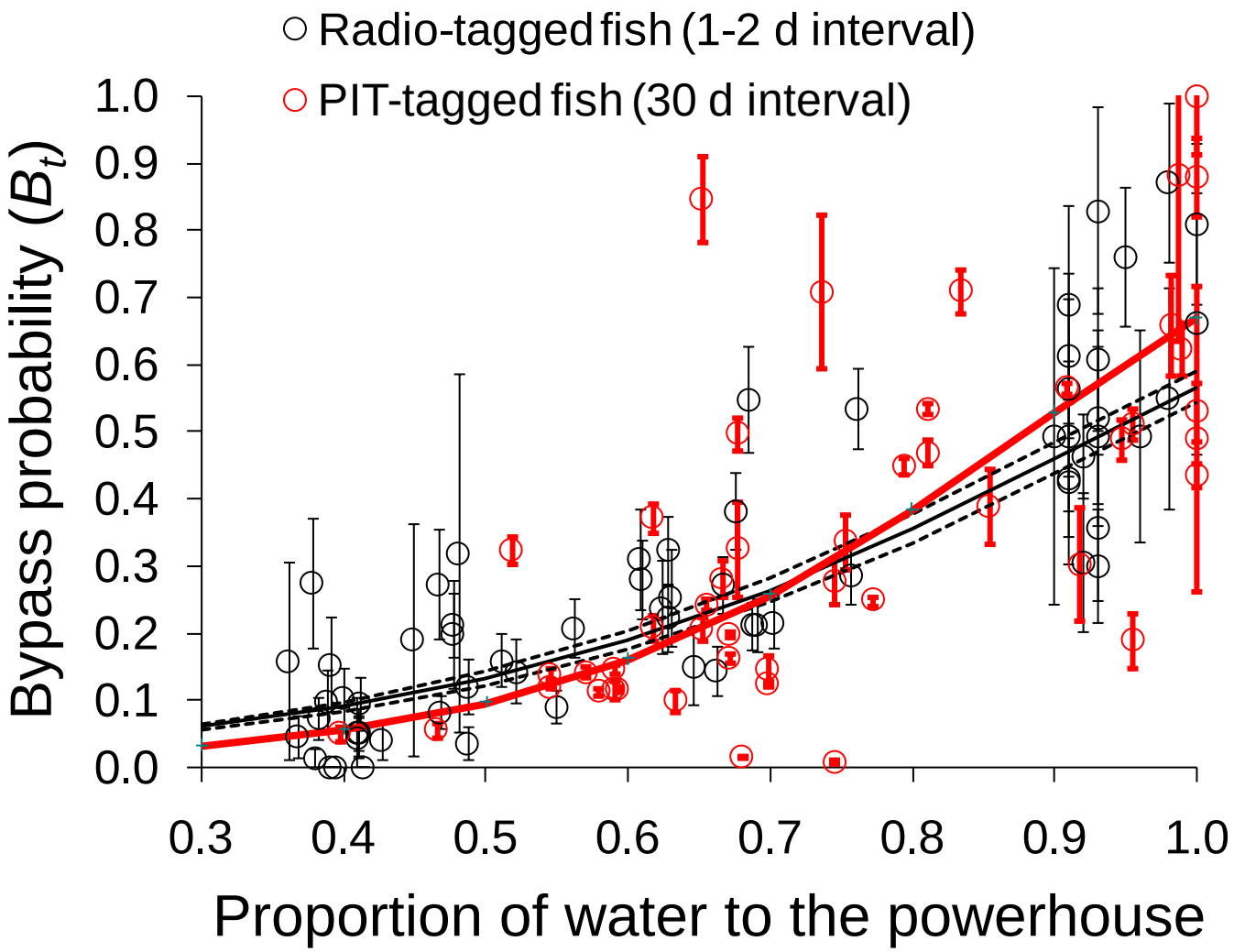
Radio Tag Model
AIC Model Selection

Model	n	K	Log likelihood	AICc	ΔAICc	LM	Wi	r_L^2
***B*(PT+TQ)**	**3852**	**131**	**-427.94**	1127	**0.00**	**1.000**	**0.452**	**0.71**
***B*(PT+TQ+SSI)**	**3852**	**132**	**-427.91**	1128	**0.44**	**0.801**	**0.362**	**0.71**
Full	**3852**	**191**	**-363.49**	1129	**1.78**	**0.410**	**0.185**	**NA**
B(PT+SSI)	**3852**	130	-435.46	1140	12.89	0.002	0.001	0.70
B(PT)	3852	131	-435.18	1142	14.47	0.001	0.000	0.70
B(TQ+SSI)	3852	131	-523.67	1319	191.46	0.000	0.000	0.41
B(TQ)	3852	130	-537.94	1345	217.86	0.000	0.000	0.34
B(SSI)	3852	130	-540.44	1350	222.85	0.000	0.000	0.33
B(Null)	3852	129	-594.36	1456	328.55	0.000	0.000	NA

Model Performance



Model Performance

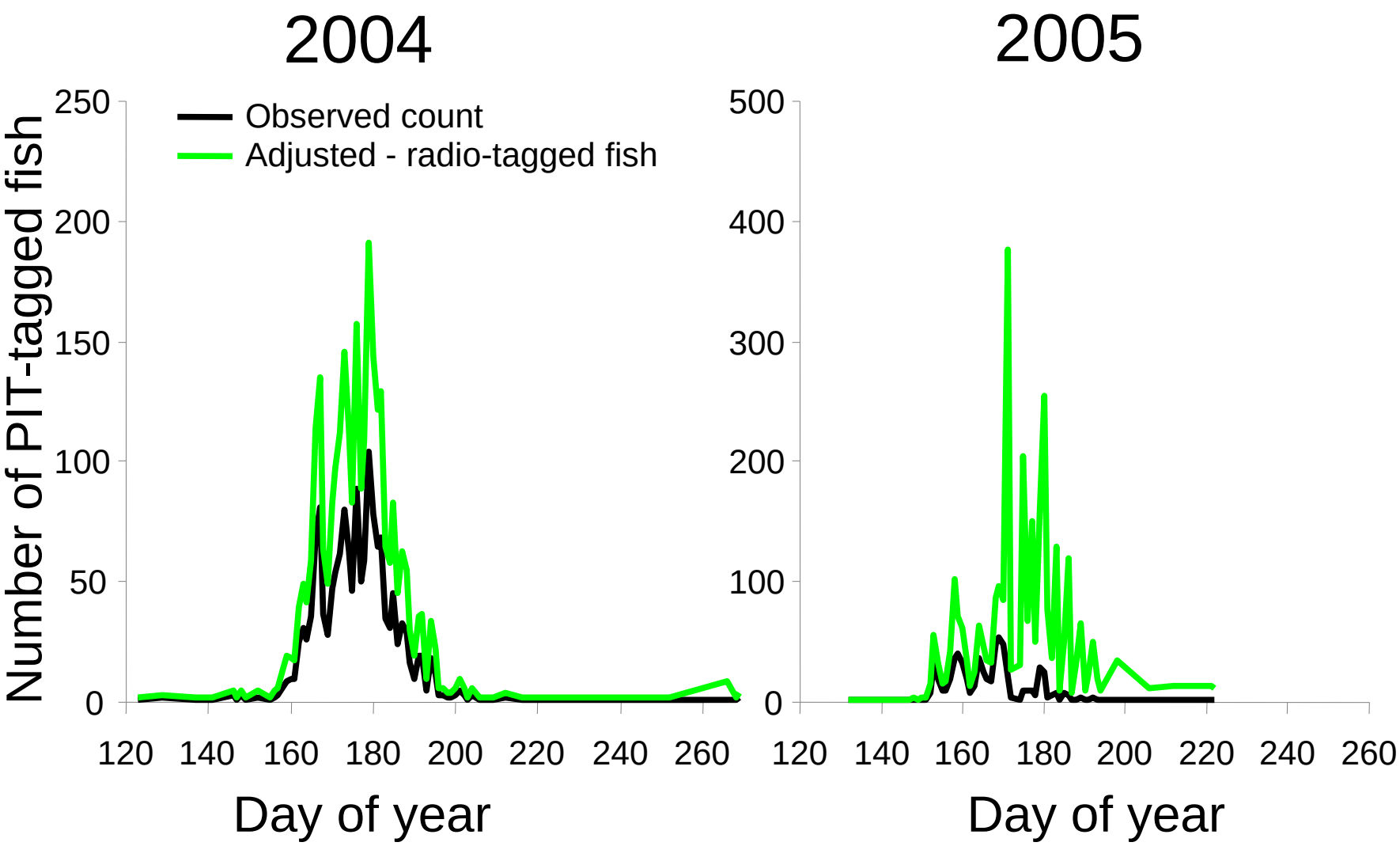


Model Application

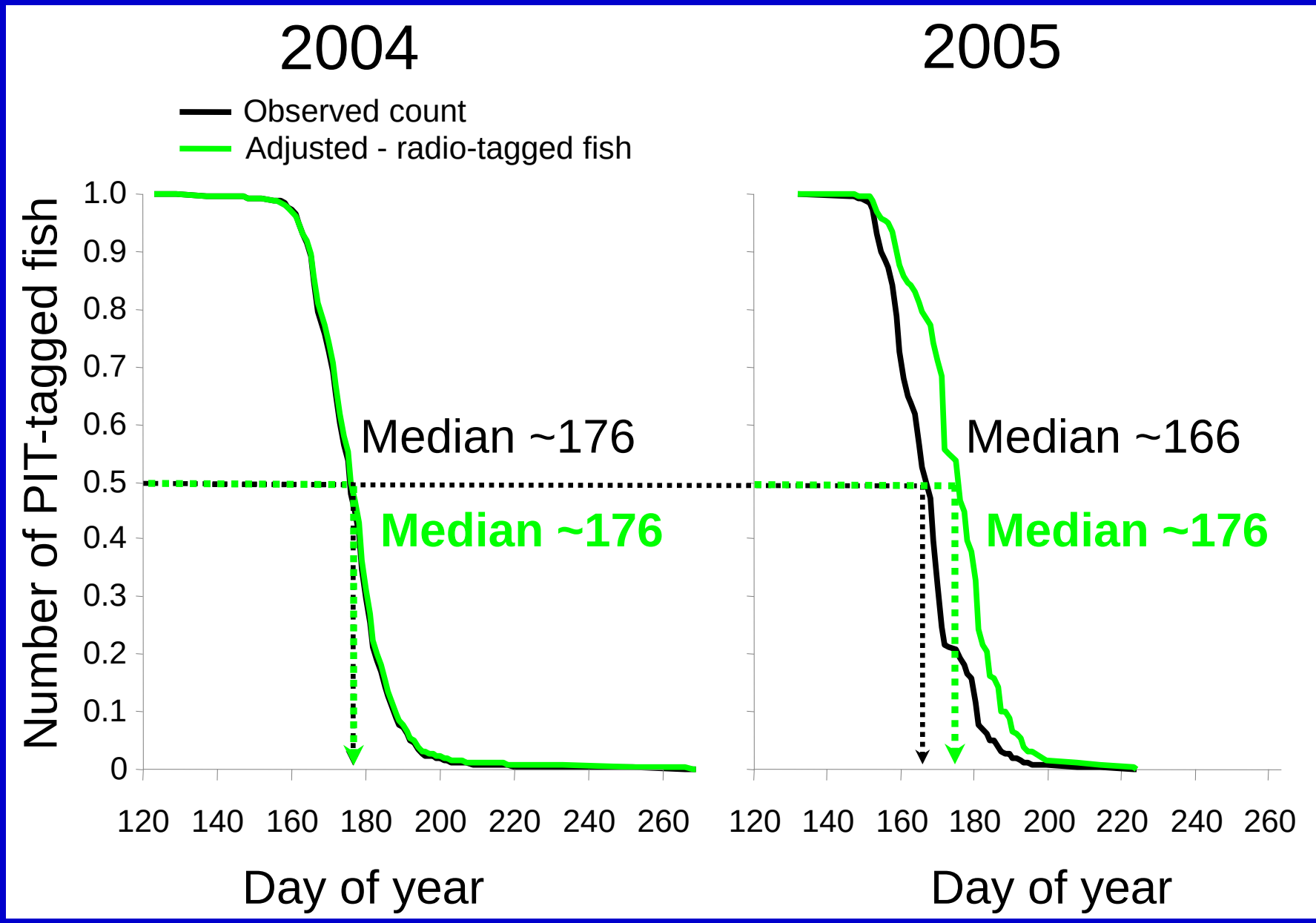
It is the changes produced in the fisheries by the regulations themselves that provide the opportunity of obtaining, by research, just the information that we may have been lacking previously... the benefits to the fisheries of such progress can hardly be exaggerated.

- Beverton and Holt (1957)

Adjustment of Observed Counts



Adjustment of Migration Timing



Summary

- Both PT and TQ were important factors
  - PT was most important
  - High summer spill can alter passage timing
- Adjustment of passage counts from dam operations data appears warranted
- Could alter annual migration timing trends and conclusions
- Adjusted counts similar between radio and PIT-tagged fish


U.S. FISH & WILDLIFE SERVICE
Thank You!
University of Idaho
USGS
science for a changing world
NEZ PERCE
FISHERIES
BONNEVILLE
POWER ADMINISTRATION
US Army Corps of Engineers
Walla Walla District
Project Funded by
BPA-F&W Program
Any Questions?

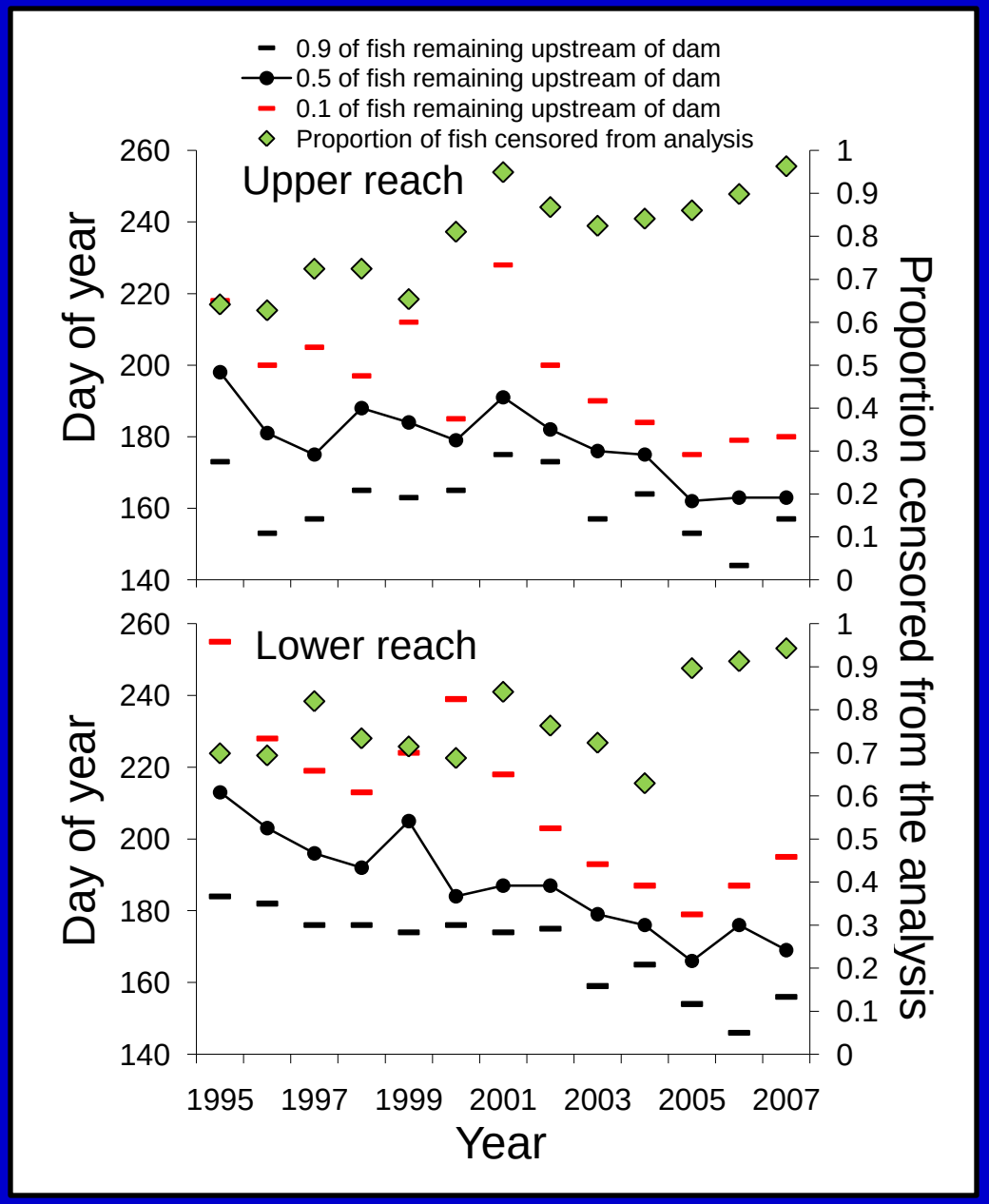
Out-Migration Timing…

- **Migration timing**
  - Annual decrease
  - Earlier for fish tagged in lower reach
- **Proportion censored**
  - Annual increase

Three options…

1) Fish died
2) Fish passed undetected during June-Nov
3) Fish passed undetected during winter

<u>Important to quantify fish trap performance</u>

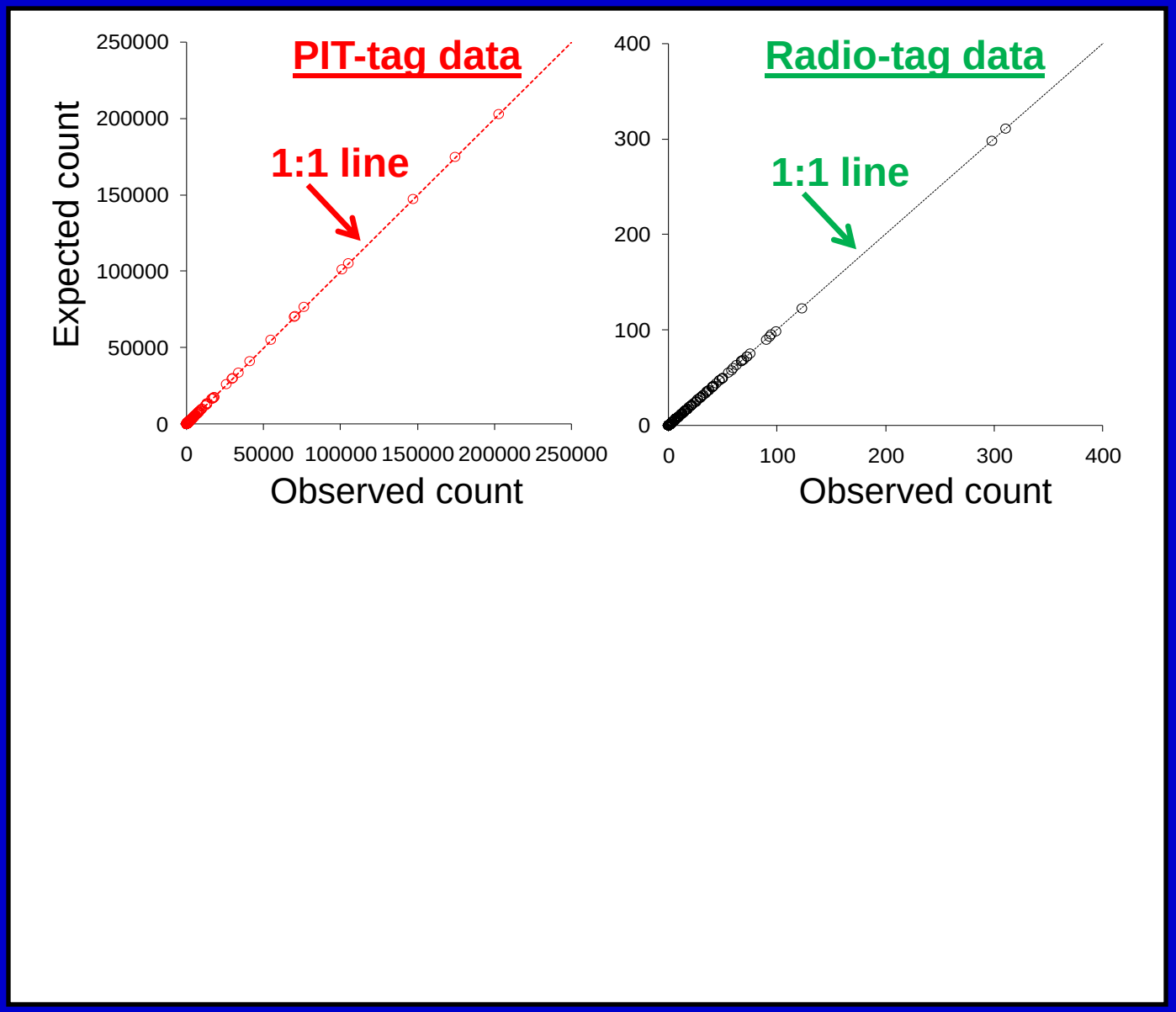


Model Goodness-of-Fit

X^2 test, P = 1
Indicates perfect fit!

Reasons:
- Very high detection rates
- Fish into 1–2-d groups

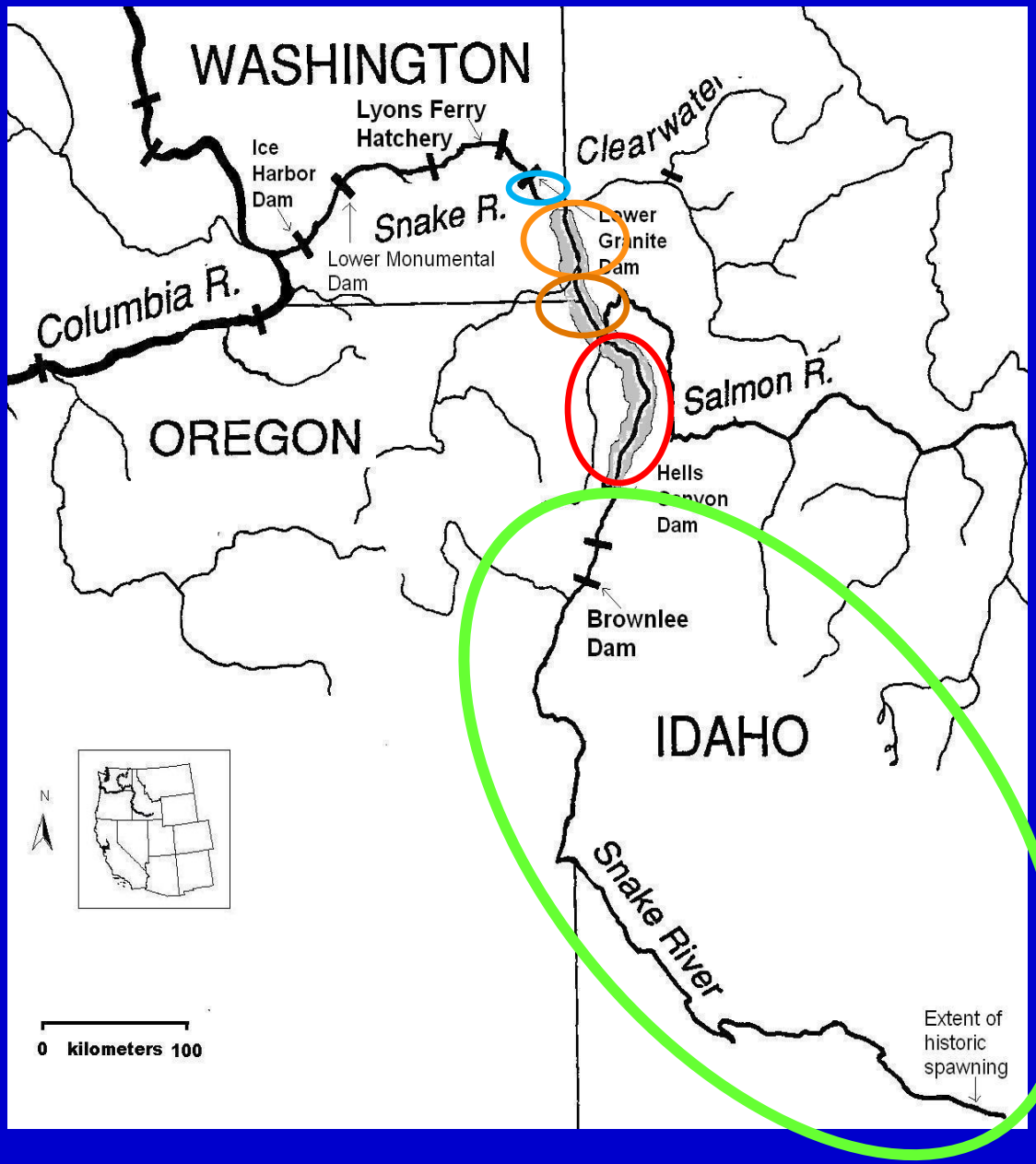
Provides a strong basis for model selection.



PIT-Tag Model
AIC Model Selection

Model	n	K	Log likelihood	AICc	ΔAICc	LM	Wi
B(Full)	1681231	421	-1813	4469	0	1	1
B(PT+TQ)	1681231	375	-4729	10209	5740	0	0
B(PT)	1681231	374	-17914	36576	32107	0	0
B(TQ)	1681231	374	-148282	297312	292843	0	0

Snake River Fall Chinook Salmon



- **Despite their adverse impacts…**

Dams provide key Information on fish behavior and abundance

Use detections and dam operations to understand wild SR fall Chinook salmon