



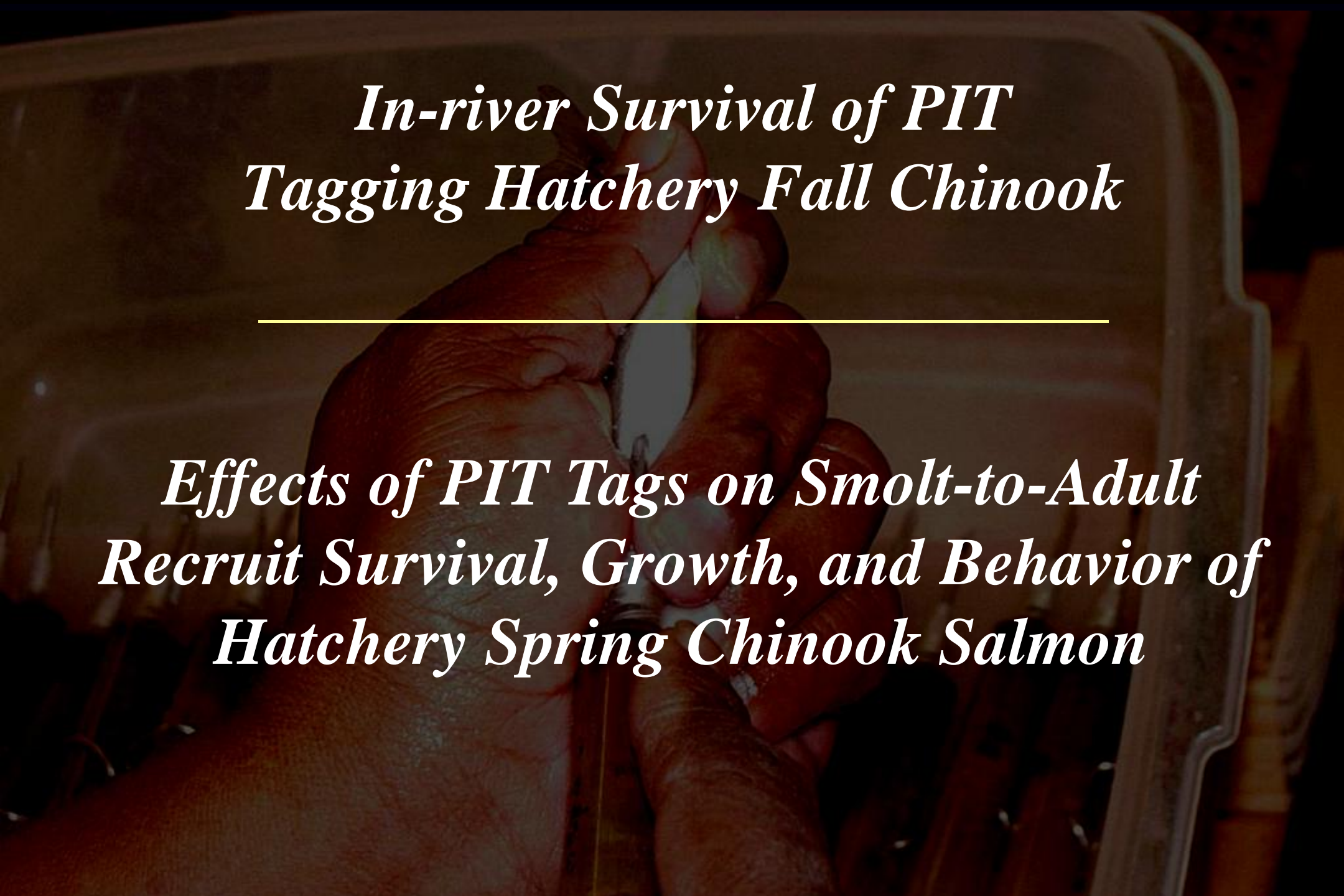
*Short- and long-term impacts of PIT  
tags on hatchery Fall and Spring  
Chinook salmon*

**Curtis Knudsen<sup>1</sup>, Steve Schroder<sup>2</sup>, Mark Johnston<sup>3</sup>,  
Todd Pearson<sup>2</sup> and Dave Fast<sup>3</sup>**

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<sup>3</sup>Yakama Indian Nation



*In-river Survival of PIT  
Tagging Hatchery Fall Chinook*

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*Effects of PIT Tags on Smolt-to-Adult  
Recruit Survival, Growth, and Behavior of  
Hatchery Spring Chinook Salmon*



*In-river Survival of PIT  
Tagging Bingham Creek  
Hatchery Fall Chinook*

*Curtis Knudsen and Steve Schroder (WDFW)*

# Acknowledgments

- **Debbie Frost (NOAA/NMFS) PIT tagging**
- **Earl Prentice (NOAA/NMFS) provided PIT tags**

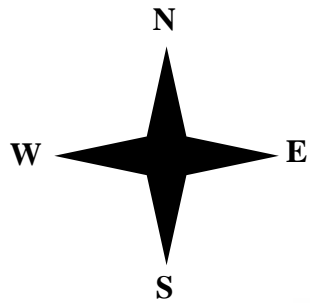
**Legend**

 Trap Sites

 Lakes

 Streams

 Miles  
0 5 10



*Bingham Ct.*

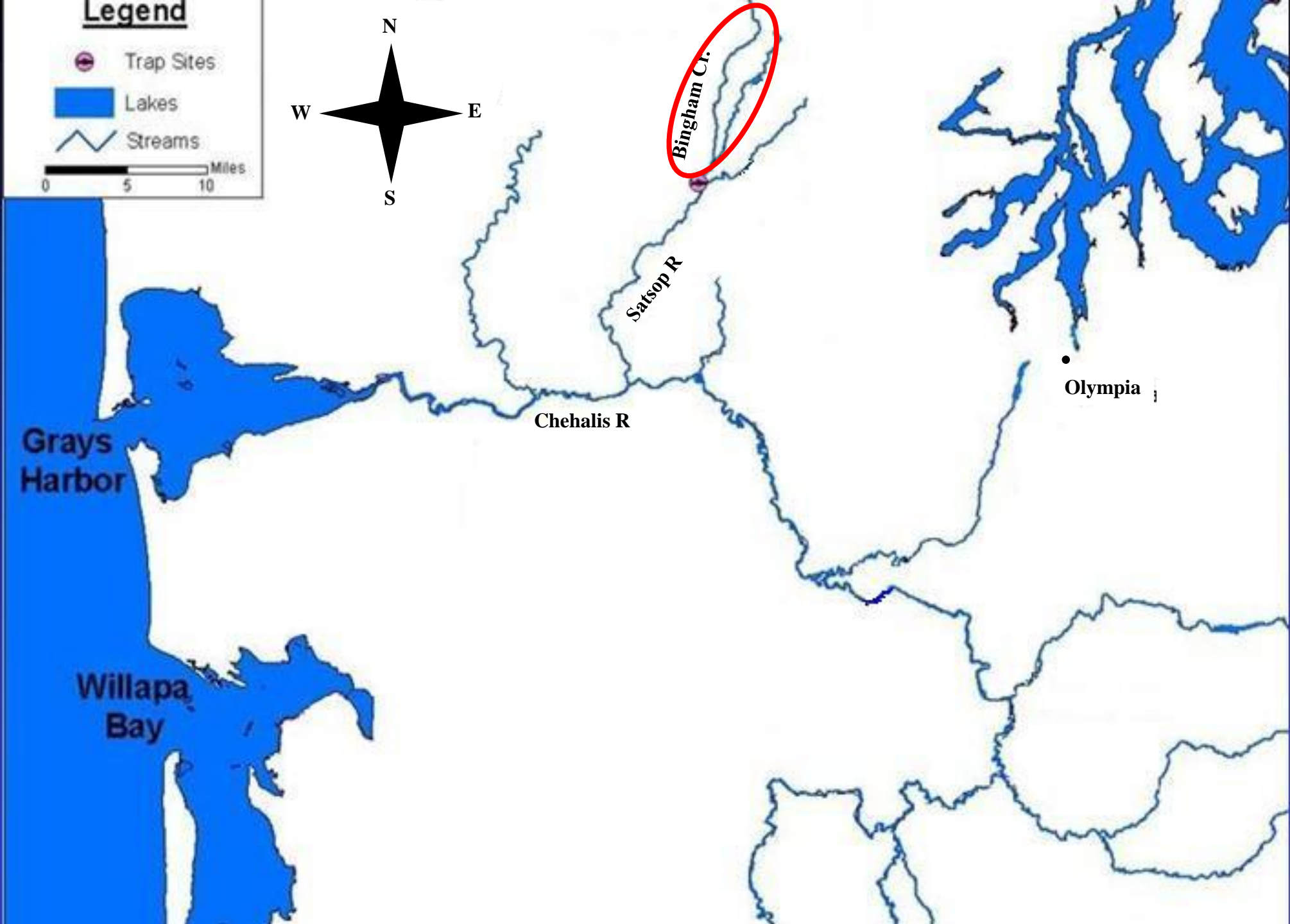
Satsop R

Chehalis R

• Olympia

Grays Harbor

Willapa Bay

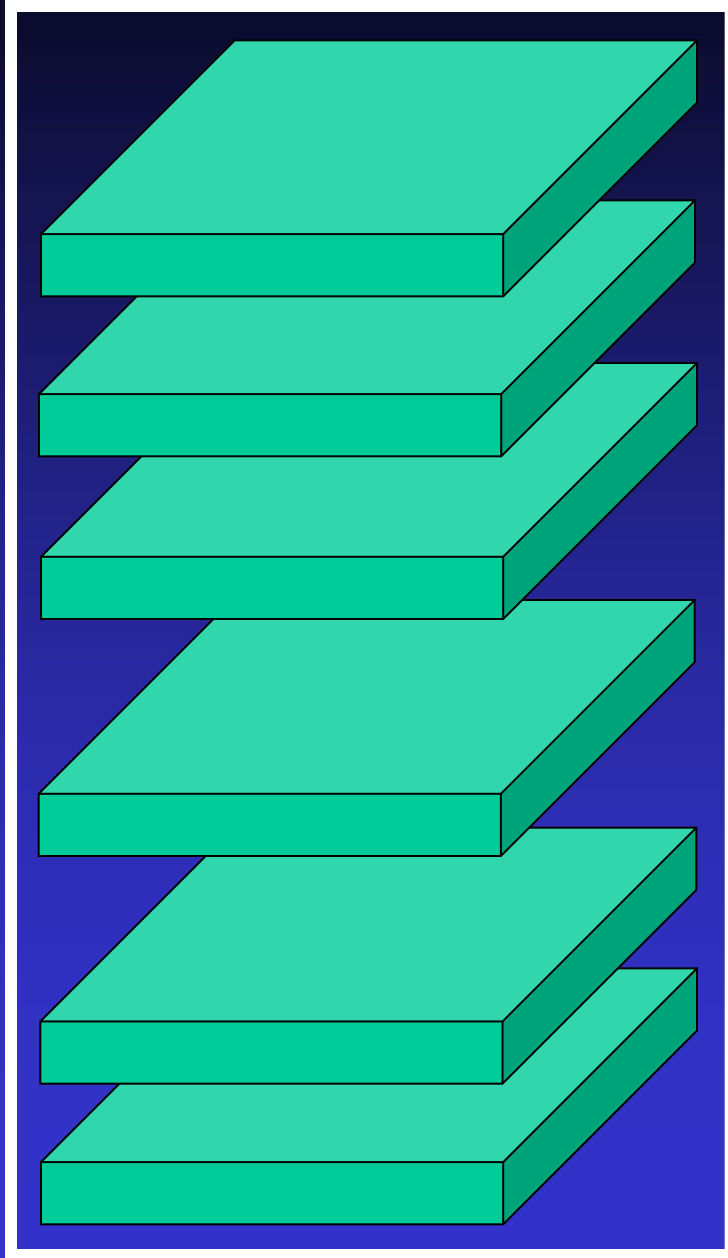


**Purpose: Compare PIT tagged fish survival rates to Control group survival rates**

- PIT tagged group
- Two control groups
  - Unhandled Control
    - During tagged left undisturbed
  - Handled Control
    - Netted, transferred, and anesthetized without being marked

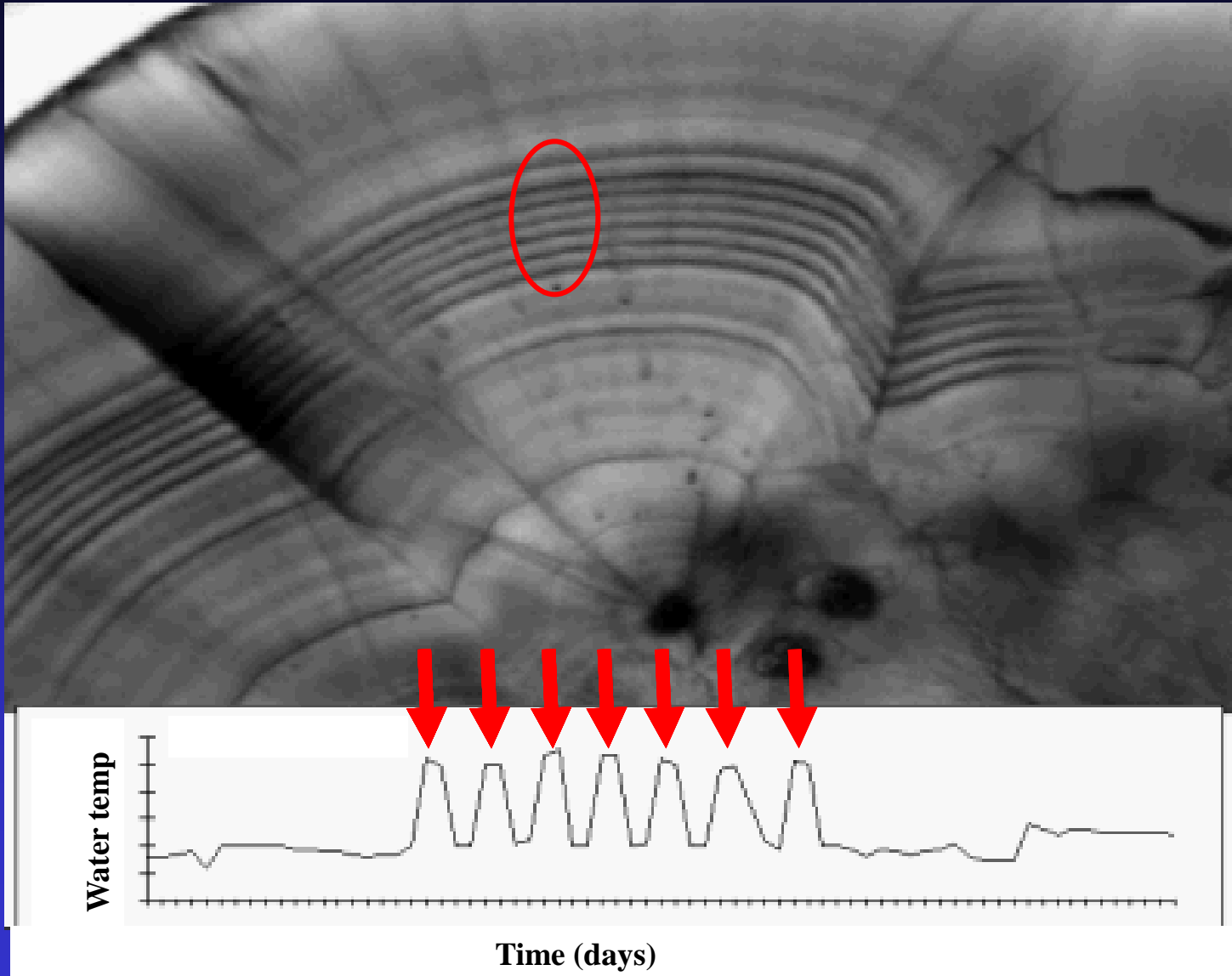
**Two releases of each - a total of 6 groups released**

## Ambient water



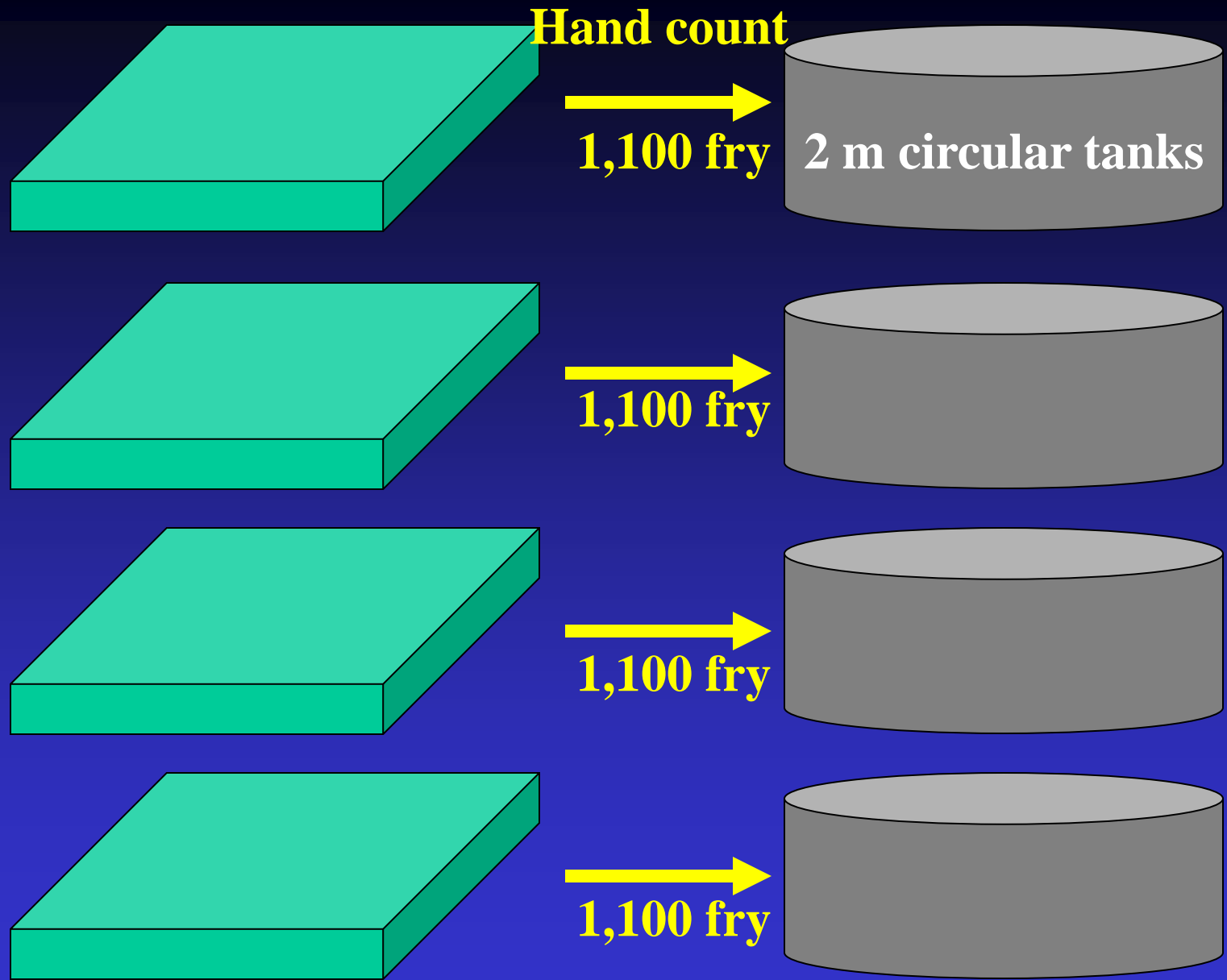
## Chilled Water 4°C

**Eggs within each of  
the 6 trays developed  
unique otolith codes**



Taken from: <http://npafc.taglab.org>



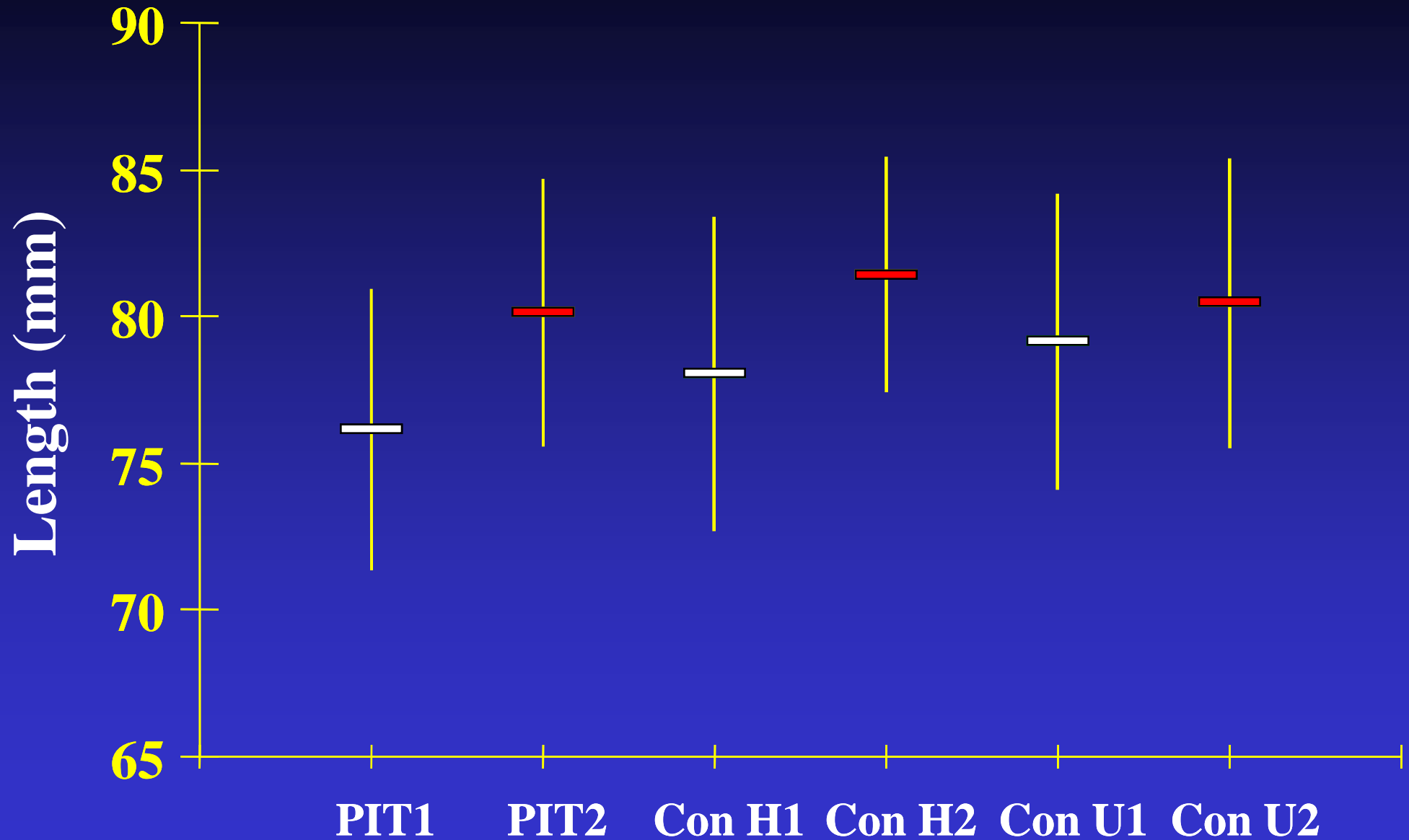


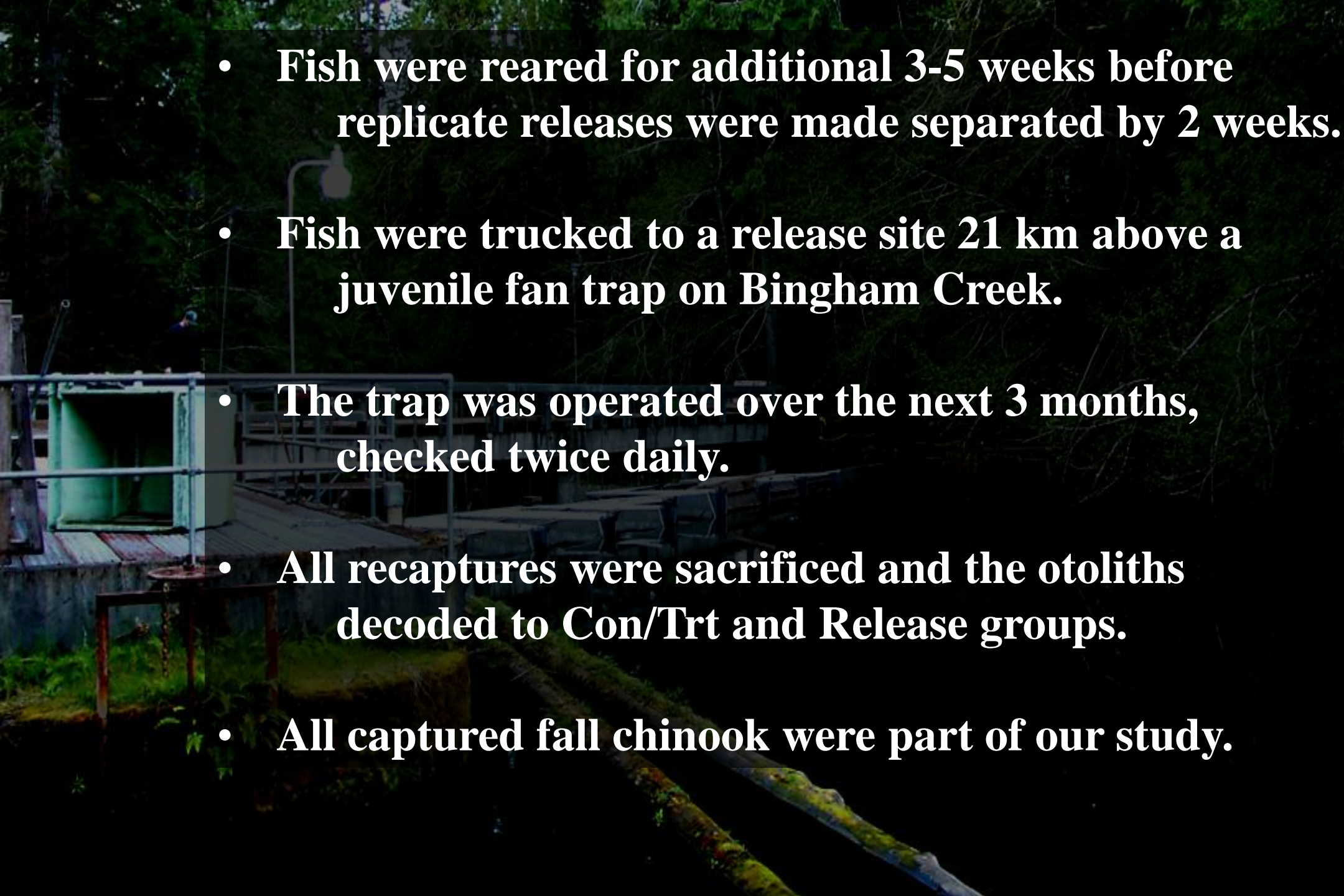
**Randomly assigned tanks to treatment and control groups**

# Fish Length At Tagging

- Fish averaged 75-78 mm at the time of PIT tagging (sd=4-5 mm)
- No fish less than 60 mm were PIT tagged
- Fish were reared for additional 3-5 weeks before replicate releases were made separated by 2 weeks

# Mean Fork Length $\pm 1$ sd at Release



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- **Fish were reared for additional 3-5 weeks before replicate releases were made separated by 2 weeks.**
  - **Fish were trucked to a release site 21 km above a juvenile fan trap on Bingham Creek.**
  - **The trap was operated over the next 3 months, checked twice daily.**
  - **All recaptures were sacrificed and the otoliths decoded to Con/Trt and Release groups.**
  - **All captured fall chinook were part of our study.**

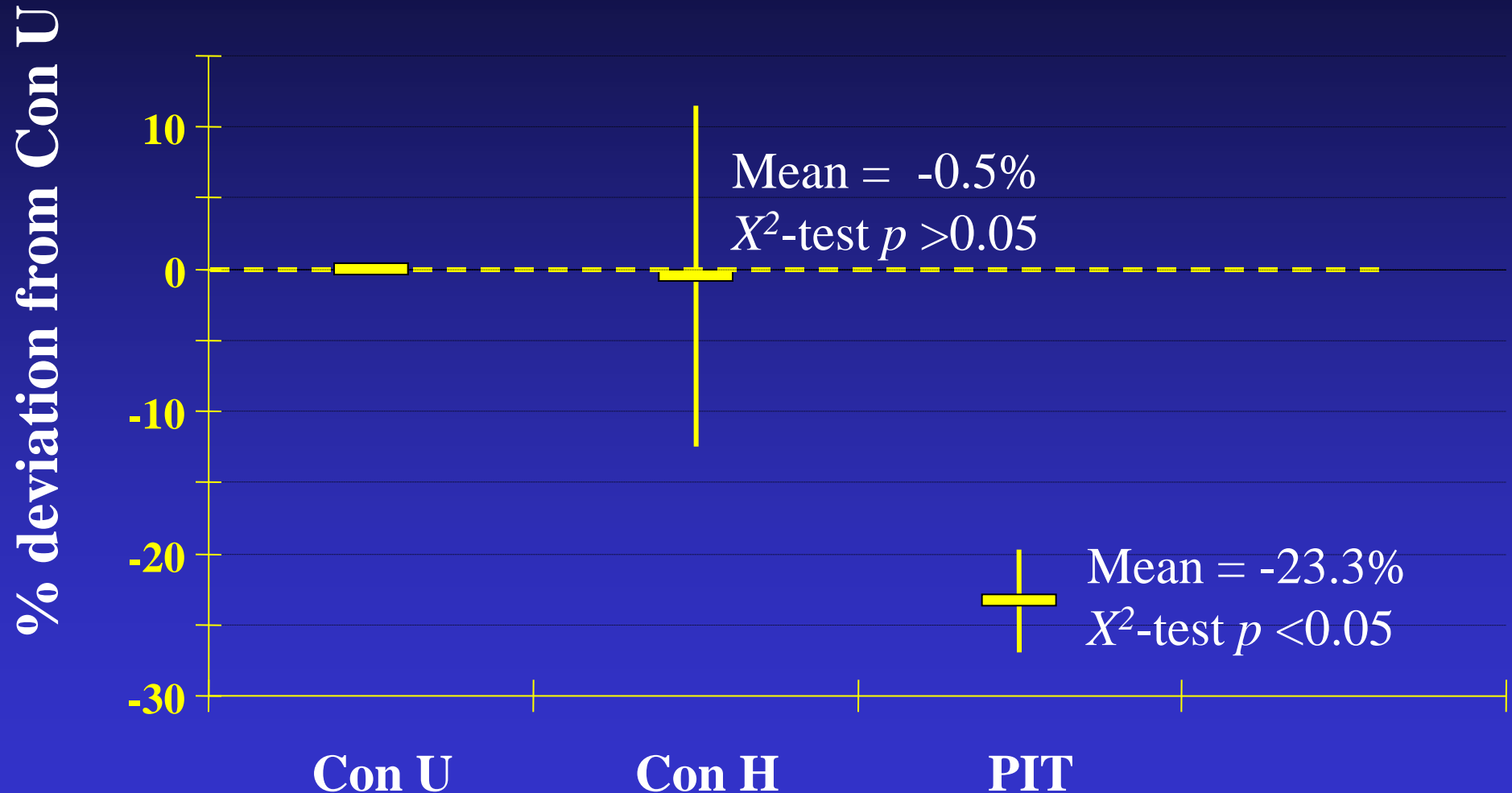
# Bingham Creek Fan Traps



# PIT Tag Loss From Recaptures

- First release group lost 2.0% of their PIT tags
- Second release had no tag loss

# Mean and Range of Survivals Relative to Control Unhandled Group Over First and Second Releases



# Conclusions

- Marked fish were held long enough to recovery from general handling stress (ConU=ConH post-release survival)
- PIT tag loss was  $\leq 2\%$  over the 90 days trapping
- PIT tagged groups showed significantly higher post-release mortality (mean 23%) relative to the Control Unhandled group over the 90 days of trapping



A close-up photograph of a person's hands holding a small, light-colored fish, likely a Chinook salmon, in a hatchery setting. The fish is being held gently, and the background shows a white plastic container. The text is overlaid on this image.

*Effects of PIT Tags on Smolt-to-Adult  
Recruit Survival, Growth,  
and Behavior of Hatchery Spring  
Chinook Salmon*

**Knudsen, C., M. Johnston, S. Schroder, W. Bosch, D. Fast and C. Strom. 2009. *Effects of Passive Integrated Transponder Tags on Smolt-to-Adult Recruit Survival, Growth, and Behavior of Hatchery Spring Chinook Salmon.* NAJFM 29:658–669.**

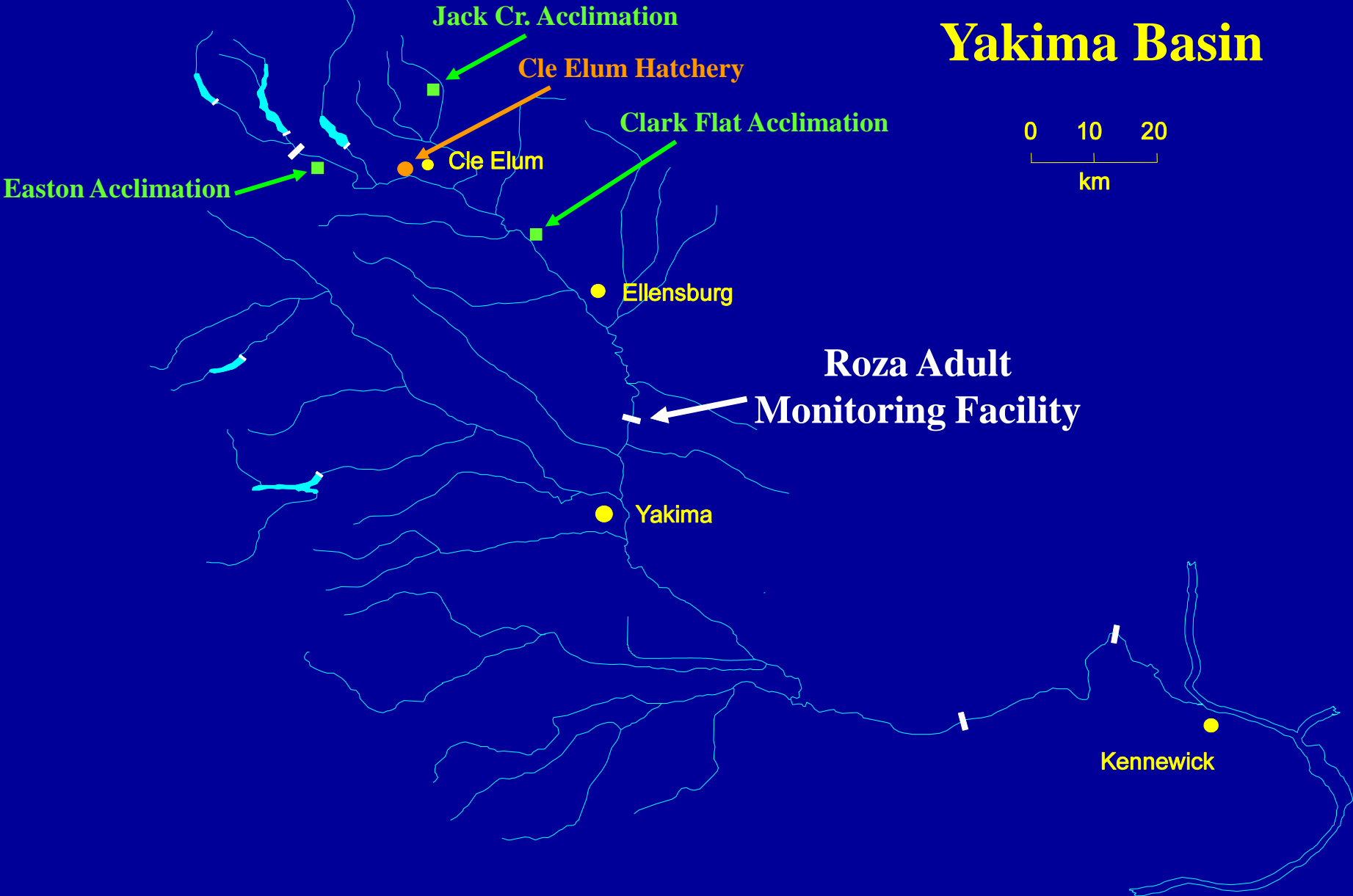
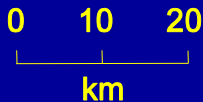
# Acknowledgments

- Tagging of juveniles and recovery of adults was by Yakama Nation personnel
- BPA for providing the funding through the YKFP Monitoring and Evaluation Program

# Study Design

- Double tag (PIT and snout CWT) approximately 40K juvenile spring chinook in October-December
- Held for 1.5 additional months and volitionally released from March 15-May 30
- Repeated over 5 years (releases in 1999 to 2003)
- All hatchery origin adults (ages 3, 4 and 5) were interrogated for tags at Roza adult trap (April-Sept.) sampled for length, weight, and age (scales)
- SARS and tag loss were estimated based on recapture data by broodyear

# Yakima Basin



## Broodyear

Juvenile Releases	1997	1998	1999	2000	2001
PIT/CW tagged	39,892	37,385	38,791	37,580	40,020
Non-PIT (marked)	346,156	552,298	719,998	796,705	334,358
Total released	386,048	589,683	758,789	834,285	374,378



**Roza Adult  
Monitoring  
Facility**



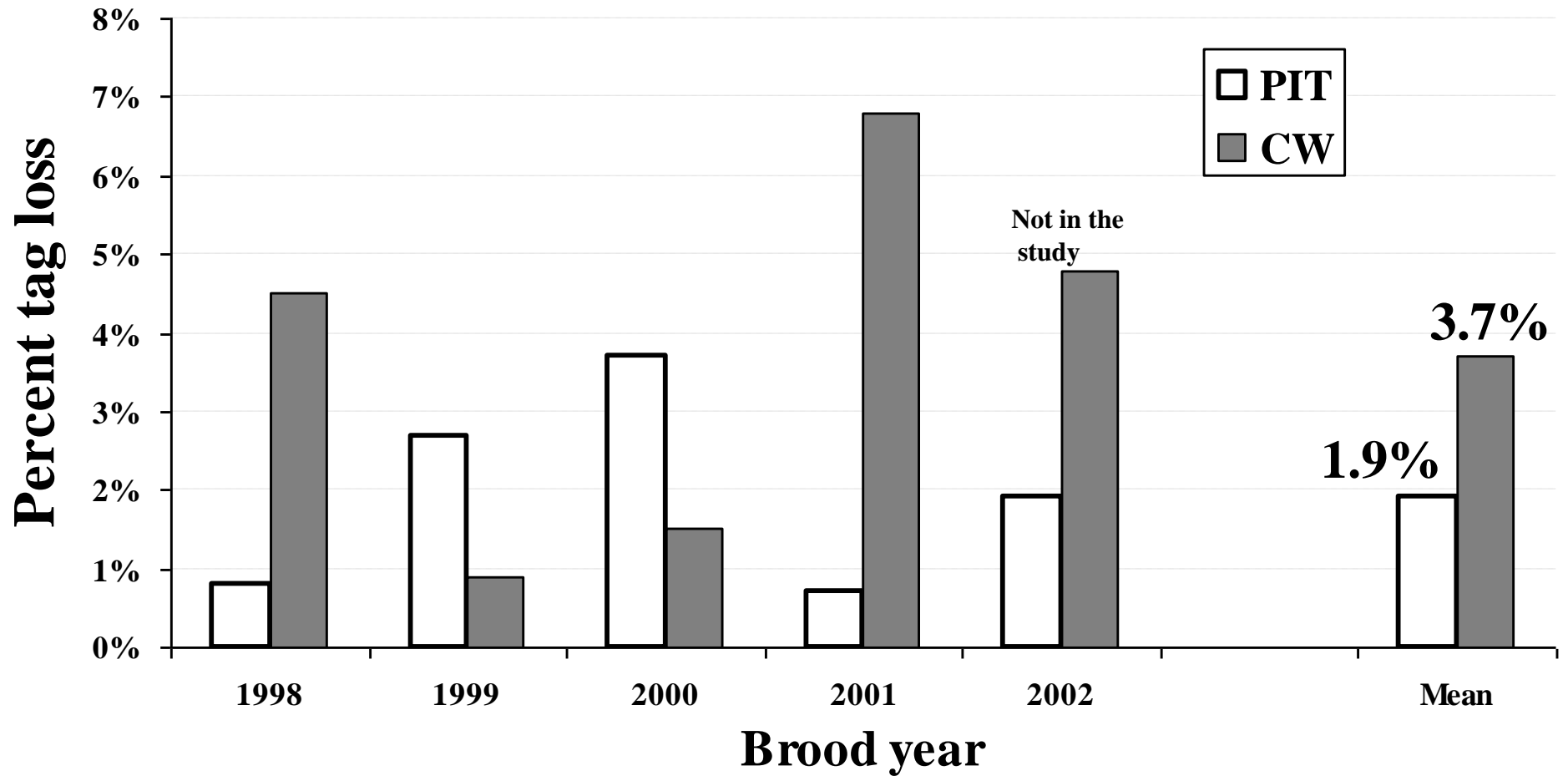
**Fish ladder**



$$\hat{\Pr}_{pit} = [\text{Probability of losing a PIT tag}] = \frac{R_{cwt}}{(R_{cwt} + R_{pit,cwt})}$$

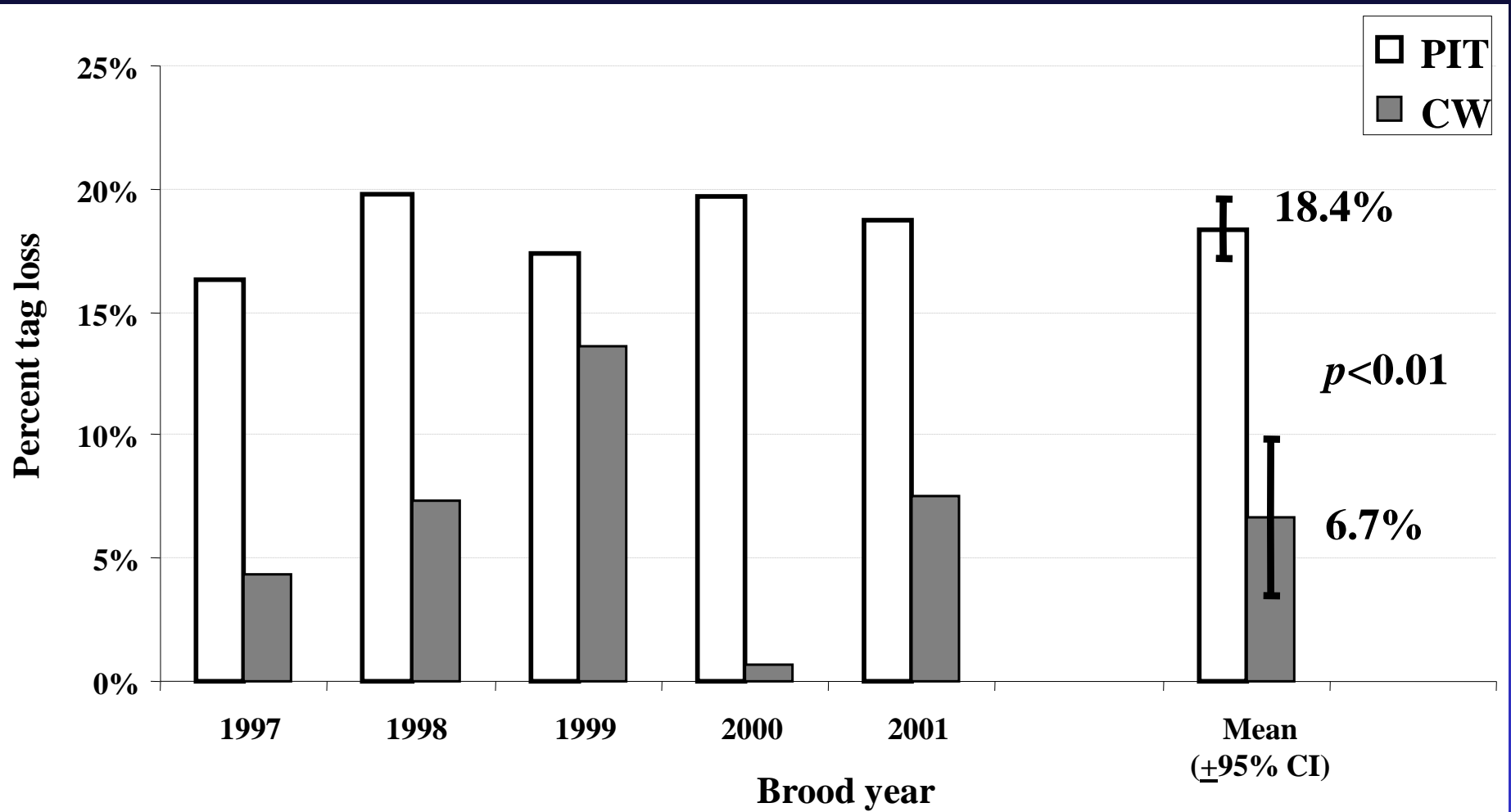
$$\hat{\Pr}_{cwt} = [\text{Probability of losing a snout CW tag}] = \frac{R_{pit}}{(R_{pit} + R_{pit,cwt})}$$

# Juvenile tag loss rates before release





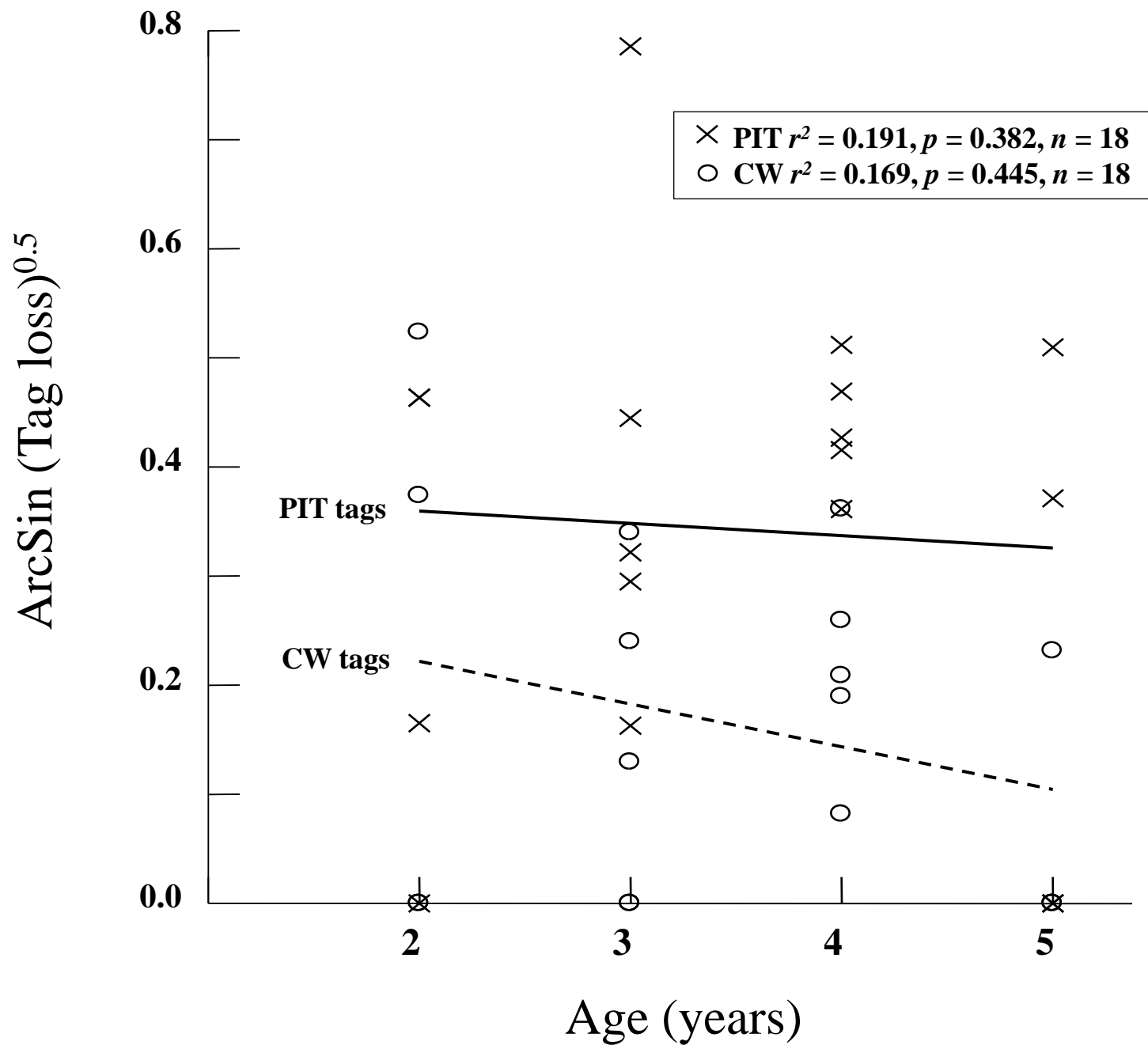
# Adult PIT and CW tag loss rates



## Roza PIT tag recovery efficiency estimates

Recovery year	NOAA carcass PIT tag recoveries	PIT tags observed at RAMF	% observed at RAMF
<b>2002</b>	<b>13</b>	<b>12</b>	<b>92.3</b>
<b>2003</b>	<b>9</b>	<b>9</b>	<b>100.0</b>
<b>2004</b>	<b>10</b>	<b>10</b>	<b>100.0</b>
<b>2005</b>	<b>2</b>	<b>2</b>	<b>100.0</b>
<b>2006</b>	<b>8</b>	<b>8</b>	<b>100.0</b>
<b>2007</b>	<b>2</b>	<b>2</b>	<b>100.0</b>
<b>Total</b>	<b>44</b>	<b>43</b>	<b>Mean 98.7</b>

Data provided by Andy Dittman, NOAA



From: *Seber. 1982. The estimation of animal abundance*

$\hat{R}$  is the number of recaptures corrected for tag loss

$$\hat{R} = c(R_{cwt} + R_{pit} + R_{pit,cwt})$$

$$c = \left[ 1 - \frac{R_{cwt} * R_{pit}}{(R_{cwt} + R_{pit,cwt})(R_{pit} + R_{pit,cwt})} \right]^{-1}$$



**(Joint probability of losing both PIT and CW tags)**

## SARS Corrected for PIT Tag Loss

$$\text{Uncorrected PIT SARS} = \frac{R_{pit} + R_{cwt+pit}}{\# PIT_{Released}}$$

$$\text{Corrected PIT SARS} = \hat{R}_{pit} / (\# PIT_{Released})$$

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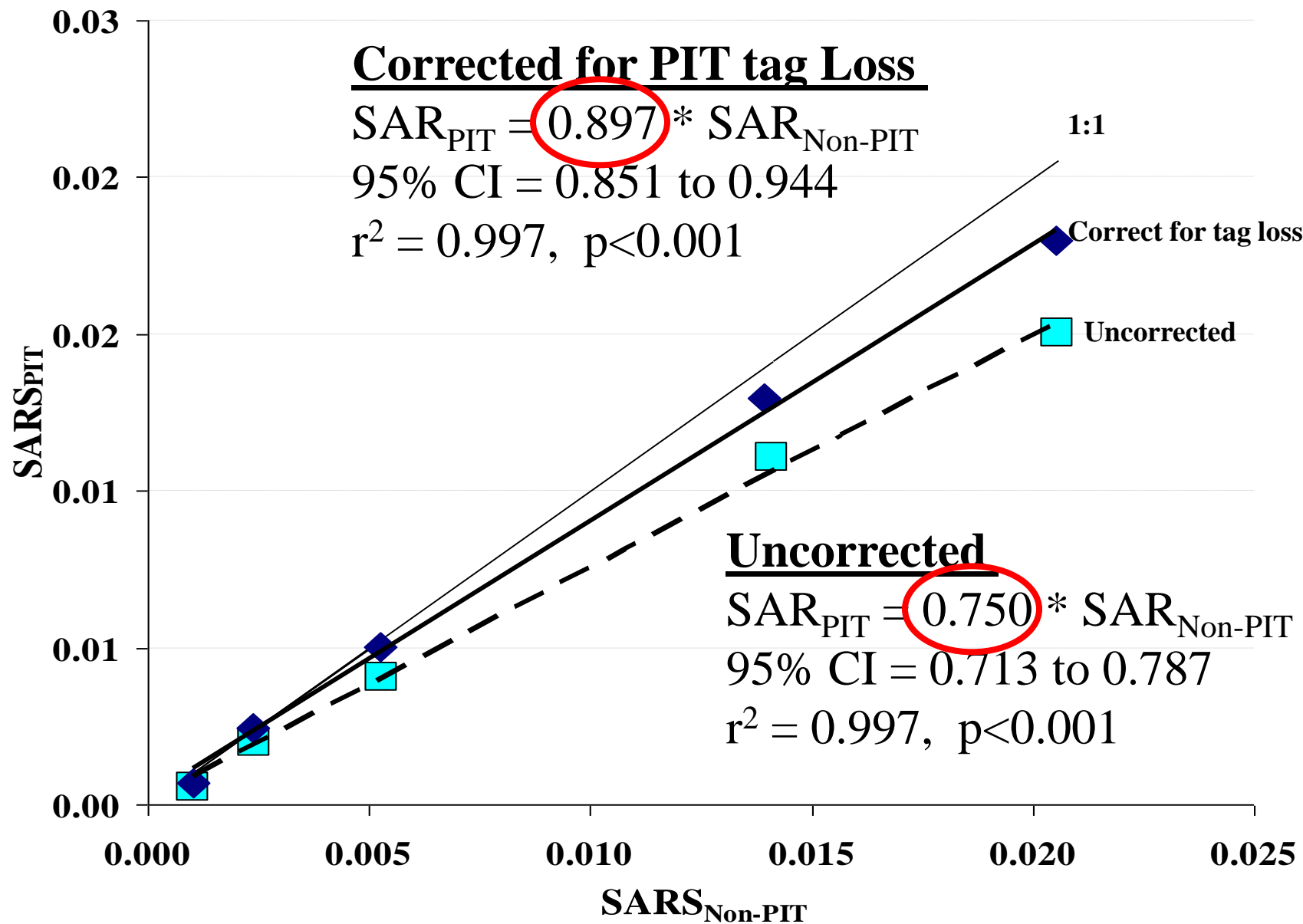
$$\text{Uncorrected Non-PIT SARS} = \frac{(\# \text{ Non-PIT recoveries})}{(\# \text{ Non-PIT released})}$$

$$\text{Corrected Non-PIT SARS} = \frac{(\# \text{ Non-PIT recaps} - \text{Est PIT/CW tag lost})}{(\# \text{ Non-PIT released})}$$

Linear model of PIT tag effect:

$$SARS_{PIT} = [(1 - PIT_{effect}) * SARS_{NonPIT}] + \epsilon$$

**Regressed  $SARS_{NonPIT}$  vs  $SARS_{PIT}$  and the slope is an estimate of  $(1 - PIT_{effect})$**



- **PIT Tag Loss + Mortality → 25% mean reduction in adults SARS**
- **PIT tag mortality → 10% mean after correcting for PIT tag loss**



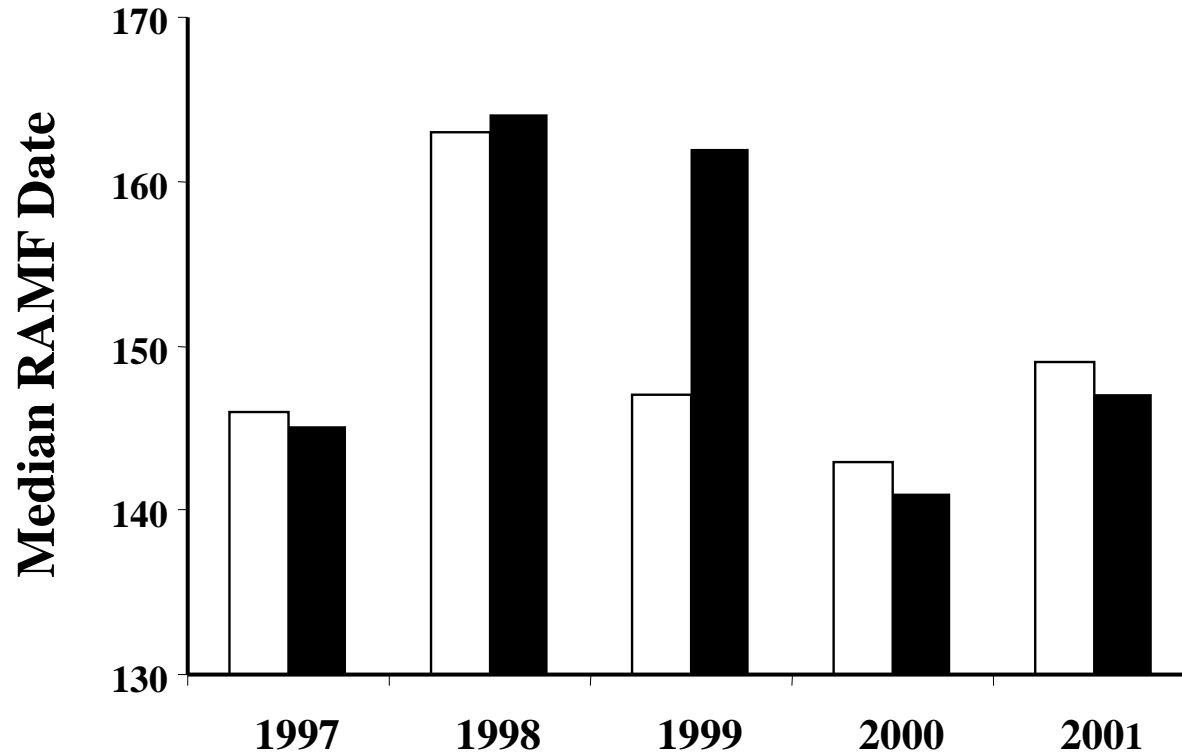
**Median Date of  
Passage at Roza  
Adult Monitoring  
Facility**

- Mann-Whitney  
All  $p > 0.09$

- No consistent  
trend over brood  
years

**Age 4**

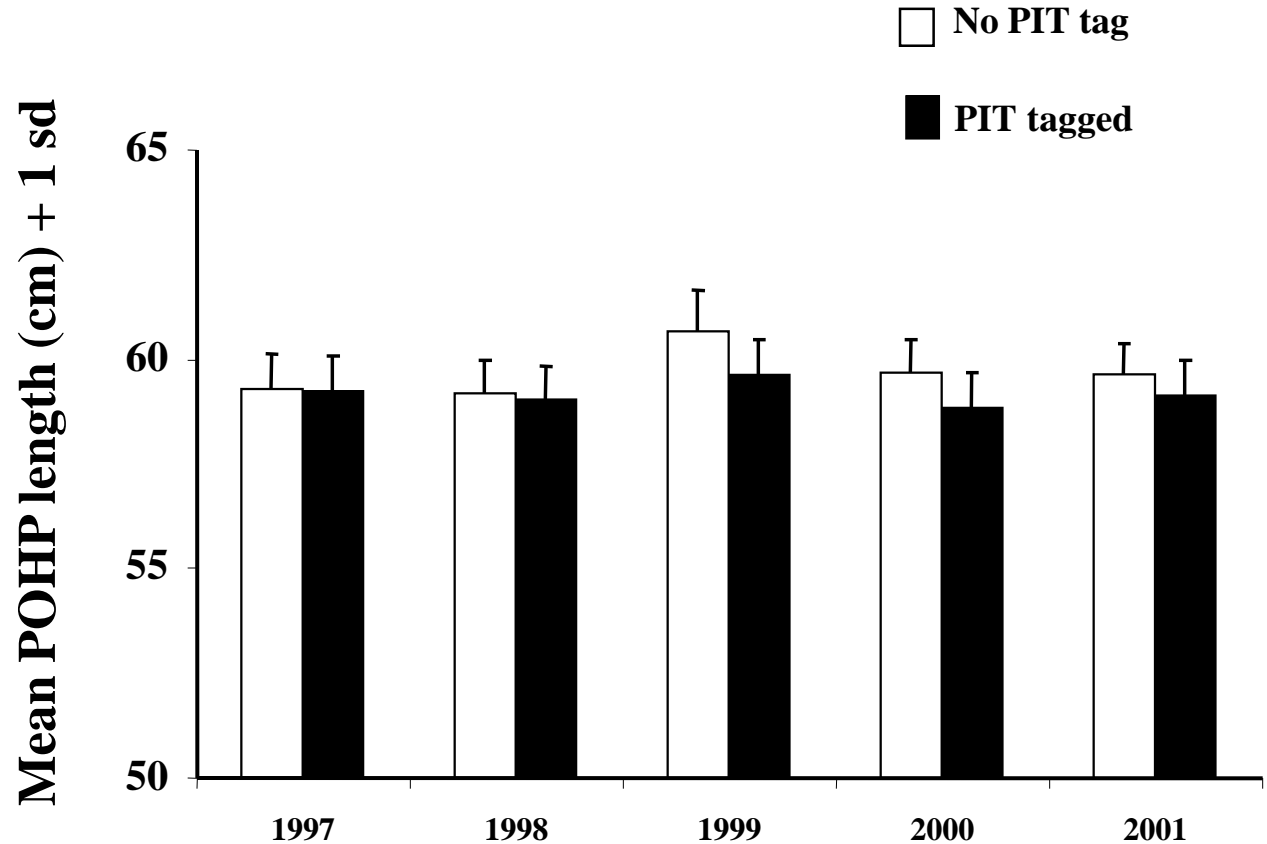
□ No PIT tag  
■ PIT tagged



## Age 4

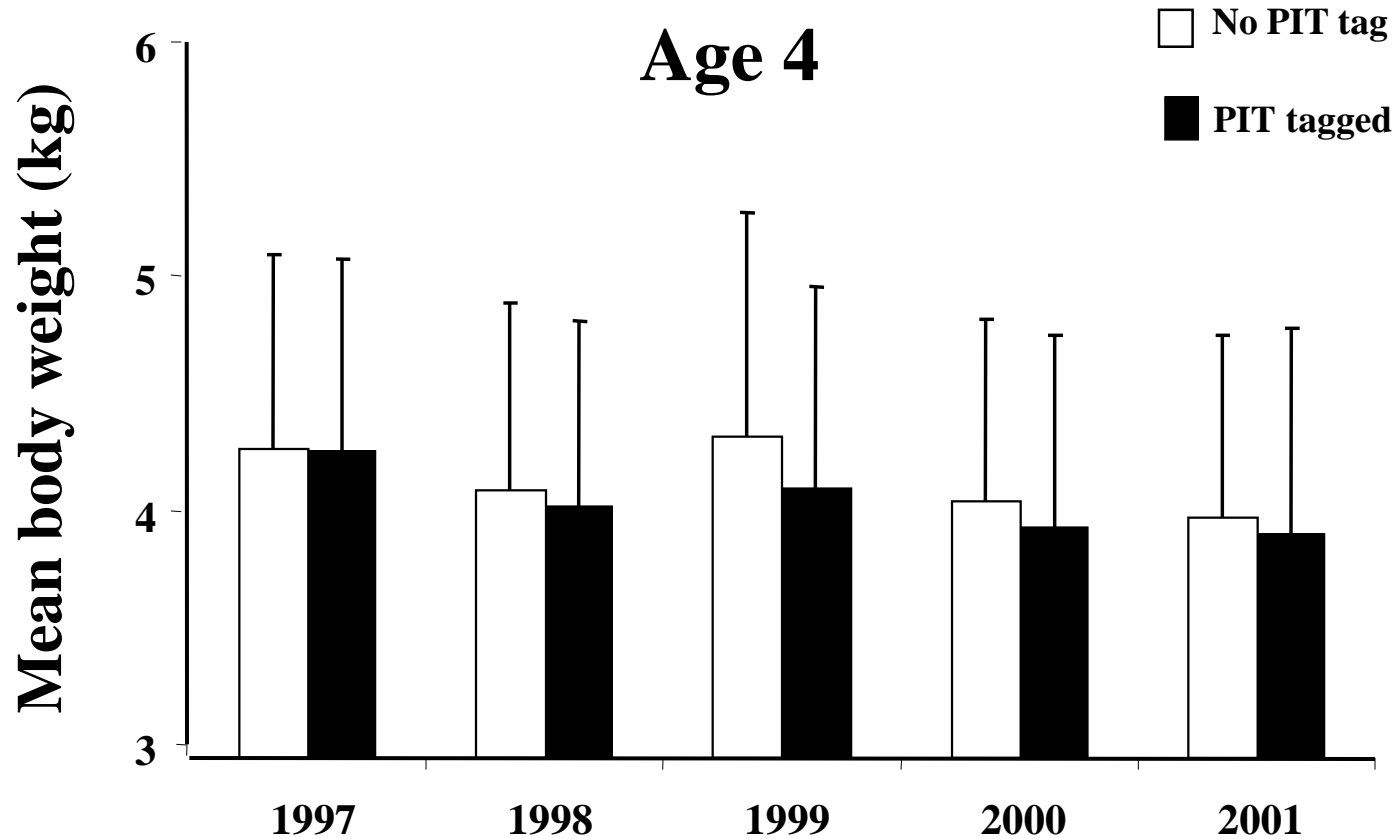
### Mean POHP Length

- All comparisons PIT < Non-PIT
- Only Age 4 significant; mean 1.1 cm
- 2-way (Tag x BY)  
ANOVA  
Tag effect  $p = 0.024$

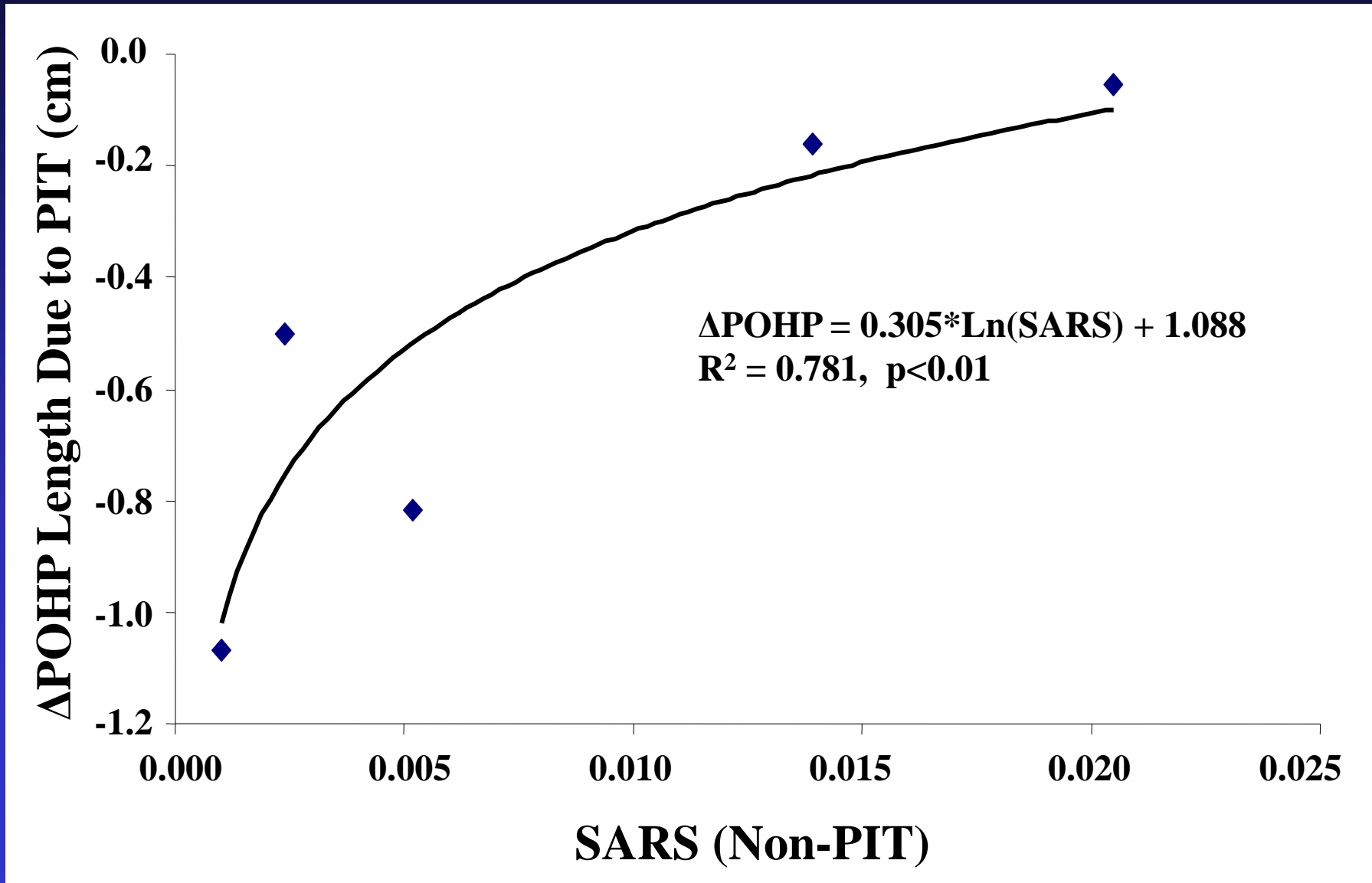


## Mean Body Weight

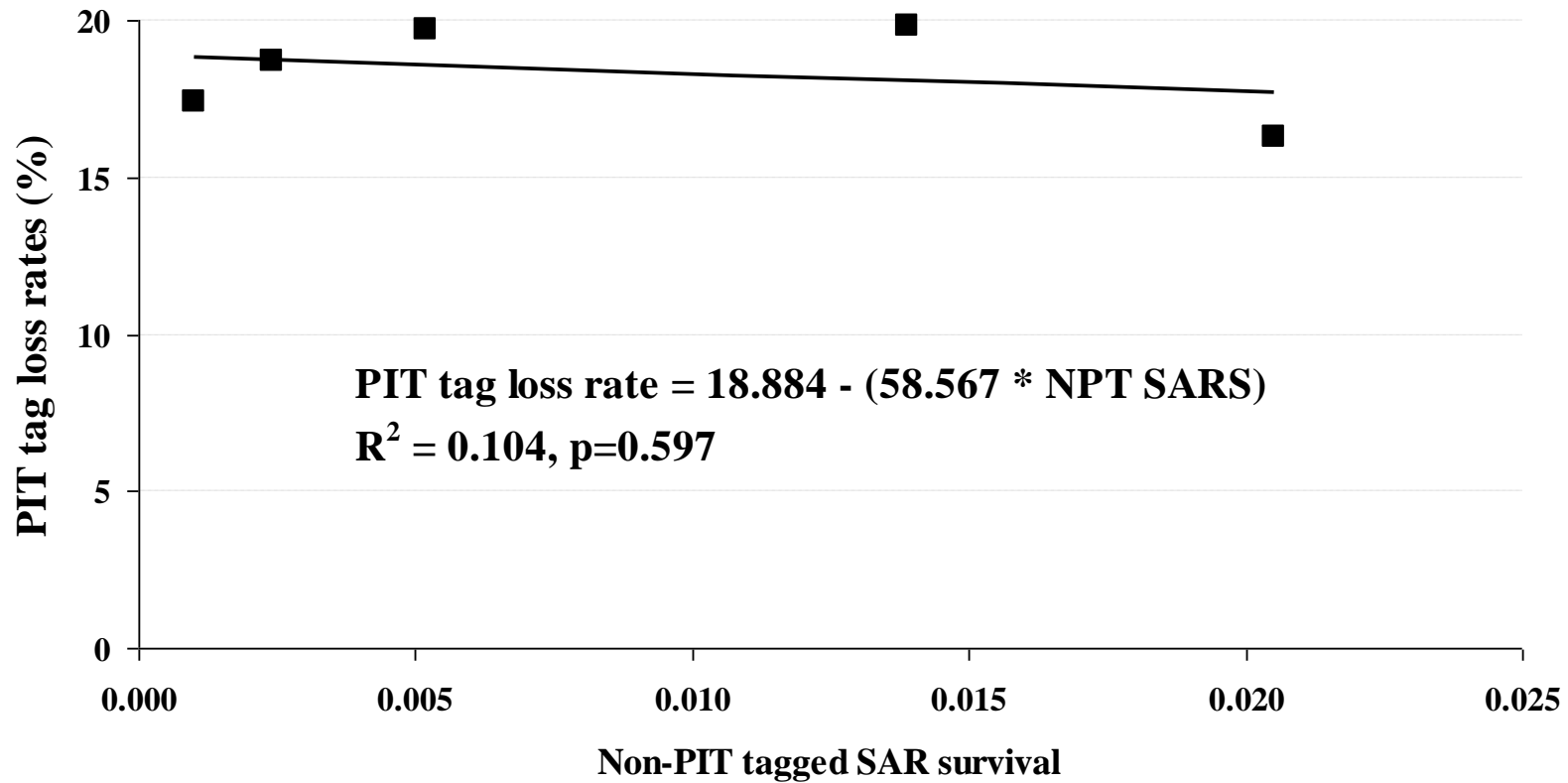
- All comparisons PIT < Non-PIT
- Only Age 4 significant (mean 0.1 kg)
- 2-way ANOVA Tag effect  $p = 0.043$



# Reduction in POHP length due to PIT tag effects vs SARS of Non-PIT tagged fish



There was no significant correlation between SARS of Non-PIT tagged fish and PIT tag loss rates



# Conclusions

- **Bingham Creek Hatchery Fall chinook**
  - PIT tag loss was  $\leq 2\%$  over the 3 months post-tagging
  - PIT tag induced mortality averaged 23.3% post-release and was significantly higher than in the two Control groups

# Conclusions

- **Yakima River Hatchery Spring Chinook**
  - PIT tagged Adults were smaller; increased effect with lower SARS
  - No difference in return timing to the upper Yakima River
  - Mean PIT tag loss was 18%; stable over years
  - PIT tag loss occurred within the first 6 months after release and did not increase with age
  - Brood year SARS were underestimated by up to 45% due to a combination of tag loss and induced mortality; averaging 25%
  - Estimated PIT tag induced mortality was as great 33% and averaged 10% over all brood years

# Big Picture Points

- PIT tags can have a significant impact on study fish
- Different species, basins and ecological circumstances will result in different tag effects
- Design studies to include double-tagged fish to assess tag loss
- Include non-PIT tagged fish to assess PIT tag effects on survival



**QUESTIONS?**





Brood- year	$R_{cwt}$	$\hat{\text{Pr}}_{pit}$	$R_{pit}$	$\hat{\text{Pr}}_{cwt}$	$R_{pit,cwt}$	$\hat{R}$	$\hat{R} - R'$	Total recoveries
1997	112	0.163 ( $\pm 0.002$ )	26	0.043 ( $\pm 0.001$ )	574	716.9	5.1	7004
1998	95	0.198 ( $\pm 0.004$ )	30	0.073 ( $\pm 0.003$ )	384	517.0	7.4	7678
1999	4	0.174 ( $\pm 0.022$ )	3	0.136 ( $\pm 0.020$ )	19	26.5	0.6	724
2000	37	0.197 ( $\pm 0.002$ )	1	0.007 ( $\pm < 0.001$ )	151	189.3	0.2	4160
2001	17	0.187 ( $\pm 0.009$ )	6	0.075 ( $\pm 0.006$ )	74	98.4	1.4	887
Total	265		66		1202			20453
Mean (Bootstap 95% CI)		0.184 ( $\pm 0.012$ )		0.067 ( $\pm 0.032$ )				