



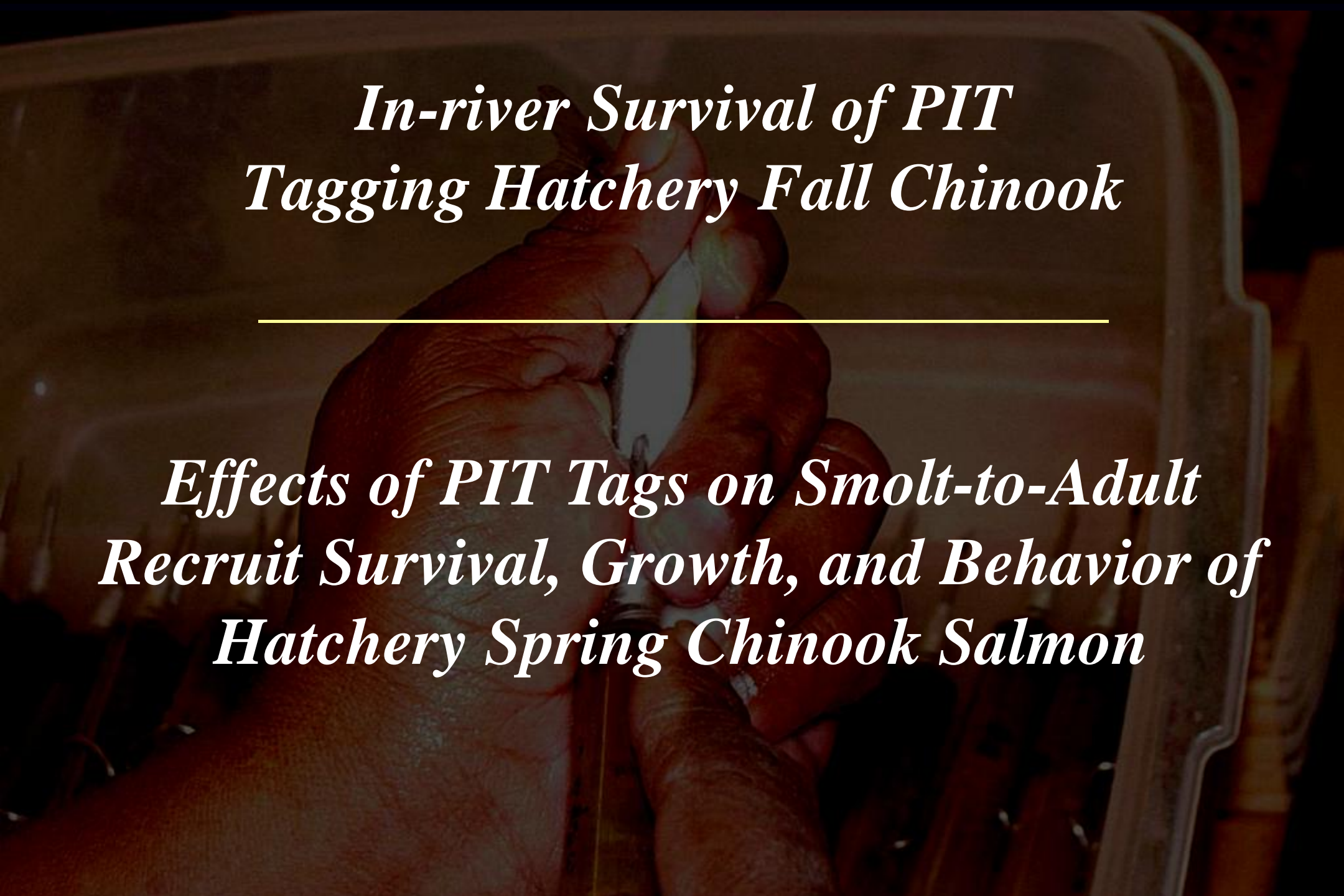
*Short- and long-term impacts of PIT
tags on hatchery Fall and Spring
Chinook salmon*

**Curtis Knudsen¹, Steve Schroder², Mark Johnston³,
Todd Pearson² and Dave Fast³**

¹Oncorh Consulting

²Washington Department of Fish and Wildlife

³Yakama Indian Nation



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

*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**

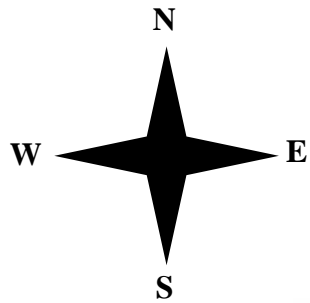
Legend

 Trap Sites

 Lakes

 Streams

 Miles



Bingham Ct.

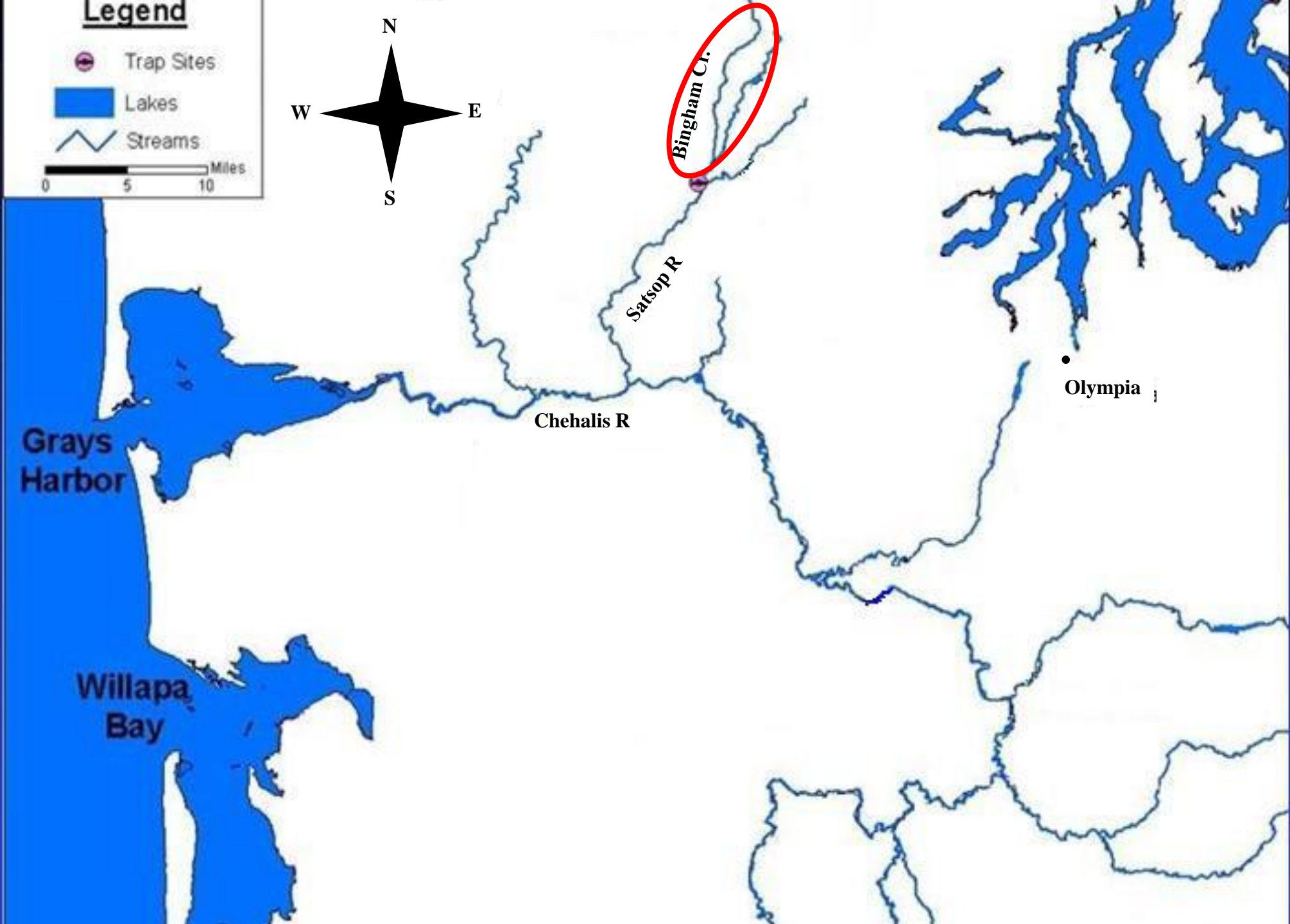
Satsop R

Chehalis R

Olympia

Grays Harbor

Willapa Bay

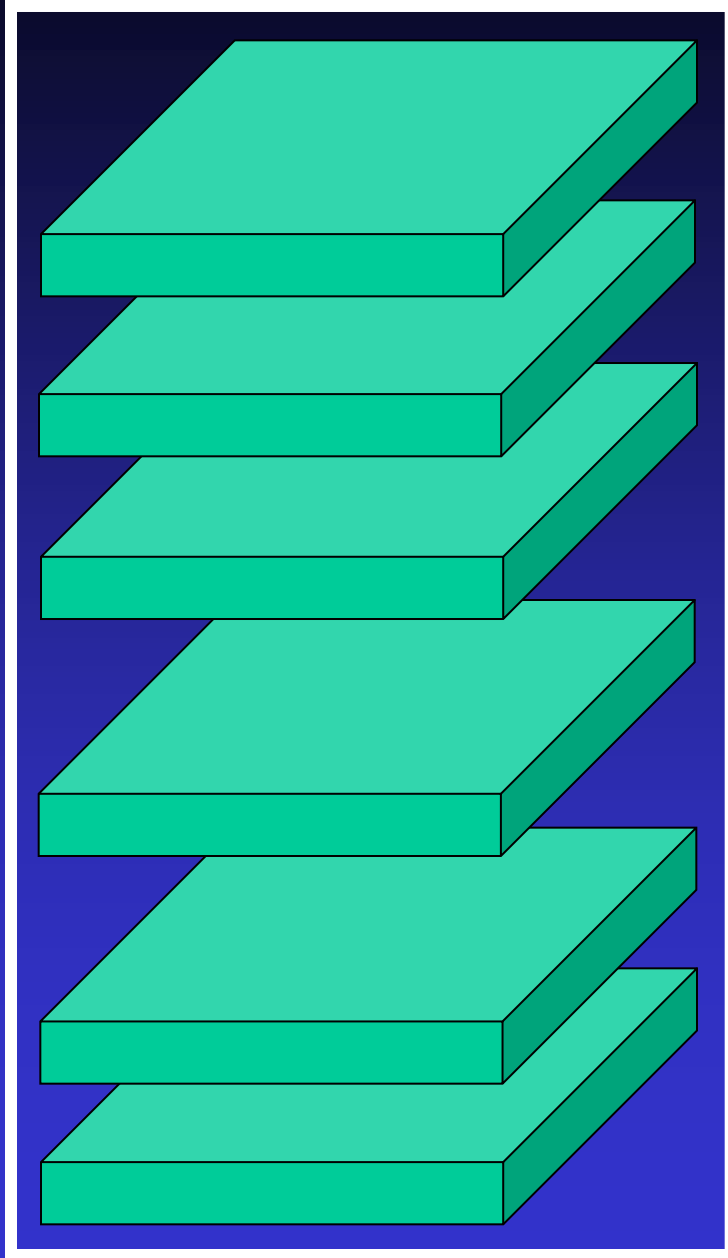


Purpose: Compare PIT tagged fish survival rates to Control group survival rates

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

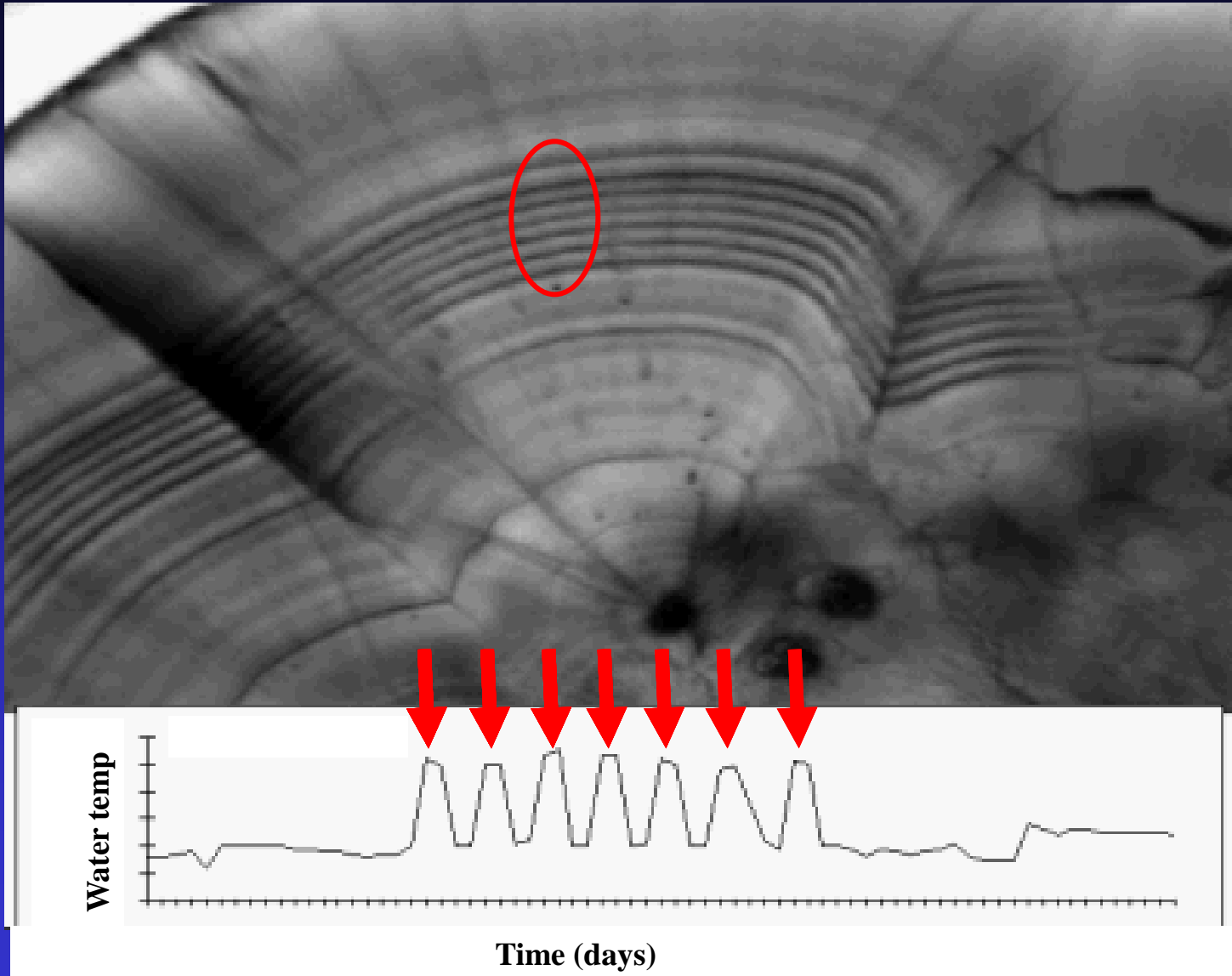
Two releases of each - a total of 6 groups released

Ambient water

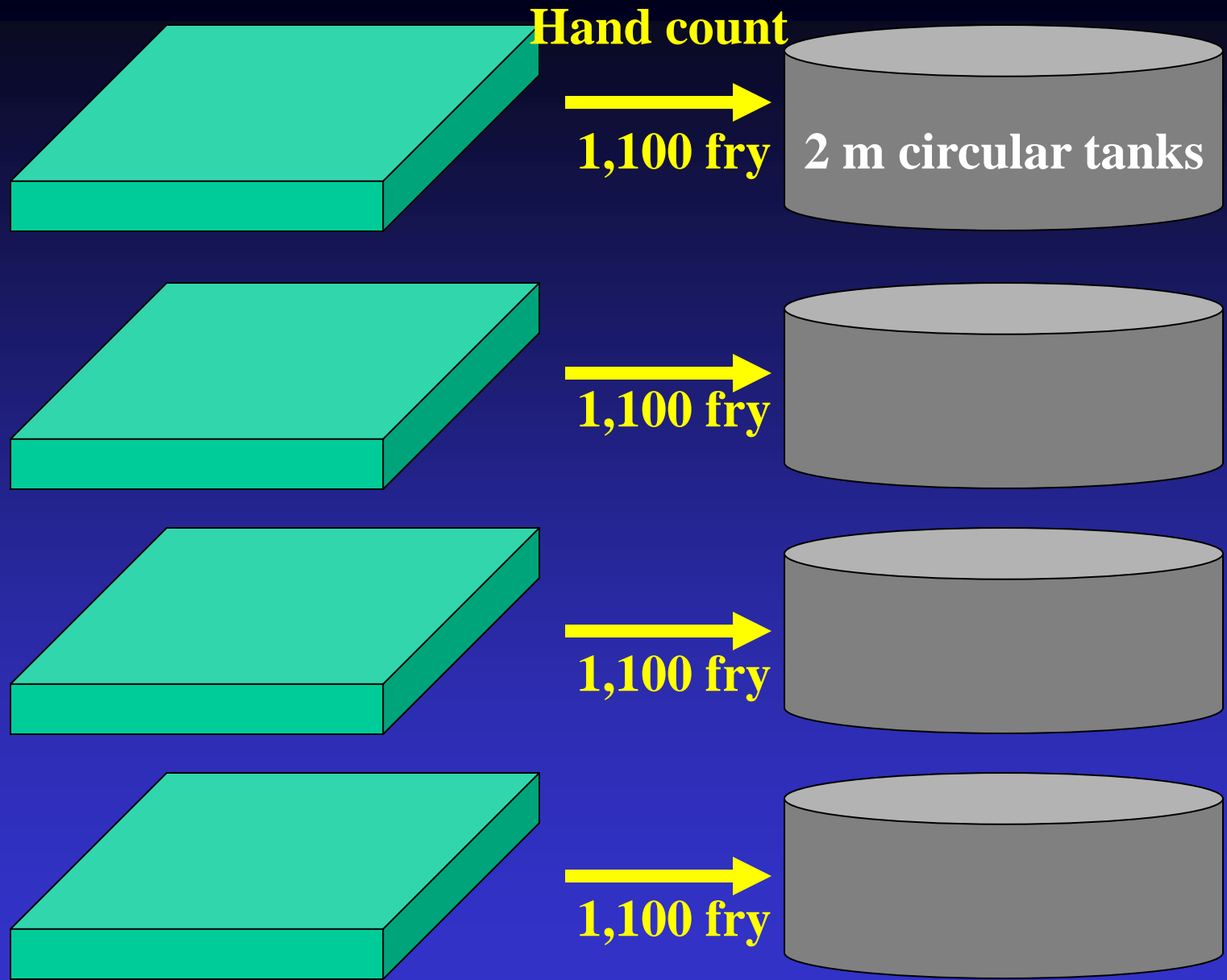


Chilled Water 4°C

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



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

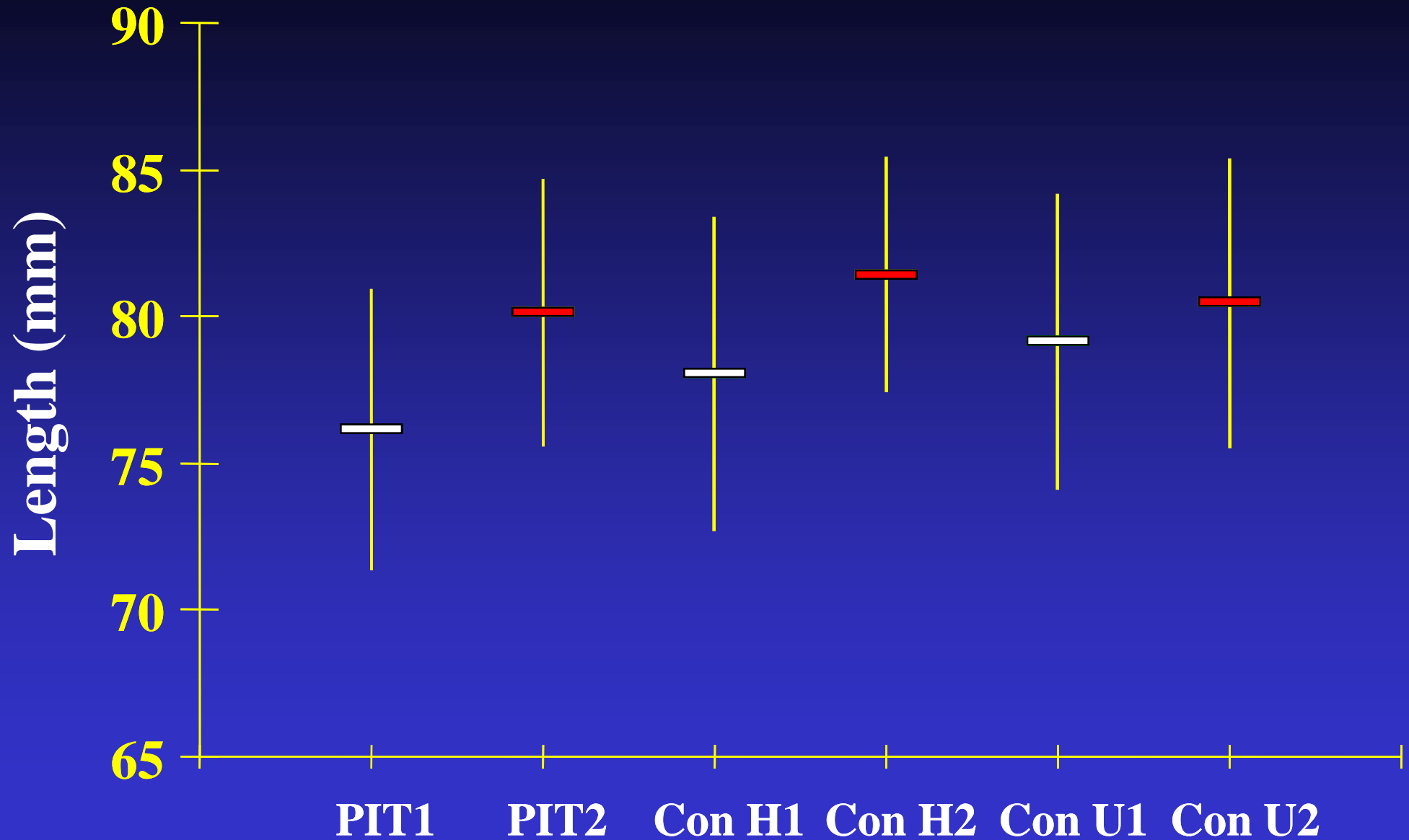


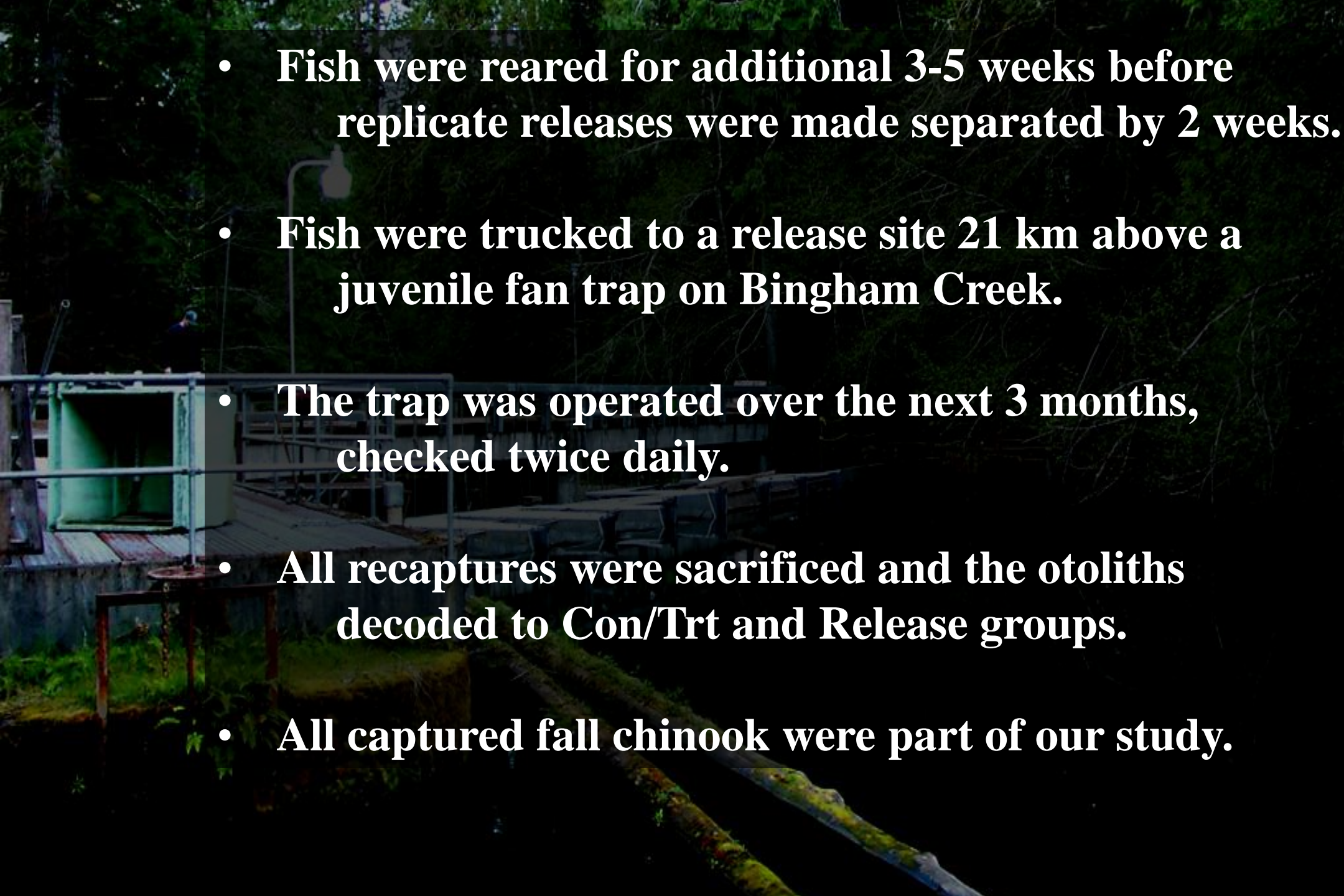
Randomly assigned tanks to treatment and control groups

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 ± 1 sd at Release



- 
- **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.**

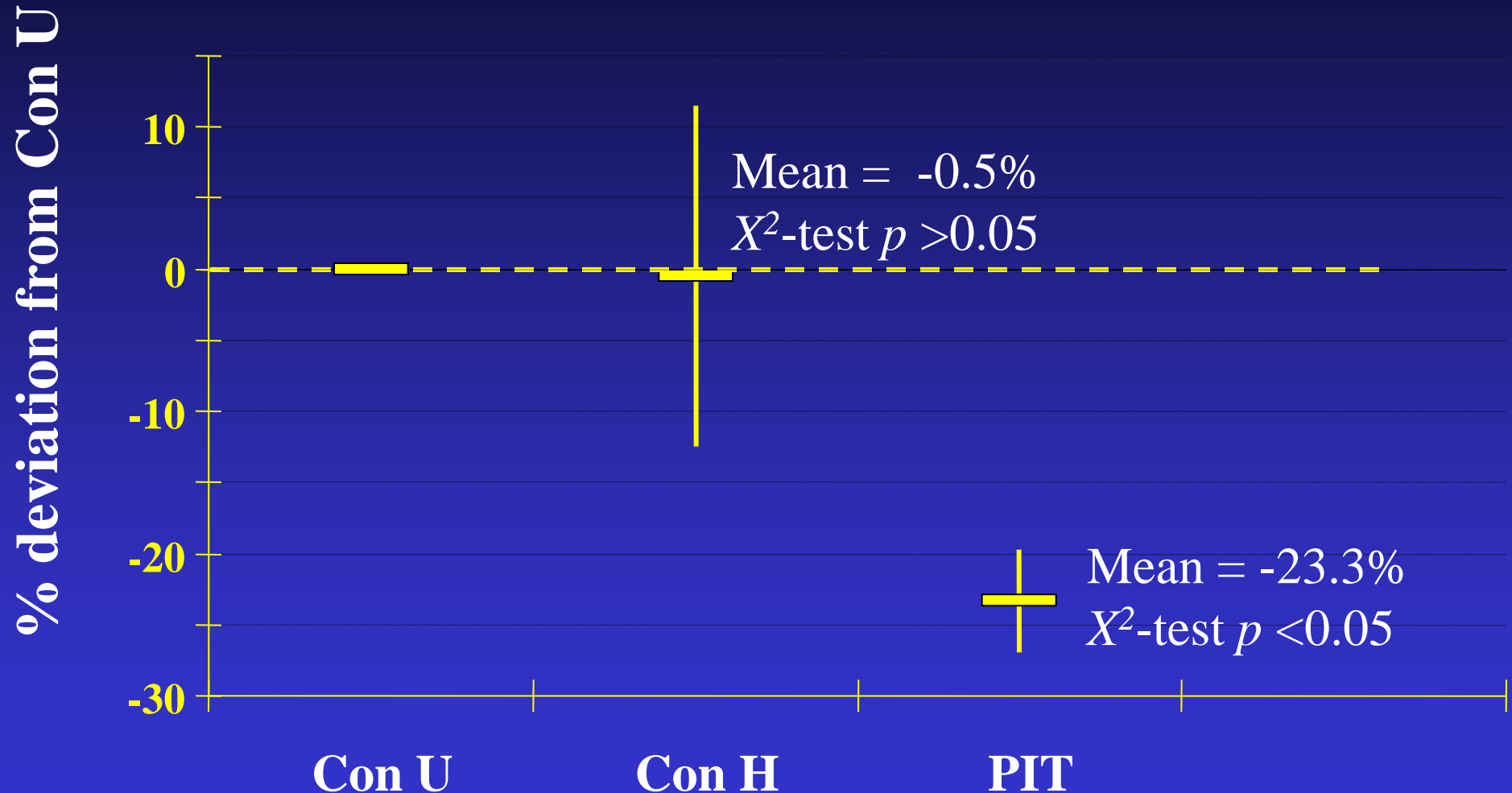
Bingham Creek Fan Traps



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.

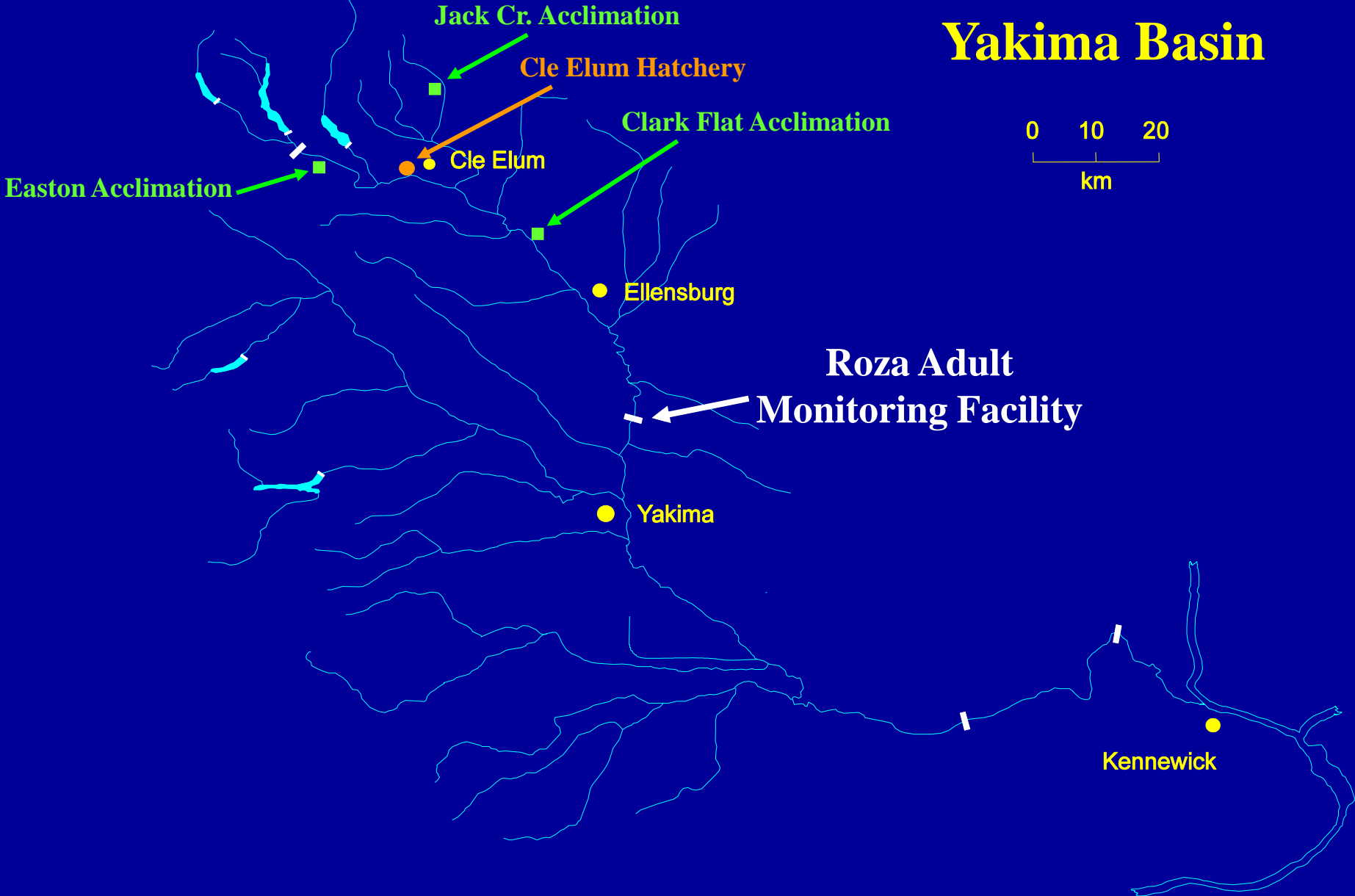
Acknowledgments

- 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



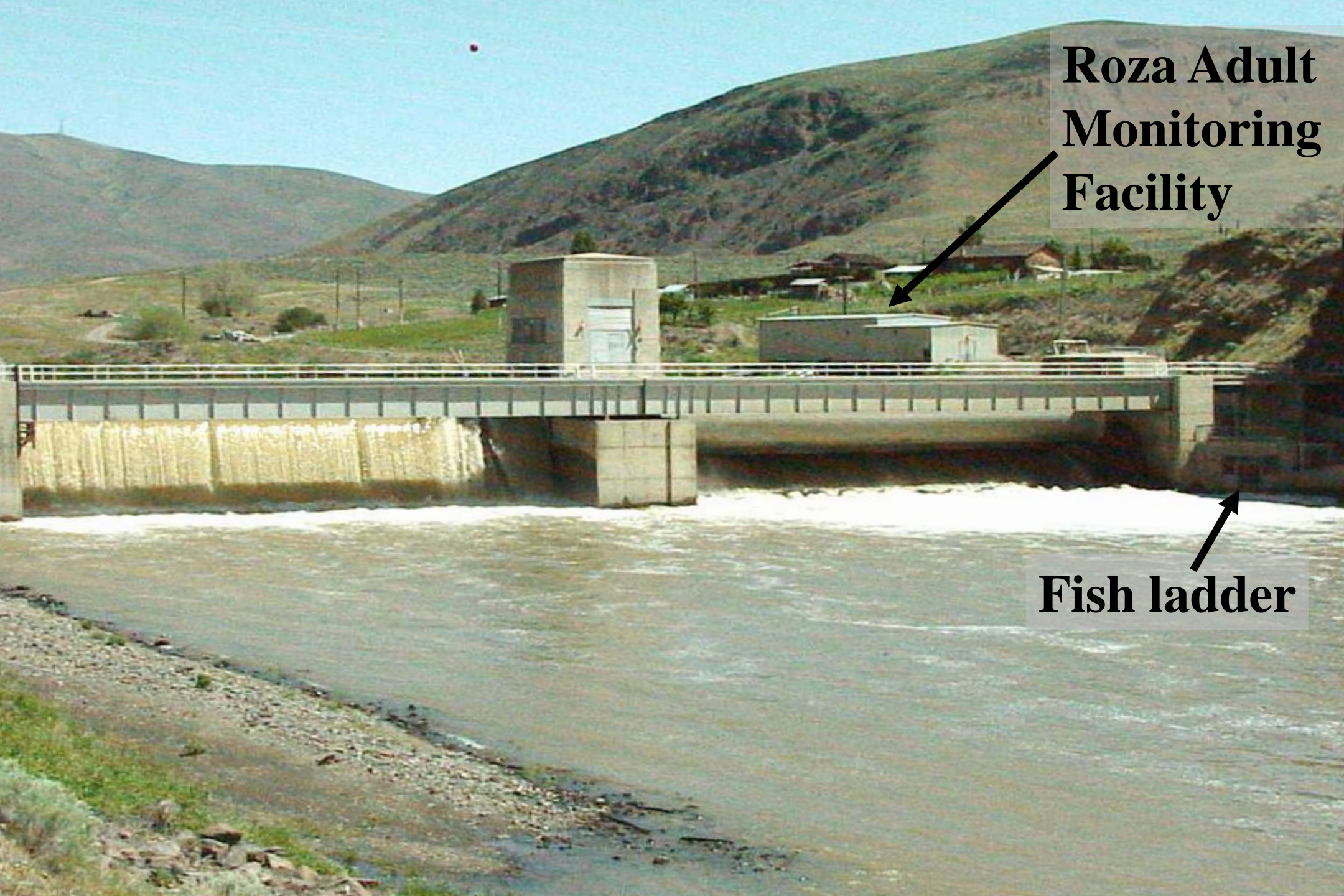
Broodyear

| 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**



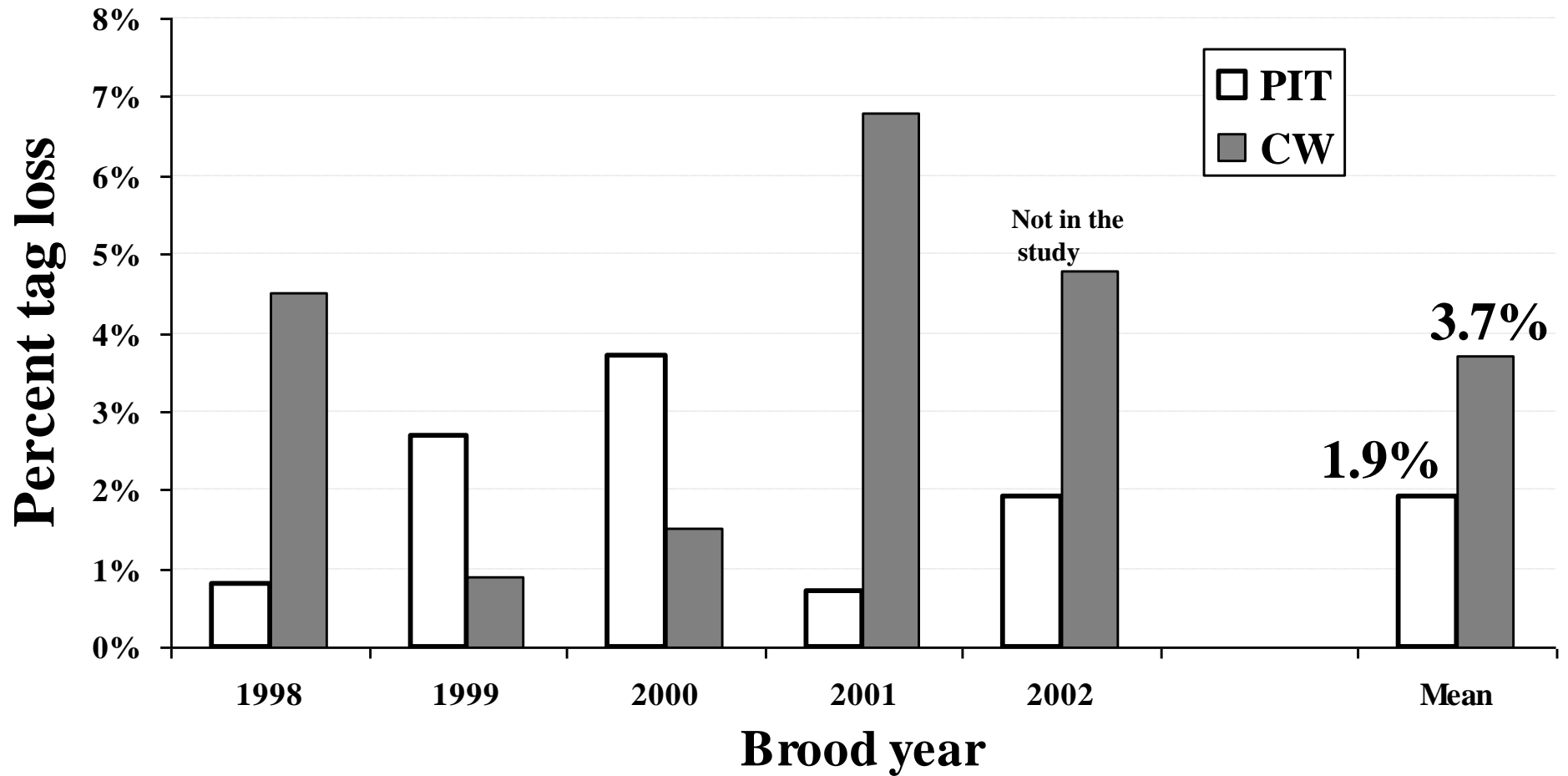
Fish ladder



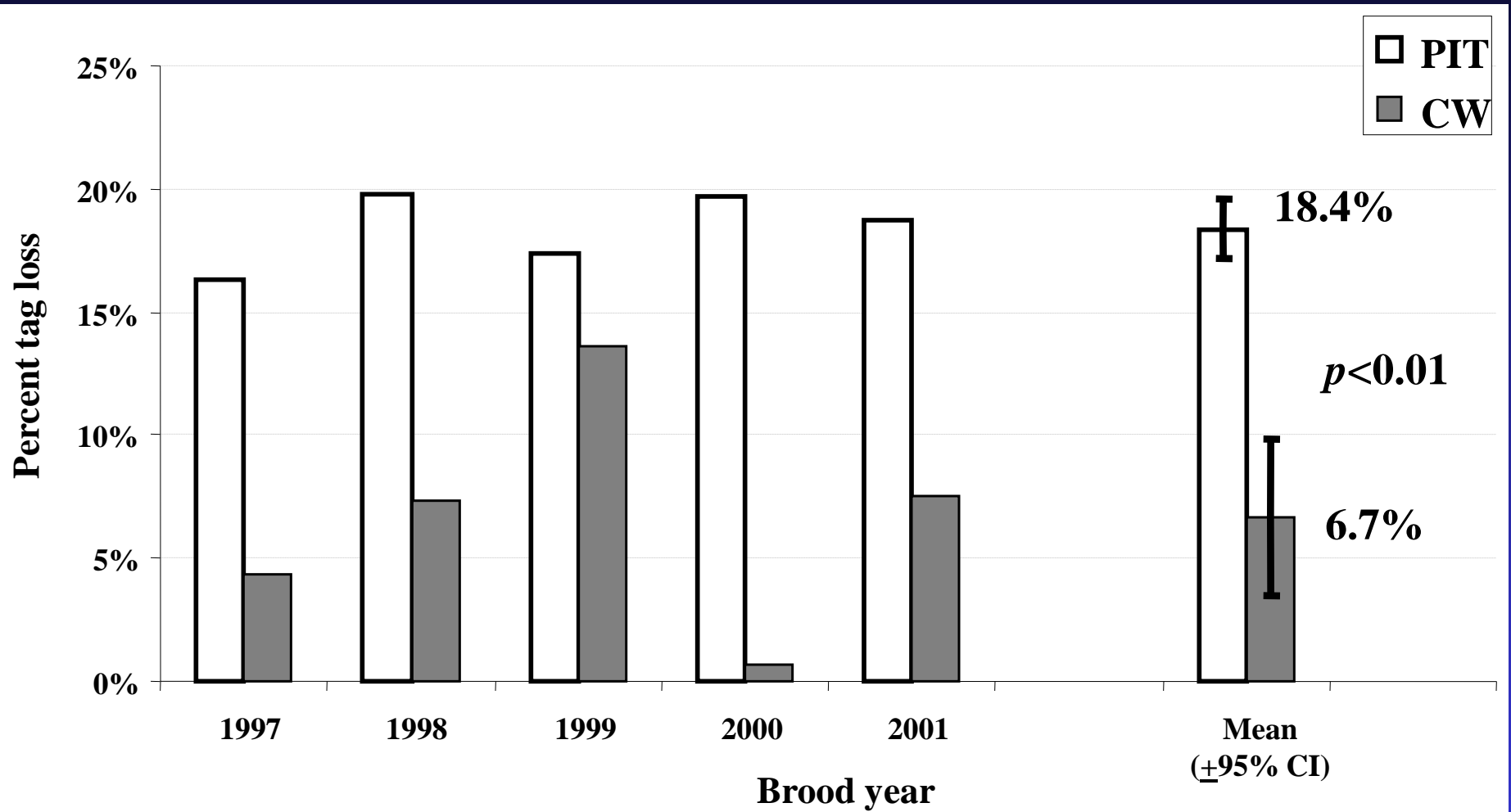
$$\hat{\Pr}_{pit} = [\text{Probability of losing a PIT tag}] = \frac{R_{cwt}}{(R_{cwt} + R_{pit,cwt})}$$

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

Juvenile tag loss rates before release



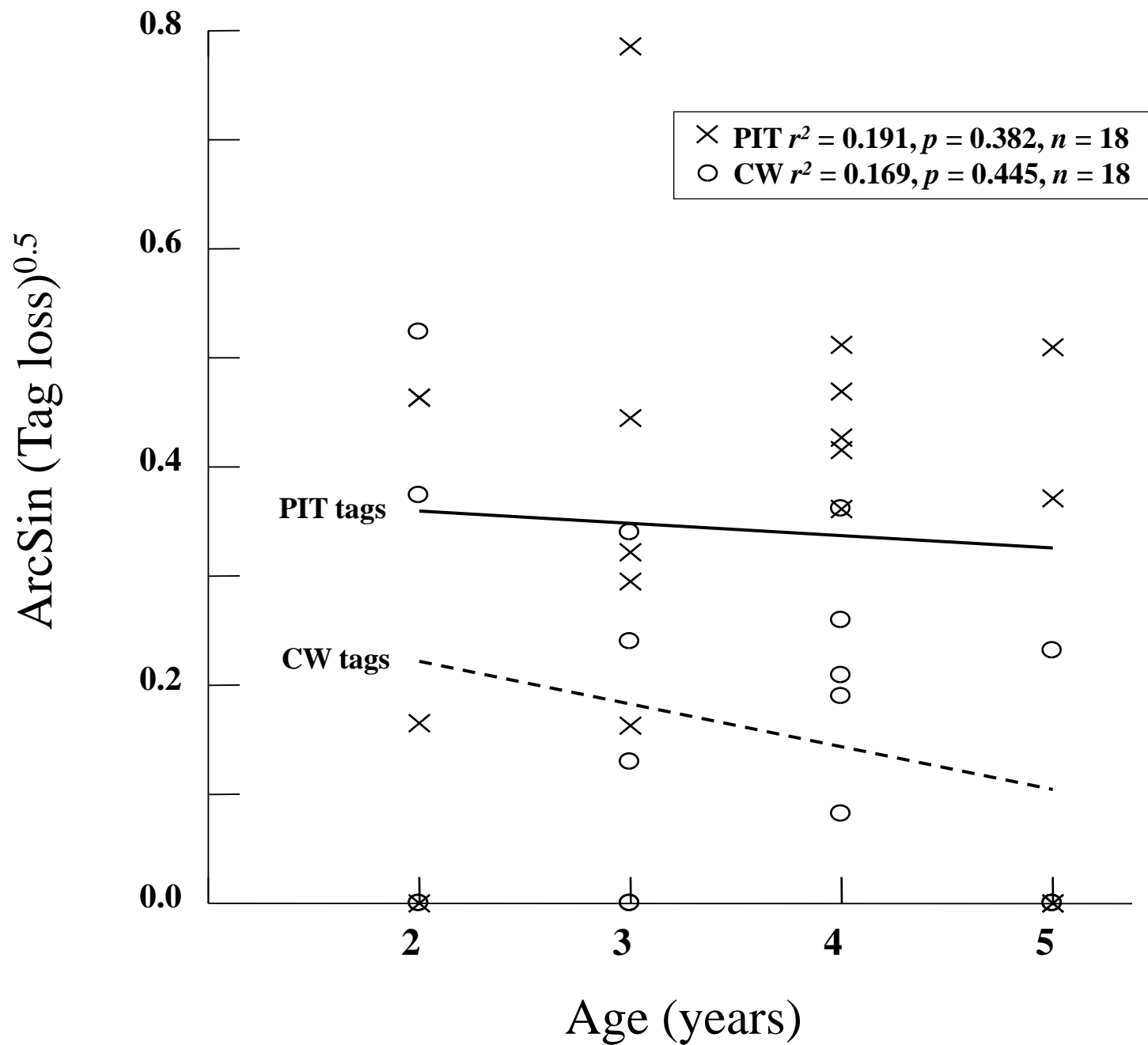
Adult PIT and CW tag loss rates



Roza PIT tag recovery efficiency estimates

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

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

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

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

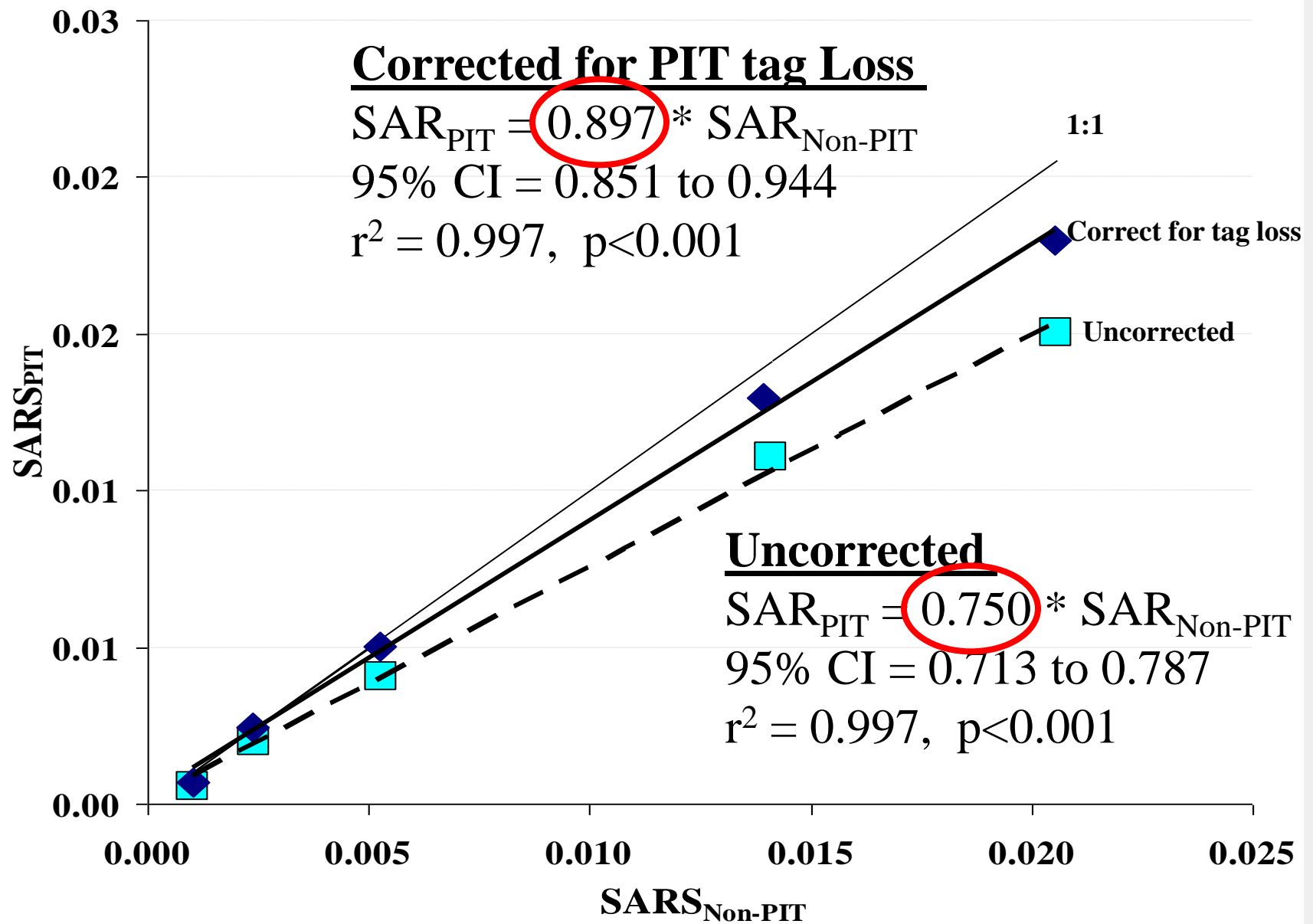
$$\text{Uncorrected Non-PIT SARS} = \frac{(\# \text{ Non-PIT recoveries})}{(\# \text{ Non-PIT released})}$$

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

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**

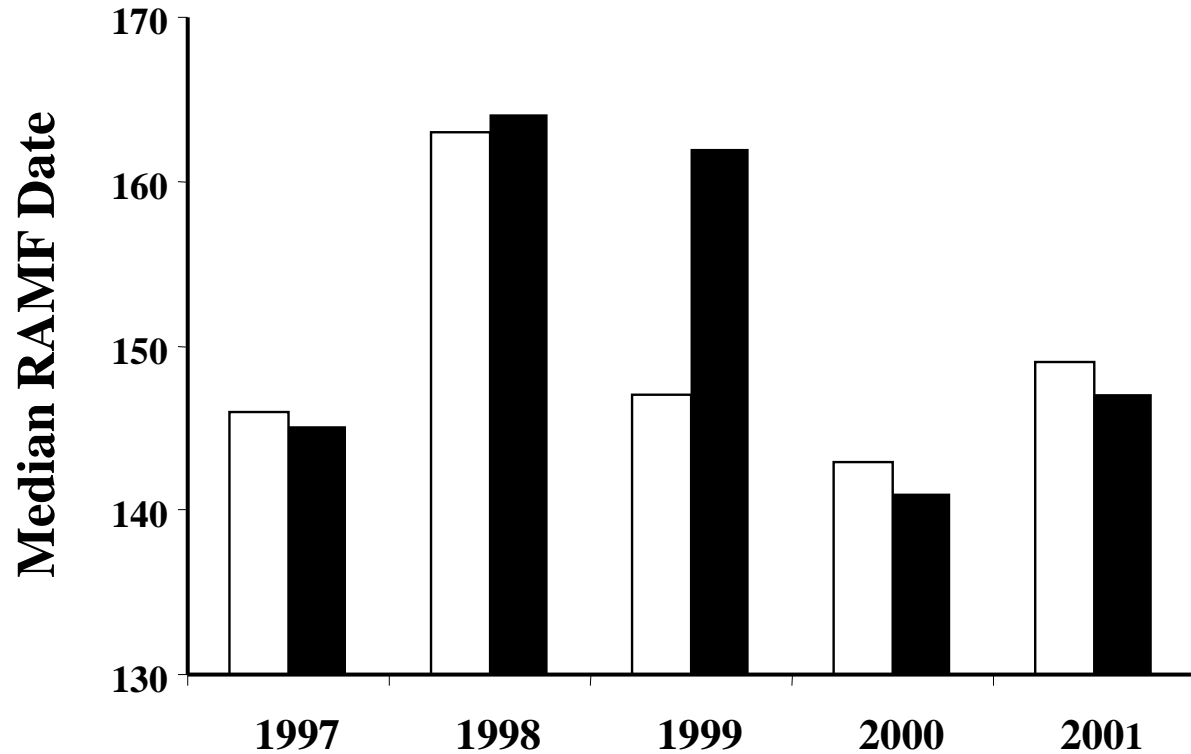
**Median Date of
Passage at Roza
Adult Monitoring
Facility**

- Mann-Whitney
All $p > 0.09$

- No consistent
trend over brood
years

Age 4

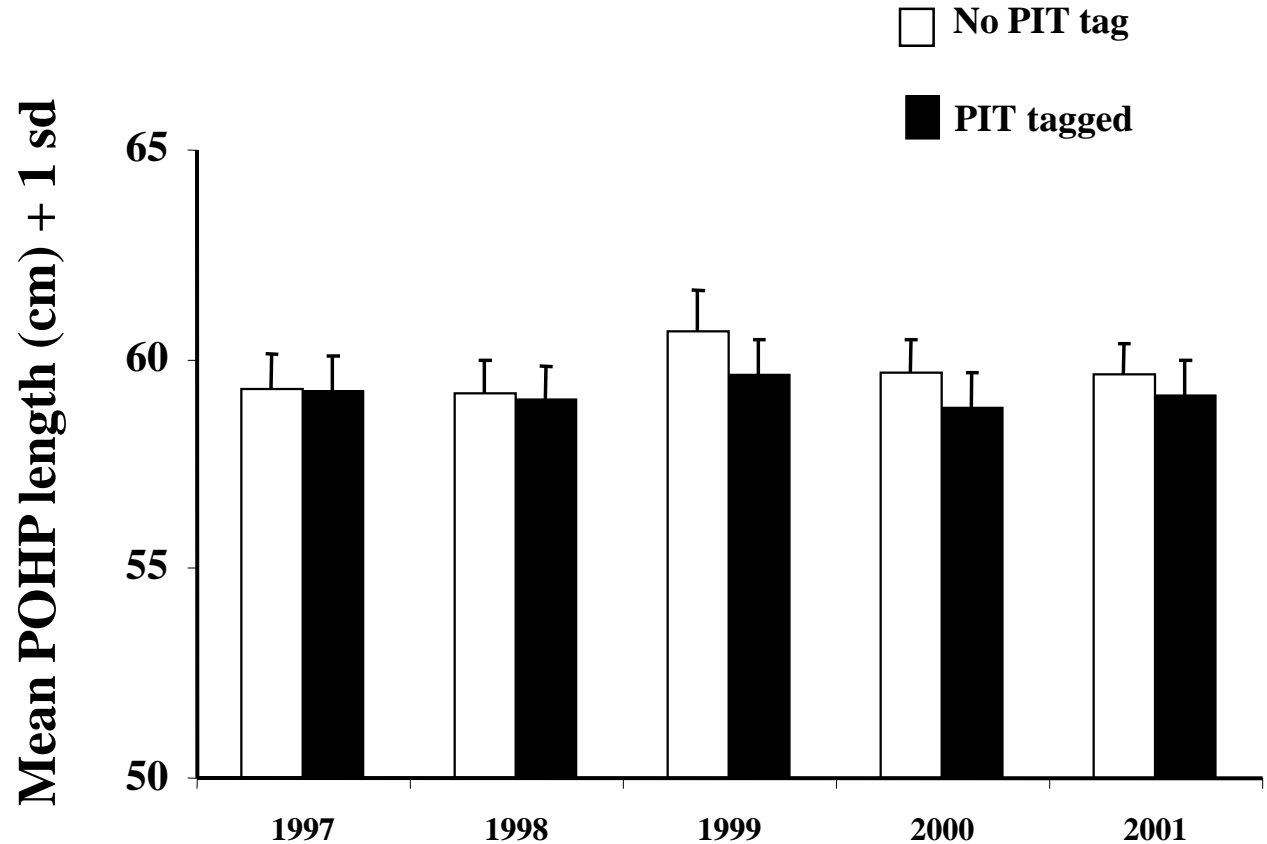
□ No PIT tag
■ PIT tagged



Age 4

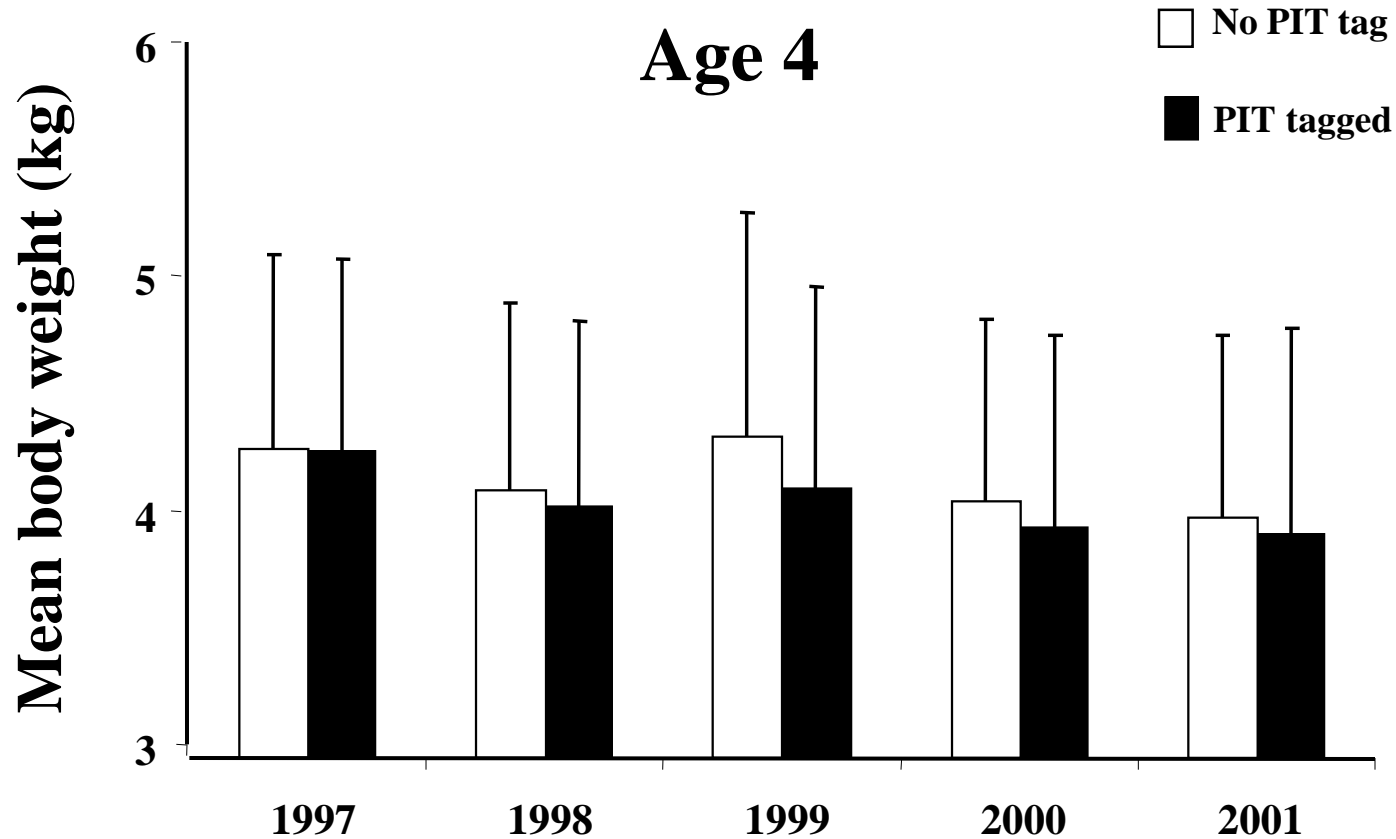
Mean POHP Length

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

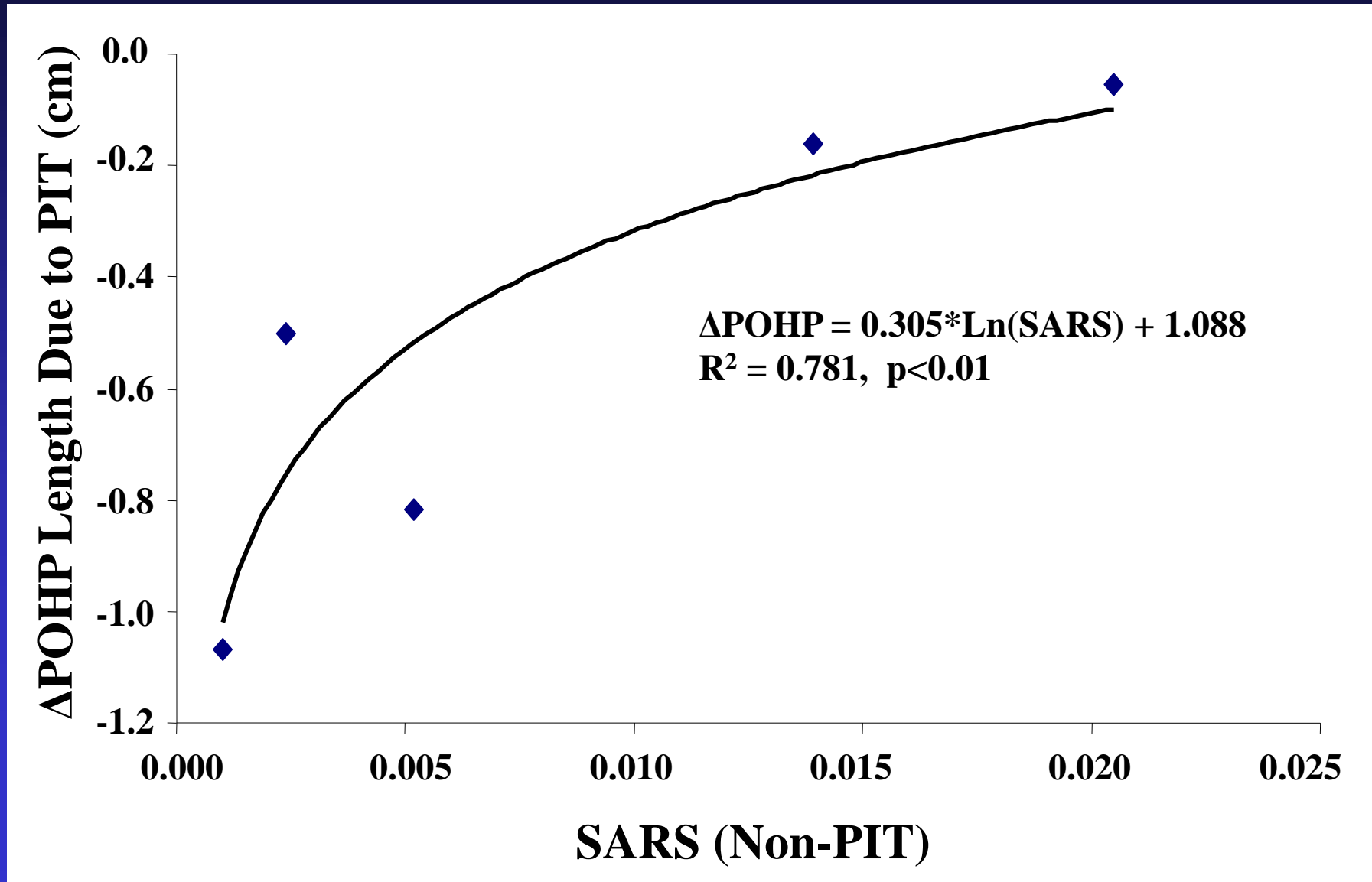


Mean Body Weight

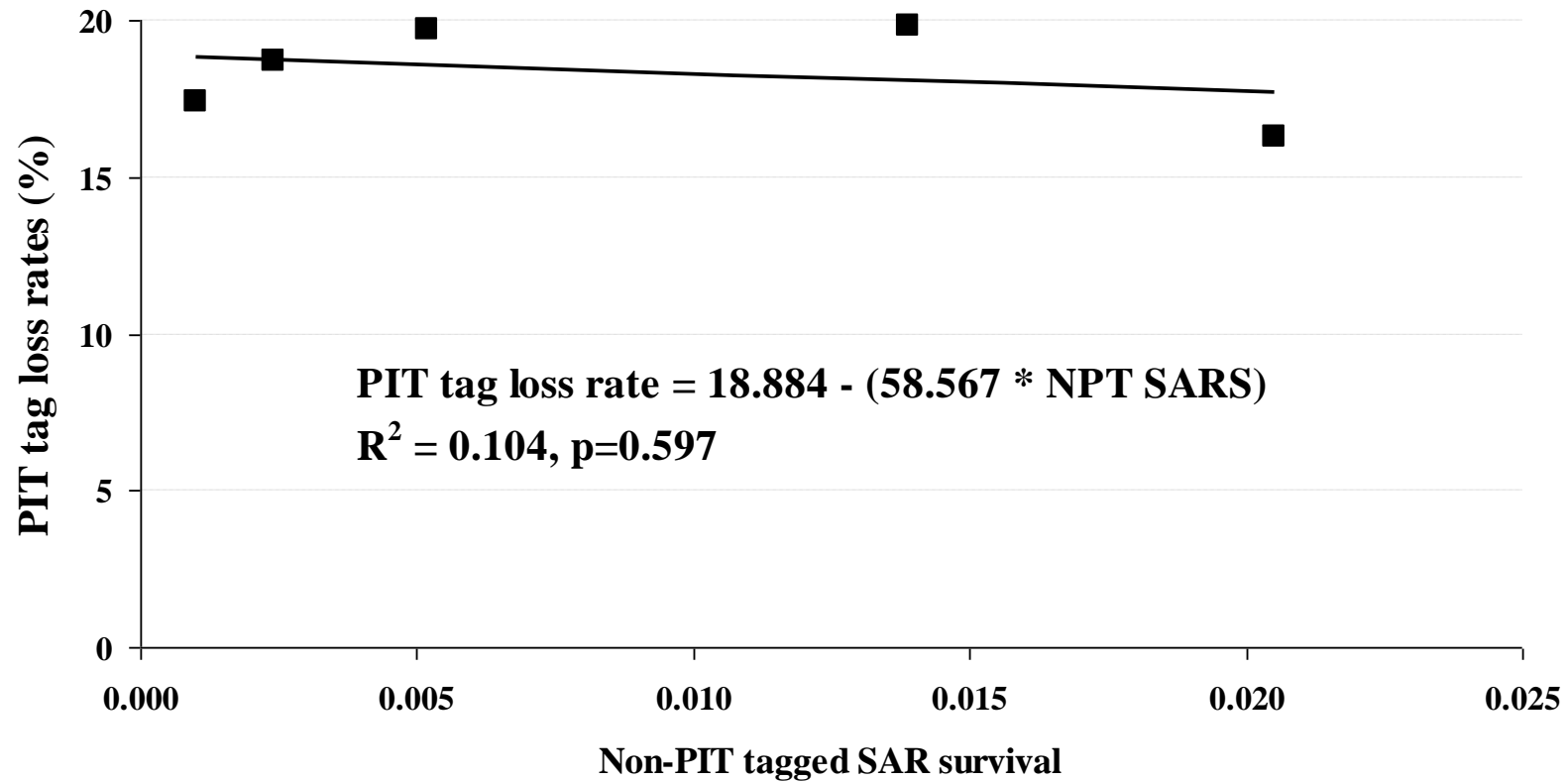
- All comparisons PIT < Non-PIT
- Only Age 4 significant (mean 0.1 kg)
- 2-way ANOVA Tag effect $p = 0.043$



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 (± 0.002) | 26 | 0.043 (± 0.001) | 574 | 716.9 | 5.1 | 7004 |
| 1998 | 95 | 0.198 (± 0.004) | 30 | 0.073 (± 0.003) | 384 | 517.0 | 7.4 | 7678 |
| 1999 | 4 | 0.174 (± 0.022) | 3 | 0.136 (± 0.020) | 19 | 26.5 | 0.6 | 724 |
| 2000 | 37 | 0.197 (± 0.002) | 1 | 0.007 ($\pm < 0.001$) | 151 | 189.3 | 0.2 | 4160 |
| 2001 | 17 | 0.187 (± 0.009) | 6 | 0.075 (± 0.006) | 74 | 98.4 | 1.4 | 887 |
| Total | 265 | | 66 | | 1202 | | | 20453 |
| Mean (Bootstap 95% CI) | | 0.184 (± 0.012) | | 0.067 (± 0.032) | | | | |