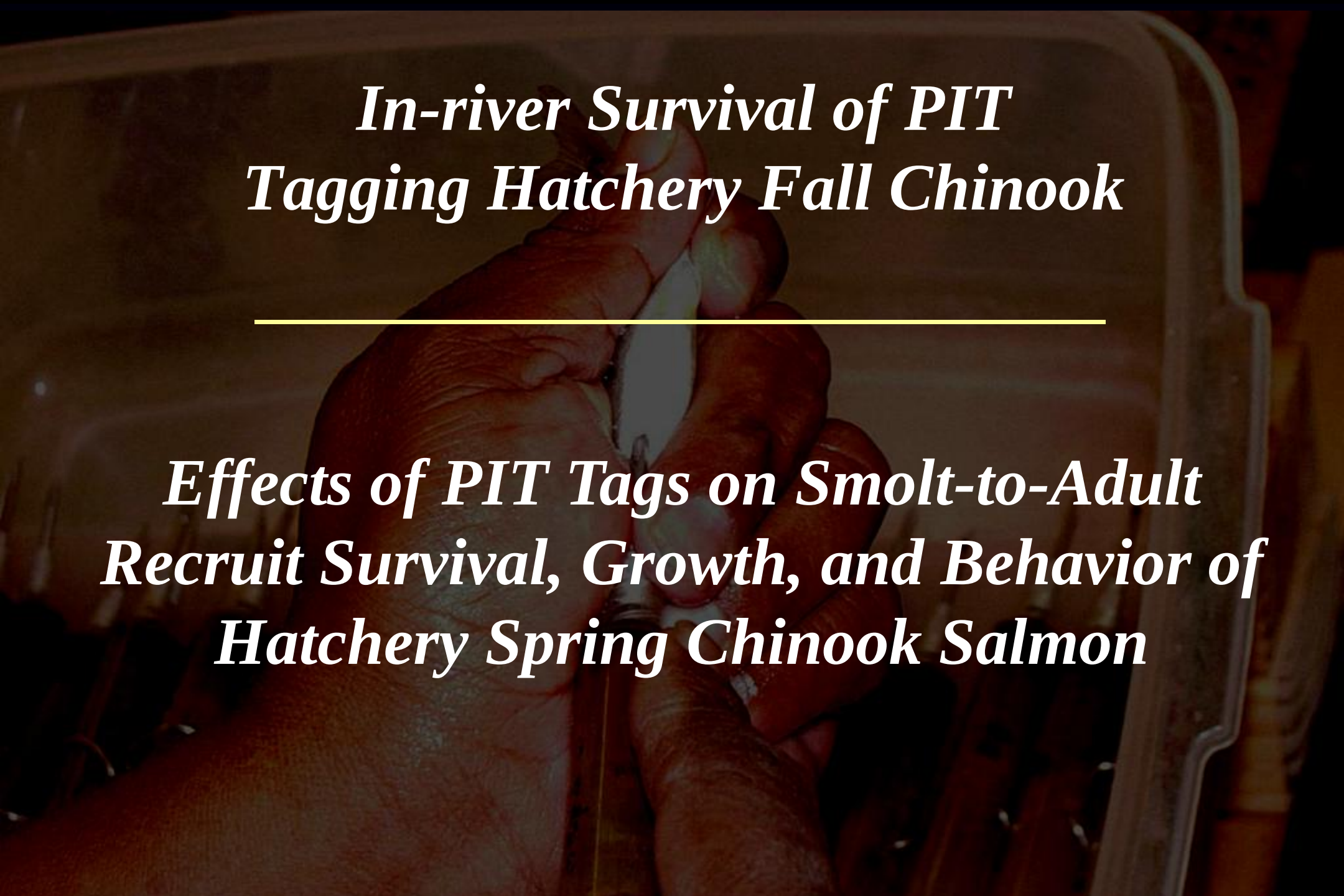
Short- and long-term impacts of PIT tags on hatchery Fall and Spring Chinook salmon

Curtis Knudsen[1], Steve Schroder[2], Mark Johnston[3], Todd Pearson[2] and Dave Fast[3]

[1]Oncorh Consulting

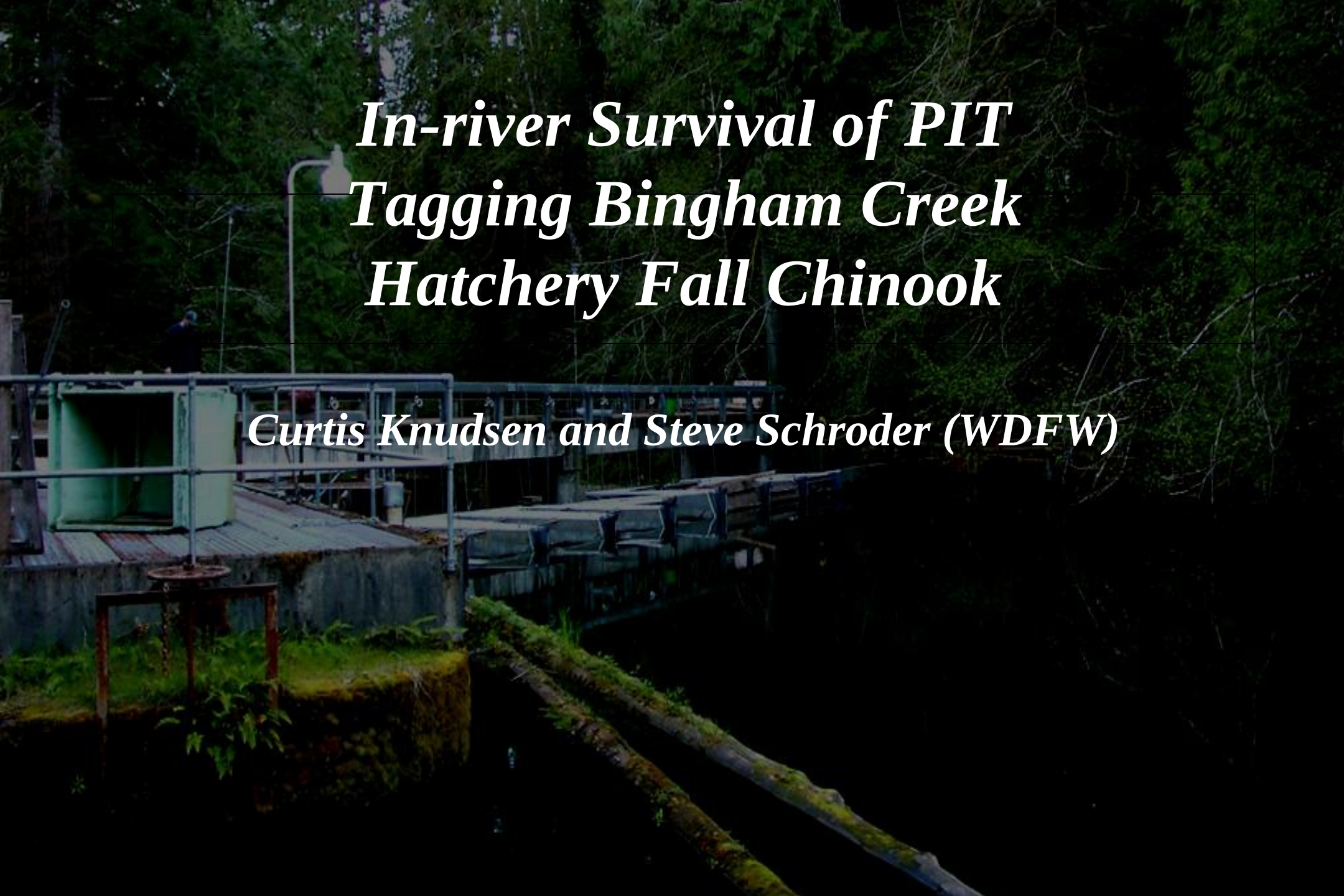
[2]Washington Department of Fish and Wildlife

[3]Yakama 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

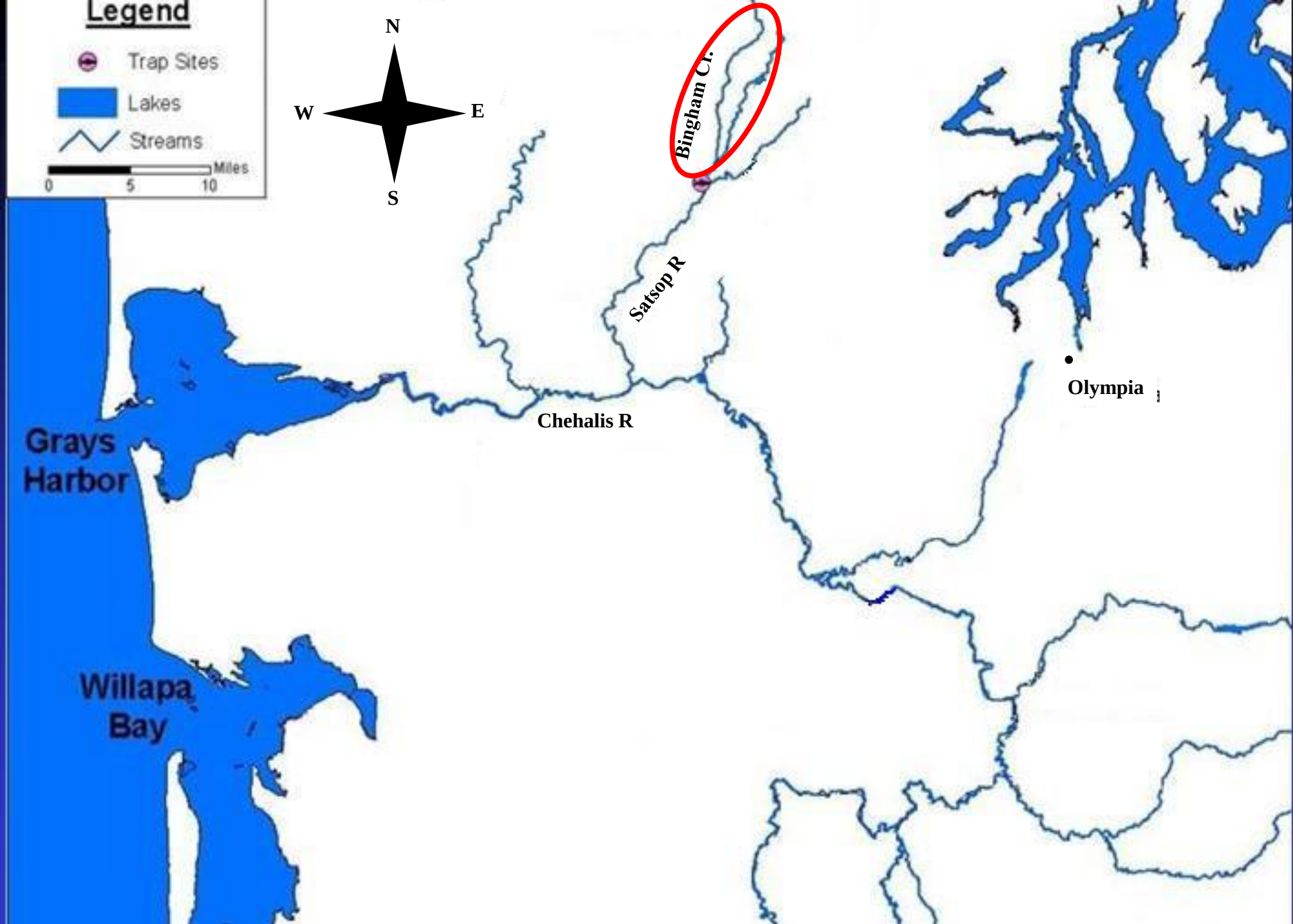


In-river Survival of PIT Tagging Bingham Creek Hatchery Fall Chinook

Curtis Knudsen and Steve Schroder (WDFW)

Acknowledgments

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

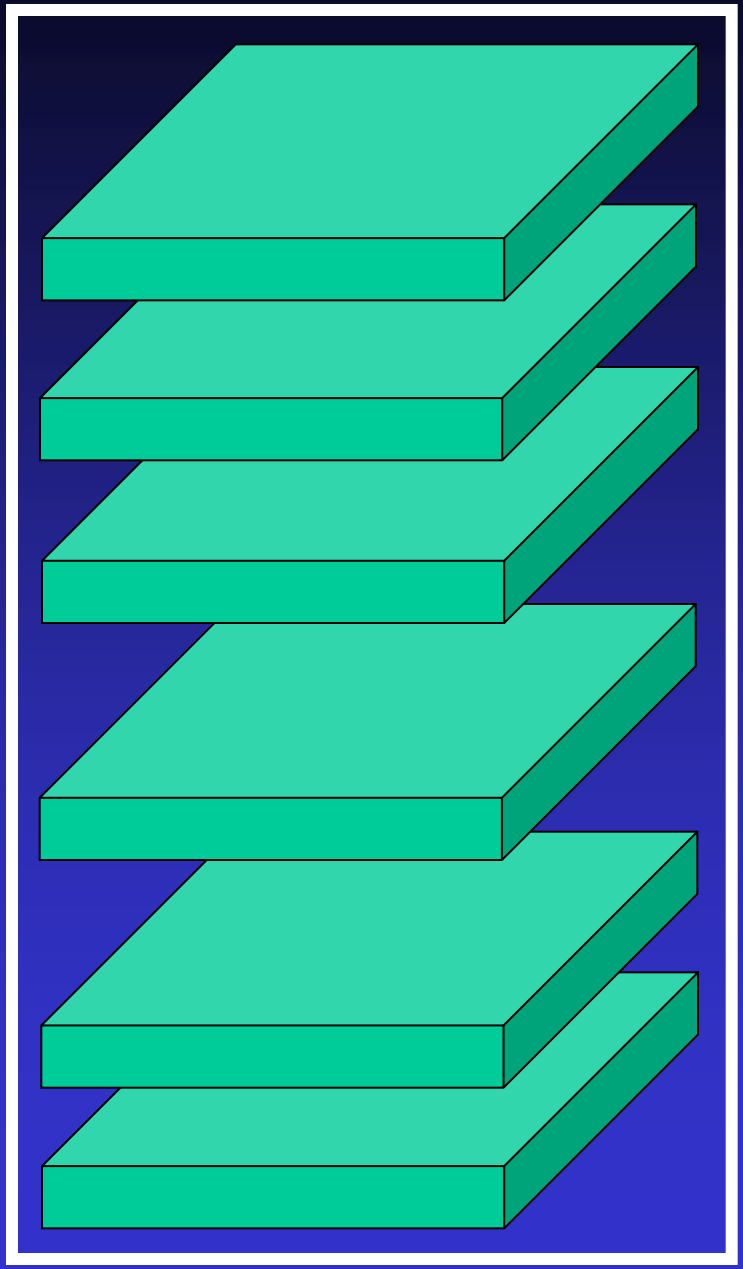

Legend
Trap Sites
Lakes
Streams
Miles
0
5
10
N
W
E
S
Bingham Cr.
Satsop R
Chehalis R
Olympia
Grays Harbor
Willapa Bay

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**

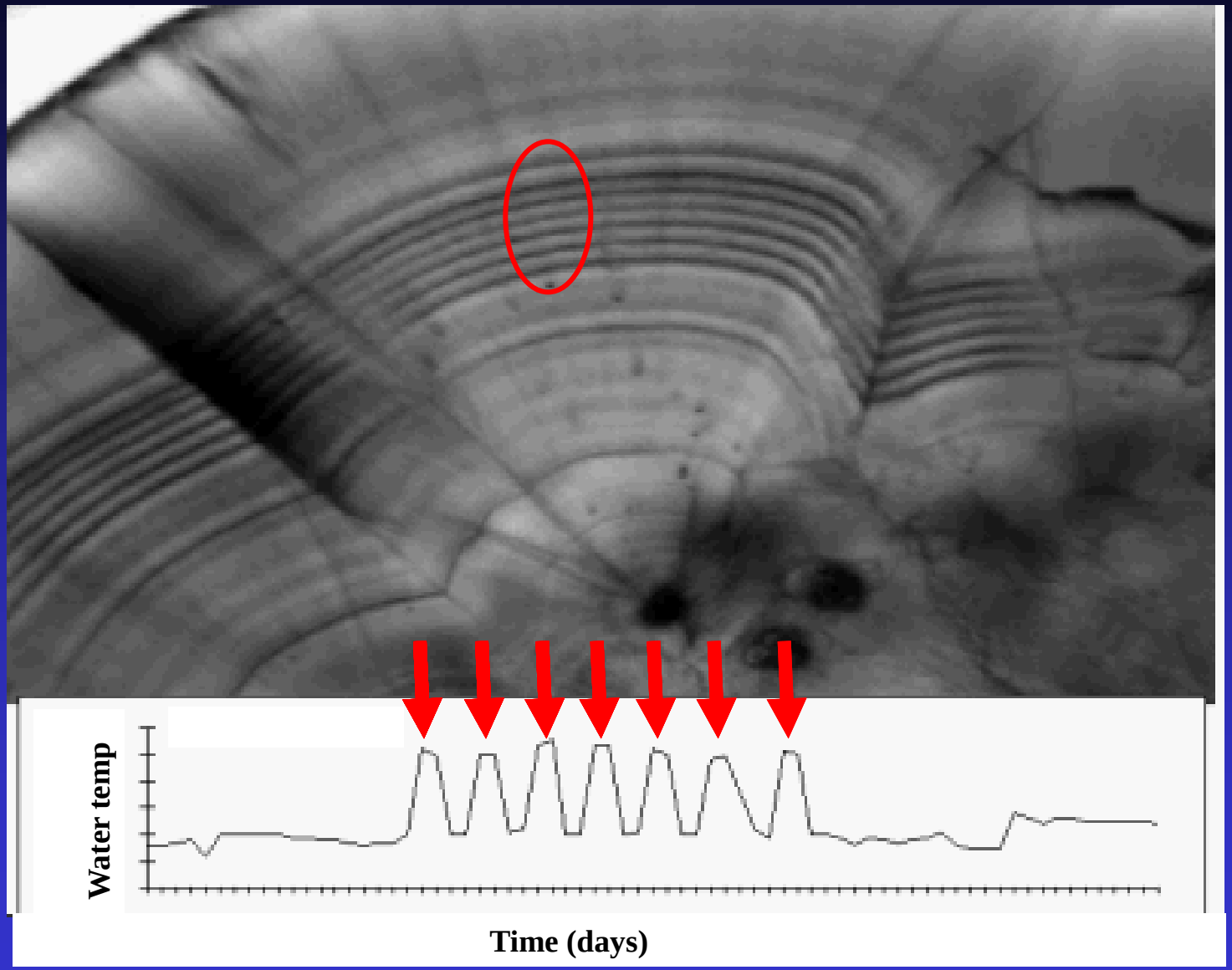
Two releases of each - a total of 6 groups released

Ambient water

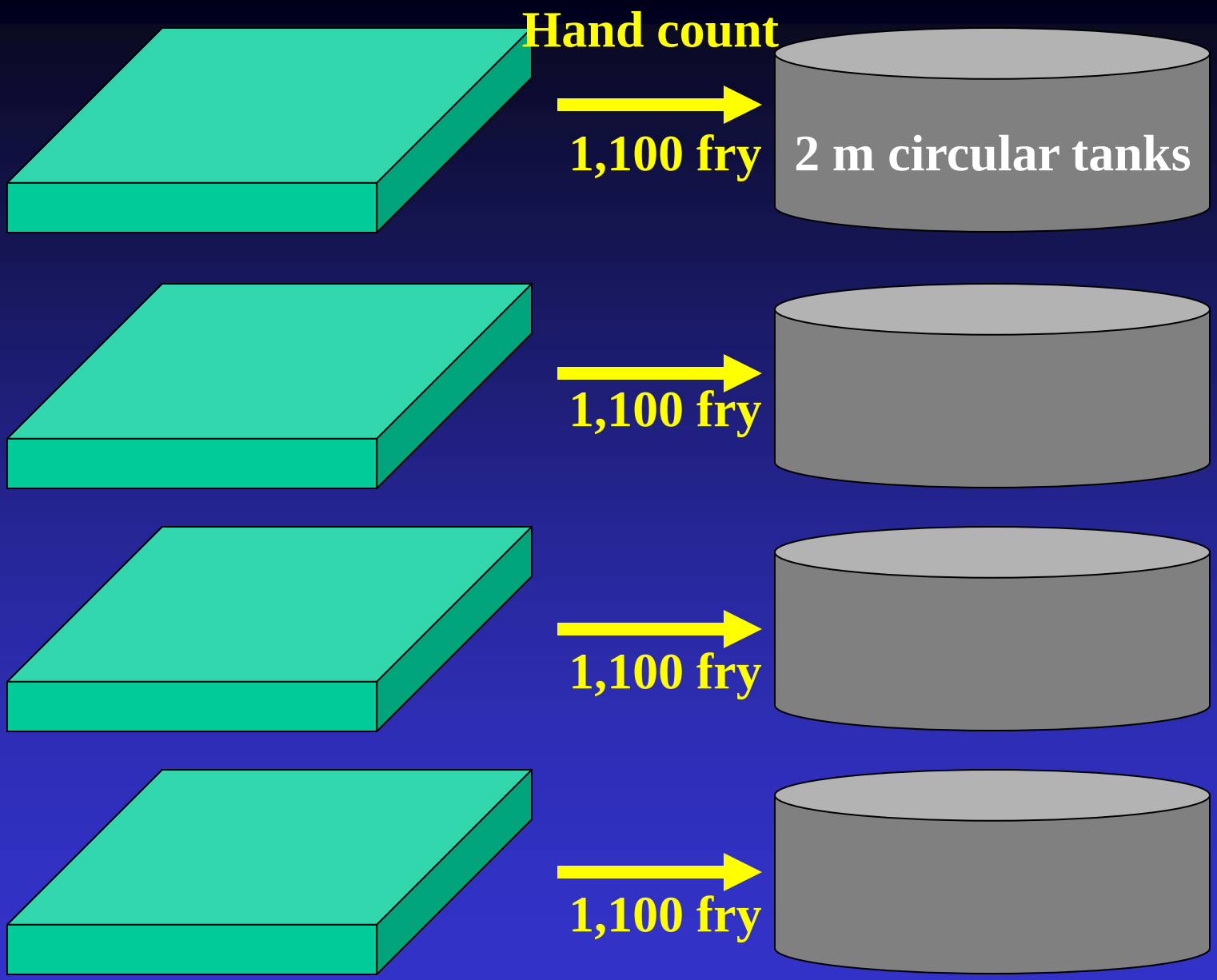


Chilled Water 4°C

Eggs within each of the 6 trays developed unique otolith codes



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

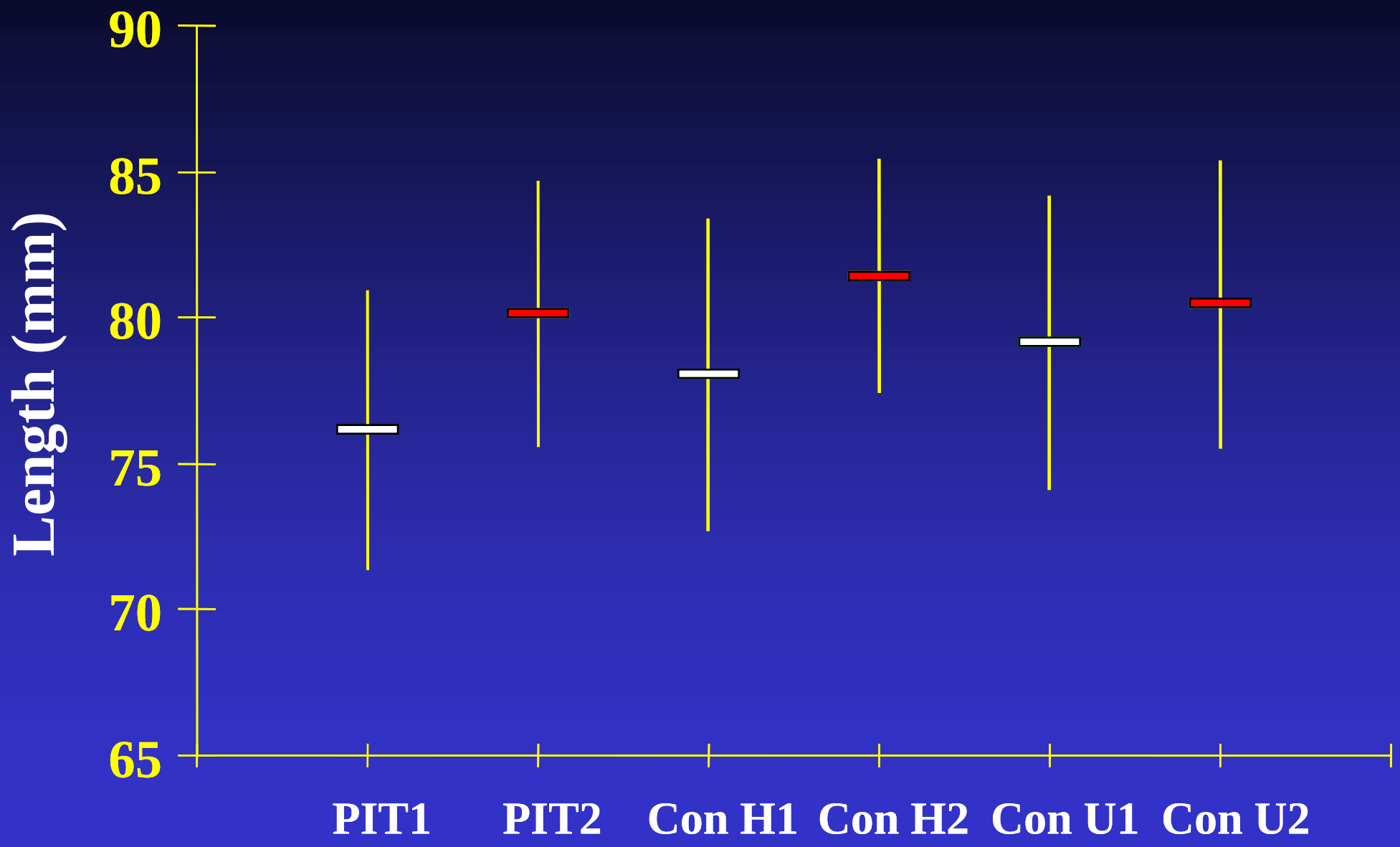


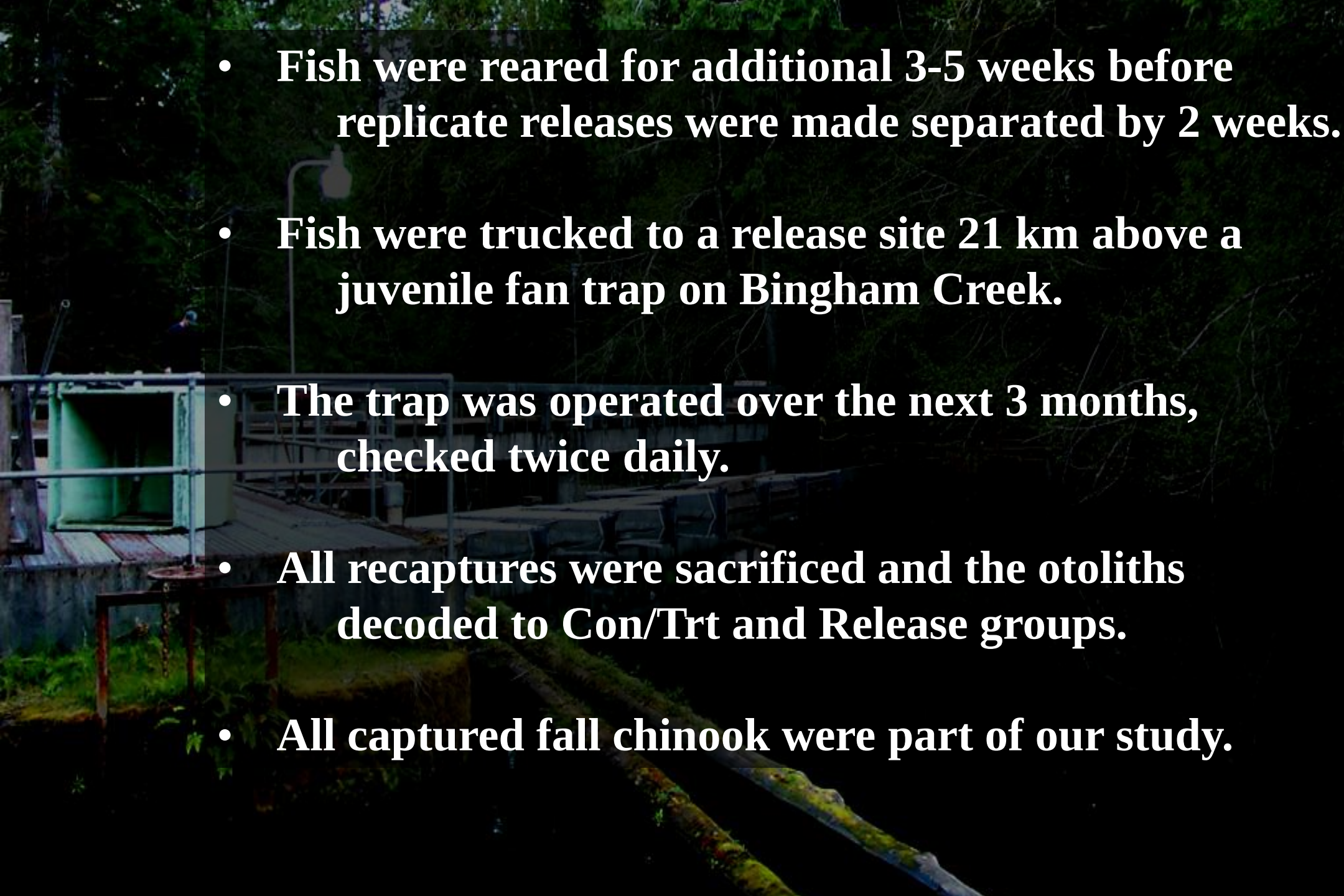
Randomly assigned tanks to treatment and control groups

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





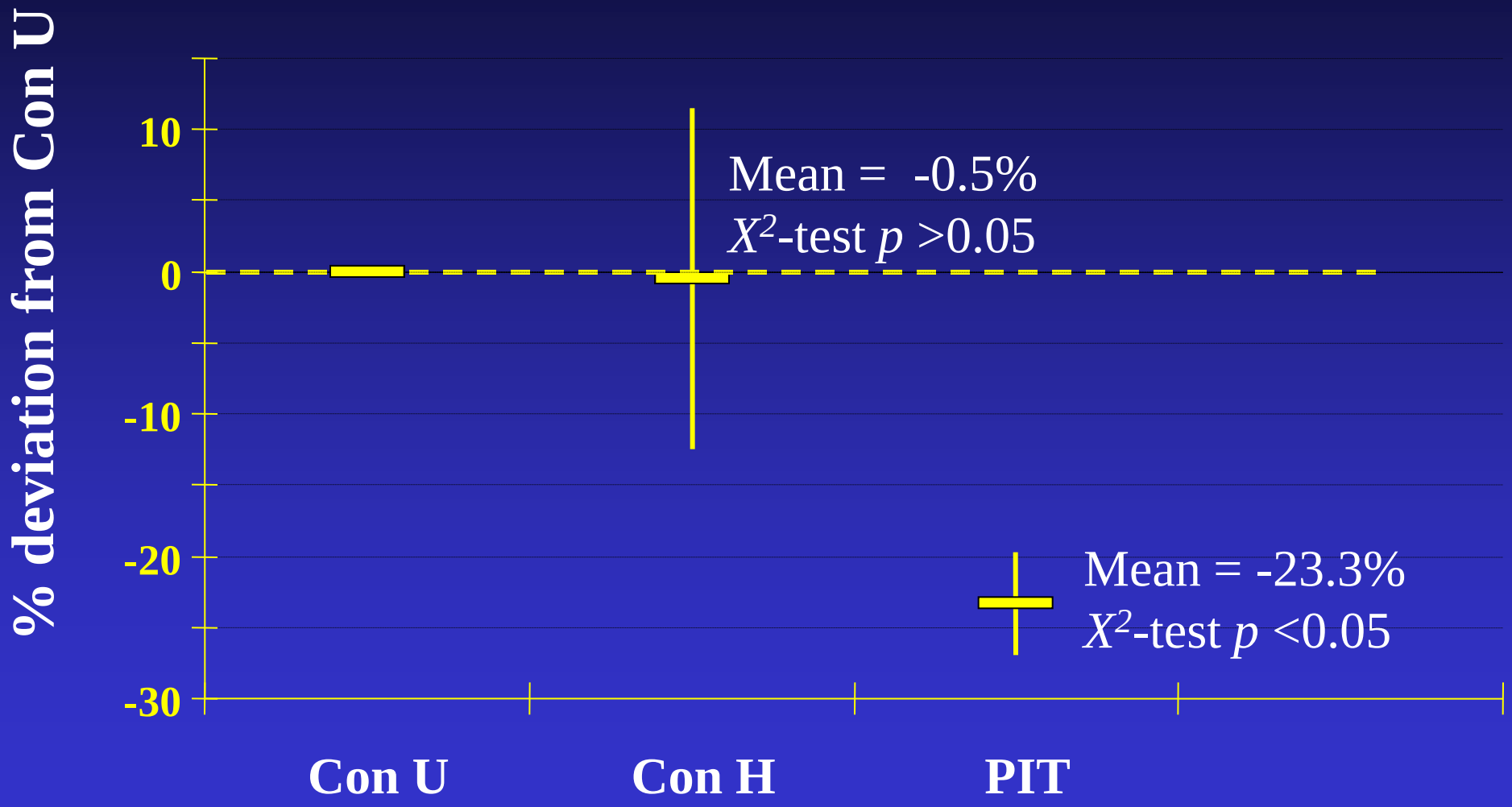
- Fish were reared for additional 3-5 weeks before replicate releases were made separated by 2 weeks.
- Fish were trucked to a release site 21 km above a juvenile fan trap on Bingham Creek.
- The trap was operated over the next 3 months, checked twice daily.
- All recaptures were sacrificed and the otoliths 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

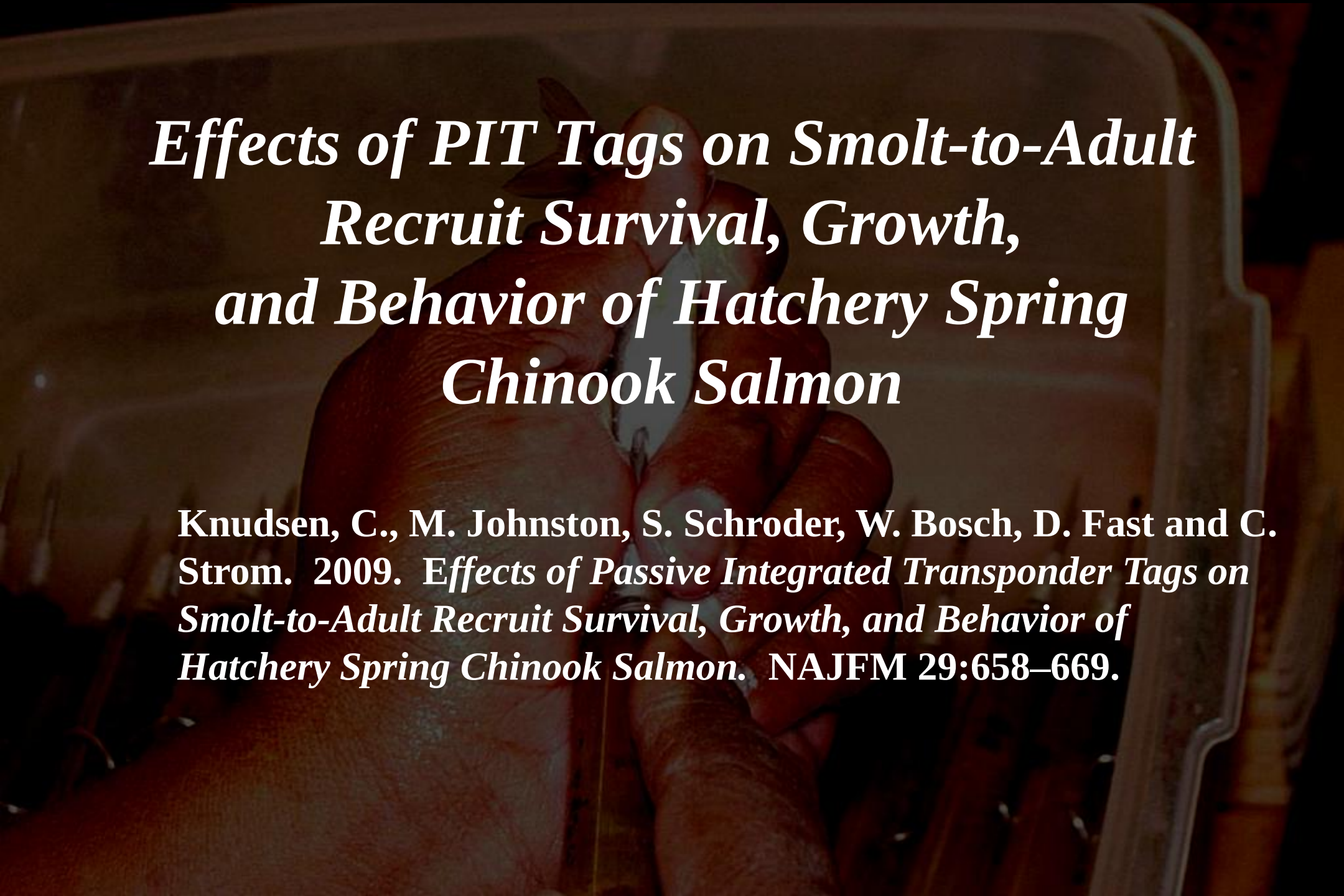
- First release group lost 2.0% of their PIT tags
- Second release had no tag loss

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 ≤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



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

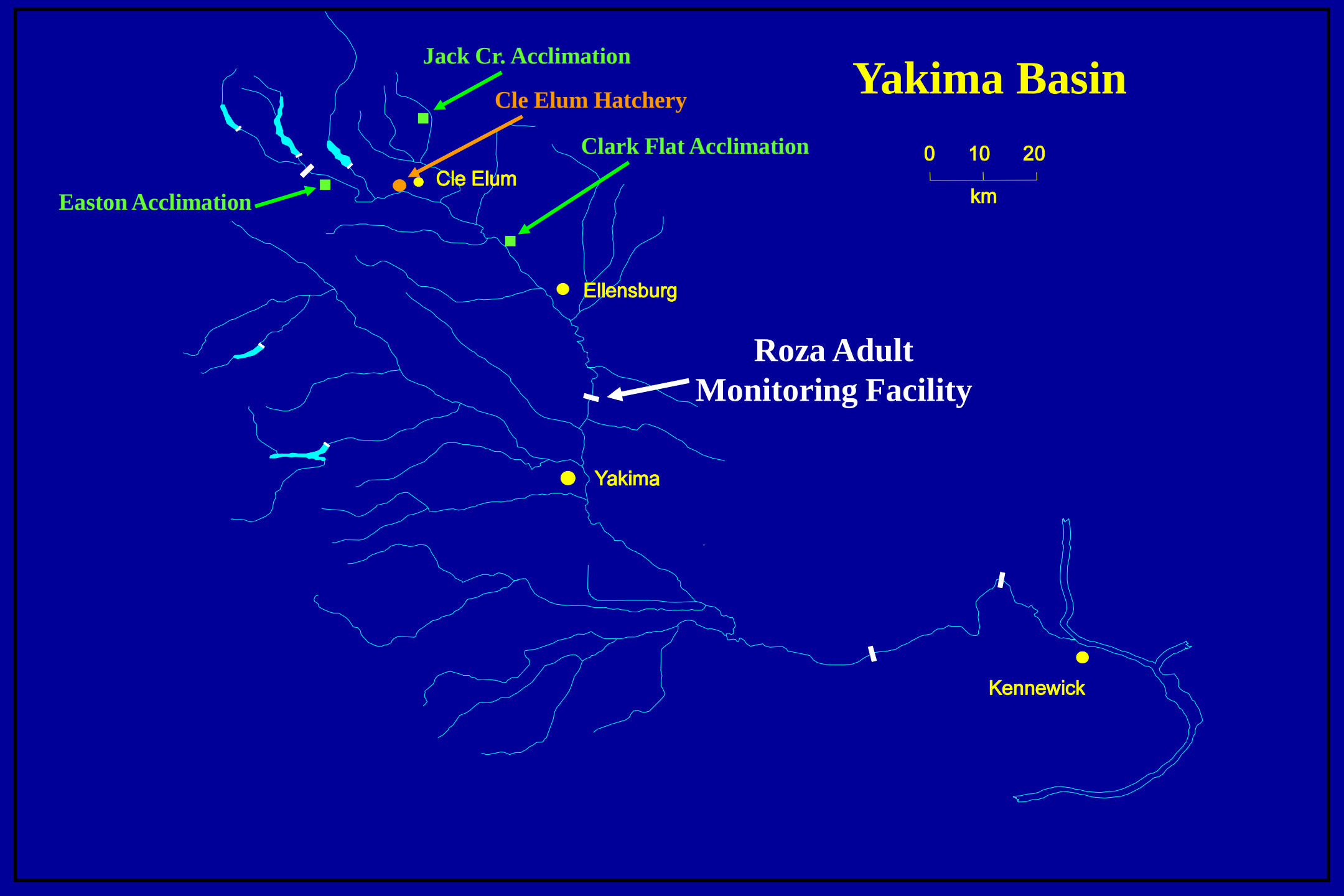
Knudsen, C., M. Johnston, S. Schroder, W. Bosch, D. Fast and C. Strom. 2009. E*ffects of Passive Integrated Transponder Tags on Smolt-to-Adult Recruit Survival, Growth, and Behavior of Hatchery Spring Chinook Salmon.* NAJFM 29:658–669.

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
Jack Cr. Acclimation
Cle Elum Hatchery
Clark Flat Acclimation
Easton Acclimation
Cle Elum
Ellensburg
Roza Adult
Monitoring Facility
Yakima
Kennewick
0
10
20
km

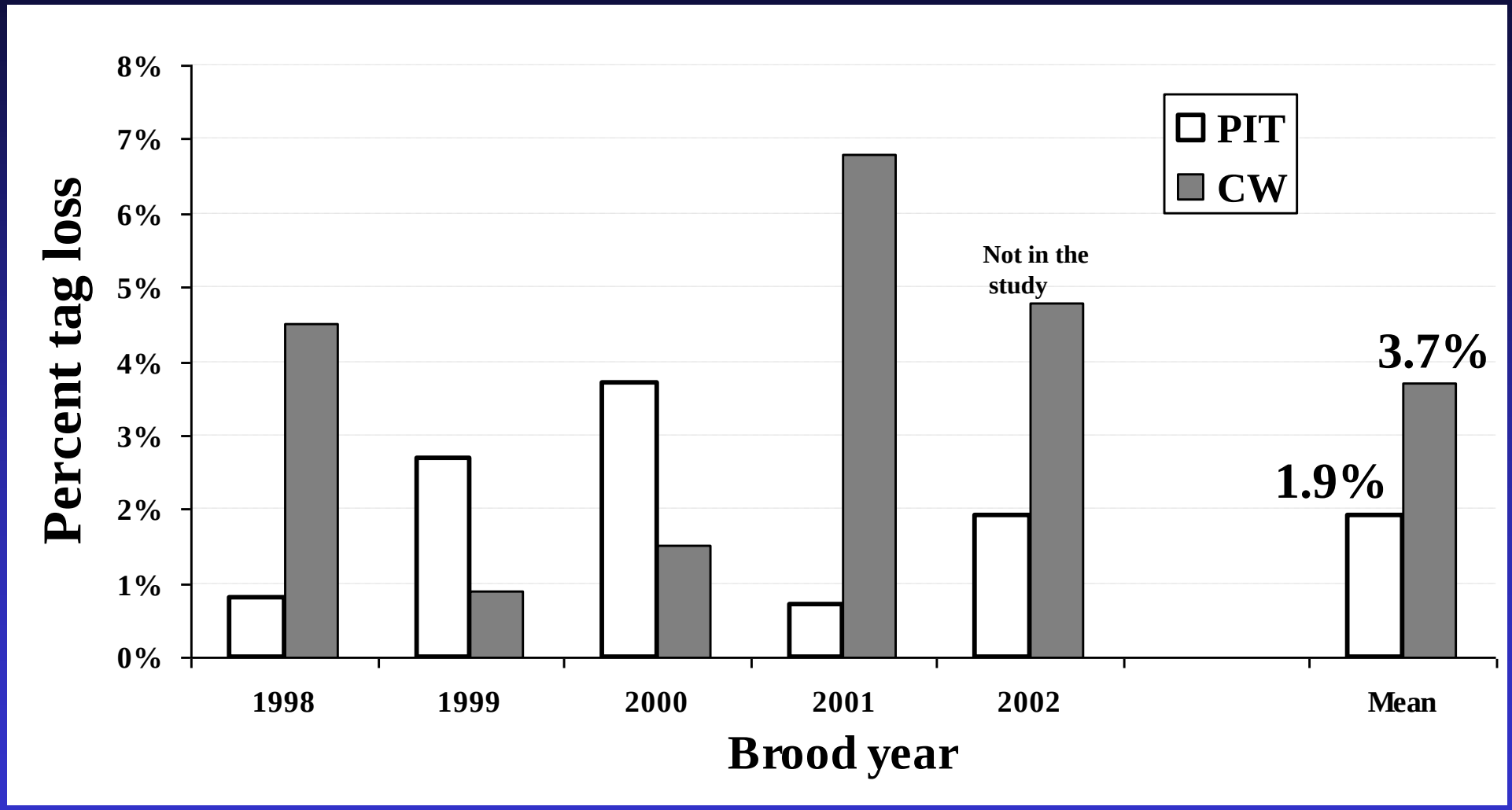
Juvenile Releases	Broodyear				
	1997	**1998**	**1999**	**2000**	**2001**
PIT/CW tagged	39,892	37,385	38,791	37,580	40,020
Non-PIT (marked)	346,156	552,298	719,998	796,705	334,358
Total released	386,048	589,683	758,789	834,285	374,378


Roza Adult Monitoring Facility
Fish ladder

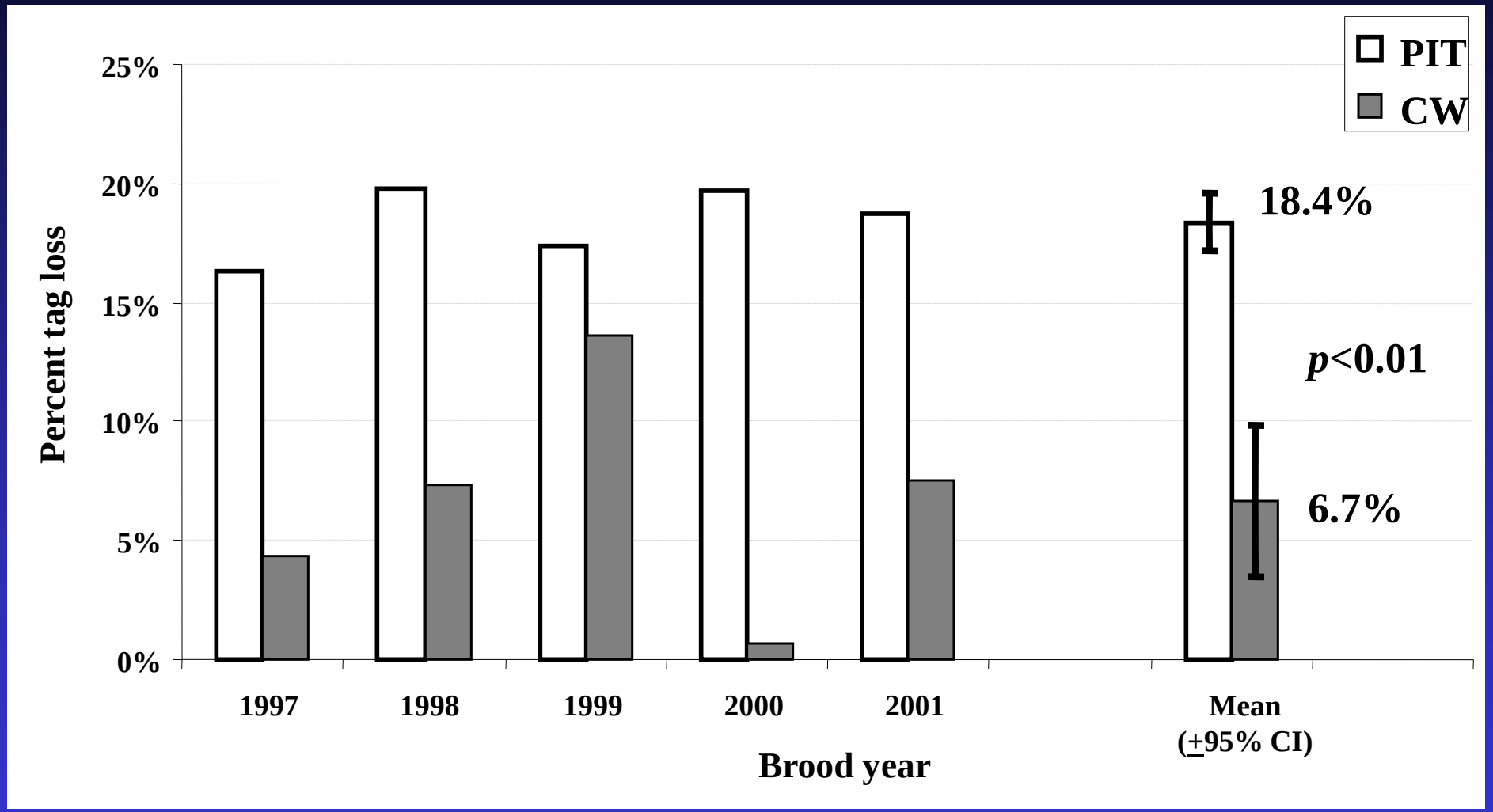
$$\hat{\Pr}_{pit} = [\text{Probability of losing a PIT tag}] = \frac{R_{cwt}}{(R_{cwt} + R_{pit,cwt})}$$

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

Juvenile tag loss rates before release



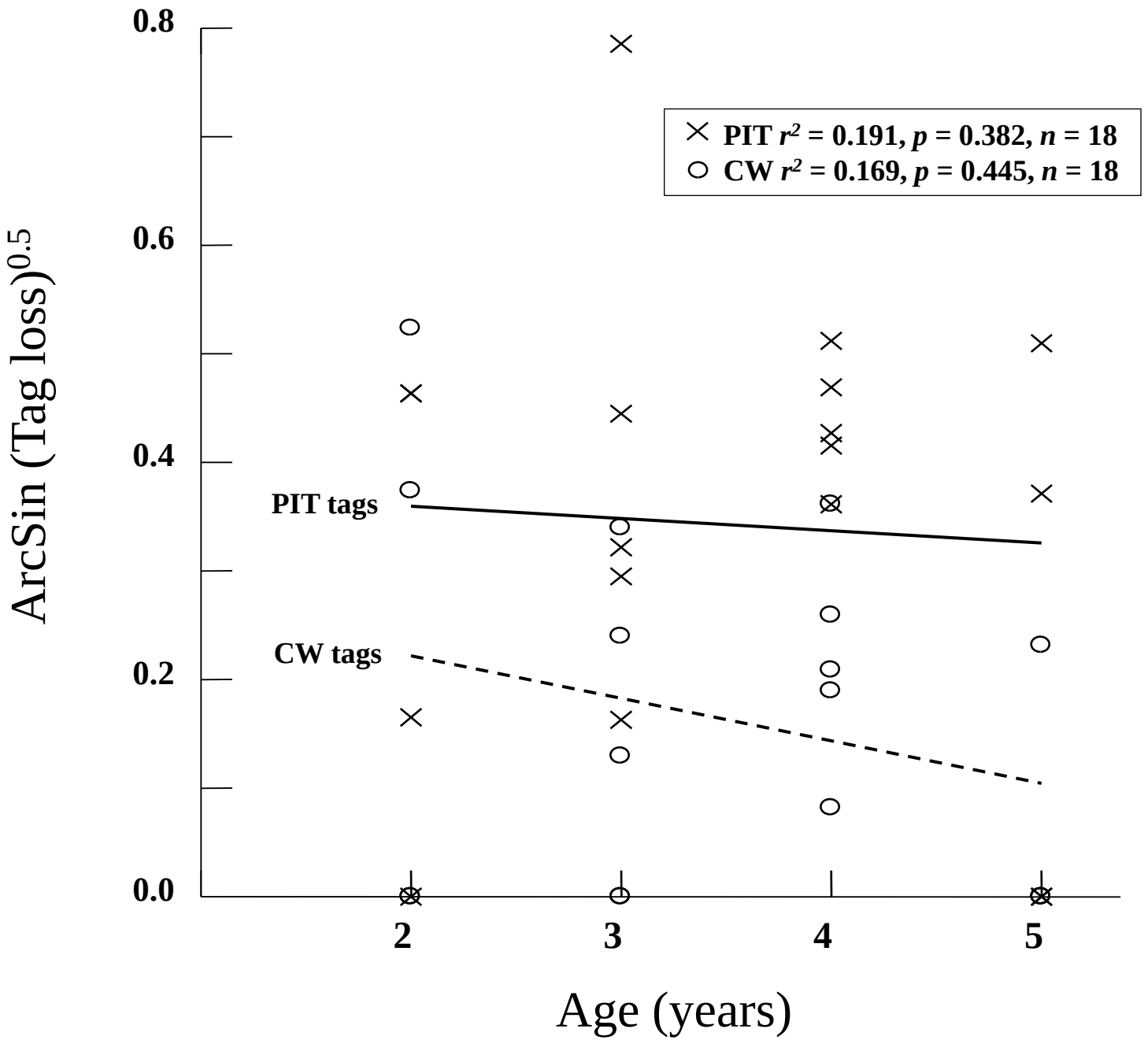
Adult PIT and CW tag loss rates



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


0.8
0.6
0.4
0.2
0.0
ArcSin (Tag loss)^0.5
PIT r² = 0.191, p = 0.382, n = 18
CW r² = 0.169, p = 0.445, n = 18
PIT tags
CW tags
2
3
4
5
Age (years)

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

Uncorrected PIT SARS = $\dfrac{R_{pit} + R_{cwt+pit}}{\#PIT_{\mathrm{R}eleased}}$

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

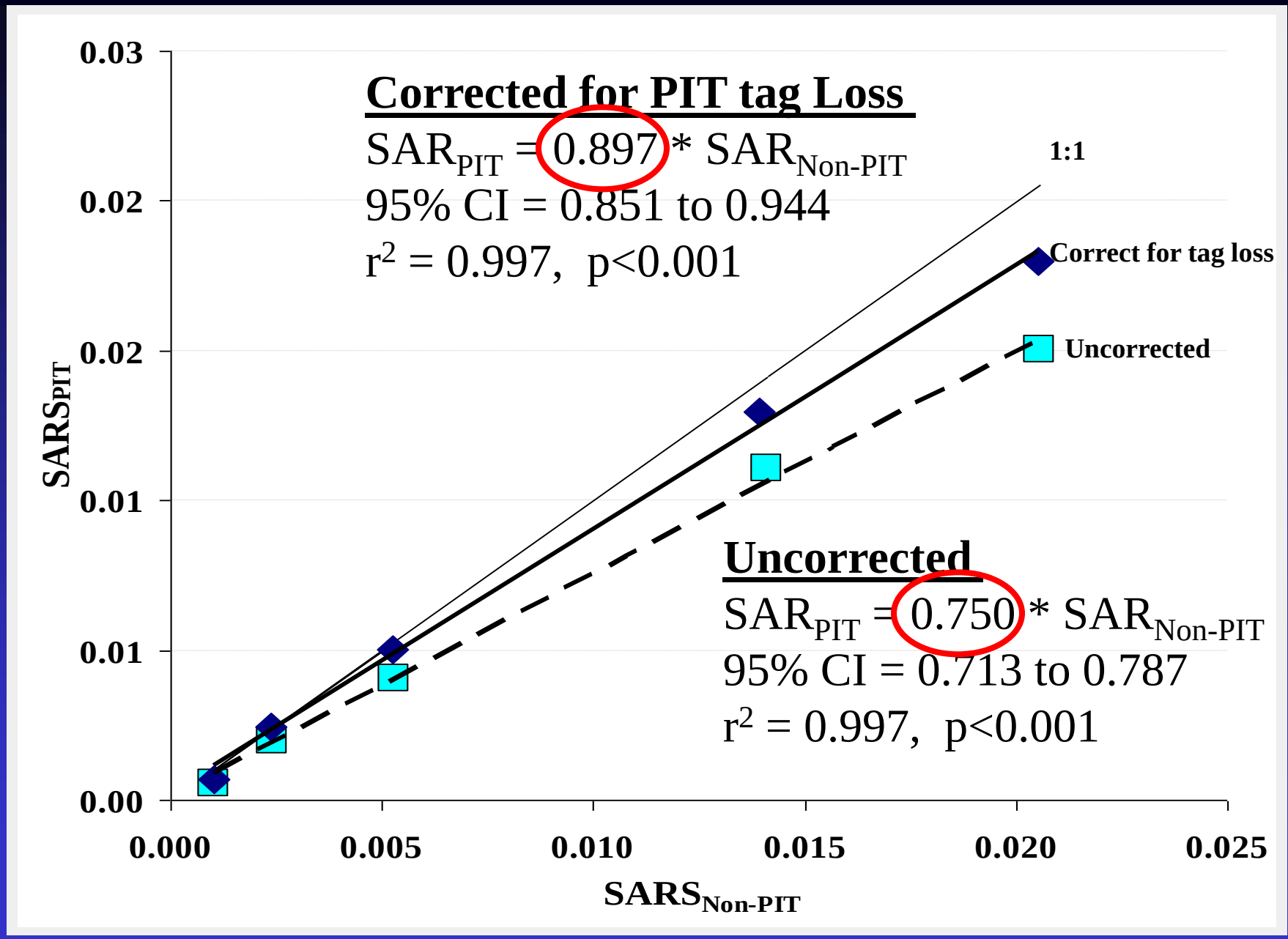
Uncorrected Non-PIT SARS = $\dfrac{\text{(\# Non-PIT recoveries)}}{\text{(\# Non-PIT released)}}$

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

Linear model of PIT tag effect:

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

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

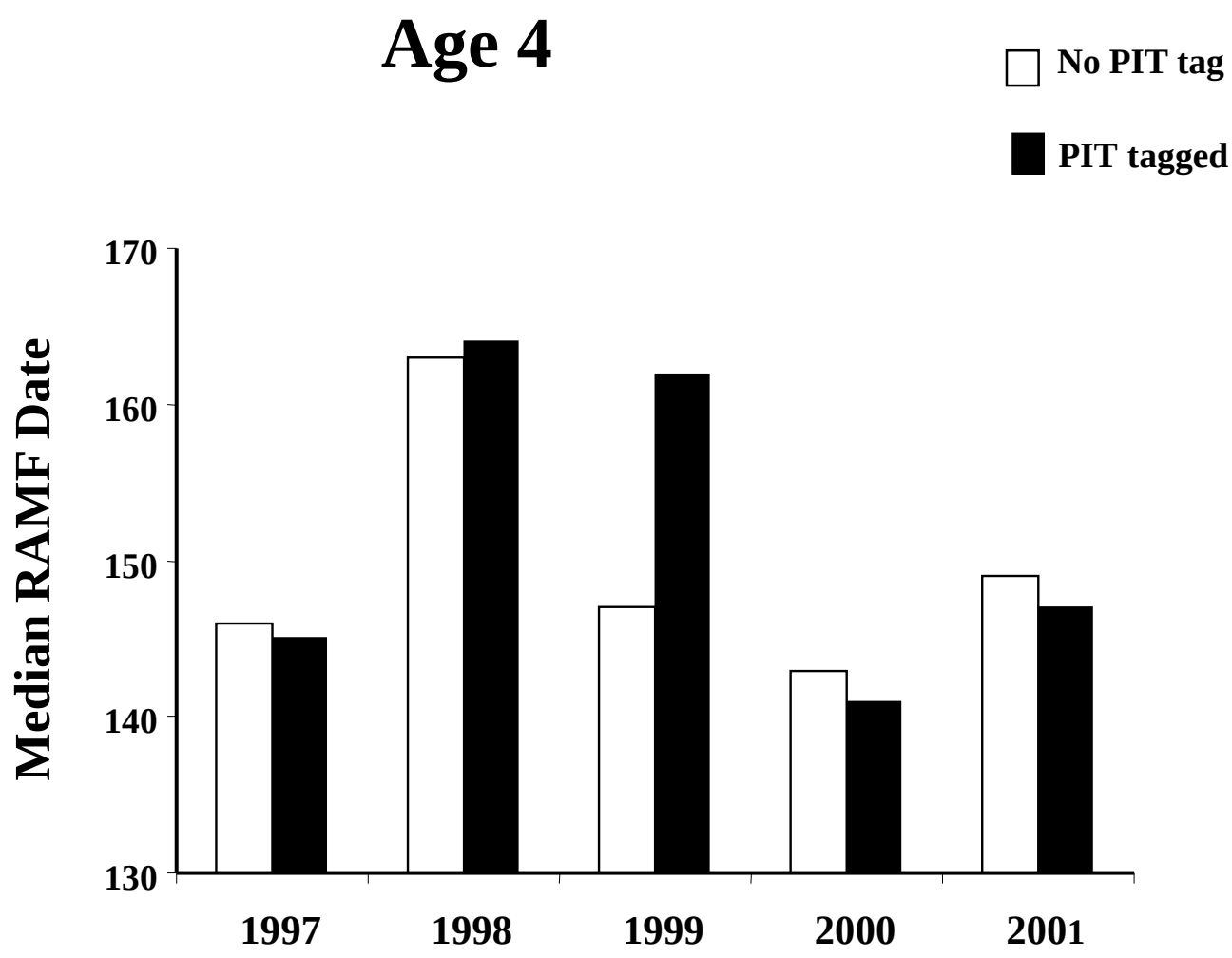

Corrected for PIT tag Loss
SAR_PIT = 0.897 * SAR_Non-PIT
95% CI = 0.851 to 0.944
r2 = 0.997, p<0.001
1:1
Correct for tag loss
Uncorrected
Uncorrected
SAR_PIT = 0.750 * SAR_Non-PIT
95% CI = 0.713 to 0.787
r2 = 0.997, p<0.001
SARS_PIT
SARS_Non-PIT
0.03
0.02
0.02
0.01
0.01
0.00
0.000
0.005
0.010
0.015
0.020
0.025

- **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 $p > 0.09$

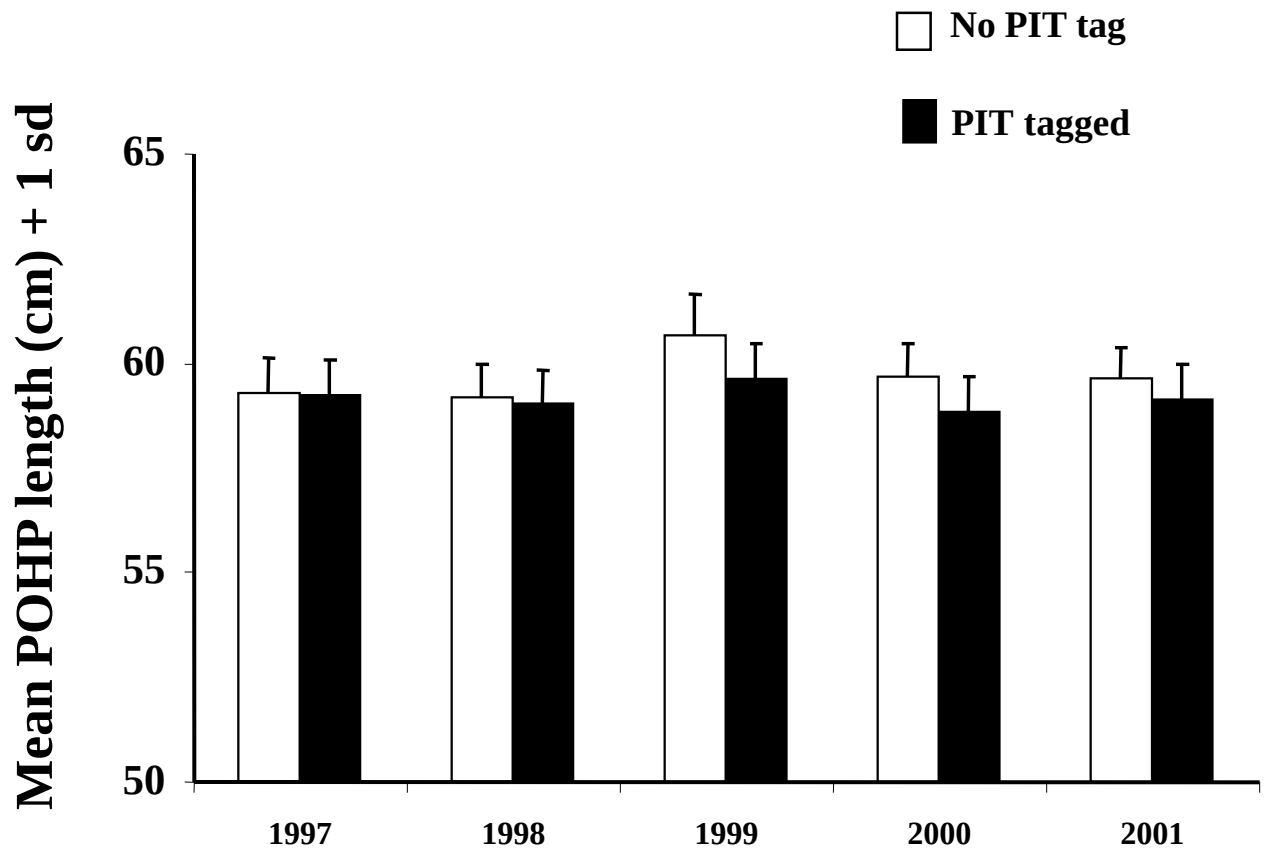
- No consistent trend over brood years



Age 4

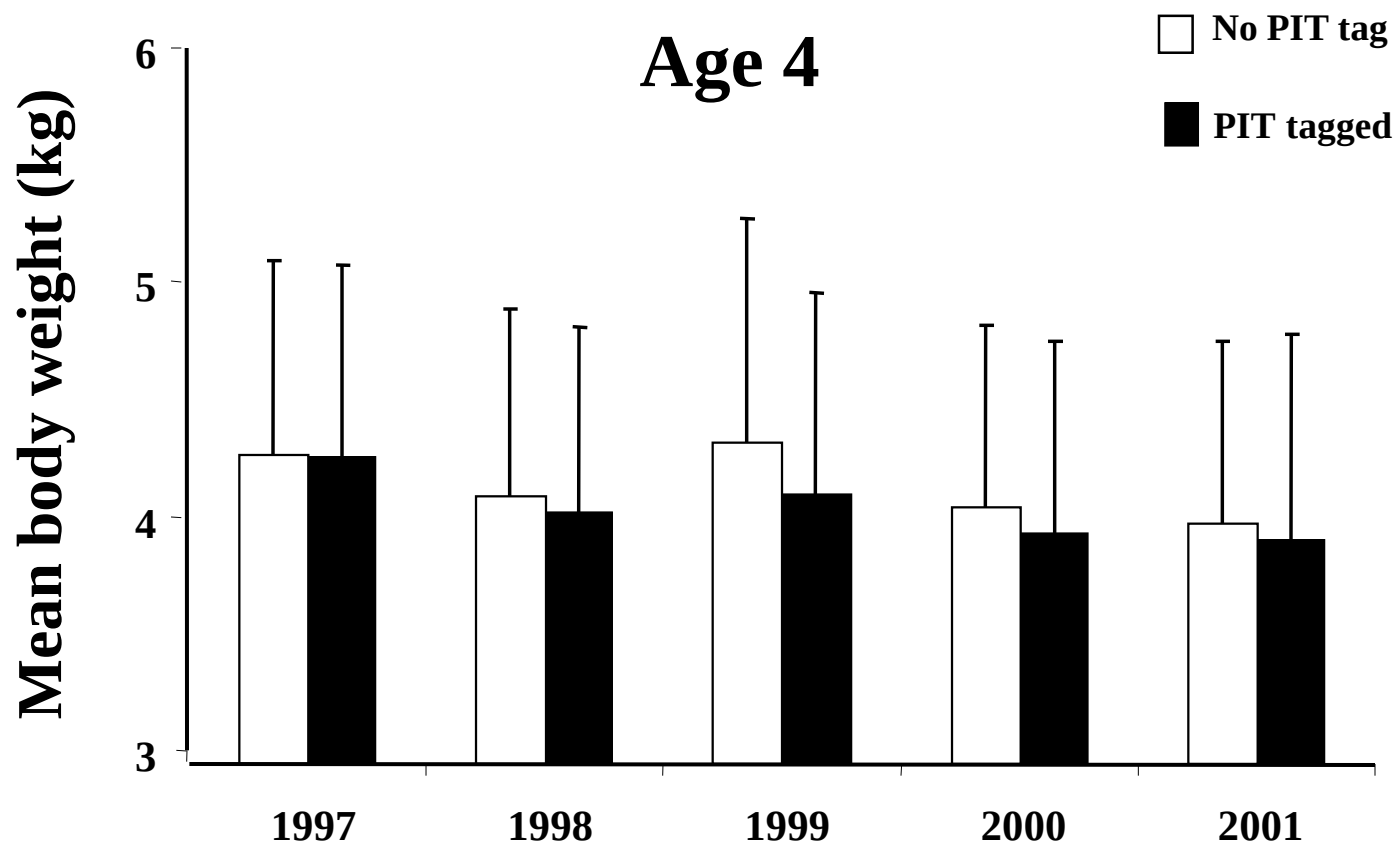
Mean POHP Length

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

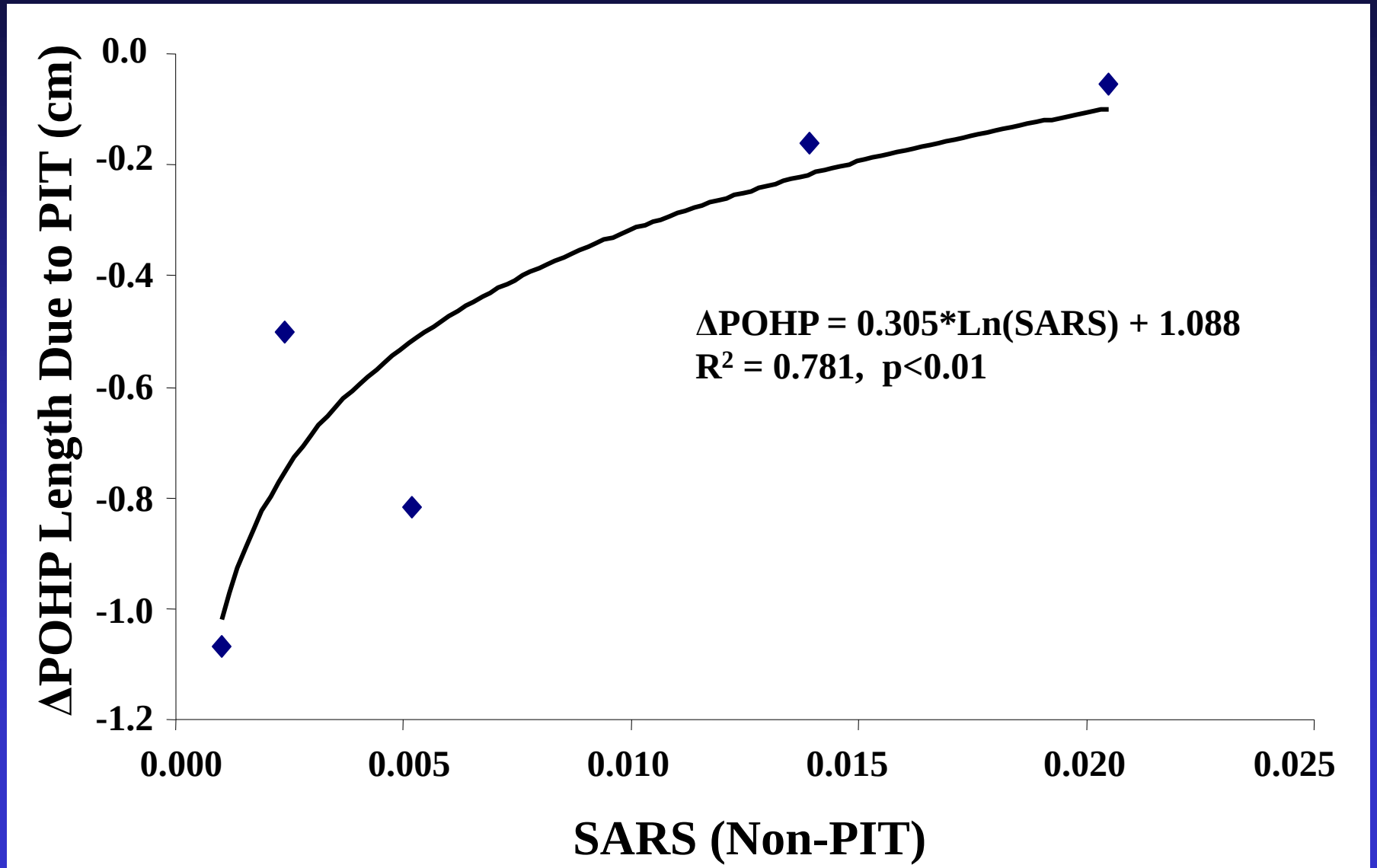


Mean Body Weight

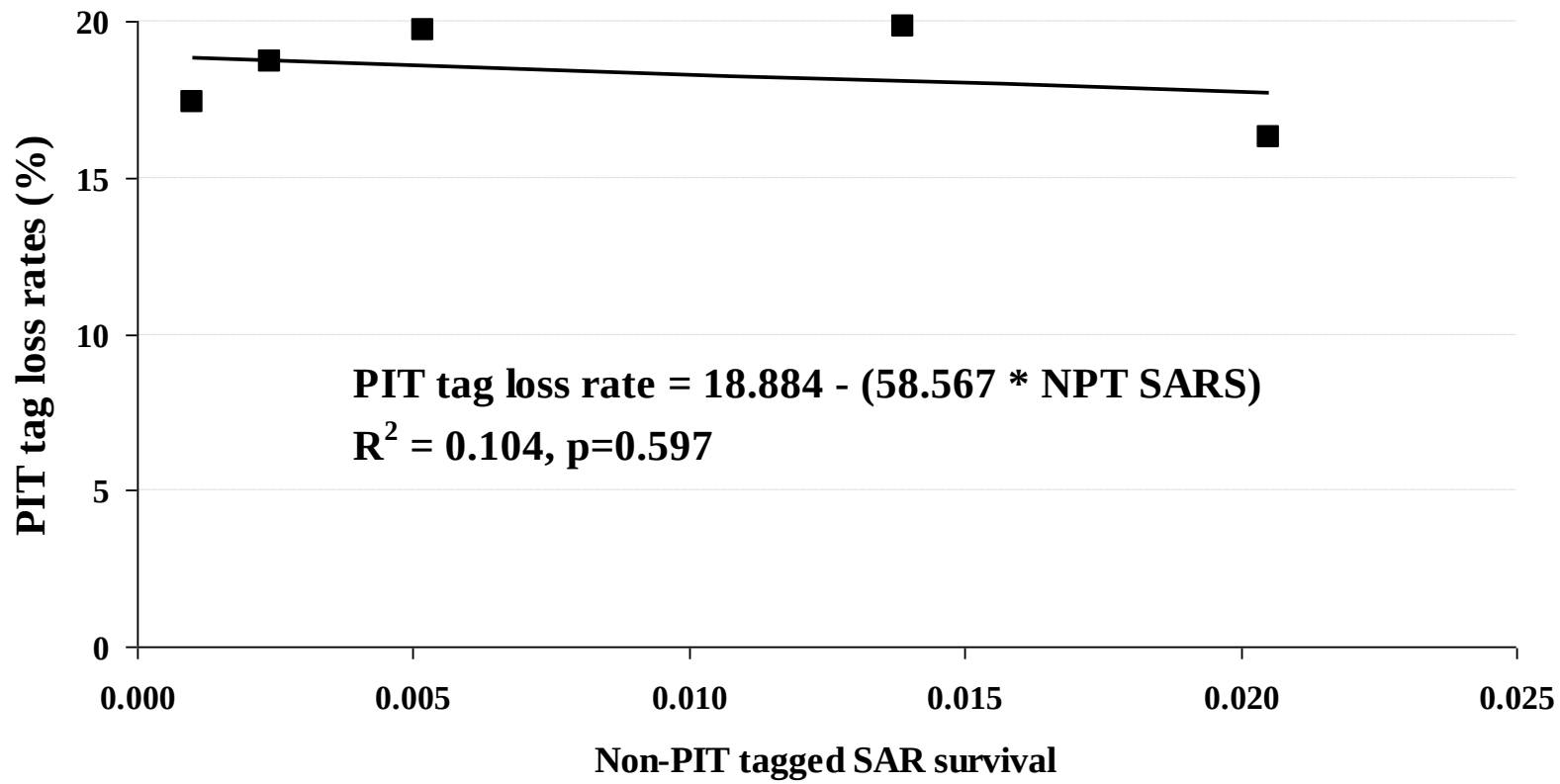
- All comparisons PIT<Non-PIT
- Only Age 4 significant (mean 0.1 kg)
- 2-way ANOVA Tag effect $p = 0.043$



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 ≤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}	$\hat{\Pr}_{pit}$	R_{pit}	$\hat{\Pr}_{cwt}$	$R_{pit,cwt}$	$\hat{R}$	$\hat{R} - R'$	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 (±<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)				