Life-History and Genetic Traits of Wild Origin Yakima River Basin Spring Chinook

Curtis M. Knudsen[1], Anne R. Marshall[2], Mark V. Johnston[3], Todd N. Pearsons[2], Craig S. Busack[2], Todd W. Kassler[2] Steve L. Schroder[2], Charles R. Strom[3], and David E. Fast[3]

[1] Oncorh Consulting

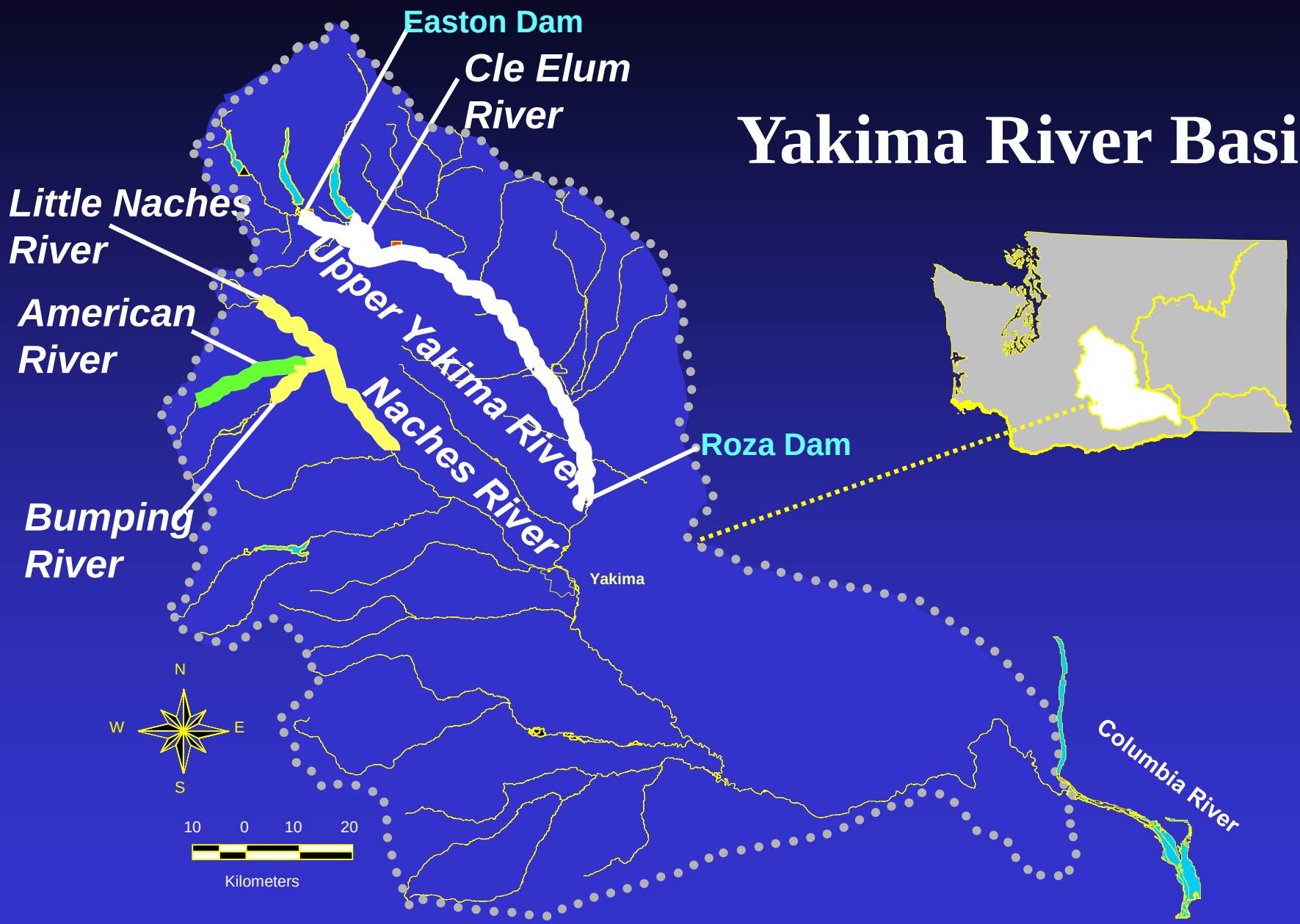
[2] Washington Department of Fish and Wildlife

[3] Yakama Nation

Objectives:

- **Synthesize existing genetic data to determine populations of spring chinook within the Yakima River Basin (reproductive isolation)**
- **Compare the life-history traits of Yakima River spring chinook populations and identify where populations diverge**
- **Compare components of their environments and infer which are likely driving local adaptation and divergence**

Yakima River Basin



Yakima River Spring Chinook Spawning Areas Genetically Sampled - Allozymes

- **American River –** 1989-1993
- **Naches River -** 1989-1993
- **Little Naches -** 1989-1993
- **Bumping River -** 1989-1993
- **Cle Elum River –** 1989, 1991
- **Upper Yakima R (Easton) -** 1989-1993
- **Upper Yakima R (below Roza Dam) –** 1990, 1991

Yakima River Spring Chinook Spawning Areas Genetically Sampled - DNA

- **American River – 1989, 1991, 1993**
- **Naches River – 1989, 1993**
- **Little Naches - 1993**
- **Bumping River - 1989**
- **Cle Elum River – none**
- **Upper Yakima R (Easton) – 1992, 2003**
- **Upper Yakima R (below Roza Dam) – none**


89 AMERICAN
92 AMERICAN
90 AMERICAN
100
93 AMERICAN
91 AMERICAN
87
89-93 BUMPING
92 NACHES
91 NACHES
89-90 LIT. NACHES
89 NACHES
91 LIT. NACHES
93 NACHES
91
90 NACHES
99
93 LIT. NACHES
92 LIT. NACHES
89+91 CLE ELUM
91 YAKIMA/EST
92 YAKIMA/EST
100
90+91 YAKIMA/ROZA
89 YAKIMA/EST
90 YAKIMA/EST
0.1333
0.1000
0.0667
0.0333
0.0000
Cavalli-Sforza and Edwards chord distance

Identified Three Reproductively Isolated Populations

- American River
- Naches River and tributaries
- Upper Yakima River and tributaries

Natural Populations

- In order for local adaptation to occur populations must be isolated temporally and/or spatially, e.g. reproductively
- Local adaptation can be expressed in traits such as:
  - Size-at-age
  - Age composition
  - Sex composition
  - Spawn timing
  - Reproductive traits (egg size, fry size)

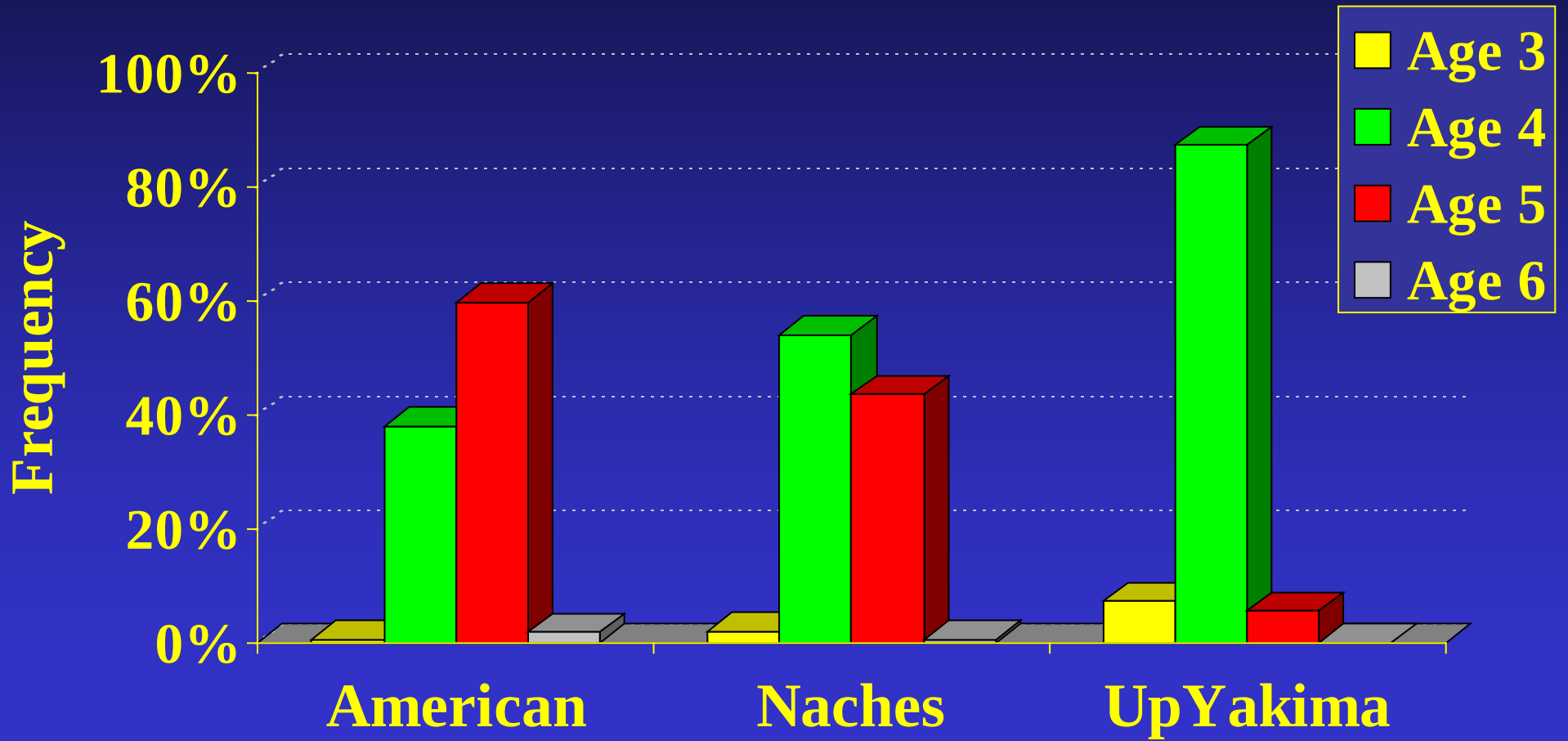
Comparisons of Yakima River Spring Chinook Populations 1988-2004

- **Life-history Traits**
  - Age composition
  - Size-at-age
  - Sex ratio
  - Spawn timing (redds surveys)

Age Composition

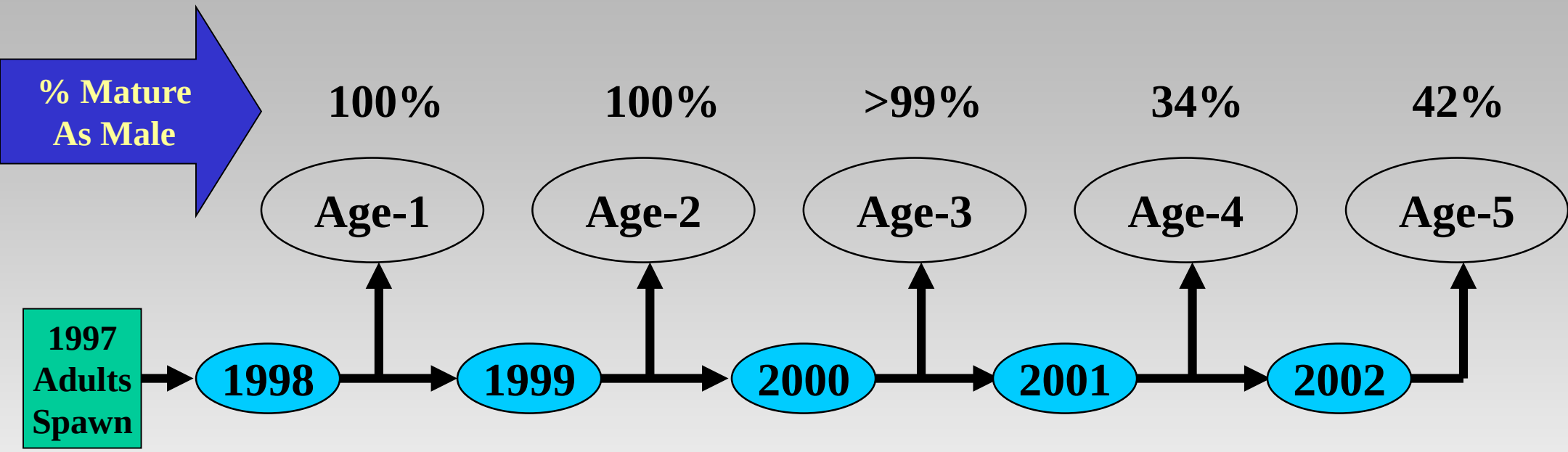
Mean Age Composition: 1988-2004

(YN Carcass recoveries)



Sex Composition by Population

- Estimated from carcass recoveries (recovery bias assumed equal across populations)
- Differences can reflect male life history strategies
  - Jacks (age-3)
  - Non-anadromous precocious males (age-1 and age-2)

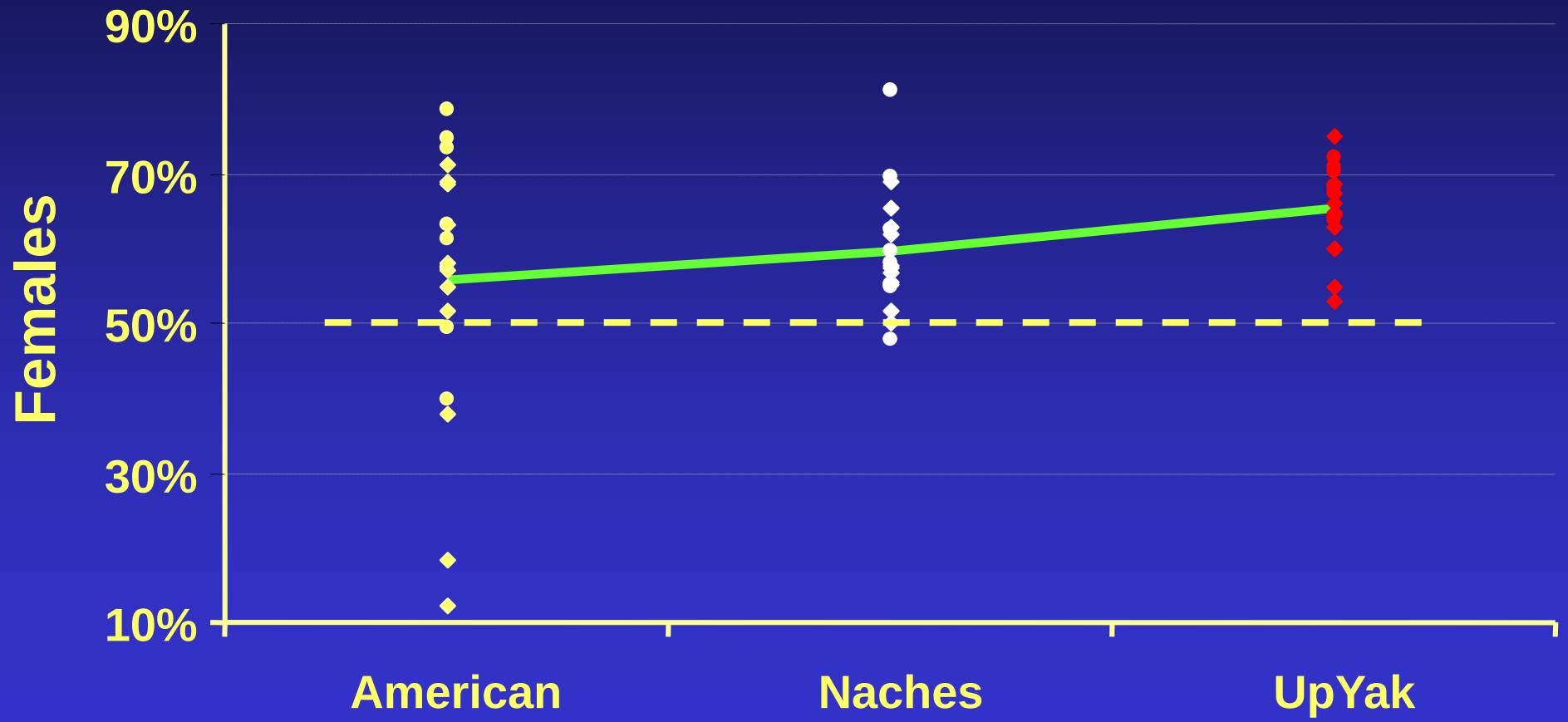

% Mature
As Male
100%
100%
>99%
34%
42%
Age-1
Age-2
Age-3
Age-4
Age-5
1997
Adults
Spawn
1998
1999
2000
2001
2002

Sex Composition by Population

- Estimated from carcass recoveries (recovery bias assumed equal across populations)
- Differences can reflect male life history strategies
  - Jacks (age-3)
  - Non-anadromous precocious males (age-1 and age-2)
- Sex specific mortality, i.e. selective fishery

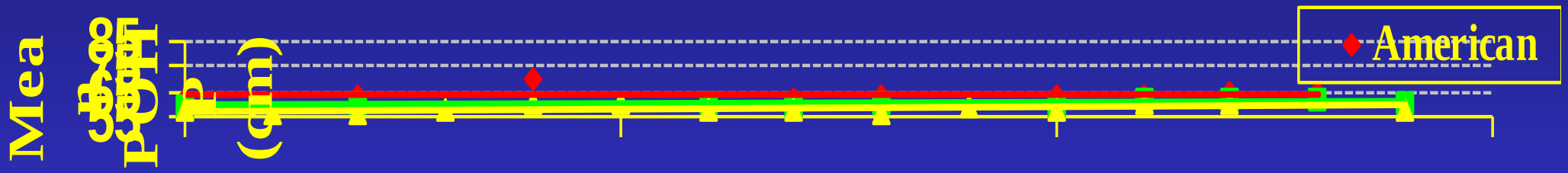
Percent Females Broodyears: 1985-2000

(YN Carcass recoveries)

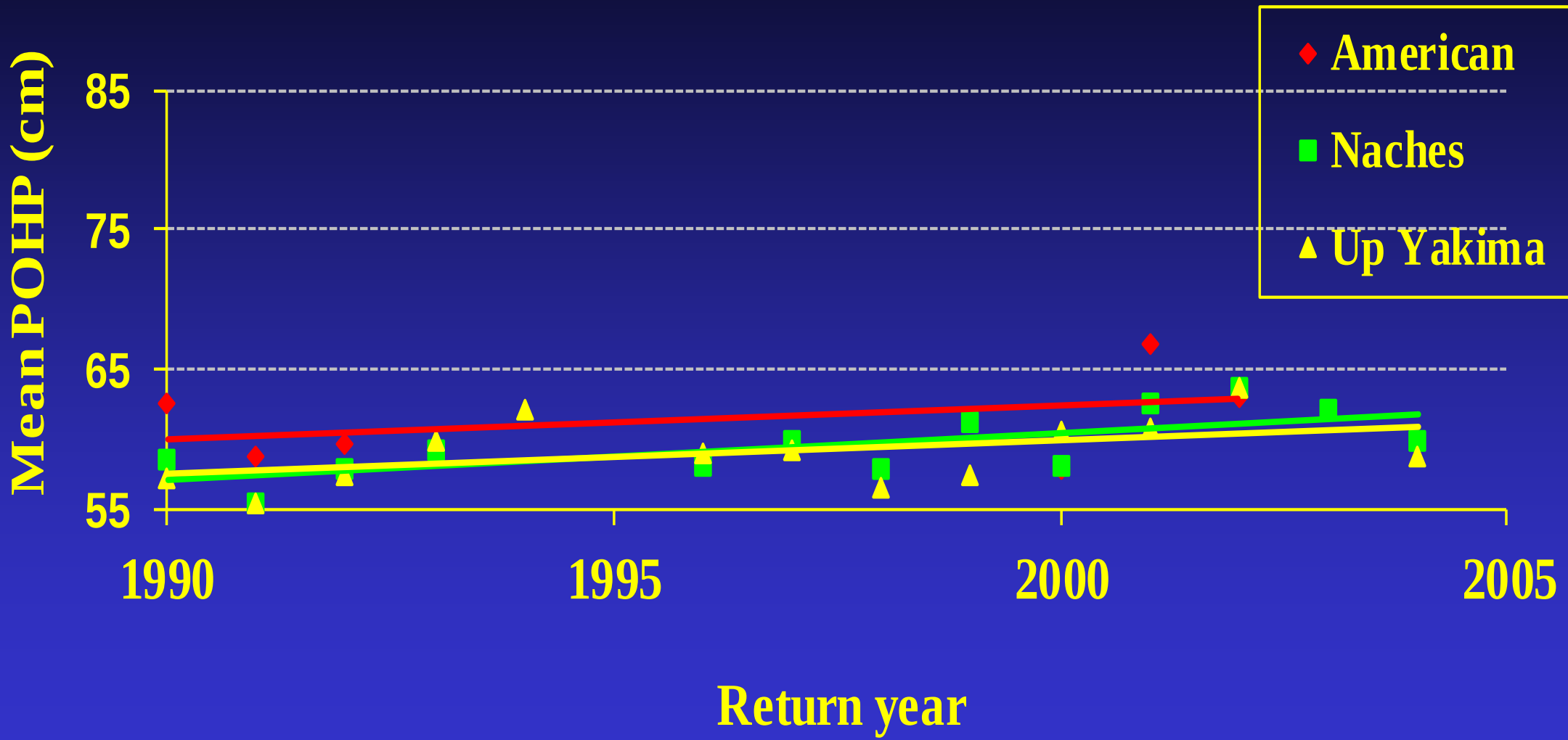



Size-at-Age

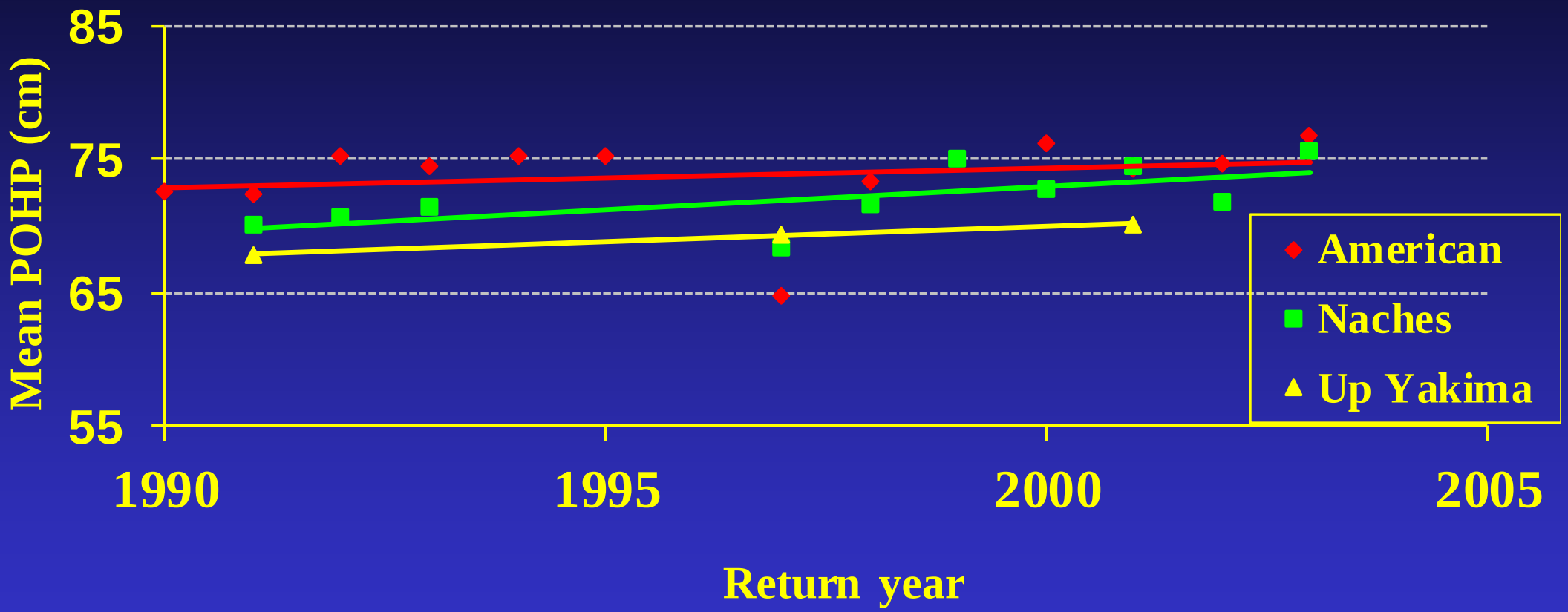
Age 4 Females



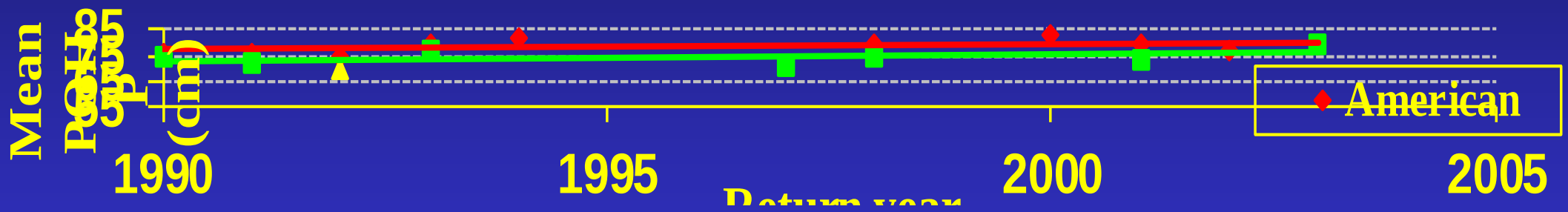
Age 4 Males


American
Naches
Up Yakima
Mean POHP (cm)
85
75
65
55
1990
1995
2000
2005
Return year

Age 5 Females



Age 5 Males

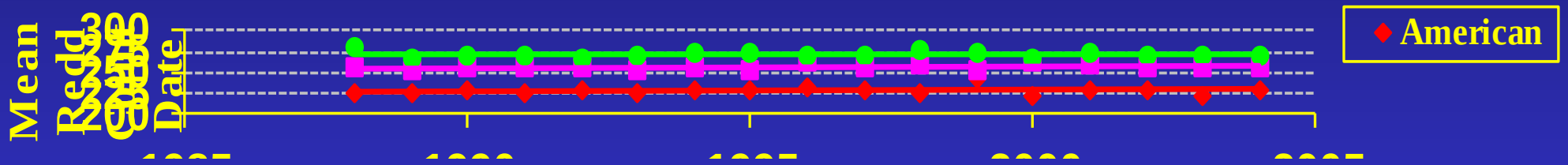


Size-at-age vs Age Composition

- The usual assumption is that slower growing fish will mature at an older age.
- Thus, the population that grows at the slowest rate should return at the oldest mean age of maturation.
- However, the fastest growing population, American (largest size-at-age), returns at the oldest mean age.

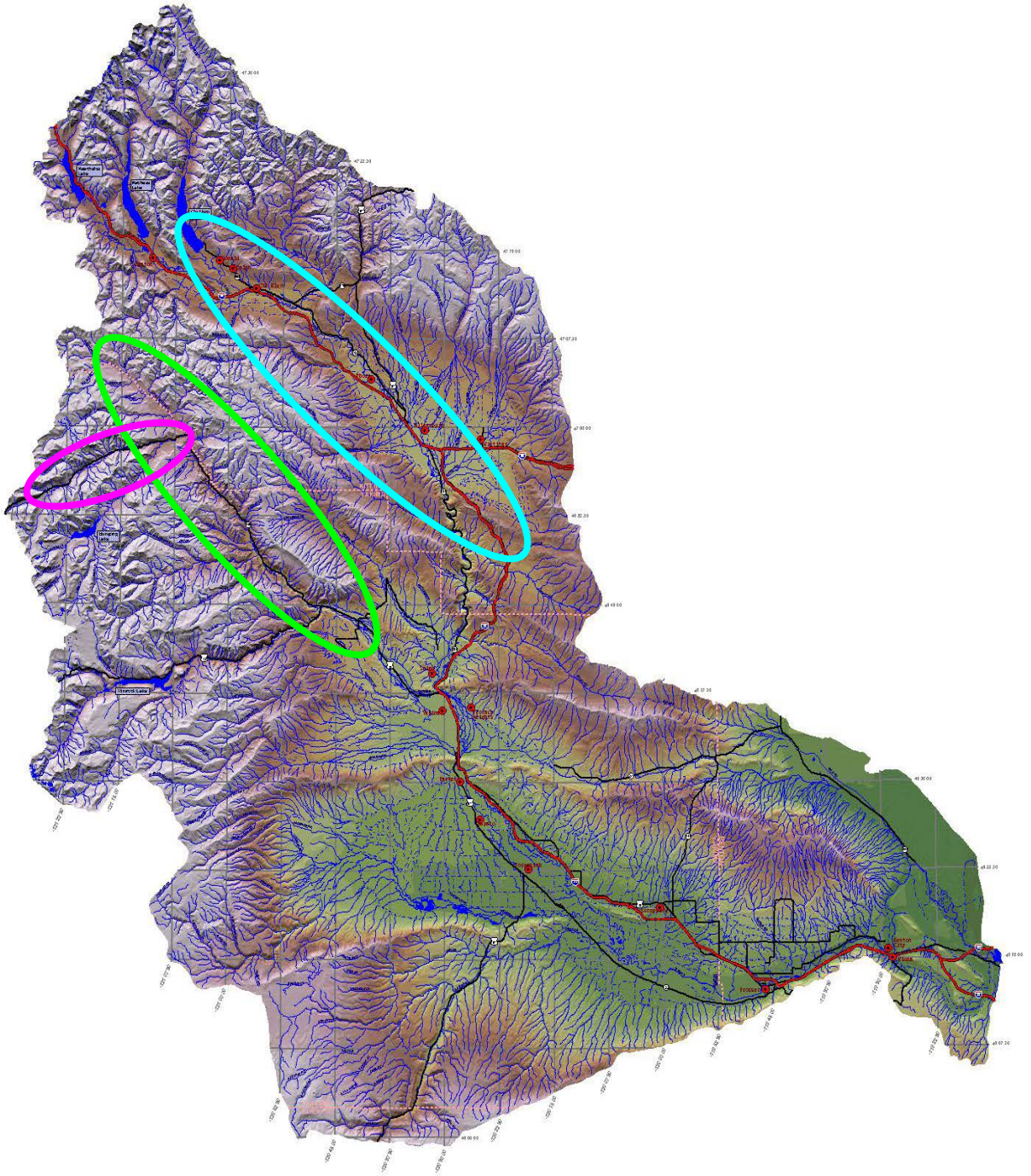

Spawn Timing

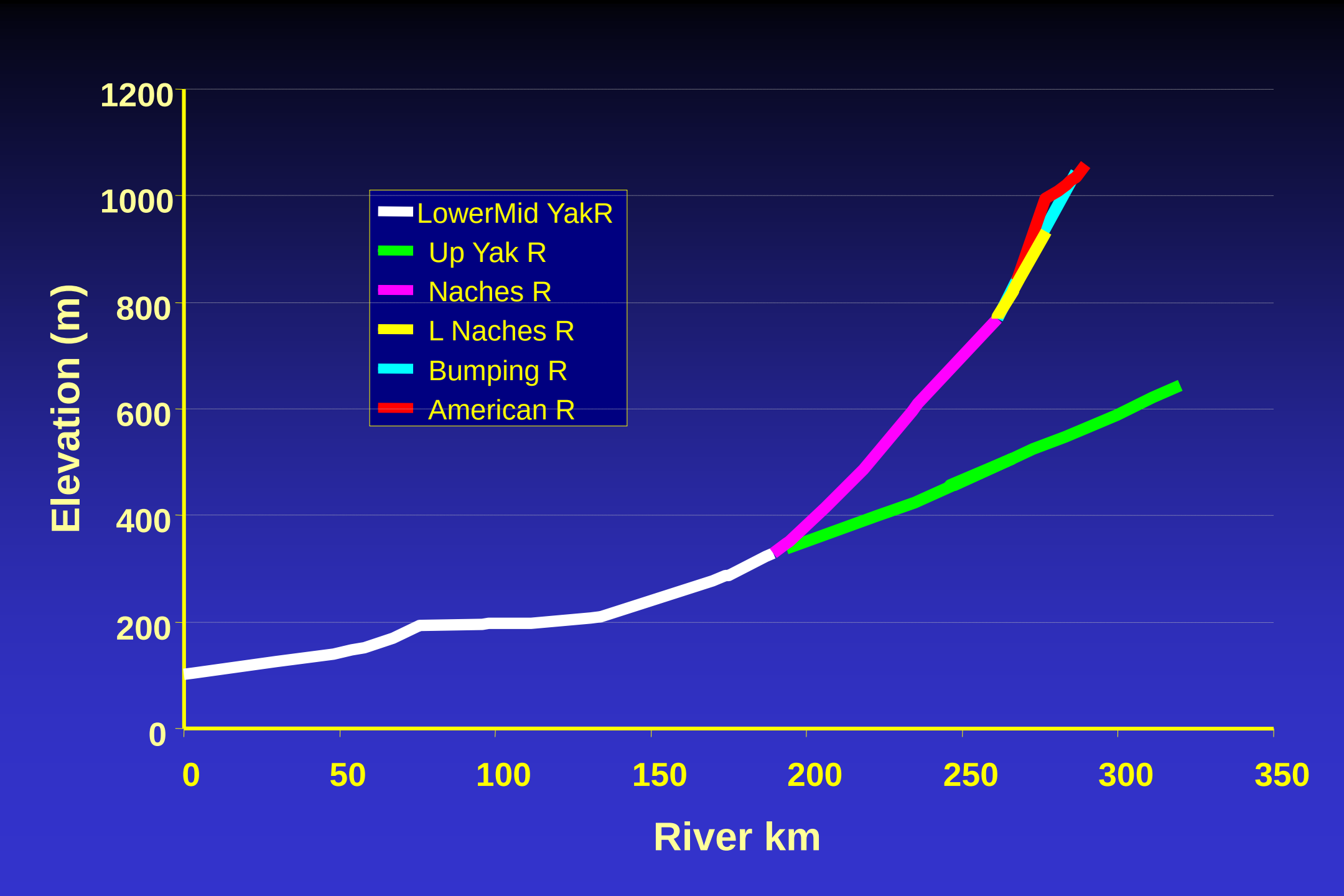
Mean Redd Count Date 1988-2004



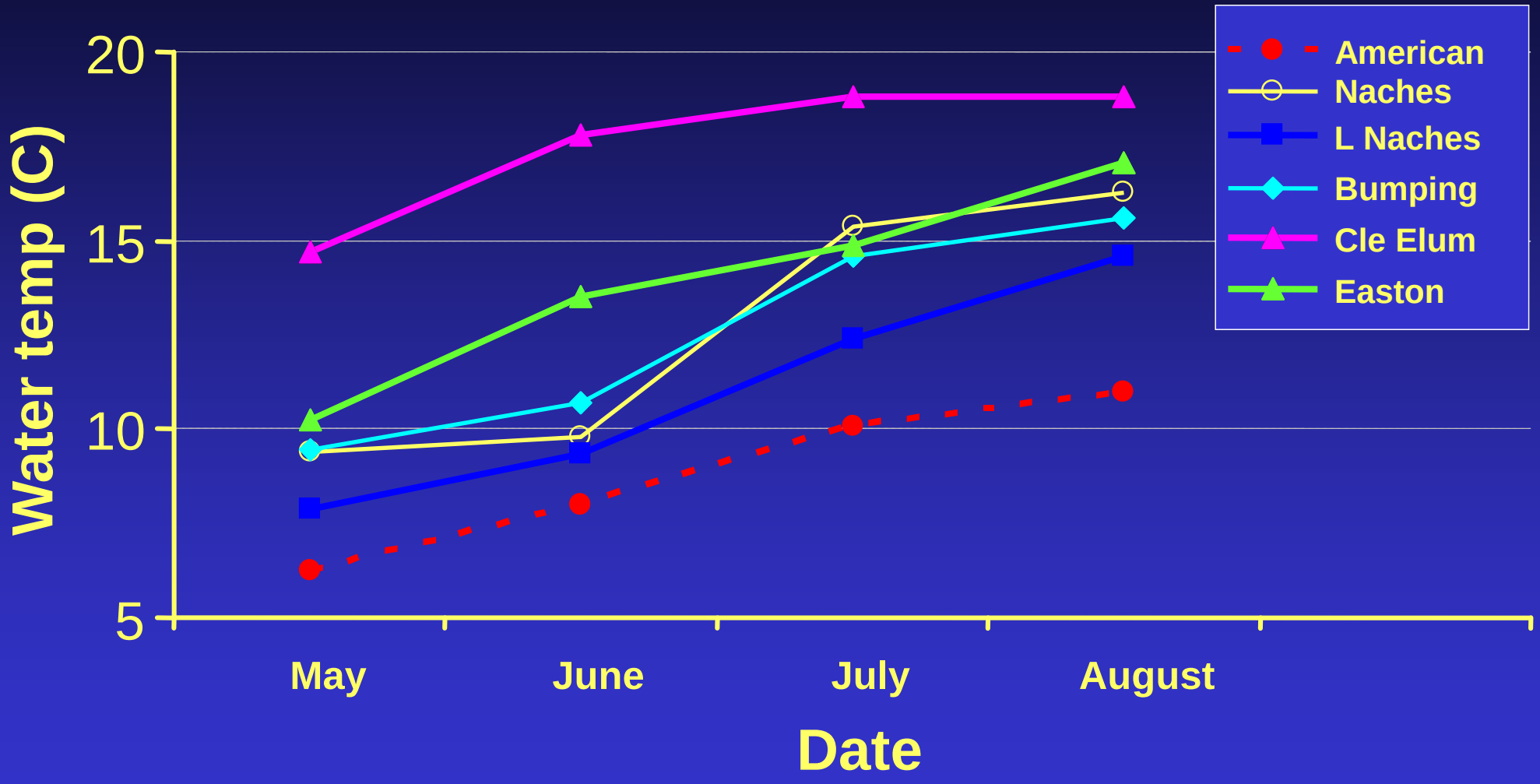
Selection Pressures

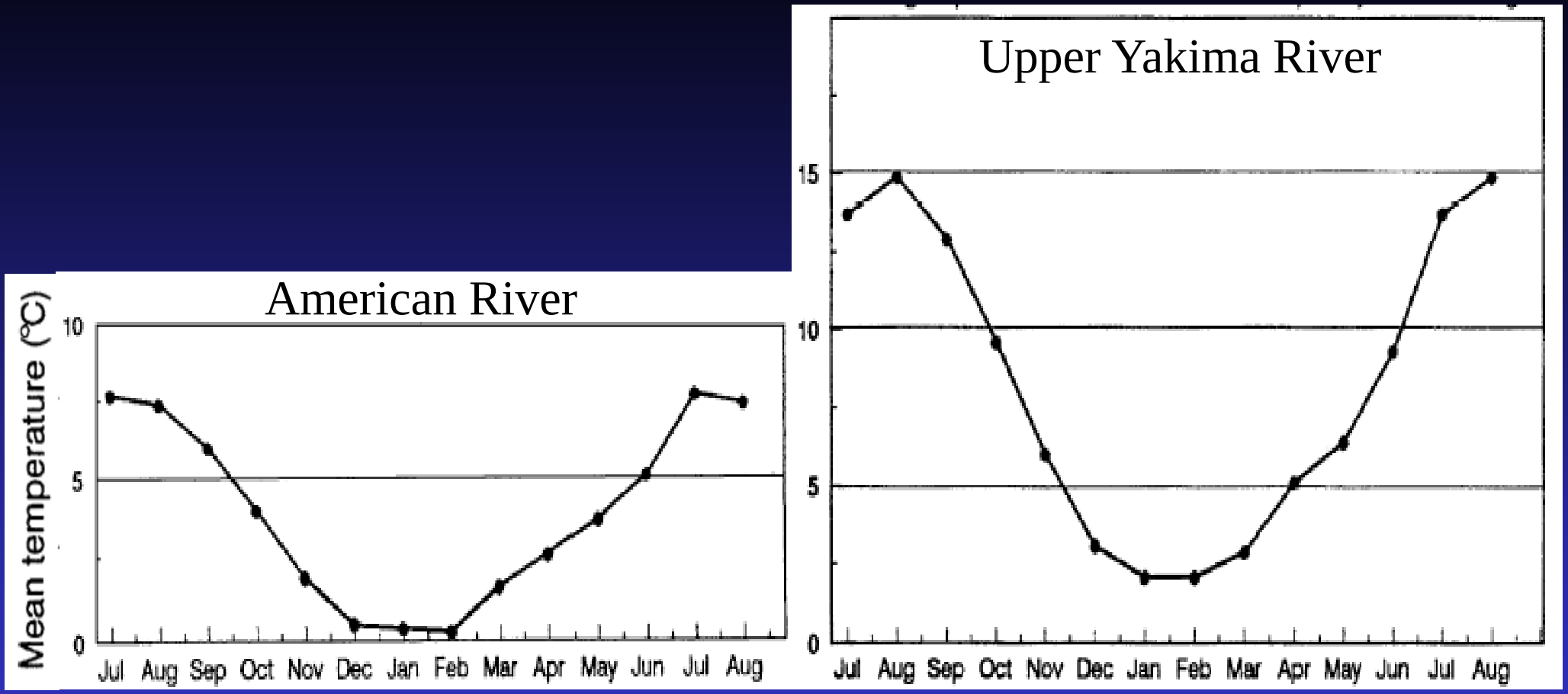
- **Adult migration difficulty – slope/gradient and distance**
- **Water temperature - during adult holding, spawning, egg incubation and juvenile rearing**
  - **Water source – snow melt, storage reservoir**
  - **Solar input – river compass orientation and shading (tree canopy and mountains)**




1200
1000
800
600
400
200
0
Elevation (m)
0
50
100
150
200
250
300
350
River km
LowerMid YakR
Up Yak R
Naches R
L Naches R
Bumping R
American R

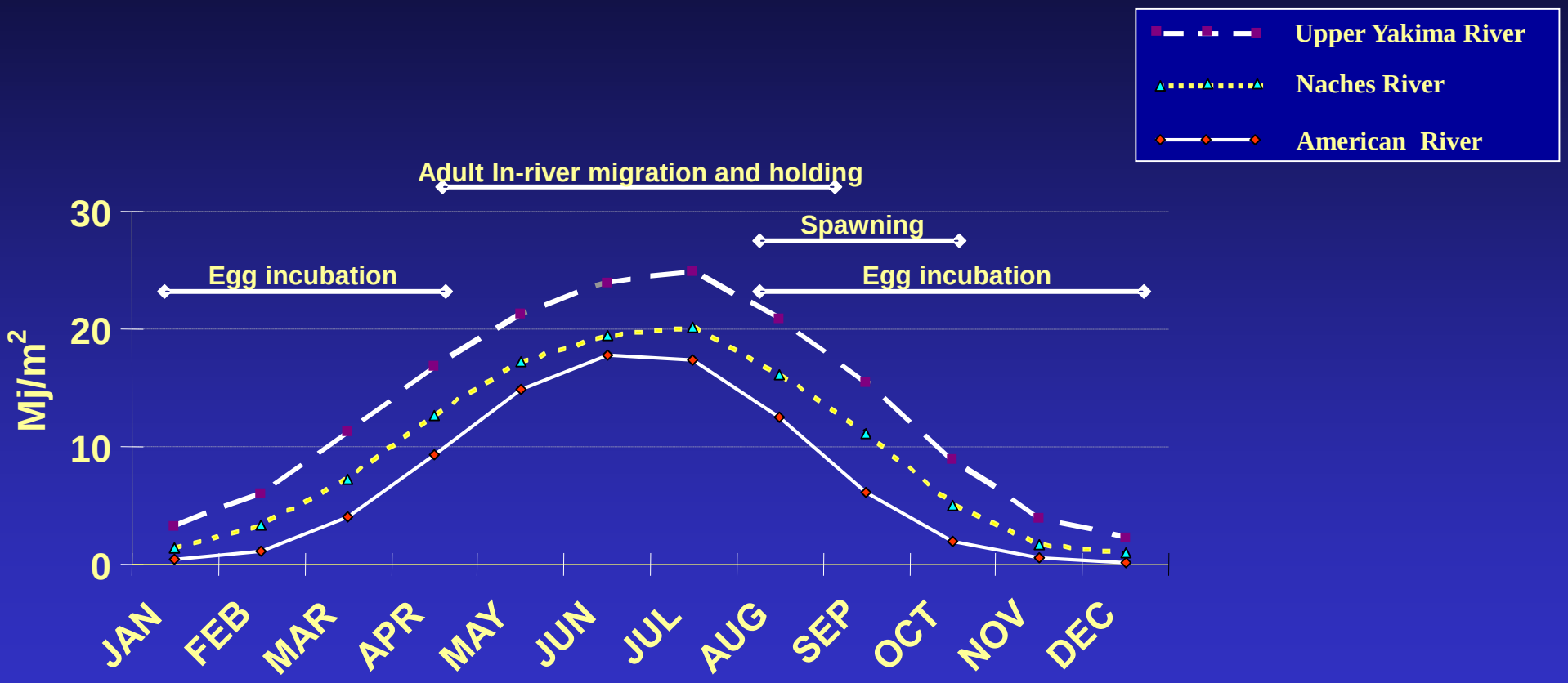
Mean Monthly Water Temperatures

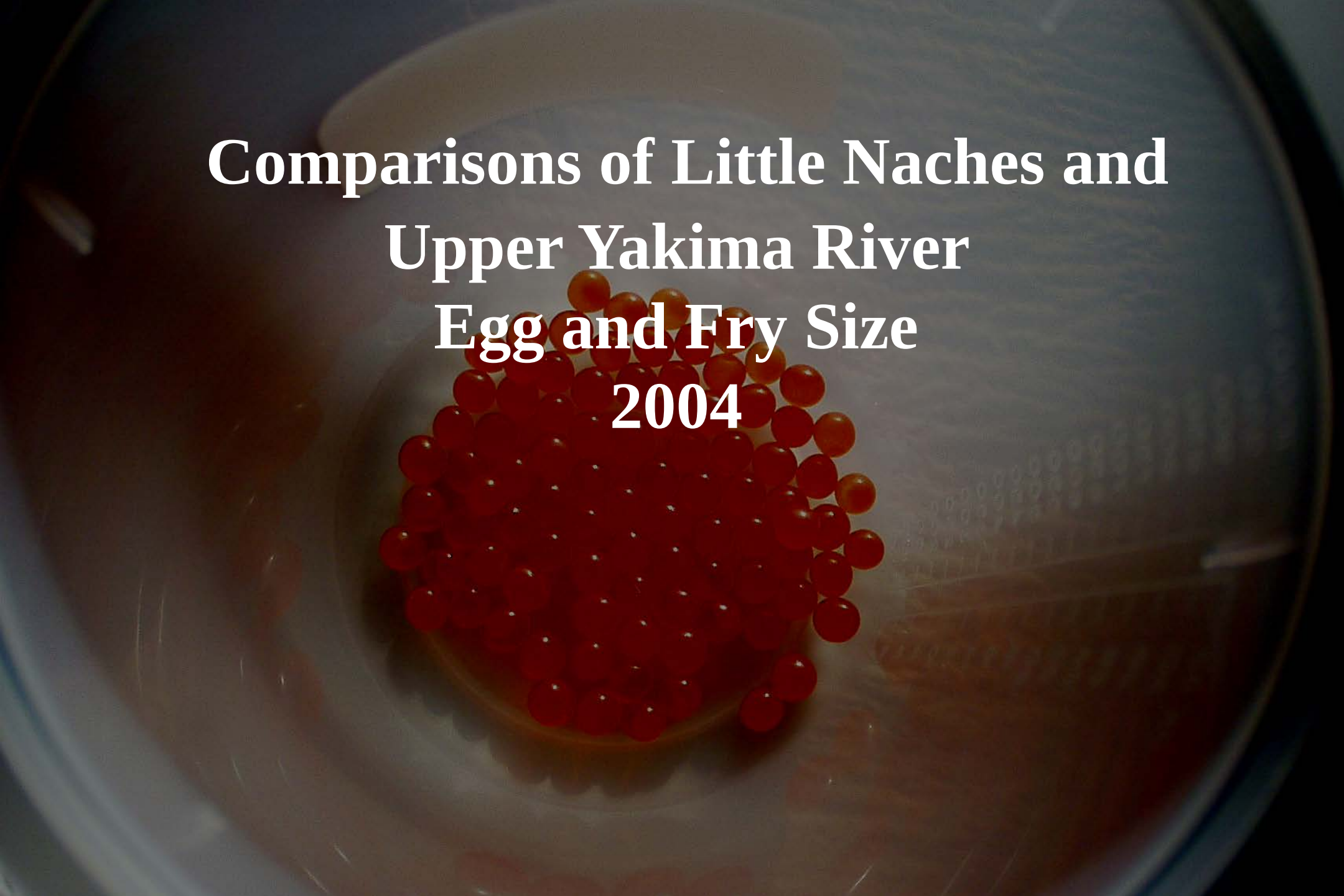




Taken from: Brannon, E. L., M. S. Powell, T. P. Quinn, and A. Talbot. 2004. Population Structure of Columbia River Basin Chinook Salmon and Steelhead Trout. Reviews in Fisheries Science 12: 99–232.

Mean monthly solar input ($Mj \cdot m^{-2}$) by Population

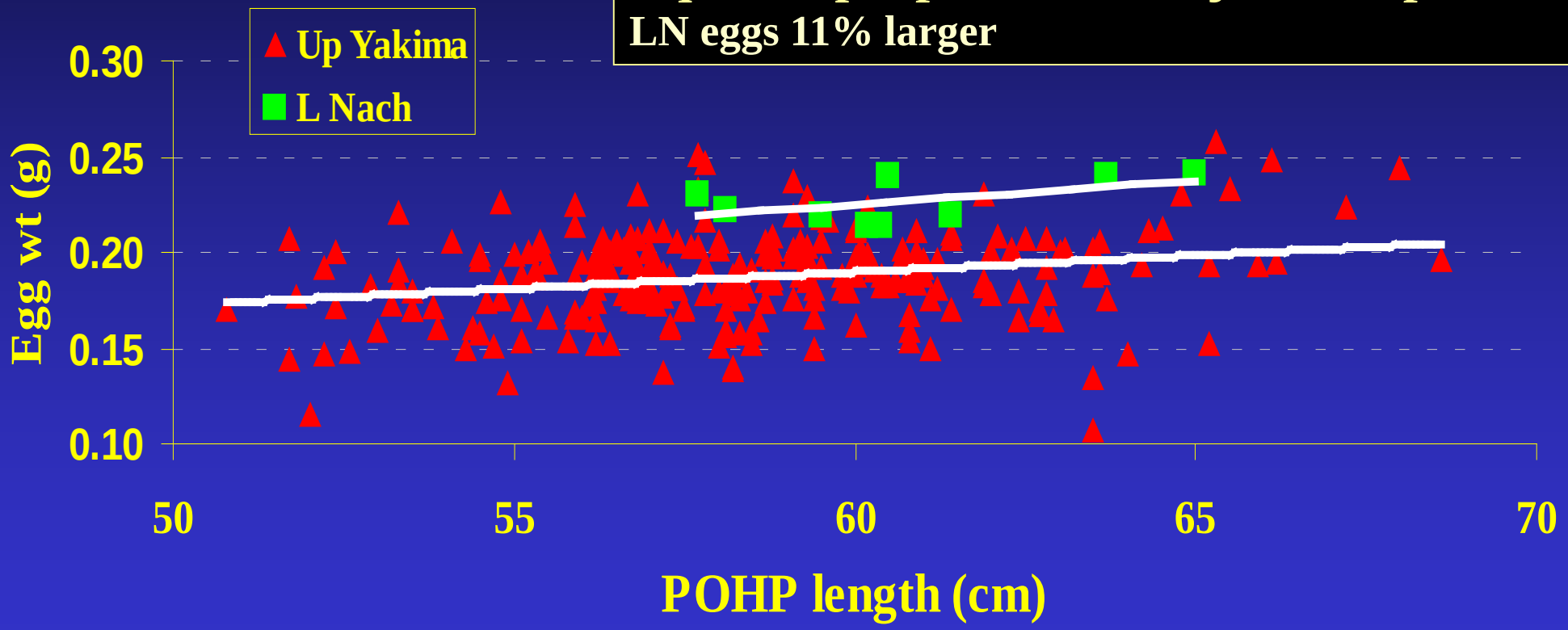




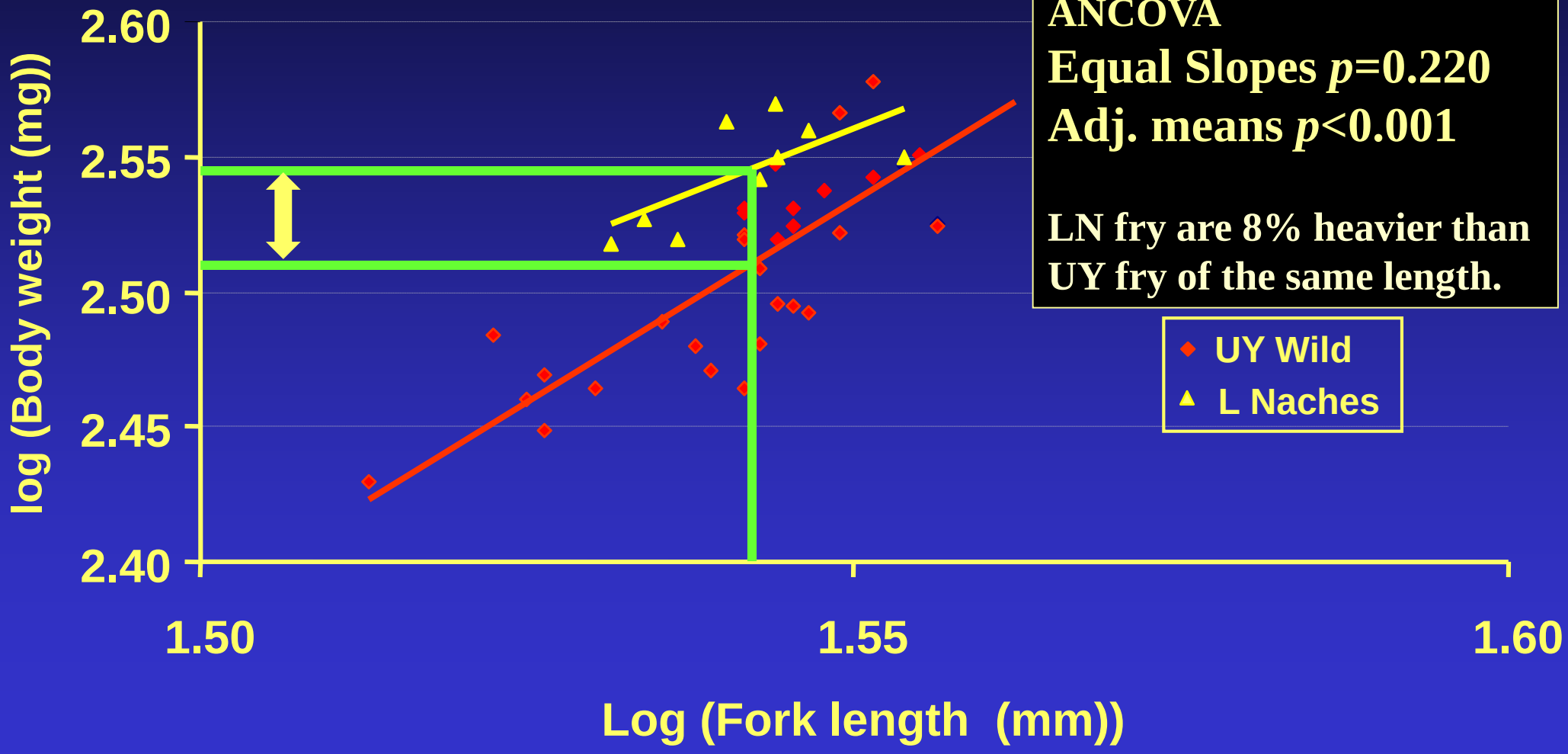
Comparisons of Little Naches and Upper Yakima River Egg and Fry Size 2004

Little Naches and Up Yakima
Egg weights vs Female Length

ANCOVA
Equal slopes p=0.987; Adj. means p=0.020
LN eggs 11% larger



Little Naches and Up Yakima
Emergent Fry Length vs Fry Weight



ANCOVA

Equal Slopes p=0.220

Adj. means p<0.001

LN fry are 8% heavier than UY fry of the same length.

Conclusions: Wild Population Genetic Traits

- **Confirmed that the three reproductively isolated populations; American, Naches and Upper Yakima, based on genetic analyses.**

Conclusions: Wild Population Life-History Traits

- Spawning is spatially isolated – Amer and UY separated by greatest distance.
- Spawn timing of Amer fish was earliest, UY latest, and Naches intermediate in all years.
- American followed closely by Naches have the steepest migration, UY lesser gradient.
- UY highest water temperatures and American the lowest.
- UY highest solar input and American the lowest.

Conclusions: Wild Population Life-History– cont'd

- UY sex ratios were more highly skewed toward females than either American or Naches.
- Average age was greatest in the American, lowest in the UY and, intermediate in the Naches.
- Size-at-age of American returns was largest, UY smallest, and Naches intermediate.
- No trend in body size over time in 9 of 11 comparisons.

Conclusions: Upper Yakima vs Little Naches Gametic Traits

- **Little Naches females had significantly larger eggs than UY females after adjusting for body size differences.**
- **LN emergent fry were significantly heavier than UY fry of the same length (more yolk at emergence) indicating increased parental care.**
- **LN females are less fecund than UY females of the same size, if the populations have equivalent reproductive effort.**

Acknowledgements

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