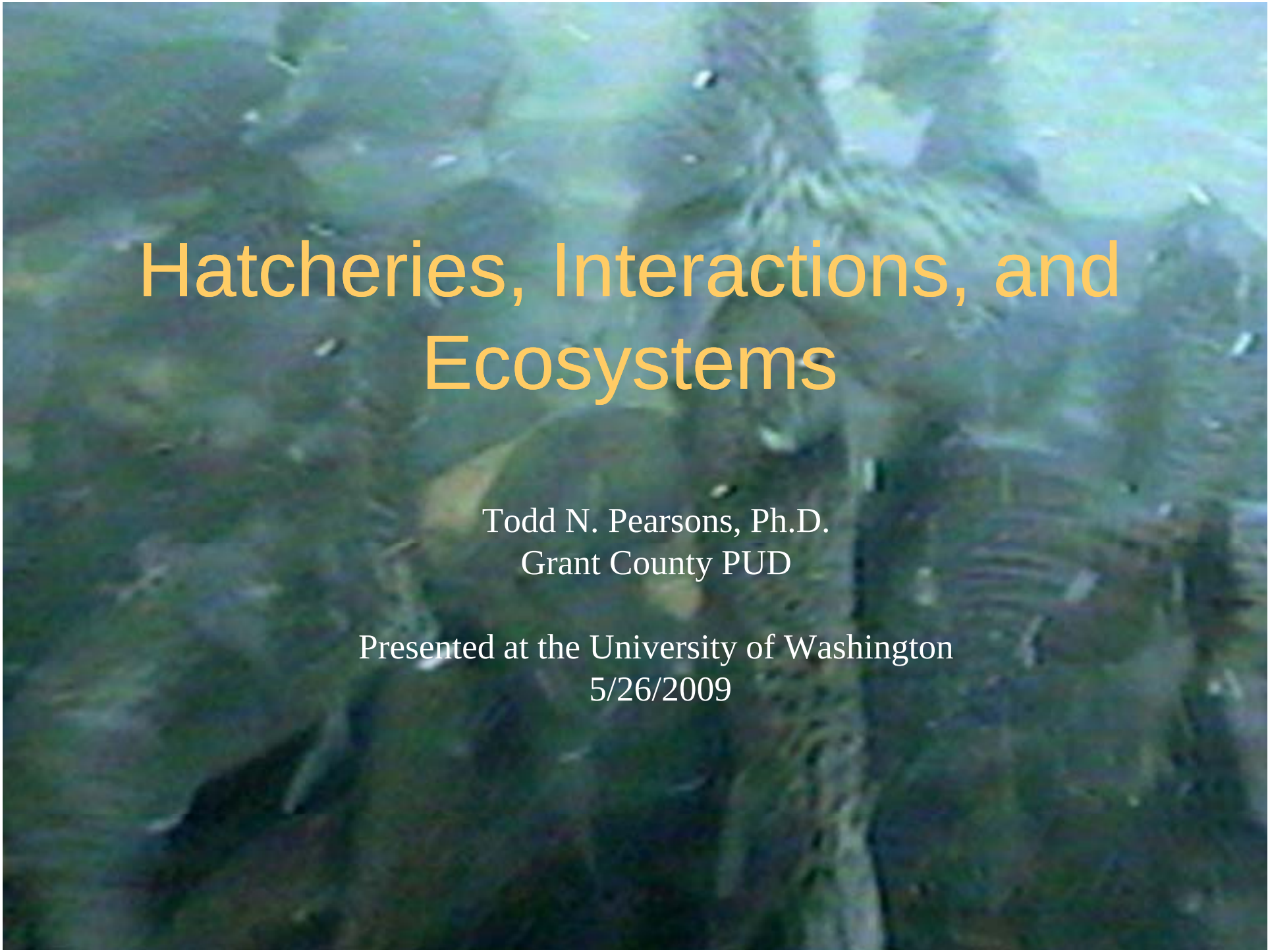

Hatcheries, Interactions, and Ecosystems

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Grant County PUD

Presented at the University of Washington
5/26/2009

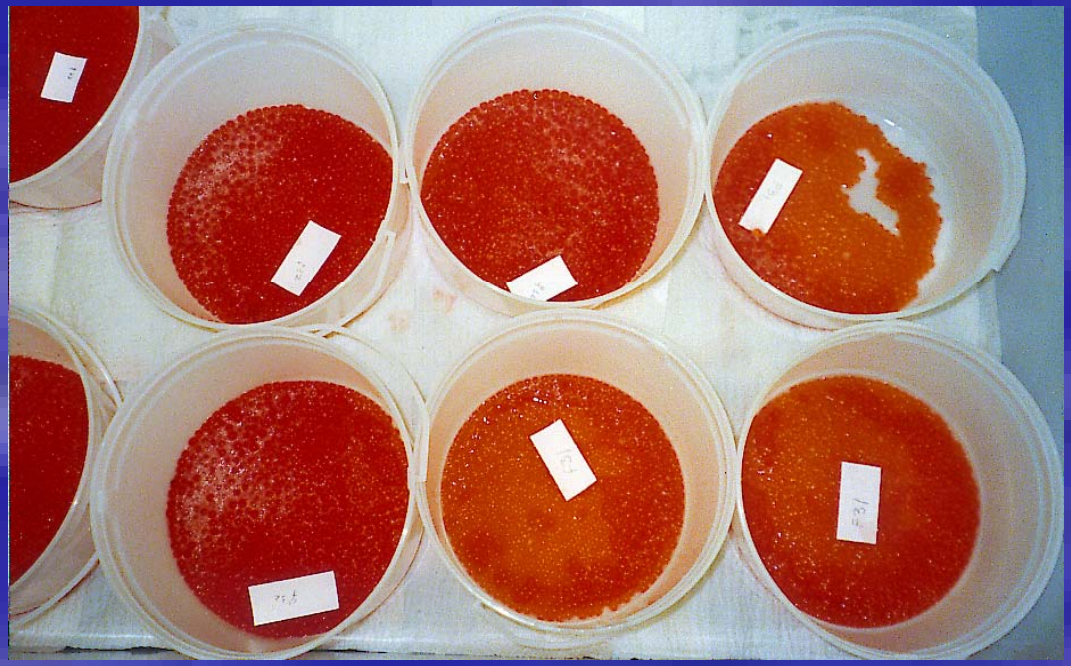

I. Hatcheries

Hatchery Definition (Webster's)

1. A place for hatching eggs
2. A place for the large-scale production of weanling feeder pigs

Hatchery Definition

- The use of artificial breeding, feeding, or protection at any life-stage to enhance the abundance of a taxa



Artificial Propagation - Food

- Plant hatcheries (farming, corn, wheat)
- Mammal hatcheries (ranching, dairies, feed lots, cows, sheep)
- Reptile hatcheries (alligators, crocodiles)
- Bird hatcheries (chickens, turkeys)
- Shellfish hatcheries (shrimp, abalone)
- Fish hatcheries (tilapia, trout, catfish, salmon)

Artificial Propagation - Entertainment

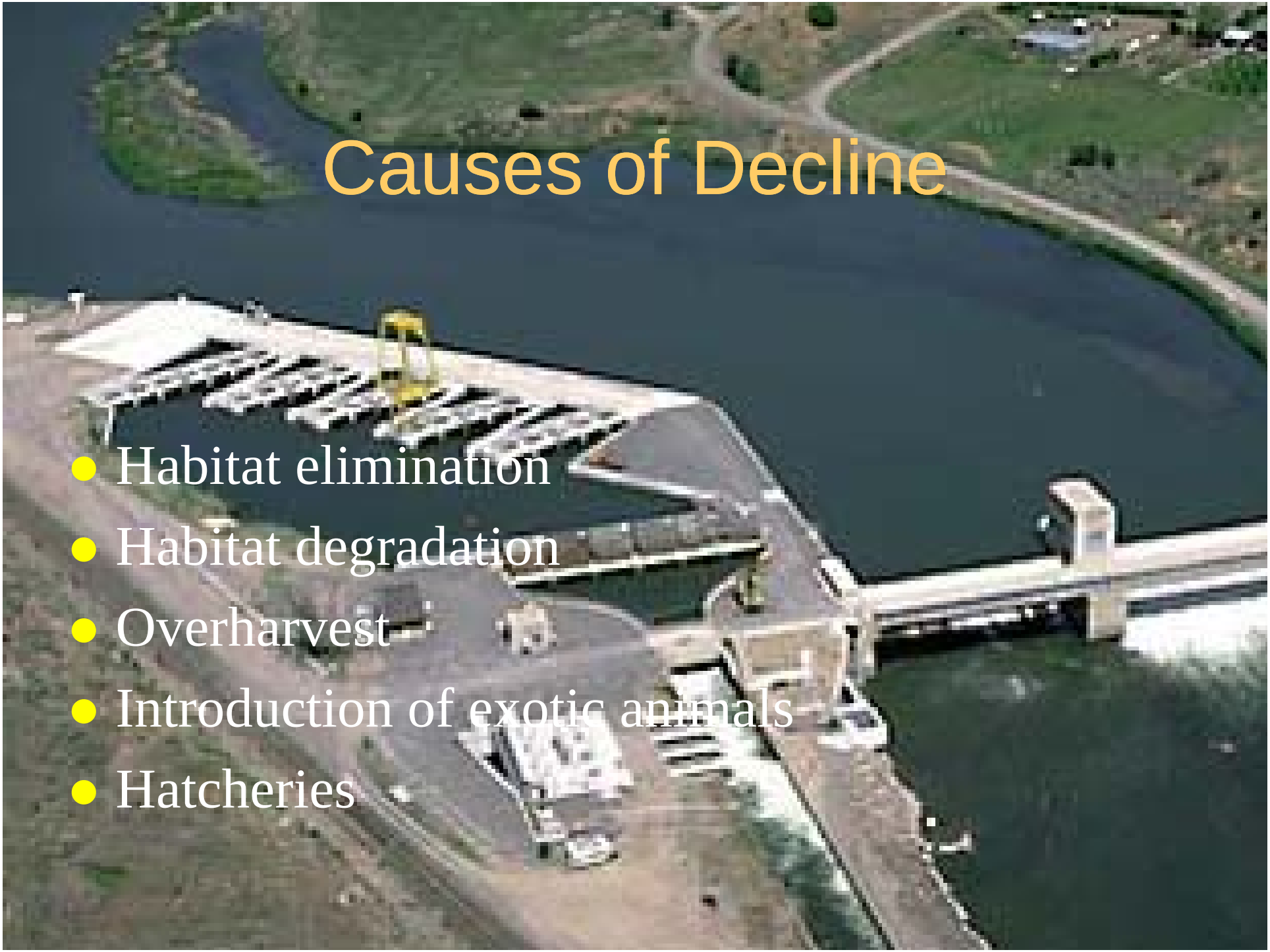
- Zoos
- Aquaria
- Pet stores (dogs, cats, reptiles, birds)
- Movies

Artificial Propagation - Conservation

- Plants (northern wormwood)
- Insects (butterflies)
- Reptiles (turtles)
- Birds (condor)
- Mammals (black-footed ferret, pygmy rabbit, rhinos)
- Fish (Dexter NFH, salmon)

Why We Use Artificial Propagation

- We use artificial propagation because we don’t have enough plants and animals produced in the natural environments to satisfy human needs and/or desires



Causes of Decline

- Habitat elimination
- Habitat degradation
- Overharvest
- Introduction of exotic animals
- Hatcheries

Difficulty

- It is relatively easy to artificially produce plants and animals for food or pets compared to producing plants and animals for contributing to conservation of species in nature
- Challenge – do no harm

Focus on Salmon Hatcheries

- One of the most propagated taxa
- One of the richest propagation histories
- One of the most studied propagated taxa
- One of the most culturally important
- One of the most legally mandated and litigated
- One of the most ecologically significant

Types of Hatcheries

- Integrated (supplementation)
- Segregrated

Supplementation

Wild Fish as Parents

Natural

Hatchery

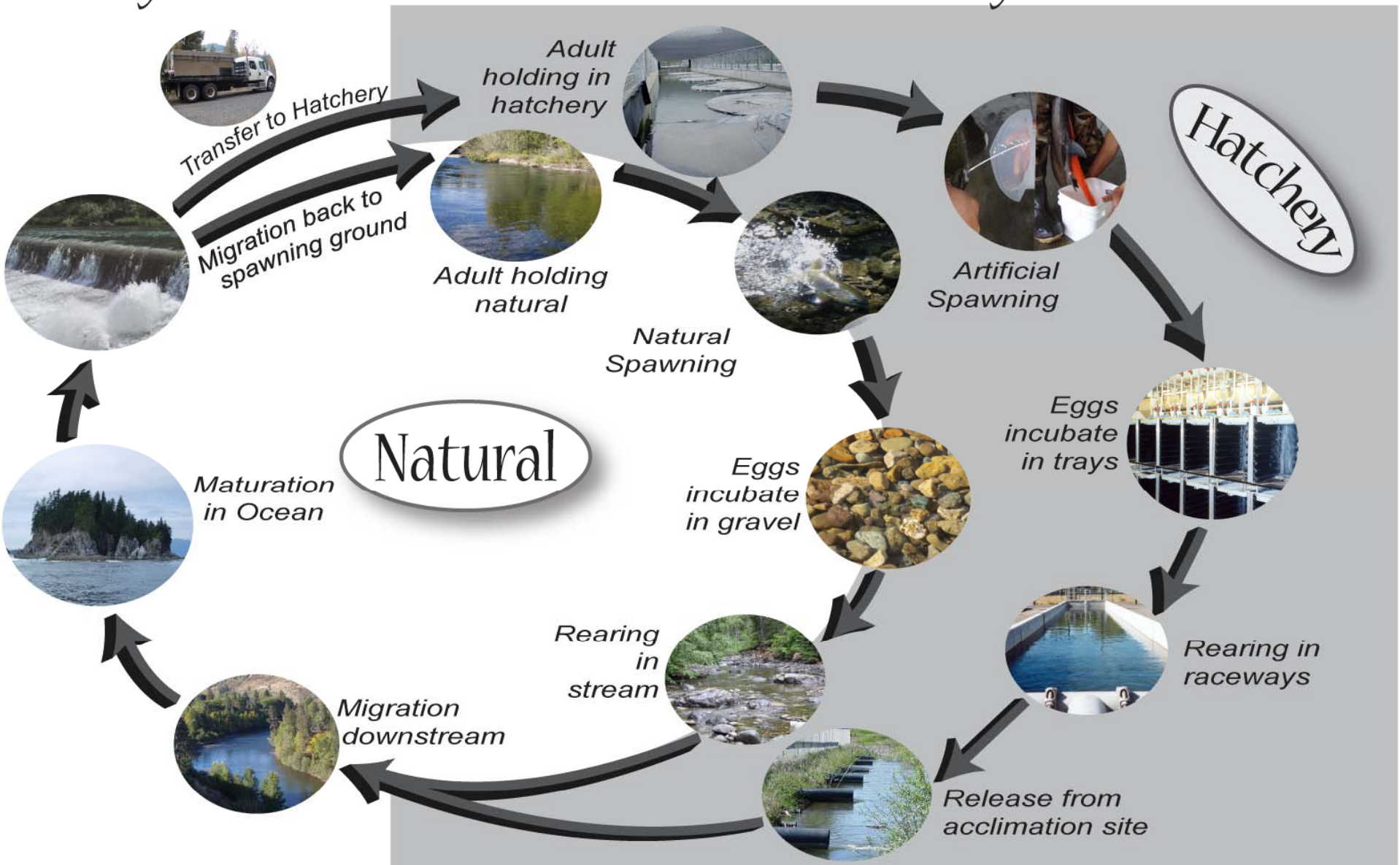
Natural Origin Children

Hatchery Origin Children

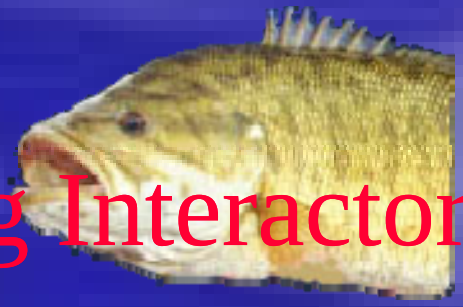
Natural

Natural Origin Grandchildren

Life Cycle of Salmon in Natural & Hatchery Environments



II. Interactions



Strong Interactor Taxa

Spring Chinook Salmon

Stewardship and Utilization Taxa

Critical Scientific Uncertainties

- Can integrated hatchery programs be used to increase long-term natural production?
- Can integrated hatchery programs limit genetic impacts to non-target Chinook populations?
- Can integrated hatchery programs limit ecological impacts to non-target populations?

First Generation Effects

- Cutting-edge facilities and fish culture practices
- Over 30 traits measured

Interactions

- Genetic (domestication)
  - Life-history
  - competition
  - predation
  - precocious maturation
  - reproductive success
- Ecological
  - carrying capacity
  - bass predation
  - bird predation
  - Non-target taxa (spc predation)

Life History Traits

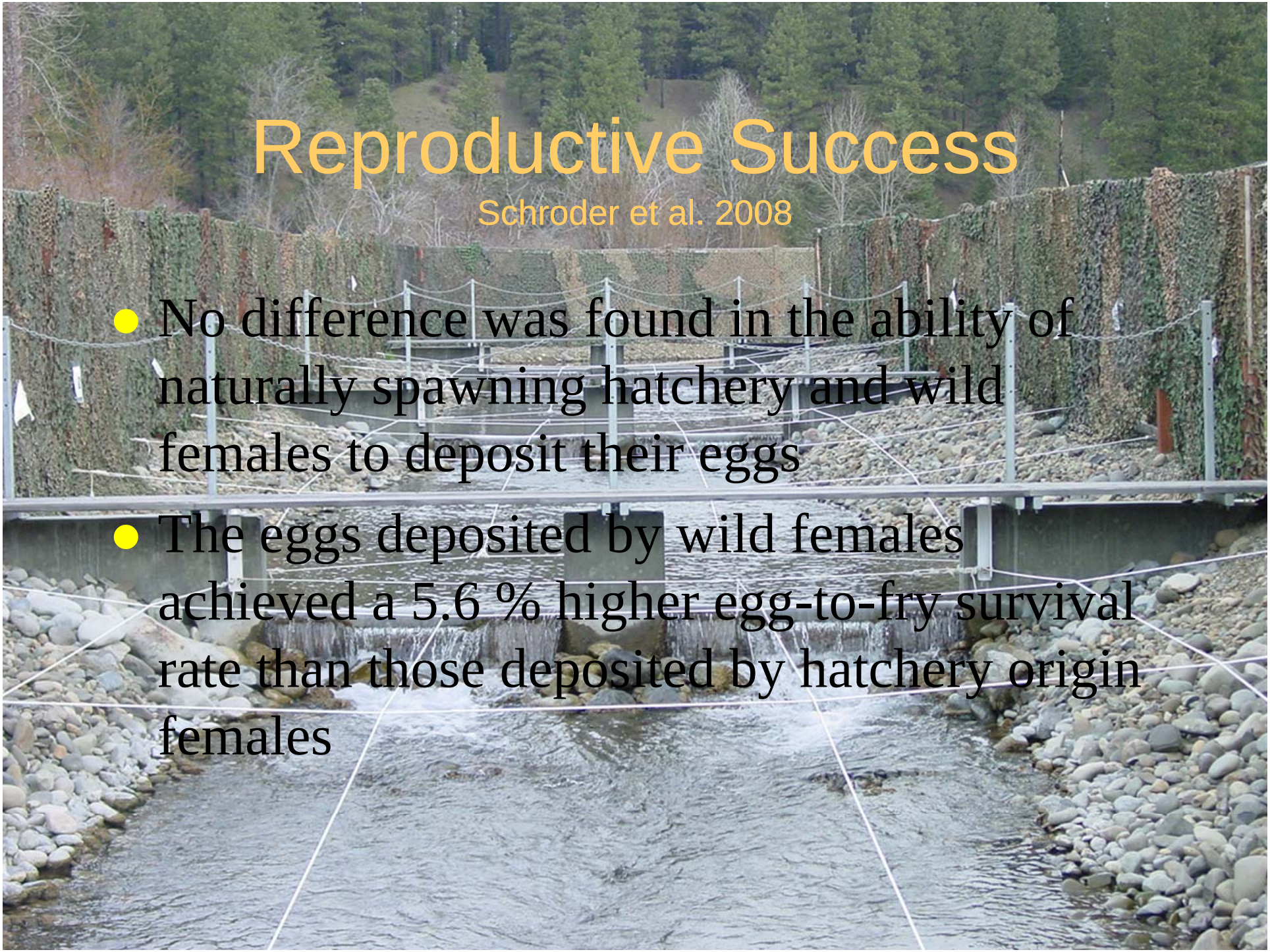
Knudsen et al. 2006

- Hatchery male proportions increased from 38 to 49% (mostly jacks) but changes in natural origin fish were not detected
- Size at age of hatchery fish was smaller
- Mean spawn timing of hatchery fish was 5.1 days earlier than natural origin fish

Female Reproductive Traits

Knudsen et al. 2008

- Relative Fecundity was on average 1.3% greater in hatchery than wild females. Wild females averaged 8.8% greater Total Gamete Mass, 0.8% heavier Individual Egg Mass, 7.7% greater Fecundity, and 0.8% greater Reproductive Effort than hatchery females. After adjusting for egg size, hatchery fry were on average ~1% heavier than wild fry.
- Differences between H and W were mostly due to differences in fish size



Reproductive Success

Schroder et al. 2008

- No difference was found in the ability of naturally spawning hatchery and wild females to deposit their eggs
- The eggs deposited by wild females achieved a 5.6 % higher egg-to-fry survival rate than those deposited by hatchery origin females

Reproductive Success

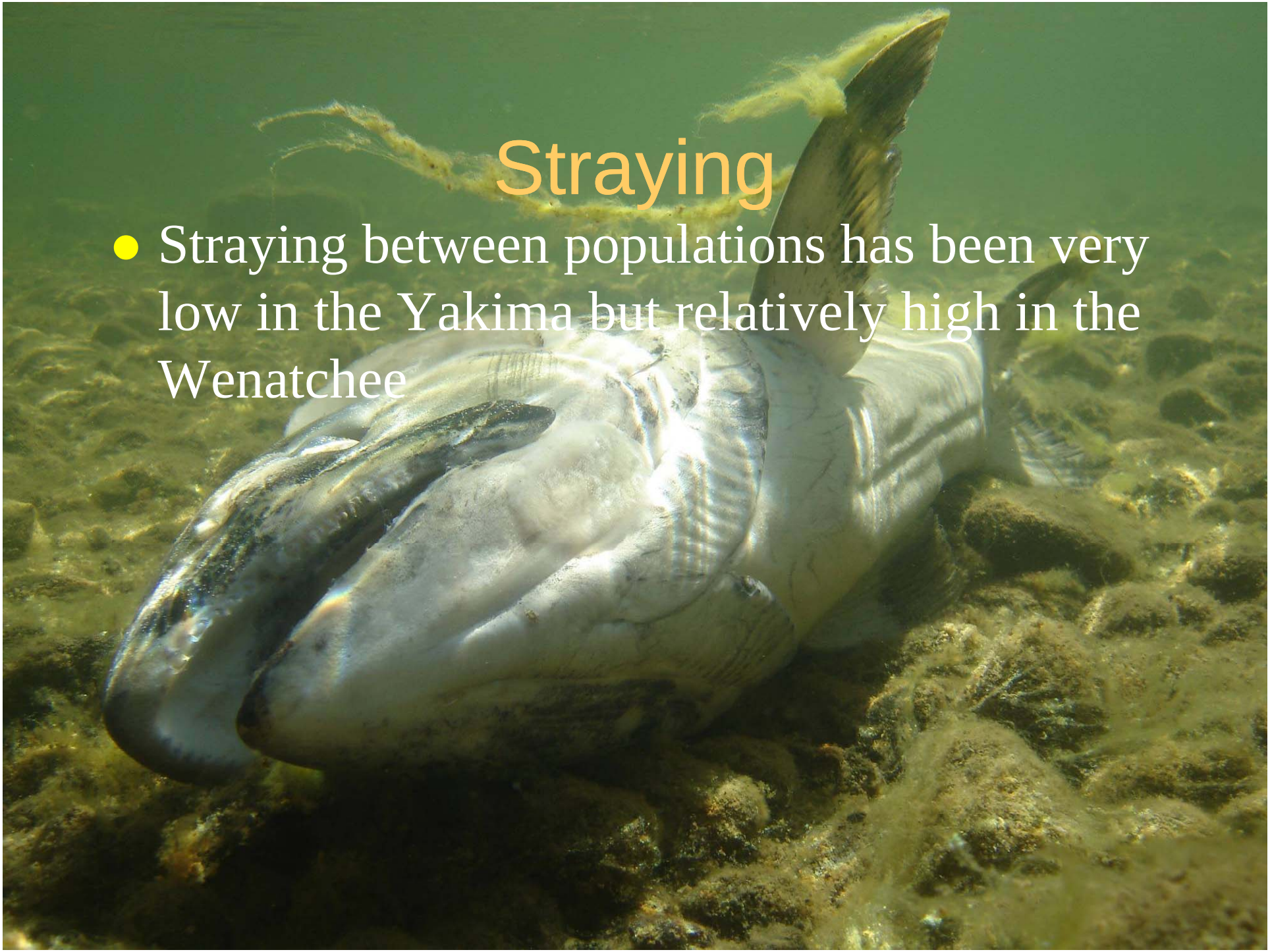
Williamson et al. in review

- Hatchery Chinook had lower reproductive success than wild Chinook in the Wenatchee Basin
- Differences in age structure, spawning location, weight and run timing were responsible for a portion of the difference in fitness between hatchery and natural origin fish
- Spawning location within the river had a significant effect on fitness for both males and females, and for females explained much (but not all) of the reduced fitness observed for hatchery fish in this population

Spawning Habitat

Knudsen et al. in press

- No difference in redd microhabitat was detected between hatchery and wild fish
- Significant differences in microhabitats used among years
- Some differences in spawning location may occur



Straying

- Straying between populations has been very low in the Yakima but relatively high in the Wenatchee

Competition

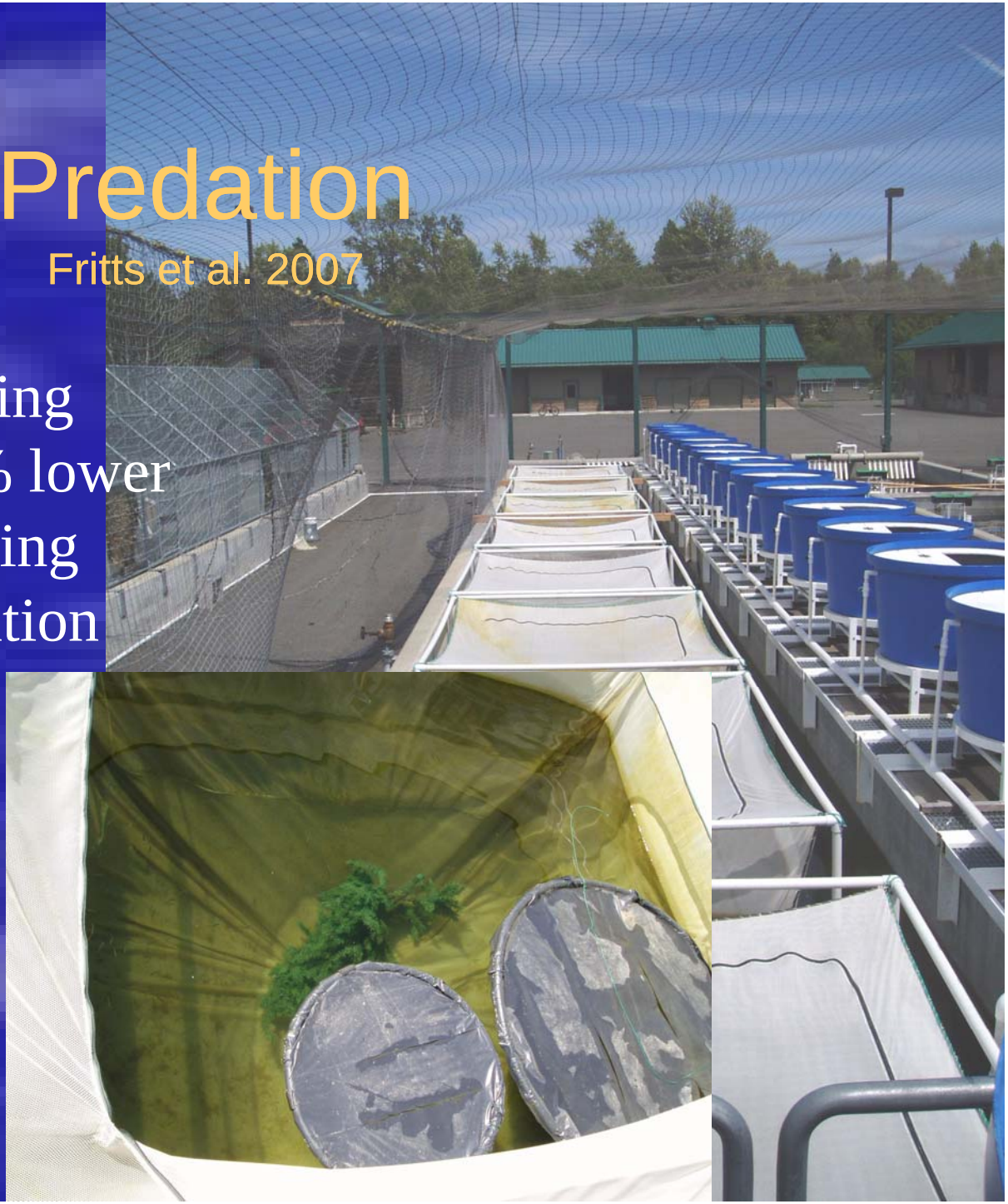
Pearsons et al. 2007

- Hatchery offspring were 6% less dominant P=0.058), 4% less aggressive, and grew 36% less by weight than wild offspring in BY 02 and 03 combined.

Predation

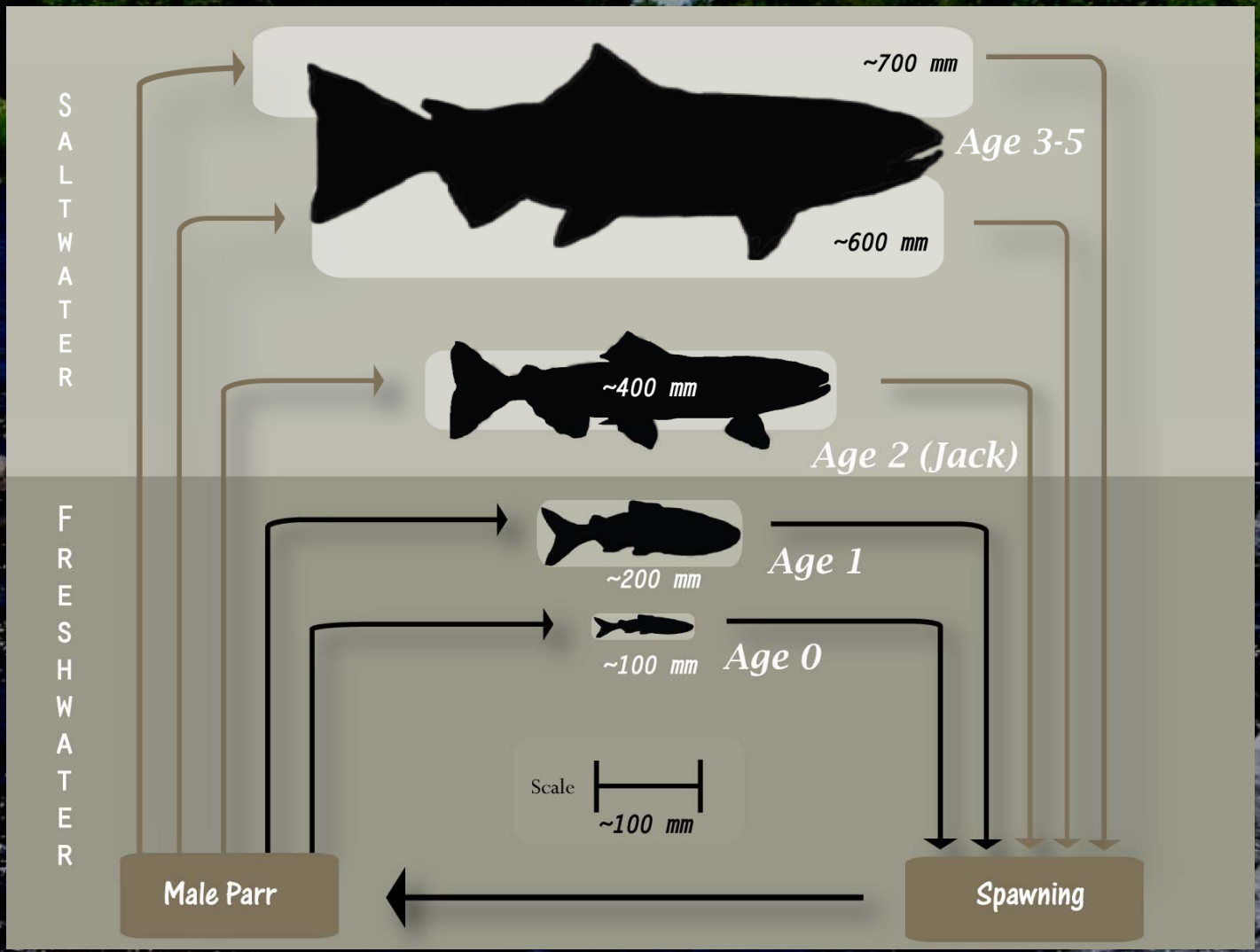
Fritts et al. 2007

- Hatchery offspring survival was 2% lower than wild offspring after one generation (BY 02 and 03 combined).



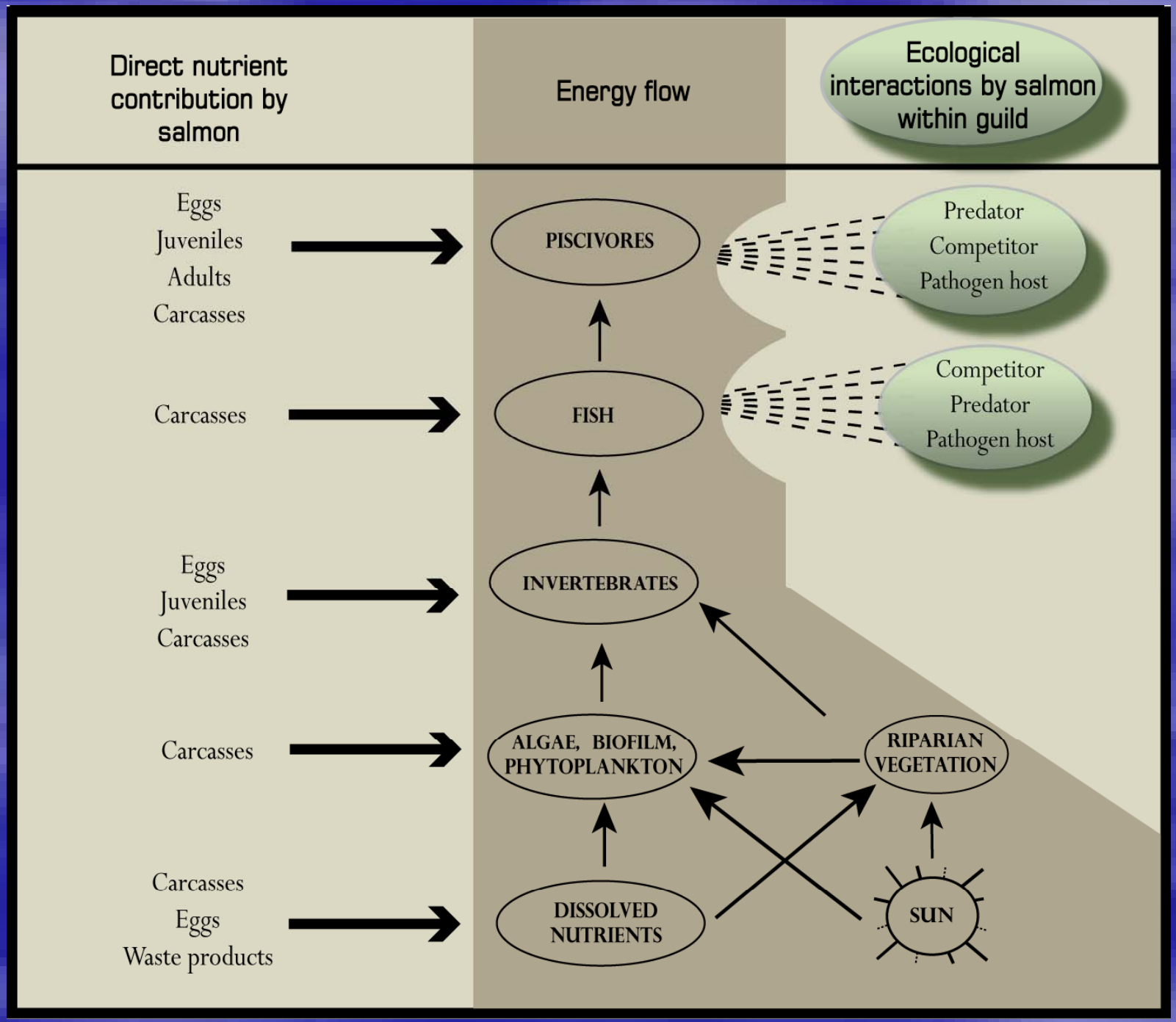
Precocious Male Life-History

Pearsons et al. 2009

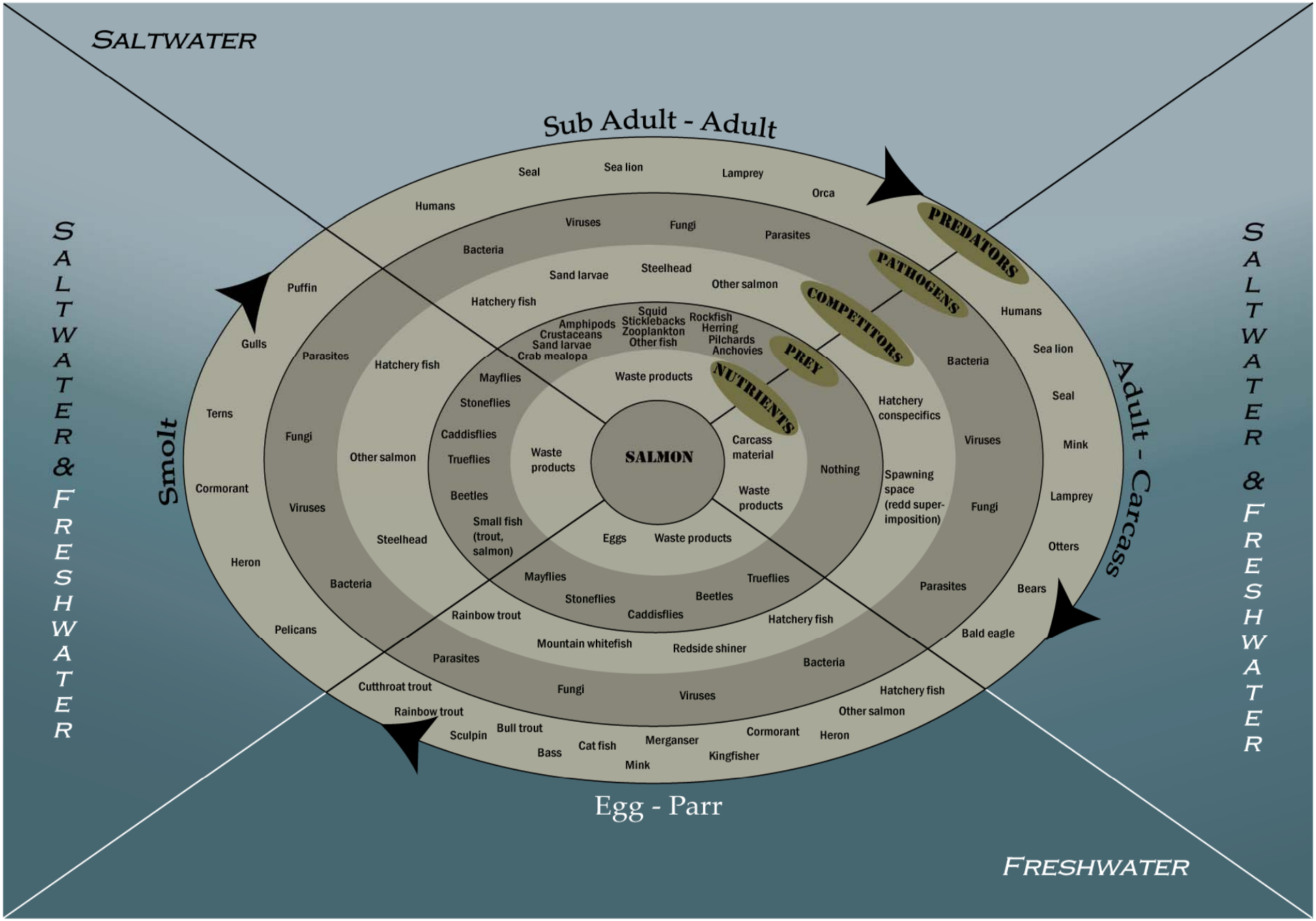


Ecological Interactions

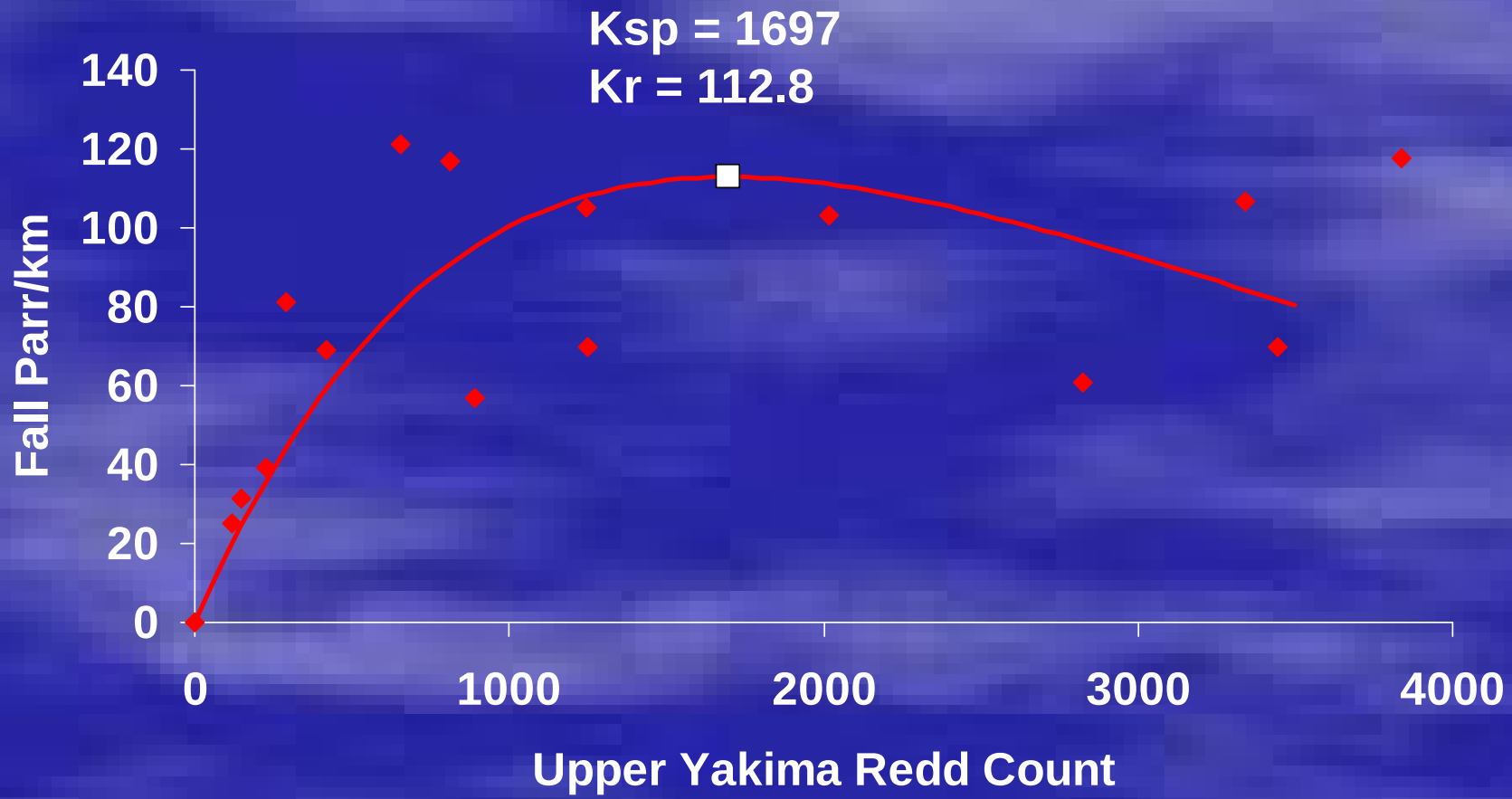
- Concepts
  - carrying capacity
  - bass predation
  - bird predation
  - Non-target taxa (spc predation)


Direct nutrient contribution by salmon
Energy flow
Ecological interactions by salmon within guild
Eggs
Juveniles
Adults
Carcasses
PISCIVORES
Predator
Competitor
Pathogen host
Carcasses
FISH
Competitor
Predator
Pathogen host
Eggs
Juveniles
Carcasses
INVERTEBRATES
Carcasses
ALGAE, BIOFILM, PHYTOPLANKTON
RIPARIAN VEGETATION
Carcasses
Eggs
Waste products
DISSOLVED NUTRIENTS
SUN

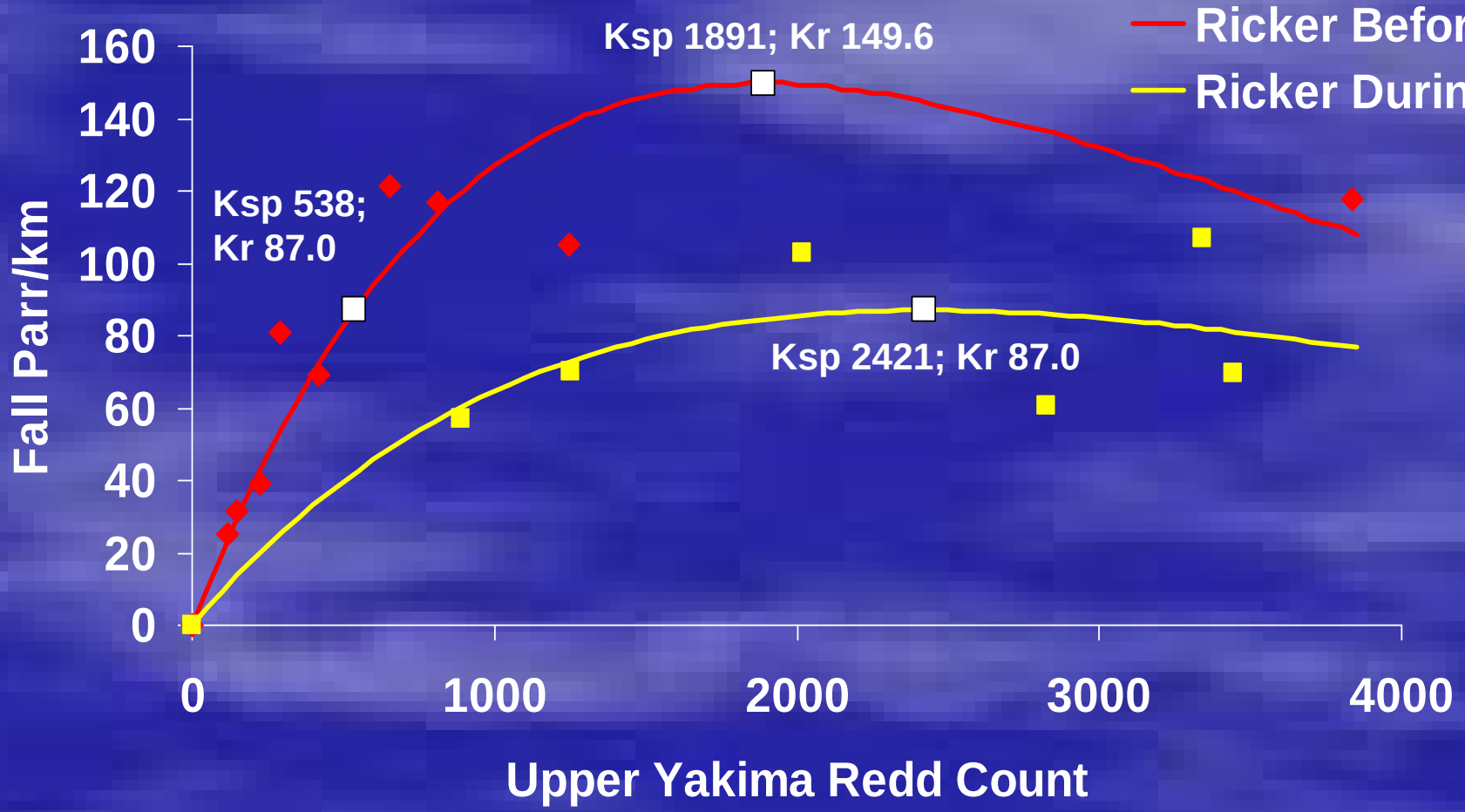
Ecological Interactions Between Salmon and Other Species



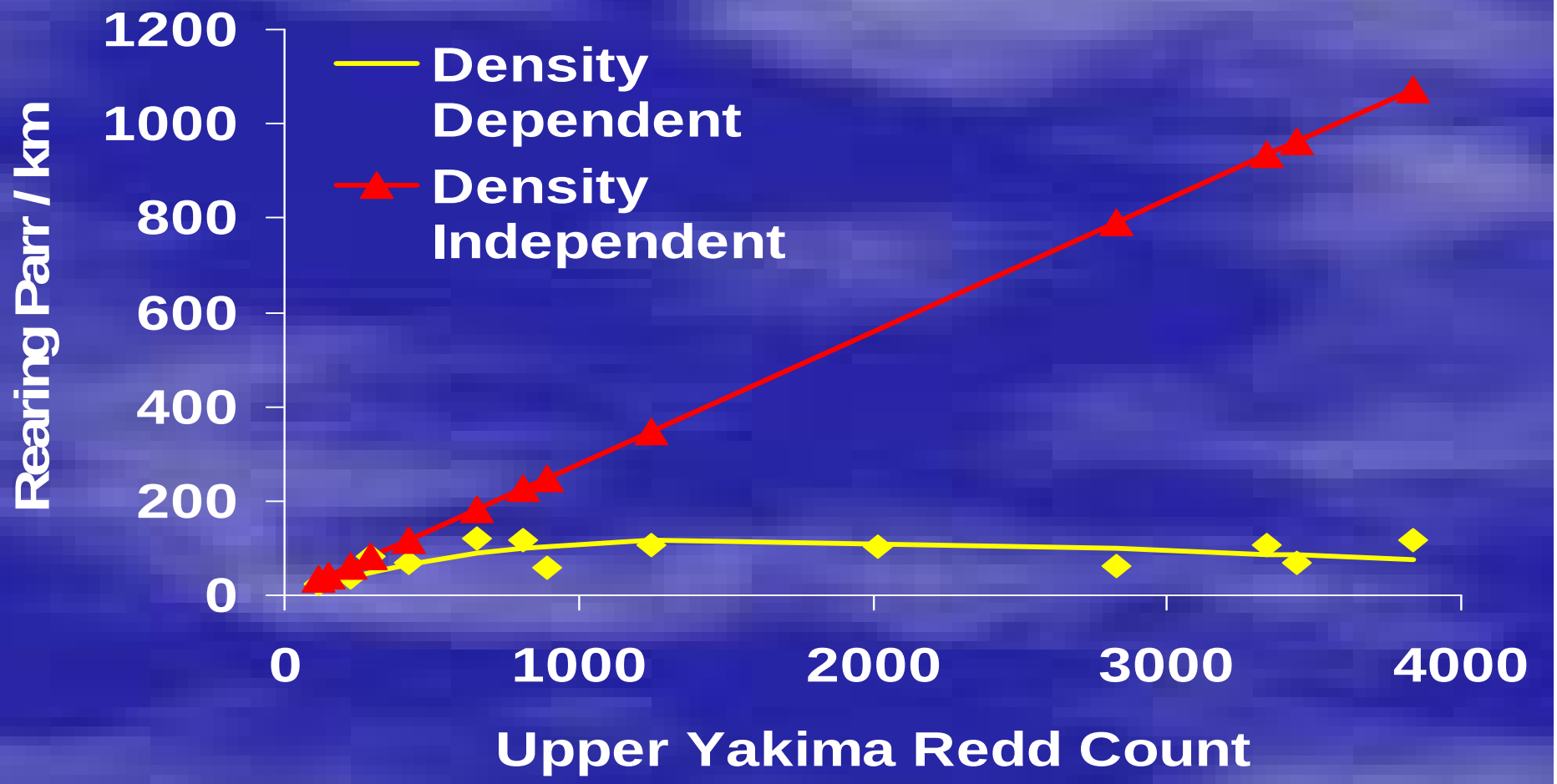
Upper Yakima Redds to Fall Parr (1 year later)



Ricker Model Before vs. During Supplementation



Carrying Capacity



Preliminary Findings

- Density-dependent constraints to natural parr production and size
- Reduction in natural parr productivity associated with supplementation
- Natural production is limited by an interaction between environmental and biological capacity of hatchery fish

Smallmouth Bass Predation

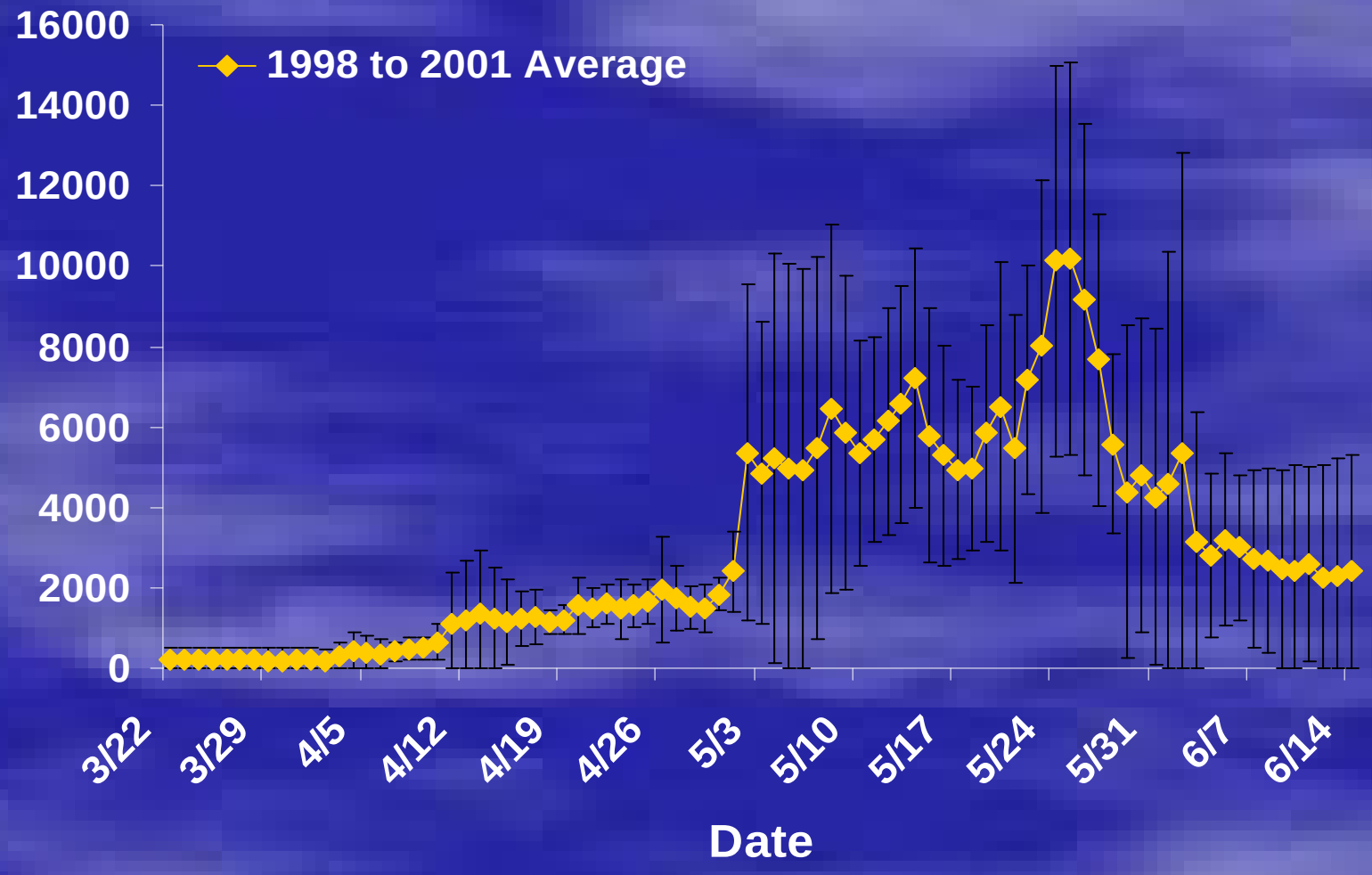
Fritts and Pearsons 2004, 2006, 2008

Yakima History

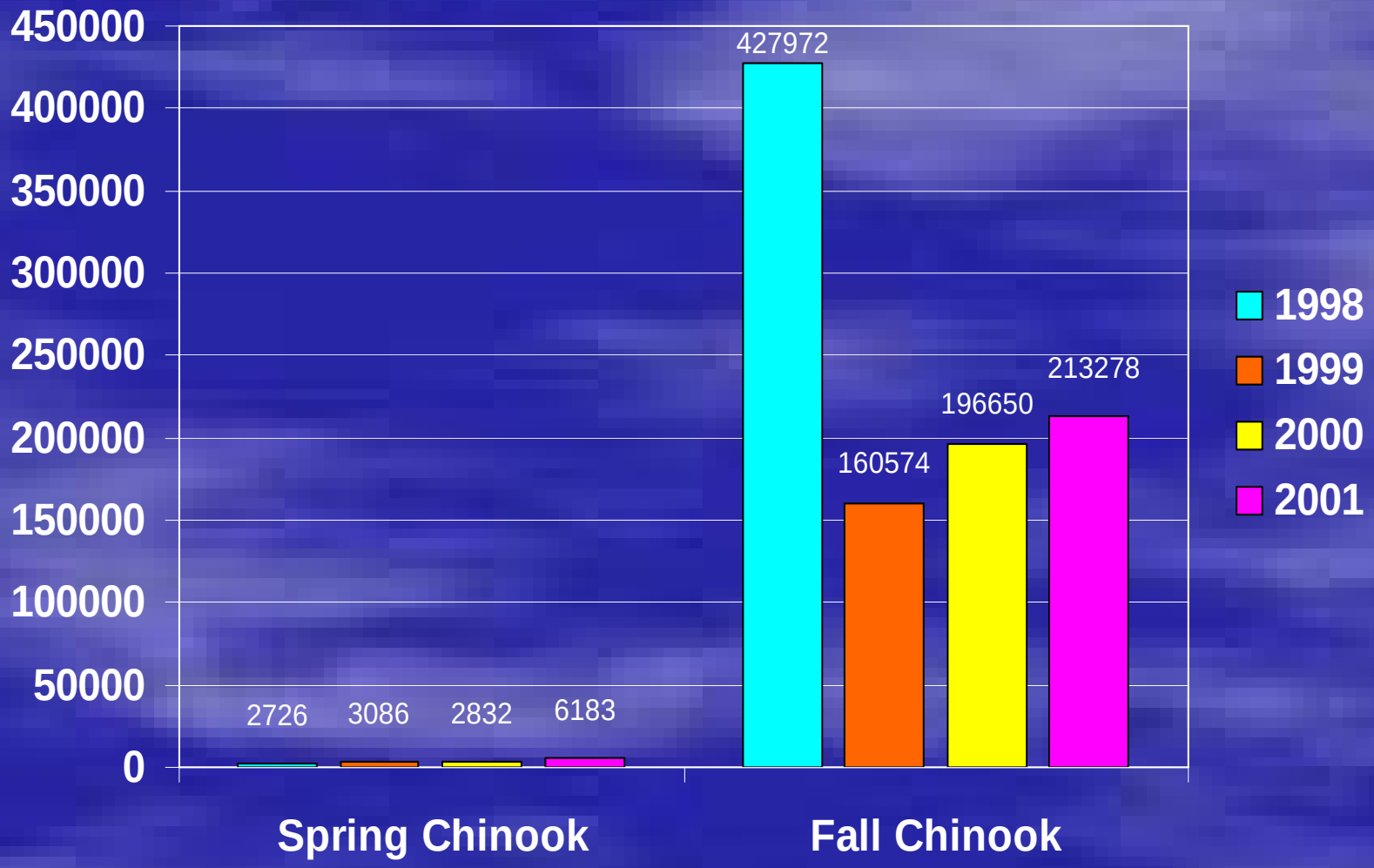
- 5000 planted in the Yakima River in 1925 from an eastern state by state game protector N. E. Palmer
- Second planting in 1934 by N. E. Palmer
- “plentiful from Prosser downstream to the mouth of the Yakima” (M. H. Kershaw, Chief of Police, Kennewick, during the 1940’s)

Methods - Field

Average Daily Population Consumption of Salmonids



Population Consumption



Bird Predation

Major et al. 2005; others

- Local and non-local birds
- Predation is high at “hot spots” (<10.3% of juvenile salmonids passing assuming all fish consumed were salmonids
- Abundance and dominant bird species have changed dramatically over the years

Non-target Taxa Monitoring

Pearsons and Temple

Ecological Interactions Team

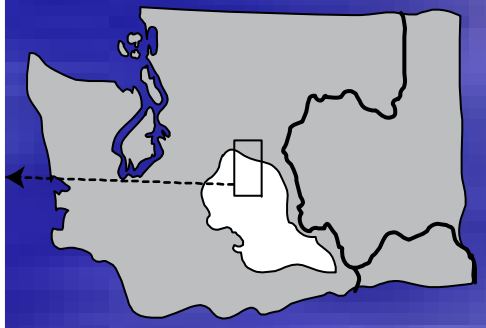
Washington Department of Fish and Wildlife

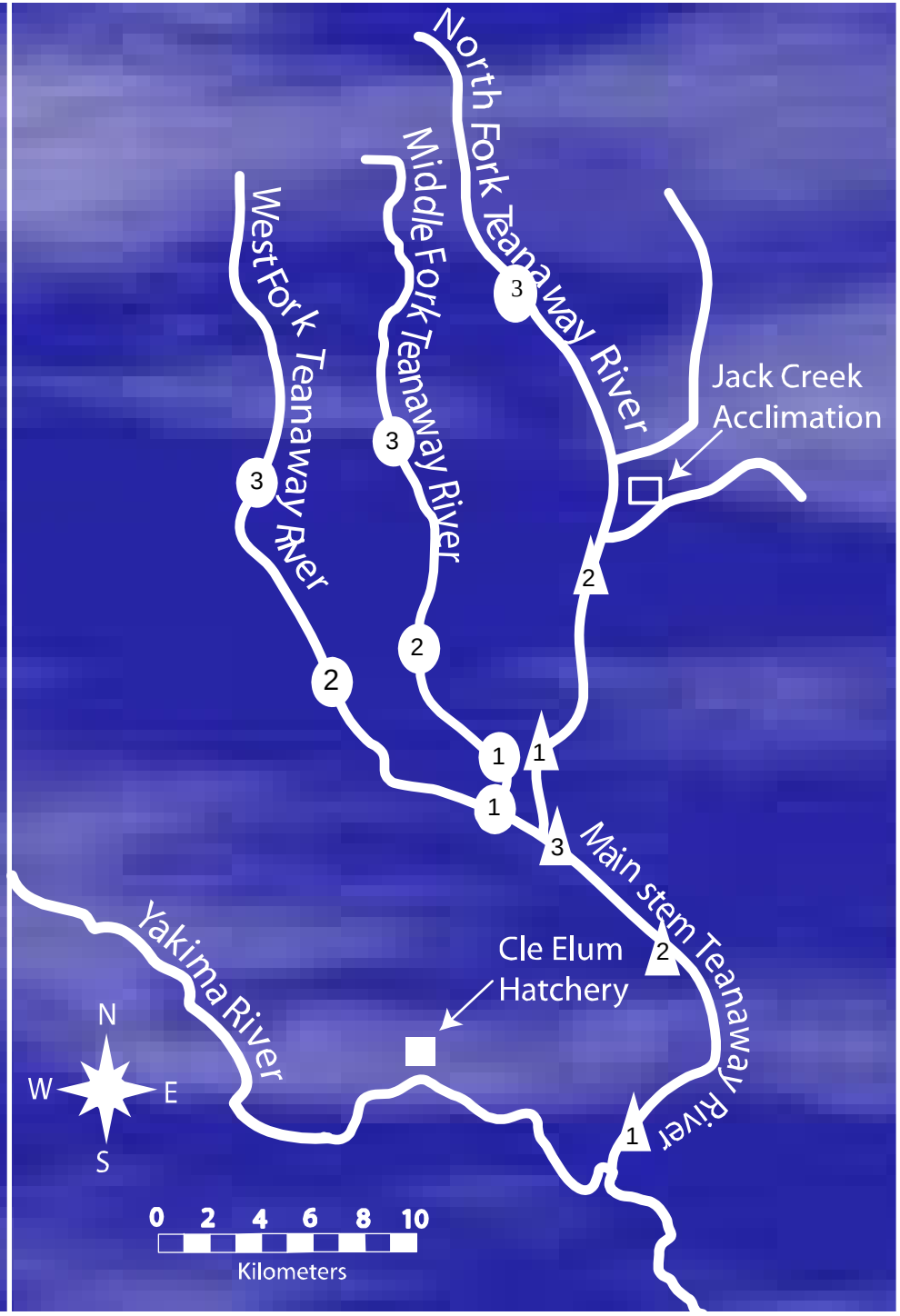
Methods…..

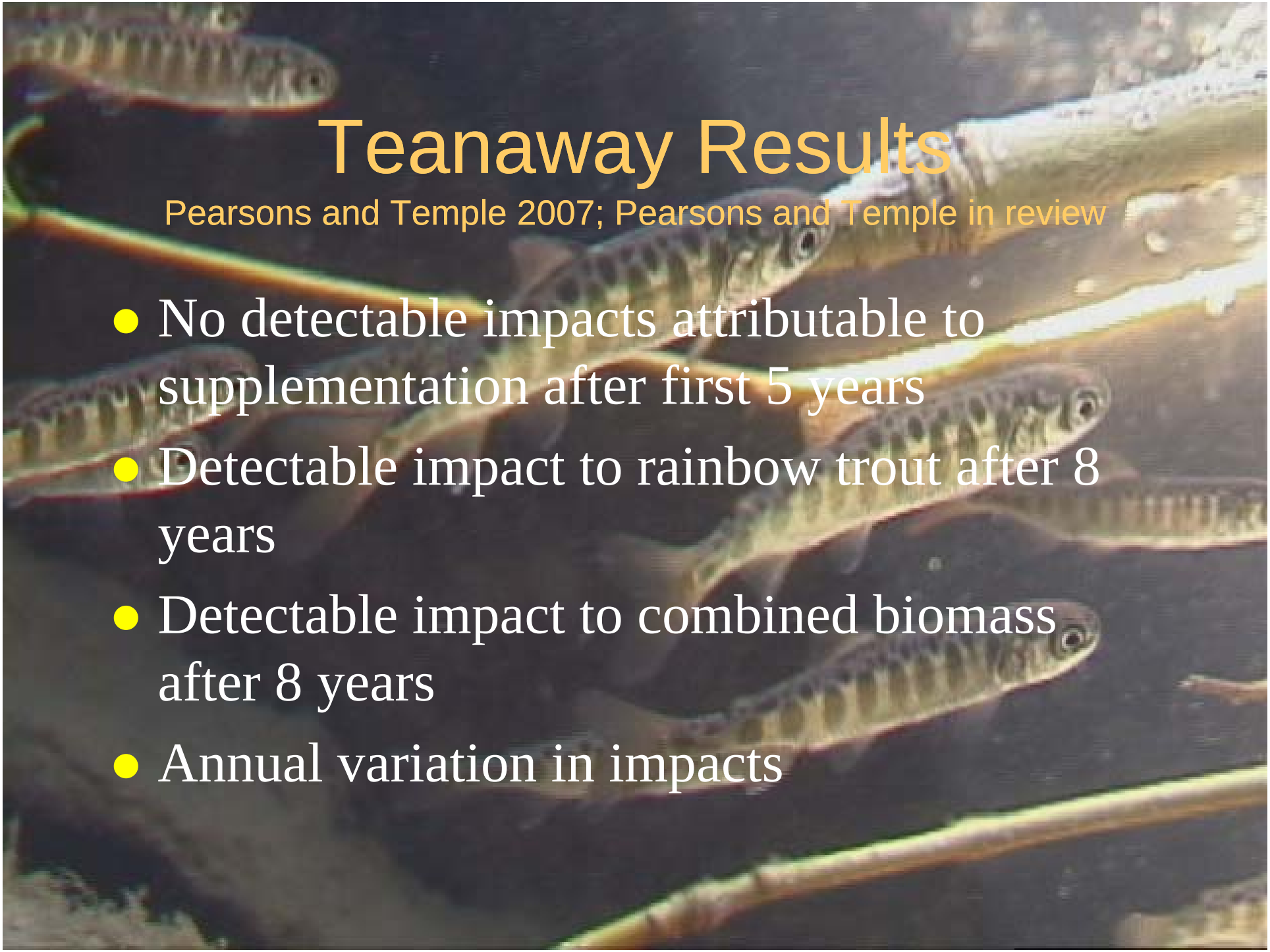
Special thanks: BPA, YN, and EIT staff


Containment Objectives
≤0%
≤5%
≤10%
≤40%
sustainability
Pearsons et al. 1998, BPA Report DOE/BP 64878-6

Teanaway Basin BACIP Sites







Teanaway Results

Pearsons and Temple 2007; Pearsons and Temple in review

- No detectable impacts attributable to supplementation after first 5 years
- Detectable impact to rainbow trout after 8 years
- Detectable impact to combined biomass after 8 years
- Annual variation in impacts

Ecological Implications
(Pearsons 2008)

- We shouldn't expect that altering the abundance of a strong interactor like salmon will not have impacts to other species
- How do we facilitate the positive interactions (e.g., nutrient enhancement, predator swamping, niche partitioning) and reduce the negative ones (competition, predation, disease)?

Hatchery Reform

- The findings from the examples listed were from a program that was consistent with the recommendations of the HSRG
- Is there room for more reform (ecosystem perspective)?


III. Ecosystems

Adaptive Stocking Concept

(Pearsons, In review)

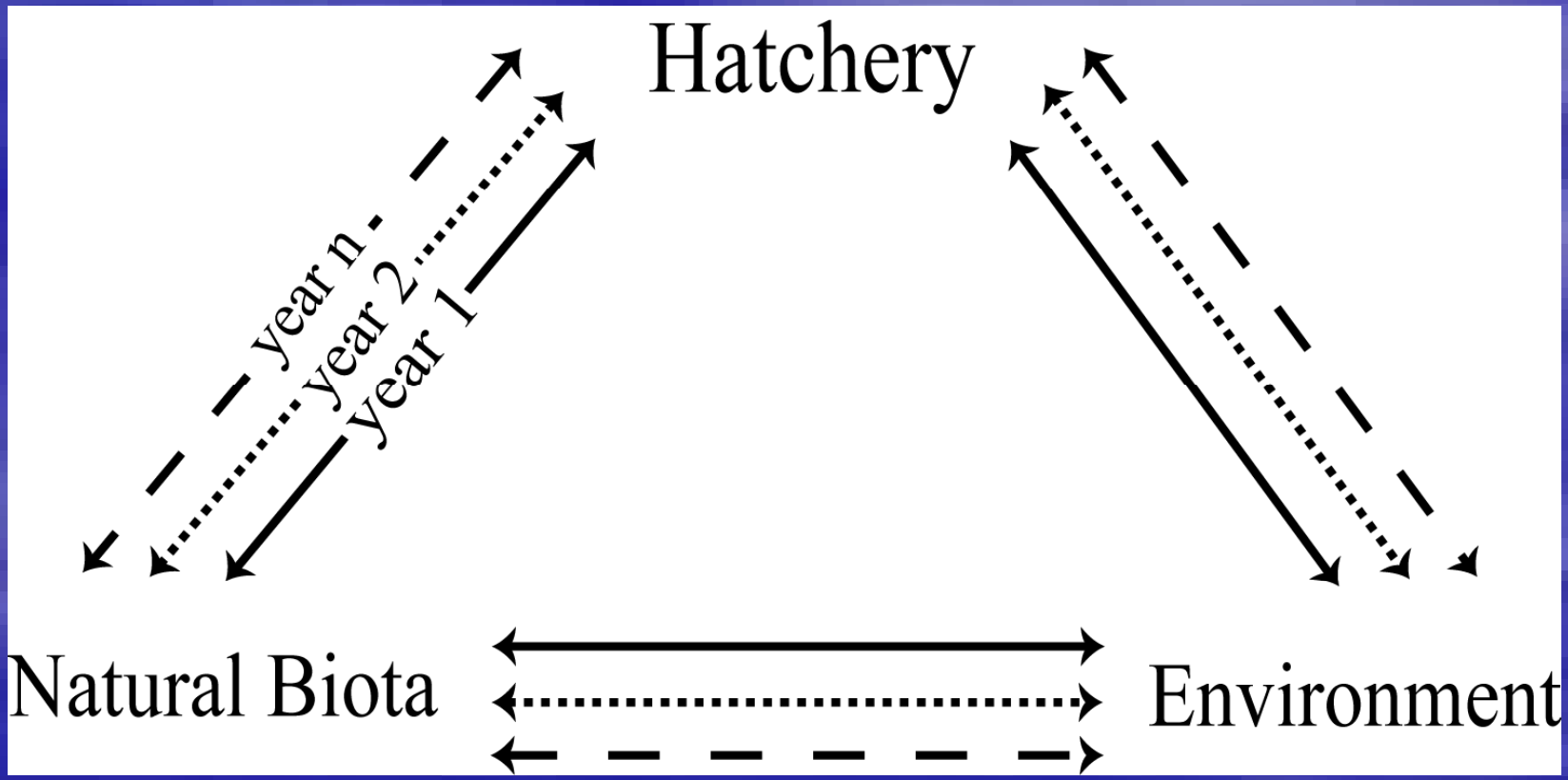
Traditional Hatchery Paradigm

- Release approximately the same species and number of fish every year from the same location(s) regardless of ecological conditions

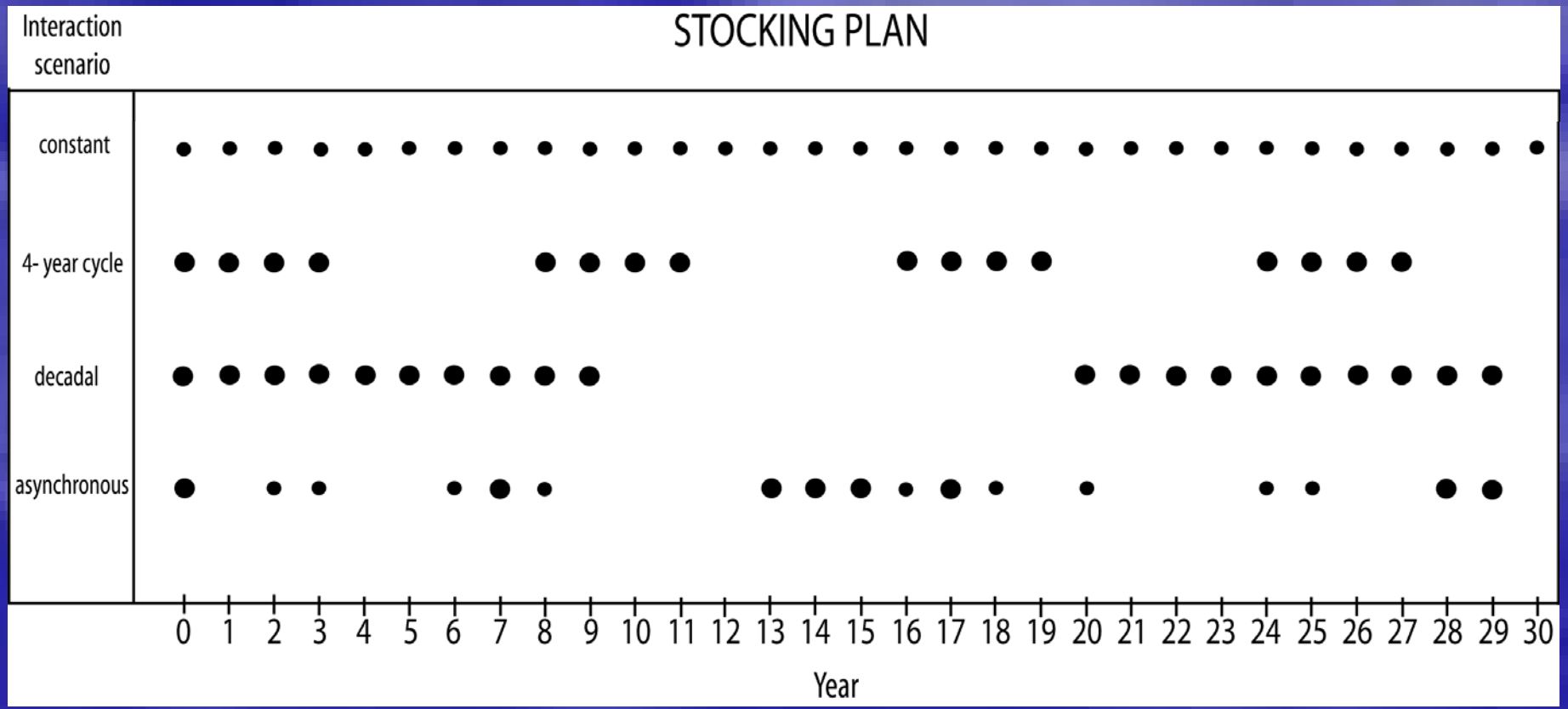
Deficiencies of Paradigm

- Ignores ecological feedback mechanisms
- Assumes carrying capacity is static and under-seeded
- Low consideration of impacts to other species

Temporal Variation



Hypothetical Stocking Plans



Adaptive Stocking Approach

- Stock when ecosystem indicators are acceptable
- Do not stock when ecosystem indicators are not acceptable

Ecosystem Indicators

1. Risks to non-target taxa
2. Carrying capacity or density dependent impacts
3. Ecological feedback

1. Risks to non-target taxa

- Expert based approach
- Modeling approach
- Containment monitoring approach

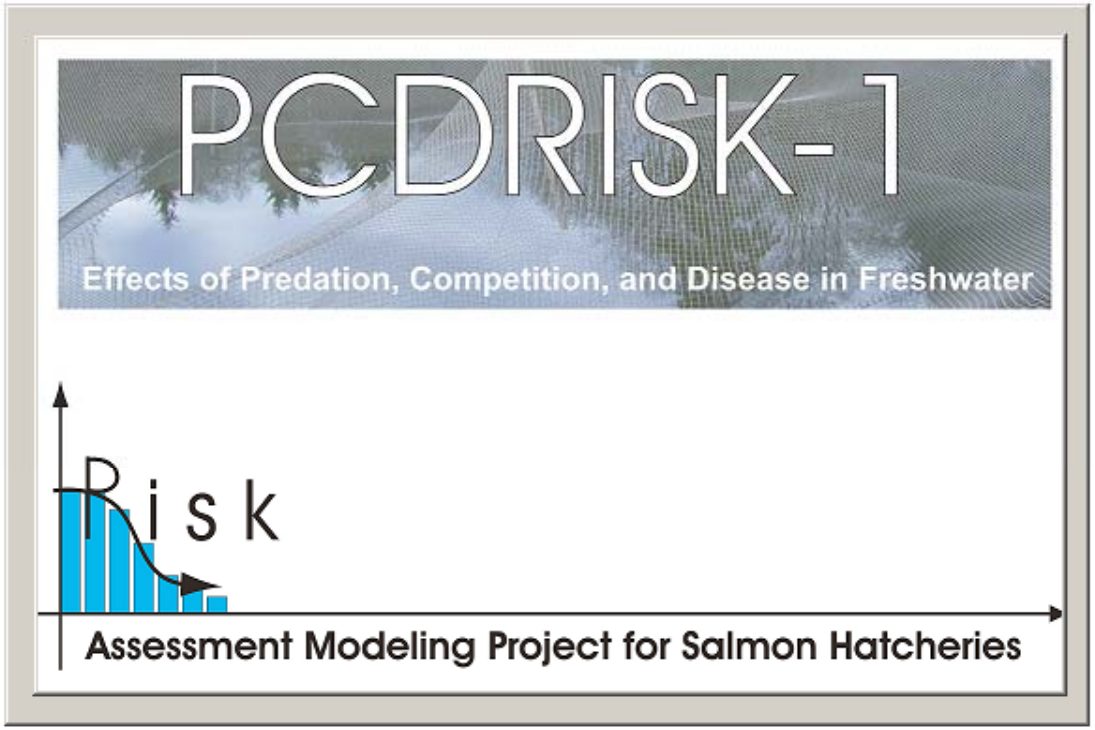
Expert Based Approach
(Pearsons and Hopley 1999)

- Experts estimate impact probabilities to NTTOC and then the probabilities are averaged and variance estimated
- Critical assumptions are documented

RAMP-E PCDRISK 1 Predation/Competition/Disease Model

Run Program · How to Run the Program · Input Help · Program Logic · About_PCD · Exit

Busack et al. 2005

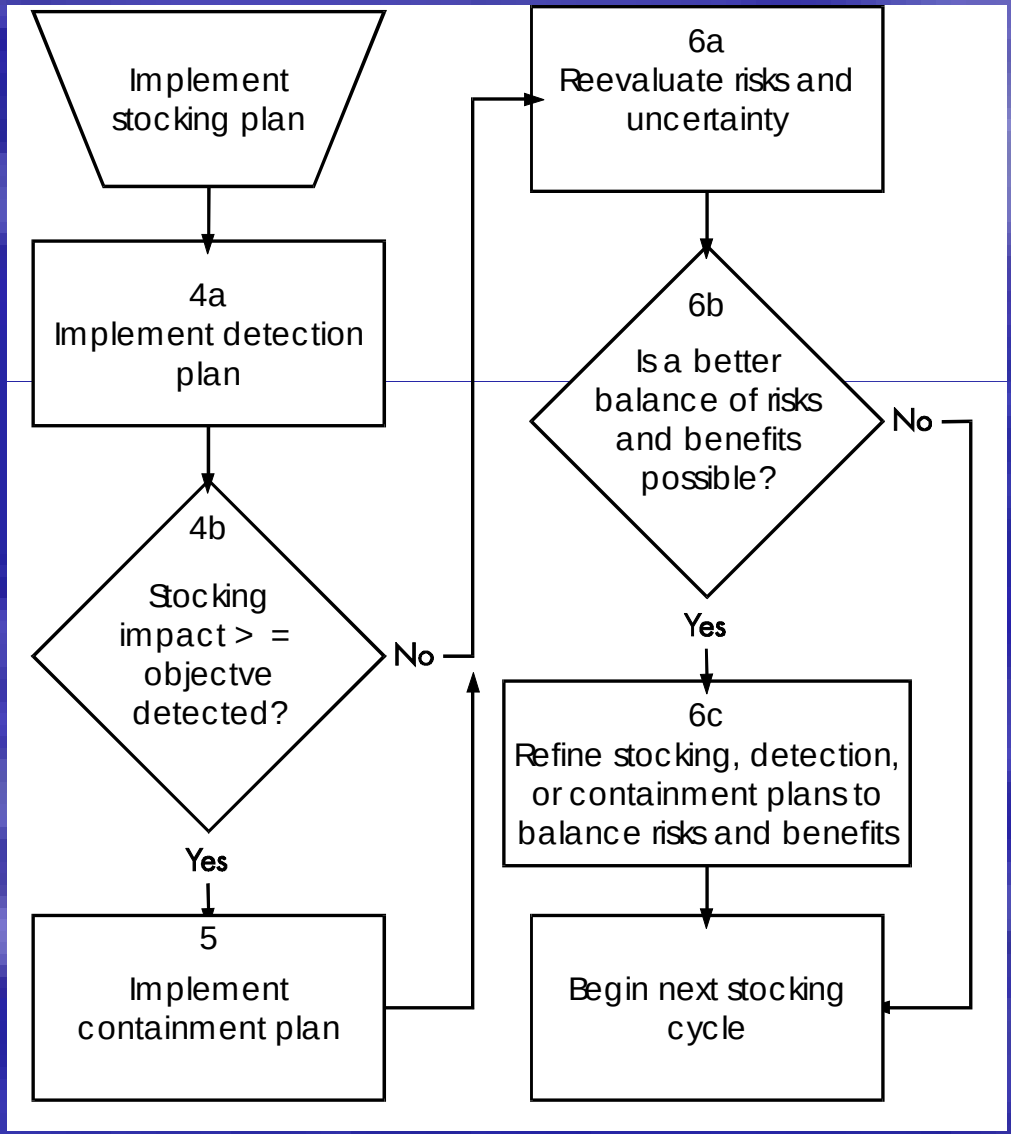


Downloadable from the BPA website

ftp://ftp.bpa.gov/pub/efw-RAMP/

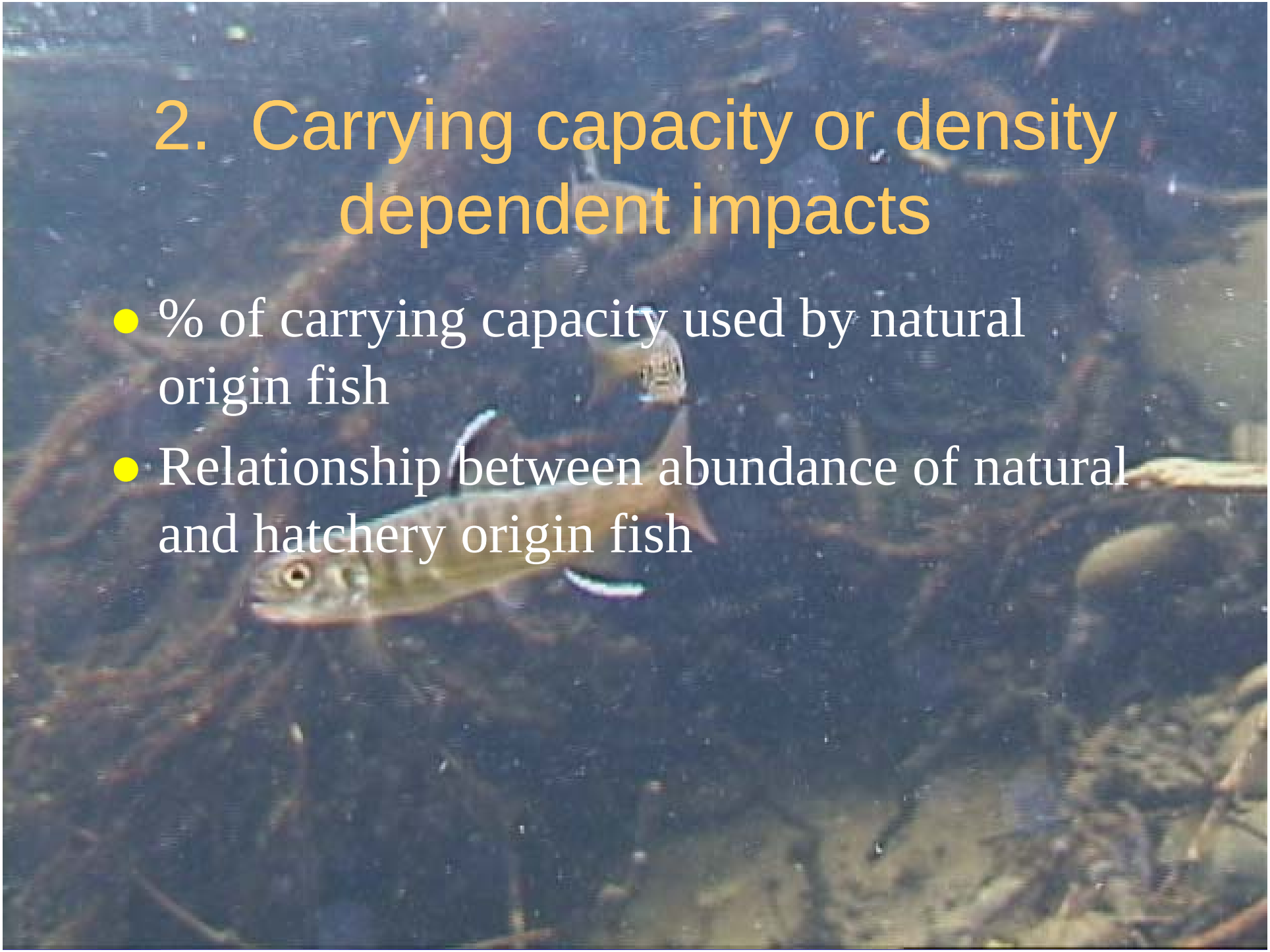
Start | PCD Risk 1 paper - Micro... | RAMP-E PCDRISK 1 Pr... | Microsoft PowerPoint - [P... | 1:08 PM

Risk containment process for one stocking cycle



Ham and Pearsons 2001. Fisheries 26(4):15-23

Ham and Pearsons 2000 CJFAS



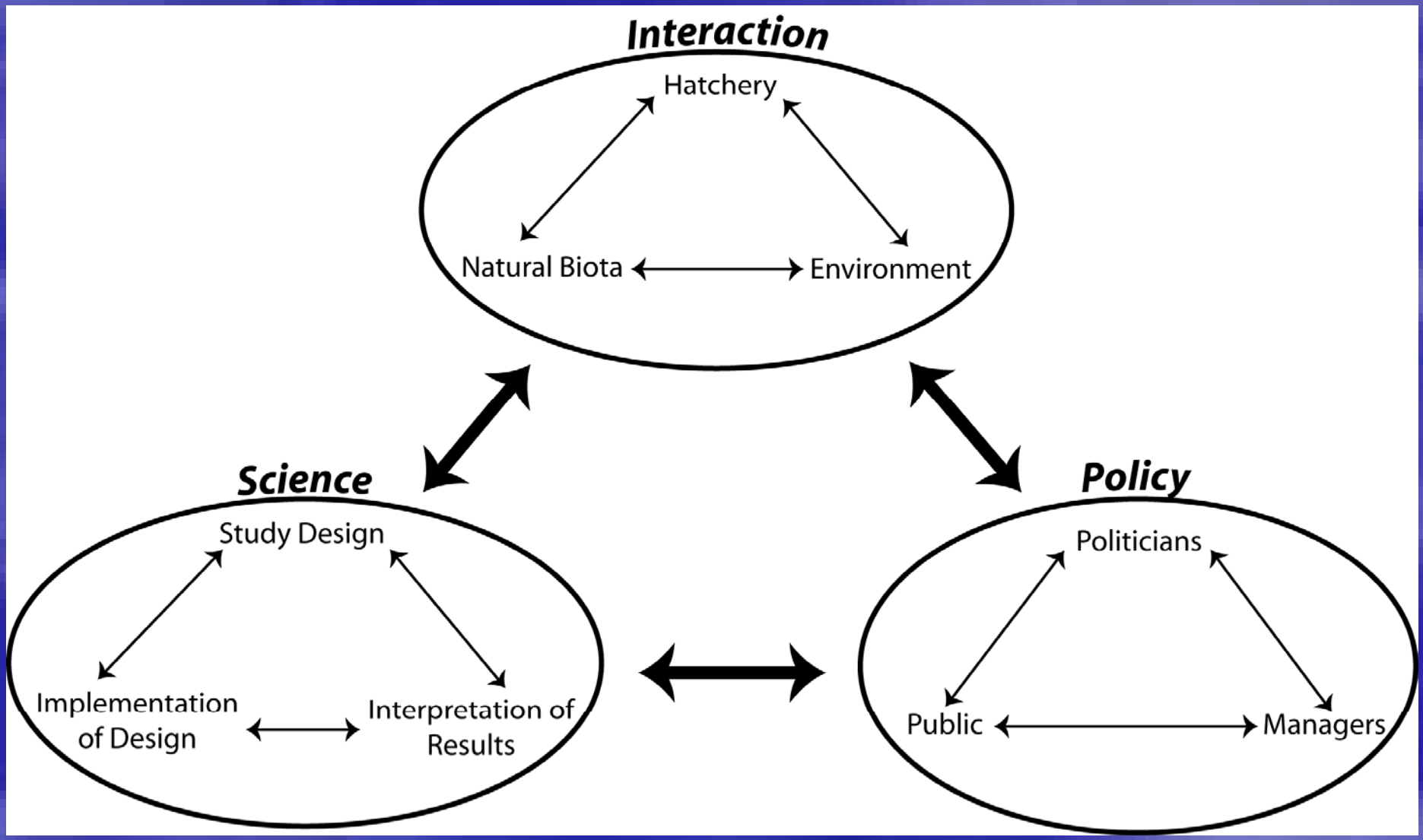
2. Carrying capacity or density dependent impacts

- % of carrying capacity used by natural origin fish
- Relationship between abundance of natural and hatchery origin fish

3. Ecological feedback

- Hatchery and wild fish survival
- Predation mortality potential of animals that feed on hatchery salmon
- Pathogen mortality potential of pathogens that infect hatchery fish

Interactions will occur



Predictions

- Hatcheries will be around for a long time
- Management of hatcheries will increasingly be managed within an ecosystem perspective
- Interaction between hatcheries and climate change will be discussed relative to planning and modification of hatcheries
- Species valuations will be forced due to limited and shared resources

Predictions

- Cumulative effects in the estuary and ocean will be one of the next big issues
- Critical data mass of scientific studies will be available for many species within 5 years
- Management will not require $P<0.05$ (weight-of-evidence and pulling the trigger)

Thanks

- All of the people from the Yakama Nation, Washington Department of Fish and Wildlife, and National Marine Fisheries Service who worked on the studies described
- BPA funded this work
- Molly Kelly constructed schematics