

# Evidence of and factors affecting competition between wild and hatchery anadromous salmonids in fresh water

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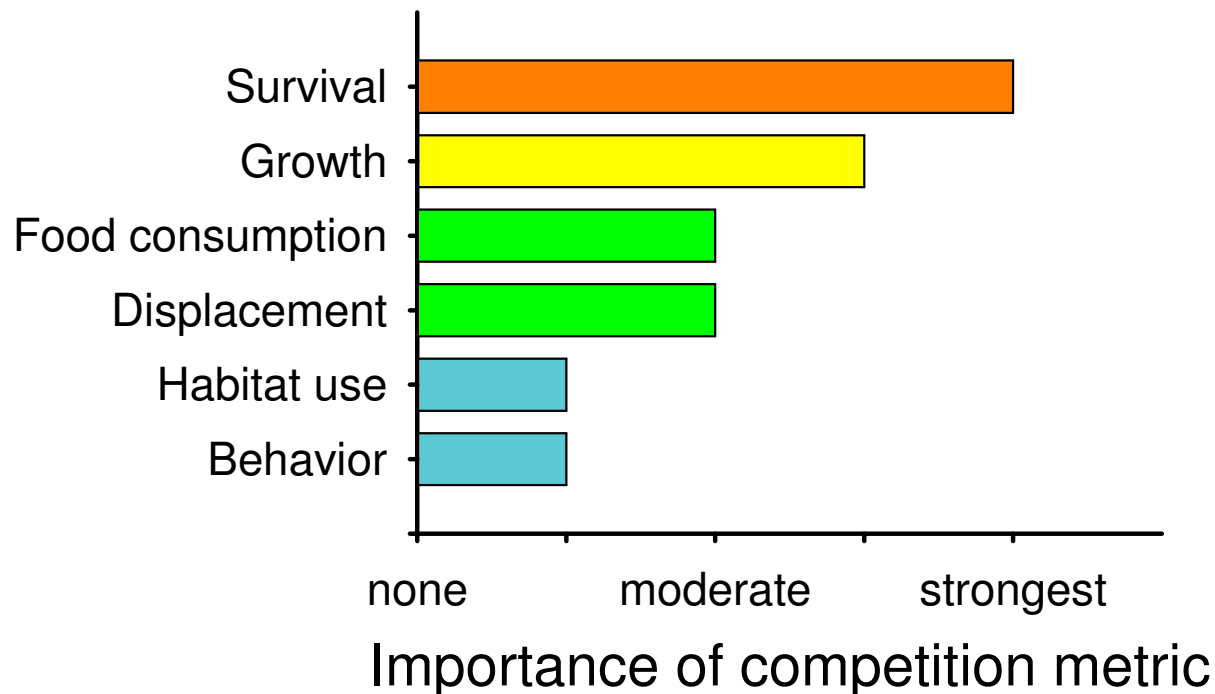
NOAA, Northwest Fisheries Science Center,  
Manchester Research Station

# Overview

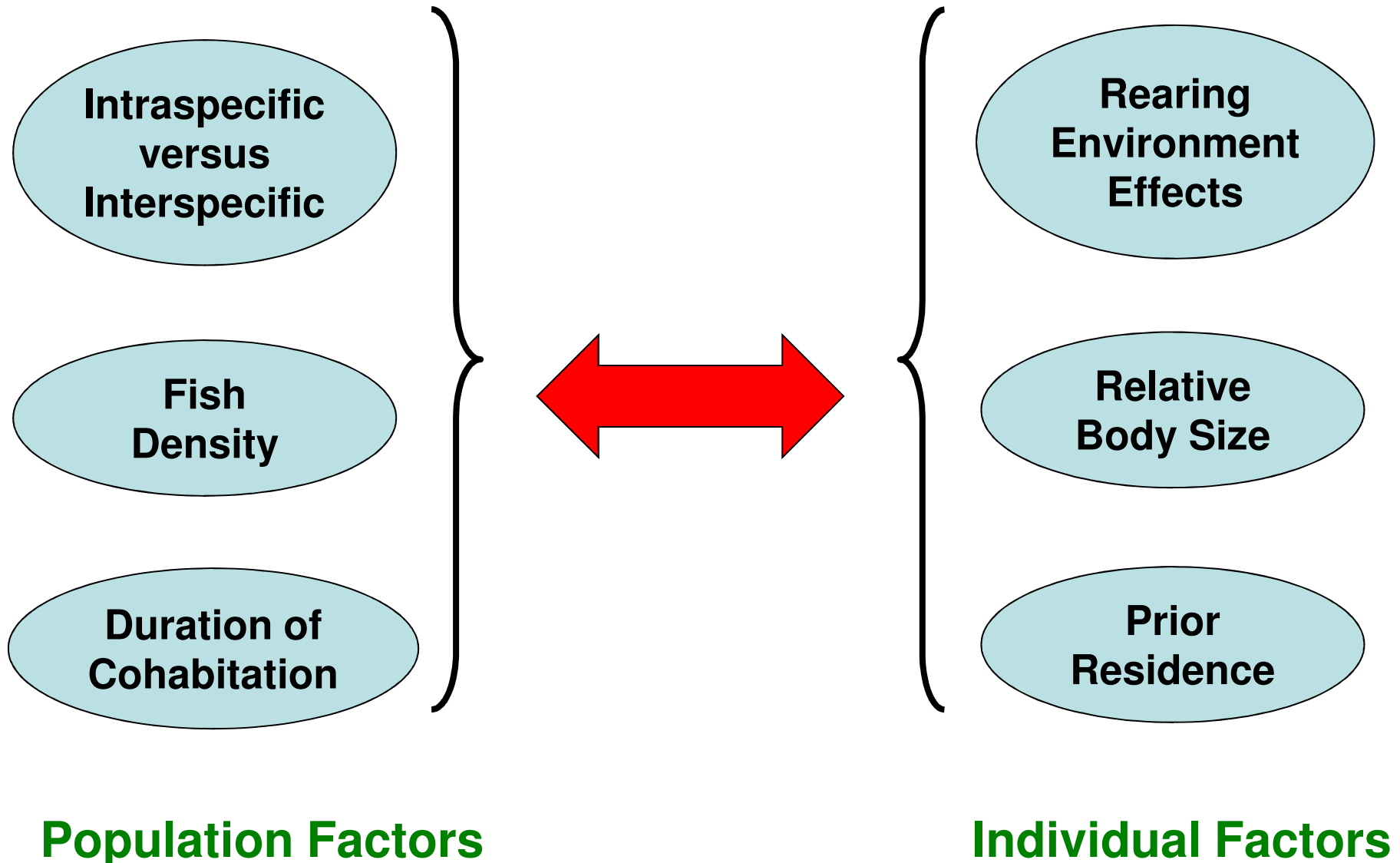
- What is competition and how do we measure it?
- Factors affecting competition
- Evidence of competition
  - Relative competitive ability
- Research needs and approaches
- Summary

# Measures of competition

- Competition occurs when multiple organisms exploit a common limited resource
  - Reduced quantity and quality of freshwater habitat
  - Increased production of hatchery fish

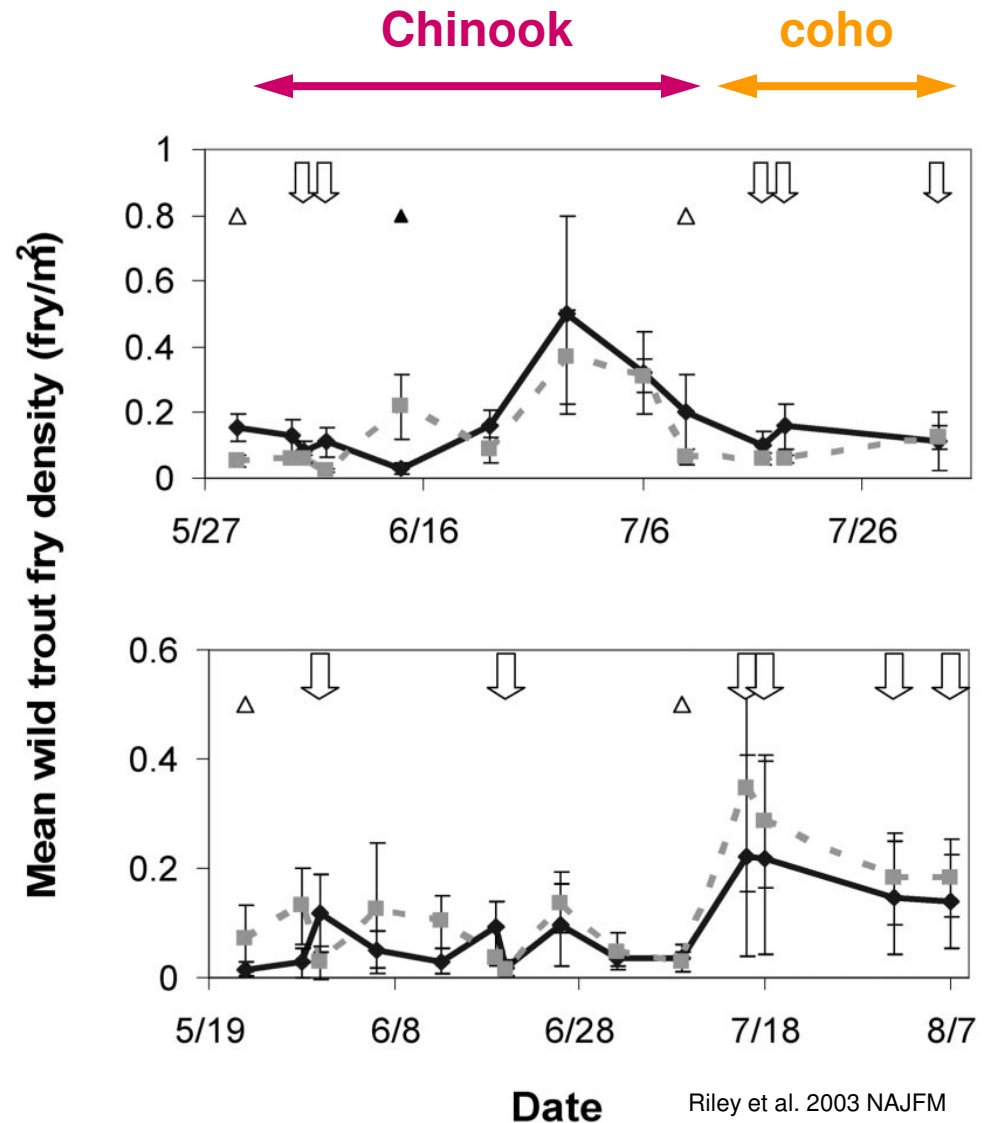


# Factors affecting competition



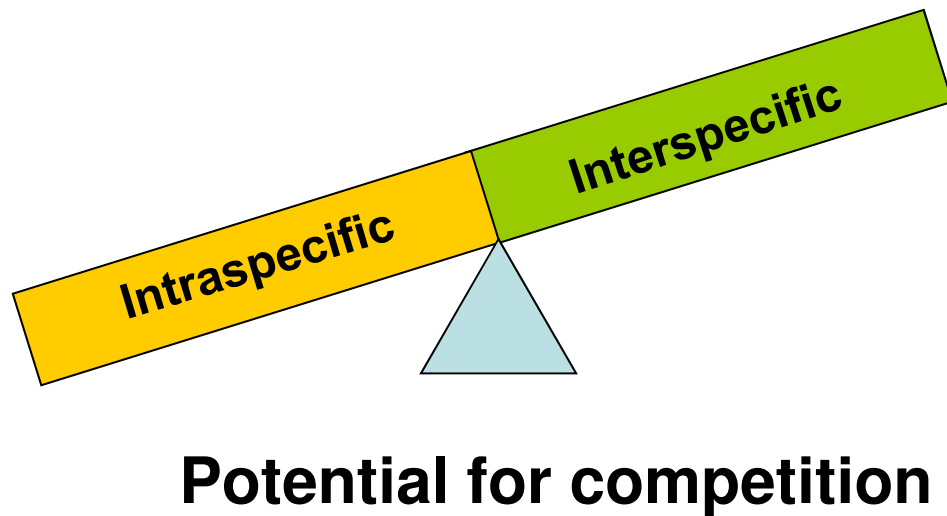
# Interspecific competition

- Assemblages of salmonid species occupy different ecological niches
  - Spatial partitioning
    - Coho, steelhead, and cutthroat use habitat differently according to channel hydraulics and body shape (Bisson et al. 1988)
  - Temporal
    - Life history differences (e.g., spawning time of salmon and steelhead)

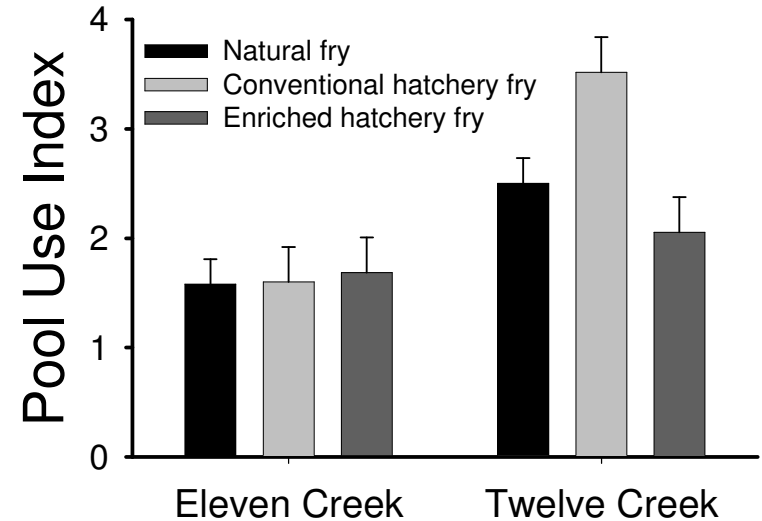


# Intraspecific competition

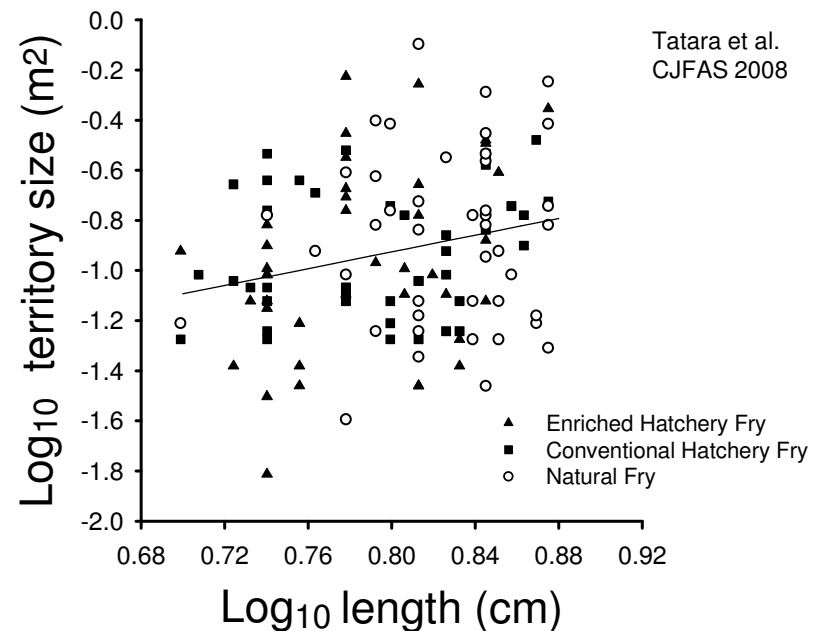
- Habitat preferences and ecological niches of hatchery salmonids are similar to their wild conspecifics



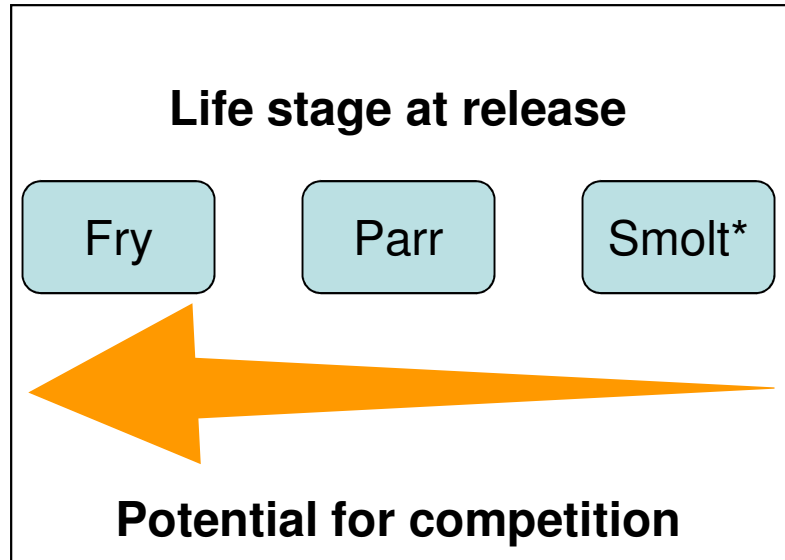
Tatara et al. TAFS 2009



Tatara et al.  
CJFAS 2008



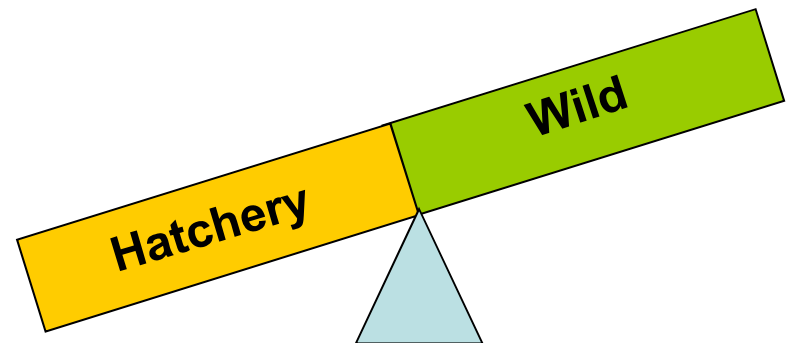
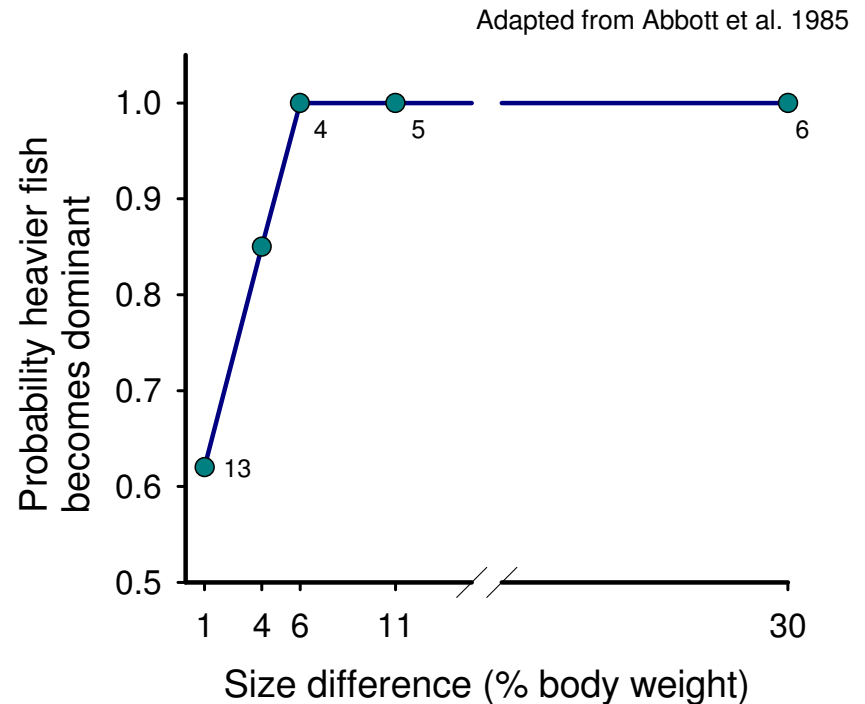
# Duration of freshwater cohabitation



Species	Seaward migration age				
	0	1	2	3	4
Pink	++				
Chum	++				
Chinook	++	++	+		
Coho	+	++	++	+	
Sockeye	+	++	++	+	+
Masu		++	++	+	
Steelhead		+	++	++	+

# Body size

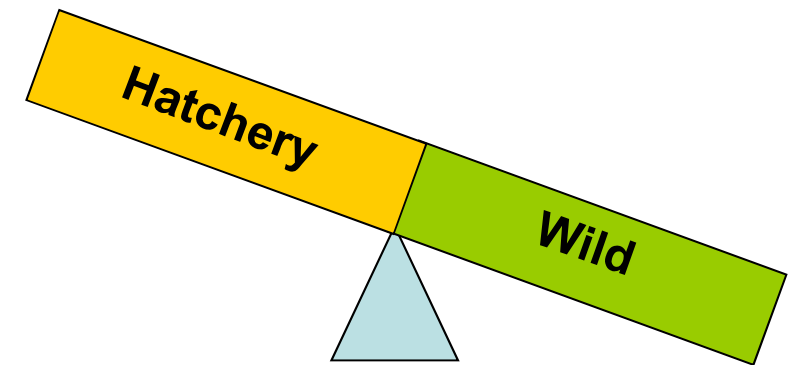
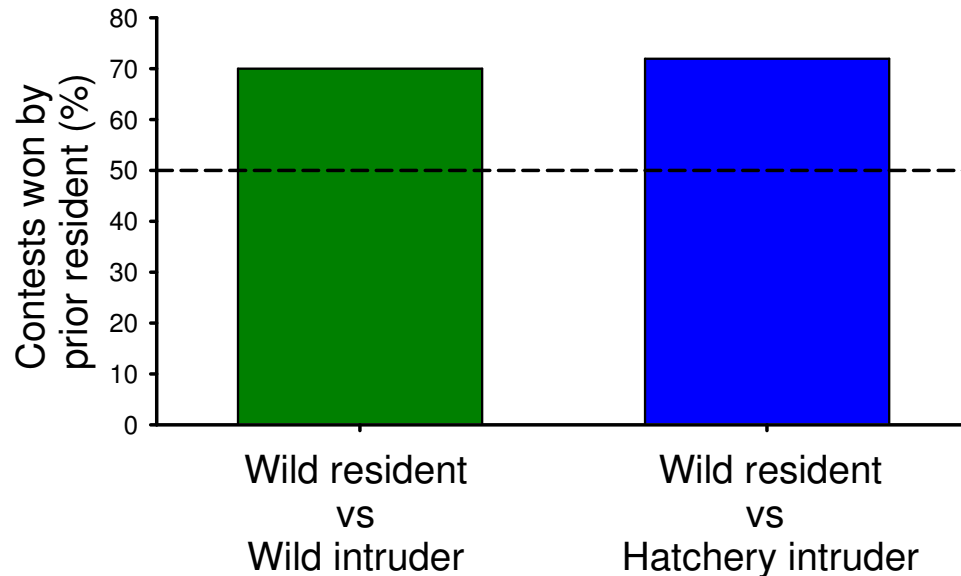
- Relative body size
- Size differences of 5% are sufficient to ensure dominance
  - Dependent on group size
- Important role in interspecific competition and niche partitioning
- Hatchery fish > wild fish



**Advantage of body size**

# Prior residence

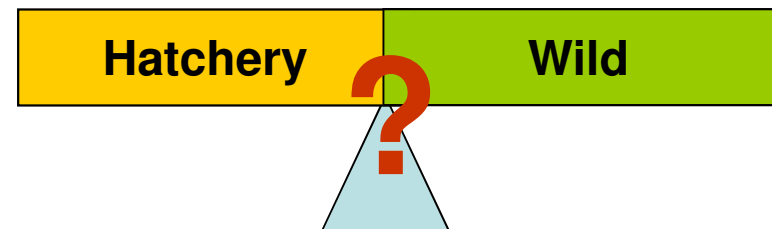
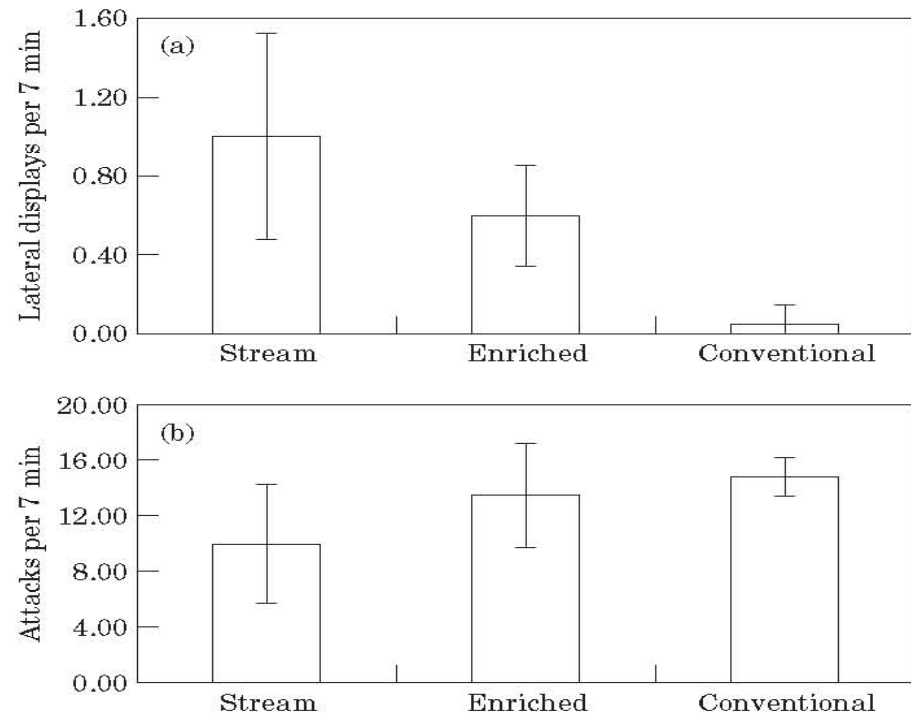
- Juvenile salmonids with established territories have a competitive advantage over challengers or intruders
  - wild or hatchery
  - demonstrated for intraspecific competition (possible for interspecific)
- Prior residence benefits wild fish because stocking practices most often make hatchery fish the intruders
  - can be overcome by size differences or rearing environment (coho salmon)



**Advantage of prior residence**

# Rearing environment

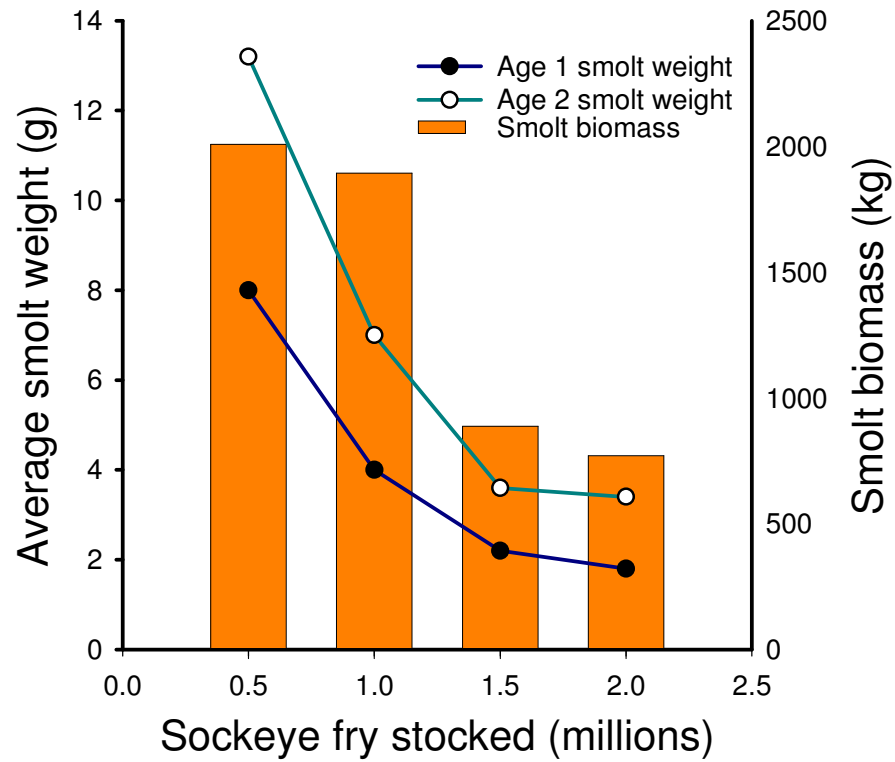
- Hatchery rearing of salmonids can change behavior and competitive ability
- Two mechanisms
  - Genetic (selection)
    - Deliberate or unintentional
  - Environmental
- Differences are not consistent among species or hatchery populations within species
  - Reviews:
    - Weber & Fausch 2003
    - Einum & Fleming 2001



**Advantage of rearing environment**

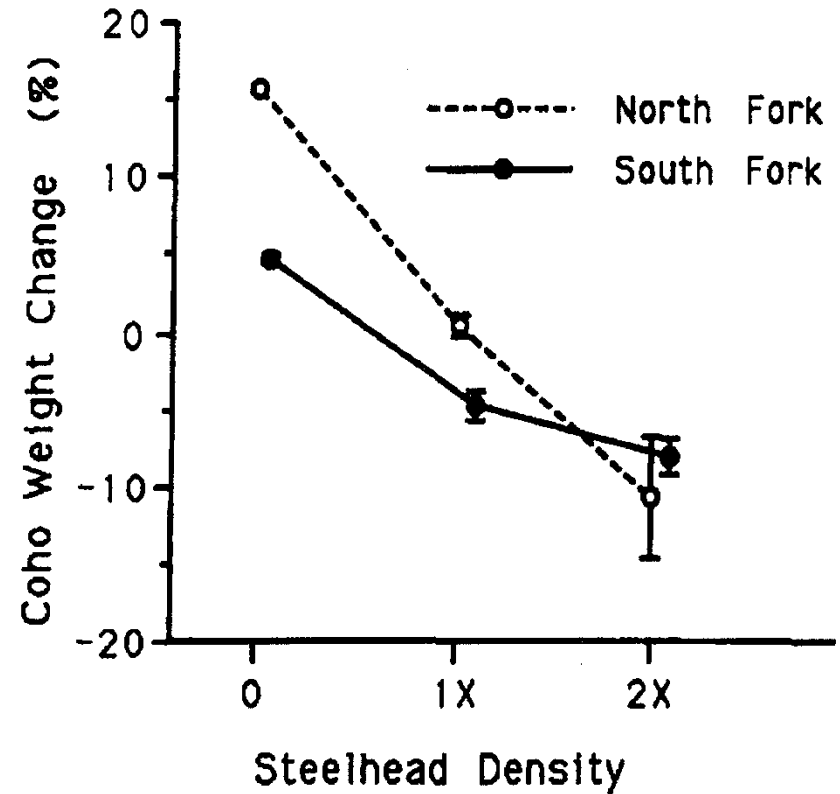
# Factor: Fish density

## Intraspecific



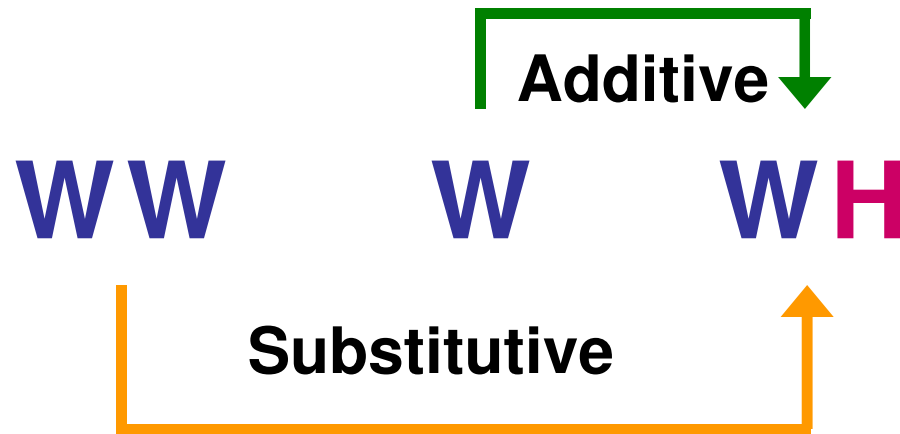
Data from Koenings and Burkett 1987

## Interspecific



Harvey & Nakamoto 1996 TAFS

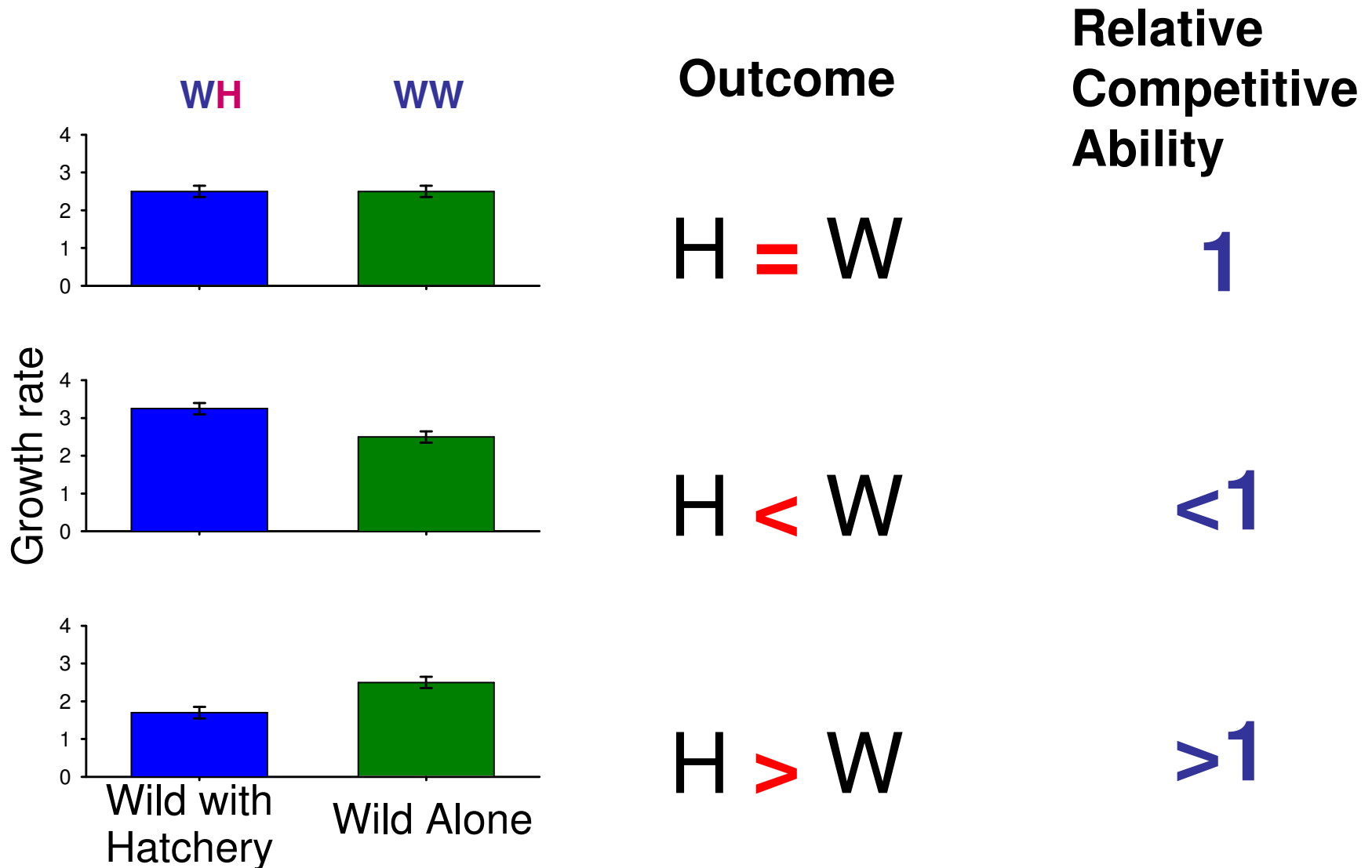
# Measuring hatchery fish competitive ability



Adapted from Weber & Fausch 2003 CJFAS

- Additive design
  - Density different among treatments – measures effect of competition
- Substitutive design
  - Density constant among treatments – measures relative competitive ability
- Same design used to study interspecific competition

# Interpreting substitutive results



# Substitutive studies of competition

Species	Metric	Result	RCA	Reference
Steelhead	Aggression (n=6)	W > H	0.54	Riley et al. 2005
	Feeding (n=6)	W < H	1.39	
Steelhead	Aggression (n=4)	W < H	1.39	Riley et al. 2009
	Feeding (n=4)	W < H	1.13	
Chinook salmon	Aggression (n=4)	W < H	4.9	Peery and Bjornn 1996
	Growth (n=6)	WW > WH	1.8	
Chinook salmon	Growth	WW = WH	1.1	Weber and Fausch 2005
	Survival (n=2)	WW = WH	0.95	
White-spotted charr	Growth A	WW < WH	0.85	Yamamoto et al. 2009
	Growth B	WW = WH	0.99	
Brown trout	Growth	W > H	0.8	Sundstrom et al. 2004
Brown trout	Growth	WW > WH	2.6	Vehanen et al. 2009
Brown trout	Growth	WW = WH	1.05	Bohlin et al. 2002

# Research needs & approaches

- More substitutive experiments
  - Better understand relative competitive ability
    - Intraspecific (n = 8 studies)
      - No studies for coho or sockeye salmon
    - Interspecific (n = 0 studies)
- Study juvenile competition at a larger scale & for longer durations
  - Problems with substitutive experiments
  - Field scale experiments
    - Establish replicated treatment and control reaches or tributaries
    - Monitor supplemented and non-target species before and after supplementation
      - Intra- and interspecific competition
    - Make comparisons using BACI design
      - Pearsons and Temple 2007 NAJFM, 2010 TAFS

# Summary

- Hatchery fish are more likely to compete with wild fish of the same species – niche overlap
- Competition increases with duration of freshwater residence, fry & parr releases, and high residualism rates
- Size asymmetries typically favor hatchery fish
- Prior residence favors wild fish
- Hatchery environmental effects appear equivocal
- Competition is density dependent in relation to habitat carrying capacity
- Current body of substitutive experiments suggest RCA of hatchery and wild fish is about equal for growth metrics