



# The Evolution and Management Application of the Lake Michigan Predator-Prey Ratio (PPR)

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Research Biologist

Charlevoix Fisheries  
Research Station



# Collaborators & Acknowledgements

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Richard Clark (QFC, MSU)  
Czesny, Sergiusz (INHS)  
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Madenjian, Chuck (USGS)  
Tsehaye, Iyob (WIDNR)  
Turschak, Ben (MI DNR)  
Warner, Dave (USGS)



# Managing Predator-Prey Balance: Historical Perspective

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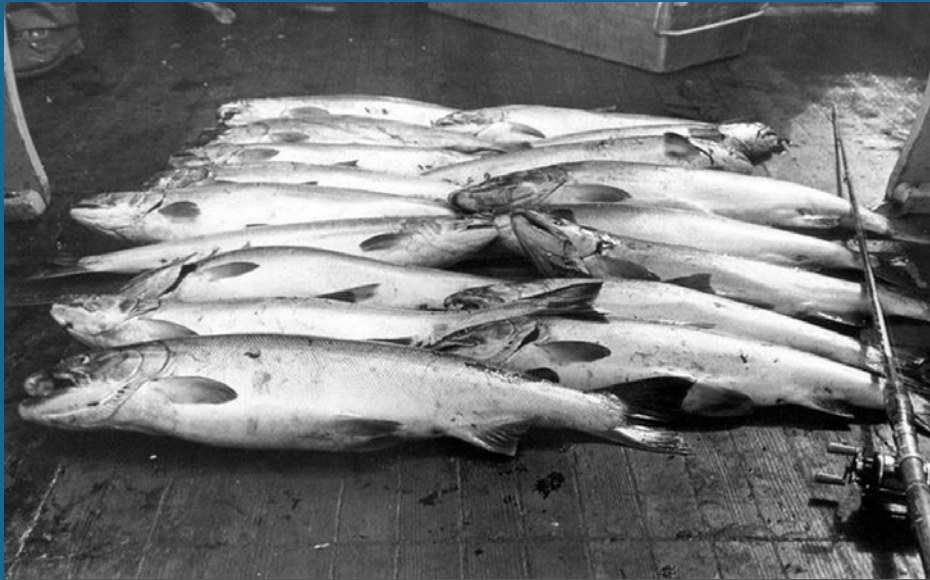
# Managing Predator-Prey Balance: Historical Perspective

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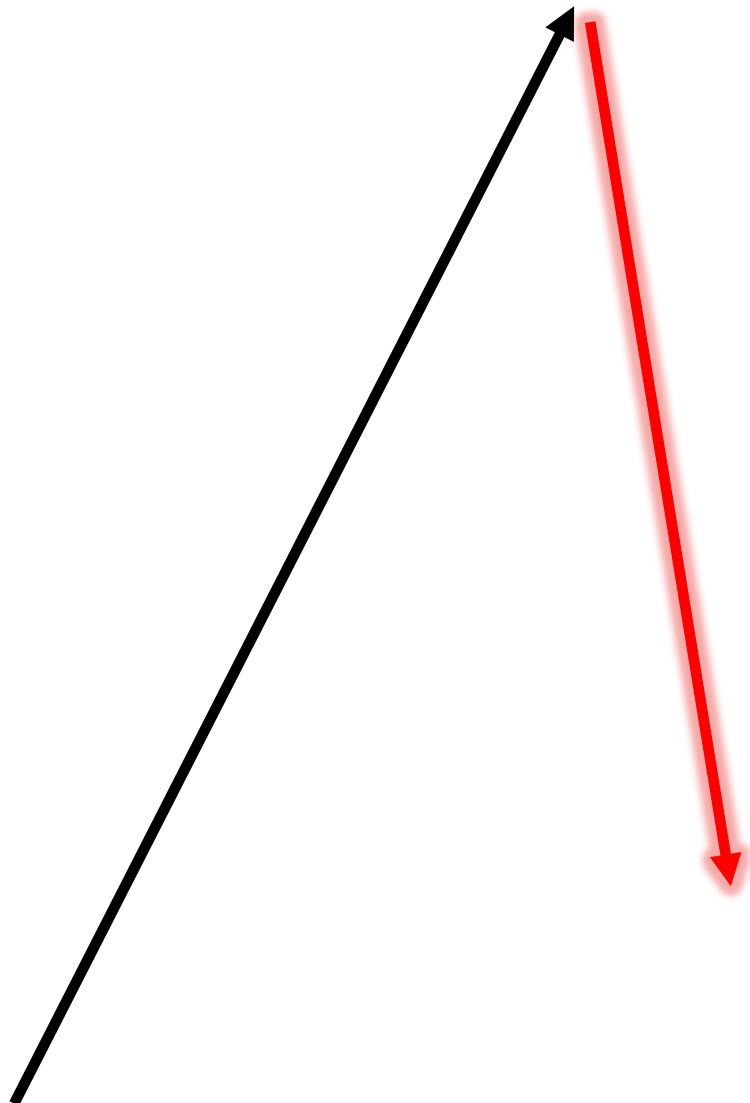
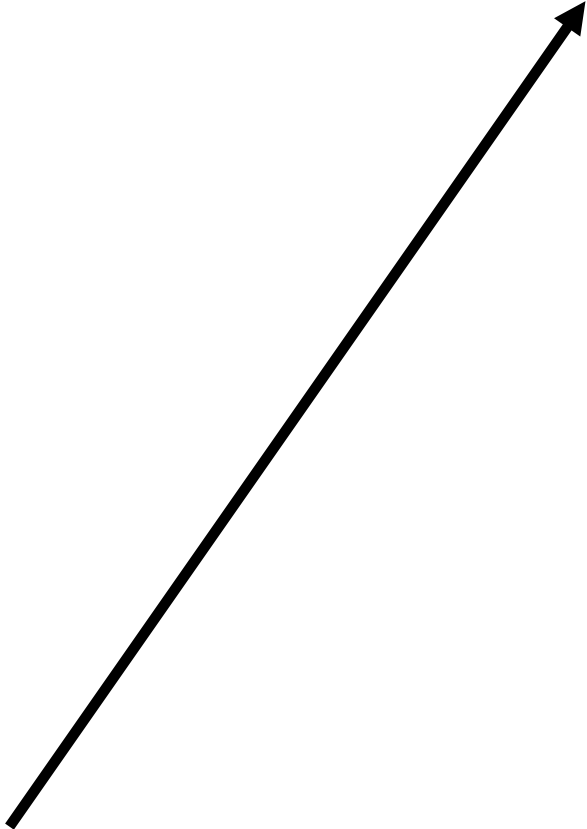
Milwaukee Journal Sentinel  
-Matthew Dae Smith



# Managing Predator-Prey Balance: Historical Perspective (*Coho Fever*)



- LM\_Stocked
- LH\_Stocked
- Wild





# Managing Predator-Prey Balance: Historical Perspective

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Bacterial Kidney Disease  
(BKD)



# 50 Years of Tools to Measure Predator-Prey Balance (1970s-today)!

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1. Wisconsin Bioenergetics Model
2. SIMPLE-Part I (*Sustainability of Intensively Managed Populations in Lake Ecosystems*)
3. SIMPLE-Part II
4. *CONNECT*
5. Decision Analysis
6. **Predator-Prey Ratio Analysis**





# Predator-Prey Ratio

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Chinook Total  
Lake Biomass



Alewife Total  
Lake Biomass



P/P  
Ratio

Tsehaye, I., Jones, M.L., Brenden, T.O., Bence, J.R., Randall, M., and Claramunt, R.M. 2014b. Changes in the salmonine community of Lake Michigan and their implications for predator – prey balance. *Trans. Am. Fish. Soc.* **143**(October 2014): 420–437.

Tsehaye, I., Jones, M.L., Bence, J.R., Brenden, T.O., Madenjian, C.P., and Warner, D.M. 2014a. A multispecies statistical age-structured model to assess predator – prey balance : application to an intensively managed Lake Michigan pelagic fish community. *Can. J. Fish. Aquat. Sci.* **71**(January): 627–644



# Predator-Prey Ratio

**Chinook Total  
Lake Biomass**

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**Alewife Total  
Lake Biomass**

=

**P/P  
Ratio**

Number stocked

Number wild

Angler hours

Angler harvest

**Chinook  
SCAA**

Harvest age  
composition

Weight-at-age at  
harvest/spawn

Weight-at-age at  
annulus formation

**Abundance by age for Chinook salmon**

**Biomass by age for Chinook**



# Predator-Prey Ratio

Chinook Total  
Lake Biomass

Number stocked

Number wild

Angler hours

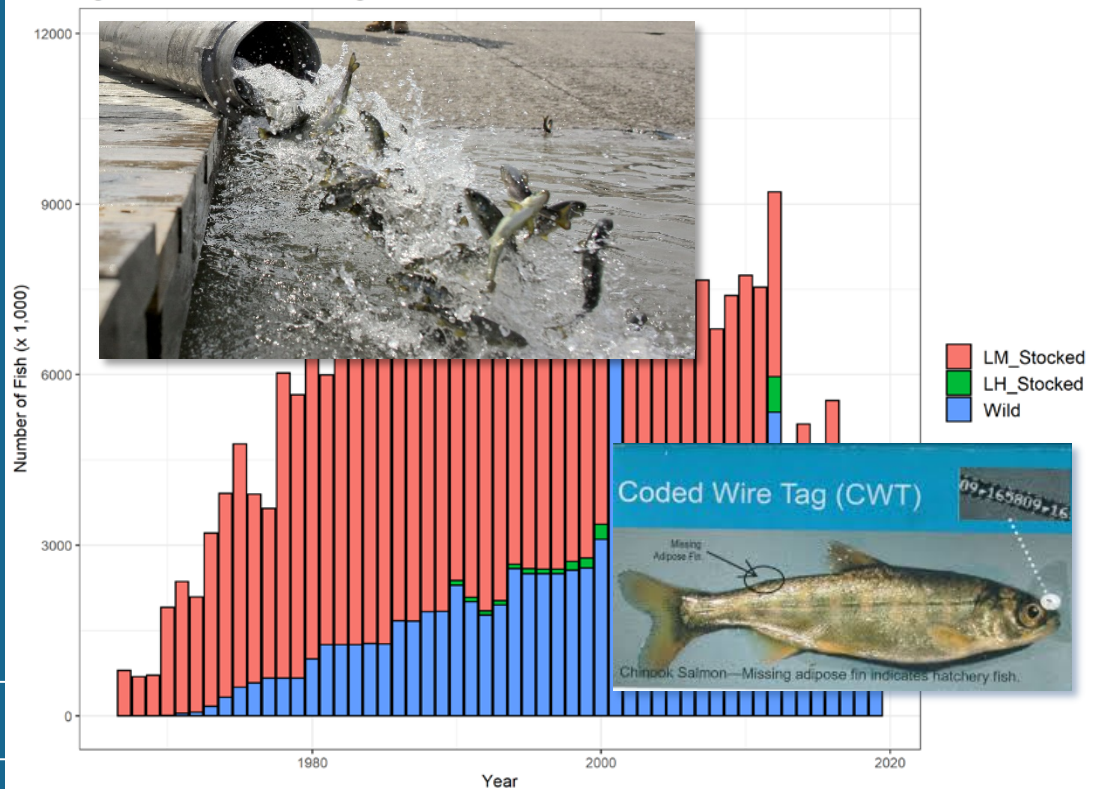
Angler harvest

Abundance by

Alewife Total

P/P

Age-0 Chinook Salmon Stocking Abundance



Biomass by age for Chinook





# Predator-Prey Ratio

## Chinook Total Lake Biomass

Number stocked

Number wild

Angler hours

Angler harvest



Abundance by age for Chinook salmon

Biomass by age for Chinook



# Predator-Prey Ratio

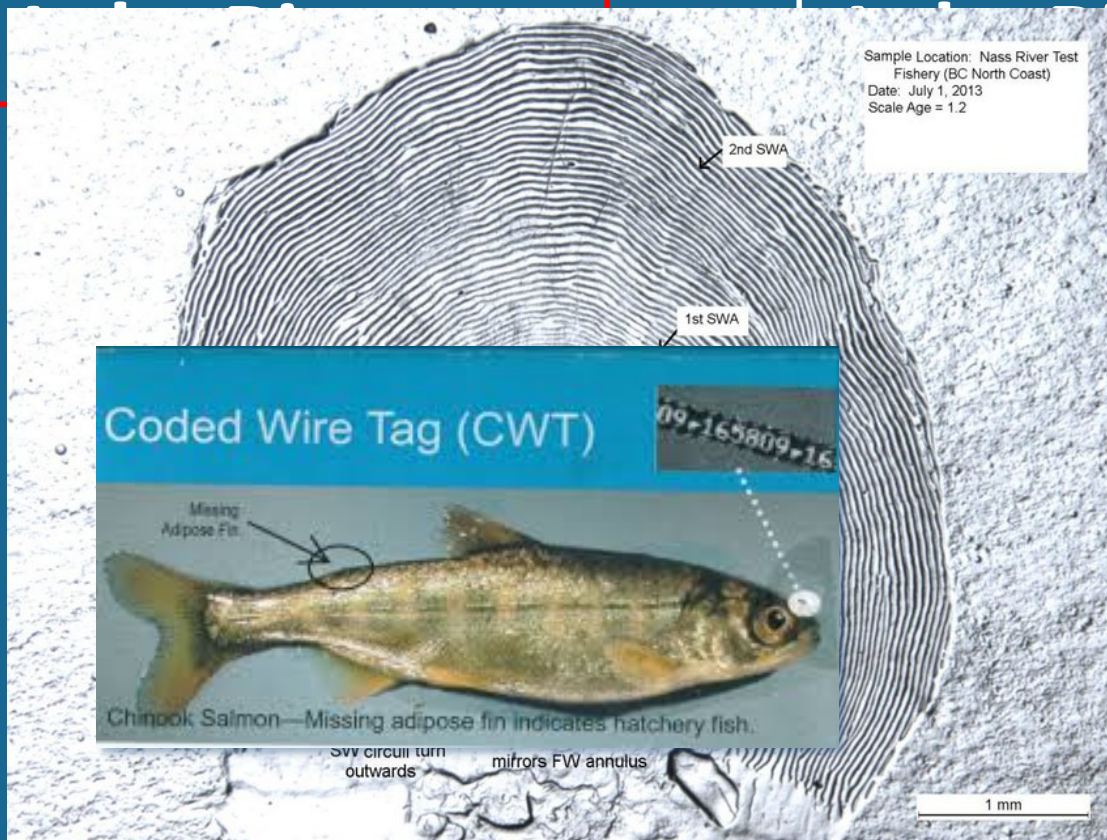
Chinook Total

$\frac{\cdot}{-}$

Alewife Total  
omass

$=$

P/P  
Ratio



Harvest age composition

Weight-at-age at harvest/spawn

Weight-at-age at annulus formation

Chinook Salmon

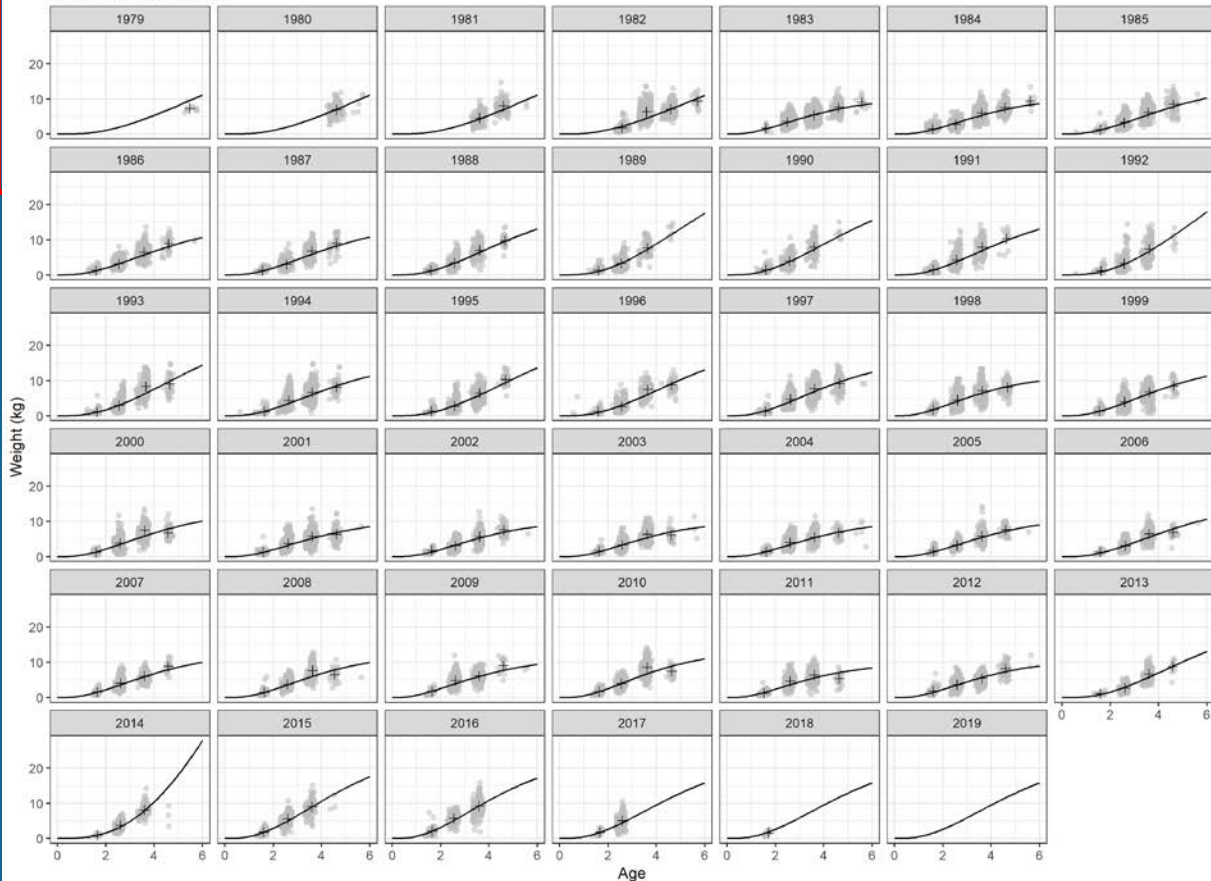


Biomass by age for Chinook



# Predator-Prey Ratio

Cohort Weight at Age



Total  
mass

=

P/P  
Ratio

Harvest age  
composition

Weight-at-age at  
harvest/spawn

Weight-at-age at  
annulus formation

n



Biomass by age for Chinook





# Predator-Prey Ratio

Chinook  
Lake Bio

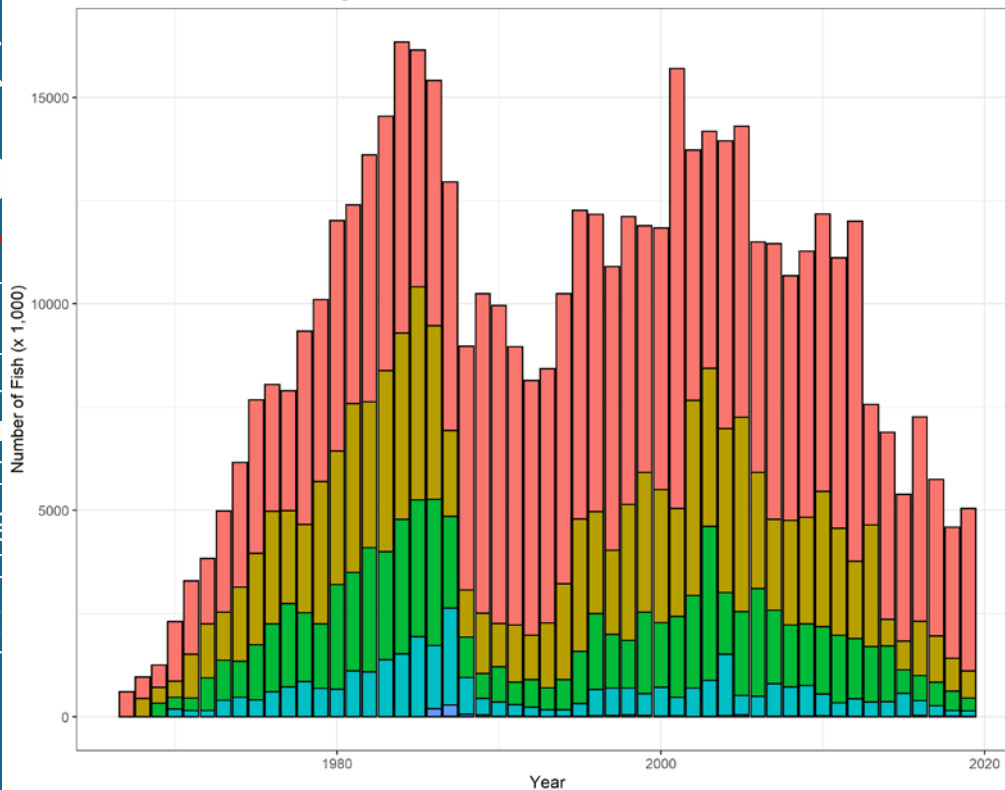
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2. Estimated Abundance at Age



=

P/P  
Ratio

Abundance by age for Chinook salmon



Biomass by age for Chinook



# Predator-Prey Ratio

Chinook  
Lake Bio

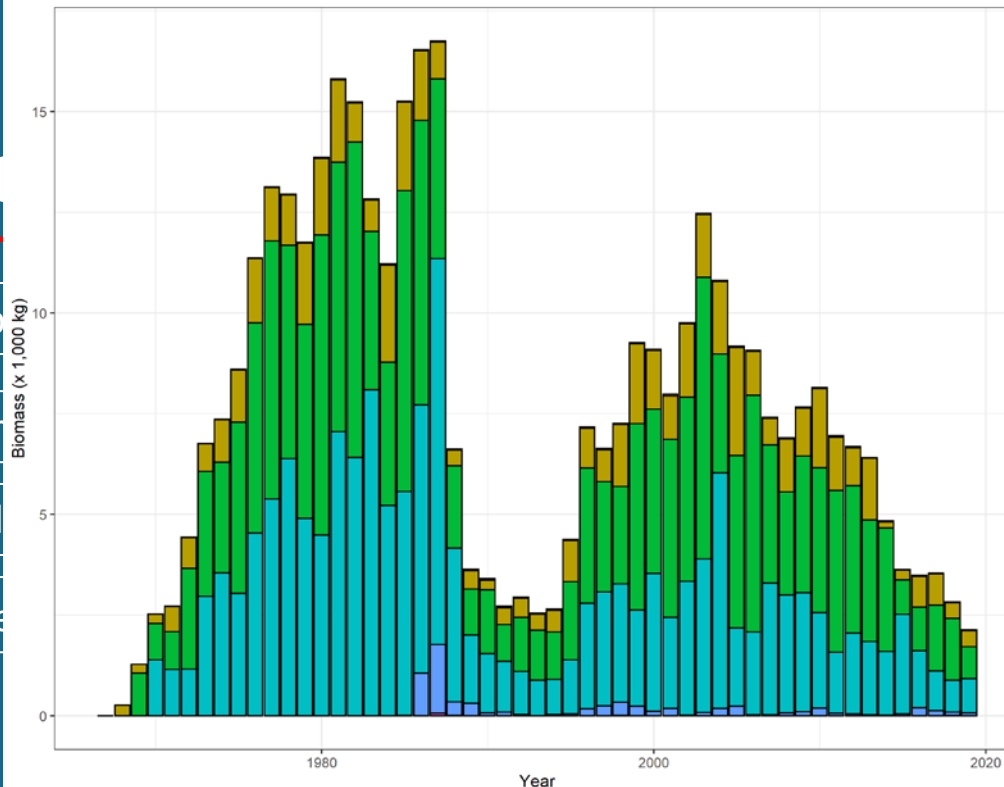
Number

Number

Angle

Angle

2. Estimated Biomass at Age



P/P  
Ratio

Abundance by age for Chinook salmon



Biomass by age for Chinook



# Predator-Prey Ratio

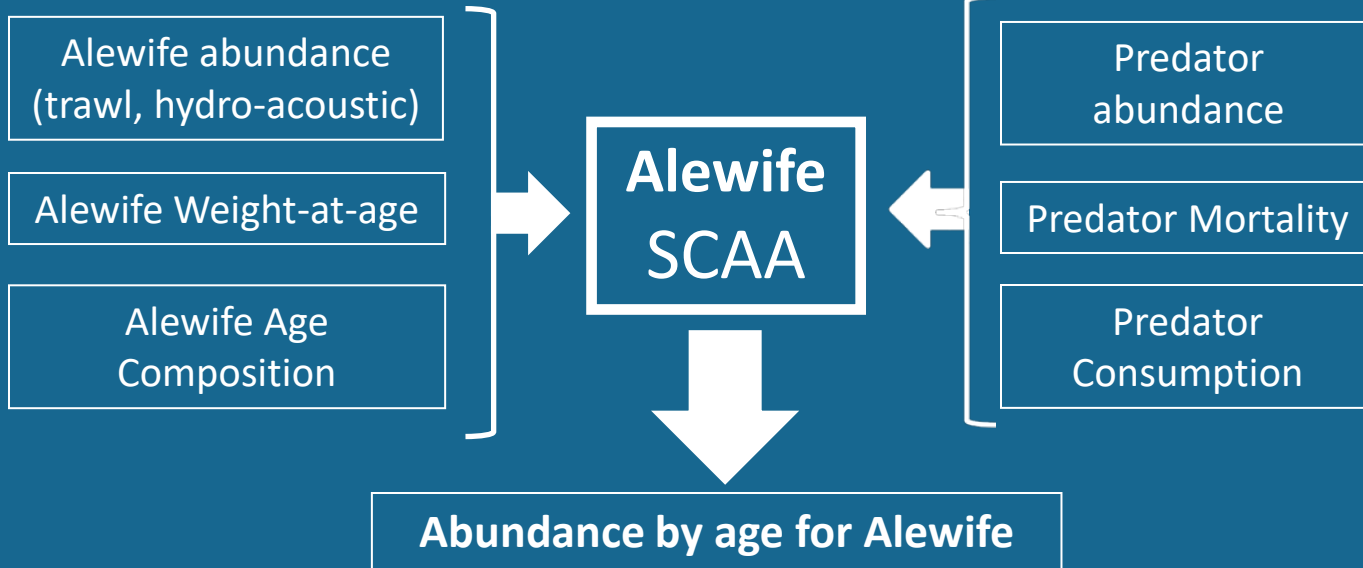
Chinook Total  
Lake Biomass

÷

Alewife Total  
Lake Biomass

=

P/P  
Ratio



Tsehaye, I., Jones, M.L., Bence, J.R., Brenden, T.O., Madenjian, C.P., and Warner, D.M. 2014a. A multispecies statistical age-structured model to assess predator – prey balance : application to an intensively managed Lake Michigan pelagic fish community. Can. J. Fish. Aquat. Sci. 71(January): 627–644





# Predator-Prey Ratio

Chinook Total  
Lake Biomass



Alewife abundance  
(trawl, hydro-acoustic)

Alewife Weight-at-age

Alewife Age  
Composition



Abundance by age for Alewife



Biomass by age for Alewife



# Predator-Prey Ratio

Chinook Total  
Lake Biomass

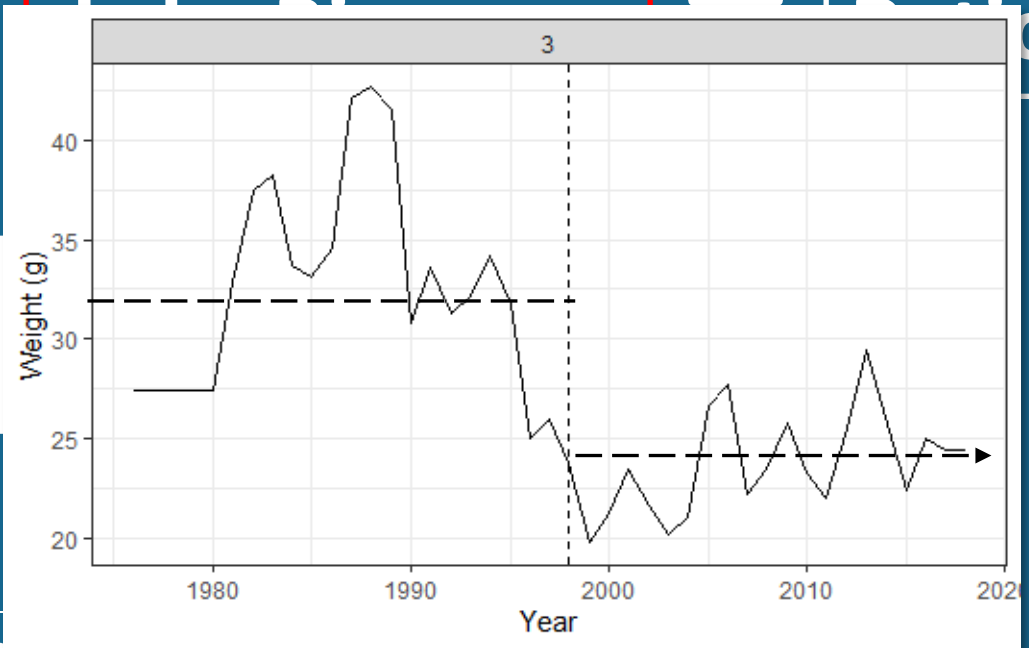
Alewife Total

P/P

Alewife abundance  
(trawl, hydro-acoustic)

Alewife Weight-at-age

Alewife Age  
Composition



Abundance by age for Alewife

Biomass by age for Alewife



# Predator-Prey Ratio

## Chinook Total Lake Biomass

Alewife abundance  
(trawl, hydro-acoustic)

Alewife Weight-at-age

Alewife Age  
Composition



Abundance by age for Alewife



Biomass by age for Alewife



# Predator-Prey Ratio

Chinook Total  
Lake Biomass

÷

Alewife Total  
Lake Biomass

=

P/P  
Ratio

Alewife abundance  
(trawl, hydro-acoustic)

Alewife Weight-at-age

Alewife Age  
Composition

Alewife  
SCAA

Predator  
abundance

Predator Mortality

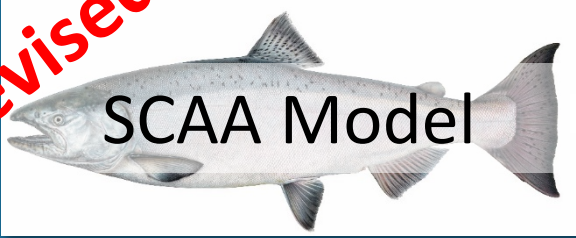
Predator  
Consumption

Abundance by age for Alewife

Biomass by age for Alewife



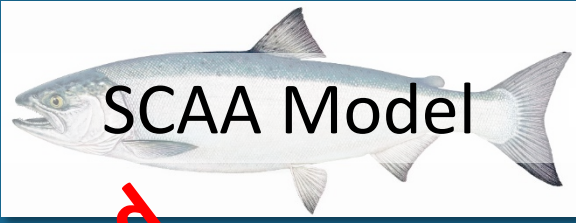
Revised



SCAA Model



Chinook Abundance, Mortality, & Consumption

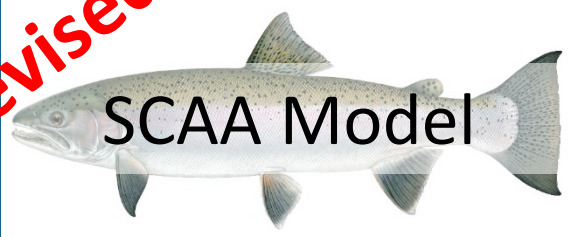


SCAA Model



Coho Abundance, Mortality, & Consumption

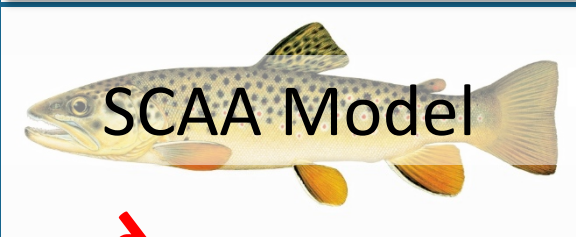
Revised



SCAA Model



Steelhead Abundance, Mortality, & Consumption

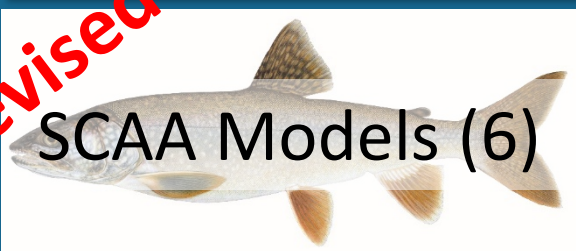


SCAA Model

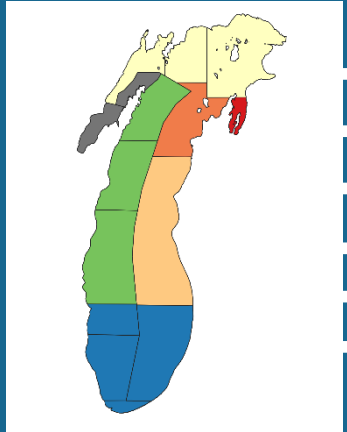


Brown Trout Abundance, Mortality, & Consumption

Revised



SCAA Models (6)



Lake Trout Abundance, Mortality, & Consumption

Alewife SCAA



# Predator-Prey Ratio

Chinook Total  
Lake Biomass

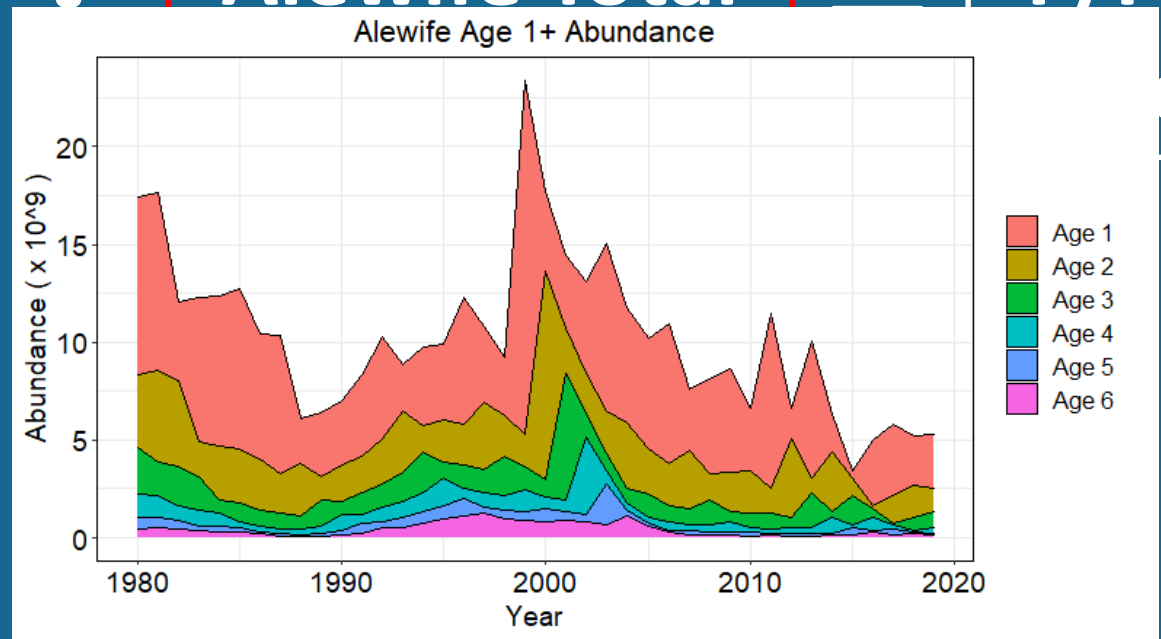
Alewife abundance  
(trawl, hydro-acoustic)

Alewife Weight-at-age

Alewife Age  
Composition

Alewife Total

P/P



Abundance by age for Alewife



Biomass by age for Alewife



# Predator-Prey Ratio

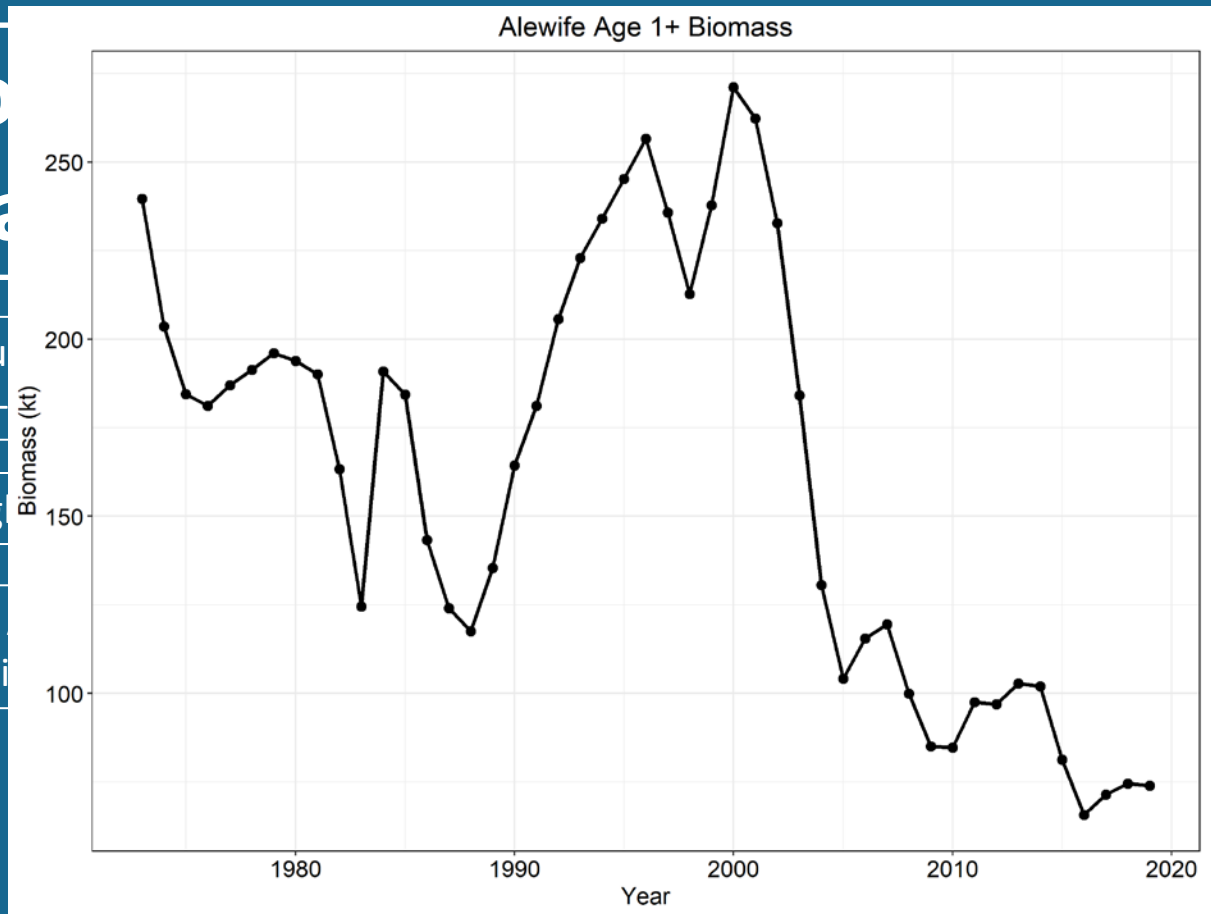
Chinook To  
Lake Bioma

P/P  
Ratio

Alewife abu  
(trawl, hydro-

Alewife Weig

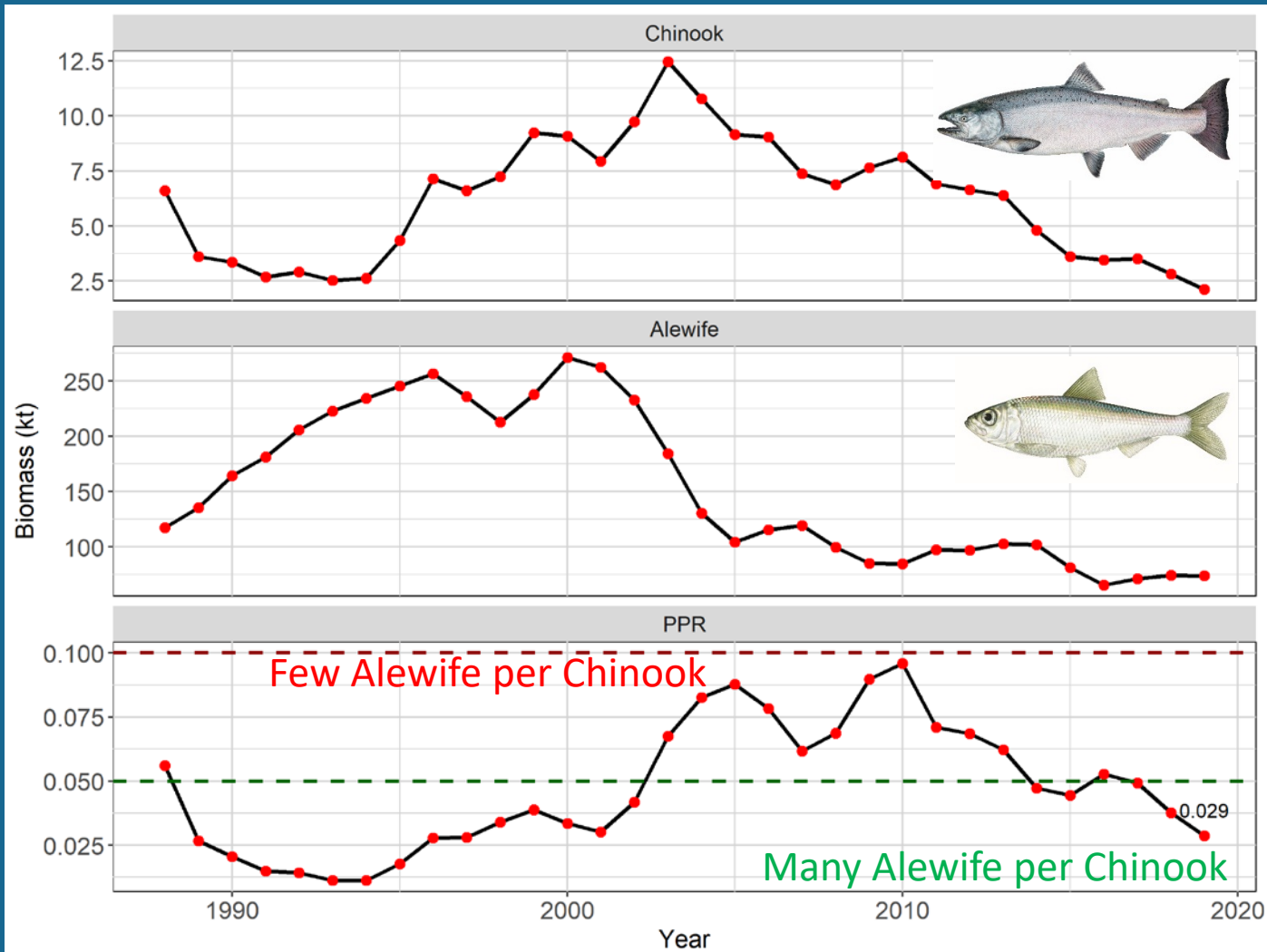
Alewife  
Composi



Biomass by age for Alewife



# Predator-Prey Ratio



# Evaluation and Auxiliary Indicators

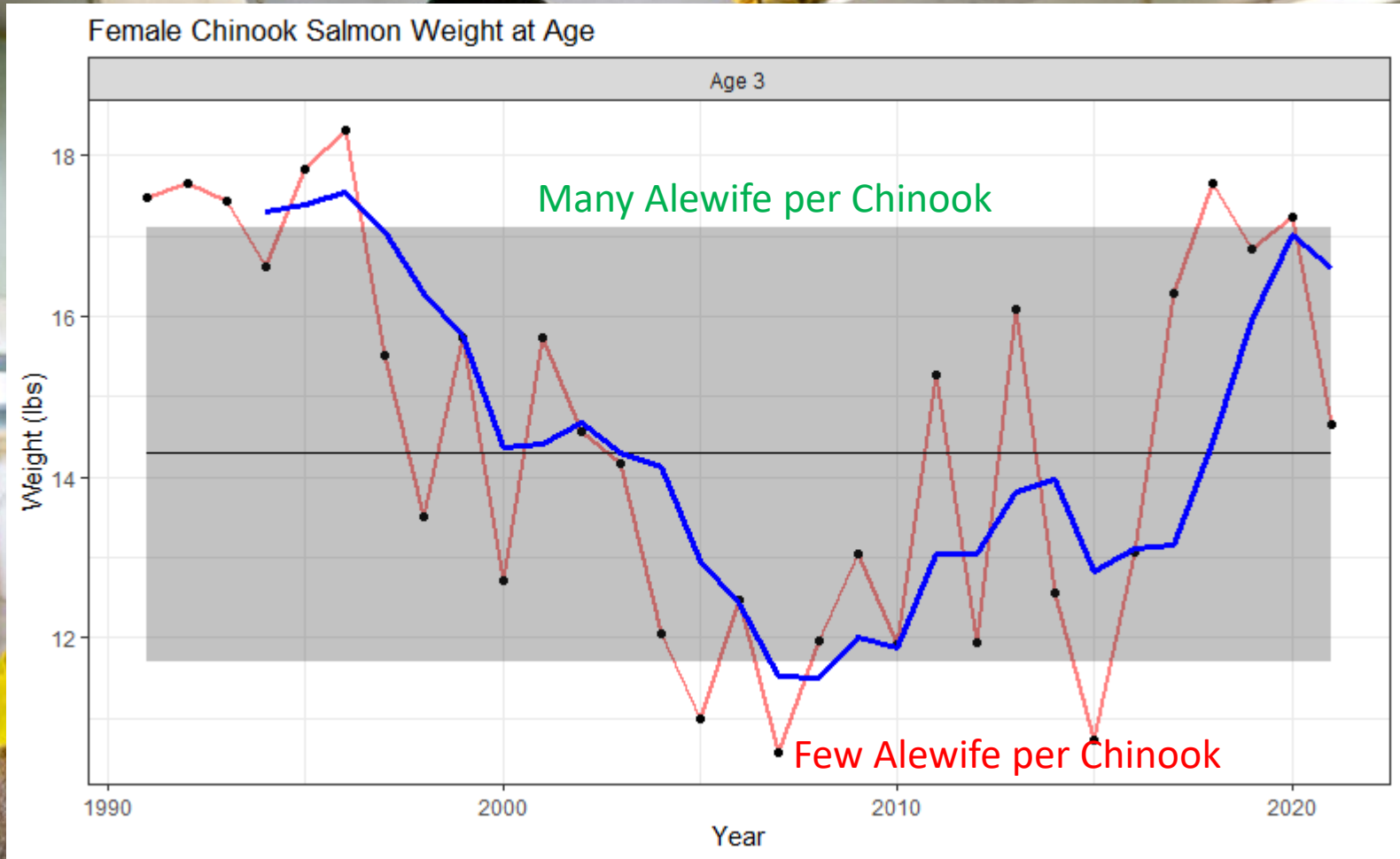
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- Alewife Biomass (Alewife SCAA model)
- Alewife Age Structure (Alewife SCAA model)
- Length/Weight of Recreationally harvested Chinook (Creel)
- Catch per Hour (Charter Boats)
- Species Composition of Angler Catch
- Weights of Age-3 Chinook



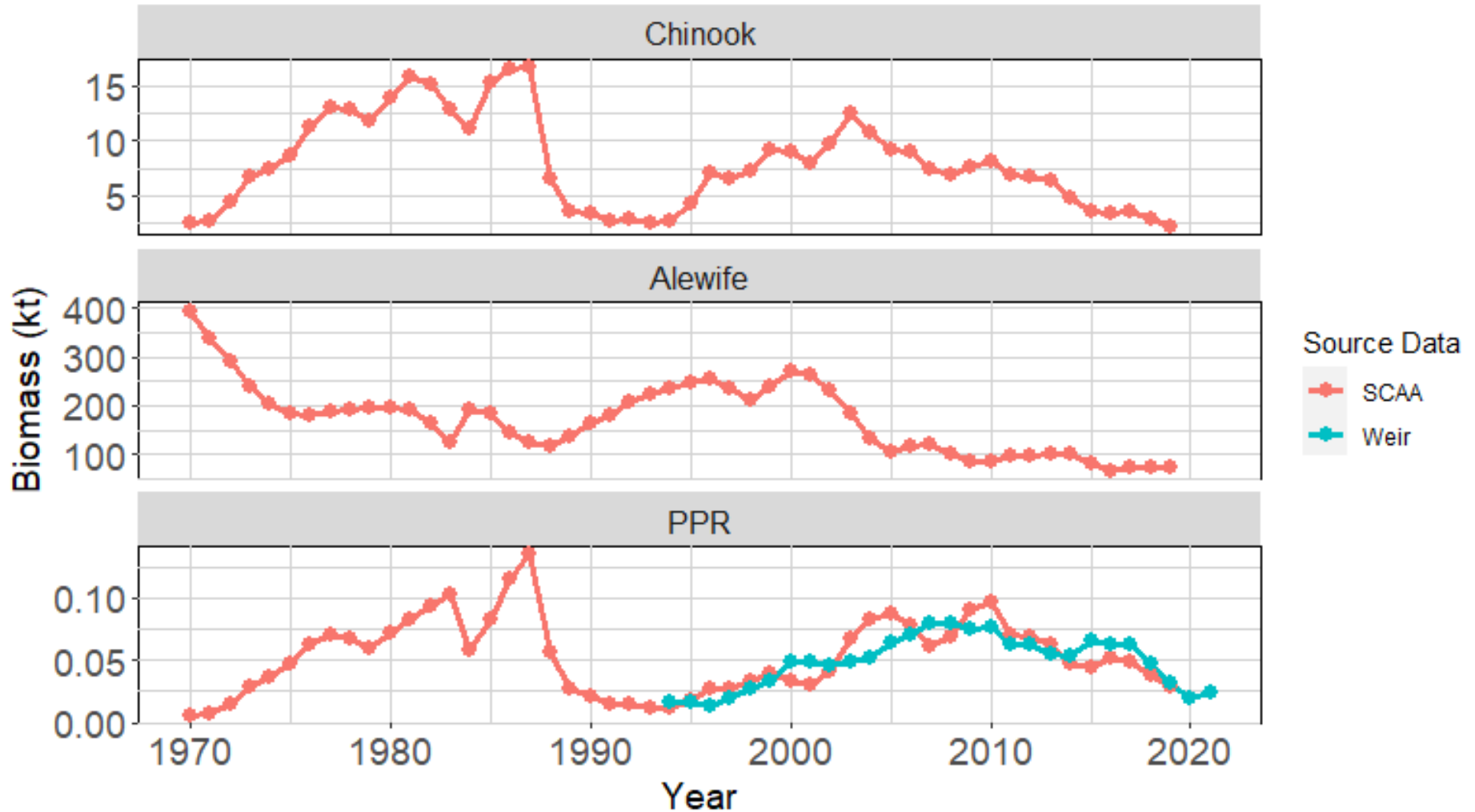
# Evaluation and Auxiliary Indicators

Weight of age 3 Chinook returning to weirs

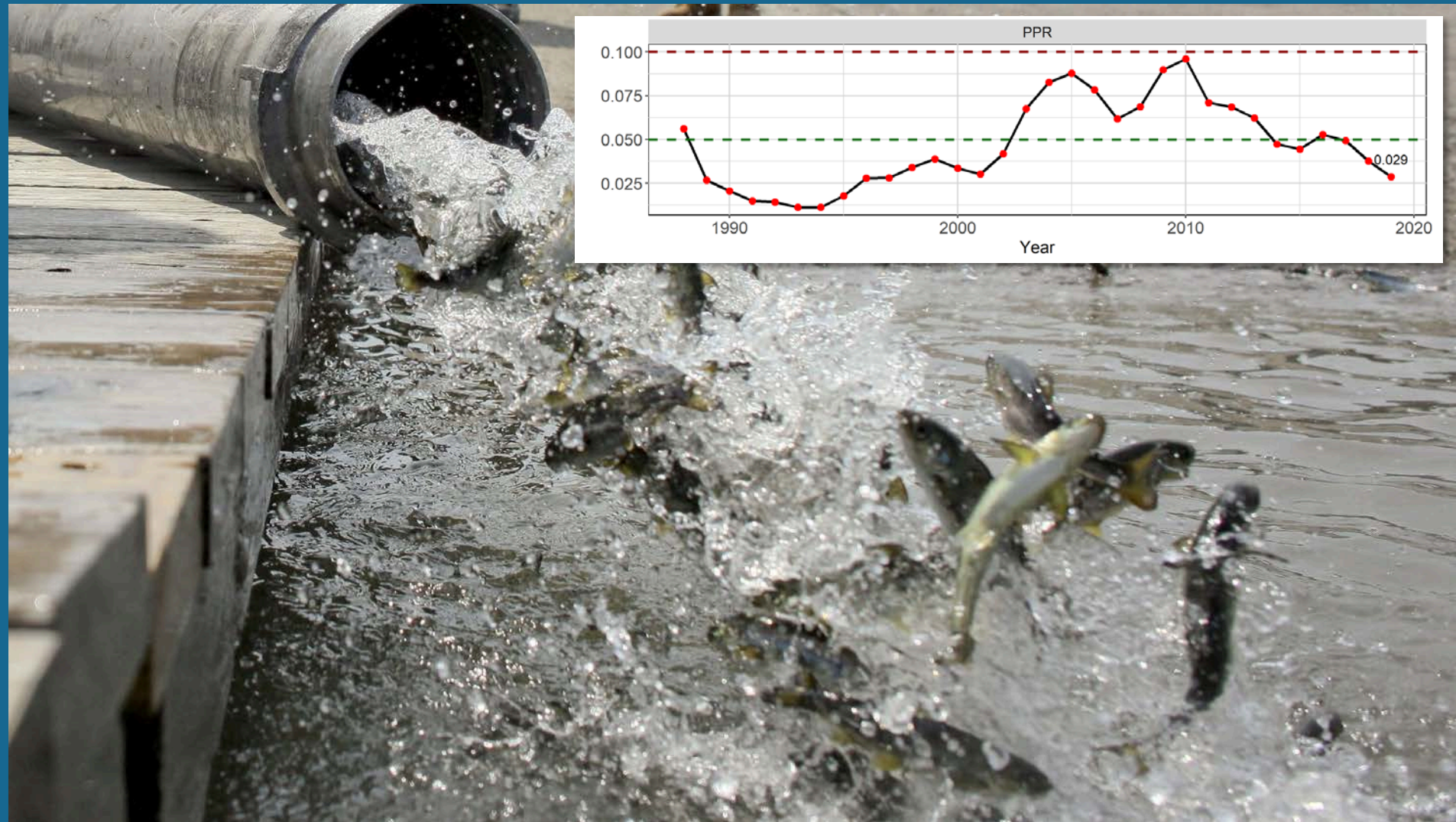




# Evaluation and Auxiliary Indicators



# Management Application





# Thank You!

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