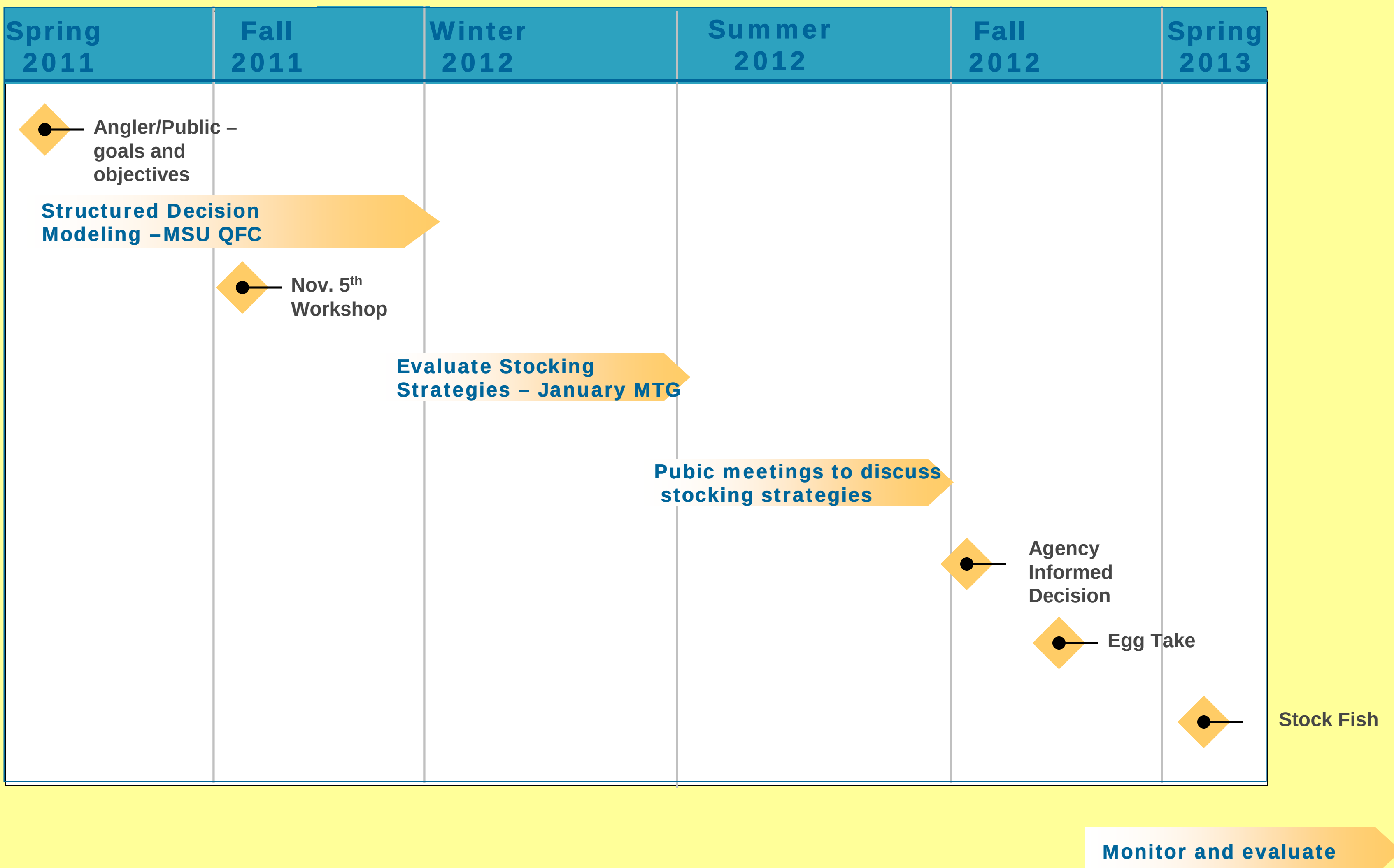
Lake Michigan Stocking Strategy Timeline



Searching for a good stocking policy for Lake Michigan salmonines

Michael L. Jones and Iyob Tsehaye
Quantitative Fisheries Center, Fisheries and Wildlife
Michigan State University

Decision Analysis

Structured, formal method for comparing alternative management actions

Main components:

- Specify objectives
- Identify management options
- Account for uncertainties: assessment models
- Use model to compare outcomes: forecasting model

  - Consider the possible consequences of a decision, rather than just predicting the most likely consequence

Options/Objectives from Agencies

- Options
  - Different stocking rates for salmon and trout
- Objectives
  - Maintain acceptable catch rates
    - 8-12 fish/100 hrs
  - Maintain diverse fishery
    - > 50% Chinook; > 25% other species
  - Maintain good salmon growth
    - Age 3 Chinook > 7 kg, late summer
  - Maintain alewife at or below undesirable levels
    - Target level not specified
  - Adequate spawning stock biomass for lake trout
    - To support reproductive success, level not specified

Stakeholder Options and Objectives Michigan/Indiana meeting

Goals/Objectives

- Preserve sport fishery
- Maintain ecosystem balance
- Maximize harvest and rates (catch per effort or CPE)
- Limit catches
- Maximize sport fish potential
- Diversity of opportunity (species and types of activity)
- Balance sport, commercial, tribal
- Maximize sustainable benefits
- Protection of forage bio-mass
- Maximize use of natural reproduction
- Avoid loss of native species
- Minimize collapse

Options

- Stocking (more or less)
- Fish—quality of stocked fish
- Species composition – (what is stocked)
- Restoration activities – (habitat)
- Where stocked fish go – (where, which species, when)
- Maximize reproduction thru protection of wild fish
- Optimize species/ seasonal opportunity- (drowned river mouths)

Stakeholder Options and Objectives Wisconsin/Illinois Meeting

Goals/Objectives

- Maximize Catch rates
- Maintain Fall / Spring steelhead runs
- Provide larger chinook, 16 to 18 lbs range at age 3+
- Maximize early survival
- Maintain stable fishery
- Maintain diverse fishery
- Sufficient forage available for objectives
- Understand AIS impacts on salmon fishery

Options

- Stocking: numbers and species
- Use net pens to increase survival
- Barrier removal
- Better understanding of the forage base

The Challenge

How many salmon and trout should we stock into Lake Michigan each year?

- more stocking leads to greater harvest, and thus benefits - unless…
- too much stocking leads to poor feeding conditions and increased mortality, but
- too little stocking may lead to negative effects of alewife on other species

Four key questions: assessment models

1. How many salmon and trout are out there, feeding?
2. How much do they eat?
3. How capable are the prey fish of meeting this demand?
4. What happens to salmon and trout feeding when prey numbers are low?

Our approach

1. Analyze the past
   - Salmonine abundance
   - Salmonine consumption
   - Prey fish production
   - Supply vs demand
2. Forecast the future
   - Predictive model

Data we used

- Stocking and harvest
- Growth and diet data
- Prey fish survey data

How many salmon and trout are out there, feeding?

- The numbers of salmon in the lake depends on:
  - How many new fish are added each year
  - How many fish die from natural causes
  - How many fish are harvested
  - How many fish return to rivers to spawn
- We have data on:
  - How many fish we stock
  - How many fish are harvested
  - How many fish return to spawn
  - How many wild salmon are being produced

Our assessment model asks, what combination of recruitment, mortality, and spawning, best explains these data?

From this we can calculate… how many salmon and trout are out there, feeding

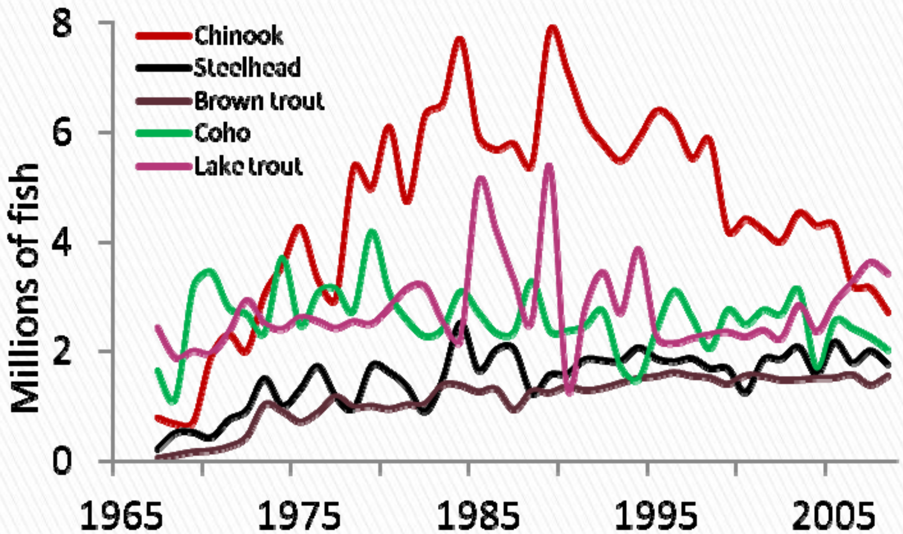
How many salmon and trout are out there, feeding?

The data

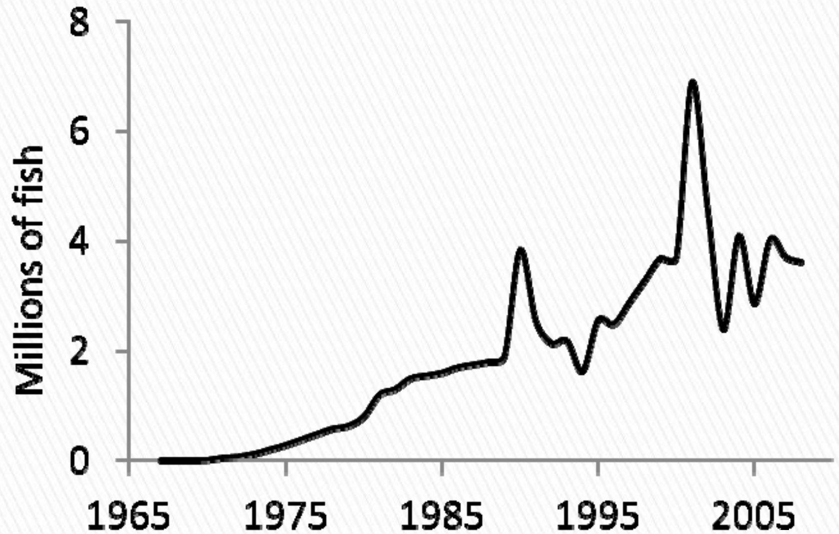
- Stocking data (1966-2008)
  - all species
- Wild recruitment estimates
  - Data 1992-1995; 2001-2004; 2007-2009
- Fishery data (1985-2008)
  - annual total harvest
  - annual fishing effort
  - age composition of the annual total harvest and maturity status
- Weir data (1985-2008)
  - age composition of the annual weir harvest

How many salmon and trout are out there, feeding?

Numbers stocked



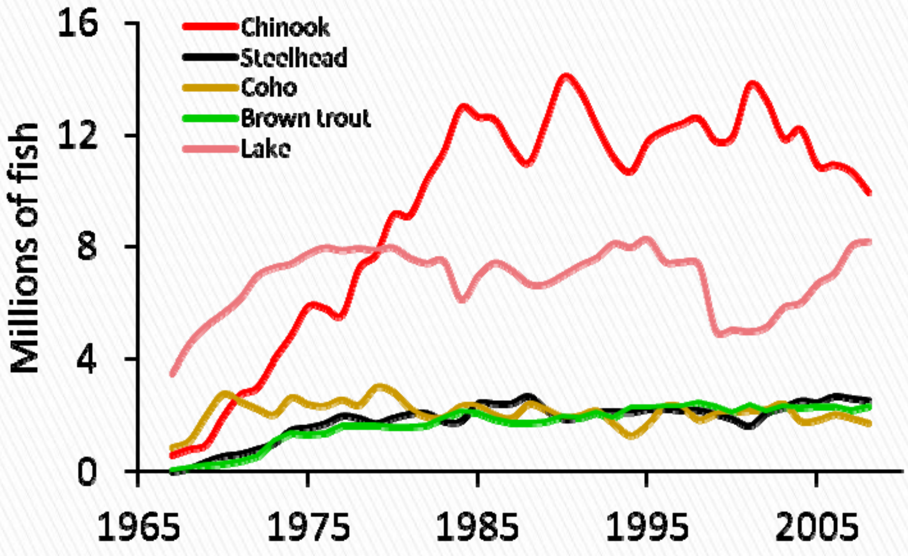
Chinook salmon wild recruitment



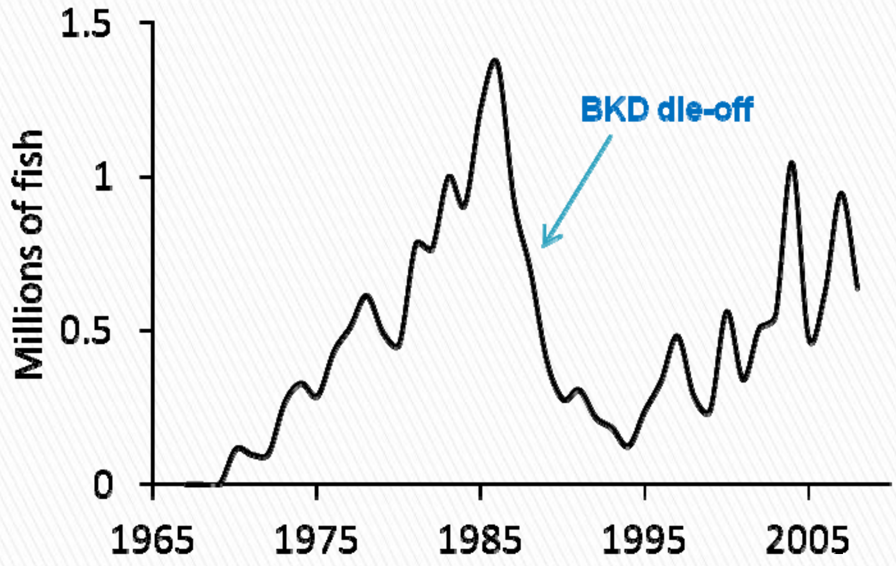
The data

How many salmon and trout are out there, feeding?

Salmonine abundance



Age-3 Chinook numbers



Model estimates

Conclusions: Question 1

- Total salmonine numbers have remained relatively stable since 1990
- Reduced Chinook stocking has been offset by increased wild fish production
- More recently, improved survival of older Chinook salmon has also offset reduced stocking

How much do they eat?

- Consumption (C) depends on:
  - How many fish are feeding (N)
  - How much each fish eats (c)… which in turn depends on:
    - How much they grow (G), and
    - How efficiently they convert food into growth (GCE)

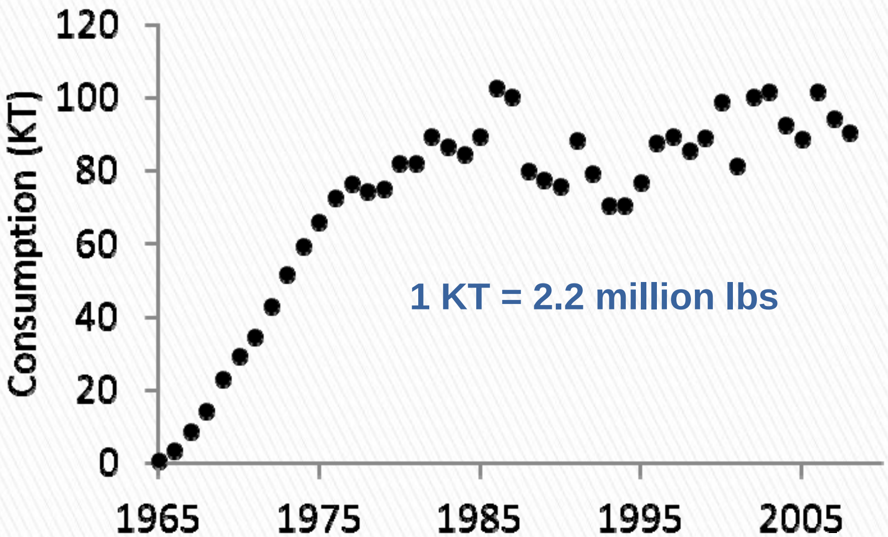
$$C = c \times N$$ ← We've already got N

$$c = G \div GCE$$

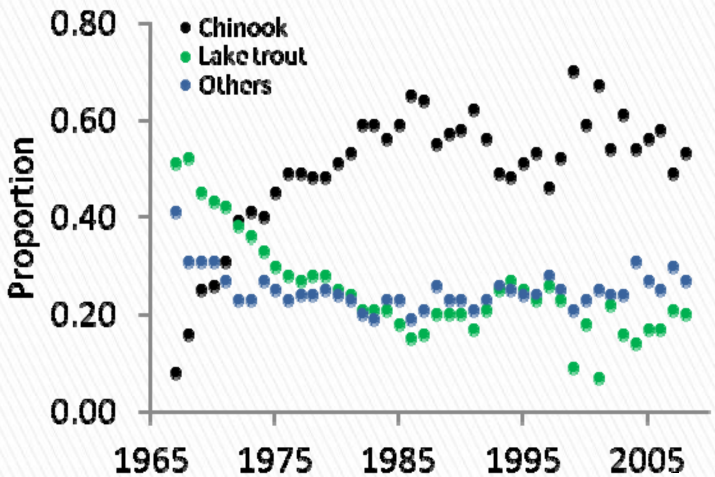
- We have data (or estimates) for:
  - How many salmon and trout are feeding
  - Weights-at-age for harvested fish (change in weight-at-age = growth)
  - Conversion efficiency estimates from **bio-energetics research**

How much do they eat?

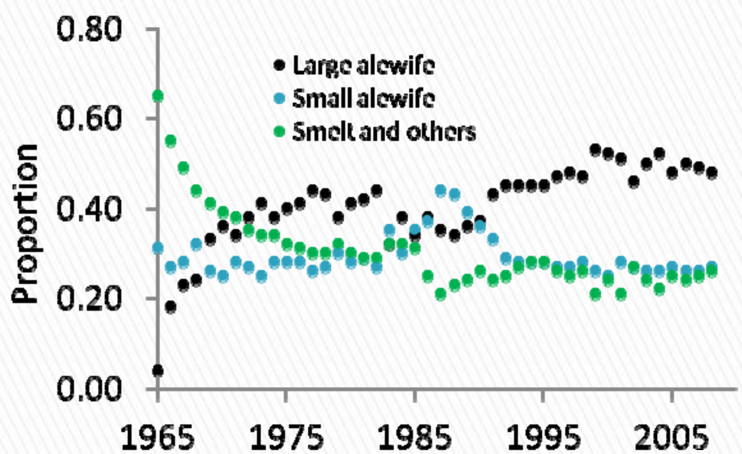
Consumption by all species
of salmon and trout



Consumption by predator type



Consumption by prey type



Conclusions: Question 2

- Total consumption has remained fairly stable for last decade
- Chinook salmon have accounted for more than half of total demand consistently since 1980
- Large alewife accounted for more than 40% of total prey consumed since 1980, except in the late 1980s when small alewife dominated

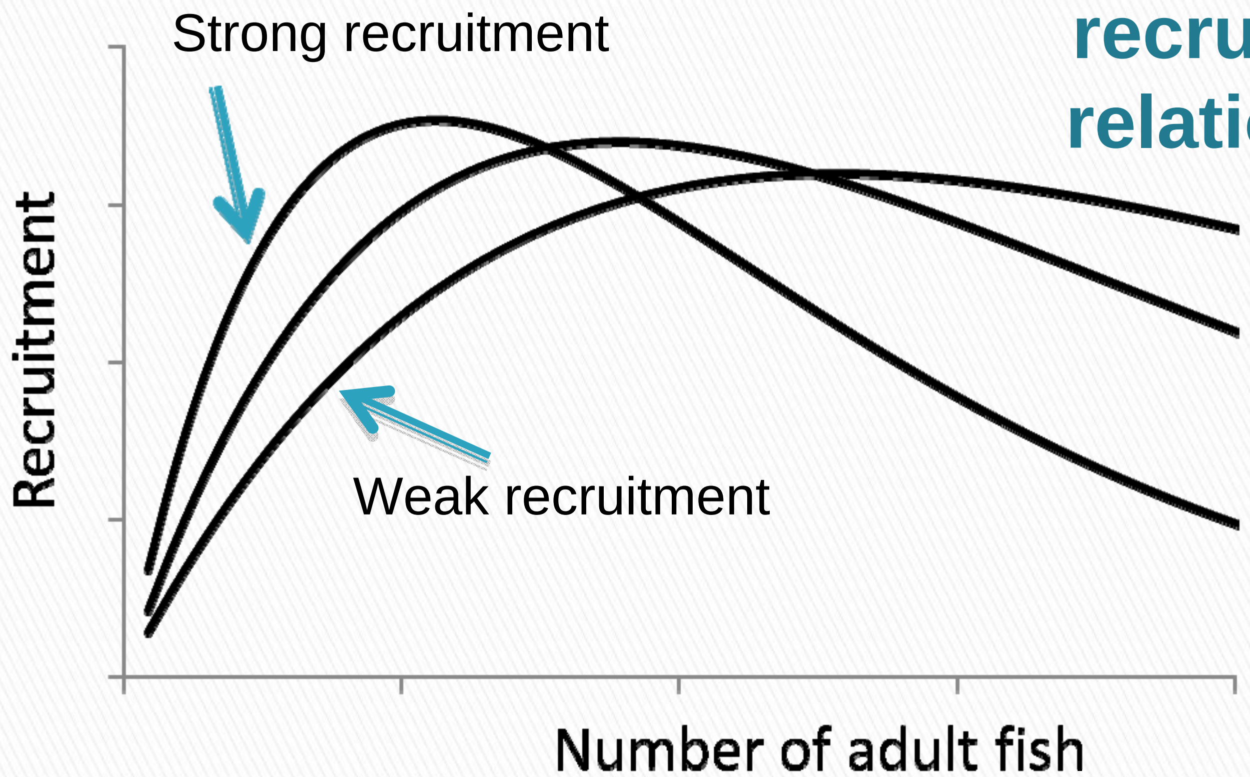
How capable are the prey fish of meeting this demand?

- For prey fish:
  - Supply = **Recruitment**

  = Additions of new fish to the population each year

How capable are the prey fish of meeting this demand?

Stock-recruitment relationship



How capable are the prey fish of meeting this demand?

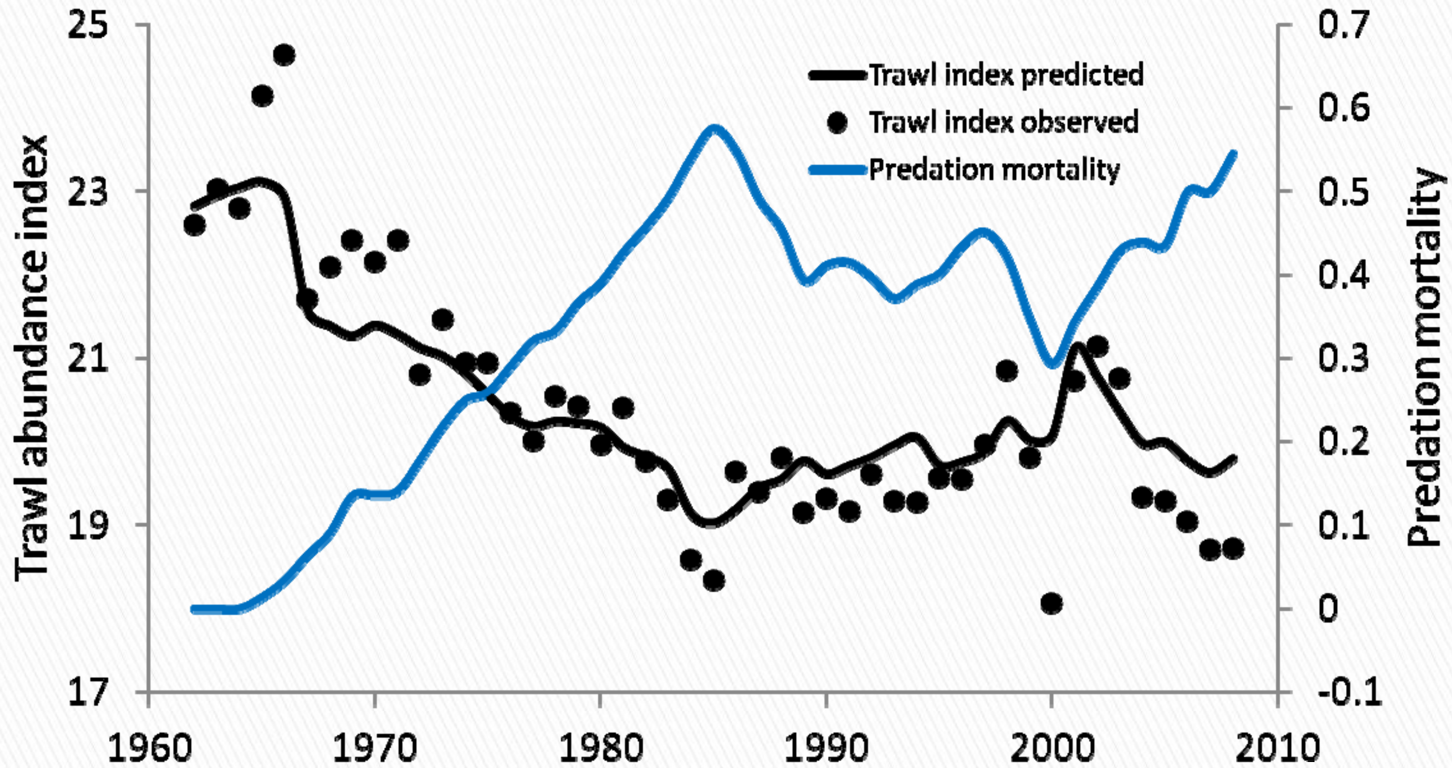
- We need to know:
  - How does prey fish recruitment change over time, as the number of adult fish changes?
- We have data on, or estimates of:
  - Numbers of prey fish caught or observed in survey gear
  - (bottom trawl and hydroacoustic) – 1962-2008
  - Number of prey fish consumed by predators
  - Salmonine consumption estimates (from Question 2) – 1967-2008
  - Salmonine diet data – to divide consumption among prey types (1967-2008)

Recruitment = Number of "new" fish estimated to be present in fall, based on surveys + Numbers that were eaten by predators

Our model asks how many fish need to be there, to account for survey data and consumption estimates?

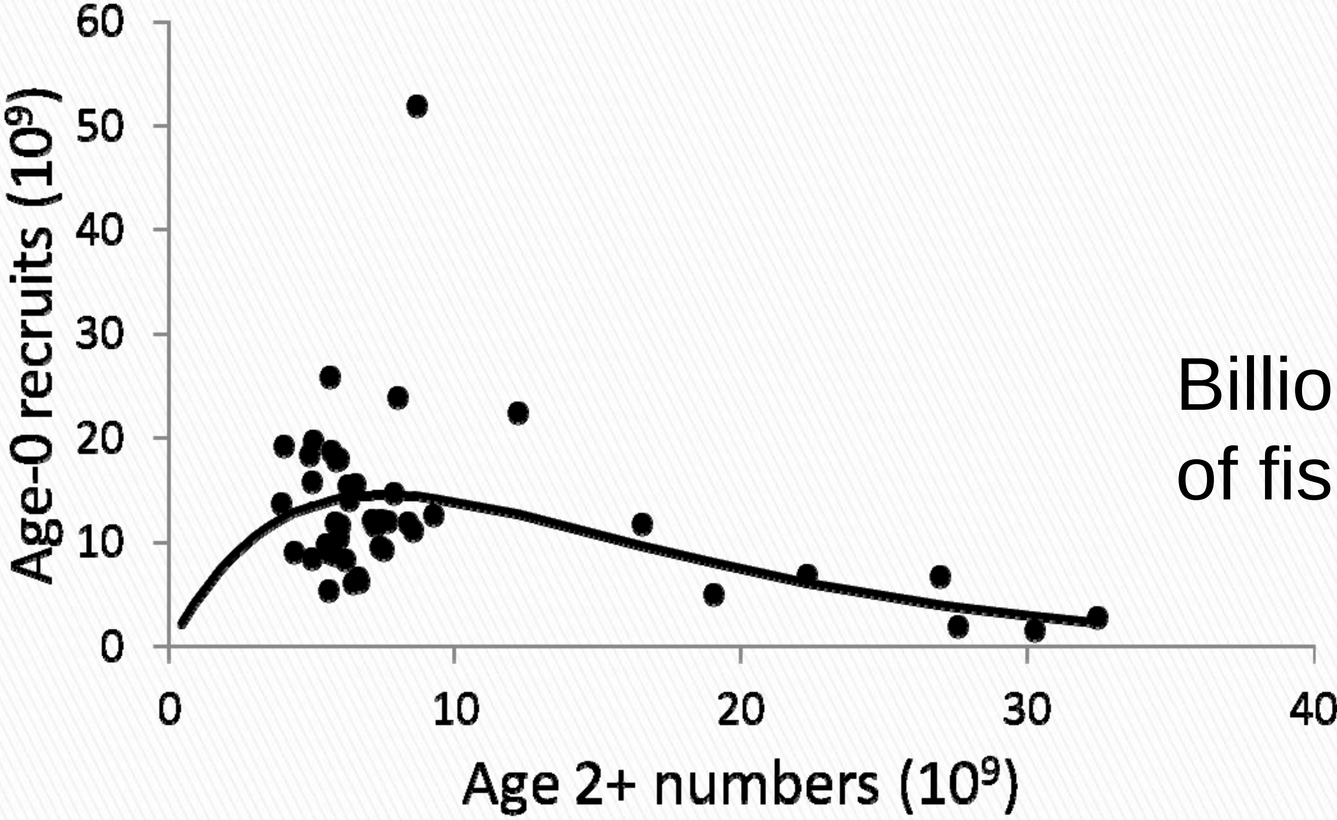
How capable are the prey fish of meeting this demand?

Observed and predicted abundance estimates for age-3+ alewife & predation mortality



How capable are the prey fish of meeting this demand?

Estimated stock-recruitment relationship for alewife

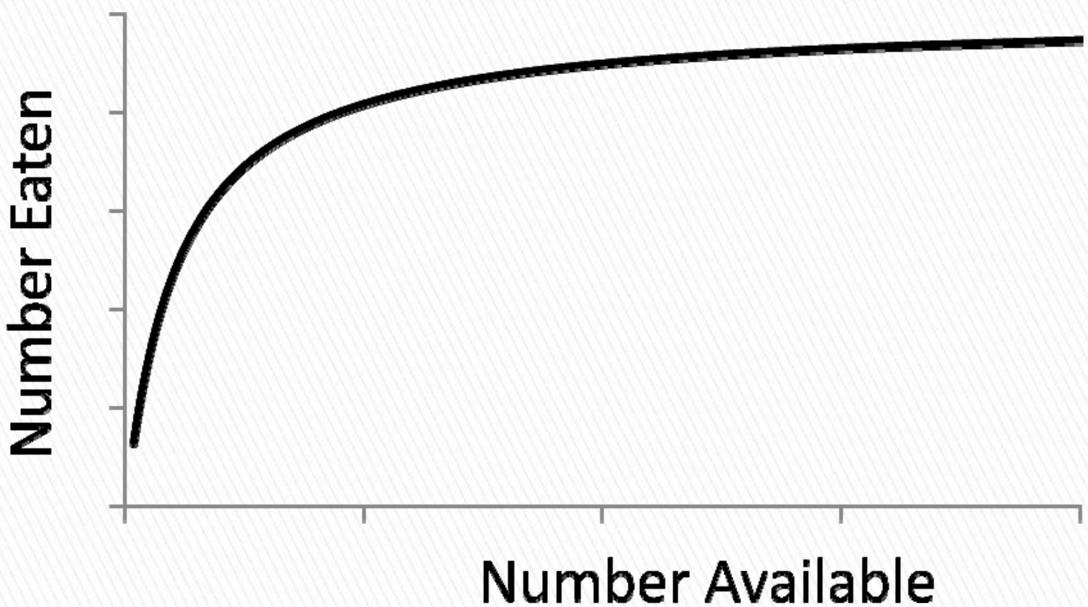


Billions of fish

Conclusions: Question 3

- Predation rates on alewife have ranged from 25%-45% per year from the mid-1980's to present
- Predation peaked in mid-1980's and has approached peak levels again recently
- Alewife (and rainbow smelt) recruitment is variable and not strongly related to adult abundance

What happens to salmon and trout feeding when prey numbers are low?



Functional Response

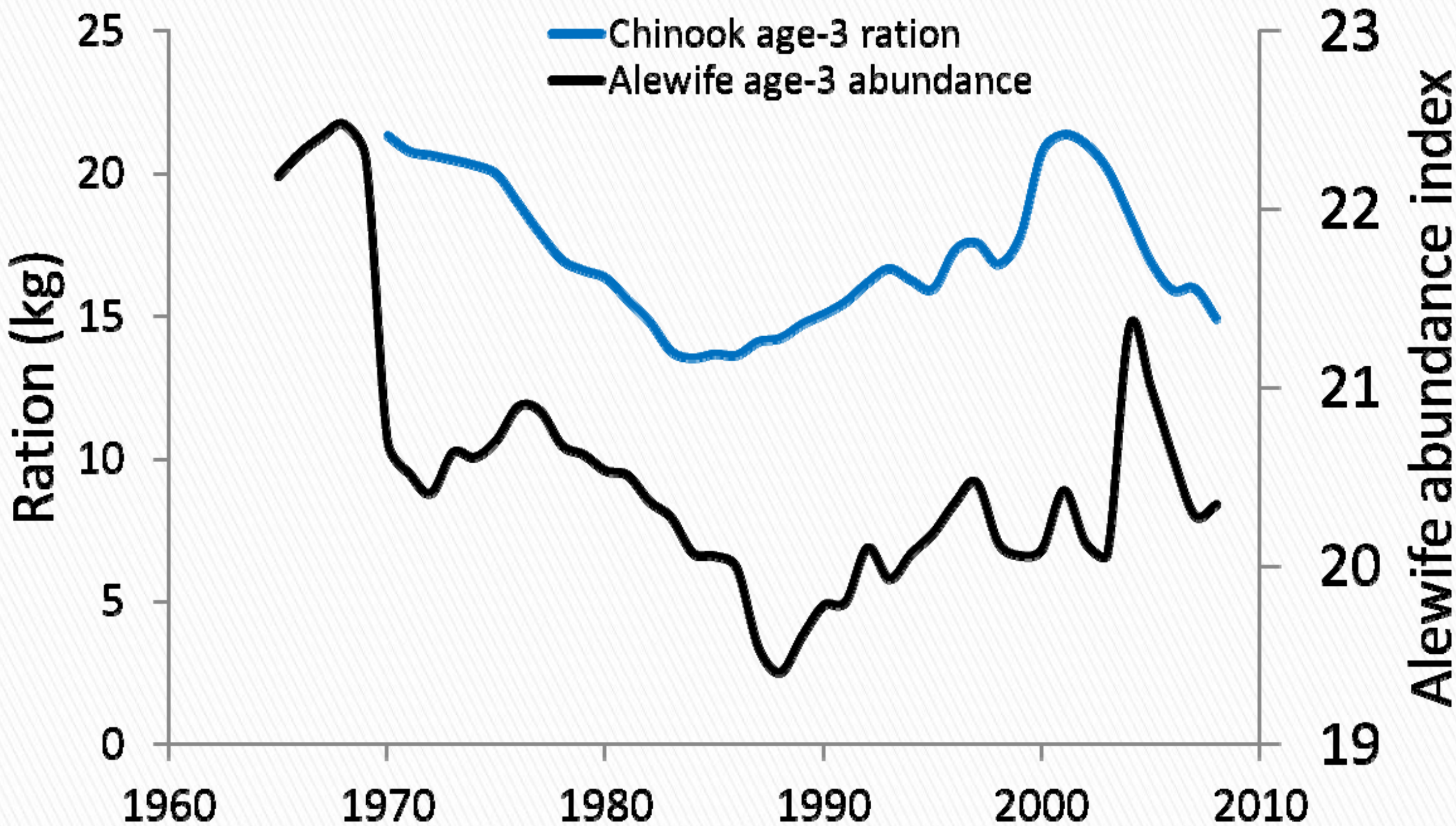
Mortality = Number eaten / Number available

So, if number eaten remains high while number available goes down, mortality goes **UP**

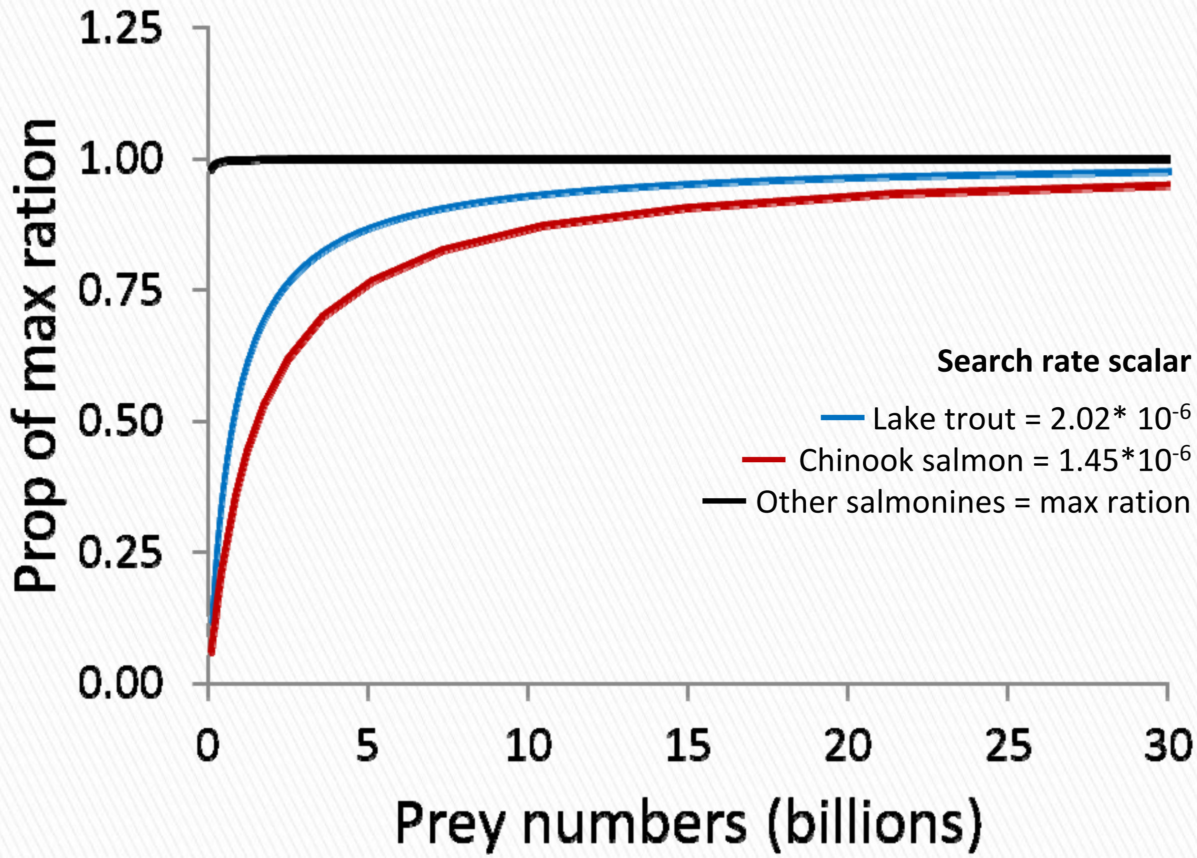
What happens to salmon and trout feeding when prey numbers are low?

- Functional response analysis:
  - Predator growth data tells us about what was eaten
  - Prey fish survey data tells us about what was available
  - If growth rates declined when prey became less abundant, we can estimate the functional response
- This strategy worked for Chinook and Lake Trout, but not for the other predators

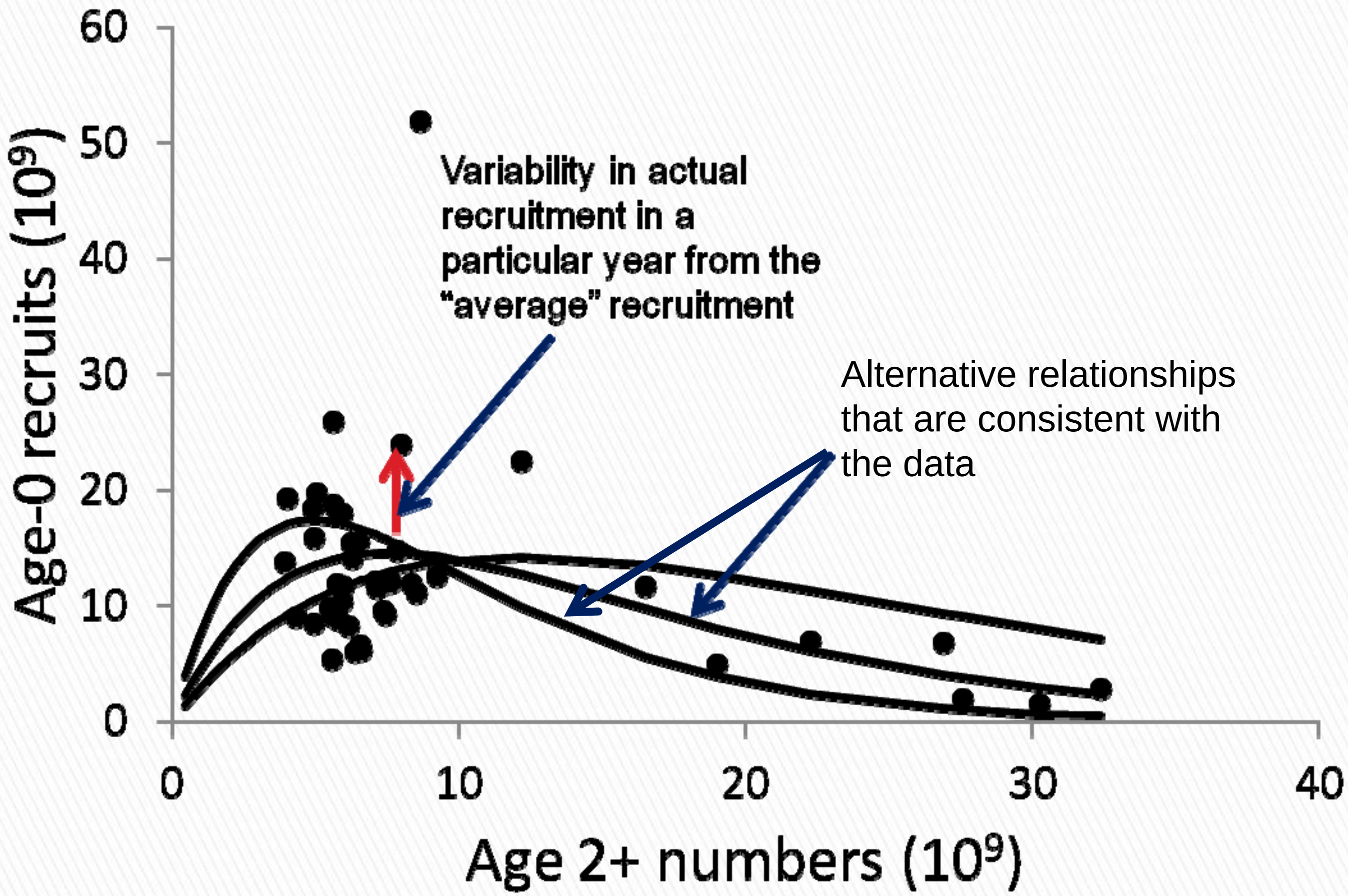
What happens to salmon and trout feeding when prey numbers are low?



What happens to salmon and trout feeding when prey numbers are low?



Uncertainty: Prey recruitment



Uncertainty: Predator Feeding

- We consider alternative functional response search rate values for Chinook salmon and lake trout

Other Uncertainties

- Chinook salmon wild recruitment
- Recreational fishing effort

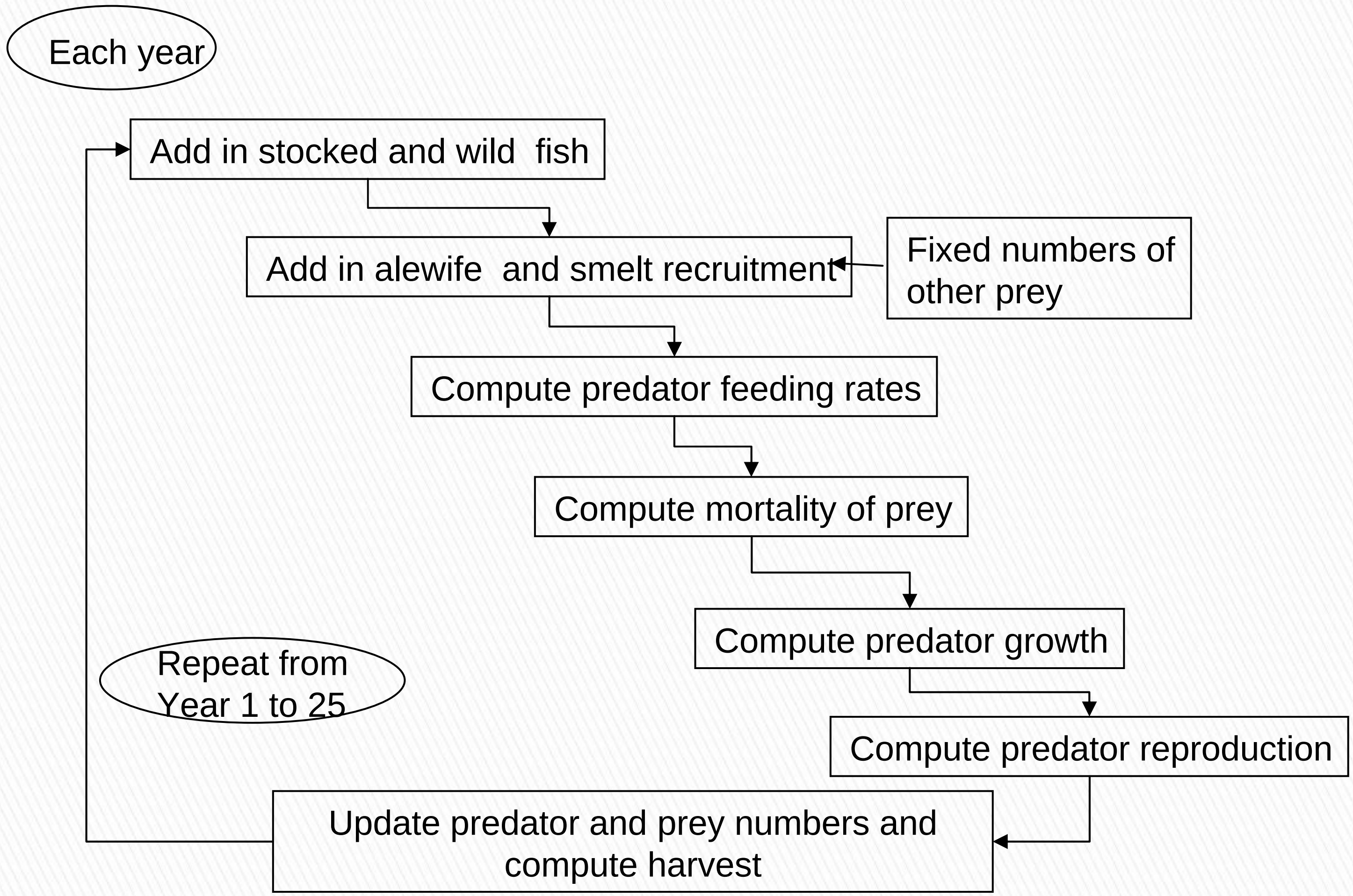
Decision Analysis: forecasting model

- Simulation model – forecasts possible future changes in fish populations and harvest, given a stocking policy
- The model updates predator and prey numbers, weight and length on a monthly basis
- The model uses the results from our "retrospective" analysis to describe how we think the populations will change in the future

  Accounts for uncertainties: key uncertainties concern prey recruitment (supply) and predator feeding (demand)

- We hedge our bets by considering many possible truths, based on the data

Forecasting model structure

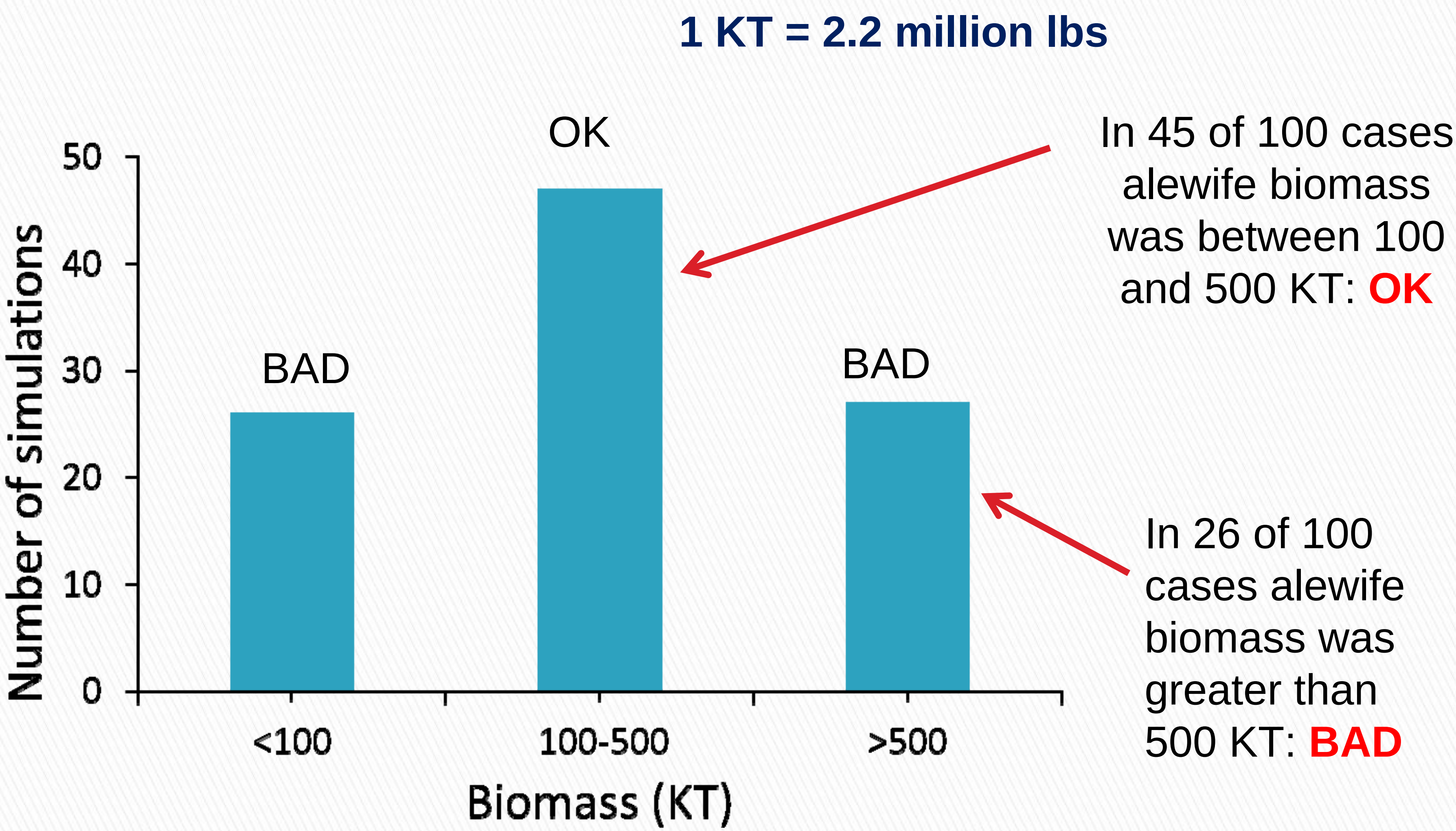


Repeat the simulation 100 times for each policy, and record the outcome each time
Then, look at the distribution of outcomes

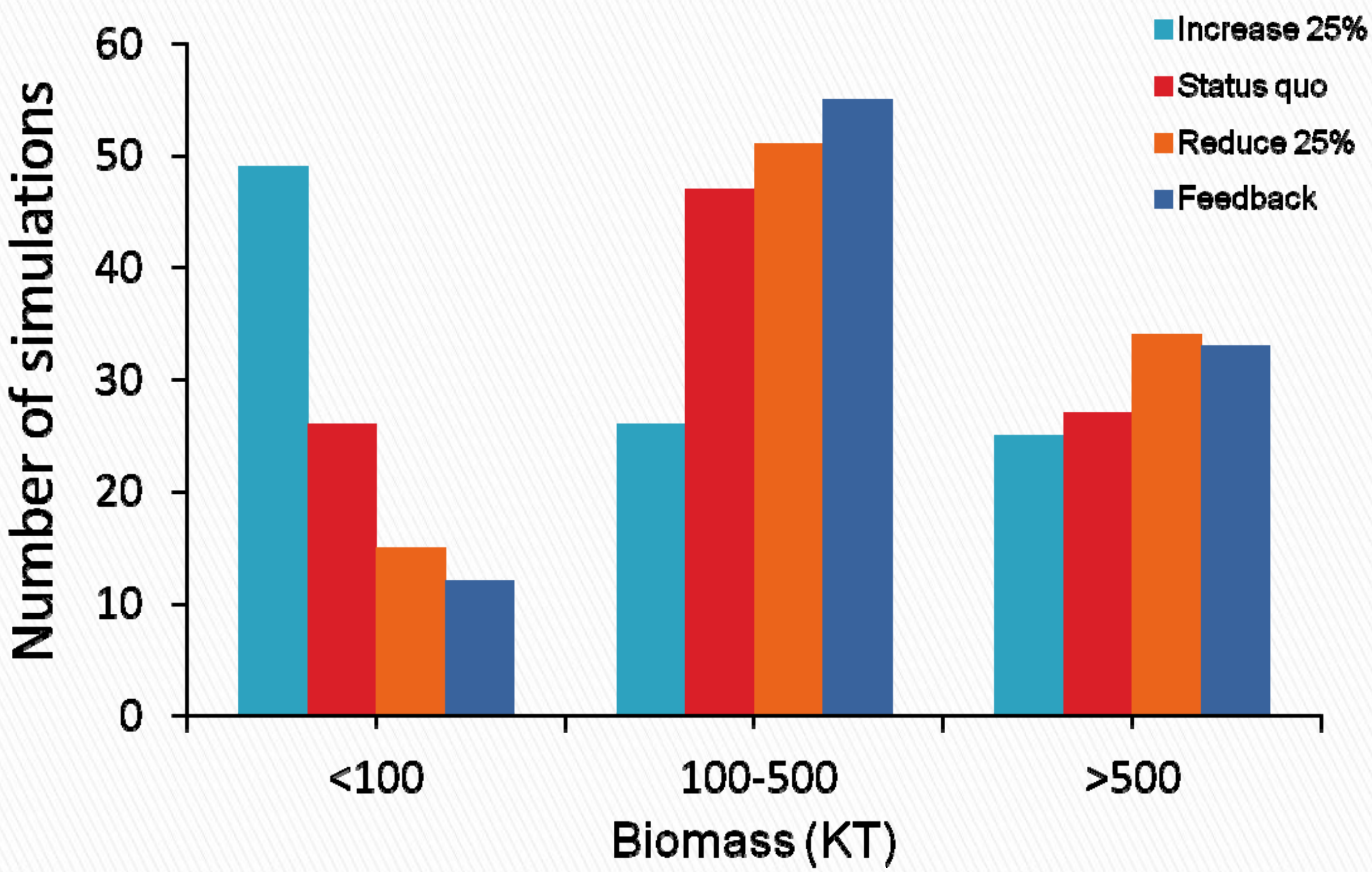
Sample stocking policies

- Examples of simulations we have run:
  - Three fixed stocking strategies
    - Status quo
    - 25% increase in all species
    - 25% decrease in all species
  - Feedback policy
    - If < 7 kg, reduce stocking of all species 25%
    - If >8 kg, restore stocking

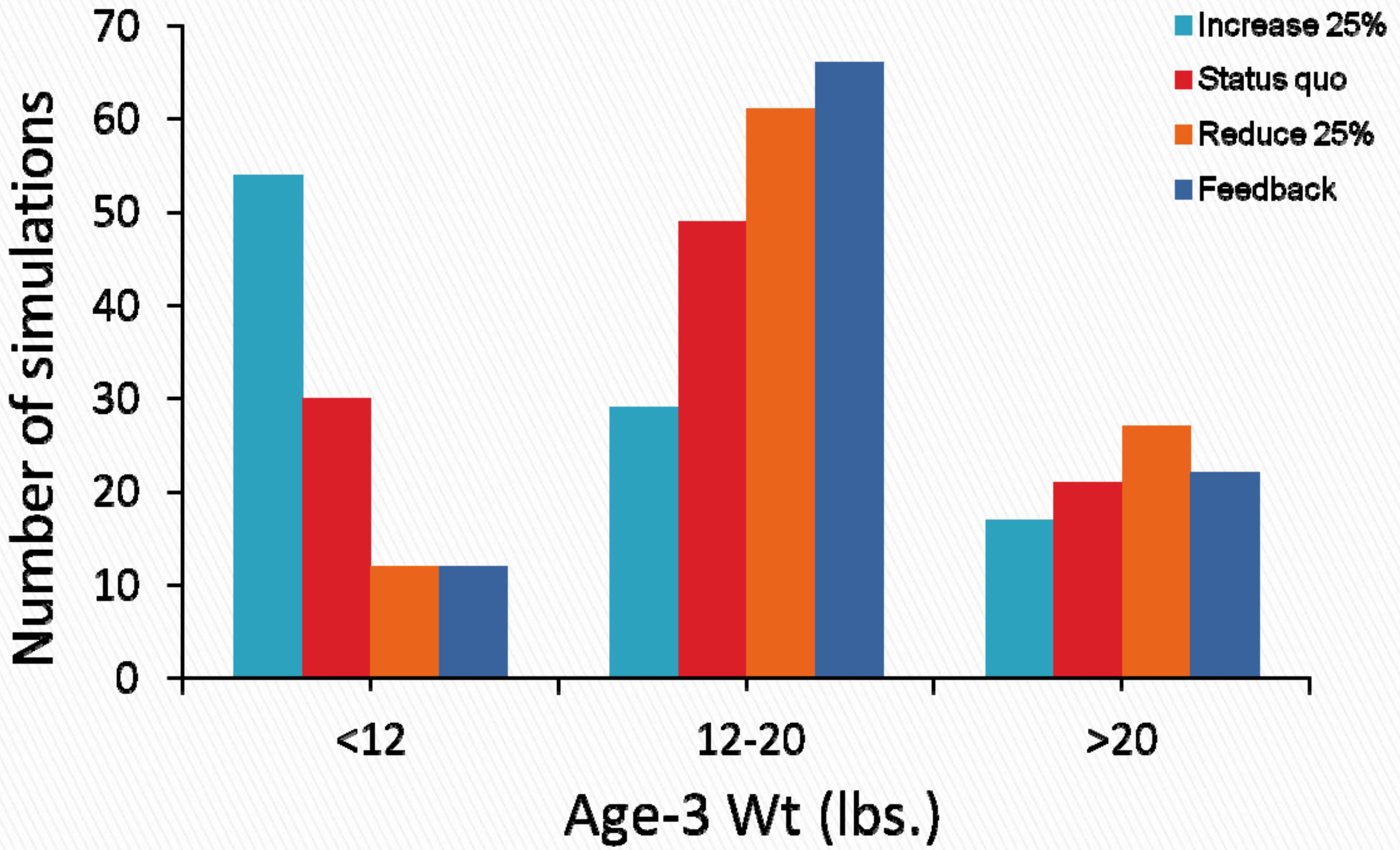
Status quo policy – forecasted Alewife biomass



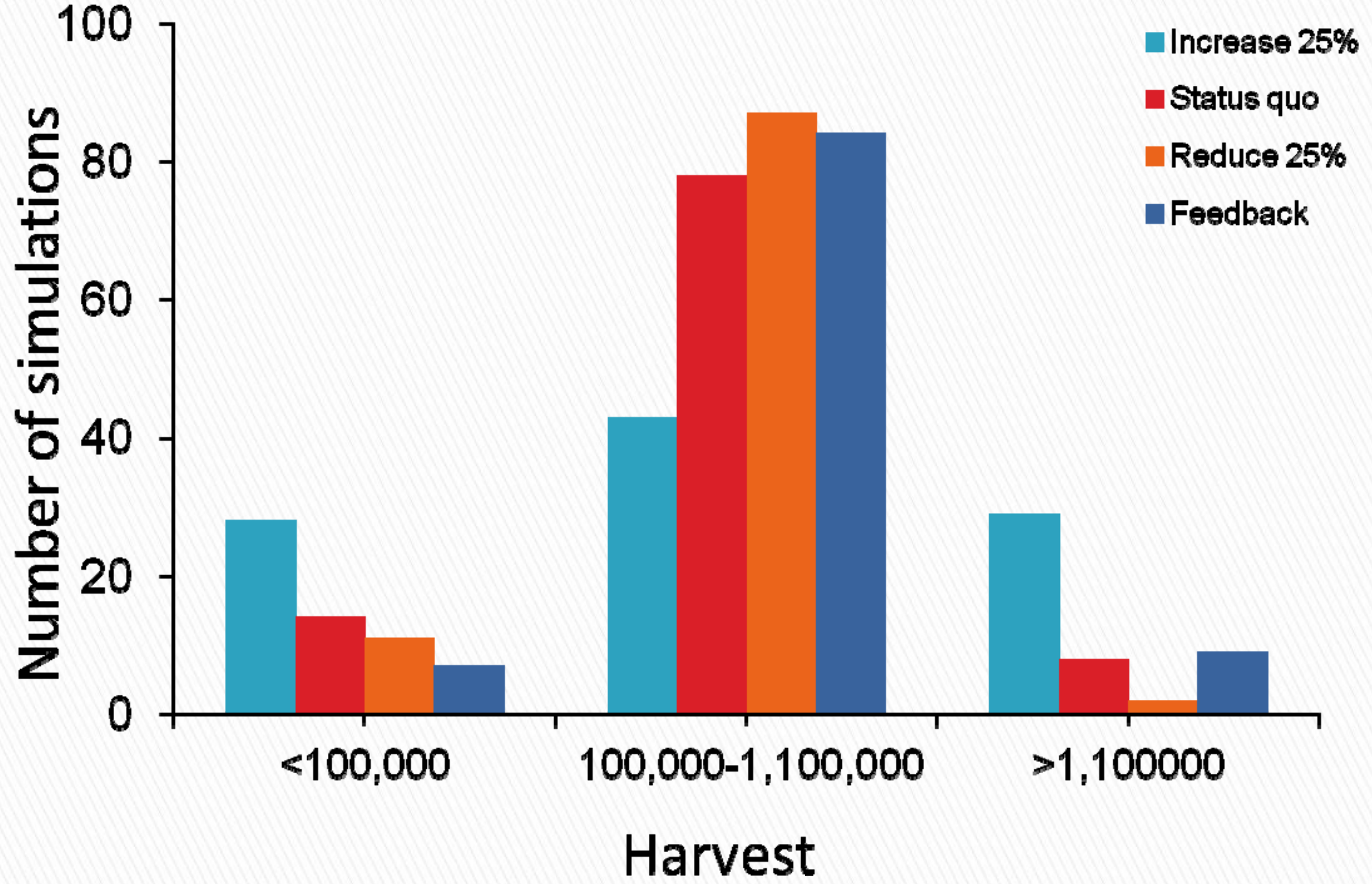
Policy comparison – forecasted alewife biomass



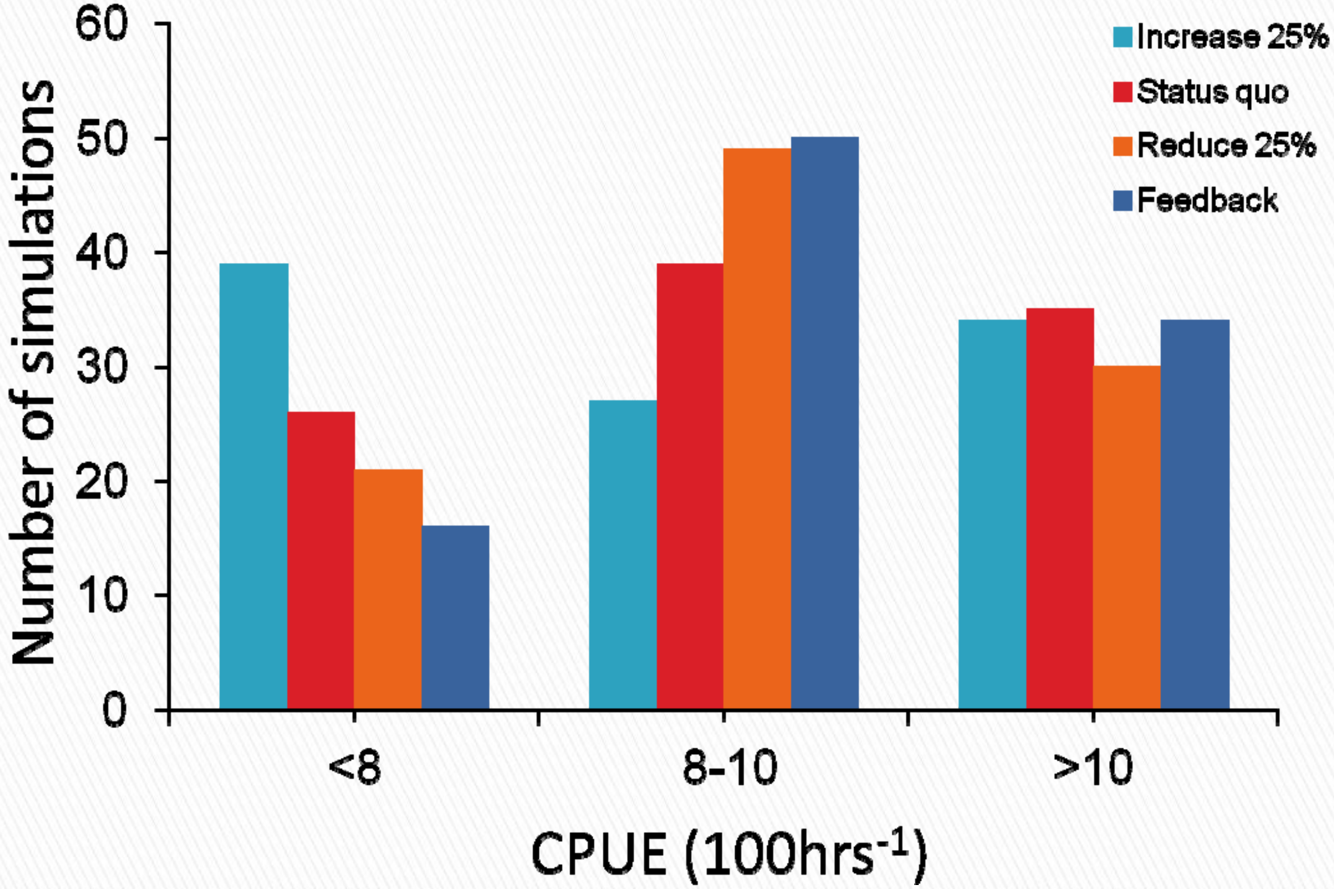
Policy comparison – forecasted Age 3 Chinook weight



Policy comparison – forecasted Chinook harvest



Policy comparison – forecasted Chinook CPUE



What other stocking policies should be considered?

- Three fixed stocking strategies
  - Status quo
  - 25% increase in all species
  - 25% decrease in all species

- Feedback policy
  - If < 7 kg, reduce stocking of all species 25%
  - If >8 kg, restore stocking