Ministry of Natural Resources

Ontario

Preliminary assessment of the trophic consequences of Asian Carp establishment in offshore Lake Ontario

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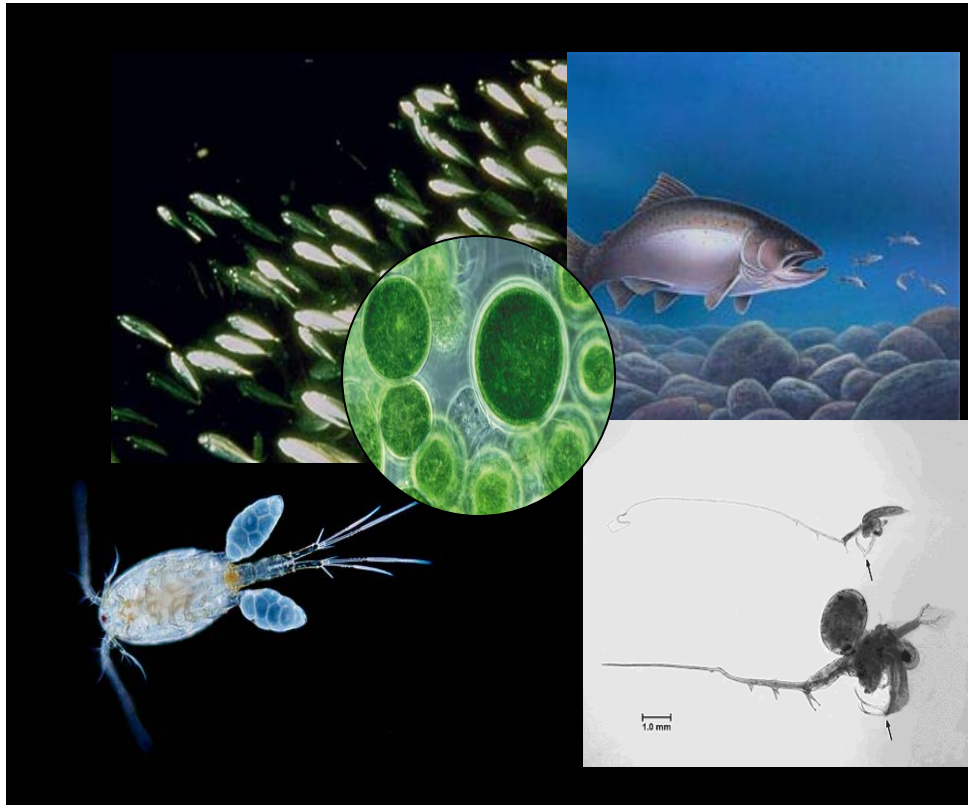
Introduction

- The risk of GLs Asian Carp introduction and establishment is real
- Predictions are that the food web would be disrupted, because like *Dreissenid* mussels, AC feed at lower trophic levels



Introduction

- In Lake Ontario, Alewife are a key prey species important in the diet of all large predators.
- The also feed on lower trophic levels and could be impacted if AC are established
- This in turn could impact important fisheries, especially the Chinook Salmon fishery

Objectives

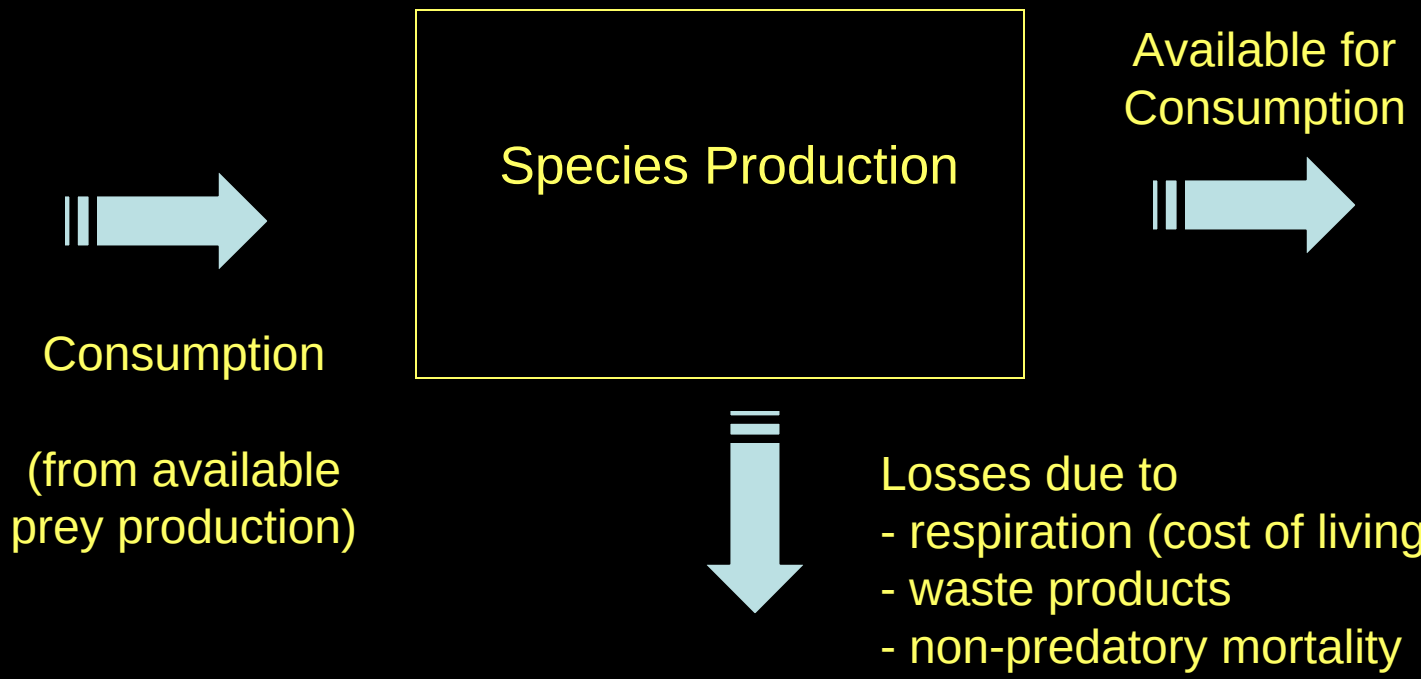
- Is it trophically possible to sustain AC in the offshore Lake Ontario food web and at what level of biomass?
- What are the consequences of AC establishment to the sustainable biomass of Alewife and Chinook Salmon

Methods

- Using Silver Carp (*Hypophthalmichthys molitrix)* and Bighead Carp *(H. nobilis*) as examples we:
  - Derived probable diets
  - Estimated a Production/Biomass ratio
  - Estimated a Consumption/Biomass ratio
- Assumed levels of AC biomass that ranged from low (comparable to a top predator biomass) to a high (comparable to prey fish biomass)
- Applied a replicated mass-balanced flow network analysis implemented in ECOPATH and applied to Lake Ontario (Kavanagh 2004, Stewart and Sprules 2010) to simulate establishment

Mass Balance Flow Network

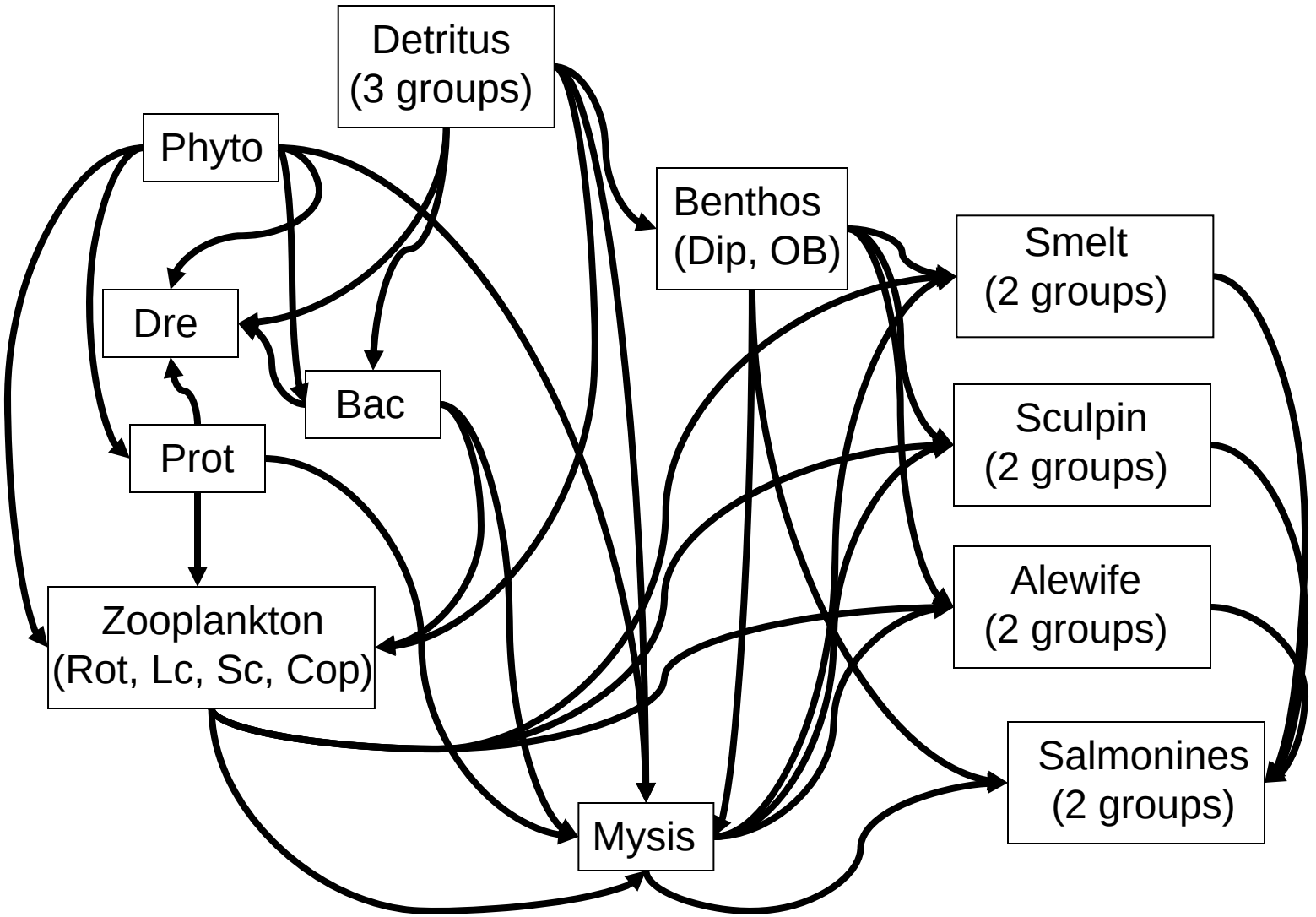
Flows (g C · m^{-2}·year $^{-1}$) in a Food Web
Consumption, Production, Respiration, Waste



Predator consumption cannot exceed production of its prey

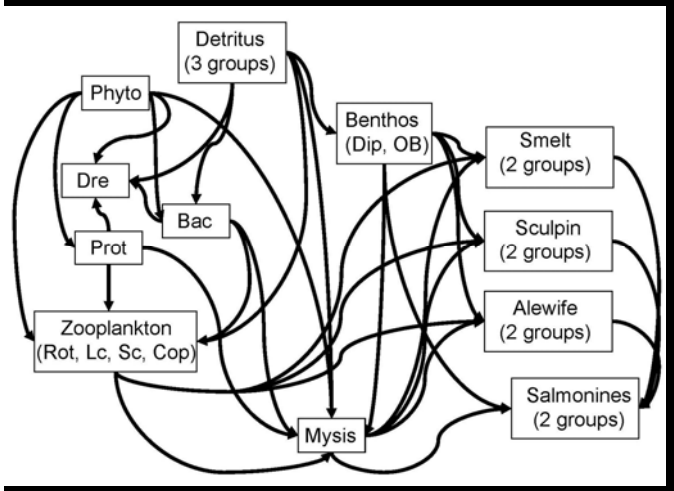
Simplified Lake Ontario Offshore Food Web

From: Stewart and Sprules 2010: Ecological Modelling 222:692-708



A replicated mass balance flow model network

Model Structure + Observations & Assumptions + Uncertainty



species-groups & topology

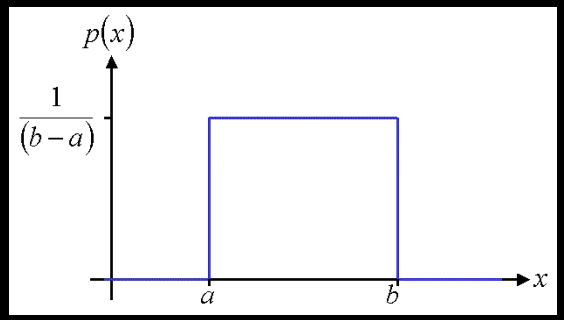
spatial organization

Biomass

Production & Consumption Rates

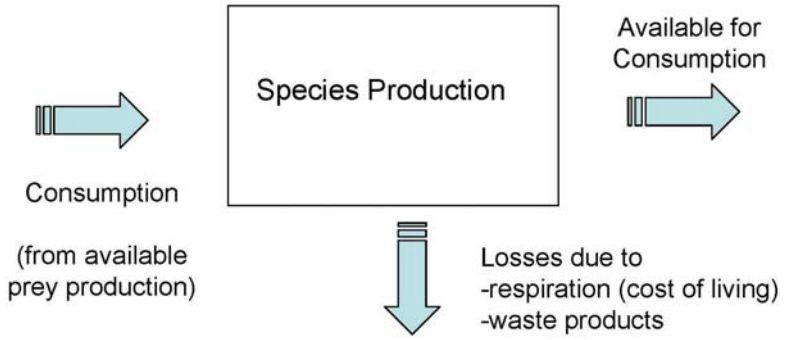
Diets

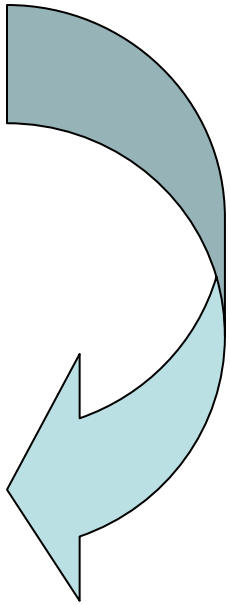
Bounded Variation



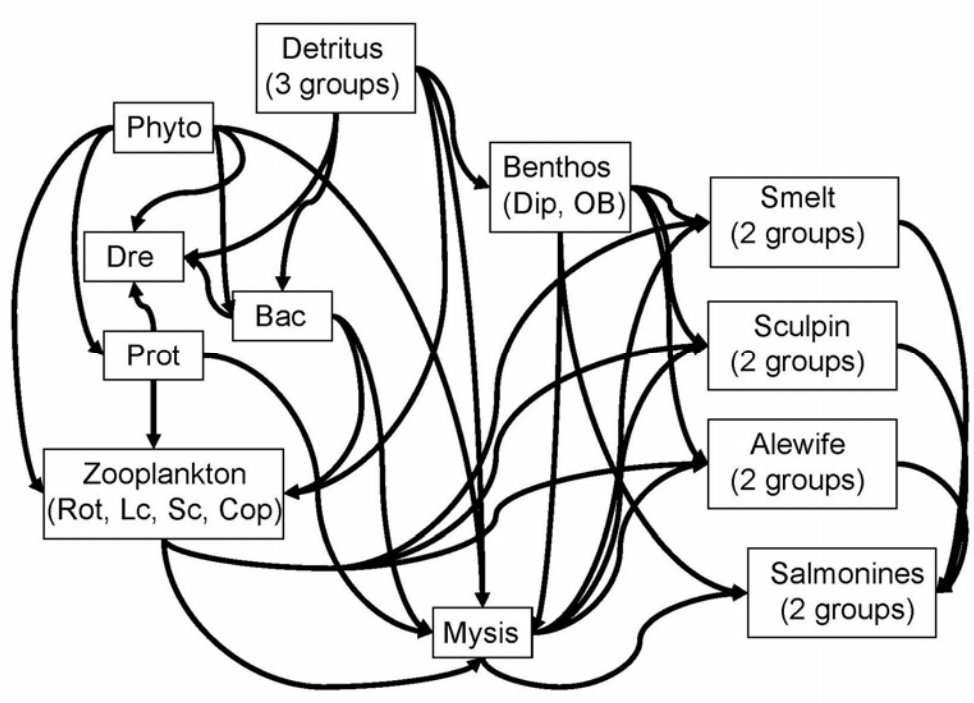
Biomass & Diets

Mass-balanced flow network





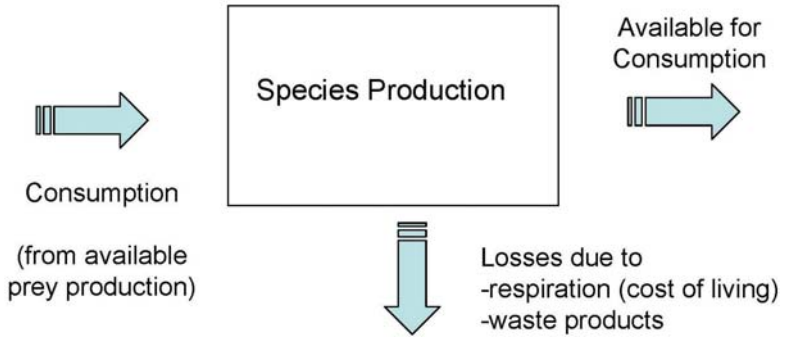
Mass-balance analysis balances the flows (production & consumption) in a network of consumers and producers



Already complete for Lake Ontario (2001-2005)

Stewart and Sprules 2010, Ecological Modelling 222: 692-708

Mass-balanced flow network



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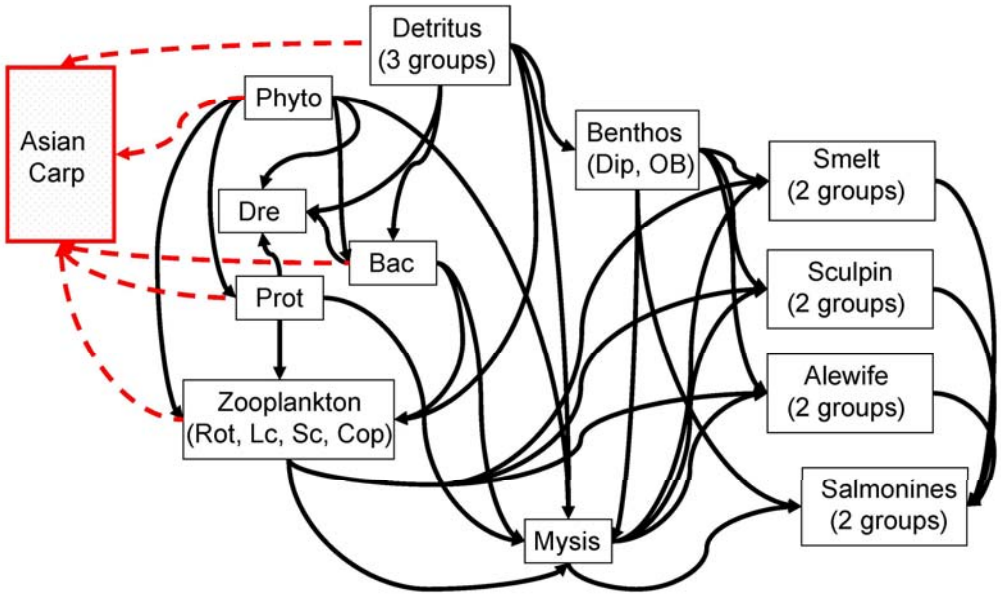
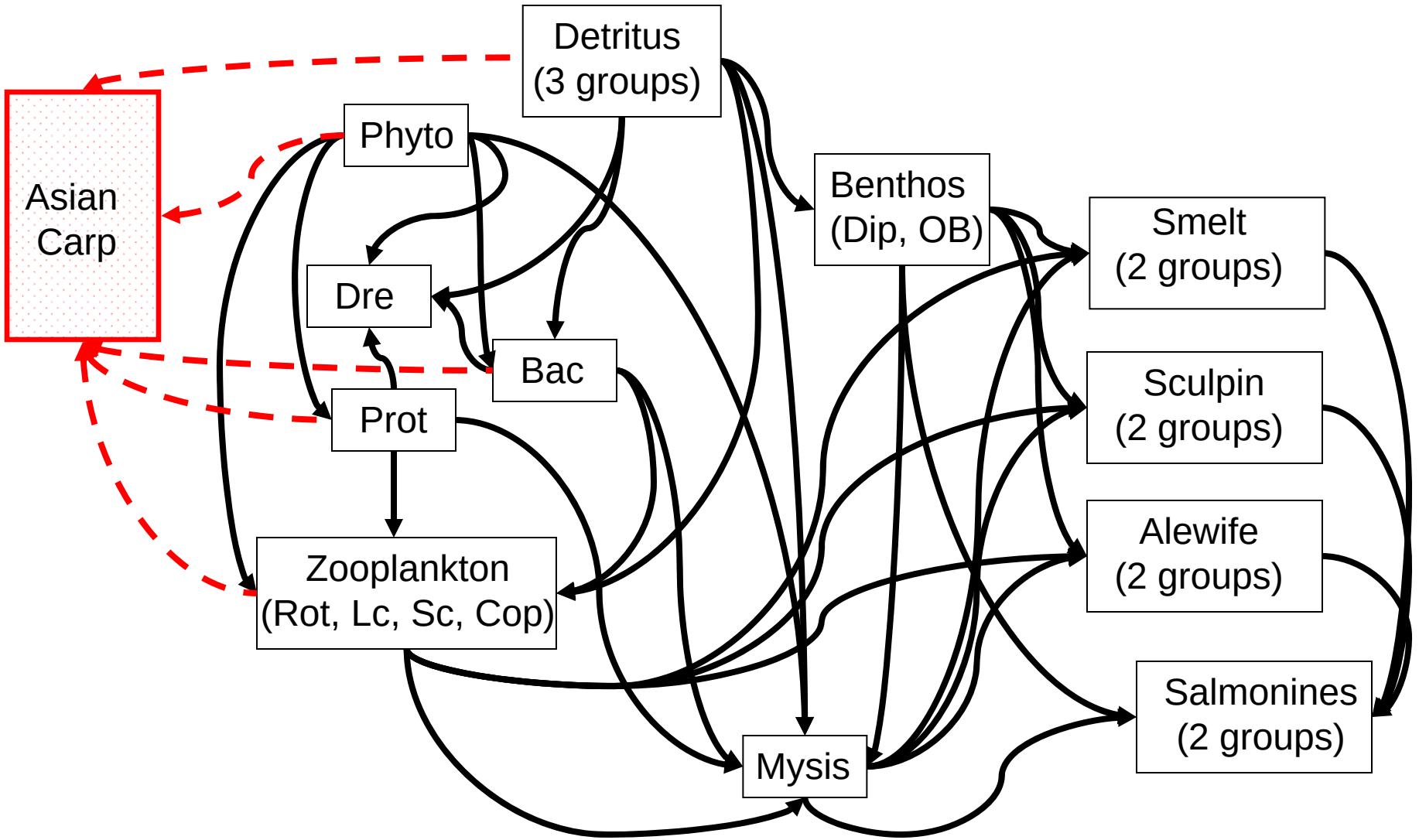


This Study Repeated including Asian Carp

Simplified Lake Ontario Offshore Food Web
Asian Carp Added



Methods

- Used literature observations values to derive diets for Silver Carp and Bighead Carp
  - Chen (1982) reported seasonal diets of both AC species as proportion of detritus, bacteria, phytoplankton, zooplankton
  - took seasonal averages and applied Lake Ontario species proportions to derive Lake Ontario diets (lumping protozoans with bacteria)
  - developed possible alternative diets dominated (50% by weight) by either detritus, bacteria, phytoplankton, or zooplankton, or evenly distributed.
- Applied 3 different methods to estimated consumption to biomass ratios (Q/B) and averaged them
  - Chen et al. 1989, Palomares & Pauly 1998, Cooke and Hill 2010
- Assumed P/B was equal to total natural mortality and was calculated from Pauly (1980) general size and temperature based empirical relationship

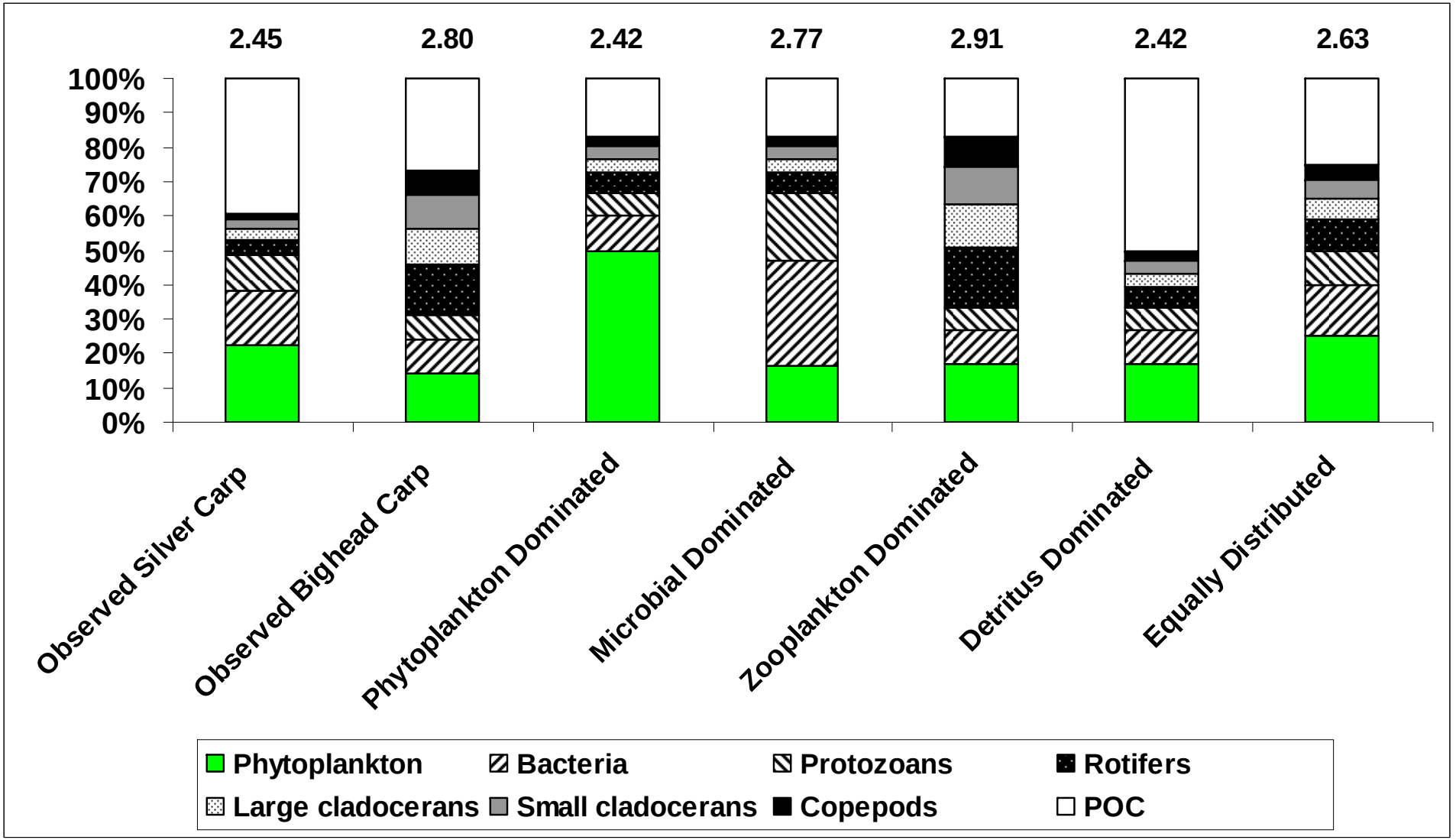
Methods

- A few modelling details
  - Fixed levels of lower trophic level production, biomass and diets based on mass-balance analysis for 2001-2005 (Stewart and Sprules 2010).
  - Allowed Asian Carp and higher trophic level (prey fish and predator fish) biomasses and diets to vary
  - 5 replicate mass-balances derived for each initial diet (7) across 3 levels of biomass for a total of 105 unique mass balance solutions
  - Implemented using Ecopath V5.1

Qualification of Results

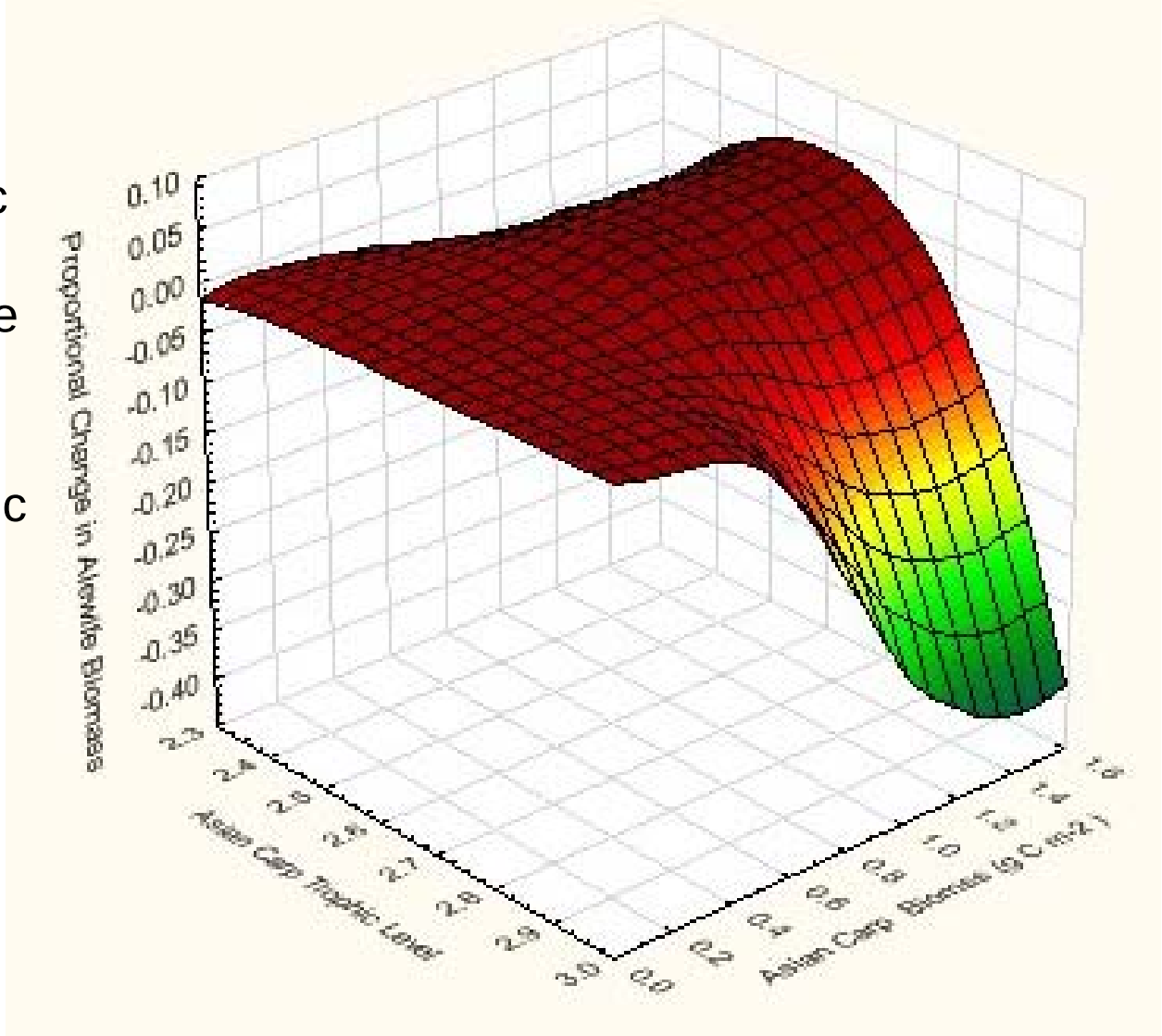
- Based on 2001-2005 food web with a bias towards offshore
- Is a food supply mass balance analysis and ignores other potential species interactions
- Ignores potential early life-history/reproduction bottle necks… starts with the assumption of an established adult population
- Knowledge of Asian Carp diets and production-consumption/biomass ratios are very poor

Simulated Asian Carp Diets



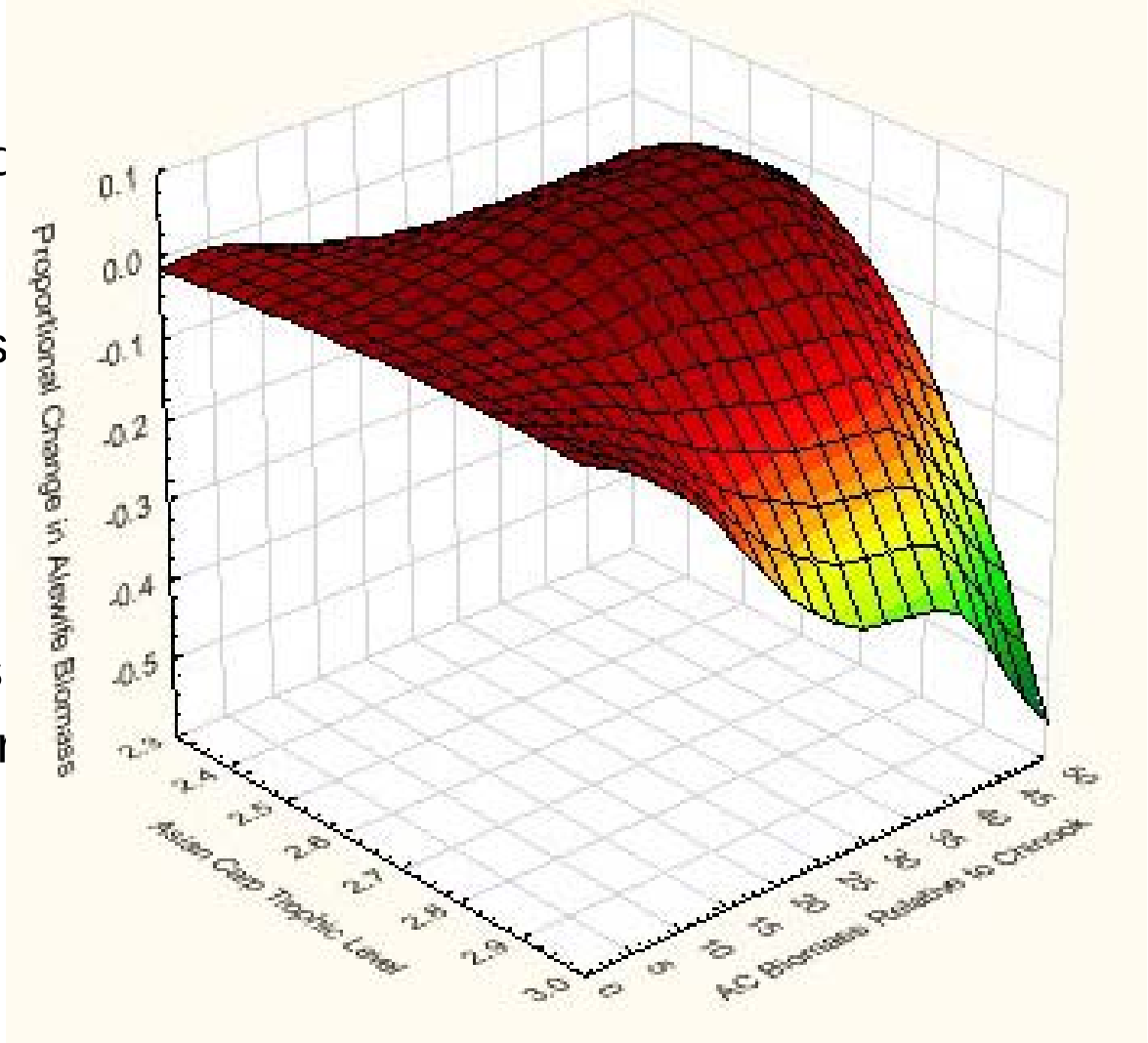
Can Alewife biomass be sustained?

- Assuming lower trophic level diets or low biomass of AC, Alewife biomass can be sustained
- Assuming higher trophic level diets or high AC biomass, Alewife biomass cannot be sustained



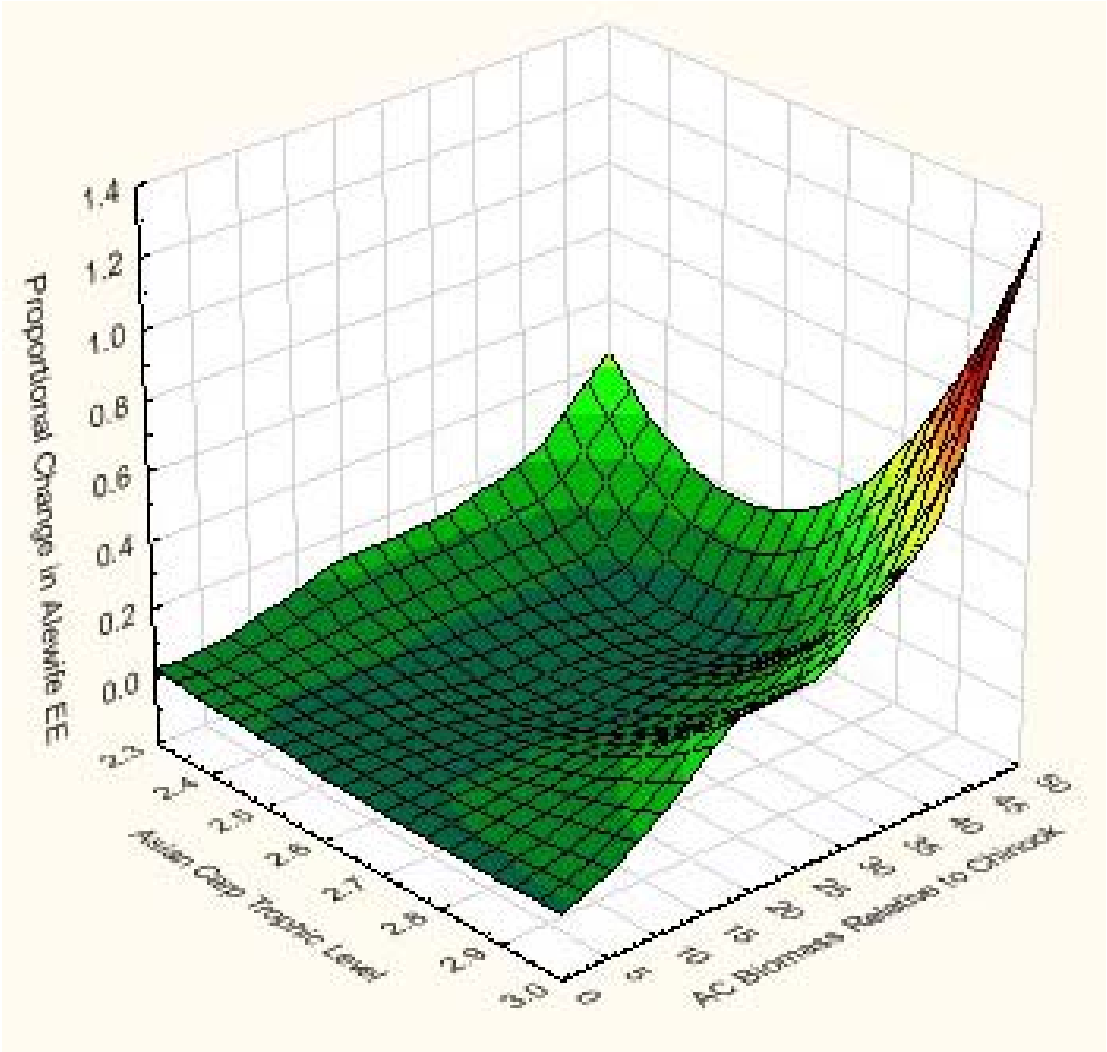
Carp Biomass vs Chinook Biomass

- Biomass of AC can exceed Chinook biomass by a factor of 10 without a change in Alewife biomass
- Biomass levels of AC that are 30-40X Chinook salmon biomass are sustainable but require a decline in Alewife biomass
- Less so if feeding at higher trophic levels



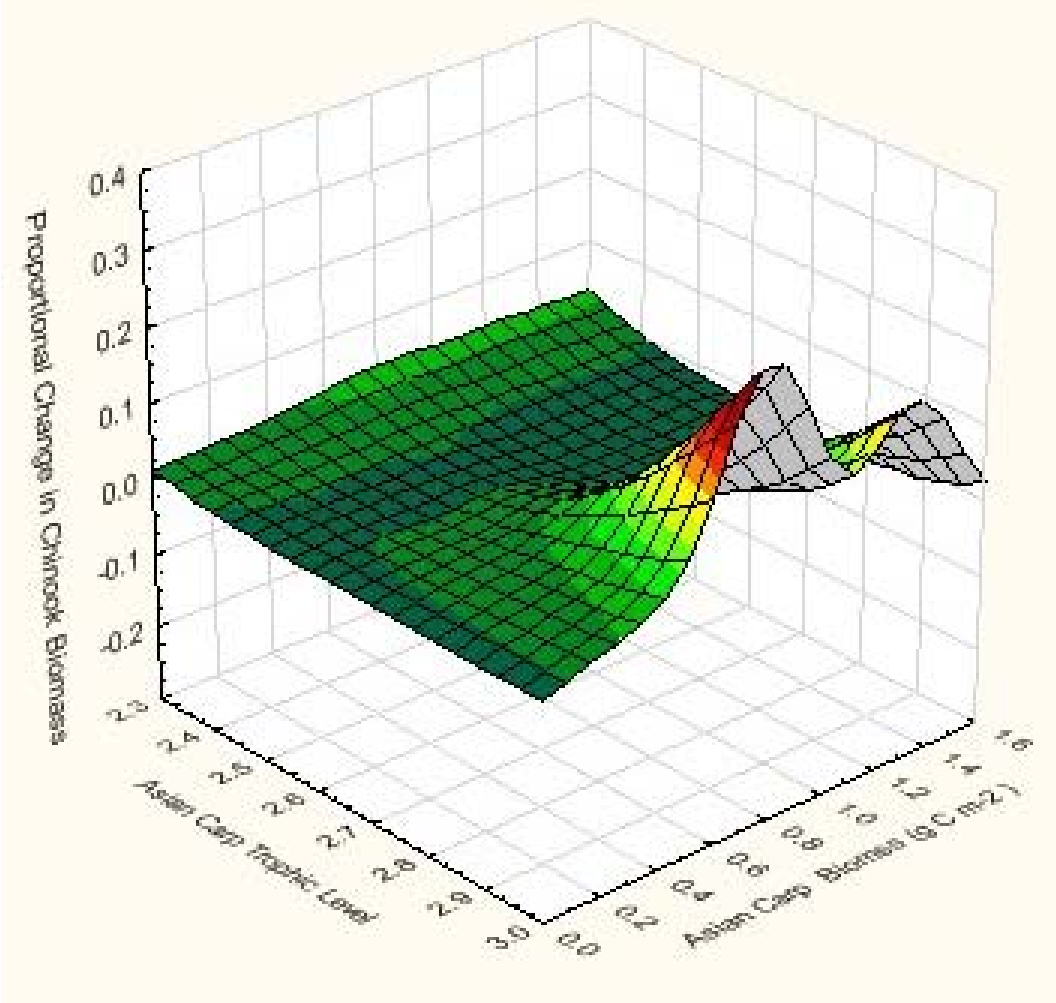
Risk to Alewife Collapse

- EE refers to “Ecotrophic Efficiency”, the proportion of the alewife production consumed by predators
- Higher levels increase the risk of Alewife collapse
- A value >1 means complete elimination of Alewife by consumption by predators
- This is more likely to occur if AC feed at higher trophic levels and reach higher levels of biomass



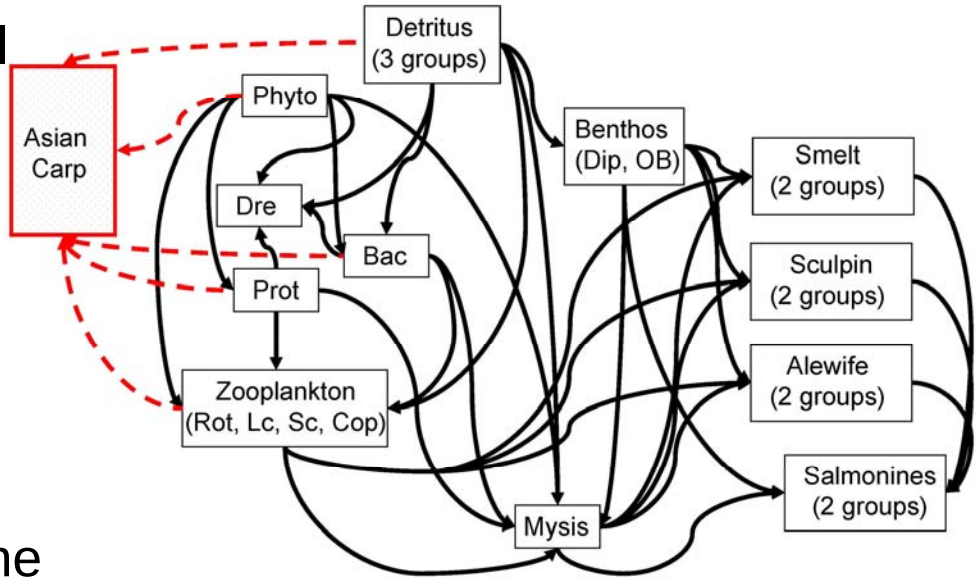
Impact on Chinook Salmon

- No evidence of general food supply (Alewife) issue for Chinook salmon with the introduction of Asian Carp
- This implies in 2001-2005, at least, there was a surplus of Alewife sufficient to support Chinook Salmon
- However, previous results, confirm that this buffer is reduced in the presence of Asain Carp and increases the likelihood of severe Alewife decline



Conclusions

- Results suggest that, if established in Lake Ontario, Asian Carp may be able to find sufficient resources to sustain a large population by exploiting under-utilized lower trophic level food resources
- The effects will cascade up the food web with unpredictable consequences
- Uncertainty in Asian Carp population dynamics, bioenergetics and diet makes it difficult to predict the extent of the disruption



Next Steps

- Modeling is a valuable tool to anticipate impacts, but given uncertainty must be based on stochastic risk-based framework
  - continue to accumulate knowledge on the populations dynamics, bioenergetics and trophic ecology of Asian Carp to better bound the uncertainty (work presented at this conference)
  - Apply modeling tools that allow for uncertainty in key parameters
    - Linear Inverse Modeling of food webs
    - Application of Structured Expert Judgment (Rutherford et al.)
    - New work in this regard recently encouraged by initial funding from the Federal/Provincial Invasive Species Centre (Thank you !)
- Continue to be vigilant and prevent establishment as food web impacts unlikely to be benign