

# A Coupled Bioeconomic Model of a Regional Economy and an Aquatic Food Web

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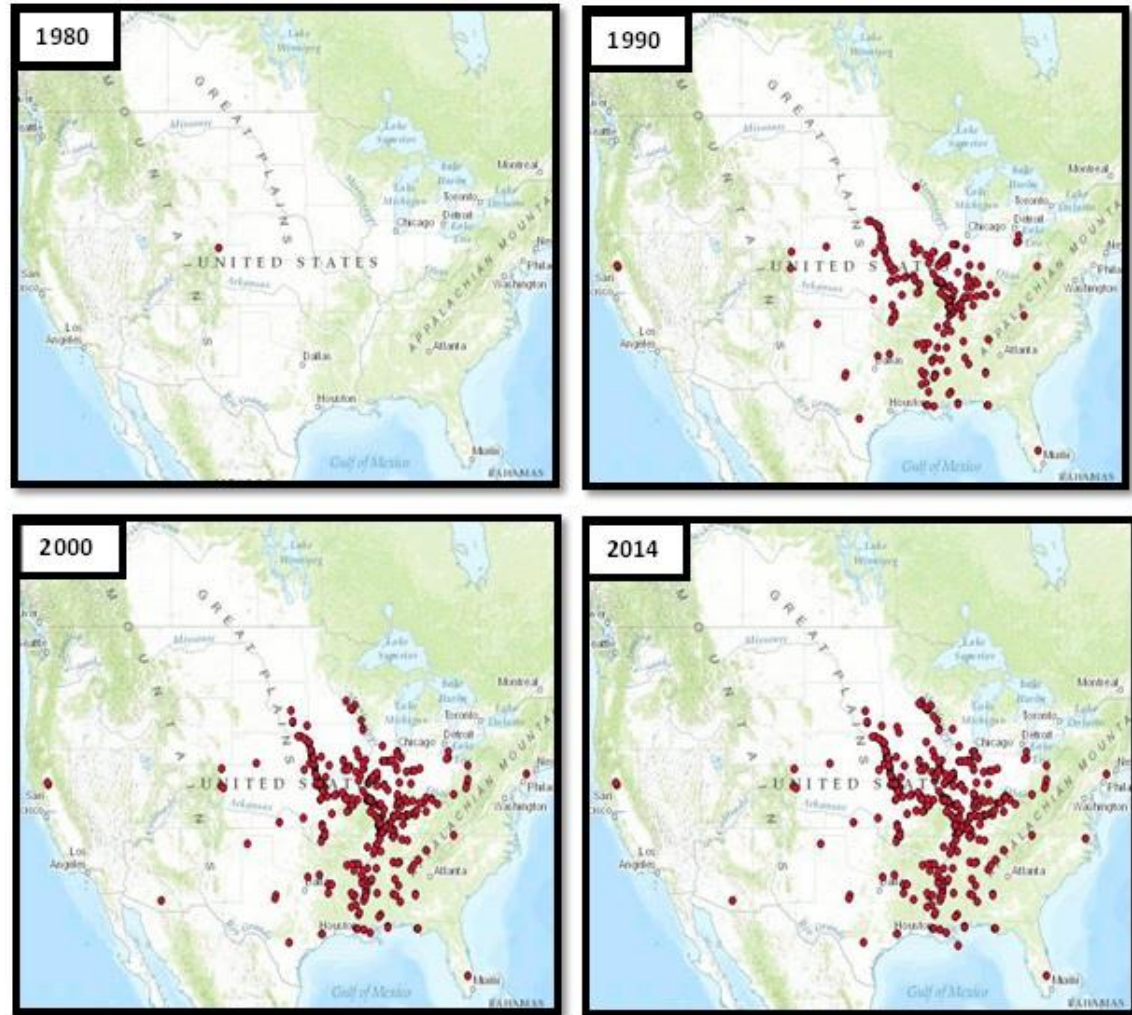
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# Asian carp

- Bighead carp and silver carp: introduced to southern US in 1970s
- Spread north through river systems
- Lake Erie and Lake Michigan: highest risk
- Unknown whether Asian carp will have similar **negative** impacts in the Great Lakes



# Lake Erie: Impact of Asian carp

## Recreational and commercial fishing

- Commercial fishery (Canada)
- Recreational fishery (USA)

## System ecology/function

- Altered food web

Lake Erie  
food web

Regional  
economy

## System ecology/function

- Impacted by choice of targeted fish species, harvest



## RESEARCH QUESTIONS

- What are the economic impacts of an Asian Carp invasion on Lake Erie?
- How do considering harvest impact on food web affect estimated impacts?

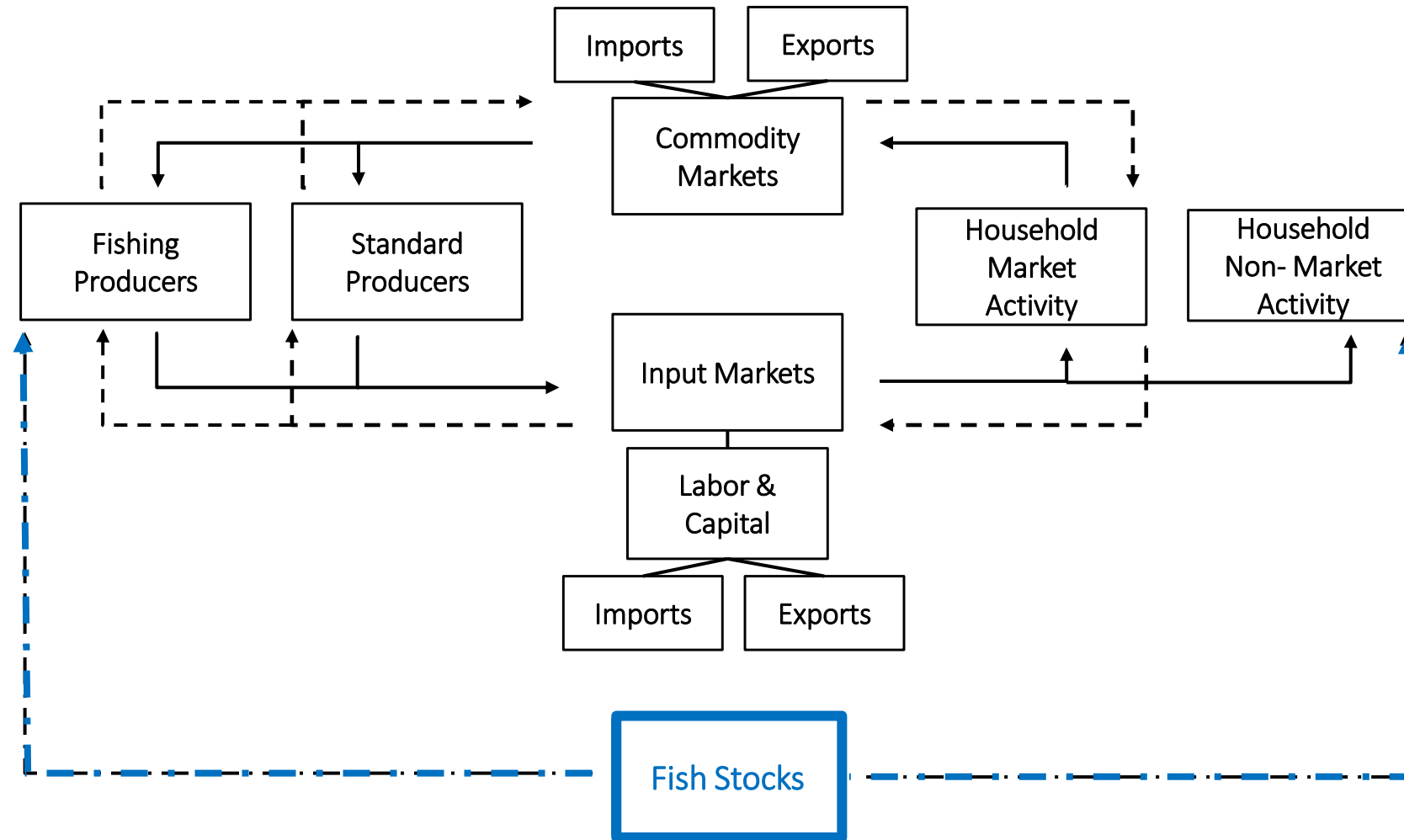
## APPROACH

- Model bioeconomic feedbacks by coupling
  - Computable general equilibrium model
  - Ecological food web model

## TAKE-AWAYS

- Mixed impact of Asian carp invasion on species (+/-)
- Including/ignoring feedback loops significantly changes estimates

# Overview: Linking CGE and food web models

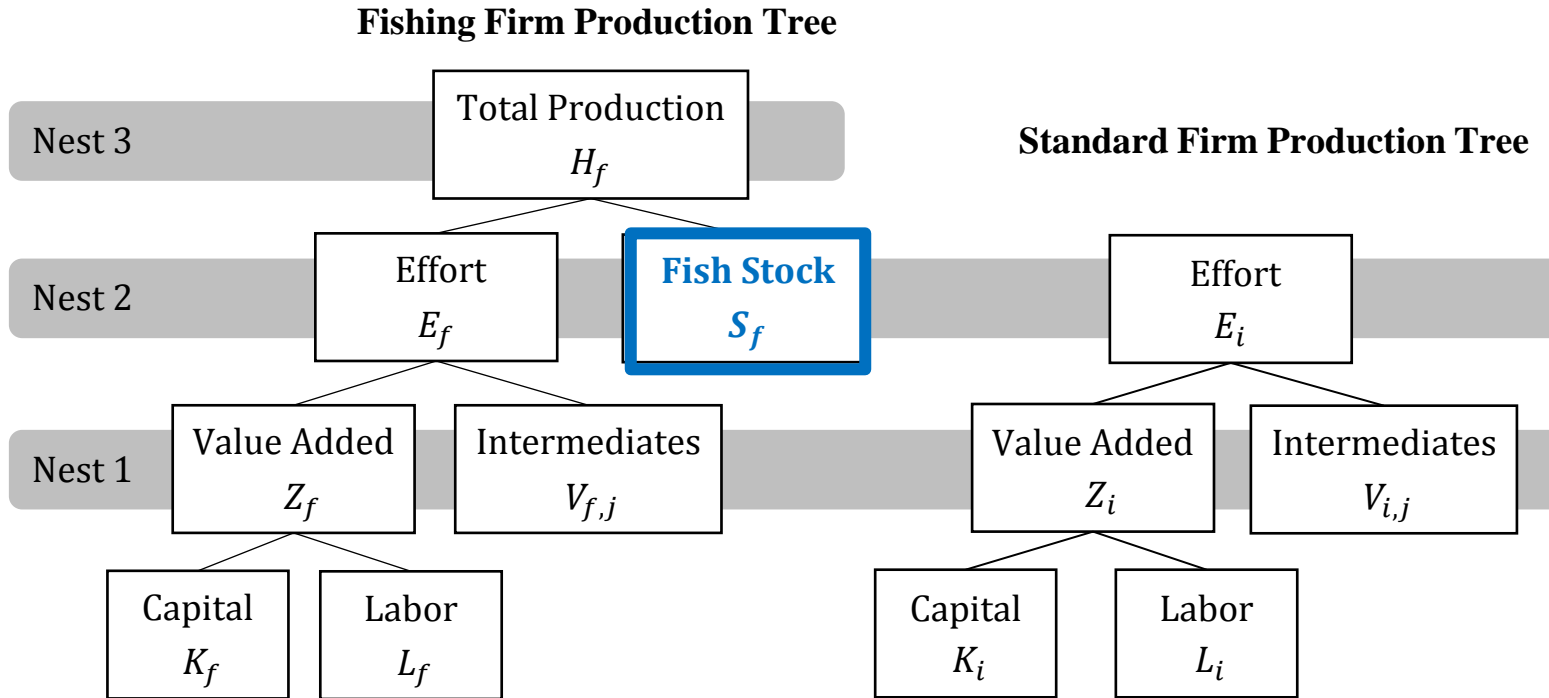


↔ Ecosystem Services

→ Monetary Flows

← Physical Flows

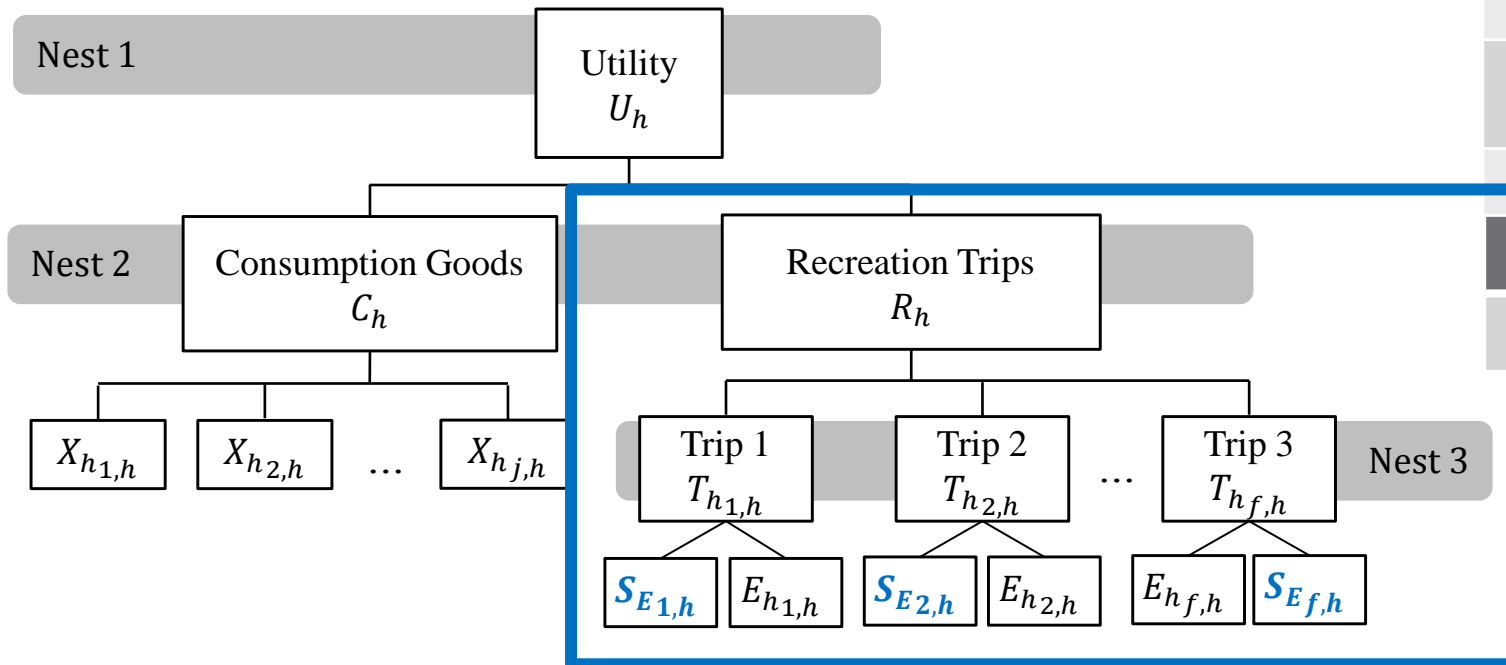
# Model: Producer choice



$f$  indicates fishing sector  $f$ , a subset of sectors  $i$ .

Endogenous Variables	
$H_f$	Harvest
$E_f$	Effort
$Z_f$	Value Added
$V_{f,j}$	Intermediate Demands
$K_f$	Capital
$L_f$	Labor
Exogenous Parameter	
$S_f$	Stock

# Model: Household choice

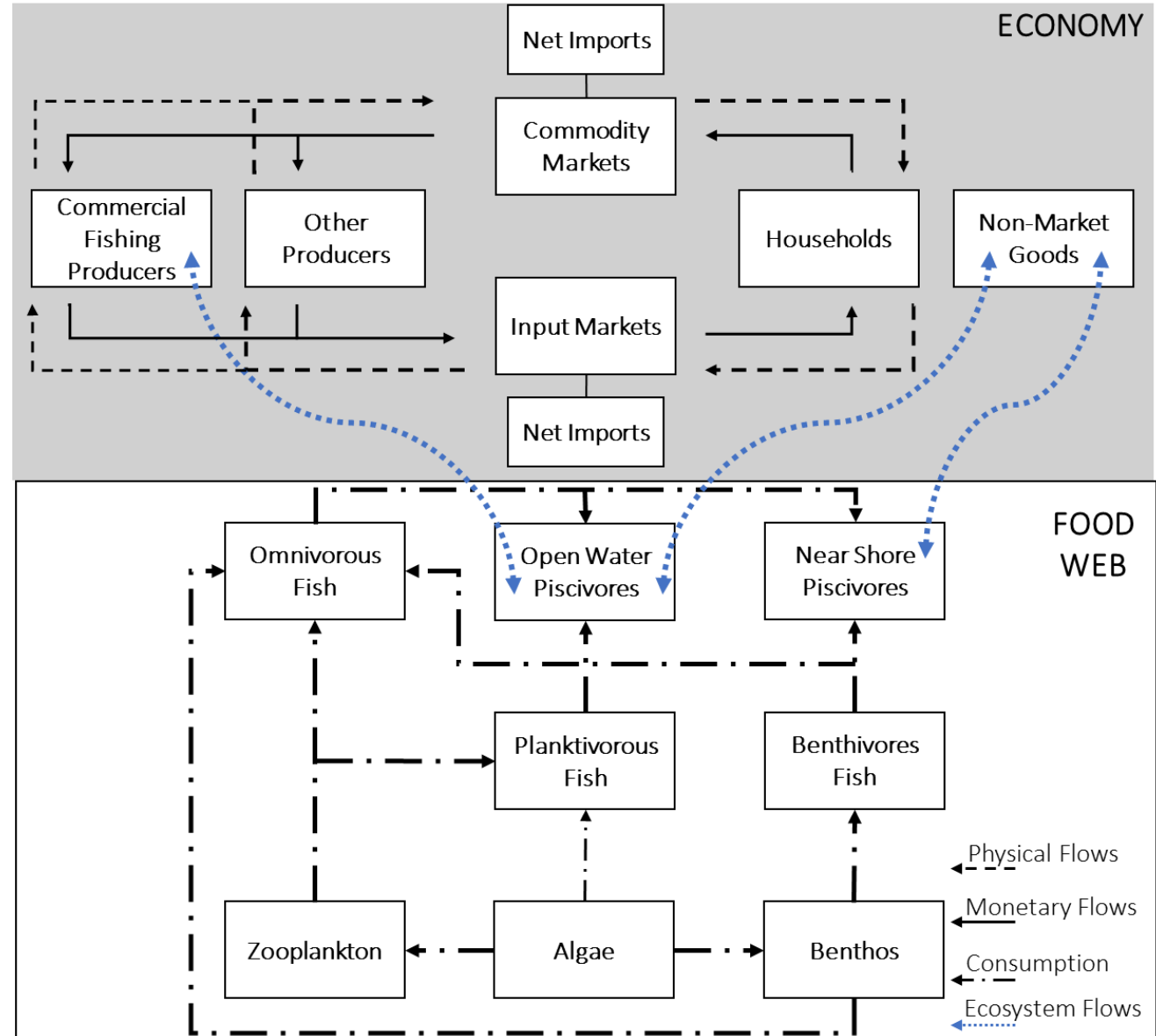


Endogenous Variables	
$U_h$	Utility
$R_h$	Recreation
$C_h$	Consumptive Goods
$X_{hi,h}$	Market Good
$T_{hf,h}$	<b>Species-Specific Fishing Trip</b>
$E_{hf,h}$	Household Effort
Exogenous Parameter	
$S_f$	<b>Fish Stock</b>

# Full bioeconomic model

## Ecopath with Ecosim (EwE) Model (Zhang et al. 2016)

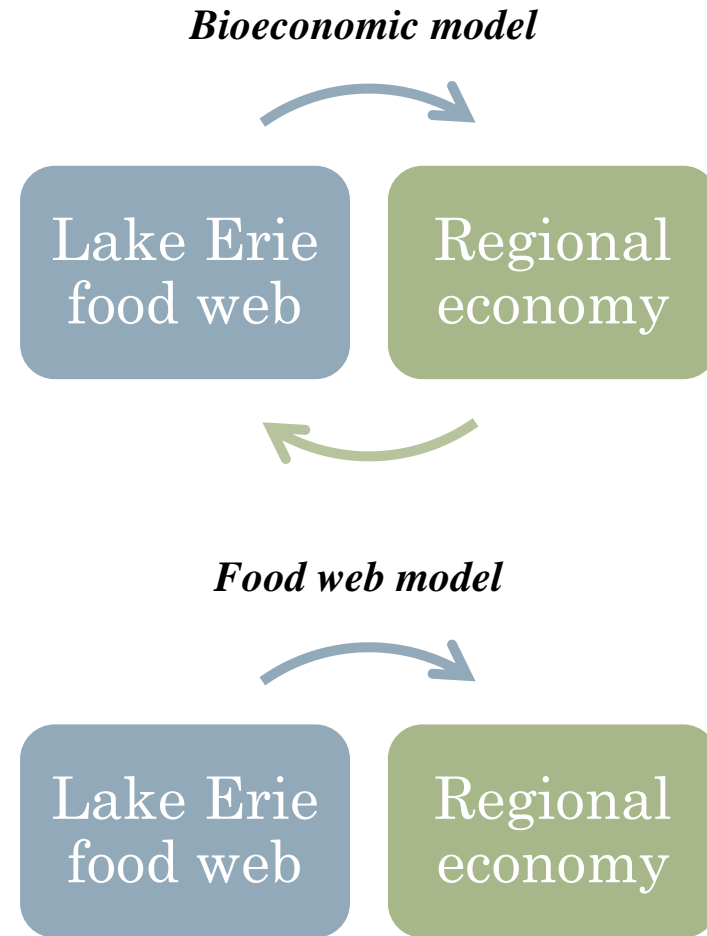
- Analyze responses to past and future perturbations to aquatic ecosystems
- Incorporates species populations, trophic levels, and energy (food) availability
- 47 species groups





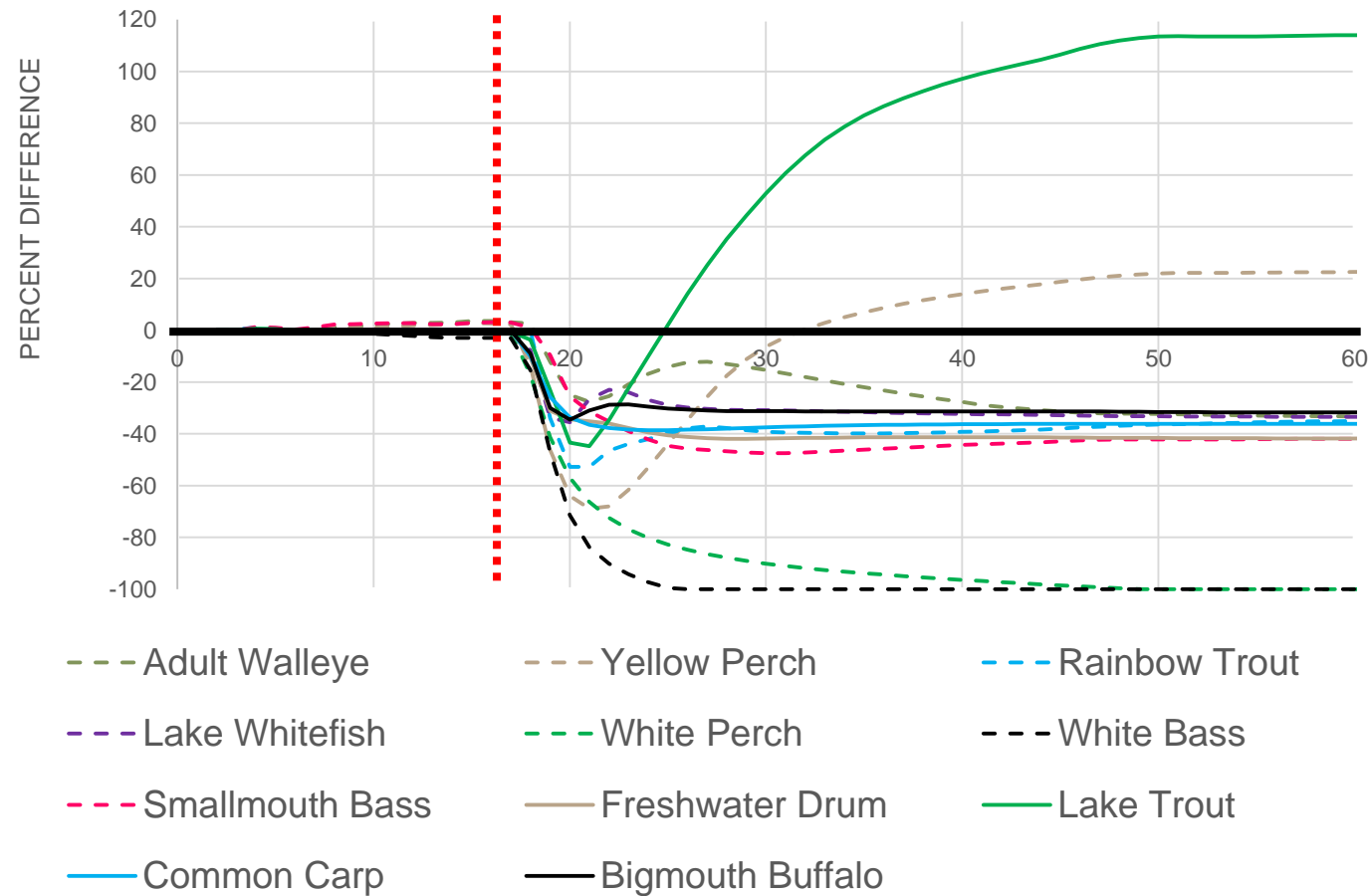
# RESULTS - ROADMAP

- **Ecological impact of invasion using bioeconomic model**
- **Economic impact of invasion using bioeconomic model**
- **Compare ecological outcome of invasion between food web and bioeconomic models**



# Bioeconomic model: ecological impacts invasion

## Percent difference in biomass between AC and no AC invasion



# Bioeconomic model: ecological impacts invasion

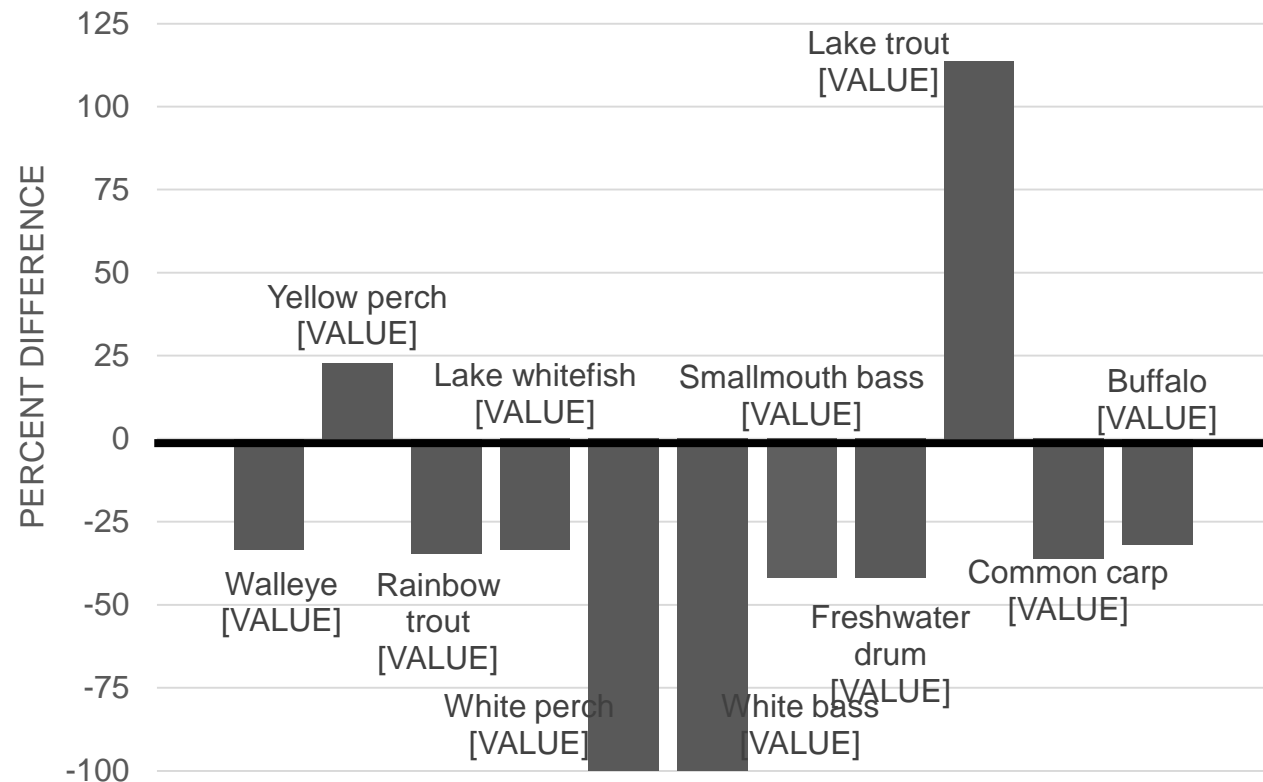
**Lake trout populations increase by 100% following AC invasion.**

- Overall increased biomass of prey
- + juvenile AC, - other species

**White bass and white perch populations decrease following AC invasion.**

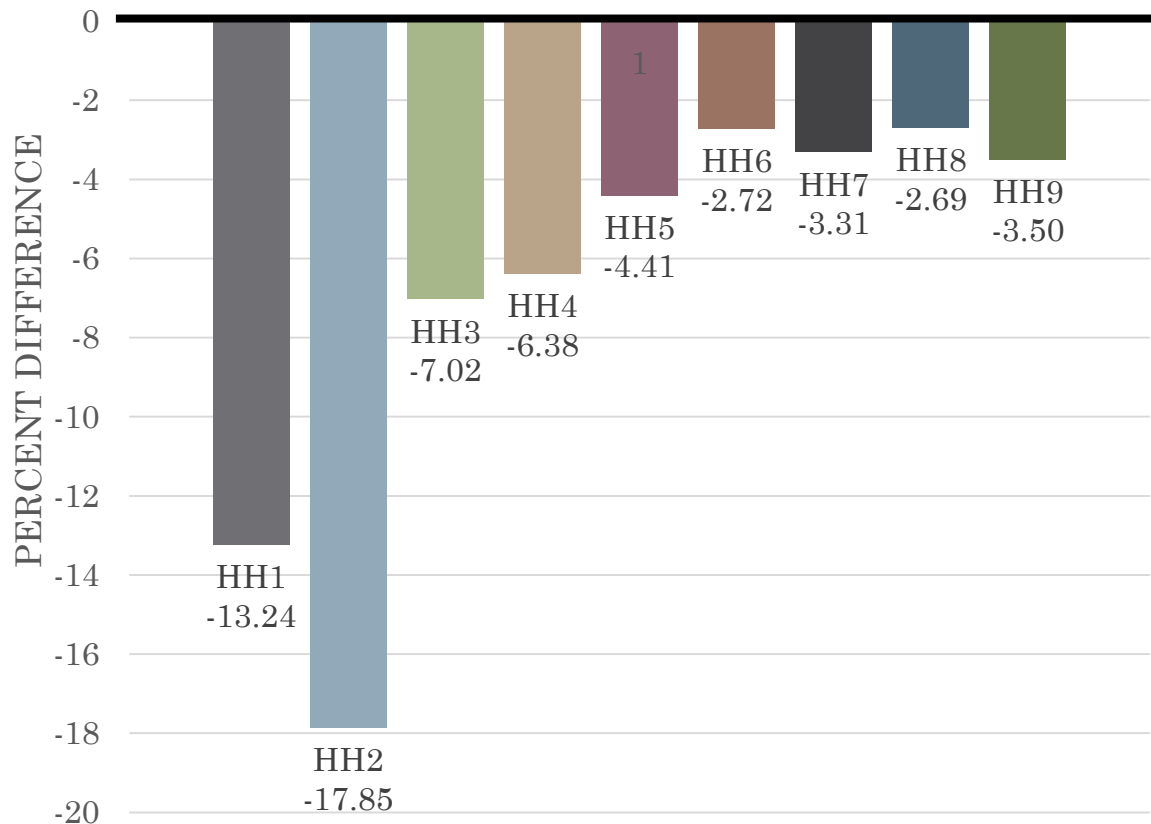
- Diets overlap with AC throughout lifecycles

**Long-run % difference in biomass between AC and no AC invasion**



# Bioeconomic model: economic impacts invasion

**Long-run % difference in welfare between AC and no AC invasion**



**Total welfare decreases by 4.5%**

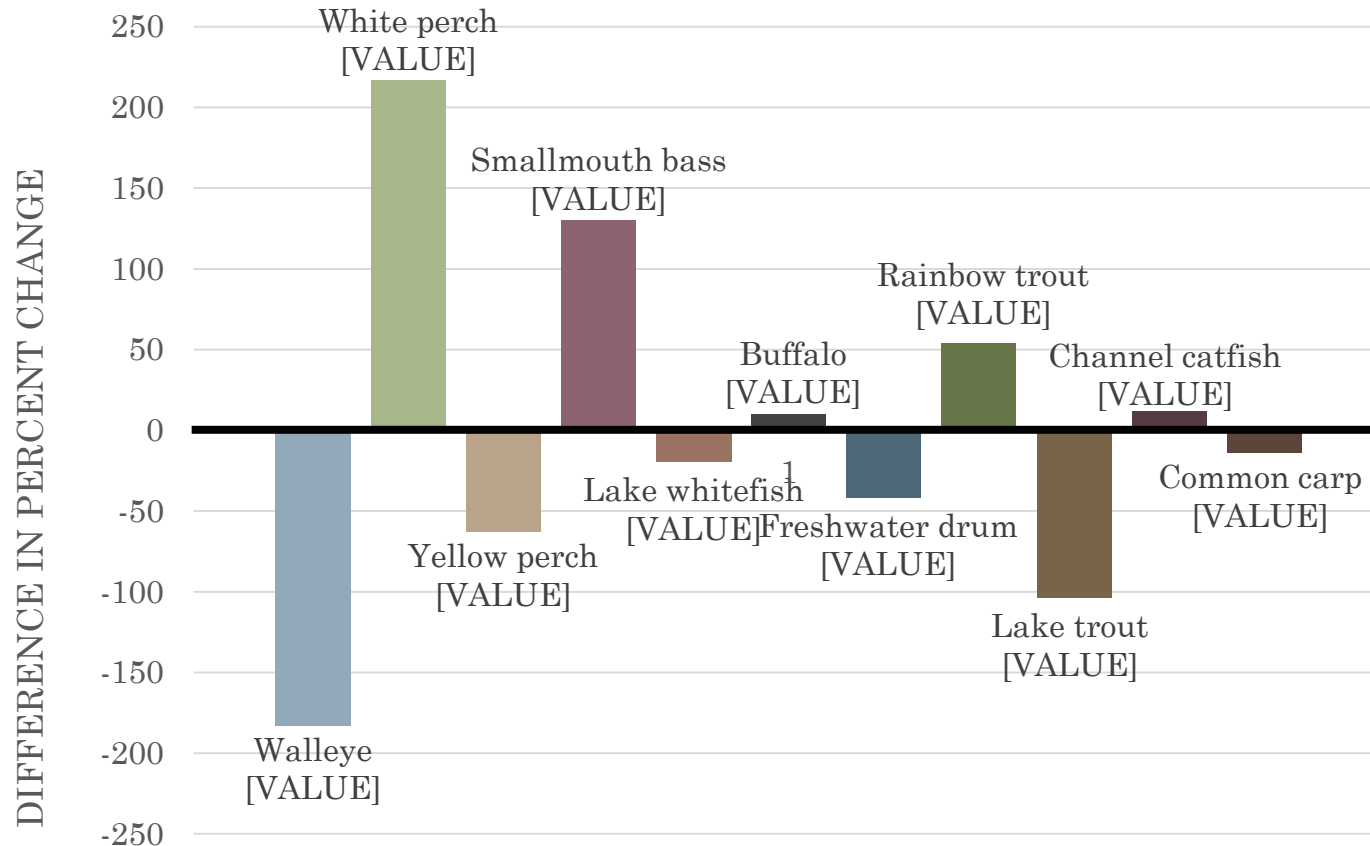
**Households experience welfare losses, heterogeneous in magnitude.**

**Welfare losses are driven by price changes.**

# Comparing models

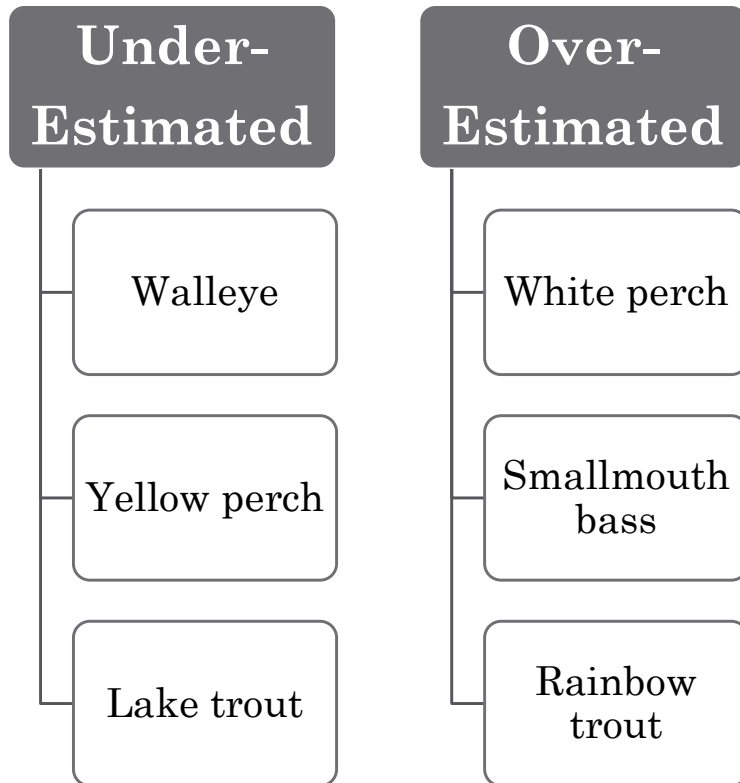
## How do biomass estimates differ?

Measured as: biomass result from food web – biomass result from bioeconomic



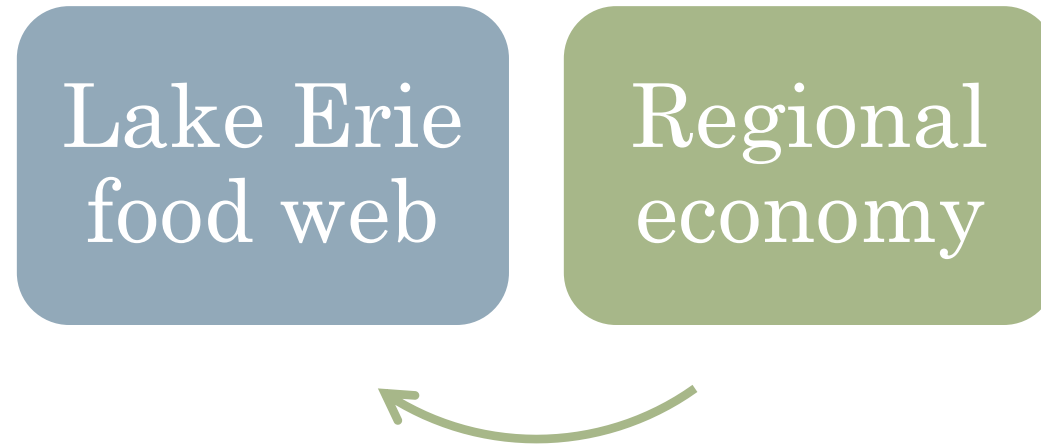
# Comparing model results

## Food web model biomass:



What causes overestimate/underestimate?

- Effort-intensiveness of fishery
- There's not a one size fits all rule for under/overprediction.



# Conclusions

**Asian carp will *in general* reduce biomass of fish species in Lake Erie. Not all species, not to same degree.**

**Welfare impacts are negative but heterogeneous in magnitude, income dependent.**

**Ignoring the impact of human influence on fish stocks significantly alters results. Critical to get this right in management.**