Evaluating adaptation scenarios for fishing communities facing climate-driven species changes

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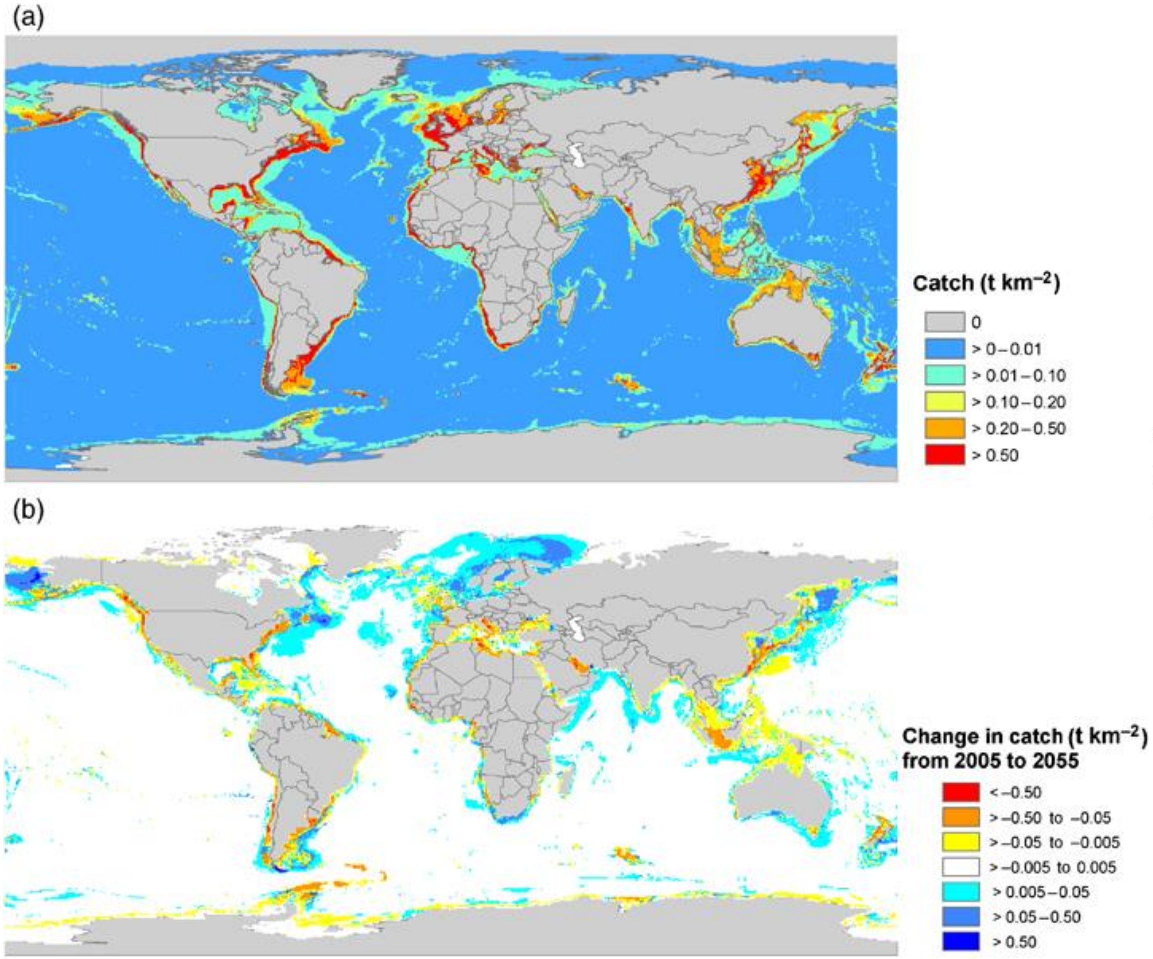
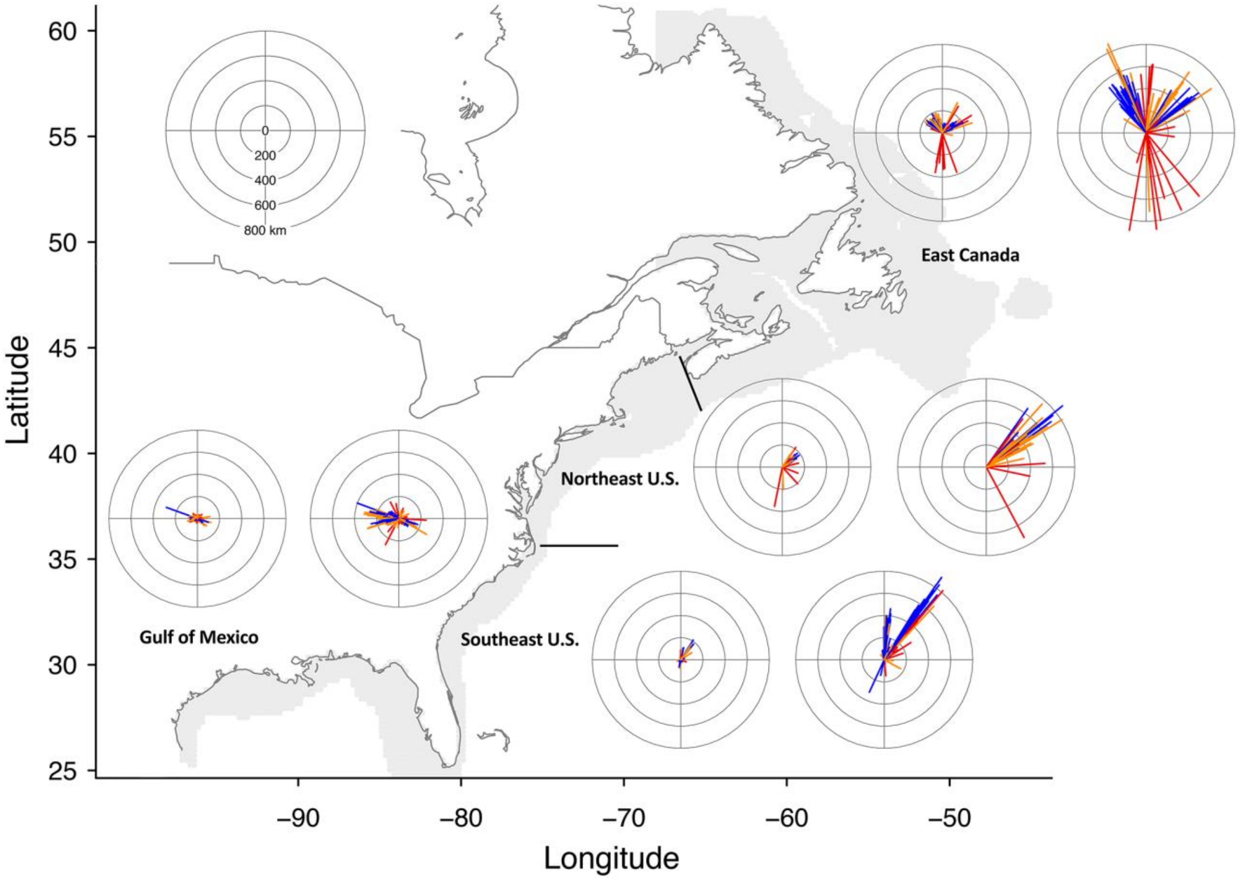
Science. Education. Community.

Species Distribution Models

Cheung et al. (2009)



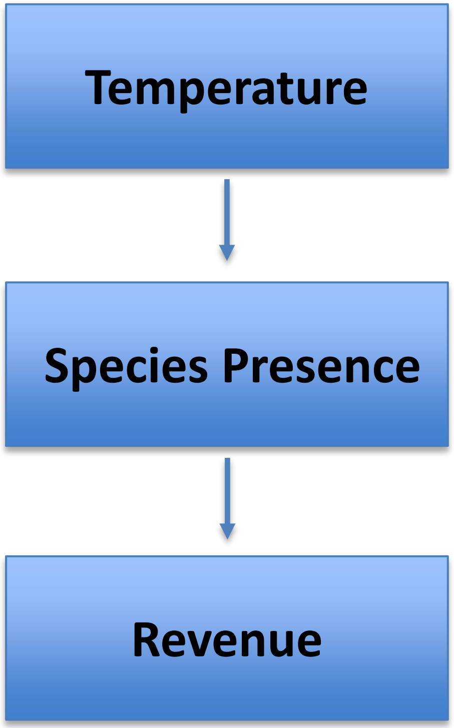
Morley et al. (2018)



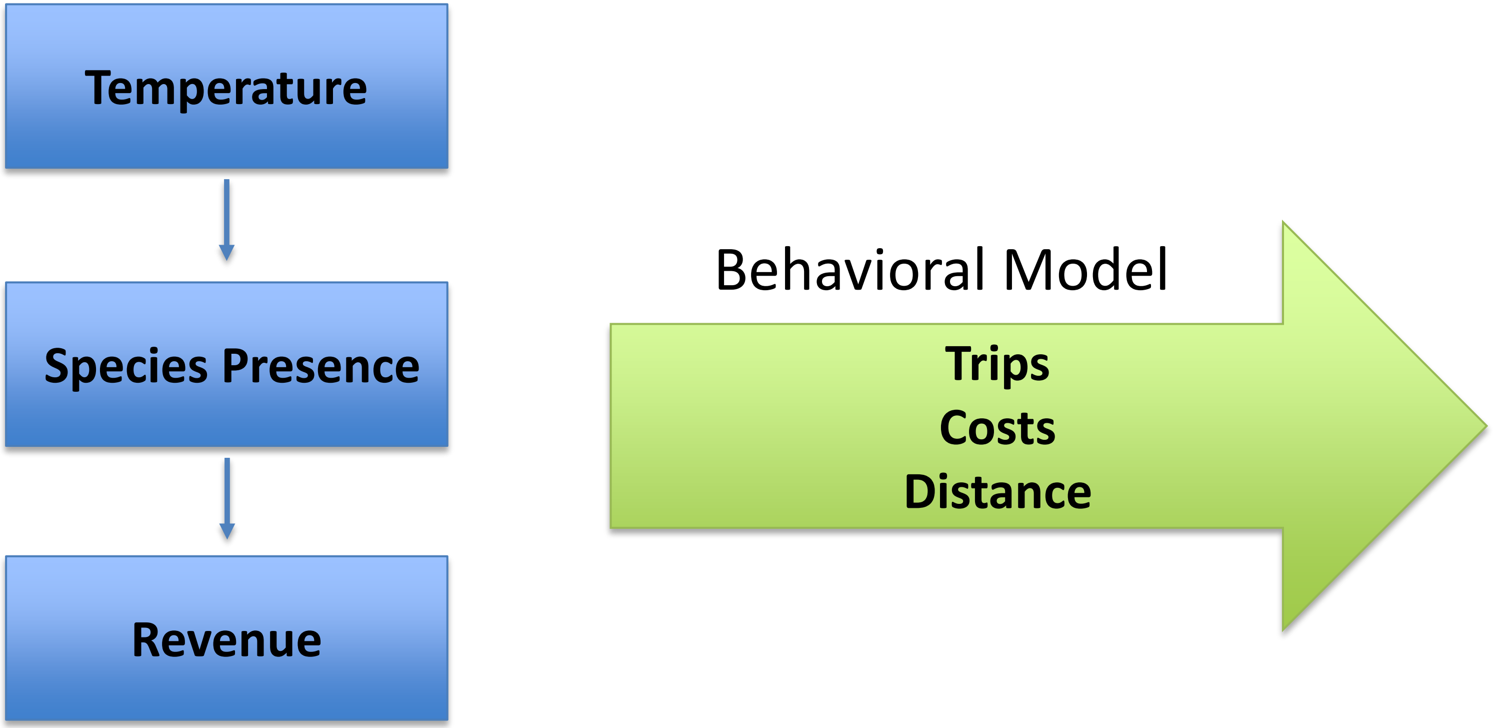
Economic Questions

- What are the potential economic costs of climate-driven changes in distribution of fish species?
- To what degree can adaptation offset these costs/add benefits?
- How can fisheries management facilitate adaptation?

Adding economics to species distribution change



Adding economics to species distribution change



Adding economics to species distribution change

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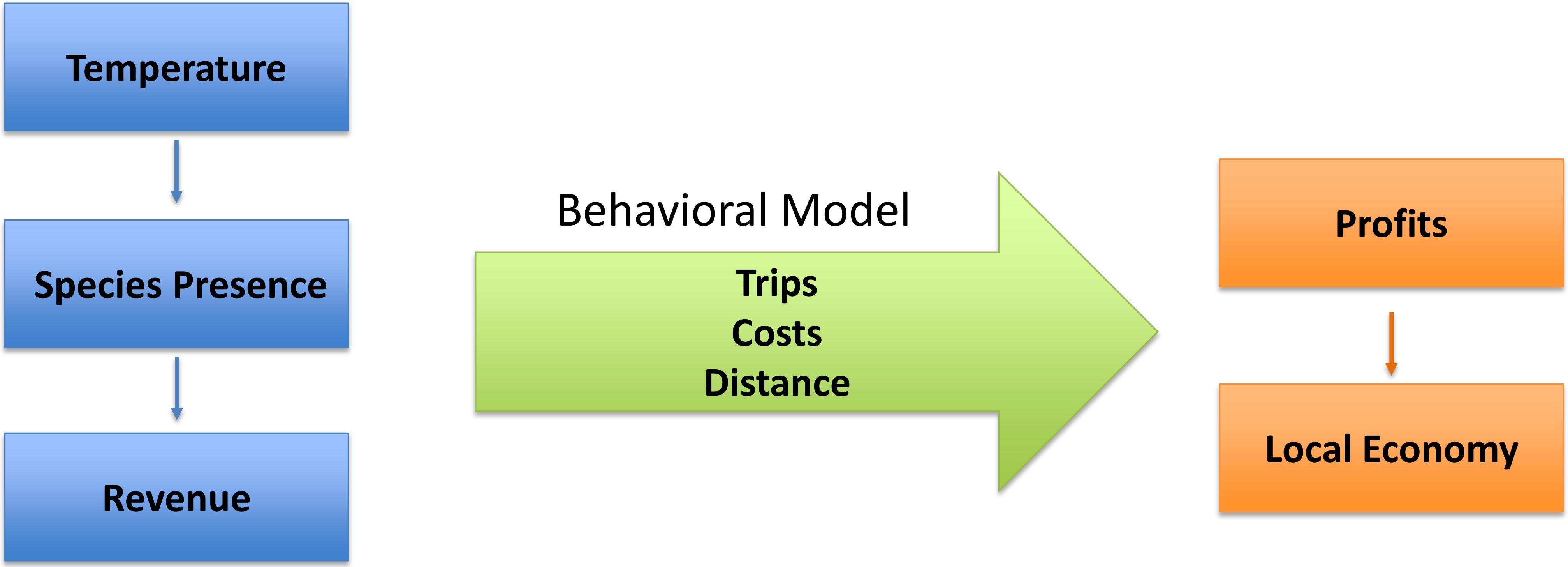

Integrated Modeling Framework: Port-Level Economics

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- Goal: Develop a framework that accounts for adaptation at the port level and estimates changes in industry profits, community impacts

- Local analysis
  - Multiple activities
  - Fishing patterns
  - Resources available
  - Adaptation strategies

GMRI Integrated Modeling Framework

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Climate Scenario — Species Distribution — Fishing Strategies — Industry Profits — Community Impacts

Species Distribution Model: Details

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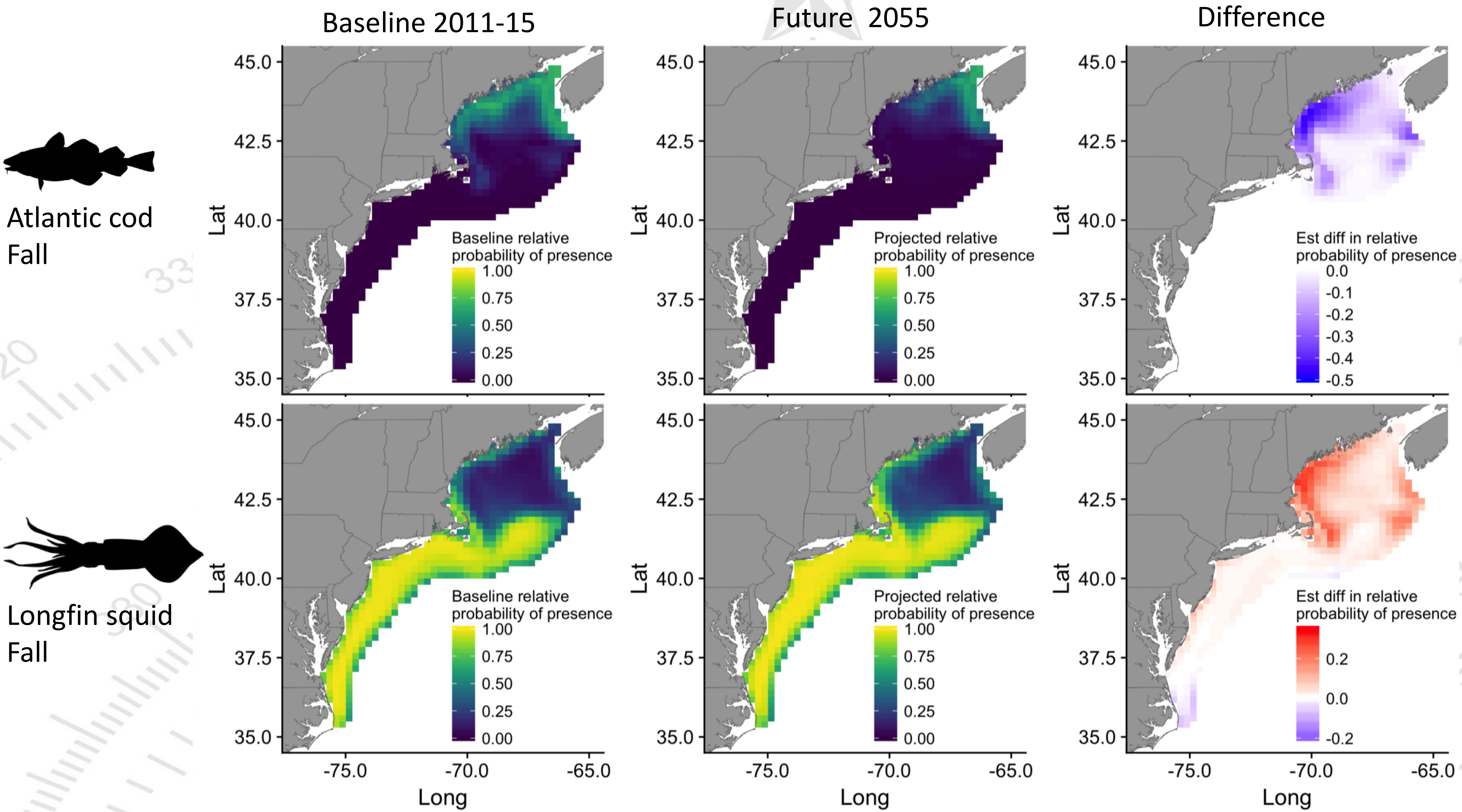
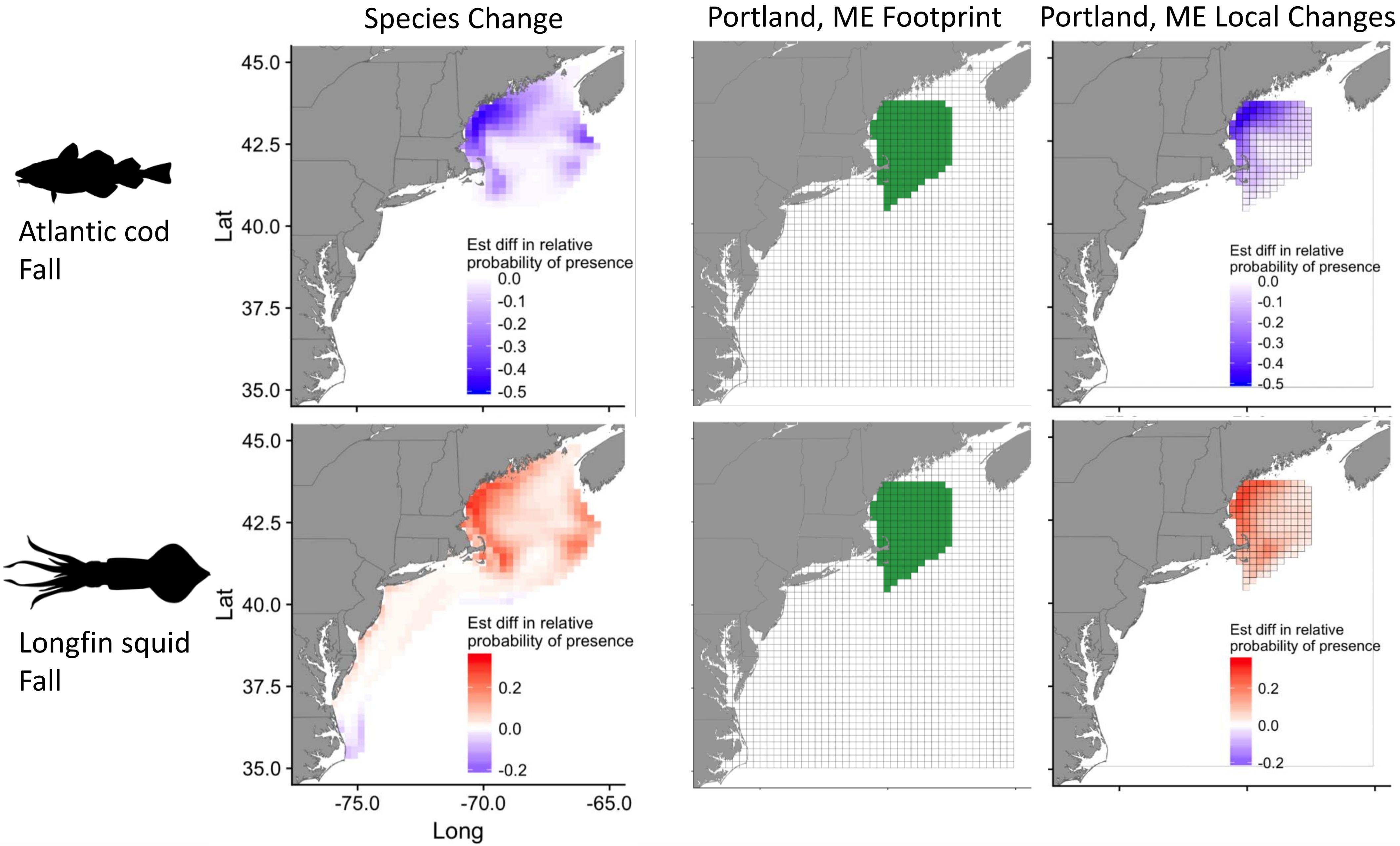
- Northeast U.S. Continental Shelf Large Marine Ecosystem
- CMIP 5 Climate Ensemble RCP 8.5 scenario
- 54 species modeled

Species distribution projections for selected species



Localizing change via fishing footprints

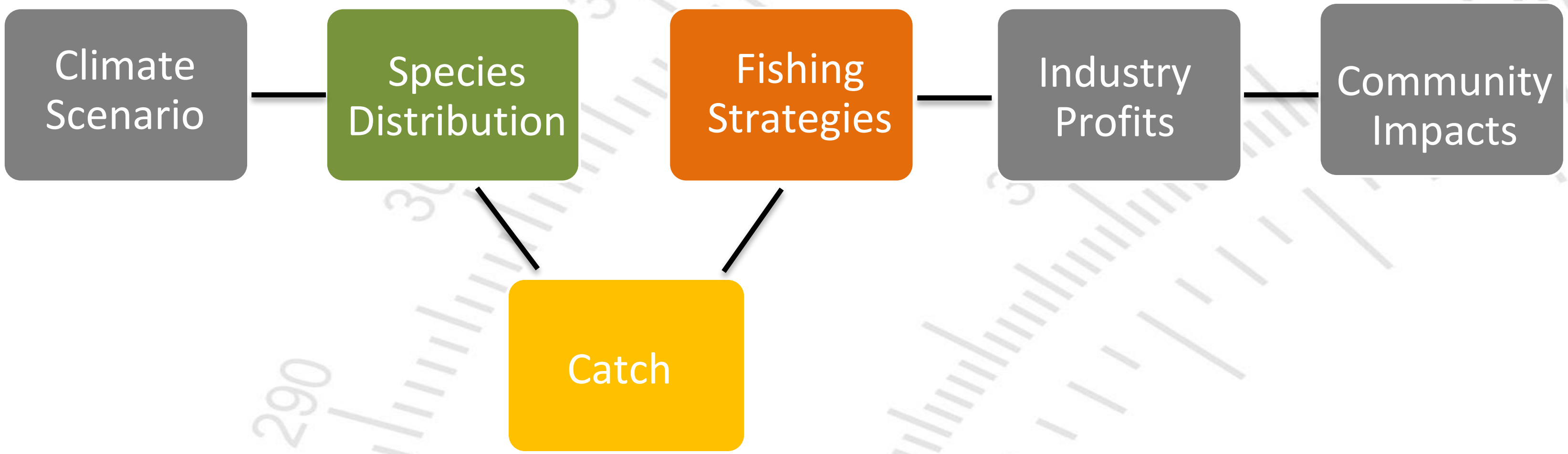


Catch

Problem: Economic model cannot directly use probability of presence.

How to relate presence to catch?

What should catch be for emerging species at a given port?



Relating Presence to Catch

One Answer:

$$C_t = (p_t / p_{t-1})^{\alpha} * C_{t-1}$$

- C_t is Catch per trip
- p_t is probability of presence
- α in (0,2) reflects degree of sensitivity of catch to change in presence
- High alpha → high sensitivity

- If baseline presence or average catch = 0 (not available or not allowed)

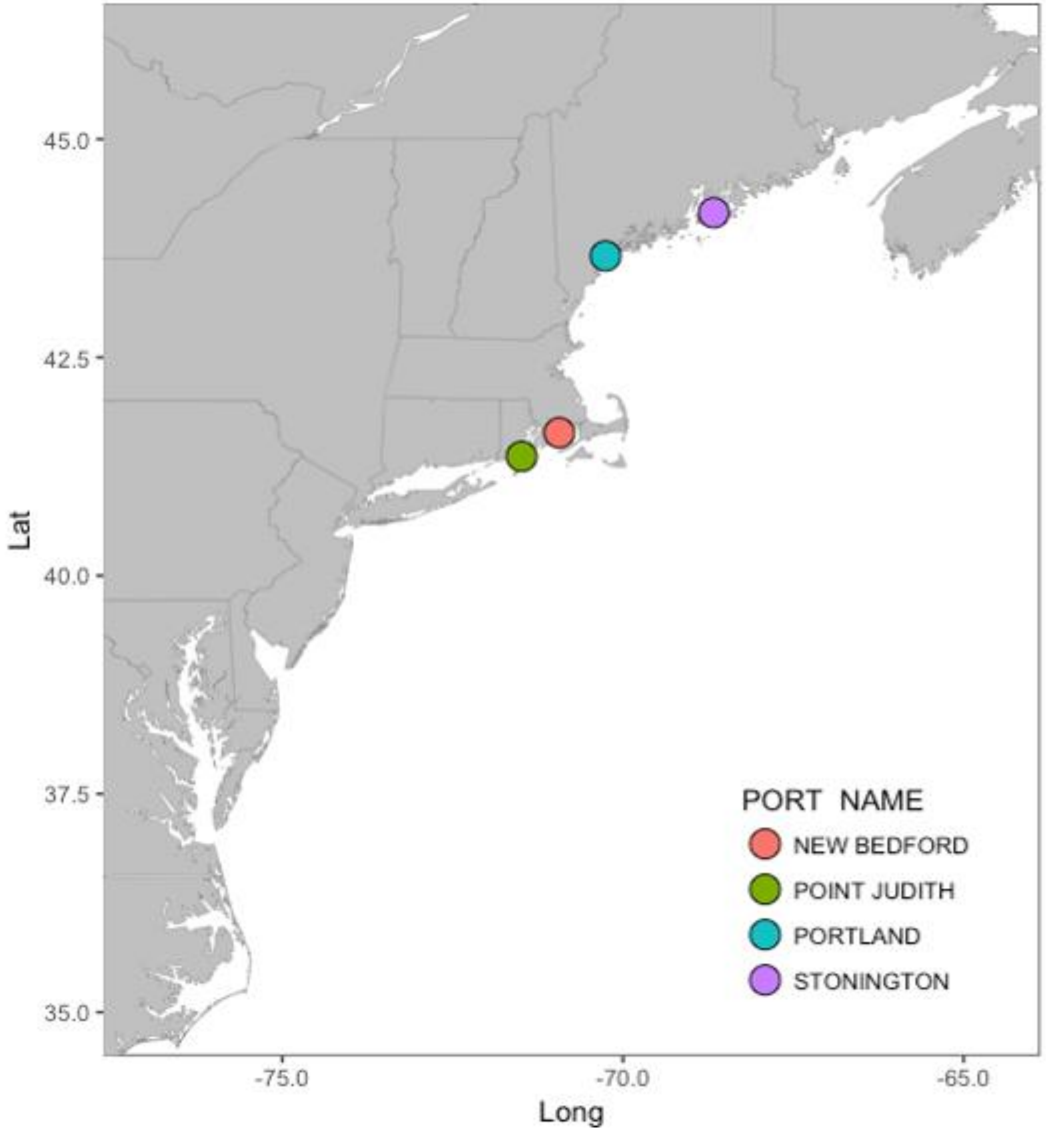
$$C^{Port}{}_{t} = (p^{Port}{}_{t} / p^{Region}{}_{t-1})^{\alpha} * C^{Region}{}_{t-1}$$

Economic Data

- Baseline period: 2011-2015
- Landings, effort, gear use
  - VTR, CFDERS
- Cost data:
  - I-O study by Scott Steinback (NEFSC)
    - Bait, crew, fuel, other variable costs
- Size class
  - State licensing data for ME, MA,RI

Focal Ports

NEW BEDFORD			STONINGTON		
Species	$ M	% Value	Species	$ M	% Value
Sea Scallop	239.7	85%	Lobster	52	98%
POINT JUDITH			**PORTLAND**		
Species	$ M	% Value	Species	$ M	% Value
Loligo Squid	8.4	28%	Lobster	13	45%
Lobster	4.8	16%	Herring	7.5	26%
Sea Scallop	4.6	15%	Pollock	2.2	8%
Summer Flounder	4.2	14%	White Hake	2.1	7%
Scup	2.3	8%	Hagfish	1	4%



Defining Fishing Activities

Organization Scheme

Port Gear Type * Species Targeted*

Key Variables

-# Trips
-Landings
-Variable Costs
- Profits

Sample Fishing Activity Matrix: Volume (1,000 lbs) landed

Species

Gear /Fishing Activity	*Cod*	*Hagfish*	*White Hake*	*Lobster*	*Pollock*	*Redfish*	**Totals**
Gillnet	182		398		1,605	74	2,259
Pot/Trap		81		431			512
Totals	182	81	398	431	1,605	74	

Selected Scenarios

1. Baseline - 2011-2015

2. No Adaptation - climate impact when no adaptation measures taken

3. Gear Change - changes in fishing effort by gear type
   - Dredge
   - Gillnet
   - Pot/Trap
   - Purse Seine
   - Trawl

4. Emerging Species - ability to fish new species
   - Black Sea Bass, Scup
   - Squid (Illex & Loligo)
   - Dogfish (Smooth & Spiny)

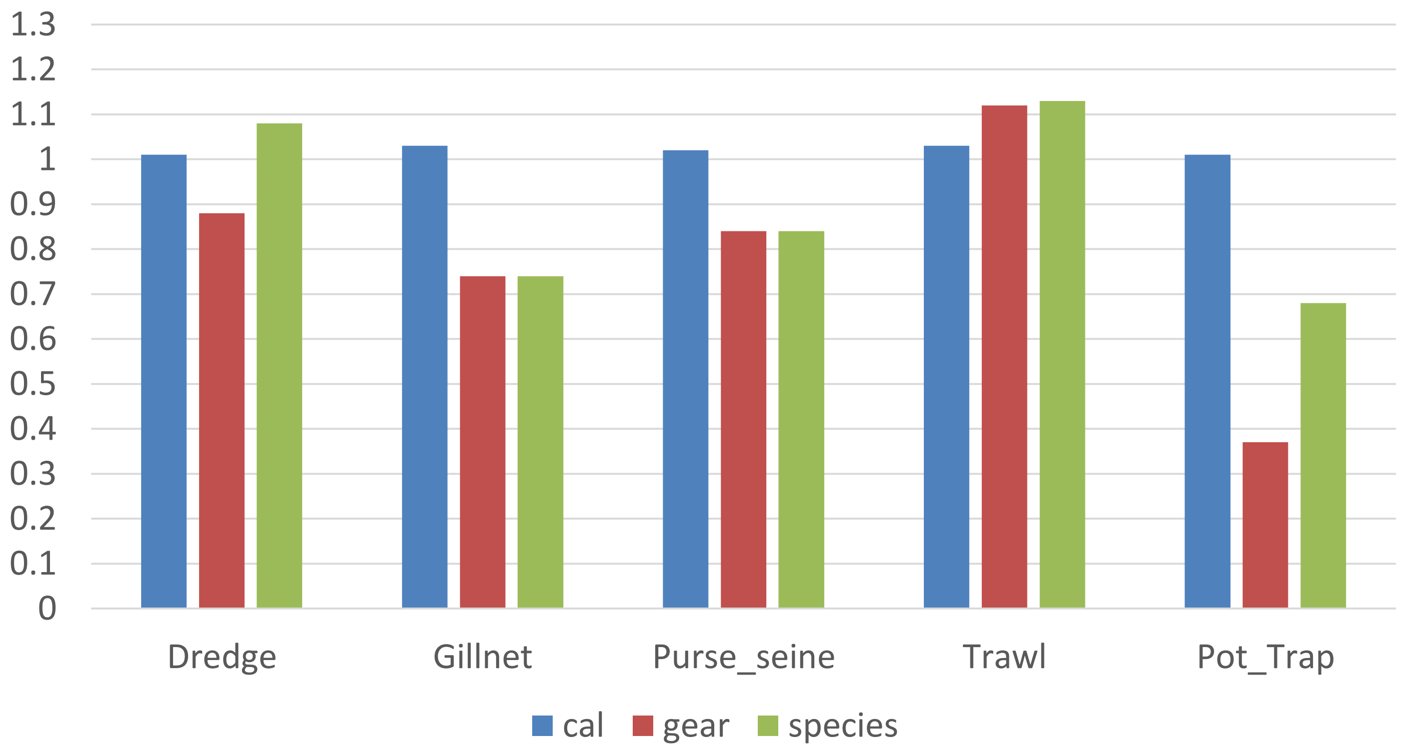
Results: Fishing Activities

Total Trips By Port, Model (Baseline = 1)

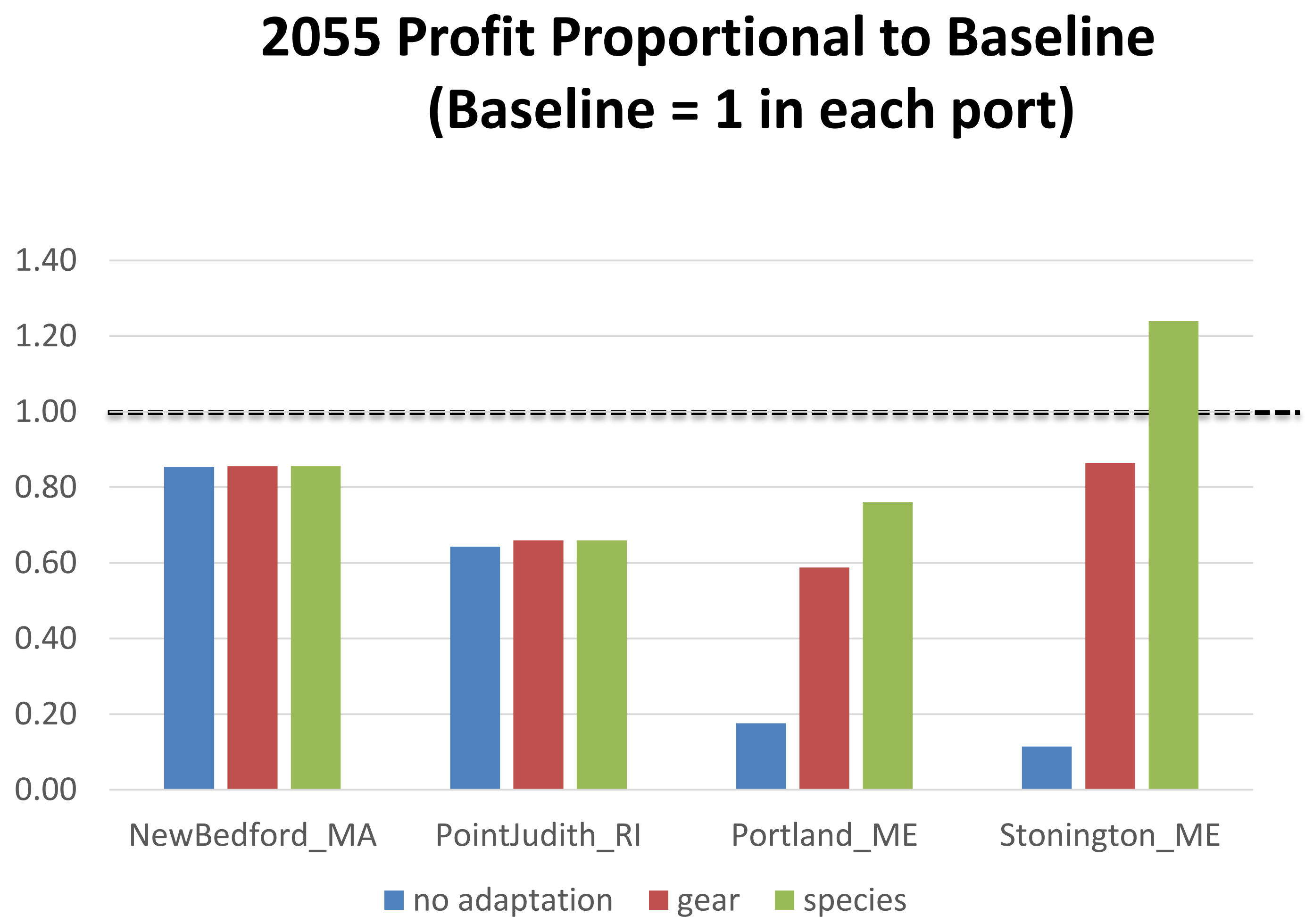
Port	cal	gear	species
New Bedford	0.82	0.73	0.73
Point Judith	1.02	0.89	0.89
Portland	1.02	0.79	0.89
Stonington	1.01	0.95	1.06

Cal denotes model calibration

Trips by Gear Type – Portland (Baseline = 1)



Results aggregate profit by port



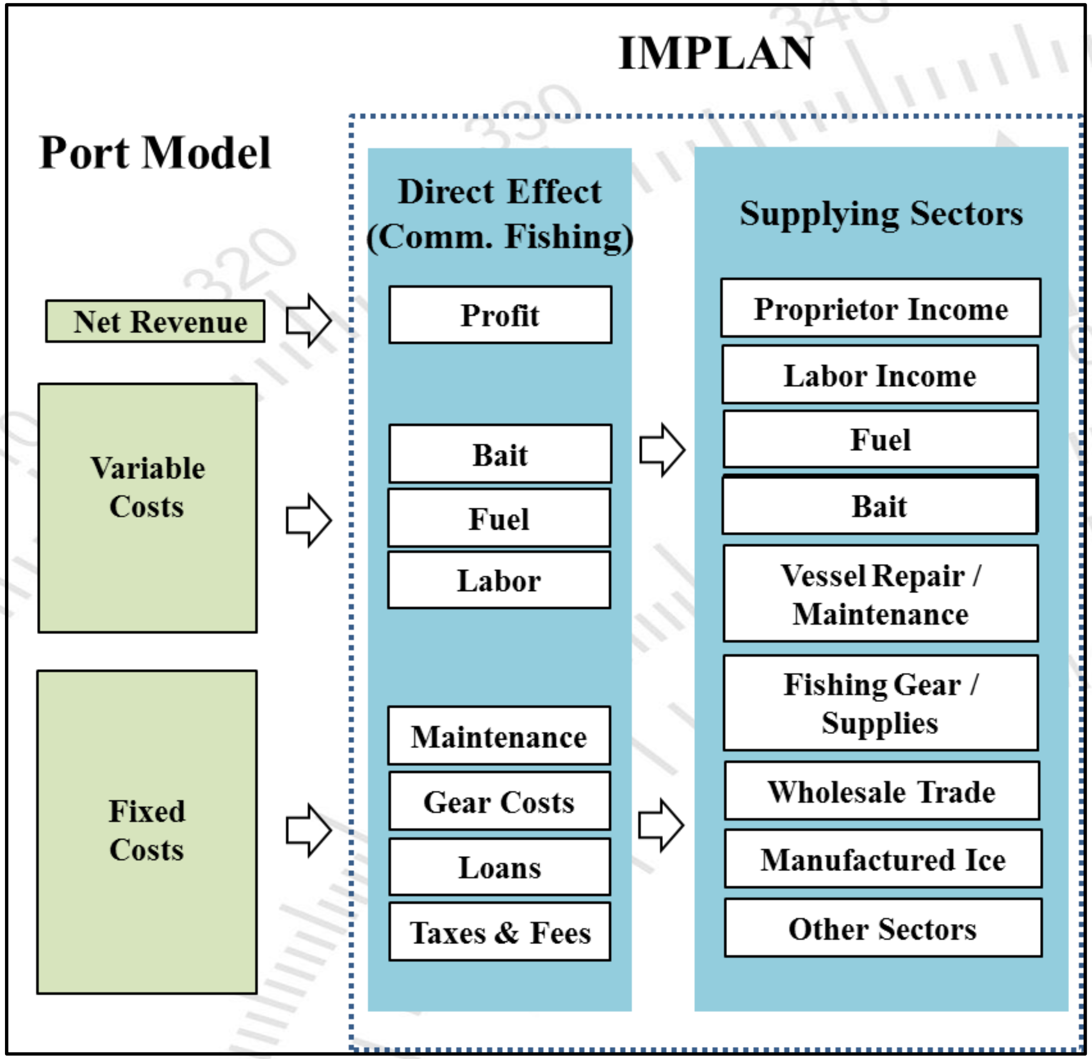
- Relatively minor impacts in New Bedford and Pt. Judith
- Substantial impacts in Portland and Stonington, largely offset by gear adaptation
- Stonington could benefit greatly from emerging species

Community Impacts

Scaling economic impacts: fishing sector → community → region

Input-Output model generates county/regional estimates of changes to:

- Employment
- Income
- Supporting Industries
- Tax Revenue



Conclusions & future work

Conclusions

- Impacts and adaptation benefits depend on baseline mix of activities
- Key species (lobster, scallop) have large influence on specialist ports
- Not allowing adaptation can overstate impacts
- Supporting new fisheries may be key to adaptation
- Profit levels key to understanding industry health, local impacts

Future improvements

- Allow adjustment of footprints
- Extend to other ports
- Specify fishing activities in greater detail

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Thank You

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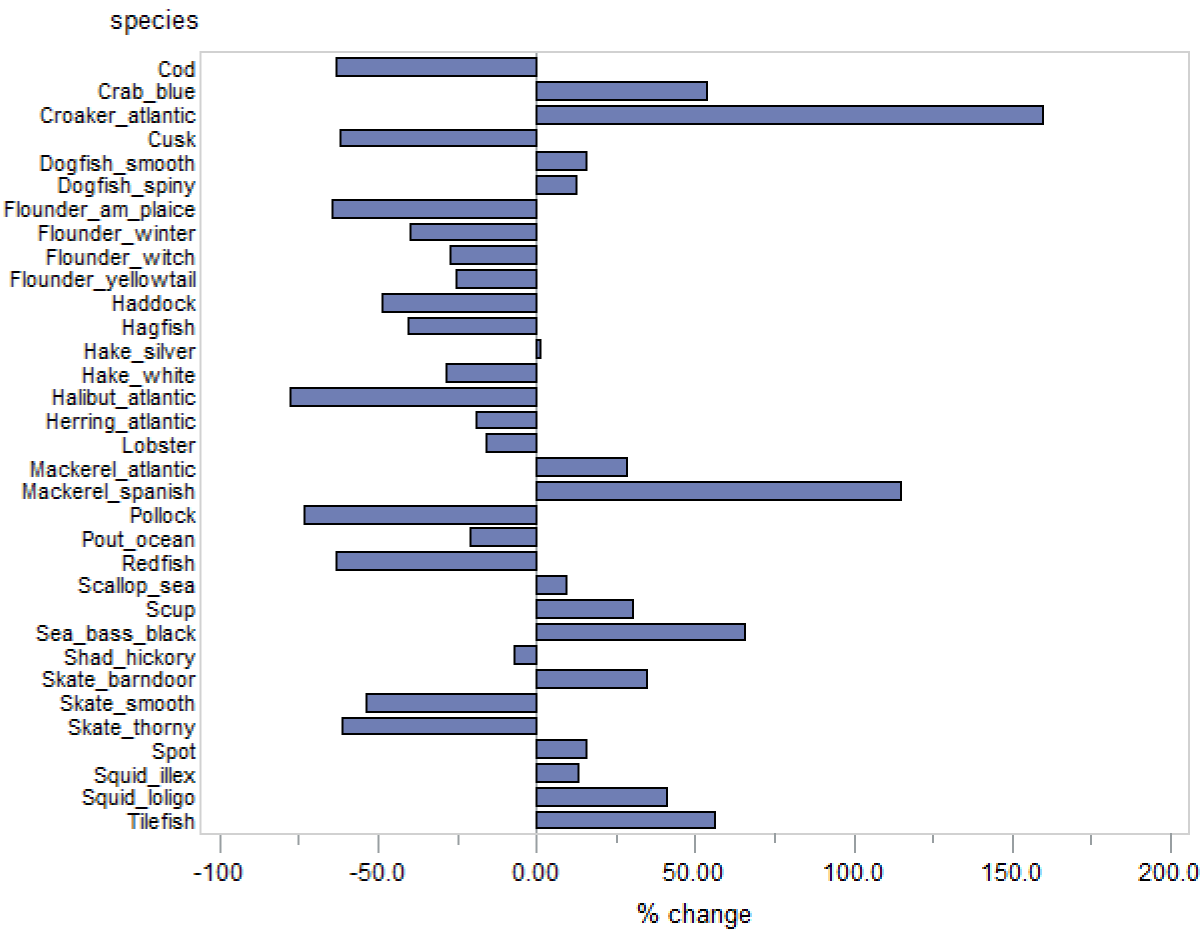
APPENDIX

Mean % change in presence – key ports



Pooled mean change across species is -4.2%
But range is -78% to 159%
Most valuable species: lobster down 15.7% but scallops up 9.5%

Emerging Species

Stonington

BLACK SEA BASS
BARNDOOR SKATE
ILLEX SQUID
LOLIGO SQUID
SMOOTH DOGFISH
SPINY DOGFISH
SILVER HAKE
MACKEREL
OCEAN POUT
SCUP

Portland

BARNDOOR SKATE
BLACK SEA BASS
LOLIGO SQUID
SCUP
SMOOTH DOGFISH

Economic Model Components