Modeling population-scale responses of iconic fisheries to OA

Sarah Cooley , Jennie Rheuban, Dvora Hart, Victoria Luu, David Glover, Jon Hare, Scott Doney

Ocean Acidification Principal Investigators' Workshop, Woods Hole, MA • June 11, 2015

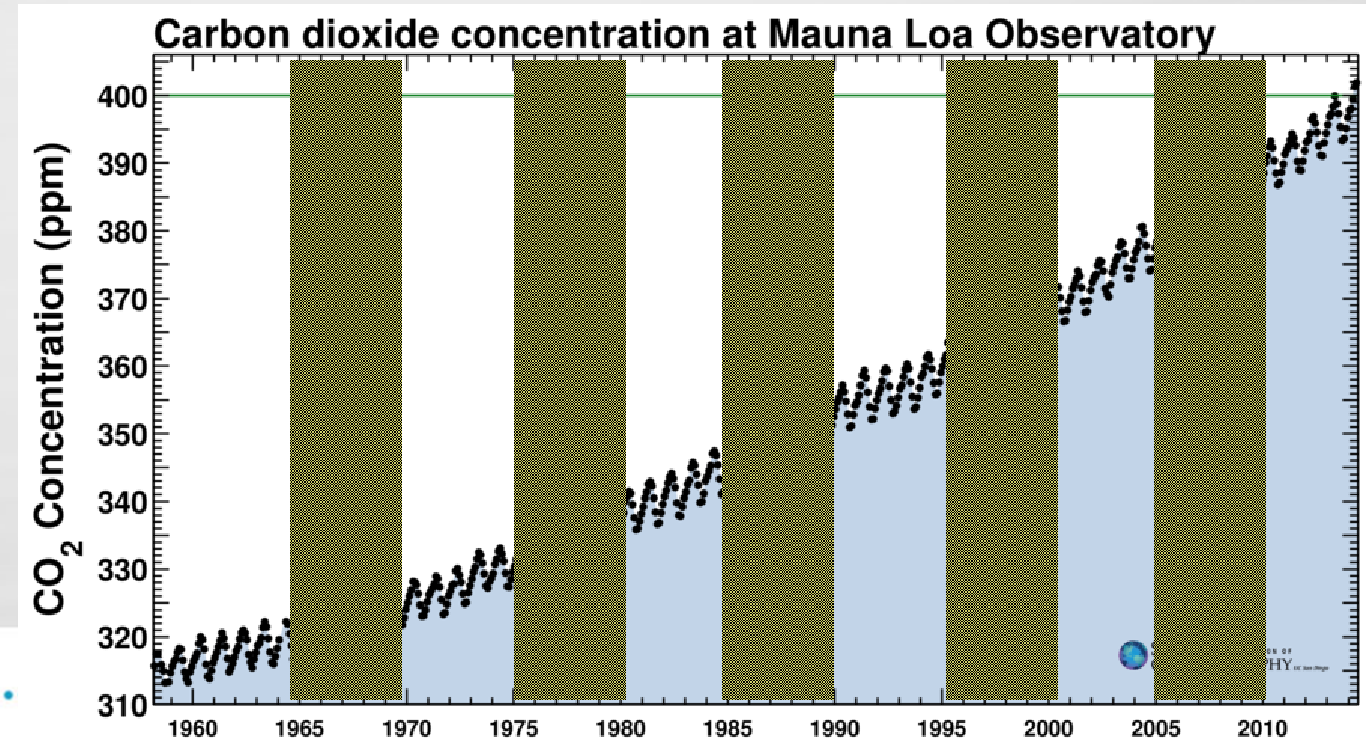
Ocean Conservancy

Real-world context

- Will OA affect my resource?
- When will it happen?
- How bad will it be?
- What can we do about it?

Problem

- Mismatch between global change, marine resource use & management timescales
- Few tools exist to explore both
- Decision-relevant information is lacking
- What to do for specific resources?



Ocean Conservancy

2 studies trying to change that

An Integrated Assessment Model for Helping the United States Sea Scallop (*Placopecten magellanicus*) Fishery Plan Ahead for Ocean Acidification and Warming

Sarah R. Cooley[1,2]*, Jennie E. Rheuban[2], Deborah R. Hart[3], Victoria Luu[4], David M. Glover[2], Jonathan A. Hare[5], Scott C. Doney[2]

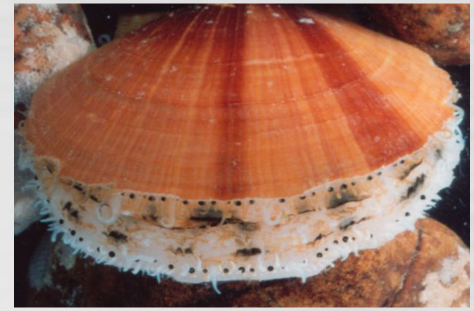
PLOS One, 2015

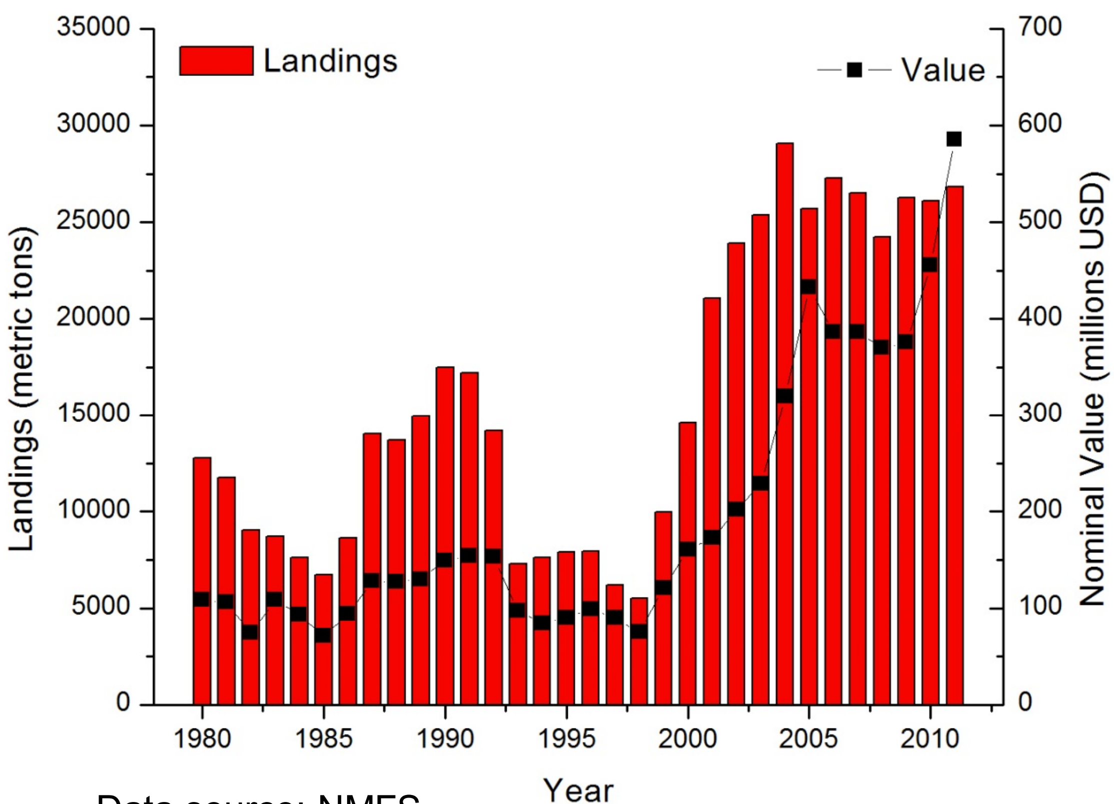
Evaluating the impact of ocean acidification on fishery yields and profits: The example of red king crab in Bristol Bay

André E. Punt[a,*], Dusanka Poljak[a], Michael G. Dalton[b], Robert J. Foy[c]

Ecological Modelling, 2014

Sea Scallop Fishery





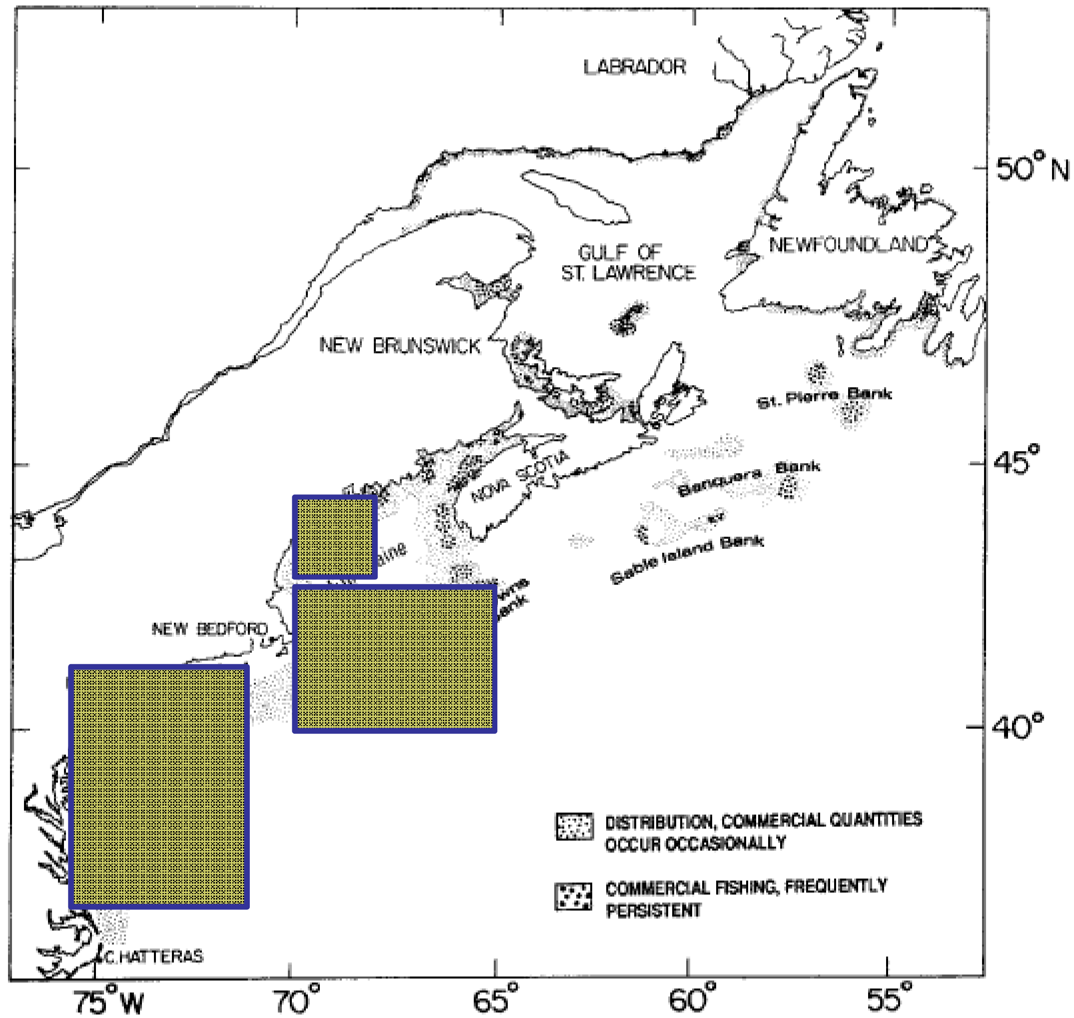
Data source: NMFS

- One of most valuable single-species, wild-caught fishery in US
- Currently a ~500 million USD industry
- Considered “overfished” in mid-1990s

Ocean Conservancy

Sea Scallop Habitat

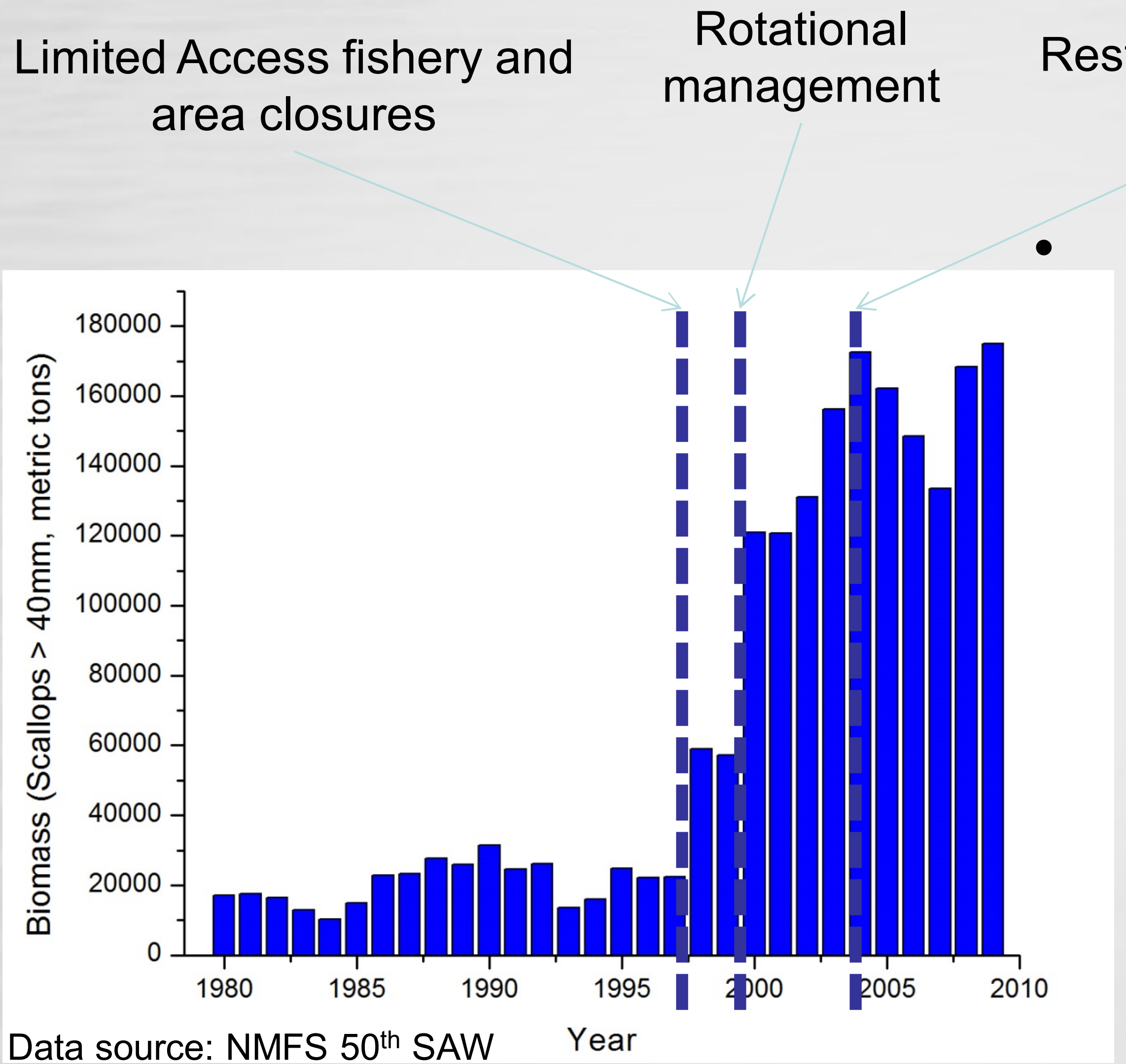
- Found abundant along the northeastern Atlantic shelf at depths 40 – 100 m
- US fisheries located Mid-Atlantic Bight, Georges Bank, and Gulf of Maine
- Tolerate water temperatures ~ 6 – 18 ° C



Hart and Chute 2004

Ocean Conservancy

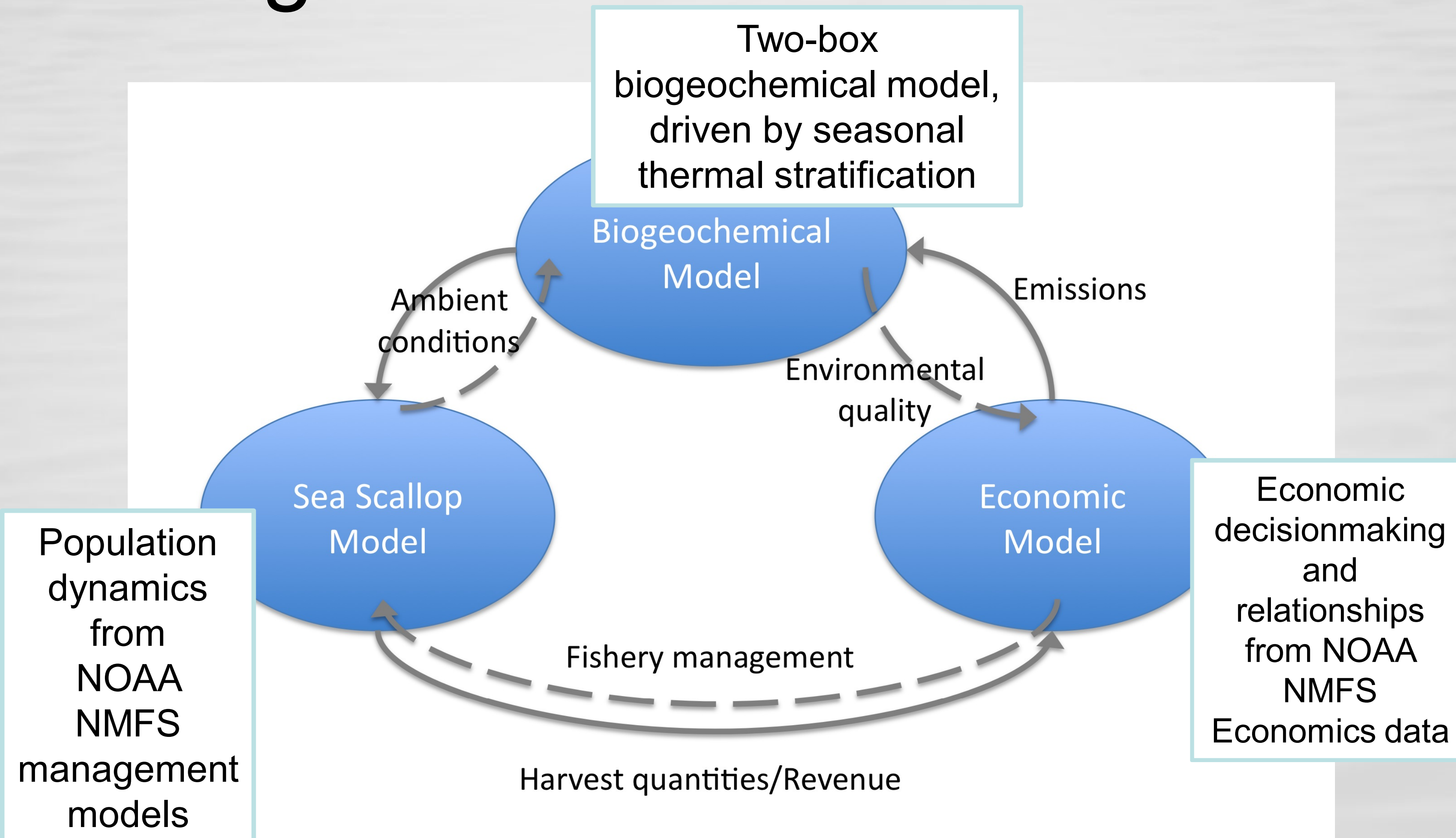
Sea Scallop Management Success



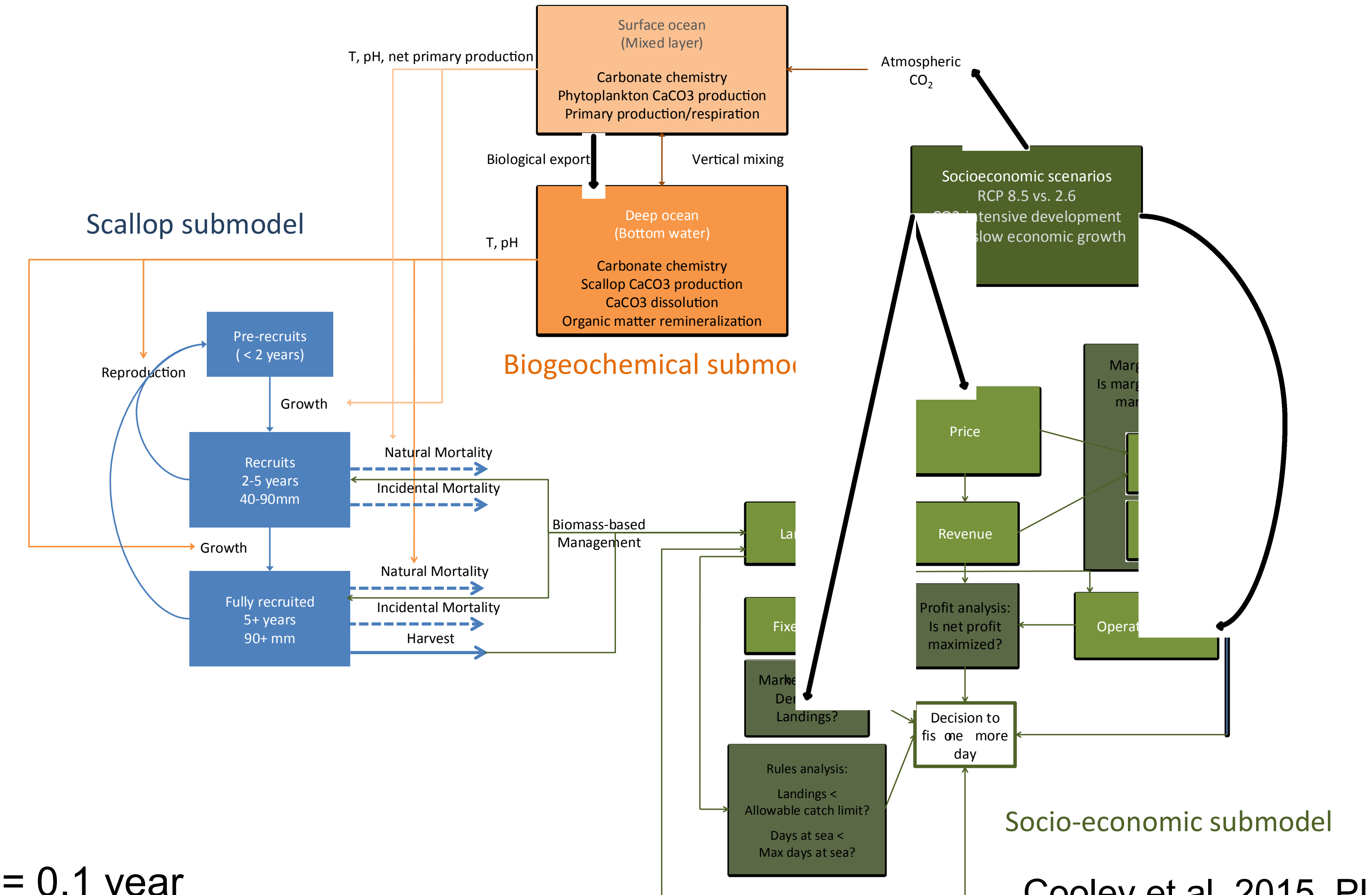
Data source: NMFS 50th SAW 2010

- Managed through regulations on:
  - Limited access fishery
  - Fishing location
  - Effort allocated by vessel
  - Minimum gear size – 4in. ring (~90 mm scallop)
  - Crew size limited to 7

Integrated Assessment Model



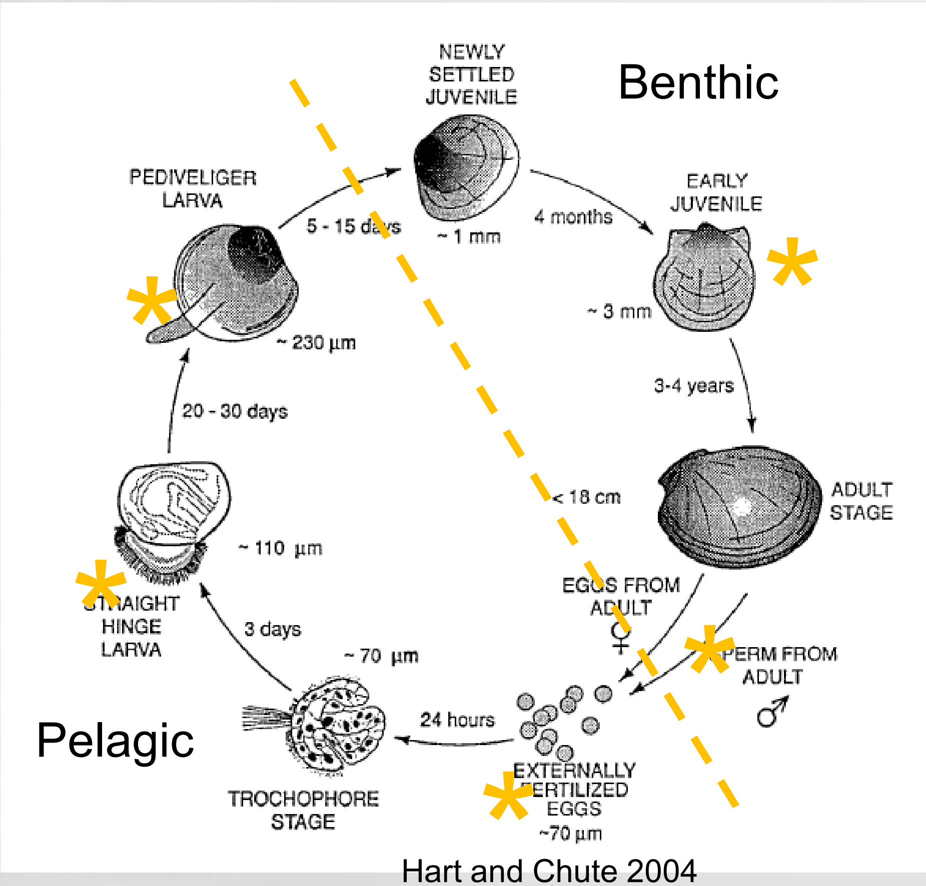
IAM with full detail



Δt = 0.1 year

Cooley et al. 2015. PLOS One

OA's effect on sea scallops



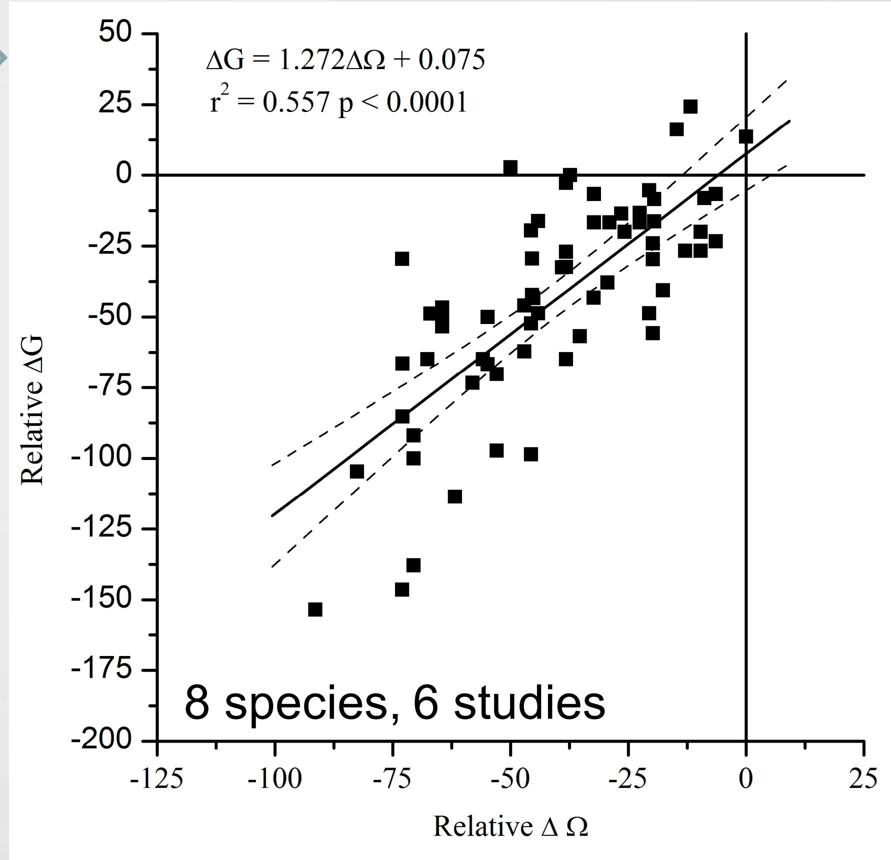
Hart and Chute 2004

* Likely growth/survival impacts, based on other species studied

OA's effect on sea scallops

- OA affects scallop growth in deep water
- T affects scallop growth in deep water
- OA affects recruitment in surface

Meta-analysis of bivalve growth response

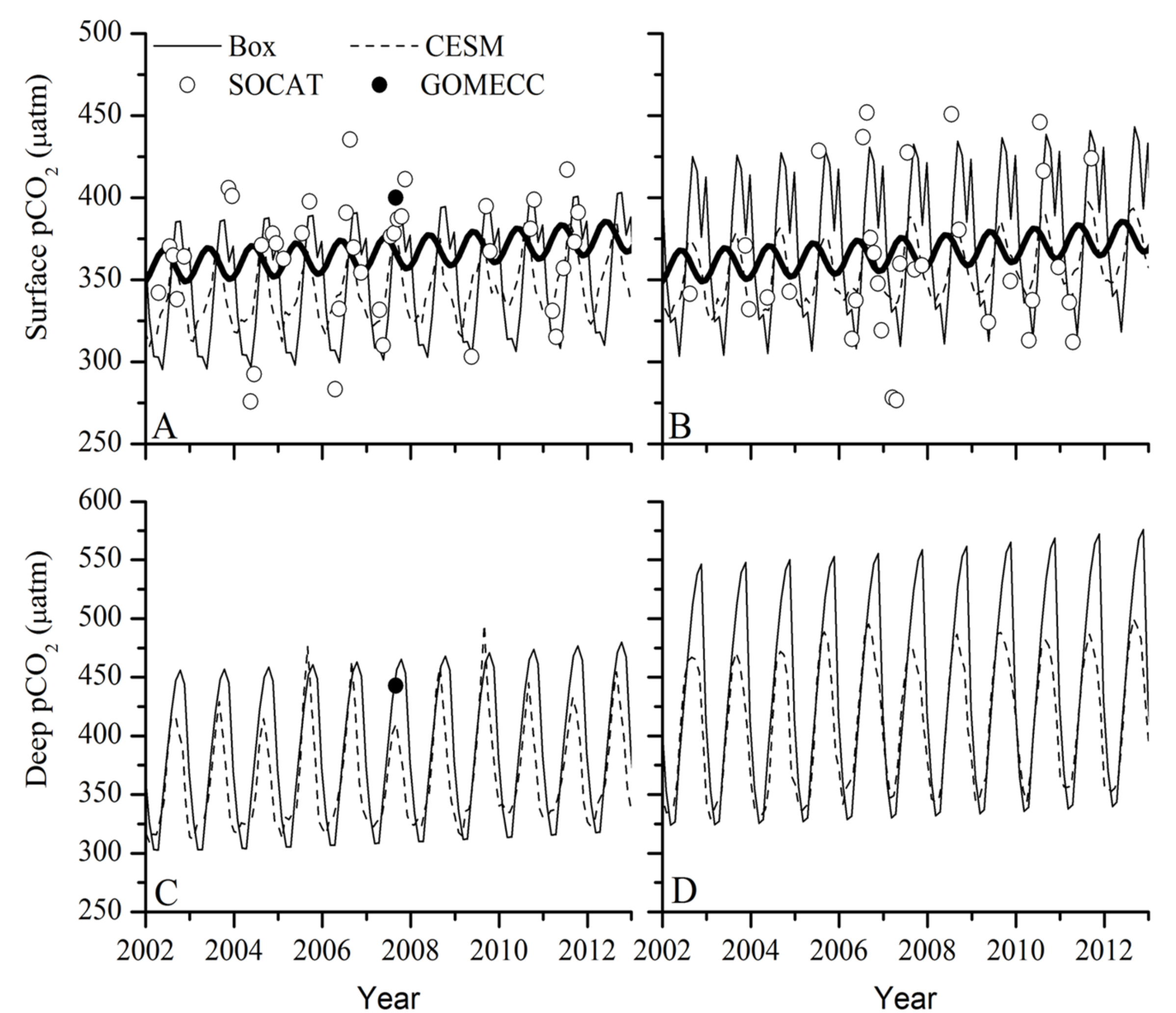


Cooley et al. 2015. PLOS One

Modeled CO_2 chemistry

Surface pCO2

Deep pCO2

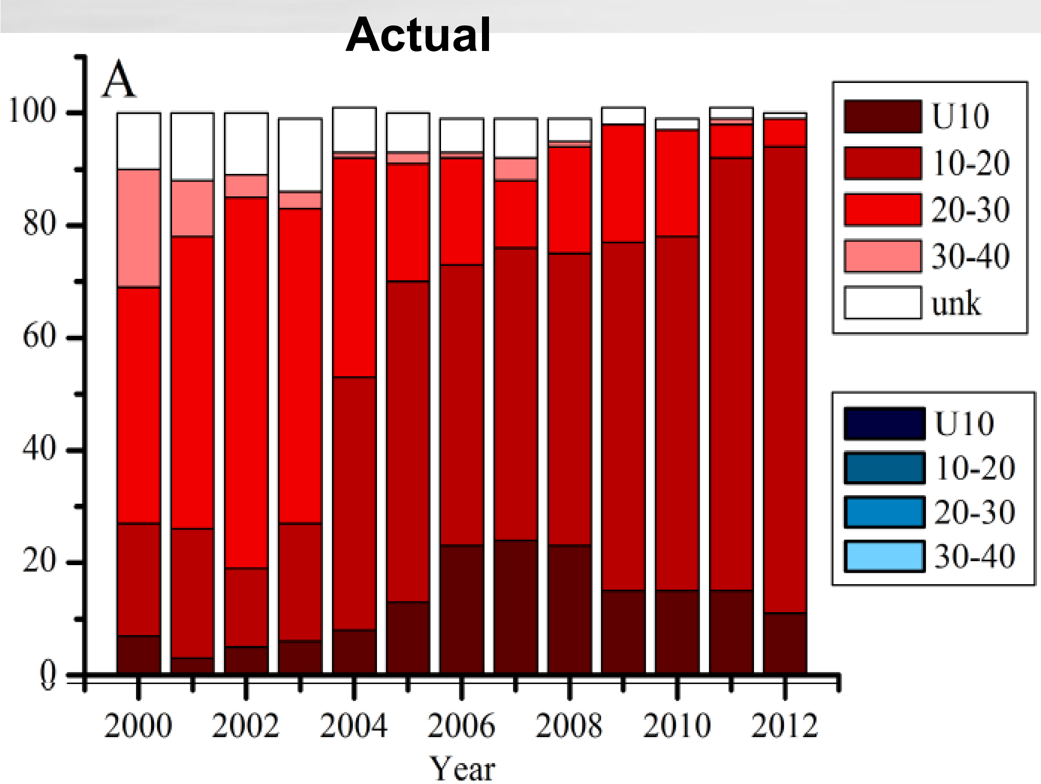


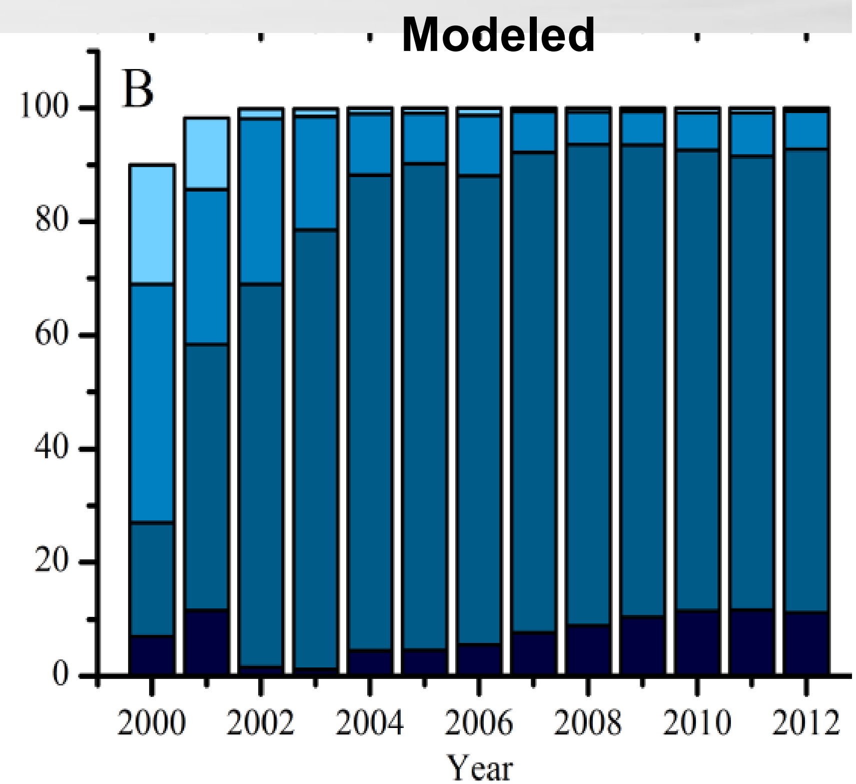
Cooley et al. 2015. PLOS One

Georges Bank

Mid Atlantic Bight

Landings



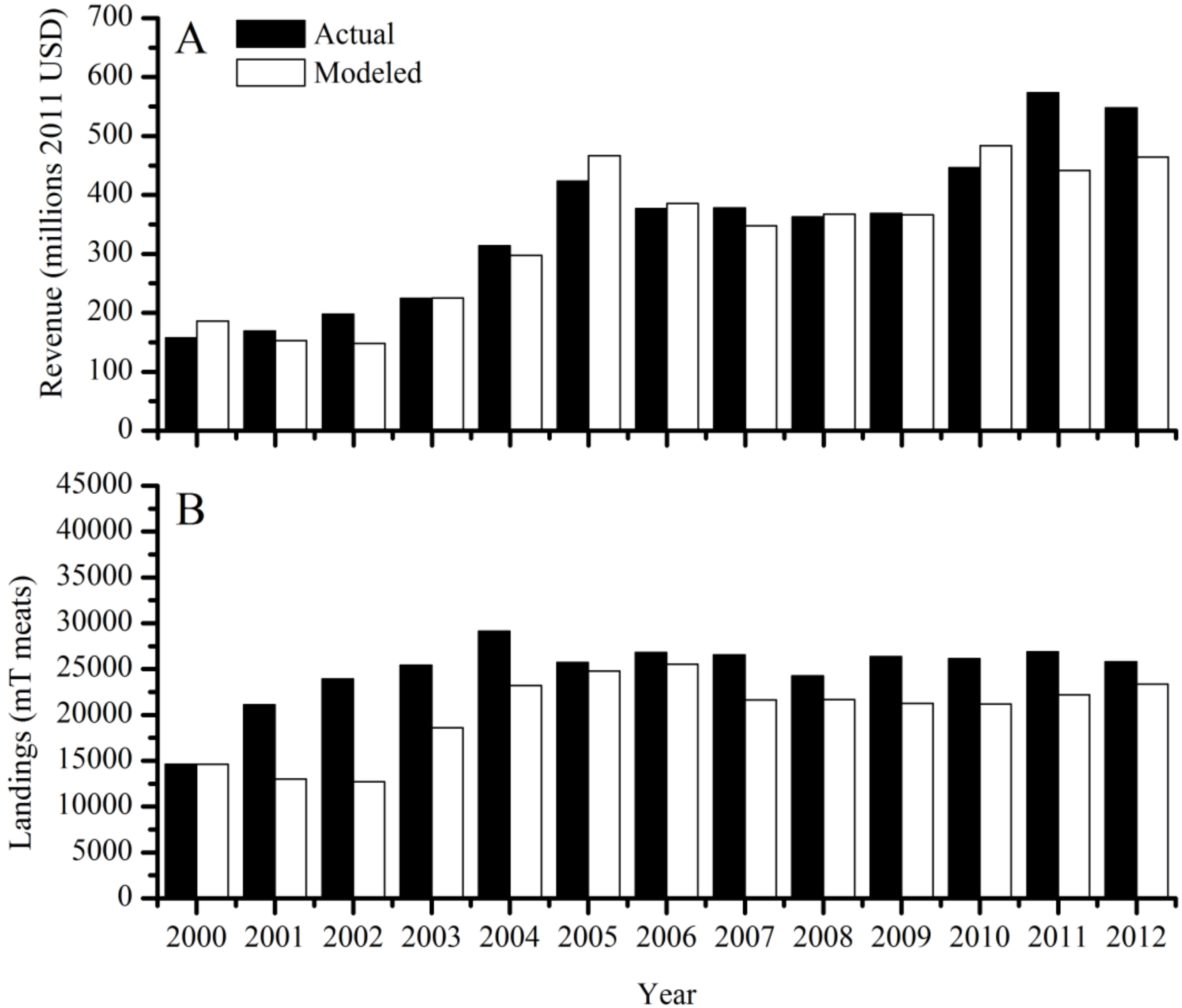


Not significantly different

Cooley et al. 2015. PLOS One

Ocean Conservancy

Socioeconomic Data



Revenues

Landings

Cooley et al. 2015. PLOS One

Cooley et al. 2015. PLOS One

Deep pH

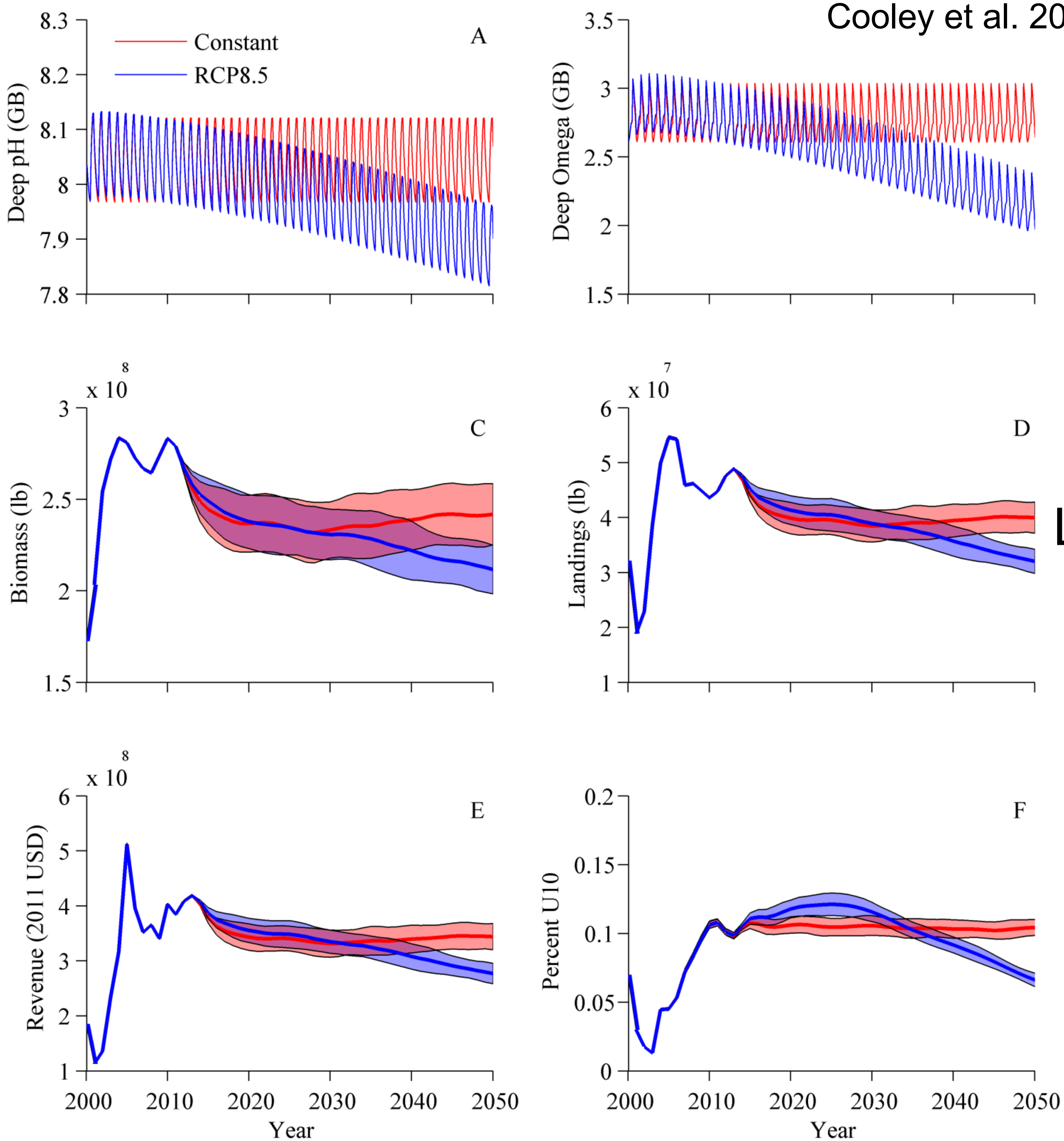
Deep Ω

Biomass

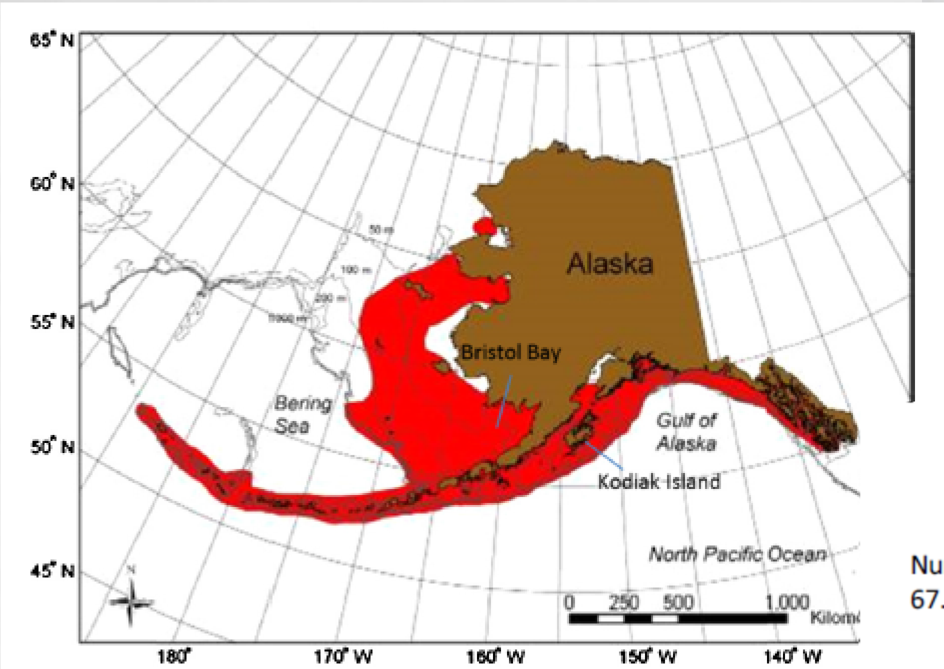
Landings

Revenue

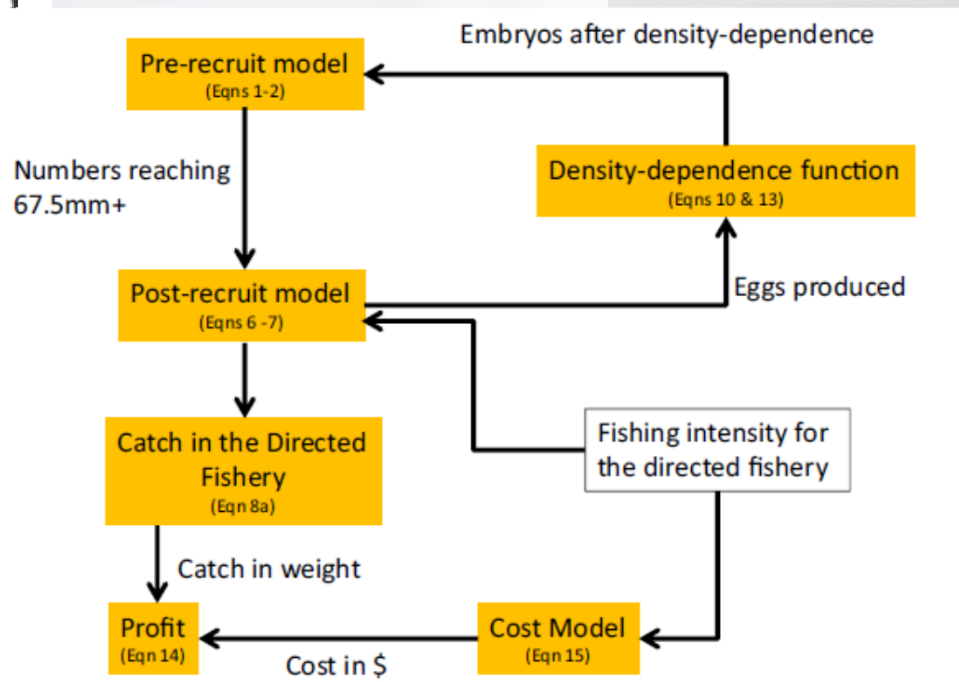
% U10



Red King Crab in Bristol Bay



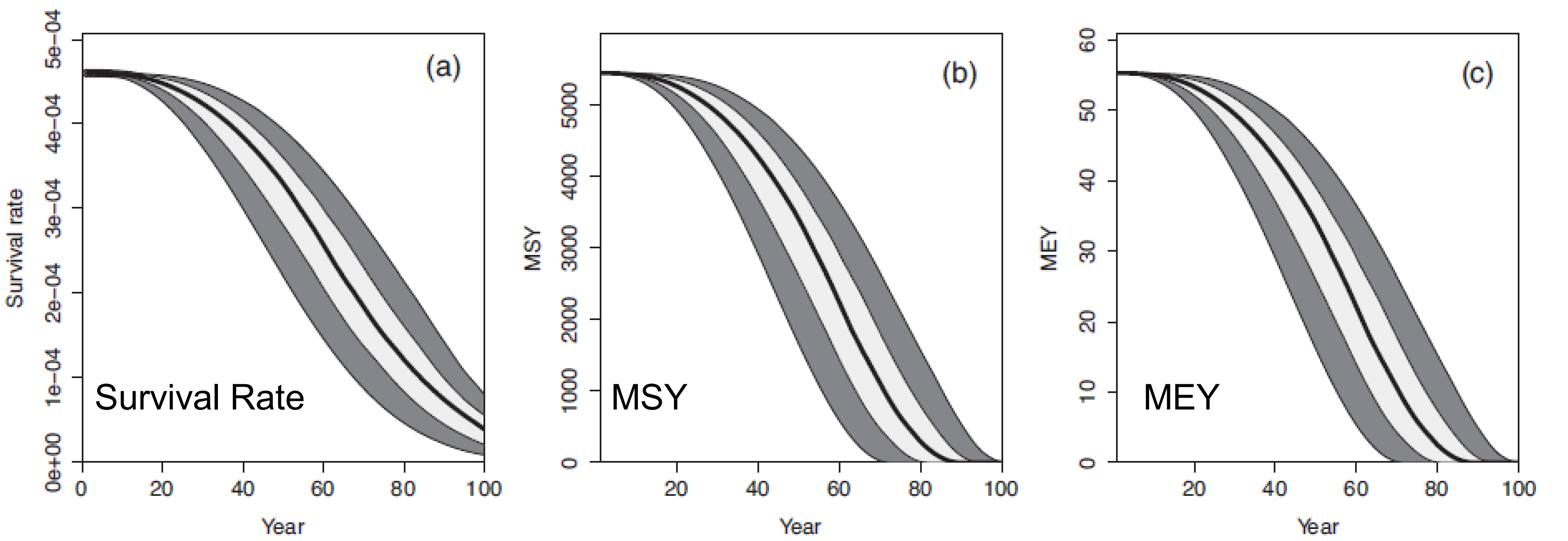
Punt, Poljak, Dalton, Foy (2014).
Ecol. Modelling



~$115M/yr first wholesale value
8.5M lb/yr finished products

Red King Crab in Bristol Bay

- Juvenile % survival data at pH 8.0, 7.8, 7.5 from experiments
- Recruitment changes into stage-structured population model linked to bioeconomic model



Bioeconomic models for OA

- Potential for integrating short, long term influences
- High-yield single species fisheries
  - Lots of data, lots of $, cultural importance
- Sticking point: how to link OA (and other drivers) and population-scale processes.
  - So far: growth, juvenile survival.
  - Yet to come: Fecundity? Multiple stressors?