

Implications of Ocean Acidification for Shellfish

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AGI Critical Issues Webinar:

Ocean Acidification Impacts on Fisheries

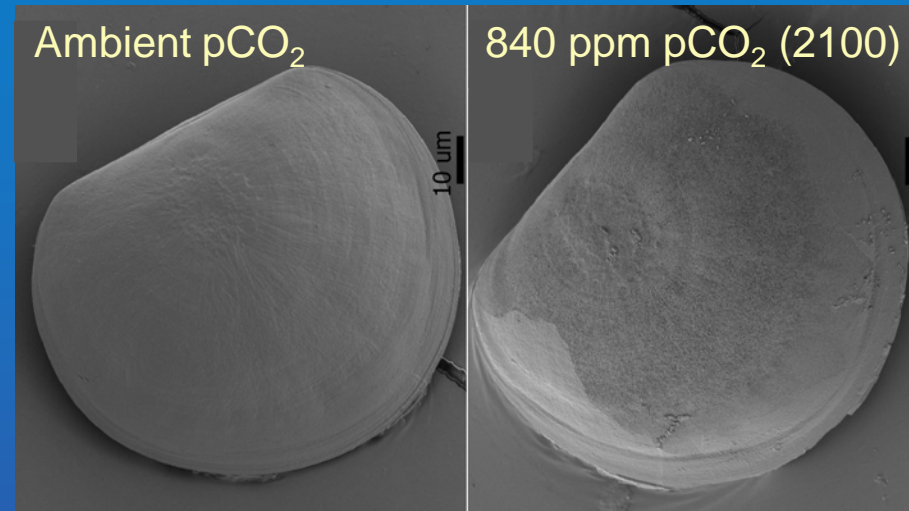
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OA and Calcifying Organisms



- OA may decrease calcifier populations via
 - calcification decreases
 - declining larval survival
 - life history changes



Bay Scallop (*Argopecten irradians*)
Anne Cohen, WHOI, 2009

- Calcifiers provide income and high-quality nutrition worldwide

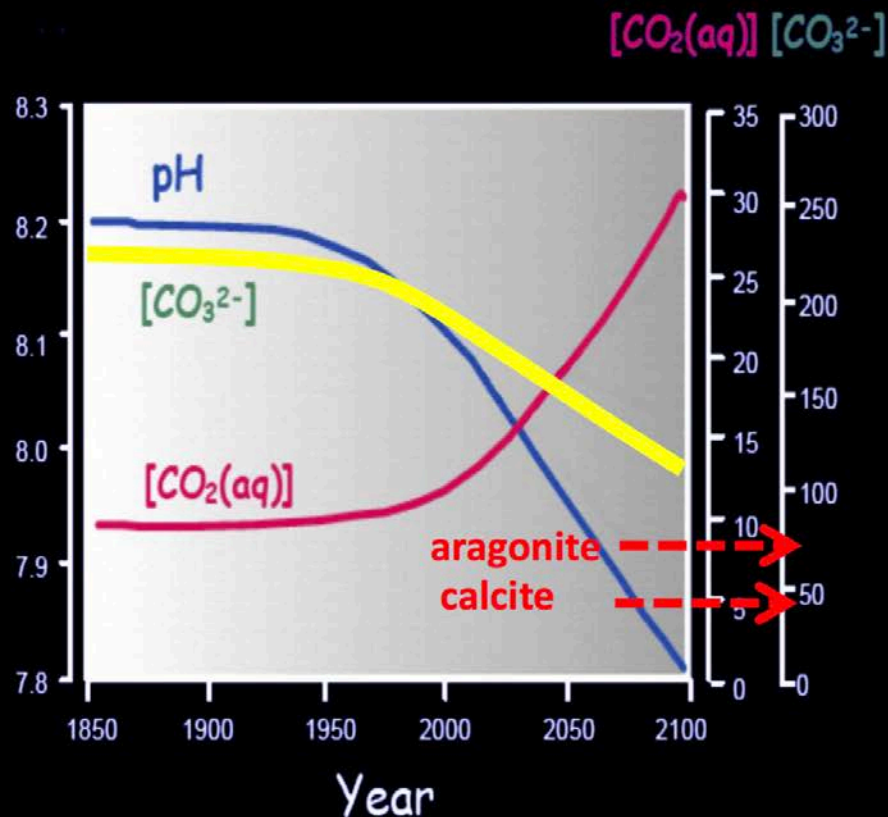


Skip Brown

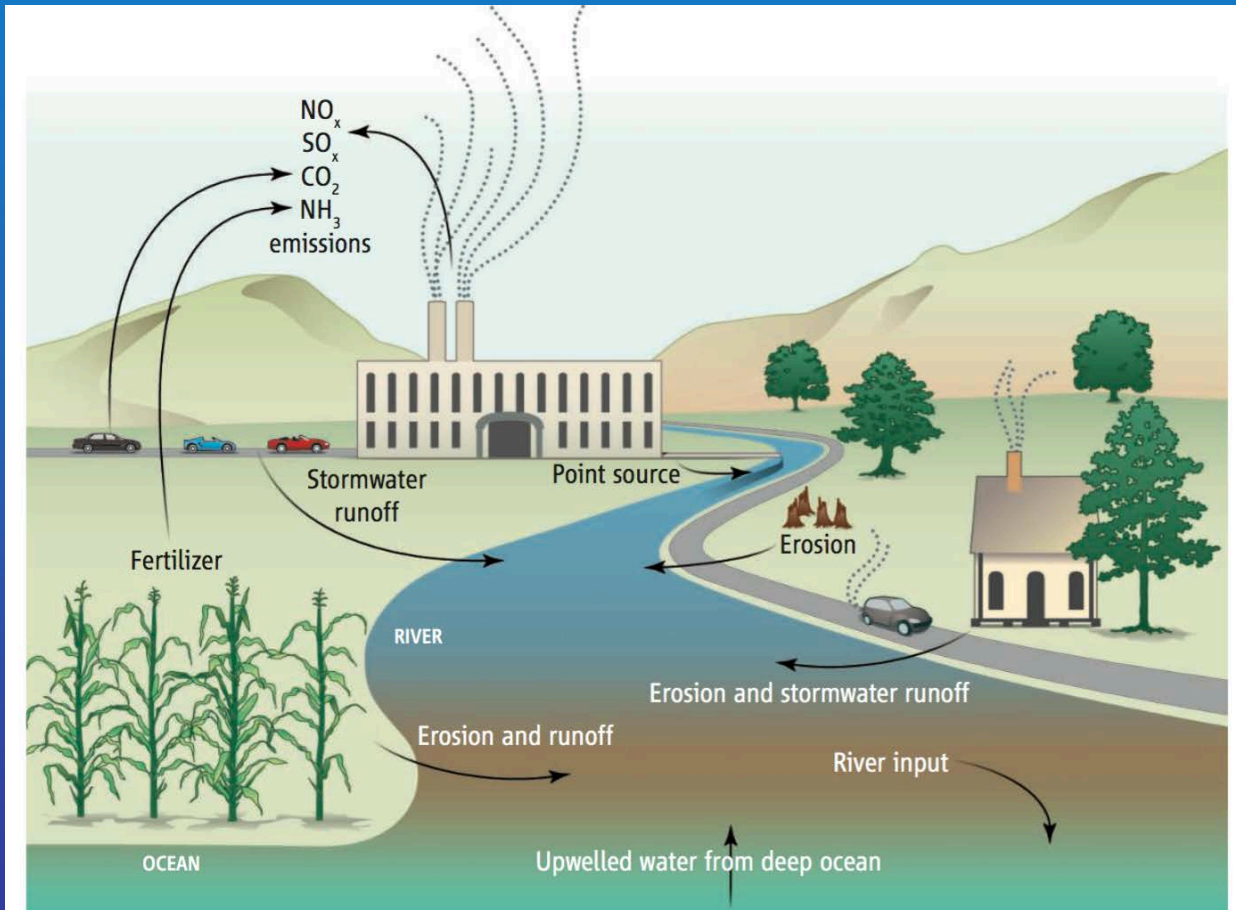
Shellfish larvae are particularly at risk



Aragonite dissolves at higher carbonate ion concentration than calcite

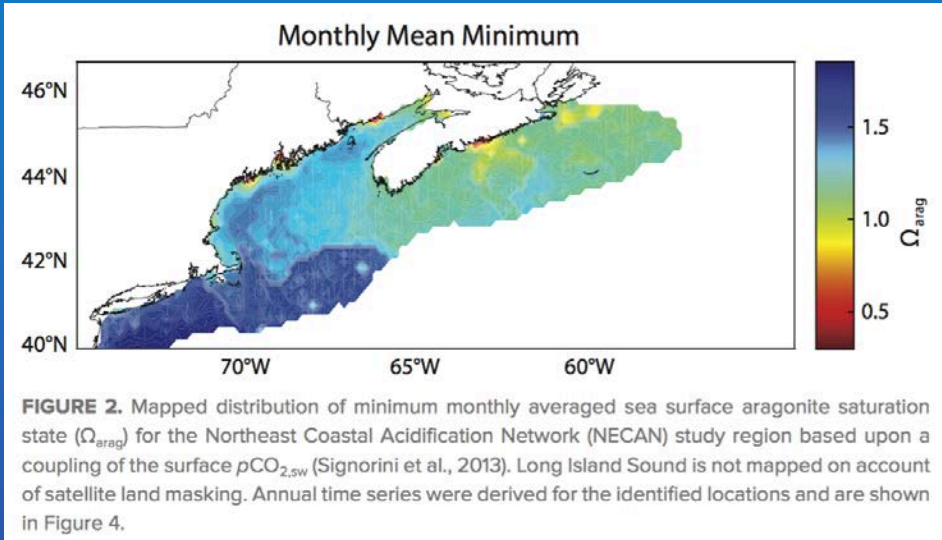


Ocean Acidification vs. Coastal Acidification

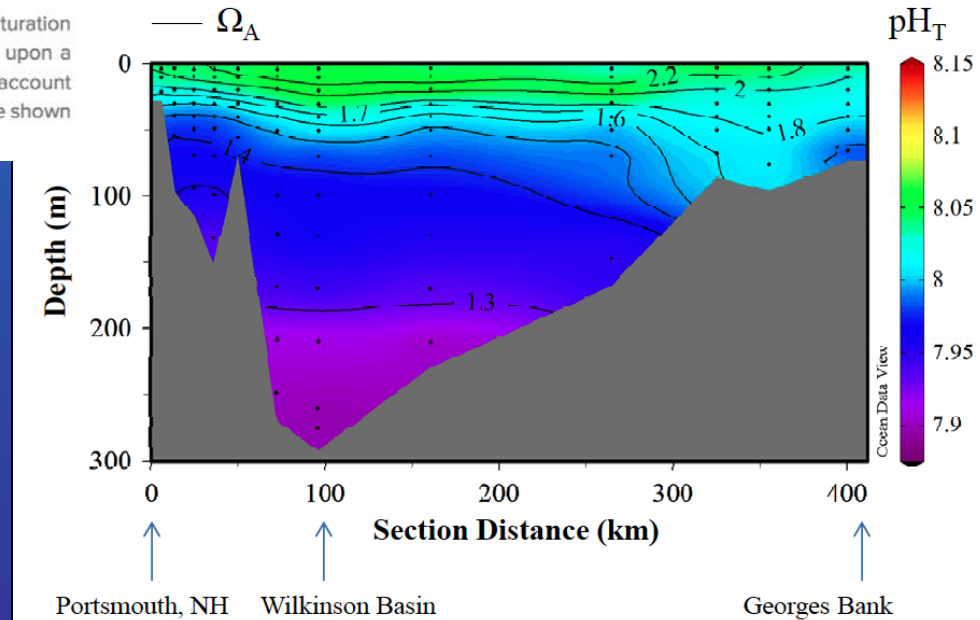


Contributors to ocean acidification. In addition to global atmospheric CO_2 , this figure depicts the major local (within 100 km) sources contributing to coastal ocean acidification.

OA vs. CA



Gledhill et al. 2015

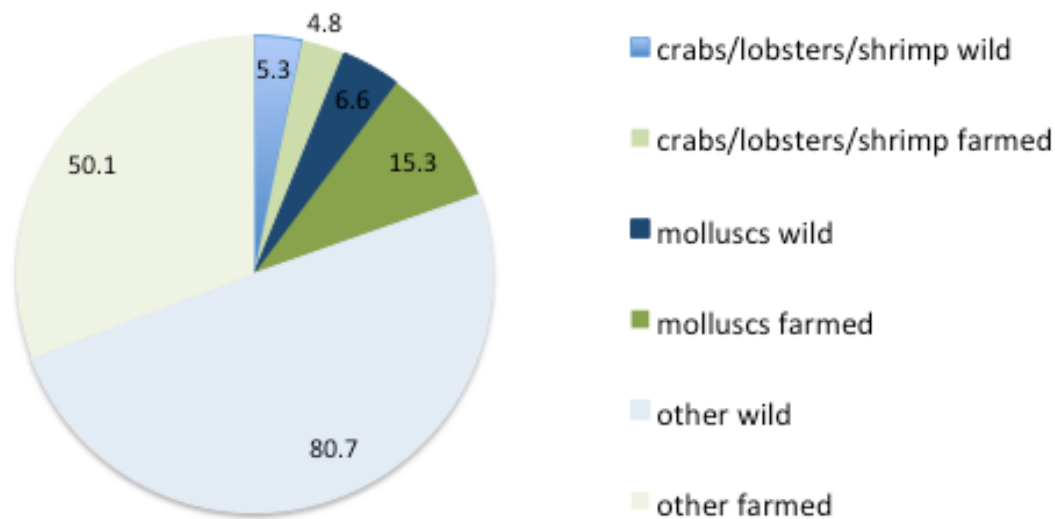


OA Effects from Lab Experiments

Species Group	OA Effects
Mollusks	Slowed shell growth (all age groups) Elevated mortality (larvae, juveniles)
Crustaceans	Mixed results; population-specific?
Other benthic invertebrates	Echinoderms (sea urchins) negative
Finfish	Embryonic survival negative (flounder) Cod: effects population-specific
Zooplankton	Copepods relatively robust Pteropods negative
Phytoplankton	Small effects; species-specific
Macroalgae, seagrass	Some aspects of photosynthetic performance positive in some species

Economic Value Potentially at Stake

Global Seafood Production 2013, million tons



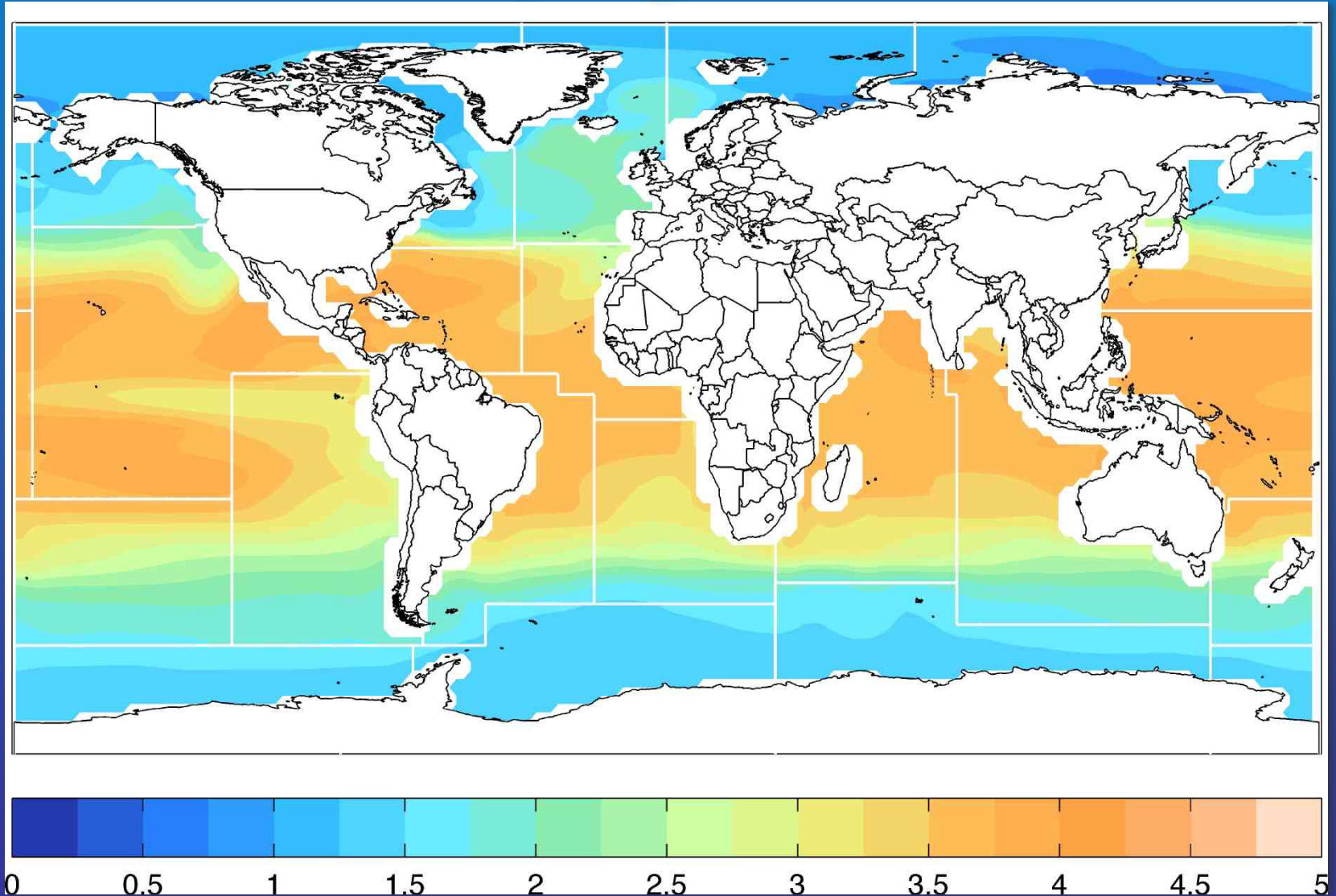
\$300-400 billion/year total value

~\$100 billion/year shellfish

Present oceanic conditions



Mean Ω_{ar} in 2010

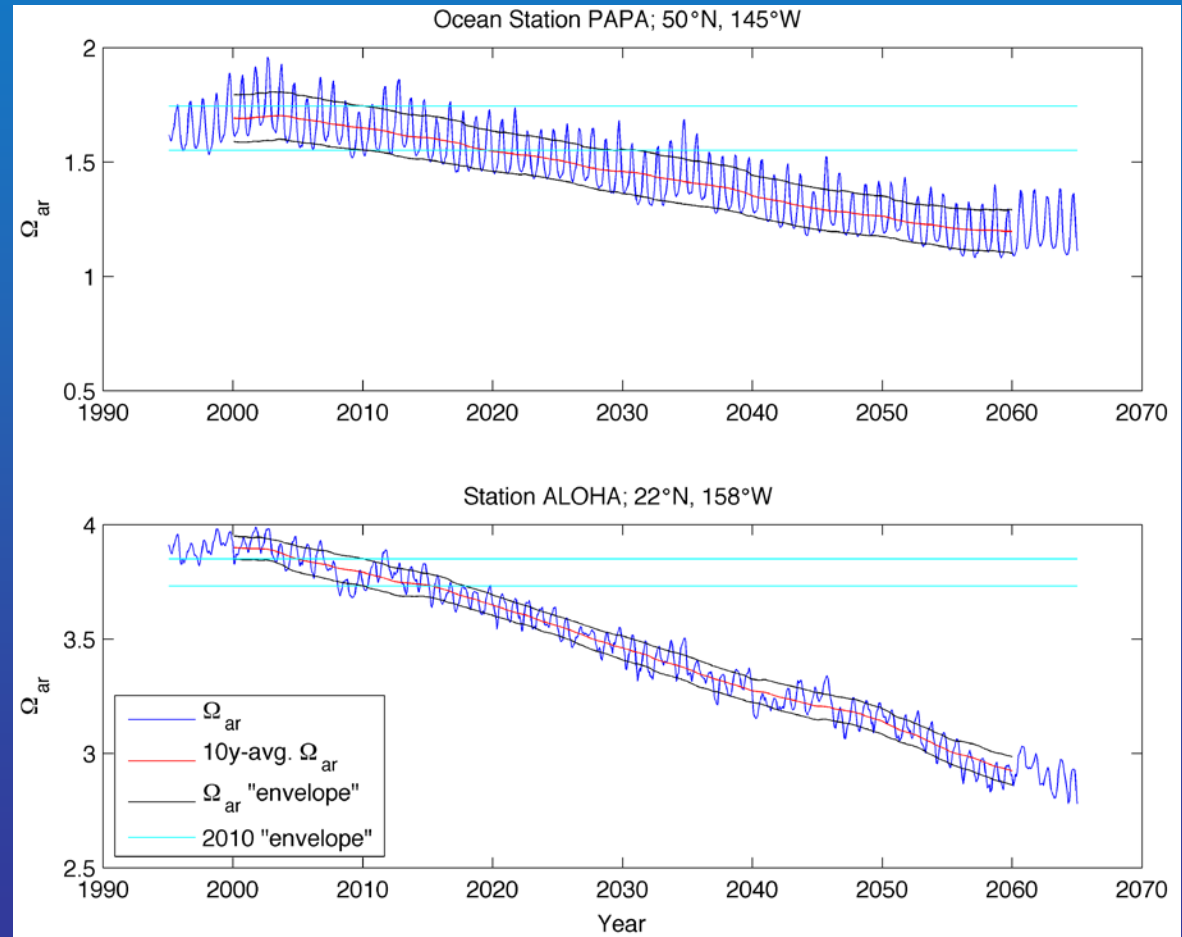


Calculated from Community Climate System Model 3.1 output as described in Cooley et.

When is Ω_{ar} significantly different from today?



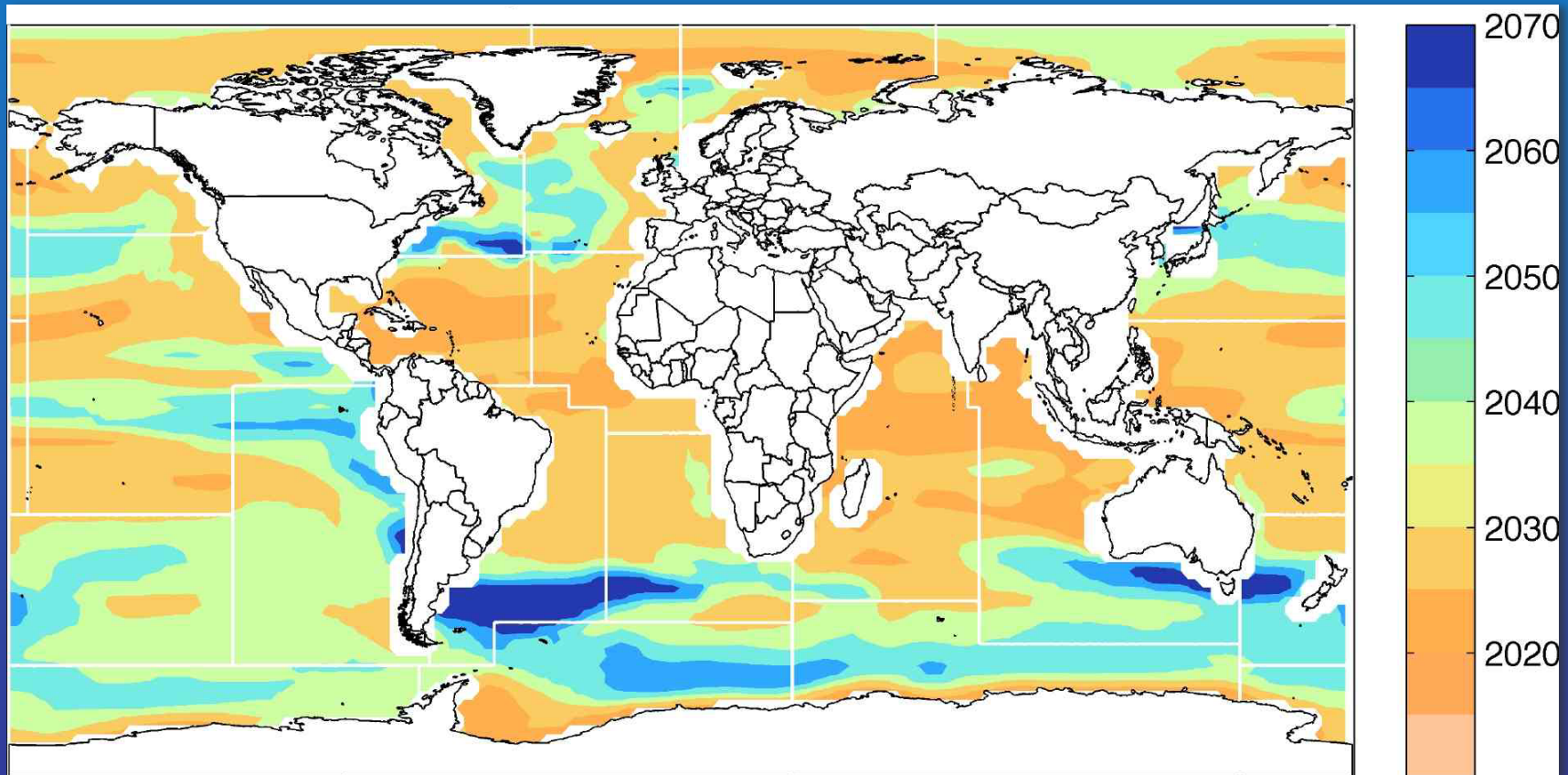
Monthly mean Ω_{ar}
Decadal mean Ω_{ar}
2010 Ω_{ar} envelope
Running Ω_{ar} envelope



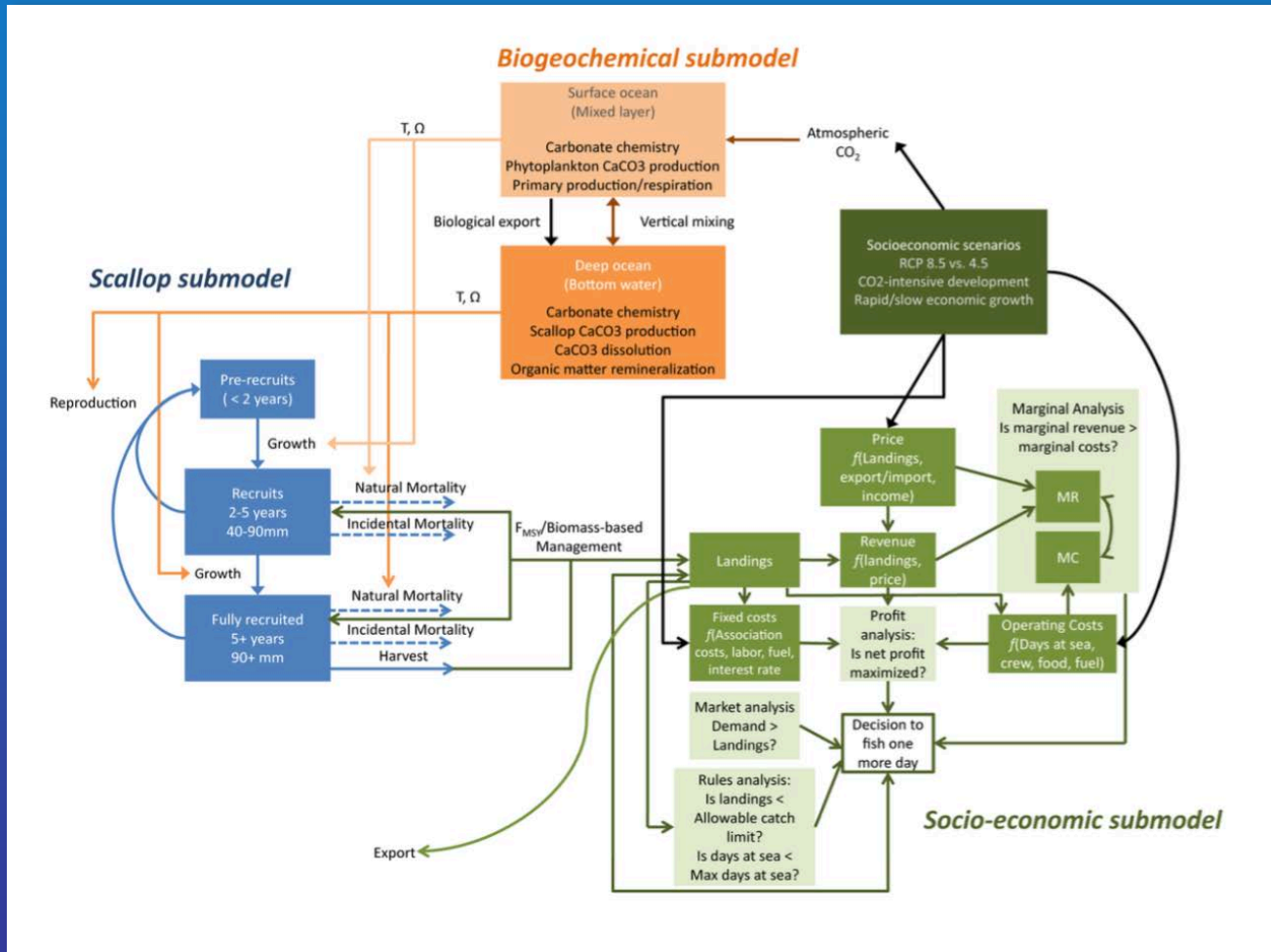
“envelope” =
mean \pm RMS

Threshold date

When Ω_{ar} will be profoundly different from 2010

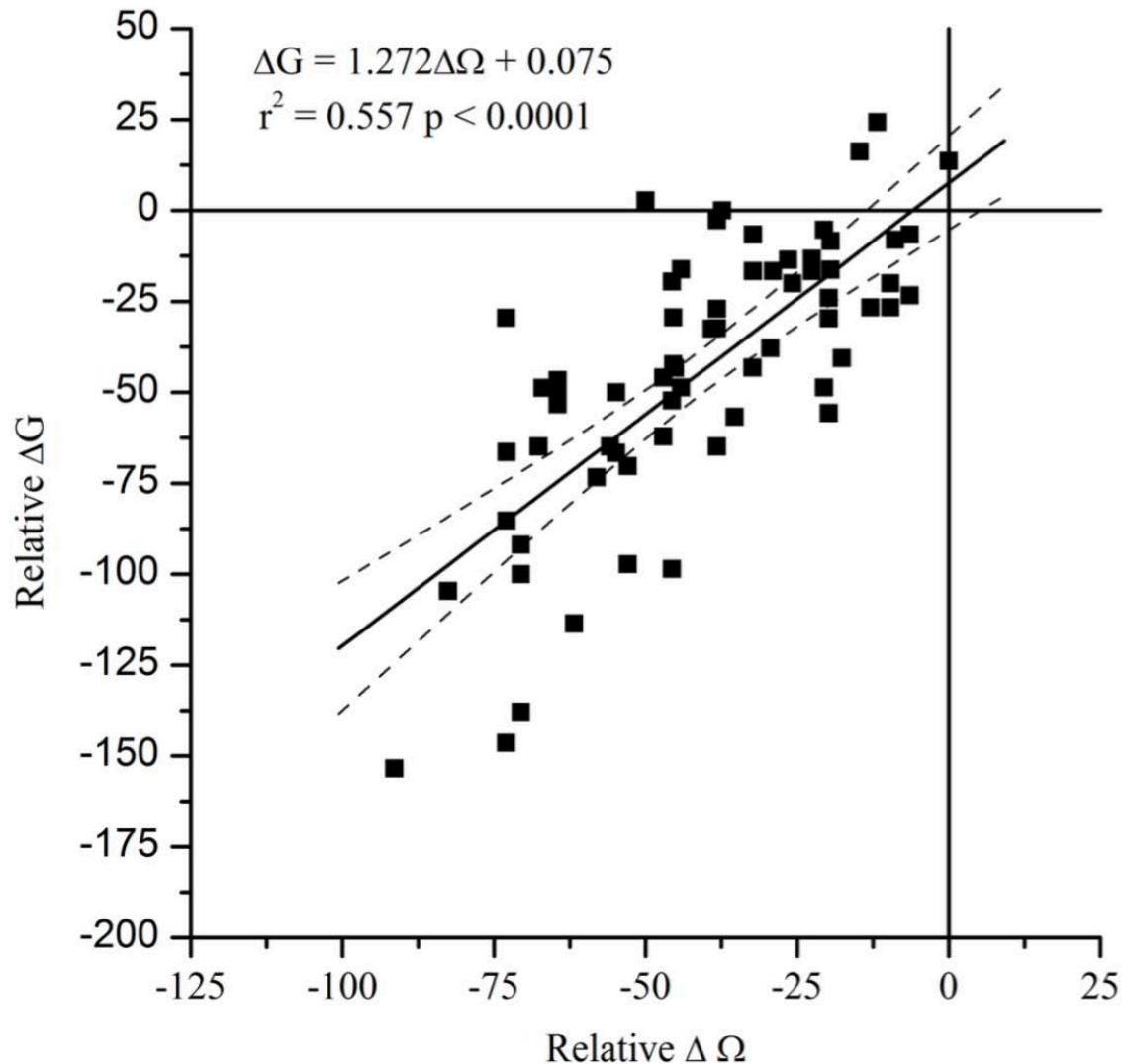


US Scallop Fishery



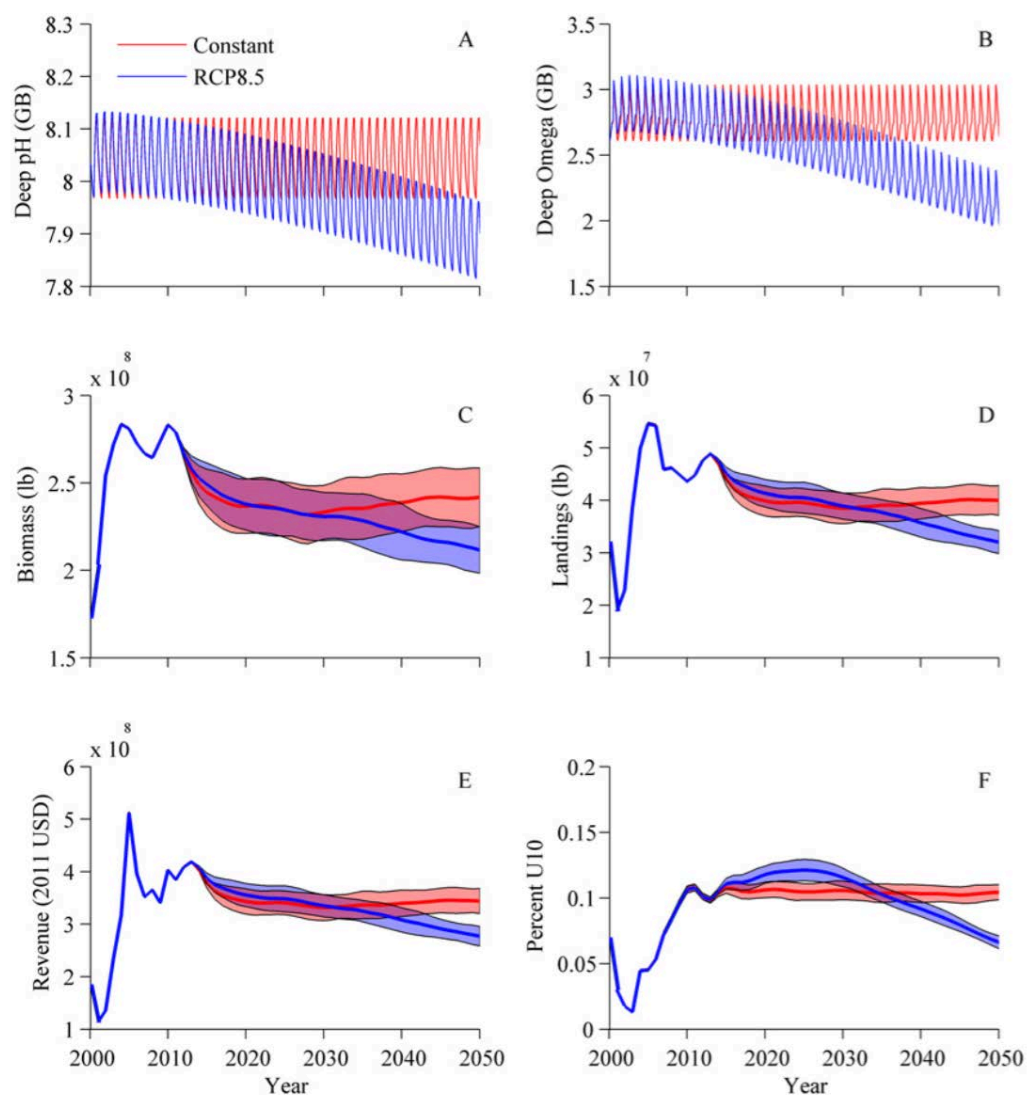
Combined biogeochemical, scallop stock recruitment, and economic models.

US Scallop Fishery



Relationship between aragonite saturation and bivalve growth rate, from studies of 7 species (not scallops).

US Scallop Fishery



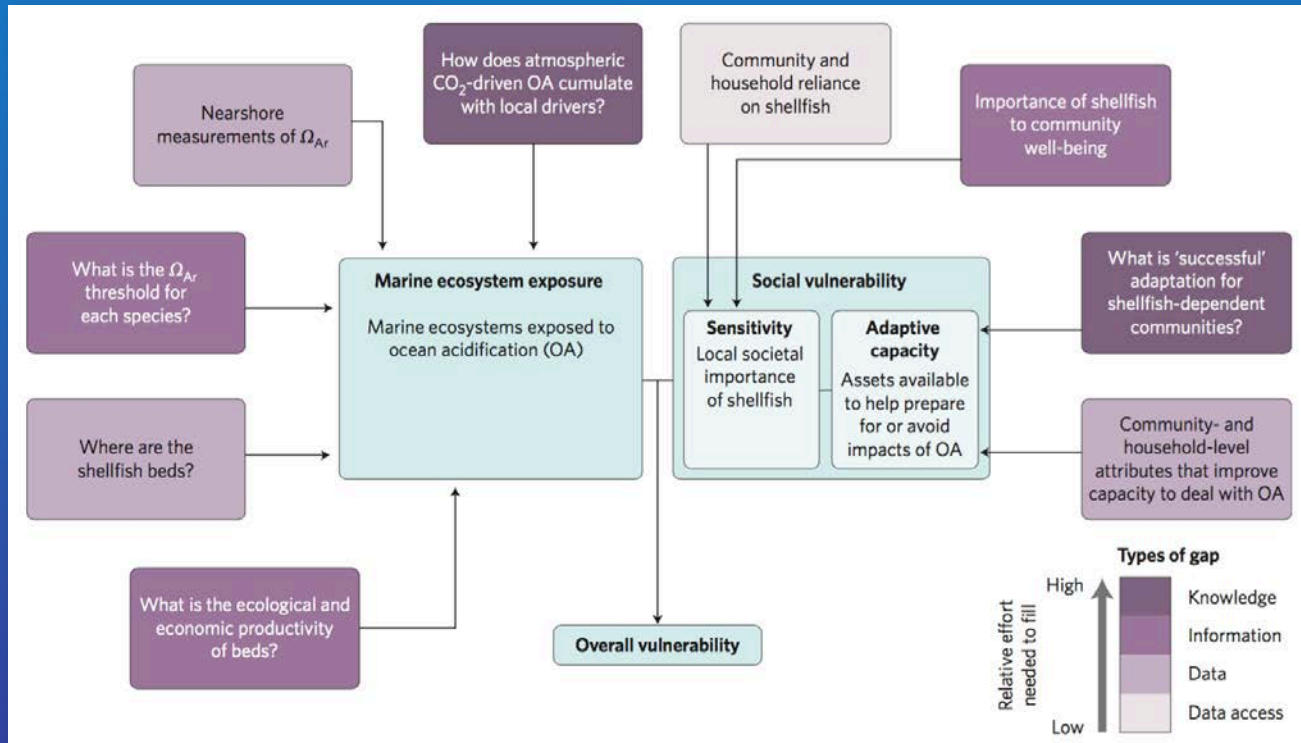
Modeled future pH and saturation state for deep water on Georges Bank, and modeled effect on biomass, landings, and revenue for the commercial scallop fishery.

Projects ~20% revenue decline by 2050.

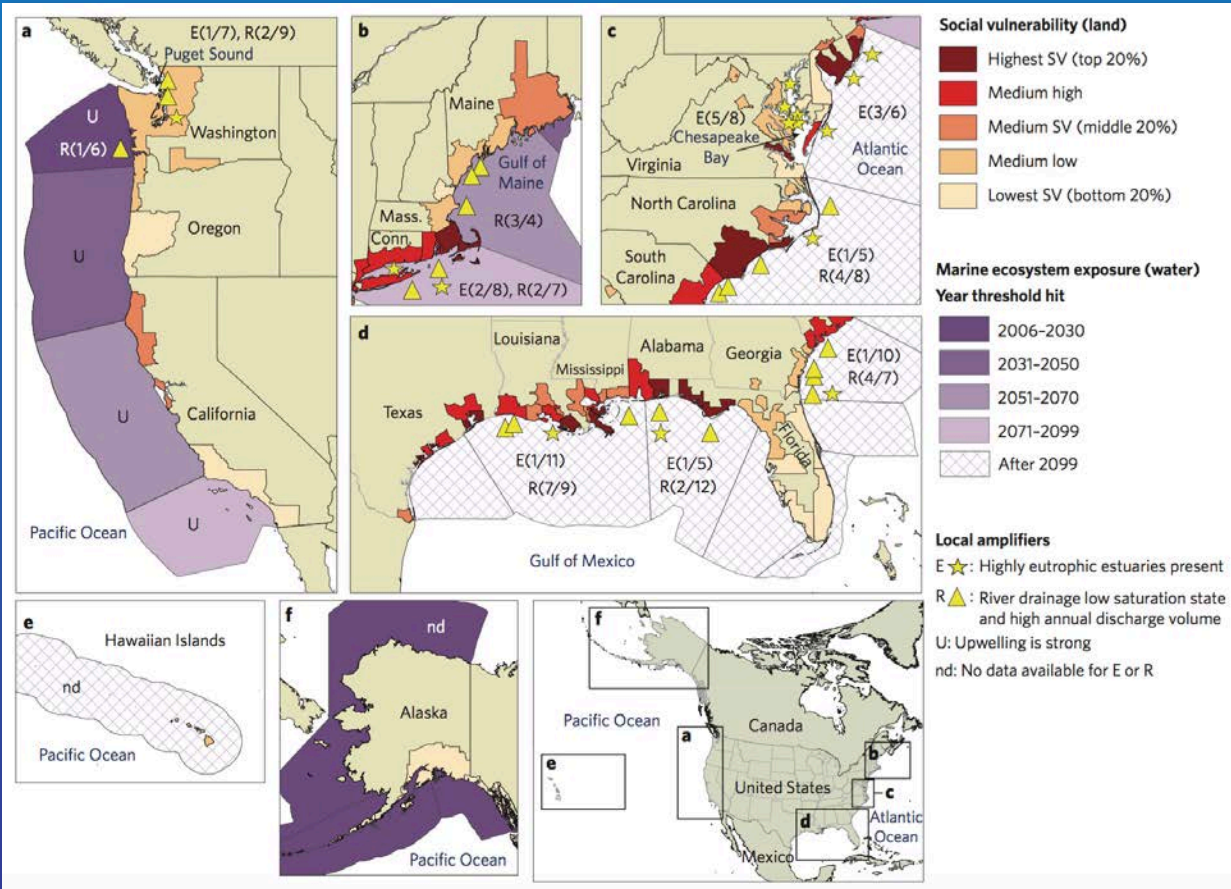
Vulnerability and Resilience: US

Overall societal vulnerability depends on:

- Marine ecosystem
- Economic importance
- Adaptive capacity

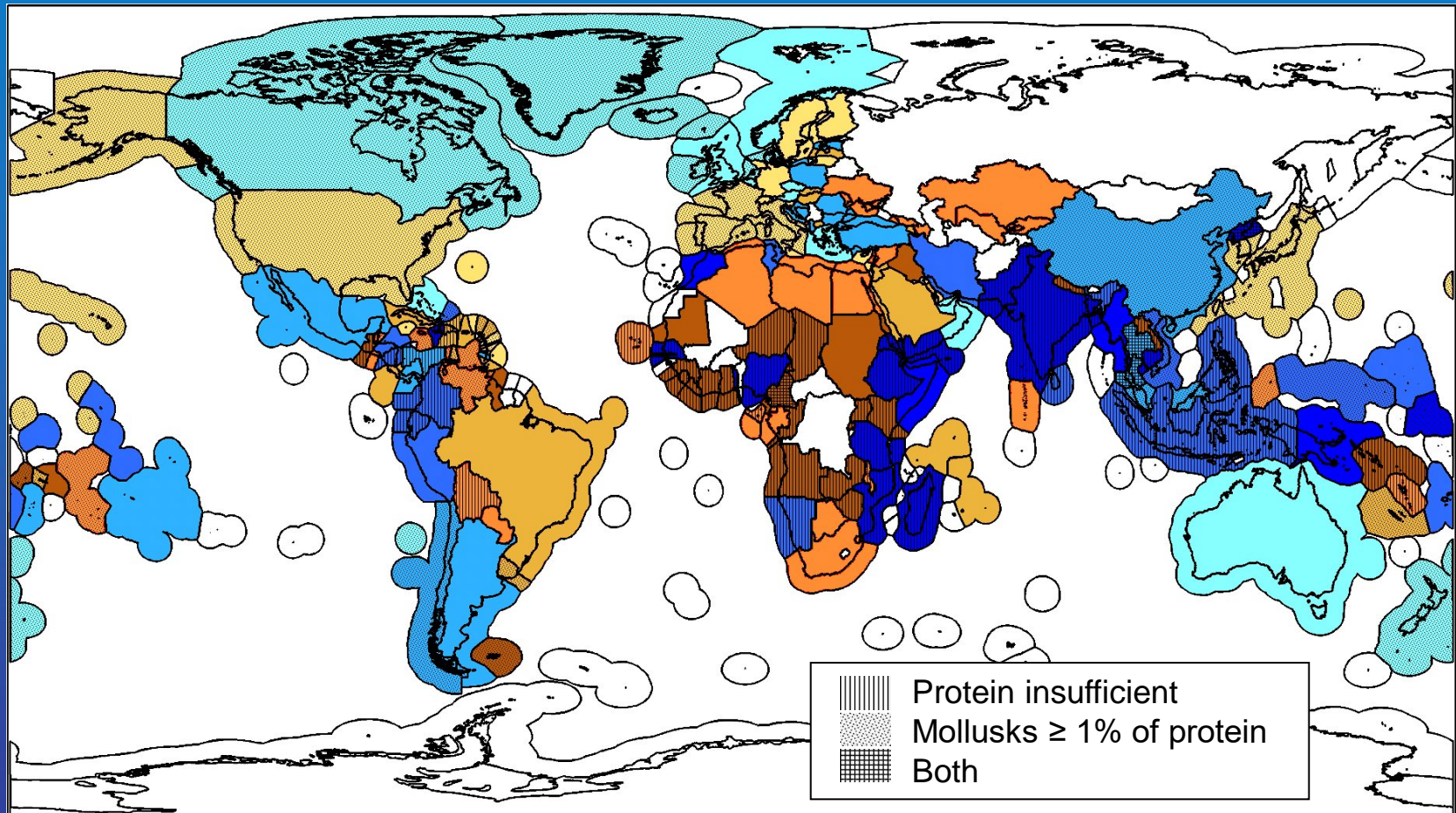


Vulnerability and Resilience: US



Societal vulnerability to OA effects varies greatly by location – even within the US.

Vulnerability from socioeconomic links to mollusks



Net importers



Net exporters



Least adaptable

Most adaptable

Adaptation and Mitigation



- Limit coastal acidification by reducing nutrient loading
- Use algal “curtains” to buffer water (raise pH) around shellfish farms
- Move shellfish hatcheries and farms away from shore
- Select for shellfish populations that are more resilient to low pH stress

Summary



- **OA is a significant potential threat to calcifying organisms, including mollusks and corals**
- **effects are often species/population-specific**
 - multiple stressors
 - ocean vs. coastal OA:
 - high natural variability in pH near shore and on reefs
- **economic value potentially at risk: [\$10s billion / year]**
- **potential adaptation/mitigation measures**
 - limit nutrient loading and other stresses in coastal waters
 - select for less vulnerable species
 - shellfish farming in engineered environments
 - move shellfish hatcheries to offshore waters