Offshore wind development and climate impacts on mid-Atlantic commercial shellfish fisheries: An agent-based modeling approach

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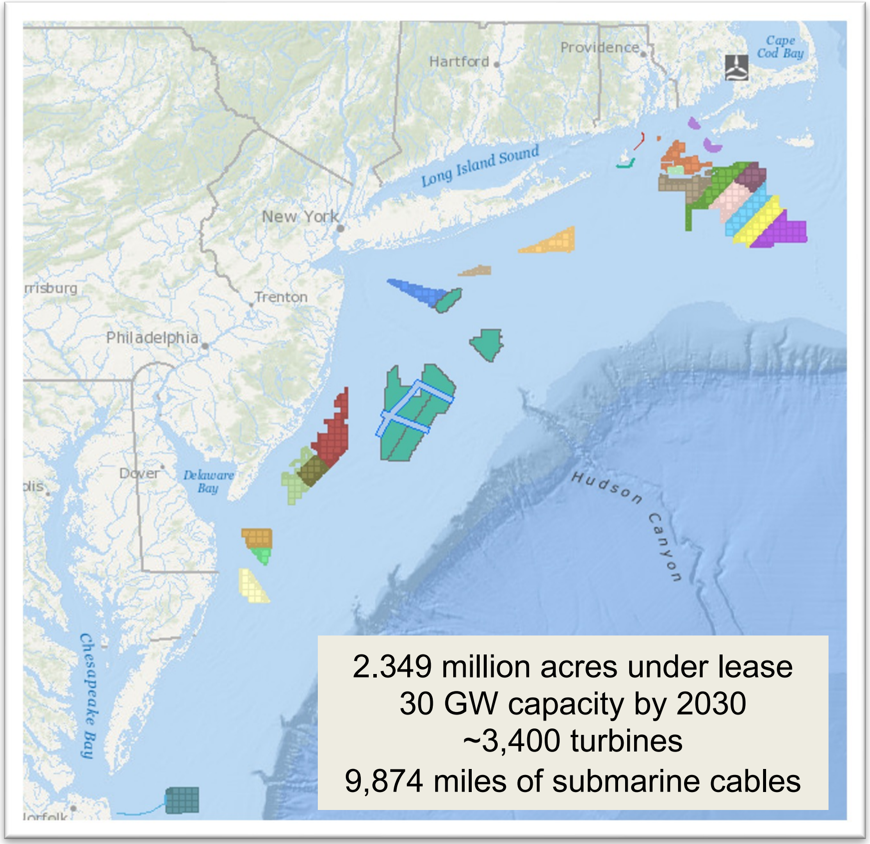
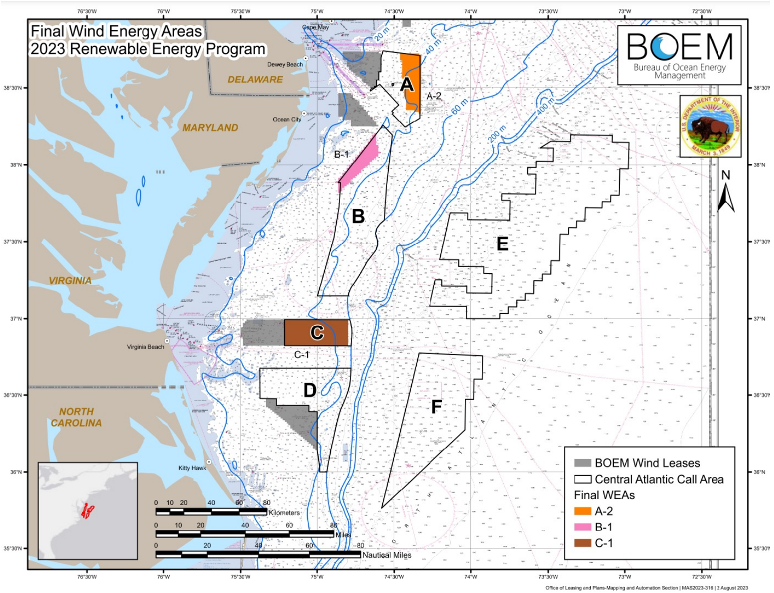
MAFMC SSC Meeting
September 12, 2023





Recently announced WEAs

FISHERIES OCEANOGRAPHY

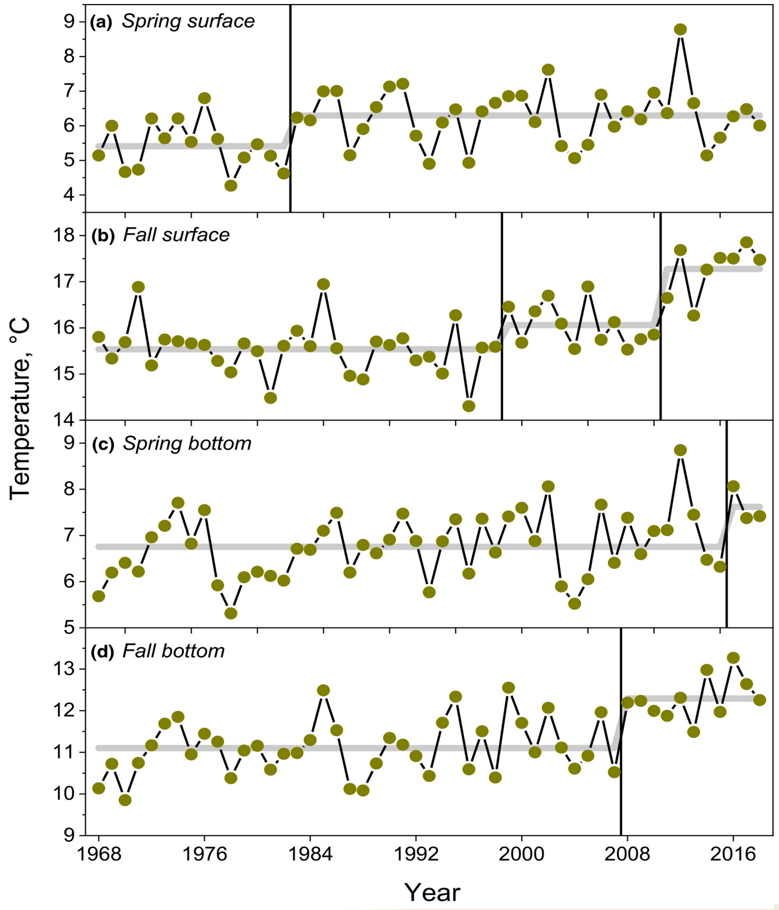
ORIGINAL ARTICLE | Full Access

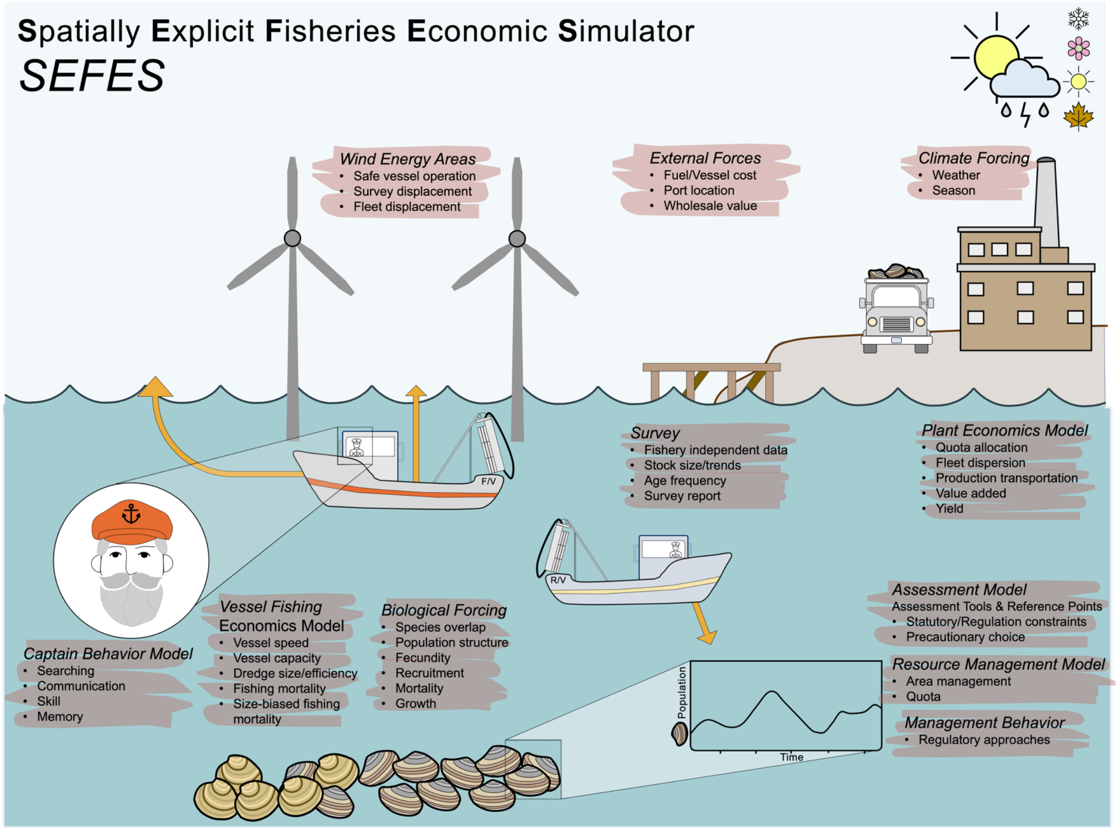
Trends and change points in surface and bottom thermal environments of the US Northeast Continental Shelf Ecosystem

Kevin D. Friedland, Ryan E. Morse, James P. Manning, Donald Christopher Melrose, Travis Miles, Andrew G. Goode, Damian C. Brady, Josh T. Kohut, Eric N. Powell

Habitat is changing

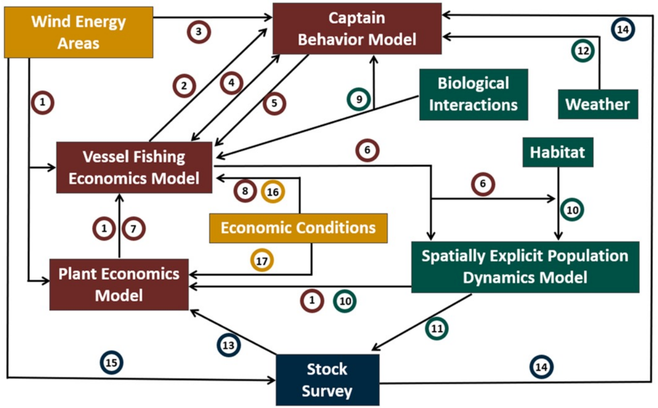
Bottom temperatures warming between 0.8°C and 1.3°C per decade



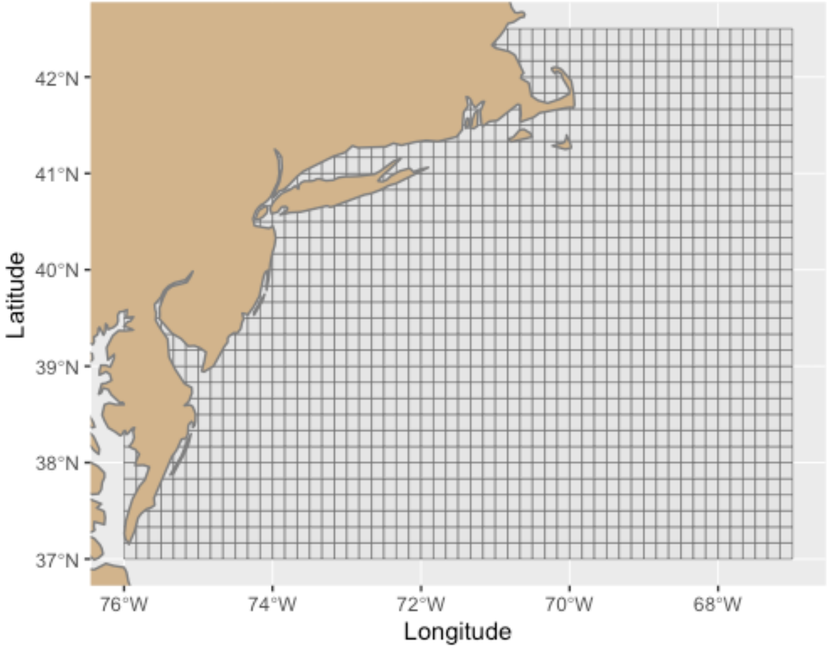


SEFES

Agent-based model developed to assess changes in commercial shellfish fisheries arising due to offshore wind development and climate change



Category	Component Processes	Property	Source
Fishery Processes			
1	Fleet dispersion	Location and movement	Fishery dependent data and stock assessment
2	Vessel characteristics: speed & capacity, dredge size & efficiency	Speed (knots), capacity (cages), dredge size (length), dredge efficiency (rate of catch)	Industry advice and stock assessment
3	Safe vessel operation	Subjective	Industry advice
4	Captain memory, searching & communication	Catch (LPUE) per TMS	Industry advice
5	Captain skill	Rate of catch	Industry advice
6	Fishing mortality (size-selective)	Rate of catch by size class	Stock assessment
7	Vessels in the fleet, quota allocation	Number and properties of vessels, and quota (bushels)	Industry advice and fishery dependent data
8	Port location	Location (TMS)	Fishery dependent data and stock assessment
Biological & Environmental Processes			
9	Species overlap – Atlantic surfclams and ocean quahogs	Location (TMS)	Industry advice and unpublished research data
10	Biological processes: recruitment, mortality, growth, yield	Recruitment (clams per m^2), mortality (natural mortality rate), growth (shell size over time), yield (mass per size over season)	Industry advice, stock assessment, and unpublished data
11	Population structure	Length frequency and abundance by TMS	Stock assessment
12	Wind & temperature	Wind (kilometers per hour), temperature (° C)	Meteorological and airport records
Management Processes			
13	Quota, stock trends, & fishery independent data	Quota (bushels), trends (abundance and body size over time), fishery independent data (catch statistics)	Stock assessment, MAFMC 2020, research papers
14	Survey Report	Stock distribution and biomass by TMS	Stock assessment
15	Survey displacement	Location and movement	Advisor advice
External Forces			
16	Fuel & vessel costs	Rates	Industry advice and published prices (Energy Information Administration)
17	Wholesale value	Prices by product type	Industry advice



Spatially explicit model → structured on 10’x10’ grid

Shoreside integration

$$C^{trans}_{c,t} = \sum_{i,c} Cages_{i,t}\ Distance_{i,c}\ FreightRate,$$

Industry-informed financials

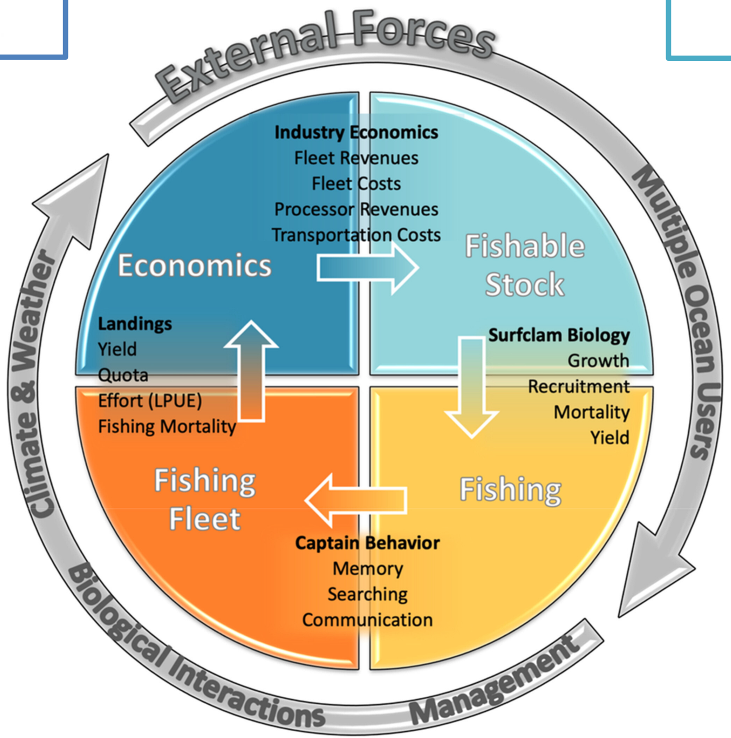
$$C^{share}_{i,t} = fr\ R_{i,t},$$

$$C^{fuel}_{i,t} = FuelPrice_{p} \times \left(Hr^{steam}_{i,t}\ FuelSteam_{i} + Hr^{fish}_{i,t}\ FuelFish_{i}\right),$$

$$C^{maint}_{i,t} = (MjrMnt_{i}\ \ TSurf_{i}) + (RegMnt_{i}\ NTrip_{i,t}),$$

Representative fleet

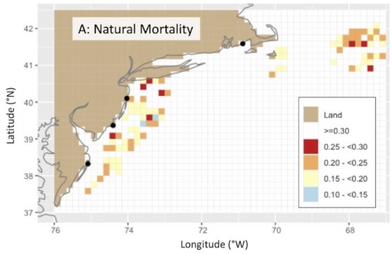
Vessel Category	Hull Length (m)	Number of Vessels	Average Cage Capacity	Average Vessel Steaming Speed (m s^{-1})	Average Dredge Width (m)	Wind Conditions Preventing Fishing (m s^{-1})
Small	≤24	11	31	4.5	2.3	>5
Medium	24–29	10	54	4.6	3.3	>8
Large	29–33	8	66	4.9	3.7	>8
Jumbo	>33	4	140	5.1	4.6	>10



Length-structured population

$$L = L_{\infty}\left(1 - e^{-kA}\right)$$

Spatially-variable mortality



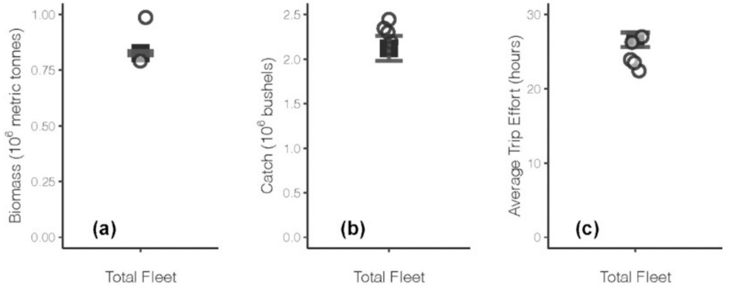
Decisions informed by memory

$$M_{LPUE} = f\,Old_{LPUE} + (1-f)\,New_{LPUE}$$

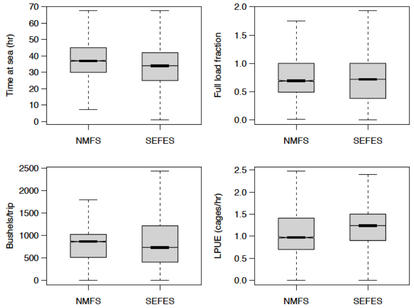
Parameterization and model validation

- Represent existing stock and industry
- Parameterize: stock assessment / available biological information; captain, industry interviews; vessel trip reports
- Validate: compare model output to assessment and fishery data
- Utilize industry and management advisors throughout model development

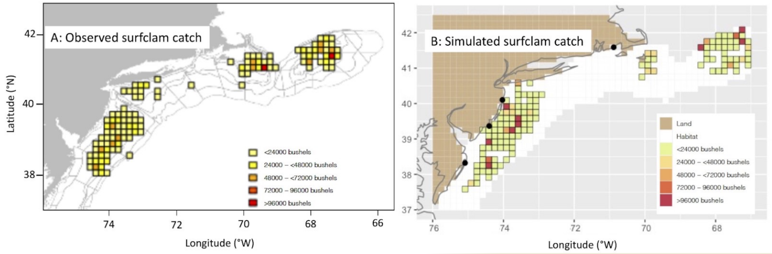
BOEM



Aggregate fishery

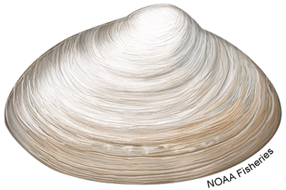


Individual vessels



Spatial distribution

Current SEFES implementations:

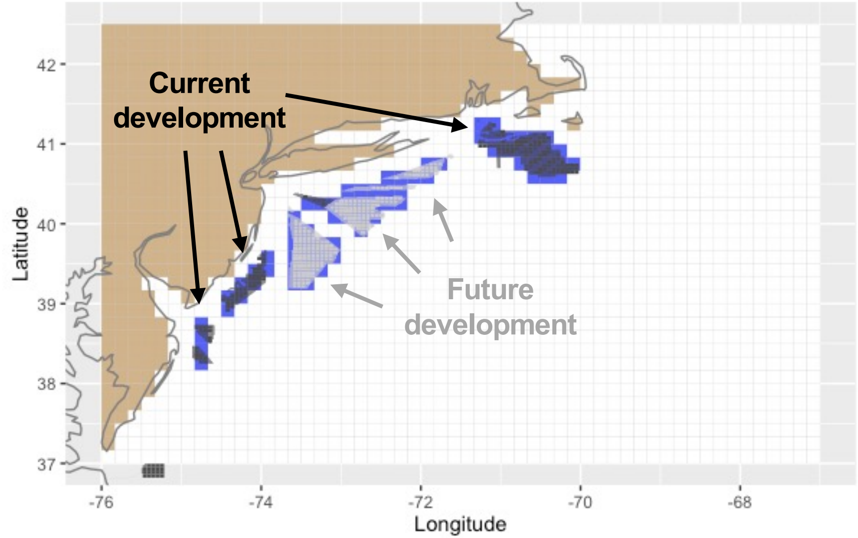


- Atlantic surfclam (*Spisula solidissima*)
    - Offshore wind impacts, climate driven population shifts

- Atlantic sea scallop (*Placopecten magellanicus*)
    - Offshore wind impacts

- Ocean quahog (*Arctica islandica*) considered via technical interaction in surfclam model, future model development being explored

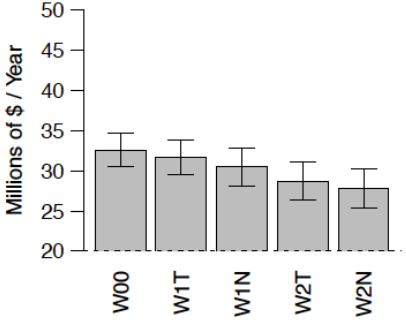
Evaluating impacts of offshore wind



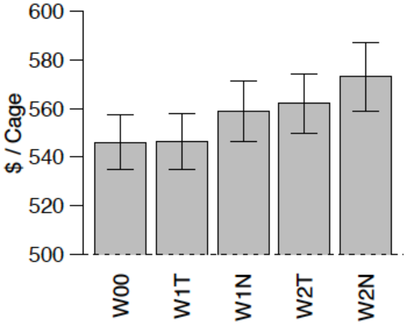
Simulation strategy: evaluate changes in fishery across different wind energy development scenarios

Wind energy scenario	*Description*
W00	Status quo; no wind farms
W1T	Current wind farms; Transit allowed — CURRENT LEASES
W1N	Current wind farms; No transit allowed — CURRENT LEASES
W2T	Current & future wind farms; Transit allowed — CURRENT LEASES, FUTURE LEASES
W2N	Current & future wind farms; No transit allowed — CURRENT LEASES, FUTURE LEASES

Fleet revenues



Average costs



Surfclam results

- Number of trips reduces, time at sea increases
- Decrease in revenues of ~3-15%
- Effort displacement increases average costs 0-5% (fuel costs +0-10%)
- Processor transportation costs increased ~1-4%

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ICES CIEM International Council for the Exploration of the Sea / Conseil International pour l'Exploration de la Mer

The Atlantic surfclam fishery and offshore wind energy development: 1. Model development and verification

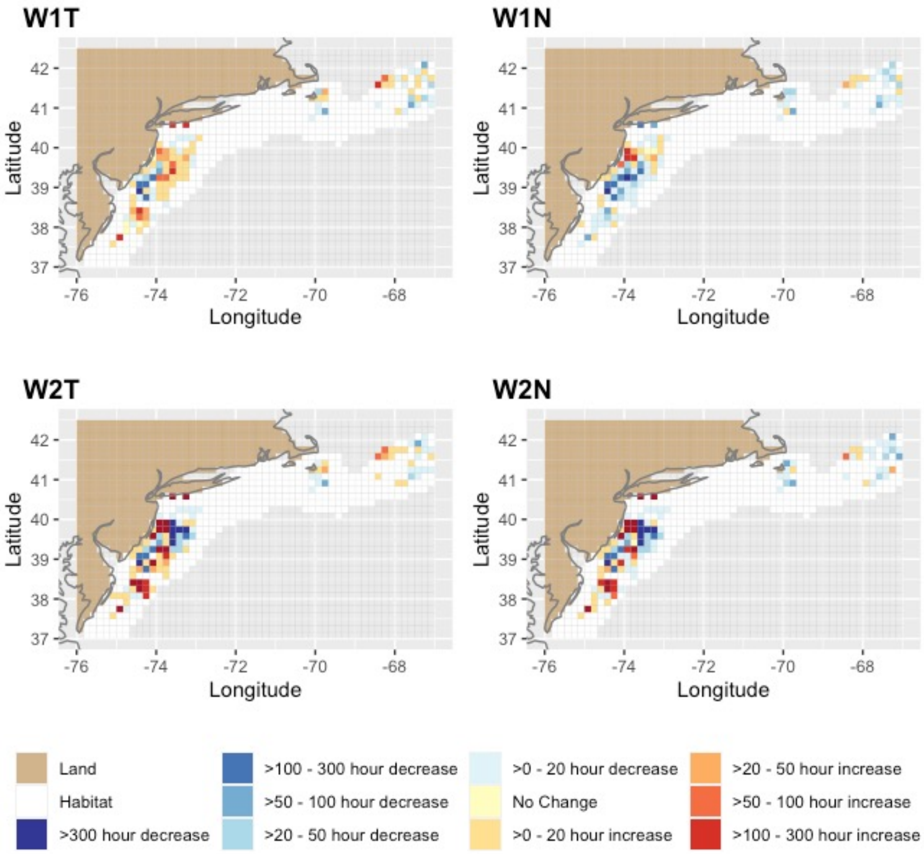
Daphne M. Munroe[1,*], Eric N. Powell[2], John M. Klinck[3], Andrew M. Scheld[4], Sarah Borsetti[1,4], Jennifer Beckensteiner[4,5] and Eileen E. Hofmann[3]

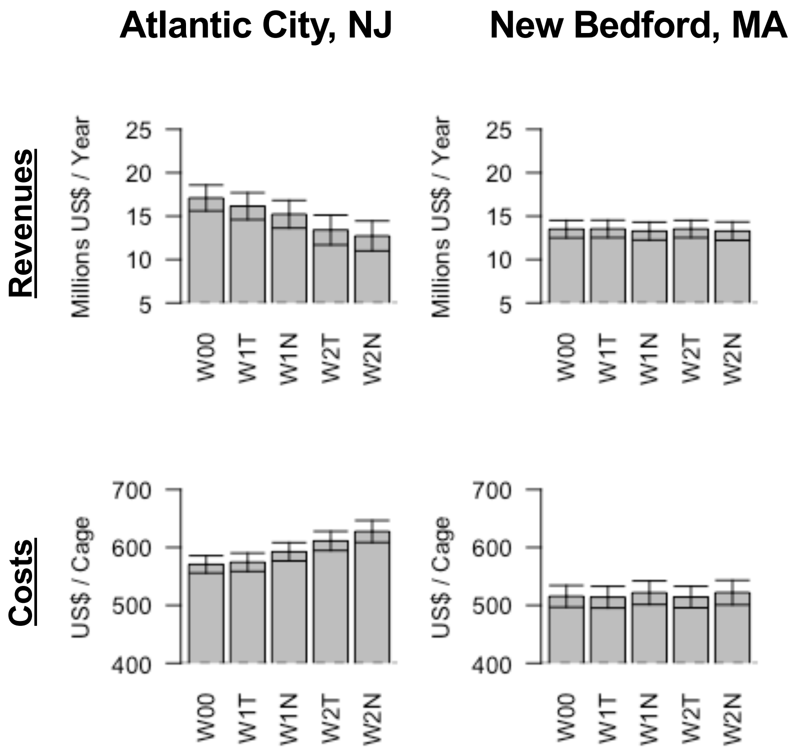
022, **79**, 1801–1814
20 June 2022

ICES CIEM International Council for the Exploration of the Sea / Conseil International pour l'Exploration de la Mer

The Atlantic surfclam fishery and offshore wind energy development: 2. Assessing economic impacts

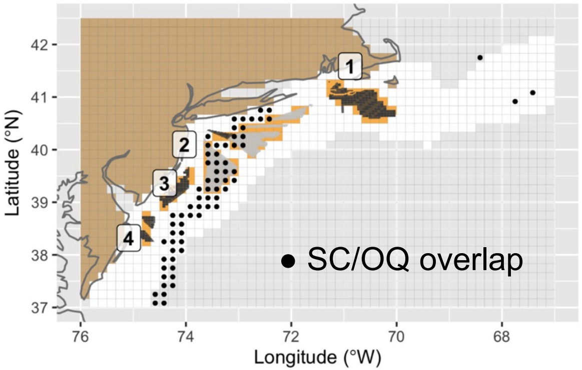
Andrew M. Scheld[1,*], Jennifer Beckensteiner[1,2], Daphne M. Munroe[3], Eric N. Powell[4], Sarah Borsetti[3], Eileen E. Hofmann[5] and John M. Klinck[5]

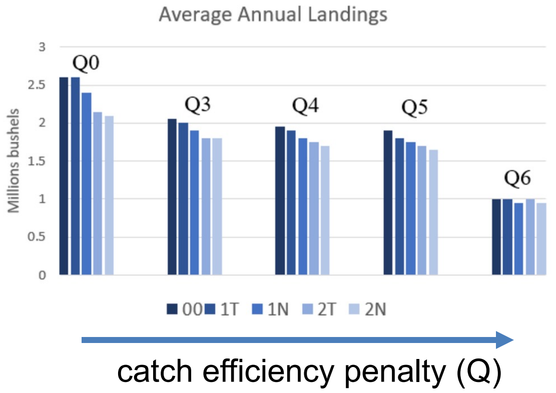

W1T
W1N
W2T
W2N
Latitude
Longitude
42
41
40
39
38
37
-76
-74
-72
-70
-68
Land
Habitat
>300 hour decrease
>100 - 300 hour decrease
>50 - 100 hour decrease
>20 - 50 hour decrease
>0 - 20 hour decrease
No Change
>0 - 20 hour increase
>20 - 50 hour increase
>50 - 100 hour increase
>100 - 300 hour increase

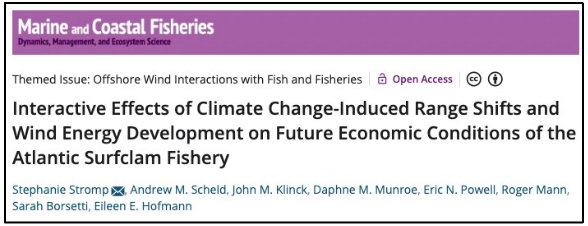

Atlantic City, NJ
New Bedford, MA
Revenues
Millions US$ / Year
25
20
15
10
5
Costs
US$ / Cage
700
600
500
400
W00
W1T
W1N
W2T
W2N

Technical interactions with ocean quahog

- Trips cannot land mixed catch → overlap increasing due to differences in climate response
- Model used to evaluate interactive effects of OQ overlap and effort displacement due to offshore wind development
  - Range of catch efficiency penalties in overlap areas tested
- Impacts of effort displacement amplified under reduced overlap penalties






Marine and Coastal Fisheries
Dynamics, Management, and Ecosystem Science

Themed Issue: Offshore Wind Interactions with Fish and Fisheries | Open Access

Interactive Effects of Climate Change-Induced Range Shifts and Wind Energy Development on Future Economic Conditions of the Atlantic Surfclam Fishery

Stephanie Stromp, Andrew M. Scheld, John M. Klinck, Daphne M. Munroe, Eric N. Powell, Roger Mann, Sarah Borsetti, Eileen E. Hofmann

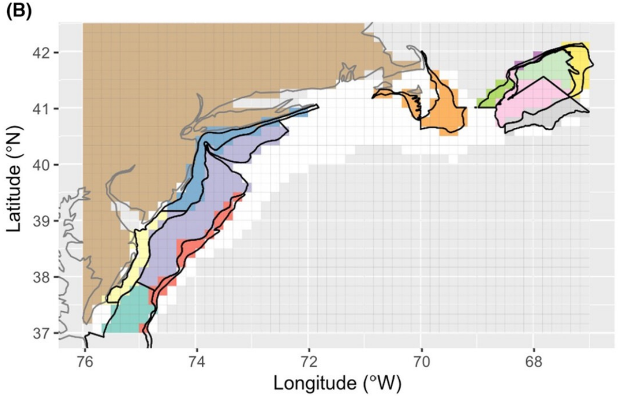
Survey, management implications

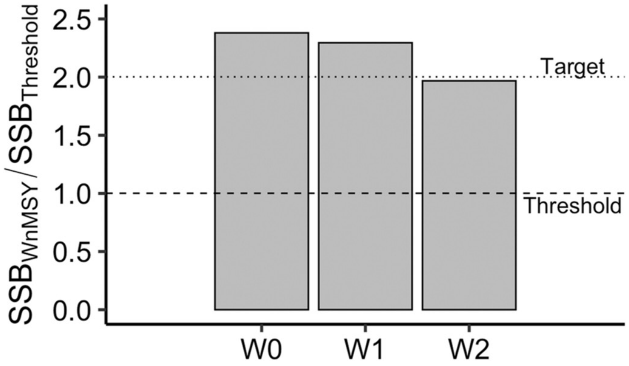
- Offshore wind development will restrict federal survey

- Model used to simulate restricted survey and estimate SSB, F in context of effort displacement

- Small increase in simulated biomass (~1%) due to effort reductions with offshore wind

- SSB estimates decrease 3.5-17.3%, F increases 0.7-7.3% when excluding wind areas






Marine and Coastal Fisheries
Dynamics, Management, and Ecosystem Science

Themed Issue: Offshore Wind Interactions With Fish And Fisheries | Open Access

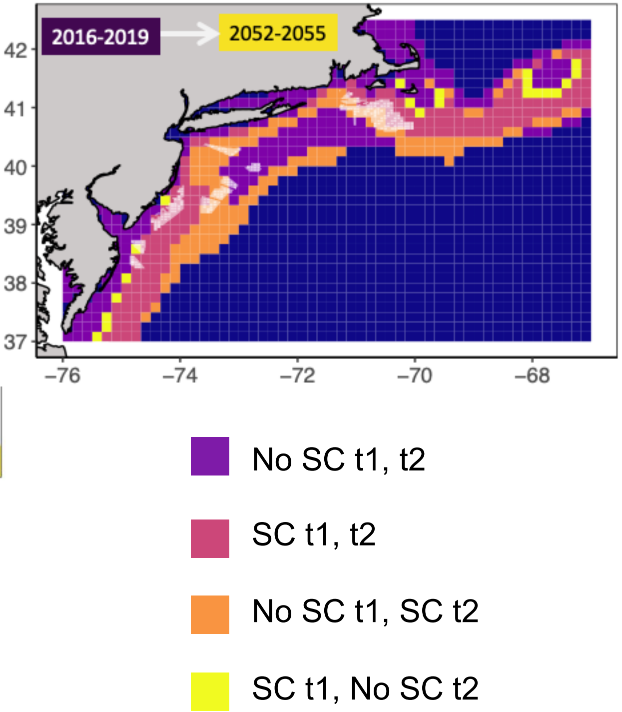
Potential Repercussions of Offshore Wind Energy Development in the Northeast United States for the Atlantic Surfclam Survey and Population Assessment

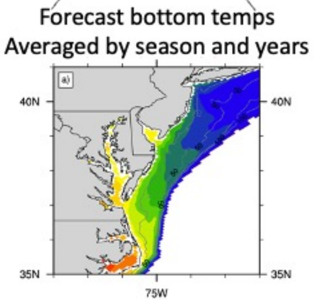
Sarah Borsetti, Daphne M. Munroe, Andrew M. Scheld, Eric N. Powell, John M. Klinck, Eileen E. Hofmann

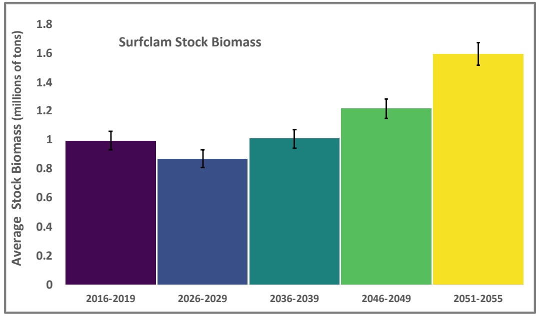
Climate effects

- Warming bottom water temperatures are shifting suitable habitat, e.g., >21ºC reduces feeding, leads to starvation of Atlantic surfclam

- Bottom water temperature forecasts (ROMS output) used to force biological sub-model







Conclusions

- Integrated bioeconomic modeling approach used to assess impacts of changes in ocean use and habitat for economically important shellfish
- Compare simulated output across parameterizations reflecting existing and potential future conditions → highly customizable (data heavy)
- Suite of species and conditions considered expanding; model development and validation is an intensive process

Contact: scheld@vims.edu

Dan Mohr

Thank you –

Funders:

BOEM – Bureau of Ocean Energy Management

NOAA – National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Atlantic Shores offshore wind

SCEMFIS – Science Center for Marine Fisheries

Industry collaborators:

Atlantic Capes Fisheries, Inc.

SeaWatch International

LaMonica – Quality Is a Family Tradition – Since 1923

Surfside Foods Seafood Products, LLC