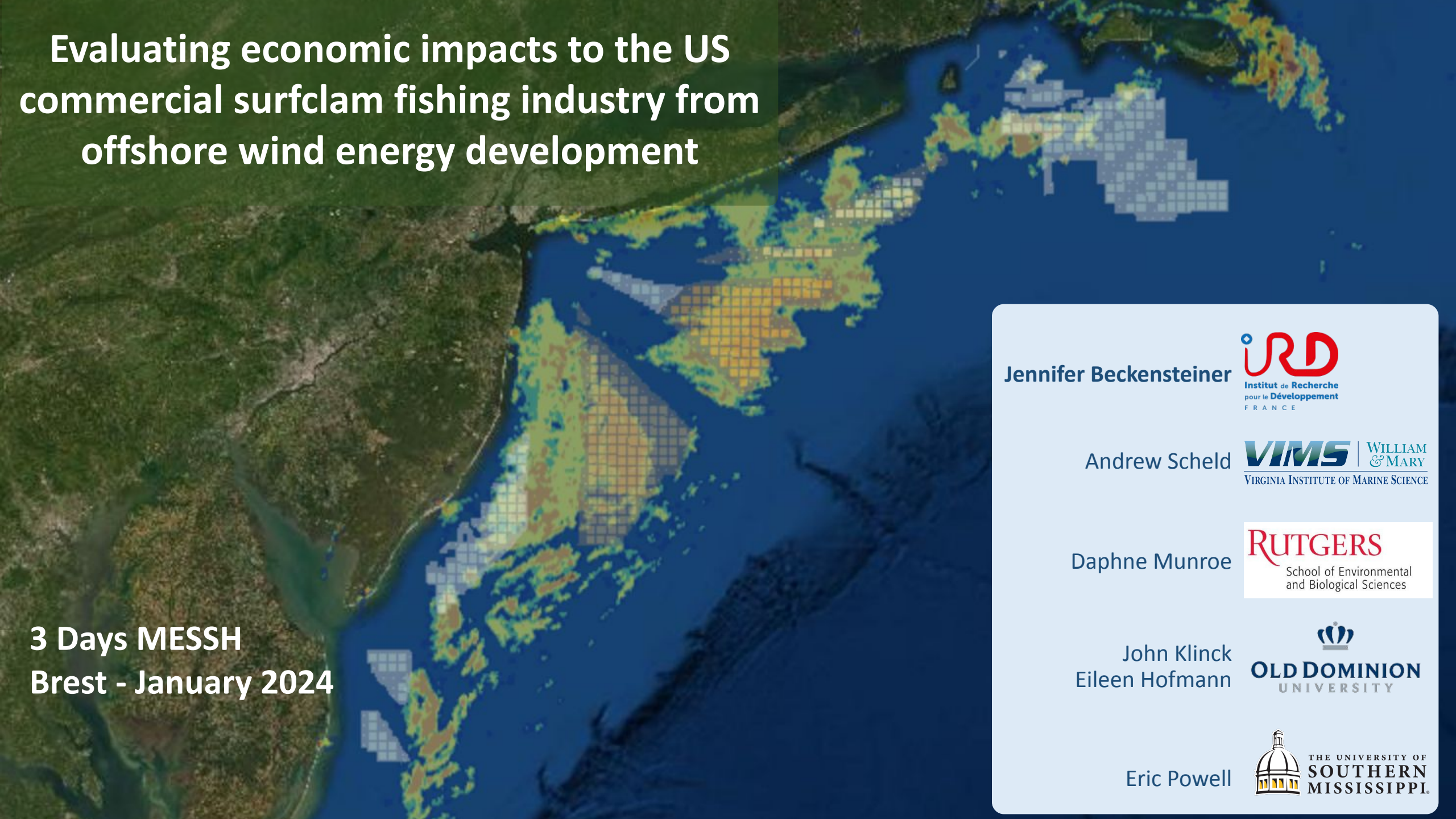
Evaluating economic impacts to the US commercial surfclam fishing industry from offshore wind energy development



3 Days MESSH
Brest - January 2024

Jennifer Beckensteiner — Institut de Recherche pour le Développement FRANCE

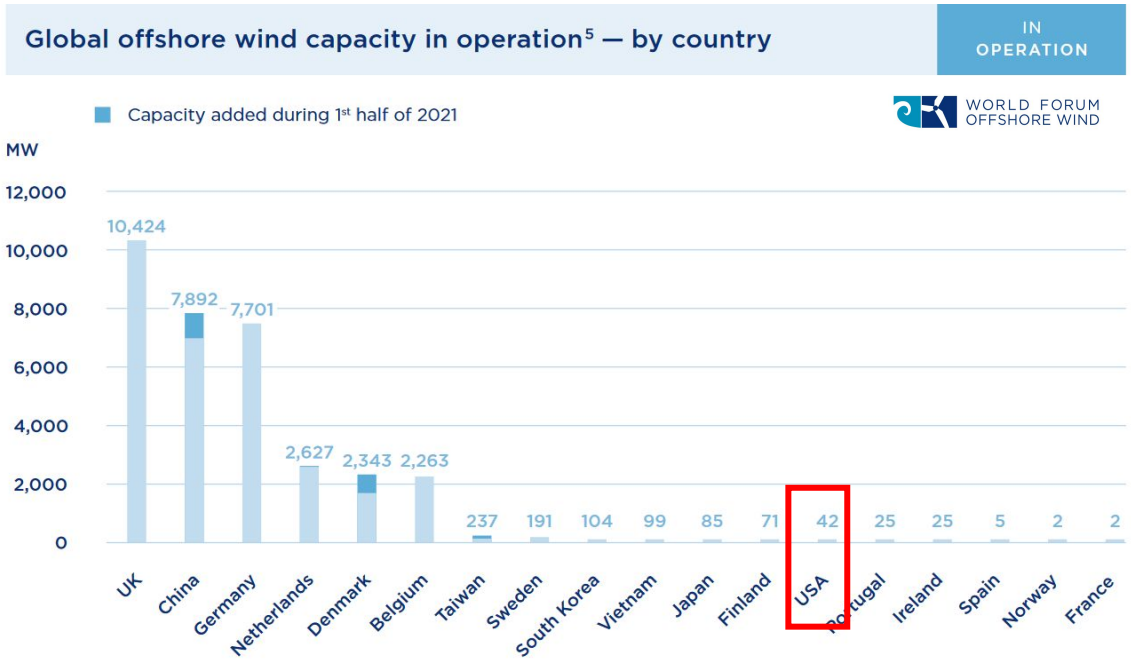
Andrew Scheld — VIMS | William & Mary, Virginia Institute of Marine Science

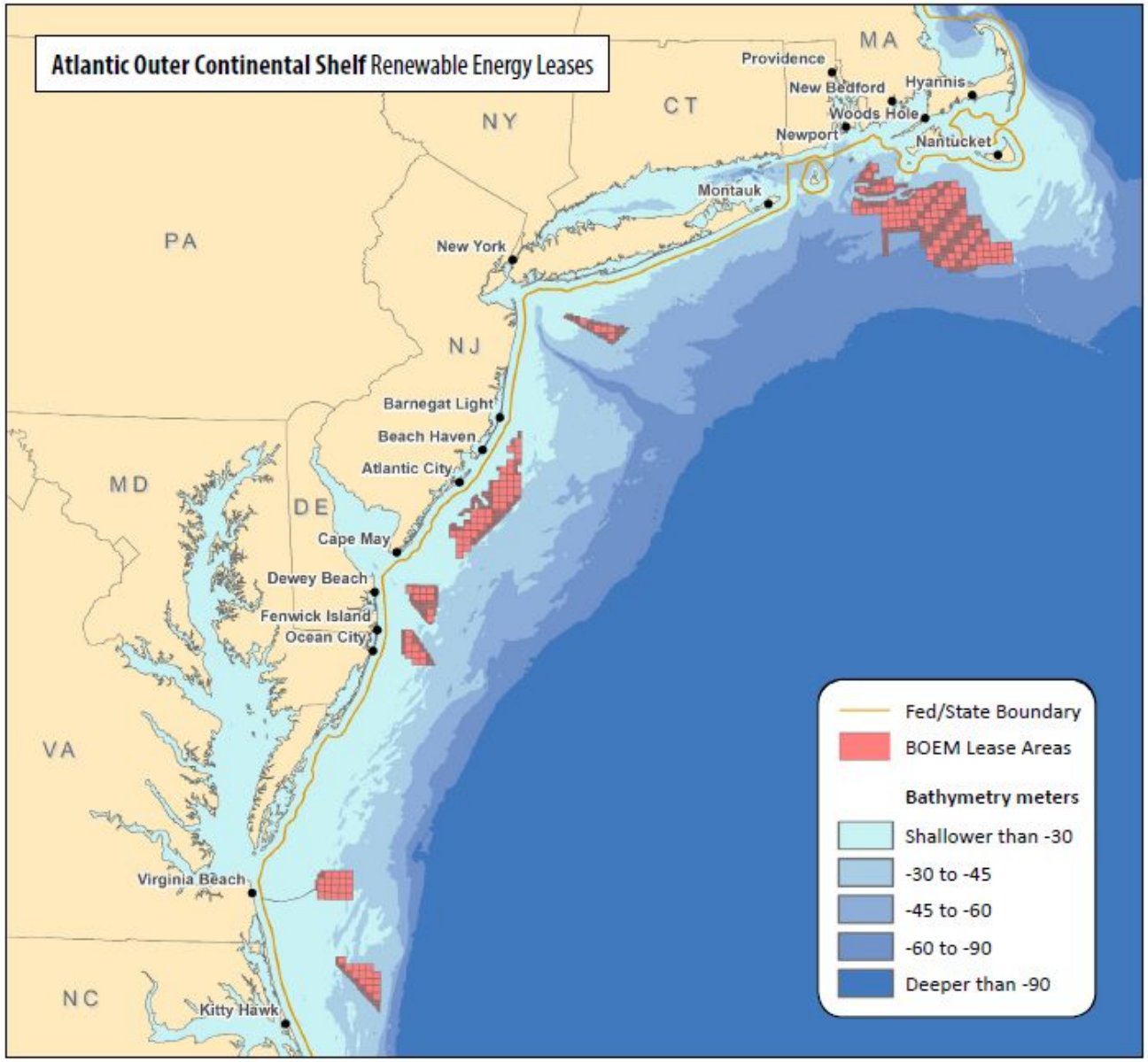
Daphne Munroe — Rutgers, School of Environmental and Biological Sciences

John Klinck
Eileen Hofmann — Old Dominion University

Eric Powell — The University of Southern Mississippi

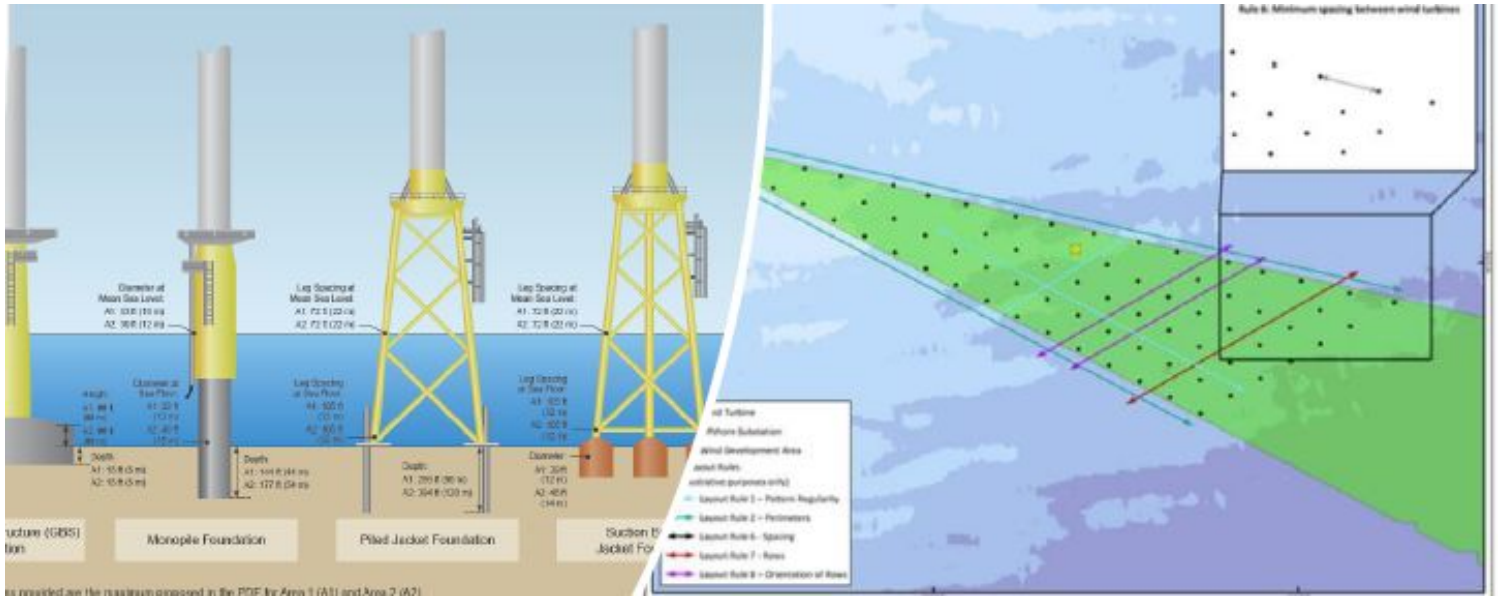
Offshore wind energy development in the US (2021)

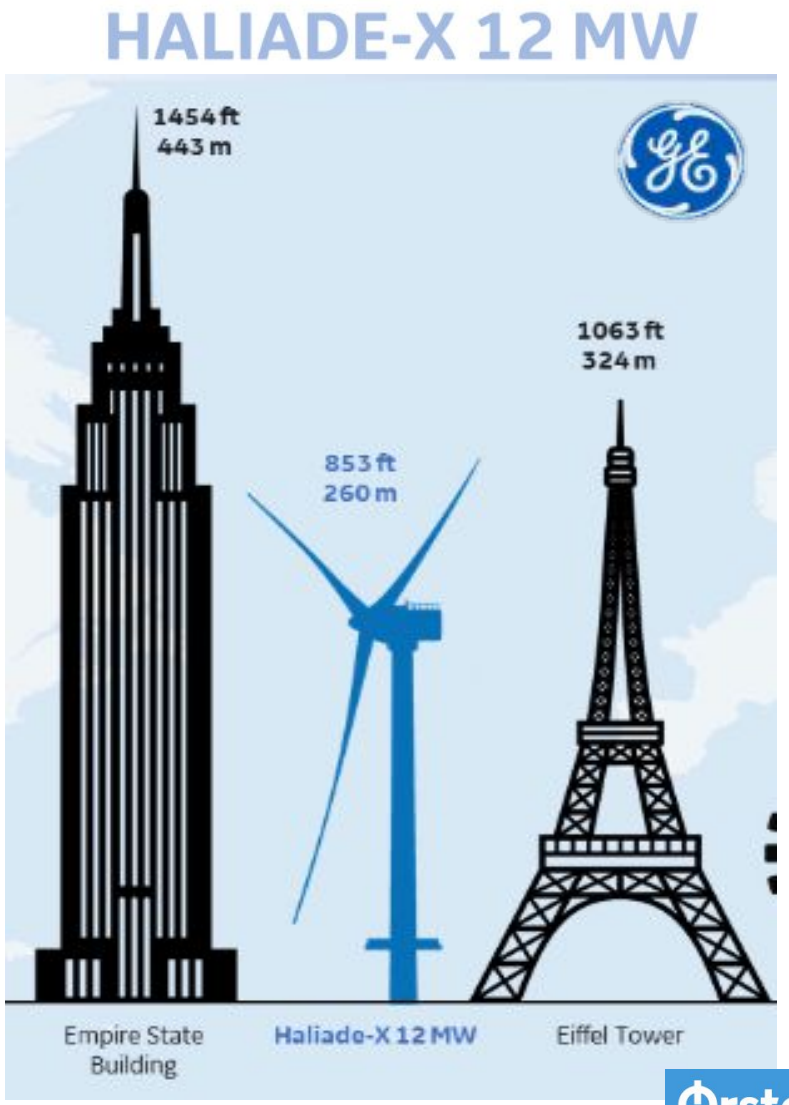




Offshore wind energy development in the US

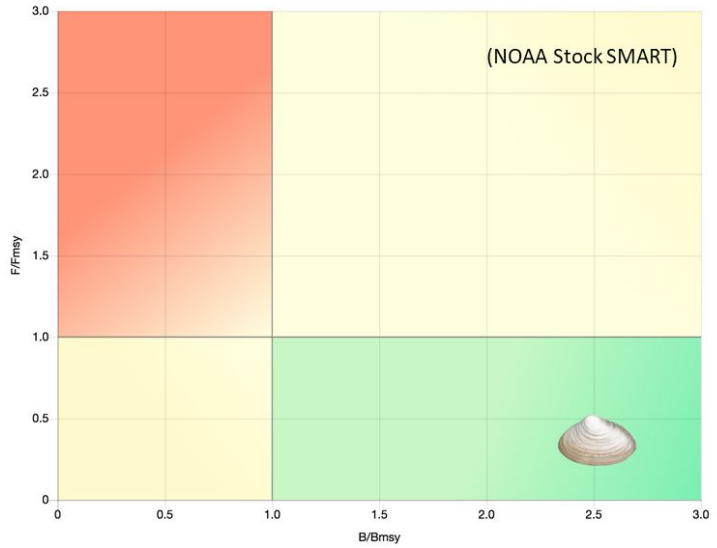
- **12 MW** capacity
- **220**-meter rotor
- **107**-meter long blades
- **260** meters high
- **67 GWh** gross AEP
- **63%** capacity factor
- **38,000** m² swept area
- **Wind Class IEC: IB**



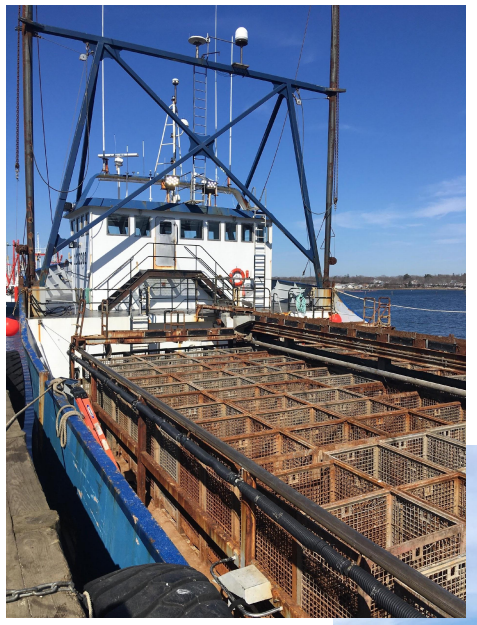


The Atlantic surfclam (*Spisula solidissima)* fishery

- Fishery throughout Mid-Atlantic and to Georges Bank (~ US $30M/year)
- Growth rates affected by temperature → faster in northern areas
  - Stock has shifted north in response to warming waters (Powell et al. 2020)
- Not overfished, overfishing not occurring
- Annual quota set at 3.5M bushels



The Atlantic surfclam (*Spisula solidissima)* industry



- Harvested using **hydraulic dredge**
- Four large **vertically integrated** companies:

Atlantic Capes FISHERIES, INC.

Quality Is a Family Tradition LaMonica SINCE 1923

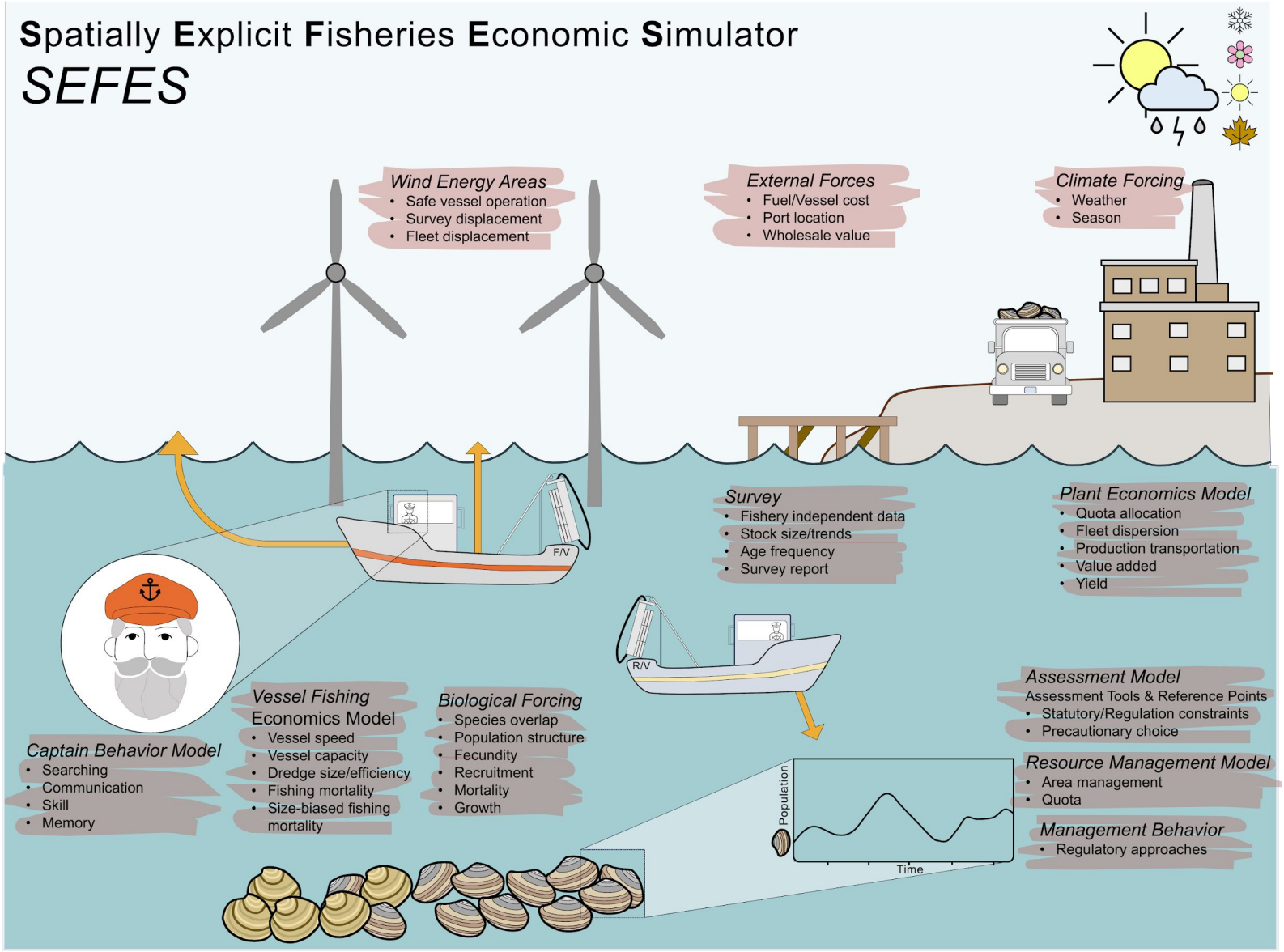
Surfside Foods SEAFOOD PRODUCTS, LLC

SEAWATCH INTERNATIONAL

Nearly all vessels associated with a single processor

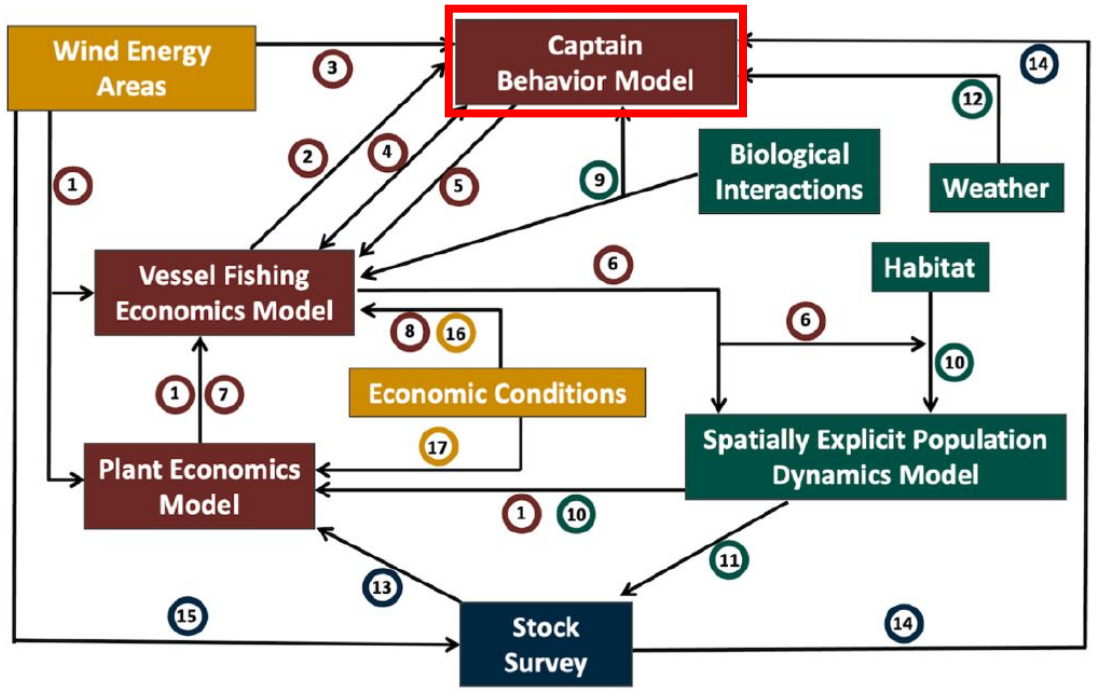
- Variety of product types (fresh, frozen, canned)
  - Clam strips - large seasonal demand
- Identified as among the **most exposed** to offshore wind energy development due to location of harvests, ports, and gear used

SEFES - Spatially Explicit Fisheries Economic Simulator



- Agent-based model
- Spatially explicit
- Variety of interacting submodels (biology, fishery, management, processing)

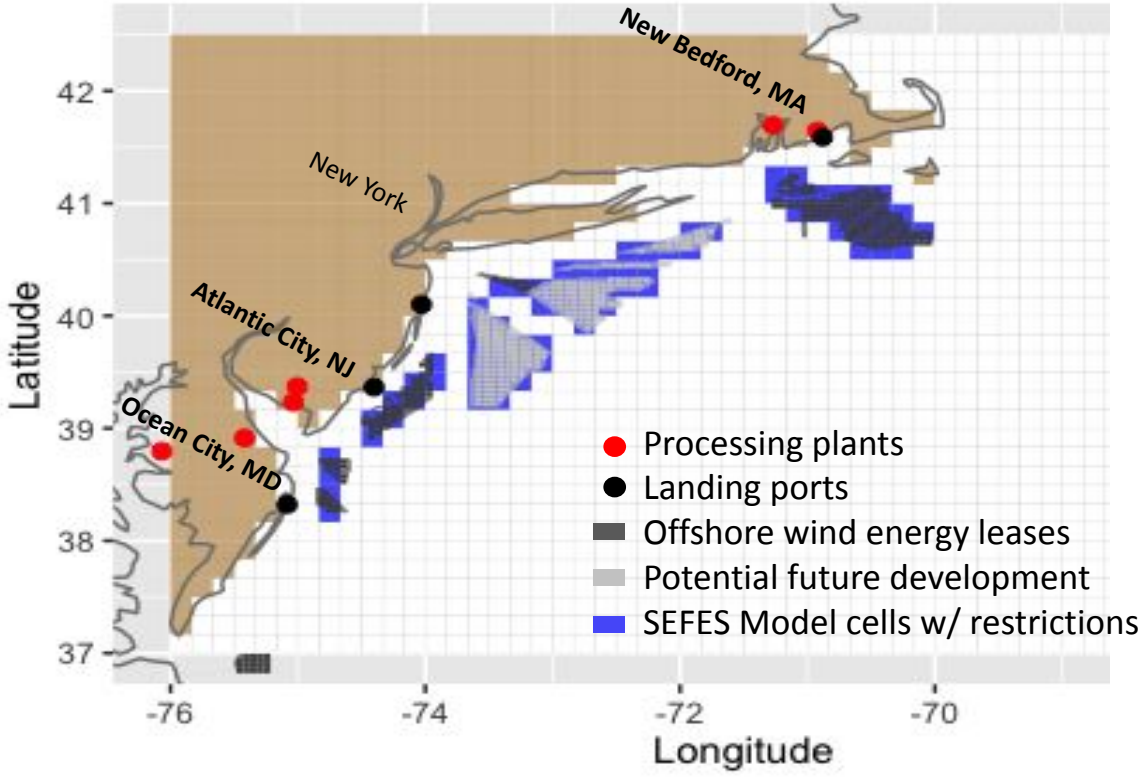
SEFES - Spatially Explicit Fisheries Economic Simulator

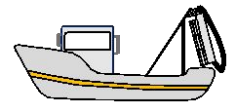
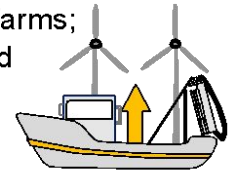
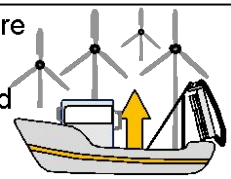
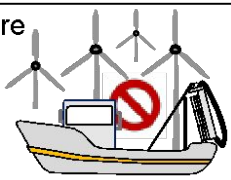


Processes	Components	Property	Source
Fishery			
1	Fleet dispersion	Location and movement	Fishery dependent data & stock assessment
2	Vessel characteristics: speed & capacity, dredge size & efficiency	Speed (knots), capacity (cages), dredge size (length), dredge efficiency (rate of catch)	Industry advice & 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 & fishery dependent data
8	Port location	Location (TMS)	Fishery dependent data & stock assessment
Biological & Environmental			
9	Species overlap	Location (TMS)	Industry advice & unpublished research data
10	Biological processes: recruitment, mortality, growth, yield	Recruitment (clams per m2), mortality (natural mortality rate), growth (shell size over time), yield (mass per size over season)	Industry advice, stock assessment, & unpublished data
11	Population structure	Length frequency and abundance by TMS	Stock assessment
12	Wind & temperature	Wind (miles per hour), temperature (°C)	Meteorological & airport records
Management			
13	Quota, stock trends, & fishery independent data	Quota (bushels), trends (abundance and 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 & published prices
17	Wholesale value	Prices by product type	Industry advice

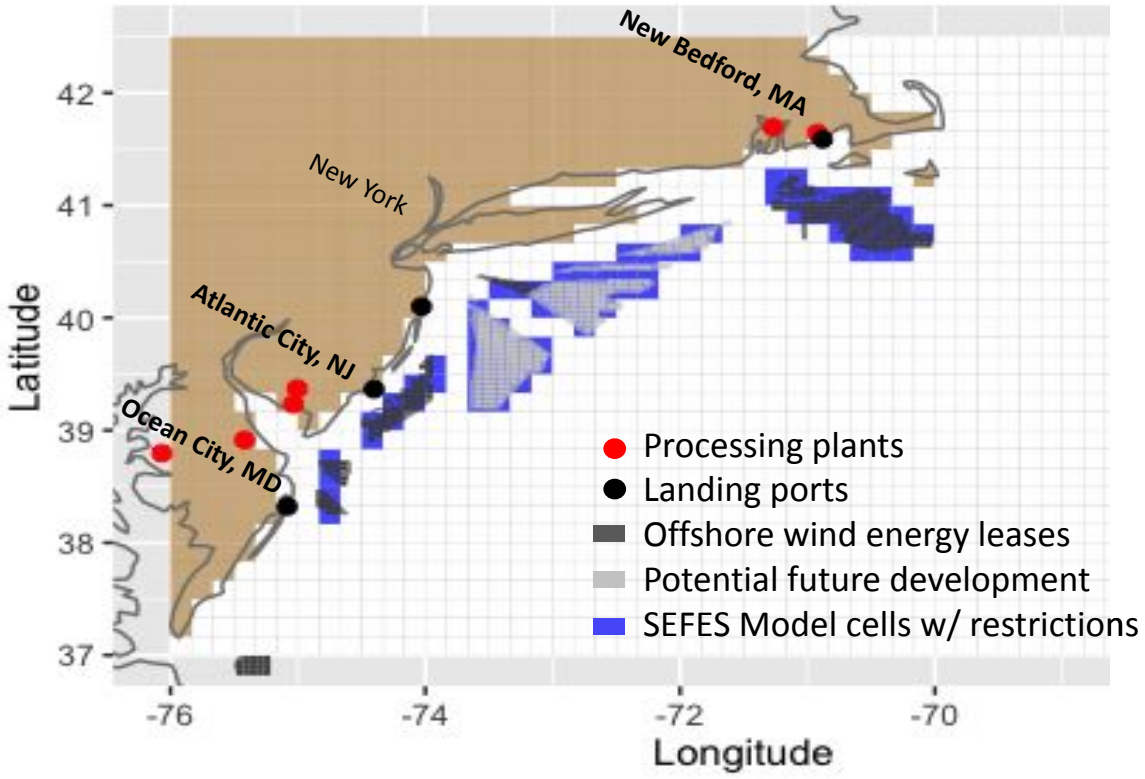
Decision rule: captain chooses where to fish such that this grid cell minimizes time at sea, based on expected catch rates informed by memory log & inbound travel time

Wind energy 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

Expected economic impacts of offshore wind



- Changes in vessel behavior (trips, fishing locations, transit routes)
  - Will depend on wind energy area restrictions and captain preferences
  - Evaluate changes in landings (revenues) and fuel use, trip taking (costs)
- Changes in product landing locations and/or times
  - Could affect product delivery to plants, processing, inventory
  - Evaluate potential changes in processor revenue, freight costs

Fishery data

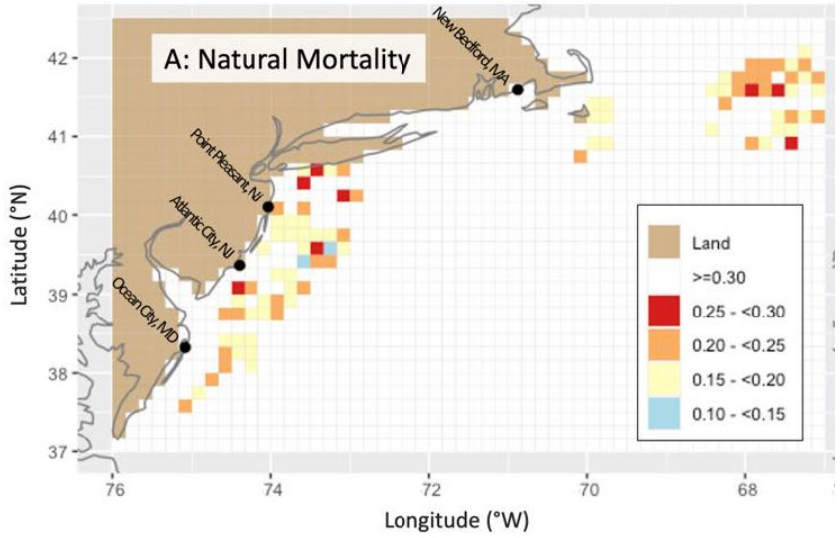
- Project industry advisory board includes representatives from 4 processing companies
  - Provide data on vessels and processing facilities
  - Facilitate conversations with captains

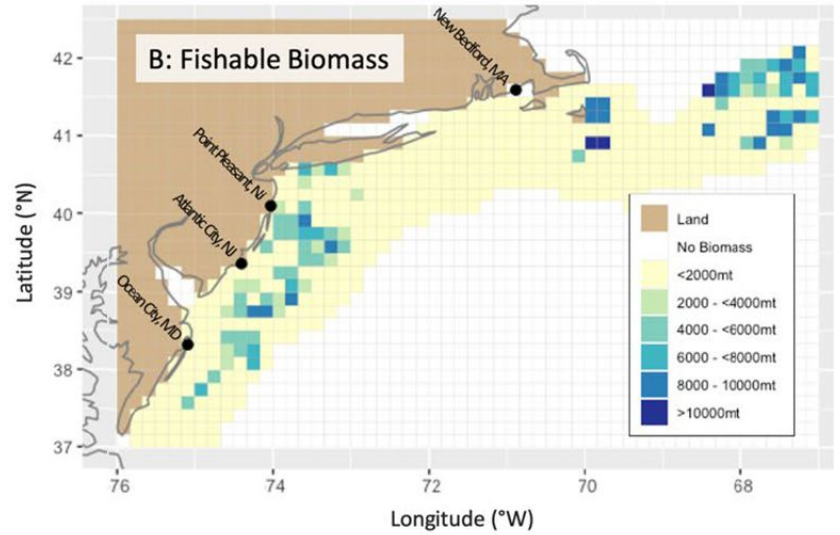
- Vessel and dealer/processor surfclam reports (CLOG-V and CLOG-D) from 2015 to 2020 requested from NOAA-Fisheries
  - **CLOG-V:** Vessel | Catch Date | Latitude | Longitude | Time at Sea| Time Fishing | Dealer | Bushels
  - **CLOG-D:** Vessel | Purchase Date | **Dealer** | Bushels

- Data used to parameterize and validate simulation model

Model parameterization

- Stock biology → spatially variable rates of growth, recruitment, and mortality
  - Based on NMFS assessment data
- Vessels → home port, catch capacity, fuel use, dredge width, max trip length, proportion of annual trips for surfclams (vs. ocean quahogs)
  - 33 boats simulated to <u>represent existing fleet</u>
  - Data obtained from Industry and management advisors, captain interviews





Economic sub-models - FLEET

- Landings revenues for vessel *i* at time *t* :

***SEFES output**

$$R_{it} = \boldsymbol{Cages_{it}} \times CagePrice$$

- Operational costs for vessel *i* at time *t* :

$$TC_{it} = C_{it}^{share} + C_{it}^{fuel} + C_{it}^{maint} + C_{it}^{insur} + C_{it}^{quota} \rightarrow \text{Total costs}$$

$$C_{it}^{share} = \boldsymbol{R_{it}} \times 0.30 \rightarrow \text{Captain and crew share}$$

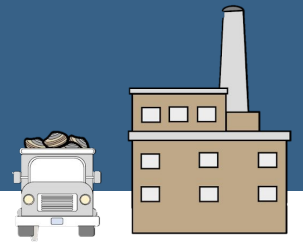
$$C_{it}^{fuel} = FuelPrice_p \times \left(\boldsymbol{Hr_{it}^{steam}} \times FuelSteam_i + \boldsymbol{Hr_{it}^{fish}} \times FuelFish_i\right) \rightarrow \text{Fuel costs}$$

$$C_{it}^{maint} = MjrMnt_t \times TSurf_i + RegMnt_i \times \boldsymbol{NTrip_{it}} \rightarrow \text{Vessel and gear maintenance costs}$$

$$C_{it}^{insur} = (HulIns_{it} + PIIns_t \times NCrew_i + OtherIns_t) \times TSurf_i \rightarrow \text{Insurance costs}$$

$$C_{it}^{quota} = \boldsymbol{Cages_{it}} \times QuotaRentalPrice \rightarrow \text{Quota cost}$$

Economic sub-models - PROCESSORS



- Revenues for processing company *c* at time *t* :

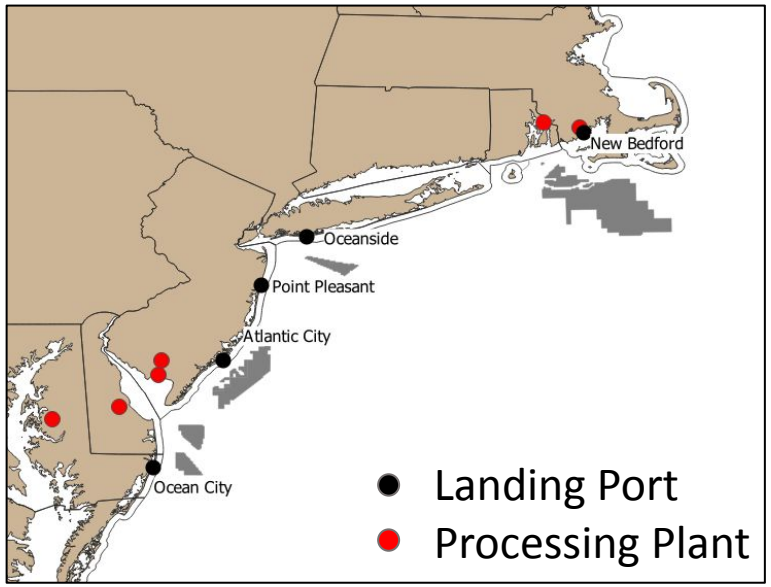
***SEFES output**

$$R_{ct}^{proc} = \sum_j \sum_{i \in c} \boldsymbol{Weight_{it}} \times (1 - MeatLoss) \times ProductFrac_{cj} \times WhsPrice_j$$

- Transportation costs for processing company *c* at time *t* :

$$C_{ct}^{trans} = \sum_{i' \in c} \boldsymbol{Cages_{i't}} \times DistancePortPlant_{pc} \times FreightRate$$

Port location	Vessels (number)	Processors (number)	Fuel price (USD l^{-1})	Processing distance (km)
New Bedford, MA	11	2	0.81	335
Point Pleasant, NJ	2	1	0.85	167
Atlantic City, NJ	18	3	0.85	129
Ocean City, MD	2	1	0.85	266

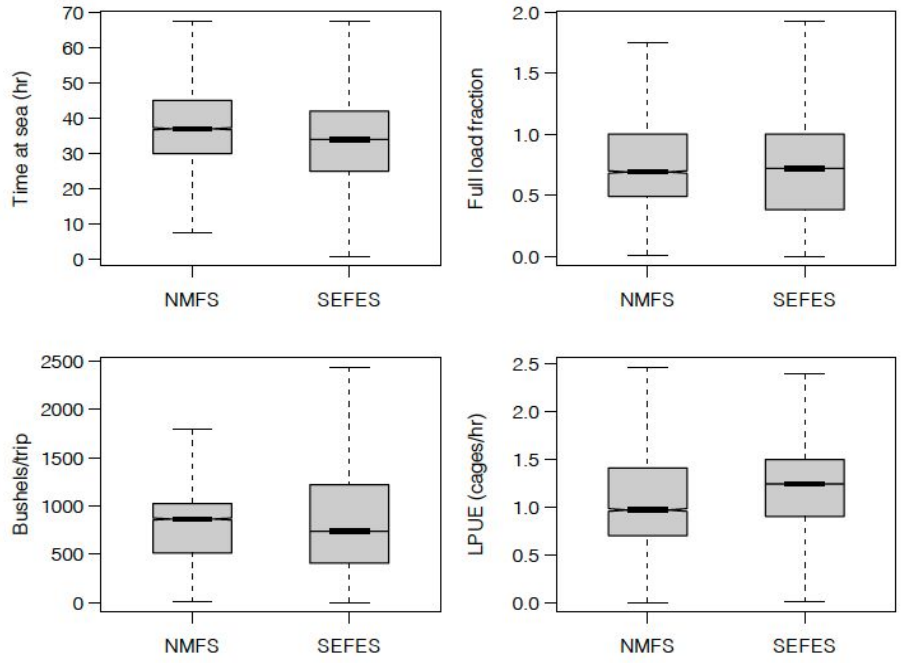


Model validation

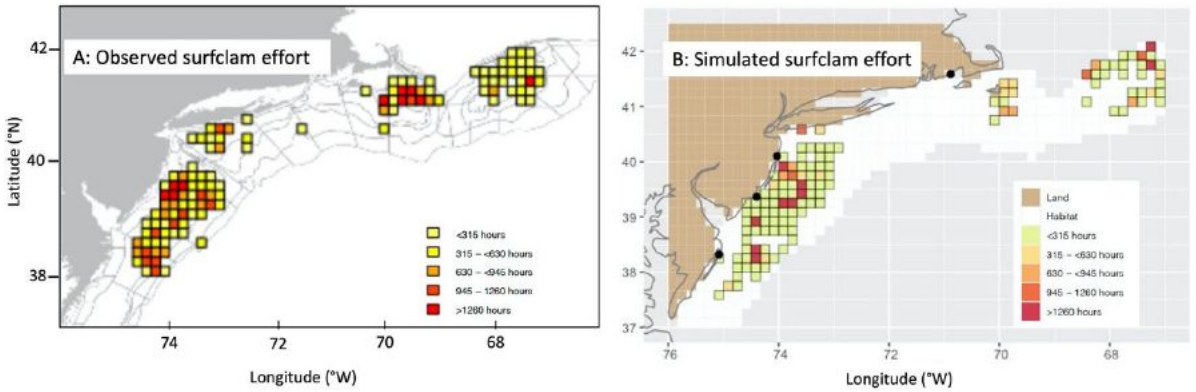
Simulated fisheries Key fishery validation metrics from logbook data:

- **Total annual catch**
- **Landings per unit effort** (LPUE; cages/hour) → primary productivity measure; location dependent
- **Time at sea** → critical due to spoilage / meat quality; constrains effort
- **Full load frequency** → often <100% due to weather and time constraints
- **Spatial distribution of fishing effort**

Compared key fishery metrics

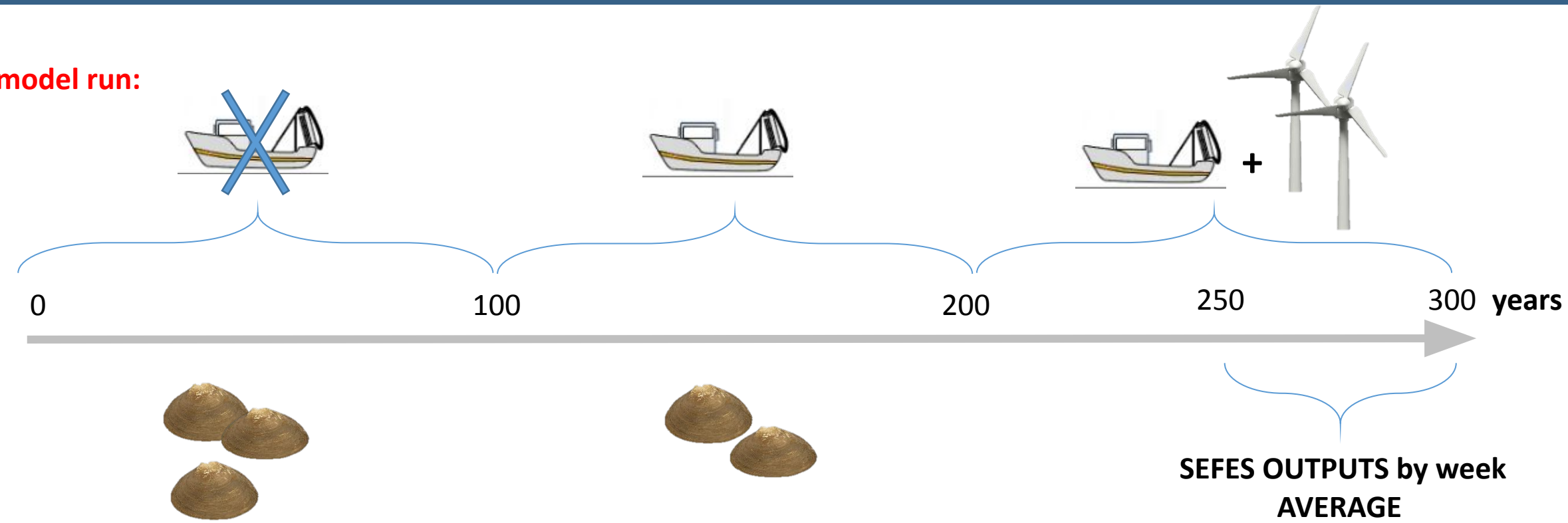


Stock Assessment data NMFS **SEFES**



Model runs

1 model run:

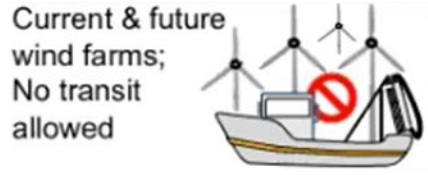


For each scenario of windfarms:
12 captains types, randomly assigned to 33 vessels
- regional search on 0%, 5%, 10% of trips
- memory weight of 20%, 90%, 98% or 99%

200 model runs

= 17,160,000 weekly vessel-level observations
- aggregated to 330,000 annual vessel-level observations
- aggregated to **10,000 annual fleet-level observations**

Results – Changes in fishing activity



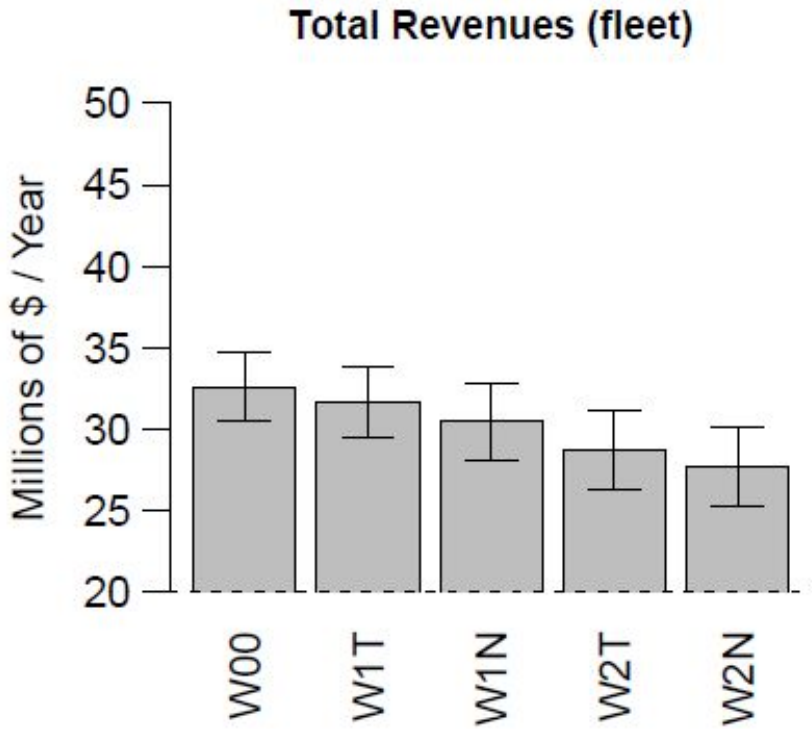
	W00	W1T	W1N	W2T	W2N
Average LPUE	1.51 cage/h	1.63 %	3.46 %	-1.87 %	-0.29 %
Average Time at Sea	**41.63 h/trip**	**1.25 %**	**8.60 %**	**5.19 %**	**12.68 %**
Average Time Fishing	25.12 h/trip	-0.47 %	-2.47 %	1.51 %	*-0.09 %**
Total Trips	**1870.21**	**-3.96 %**	**-7.42 %**	**-11.61 %**	**-14.57 %**

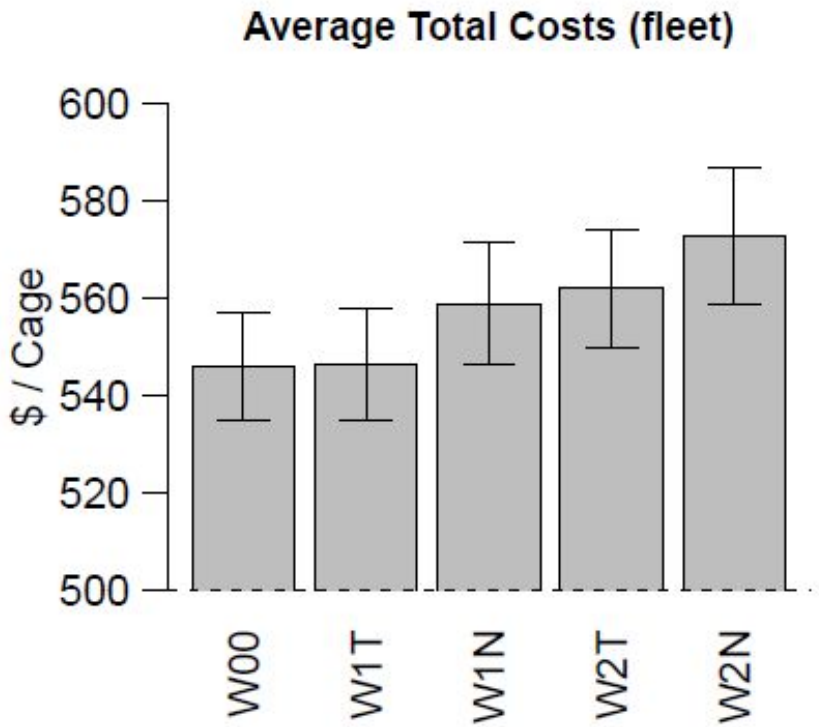
*Non-significantly different from status quo according to Welch's two-sample t-test

Avg time at sea ↗ from +1.3% to +13%

Number of trips ↘ from -4% to -15%

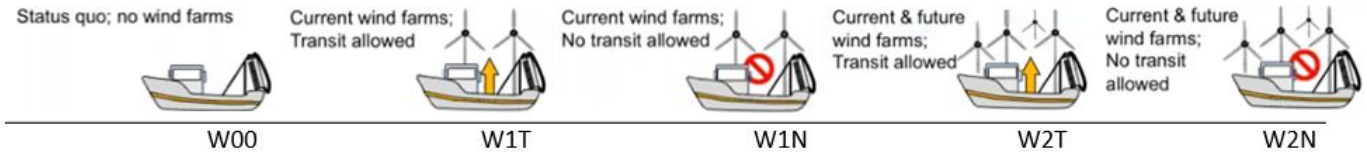
Results – Economic impacts



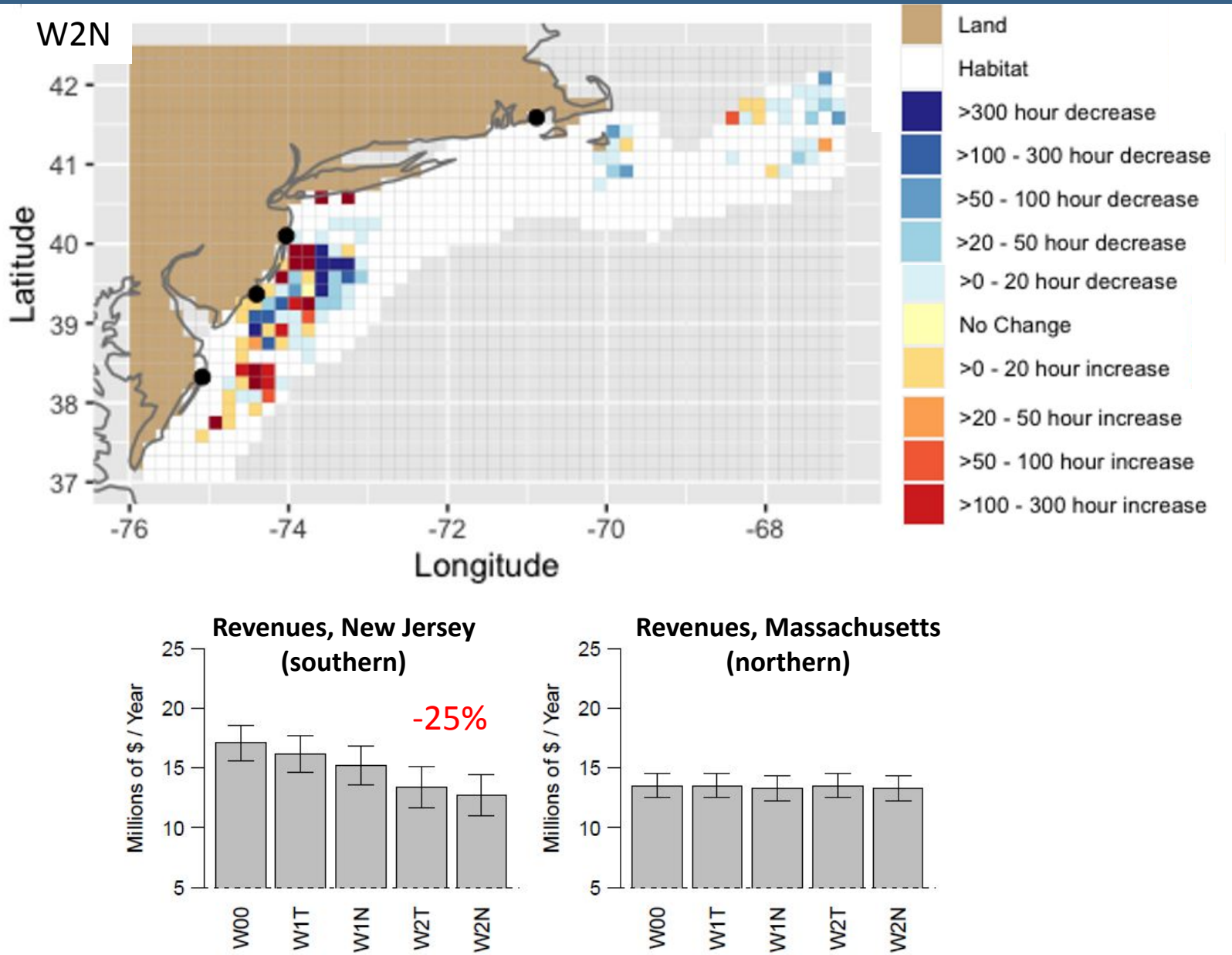


 Decrease in fishing activity leads to decrease in revenues ~-3 to -15%

Effort displacement increases fuel costs ~0-10%



Results – Economic impacts



- Spatial shift in fishing effort (to southern, inshore waters)
- Impacts spatially heterogeneous across fleet
- Average transportation costs increased as more product was landed in New Bedford (MA) following greater changes in fishing activity for the southern fleet.

Conclusions

- Fishing sector impacts depend on wind energy location, scale, and changes in vessel operation

- Southern surfclam fleet has greatest impacts
    - Other fisheries potentially more problematic in northern areas (scallop, ocean quahog)

- Impacts extended beyond fishing fleet to processing sector (other shore-based support industries)

Dan Mohr

Conclusions

Thank you -

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Original Article

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

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

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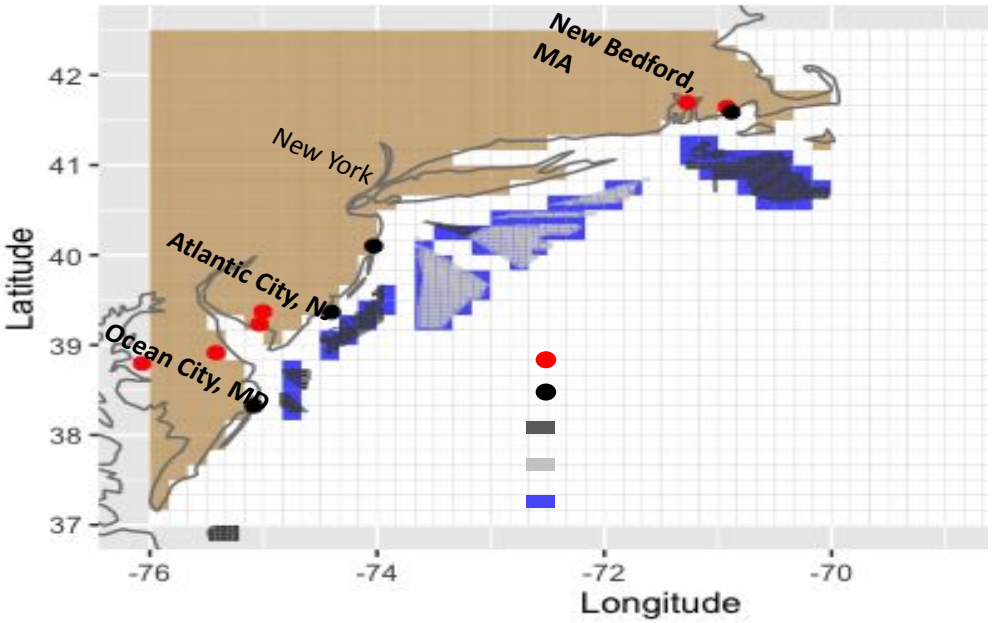
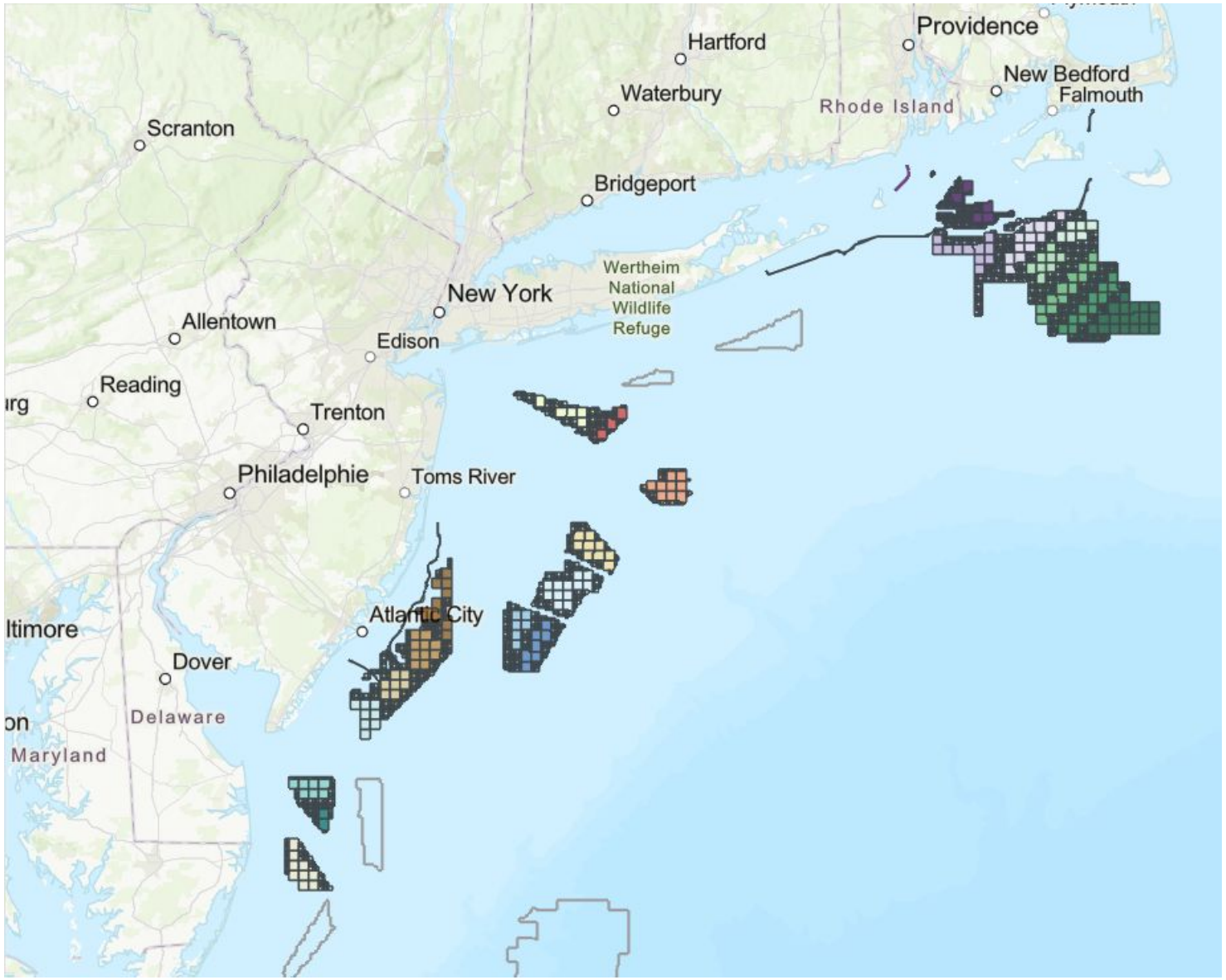
Offshore wind energy lease and anticipated areas as Dec. 2023





Several characteristics of captains are used in these simulations.

- **Use of survey** = Captains may (or may not) use the annual survey to improve their knowledge of the location of the stock. In the current simulations, the captains can access a survey every third year (if they use the survey at all).

- **Memory** = Captains have different weight put on old information as they fish. This controls how long they retain information from fishing or from the survey. The procedure is after a fishing trip, a captain updates his catch rate for the square that was just fished with F*old rate + (1 - F)* new rate. F ranges from 0.2 to 0.99.

- **Searching** = Captains may fish adjacent to their main fishing location which allows them to gain information about the stock in nearby 10 min squares. A frequency is specified (typically 0.0 or 0.8) for searching or not. Captains may choose to search on any given fishing trip. Rather than going to a known location, the captain chooses a random square within 6 hr steaming of the port to go fishing. A frequency for searching is specified (typically 0.0 or 0.1).

- **Communication** = Captains may communicate about fishing catch with each other at some frequency. The effect of this communication is for a captain to update the catch history based on the catch history of the other captain. A special communication table is specified so that boats from the same company communicate catch data frequently, while boats at the same port from different companies communicate less frequently and boats at different ports from different companies communicate least frequently. Some of the "communication" is spying of captains on each other.

Economic Submodels - FLEET

- Landings revenues for vessel *i* at time *t* were calculated as:

$$R_{it} = \boldsymbol{Cages_{it}} \times BushelPerCage \times BushelPrice$$

$14.34/bu (2019 $, ex-vessel price)

32 bushels into 1.7 m^3 cage

- Costs for vessel *i* at time *t* were calculated as:

7% x 3 crew members + 9% for the captain

$$C_{it}^{share} = \boldsymbol{R_{it}} \times 0.30$$

$0.81/L in MA, otherwise $0.85/L

$$C_{it}^{fuel} = FuelPrice_p \times \left(\boldsymbol{Hr_{it}^{steam}} \times FuelSteam_i + \boldsymbol{Hr_{it}^{fish}} \times FuelFish_i\right)$$

$150,000 every 2,5 yrs /vessel

$5,000/trip for jumbo vessels, otherwise $3,000/trip

$$C_{it}^{maint} = MjrMnt_t \times TSurf_i + RegMnt_i \times \boldsymbol{NTrip_{it}}$$

$10,000/yr (small), $20,000/yr (medium + large), $60,000/yr (jumbo)

$$C_{it}^{insur} = (HulIns_{it} + PIIns_t \times NCrew_i + OtherIns_t) \times TSurf_i$$

$5,000/crew

$10,000/yr

$$C_{it}^{quota} = \boldsymbol{Cages_{it}} \times QuotaRentalPrice$$

$3/bu

The Fleet

Table 1: Vessel characteristics by category of the simulated fishing fleet.

Vessel Category	Hull Length (feet)	Number of Vessels	Average Cage Capacity	Average Vessel Steaming Speed (knots)	Average Dredge Width (m)	Wind Conditions Preventing Fishing (knots)
Small	≦79	11	31	8.7	2.3	>10
Medium	80 – 94	10	54	9.0	3.3	>15
Large	95 – 110	8	66	9.5	3.7	>15
Jumbo	>110	4	140	10	4.6	>20

Table 2: Fishing vessel economic characteristics by category*.

Vessel Category	Crew Size (number)	Fuel Steam (L hr^{-1})	Fuel Fish (L hr^{-1})	Targeted Trips (%)
Small	3.55	86.38	132.15	100.00
	0.52	*39.22*	*61.13*	*0.00*
Medium	3.60	138.92	190.41	86.00
	0.52	*42.62*	*41.34*	*30.00*
Large	4.25	198.28	287.69	71.00
	0.46	*49.44*	*98.23*	*41.00*
Jumbo	4.75	266.87	300.94	75.00
	0.50	*55.42*	*57.77*	*29.00*

* Shown as mean values and standard deviations (italics)

Economic Submodels - PROCESSORS

- Processor revenues for processor *c* at time *t* were calculated as:

$$R_{ct}^{proc} = \sum_j \sum_{i \in c} \boldsymbol{Weight_{it}} \times (1 - MeatLoss) \times ProductFrac_{cj} \times WhsPrice_j$$

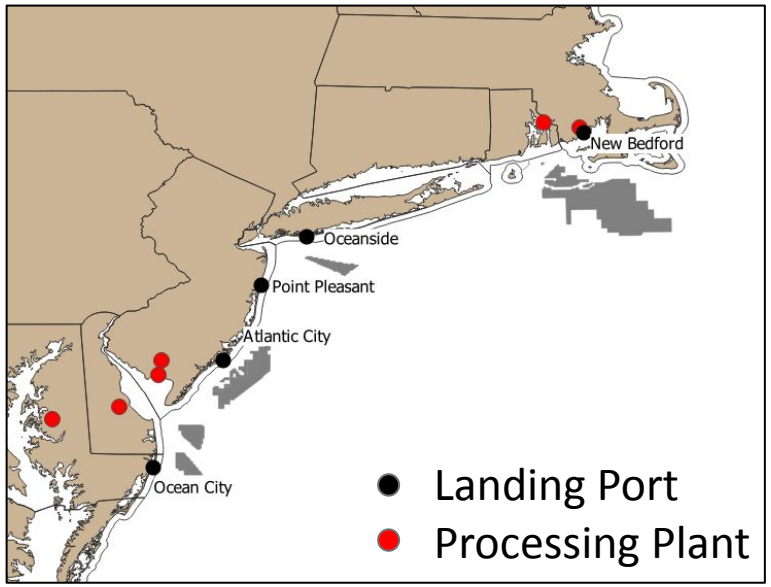
15%

Wholesale fixed price of $9.92/kg

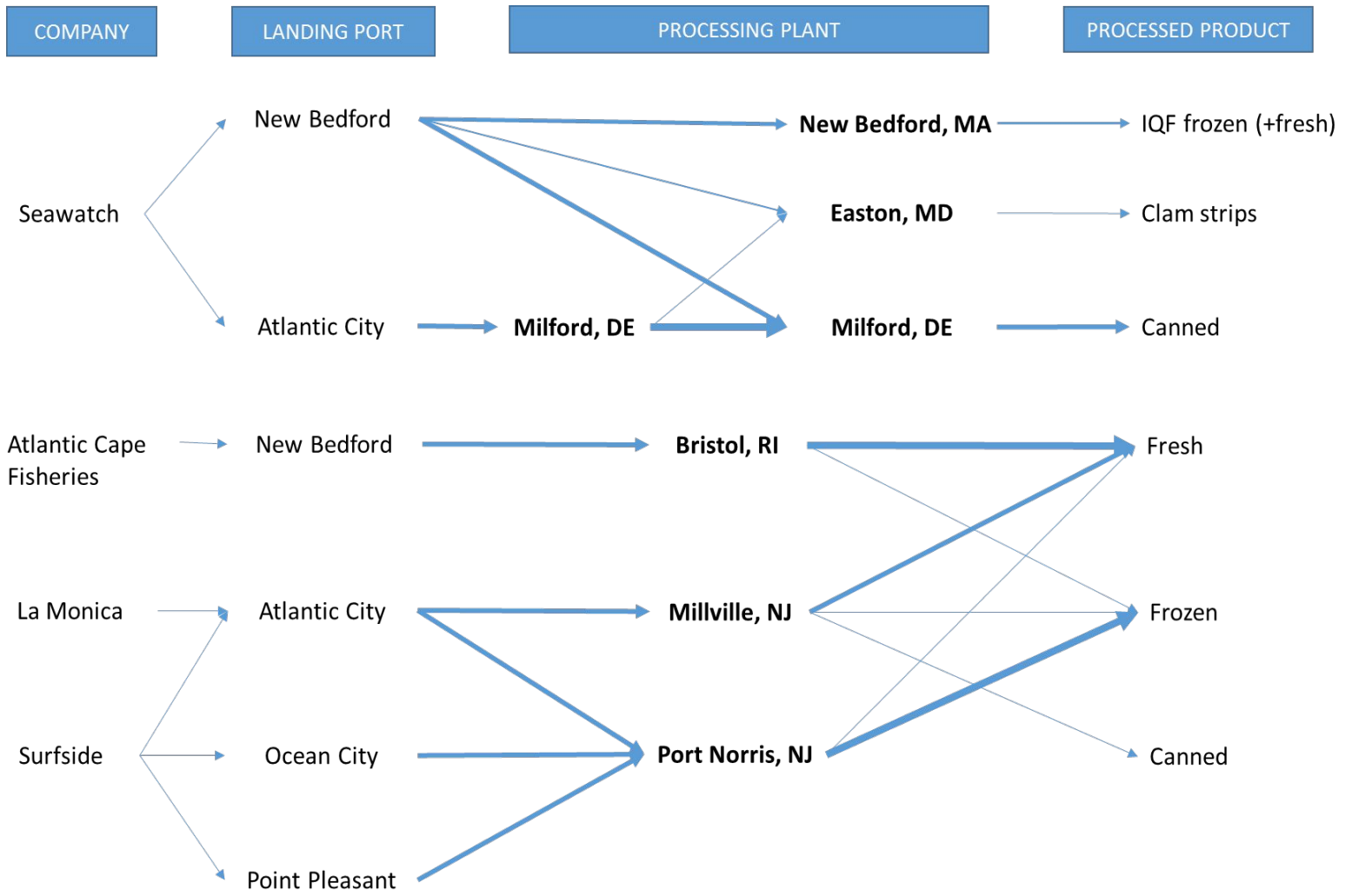
- Transportation costs for company *c* at time *t* were calculated as:

$$C_{ct}^{trans} = \sum_{i' \in c} \boldsymbol{Cages_{i't}} \times DistancePortPlant_{pc} \times FreightRate$$

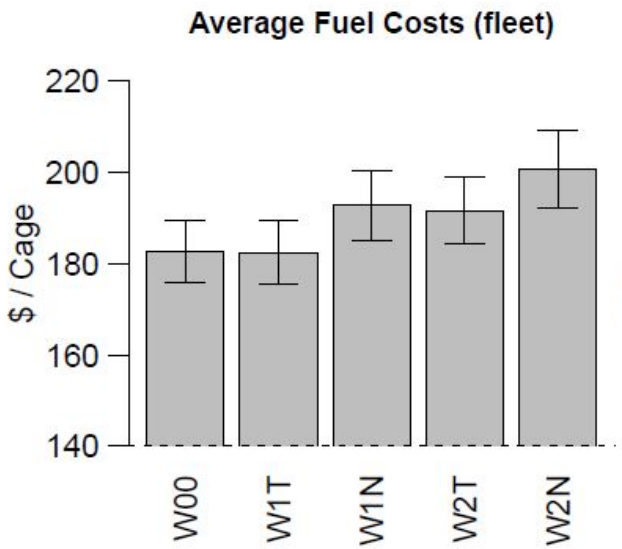
$1.10/km for a truck with 14 cages ($0,08/km/cage)

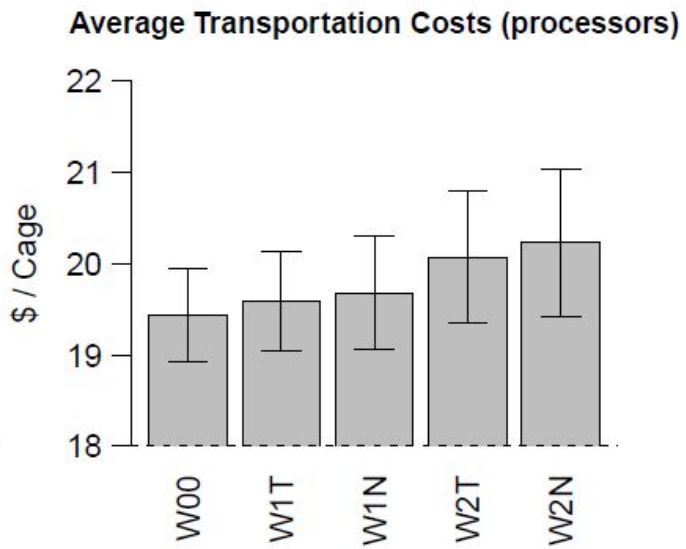


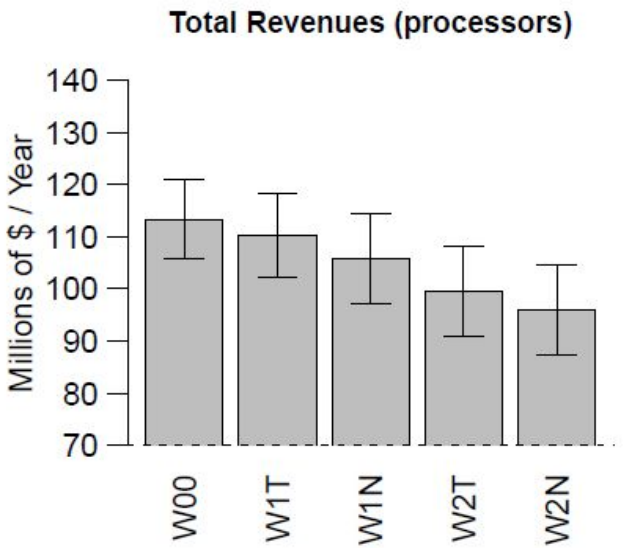
Characteristics of the four main surfclam processing companies



Results


Average Fuel Costs (fleet)
$ / Cage
220
200
180
160
140
W00
W1T
W1N
W2T
W2N


Average Transportation Costs (processors)
$ / Cage
22
21
20
19
18
W00
W1T
W1N
W2T
W2N


Total Revenues (processors)
Millions of $ / Year
140
130
120
110
100
90
80
70
W00
W1T
W1N
W2T
W2N

Interactive Effects of Climate Change-Induced Range Shifts and Wind Energy Development

Stromp et al. 2023

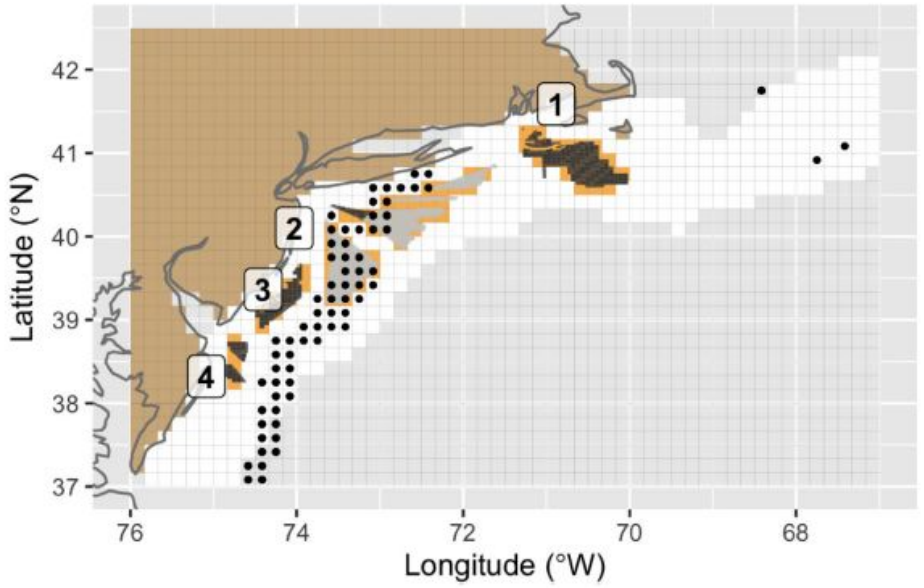


FIGURE 2. Map of the Spatially Explicit Fishery Economics Simulator model domain, showing 10-min (10′) squares with ocean quahogs (black dots), wind farm leases (dark gray), potential future wind farm leases (light gray), and grid cells around leases with restricted fishing and transit (orange). Landing ports for Atlantic surfclam fishing vessels are indicated: (1) New Bedford, Massachusetts; (2) Point Pleasant, New Jersey; (3) Atlantic City, New Jersey; and (4) Ocean City, Maryland. Figure is

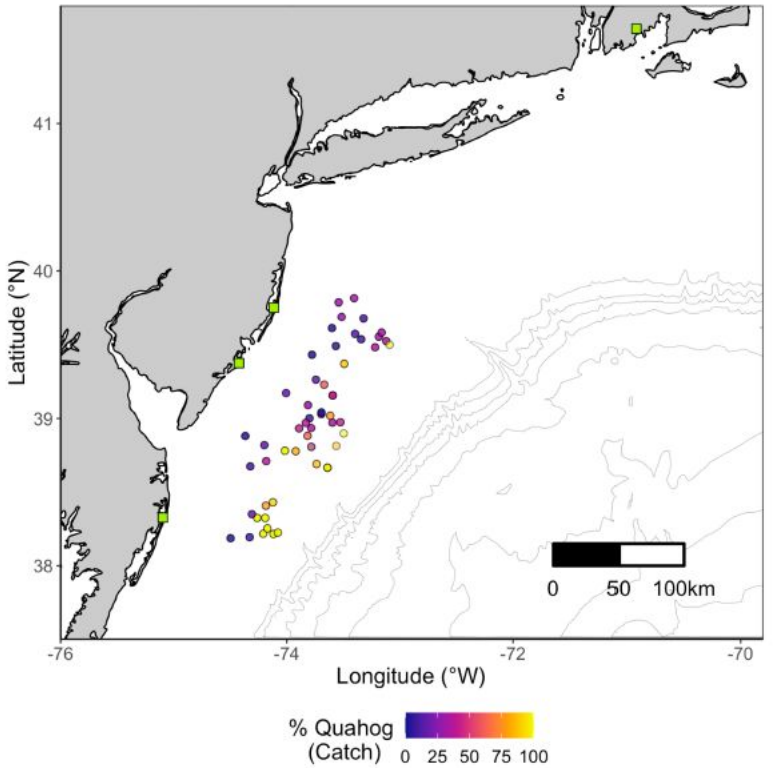


FIGURE 3. Atlantic surfclam and ocean quahog overlap from off northern Delmarva to Hudson Canyon as of September 2021. Dark-blue circles indicate locations of 100% Atlantic surfclam catch; yellow circles indicate locations of 100% ocean quahog catch. Intermediate colors on the gradient show regions in which the catch is a mix of both species. Landing ports for Atlantic surfclam fishing vessels are represented by green squares (from north to south): New Bedford, Massachusetts; Point Pleasant, New Jersey; Atlantic City, New Jersey; and Ocean City, Maryland.