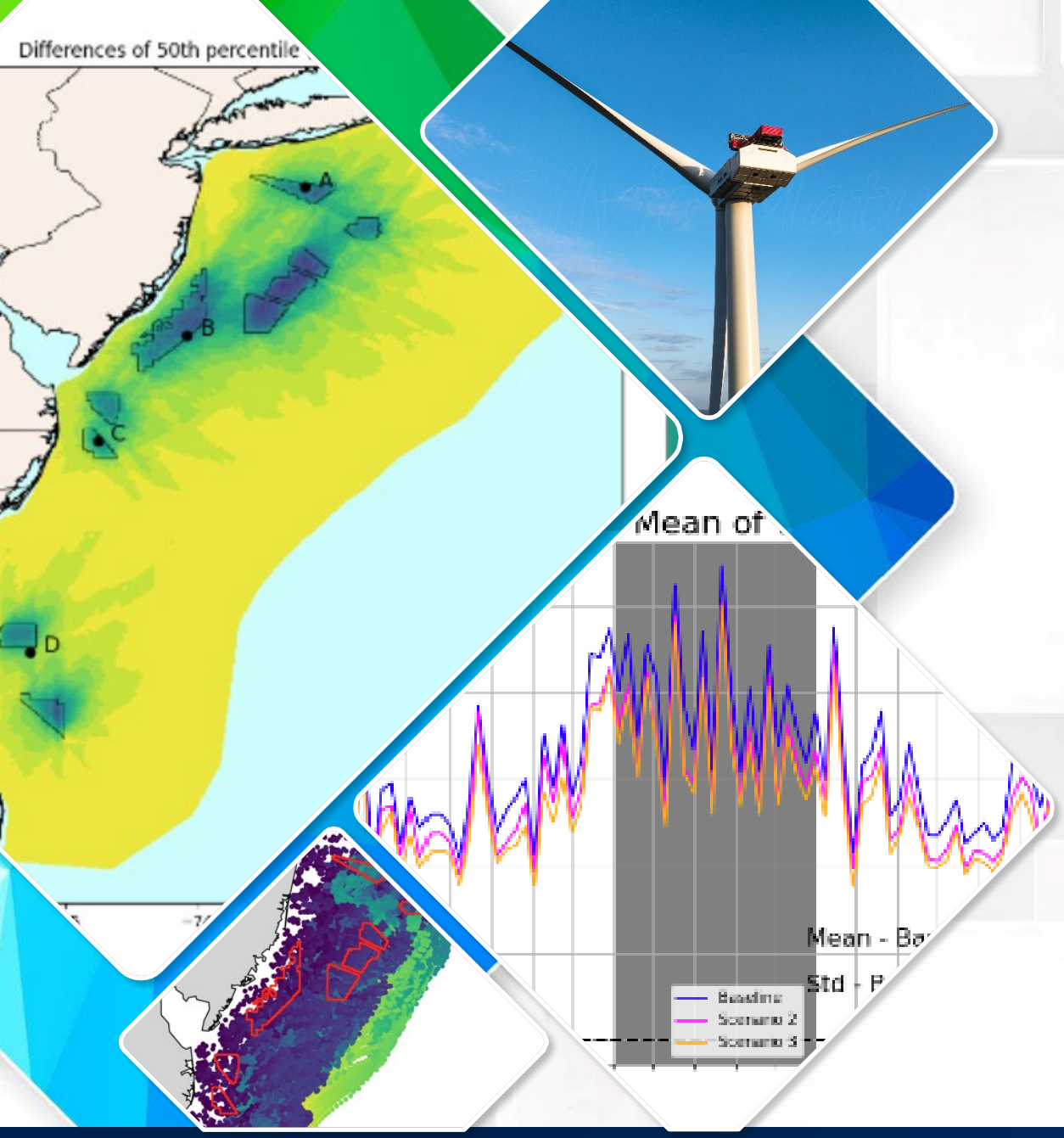
Fisheries Technical Working Group (F-TWG) Meeting

September 27, 2024

NEW YORK STATE | NYSERDA

Ground Rules

- Contribute – your perspectives are important
- Share time – lots to cover and many people around the table
- Integrate ideas and pose questions
- Stay focused on the agenda
- Avoid multitasking and other distractions
- We all have our unique challenges in a hybrid environment – it will take all of us being mindful to make this work



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Offshore Wind Impact on Oceanographic Processes: Cape Hatteras to Long Island

Mahmud Monim, Emily Day, Dan Codiga, Lily Engel, Lenaïg Hemery, Lysel Garavelli and Nickitas Georgas

NYSERDA Fisheries – Technical Working Group meeting

September 27, 2024

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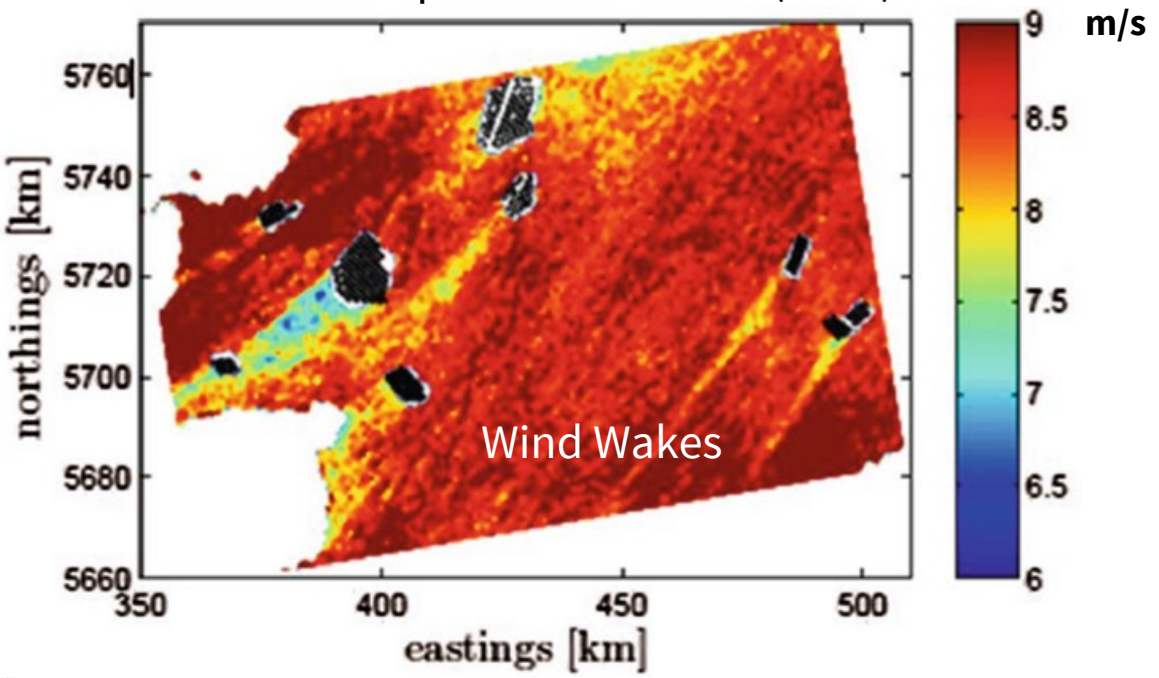
Pacific Northwest NATIONAL LABORATORY

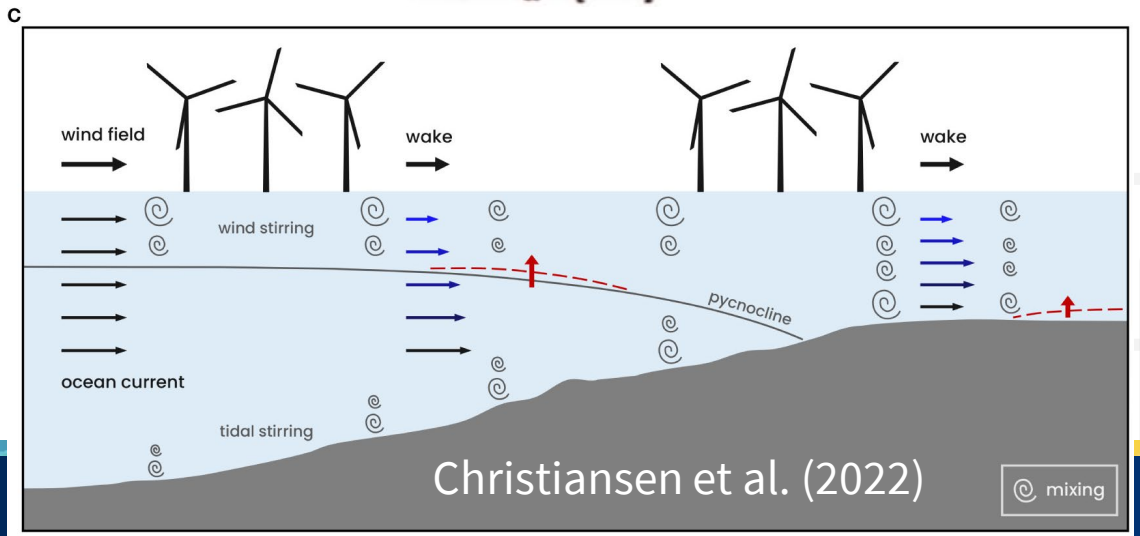
BOEM Bureau of Ocean Energy Management

Some potential Offshore Wind Development impacts

- Surface wind through wind wakes (downstream deficits)
- Surface waves through wind stress reduction
- Currents through wind stress reduction, foundation resistance and flow separation
- Air-sea heat flux, ocean temperature, mixing, stratification (Pycnocline)
- Sediment mobility
- Larval transport and fisheries

Dörenkämper and Steinfeld (2022)



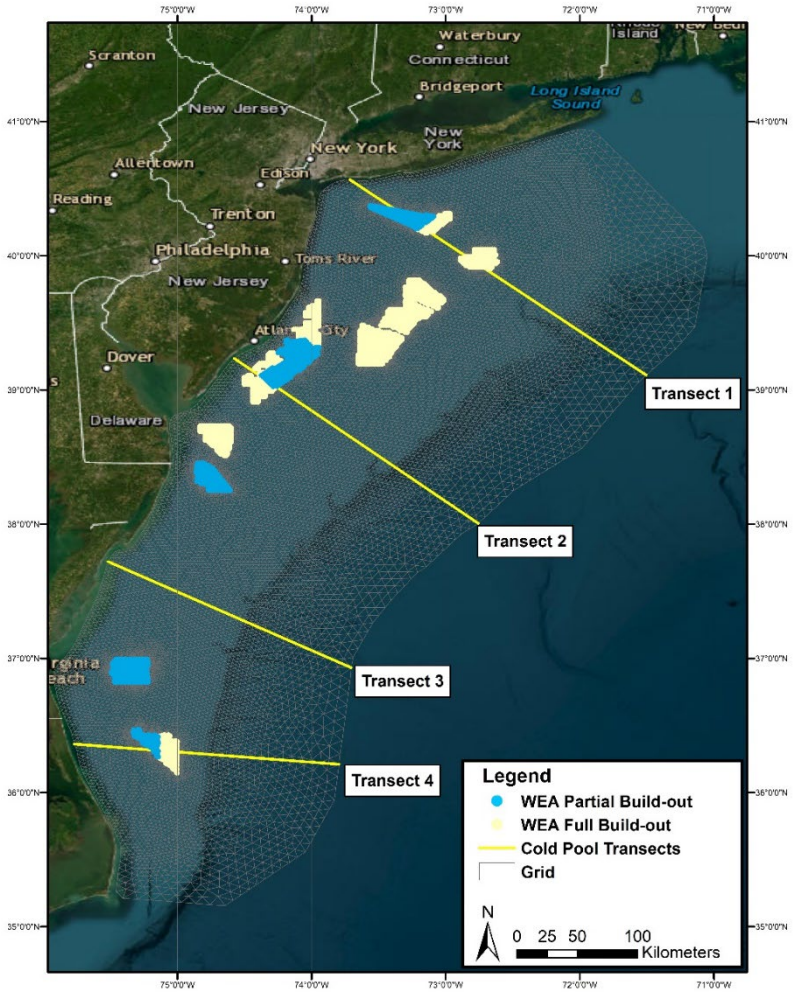


Christiansen et al. (2022)

Offshore Wind Development over MAB

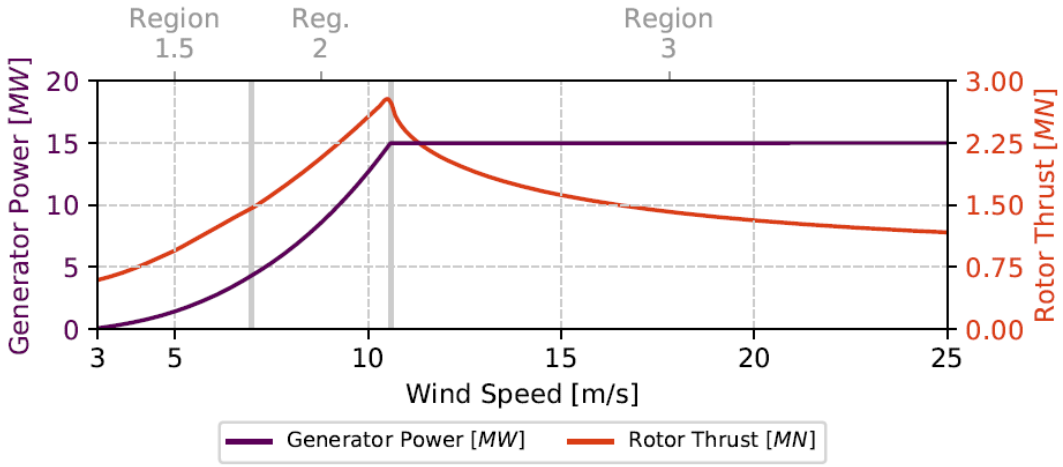
- 15MW NREL Wind Turbine:
  - 150m hub, 240m rotor diameter
  - 10m monopile diameter
  - 3-25m/s cut-in cut-off speed

- Three scenarios:
  1. Baseline, no wind turbines
  2. Partial / Limited 27.8GW
     1852 WTGs, all publicly available
  3. Full build-out 95.3GW
     6353 WTGs, provided by BOEM

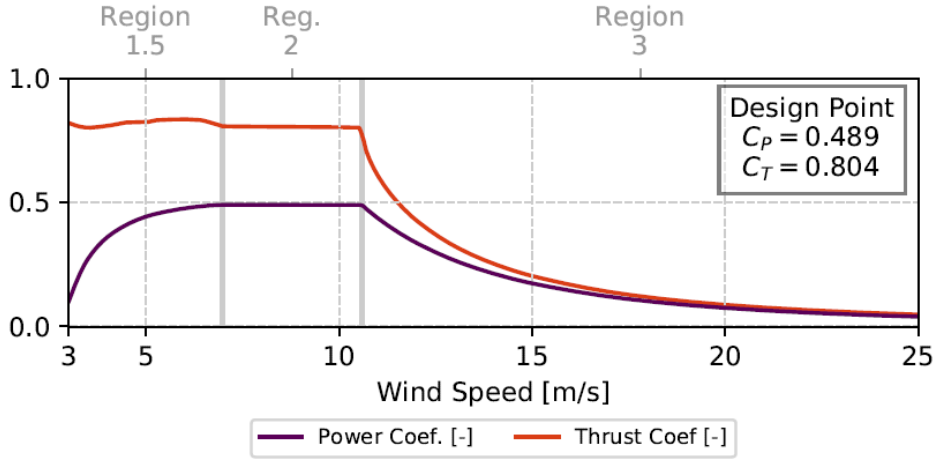


15MW Wind Turbine Specs; Power (and wake) generation

- 15MW NREL Wind Turbine:
  - 150m hub, 240m rotor diameter
  - 10m monopile diameter
  - 3-25m/s cut-in cut-off speed



- Design curve:
  - Power coefficient
    - Efficiency of energy conversion
    - Maximum 7 – 11m/s (Region 2)
  - Thrust coefficient
    - Axial force from wind to blades
    - Peak from 3 – 11m/s (Regions 1.5&2)

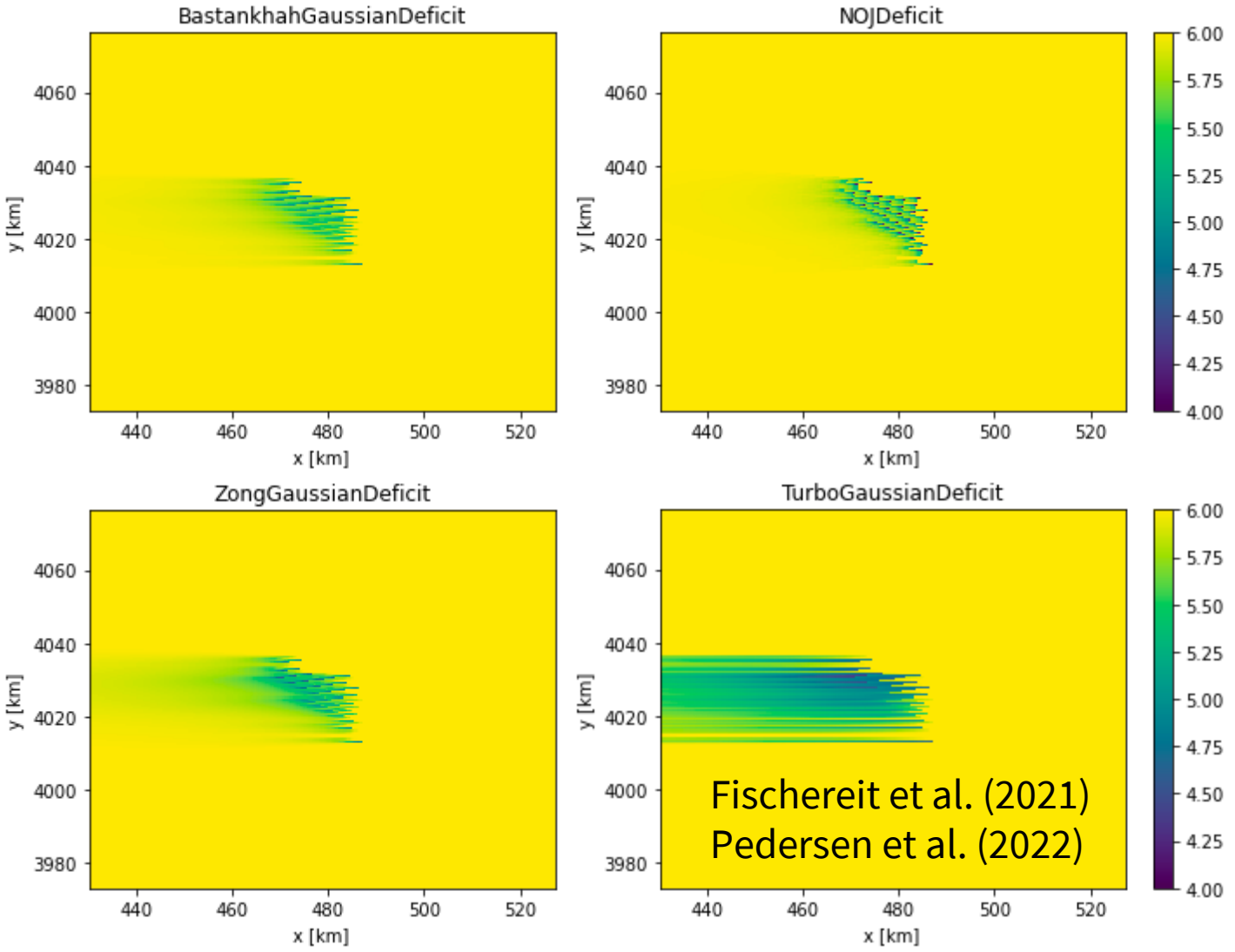


PyWake Models for Wind Wake Deficit

- Based on WTG design specs
  - Physical dimensions
  - Power and Thrust curves

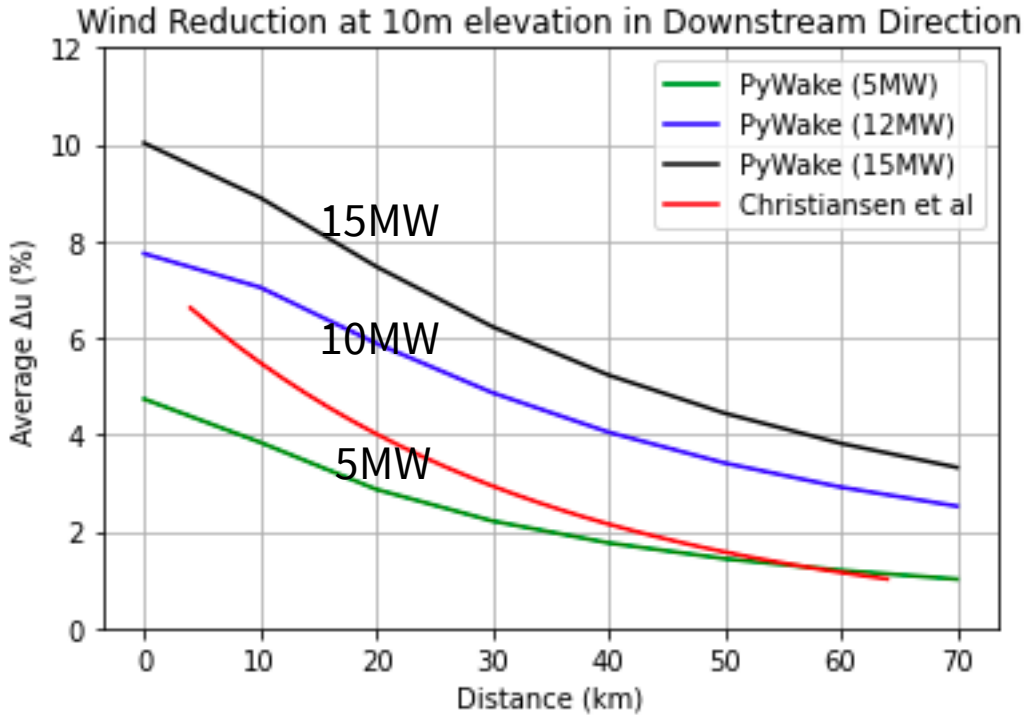
  And on wind farm design
  - Individual turbine orientation and placement within a wind farm

- Calculates wind wake
  - Downstream wind deficit
  - Accounting for turbine to turbine and farm to farm interactions
  - Based on Engineering models



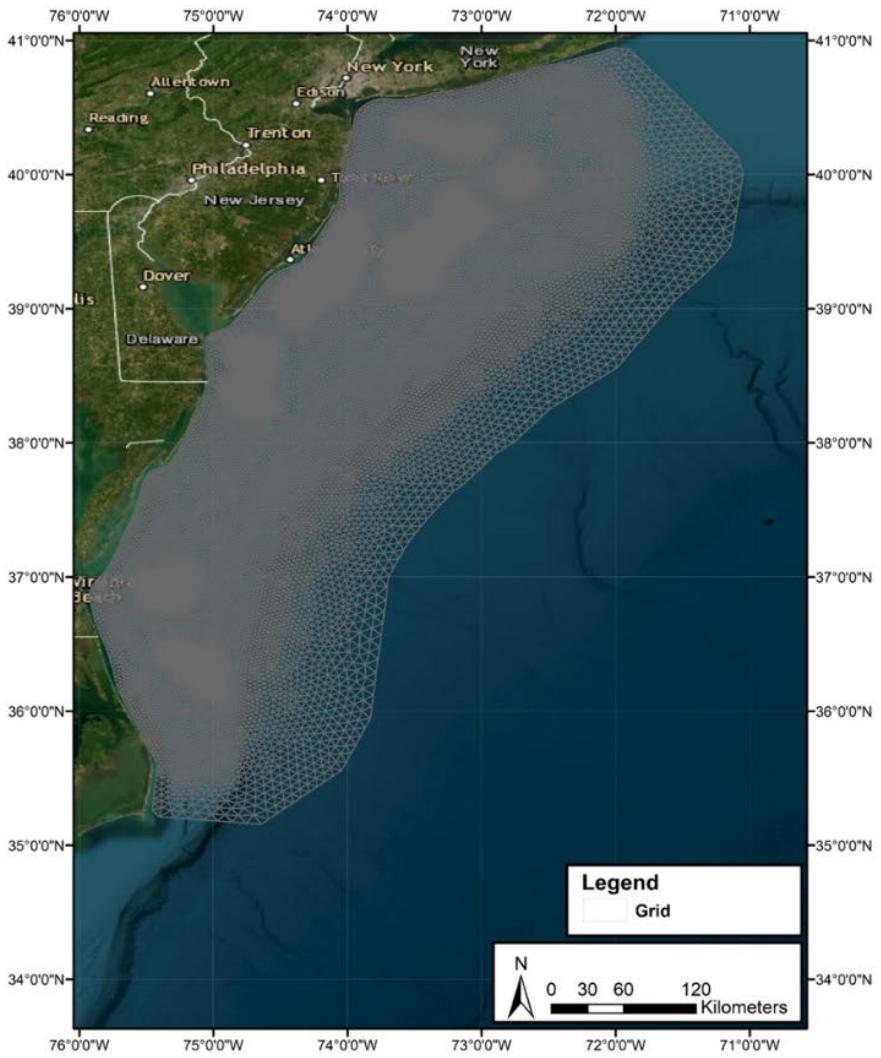
PyWake Engineering Models for Wind Wake Deficit

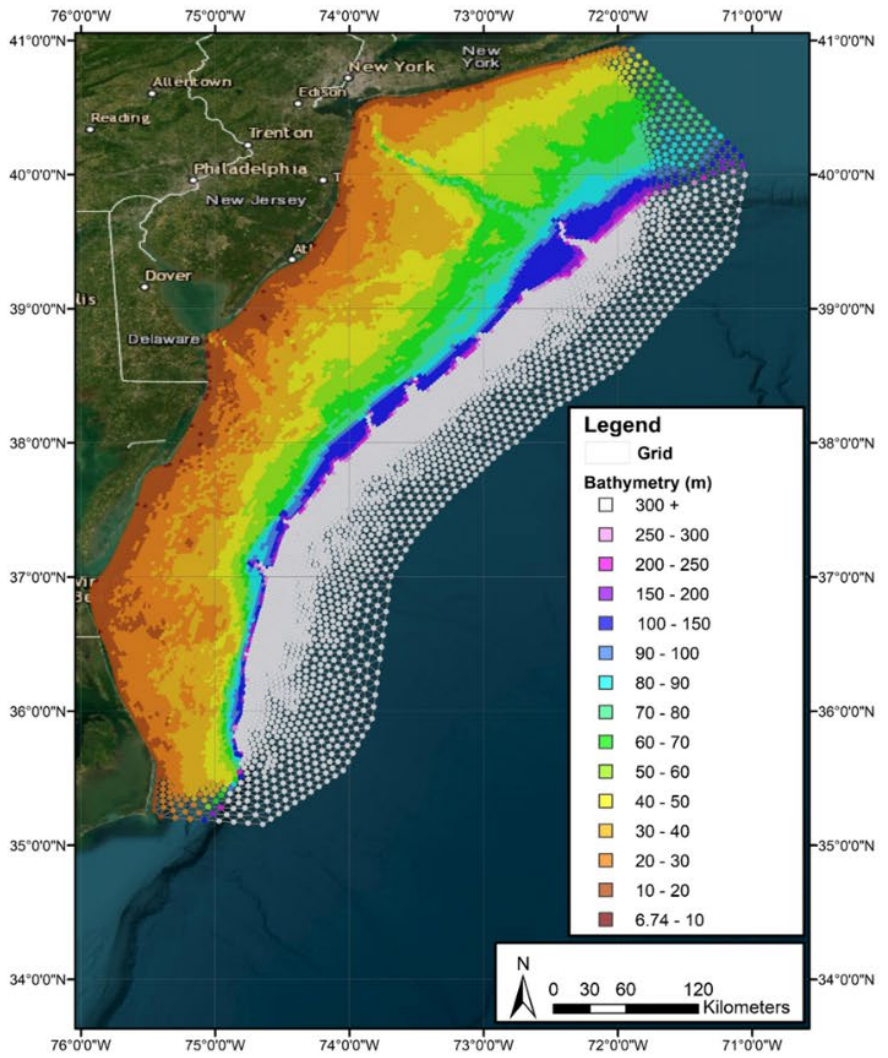
- Wind wake curve at hub height follows thrust coefficient curve
  - % deficit is constant between 3-11m/s free wind, then decreases
  - Maximum deficit for 11m/s winds
- Validated qualitatively against SAR 10m wind data
  - Christiansen et al., 2022 for 5MW WTG farm
  - Larger turbines, larger wake



Delft3D-FM & SWAN Hydrodynamic and Wave model

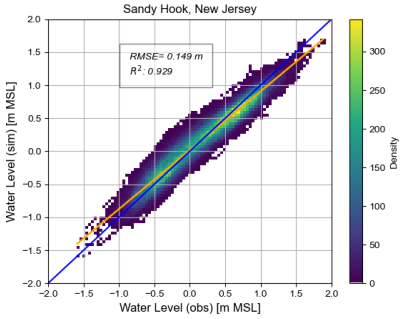
- Common Grid
  - Highest resol. in the farms
- Nested within Doppio (10km) and ERA5 waves
- ERA5 winds and heat fluxes (with PyWake deficits)
- Monopile restrictions
- Feb 2018-Jan 2020 simulation period

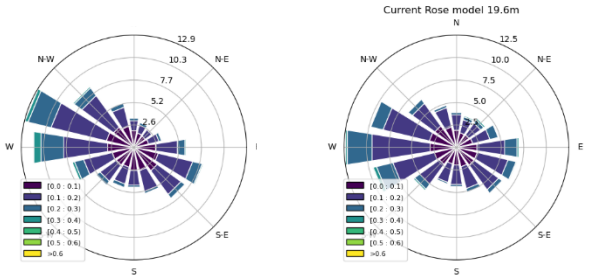


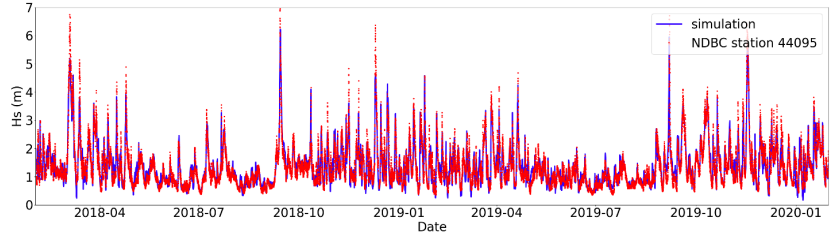


Comprehensive Validation

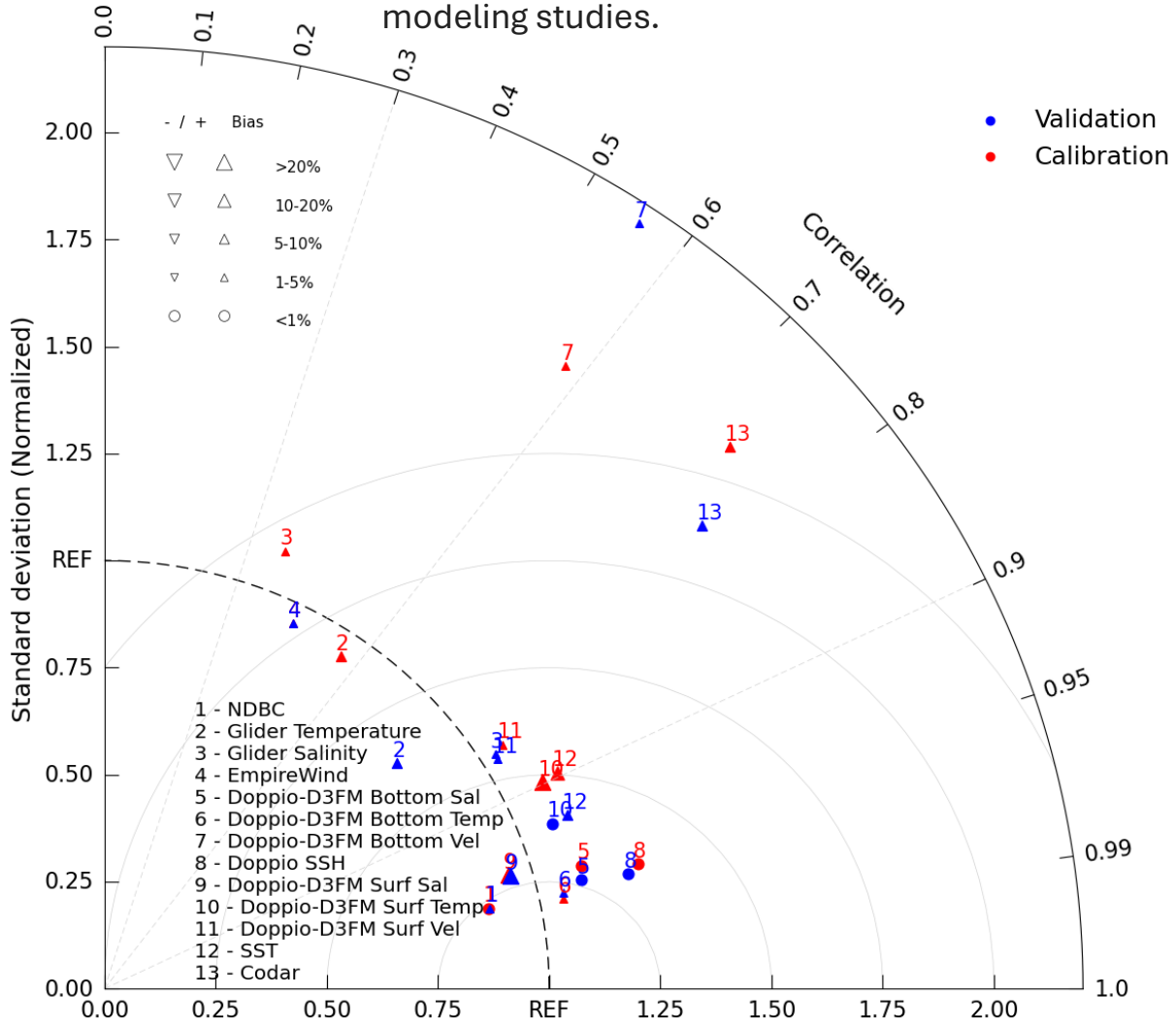
- Tide gage and ADCP data
- NDBC buoy data
- Satellite data
  - SSH
  - SST
- Glider T&S
- HF-Radar data
- Doppio







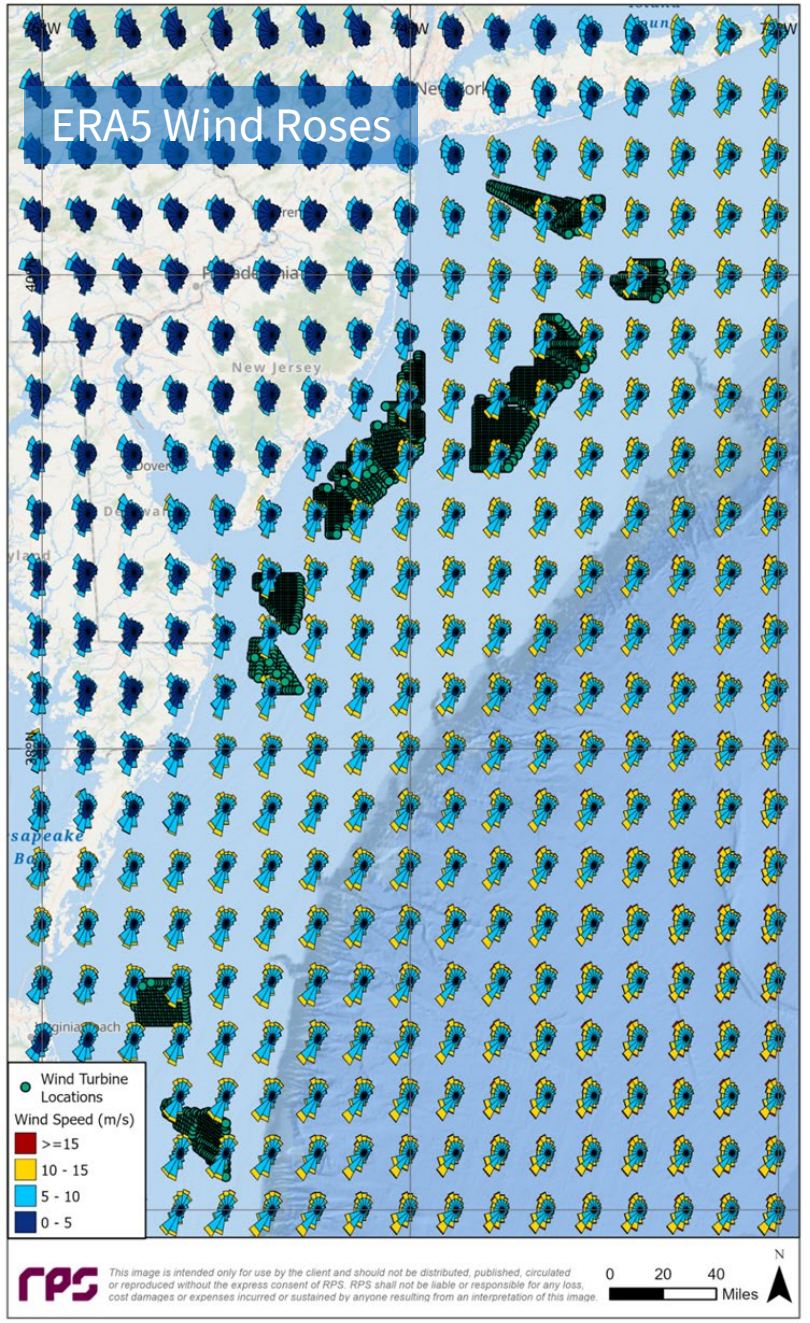
The index of agreement, root mean square error, and other metrics are on par with published values from comparable state of the art modeling studies.

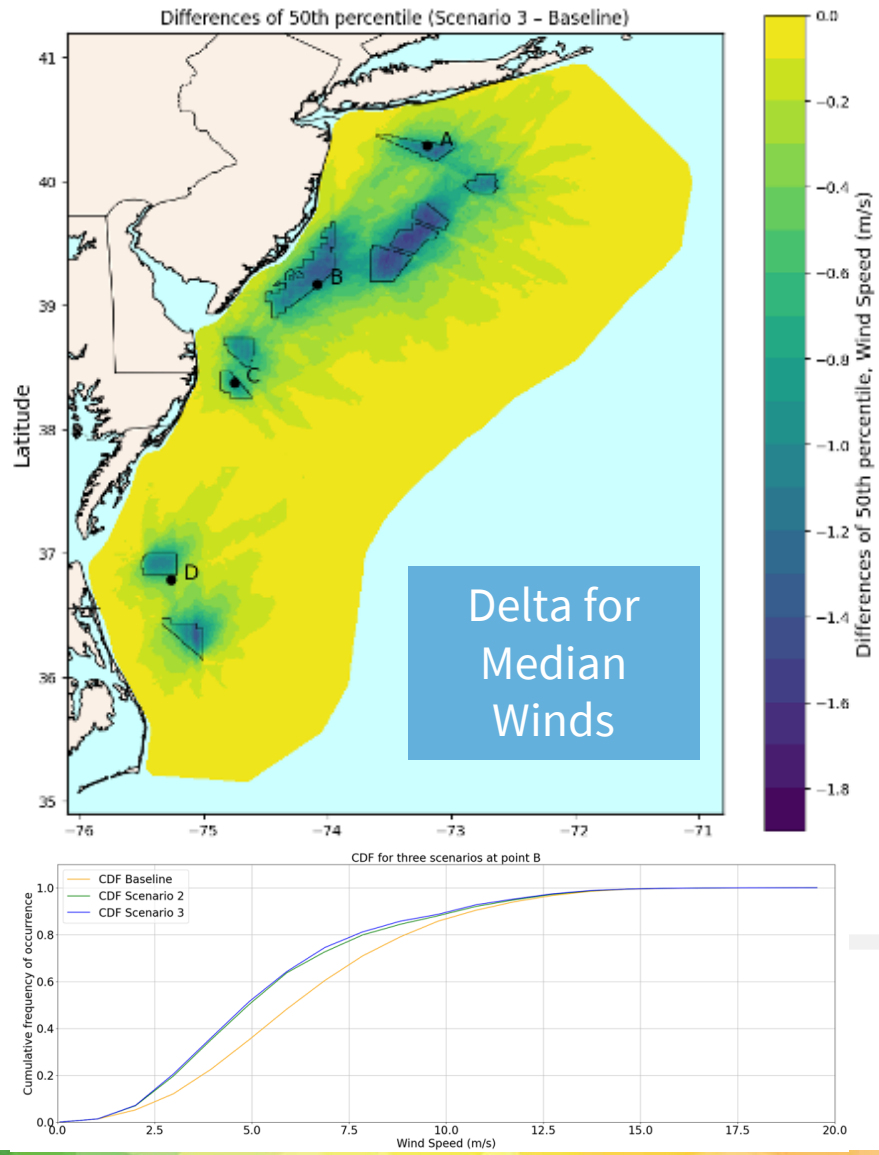


Effect on 10m Winds

- Max deficits within farms aligned with prevailing winds
  - ~20% reduction, climatological
  - Up to 30-50%, 1% of the time
- Wakes extend 50 to 200km or more
- Farm to farm interactions
- Full buildout (Scenario 3) has highest reductions

* Reductions more pronounced than Golbazi et al. (2022)





Effect on Waves

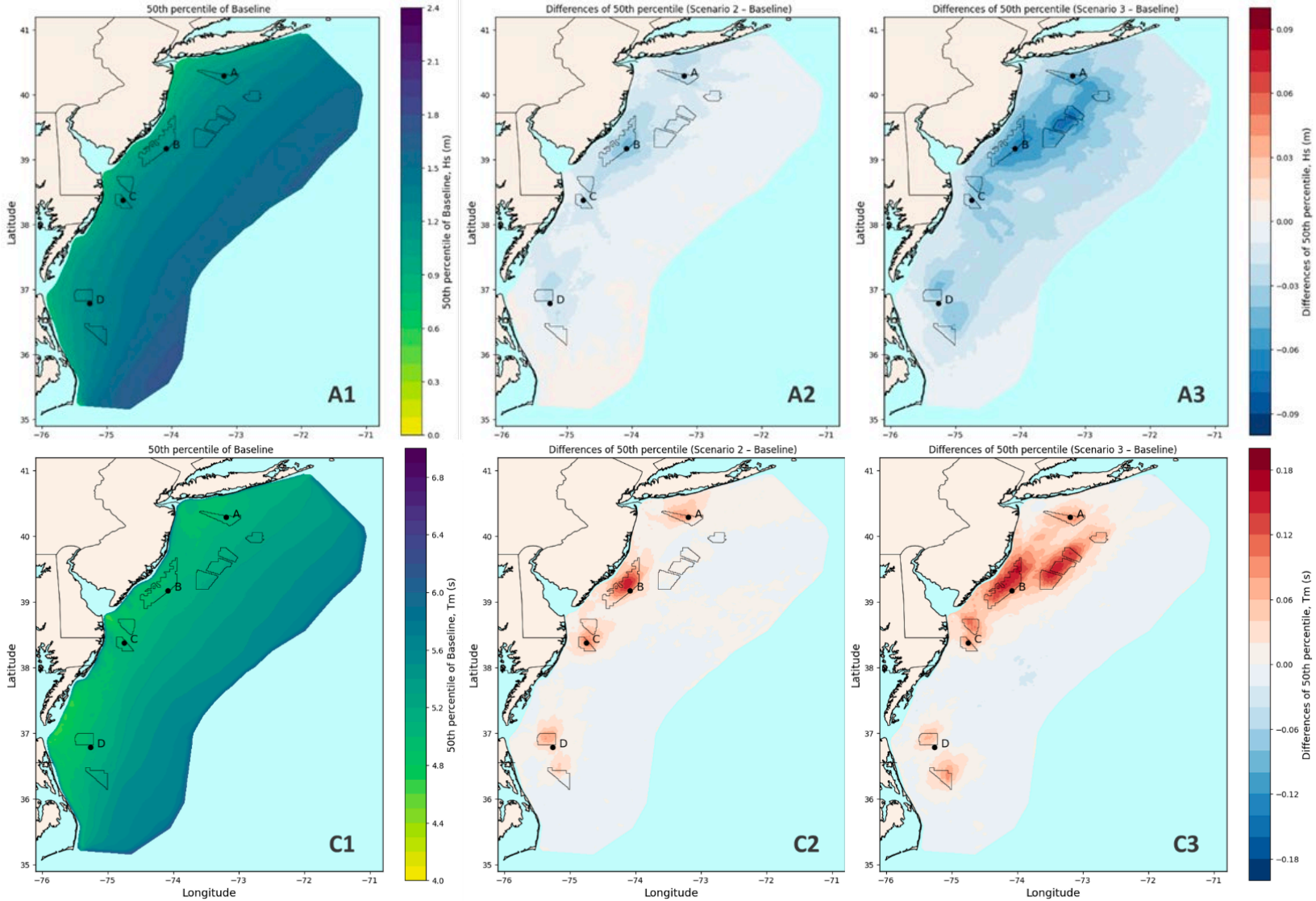
- Similar footprint as wind reductions – alignment with prevailing winds
- Small changes relative to climatology:
  - <-5% SWH
  - Up to +0.16s Period (reduced wind waves to ~constant swell)

* Consistent with Fischereit et al. (2022) and Bärfus et al. (2021).

Baseline | Scenario 2 delta | Scenario 3 delta

SWH

Period



MAB General Circulation Update and synthesis: Chen and Young (2024) C-Y 2024

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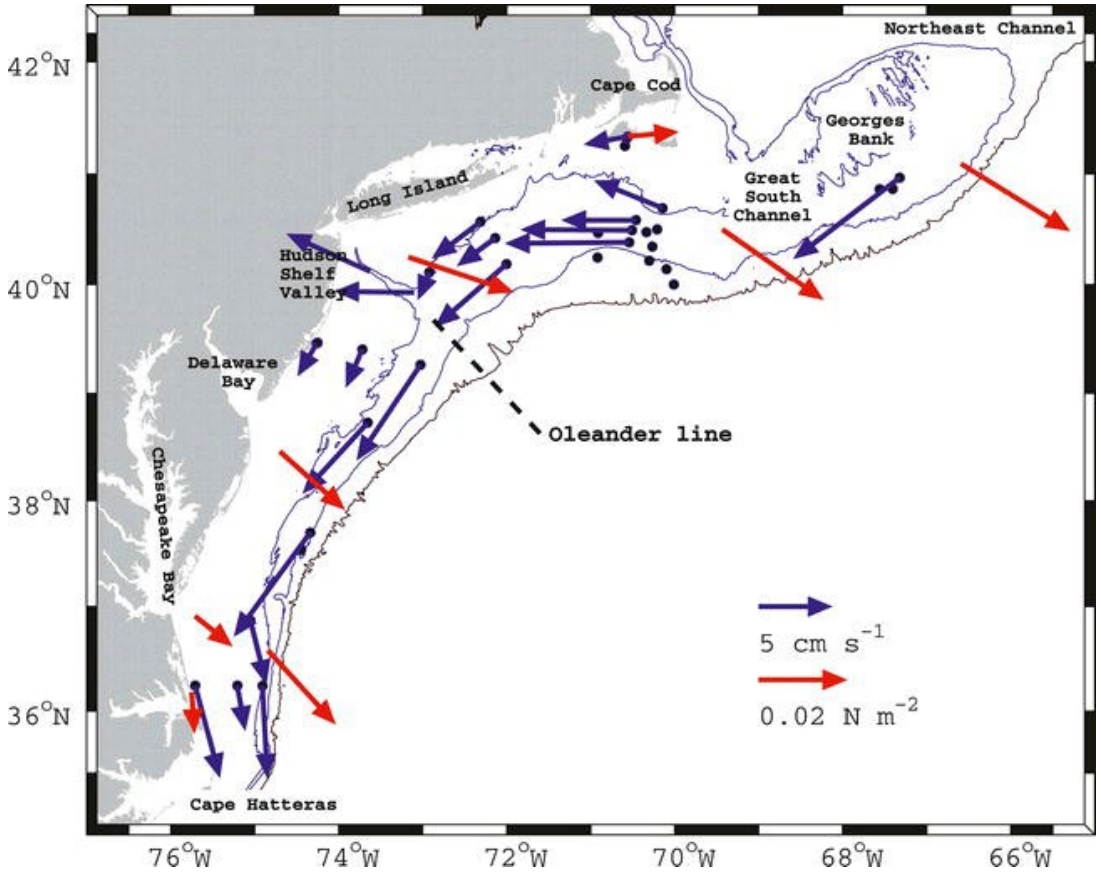
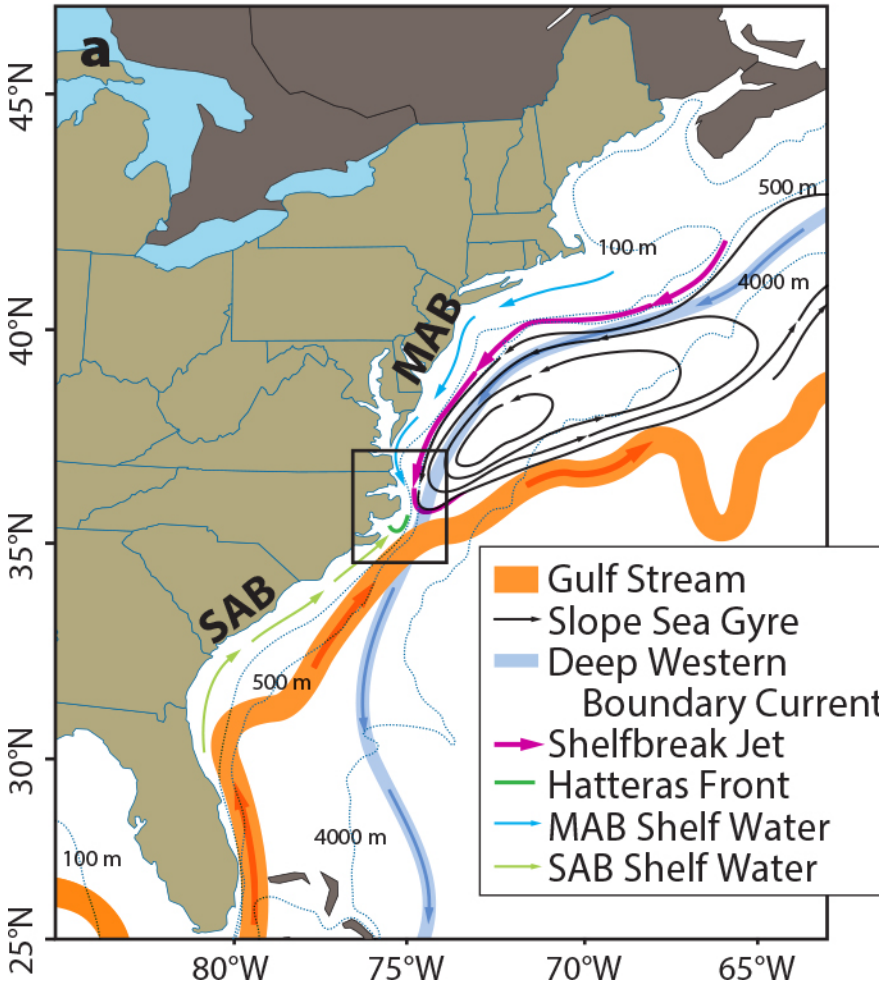
Lentz (2008)



Seim et al. (2022)



"In the absence of the dominant wind forcing, alongshelf current would strengthen in the MAB" C-Y 2024

Effect on Tidal Residual Currents

Although reductions in total currents can be seen, the median and 75% alongshelf tidal residual currents tend to increase with the wind farms.

50%

75%

Baseline

Scenario 2 delta

Scenario 3 delta

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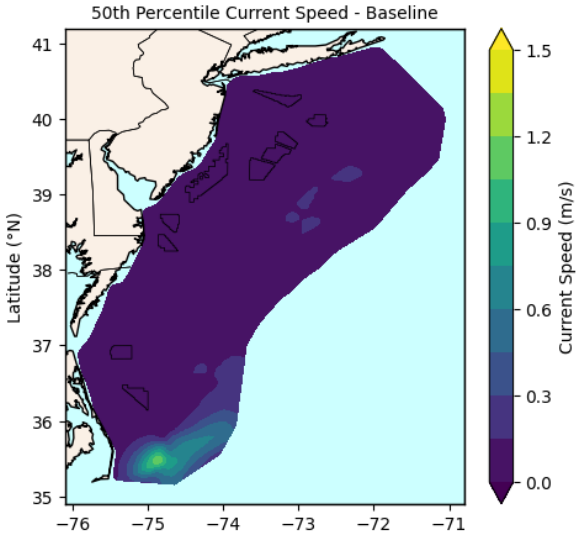

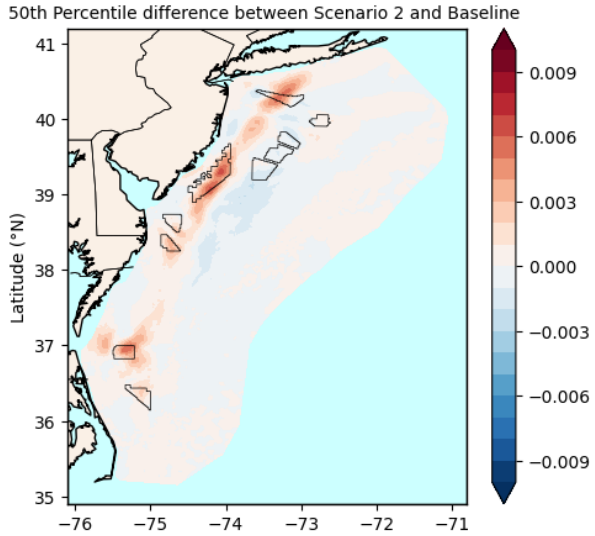

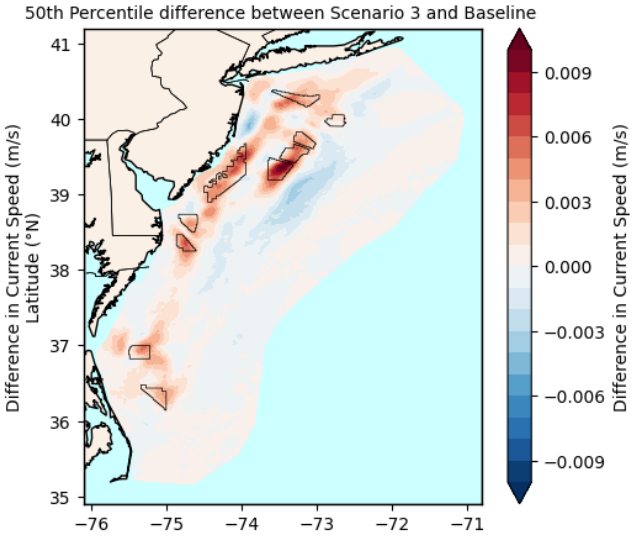

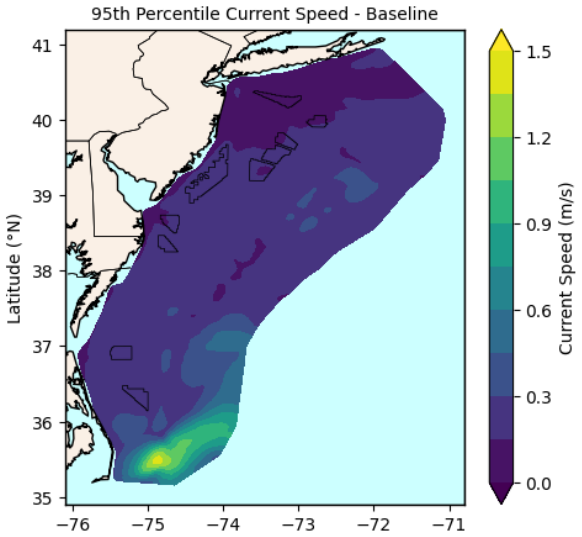

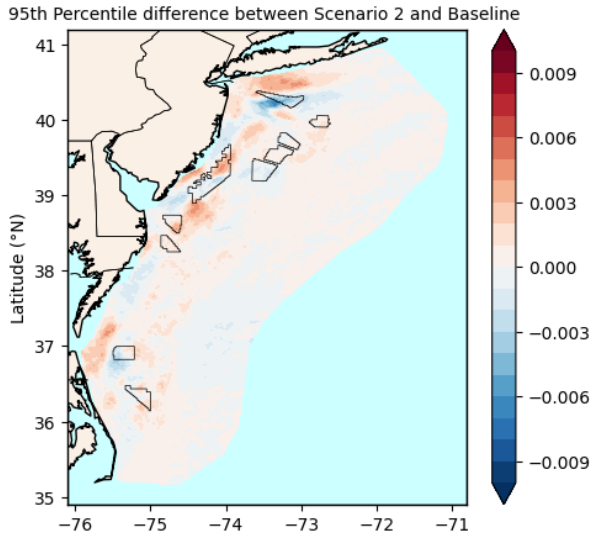

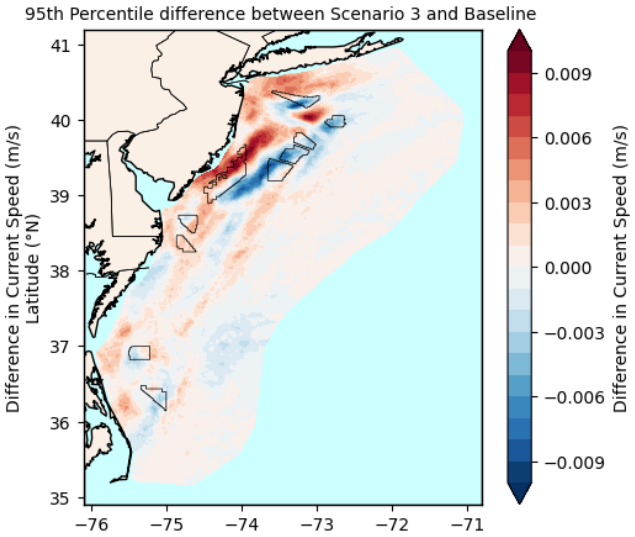

Effect on Summer Stratification (Delta T)

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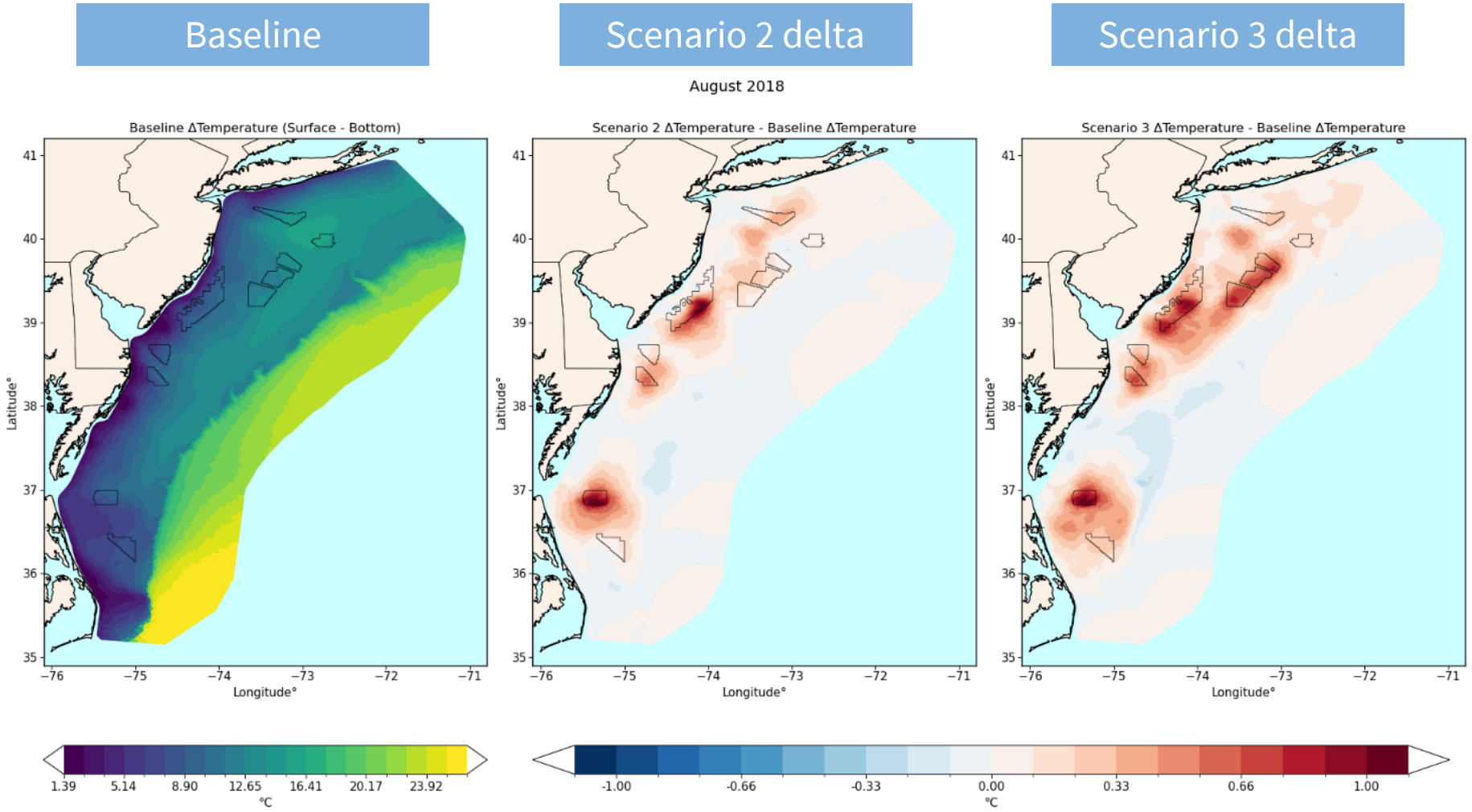
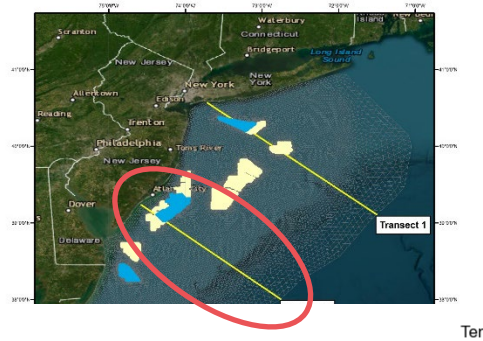
- Dominant loss of surface wind stress ->
- Less mixing (TKE, Richardson #)->
- More stratification->
- Possible changes in upwelling



Effects on Cold Pool

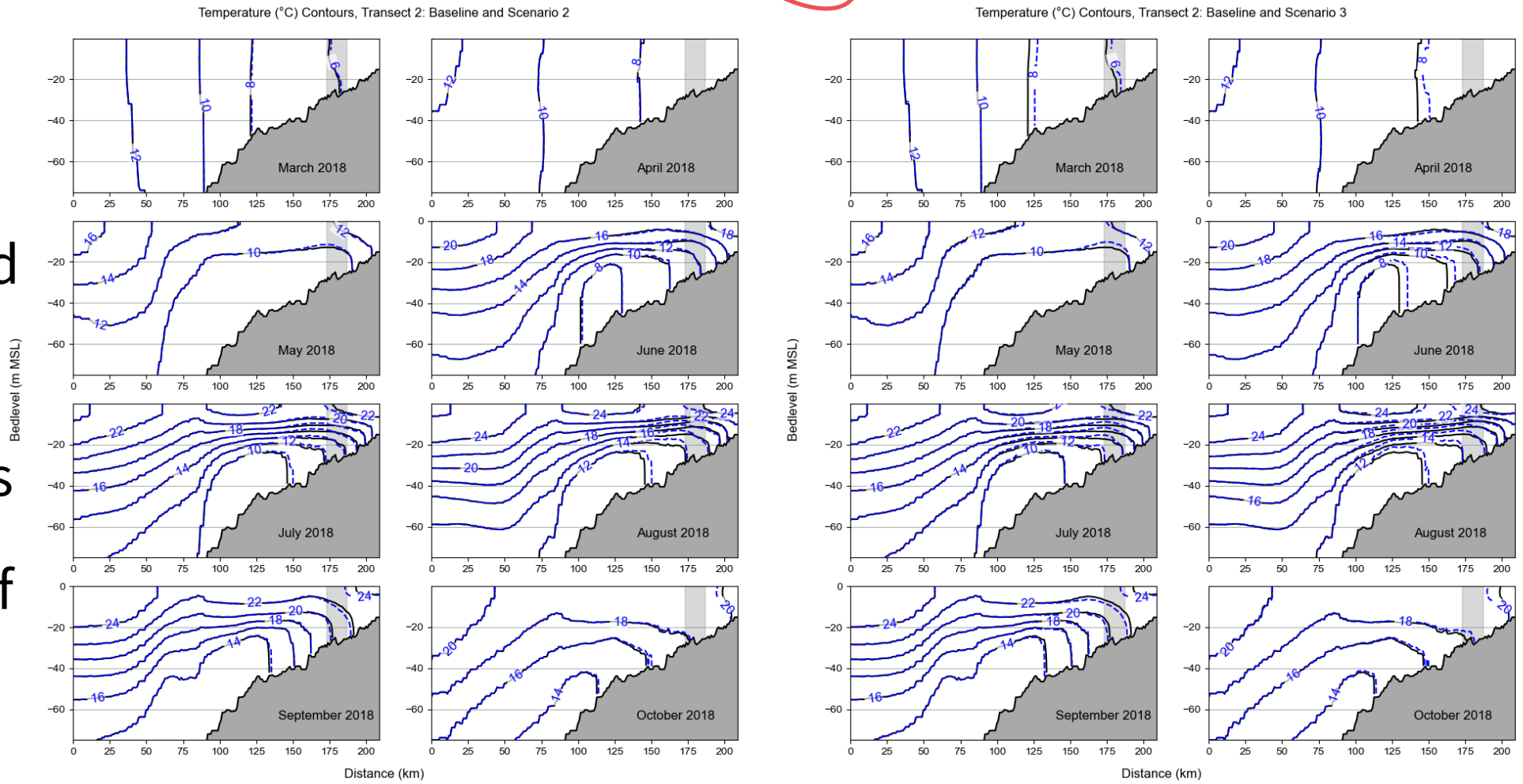


Scenario 2

Scenario 3

Cold pool dynamics captured well by model and are not altered significantly.

Some changes in upwelling and doming of the thermocline.



Summary of Results for Oceanographic Processes

- Wind turbines cause wind wake deficits, esp. for windspeeds ~3 to ~11 m/s
  - Within farms, and tens of km downwind; detectable to 200 km
  - Up to 20% reduction of average winds
  - Max 30-50% reduction (1% of the time)
- Resulting surface wave changes (mainly wind waves, not swell) relatively minor
  - Local to farms, strongest for farms aligned with wind
  - Heights reduced (~0.17 m, < ~5%), periods lengthened (~0.16s)
- Changes to the typical 2-12 cm/s southward alongshore tidal residual currents
  - Spatially complex, increases/decreases, up to 1 cm/s
  - Increases tend to be stronger, and farther inshore
- Reduced wind-driven vertical mixing affects water column
  - Doming of thermocline; summer stratification up to 1°C strongest
  - Possible changes in upwelling / downwelling
- Cold pool seasonal evolution not substantially modified

Offshore Wind Development May Impact Fisheries

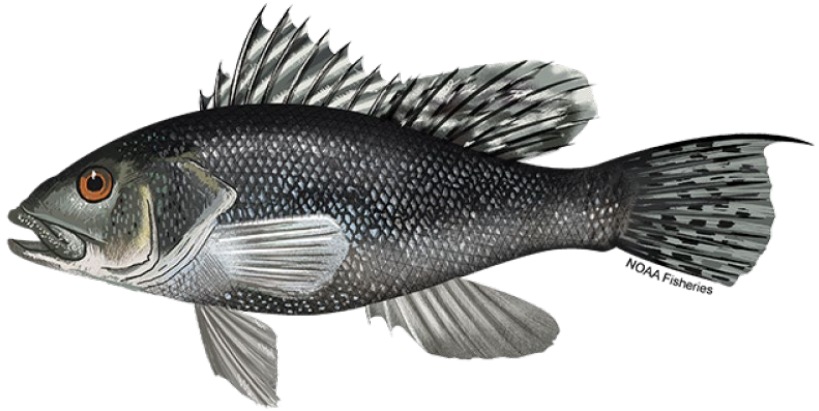
- A lot of marine species life stages include a larval pelagic phase
- Changes in hydrodynamics may influence larval dispersal
- May cause habitat disruption
- May lead to food chain disruptions

> **How will offshore wind development off the East Coast of the USA affect three important commercial fisheries?**

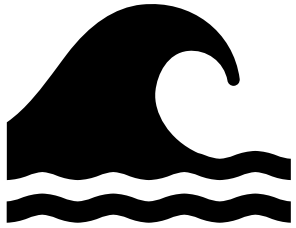
Selected Species

Atlantic sea scallop
Placopecten magellanicus

Atlantic surfclam
Spisula solidissima

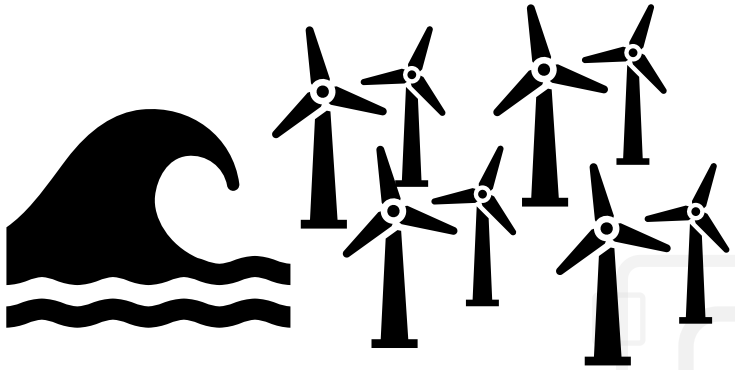


Black sea bass
Centropristis striata



Scenario 1: Base = No turbines

Scenario 2: Partial buildout

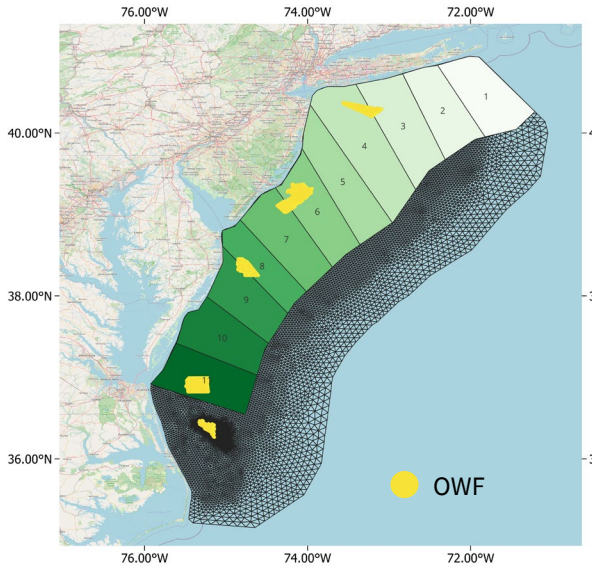


Scenario 3: Full buildout

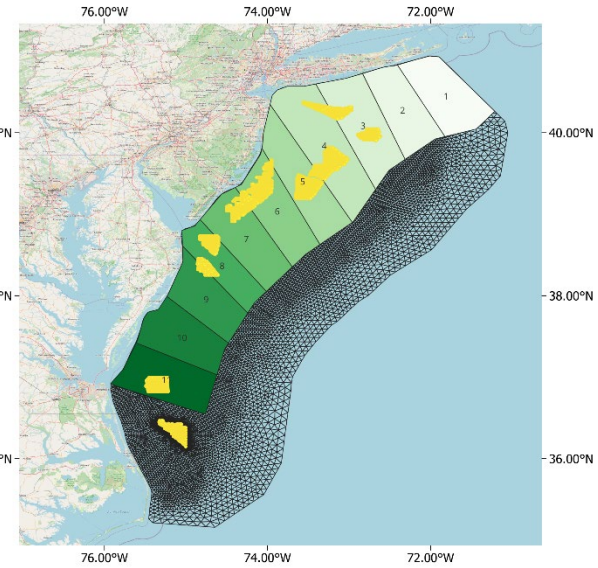
Spawning And Settlement Zones – Atlantic Sea Scallop

- Spawning: 15-110 m bathymetry, release from bottom layer (90% of total depth)
- Settlement: Same zones as spawning, only possible within 15-60m bathymetric depth
- Drift for 45 days, can settle after 28 days if other requirements met
- 1,000 larvae
- Release once a week at midnight May through October 2018 and 2019

Scenario 2



Scenario 3



- When included, diurnal vertical migration (DVM) is modeled as instantaneous vertical movement to 3m deep at 6:00pm and to 20m deep at 6:00am

Biophysical Larval Dispersal Model

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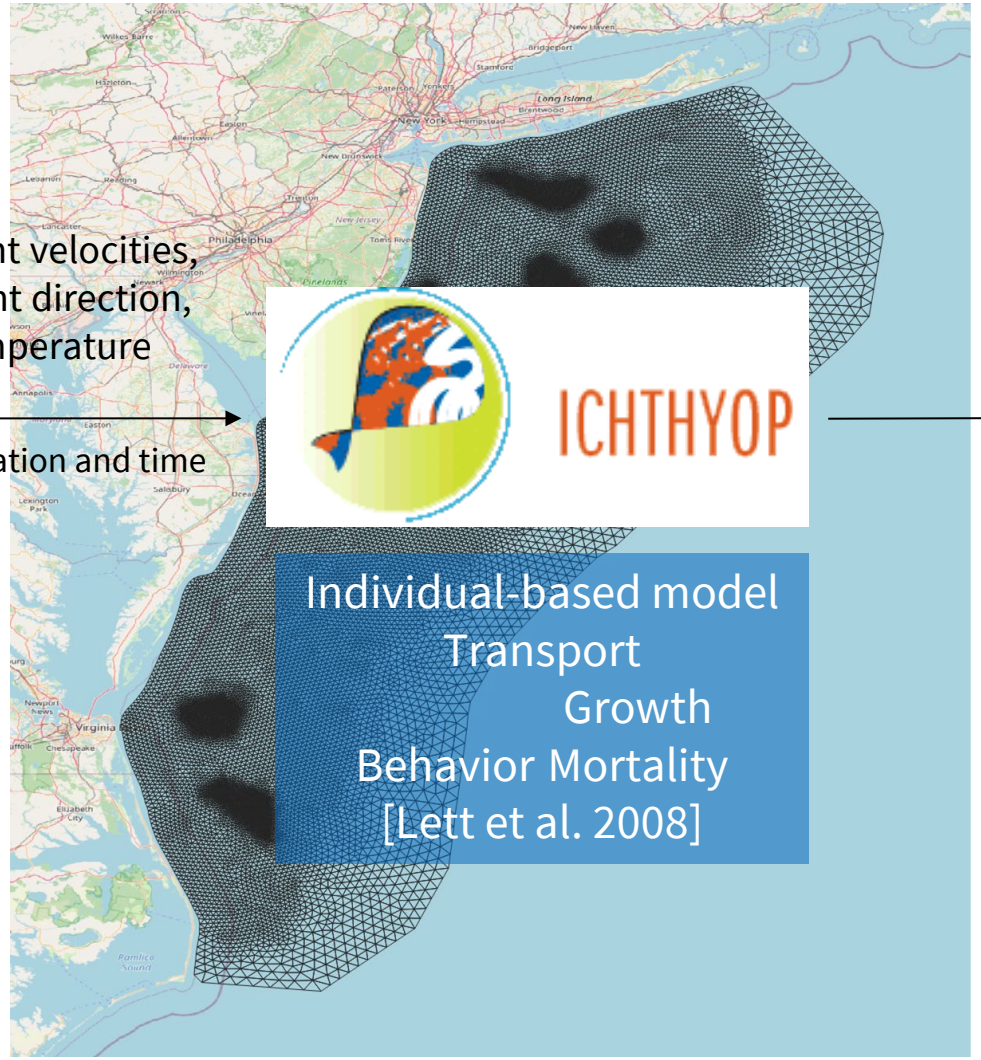
Hydrodynamic model

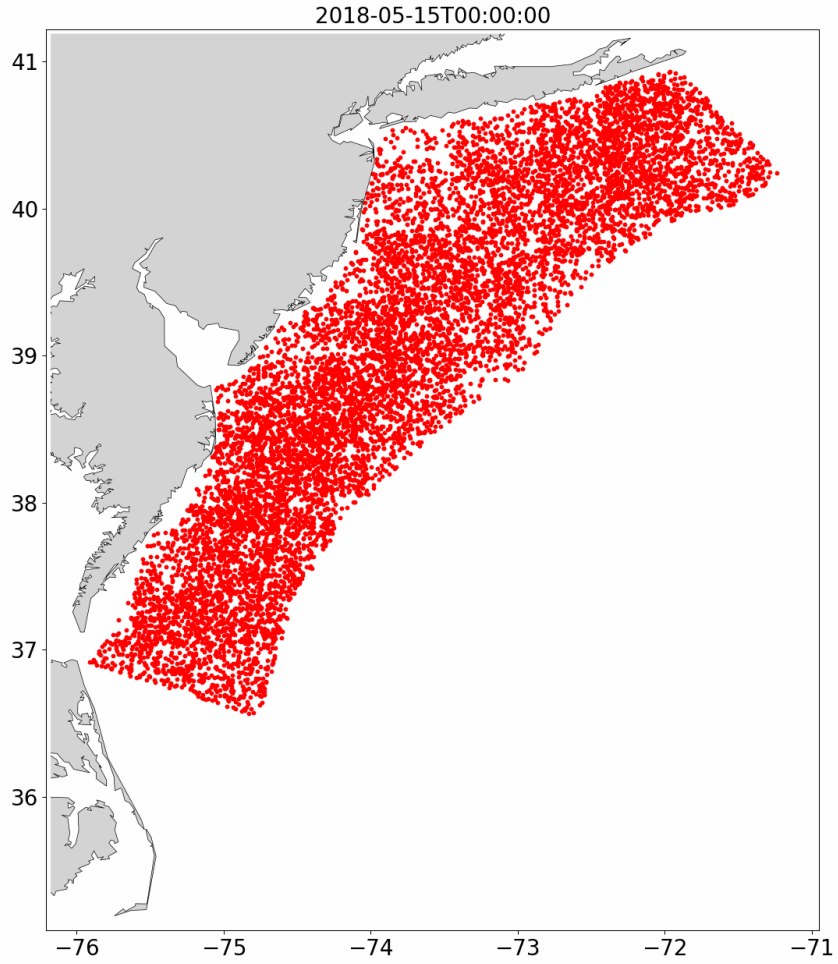
Current velocities, current direction, temperature

Per location and time



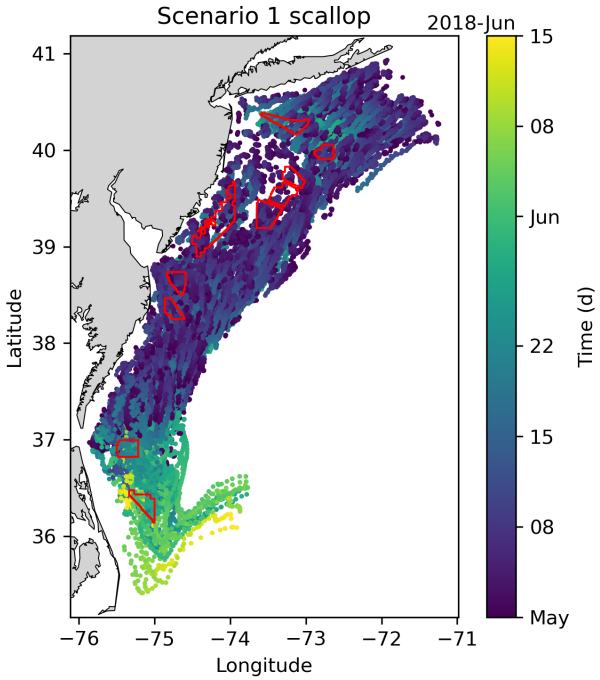
Larvae position at each timestep

Scallop Larvae Released 5/14/18



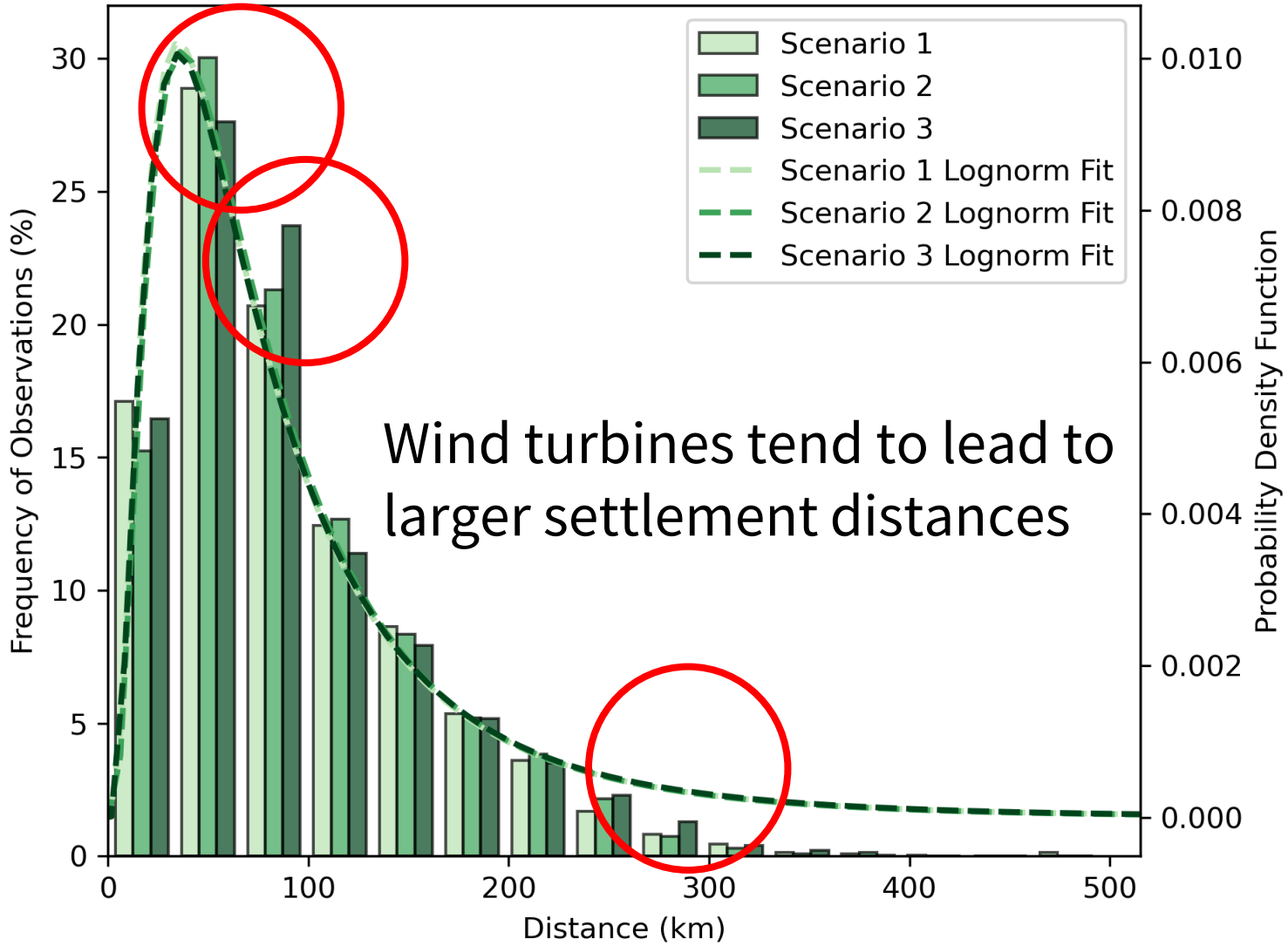
First settlement occurs on day 28

Trajectories expand further with turbines



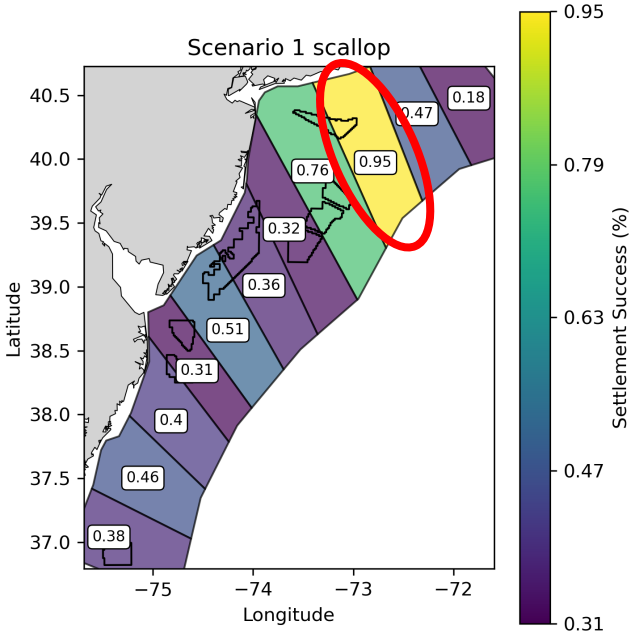
Trajectories slightly extend further with turbines

Larval Settlement Distance (Passive)

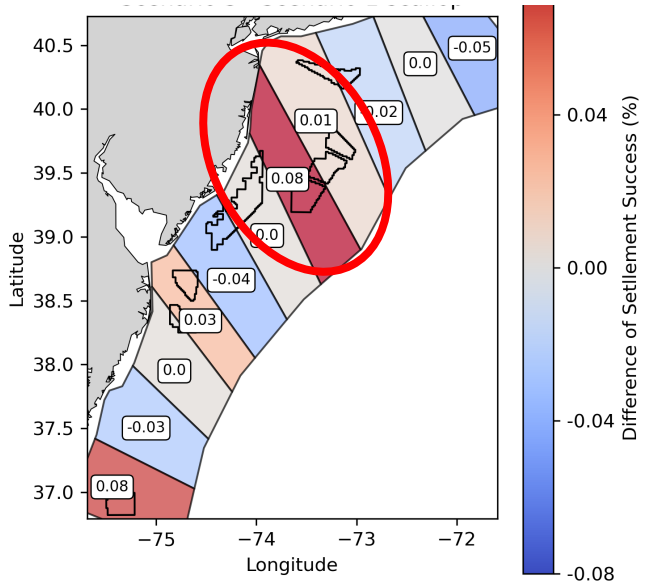


Larval Settlement Success (Passive)

$$\text{Settlement success (\%)} = \frac{\#\ \text{settled larvae each zone}}{\text{total larvae released}} * 100$$



Larvae get trapped within turbine area

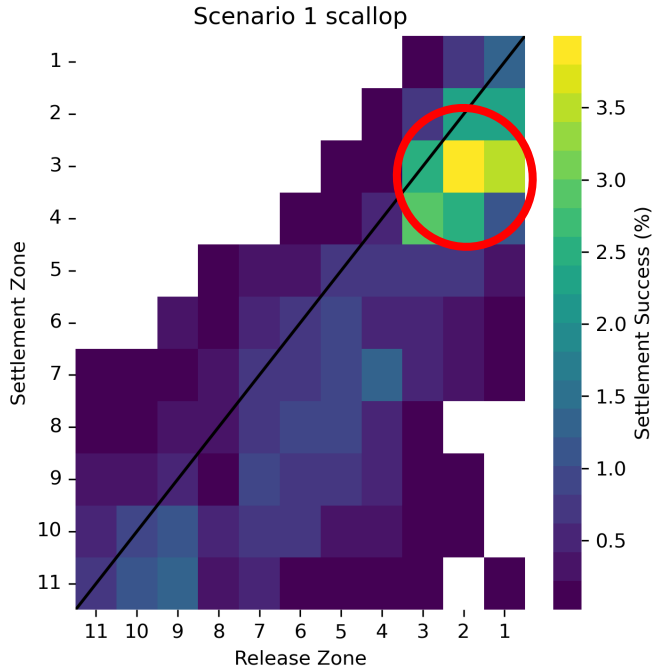


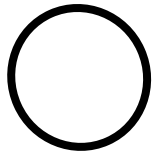
A majority of larvae beach and die

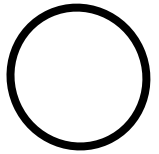
But there is patchiness and changes with turbines as larvae get trapped in certain areas

Connectivity Matrices (Passive)

$$\text{Settlement success (\%)} = \frac{\#\ \text{settled larvae each zone}}{\text{total larvae released}} * 100$$







Hot spot changes

Effects of wind turbines vary strongly with location and buildout scenario

Including Diurnal Vertical Migration (DVM)

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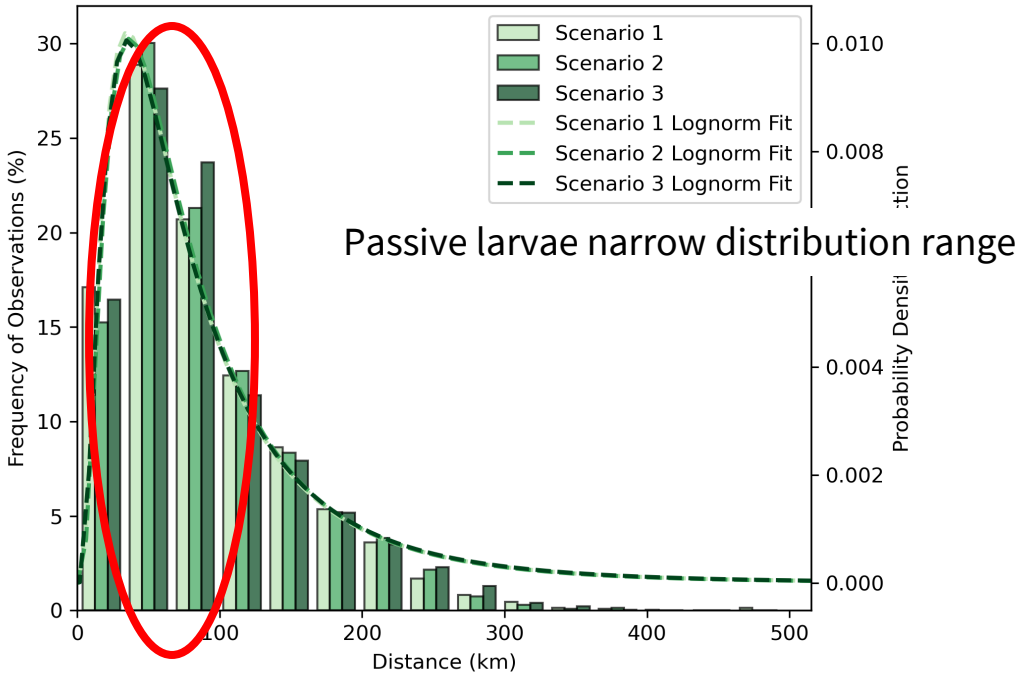
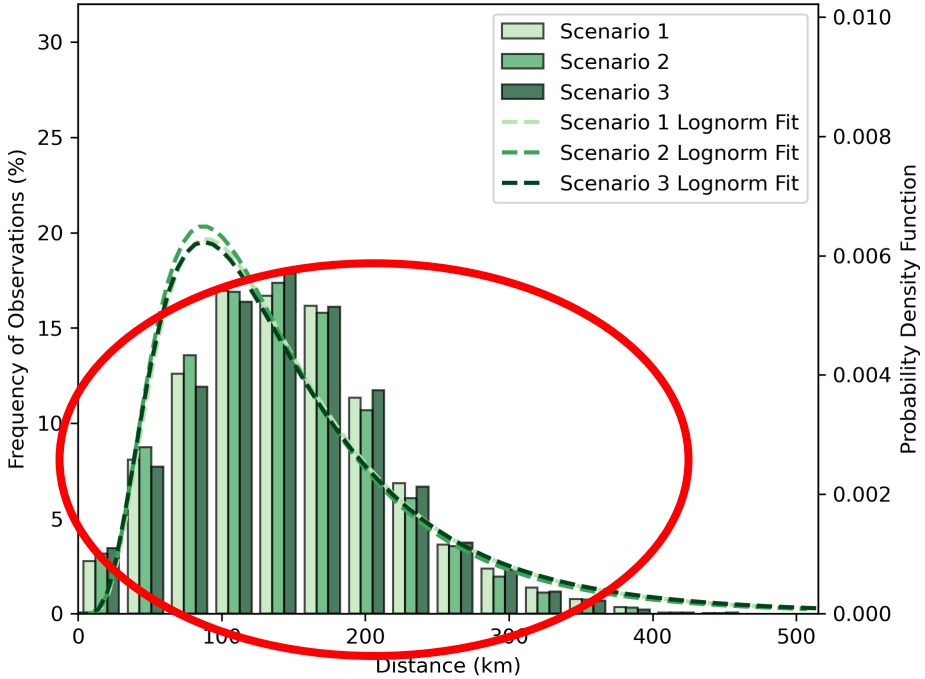
Passive



Passive larvae narrow distribution range

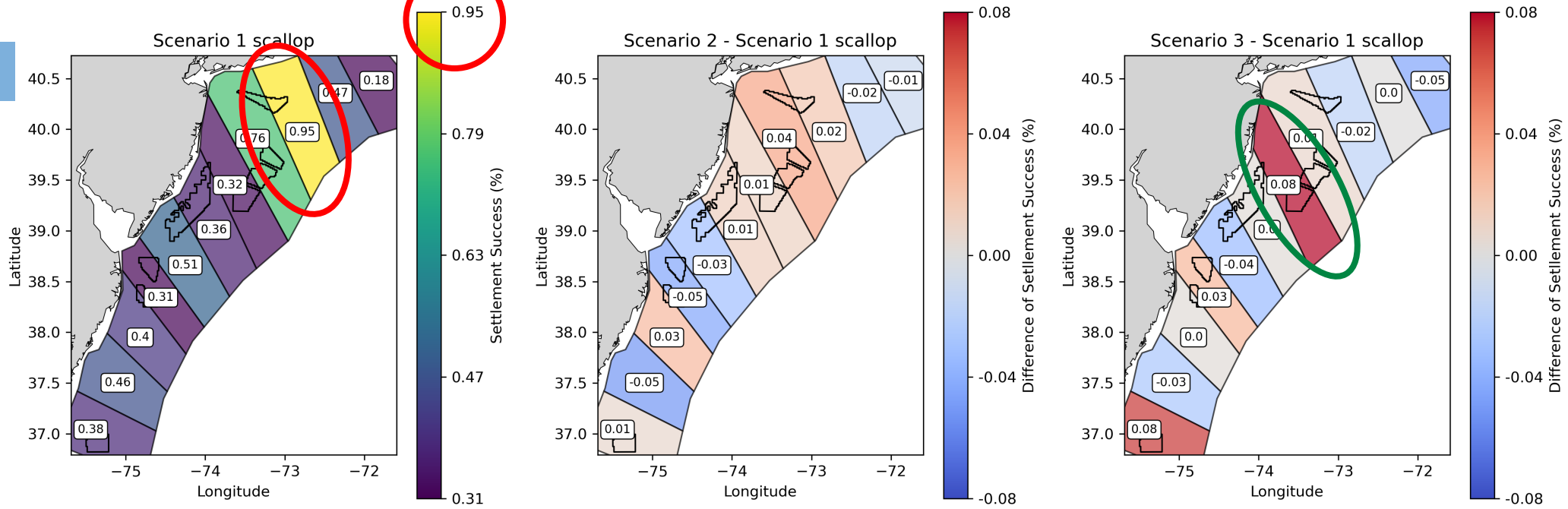
DVM



DVM more spread out

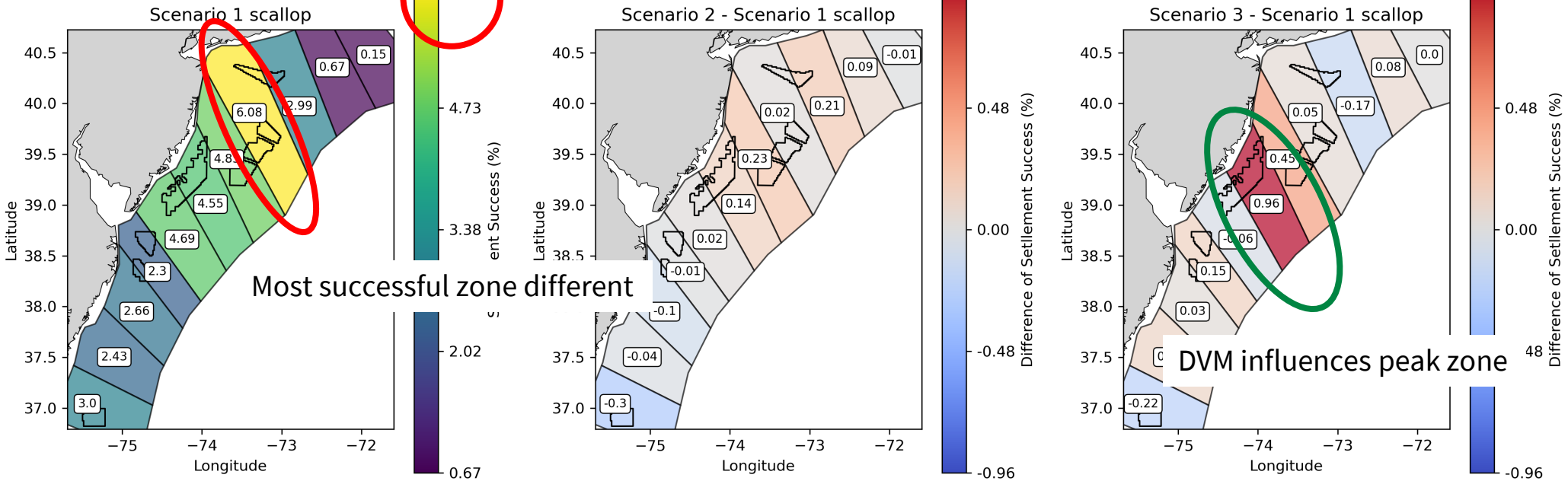
Dispersal distances increase with DVM because larvae are higher in the water column where currents are stronger

Passive



Settlement success increases

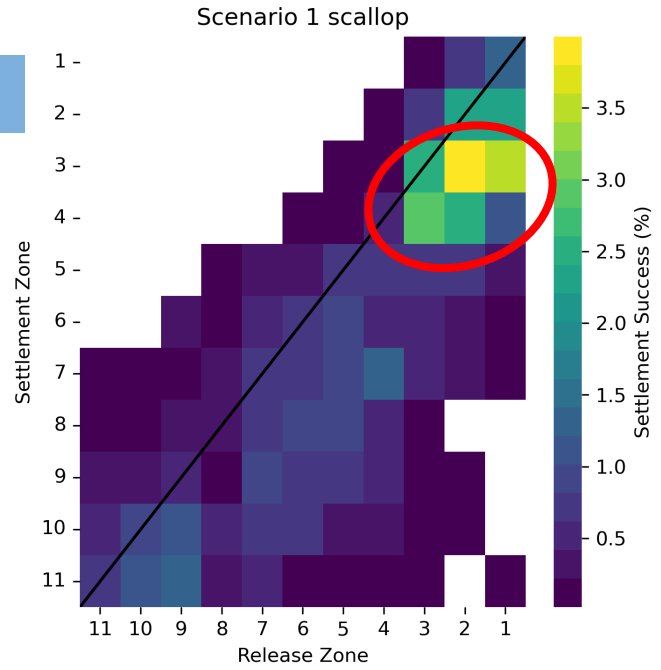
DVM

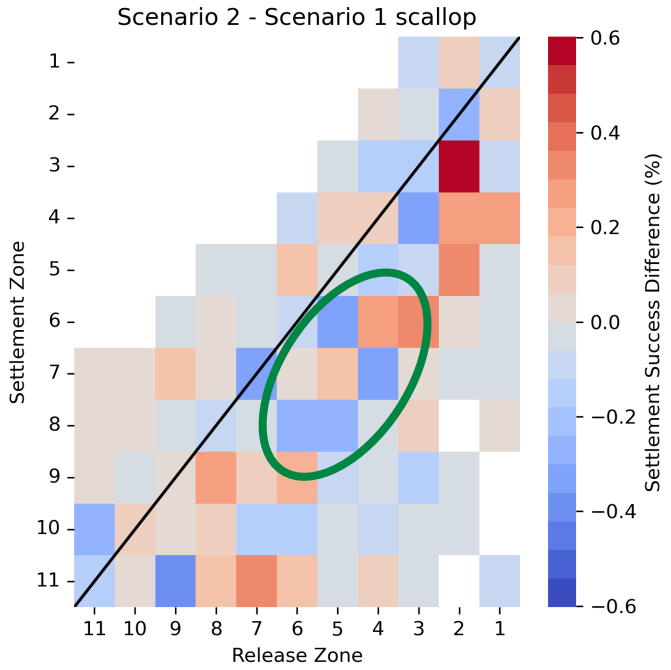


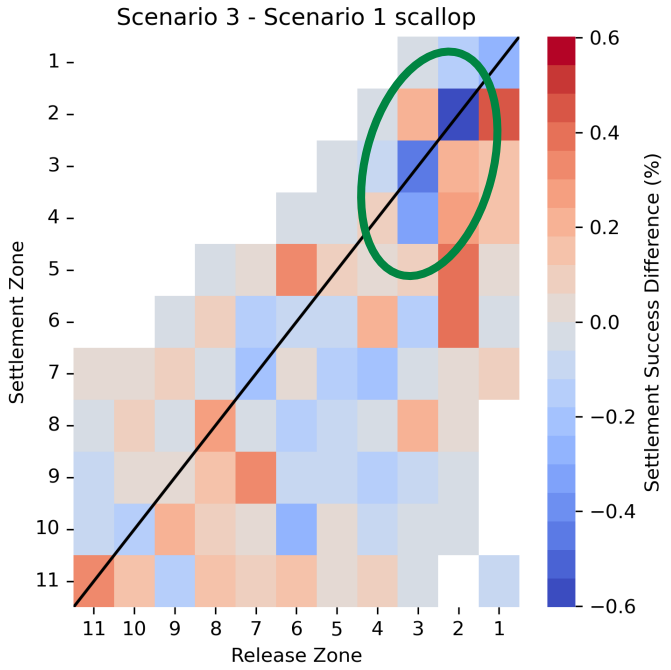
Most successful zone different

DVM influences peak zone

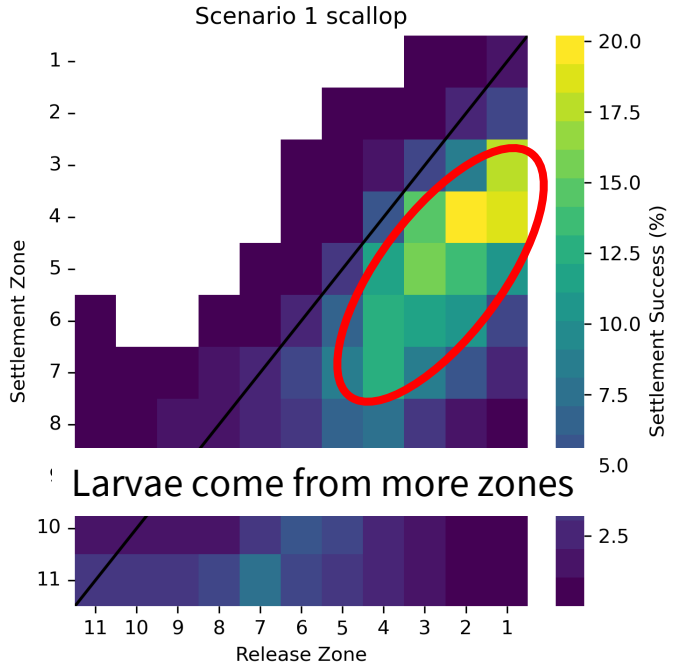
Passive

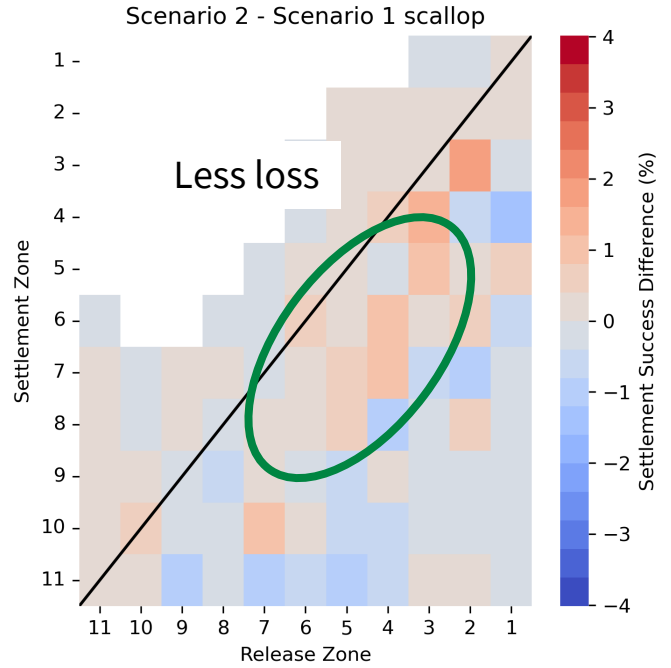

Scenario 1 scallop
Settlement Zone
Release Zone
Settlement Success (%)

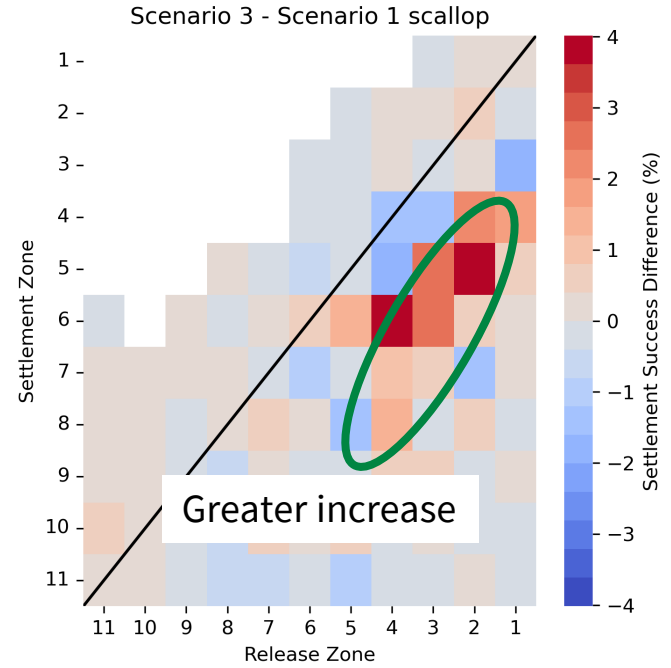

Scenario 2 - Scenario 1 scallop
Settlement Zone
Release Zone
Settlement Success Difference (%)


Scenario 3 - Scenario 1 scallop
Settlement Zone
Release Zone
Settlement Success Difference (%)

DVM


Scenario 1 scallop
Larvae come from more zones
Settlement Zone
Release Zone
Settlement Success (%)


Scenario 2 - Scenario 1 scallop
Less loss
Settlement Zone
Release Zone
Settlement Success Difference (%)


Scenario 3 - Scenario 1 scallop
Greater increase
Settlement Zone
Release Zone
Settlement Success Difference (%)

Conclusions for Larvae

- Larval connectivity effects of wind turbines are location dependent
- Connectivity hot spot for Atlantic sea scallop in northern part of domain persists with offshore wind development
- Inclusion of vertical migration behavior influences larval dynamics with and without offshore wind turbines
- The other species (Atlantic surfclam and black sea bass) see similarly mixed responses to offshore wind turbines.

Source: ACP

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Next Steps

The next F-TWG Meeting will be held on October 15, 2024, from 10:00 am – 12:00 pm EST

Agenda topics to include:

- **Cooling Water Use at Offshore Converter Stations Study, *Tetra Tech***
- **Boulder Relocation and Management Guidance Framework, *MA CZM***
- **OSW Overview Update, *BOEM***

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