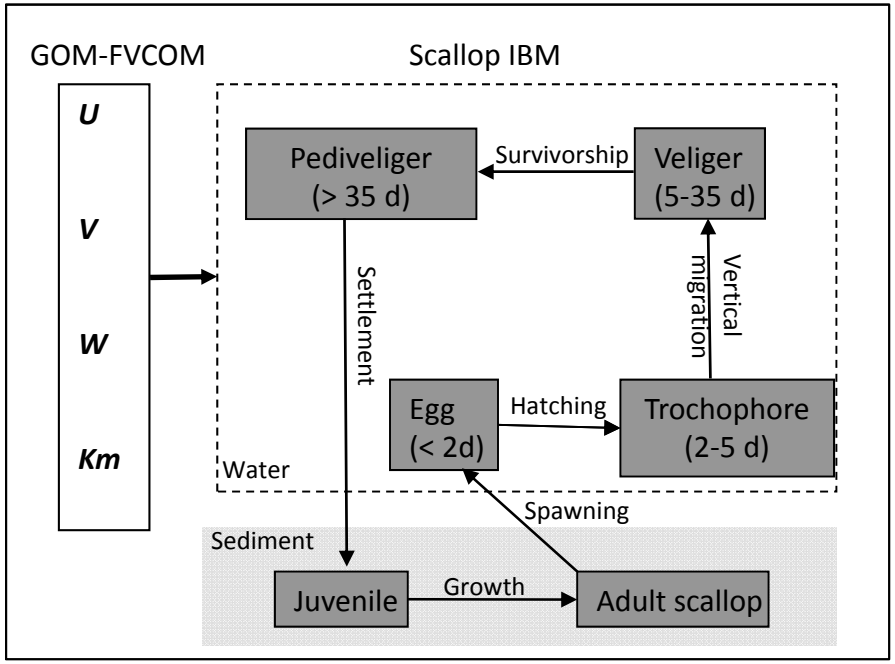
Critical Issues in Modeling the Dispersion and Settling of Scallop Larvae in the Northeast U.S. Coastal Ocean

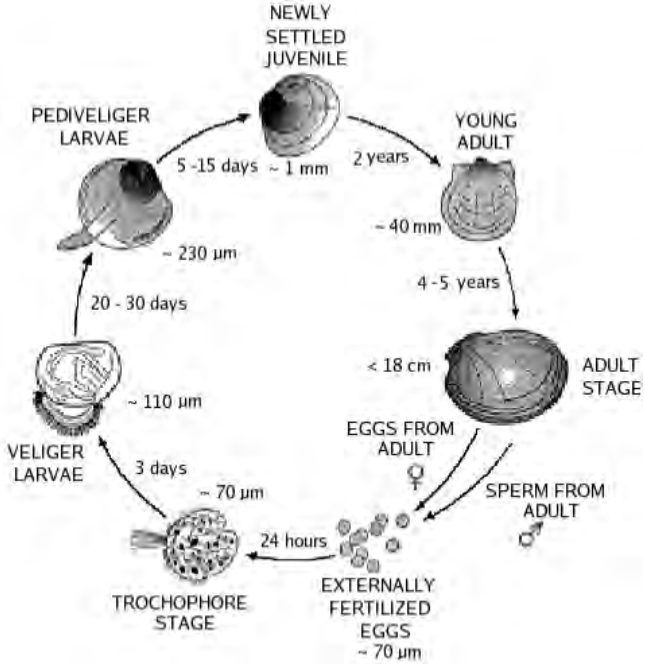
Changsheng Chen
School for Marine Science and Technology
University of Massachusetts-Dartmouth, New Bedford, MA 02744

Robert C Beardsley
Department of Physical Oceanography
Woods Hole Oceanographic Institution, Woods Hole, MA 02543

Population Dynamics Model of Sea Scallop

(Tian et al, 2009)

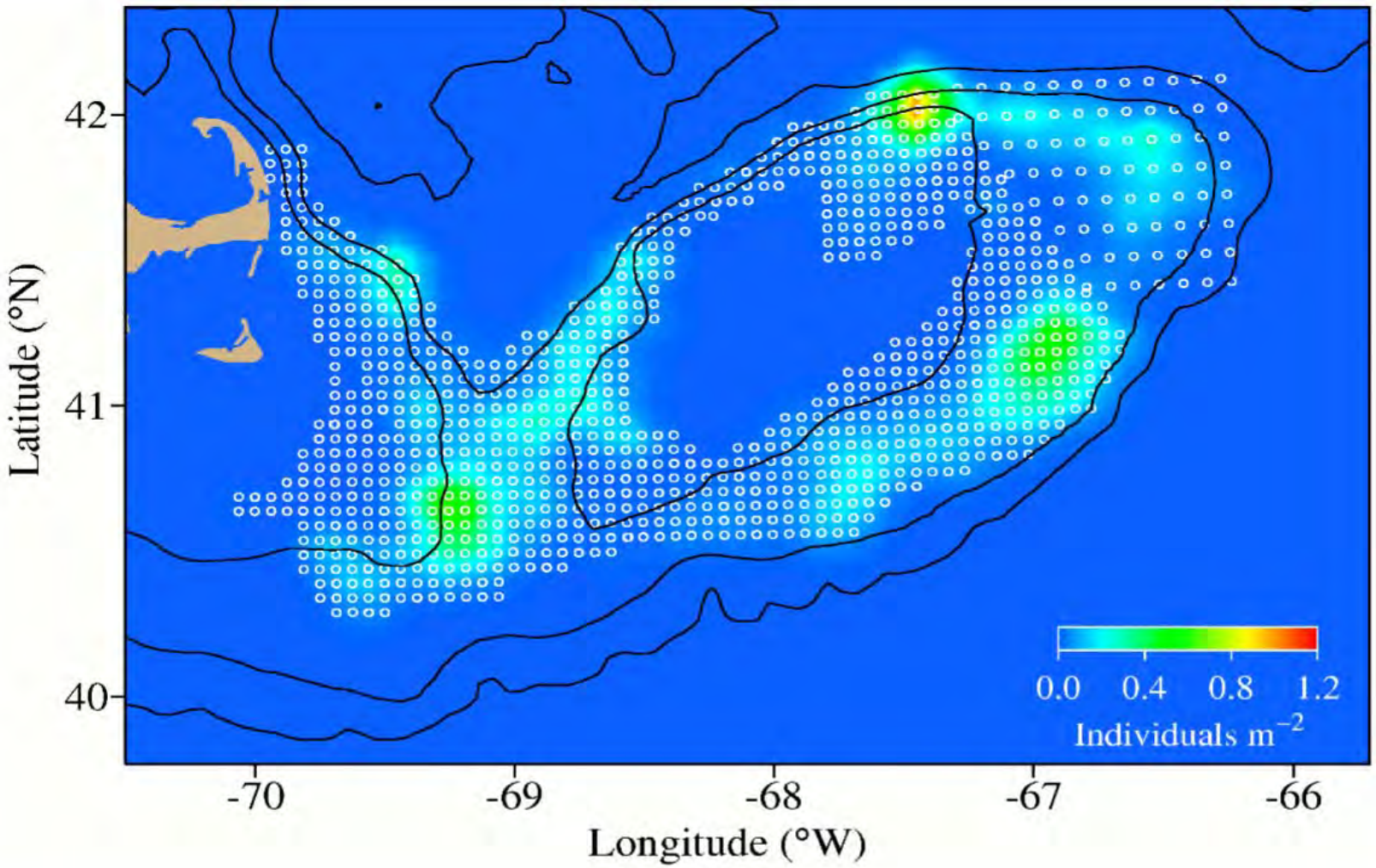


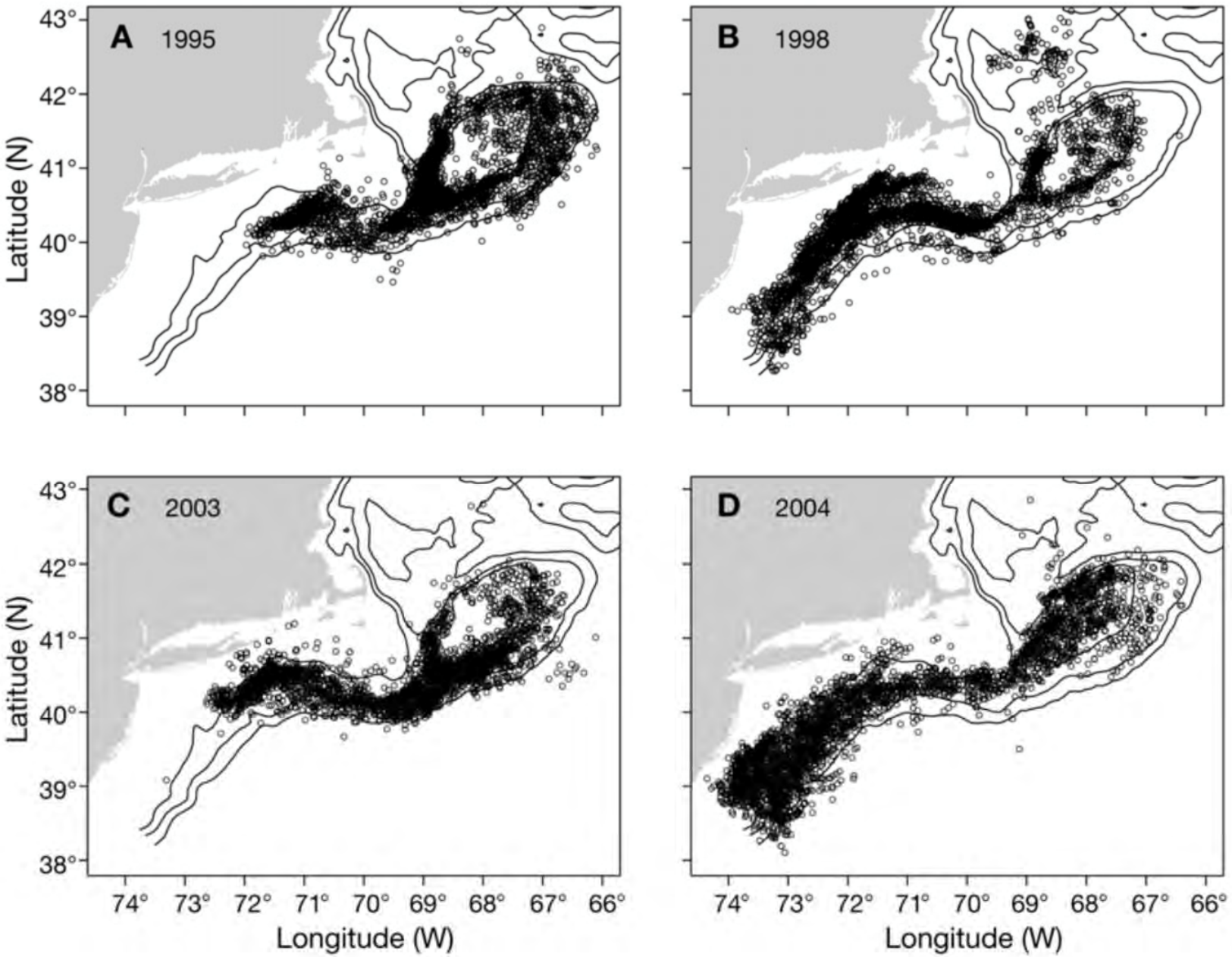


4 pelagic stages: egg, trochophore, veliger, and pediveliger

2 benthic stages: juvenile, and adult.

Spawning stocks determined by interpolating scallop abundance data onto the model grids. Scallop data (white circle) are from Stokesbury et al., (2004) and Thouzeau et al. (1991).

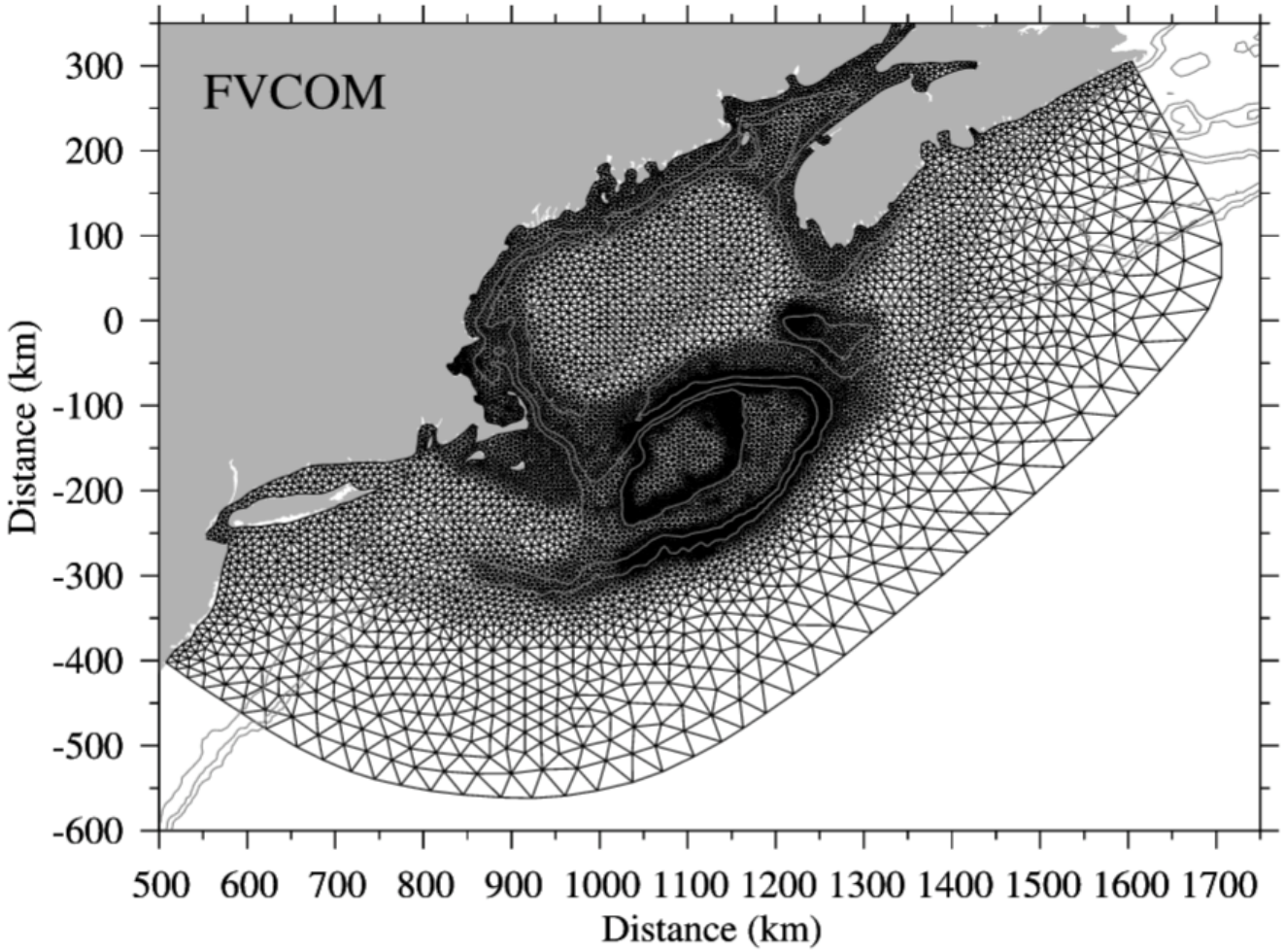



A 1995
B 1998
C 2003
D 2004
Latitude (N)
43°
42°
41°
40°
39°
38°
74°
73°
72°
71°
70°
69°
68°
67°
66°
Longitude (W)

What are missing regarding physical and Biological processes?

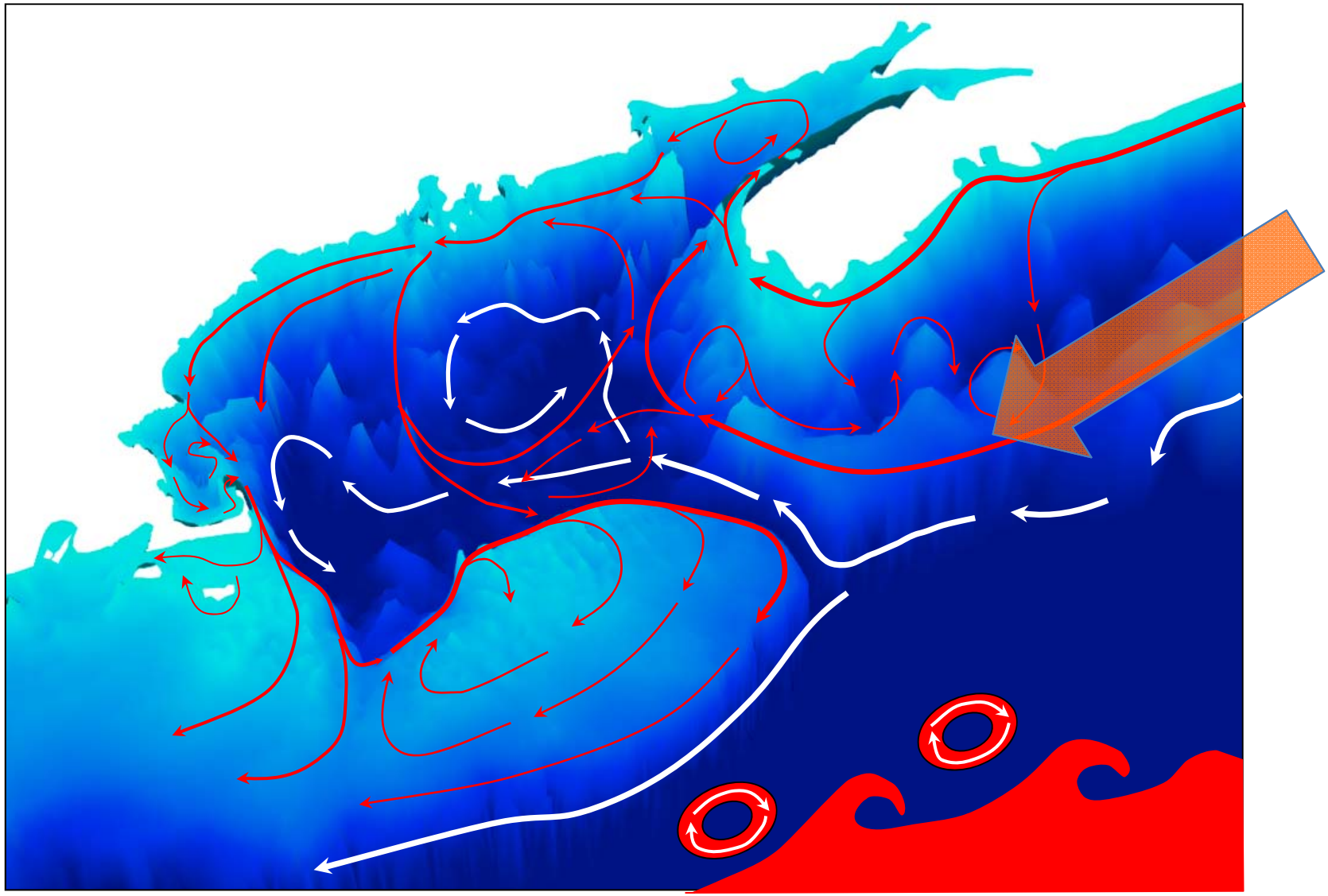
Physical Process:

First Generation Gulf of Maine FVCOM (GOM-FVCOM)



1. No interaction with the Gulf Stream
2. No upstream boundary flux

Schematic of the Upper and Deep Circulations



Biological Processes:

1. Post settlement growth with influence of post settlement swimming behavior:

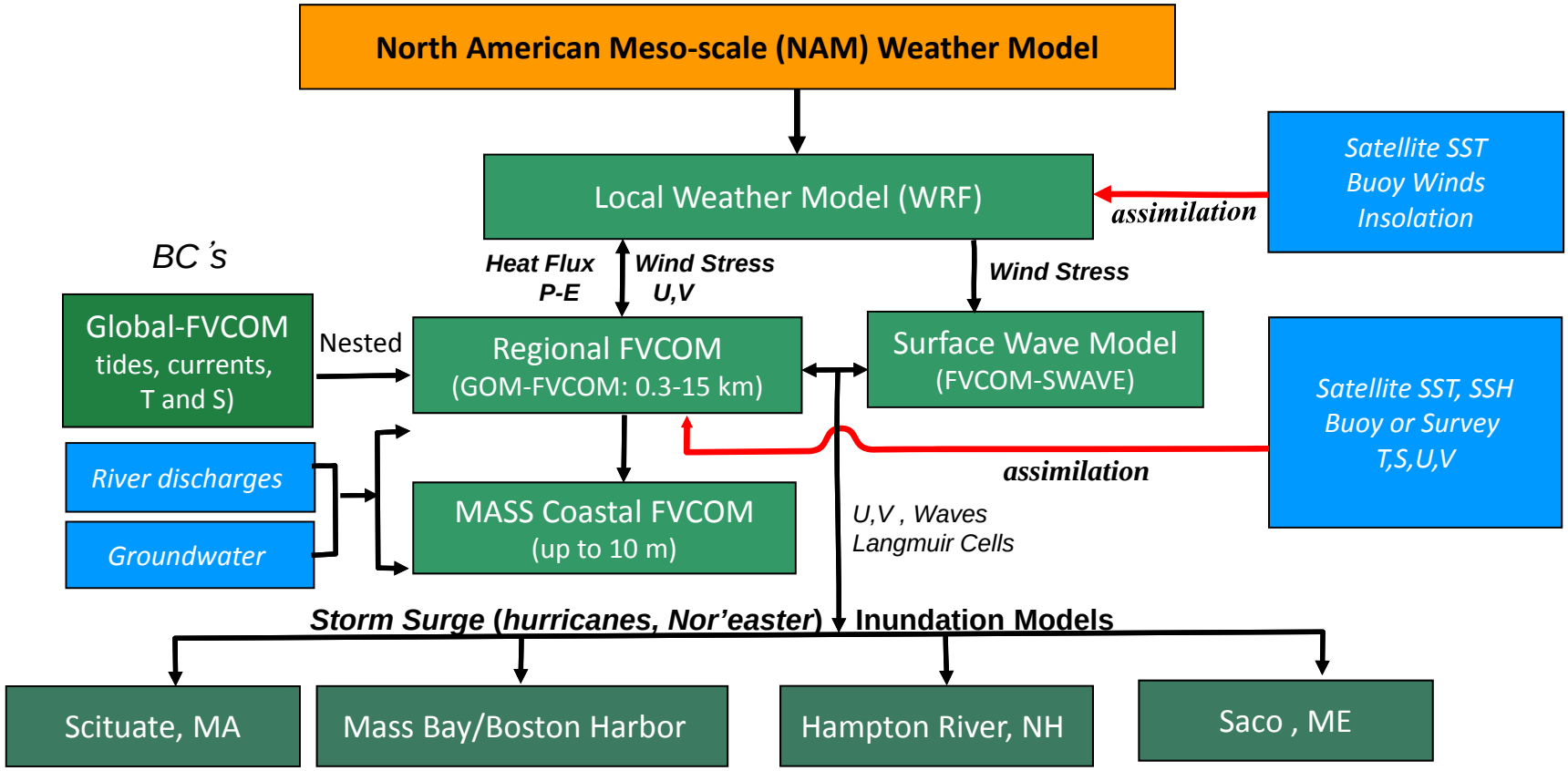
While early prodisochonch larvae (4 to ~40 days) actively swim between surface and thermoclines, late-stage pediveligers (40 to 50 days) cross the thermoclines and descend towards the bottom in preparation for settlement (Gallager et al., 1996).

2. Larvae's responses to algal density (food) and turbulences:

Larvae respond to algal density (food) in a concentration-dependent way by spending more time at depths where algal density is higher (Gallager et al., 1996). Larvae also respond to ephemeral pulses of turbulence greater than 10^{-7} $W.Kg^{-1}$ by withdrawing their velum and sinking rapidly until the turbulent energy has subsided (Pearce et al., 1998).

3. Benthic stages: feeding, predation, starvation, resuspension and natural/fishing mortality.

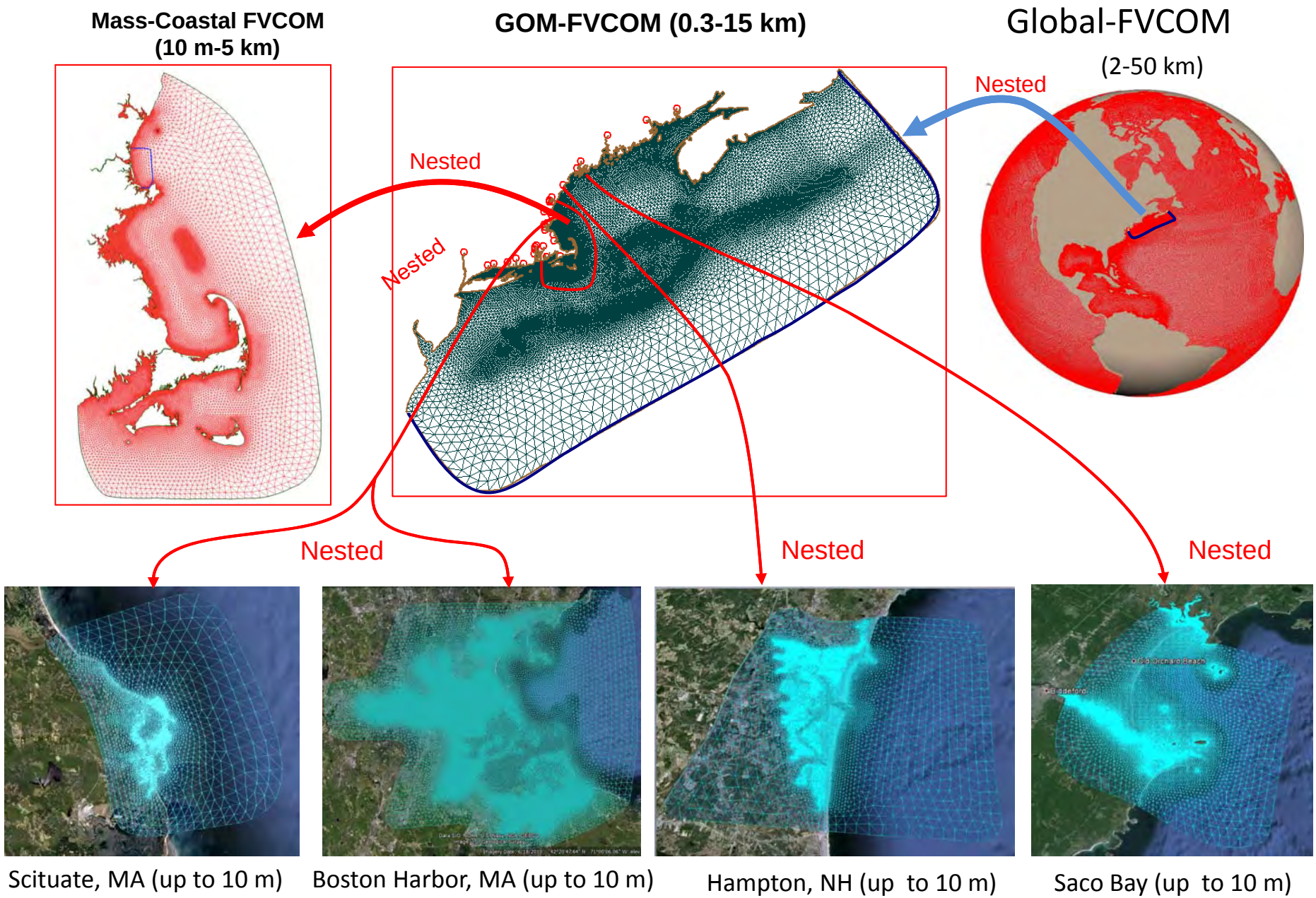
Northeast Coastal Ocean Forecast System (NECOFS)



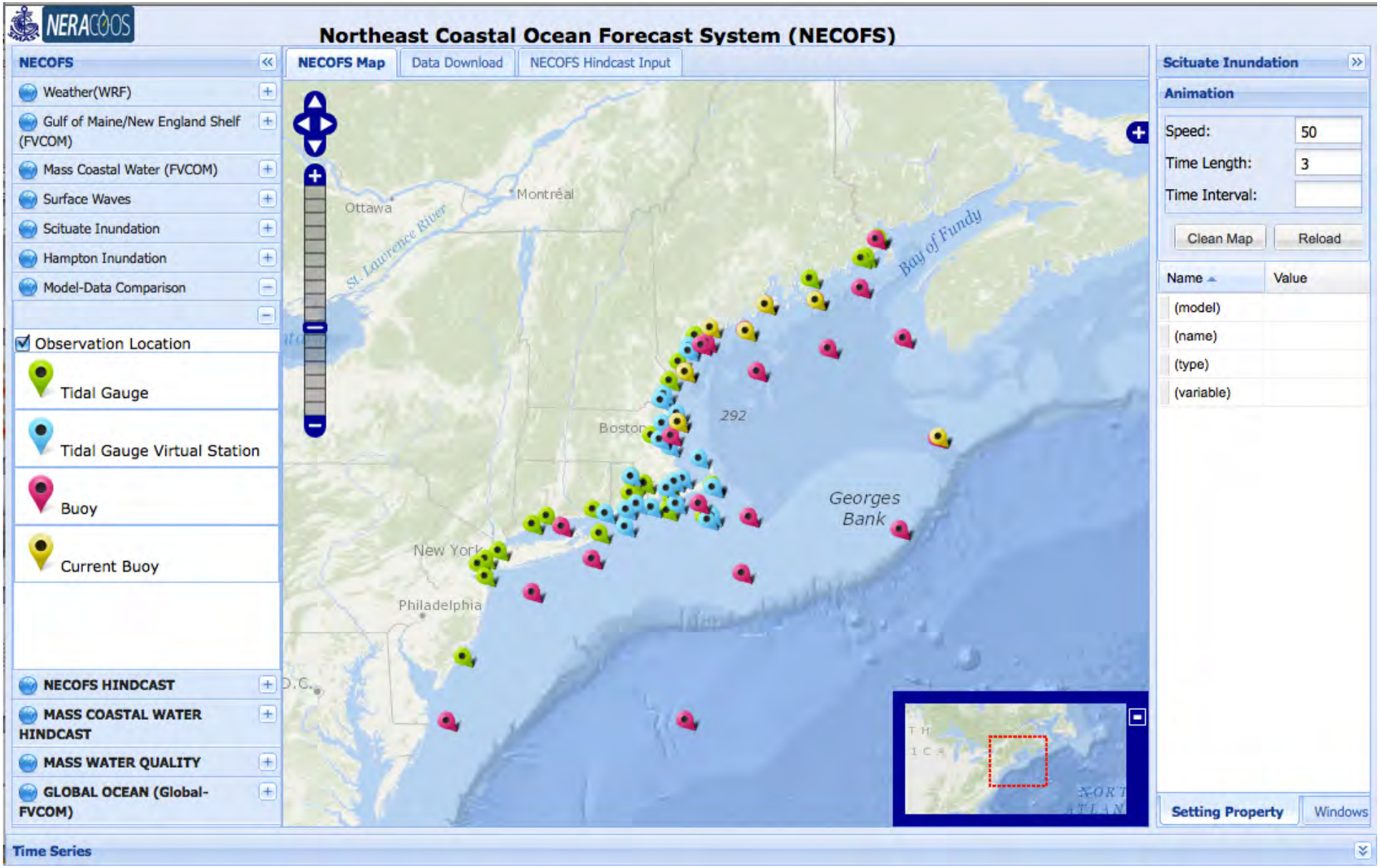
Products:
Weather: winds, air temperature, air humidity, air pressure, heat flux, E-P
Oceans: sea level, currents, T, S, wave heights, wave frequencies, icing
Lands: inundation areas

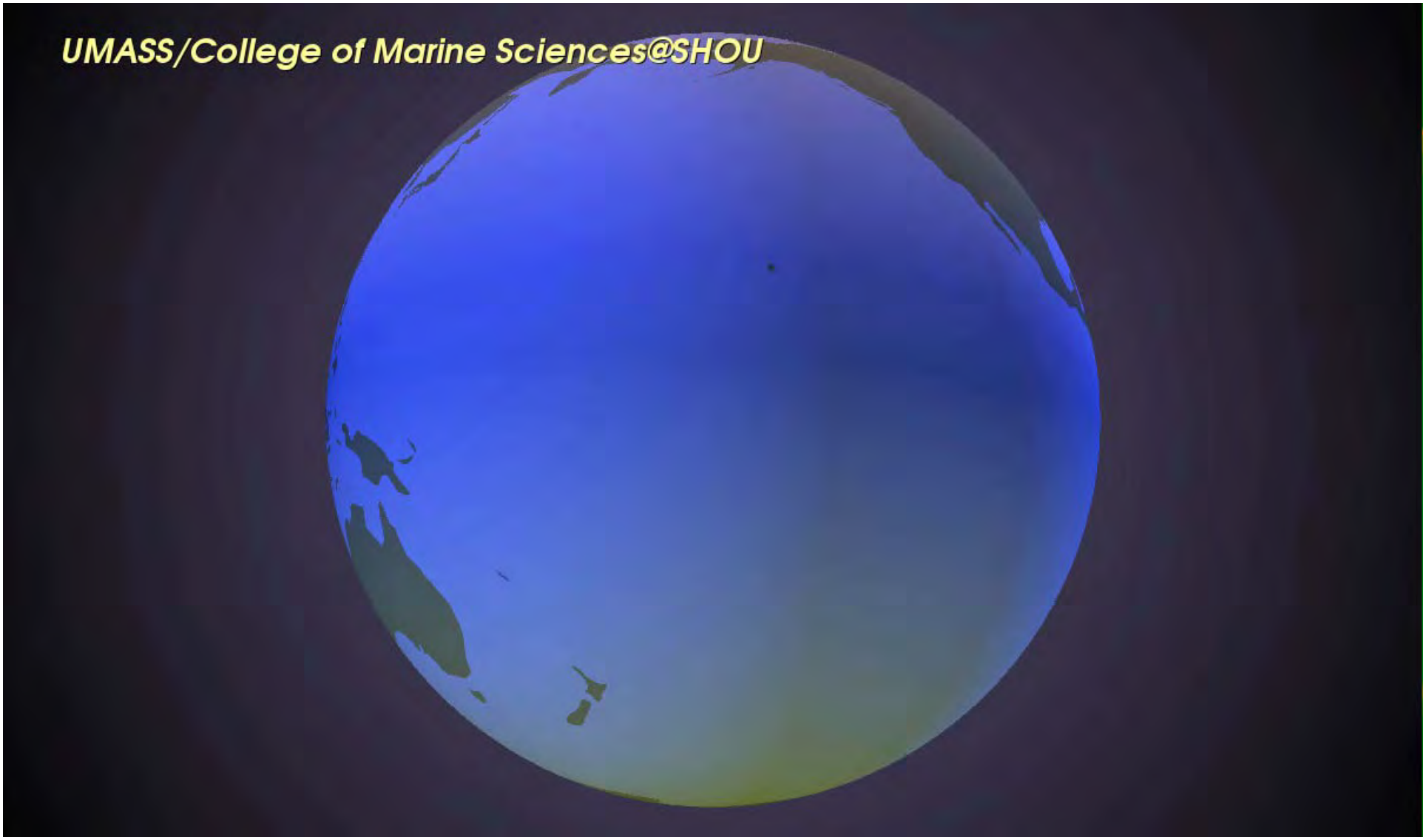
KEY

- Existing Models
- NECOFS
- Data
- Products


Mass-Coastal FVCOM
(10 m-5 km)
GOM-FVCOM (0.3-15 km)
Global-FVCOM
(2-50 km)
Nested
Nested
Nested
Nested
Nested
Nested
Scituate, MA (up to 10 m)
Boston Harbor, MA (up to 10 m)
Hampton, NH (up to 10 m)
Saco Bay (up to 10 m)

http://porpoise1.smast.umassd.edu:8080/fvcomwms/




UMASS/College of Marine Sciences@SHOU

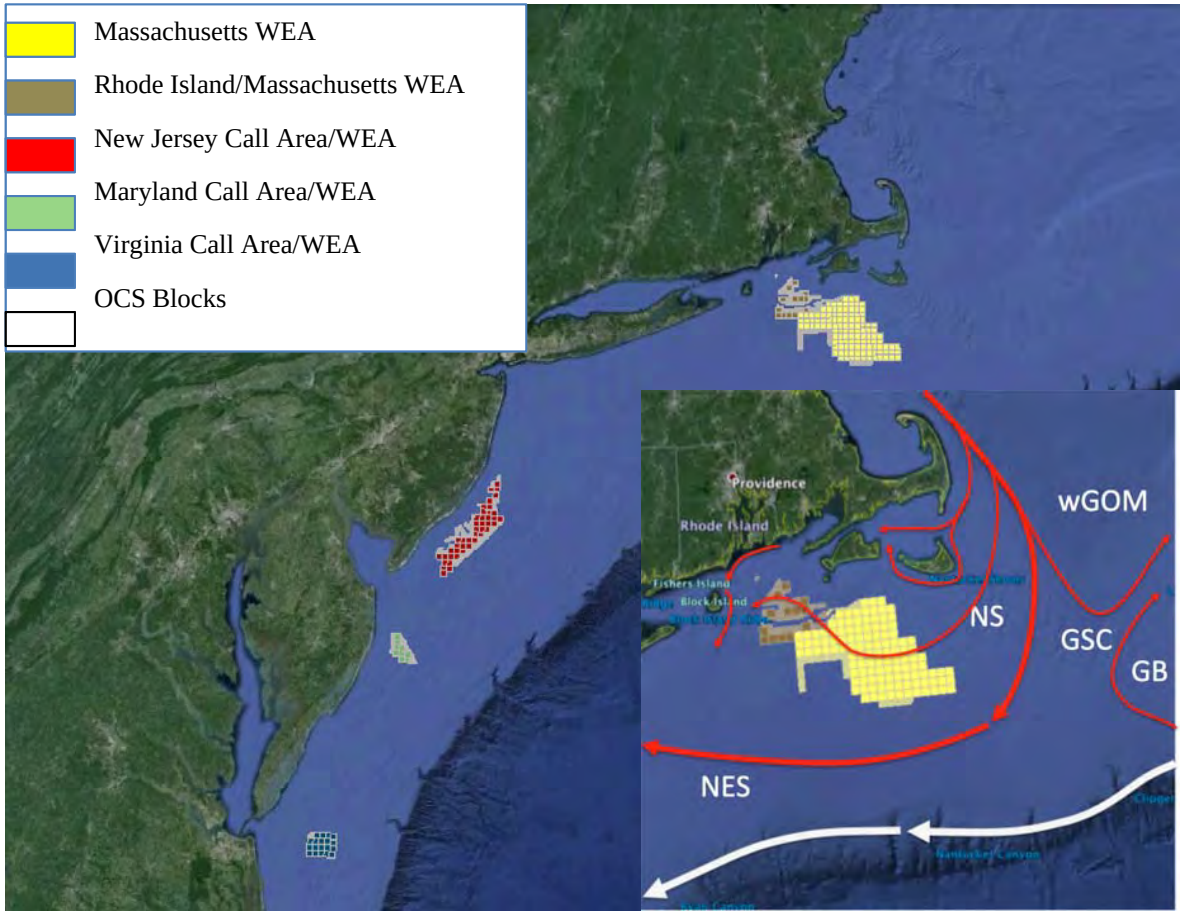
Products:

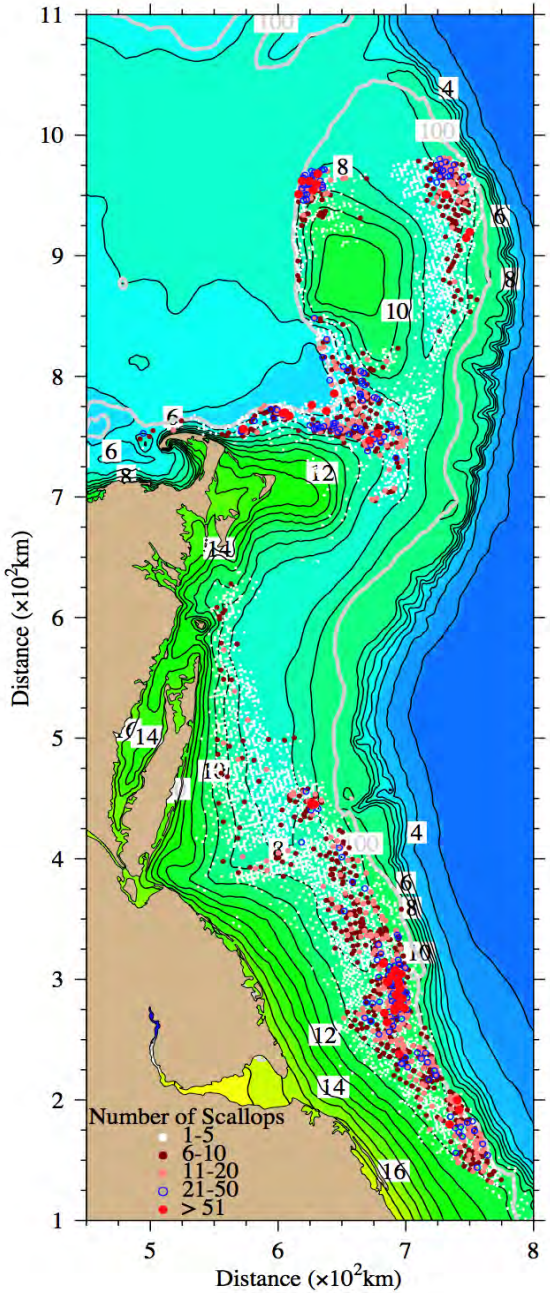
The Global-regional nested FVCOM system has produced hourly hindcast assimilation physical field over the period from 1978 to present (2015) .

The results has been validated for

- Water level measurements at tidal gauges (Chen et al, 2011)
- Temperature and salinity (Li et al., 2015)
- Surface current measurements (Sun et al. 2015)
- Model-drifter comparisons (Sun, 2014)

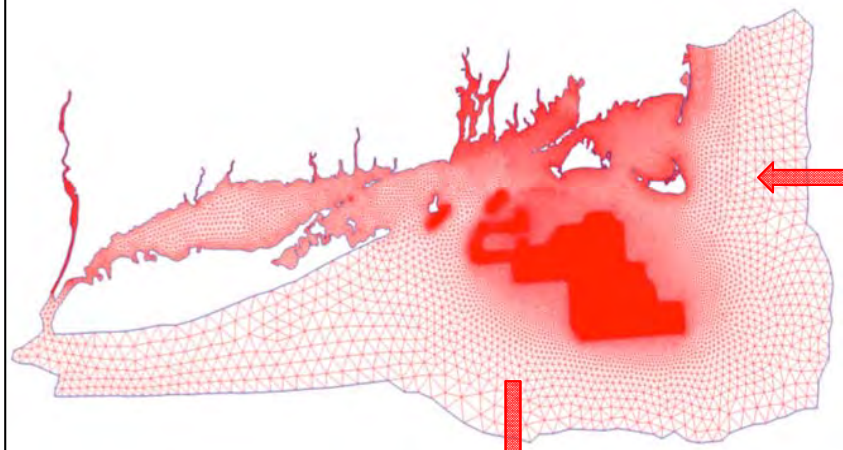
Could the offshore wind renewal energy development affect the connectivity of scallop between Georges Bank/South South Channel and Mid-Atlantic Bight?

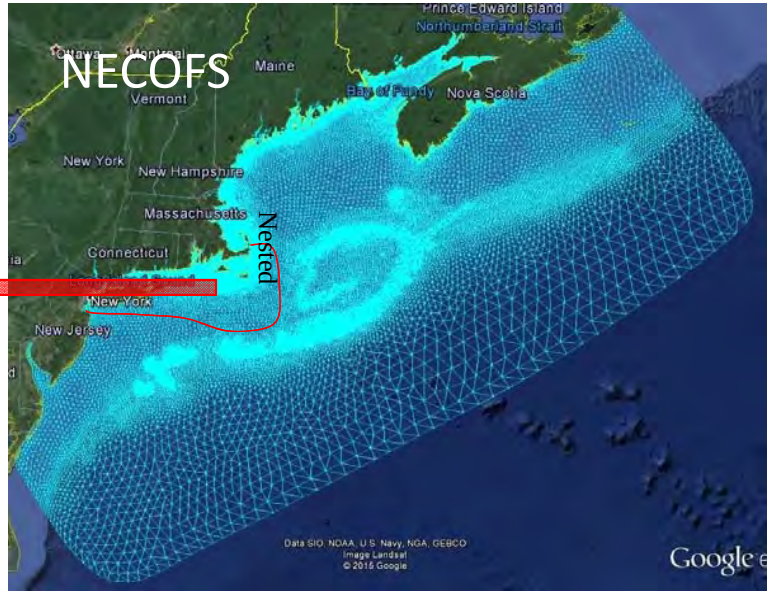




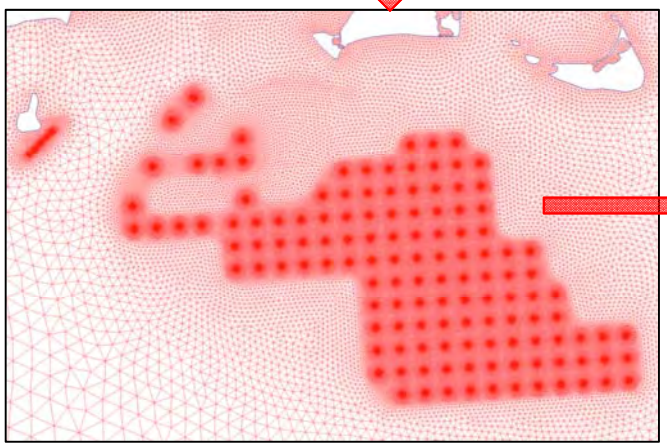
New NECOFS system with inclusion of a nested subdomain wind turbine-resolving FVCOM

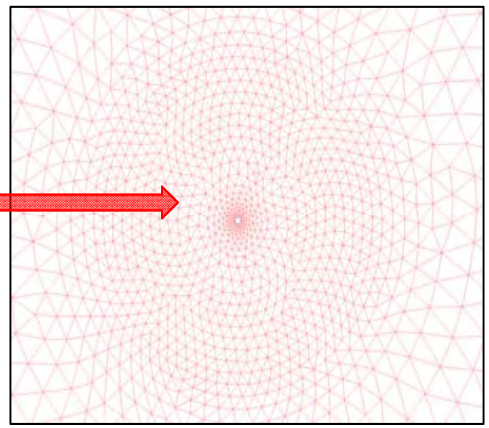
NS-FVCOM with wind turbines

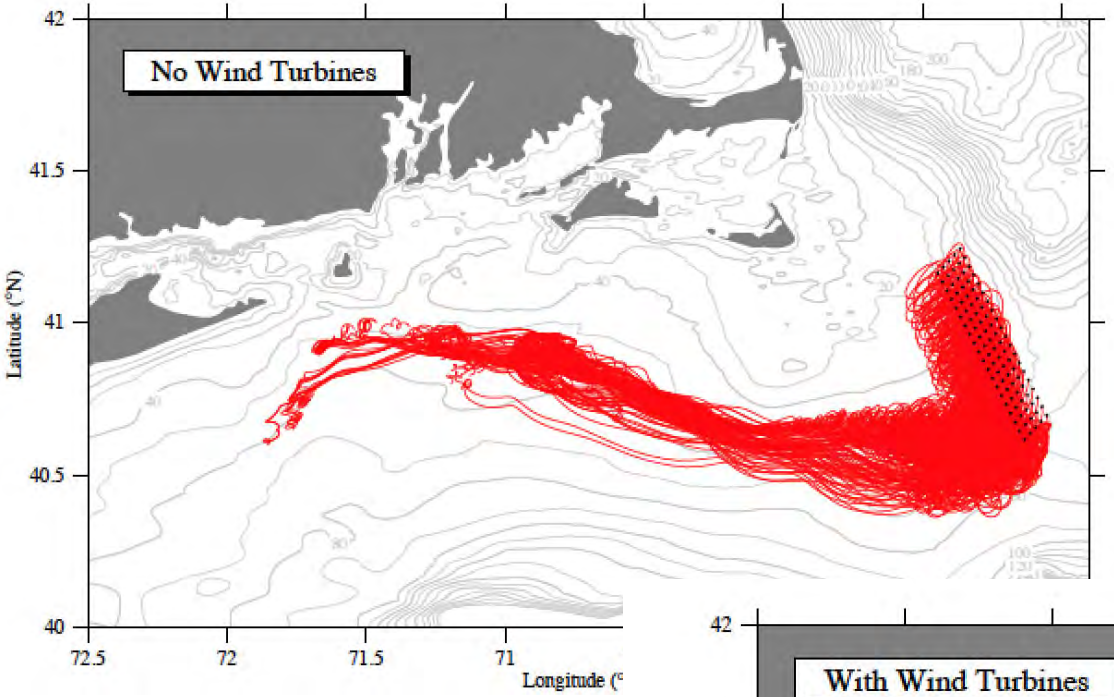




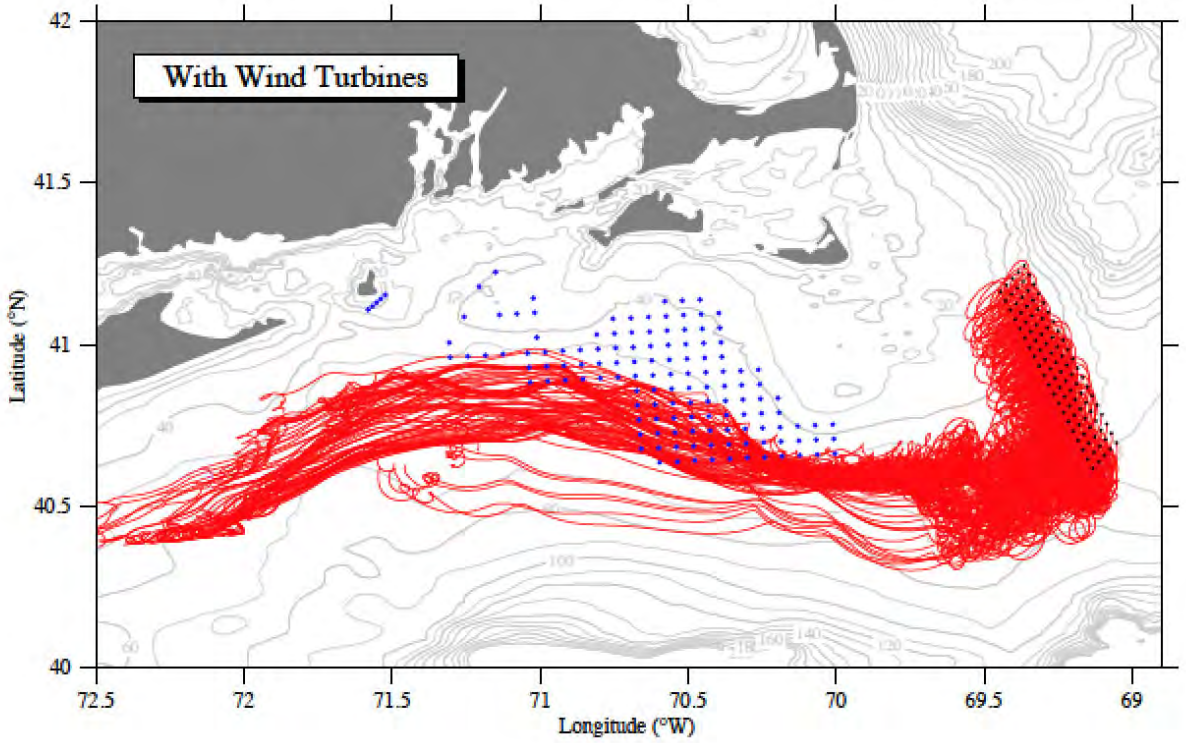
Enlarged view of the grid







The 1978 February Nor'easter Storm case.



What could happen during the spawning, transport, settlement and growth stages of scallop larvae with a long-time simulation?

Summary

- It is worth to re-conduct the scallop-IBM experiments using the new physical fields with inclusion of 1) the upstream inflow and interactions with the Gulf Stream and 2) more complete and realistic biological processes.

- An assessment of the potential impact of the offshore wind farm development on the connectivity of scallop larvae between Georges Bank/South South Channel and Mid-Atlantic Bight should be also carried out.