# Assessing vulnerability of the Atlantic Sea Scallop social-ecological system in the northeast waters of the US

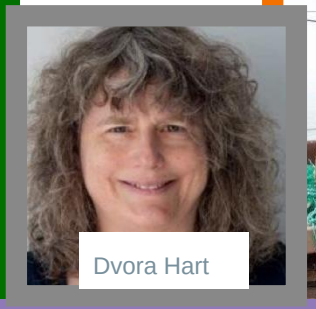
**Project Team:**
**Siedlecki (co-lead), Meseck (co-lead), Colburn (co-lead), Hart, Bethoney, Matassa, Curchitser**

Image credit: NASA

Oceanographers, Scallop Biologists, Ecologists, Social Scientists, Managers, Industry Partners

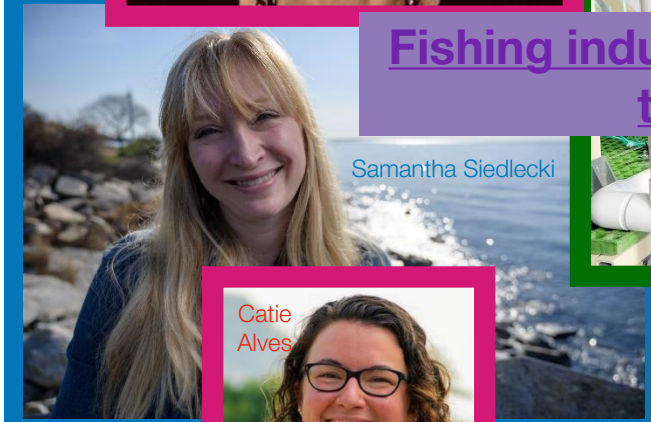
# Meet the multidisciplinary project team







**Fishing industry feedback is a core component of the success of this project.**



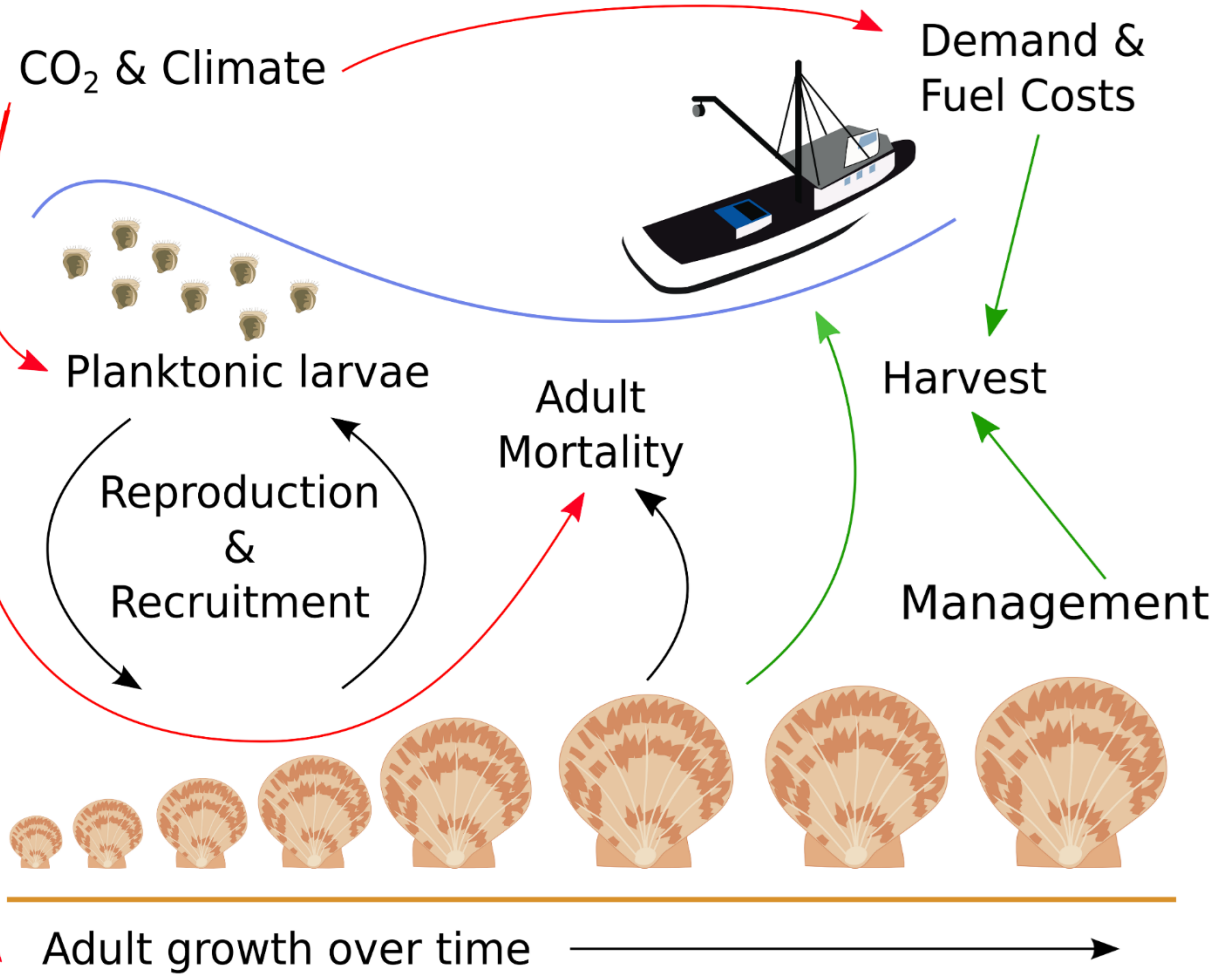







Our goal is to help people continue fishing in the region in the future, despite anticipated changes, by investigating ways in which the fishery could build resilience






Scallops live for a long time - projections out to 2100 traverse only *4 generations* from now

Adults grow for a long time - 4 to 5 years until harvest size currently

Larvae and adults occupy different regions of the water column

Figure from Rheuban et al. 2018

# Fishery already seeing changes

## Ocean Warming, Ocean Acidification, or both?

- Shift in biomass north into the Gulf of Maine observed over many decades (1990 to 2015)
- Formal managed rotational closure program began in 2004
- NEFMC closes areas with large concentrations of fast-growing, small sea scallops to protect them
- This process boosts sea scallop meat yield and yield per recruit (Hart 2003)

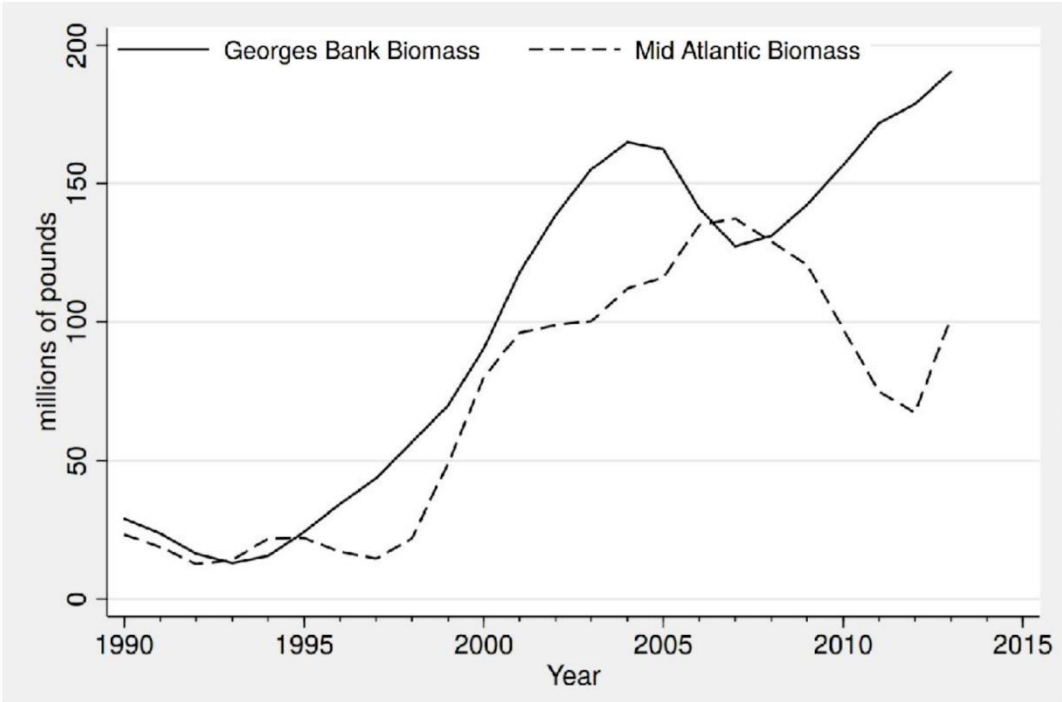
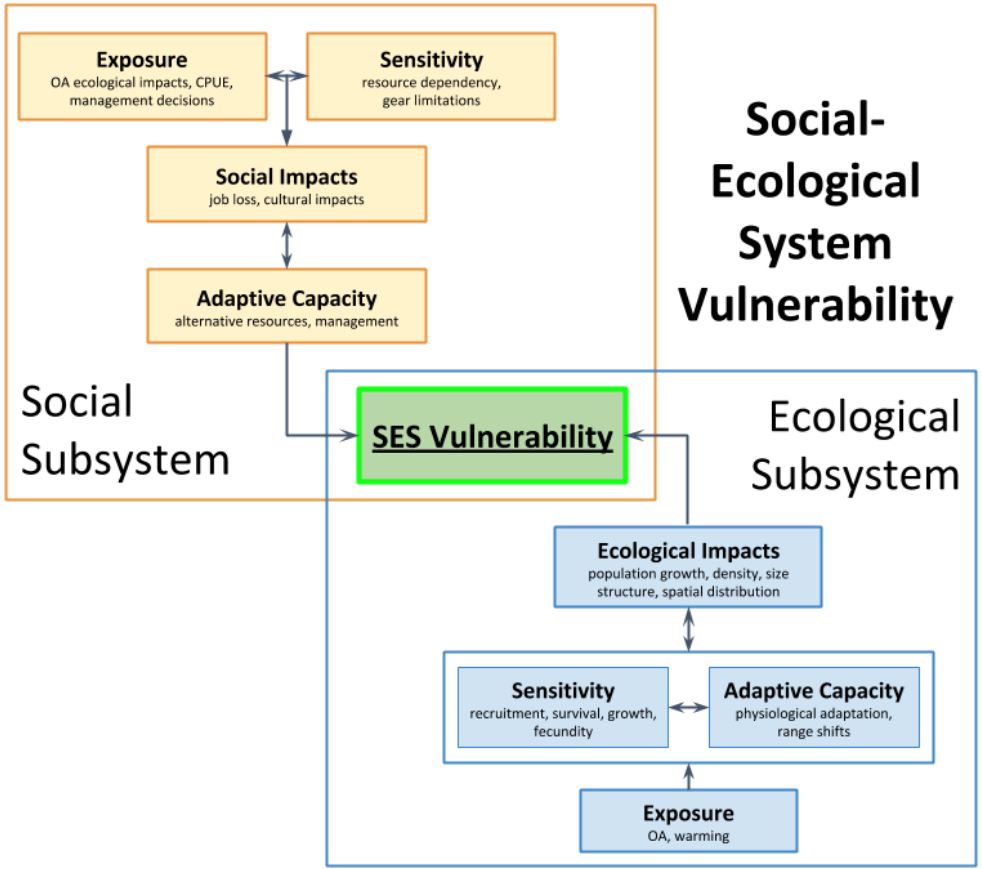



Figure from Lee et al. 2017




Main project objectives:

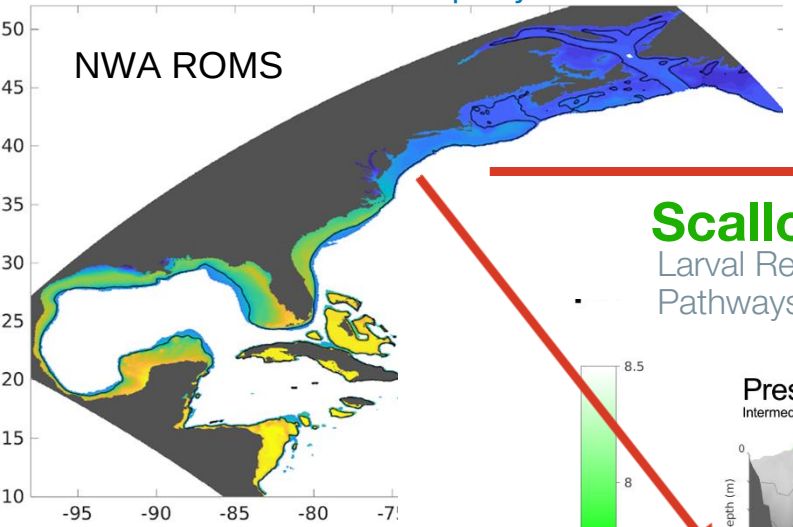
1.) Determine the vulnerability of the sea scallop fishery to OA and temperature changes

2.) Investigate ways in which the fishery could choose to build resilience to these projected changes.

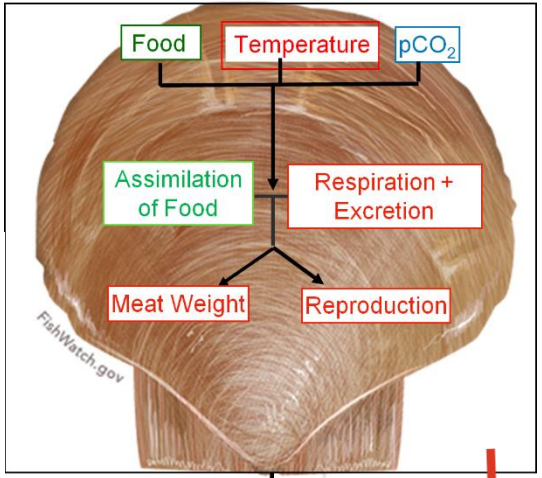
*(Yesenia Carrero /UConn Illustration)*

# Natural Science tools applied to the issue -Models

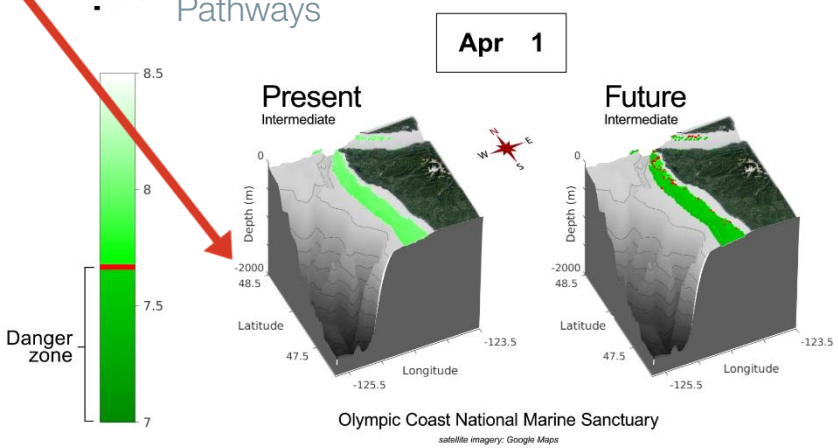
## Ocean Conditions
Historical trends and projections




## Scallop Biology
Dynamic Energy Budget Model




## Scallop Distribution
Larval Recruitment and Retention Pathways



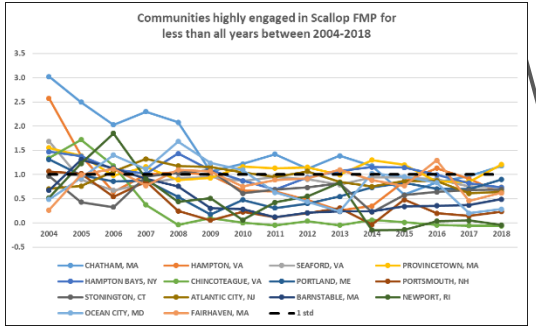

**Maps of projected growth rate (time to harvest) and recruitment changes expected**

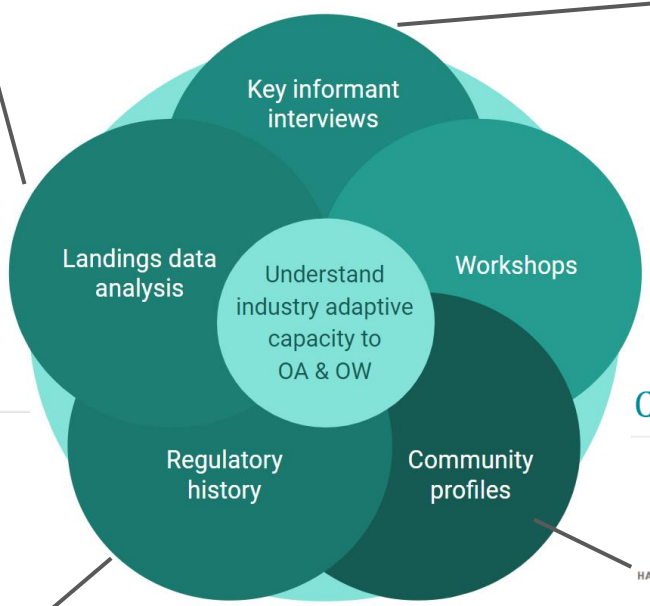
COASTAL BIOGEOCHEMISTRY DYNAMICS LAB

UCONN AVERY POINT

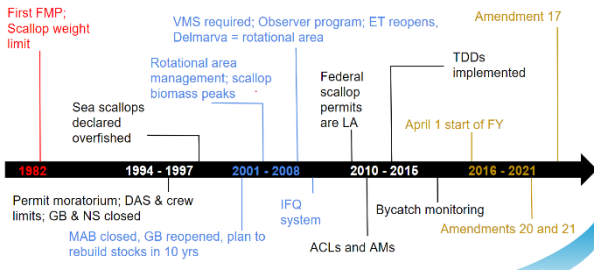
RUTGERS

# Social Science tools used to understand the human dimensions of the scallop industry

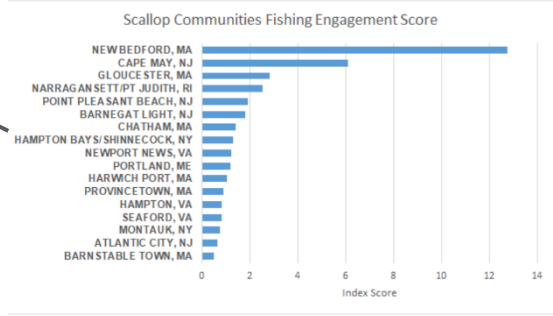



## Regulatory history




## Community Profiles



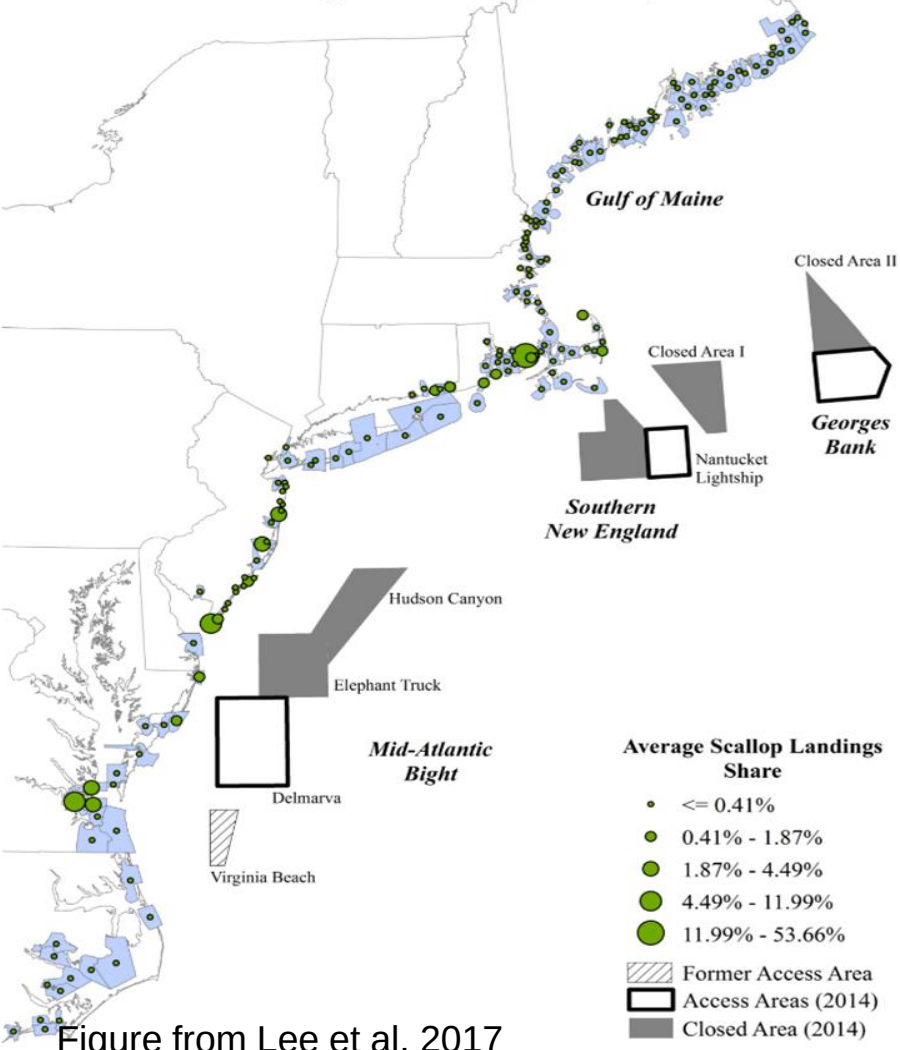



Figure from Lee et al. 2017

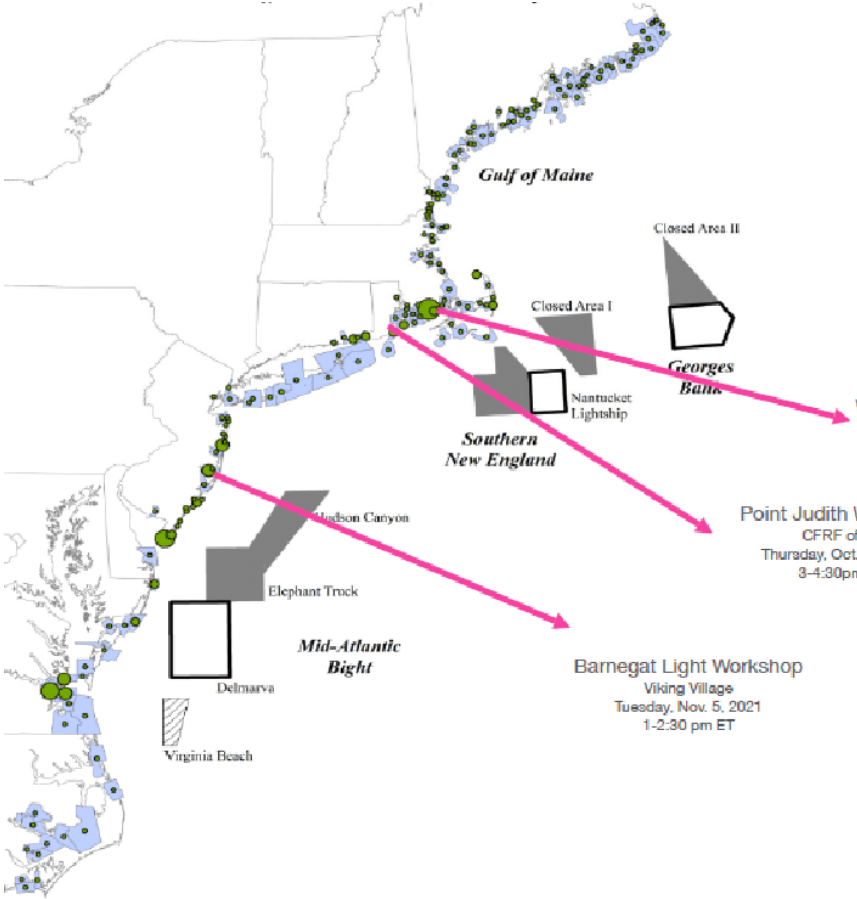
# Using rigorous, transparent scientific methods, we plan to:

1. Study sea scallops' biological vulnerability to warming and acidification using computer models enriched by laboratory results from previous NOAA-based scallop research;
2. Use future scenarios of ocean change that include realistic levels of ocean warming and acidification to understand the degree to which sea scallop populations are exposed to harmful OA and temperature conditions;
3. Seek the input of fishery members to understand how exposed the sea scallop fishery is to any harvest changes that may follow from future ocean conditions;
4. Collaborate with the sea scallop industry and resource managers to identify useful management options that can be used by the existing successful management system to help ensure an abundant fishery, now and in the future;

# Key Products

**In collaboration with the sea scallop industry and managers, generate recommendations for future management actions based on our findings for use in resilience planning, and management.**

*(Yesenia Carrero /UConn Illustration)*




Lee et al. 2017

# Workshops

## Stakeholder input needed

- New Bedford, Whaling City Seafood Auction, October 5 (8 external participants)
- Point Judith, Commercial Fisheries Research Foundation, October 21 (4 participants)
- New Jersey, Viking Village, November 5 (17 participants plus Anastasia Lennon, reporter from New Bedford Light)

# Workshop Announcement Flyer

## Adapting to Ocean Warming and Acidification in the Atlantic Sea Scallop Fishery

### What is Ocean Acidification (OA)?

Carbon dioxide ($CO_2$) from the air added to seawater changes the water chemistry, reducing pH and carbonate levels in the ocean. Saturation state ($\Omega$) is a measure of carbonate concentrations: lower $\Omega$ = lower carbonate.

**Scallops need carbonate to grow and maintain shells**

### SIGNS OF OA ON ATLANTIC SEA SCALLOPS


We are a multidisciplinary team seeking to understand how changing ocean conditions ( ocean warming and OA) affect the Atlantic Sea scallop fishery, and how the fishing industry and communities can prepare for and adapt to those changes.

We will be hosting a series of workshops with the scallop industry across the Northeast region with regional experts to answer any questions about the current oceanographic and biological knowledge on ocean warming and OA impacts, learn about your experiences, and answer any questions about the project.

**Fishing industry feedback is a core component of the success of this project.**

Using predictive models of how sea scallop populations will respond to ocean changes and the socio-economic impacts of those changes, alongside workshop outcomes, we will investigate ways the fishery could choose to build resilience to these projected changes.

Our goal is to co-develop tools and strategies to help scallop fishing communities adapt.

Learn more about the team and project HERE

**It is important to get input from the scallop industry about what information is needed.**

## WORKSHOPS

Workshop participation will be both in person and remote

**New Bedford, MA: October 5, (11:00-12:30pm)**
**Whaling City Seafood Auction**

**Point Judith, RI: October 21, (3:00-4:30pm)**
**Commercial Fisheries Research Foundation**

**Barnegat Light, NJ: November 5, (1:00-2:30pm)**
**Viking Village**

Contact Susan Inglis at singlis@cfrfoundation.org for more information on the workshops and the weblink to participate remotely

# Digital Tri-Folding Workshop Brochure

## MEET THE TEAM

**University of Connecticut**
- Samantha Siedlecki
- Catherine Matassa

**Commercial Fisheries Research Foundation**
- N. David Bethoney
- Susan D Inglis
- Michael Long

**National Marine Fisheries Service**
- Lisa L. Colburn
- Shannon Meseck
- Dvora Hart
- Mike Alexander

**Rutgers University**
- Enrique Curchitser

**Advisory Council**
- Michael Marchetti (Captain, Eastern New England Scallop Association)
- Beth Turner (NECAN Northeast Coastal Acidification Network)
- Sarah Cooley (Climate Policy, Ocean Conservancy)

## WE NEED YOUR HELP

Workshops for stakeholders will be conducted to answer questions, get your input and discuss:
- current conditions
- changes you are observing
- your concerns on fishery impacts
- project recommendations
- project results




Illustration from Rheuban et al 2018 PloS ONE

To learn more about this project visit http:// www. cfrfoundation. org/ Atlantic Sea Scallop Social- Ecological System

if you are interested in joining a workshop contact:
Susan Inglis: singlis@ cfrfoundation. org
(401) 515-4892

**Stay Tuned For Workshop Dates!**

## WILL CHANGES IN OCEAN WATER TEMPERATURE AND CHEMISTRY IMPACT YOUR FISHING COMMUNITIES?



**A COLLABORATIVE RESEARCH PROJECT**

Funding provided by the National Oceanic and Atmospheric Administration NOAA

## ARE SCALLOPS SENSITIVE TO OCEAN ACIDIFICATION?

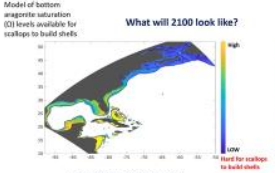
The Atlantic sea scallop fishery in the Northeast provides the second highest fisheries revenue in the United States.

This ecosystem is experiencing dynamic changes in temperature (increasing 3x faster than the global average), precipitation, and ocean acidification that may threaten this fishery.

Calcium carbonate is usually abundant or supersaturated in oceans so scallops can build shells

**BUT**

ocean acidification can reduce the saturation ($\Omega$) level of available calcium carbonate making it harder for scallops to build their shells.




NorthWest Atlantic model

**Scallops use calcium carbonate (calcite and aragonite) to build their shells, ocean acidification can negatively impact:**
- scallop growth
- survival
- calcification (shell repair/maintenance)
- settlement

*The vulnerability and resilience of fishing communities to the effects of ocean warming and acidification is dependent on their ability to adapt to changes to their fisheries.*

## PROJECT GOALS

1. Identify sea scallop fishing communities vulnerable to ocean agnographic changes
2. Learn how resilient these sea scallop dependent communities are regionally
3. Improve population level vulnerability assessment methods for scallops
4. Develop projections for sea scallop fishery vulnerability in 2100:
   - historical and future ocean acidification level effects on sea scallop populations
   - how information on ocean acidification and water temperature can be used in fishery decisions regionally
   - generate management recommendations using community, industry and manger input

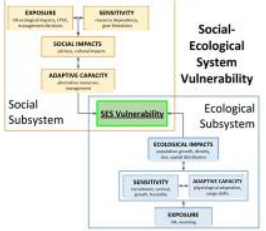
*To understand the impact of changes in water temperature and ocean acidification to the scallop fishery, this project looks at how vulnerable sea scallops and the fishing communities are to these changes, and develops recommendations on how to build resiliency to these changes.*

## COLLABORATION

This study looks at the scallop fishery social ecological system vulnerability to ocean changes using data from stakeholder workshops and biological and oceanographic models.

Photo From: Resilient Fisheries R Project

Stake holder workshops collect input on what changes are being observed and options to create community resiliency to these changes.




Industry collected data sets from CFRF/WHOI Shelf Research Fleet and CFRF Lobster and Jonah Crab Research Fleet will be used to help evaluate the model

Commercial Fisheries Research Foundation (CFRF)-WHOI Oceanographic Research Fleet

**Flyer and Brochure Distribution**

Digital:

CFRF Eblast, Facebook, Web page

*Telephone calls to scallop industry to let them know about workshops

Hard Copies:

Processing plants, scallop auction

## Summary of Workshops in 2021

**Pilot Workshop** took place April 2, 2021 with 5 scallop industry partners.

- Based on their feedback we made modifications to the agenda to better address fishermen's questions about OA and its impact on the scallop fishery.

**Three Workshops**: New Bedford (8), Point Judith (4), Barnegat Light (17 plus reporter)

- Overall, the workshops were successful at generating interest in OA impacts on the scallop fishery and fishermen had a lot of questions following the presentations.

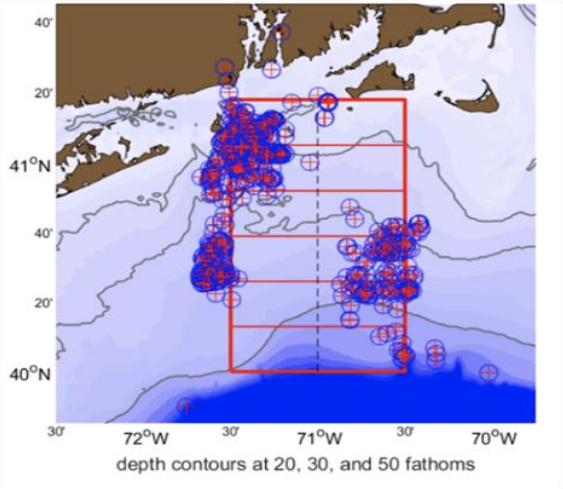
- Noticed an increased interest in the workshop content in the Point Judith and New Jersey workshops. This may be due to fishermen starting to observe some of these changes, particularly warming sea water temperatures.

- Workshops were helpful providing contacts for the Interviews

# Key Workshop activity - Trust Building with the model - comparisons to industry collected T, S data

## The CFRF-WHOI Shelf Research Fleet Obs. Dataset

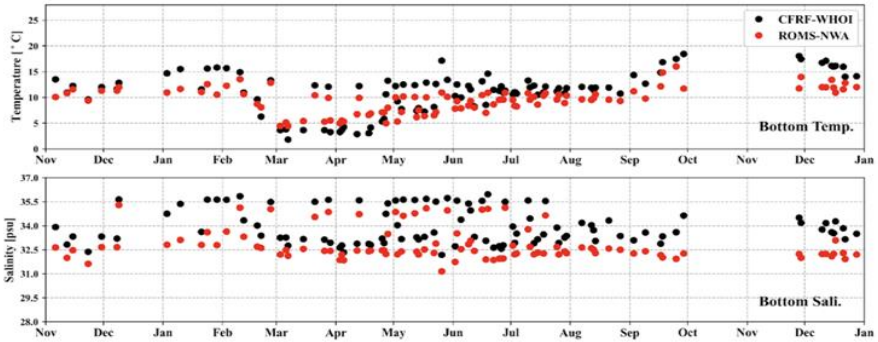
- 711 CTD profiles collected by Rhode Island Fis as part of the program as of July 08, 2021 since 2014
- Vertical resolution: 1m; 6 zones
- http://science.whoi.edu/users/seasoar/cfrfwhoi/



depth contours at 20, 30, and 50 fathoms

## CFRF-WHOI vs. ROMS-NWA Bottom Temp. and Salinity (within the bottom 5m of the water column) Comparison

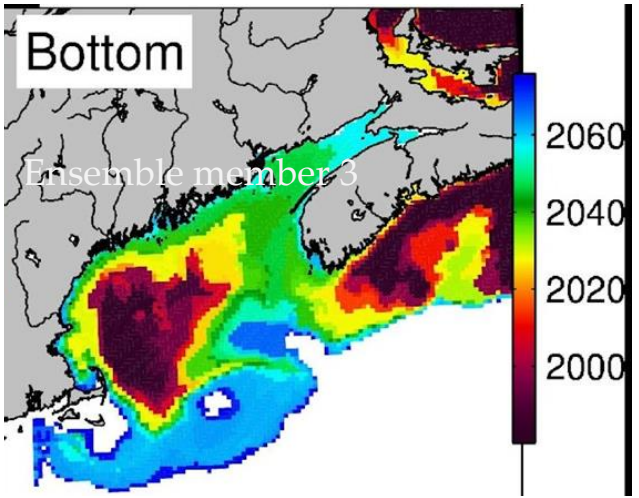
2014.11.29 – 2015.12.08 (138 profiles in total)



# Key workshop activity - localized mapped information

Model simulations indicate that calcium carbonate saturation states are going to decline over the next two decades

Simulated Year when Ω <1.5 dominates annually along the bottom

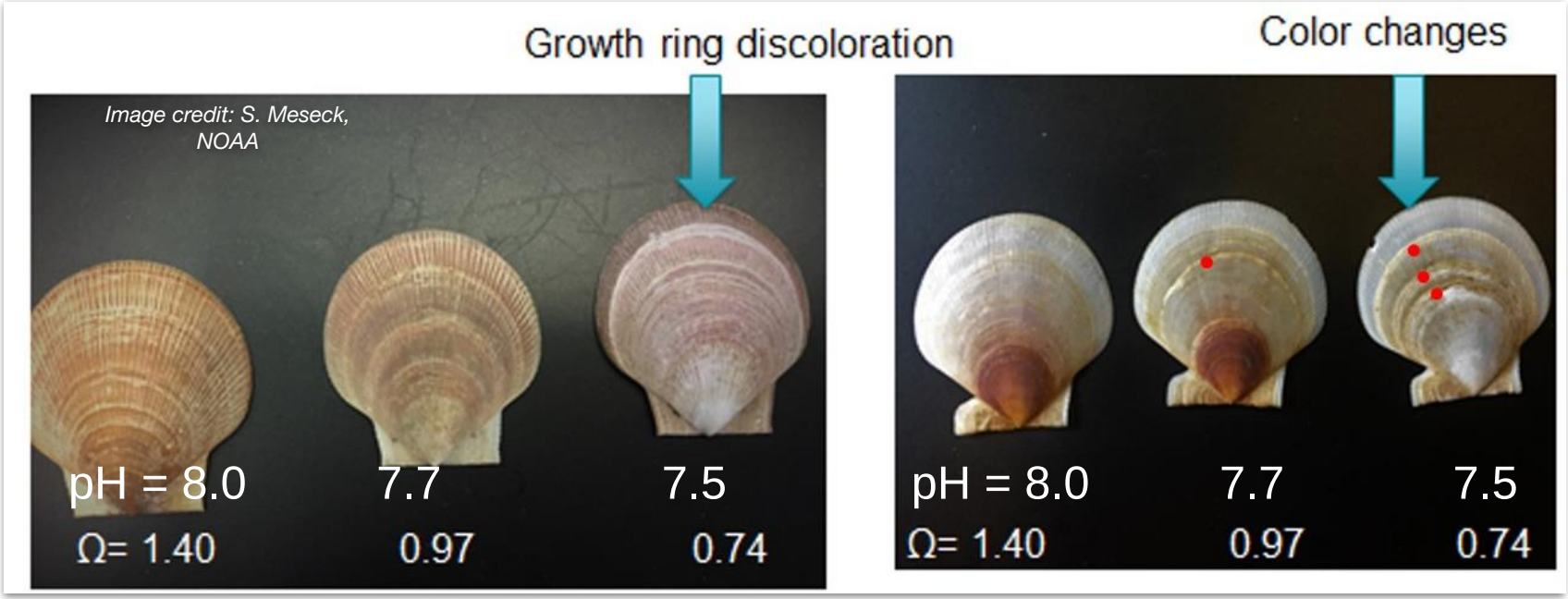



DFO-GSBM with dynamic BGC
Baseline = 1991-2010 and future = 2041-2060

Ω<1.5 is already surpassed in the benthic environment

*Siedlecki et al. 2021*

# Key workshop activity - passing around scallop shells reared under OA conditions




Current

Future

Like other bivalves, the sea scallop shells experience visible color changes and bleaching under low Ω

# Key workshop activity - Learn about industry resilience and adaptation strategies at workshops and in one-on-one interviews

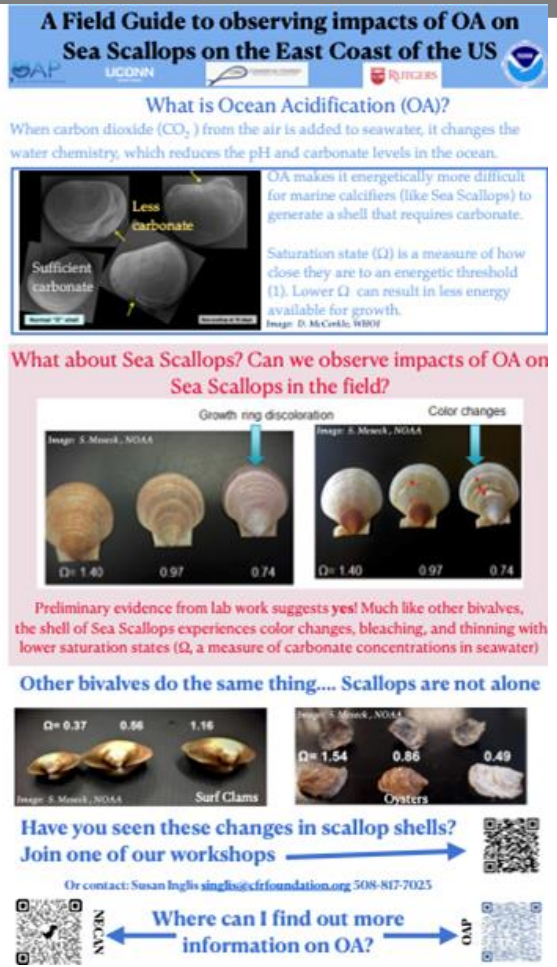
**We asked industry members to tell us about their:**

1. History in the scallop industry

1. Adaptation strategies in response to disruptive events

1. Views on environmental changes, especially on OA & OW

1. Vision for the future of the industry & their role




# Workshop outcome - Scallop OA impacts Informational Flyer for Distribution

- Plan to distribute this through Auction contacts as well as to some of the owners who attended the workshops who were willing to share it with their fleets
- Other ideas?

# Next steps

- Future model run finished - continuously simulated under SSP5-8.5 out to 2100. Plan to run an additional lower SSP
- Create local maps for MAB in particular of both historical and future conditions
- Dynamic Energy Budget modeling
- Continue key informant interviews with industry
- Integration of the social, biological, and oceanographic components
- Continue creating local educational materials to include in year 2 workshops - suggestions and existing resources welcome!

# extra

# RVA Industry Workshop Agenda

**Housekeeping: Slide on how to use Google Meet Participant Introductions (Susan) (10 minutes)**

**Project Overview (Sam) (15 min)**

**What is Ocean Acidification (Sam)? (15 minutes)**

- Define
- Let them know fishermen are not the problem
- Historical review of OA trends in the region.
- Why models can be trusted to forecast. Examples of simulations and models against real world data to verify outputs or results.
- What do future projections look like in the area?
- Conclude with the product(s) from this project (this component) and stress why it is important to scallop fishery (maps).

**How can OA affect scallop fishery and how can we use models to determine this (Shannon)? (15 minutes)**

- OA is an issue for ALL bivalves - now
  - Warming can either help or hurt depending on where we are at in terms of carbon dioxide content
- What do laboratory experiments tell us about bivalves?
  - Growth, meat weights -condition, shell conditions
  - Role of OA on its own and OWA
- What are DEB models, how they work (simplified)
- Biological impacts on scallops
  - Recruitment, settlement, predation
- What to look for as signs of OA on molluscs (use surf clams as example)
  - Included samples passed around with palpable shell damage
- Conclude with the products from this component of the project and stress why important to scallop fisher

**How can it affect scallop fishing communities (Lisa)? (15 mins)**

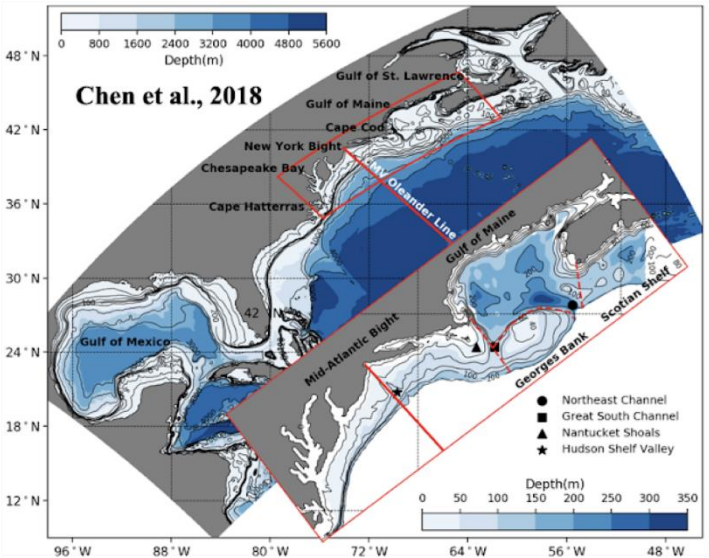
- Changes in where and when you fish
- Increased CPUE
- Conclude with the products from this component of the project and stress why important to scallop fishery

**Conclusion (Susan) (15 mins)**

- Final message on why this project is important and how they can help us
- Plan to schedule one-on-one conversations to develop in-depth profile of industry
- Let them know to stay tuned as we will be sending out regular updates of results

# The ROMS-NWA Hindcast Simulation

- Share the same model grid with ROMS-NWA; ~7km horizontal resolution; 40 vertical terrain-following levels;
- SODA3; JRA55
- Daily output from 1980.01.22 to 2015.12.08




NWA -ROMS

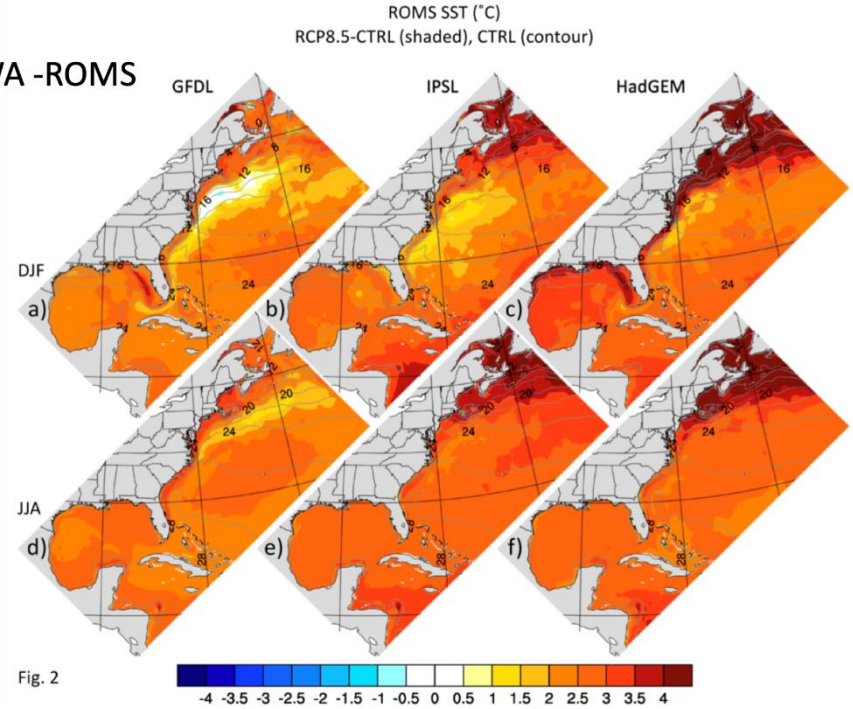



Fig. 2

Alexander et al., 2020