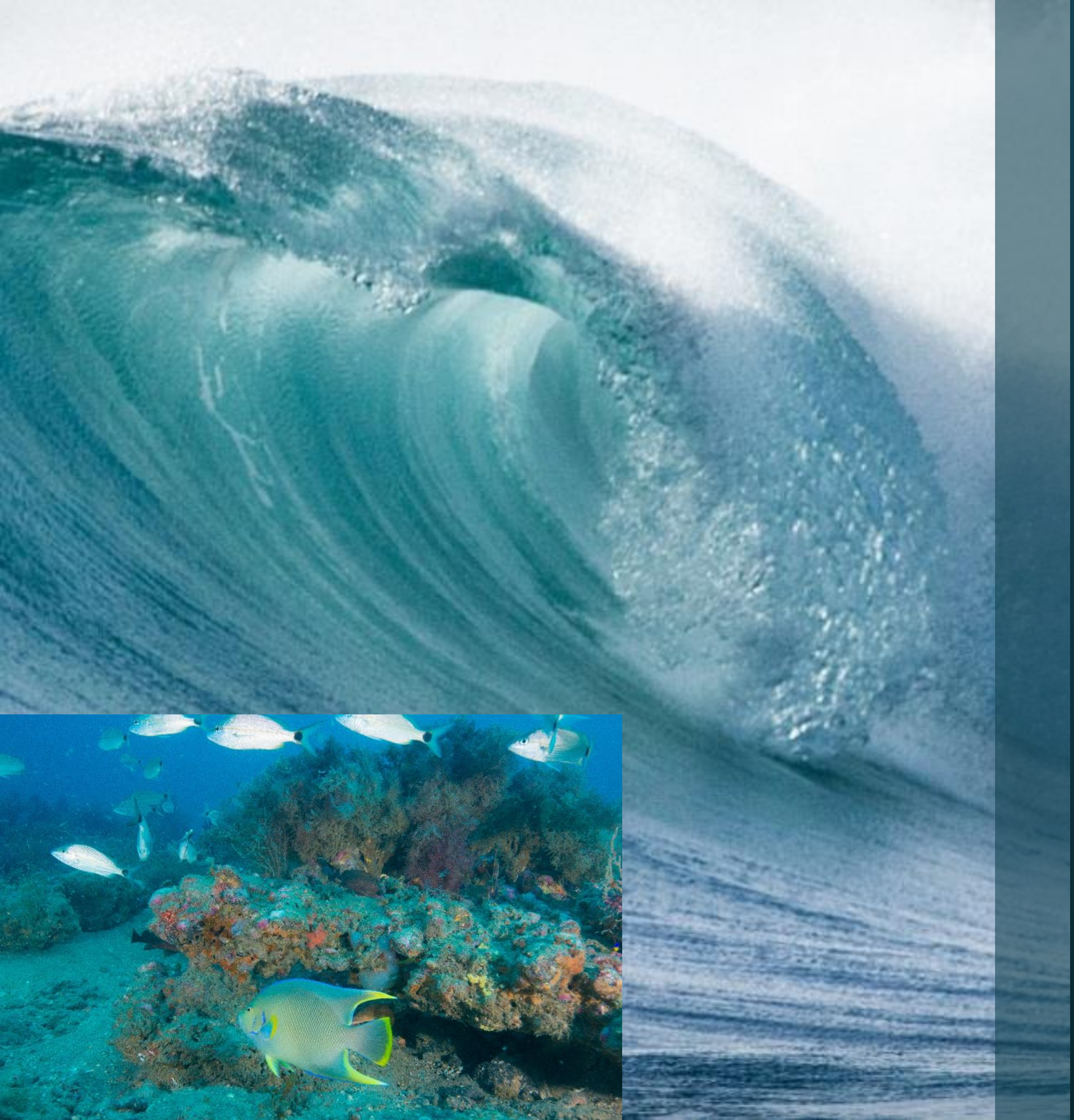


Benthic Habitat Mapping & Assessment: Wilmington-East Call Area

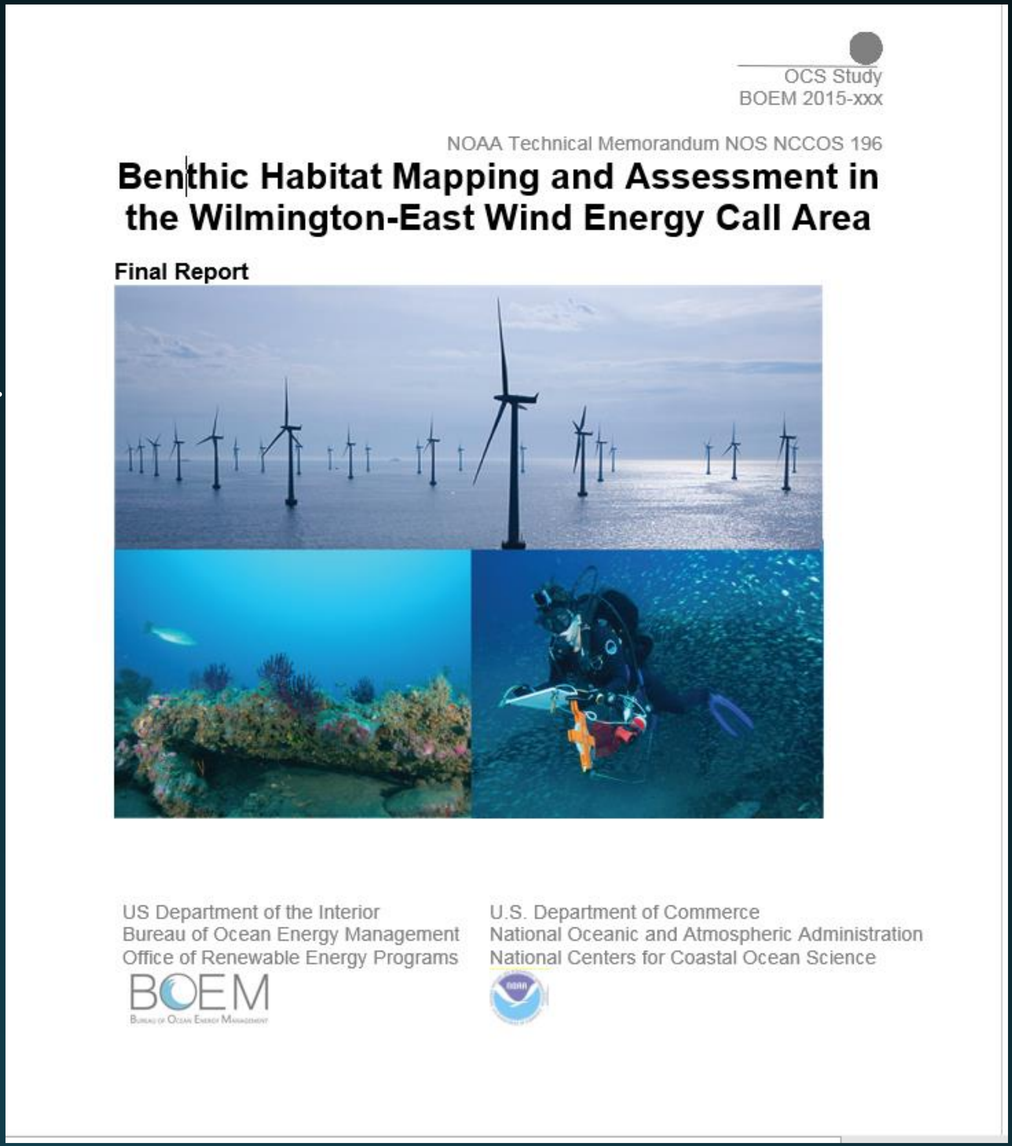
Presentation by Christine Voss, PhD
UNC Institute of Marine Sciences

North Carolina Renewable Energy Task Force Meeting
7 October 2015
Wilmington, NC

A collaborative effort:

- U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM). *Benthic Habitat Mapping and Assessment in the Wilmington-East Wind Energy Call Area*. Taylor, J. C., A. B. Paxton, C. M. Voss, B. Sumners, C. A. Buckel, J. Vander Pluym, E. B. Ebert, T. S. Viehman, S. R. Fegley, E. A. Pickering, A. M. Adler, C. Freeman, and C. H. Peterson. Atlantic OCS Region, Sterling, VA. OCS Study BOEM 2015-xxxx.

  - BOEM
  - NOAA
  - UNC-IMS
  - Geodynamics, LLC


OCS Study
BOEM 2015-xxx

NOAA Technical Memorandum NOS NCCOS 196

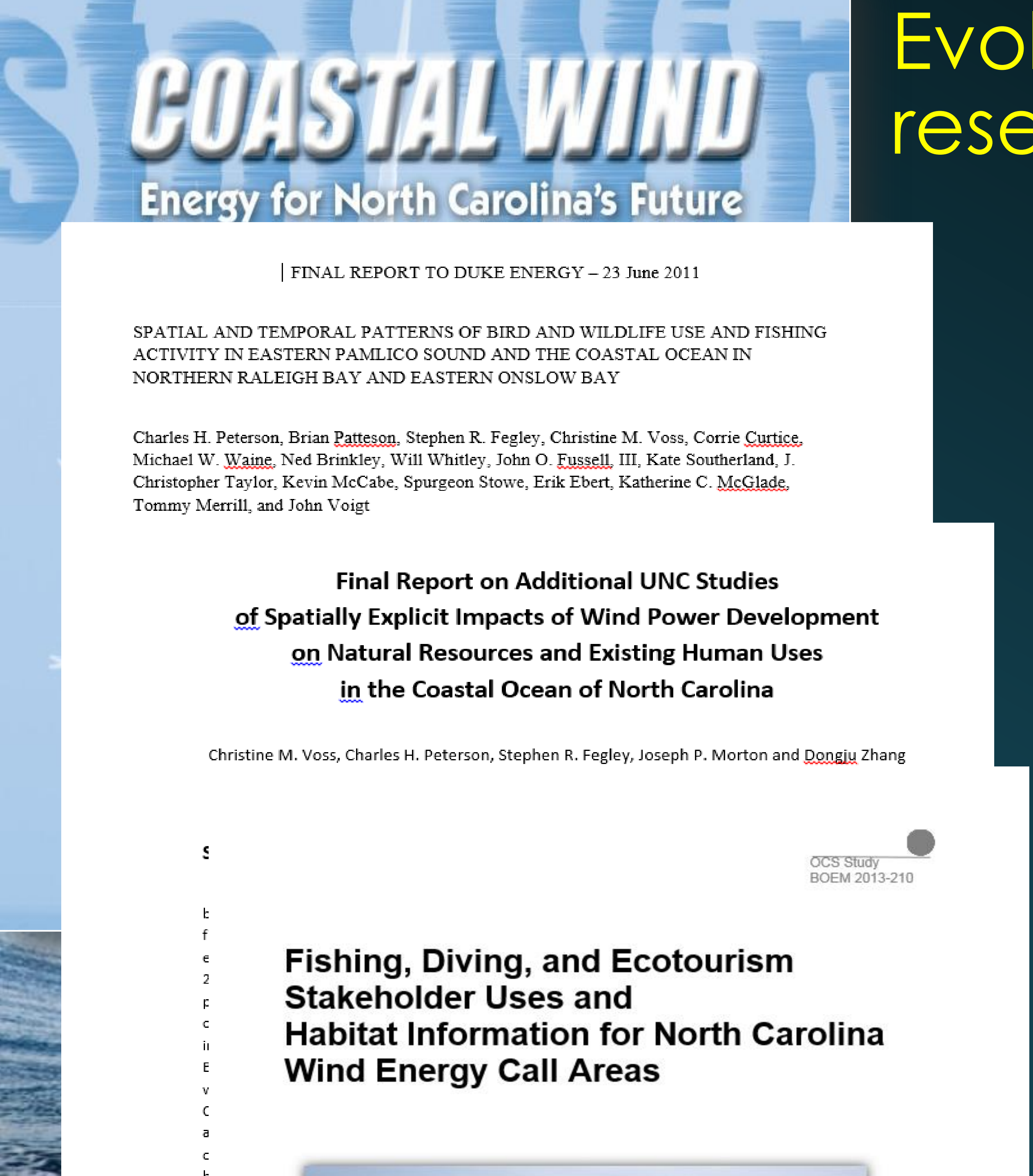
Benthic Habitat Mapping and Assessment in the Wilmington-East Wind Energy Call Area

Final Report

US Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Centers for Coastal Ocean Science

Evolution of offshore wind research in NC


COASTAL WIND

Energy for North Carolina's Future

| FINAL REPORT TO DUKE ENERGY – 23 June 2011

SPATIAL AND TEMPORAL PATTERNS OF BIRD AND WILDLIFE USE AND FISHING ACTIVITY IN EASTERN PAMLICO SOUND AND THE COASTAL OCEAN IN NORTHERN RALEIGH BAY AND EASTERN ONSLOW BAY

Charles H. Peterson, Brian Patteson, Stephen R. Fegley, Christine M. Voss, Corrie Curtice, Michael W. Waine, Ned Brinkley, Will Whitley, John O. Fussell, III, Kate Southerland, J. Christopher Taylor, Kevin McCabe, Spurgeon Stowe, Erik Ebert, Katherine C. McGlade, Tommy Merrill, and John Voigt

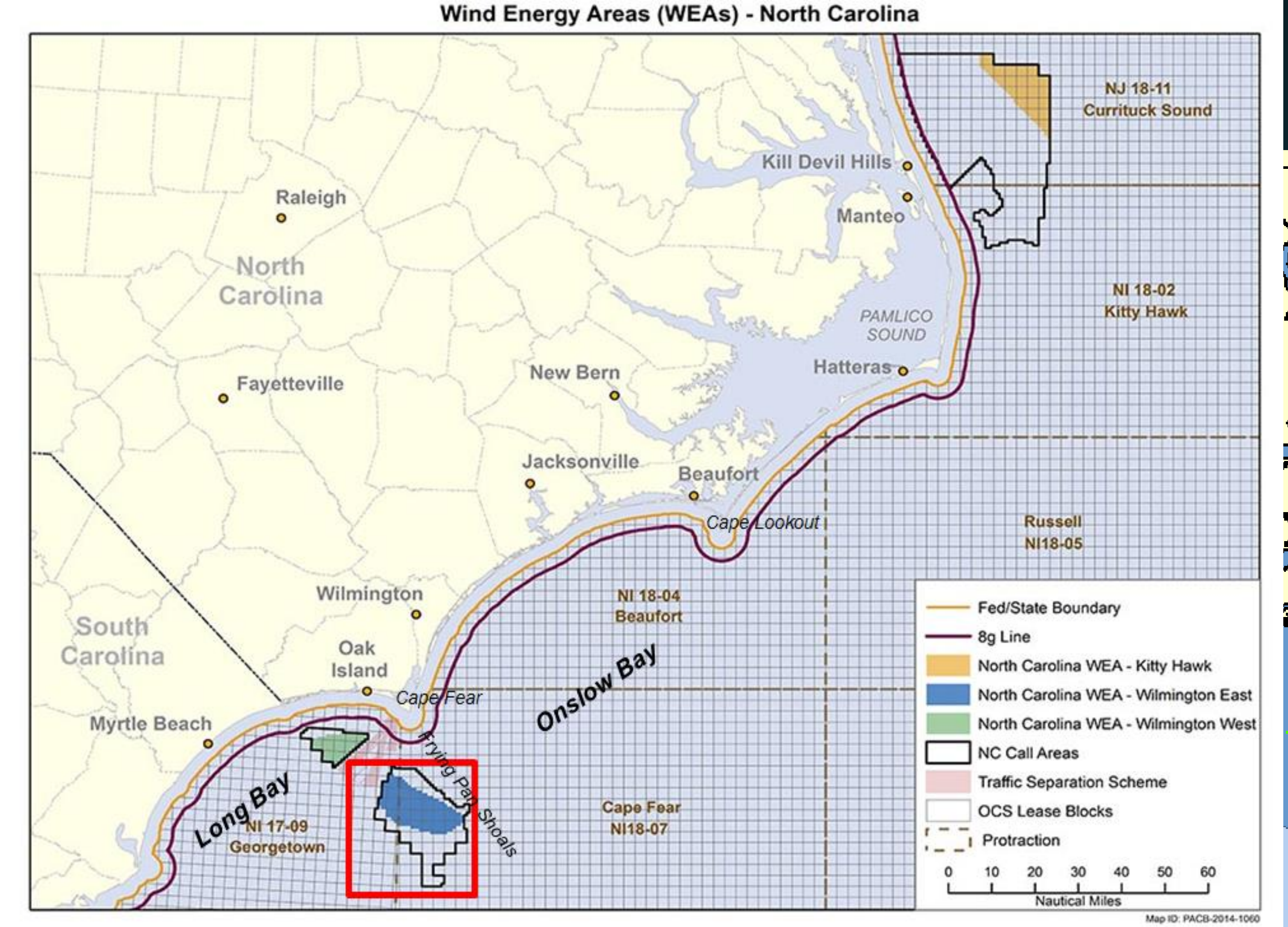
Final Report on Additional UNC Studies of Spatially Explicit Impacts of Wind Power Development on Natural Resources and Existing Human Uses in the Coastal Ocean of North Carolina

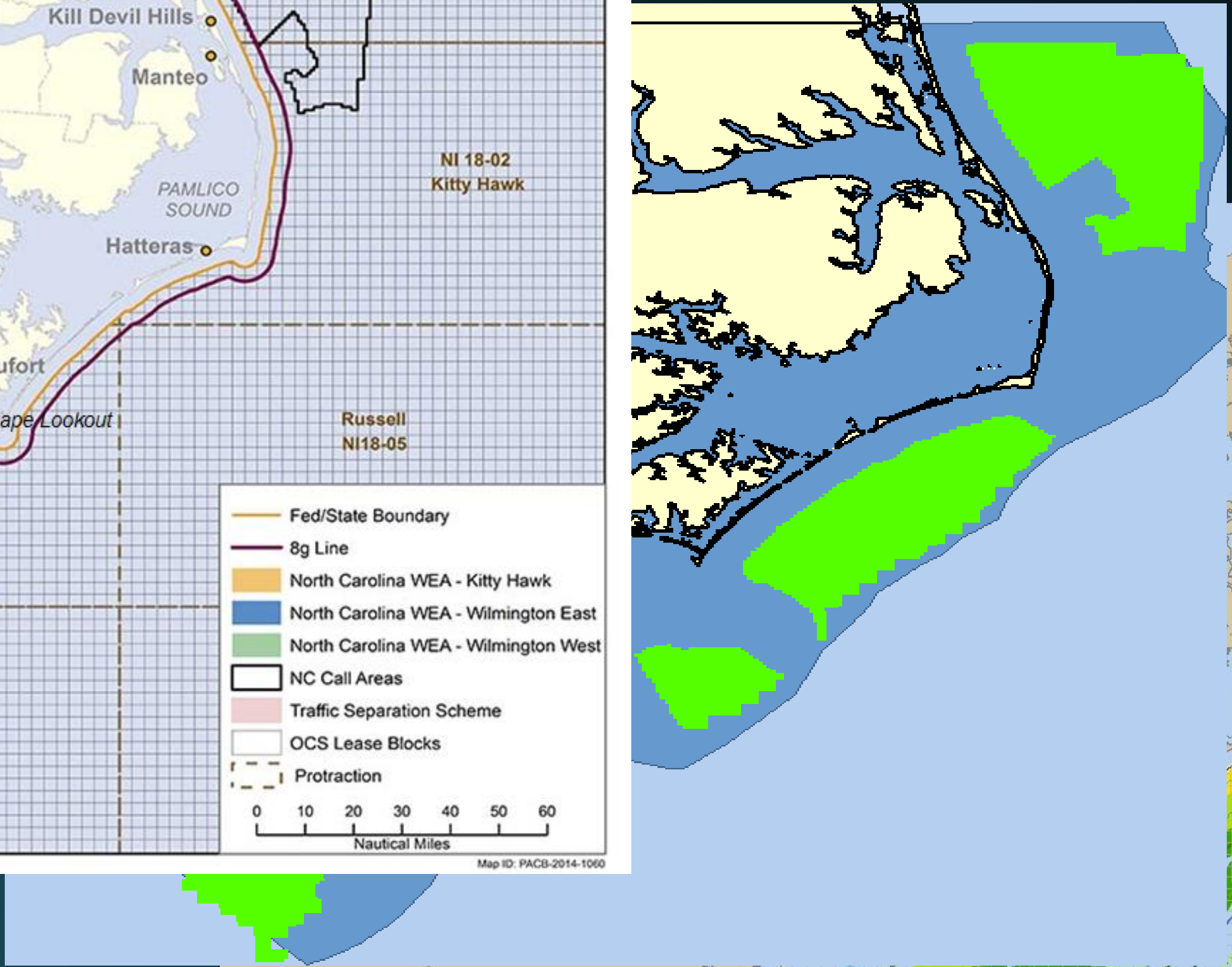
Christine M. Voss, Charles H. Peterson, Stephen R. Fegley, Joseph P. Morton and Dongju Zhang

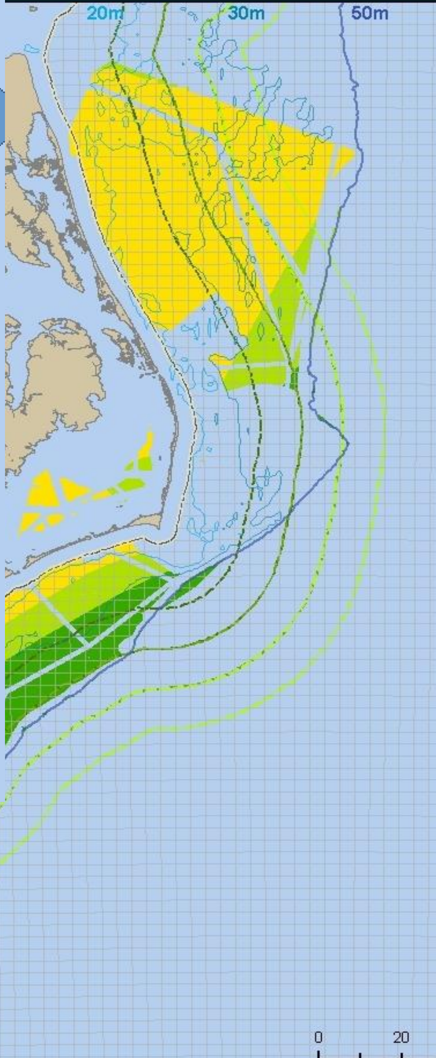
OCS Study
BOEM 2013-210

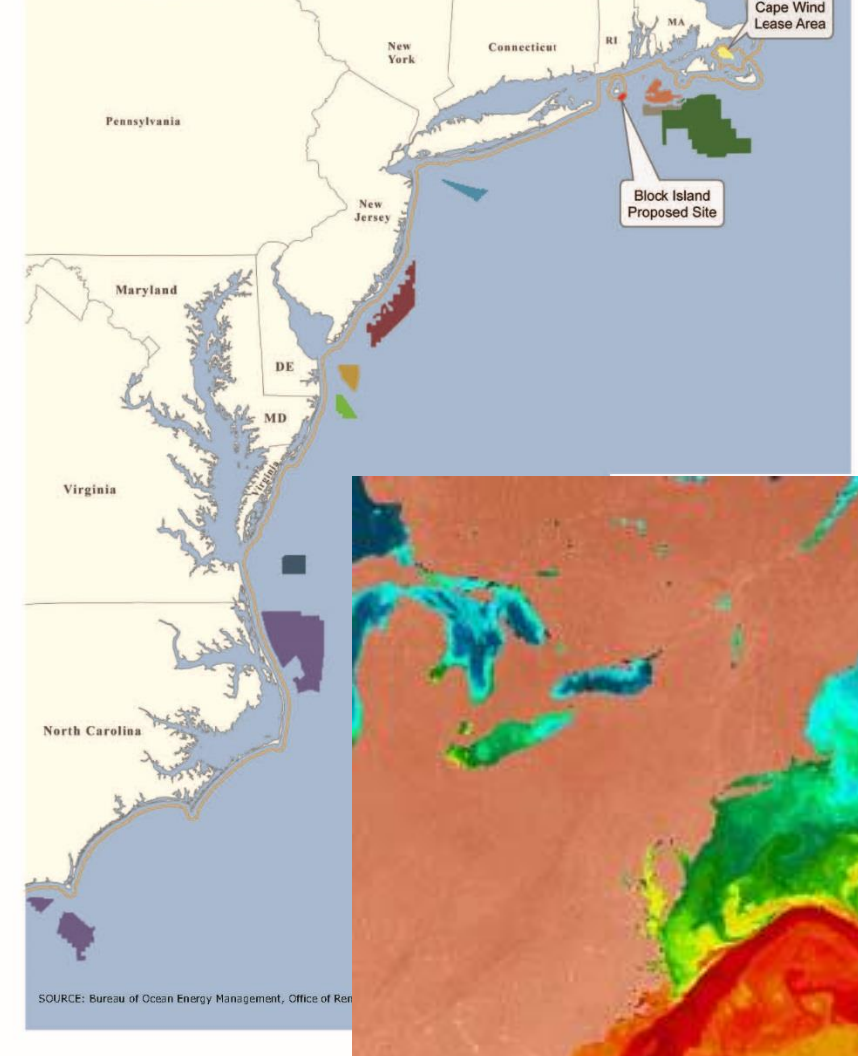
Fishing, Diving, and Ecotourism Stakeholder Uses and Habitat Information for North Carolina Wind Energy Call Areas

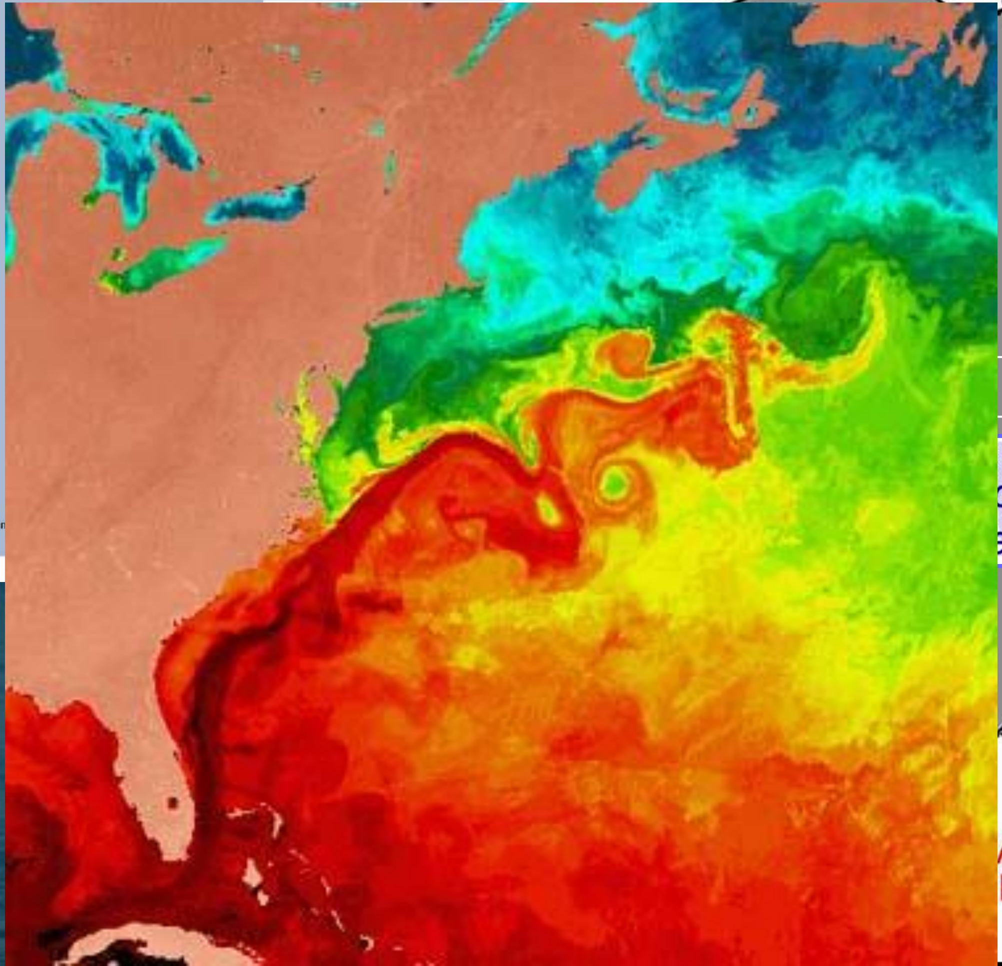
- 2008 request by the North Carolina General Assembly to assess the resource & feasibility of development
- 2009 UNC-CH interdisciplinary study
- 2011 UNC-IMS study for Duke Energy
- 2012 UNC-IMS study for NC Dept. of Commerce
- 2013 UNC-IMS study for BOEM
- 2015 UNC-IMS & NOAA study for BOEM

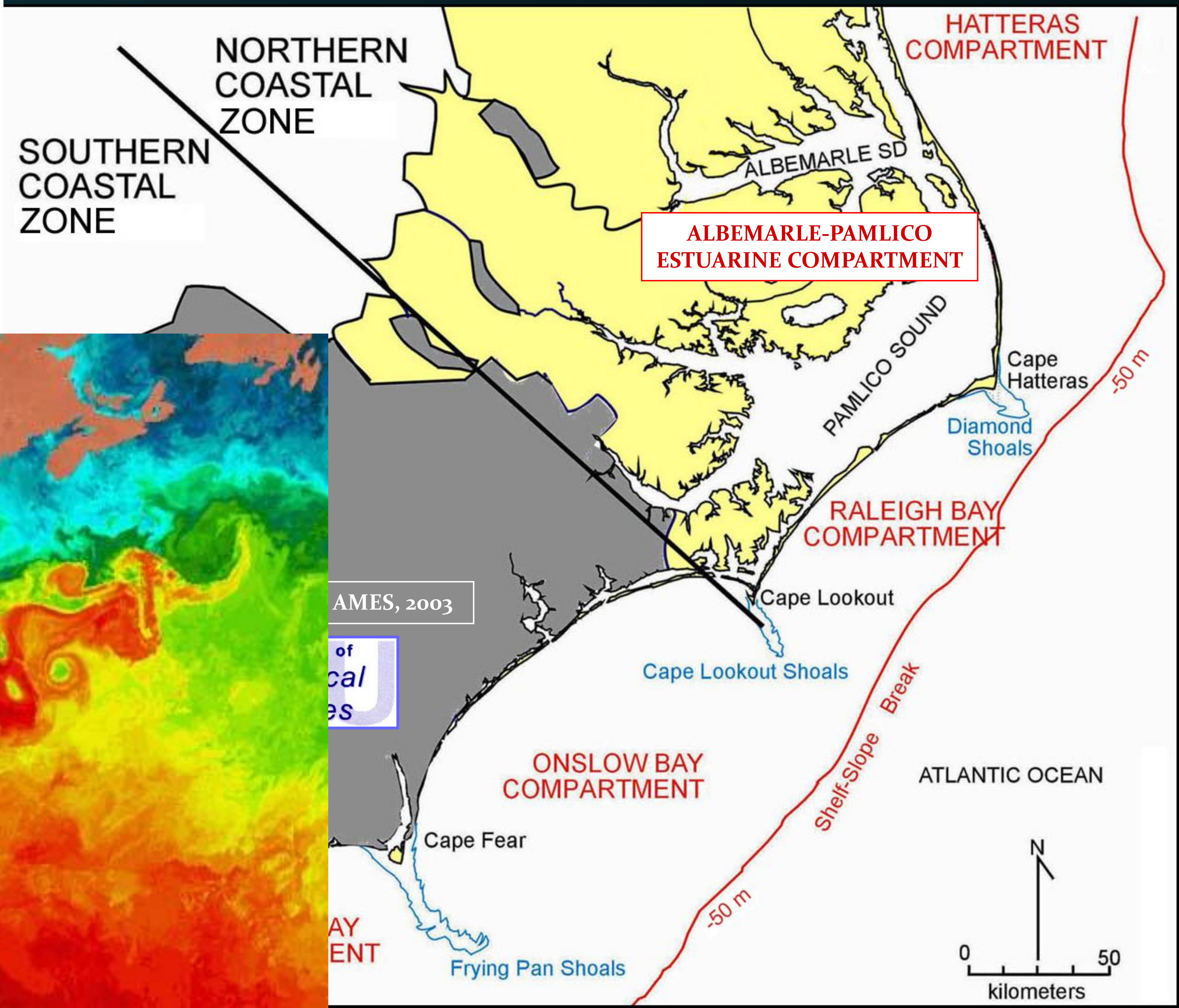

Wind Energy Areas (WEAs) - North Carolina
NJ 18-11
Currituck Sound
Kill Devil Hills
Manteo
Raleigh
North Carolina
PAMLICO SOUND
NI 18-02
Kitty Hawk
Hatteras
Fayetteville
New Bern
Jacksonville
Beaufort
Russell
NI18-05
Cape Lookout
Wilmington
NI 18-04
Beaufort
South Carolina
Oak Island
Onslow Bay
Cape Fear
Myrtle Beach
Frying Pan Shoals
Long Bay
NI 17-09
Georgetown
Cape Fear
NI18-07
Fed/State Boundary
8g Line
North Carolina WEA - Kitty Hawk
North Carolina WEA - Wilmington East
North Carolina WEA - Wilmington West
NC Call Areas
Traffic Separation Scheme
OCS Lease Blocks
Protraction
0 10 20 30 40 50 60
Nautical Miles
Map ID: PACB-2014-1060




20m
30m
50m
0
20

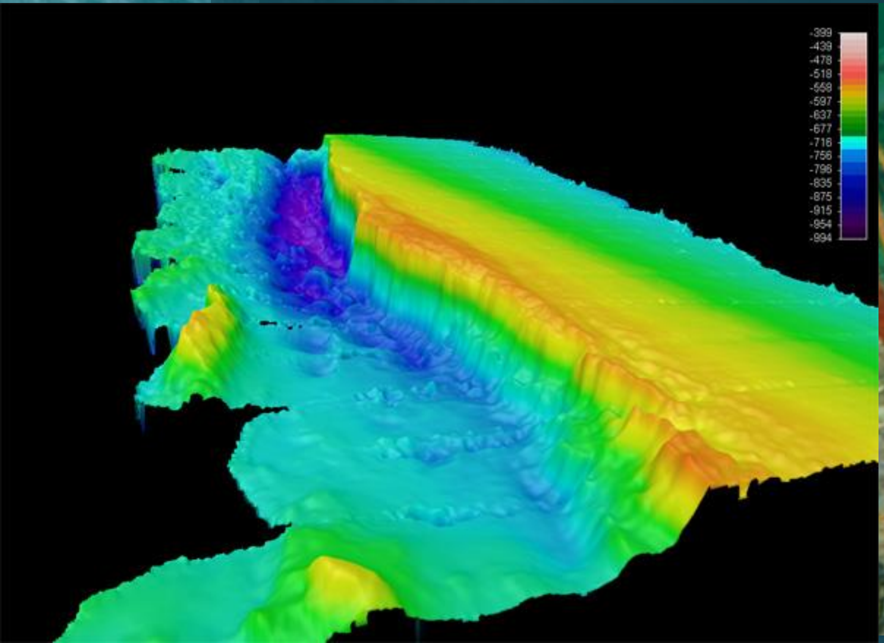

Cape Wind
Lease Area
MA
RI
New
York
Connecticut
Pennsylvania
Block Island
Proposed Site
New
Jersey
Maryland
DE
MD
Virginia
North Carolina
SOURCE: Bureau of Ocean Energy Management, Office of Ren



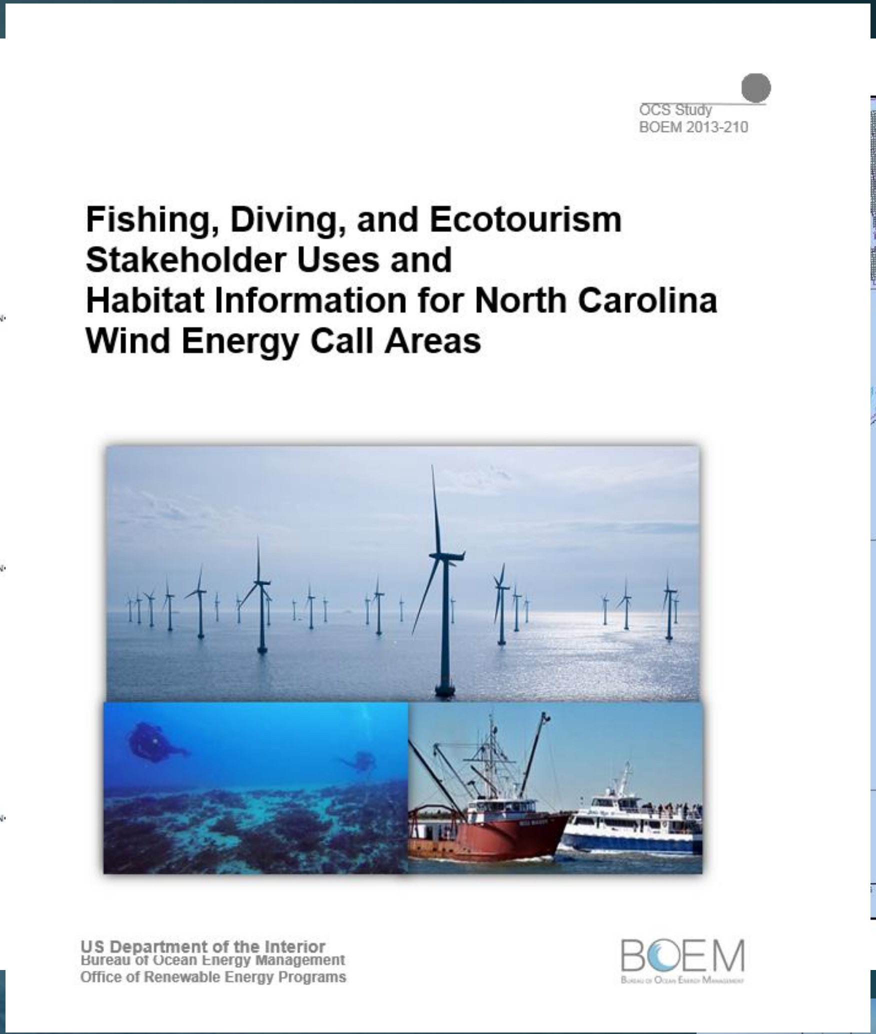

NORTHERN
COASTAL
ZONE
SOUTHERN
COASTAL
ZONE
HATTERAS
COMPARTMENT
ALBEMARLE SD
ALBEMARLE-PAMLICO
ESTUARINE COMPARTMENT
PAMLICO SOUND
Cape
Hatteras
Diamond
Shoals
-50 m
RALEIGH BAY
COMPARTMENT
Cape Lookout
AMES, 2003
Cape Lookout Shoals
Shelf-Slope Break
ONSLOW BAY
COMPARTMENT
ATLANTIC OCEAN
Cape Fear
-50 m
N
0
50
kilometers
Frying Pan Shoals

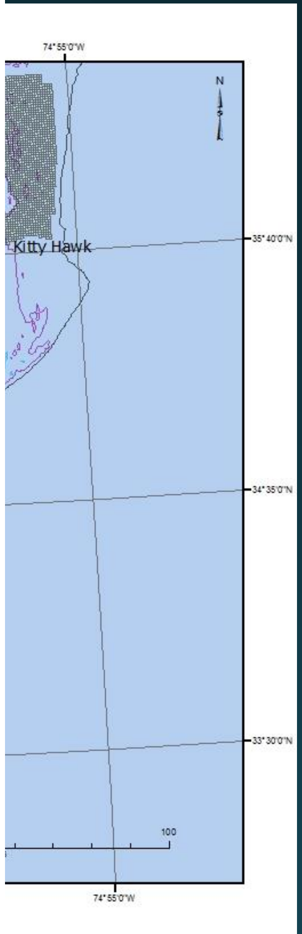
Hardbottom Habitat

- Protected as Essential Fish Habitat by the Magnuson-Stevens Fisheries Conservation and Management Act (NOAA)
- Flat hardbottom: pavement, rock outcroppings & ledges, high-relief rocky reefs
- Turbine monopile & scour apron could provide substrate to enhance hardbottom habitat with proper siting



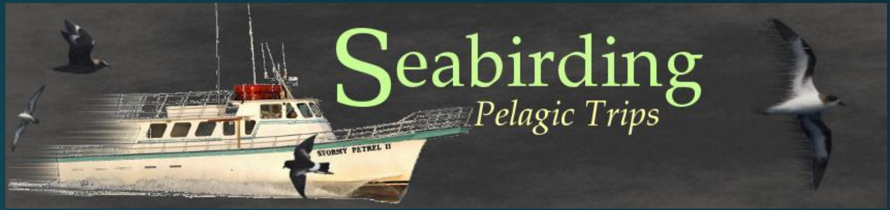
Stakeholders' meetings





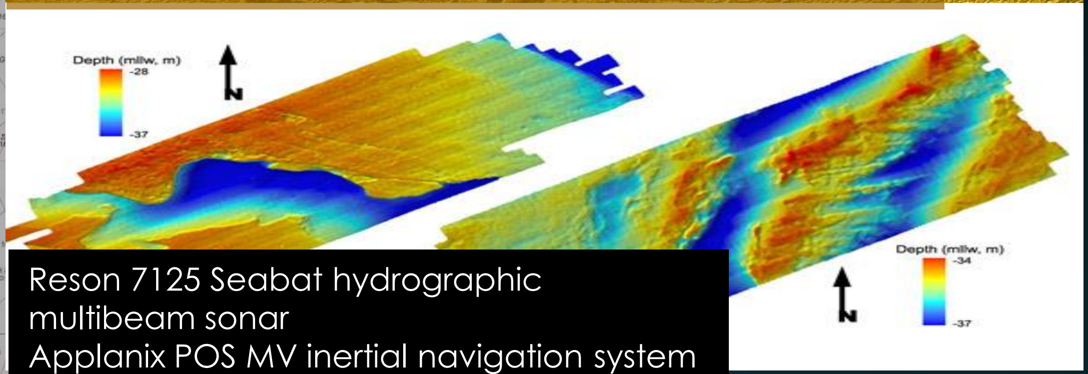
- Meetings held in each of 3 regions: northern, central, & southern
- Stakeholders shared proprietary information & knowledge about sea floor habitats, especially hardbottom (EFH)
- All data sources combined to provide BOEM with spatially explicit information indicating where wind energy development can avoid or minimize conflicts with fish, fish habitat, fishing, diving, and ecotourism
- Key stakeholder topics:
  1. Access to traditional fishing grounds
  2. Maintaining transit corridors
  3. Positive feedback on enhancing habitat

Voss, C.M., C.H. Peterson, and S.R. Fegley. 2013. Fishing, Diving, and Ecotourism Stakeholder Uses and Habitat Information for North Carolina Wind Energy Call Areas. U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, Herndon, VA. OCS Study BOEM 2013-210. 23pp.

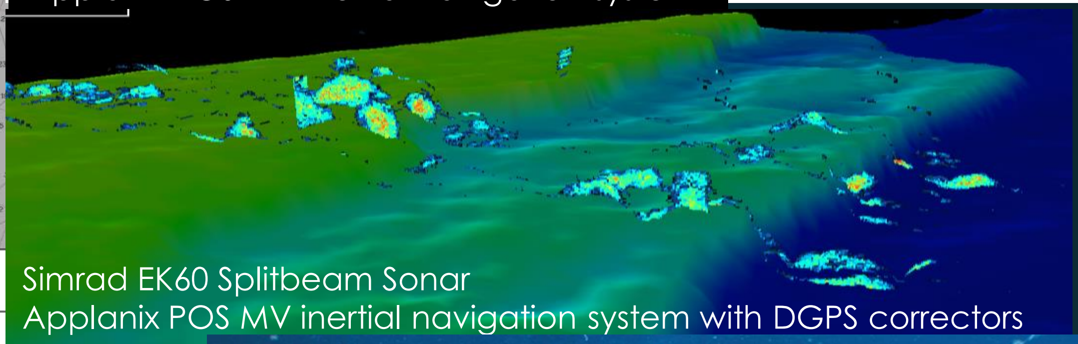


Simultaneous mapping of seafloor & fishes

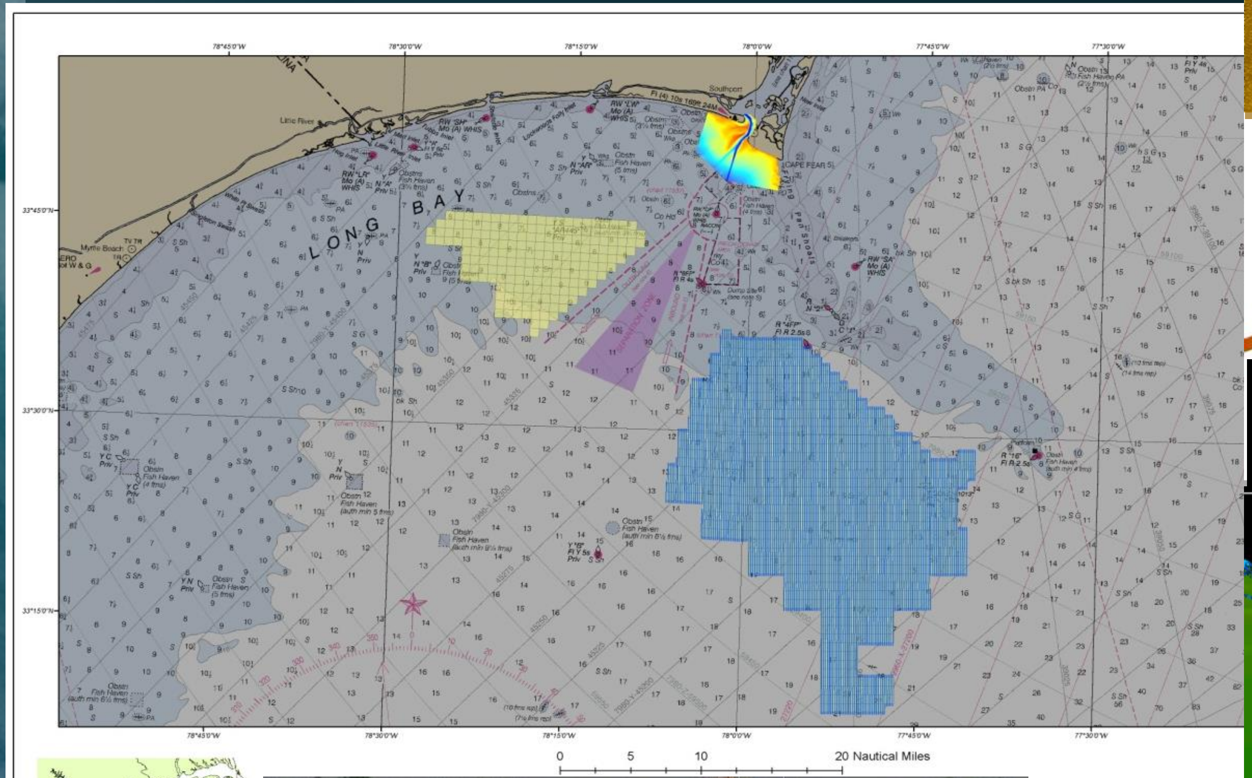
Edge Tech 4200 digital sidescan sonar
Applanix POS MV inertial navigation system with DGPS correctors

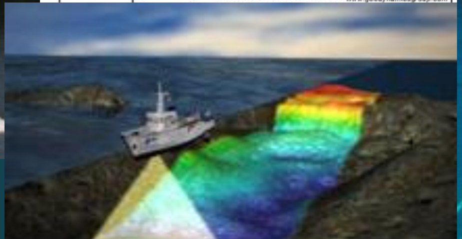


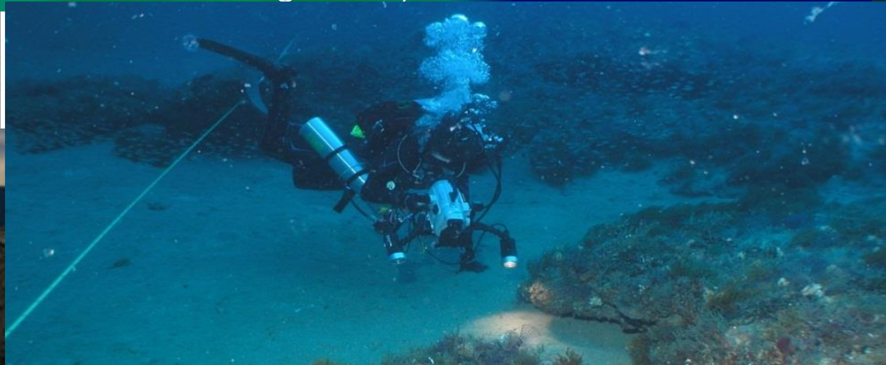
Reson 7125 Seabat hydrographic multibeam sonar
Applanix POS MV inertial navigation system



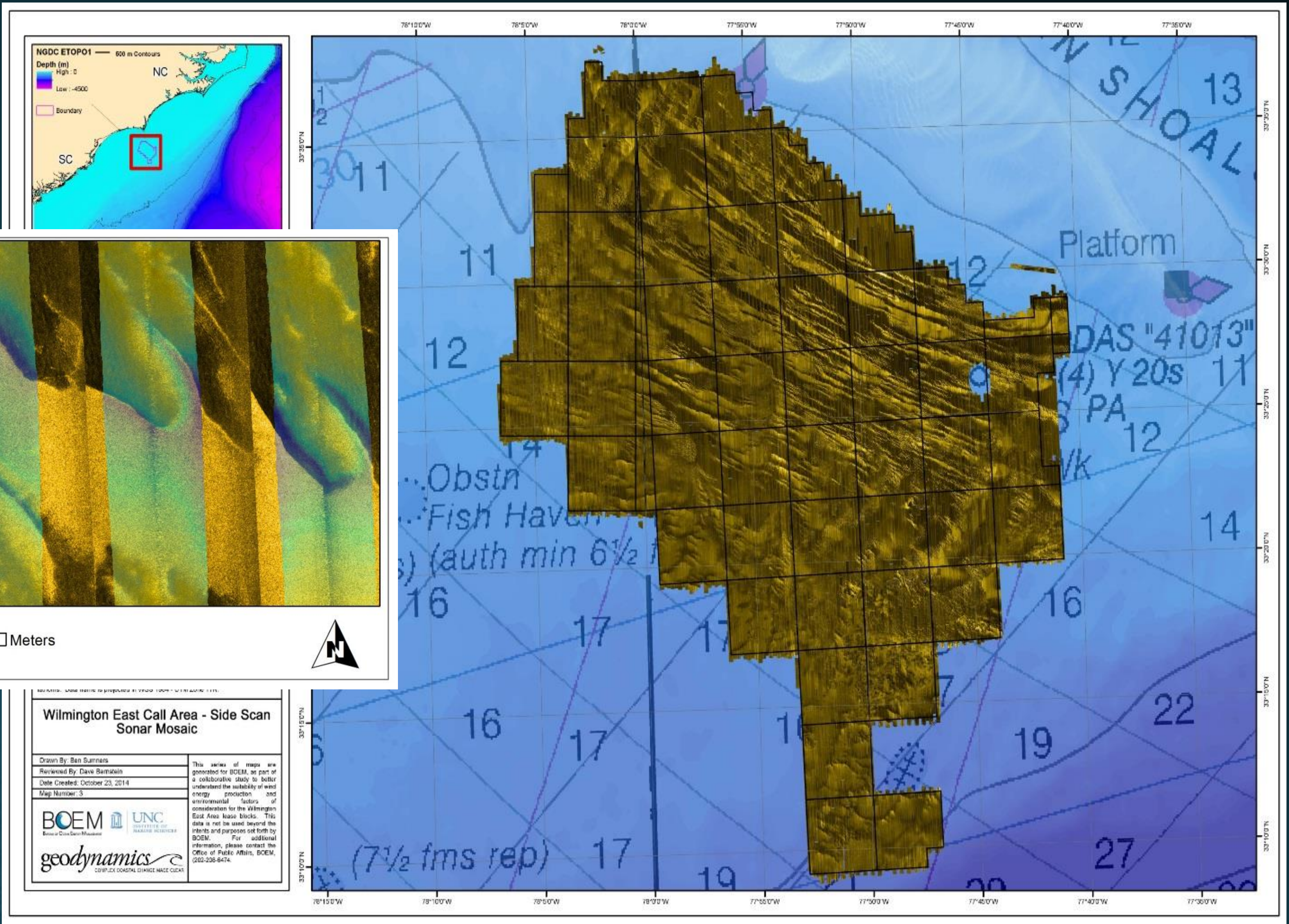
Simrad EK60 Splitbeam Sonar
Applanix POS MV inertial navigation system with DGPS correctors

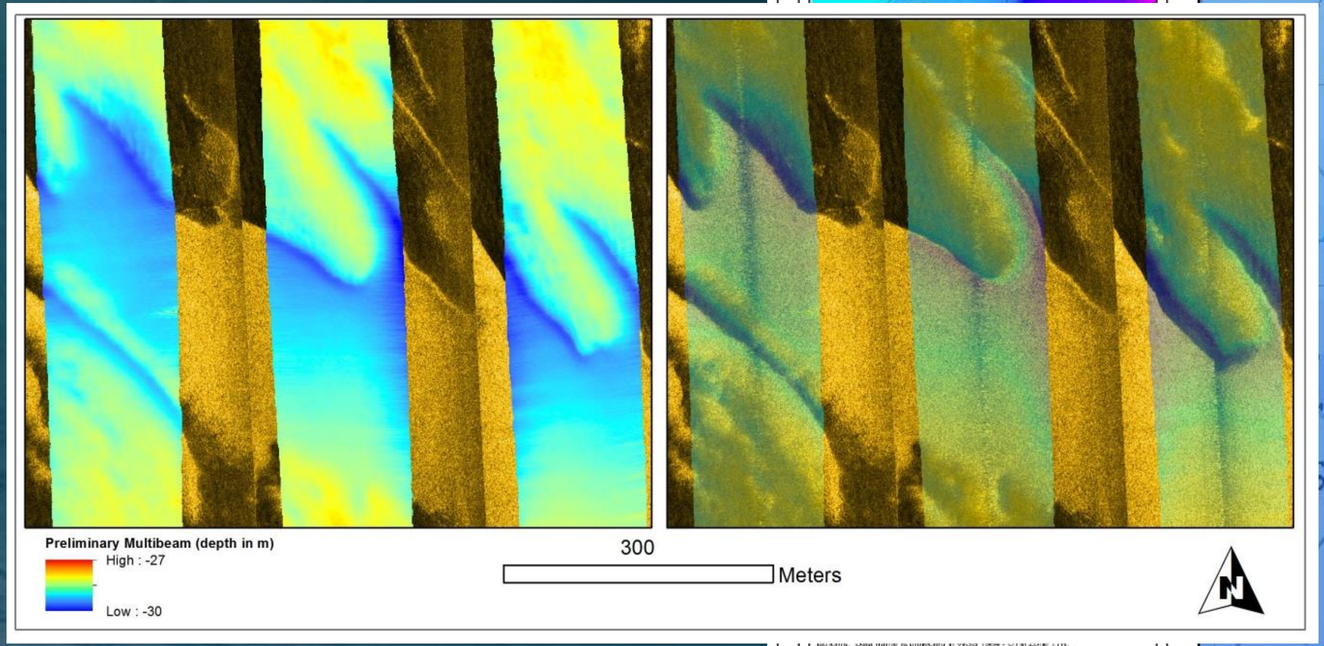




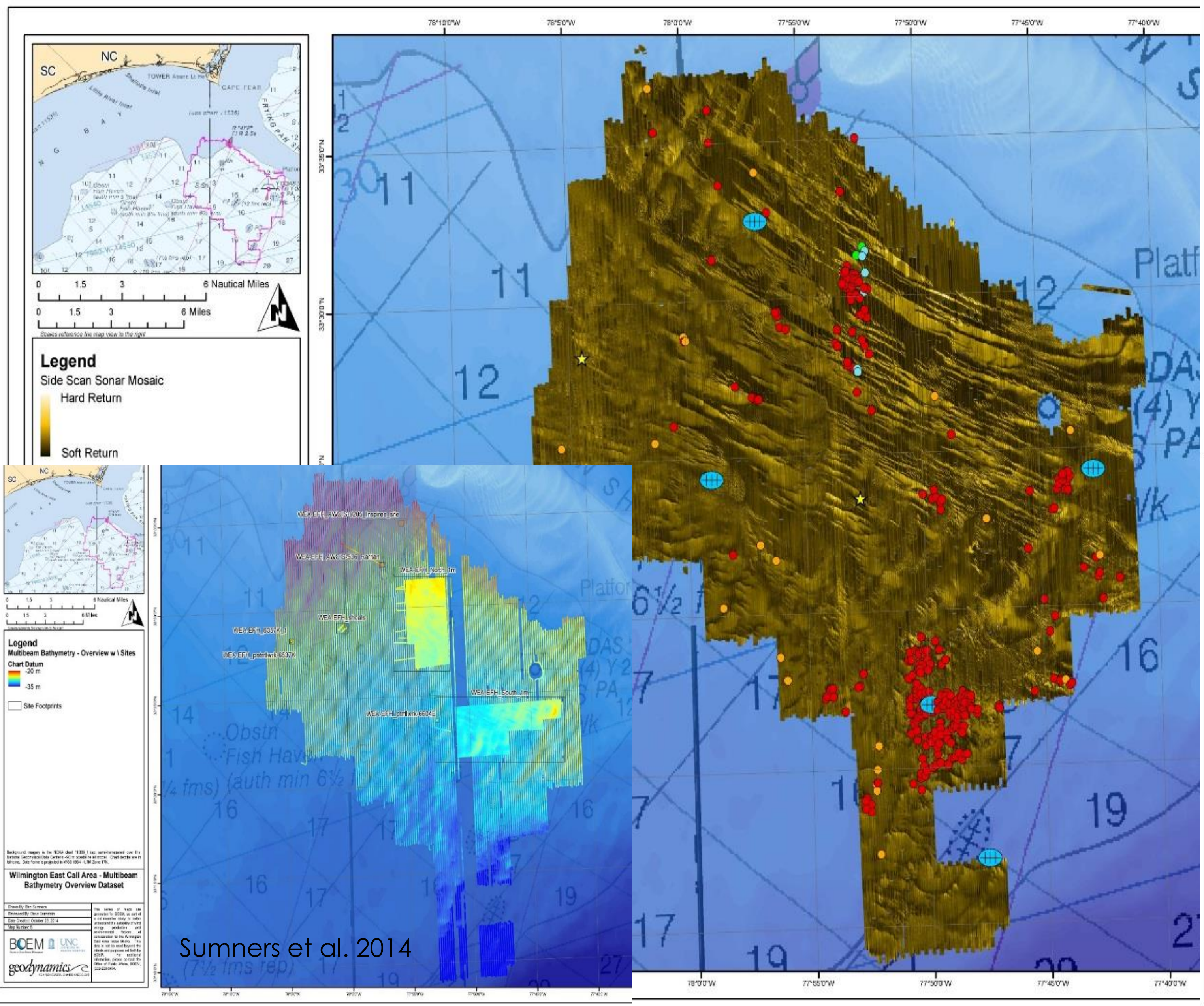


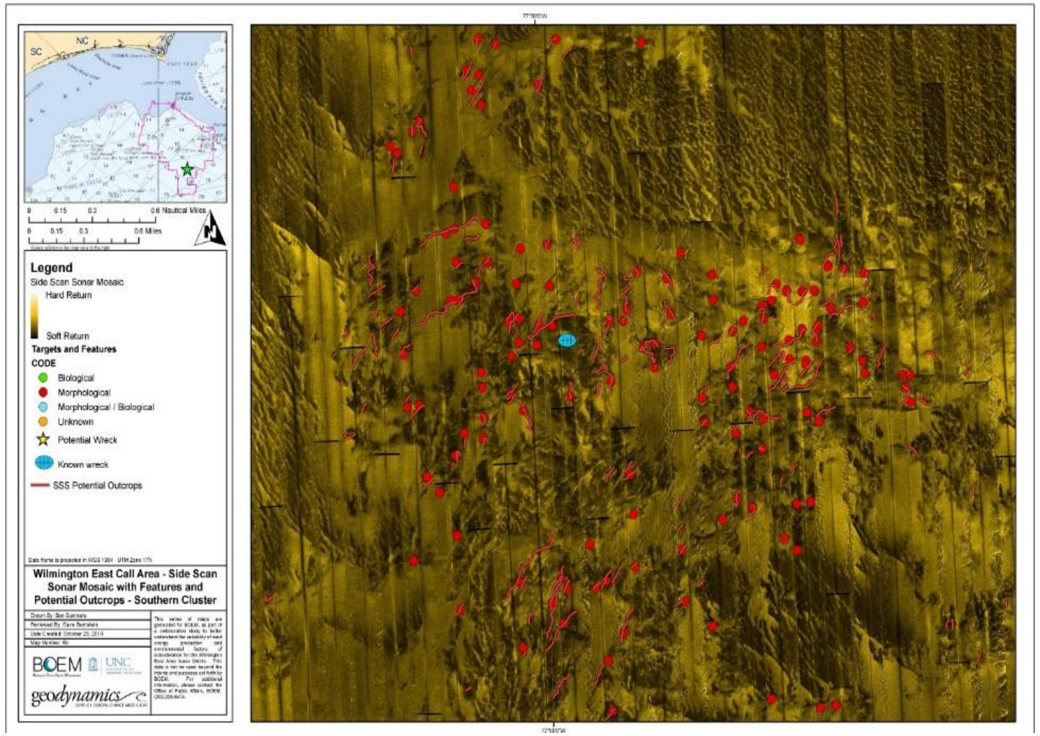
Side scan sonar imagery overlaid by multibeam bathymetry

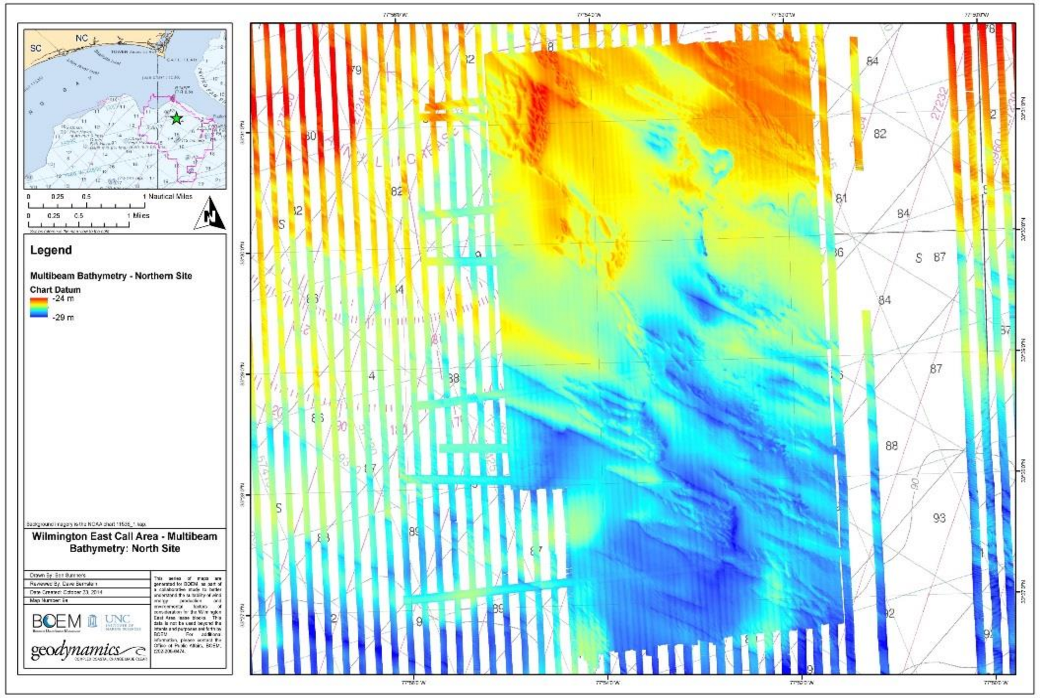




Seafloor mapping (to 25-cm resolution)



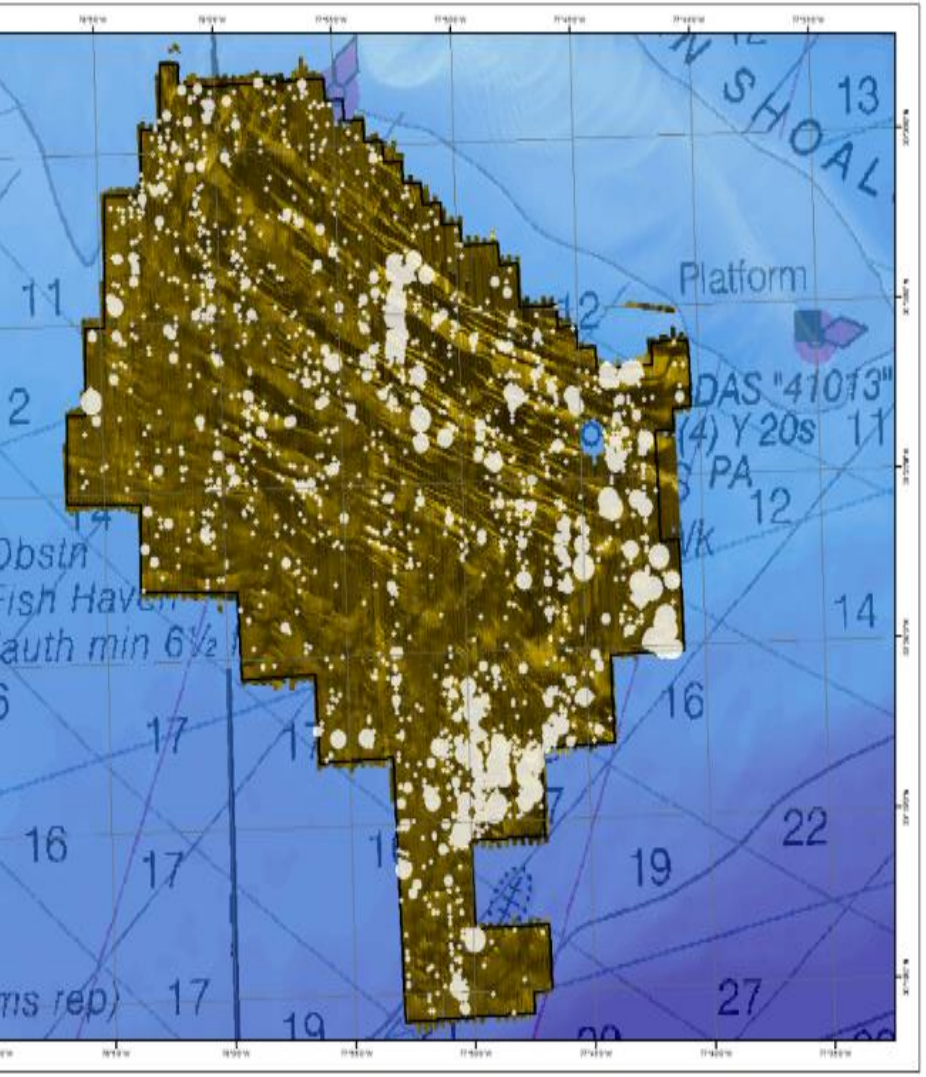




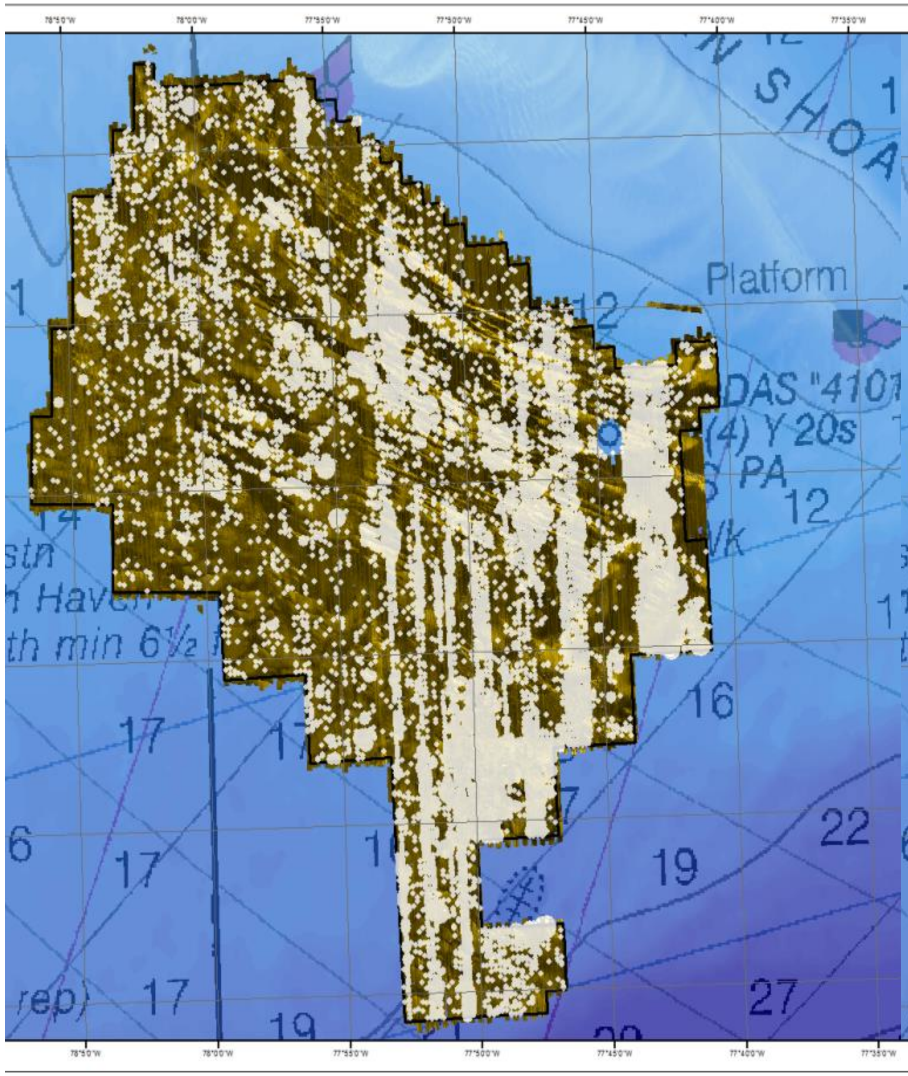
Distribution of fish densities from Splitbeam Echosounder

White symbols are proportional in size to relative density

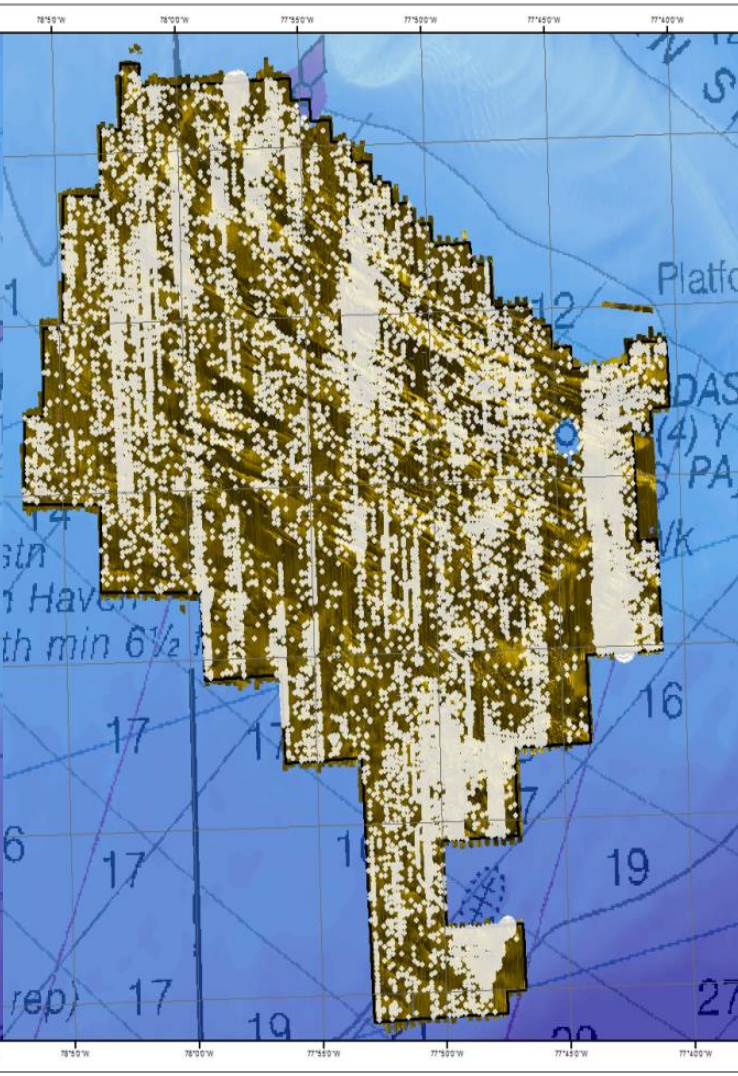
Large (> 29 cm)



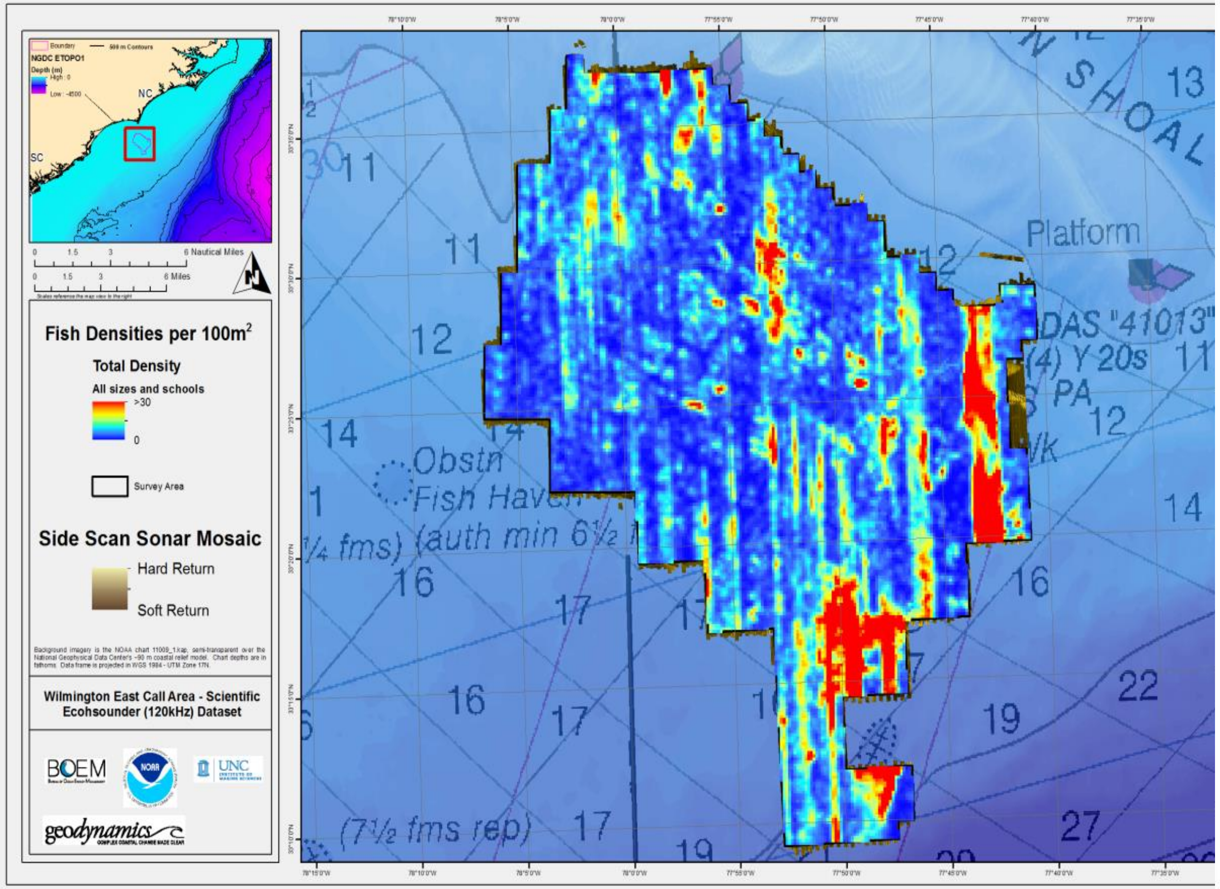
Medium (12 - 29 cm)

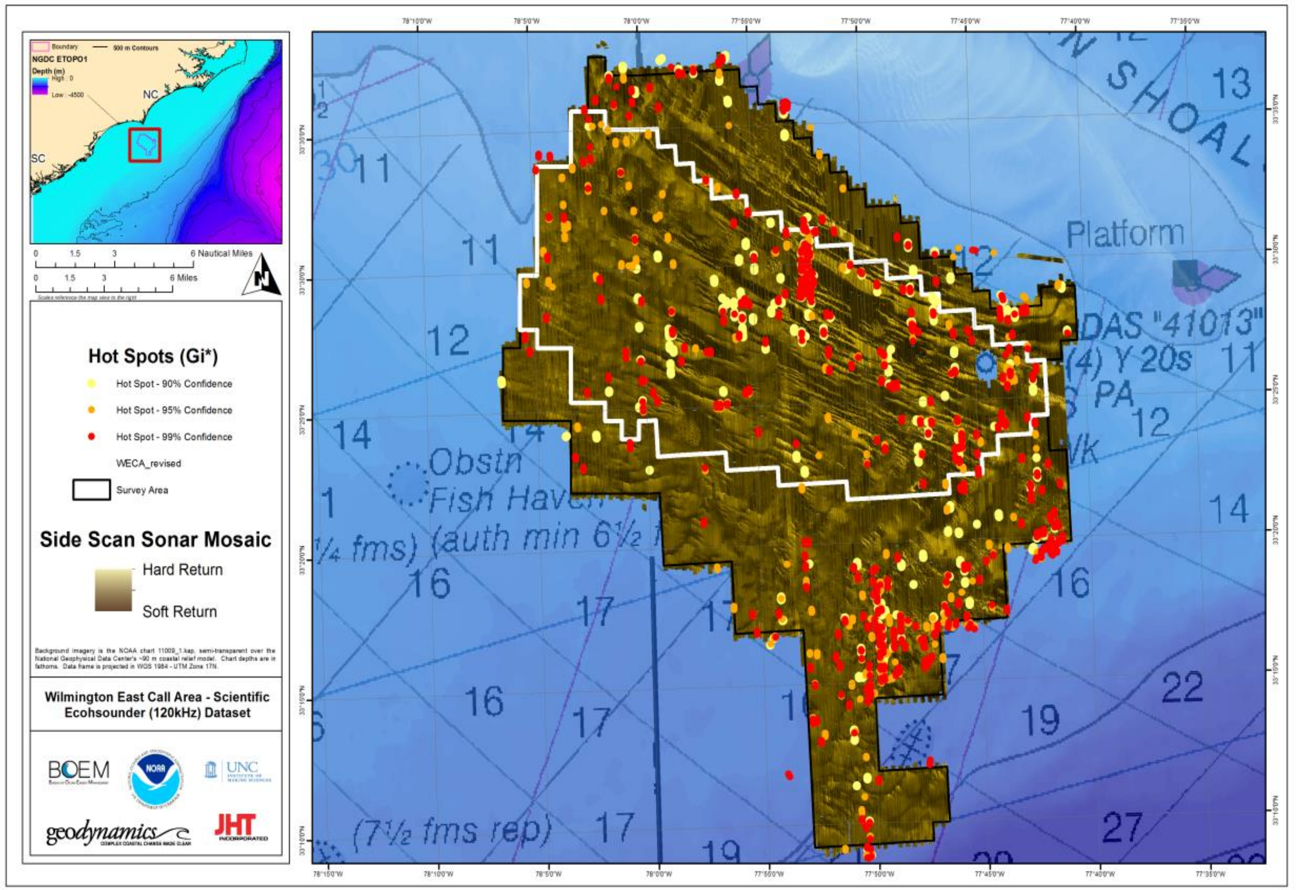


Small (< 12 cm)



Where are the fishes ?



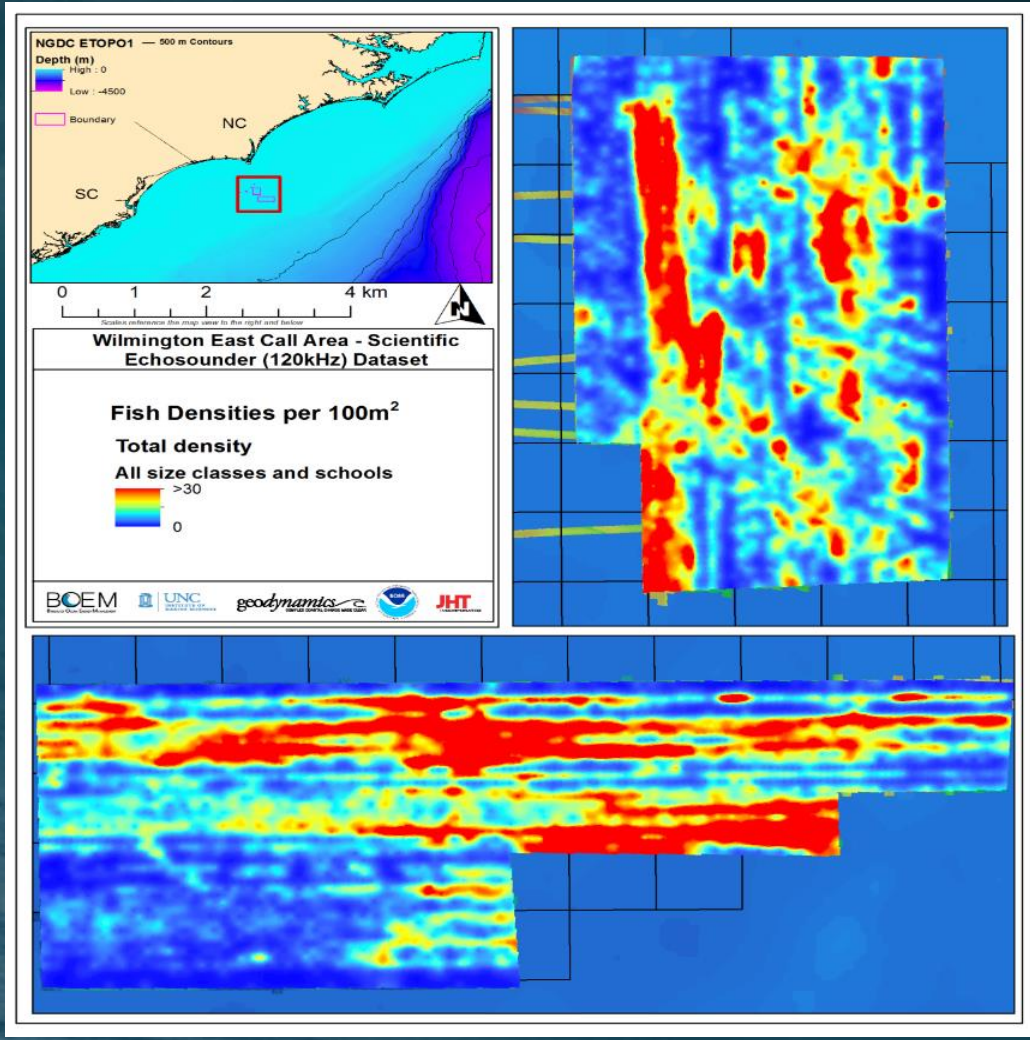


Kriging interpolation of total fish density, including all size classes and fish schools.
Densities are scaled from blue (zero) to red (high).

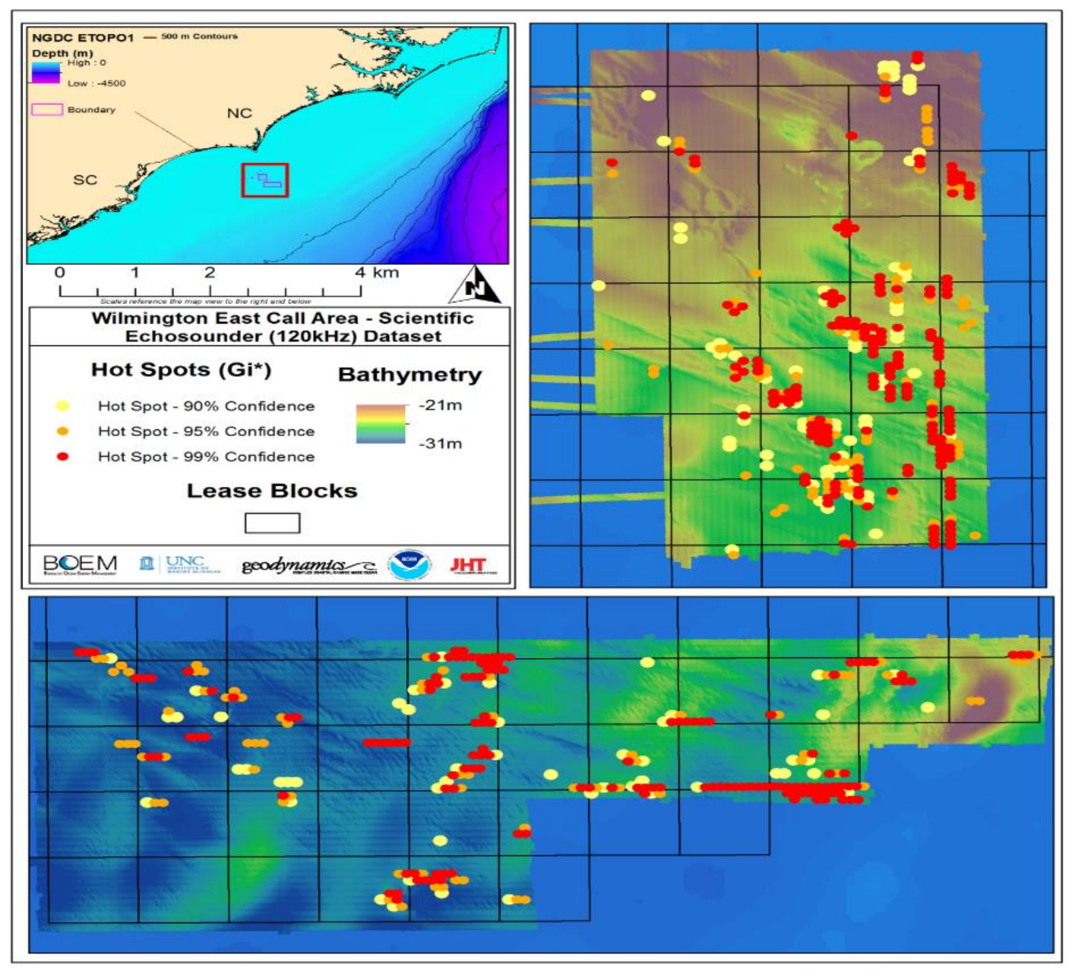
Significant hotspots for large fish size class.
Gi* hotspot p-value: >90% , >95% and >99%
indicating increase likelihood of clusters of high fish densities compared to random.
WEA outlined in white

Fish – habitat relationships

- Depth, relief (slope, slope change), & habitat classification clearly influence location of fish densities
- High relief & complexity = ↑ spp. richness & large fishes
- Fish more broadly distributed at night
- Higher fish abundance (& planktivorous spp.) on wrecks (Paxton et al. 2015)

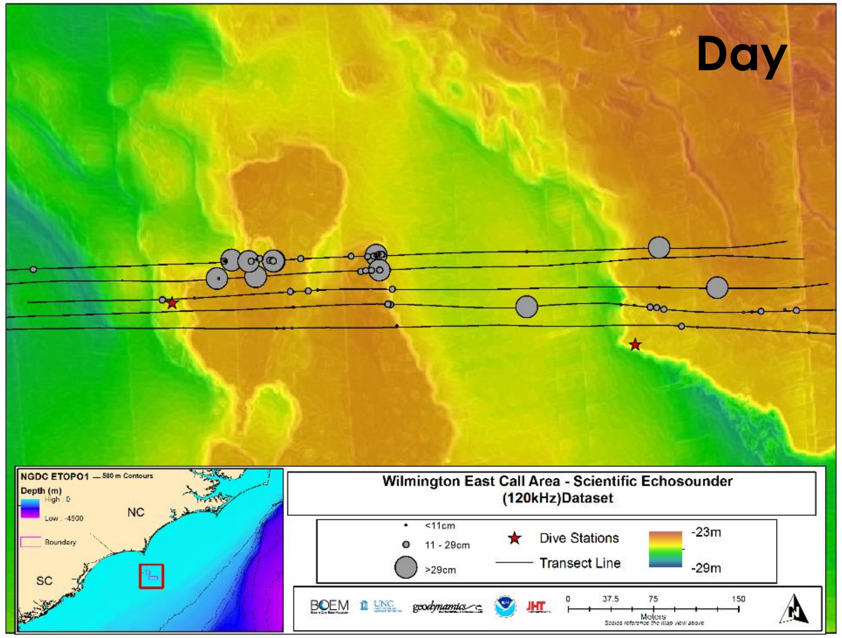


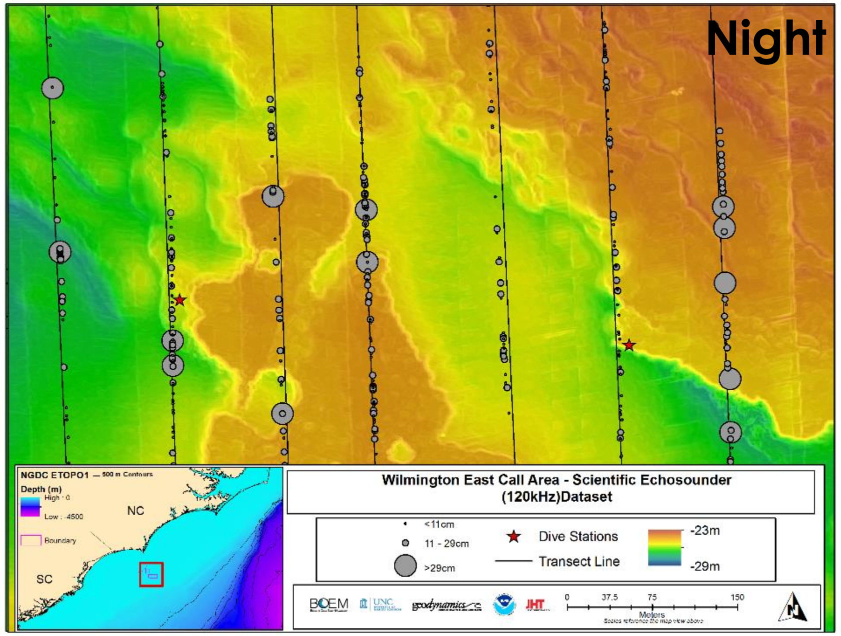
Kriging interpolation of total fish densities



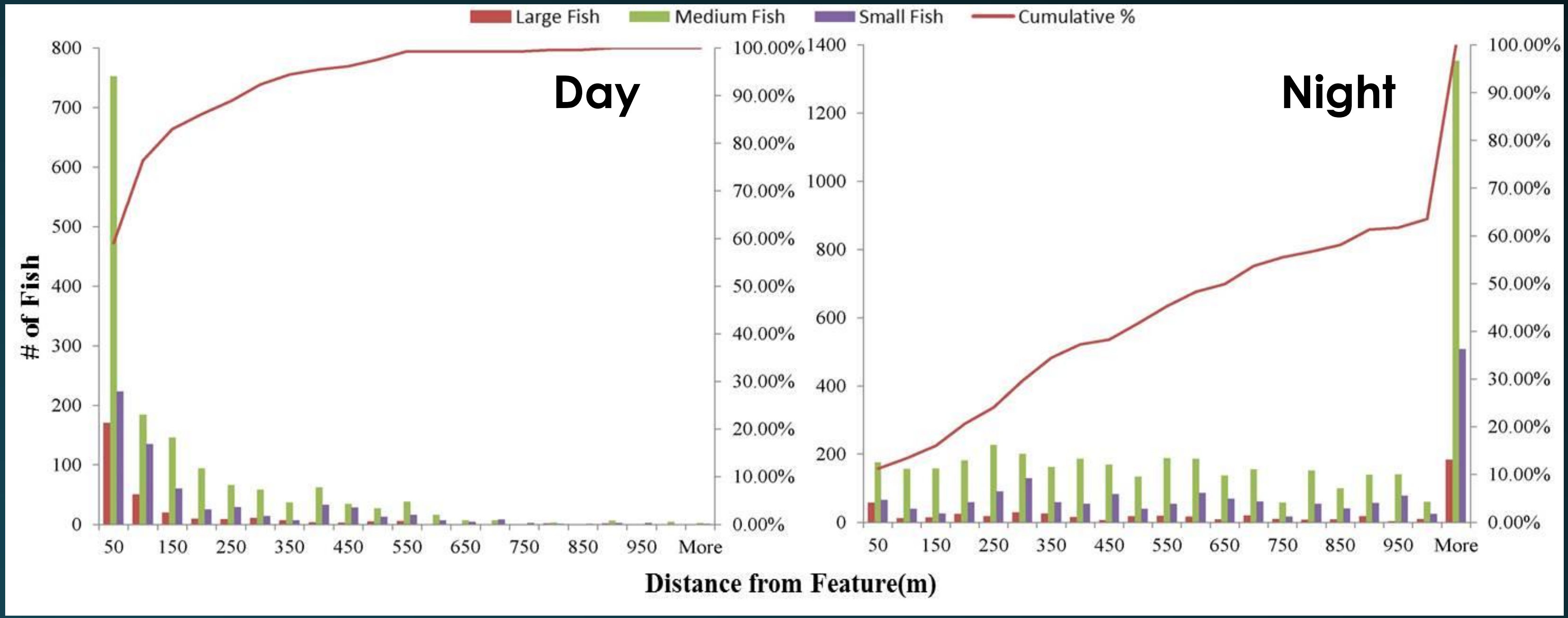
Significant hotspots for large fish size class

Buffer distance for hardbottom





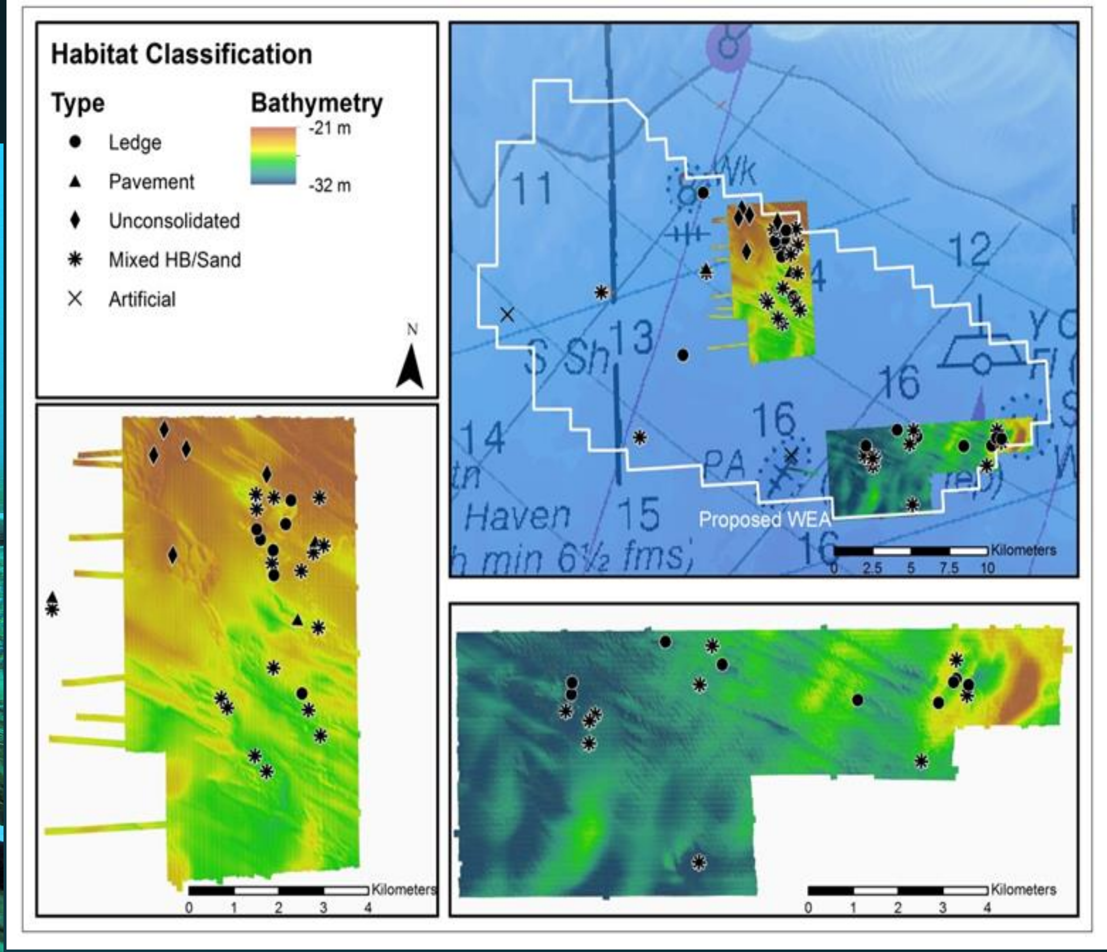
SBES survey lines (black lines) over a set of diver stations on high-relief ledge hardbottom habitats (red stars).
Bathymetry base layer is shown as orange (shallow) to deep (blue).
Individual fish are scaled according to size class.



Cumulative frequency histograms of the distance from ledge hardbottom features show:

- 80% of the large fish within 150 m &
- 100% were within 500 m during day
- > 900 m at night

Diver biological assessments



Habitat types surveyed

Ledge

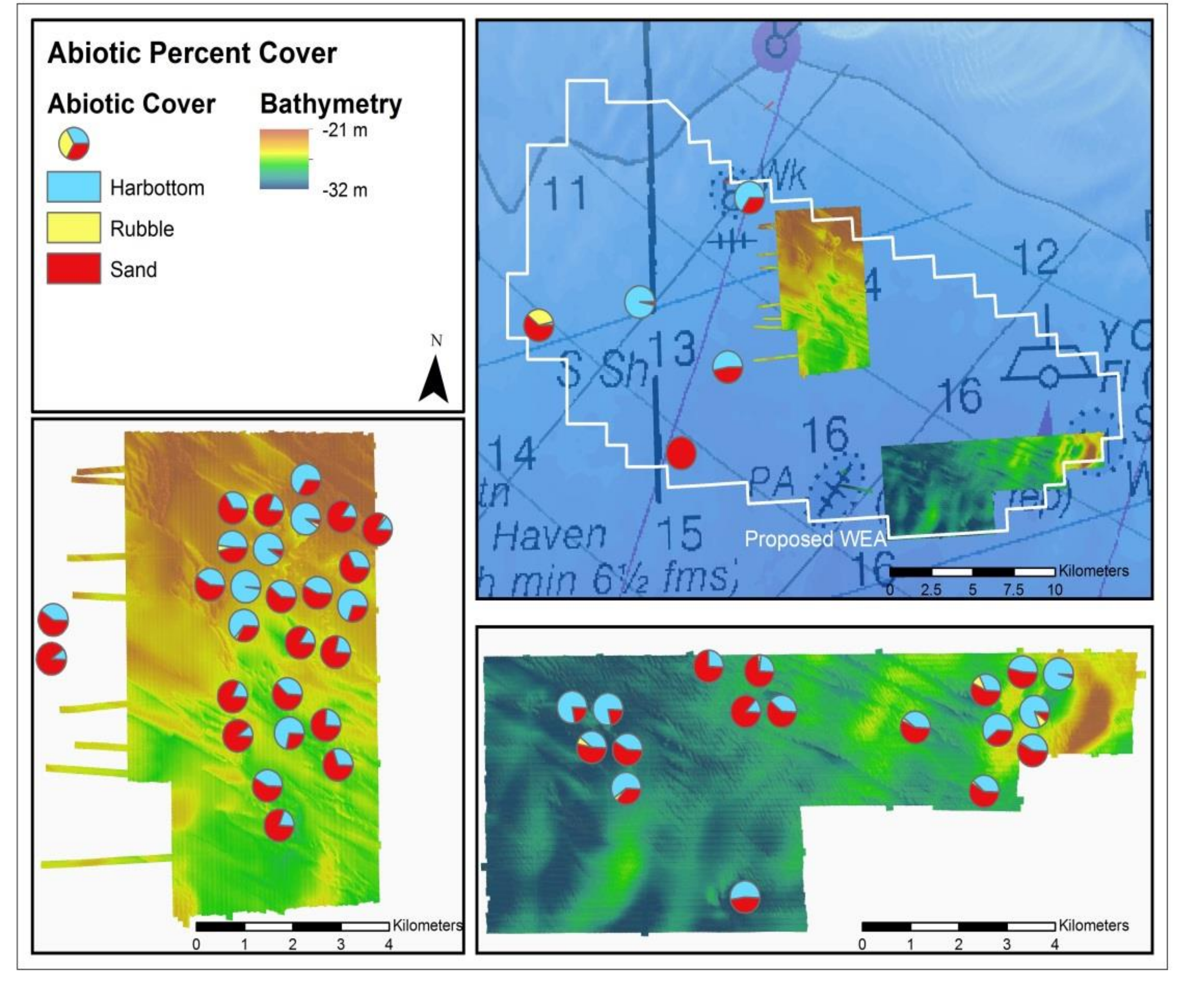
Mixed Hardbottom

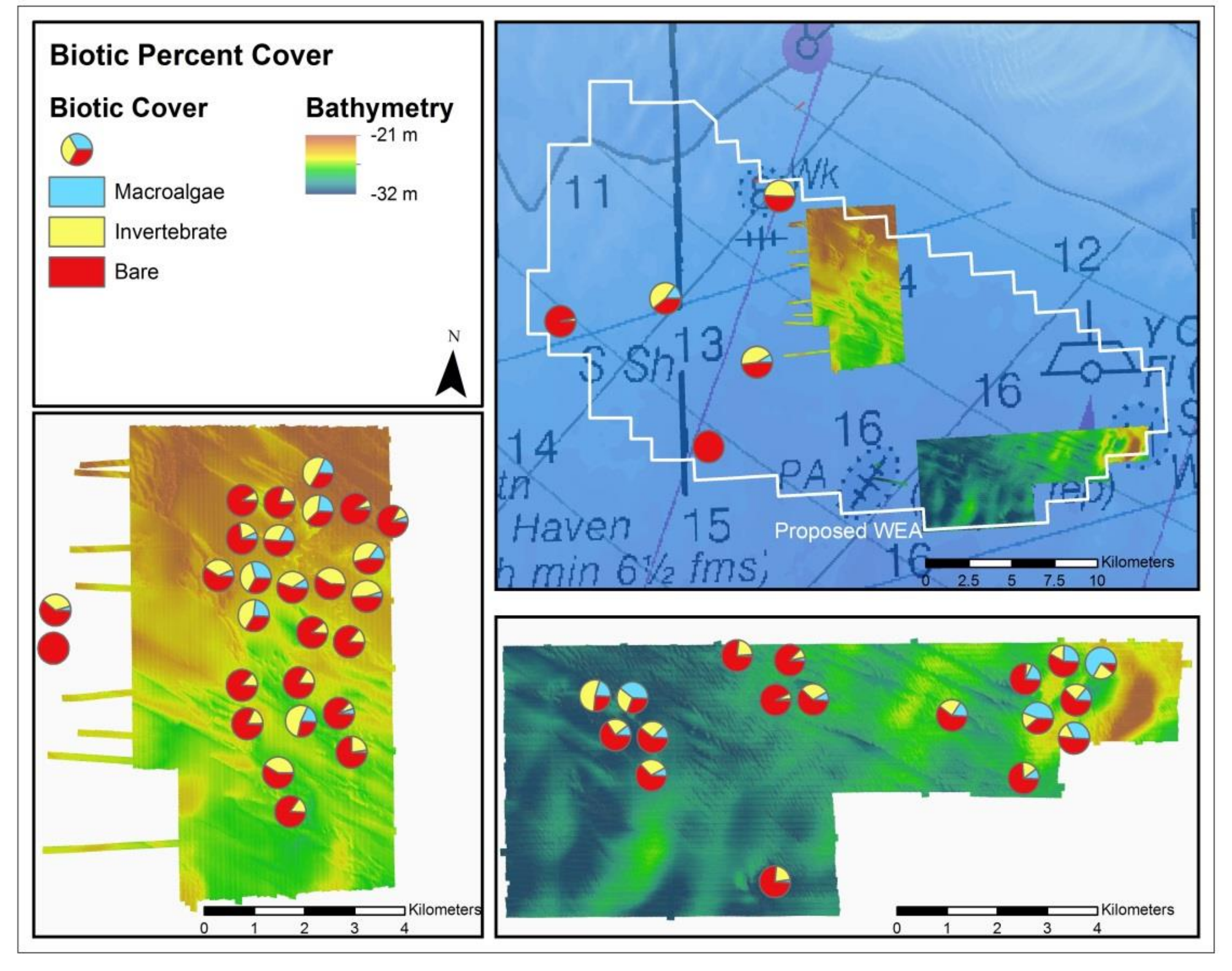
Pavement

Sand

Artificial

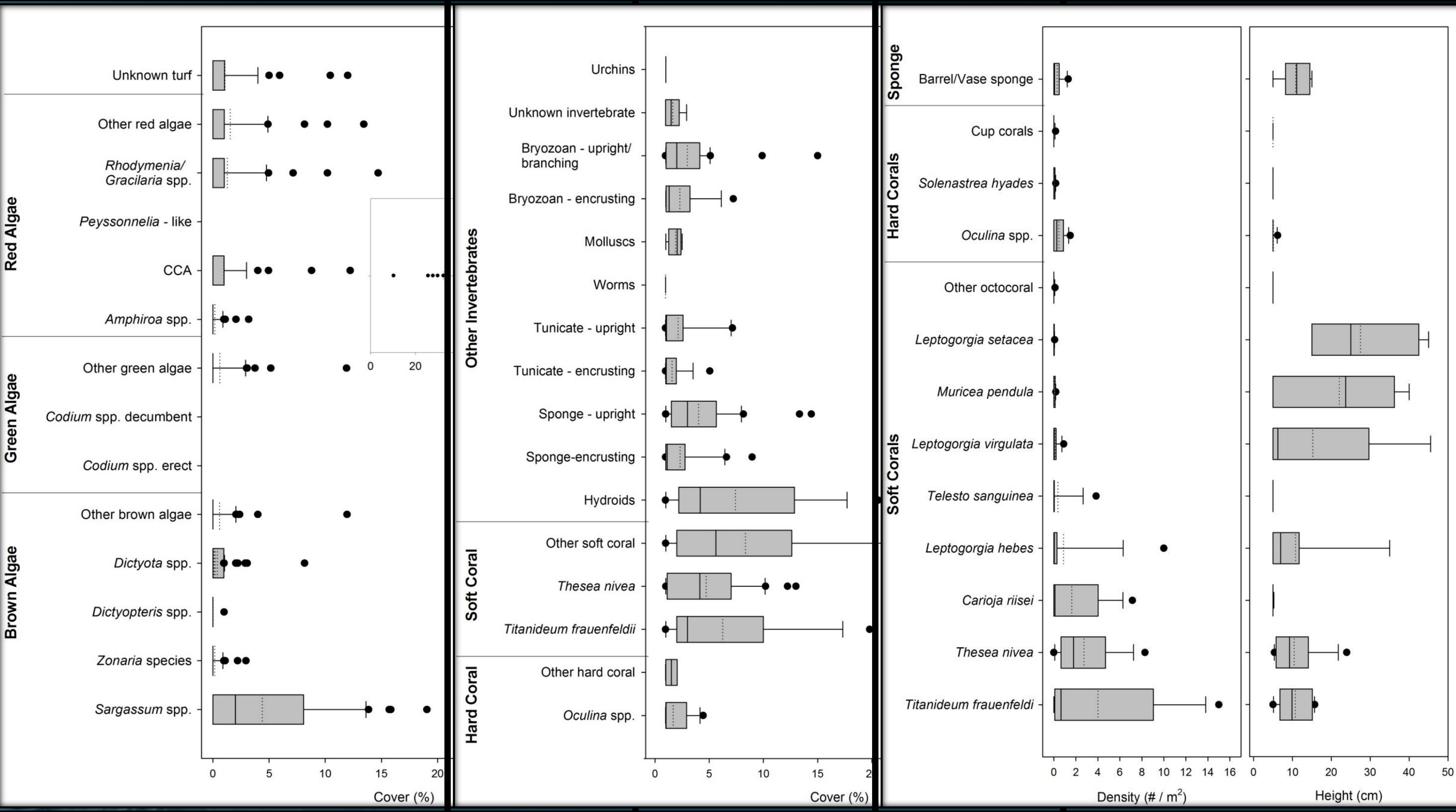
WEA habitat type	Geoform Component	Substrate Component	Biotic Setting	Biotic Component	Page Reference in CMECS for each site description
Sand	Sediment Wave Field	Unconsolidated mineral Substrate	None	None	
Ledge	Rock Outcrop	Rock Substrate	Benthic/ Attached Biota	Attached fauna and diverse colonizers and benthic macroalgae including sponges, soft corals, gorgonians and algae	Pg 148, 152-173
Mixed HB	Rubble Field	Coarse Unconsolidated Substrate: Boulder and Cobble	Benthic/ Attached Biota	Attached fauna and diverse colonizers and benthic macroalgae including sponges, soft corals, gorgonians and algae	Pg 148, 152-173
Pavement	Pavement Area	Unconsolidated mineral substrate	Benthic/ Attached Biota	Sparse attached fauna and diverse colonizers and benthic macroalgae including sponges, soft corals, gorgonians and algae	
Artificial	Wreck	Anthropogenic Wood or Metal	Benthic/ Attached Biota	Sparse attached fauna and diverse colonizers and benthic macroalgae including sponges, soft corals, gorgonians and algae	Pg 148, 152-173


Abiotic Percent Cover
Abiotic Cover
Bathymetry
-21 m
-32 m
Harbottom
Rubble
Sand
N
11
12
13
14
15
16
S Sh
Haven
h min 6½ fms)
PA
Proposed WEA
Kilometers
0 2.5 5 7.5 10
0 1 2 3 4


Biotic Percent Cover
Biotic Cover
Bathymetry
-21 m
-32 m
Macroalgae
Invertebrate
Bare
N
11
12
13
14
15
16
S Sh
Haven
h min 6½ fms)
PA
Proposed WEA
Kilometers
0 2.5 5 7.5 10
0 1 2 3 4

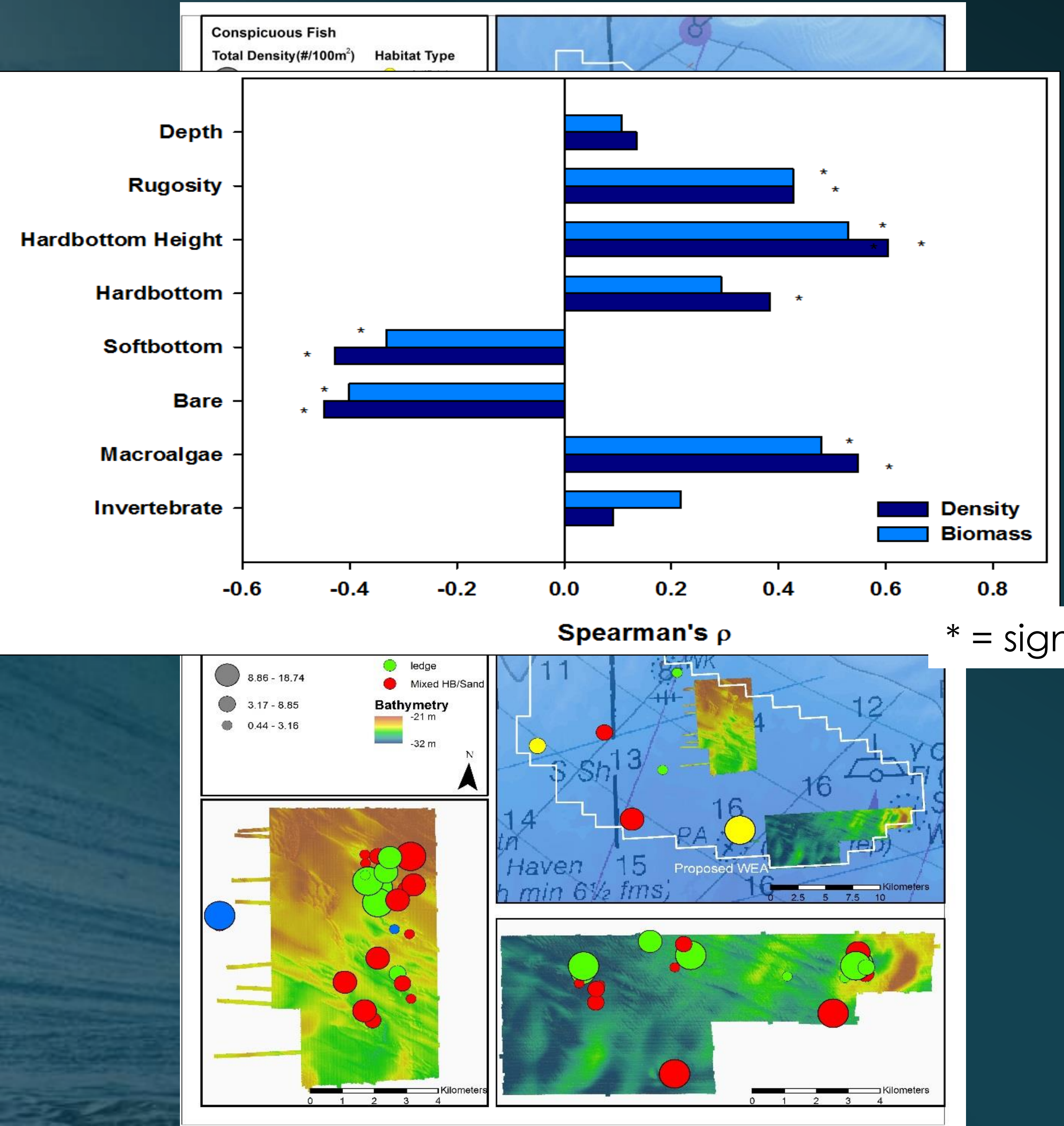

Mixed soft corals

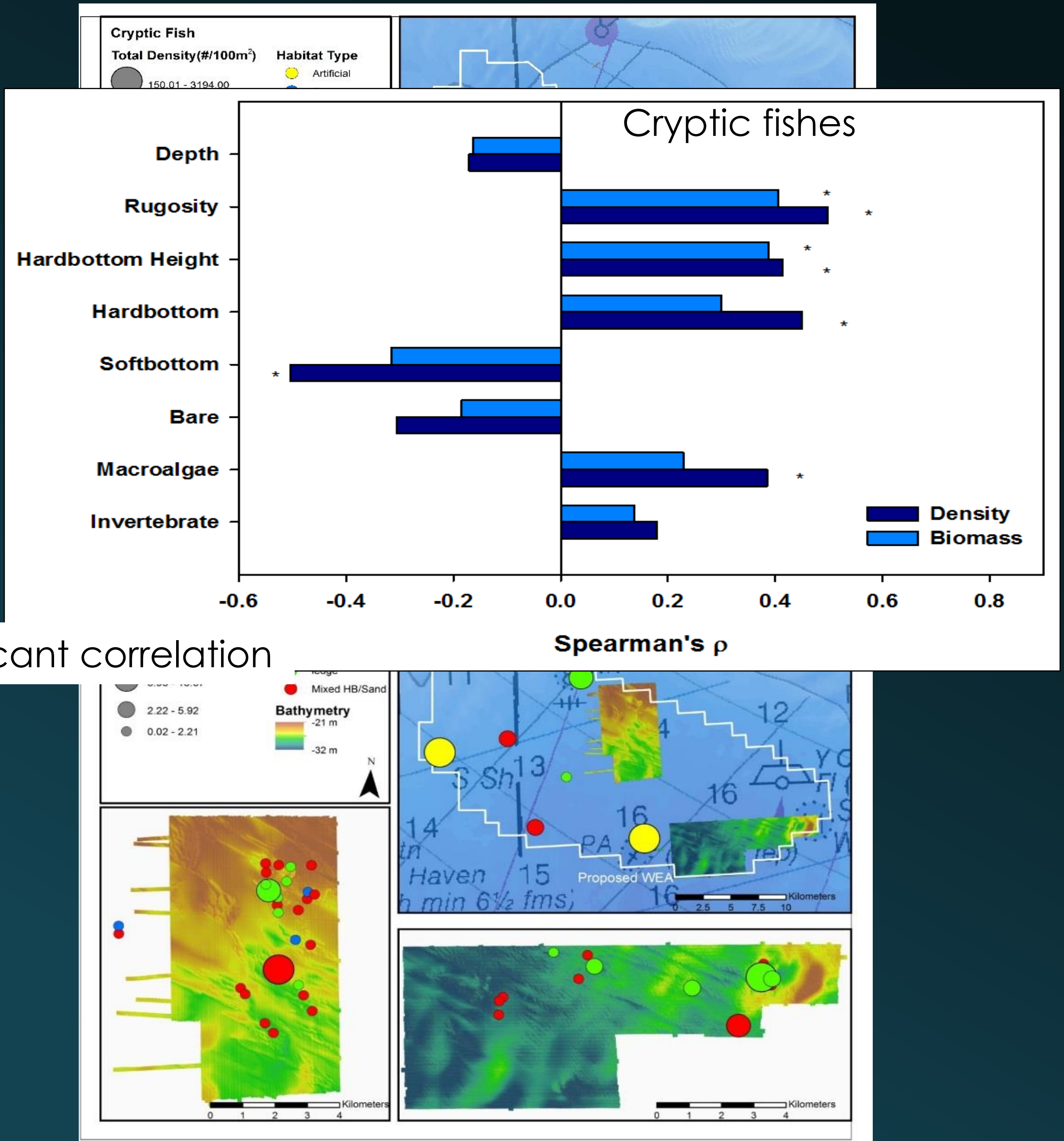

Titanideum frauenfeldii


Unknown turf
Red Algae
Other red algae
Rhodymenia/ Gracilaria spp.
Peyssonnelia - like
CCA
Amphiroa spp.
Green Algae
Other green algae
Codium spp. decumbent
Codium spp. erect
Brown Algae
Other brown algae
Dictyota spp.
Dictyopteris spp.
Zonaria species
Sargassum spp.
0
20
0
5
10
15
20
Cover (%)
Other Invertebrates
Urchins
Unknown invertebrate
Bryozoan - upright/ branching
Bryozoan - encrusting
Molluscs
Worms
Tunicate - upright
Tunicate - encrusting
Sponge - upright
Sponge-encrusting
Hydroids
Soft Coral
Other soft coral
Thesea nivea
Titanideum frauenfeldii
Hard Coral
Other hard coral
Oculina spp.
0
5
10
15
Cover (%)
Sponge
Barrel/Vase sponge
Hard Corals
Cup corals
Solenastrea hyades
Oculina spp.
Soft Corals
Other octocoral
Leptogorgia setacea
Muricea pendula
Leptogorgia virgulata
Telesto sanguinea
Leptogorgia hebes
Carioja riisei
Thesea nivea
Titanideum frauenfeldi
0
2
4
6
8
10
12
14
16
Density (# / m2)
0
10
20
30
40
50
Height (cm)

Fish use of habitats

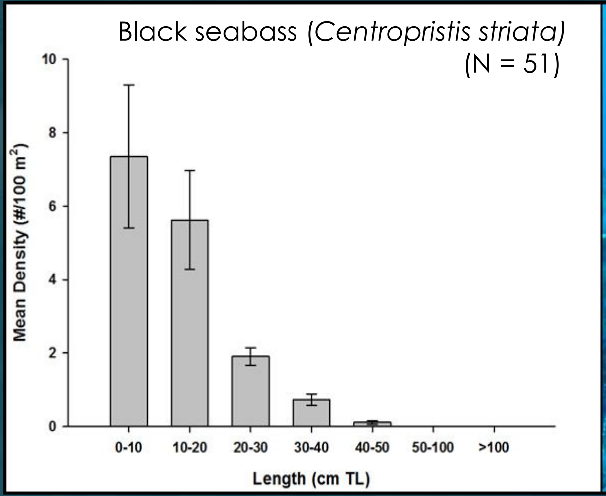
did not differ significantly by habitat type

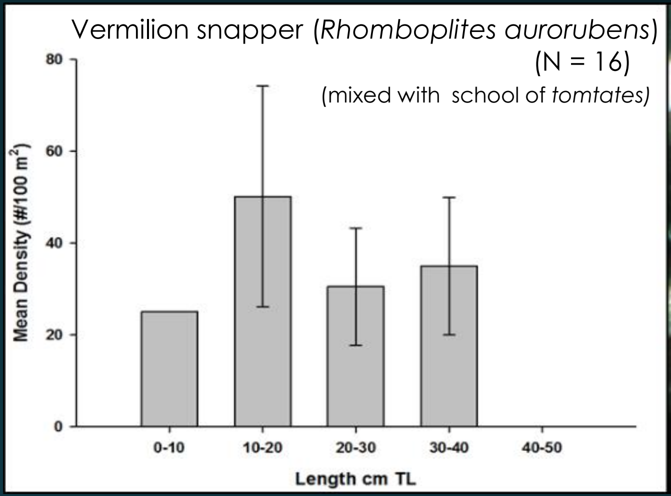


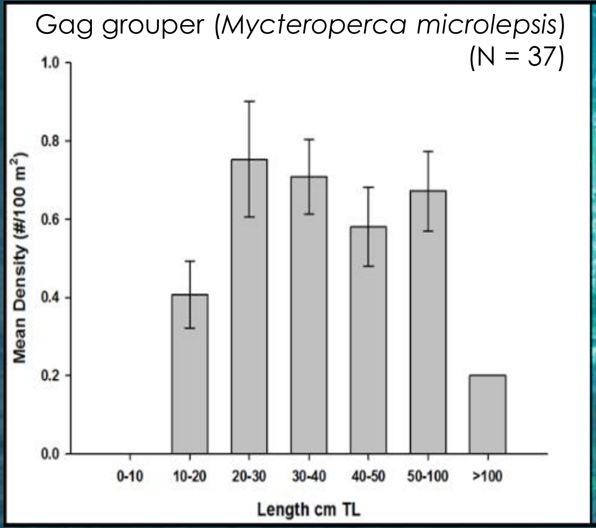


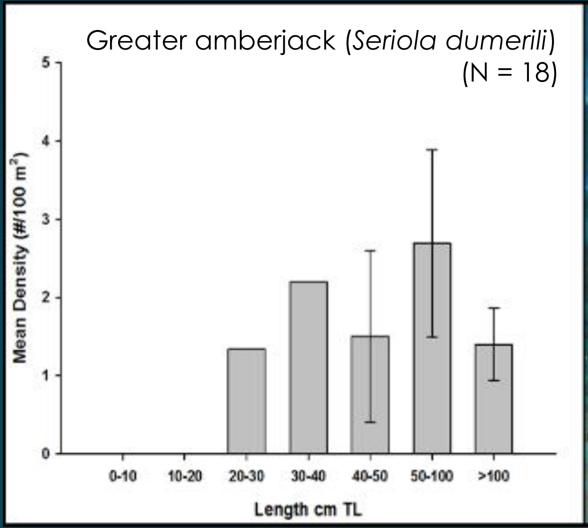
* = significant correlation

Fish length frequencies

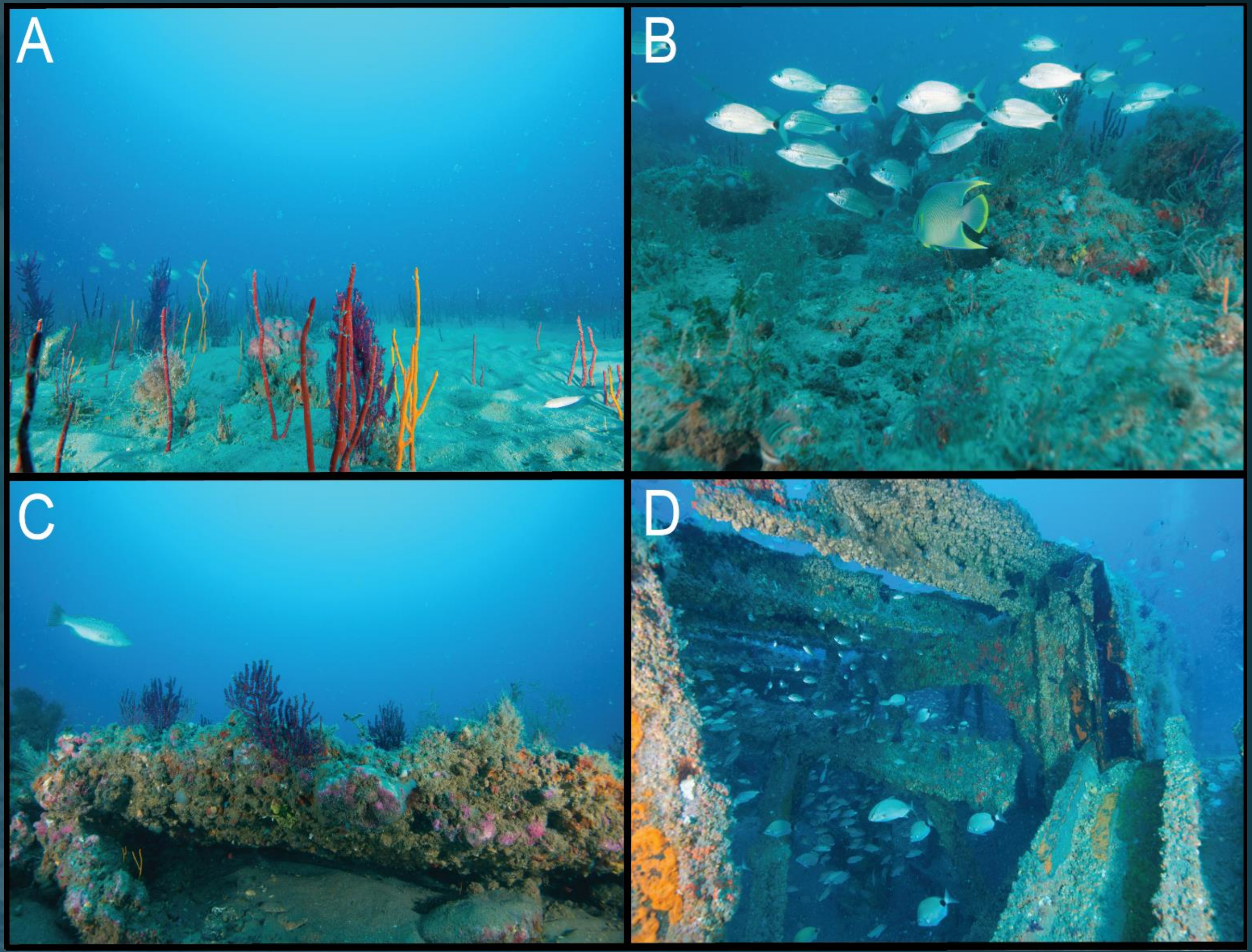




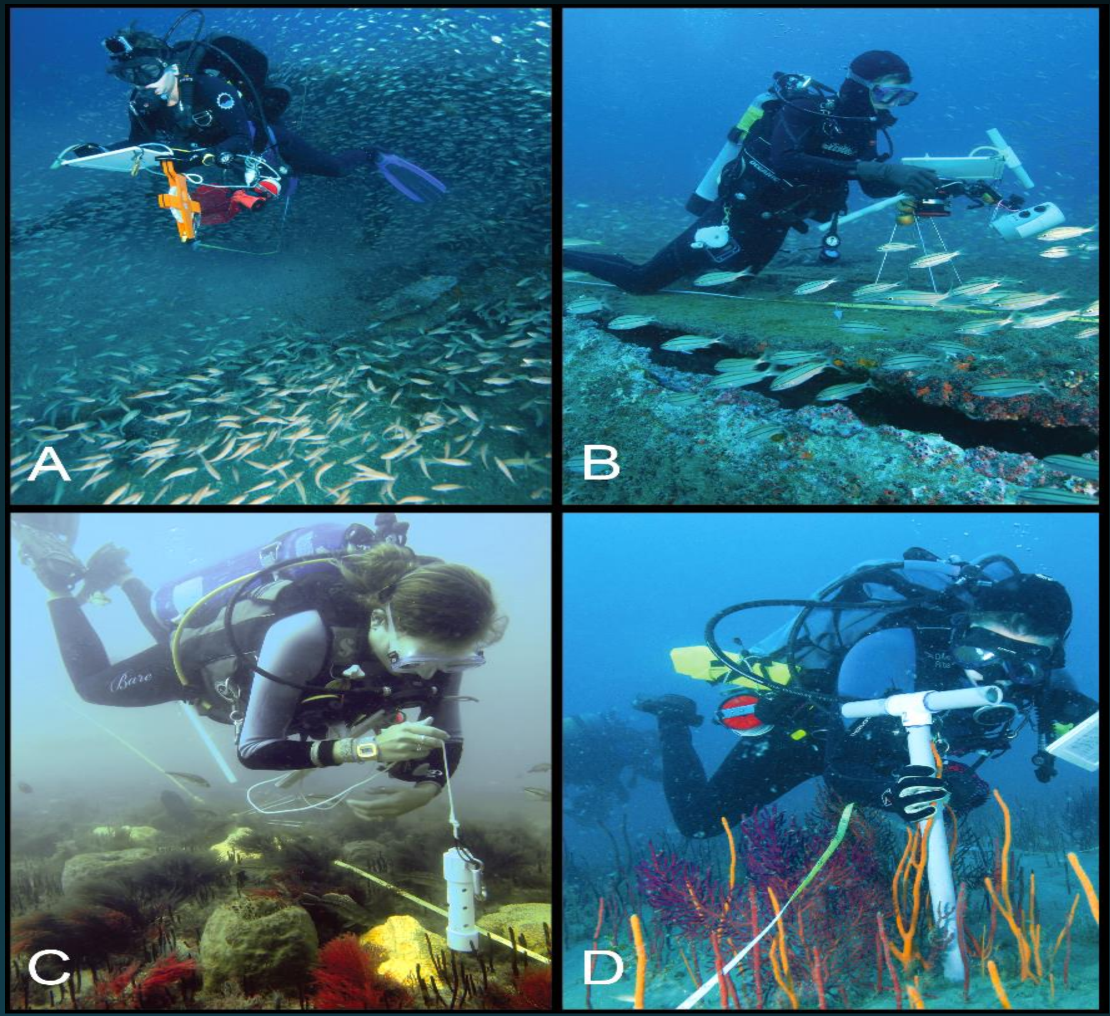




Diver seasonal assessments



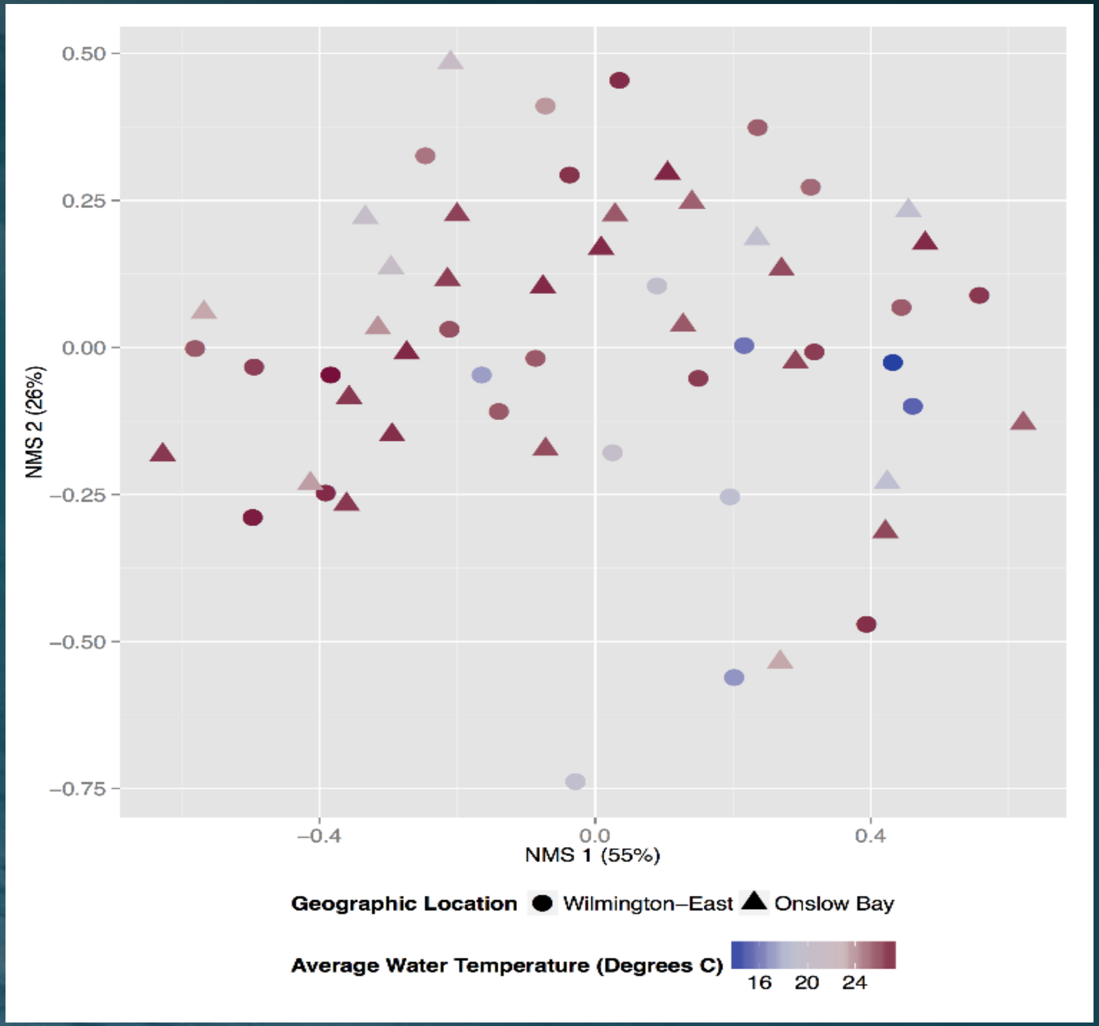
Hardbottom reef types based on structural complexity:
A) Natural reef – flat pavement; B) Natural reef – rubble field;
C) Natural reef – pronounced ledge; D) Artificial reef.



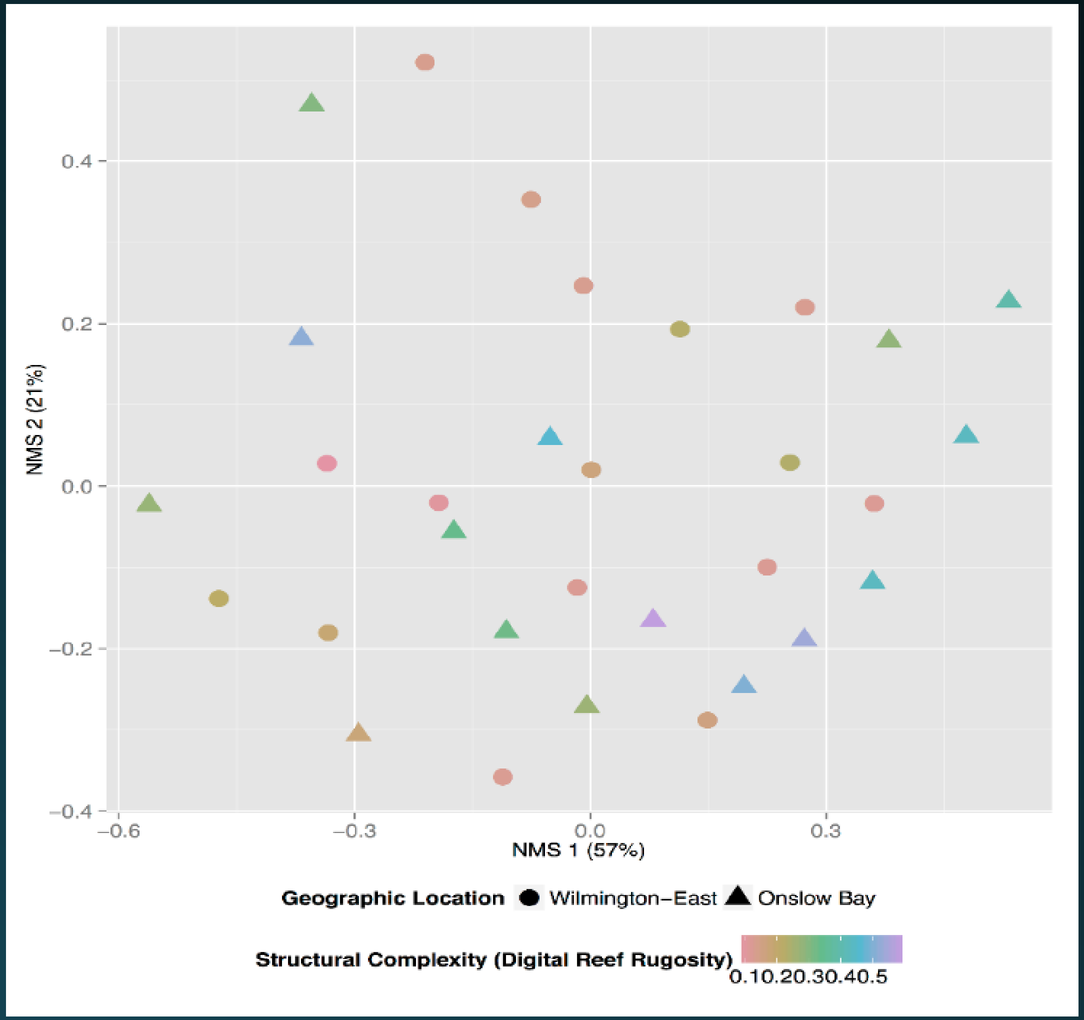
Survey methods for seasonal assessments of hardbottom habitat & biological communities

A) fishes along a belt transect
B) benthic community in a photoquadrat
C) structural complexity using a water level logger
D) sediment depth using a T-rod.

Fish use of habitat by habitat characteristics

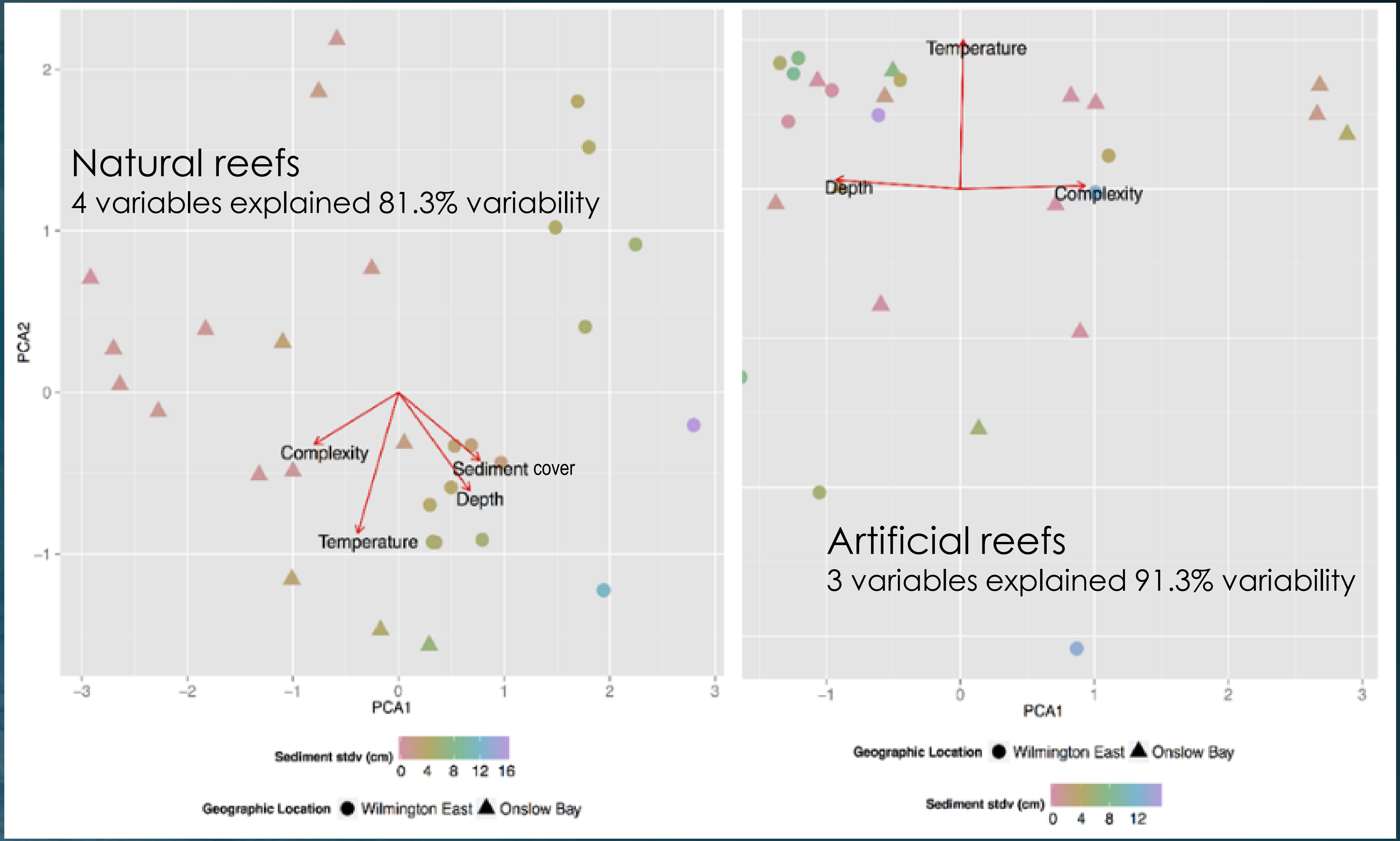


Non-metric multidimensional scaling (nMDS) ordination of snapper-grouper complex fish community on natural & artificial reefs



nMDS plot of fishes on natural reefs that differ by structural complexity: pavement < rubble fields < ledges < artificial reefs

Benthic community composition

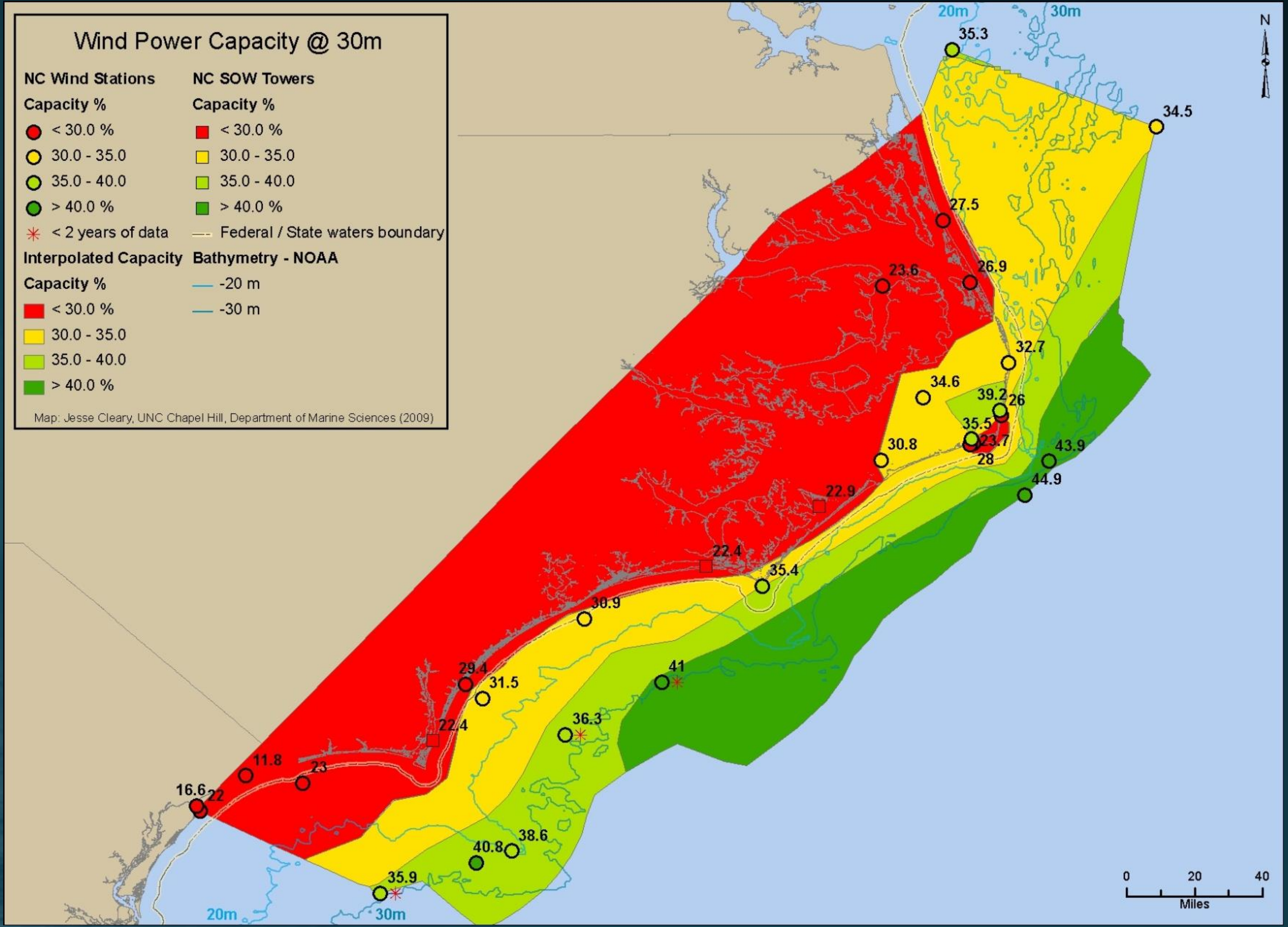


- Benthic community= invertebrates & macroalgae
- Benthic community composition on natural reefs differed between WECA vs. Onslow Bay, likely due to greater degree of sediment dynamics
- Benthic community composition did not differ with location for artificial reefs

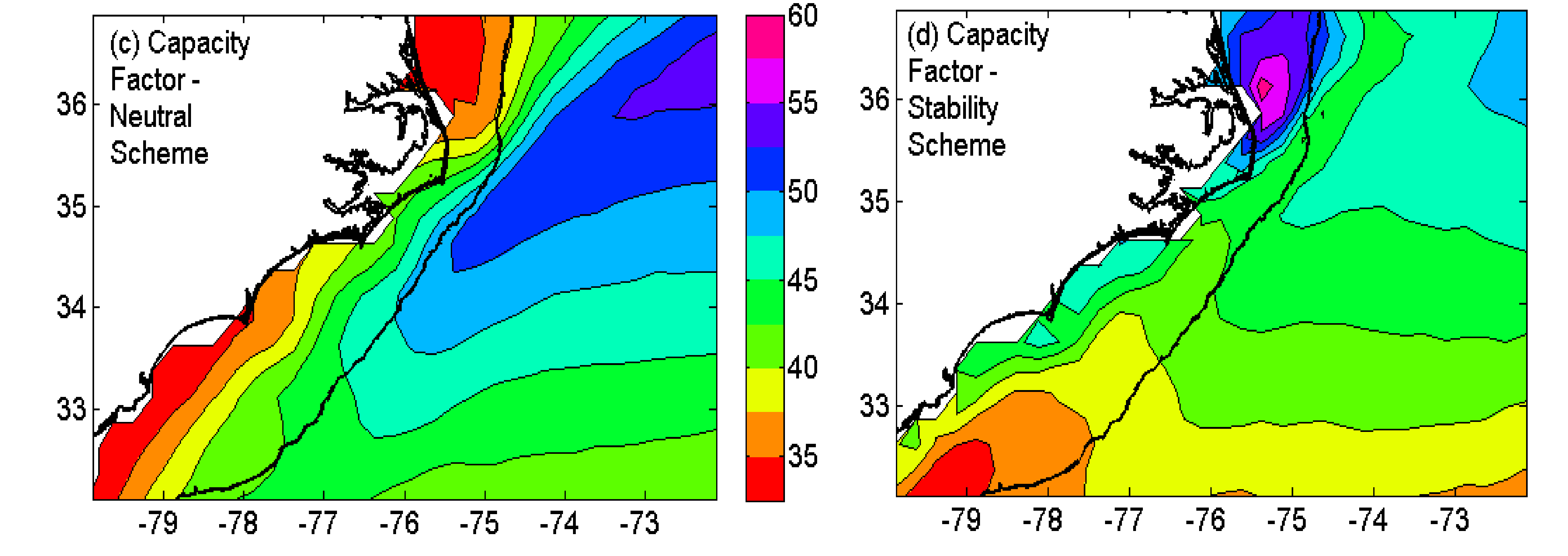
Principal components analysis ordination of benthic community by phyla on reefs
Red arrows and corresponding black labels represent environmental vectors

An important update

Wind Capacity Factor Map (2009)



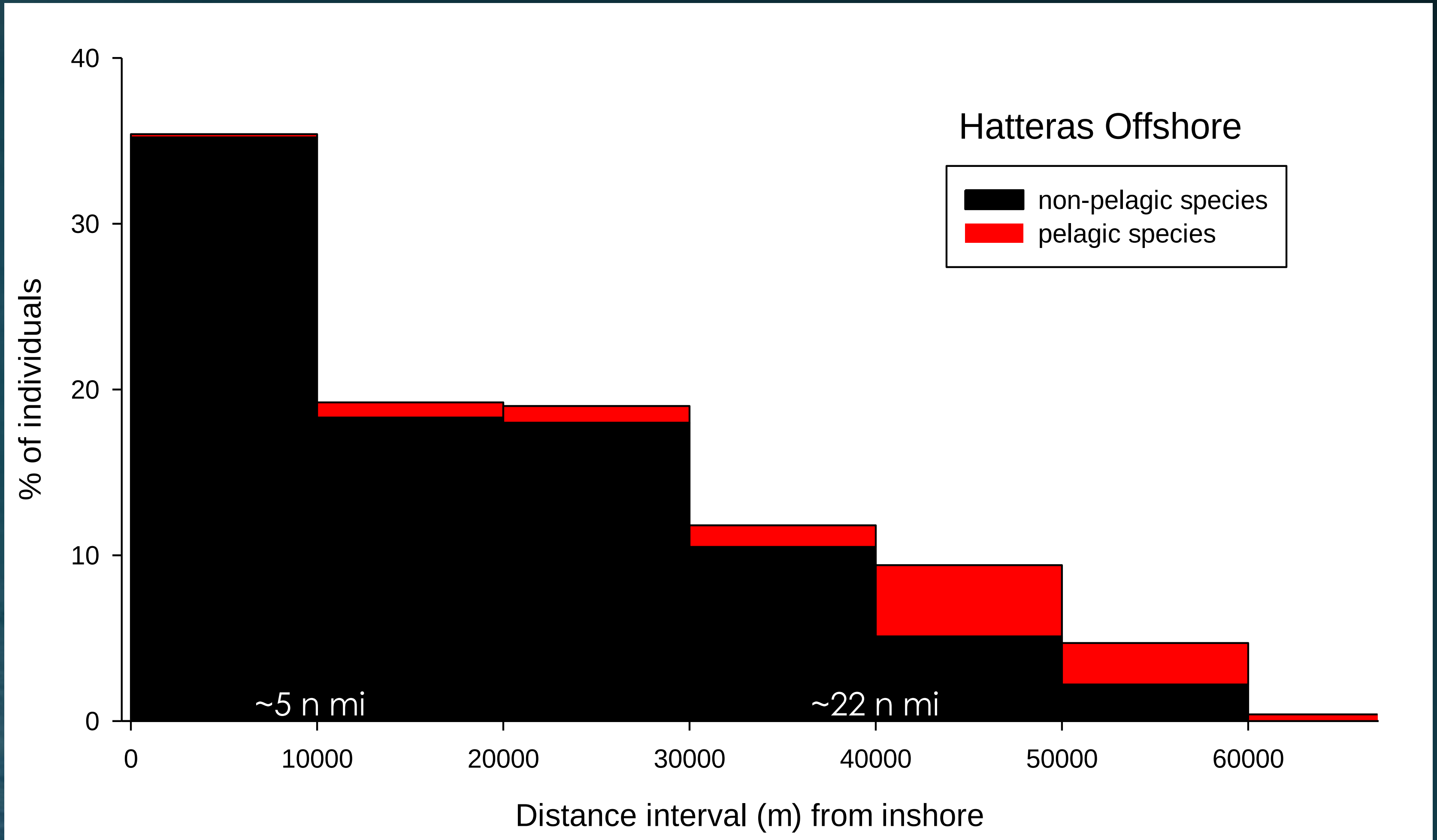
Updated Wind Capacity Factor Map (2015)



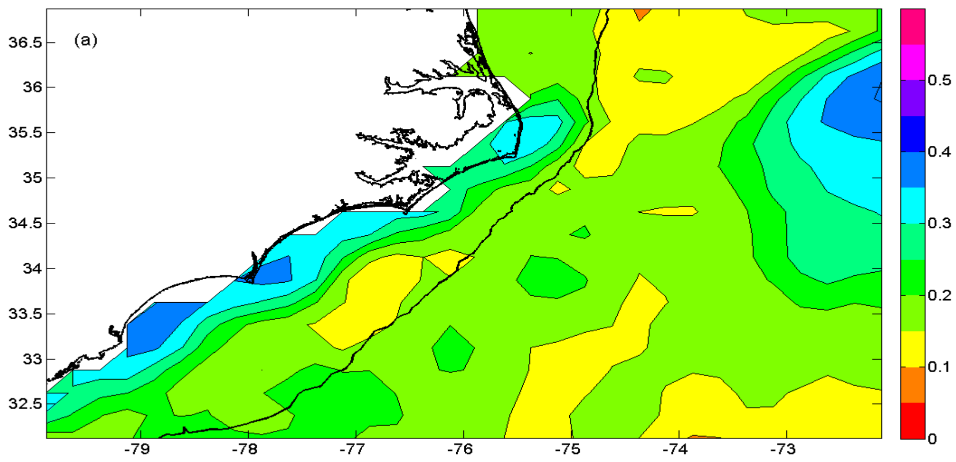
Thomas et al. 2015

Video credit: J. McCord, UNC-SCI

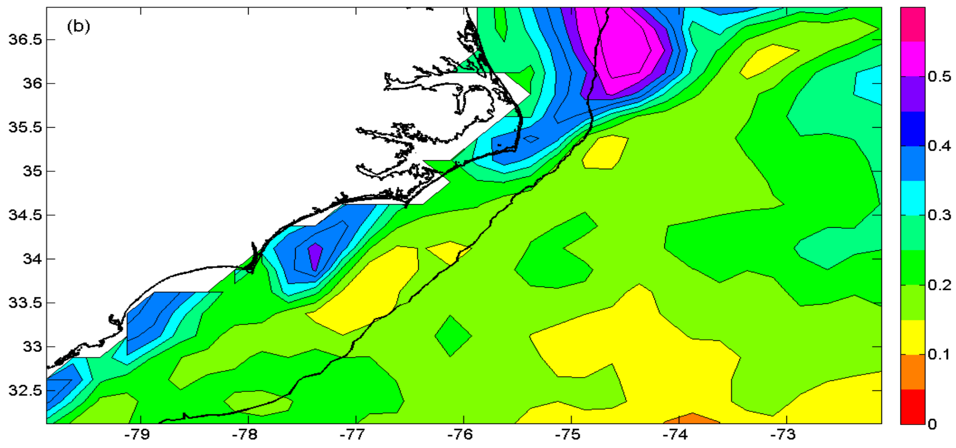
Percentage of individuals of non-pelagic (coastal) & pelagic birds (seabirds) observed with increasing distance from land



Inter-annual variation: standard deviation of annual-averaged wind speeds indicate greatest variability near the coast and for Gulf Stream position at eastern boundary. Big variation at shelf-edge off NE NC in MOS scheme

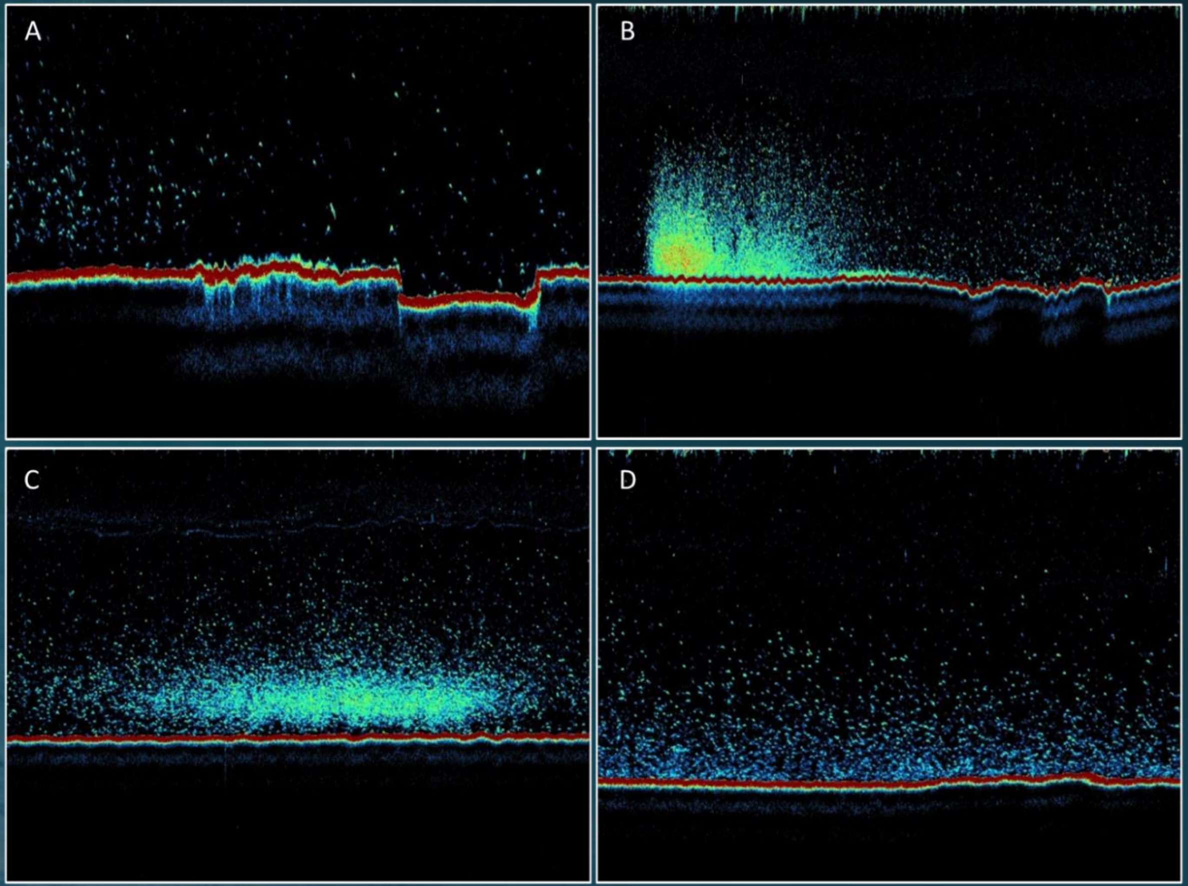


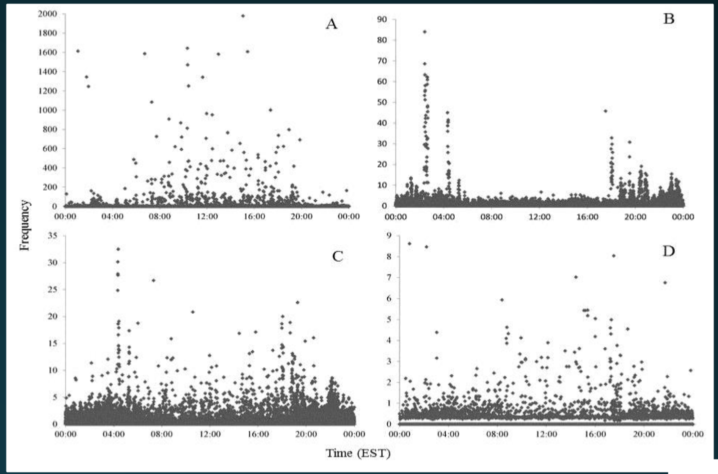
Neutral scheme

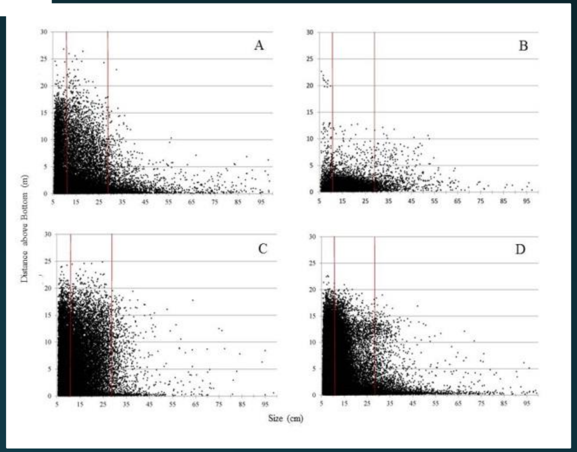


MOS scheme

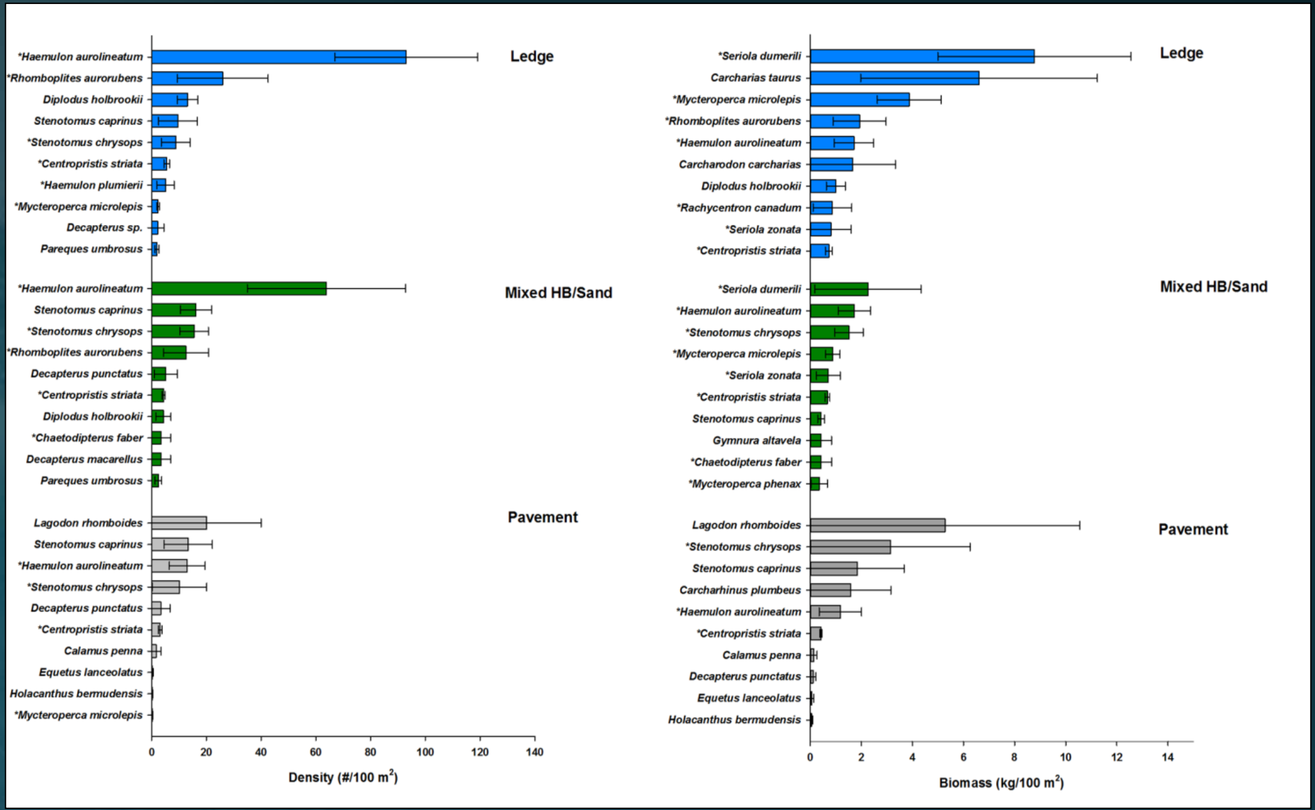
Example splitbeam echosounder echograms showing the seafloor (red) and individual fish (green-yellow-orange) near a ledge (A) or fish schools in the water column (green-yellow-orange) over a mixed hardbottom (B) or unconsolidated bottoms (C & D).

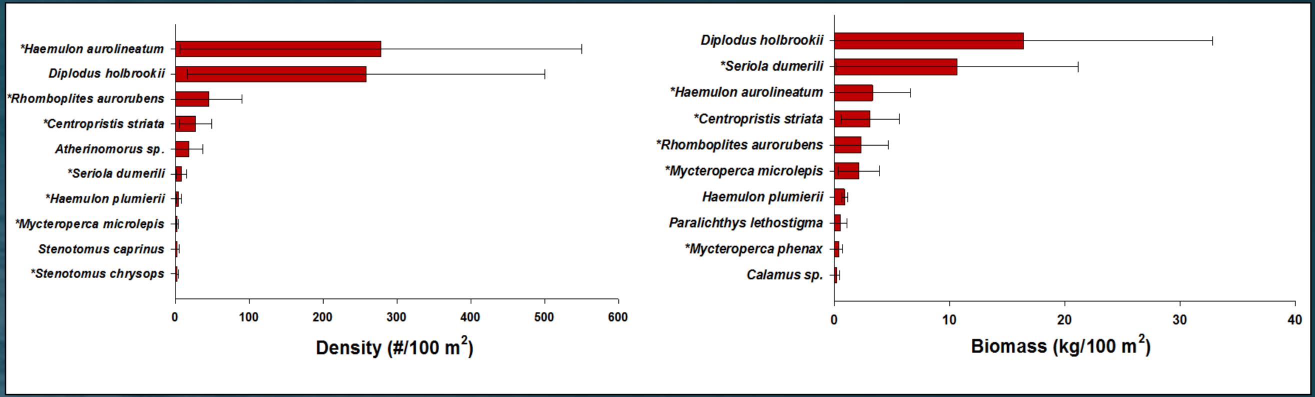




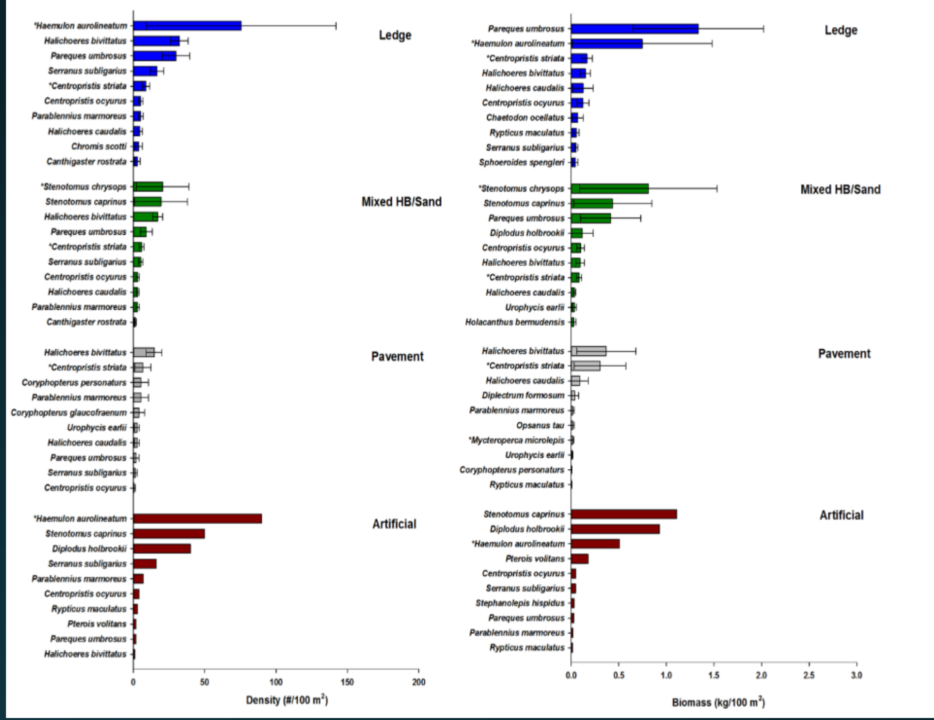


Distance above the seafloor for individual fish detected during SBES surveys for 2013 day (A) and night (B) and 2014 day (C) and night (D). Fish sizes in cm are estimated from acoustic target strength. Red vertical bars indicate divisions of pre-determined size classes for small fish (<12 cm), medium fish (12 to 19 cm) and large fish (>29 cm).



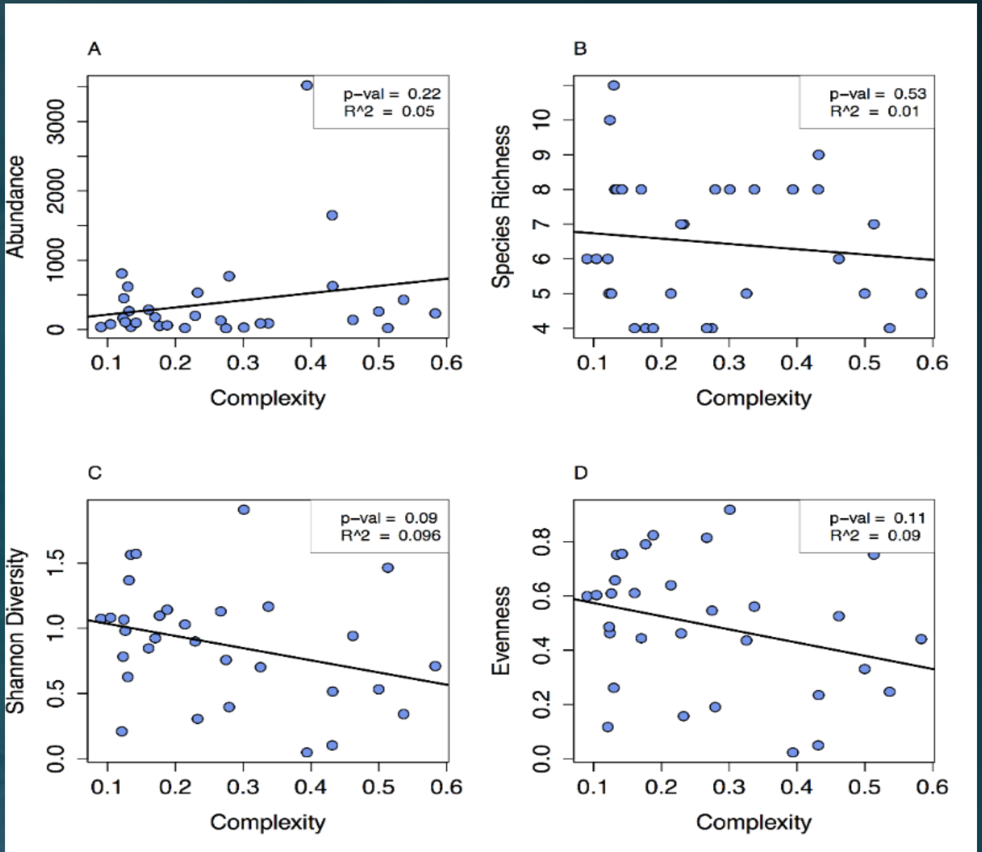


The top ten species of the conspicuous community's mean density (#/100 m²) and mean biomass (kg/100 m²) by natural hardbottom type: ledge, MHB/sand, and pavement. The asterisk (*) denotes a member of the Snapper Grouper Management Complex managed by the SAFMC.

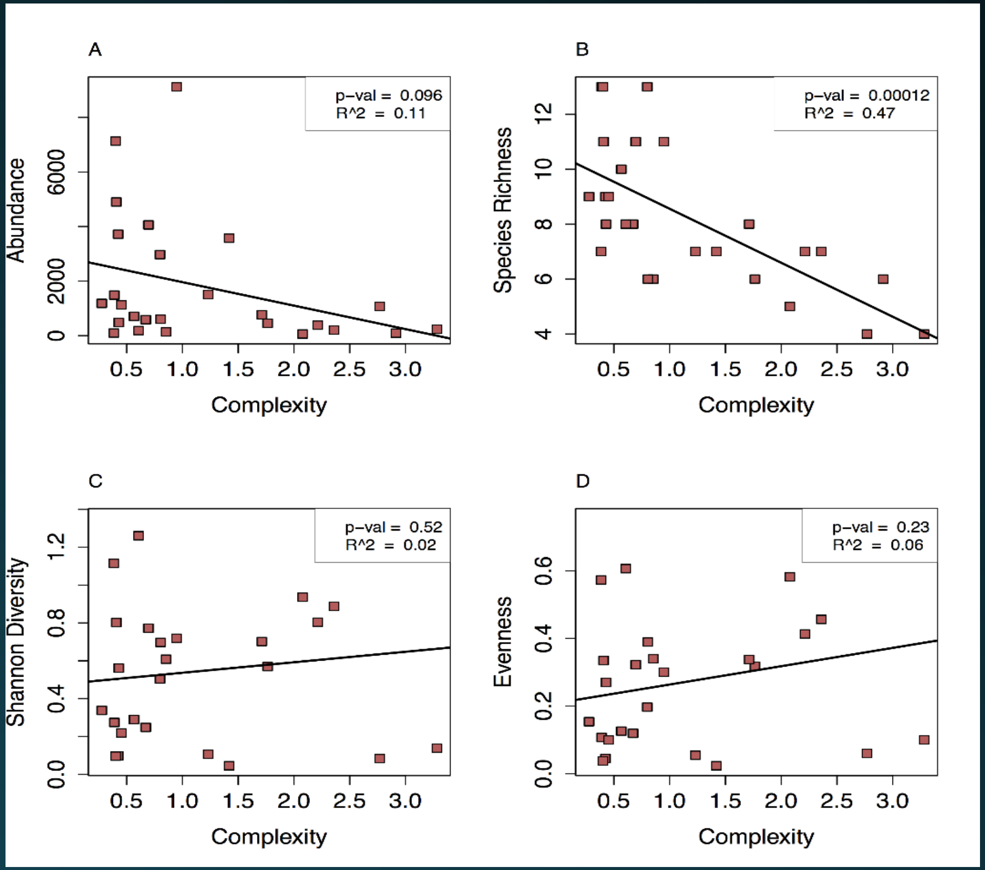


Cryptic fishes: top ten species by mean site density (#/100 m²) and mean site biomass (kg/100 m²) by habitat type: Ledge (N = 15), MHB/s (N = 27), Pavement (N = 3), and Artificial (N = 1).

NOAA diver counts a school of *Seriola zonata*, a numerous species in the large fish size class



Effect of structural complexity of natural hardbottom on community metrics of fish in the snapper-grouper complex on A) abundance, B) species richness, C) Shannon-Wiener species diversity, and D) evenness. Black lines represent linear models



Effect of structural complexity of artificial reefs on community metrics of fish in the snapper-grouper complex on A) abundance, B) species richness, C) Shannon-Wiener species diversity, and D) evenness. Black lines represent linear models =marginal negative differences with structural complexity of artificial reefs (PERMANOVA, p = 0.0499).