Impact of Disturbance on Habitat Recovery in Habitat Management Areas on the Northern Edge of Georges Bank

Ecosystem Perturbation Experiment

Woods Hole Oceanographic Institution
Scott Gallager, Steve Lerner, Mike Saminsky

Fishing Community
Lund’s Fisheries: Wayne Reichle, Jeff Kaelin,
Captain Brady of the F/V Jersey Cape

Scallop Plan Development Team August 28, 2017
2016 Scallop Research Set-Aside
NOAA-NMFS-NEFSC-2016-2004548
Plankton Image Microscope
CTD, Chloro, Turb, PAR
C3D Interferometric Sonar
Stereo Cameras

HabCamV5
V-fin
Habitat Aware Reconnaissance and Imaging Module (HARIM)

Specifications
- Vehicle: REMUS 600

Sensors
- Stereo PT Grey 10 Mpixel cameras, 12mm lenses
- TX2 6 core processor
- CTD, Chlorophyll, turbidity
- Sidescan
- Plankton imaging and classification (CPICS)

Capabilities
- On-board stereo imaging, light-field and color correction, rectification, point cloud production, and target segmentation
- Benthic target acquisition using sidescan followed by classification using stereo imaging
- On-board plankton classification
- Habitat characterization, spatial analysis, dynamic spatial sampling based on habitat type
- 10 hour deployments up to 600m depth in 3 kt current
Objectives of Two Year Study

1) To determine the persistence of mechanical impacts of scallop dredging and long-term ecosystem resiliency as a function of substrate type (e.g., sand, sand/gravel, gravel/cobble).

2) To complete Before-After Control-Impact (BACI) habitat characterizations at three impact scales (Heavy (5%), Light (0.2%, None (0%)) and three habitat types (sand, sand/gravel/shell, gravel/epifauna) to evaluate ecosystem and habitat resiliency.

(Metrics for Recovery Rate that relate Impact Intensity and Habitat Type over time will allow for a direct, statistical description of where, at what scale, and how often HMAs could be opened to target high density scallops with minimum impact on sensitive habitat).

3) To complete high resolution survey of scallop abundance in the CLA II HMAs to provide information to the Council as to where targeted scallop fishing might be allowed on a limited basis while concurrently mitigating impact on habitat.

(New Habitat Characterization Module for the REMUS 600 Autonomous Underwater Vehicle (AUV) with very high resolution (mm scale) stereo imagery and a sidescan unit (cm to 100m scale).)
Northeast Reduced Impact Habitat Management Area (NERIA)

Areas surveyed:
NERIA: 349.50 km²
NEHMA: 700.36 km²
EGS: 439.06 km²

# Image pairs taken: 852,145
# annotated: 17,105
(1/50, continuing)

Total area imaged: ~ 851,000 m²

All images auto-annotated for habitat
Highest # scallops / image:  39
Number of annotators:    7

Bathymetry
Exploitable shell heights based on Dupaul, 2008

\[
a = -12.6 \\
b = 0.12 \\
sh\_bin = \text{linspace}(10,200,\text{length}(\text{lengths})); \\
r = \exp(a+b \times \text{sh\_bin})./(1+\exp(a+b \times \text{sh\_bin})); \\
\text{exploit\_num} = \text{lengths} : \times \text{r}';
\]

JSR 3 (4) 1133-1144

\[
E(M) = \exp(\alpha + \gamma \ln D + \delta \ln L + \theta u + \beta \ln H + r_1 + r_2 \ln H)
\]

D: depth, L: latitude, H: Shell Height, u: subarea, + random effects
### Density of Scallops by Area

<table>
<thead>
<tr>
<th></th>
<th>Exploitable</th>
<th>SE</th>
<th>Medium</th>
<th>SE</th>
<th>Small</th>
<th>SE</th>
<th>All Scallops</th>
</tr>
</thead>
<tbody>
<tr>
<td>NERIA</td>
<td>24,247,050</td>
<td>0.39</td>
<td>8,525,126</td>
<td>0.09</td>
<td>444,462</td>
<td>0.02</td>
<td>33,216,639</td>
</tr>
<tr>
<td>NEHMA</td>
<td>739,585</td>
<td>0.03</td>
<td>668,371</td>
<td>0.05</td>
<td>181,772</td>
<td>0.02</td>
<td>1,589,728</td>
</tr>
<tr>
<td>EGS</td>
<td>4,169,315</td>
<td>0.09</td>
<td>2,862,352</td>
<td>0.08</td>
<td>287,892</td>
<td>0.01</td>
<td>7,319,559</td>
</tr>
<tr>
<td>SAM CA2-N-NA</td>
<td>21,451,290</td>
<td>0.35</td>
<td>6,684,256</td>
<td>0.35</td>
<td>450,534</td>
<td>0.02</td>
<td>28,586,081</td>
</tr>
</tbody>
</table>

### Biomass of Scallops (MT) by Area

<table>
<thead>
<tr>
<th></th>
<th>Exploitable</th>
<th>SE</th>
<th>Medium</th>
<th>SE</th>
<th>Small</th>
<th>SE</th>
<th>All Scallops</th>
</tr>
</thead>
<tbody>
<tr>
<td>NERIA</td>
<td>7,070</td>
<td>141.24</td>
<td>270</td>
<td>4.81</td>
<td>0.72</td>
<td>0.04</td>
<td>7,487</td>
</tr>
<tr>
<td>NEHMA</td>
<td>173</td>
<td>7.93</td>
<td>20</td>
<td>1.32</td>
<td>0.17</td>
<td>0.02</td>
<td>202</td>
</tr>
<tr>
<td>EGS</td>
<td>756</td>
<td>17.16</td>
<td>91</td>
<td>2.43</td>
<td>0.29</td>
<td>0.02</td>
<td>867</td>
</tr>
<tr>
<td>SAM CA2-N-NA</td>
<td>6,666</td>
<td>126.00</td>
<td>211</td>
<td>3.76</td>
<td>0.23</td>
<td>0.03</td>
<td>6,877</td>
</tr>
</tbody>
</table>
Grid 30 m squares

Ordinary Kriging with depth as co-variate
Northeast Reduced Impact Habitat Management Area (NERIA)

Gridded to 30 m squares

Ordinary Kriging with depth as co-variate

Also comparing with Empirical Bayesian kriging
Northeast Habitat Management Area (NEHMA)
Eastern Georges Shoals (EGS)
Biomass

Northeast Reduced Impact Habitat Management Area (NERIA)
Biomass

Northeast Habitat Management Area (NEHMA)
Biomass

Eastern Georges Shoals (EGS)
CL2-N-NA Area 442.011
2017 Survey July 20-24

<table>
<thead>
<tr>
<th>Density of Scallops by Area</th>
<th>Exploitable</th>
<th>SE</th>
<th>Medium</th>
<th>SE</th>
<th>Small</th>
<th>SE</th>
<th>All Scallops</th>
</tr>
</thead>
<tbody>
<tr>
<td>NERIA</td>
<td>24,247,050</td>
<td>0.39</td>
<td>8,525,126</td>
<td>0.09</td>
<td>444,462</td>
<td>0.02</td>
<td>33,216,639</td>
</tr>
<tr>
<td>NEHMA</td>
<td>739,585</td>
<td>0.03</td>
<td>668,371</td>
<td>0.05</td>
<td>181,772</td>
<td>0.02</td>
<td>1,589,728</td>
</tr>
<tr>
<td>EGS</td>
<td>4,169,315</td>
<td>0.09</td>
<td>2,862,352</td>
<td>0.08</td>
<td>287,892</td>
<td>0.01</td>
<td>7,319,559</td>
</tr>
<tr>
<td>SAM CA2-N-NA</td>
<td>21,451,290</td>
<td>0.35</td>
<td>6,684,256</td>
<td>0.35</td>
<td>450,534</td>
<td>0.02</td>
<td>28,586,081</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biomass of Scallops (MT) by Area</th>
<th>Exploitable</th>
<th>SE</th>
<th>Medium</th>
<th>SE</th>
<th>Small</th>
<th>SE</th>
<th>All Scallops</th>
</tr>
</thead>
<tbody>
<tr>
<td>NERIA</td>
<td>7,070</td>
<td>141.24</td>
<td>270</td>
<td>4.81</td>
<td>0.72</td>
<td>0.04</td>
<td>7,487</td>
</tr>
<tr>
<td>NEHMA</td>
<td>173</td>
<td>7.93</td>
<td>20</td>
<td>1.32</td>
<td>0.17</td>
<td>0.02</td>
<td>202</td>
</tr>
<tr>
<td>EGS</td>
<td>756</td>
<td>17.16</td>
<td>91</td>
<td>2.43</td>
<td>0.29</td>
<td>0.02</td>
<td>867</td>
</tr>
<tr>
<td>SAM CA2-N-NA</td>
<td>6,666</td>
<td>126.00</td>
<td>211</td>
<td>3.76</td>
<td>0.23</td>
<td>0.03</td>
<td>6,877</td>
</tr>
</tbody>
</table>
Bathymetry with Epifauna Contours
Dark Sand with Gravel (white) Epifauna (black) Contours
Sand / Gravel with Gravel (white), Epifauna (black), Shell Hash (brown) Contours
Exploitable Scallops with Gravel (white), Epifauna (black), Shell Hash (brown) Contours
Medium Scallops with Gravel (white), Epifauna (black), Shell Hash (brown) Contours
Integration of optics and acoustics to characterize habitat

Stereo image mosaic recorded down nadir

Teledyne Benthos C3D Interferometric sidescan sonar 200 kHz

100 m
Sand wave wavelength = 0.75m

Sand dollar Correlation length scale = 0.79m

50 m
C3D Side scan Sonar

Stereo Camera - 2x Prosilica 2750C

Sonar Rugosity = 113  3D Image Rugosity = 77  Correlation Length Scale = 45.8262 cm
Georges Bank Closed Area II   HAPC   western section
Georges Bank Closed Area II  HAPC  central section
Georges Bank Closed Area II  HAPC  southern section
Northern Edge Reduced Impact Area
NERIA
• Imagefile: 201603.20160.png
Alt: 1.87
StAlt: 1.86
Depth: 55.80
TotDepth: 57.67
Lat: 42.118503
Lon: -67.135927
Hdg: 281.43
Pitch: -2.66
Roll: 1.01
Northern Edge HMA (NEHMA)
Eastern Georges Shoals
EGS