Opportunities for habitat mapping approaches using bathymetry in fisheries assessment

Daniel Ierodiaconou¹, Mary Young¹, Eric Treml¹, Emilie Novaczech², Elaine Hynick³, Rodolphe Devillers²

¹Deakin University, Warrnambool, Victoria, Australia
²Memorial University of Newfoundland (MUN), St. John’s, Newfoundland, Canada
³Department of Fisheries and Oceans (DFO), St. John’s, Newfoundland, Canada
Overview

Case studies

• Patterns of interaction between habitat and oceanographic variables affecting the connectivity and productivity of fisheries- Victoria, Australia

• Regional seabed mapping with crowd sourced bathymetry- Newfoundland, Canada
Translating data to information
A changing climate

- Changes in Current Patterns
- Increasing Ocean Temperatures
- Changes in Wave Environment
- Washington Post
- Uni of Queensland
- Uni of Western Australia
Determine the drivers of spatio-temporal productivity fisheries
Abalone Fishery

20 yrs of data ~180 sites
6 Transects/Sites
30 m long, 1 m wide

Abalone viral ganglioneuritis (AVG)

Centrostephanus rodgersii.
State Seabed Mapping Coverage

https://vmdp.deakin.edu.au/
**Boosted Regression Tree (BRT) Results**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Influence on Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer SST</td>
<td>25%</td>
</tr>
<tr>
<td>Annual Self Recruitment</td>
<td>13.1%</td>
</tr>
<tr>
<td>Max Annual Current Speed</td>
<td>12.1%</td>
</tr>
<tr>
<td>Annual In Degree</td>
<td>11.8%</td>
</tr>
<tr>
<td>Max Winter Wave Orbital Velocity</td>
<td>10.6%</td>
</tr>
<tr>
<td>Depth</td>
<td>7.9%</td>
</tr>
<tr>
<td>Reef Area</td>
<td>6.3%</td>
</tr>
<tr>
<td>BPI 50 m</td>
<td>6%</td>
</tr>
<tr>
<td>Vector Ruggedness Measure</td>
<td>4.9%</td>
</tr>
<tr>
<td>AVG Infection</td>
<td>2.2%</td>
</tr>
</tbody>
</table>

The graph shows the observed biomass versus the predicted biomass with a correlation coefficient $r = 0.66, P < 0.001$. 

$$r = 0.66, P < 0.001$$
Biophysical Modelling
Spatial & Temporal Connectivity

Annual Variability in Connectivity from 1990-2015

Larval connectivity distance of abalone appears to be on the order of less than 50 km (perhaps occasionally up to 100 km).

The primary sources of abalone larvae are from those large populations in the west half of the state, with a few strong sources in the east.
Temporal Variation in Biomass

![Map showing temporal variation in abalone biomass from 1995 to 2015.](image)

Abalone Biomass
- **High**
- **Low**
- **Absent**
Annual Biomass Predictions


Space Time Cube
Biomass: Emerging Patterns

- **38%** - No Pattern
- **12%** - Hot Spots
- **50%** - Cold Spots

### Emerging Hot Spot Pattern

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Percentage of Victoria</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Pattern Detected</td>
<td>38%</td>
</tr>
<tr>
<td>Persistent Hot Spot</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Diminishing Hot Spot</td>
<td>8%</td>
</tr>
<tr>
<td>Sporadic Hot Spot</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Historical Hot Spot</td>
<td>4%</td>
</tr>
<tr>
<td>Oscillating Cold Spot</td>
<td>9%</td>
</tr>
<tr>
<td>Sporadic Cold Spot</td>
<td>32%</td>
</tr>
<tr>
<td>Consecutive Cold Spot</td>
<td>3%</td>
</tr>
<tr>
<td>Intensifying Cold Spot</td>
<td>4%</td>
</tr>
<tr>
<td>New Cold Spot</td>
<td>3%</td>
</tr>
</tbody>
</table>
Regional seabed mapping with crowd sourced bathymetry

Newfoundland and Labrador Shelf Case Study

- Need for habitats maps for seabed type, structure and ecosystem based management
- DFO need for spatially explicit models for ESBFM
- Decrease in groundfish linked to overfishing and a changing climate
• Multibeam Sonar coverage limited by cost and effort
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• OLEX crowd sourced bathymetry dramatically improving coverage
Geostatistical interpolation using Empirical Bayesian Kriging

- estimating the underlying semi-variogram from hundreds of iterations for error estimation

- 100 x 100km subsets interpolated to speed up EBK process

- Mosaicked post EBK processes
>100x finer resolution bathymetry than previously available for the majority of the study area
690 725 km² of continuous bathymetry and terrain derivatives
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Geomorphology as predictors of substrate type and species distribution.
Boosted regression trees

- Grab samples + crowdsourced bathymetry + GLORYS2 oceanographic data
  - CV correlation = 0.81
  - CV ROC = 0.945
  - Hold-out accuracy = 0.78

Substrate class ~ depth + slope + BPI + rugosity + aspect + current speed + current direction
Fish density ~ depth + slope + BPI + rugosity + current + salinity + temperature
Fish distribution (Autumn 2014)

- Fish distribution models trained on all preceding survey years (1995-2013)
- Predictions generated based on environmental conditions in 2014

Greenland Halibut (Commercial fishery)
- CV correlation = 0.78
- CV ROC = 0.95
- Correlation to 2014 tows = 0.75

Atlantic Wolffish (Species at Risk)
- CV correlation = 0.61
- CV ROC = 0.87
- Correlation to 2014 tows = 0.57
Conclusions

- Whilst not a replacement for high resolution bathymetry data CROWD SOURCED BATHYMETRY does provide a source for planning, reconnaissance, groundtruthing and modelling.

- Opportunity to creatively use existing datasets (collect once use many times) and resources to improve seafloor maps at minimal cost.

- Develop/ adopt a data structure to handle scalable bathymetry, uncertainty and associated metadata.
Thanks for listening....
contact: iero@deakin.edu.au
www.marinemapping.org

Deakin Marine Mapping Group
Global Ocean Refuge Platinum Award