Evaluation of a real-time communication system for bycatch avoidance in the US Sea Scallop Fishery

Brooke Wright¹, Cate O’Keefe², Steve Cadrin¹
International Flatfish Symposium
16 November 2017
Saint-Malo
O-65

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²Massachusetts Division of Marine Fisheries, 251 Causeway Street, Suite 400, Boston, MA 02114
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Acknowledgements

• Northeast Fisheries Science Center:
  • Dvora Hart, Chad Keith, Shannah Jaburek, Ryan Silva
• Scallop fishery program participants
• Funding: NOAA Fisheries Scallop Research-Set-Aside
US Sea Scallop Fishery

- New Bedford, MA
  - #1 fishing port in USA for almost 20 years
  - 2015 landings valued over 320 million USD.
Georges Bank Yellowtail Flounder

- Uncertain stock assessment
- Switched from model-based to empirical assessment
  - No projections
  - No reference points
    - Stock status unknown
  - Resource state is poor
Flatfish Bycatch Management Highlights

- **1993** closed areas on Georges Bank
- **2004** rotational area management
- **2010** whole stock sub-ACL for yellowtail; in-season closure when yellowtail ACL is reached
- **2011** accountability measures to take effect the year *after* an overage occurs
- **2012** accountability measures by close areas in different month(s)
- **2013** revised seasonal closures in GB access areas
Flatfish Bycatch Management Highlights

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SMAST Bycatch Avoidance Program

- Voluntary participation
- Response to in-season closures
- Near real-time advisories based on fishermen’s data
- Expansion over time
  - 2010 - program inception
  - 2011 through 2015 (annually) - spatial expansion
  - 2014 - expansion to include windowpane flounder

<table>
<thead>
<tr>
<th>Cell:</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td># Tows:</td>
<td>6</td>
</tr>
<tr>
<td>Pounds Yellowtail:</td>
<td>55</td>
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</tbody>
</table>
Program Implementation: 2010

- 122 vessels
- 100% scallop
- 32% yellowtail
Program Expansion: 2011

- 211 vessels
- 100% scallop
- 30% yellowtail
Program Expansion: 2012

- 243 vessels
- 100% scallop
- 87% yellowtail
Program Expansion: 2013

- 253 vessels
- 90% scallop
- 60% yellowtail
Program Expansion: 2014

- 253 vessels
- 81% scallop
- 116% Georges Bank yellowtail
- 98% Southern New England yellowtail
- 77% windowpane
Program Expansion: 2015

- 258 vessels
- 62% scallop
- 99% Georges Bank yellowtail
- 79% Southern New England yellowtail
- 115% windowpane
SMAST bycatch avoidance program evaluation

• Decreasing participation rate
• Review effectiveness in changing fishing behavior
  • Evaluate patterns in program data
• Compare to Northeast Fisheries Observer Program data for vessels that did and did not participate in the avoidance program
Program Evaluation Objectives and Methods

• Terms of Reference
  • “Evaluate and quantify, to the extent possible, *behavioral changes and movement of scallop vessels* as a result of SMAST bycatch advisories.”
  • “Evaluate and quantify, to the extent possible, *reductions in bycatch of yellowtail and windowpane flounder* as a result of SMAST bycatch advisories.”
Program Evaluation Objectives and Methods

• We developed loglinear models to test for associations between fishing location and bycatch advisory classification
  • Closed Area II 2011-2014 and Nantucket Lightship 2012-2014
  • Data from the SMAST avoidance program and from Northeast Fisheries Observer Program (vessels that did and did not participate in the avoidance program)
  • Final models were selected based on AIC and dissimilarity index.
## Program Evaluation Results

<table>
<thead>
<tr>
<th></th>
<th>Avoidance Program Data</th>
<th>Observer Data: Program Participants</th>
<th>Observer Data: Non-Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed Area II 2011</td>
<td></td>
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<tr>
<td>Closed Area II 2012</td>
<td></td>
<td></td>
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<tr>
<td>Closed Area II 2014</td>
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<tr>
<td>Nantucket Lightship</td>
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<td>Closed Area 2012</td>
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<tr>
<td>Nantucket Lightship</td>
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<td></td>
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<tr>
<td>Closed Area 2013</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Program Evaluation Results

• Bycatch Avoidance Program was most effective in CAII in early years
• Changing incentives over time
  • In-season closures →
  • Accountability Measures implemented in subsequent fishing years
• Implications for Accountability Measures
  • Clarify objective(s) when considering alternative actions
Discussion

• SMAST Bycatch Avoidance System is no longer an effective tool for influencing fishing behavior to avoid bycatch hotspots

• Need to consider incentives when designing voluntary programs
  • Changing from in-season to subsequent year closures reduced incentives to voluntarily alter fishing behavior

• Need to consider the objective of management actions in the design
  • Prevent overfishing, reduce bycatch, penalties
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Thanks for your attention!
QUESTIONS?
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Supplemental slides
<table>
<thead>
<tr>
<th>Year</th>
<th>Avoidance Program Data</th>
<th>Observer Data: Program Participants</th>
<th>Observer Data: Non-Participants</th>
</tr>
</thead>
</table>
| **Closed Area II 2011** | • First month – derby fishery; mixed results  
• Sept – Nov: no significant high bycatch area avoidance but significant preference for low areas relative to medium or unknown | • No info on high cells in first month; mixed avoidance results for low, medium, and unknown | • No significant bycatch avoidance in any period                |
| **Closed Area II 2012** | • Significant high bycatch avoidance and low bycatch preference                        | • Significant high bycatch avoidance in most periods, significant low bycatch preference more often than not | • Significant high bycatch avoidance relative to low in August  
• Significant high relative to unknown bycatch in first two months |
<p>| <strong>Closed Area II 2014</strong> | • Significant preference for high relative to medium                                    | • Significant high bycatch avoidance across all periods                      | • Significant high bycatch avoidance relative to unknown     |</p>
<table>
<thead>
<tr>
<th></th>
<th>Avoidance Program Data</th>
<th>Observer Data: Program Participants</th>
<th>Observer Data: Non-Participants</th>
</tr>
</thead>
</table>
| Nantucket Lightship Closed Area 2012 | • Significant high bycatch avoidance relative to low and preference for low areas relative to all  
• Significant high bycatch preference relative to medium or unknown | • Significant high bycatch avoidance relative to low and medium and significant preference for low bycatch relative to unknown across all time periods  
• Significant preference for high relative to unknown | • Significant low bycatch preference in all periods  
• No data on high bycatch areas |
| Nantucket Lightship Closed Area 2013 | • Significant high avoidance relative to medium  
• Significant high preference relative to unknown | • Significant avoidance of high bycatch relative to unknown | • Significant high bycatch preference relative to unknown areas |
Evaluation: Model Structure

• Loglinear models:

  \[ \log \mu_{ijk} = \lambda + \lambda_i^X + \lambda_j^Y + \lambda_k^Z + \lambda_{ij}^{XY} + \lambda_{jk}^{YZ} + \lambda_{ik}^{XZ} + \lambda_{ijk}^{XYZ} \]

  • Superscripts (not exponents) X, Y, and Z are categories (source, time period, classification)
  
  • Subscripts i, j, and k are indices for the level of each category (e.g. High, Medium, Low)

  • \( \mu \) is the model estimated frequency in cell \( ijk \)

• Parameters relate to odds ratios (\( \theta \))

  \[ \log \theta_{ij(k)} = \log \frac{\mu_{ijk}/\mu_{i,j+1,k}}{\mu_{i+1,jk}/\mu_{i+1,j+1,k}} = \lambda_{i,j}^{XY} + \lambda_{i+1,j+1}^{XY} - \lambda_{i,j+1}^{XY} - \lambda_{i+1,j}^{XY} \]

Agresti, 2013
<table>
<thead>
<tr>
<th>Area</th>
<th>Year</th>
<th>Model</th>
<th>df</th>
<th>AIC</th>
<th>Dissimilarity Index</th>
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<tbody>
<tr>
<td>CALI</td>
<td>2012</td>
<td>Source*Class</td>
<td>8</td>
<td>12328</td>
<td>0.39</td>
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<tr>
<td>CALI</td>
<td>2012</td>
<td>Source*Class + Period</td>
<td>13</td>
<td>2685</td>
<td>0.13</td>
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<tr>
<td>CALI</td>
<td>2012</td>
<td>Source<em>Class + Class</em>Period</td>
<td>28</td>
<td>1177</td>
<td>0.08</td>
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<tr>
<td>CALI</td>
<td>2012</td>
<td>Source<em>Class + Class</em>Period+ Source*Period</td>
<td>33</td>
<td>886</td>
<td>0.05</td>
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<tr>
<td>CALI</td>
<td>2012</td>
<td>SCP</td>
<td>48</td>
<td>394</td>
<td>0.00</td>
</tr>
</tbody>
</table>

\[ \hat{\Delta} = \sum_{i} \frac{|n_i - \hat{\mu}_i|}{2n} \]
Evaluation: Results

- Interpret three-way interaction
  - for each period: odds ratio of source and classification
  - for each classification: odds ratio of source and period
  - for each source: odds ratio of period and classification

\[
\begin{align*}
\text{High advisory} & / \text{High report} \\
\text{Low advisory} & / \text{Low report}
\end{align*}
\]
Table 6. Odds ratios for preferred models of avoidance program data (see text for details).

**CAII 2012: Source*Class*Period**

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1.41 (1.11, 1.79)*</td>
<td>0.81 (0.62, 1.06)</td>
<td>0.21 (0.16, 0.27)*</td>
<td>0.57 (0.49, 0.68)*</td>
<td>0.15 (0.13, 0.17)*</td>
<td>0.26 (0.21, 0.31)*</td>
</tr>
<tr>
<td>2</td>
<td>6.81 (4.69, 9.9)*</td>
<td>9.31 (6.21, 13.94)*</td>
<td>0.37 (0.19, 0.69)*</td>
<td>1.37 (1.07, 1.75)*</td>
<td>0.05 (0.03, 0.09)*</td>
<td>0.04 (0.02, 0.07)*</td>
</tr>
<tr>
<td>3</td>
<td>42.00 (21.7, 81.32)*</td>
<td>82.91 (33.61, 204.5)*</td>
<td>12.26 (5.81, 25.87)*</td>
<td>1.97 (1.04, 3.76)*</td>
<td>0.29 (0.2, 0.43)*</td>
<td>0.15 (0.07, 0.31)*</td>
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<tr>
<td>4</td>
<td>3.85 (2.76, 5.38)*</td>
<td>1.78 (0.88, 3.58)</td>
<td>0.10 (0.02, 0.42)*</td>
<td>0.46 (0.24, 0.87)*</td>
<td>0.03 (0.01, 0.11)*</td>
<td>0.06 (0.01, 0.26)*</td>
</tr>
<tr>
<td>5</td>
<td>72.35 (17.29, 302.66)*</td>
<td>60.79 (13.26, 278.64)*</td>
<td>NA</td>
<td>0.84 (0.47, 1.49)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>1.49 (0.78, 2.86)</td>
<td>3.34 (1.4, 7.95)*</td>
<td>3.40 (1.81, 6.39)*</td>
<td>2.23 (1.09, 4.58)*</td>
<td>2.27 (1.52, 3.4)</td>
<td>1.02 (0.5, 2.05)</td>
</tr>
</tbody>
</table>

**NLCA 2012: Source*Class + Class*Period + Source*Period**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.05 (0.11, 0.14)*</td>
</tr>
<tr>
<td>2</td>
<td>1.16 (1.15, 2.67)*</td>
<td>0.26 (0.2, 0.74)*</td>
<td>0.06 (0.14, 0.33)*</td>
<td>0.22 (0.13, 0.37)*</td>
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<tr>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.22 (0.13, 0.37)*</td>
<td>0.05 (0.11, 0.14)*</td>
</tr>
</tbody>
</table>
Results: Conditional Presence

• Full model:
  • main effects: area, latitude, longitude, bottom temperature, depth, zenith, year, season
  • eight interaction effects

• Simplified model:
  • main effects: longitude and latitude
  • interactions effects: longitude and latitude; longitude and month; latitude and month; and latitude, longitude, and month