The Importance of Location and Timing of Fishing Effort for Bycatch Avoidance in the BSAI Non-Pollock Groundfish Trawl Fishery

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How?

• A story of “multiple margins”
  – These margins have all been validated by interviews with captains
1. Large scale choice of fishing ground
  – The choice of “sock drawer”
2. “Reactive” spatial avoidance
3. Reductions in night fishing
Margin 1:
Proactive large-scale spatial avoidance
Large scale spatial avoidance: Jan - Apr
Large scale spatial avoidance: Jan - Apr
Large scale spatial avoidance: May - Aug
Large scale spatial avoidance: Sep - Dec

• No discernable large scale pattern of avoidance
  – Consistent with a late-season relaxation of avoidance efforts after uncertainty over multi-species quota scarcity is resolved
Margin 2:
Reactive spatial avoidance
Selectivity Margin 2: Reactive spatial avoidance

• Halibut bycatch is driven by extreme “hot spot” events
  – 10% of hauls account for ~55% of total halibut bycatch
• Avoiding even a few such “hot spot” events could significantly reduce the average halibut/target ratio

• Questions
  • Can relatively small movements away from “hot spots” reduce halibut bycatch?
  • Did coop members engage in such avoidance behavior more than their non-coop competitors?
Does moving help?
Does moving help?

- We regress change in halibut as a share of total catch (STC) on
  - Dummy variables for different movement thresholds (base<1nm)
  - Full suite of vessel, spatial (STAT6) and month fixed effects (dummy variables)
- Samples restricted to hauls with 2-5%, 5-10% and >10% halibut in previous haul
<table>
<thead>
<tr>
<th></th>
<th>2% to 5%</th>
<th>No Controls</th>
<th>Full Controls</th>
<th>5% to 10%</th>
<th>No Controls</th>
<th>Full Controls</th>
<th>&gt;10%</th>
<th>No Controls</th>
<th>Full Controls</th>
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</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.004***</td>
<td>-0.032***</td>
<td>-0.021***</td>
<td>-0.067***</td>
<td>-0.066***</td>
<td>-0.083**</td>
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<tr>
<td></td>
<td>(-5.74)</td>
<td>(-5.60)</td>
<td>(-12.24)</td>
<td>(-7.46)</td>
<td>(-15.63)</td>
<td>(-2.70)</td>
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<tr>
<td>1 nm&lt;Move&lt;3 nm</td>
<td>0.001</td>
<td>0.002*</td>
<td>-0.004</td>
<td>-0.003</td>
<td>-0.012*</td>
<td>-0.011</td>
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</tr>
<tr>
<td></td>
<td>(1.14)</td>
<td>(2.24)</td>
<td>(-1.77)</td>
<td>(-1.31)</td>
<td>(-2.20)</td>
<td>(-1.88)</td>
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<tr>
<td>3 nm&lt;Move&lt;7 nm</td>
<td>-0.002</td>
<td>0.000</td>
<td>-0.010**</td>
<td>-0.007*</td>
<td>-0.025***</td>
<td>-0.024**</td>
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<tr>
<td></td>
<td>(-1.46)</td>
<td>(-0.08)</td>
<td>(-3.30)</td>
<td>(-2.31)</td>
<td>(-3.60)</td>
<td>(-3.19)</td>
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<tr>
<td>Move&gt;7 nm</td>
<td>-0.002</td>
<td>0.000</td>
<td>-0.010***</td>
<td>-0.008**</td>
<td>-0.049***</td>
<td>-0.048***</td>
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<td></td>
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<td></td>
<td>(-1.32)</td>
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<td>(-7.71)</td>
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<td>N</td>
<td>6,929</td>
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<td>3,196</td>
<td>3,194</td>
<td>1,387</td>
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<tr>
<td>R-Squared</td>
<td>0.001</td>
<td>0.104</td>
<td>0.006</td>
<td>0.124</td>
<td>0.052</td>
<td>0.143</td>
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</table>
Did coop members move in reaction to high halibut bycatch events more than their common pool competitors?
<table>
<thead>
<tr>
<th></th>
<th>Pre-A80</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Halibut as % of catch in previous haul</td>
<td>&lt;2%</td>
<td>2% to 5%</td>
<td>5% to 10%</td>
<td>&gt;10 %</td>
</tr>
<tr>
<td>Don't move</td>
<td></td>
<td>13,941</td>
<td>4,029</td>
<td>2,170</td>
<td>994</td>
</tr>
<tr>
<td>% of column</td>
<td>71.3%</td>
<td>76.1%</td>
<td>72.7%</td>
<td>70.6%</td>
<td>72.3%</td>
</tr>
<tr>
<td>Move</td>
<td></td>
<td>5,616</td>
<td>1,265</td>
<td>814</td>
<td>414</td>
</tr>
<tr>
<td>% of column</td>
<td>28.7%</td>
<td>23.9%</td>
<td>27.3%</td>
<td>29.4%</td>
<td>27.7%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>19,557</td>
<td>5,294</td>
<td>2,984</td>
<td>1,408</td>
</tr>
<tr>
<td>% of row</td>
<td>66.9%</td>
<td>18.1%</td>
<td>10.2%</td>
<td>4.8%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Post-A80</th>
<th></th>
<th>&lt;2%</th>
<th>2% to 5%</th>
<th>5% to 10%</th>
<th>&gt;10 %</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don't move</td>
<td>13,917</td>
<td>2,202</td>
<td>731</td>
<td>188</td>
<td>17,038</td>
<td></td>
</tr>
<tr>
<td>% of column</td>
<td>66.0%</td>
<td>64.6%</td>
<td>59.6%</td>
<td>40.6%</td>
<td>65.1%</td>
<td></td>
</tr>
<tr>
<td>Move</td>
<td>7,161</td>
<td>1,207</td>
<td>495</td>
<td>275</td>
<td>9,138</td>
<td></td>
</tr>
<tr>
<td>% of column</td>
<td>34.0%</td>
<td>35.4%</td>
<td>40.4%</td>
<td>59.4%</td>
<td>34.9%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>21,078</td>
<td>3,409</td>
<td>1,226</td>
<td>463</td>
<td>26,176</td>
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<tr>
<td>% of row</td>
<td>80.5%</td>
<td>13.0%</td>
<td>4.7%</td>
<td>1.8%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Tabulation of the decision to move (assuming a threshold of >3 nm) or not for cooperative member vessels in the Bering Sea fishery versus the halibut content of the previous haul.
Coop members

Baseline (halibut<2%)

2%<Halibut<5%

5%<Halibut<10%

Halibut>10%

Move if dist>=1  Move if dist>=3  Move if dist>=5  Move if dist>=7
Common-pool members

Baseline (halibut<2%)

Year

Baseline (halibut<2%)

Year

2%<Halibut<5%

Year

5%<Halibut<10%

Year

Halibut>10%

Year

- Move if dist>=1  - Move if dist>=3  - Move if dist>=5  - Move if dist>=7
Margin 3:
Reduced night fishing
Selectivity Margin 3: Reduced night fishing

• Species exhibit different patterns of behavior (foraging, gear avoidance, etc.) based on the time of day

• Interviews with skippers suggest
  – Vessels are shifting processing activities and travel to nighttime hours
  – This is often a bycatch avoidance mechanism

• We want to know
  • What is the effect on catch composition (including bycatch) of fishing at night?
  • How much effort shifted away from nighttime hours?
How did night fishing behavior change?
<table>
<thead>
<tr>
<th>Year</th>
<th>Full Season</th>
<th>January - April</th>
<th>May - August</th>
<th>September - December</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>1.019 0.004</td>
<td>1.083 0.018</td>
<td>1.016 0.003</td>
<td>1.146 0.032</td>
</tr>
<tr>
<td></td>
<td>(0.56) (0.56)</td>
<td>(1.61) (1.61)</td>
<td>(0.33) (0.33)</td>
<td>(1.31) (1.33)</td>
</tr>
<tr>
<td>2003</td>
<td>1.059 0.011</td>
<td>1.133* 0.029*</td>
<td>0.985 -0.002</td>
<td>1.195 0.042</td>
</tr>
<tr>
<td></td>
<td>(1.69) (1.70)</td>
<td>(2.45) (2.45)</td>
<td>(-0.34) (-0.34)</td>
<td>(1.62) (1.64)</td>
</tr>
<tr>
<td>2004</td>
<td>1.062 0.011</td>
<td>1.145** 0.031**</td>
<td>0.984 -0.003</td>
<td>1.104 0.024</td>
</tr>
<tr>
<td></td>
<td>(1.76) (1.76)</td>
<td>(2.66) (2.67)</td>
<td>(-0.38) (-0.38)</td>
<td>(0.84) (0.84)</td>
</tr>
<tr>
<td>2005</td>
<td>1.069 0.013</td>
<td>1.112* 0.024*</td>
<td>1.016 0.003</td>
<td>0.870 -0.035</td>
</tr>
<tr>
<td></td>
<td>(1.93) (1.94)</td>
<td>(2.17) (2.18)</td>
<td>(0.35) (0.35)</td>
<td>(-1.10) (-1.10)</td>
</tr>
<tr>
<td>2006</td>
<td>1.024 0.005</td>
<td>1.070 0.015</td>
<td>0.933 -0.011</td>
<td>1.096 0.022</td>
</tr>
<tr>
<td></td>
<td>(0.65) (0.65)</td>
<td>(1.35) (1.35)</td>
<td>(-1.40) (-1.40)</td>
<td>(0.56) (0.56)</td>
</tr>
<tr>
<td>2008</td>
<td>0.775*** -0.049***</td>
<td>0.690*** -0.081***</td>
<td>0.742*** -0.043***</td>
<td>1.083 0.019</td>
</tr>
<tr>
<td></td>
<td>(-6.69) (-6.65)</td>
<td>(-5.89) (-5.95)</td>
<td>(-5.62) (-5.43)</td>
<td>(0.79) (0.79)</td>
</tr>
<tr>
<td>2009</td>
<td>0.799*** -0.044***</td>
<td>0.742*** -0.067***</td>
<td>0.782*** -0.067***</td>
<td>1.066 0.015</td>
</tr>
<tr>
<td></td>
<td>(-5.44) (-5.43)</td>
<td>(-4.58) (-4.61)</td>
<td>(-4.17) (-4.61)</td>
<td>(0.61) (0.62)</td>
</tr>
<tr>
<td>2010</td>
<td>0.758*** -0.055***</td>
<td>0.796*** -0.051***</td>
<td>0.710*** -0.05***</td>
<td>0.884 -0.029</td>
</tr>
<tr>
<td></td>
<td>(-6.75) (-6.73)</td>
<td>(-3.58) (-3.60)</td>
<td>(-5.03) (-5.06)</td>
<td>(-1.17) (-1.16)</td>
</tr>
<tr>
<td>N</td>
<td>18,260</td>
<td>7,461</td>
<td>8,010</td>
<td>2,789</td>
</tr>
</tbody>
</table>
How does night fishing affect catch composition?
Catch rates: night & day

• Factors that alter catch rates aren’t randomly assigned over night and day

• Our approach compares haul-level catch rates for individual vessels using variation within narrow regions of time and space for a given vessel

\[ E(Catch_{isth}|c_{isth}, x_{isth}, Duration_{isth}, PctNight_{isth}) = c_{isth} \cdot Duration_{isth}^{\alpha} \cdot \exp(\beta'x_{isth} + \gamma PctNight_{isth}) = c_{isth} \cdot \exp(\alpha \ln(Duration_{isth}) + \beta'x_{isth} + \gamma PctNight_{isth}). \]

• FEs defined by intersection of day, vessel, and spatial zone
incidence rate $= \exp(\ )$

<table>
<thead>
<tr>
<th>Species</th>
<th>Full Season</th>
<th>January - April</th>
<th>May - August</th>
<th>September - December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Catch</td>
<td>0.722***</td>
<td>0.761***</td>
<td>0.762***</td>
<td>0.664***</td>
</tr>
<tr>
<td></td>
<td>(-28.70)</td>
<td>(-13.85)</td>
<td>(-12.63)</td>
<td>(-22.46)</td>
</tr>
<tr>
<td>A80 Species</td>
<td>0.748***</td>
<td>0.746***</td>
<td>0.772***</td>
<td>0.740***</td>
</tr>
<tr>
<td></td>
<td>(-23.14)</td>
<td>(-13.61)</td>
<td>(-10.41)</td>
<td>(-15.05)</td>
</tr>
<tr>
<td>Yellowfin Sole</td>
<td>0.934***</td>
<td>0.899**</td>
<td>0.954</td>
<td>0.941**</td>
</tr>
<tr>
<td></td>
<td>(-4.25)</td>
<td>(-2.75)</td>
<td>(-1.76)</td>
<td>(-2.67)</td>
</tr>
<tr>
<td>Rock Sole</td>
<td>0.671***</td>
<td>0.683***</td>
<td>0.685***</td>
<td>0.578***</td>
</tr>
<tr>
<td></td>
<td>(-17.55)</td>
<td>(-13.60)</td>
<td>(-7.61)</td>
<td>(-11.97)</td>
</tr>
<tr>
<td>Flathead Sole</td>
<td>0.271***</td>
<td>0.345***</td>
<td>0.235***</td>
<td>0.266***</td>
</tr>
<tr>
<td></td>
<td>(-45.19)</td>
<td>(-23.18)</td>
<td>(-22.04)</td>
<td>(-35.20)</td>
</tr>
<tr>
<td>Pacific Cod</td>
<td>0.405***</td>
<td>0.562***</td>
<td>0.428***</td>
<td>0.340***</td>
</tr>
<tr>
<td></td>
<td>(-34.34)</td>
<td>(-12.96)</td>
<td>(-15.46)</td>
<td>(-29.33)</td>
</tr>
<tr>
<td>Other Species</td>
<td>0.625***</td>
<td>0.784***</td>
<td>0.734***</td>
<td>0.458***</td>
</tr>
<tr>
<td></td>
<td>(-21.70)</td>
<td>(-6.51)</td>
<td>(-8.52)</td>
<td>(-22.97)</td>
</tr>
<tr>
<td>Pacific Halibut</td>
<td>1.204***</td>
<td>1.604***</td>
<td>1.147</td>
<td>0.993</td>
</tr>
<tr>
<td></td>
<td>(5.24)</td>
<td>(8.49)</td>
<td>(1.90)</td>
<td>(-0.11)</td>
</tr>
</tbody>
</table>

Night time YFS per halibut $= \frac{899}{1.604} = 0.56$ of daytime rate!
Caveats
The takeaway
1. Incentives matter!

- Bycatch is essentially an input to the production of target fish
- Market prices communicate the scarcity of many fishing inputs (i.e. fuel) and shape behavior accordingly
- In the absence of prices, management institutions “ration” bycatch
  - But the implied “shadow prices” may fall well short of desired levels
- If fishermen can substitute between target and bycatch species then multispecies ITQs make sense
2. Selectivity is (partially) behavioral

• Fishing is a process of (non-random) sampling
  – Conditioned on gear, abundance, etc.

• Management and economic conditions shape the sampling scheme

• The realized selectivity of a gear in the field is shaped by the totality of these incentives
3. Expect latent flexibility

• The margins used to enhance selectivity were known well before Amendment 80 (Abbott & Wilen 2010, 2011)
  – They were mostly “short run” in nature and didn’t require fundamental changes to gear
• But fishermen had weak incentives to adopt them unilaterally
• Nature and technology must cooperate, BUT
• Poor incentives likely bias our perceptions of gear selectivity
Acknowledgments

• Jason Anderson (ASC), John Gauvin, Bill Orr, Dave Wood, Robert Hezel

• Ron Felthoven, Steve Kasperski, Jim Wilen
Thanks!