Exploring optimum economic efficiency of fishing: Shall we move from the tradition in the post-tsunami fishery?

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東北大震災

East Japan Earthquake Picture Project
Kesennuma
気仙沼
❖ The 9th largest fishery landing values in Japan.
❖ A base port for distant water tuna fisheries.

Photo: Yuma Sugawara
In Kesennuma.
16 119MT-distant water longline fishing vessels survived.
In Kesennuma

After the 2011 Earthquake/Tsunami

Ex-vessel Price

Fuel Price

Blue shark
Swordfish
16 119 MT distant water longline fishing vessels survived.
Kesennuma Longline Fisheries

Society

Fishery

Economic Motivations

Employment generated by the processing industries

North Pacific swordfish & blue shark resources
Moving from the competitive individual operations to the group operations after the 2011 Earthquake/tsunami
Combine Catch, Cost, Revenue and Profit Analysis with 2005-2010 data under the competitive individual operation (limited open access) to explore optimum fishing efforts to maximize economic benefits from Swordfish fisheries.

Fishing Efforts (Days per Trip)

\[ \text{Fishing Efforts} = \text{Move/Search Days} + \text{(longline) Operation Days} \]

Define fishing grounds – where you fish?
Define Fishing opportunities
Ex-vessel Price Model for Swordfish

Estimating the equation is

$$\ln PriceSF_{it} = \text{const} + \beta_1 \ln SF\text{Catch}_{it} + \alpha_2 \ln \text{Trip Days}_{it} + m_t + v_i + \epsilon_{it}$$

<table>
<thead>
<tr>
<th>Estimation Result</th>
</tr>
</thead>
</table>
| **Dependent variable:** | Price_LN  
| Ln(SF Landing Weight) | -0.111***  
| (0.009) |  
| Ln(Trip Days) | -0.095***  
| (0.023) |  
| Constant | 8.075***  
| (0.094) |  
| Vessel FE | Yes  
| Month FE | Yes  
| Observations | 825  
| $R^2$ | 0.539  
| Adjusted $R^2$ | 0.512  
| F Statistic | 19.804*** (df = 46; 778)  

**Note:**  
$p < 0.1; p < 0.05; p < 0.01$

- PriceSF: price per kg  
- SF Catch: Swordfish landing per day (kg)  
- D: trip days (freshness indicator)  
- M: month effect  
- V: vessel effect

• Price elasticity on landing  
• Price has the freshness premium
Cost Model
Variable cost per day operation (effort)

- Day as the unit of fishing effort
- Fuel cost is dominated in the cost structure

<table>
<thead>
<tr>
<th></th>
<th>JPN</th>
<th>Fuel (KL)</th>
<th>unitl price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Cost for Operation Day (per day)</td>
<td>114,800</td>
<td>1.64</td>
<td>70</td>
</tr>
<tr>
<td>Fuel Cost for Move/Search Days (per day)</td>
<td>189,000</td>
<td>2.7</td>
<td>70</td>
</tr>
<tr>
<td>Bait (per operation day)</td>
<td>120,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food and Other Cost for Crews (per day)</td>
<td>15,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ice (per trip)</td>
<td>300,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Swordfish Catch (MT) =

Days for move/search for fishing grounds +
Days for Fishing Operations +
Abundance Index (others CPUE) +
Vessel Effects +
Month Effect

Model 1: Operation Days with varying parameter

Cobb-Douglas. The harvest function is

\[ Y = q \text{OpeDays}^{\beta_1} \text{CPUE}^{\beta_2 \text{(MoveDays)}} \]

The estimating equation is

\[ \ln Y_{it} = \ln q + \beta_1 \ln \text{OpeDays}_{it} + \beta_2 \ln \text{CPUE}_{it} + \beta_2 \text{(MoveDays)} \times \ln \text{CPUE}_{it} + \epsilon_{it} \]

Model 1_ves: Cobb-Douglas

The estimating equation is

\[ \ln Y_{it} = \ln q + \nu_{i} + \beta_1 \ln \text{OpeDays}_{it} + \beta_2 \ln \text{CPUE}_{it} + \beta_2 \text{(MoveDays)} \times \ln \text{CPUE}_{it} + \epsilon_{it} \]

Model 1_mon: Cobb-Douglas

Add Monthly fixed effects

The estimating equation is

\[ \ln Y_{it} = (q + m_t) + \nu_{i} + \beta_1 \ln \text{OpeDays}_{it} + \beta_2 \ln \text{CPUE}_{it} + \beta_2 \text{(MoveDays)} \times \ln \text{CPUE}_{it} + \epsilon_{it} \]

Model 1_full: Cobb-Douglas

Add Monthly and Vessel Fixed effects

The estimating equation is

\[ \ln Y_{it} = (q + m_t + v_i) + \beta_1 \ln \text{OpeDays}_{it} + \beta_2 \ln \text{CPUE}_{it} + \beta_2 \text{(MoveDays)} \times \ln \text{CPUE}_{it} + \epsilon_{it} \]
Swordfish landings and profit upon Trip days (Move/Searching days + Operation days) Catch Model Estimation

Model 1,2,3 Cobb-Douglas Production Function

Model 4,5,6 Translog Production Function

<table>
<thead>
<tr>
<th>Model 1 (1)</th>
<th>Model 2 (2)</th>
<th>Model 3 (3)</th>
<th>Model 4 (4)</th>
<th>Model 5 (5)</th>
<th>Model 6 (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln(Trip Days)</td>
<td>0.888***</td>
<td>(0.079)</td>
<td>Ln(Operation Days)</td>
<td>0.798***</td>
<td>(0.070)</td>
</tr>
<tr>
<td>Ln(Others' CPUE)</td>
<td>0.881***</td>
<td>(0.078)</td>
<td>0.940***</td>
<td>(0.078)</td>
<td>0.879***</td>
</tr>
<tr>
<td>Ln(Others' CPUE) x Move/Search Days</td>
<td>0.002***</td>
<td>(0.001)</td>
<td>0.088***</td>
<td>(0.015)</td>
<td>0.021***</td>
</tr>
<tr>
<td>Ln(Operation Days)^2</td>
<td>-0.030</td>
<td>(0.067)</td>
<td>-0.034</td>
<td>(0.218)</td>
<td>-0.010***</td>
</tr>
<tr>
<td>Ln(Others' CPUE)^2</td>
<td>0.134</td>
<td>(0.218)</td>
<td>0.134</td>
<td>(0.218)</td>
<td>0.134</td>
</tr>
<tr>
<td>Ln(Others' CPUE)^2 x Move/Search Days</td>
<td>-0.010***</td>
<td>(0.002)</td>
<td>-0.010***</td>
<td>(0.002)</td>
<td>-0.010***</td>
</tr>
<tr>
<td>Ln(Others' CPUE) x Ln(Operation Days)</td>
<td>0.414</td>
<td>(0.288)</td>
<td>-0.720***</td>
<td>(0.285)</td>
<td>-0.938***</td>
</tr>
<tr>
<td>Ln(Operation Days) x Ln(Others' CPUE) x Move/Search Days</td>
<td>-0.007***</td>
<td>(0.002)</td>
<td>-0.006***</td>
<td>(0.002)</td>
<td>-0.007***</td>
</tr>
<tr>
<td>Constant</td>
<td>0.086</td>
<td>(0.585)</td>
<td>0.388</td>
<td>(0.571)</td>
<td>0.755</td>
</tr>
</tbody>
</table>

Vessel FE Yes Yes Yes Yes Yes Yes
Month FE Yes Yes Yes Yes Yes Yes
Observations 825 825 825 825 825 825
R^2 0.421 0.423 0.433 0.469 0.446 0.441
Adjusted R^2 0.387 0.399 0.399 0.433 0.411 0.407
Residual Std. Error 0.458 (df = 778) 0.458 (df = 777) 0.454 (df = 777) 0.441 (df = 778) 0.449 (df = 775) 0.451 (df = 776)
F Statistic 12.304*** (df = 46; 778) 12.401*** (df = 46; 778) 12.625*** (df = 47; 777) 13.087*** (df = 47; 777) 12.758*** (df = 48; 777) 12.778*** (df = 48; 776)

Note: p<0.1; p<0.05; p<0.01
Competitive individual operation with 40 days trip can not materialize a profit (negative profit).

21 Days per Trip with 16 operation Maximize the profit.
Spatial Distributions of Operations
Given move/search days (which defines fishing grounds), the optimal operations should be determined.

<table>
<thead>
<tr>
<th>Move/Search.Days</th>
<th>Operation.Days</th>
<th>Average under limited open-access before 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>-994</td>
<td>-1145</td>
<td>-1255</td>
</tr>
<tr>
<td>-1406</td>
<td>-1459</td>
<td>-1503</td>
</tr>
<tr>
<td>-1539</td>
<td>-1570</td>
<td>-1597</td>
</tr>
<tr>
<td>-1620</td>
<td>-1639</td>
<td>-1653</td>
</tr>
</tbody>
</table>

Average under limited open-access before 2011
Conclusion

- Shorter search/move days would better off to maximize the profit.
- Need to explore optimal schedule by considering potential fishing grounds for each month.
Thanks!