Is size-dependent pricing prevalent in fisheries?

The case of Norwegian demersal and pelagic fisheries

F. Zimmermann and M. Heino

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Size structure in fish stocks

• Fish stock are no homogeneous biomass but contain individuals with different characteristics and traits
• Individual size is a major trait and intertwined with growth, maturation, reproductive output, survival, etc.
• Size structure is relevant for:
  – population dynamics
  – recruitment potential
  – population stability
  – natural mortality
  ..and therefore for resource economics!
The fish market

However, there is also a direct connection between size and economic value..
Fish attributes and price
Product state and price
Origin/fishery
End market
Fish and their price

- Fish of the same species can have different prices (per kg)
- Various reasons:
  - Consumer preference
    - Fish attributes (flesh quality, fat content, fillet size, etc.)
    - State of the product (e.g. value added through processing)
    - Origin
  - End market (e.g. human consumption vs. fish meal)
  - Scarcity of particular fish in catch

- Almost all attributes are directly or indirectly linked with size
- Size-price relationships are common in fisheries
Size-dependent pricing

• Economic value of fish size is widespread
• Often considered as general knowledge
  – Size-dependent pricing has been acknowledged in the literature for a long time (e.g. Gulland 1982)
  – However: Few facts beyond anecdotal evidence
Plate-sized fish

Fig. 3. The mean price of *Lutjanus peru* by size class and fishing cooperative. Pichilingue, Sargento, and Dorado are located at increasing distances away from the markets of La Paz.

Reddy et al. 2013
Price data of Norwegian fisheries

- What is the relationship between fish size and price in Norway?
- Analysis of price data from eight Norwegian fisheries
  - Atlantic cod, Atlantic mackerel, Greenland halibut, haddock, horse mackerel, North Sea and Norwegian spring spawning herring, saithe
- Aggregated price data from 2000-2010 as registered by Norwegian sales organizations
  - Value and total yield per weight class
  - Assumed distribution of weight-at-age and catch-at-age as in ICES stock assessment
    - Mean weight per weight class
    - Average price for mean weight per weight class
    - Analysis with weight class as fixed and year as random effect
Price data of Norwegian fisheries

Zimmermann & Heino (2013)
Price data of Norwegian fisheries

Standardized by mean catch weight:

Zimmermann & Heino (2013)
Price data of Norwegian fisheries

Patterns over time

Figure 3. Temporal patterns in price as illustrated by linear mixed models regressing price against weight, with “year” as a random intercept and weighted by log-transformed total yield. For clarity, demersal (a) and pelagic stocks (b) are illustrated separately. In all cases the random effects are significant ($p < 0.05$).

Table 2. The correlations (white) and correlations of detrended (i.e. after removing linear time trend; grey) time-series of yearly anomalies in price for all stocks.

<table>
<thead>
<tr>
<th></th>
<th>Atlantic cod</th>
<th>Haddock</th>
<th>Saithe</th>
<th>Greenland halibut</th>
<th>Atlantic mackerel</th>
<th>NSS herring</th>
<th>North Sea herring</th>
<th>Horse mackerel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic cod</td>
<td>1.000</td>
<td>0.213</td>
<td>0.308</td>
<td>−0.120</td>
<td>0.581*</td>
<td>0.119</td>
<td>0.299</td>
<td>0.464</td>
</tr>
<tr>
<td>Haddock</td>
<td>−0.037</td>
<td>1.000</td>
<td>0.844**</td>
<td>0.272</td>
<td>0.013</td>
<td>−0.065</td>
<td>−0.204</td>
<td>−0.195</td>
</tr>
<tr>
<td>Saithe</td>
<td>−0.149</td>
<td>0.854**</td>
<td>1.000</td>
<td>0.423</td>
<td>0.294</td>
<td>−0.103</td>
<td>−0.152</td>
<td>0.585*</td>
</tr>
<tr>
<td>Greenland halibut</td>
<td>−0.295</td>
<td>0.172</td>
<td>0.367</td>
<td>1.000</td>
<td>0.138</td>
<td>−0.116</td>
<td>−0.195</td>
<td>0.435</td>
</tr>
<tr>
<td>Atlantic mackerel</td>
<td>0.382</td>
<td>−0.520</td>
<td>−0.569*</td>
<td>−0.060</td>
<td>1.000</td>
<td>0.256</td>
<td>0.094</td>
<td>0.293</td>
</tr>
<tr>
<td>NSS herring</td>
<td>−0.024</td>
<td>0.007</td>
<td>0.019</td>
<td>−0.082</td>
<td>0.502</td>
<td>1.000</td>
<td>0.539*</td>
<td>0.133</td>
</tr>
<tr>
<td>North Sea herring</td>
<td>0.215</td>
<td>−0.160</td>
<td>−0.075</td>
<td>0.167</td>
<td>0.264</td>
<td>0.530*</td>
<td>1.000</td>
<td>0.563*</td>
</tr>
<tr>
<td>Horse mackerel</td>
<td>0.122</td>
<td>0.331</td>
<td>0.466</td>
<td>0.373</td>
<td>0.013</td>
<td>0.214</td>
<td>0.684**</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Significant correlations ($p < 0.05$) are indicated with two asterisks, and marginally significant correlations ($0.05 \leq p < 0.10$) with one asterisk.
Implications of size-dependent pricing

How does size-dependent pricing influence economic yield and optimal harvest?

Shift in biomass that produces MEY

Maximum sustainable economic rent shifts towards higher stock sizes

Tahvonen (2009)

Zimmermann, Steinshamn & Heino (2011)
Conclusions

• Size-dependent pricing is prevalent in most fisheries
• However: Correlation is not causality
  – Demand and supply determines prices dynamically
  – Market value of size is linked with other quality attributes
  – Size may be a proxy than the cause itself
  – Further, more detailed analysis will reveal influence of other variables and temporal dynamics
Conclusions

• Influences optimal harvest strategies
  – Fishermen know price structures and try to utilize them
  – Ignoring size-dependent pricing may create unwanted incentives and undermine management policies

• To find the true efficient solutions the biological and economic relevance of size should be considered
  – Management strategies should account for value of size
  – Size-dependent pricing can create unwanted incentives (e.g. high-grading)
  – Size-dependent pricing may enhance long-term costs of decreasing catch sizes