Choke species, discards and quota prices in multispecies fisheries

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What determines quota (lease) prices in multispecies fisheries?
Jointness in production (harvest) - individual quota prices not separable?
Not straightforward - mWTP may depend on (expected) costs associated with disposal (discarding, over-quota landings)
Quota prices then depend on behaviour
Quota demand/supply imbalances - excess demand and the problem of “choke” species
Only limited possibilities for increased targeting/selectivity
Context: EU TAC allocation system and the landing obligation for demersal fisheries 2016-19
Quote: skippers “will pay anything [for choke species quotas] in order to keep fishing”
Harvest patterns and TACs (quotas)
Multispecies harvest model

- Representative firm harvest (catch) model
- Assume compliance with quotas on landing
- Fixed proportions technology with zero harvesting costs

\[
\begin{align*}
\max_{h, q, d} & \quad \sum_i p_i [\beta_i h - d_i] - \sum_i r_i q_i - \omega \sum_i d_i, \\
\text{s.t.} & \quad h \leq \bar{h}; \quad q_i \geq \beta_i h - d_i, \quad d_i \leq \beta_i h, \quad i = 1, 2, \ldots, N.
\end{align*}
\]

where

- $\beta_i$ is the proportion of the $i$th quota stock in the harvest $h$
- $\omega$ is an expected (here unit) penalty for discarding $d_i > 0$
- quota $q_i$ has a rental price $r_i$
The profit-maximising conditions are

\[ \sum_i [p_i - r_i] \beta_i = \lambda \geq 0 \]

for \( h^* \leq \bar{h} \) and

\[ p_i + \omega = r_i, \quad i = 1, 2, \ldots, N \]

for discarding \( d_i^* > 0 \)

We then expect quota prices to satisfy

\[ r_i \in [0, p_i + \omega] \]

Thus

\[ r_i = 0 \leq p_i + \frac{1}{\beta_i} \left[ \sum_{j \neq i} [p_j - r_j] \beta_j \right] \leq p_i + \omega \]
Two species example: zero discard cost

- Consider two quota species: Sp1 and Sp2
- Assume Sp1 quota binds first: quota price bid up to the marginal opportunity cost of discarding
  \[ r_1 = p_1 \]
- Sp2 quota limits total harvest (at \( h^* \) marginal profit goes to zero)
  \[ p_2 \beta_2 = r_2 \beta_2 \implies r_2 = p_2 \]
- Or, Sp2 quota not binding at \( \bar{h} \) (\( r_2 = 0 \))
  \[ p_2 \beta_2 = \lambda > 0 \]
Two species example: positive discard cost

- Sp1 quota binds first: quota price bid up to the marginal opportunity cost of discarding
  \[ r_1 = p_1 + \omega \]
- Sp2 quota limits total harvest (at \( h^* \) marginal profit goes to zero)
  \[ r_2 = p_2 - \frac{1}{\beta_2} \omega \beta_1 \]
- Or, Sp2 quota not binding at \( \bar{h} \) (\( r_2 = 0 \))
  \[ p_2 \beta_2 - \omega \beta_1 = \lambda > 0 \]
Two species: species 1 chokes harvest (no discards)

- Assume harvest restricted (choked) by Sp1 quota
- No discards: arbitrarily high $\omega$, or “psychic cost”? 
- Sp1 quota binds first and limits harvest: Sp2 quota is slack at $h^*$ (excess supply) and $r_2 = 0$
- Sp1 quota priced at marginal value of harvest

$$r_1 = p_1 + \frac{1}{\beta_1} p_2 \beta_2$$

- Here the 2nd term on RHS can be interpreted as the shadow price of discarding
Note: non-linear discard penalties

- What if marginal (expected) discard costs are increasing?
- Let $\omega = \omega \left( \sum_i d_i \right)$, with $\omega' (\cdot) > 0, \omega'' (\cdot) > 0$
- The discard condition becomes
  \[ p_i + \omega' = r_i, \quad i = 1, 2, \ldots, N \]

- Quota prices then satisfy
  \[ r_i = 0 \leq p_i + \frac{1}{\beta_i} \left[ \sum_{j \neq i} [p_j - r_j] \beta_j \right] = p_i + \omega' \]

- Example: choke species quota price now increasing in discards, with
  \[ r_1 = p_1 + \frac{1}{\beta_1} p_2 \beta_2 = p_1 + \omega' \]
Marginal value of harvest and marginal discard penalty (2 spp)
Conclusions

- How much are fishermen willing to pay for choke species quota?
- If they behave rationally, the price ceiling is set by the opportunity cost of discarding - the ex-vessel price plus the expected marginal penalty (if any)
- Or the marginal value of the harvest, if this is smaller
- These are equalised in the non-linear case
- Choking the fishery implies no discarding and choke species quota bid up to the marginal value of the harvest
- Analysis can be extended to include the expected cost of landing over-quota fish
- What information do we then get from quota (lease) prices?