Gestion des ressources naturelles (la pêche) (Thomas Sterner)

Sém: Effets de seuil et changements de régime :
Anne-Sophie Crépin, Beijer Institute (Stockholm)
MANAGEMENT of Natural Resources

- INTERTEMPORAL setting
- Spatial setting
- Ecological Setting
Historical Thinking on Growth

Malthus (1798) The power of population is so superior to the power of the earth to produce subsistence for man, that premature death must in some shape or other visit the human race.

Mankind doomed to poverty. What do you think?
Hotelling (Journal of Political Economy, 1931): “Contemplation of the world’s disappearing supplies of minerals, forests, and other exhaustible assets has led to demands for regulation of their exploitation. The feeling that these products are now too cheap for the good of future generations, that they are being selfishly exploited at too rapid a rate, and that in consequence of their excessive cheapness they are being produced and consumed wastefully has given rise to the conservation movement.”
Is scarcity real? Malthus, RomeClub

• Physical indices: Reserve-to-use ratios (either static or exponential).
• Economic Indicators

La rareté : est elle réelle?
Resource availability according to the Rome Club (1970)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Cu</th>
<th>Au</th>
<th>Fe</th>
<th>Pb</th>
<th>Hg</th>
<th>Al</th>
<th>Gas</th>
<th>Oil</th>
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<tr>
<td>Static</td>
<td>36</td>
<td>11</td>
<td>240</td>
<td>26</td>
<td>13</td>
<td>100</td>
<td>38</td>
<td>31</td>
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<tr>
<td>Expon</td>
<td>21</td>
<td>9</td>
<td>93</td>
<td>21</td>
<td>13</td>
<td>31</td>
<td>22</td>
<td>20</td>
</tr>
</tbody>
</table>
Rente de rareté augmente

Price or quantity

Prix

Resources Extraction

Time
Un Arbitrage

- Consider a 0 inflation economy with $r=3\%$
- You have a bank account: it gives $r=3\%$
- You buy a painting by Monet for a Million.
- What is it expected to be worth next year?
The Arbitrage condition

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- 1,030 thousand. ?????
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The Arbitrage condition

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• What is it expected to be worth next year?
• 1,030 thousand.
• Assume some other value. Eg 1020 K
• Then a normal capitalist would only be prepared to pay $1020/1,030 \approx 990$ K now.
• Grace au principe de Hotelling, Maltus aura tort?
HOTELLING pricing and optimal use of finite resources. How to use an oil well with Q ton. Constant demand: $P_t = a - bq_t$

Assume pumping cost = $c$ (fixed)

$$
B_t = \int_0 (a - bq) dq = aq_t - \frac{1}{2}bq_t^2
$$

Max $L = \sum \left( \frac{aq_t - \frac{bq_t^2}{2} - cq_t}{(1+r)^{t-1}} \right) - \lambda(Q - \sum q_t)$

$$
\frac{\delta L}{\delta \lambda} = Q - \sum q_t = 0
$$
\[
\frac{\delta L}{\delta q} = \frac{a - bq_t - c}{(1 + r)^{t-1}} - \lambda = 0
\]

\[
\frac{P_t - c}{(1 + r)^{t-1}} = \lambda
\]

\[
(p_t - c) = \lambda(1 + r)^{t-1}
\]
• Grace au principe de Hotelling, Maltus aura tort?

• Les ressources non-renouvelables sont inépuisables...

• Et les ressources renouvelables??
"The cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, probably all the great sea fisheries, are inexhaustible .. nothing we do seriously affects the number of fish"

1883, Thomas H. Huxley
Fisheries

• Rather like congestion
• Fishermen would all be better off if effort brought down.
• However a tax that collects all the rent will actually make the fishermen worse off
• Fishery policy badly needed but typical policies are exact opposite of required!
A Bio-<?! model of fishing

![Graph showing the relationship between Yield, MSY, and Effort (and depletion).]
Figure 2. Depletion of fisheries.
A Bio-economic model of fishing

YIELD

COST OF FISHING

O MEY MSY OAE EFFORT (and depletion)
A Bio-economic model of fishing

\[ \Pi \]

YIELD

COST OF FISHING

O MEY MSY OAE EFFORT →

(and depletion)
Bio-economic model of fishing 2
The effect of technical progress

![Graph showing yield and cost of fishing over effort and depletion.](image-url)
Over-fishing on Zanzibar
COD

- Cod in Atlantic Banks outside Canada richest in the World
- Crashed 1992
- 30 000 fishermen unemployed
- No sign of recovery after 10 years!
Overfishing a threat to fish stocks globally

Worm et al. 2006 Science
Iceland shows the way

- World Cod catch down 75% since 1968
- 200 mile EFZ hopeful
- Private transferable quotas as SHAREs in TAC
- TAC decided by biologists
More Input  --> More Output

Fish

Nets
More Input  →  More Output?

Fish

Nets
Market/Policy Failure

• Each fisherman fishes at will – covering his own costs but not value of fish stock.

• Fishing down stock increases costs for all.

• TRAGEDY OF ... Open Access

• POLICY is needed
## Policy Instrument selection

<table>
<thead>
<tr>
<th>Price-type</th>
<th>Rights</th>
<th>Regulation</th>
<th>Info/Legal</th>
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<tbody>
<tr>
<td><strong>Taxes</strong></td>
<td>Property rights</td>
<td>Gear/Boat restriction</td>
<td>Public participation</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Information disclosure</td>
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<tr>
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<td>Zoning, Reserves</td>
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Fundamentals of Policy are Rights

TFCs are a solution: Combine a degree of asset stability with sufficient biological flexibility

Make negotiations on TAC less adversarial
Transferable Fishing Concession

• **Revocable** user entitlements to a **specific part of fishing opportunities**

• ’Fishing opportunity' means a quantified legal entitlement to fish, expressed in terms of **catches and/or fishing effort** ...
Different types of “TFC”:

• Individual Transferable Quota (ITQ)
• Cooperatives
• Area-based rights system (TURF)
Many Countries Use TFCs

Many of the major fishing nations still use traditional management.
Status Quo vs. TFCs

**Status Quo**
- Race for Fish
- Reduced season lengths
- Hard to maintain TACs
- Poor profitability
- Perverse incentives lead to decreasing stocks

**TFCs**
- Long term stake in fishery
- Flexibility to fish based on market needs
- Best way to meet TACs
- Increased CPUE
- Best way to rebuild stocks
Responsible and sustainable fishing requires decisions based on sound scientific findings and long-term management.

Decisions on total allowable catches (TAC) and fishing quotas are based on scientific advice; we are finding out more and more about the stocks that are fished. Fishing can thus be adapted to the state of stocks.

Currently, most fish stocks are exploited at levels well in excess of their maximum sustainable yield, in other words the optimal volume of catches that can be taken each year without threatening the future reproductive capacity of a fish stock.

By aiming for long-term management, the Commission has thus favoured a progressive approach, based on the introduction of multi-annual plans for specific fisheries or fish stocks which benefit stocks and fishermen alike. These plans are aimed at ensuring sustainable exploitation and, if necessary, at facilitating the recovery of stocks.

State of stocks by TAC area (2009) (in number of stocks)

<table>
<thead>
<tr>
<th>Area</th>
<th>Total</th>
<th>Green</th>
<th>Orange</th>
<th>Red</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltic Sea</td>
<td>10</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>North Atlantic, international waters</td>
<td>51</td>
<td>8</td>
<td>3</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Atlantic, North Sea and Black Sea</td>
<td>147</td>
<td>10</td>
<td>24</td>
<td>24</td>
<td>89</td>
</tr>
</tbody>
</table>


Today, 3 out of 4 stocks overfished: 82% of Mediterranean & 63% of Atlantic stocks.
TFCs improve compliance

Compliance Failure
Overfishing

TAC overages reduced. Landings/TAC (average across fisheries).
TFCs reduce discards

Commercial discards reduced. % reduction versus baseline year (year before catch shares).
TFCs can address overcapacity

- TFCs can help match fishing resources to TAC.

- In a study of US fisheries capacity fell dramatically first 5 years
TFCs can increase revenue

Employment can stabilise & Revenue can increase
Unobserved Genetic Diversity and Stock Management

• Recent DNA studies have shown earlier unknown genetic diversity among such species as cod.

• Like salmon they may have their reproductive loci (?) to which they return but the phenomenon is unobserved by man since it takes place out of sight and the cod are morphologically very similar.
A FISHING MODEL

A simple model: single stock, logistic growth. Density dependent harvest and 0-profit condition. & Regulatory agency with full info and power to set quotas.

\[ \frac{dX}{dt} = rX_t(1 - X_t) - H_t \quad (1) \]

\[ H_t = qE_t X_t \quad (2) \]

where \( w \) is the price per unit of effort \( E \) and \( F \) is the fixed cost of fishing.

\[ PH_t = wE_t + F \quad (3) \]
Simulation 1
Salmon returning home to spawn
What about cod?
Subpopulations
**ICES analyser & rekommendationer**

<table>
<thead>
<tr>
<th>ICES</th>
<th>Single-Stock</th>
<th>Predicted catch</th>
<th>Predicted catch</th>
<th>Agreement</th>
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<tbody>
<tr>
<td>Advice</td>
<td>Exploitation</td>
<td>corresp. to advice</td>
<td>corresp. to advice</td>
<td>TAC</td>
</tr>
<tr>
<td>$F = F_{	ext{max}}$</td>
<td></td>
<td>$&lt; 21$</td>
<td>$&lt; 21$</td>
<td>22.5</td>
</tr>
<tr>
<td>Reduce $F$</td>
<td></td>
<td></td>
<td></td>
<td>21.5</td>
</tr>
<tr>
<td>$F$ at $F_{	ext{med}}$</td>
<td></td>
<td>$&lt; 23$</td>
<td></td>
<td>20.5</td>
</tr>
<tr>
<td>$F$ at $F_{	ext{med}}$; TAC $\cdot TAC$</td>
<td></td>
<td>21.0</td>
<td></td>
<td>21.0</td>
</tr>
<tr>
<td>TAC</td>
<td></td>
<td>15.0</td>
<td></td>
<td>15.0</td>
</tr>
<tr>
<td>70% of $F(90)$</td>
<td></td>
<td>15.0</td>
<td></td>
<td>15.0</td>
</tr>
<tr>
<td>Precautionary TAC</td>
<td></td>
<td>15.0</td>
<td></td>
<td>15.0</td>
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<tr>
<td>No long-term gain in increased $F$ + precautionary TAC</td>
<td></td>
<td>15.5</td>
<td></td>
<td>15.5</td>
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<tr>
<td>If required precautionary TAC; link to North Sea</td>
<td></td>
<td>20.0</td>
<td></td>
<td>20.0</td>
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<tr>
<td>If required precautionary TAC; link to North Sea</td>
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<td>23.0</td>
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<td>16.1</td>
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<td>If required precautionary TAC; link to North Sea</td>
<td></td>
<td>21.9</td>
<td></td>
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<tr>
<td>$F = 0.60$ to rebuild SSB</td>
<td></td>
<td>17.9</td>
<td></td>
<td>19.0</td>
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<tr>
<td>$F$ less than 0.55</td>
<td></td>
<td>$&lt; 11.3$</td>
<td></td>
<td>11.6</td>
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<tr>
<td>lowest possible catch</td>
<td></td>
<td>7.0</td>
<td></td>
<td>7.0</td>
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<td>lowest possible catch</td>
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<tr>
<td>Closure</td>
<td></td>
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<td>3.9</td>
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<tr>
<td>Zero catch</td>
<td>Zero catch</td>
<td>0</td>
<td>0</td>
<td>3.9</td>
</tr>
<tr>
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<td>Zero catch</td>
<td>0</td>
<td>0</td>
<td>3.9</td>
</tr>
</tbody>
</table>

*Norwegian fiords not included. Weight in '000 t.*
Simulation with 5 genetically diverse stocks

- See eqns in word file page 7
- \((q_1 > q_2 > \ldots q_n)\). Note that effort \(E\) is not targeted at any particular species but for some reason (location of spawning grounds for instance) \(q\) is higher for some species. Under these conditions a perfectly wise and well enforced quota that only has one fault (neglect of subspeciation) could lead to successive extinction of sub-species. Without fishing effort, surviving stocks will eventually recover to their original size \(X_0\) but if the “stock” actually consisted of sub-stocks then only the surviving stocks will revert to their original unaffected size.
\[
\frac{dX_i}{dt} = rX_{it}(1 - X_{it}) - H_{it} \quad i = 1...n \quad (1')
\]

\[
H_{it} = q_i E_t X_{it} \quad H = \sum H_i \quad (2')
\]

\[
PH_t = wE_t + F \quad (3')
\]

Extensions: Reduce role of X in (2)
Vary also r between substocks
Employment goal instead of (3).
Depletion and partial recovery after a moratorium in year 37
Gradual extinction through misspecification of stock diversity
Now Diversity invisible: Think you are at X but you are at Y
1. Öresund
2. Skälderviken
3. Kullen
4. Laholmsbukten
5. Stengrundet
6. Fladen
7. Läsö
8. Lilla Middelgrund
9. Western Kattegat
CONCLUSIONS

• Stock management must take biological realities into account including stock structure
• Caution with ITQs. Separate for each stock?
• Marine protected areas, or local management of coastal stocks → Consider Subsistence & Recr. fish
• Trawl limits for inshore fisheries/spawning aggregations
• Involve/ compensate fishermen/communities
• Also monitoring, discarding + highgrading, multispecies problems.