Managing modified ecosystems

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How would management reform impact:

- **BIOMASS**
- **CATCH**
- **VALUE**
Global + single species
China + ecosystem
Trophic effects
Implications for management
Global fishery prospects under contrasting management regimes

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China
A. Minimum mesh size
B. Summer fishing moratoria
C. Zero growth and then negative growth (2000)
How would management reform impact:

- **Biomass**
- **Catch**
- **Value**
• Predicted catch based on depth, primary productivity, ice cover, SST, latitude, distance from shore, and upwelling with a GLM

• “Fishing effort was not used in the prediction and catches were assumed to be generally close to their maximum biologically sustainable limits.”

• China was an outlier
“Fishing effort was not used in the prediction and catches were assumed to be generally close to their maximum biologically sustainable limits.”

1) “Biologically sustainable limits” are dependent upon the structure of the ecosystem.

FAO. 2014. State of the world’s fisheries.
Primary productivity demands of global fishing fleets

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East China Sea

Yellow Sea

PP required (t x 10⁶ yr⁻¹)

Year


450

50 100 150 200 250 300 350

100 150 200 250 300 350 400 450

5.0

3.5 4.0 4.5 5.0

3.0 3.5 4.0 4.5 5.0
• The percentage of planktivorous species increased and piscivorous or omnivorous species decreased.
• TL of the same prey got lower.
• Feeding habits of some species changed, such as largehead hairtail (*Trichiurus haumela*).
Does unreported catch lead to overfishing?

Merrill B Rudd & Trevor A Branch

• Over- or under-reporting of catches results in biased estimates of biomass.
• BUT, estimates of status remain unbiased.
How would management reform impact:

- BIOMASS
- CATCH
- VALUE
Size-spectrum models
- Community dynamics
- Food consumption
- Somatic growth and reproduction
- Mortality (predation, background, starvation, fishing)
- Background resource

MIZER (R package, Scott et al. 2014)
- Maximum weight
- Weight at maturity
- Weight at length parameters
- Von Bert K
- Preferred predator/prey weight ratio
- Fishery selectivity parameters
- Maximum recruitment
- Background resource

Anderson, KH, et al. 2014. Theoretical foundations for size spectrum models of fish communities.. CJFAS.
High fishery catches through trophic cascades in China

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![Graph showing biomass and catch with different management strategies]
Transfer efficiency is ~10% between trophic levels.
- Indiscriminate fisheries take everything over a given size.
• Removing large fish conserves the lost energy by eliminating inefficiencies of transfer.
• Markets and culture matter
• Discards are non existent
THEORY

MAXIMAL YIELDS FROM MULTISPECIES FISHERIES SYSTEMS:
RULES FOR SYSTEMS WITH MULTIPLE TROPHIC LEVELS

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Trade-offs between objectives for ecosystem management of fisheries

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PRACTICE

Cascading Effects of the Loss of Apex Predatory Sharks from a Coastal Ocean

Ransom A. Myers\(^2\), Julia K. Baum\(^6\), Travis T. Shepherd\(^2\), Sean P. Powers\(^6\), Charles H. Peterson\(^6\)

Trophic Cascades in a Formerly Cod-Dominated Ecosystem

Kenneth T. Frank\(^1\), Brian Petrie\(^1\), Jae S. Choi\(^1\), William C. Leggett\(^2\)

MALTHUSIAN OVERFISHING AND EFFORTS TO OVERCOME IT ON KENYAN CORAL REEFS

Tim R. McClanahan\(^1,4\), Christina C. Hock\(^3,2\), and Emily S. Darling\(^2\)

Trophic cascades triggered by overfishing reveal possible mechanisms of ecosystem regime shifts

George M. Donnelly\(^1,4\), Alexander N. Grieg\(^5\), Sergii Rudenko\(^5\), and Vesela Mihnen\(^5\)
Unintended Cultivation, Shifting Baselines, and Conflict between Objectives for Fisheries and Conservation

CHRISTOPHER J. BROWN* AND ROWAN TREBILCO†

Table 1. Examples of fishing-induced ecosystem change benefitting fishery production of another species.

<table>
<thead>
<tr>
<th>Region</th>
<th>Benefitting fishery</th>
<th>Evidence</th>
<th>Ecosystem</th>
<th>Mechanism</th>
<th>Cause and consequent</th>
<th>Ecological features</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great Barrier Reef</td>
<td>Prawns, <em>Metapenaeus endeavours</em>, <em>Penaeus spp.</em></td>
<td>Model</td>
<td>Tropical, demersal reefs</td>
<td>Predation release</td>
<td>Reduced abundance of predatory fish because of bycatch by prawn trawlers may increase prawn abundance.</td>
<td>Invertebrate prey, vertebrate predators</td>
<td>Gribble (2003)</td>
</tr>
<tr>
<td>Gulf of Mexico</td>
<td>Menhaden, <em>Brevoortia patronus</em>; red drum, <em>Sciaenops</em></td>
<td>Model</td>
<td>Subtropical, demersal</td>
<td>Predation release</td>
<td>Reduced abundance of predatory fish because bycatch</td>
<td>Predation on juveniles, bycatch mortality of predator</td>
<td>Walters et al. (2008)</td>
</tr>
</tbody>
</table>
Take aways

• When the ecosystem is considered, triple wins disappeared.
• Trade offs must be communicated to stake holders.
• Reference points are conditional quantities; changes in trophic structure change reference points.
Decreasing

Dome-shaped

Plateau

Increasing

Chinese white shrimp (38)
Black scraper (37)
Other fish (450)
Jellyfish (43)
Anchovy (140)
Other crustaceans (130)
Cuttlefish (26)
Common orient clam (250)
Japanese spanish mackerel (57)
Slender shad (16)
Largehead hairtail (140)
Northern mauxia shrimp (72)
Souther rough shrimp (43)
Golden threadfin bream (43)
Large yellow croaker (10)
Round scad (67)
Butterfish (40)
Pacific herring (5.3)
Swimming crab (57)
Chinese white shrimp (16)
Barracuda (16)
Eel (40)
Razor clam (79)
Ark clam (36)
Giant mud crab (8.4)
Laver (algae) (12)
Grouper (12)
Seabream (17)
Other shellfish (980)
Other algae (73)
Small yellow croaker (41)
Chub mackerel (59)
Scallop (180)
Laminaria (algae) (140)
Other crustaceans (100)
Mussels (85)
Research questions

• What have been the outcome of different strategies of seafood production among provinces?
• What portfolio of aquaculture and wild-capture fisheries can balance the needs of China’s people and its marine ecosystems?
• How has aquaculture influenced wild-capture fisheries in China? Do different types of aquaculture produce different effects? Are there MPA-like effects of aquaculture?
• How resilient are different strategies for seafood production to environmental change?
If tradeoffs exist, how can we manage ocean resources?
• Tradeoffs between conservation and protein production exist in fisheries management.

• Pareto efficiency: a state from which it is impossible to improve with respect to any objective without regressing at least one other.

• Jacobsen’s results suggest:
  • (i) a trend towards ecosystem-level efficiency of fisheries;
  • (ii) ecosystem-scale win–wins may still be common;
  • (iii) single-species assessment approaches may overestimate the availability of win–wins by failing to account for trade-offs across interacting species.
• Fishing patterns in North Sea, Barents Sea and Benguela Current are nearly efficient with respect to long-term yield and ecosystem impact and that efficiency has improved over the last 30 years.
- In Baltic Sea and North East US Continental Shelf, fishing is inefficient and win–wins remain available.
If tradeoffs exist, how can we manage ocean resources?

• Model the trade-off space
• Identify wins-wins—move toward the efficiency frontier
• Have serious conversations with stakeholders about what tradeoffs are acceptable.
Collaborators and funding sources: