Application of Game Theory to Intra-EEZ Fisheries Management

L. Grønbæk, M. Lindroos,
G. Munro and B.Turris

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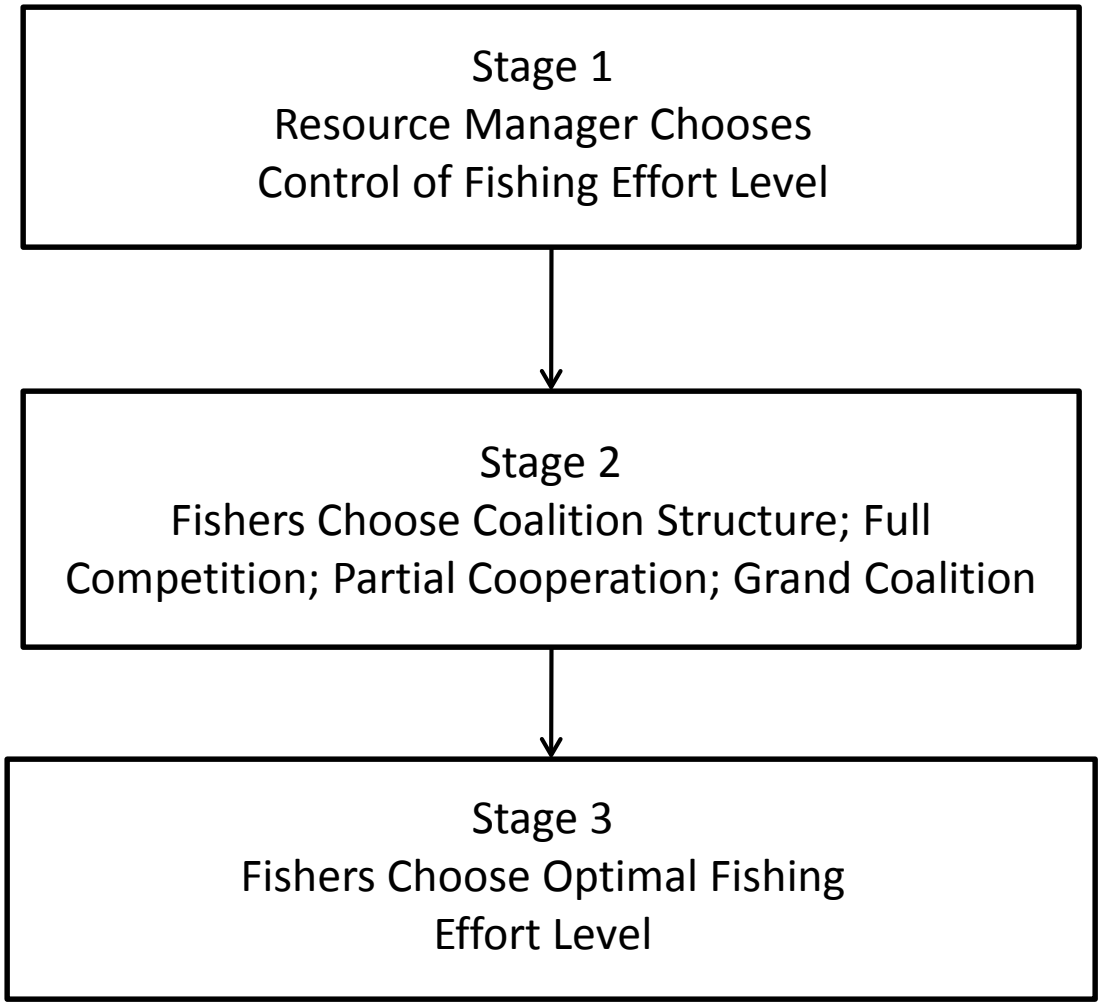
Introduction

- Our purpose is not to present new theoretical results; it is rather to propose a new research program focussed on “domestic” fisheries management
  - our contention is that, in contrast to international fisheries, game theory has been seriously underutilized in analysis of “domestic” fisheries .
    - increasing evidence of cooperation among fishers in such fisheries, and of cooperation between fishers and resources managers
- Discussion motivated by a case study from British Columbia, Canada, which has achieved prominence over past year
  - relevant fishery operates under an ITQ scheme; significant, because, of “catch share” schemes, ITQs seen as least conducive to establishment of stable fisher cooperative games

A Foundational Model

- We take as our foundational model a stage game model developed by Kronbak and Lindroos (2006) – first model to link explicitly domestic resource manager with fishers.
- In K&L model, resource manager plays a von Stackelberg leader-follower game with fishers; fishers play a non-cooperative, partially cooperative or fully cooperative (Grand Coalition) game among themselves. The fishers then choose their fishing effort level, given the chosen coalition structure.
  - partition function games employed in analysing behaviour of fishers

The Kronbak and Lindroos Three Stage Game



Source: Kronbak and Lindroos, 2006.

More on K&L Model

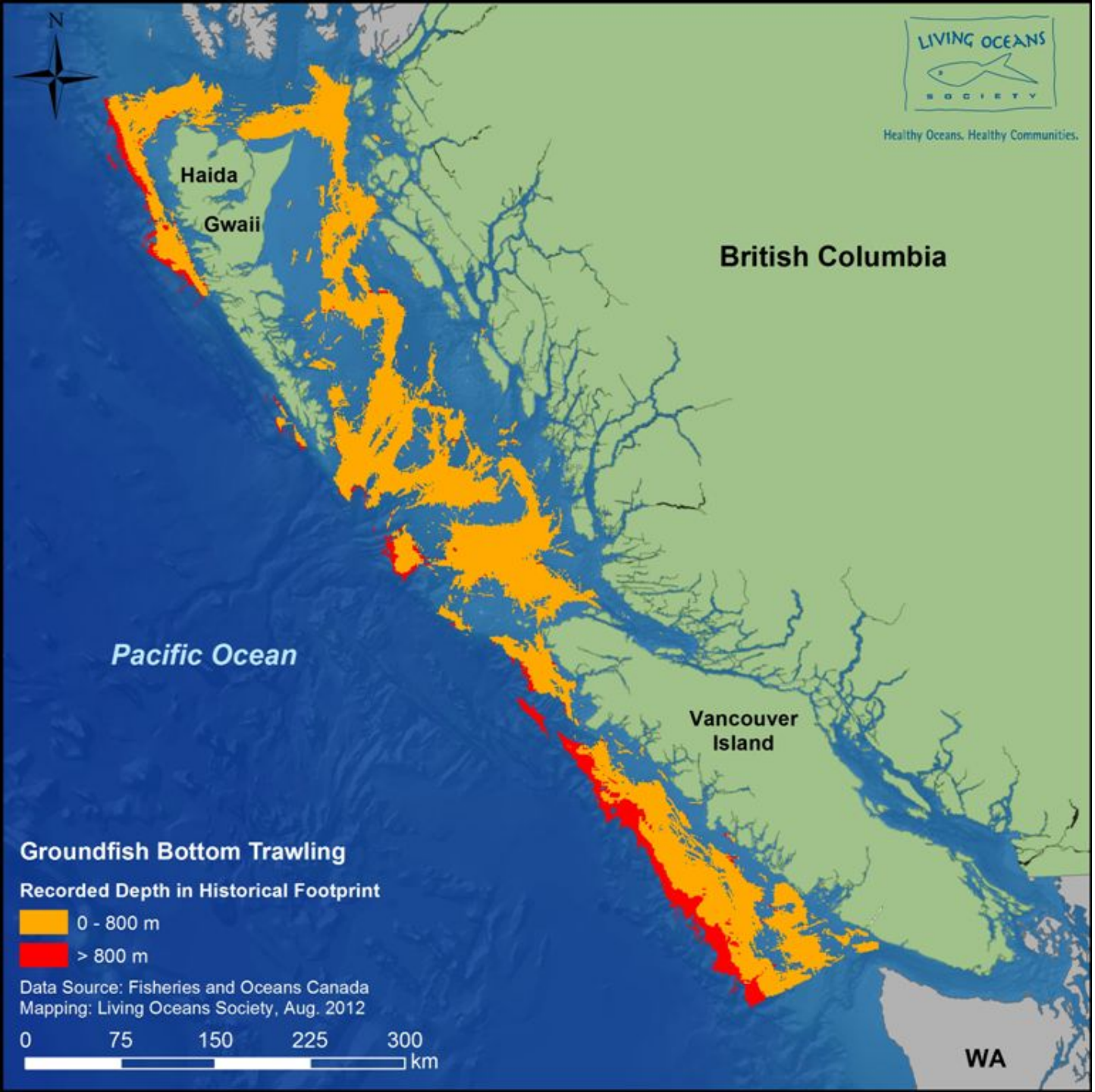
- Resource manager assumed to have only one instrument of control –control over fishing effort –will need to talk of manager having a portfolio of management schemes upon which to draw.
- K&L model is static. As case study will reveal, dynamic model essential, allowing for possibility of leader-follower switches over time.

ITQs: The Received View

- Full agreement that ITQs have power to improve efficiency in fisheries
- BUT, since, by definition, they are granted to individual fishers (vessel owners), scope for effective cooperation among ITQ holders limited, unless the holders are “few” in number, or unless they surrender some of their individual powers ,e.g., by overlaying the scheme with a formal cooperative.
  - otherwise, free riding becomes an intractable problem
- Received view sounds eminently reasonable; common sense – except that our case study provides a powerful counter example.

The Case Study

- Case study involves the British Columbia (B.C.) groundfish trawl fishery- 50 species, 55 active vessels, operating along length and breadth of B.C. coast.
  - if B.C. were an independent country, its coast would be the 8th longest in the world
  - ownership of vessels complex, but there not fewer than 30 independent players – exceeding anyone's definition of "few"
  - industry has an association –Canadian Groundfish Research and Conservation Society (CGRCS), but CGRCS has zero control over members
- Management from 1980-1995; limited entry +Olympics style TAC- fishers played competitive game –classic PD game
- In 1997, multi-species ITQ scheme established –resource manager hoped for the best



Bottom area trawled between 1997-2011

~41,000 km^2

Industry Under Attack

- In mid-2000s industry attacked by environmental NGOs (ENGOs) for destruction of sponge and coral through bottom trawling
  - attacks threatened to close off key market for industry
  - resource manager – Canadian Department of Fisheries and Oceans (DFO) –lacked legal power to address problem.
  - industry on its own.
- Industry, through CGRCS, entered into negotiations with ENGO consortium to develop world's first habitat bycatch limitation agreement, which came into force in 2012 – DFO supportive, but its role was essentially passive.

Agreement in Force

- Under Agreement, industry allowed annual global sponge/coral catch quota of 4,500 kg. -spread over 55 vessels like tiny ITQs. Any vessel exceeding its tiny quota faced with possible shutdown over reminder of season - ultimate "choke species". Long term goal – annual global quota of just under 900 kg.
- Agreement has completed four years. Results:
  - Year 1 – actual catch **500 kg**
  - Year 2,3 and 4 – actual catch *below* 500 kg. – Year 4: **280 kg**.
- Agreement and its results published in a *Marine Policy* article several months ago. Article led to representatives of ENGOs and of industry becoming joint recipients of an important aquatic conservation award, last February.

Agreement Implications

- Industry could never have entered into negotiations with ENGOs, unless ITQ holders were playing a stable cooperative game. BUT, according to the received view of ITQS, this should have been IMPOSSIBLE.
- The “followers” had turned into “leaders” –an unequivocal switch
- Growing evidence of cooperation between industry and official resource manager – emergence of ***de facto co-management***
- How to explain; how to assess applicability of B.C. experience to other world fisheries? Impossible, without extensive game theoretic analysis.

New Research Program I

- The presented case study provides us with insights that challenge the traditional way of modeling.
  - How to model Co-management?
  - Are the consequences of free riding under a co-management identical to the consequences of free riding under a traditional cooperative game?
  - If no; what drives the differences? Games with a memory, social pressure (threat-games),…?

New Research Program II

- How to model a co-management?
  - Look into the theory of partnership formation.
  - Rules of the game become an important element to be studied:
  - Members individually, jointly better off or majority is better off from new cooperative arrangements.
  - Carreras (1996) defines a partnership as binding what you can do; in a partnership players are not allowed to talk to anyone else nor make any agreements, and all players have the right to veto.

New Research Program III

- How to model a game with social pressure?
  - Suggest to model the co-management by the social pressure and its effects on the payoffs of the players.
  - Expect the social pressure to be easier with smaller number of players, in the sense that detection is likely to be easier, and the effect of non-compliance with the co-management regime would be larger.
  - The British Columbia groundfish trawl does however demonstrate an example of a fairly high number of members in a co-management regime. Somehow it would imply that the players would choose an effort level closer to the cooperative effort. We need to think about which factors would affect that.
  - A parameter/function and number of players could be a good starting point for the analysis.

New Research Program IV

Steps forward

1.Redefine the penalty function for defectors

2.The profitability of defection depends on the number of defectors

3.Partnership rules in co-management and stability issues

4.Sharing rules in the co-management and stability issues

5.The most influential elements for stability of cooperation in various economic situations

6.Cooperative arrangements under different management regimes, ITQ, etc.

Thank you