PARALLEL FISHERIES AGREEMENTS

Marko Lindroos, Department of Economics and Management, marko.lindroos@helsinki.fi

ABSTRACT

Game-theoretic fisheries models typically consider cases where some n countries harvest a common fish stock x. For this common resource they attempt to achieve an agreement that would be beneficial to all countries. The present paper considers cases where the countries may be involved in several coexisting agreements. We identify three cases where the issue may be important. In case one we have one stock and many potential agreeement, e.g.. countries (1,2) and (3,4) sign bilateral ageeements. In case two we have a two-species fishery, where an agreement is needed for both species x and y. Finally, in case three we may have some countries that find it optimal to be part of several parallel agreements concerning the same fishery.

Keywords: Coalition formation, international fisheries agreements, game theory, multi-species fisheries

INTRODUCTION

Game-theoretic fisheries models typically consider cases where some n countries harvest a common fish stock x. For this common resource they attempt to achieve an agreement that would be beneficial to all countries. The present paper considers cases where the countries may be involved in several coexisting (parallel) agreements.

We identify three cases where the issue may be important. In Section 2, we have one stock and many potential agreeement, e.g.. countries (1,2) and (3,4) sign bilateral ageeements. In Section 3, we have a two-species fishery, where an agreement is needed for both species x and y. In Section 4 we may have some countries that find it optimal to be part of several parallel agreements concerning the same fishery. Finally, Section 5 concludes and discusses future research issues.

ONE STOCK – MANY AGREEMENTS

Consider a game between four agents harvesting a common natural resource (Mesterton-Gibbons 1993). Assume sustainable use of the fish stock by four asymmetric countries:

$$\frac{dx}{dt} = F(x) - \sum_{i=1}^{4} h_i = 0 \qquad \text{(Eq. 1)}$$

The growth function is explicitly formulated as logistic growth:

$$F(x) = Rx(1 - x/K)\,. \qquad \text{(Eq. 2)}$$

Here R is the intrinsic growth rate of fish and K is the carrying capacity of the ecosystem. The production function is assumed to be linear:

$$h_i = qE_i x \qquad \text{(Eq. 3)}$$

It follows from (1) - (3) that the sustainable fish stock is given as

$$x = \frac{K}{R}(R - q\sum_{i=1}^{4} E_i) \qquad \text{(Eq. 4)}$$

Hence, the stock decreases linearly in effort.

In the first stage the agents decide their coalition. In the second stage the coalitions optimise their fishing efforts taking into account the decisions of other coalitions.

The objective of each coalition K is to maximise its profit:

$$\max \; ph_K - c_K E_K \qquad \text{(Eq. 5)}$$

Consider the following numerical example: p = 1; r = 0.8; K = 100; q = 0.8;
c1 = 7; c2 = 17; c3 = 20; c4 = 10

Let us first look at the case where a two-player coalition faces two single countries.

Table I: A game between a two-player coalition and two singletons

	Country 1	Country 2	Country 3	Country 4		
Non-cooperation	4.90	1.20	0.58	3.53		
Partial cooperation	(1,2)	(1,3)	(1,4)	(2,3)	(2,4)	(3,4)
	6.19	5.78	7.2	1.65	4.63	4.28
Free-rider values	1.07 (3)	1.65 (2)	2.45 (2)	5.78 (1)	6.19 (1)	5.78 (1)
	4.63 (4)	4.28 (4)	1.51 (3)	4.28 (4)	1.07 (3)	1.65 (2)

We see from Table I that adding a medium cost player thus, produces a situation where the newcomer does not find it optimal to cooperate with country 1. Stable coalitions are (1,2), (1,3) and (3,4).

The two two-player coalitions case yields:

Table II: A game between two two-player coalitions

Cooperation structure	(1,2), (3,4)	(1,3), (2,4)	(1,4), (2,3)
Values	8.02	8.02	9.57
	6.23	6.23	3.90

Indeed, the situation is now changed (see Table 2) since it is optimal for the outside countries to join together, thus making two simultaneous two-player coalitions. Therefore, the equilibrium cooperation structures are (1,2), (3,4) and (1,3), (2,4).

For the three-player coalition case we have:

Table III: A game between a three-player coalition and a singleton

Cooperation structure	(1,2,3), (4)	(1,2,4), (3)	(1,3,4), (2)	(2,3,4), (1)
Values	8.02	10.27	9.57	6.23
	6.23	3.07	3.90	8.02

We see from Table III that there are no stable three-player coalitions. Let us assume that the two stable two-country coalitions would be able to negotiate as groups with one another. In this case the grand coalition would be stable since no two-player coalition would be better off by leaving the grand coalition. However, we see from the sum of three-player free-rider values that the formed grand coalition would not be stable since there would be incentives for single players to free ride and leave the RFMO.

To summarize, we have a case of two parallel bilateral fisheries agreements.

MULTIPLE STOCKS

Consider three countries exploiting two stocks: Countries 1,2 sign a bilateral agreement on x but for y all countries sign an agreement. Stocks x and y fisheries may or may not be biologically and economically dependent. Further, the set of countries exploiting each stock may be same or different.

Assume we have three agents harvesting two independent fisheries. Assume further that for one fishery full cooperation is stable and for the other it is not stable. The question arises should we manage the two fisheries separately or together. The answer depends on whether the surplus cooperative benefits in the stable fishery exceed those in the unstable fishery. In this case joint management of the two stocks is beneficial since the unstable fishery is made stable by linking the negotiations. However, if the situation is reverse, so that the surplus cooperative benefits in the stable fishery are lower than those in the unstable fishery, then separate management is better since then we at least have one stable fishery.

ONE STOCK – COUNTRIES MAY BE PART OF SEVERAL AGREEMENTS

Countries may e.g. sign bilateral agreements on various issues concerning same stock. Example: Countries 1,2 agree on technology, countries 2,3 on biology, countries 1,3 on enforcement, all countries on research. The logic here resembles the previous section. Can we achieve long-term agreements by agreeing on some issues or do we have to agree on all issues?