Marine Policy 52 (2015) 52–58

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Impacts of hegemony and shifts in dominance on marine capture fisheries

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ARTICLE INFO

Article history:
Received 13 June 2014
Received in revised form
30 October 2014
Accepted 2 November 2014

Keywords:
Sustainable fisheries management
Hegemony
Cooperation
Balloon effects
Marine capture fisheries
Game theory

ABSTRACT

Catch data indicates that the world's 25 largest marine capture fisheries have generally comprised some 40–50% of the total annual reported catch (1950–2012). From a game theory perspective, there is considerable diversity across these 25 fisheries, both in terms of the number of players and the management paradigms. Here, a dominance-oriented classification system is proposed, according to which fisheries are categorized into: (1) hegemonic systems with single-player dominance; (2) coupled systems with two-player dominance; (3) group systems with shared dominance; (4) systems with no dominant player. Among these categories, the fourth represents perhaps the greatest challenge to sustainable management, while also demonstrating the challenges of managing common pool marine ecosystem services in areas beyond national jurisdiction (ABNJ). The survey and analysis highlights how hegemonic conditions tend to preclude the establishment of cooperative agreements irrespective of the number of players involved in the fishery. Shifts in dominance away from hegemony, as demonstrated most recently in the case of the highly migratory Pacific Saury, can open the door to greater cooperation. Movement of fish stocks and displacement of fishing activities, due for example to climate change, have the capacity to cause major shifts in dominance and, in some cases, destabilize existing cooperative mechanisms.

1. Introduction

Considerable work has been undertaken using the theory of strategic behavior – game theory – to understand the formation and subsequent stability of coalitions of players engaged in the management of transboundary and straddling fish stocks. Such models generally consider cooperative and competitive games, with the stability of cooperative coalitions dependent on certain conditions. First, solutions should be Pareto Optimal, meaning that in a two-player game, no change could be made to the current regime that would be to the benefit of both players. Second, cooperation must provide additional benefit to each player vis-à-vis a non-cooperative setting [19]. Splintering of a coalition into singletons "free-riding" on the cooperative management efforts of the remaining members of the coalition is presumed to arise when the potential benefits of leaving the coalition outweigh retaliatory or punitive measures levied against the singleton [14]. Free riding, in fact, has been characterized as the primary threat to international fisheries cooperation [24,20].

While this provides a compelling basis for a range of models, a considerable number of assumptions are common—the assumption of rationality, symmetrical information (all players basing their decisions on the same body of information), shared management objectives, static systemic conditions, etc. Finally, the emergence of singletons makes certain assumptions about the existence of monitoring and enforcement measures as well as the existence of (self-)enforcement mechanisms. An inspection of major fisheries, however, points to tremendous variability across all of these points.

In general, however, research has suggested a number of characteristics common to strategic behavior in cooperative fisheries management. First, the likelihood of a grand coalition involving all players sharing a fish stock decreases as the number of players increases [15], although it has also been found that a larger grand coalition is mirrored by higher relative gains from cooperation [24]. Second, depending on the respective shares of each player, it is possible for a single player to dominate a fishery to the extent of having *de facto* veto power over cooperative management of the stock [3]. Third, non-cooperative management of common pool resources will lead to conditions of bionomic equilibrium characterized by excess fleet capacity and overexploitation of fish stocks [22].

This paper seeks to inductively explore these theoretical considerations, while also considering just how little symmetry there is in the management of marine fish stocks. Throughout these calculations, the world's 25 largest marine capture fisheries are used as a reference sample for global fisheries. Since 1950, these

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http://dx.doi.org/10.1016/j.marpol.2014.11.001
0308-597X/

25 fisheries have generally comprised some 40–50% of annual reported catches (Fig. 1) according to data provided by member states to the United Nations Food and Agriculture Organization (FAO). This data as well as relevant literature on cooperative fisheries management and recent developments in specific marine fisheries, are used to propose a new categorization system for fisheries cooperation based on player dominance (ranging from hegemonic conditions to non-dominated fisheries). This categorization system considers that the dominance of a single player over a shared fish stock encompasses both ecological aspects (i.e. the player's capacity to comprehensively impact the abundance levels of the fish stock as a whole), as well as the player's corresponding dominance in value chains, processing and distribution capacity, and negotiation processes. This focus on asymmetries in terms of catch levels likewise picks up on a surprising result of the partition function game of Pintassilgo et al. [24] that found evidence for greater asymmetry among players – cost asymmetry in this case – being an indicator for the increased success of respective RFMOs.

In the final discussion, policy implications are considered and the existence of "balloon effects" is briefly introduced. While external stresses may cause the intensification or reduction of certain fishing activities, balloon effects are caused by large-scale displacement of activities from one location to another. The theoretical basis and evidence for such effects has been largely generated by study of how targeted drug control efforts have displaced illicit production and transport routes into areas of least statehood [9,11].

2. Material and methods

Containing thousands of reported and estimated catch statistics for a multitude of different species, the FAO's FishStatJ dataset is the basis for many of the calculations in this study. In addition to providing catch data by country and species, FishStatJ provides a geographical marker for each entry, corresponding to the 19 FAO Fishing Areas [12].

Aggregated FAO marine fishery catch statistics from 1950 to 2012 portray a somewhat dynamic economic sector (Fig. 1) that has remained at more-or-less steady levels since the late 1980s. To establish a meaningful sample of transboundary fish stocks for analysis in this study, the FAO catch data were sorted according to species. Over the 1950–2012 timeframe, the top 25 individual species have comprised roughly 40–50% of catch in any given year. While "marine fishes nei" (nei = not explicitly indicated) tops the list, the corresponding data lacks, by definition, a certain level of precision, representing some current limitations in the reporting capacity of member states, and a limitation in this study.

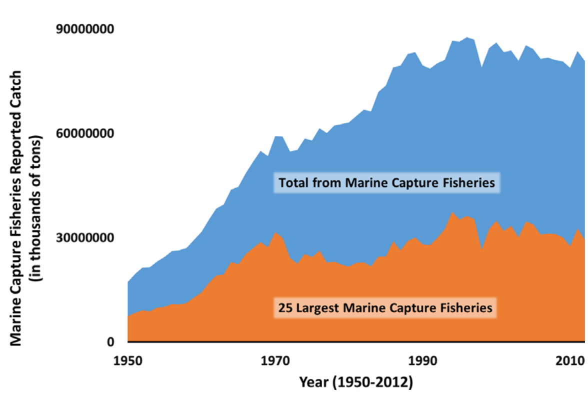

Fig. 1. Global fish catch reported 1950–2012 and share of 25 largest marine capture fisheries (source: FAO FishStatJ).

Nonetheless, the relatively consistent share of these 25 fisheries over time in global catch suggests that general trends may persist even if reporting were more specific.

Calculations were carried out to determine the level of hegemony for each of these 25 fisheries. Four categories were defined as follows (for $x_{k1} > x_{k2} > \cdots > x_{k\epsilon}$, with x being the reported catch in tons of a certain fish species, i being one of the 19 FAO fishing areas, and k a country reporting its catch of this species to FAO):

Category 1 (hegemonic single-player dominance)

$$\sum_{i=1}^{19} x_{i,\,k1} > 0.8\left[\sum_{i=1}^{19} x_{i,\,k1} + \sum_{i=1}^{19} x_{i,\,k2} + \cdots + \sum_{i=1}^{19} x_{i,\,k\epsilon}\right] \tag{1}$$

Category 2 (coupled two-player dominance)

$$\sum_{i=1}^{19} x_{i,\,k1} + \sum_{i=1}^{19} x_{i,\,k2} > 0.9\left[\sum_{i=1}^{19} x_{i,\,k1} + \sum_{i=1}^{19} x_{i,\,k2} + \cdots + \sum_{i=1}^{19} x_{i,\,k\epsilon}\right] \tag{2}$$

Category 3 (shared small group dominance)

$$\sum_{i=1}^{19} x_{i,\,k1} + \sum_{i=1}^{19} x_{i,\,k2} + \cdots + \sum_{i=1}^{19} x_{i,k5} > 0.9\left[\sum_{i=1}^{19} x_{i,k1} + \sum_{i=1}^{19} x_{i,k2} + \cdots + \sum_{i=1}^{19} x_{i,k\epsilon}\right] \tag{3}$$

Category 4 (non-dominated systems)

$$0.2\left[\sum_{i=1}^{19} x_{i,\,k1} + \sum_{i=1}^{19} x_{i,\,k2} + \cdots + \sum_{i=1}^{19} x_{i,\,k\epsilon}\right] > \sum_{i=1}^{19} x_{i,\,k\alpha}; \quad \alpha \in N \tag{4}$$

The Results section introduces how the selected fisheries can be classified into these four categories. The categorization system itself relies on four main concepts:

(1) The dominance of a single player over a specific fishery can give it a *de facto* veto power over the formation of coalitions. On the one hand, the increase in the dominant player's payoff if it engages in collaboration with other players may be minimal and little encouragement to engage in potentially complex negotiations. At the same time, if the dominant player decides not to engage in collaborative behavior with others, the remaining players may likewise see little impact from collaborative sustainable management efforts [3].

(2) Past work on game theory and fisheries has found that in the cases where stable coalitions for the management of shared fish stocks are predicted, the largest potentially stable variant is often a two-player coalition. (e.g. [8,3,18,23]).

(3) A broad gap exists between non-dominated systems and those in which a small group of players reports the majority of catches. The extensive distribution of tuna, and the large number of countries for which catch of tuna represents the majority of fishing activities pushes these highly migratory species into a separate category.

(4) A single player's dominance can extend beyond just the share of a certain fish stock in its EEZ, and the associated capacity for that player to comprehensively impact the stock's ecology. Such players can likewise exercise a dominance across other stages of the value chain and the institutional landscape, strengthening their respective position in any negotiations or cooperative undertakings.

3. Results and discussion

Using Eqs. (1)–(4), the largest 25 fisheries can be broken into four dominance-based categories as shown in Table 1. To provide additional context within this categorization system, the existence of bilateral and multilateral cooperative agreements is included in the final column, and an overview of the type of stock (straddling, transboundary, etc) is also provided. The European Union is considered