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The New-Member Problem in the Cooperative Management of High Seas Fisheries

PEDRO PINTASSILGO
Universidade do Algarve

CLARA COSTA DUARTE
Universidade Nova de Lisboa

Abstract *This paper discusses the threat that new members pose to the cooperative agreements in the management of straddling and highly migratory fish stocks and the possible solutions to this problem. In particular, the main solutions proposed in the fisheries literature are explored—namely the "transferable membership," the "waiting period" and the "fair sharing rule." The analysis is illustrated by a typical highly migratory species: the northern Atlantic bluefin tuna. The application of the analysis to the bluefin tuna fishery case study shows that, at present, the threat of the new members is not sufficient for the breakdown of the cooperative agreement. The simulation results for this case study show that both the "transferable membership" and the "fair sharing rule" solutions solve the potential new member threat.*

Key words Cooperative agreement, highly migratory fish stock, new member, regional fishery organization, straddling fish stock.

Introduction

The several cases of overexploitation of straddling and highly migratory fish stocks that followed the United Nations Convention on the Law of the Sea (UNCLOS 1982) led the UN to convene the "United Nations Inter-governmental Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks (1993–95)." In 1995, the Conference adopted the Agreement for the Implementation of the Provisions of UNCLOS, Relating to the Conservation and Management of Straddling and Highly Migratory Fish Stocks (UN 1995).[1] Although this UN Agreement has not yet been fully ratified, it is already viewed as a guideline for any attempt to solve this management problem.

According to the UN Agreement, namely Articles 5 to 8, all countries with real interest in a given fishery, both coastal states and Distant Waters Fishing Nations (DWFNs), are admonished to establish Regional Fishery Management Organizations (RFMOs), or equivalent cooperative bidding agreements, for conservation and management of these species (Munro 1999). Once this institutional "agreement" is achieved, only its members will have access to the regulated fishery resources. However, membership should be open to all countries interested in the fishery. Also,

Pedro Pintassilgo is an assistant professor in the Faculty of Economics, Universidade do Algarve, Campus Gambelas 8000-117, Faro, Portugal, email: ppintas@ualg.pt. Clara Costa Duarte is an assistant professor in the Faculty of Economics, Universidade Nova de Lisboa, Travessa Estevão Pinto 1000, Lisboa, Portugal, email: mcduarte@fe.unl.pt.

[1] UN Agreement, hereafter.

the UN Agreement requires that coastal states and DWFNs should cooperate to ensure a uniform resource management regime for both the Exclusive Economic Zones (EEZs) and the high seas. Those measures should aim at ensuring long-term sustainability of these stocks, as well as their optimal utilization.

According to Munro (1999), the UN Agreement left unsolved two important issues to the long-term economic viability of the RFMOs. Both are centered on the possible emergence of new entrants and are designated as the "new member" and the "interloper" problems. The first issue emerges as the UN Agreement states that the members of an RFMO do not have the right to bar the access of a prospective new member.[2] The "interloper" issue concerns the policing of vessels of states that are non-members of the RFMO. Both cases can lead to emergence of free riders that would benefit from the conservation efforts of the initial members, undermining the potential gains from cooperation.

The main objective of this paper is to discuss the threat that new members pose to the cooperative agreements and the possible solutions to this problem.[3] The problem is also illustrated with a case study of the North Atlantic bluefin tuna fishery. The analysis uses game theory as a useful framework to evaluate cooperative and non-cooperative behavior in harvesting fish resources.

The economics of the cooperative management of straddling and highly migratory fish stocks is still at an early stage of development. In fact, research on the cooperative management of transboundary fish resources has been centered mainly on shared fish stocks that migrate only between the EEZs of several countries and not in international waters. The cooperative solutions of the highly migratory stocks are challenged by the potential instability of the nature and number of the players, as opposed to their natural stability in shared fish stock problems.

In the fisheries literature, Kaitala and Munro have approached the topic of new entrants in successive papers since 1993. In Kaitala and Munro (1993), it is emphasized that the new-entrants issue does not arise with "shared stocks." Therefore, the economics of shared stocks can only be used to a limited extent regarding straddling and highly migratory fish stocks. They assert that the legal regime of the Law of the Sea Convention does not solve the economic problem posed by the new entrants. Kaitala and Munro (1997) address the economics of the optimal cooperative management of straddling fish stocks under the aegis of regional fishery organizations. In this study, they deal specifically with the new-member problem. They conclude that if the only bar to achieving membership in the organization is the willingness to accept its management program, then the cooperative management could most certainly be at serious risk. It is also argued that the UN Agreement does not provide guidance to solve this problem.

Recently Li (1998) addressed the new-entrant problem through a coalition game (c-game) approach. The author suggests that a suitable concept of fairness can guarantee that the participant's share of the benefits will depend on its contribution toward the formation of the grand coalition. Since inefficient new entrants contribute little, they would receive little.

The theory of new entrants is also a central topic of research on game theory and industrial organization. Regarding the formation of cooperative arrangements, it is consensual that collusion works best when there are substantial barriers to entry. Friedmann and Thisse (1994) investigate the possibility of collusion in the absence of such entry barriers. They discuss three classical scenarios: the first presumes that

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[2] The UN Agreement permits members to bar the access of a new member only if it refuses to adopt the RFMO management regime.
[3] According to Munro (1999), the entry of non-members can be regarded as an aggravated version of the new-member problem.

firms use the strategy that minimizes the payoff of a new entrant; the second relies on playing non-cooperatively against the new entrant, which gives rise to the traditional Nash-Cornout strategies; and the third incorporates entrants into the collusive arrangement. The authors also propose a fourth solution, in which the entrant is gradually incorporated into the cooperative agreement. Friedmann and Thisse argue that the new entrants most likely would be brought into the collusive scheme, but it is also expected that their introduction would be gradual. Such a gradual inclusion into a full partnership with pre-existing firms permits the collusion to continue and rewards the entrant only marginally. Note that the first two scenarios imply behavior from the RMFO that does not comply with the UN Agreement.

The New-Member Threat

The possibility of new members attempting to join a fishery is generally seen as a threat to the long-run viability of the cooperative agreements.

An illustrative example is the Southern bluefin tuna fishery. In this fishery, the threat emerged from non-members acting non-cooperatively, which Munro (1999) states "is essentially an aggravated version of the new-member problem." Here, the cooperative trilateral agreement between Japan, Australia, and New Zealand, established in 1994, has been clearly undermined since 1998 due to the increasing catches of other countries, namely Indonesia, the Republic of Korea, and Taiwan (Cox, Stubbs, and Davies 1999). The authors argue that behind Japan's motivation in deciding not to cooperate is the feeling that the returns from cooperation are less than the returns from non-cooperation. As this example clearly shows, the cooperative agreements may be undermined through time due to the emergence of new entrants or, in particular, new members.

This threat was left unsolved by the legal regime of the UN Agreement. According to Orebech, Sigurjonson, and McDorman (1998), Article 8 requires that a cooperative new member "must be offered a just and reasonable share of the TAC," although it does not specify what a "just and reasonable share" is, or if a price could be applied to it. In fact, if entrance can be made at zero cost, the problem of the free rider emerges.

This problem was formally stated in Kaitala and Munro (1997). The authors show that when an RFMO is being established, the expected payoffs of cooperation may fall below the threat-point payoffs if a prospective new member must be admitted and must be given a share of the resource harvest. They use the standard bioeconomic model used in theoretical studies and an egalitarian-sharing rule for the surplus from cooperation. In their study, no cooperative sub-coalitions are considered. Therefore, if one of the players breaks the agreement, the others will react with a non-cooperative strategy.

The threat, as defined in Kaitala and Munro (1997), can be stated for more general bioeconomic dynamics and sharing rule settings. Let us assume, as in their study, that no cooperative sub-coalitions can be formed, and that at some initial period, t, a cooperative agreement is achieved and it is binding through time; *i.e.*, once a country signs an agreement, it will not play non-cooperatively thereafter. Based on these assumptions, it can be concluded that the cooperative agreement will not be implemented if the following condition is met for any of the original members:

$$P_{i,t}(x_t, S_i^N, S_{P\{i\}}^N) > P_{i,t}(x_t, S_i^C, S_{P\{i\}}^C, S_{NM}^C) \quad (1)$$

Where: $P_{i,t}$ = payoff of player i, evaluated in period t; x_t = state of the stock at period *t*; S_i^N = strategy of player *i*, under non-cooperation; S_i^C = strategy of player *i*, under cooperation; *P* = set of players at time *t*; and *NM* = new members.

Condition (1) states that, if the threat point of any of the initial members is greater than the expected gains from cooperation with the inclusion of the new member, the initial agreement will be undermined. As is well known, a successful cooperative agreement creates an economic rent, which, in time, will attract new members. If these new members are legally allowed to participate in the fishery, condition (1) may occur very often. Also, the share of the surplus from cooperation attributed to these new members is a crucial variable in this condition. In line with this idea, Li (1998) argues that the adoption of a "fair sharing rule" can protect the cooperative agreements from the new-entrant threat.

The threat that new members pose to the cooperative agreement generally does not end with the country's initial decision to become members of a regional fishery organization and cooperate in the recovery of the stock. If the agreement is non-binding through time, this is a dynamic problem that tends to undermine cooperation in the long run. In this scenario, at any period t, and not only the initial period, each member evaluates whether or not to cooperate. It happens that, over time with the stock recovery, cooperation tends to become less appealing due to the emergence of new members and to the increase of gains of a non-cooperative strategy.

The analysis of the new-member threat can also be extended to a setting in which sub-coalitions are allowed. To this end, the fishery game must be represented in coalition form. As shown in Pintassilgo (2000b), through a coalition approach, the cooperative agreements through regional fisheries organizations tend to be unstable due to the existence of free-rider incentives. In this framework, the impact of the presence of new members is to enhance those free-rider incentives, by reducing the payoffs that members can obtain by adopting a cooperative strategy.

Solutions Schemes

In this section, three main solutions proposed in the fisheries literature for the new member problem are discussed.

Kaitala and Munro (1997) explore two solution schemes: "transferable membership" and the "waiting period." These were suggested in a draft convention by a group of coastal states during the UN Fish Stocks Conference (UN 1993). In the first one, the charter members declare the transboundary stock to be fully utilized, and, thus, a prospective new member may participate in the fishery only if one of the members relinquishes its share. In the second one, the new member is allowed to enter the RFMO, but must go through a waiting period before enjoying benefits from the fishery.

Another solution scheme concerns a "fair sharing rule." Li (1998) suggests that a "fair sharing rule," based on the contribution that each player makes to the grand coalition, may preserve cooperative agreements from free-rider behaviors of inefficient new members, even within the free-access scenario of the UN Agreement.

Let us now look at the three solution schemes in greater detail.

Transferable Membership

Kaitala and Munro (1997) conclude that the "transferable membership" solution provides some incentives for the charter members to enter into a cooperative resource management arrangement. As this scheme is based on the creation of "*de facto* property rights" for the members of the regional fishery organization, the appearance of new members will not mean the dissipation of its future returns from the fishery. In fact, the transfer will only take place if it is mutually beneficial for both parties. Thus, with a "transferable membership" scheme, new members do not pose a threat to cooperative agreement, and condition (1) will not be verified. In fact, the entry of a new member does not change the cooperative and the non-cooperative payoff of each player.

In a quota system, the "transferable membership" can take on the attributes of Individual Transferable Quotas (ITQs). In this case, each country can transfer its quota by selling it in the market. The more efficient countries would, therefore, buy quotas from the less efficient.

In implementing ITQs in the management of straddling and highly migratory fish stocks, a two-stage allocation can be considered. In the first stage, the regional fishery organization allocates the quotas among countries. In the second stage, each country distributes the quotas among its fisherman.

The use of ITQ systems in ocean fisheries is rather recent. The first comprehensive ITQ system was implemented in New Zealand in 1986, and it was followed by Australia, Canada, Iceland, and other countries. The applied studies on the implementation of ITQ systems generally conclude that they bring substantial efficiency gains, namely by providing mechanisms to eliminate redundant capital and restructure the fleet composition (Weninger 1998; Gauvin, Ward, and Burgess 1994). Some disadvantages have also been cited, namely, the consolidation of market power with big business entities, and especially when they are foreign, the creation of unemployment and significant changes in the geographical structure of the fisheries (Christy 1996). In order to minimize some of these problems, its implementation has been accompanied by restrictions in terms of divisibility and transferability of the quotas (Arnasson 1993).

In brief, the implementation of a payment scheme, such as an ITQ system, in theory, is an efficient solution for the new-member problem. Nonetheless, it generates a set of changes in the fishery, which may undermine its application in a complex social and economic context, such as that of the typical fisheries targeting highly migratory species.

Waiting Period

Kaitala and Munro (1997) conclude that the "waiting period" mechanism may not be very promising in eliminating the threat that the new members pose to cooperative agreement. The impact of introducing a "waiting period" is analyzed below in a more general setting.

Assume that a cooperative agreement is signed at some period, *t*, and is binding through time. In this scenario, the introduction of a "waiting period" results in two interconnected effects. The first is that the payoffs (net present value of profits) of prospective new members are reduced. The second is that the reduction in the payoffs of original charter members, due to the presence of new members, is smaller. Thus, even if the former effect is not sufficient to change the decision of prospective new members to enter the fishery, the latter decreases the threat that they pose to the cooperative agreement. Therefore, it can be that a cooperative agreement that would not be established due to the new-member threat becomes appealing with the introduction of a "waiting period." This occurs if condition (1) is verified for at least one player, but it is no longer verified when a "waiting period" is introduced—due to the increase of the cooperative payoff (2^{nd} member). It is also interesting to note that the higher the discount rate that nations/fleets exhibit, the more effective this solution is. The higher the discount rate, the more significant are the losses to a prospective new member due to the introduction of a "waiting period." Also, the negative impact of the integration of new members on the cooperative payoffs of the charter members is smaller.

Let us now look at the dynamic threat discussed above, which occurs when the agreement is not binding through time. In this setting, if the "waiting period" does not change the decision of new members to enter the fishery, then the dynamic threat to the cooperative agreement may not be eliminated. This is generally the case, as the "waiting period" mainly decreases the net present value of prospective new members, but does not change their decision to enter the fishery.

There is, however, a scenario in which the "waiting period" can be more effective in solving the new-member threat, even if the agreement is not binding through time. When a permanent position in a cooperative agreement implies permanent costs, such as member fees, monitoring, *etc.*, fleets with high discount rates, often the DWFN, may not be interested in entering the RFMO if it has to go through a "waiting period."

Thus, it can be argued that the "waiting period" can be an efficient solution for protecting binding agreements, especially in the presence of high discount rates. Regarding agreements, which are not binding through time, the new-member threat can only be eliminated if there are significant costs associated with the membership status in a regional fishery organization.

Fair Sharing Rule

Finally, let us consider the "fair sharing rule" solution. Li (1998) suggests that this solution may solve the new-member problem, in a scenario in which all willing participants have a right to a share of the catches.

The first step of this scheme is that all participants must agree on a legal binding cooperative agreement, in which the harvest of the stock must be sustainable and efficient. A second step is to implement an equitable distribution of the benefits, resulting from the grand coalition, through a consensual bargaining process. The agreement and the distribution of the benefits would be renegotiated with the change in the number of participants.

A suitable concept of fairness would guarantee that each participant receives a share of the benefits according to its contribution to the grand coalition. Since inefficient fleets contribute little, they would receive little.[4] Therefore, the common property would not attract inefficient fleets to the cooperative agreement that are only interested in free riding the benefits of the grand coalition.

This idea is explored through a characteristic function game (c-game) approach. In this approach, the different fleets/nations can form subcoalitions, in the case of breakdown of the grand coalition. Unlike the traditional Nash bargaining scheme, the solution concepts used in a c-game approach depend on the relative bargaining strength of the players.

With a "fair sharing rule," each player receives a payoff at least as high as its threat point. Thus, new members do not pose a threat to the cooperative agreement and condition (1) is not verified.

However, Li (1998) points out two possible limitations in using a "fair sharing rule" to solve the new-member issue. First, if the complete information assumption is relaxed, it may be difficult to avoid the entry of wholly inefficient, free-riding, potential new members. The second limitation is that with a high number of partici-

[4] In Li (1998), efficiency is set in terms of harvesting costs.

pants, the universal acceptance of a concept of fairness for benefits distribution becomes a difficult issue: "…in the end full utilization of the stock might have to be declared, effectively forever barring new entrants, including truly efficient ones" (Li 1998).

Having analyzed the three solutions, let us now confront the assumptions used in Li (1998) and Kaitala and Munro (1997). The fundamental difference between the two is that they are based on different legal settings. For Li (1998) the non-member fleets cannot be prevented under International Law from fishing in the high seas. Therefore, incorporating the new fleet in a fair manner is better than playing against it. Kaitala and Munro (1997), on the other hand, do not consider the possibility of non-cooperative behavior by the prospective new entrants. Thus, the entrance of new members in the cooperative agreement will decrease the payoffs of the charter members.

When the UN Agreement enters into force, the most likely scenario is that new entrants cannot adopt non-cooperative behavior. As stated in Article 17 of the UN Agreement, "A State which is not a member of a subregional or regional fisheries management organization, …, is not discharged from the obligation to cooperate, in accordance with the Convention and this Agreement, in the conservation and management of the relevant straddling fish stocks and highly migratory fish stocks."

The New-Member Issue in the Bluefin Tuna Fishery

Throughout this section, the new-member problem and the impact of the possible solutions is illustrated for the East stock of the Northern Atlantic bluefin tuna fishery.

The North Atlantic bluefin tuna is a high-valued, highly migratory fish stock, living in the North Atlantic and the Mediterranean Sea. It is captured by many countries, coastal states and DWFNs, using different types of fishing gears which target different age classes.[5] This fishery has been an example of the difficulties faced in the management of highly migratory fish stocks. Recent stock assessments report that this stock is severely depleted, although several recommendations and conservation measures have been proposed by the International Commission for the Conservation of Atlantic Tunas (ICCAT).[6]

Considering this species to be an interesting case study, Duarte, Brasão, and Pintassilgo (2000) studied the implications of a hypothetical cooperative bidding agreement for the management of this species, in accordance with the UN agreement recommendations. For that purpose, it was considered that all the countries actually participating in this fishery were represented in the future RMFO by only three members: European Union (EU), DWFNs, and Other Coastal States (OCS).[7] The outcomes of non-cooperation, as well as the gains from cooperation that result from different management regimes, were simulated by a multi-gear, age-structured bioeconomic model. The model developed and presented in the appendix, reflects most of the complex features of this particular fishery.[8]

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[5] The most important fishing gears in the East Atlantic stock are: longline, purse seine, trap, and bait boat. All the other gears used in this fishery are aggregated in the bioeconomic model in the category "remainder."

[6] This Commission, created in 1969, is comprised of 23 fishing nations and is responsible for collecting information and proposing scientific-based management measures.

[7] The countries were grouped according to natural mutual interest.

[8] For more detailed information on this model see Pintassilgo (2000a).

The New-Member Threat

The threat that new members pose to the above hypothetical cooperative management of the East Atlantic bluefin tuna fishery is analyzed here. Assume that three charter members, the EU, DWFNs, and OCS, representing all the countries initially involved in the fishery have established a cooperative agreement creating an RFMO. Also, assume that its members have agreed upon a management regime that achieves a sustainable and optimal utilization of the stock. The optimal policy was simulated by the bioeconomic model and is the one that maximizes the net present value of profits for all gears and for a 50-year period. It was set in terms of an annual, non-constant, TAC[9] in which the gear structure remains constant—as in the base year (1995). The optimal policy resulting from the model is to declare an initial harvest moratorium of five periods and catching at the precautionary limit of 40,000 MT thereafter. Each member receives a right to a share of the TAC for each gear according to its catch level in the base year. These shares are not transferable, and side payment schemes are not feasible.

The new-member problem is addressed in this particular context. Several scenarios for new members could be drawn; however, in this case almost all coastal states are already fishing members, so new members will most likely be DWFNs. Let us then assume that the new member (NM) that requires admission to the RMFO abides by the following conditions: (*i*) accepts to follow the management regime agreed by the previous members of the RMFO; (*ii*) uses only the longline gear and have longline fleets identical to those already in the fishery; (*iii*) receives a share of the longline quota.[10]

Let us now assume that the initial members are rational and, therefore, if the entry of a new member is anticipated, they will evaluate whether or not their payoff under cooperation exceeds that of non-cooperation. Assume that the above agreement, binding through time, is established at the initial period ($t = 0$). Also, assume that the new members will not enter the fishery if non-cooperation occurs.

In this framework, if condition (1) holds at $t = 0$ for any of the original members, the anticipated entry of new members will lead the members to non-cooperative behavior.

In order to analyze this condition, the non-cooperative and cooperative strategies were simulated for different shares of the new members (NM).[11] The payoffs are presented in table 1.

A major conclusion that emerges from table 1 is that the prospective new members clearly gain by entering the RFMO, but this does not threaten the cooperative agreement. In fact, even if the new members receive a considerable share of the longline quota, the original members would still prefer a cooperative strategy instead of a non-cooperative one. This is due to the very low level of the stock at the beginning of the game, which makes non-cooperation a low-payoff strategy.

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[9] The TAC is considered to be variable during the first 25 years, and constant thereafter. Thus, 26 variables are optimised: the TAC for the first 25 years and the constant TAC for the last 25 years.

[10] The other players share in the longline quota decrease in that proportion. Regarding this assumption, it is worth observing that in a simpler scenario, where the TAC is issued by country and is not divided by gear (as in the present ICCAT policy), the new members would naturally receive a share of the total catch. The simulation results proved that, for both scenarios, the results are qualitatively similar. Nonetheless, if the TAC is not divided by gear, the effects of the new members would be more evenly distributed among the players and not so concentrated on the DWFN, which dominates the longline gear. The option for a more complex scenario, while not changing the main results, enabled us to explore the possibility of establishing ITQs per gear.

[11] The payoffs for this strategy differ slightly from those presented in Duarte, Brasão, and Pintassilgo (2000), as the modeling of the last period has been revised.

Table 1
Payoffs by Player in the Presence of New Members at *t* = 0

	Non-cooperative	Cooperative—New-Member Share on the Longline Quota					
		0%	10%	30%	50%	70%	90%
EU	–8.8	1,327.1	1,308.3	1,270.8	1,233.2	1,195.7	1,158.2
DWFN	30.2	503.3	453.0	352.3	251.7	151.0	50.3
OCS	–3.0	589.2	573.0	540.5	508.1	475.7	443.3
NM	–	–	85.3	255.9	426.5	597.1	767.7
Total	18.4	2,419.5	2,419.5	2,419.5	2,419.5	2,419.5	2,419.5

Note: Values are in million USD.

Nonetheless, if the agreement is not binding through time, the threat posed by the new members does not end with the initial decision to cooperate in the recovery of the stock. At any period *t*, condition (1) can be evaluated—each of the players evaluates whether or not a non-cooperative strategy is worth more than a cooperative one.

In order to test the dynamics of the new-member threat, a scenario is created in which, following the initial harvest moratorium, new members join the RFMO, and each member decides whether to cooperate or not. Again, it is assumed that if one of the original members breaks the agreement, then the others will react non-cooperatively.

Table 2 shows the payoffs of the cooperative and non-cooperative strategies at the end of the moratorium. To simulate non-cooperation, it was assumed that in the period just after the moratorium, the original members use the same effort level as in the base year, and the new members use 10% of the total longline effort of that year.

Table 2 also shows that after the moratorium, for the DWFN, the incentive to break the cooperative agreement increases. In this scenario, new members with a longline share between 30% and 50% would be sufficient to make it profitable for the DWFN to break the cooperative agreement. Therefore, in this new scenario, the threat new members pose to the long-term stability of the cooperative agreement is increased. Nonetheless, the minimum share of the new members that leads to the breakdown of the cooperative agreement is still reasonably high. It is not likely that new members can receive a share of more than 30% in a real fishery.

Table 2
Payoffs by Player in the Presence of New Members at *t* = 6

	Non-cooperative	Cooperative—New-Member Share on the Longline Quota					
		0%	10%	30%	50%	70%	90%
EU	832.8	1,674.4	1,650.7	1,603.3	1,556.0	1,508.6	1,461.3
DWFN	385.8	635.0	571.5	444.5	317.5	190.5	63.5
OCS	410.3	743.3	722.9	682.0	641.1	600.2	559.3
NM	65.4	0	107.6	322.9	538.1	753.4	968.6
Total	1,694.3	3,052.7	3,052.7	3,052.7	3,052.7	3,052.7	3,052.7

Note: Values are in million USD.

Solution Schemes

In this section, the three main solutions for the new-member problem are simulated for the East stock of the Northern Atlantic bluefin tuna.

Transferable Membership

The basic premise in implementing a system of "transferable membership" within a policy of quotas, is that a prospective new member can only have access to the fishery by acquiring the corresponding quota from the member countries. The entry of new members does not change the cooperative and non-cooperative payoffs of the other players and, therefore, condition (1) is never verified.

As suggested above, this solution could be implemented through an ITQ system with a two-stage allocation. The new members would buy quota from the fisherman of the original members. This requires international trade of quotas, which is still not a common practice in world fisheries. For the bluefin tuna fishery, let us assume the ITQs are issued by gear and are non-transferable, as it was assumed in the previous section that quotas were not transferable among gears. In this context, a new member must acquire an ITQ for the particular gear it wants to use, and specific markets for each gear emerge. What will be the price of an ITQ in this fishery?[12] Table 3 shows the market price of a perpetual ITQ corresponding to a 1% share of the total catch of each gear.

In Pintassilgo (2000a), it was shown that the actual gear structure of this fishery was far from optimal, meaning that overall profits could be significantly increased if the gear structure was allowed to change. This would imply that some gears, namely purse seine and bait boats, would have to be banned, which is difficult to achieve in practice. However, if an ITQ system is implemented with no trade restrictions, meaning that an ITQ can be used to fish with any gear, a global market could be developed.

In the scenario of non-restricted transfers, the results show that, even for different discount rates, the optimal gear structure will be attained through the ITQ mar-

Table 3
Market Price of a Perpetual ITQ

ITQ		Discount Rate		
		4%	10%	20%
Non-transferable	Longline	26,573	9,793	3,700
	Purse seine	14,068	5,184	1,959
	Trap	74,084	26,761	9,492
	Bait boat	6,480	2,333	841
	Remainder	50,377	18,197	6,455
Transferable	Longline	31,206	11,529	4,397

Notes: Values are in thousand USD for a 1% of the total quota (as we allow for non-constant TACs, the rights correspond to a share of the TAC).

[12] A standard economic result, which remains valid in multi-fleet fisheries (Garza-Gil 1998), is that the market price of a perpetual ITQ is equal to the present value of the marginal returns generated by it.

ket. The trap and remainder reach their natural limits, whereas the entire remaining share (62.5%) will be designated to longline gear. The purse seine and the bait boat would exit from the fishery. The value of the ITQ in this scenario is also shown in table 3.

Different discount rates, and the respective optimal strategies, were also simulated in order to assess the importance of this parameter. From table 3 it can be concluded that the value of the ITQ is, as expected, very sensitive to the discount rate. However, the overall impact of this instrument to the stability of the agreement is the same.

In the restricted transfers scenario, the highest ITQ prices are those of the trap and the remainder, as they present high prices and the highest stock-output elasticity—thus benefiting the most from the stock recovery (Pintassilgo 2000a). In this scenario with a 4% discount rate, a new member (using longline gear) will have to pay around 26.6 million USD for a 1% share of the total catch. In the unrestricted scenario, the new member will have to pay a higher price, as the new gear structure brings a more favorable stock evolution.

With this system, a new entrant will have to pay for its share in order to have access to the fishery. Therefore, it will only buy the share if it is at least as efficient as the marginal longline fleet in the RFMO. This eliminates the incentives of inefficient prospective new members to enter the fishery once the stock is recovered, as the ITQ price will increase.

In this particular case, it can be concluded that implementing an ITQ system without restrictions on the transfers between gears is an efficient solution. It not only solves the new-member problem, but also changes the gear composition to one that yields higher returns and is more favorable in terms of stock preservation. The gears with more destructive impact on the stock, such as bait boat and purse seine, are eliminated.

The ITQ system also indicates that the players with a more long-term interest in the stock (more conservative) will tend to buy the ITQs, as they attribute more value to the resource due to their smaller discount rates.

Waiting Period

In this section, we evaluate if imposing a "waiting period" to the prospective new members can protect the cooperative agreement on the bluefin tuna fishery.

In order to shed some light on this issue, a hypothetical scenario is created in which the new members get a 50% share of the longline catch. The other members see their longline share reduced proportionally. For this share, condition (1) is not verified at $t = 0$, but it is at $t = 6$. With these assumptions three situations are simulated: a "five-year waiting period," "no waiting period," and no entry (by the new members). In this setting, "no waiting period" means that the new member will start to catch, together with the other players, immediately following the harvest moratorium. The "five-year waiting period" means the new member will only start to catch five years after the moratorium.

Table 4 shows the payoffs for the different players. In order to analyze the impact of the discount rate on the results, different rates are considered.

By comparing the payoffs of the "no waiting period" with those of "five-year waiting period," it can be concluded that the introduction of a "waiting period" increases the payoffs of the original members, and the rate of this increase rises with the discount rate. For example, with a 4% discount rate the payoff of the DWFN rises 20.7%. For a 20% discount rate, that increase is 70.1%. This indicates that this scheme may be relevant in the context of high discount rates.

Table 4
Payoffs of the Fishery—Waiting Period Scenario

	Discount Rate								
	4%			10%			20%		
	No Entry	0 Years	5 Years	No Entry	0 Years	5 Years	No Entry	0 Years	5 Years
EU	1,327.1	1,233.2	1,252.6	484.2	449.6	464.2	177.6	164.5	173.7
DWFN	503.3	251.7	303.7	185.5	92.7	131.9	70.1	35.1	59.7
OCS	589.2	508.1	524.9	215.0	185.2	197.8	78.8	67.5	75.4
NM	0	426.5	338.3	0	157.2	90.8	0	59.4	17.7
Total	2,419.5	2,419.5	2,419.5	884.7	884.7	884.7	326.5	326.5	326.5

Note: Values are in million USD.

In order to evaluate the impact of introducing a “waiting period,” in terms of the dynamic threat to the cooperative agreement, let us consider t = 0 and t = 6. For a 4% discount rate, table 5 presents the payoffs of the non-cooperative and cooperative scenarios (“no entry,” “no waiting period,” and a “five-year waiting period”).

Table 5 shows that from t = 0 to t = 6, there is a substantial increase in the payoffs of the non-cooperative scenario. As a result, the total gains from cooperation are reduced. At t = 0, new members with a 50% share of the longline quota do not pose a threat to the cooperative agreement. Thus, the impact of introducing a “five-year waiting period” is only to reduce the decrease of the payoff of the original members due to the entry of the new members. After the moratorium, the entry of new members with “no waiting period” makes it profitable for the DWFN to break the cooperative agreement. Introducing a “five-year waiting period” does not eliminate the incentive of the DWFN to break the agreement, and condition (1) remains effective. In this case, the waiting period does not solve the new member threat.

Fair Sharing Rule

The purpose of the following analysis is to evaluate the extent to which a sharing rule based on the bargaining strength of the players can eliminate the threat that new members pose to the cooperative agreement. In order to apply this approach to the bluefin tuna fishery, a typical concept of the fair sharing rule was selected: the Shapley

Table 5
Dynamic Threat—4% Discount Rate—Waiting Period Scenario

	$t = 0$				$t = 6$			
	Non-coop	No Entry	0 Years	5 Years	Non-coop	No Entry	0 Years	5 Years
EU	–8.8	1,327.1	1,233.2	1,252.6	832.8	1,674.4	1,556.0	1,579.6
DWFN	30.2	503.3	251.7	303.7	385.8	635.0	317.5	380.8
OCS	–3.0	589.2	508.1	524.9	410.3	743.3	641.1	661.5
NM	–	–	426.5	338.3	65.4	–	538.1	430.8
Total	18.4	2,419.5	2,419.5	2,419.5	1694.3	3,052.7	3,052.7	3,052.7

Note: Values are in million USD.

value. The analysis of this sharing rule is extended from the three original players (Duarte, Brasão and Pintassilgo 2000) to another aggregated player—the *NM*.[13]

Let us start by defining a c-game approach. Let (M, V^*) denote the c-game, where $V^*(K)$ is the value of coalition K that measures the increase in the Net Present Value (NPV) achievable with this coalition. This is equal to its own payoffs less the sum of the non-cooperative payoffs of its members (Mesterton-Gibbons 1992), and M is the set of all possible coalitions. Also, the normalized values are given by $V(K) = V^*(\mathrm{K})/V^*(K_g)$, where K_g represents the grand coalition made up of all the players.

The value of each coalition was determined through the use of the bioeconomic model. It was assumed that the members of the coalition optimize their strategy given that the others play non-cooperatively.

The optimal cooperative strategy of each coalition is defined as a non-constant TAC. The result for all the relevant coalitions is to declare an initial harvest moratorium followed by a catch of 40,000 MT thereafter. The values of all relevant coalition[14] are given in table 6.

Let the Shapley value be the allocation:

$$Z^S = (Z^S_{EU}, Z^S_{DWFN}, Z^S_{OCS}, Z^S_{NM})$$

where

$$Z^S_i = \sum_{K \subset M} \left[V(K) - V(K - \{i\}) \right] \frac{(k-1)!\,(m-k)!}{m!}$$

K defines all the coalitions to which player i belongs, M is the set of all possible coalitions, k denotes the number of elements in K, and m the total number of players. Also, $V(K - \{i\})$ defines the value of coalition K excluding player i. The Shapley values and the corresponding payoffs are shown in table 7.

Table 6

Coalition Values

Coalition	$V^*(K)$	$V(K)$
(EU,DWFN,OCS,NM)	2,401.1	1.00
(EU,DWFN,OCS)	1,072.8	0.45
(EU,DWFN,NM)	374.8	0.16
(EU,OCS,NM)	344.8	0.14
(DWFN,OCS,NM)	0.0	0.00
(EU,DWFN)	306.9	0.13
(EU,OCS)	279.3	0.12
(EU,NM)	104.9	0.04

Note: Payoff values are in 10^6 USD.

[13] All possible new members were aggregated into only one player (*NM*). It is assumed that *NM* when playing non-cooperatively, start with 10% of the longline effort of the base year. As the different prospective new members may not be able to coordinate their action, the Shapley value may overestimate the bargaining power of the new members. For the computation of the Shapley value with a large number of players, see Lindroos (1998).

[14] Relevant coalitions are those that generate positive net values, meaning that they have positive gains in cooperation.

From table 7 it can be seen that the Shapley value, reflecting the average contribution of each player in the set of possible coalitions, gives the highest share to the EU. The NM receives the smallest share (14.7%), as it has the least bargaining power. This is also reflected in table 6, by noting that if the NM plays non-cooperatively against the coalition formed by all the other players (EU, DWFN, OCS), the latter is still able to reach a coalition value of 0.45. The impact of non-cooperative behavior by any of the other players is clearly higher.

The adoption of a "fair sharing rule" guarantees that the final payoff is always higher than the non-cooperative one, meaning that condition (1) is never verified. Therefore, the cooperative agreement will not be threatened.

Concluding Remarks

This paper sets an economic approach to the new-member problem faced by regional fishery organizations in the management of straddling and highly migratory fish stocks. It establishes a condition under which the threat that the new members pose to the cooperative agreements can be verified for general bioeconomic dynamics and sharing rule settings.

The main solutions proposed in the fisheries literature for the new-member problem are discussed here; namely, the "transferable membership," "waiting period," and "fair sharing rule."

Regarding the "transferable membership," as the new member has to acquire the right to fish from the initial members, this solution will always preserve their payoffs, eliminating the threat of new members. If an ITQ system is used, it not only eliminates the free-rider incentives of prospective new members, but can also solve, in theory, other inefficiency problems. Nonetheless, it demands, in practice, a set of changes in the fishery, which may undermine its application in a complex social and global economic context. It also requires international quota trade, which is still not a common practice in world fisheries.

The introduction of a "waiting period" can be used to protect binding agreements, especially in the presence of high discount rates. Regarding agreements that are not binding through time, the new-member threat can be diminished if there are significant permanent costs of being part of the cooperative agreement.

From the analysis of the implementation of a fair sharing rule, it is concluded that this solution is effective to protect the cooperative agreements, in the context of a small number of players.

The application of the analysis to the bluefin tuna fishery case study shows that, at present, the threat of the new members is not sufficient for the breakdown of the cooperative agreement. This is due to the very low level of the stock, which makes non-cooperation a low-payoff strategy. As the optimal cooperative strategy calls for

Table 7
Shapley Value and Players' Payoffs

	EU	DWFN	OCS	NM	Total
Z_i^S	33.6%	26.2%	25.6%	14.7%	100%
Dist. Gains – $Z_i^S * V(K_g)$ – (1)	807.2	628.3	613.7	351.9	2,401.1
NPV- Non-cooperation (2)	–8.8	30.2	–3.0	0.0	18.4
Final payoff (2)+(1)	798.4	658.5	610.7	351.9	2,419.5

Note: Payoff values are in million USD.

an initial harvest moratorium, the threat becomes progressively more relevant, showing that this is a dynamic problem, which is aggravated in the long run.

Simulating the solutions for this case study show that both the "transferable membership" and the "fair sharing rule" solutions solve the potential new member threat. In addition, an unrestricted ITQ system will not only solve the new-member problem, but also change the gear composition to one that yields a higher payoff and is also more favorable in terms of stock preservation.

The main conclusion of this paper is that the new member can create a threat to the cooperative management of the straddling and highly migratory fish stocks. The solution scheme should be selected according to the specific nature of the fishery. The ITQ system, despite some possible problems, is generally the most efficient solution.

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Appendix

The Model Equations

Biological Submodel

Population numbers

$$N_{j,0,a} = \tilde{N}_{j,a} \quad \text{for } 1 \le a \le A \tag{1}$$

$$N_{j,t,0} = SRR_j(SSB_{j,t-2}) \tag{2}$$

$$N_{j,t,a} = N_{j,t-1,a-1} e^{-M_{j,a-1} - F_{j,t-1,a-1}} \quad \text{for } \; a = 1, 2, ..., 9; \; t = 1,2,... \tag{3}$$

$$N_{j,t,A} = N_{j,t-1,9} e^{-M_{j,9} - F_{j,t-1,9}} + N_{j,t-1,A} e^{-M_{j,A} - F_{j,t-1,A}} \tag{4}$$

$$SSB_{j,t} = \sum_{a=1}^{A} Mat_{j,t,a} N_{j,t,a} W_{j,t,a} \tag{5}$$

$$B_{j,t} = \sum_{a=1}^{A} N_{j,t,a} W_{j,t,a} \tag{6}$$

Catch at age by gear

$$F_{j,t,a,s} = FMax_{j,t,s}.Sel_{j,a,s} \tag{7}$$

$$F_{j,t,a} = \sum_{s=1}^{S} FMax_{j,t,s}.Sel_{j,a,s} \tag{8}$$

$$CN_{j,t,a,s} = \frac{F_{j,t,a,s}.N_{j,t,a}}{\sum_{s=1}^{S}(F_{j,t,a,s} + M_{j,a})}\left(1 - e^{-\sum_{s=1}^{S}(F_{j,t,a,s}+M_{j,a})}\right) \tag{9}$$

$$CB_{j,t,s} = \sum_{a=1}^{A} CN_{j,t,a,s}.W_{j,a} \tag{10}$$

$$C_{j,t,s} = \sum_{a=1}^{A} \frac{FMax_{j,t,s}.Sel_{j,a,s}.N_{j,t,a}.W_{j,t,a}}{\sum_{s=1}^{S}(FMax_{j,t,s}.Sel_{j,a,s} + M_{j,a})}\left(1 - e^{-\sum_{s=1}^{S}(FMax_{j,t,s}.Sel_{j,a,s}+M_{j,a})}\right) \tag{11}$$

for $s = 1,\ldots, S$

Harvest Function

$$C_{p,j,t,s} = q_{j,s}\, E_{p,j,t,s}\, B_{j,t}^{\alpha_s} \tag{12}$$

$$C_{p,j,0,s} = sh_{p,j,0,s} * C_{j,0,s} \tag{13}$$

$$E_{p,j,0,s} = sh_{p,j,0,s} * E_{j,0,s} \tag{14}$$

Economic Submodel

$$\mathrm{Rev}_{p,j,t,s} = \overline{P}_{j,s} * C_{p,j,t,s} \tag{15}$$

$$Cost_{p,j,t,s} = wg_{j,s} * E_{p,j,t,s} + \gamma_{j,s}(\overline{P}_{j,s} * C_{p,j,t,s}) \tag{16}$$

$$\Pi_{p,j,t,s} = \mathrm{Rev}_{p,j,t,s} - Cost_{p,j,t,s} \tag{17}$$

$$TNPV_j = \sum_{p} \sum_{s=1}^{S} \sum_{t=1}^{25} \Pi_{j,t,s} * \left(\frac{1}{1+r}\right)^t \tag{18}$$

Open-access Dynamics

$$E_{p,j,t,s} = \begin{cases} (1-\beta_{j,s})E_{p,j,t-1,s} & \text{if } \Pi_{\mathrm{p,j,t\text{-}1,s}} \leq -\Pi b_{j,s} \\ E_{p,j,s,t-1} & \text{if } -\Pi b_{\mathrm{j,s}} \leq \Pi_{\mathrm{p,j,t\text{-}1,s}} \leq \Pi b_{j,s} \\ (1+\beta_{j,s})E_{p,j,t-1,s} & \text{if } \Pi_{\mathrm{p,j,t\text{-}1,s}} \geq \Pi b_{j,s} \end{cases} \tag{19}$$

Exit Condition

$$Cost_{p,j,t-1,s} > (1 + h_{j,s}) * \mathrm{Rev}_{p,j,t-1,s} \tag{20}$$

Table A.1
Glossary of Symbols

Variables		Coefficients	
N	No. of Fish (Beginning of Year)	M	Instantaneous Natural Mortality
$\tilde{N}$	Estimated No. Fish (Beginning of 1995)	Mat	Maturity Rate
SRR	Stock Recruitment Relation	W	Average Weight
SSB	Spawning Stock Biomass	q	Production Function Parameter
F	Instantaneous Fishing Mortality	α	Catch-Stock Elasticity
$FMax$	Fishing Mort. at Maximum Selectivity	wg	Costs Parameter
B	Total Biomass	γ	Crew Share
Sel	Selectivity	r	Interest Rate
CN	Catch Numbers	β	Effort Adjustment Parameter
CB	Catch Biomass	Π_b	Profit Bound
E	Effort	h	Exit Condition Parameter
C	Catch		
Rev	Revenue	Indices	
Cost	Cost		
$\overline{P}$	Average Price	p	Player (EU, OCS, DWFN, …)
Π	Profit	j	Stock (j = East Atl., West Atl.)
$TNPV$	Total Net Present Value	t	Time ($t = 1,\ldots,T$), T = 25 (2020)
		a	Age ($a = 1,\ldots,9,A$), A = 10+
		s	Gear ($s = 1,2,\ldots,S$)