Discussion Paper

On the Management of Shared Fish Stocks

by

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Introduction

The Government of Norway, in cooperation with FAO, is to hold an Expert Consultation on the management of shared fishery resources. The Consultation is being convened in recognition of the fact that the management of these resources stands as one of the great challenges on the way towards achieving long-term sustainable fisheries. The objective of the Expert Consultation is to assist countries in improving their efficiency and performance in meeting this challenge.

This paper is designed to serve as one of several background document for the Expert Consultation. As such, it will attempt to perform two tasks. First it will review definitions, legal and otherwise, of shared stocks and attempt to outline the scope and magnitude of the relevant resource management issues, on a worldwide basis.

The Concept Paper for the Expert Consultation, refers to the academic, or theoretical, aspects of the management of shared fishery resources, and, in so doing, states that these aspects should serve as a background for the Expert Consultation. The second task of this paper, then, will be to review these academic aspects in a non-technical manner, and go on to illustrate key points arising from the academic analysis, by drawing upon brief case studies from the real world. It is anticipated that all of the case studies drawn upon in the paper will be discussed in detail during the Expert Consultation.

Shared Fish Stocks: An Overview

Some Definitions

The term "shared fish stocks" is understood, by the FAO and others, to include the following:

(a) fish resources crossing the EEZ boundary of one coastal State into the EEZ(s) of one, or more, other coastal States – transboundary stocks

(b) highly migratory fish stocks, which, due to their highly migratory nature, are to be found, both within the coastal State EEZ and the adjacent high seas

(c) all other fish stocks (with the exception of anadromous/catadromous stocks) that are to be found, both within the coastal State EEZ and the adjacent high seas – straddling stocks

(d) fish stocks to be found exclusively in the high seas

Clearly, these categories are not mutually exclusive. One can find many examples of fish stocks that fall into category (b), or category (c), which also fall into category (a). Be that as it may, it is the express intention of the Norway-FAO Expert Consultation on the Management of Shared Fish Stocks to focus its attention on categories (a) and (c) stocks, that is to say, on transboundary and straddling stocks.

John Caddy (1997) provides a definition of transboundary stocks,which, with minor modficiation,can be extended to cover straddling stocks. The modified Caddy definition is as follows:

a group of commercially exploitable organisms, distributed over, or migrating across, the maritime boundary between two or more national jurisdictions, or the martime boundary of a national jursiduction and the adjacent high seas,whose exploitation can only be managed effectively by cooperation between the States concerned ----

Not all would agree with Caddy, by the way, that these resources can only be managed effectively by the relevant States agreeing to cooperate. Indeed, this is one of the key issues to be discussed.

Having said this, the participants in the UN Third Conference on the Law of the Sea certainly took the view that cooperation was required for the management of such resources, as evidenced by the UN Convention on the Law of the Sea, arising from the Conference (1982 UN Convention, hereafter) (UN, 1982). Relevant States are admonished to so cooperate in Article 63(1), and Article 63(2) of the Convention. Article 63(1), the transboundary stocks paragraph, reads as follows:

> *Where the same stock or stocks of associated species occur within the exclusive economic zones of two or more coastal States, these States shall seek, either directly or through appropriate subregional or regional organizations, to agree upon measures necessary to co-ordinate and ensure the conservation and development of such stocks without prejudice to other provisions of this Part,*

while Article 63(2), the straddling stocks paragraph, is as follows (UN, 1982):

> *Where the same stock or stocks of associated species occur both within the exclusive economic zone and in an area beyond and adjacent to the zone, the coastal State and the States fishing for such stocks in the adjacent area shall seek, either directly or through appropriate subregional or regional organizations, to agree upon measures necessary for the conservation of these stocks in the adjacent ar*ea.

At the close of the UN Third Conference on the Law of the Sea, there was a clear recognition that, under Extended Fisheries Jurisdiction, transboundary fish stocks would present major resource manageme nt problems. It was not expected that straddling fish stocks would be a source of serious management problems, if for no other reason than that only 10 per cent of the commercially exploitable marine capture fishery resources were to be found in the remaining high seas (or so it was believed) (Munro, 2000). The experience of the second half of the 1980s, and the early 1990s, was to demonstrate that this sanguine view of straddling fish stocks was quite simply wrong.

Some Characteristics of Transboundary and Straddling Fish Stocks

One of the earliest analyses of the problems of management of shared fishery resources was that prepared by John Gulland (1980). In his article, Gulland focusses on transboundary fishery resources, because of their then apparent importance. His analysis can, however, be readily extended to straddling fish stocks.

In any event, Gulland presents a biological/geographical categorization of transboundary fish stocks, which is useful in setting the stage for the discussion of the problems of managing the resources. He makes the following distinctions:

I. stocks occurring within two or more EEZs, but showing no clear migratory pattern

II. stocks occurring within two or more EEZs, and displaying a clear pattern of movement:
1) resulting from seasonal migration
2) according to development stages

Change *stocks occurring within two or more EEZs,* in I and II, to *stocks occuring within the EEZ and the adjacent high seas*, and one has a description of straddling fish stocks.

In the case of (I), Gulland contends, it is not always clear that exploitation on one side of the relevant boundary will necessarily have a significant impact upon harvesting opportunities on the other side of the boundary. Munro (1987) provides such an example in the form of the rich Georges Bank scallop fishery, shared by Canada and the United States. The resource was, and is, clearly a transboundary fish stock. It was, however, questionable whether Canadian (American) harvesting of scallops would have any significant impact upon American (Canadian) harvesting opportunities. Adult scallops are more or less stationary. Moreover, while there is some transboundary movement at the larval stage, there were, in 1987, extensive beds of larvae producing scallops, which were free from exploitation due to the sea bed terrain.

These facts led to the argument that, since Americans and Canadians could harvest the resource with out affecting one another's harvest opportunities, cooperative fisheries management of this shared resource was beside the point (Munro, 1987). Whether the situation, which prevailed in 1987, continues to prevail today is not known to this writer. Nonetheless, the point remains, and leads to our first conclusion, namely that cooperative fisheries management of a "shared" fishery resource is not, in all cases, necessarily required, or desirable. The conclusion is reinforced by the fact that establishing a cooperative fisheries management regime is not a costless undertaking. If the net benefits from cooperation are negative, then obviously the case for cooperation collapses.

Levels of Cooperation in Resource Management

Suppose now that the harvesting activities of one state sharing a fishery resource do impinge significantly upon the harvesting opportunities of the one, or more, other states sharing the resource, so that a *prima facie* case for cooperation does, in fact, exist. The question, which then arises, is the appropriate level of cooperation. There are, as Gulland points out, at least two levels of cooperation (Gulland, 1980). The first level, or what we might term the primary level, consists of cooperation in research alone, without reference to coordinated management programs. Since all parties should stand to benefit from improved information and data, the cooperation should be relatively easy to achieve. The emphasis is on the word relative, however. It is still possible that one or more parties may suspect that research information, which it shares, will serve to benefit its rival exploiters of the resource, at its own expense.

In any event, if it is not possible to achieve cooperation at this primary level, it certainly will not be possible to achieve cooperation in active management of the resource. In actual cooperative management regimes, which have proven to be successful, cooperation in research alone is often seen, in retrospect, to have been the precursor to cooperation in active management.

What we might call secondary cooperation - "active management" - involves, almost by definition, the establishment of coordinated joint management programs.
As Gulland (1980) informs us, this will require:

(a) determination of an optimal management strategy through time, including, *inter alia*, the determination of optimal global harvests over time
(b) allocation of harvest shares among the participating participating states (or entities)
(c) implementation and enforcement of coordinated management agreements.

Obviously, this is a much more formidable undertaking than the primary level of cooperation. To begin, even cooperation in research may lose its benign character. Research findings can influence harvest allocations, and thus can, as will be pointed out in case studies to follow, easily become "tools of combat" in negotiations between and among relevant states.

For a second example, consider (a). There is no assurance that the relevant states will have identical resource management goals. The FAO recognized this fact, as early as 1979, with reference to transboundary stocks, through its Advisory Committee on Marine Research (FAO, 1979). The Committee pointed out that, if two coastal states share a fishery resource, one might favour low long run TACs, but a large stock and high catch rates, while the other might favour high long run TACs, and accept with good grace low catch rates. If management goals are not identical, then one is faced with the burden of developing a mutually acceptable compromise resource management program, or so it would seem (FAO, *ibid*.).

Thus, establishing cooperative management at the secondary level can prove to be frustrating and costly. One can add that the anticipated cost might be not only be in monetary form, but may also appear, as far as coastal states are concerned, in the form of perceived loss of sovereignty. If, what we might call the gross benefits from cooperative management, appear not to be substantial, the relevant states may conclude, to use an old English expression, that "the game is not worth the candle".

Each relevant state could conclude that the aforementioned gross benefits of cooperation are not substantial by taking that view that, if it, and its fellow states sharing the resource, manage their respective segments of the resource in a rational manner, the overall resource management results, while not being ideal, will be adequate. One of the central questions to be addressed in the discussion of the analytical aspects of this resource management issue, is whether or not this comfortable view of the world is, in fact, reasonable.

The Significance of Shared Fish Stocks in World Capture Fisheries

Difficulties of achieving effective cooperation in resource management to one side, the significance of the issue of cooperative management of shared fishery resources is dependent ultimately upon the importance of shared fishery resources in terms of world fisheries. The most complete investigation of this question is to be found in Caddy (1997). Caddy's investigations, it must be noted in passing, are confined to transboundary fish stocks .

Caddy first observes that he pointed out in 1982, as the world EEZ regime was emerging, that a significant proportion of fishery resources then being encompassed by EEZs would be found to be shared with other coastal States. He subsequently proceeds, with the aid of the Geographical Information System database, to estimate the number of contiguous EEZ maritime boundaries. Then, making a very conservative estimate of the number of fishery resources crossing these boundaries on average, he comes forth with an estimate of 1,000 to 1,500 transboundary fishery resources. The number is large indeed. He then maintains that the number of such resources under effective cooperative resource management regimes is very modest, in relation to the global total (Caddy, 1997). We can only guess at the number of additional stocks that have to be included, once straddling fish stocks are taken into account.

If it is in fact the case that cooperative management is important for the long term sustainability of most of these resources, then the Caddy analysis forces us to the following conclusions. First, the scope for improved management of shared fishery resources is immense. Secondly, potential significance of such an improvement to world fisheries is very high indeed.

A Review of the Basic Economics of the Management of Transboundary Fish Stocks

The economics of the management of shared fish stocks has been developed in two stages. The first stage, which dates back to the late 1970s (Munro, 1979), has consisted of developing the economics of the management of transboundary fish stocks. This is a reflection of the fact that, at the dawn of Extended Fisheries Jurisdiction, the management of transboundary fish stocks was recognized as being an important problem, while the management of straddling fish stocks was not.

It is also a reflection of the fact that the management of transboundary fish stocks is considerably less complex than is the management of straddling fish stocks. In the case of transboundary fish stocks, in contrast to straddling fish stocks, the states involved are, with few exceptions, fixed through time, and the shared, or joint, property rights to the relevant resources are reasonably straightforward (McRae and Munro, 1989). Furthermore, the number of states involved is usually relatively small. In the economic analysis of the management of these resources, one can often make do with models consisting of just two countries.

The second stage, consisting of the development of the economics of the management of straddling (and highly migratory) fish stocks, dates back only to the early 1990s (Kaitala and Munro, 1993). In the second stage, the economics of the management of transboundary fish stocks is used as a foundation. The question is then asked what modifications to, and what extensions of, the analysis are required, in light of the special problems arising from, and issues raised by, the management of straddling fish stocks. The question has by no means been fully answered at the time of writing. The second stage is thus very much a "work in progress".

We commence then, with a review of the basic economics of the management of transboundary fish stocks. In the section to follow, we shall review the economics, as it now stands, of the management of straddling fish stocks.

The basic economics of the management of transboundary fish stocks, which is now reasonably well developed, has moved well beyond the realm of academic economists. It is finding its way into official publications, as exemplified by the 1997 OECD publication, *Towards Sustainable Fisheries* (OECD, 1997), and the study, *Managing Transboundary Stocks of Small Pelagic Fish*, prepared by M. Agüero and E. Gonzalez for the World Bank (Agüero and Gonzalez, 1996). It is also being discussed by specialists in fisheries, from disciplines other than economics. The 1997 paper by John Caddy (Caddy, 1997), which has been, and will be, cited extensively, provides a case in point.

The economic model, which is used in the analysis of the management of transboundary fishery resources, is a blend, consisting of two components. The first component consists of the now standard bioeconomic model used for the analysis of fisheries confined to waters of a single coastal State (see, for example: Clark, 1990; OECD, 1997). The second component consists of the theory of games. The reason for incorporating game theory into the analysis is the realization that, without game theory, the analysis of the economics of shared fish stock management degenerates into incomprehensibility.

On the assumption that most readers are not familiar with the theory of games, we turn now to a review of the essentials of the theory.

The Theory of Games: A Brief Overview

The theory of games is designed to analyze strategic interaction between and among individuals", be the individuals" persons, firms, nations or others. The theory of games is relevant when the actions of one "individual" has a clearly perceived impact upon other "individuals", thereby inviting a reaction from these other "individuals". One field of economics, where game theory has come to play a major role, is Industrial Organization, which is generally devoted to the study of industries dominated by a few large firms. Let the airline industry serve as an example. The fare structure, and other policies, implemented by a major airline, such as SAS, is bound to have an impact upon rival airlines. The rivals can be expected to react. SAS will, of course, anticipate such reactions, and will factor these expected reactions into its planning.

Industrial Organization is only one of numerous fields, in which one can anticipate interactions between and among "individuals". Many fields of economics are influenced by game theory, as now are many areas outside of economics, such as international relations and legal studies. The use of game theory is also to be found in some natural sciences. Game theory does, for example, play a major role in evolutionary biology.

Cooperative resource management between, or among, coastal States sharing a fishery resource becomes worthy of consideration, we have now argued, if the harvesting activities of one coastal state has a significant impact upon the harvesting opportunities open to the other state(s) sharing the resource. If this condition is met, then strategic interaction between "individuals", in the form of states sharing the resource, becomes virtually inescapable. It is for this reason that it was very difficult to make significant progress in developing the economics of the management of transboundary fishery resources, until the analytical tools provided by the theory of games were brought to bear.

Perhaps the greatest drawback, from which the theory of games suffers, is its very name. It creates the impression that the theory is frivolous. It is not. In recognition of the theory's rapidly growing application, the 1994 Nobel Prize in Economics was awarded to a trio of game theorists, one of whom, John Nash, can be seen as the founder of modern game theory, as applied to economics. In commenting on the award, *The Economist* (October 15, 1994), argued that, whereas up to the early 1970s, game theory was seen as an esoteric specialty, now no one hoping for a respectable degree in economics can expect to receive the degree, without an understanding of at least the rudiments of game theory. In the same article, *The Economist* maintained that the time is coming when game theory will be commonplace among MBA students, as well.

In the terminology of game theory, the "individuals" are referred to as "players". The "players" are assumed to be rational and to have various courses of action open to them, which are referred to as "strategies". The expected return to a player, in following a particular strategy, is then referred to as a "payoff". The size of the expected return or "payoff" will, needless to say, be dependent upon the expected reactions of other "players". The interaction between, or among, the players, as they execute their strategies, is the game. The stable outcome of a game, if it exists, is termed the "solution" to the game. Finally the game may be a "once only" affair, or it may be repeated.

There are two broad categories of games, these being competitive, or non-cooperative, games, and cooperative games. In a cooperative game, the players are assumed to be motivated entirely by self interest, but have some incentive to endeavour to cooperate. Of critical importance is the fact that players are able to communicate with one another effectively. In competitive, non-cooperative, games, the lines of communication between and among the players are faulty, or are simply non-existent.

In analyzing the economics of the management of shared fishery resources, economists have asked themselves two fundamental questions, with the first one being: what are the consequences of coastal states sharing a fishery resource refusing to cooperate in the management of the resource? The implication is that, in the absence of cooperation, each coastal state will simply go its own way and manage its segment of the resource as best it can. If the answer to the question is that the negative consequences of non-cooperation are trivial, then one need proceed no further.

If, on the other hand, the answer to the question is that the negative consequences of non-cooperation are severe, then cooperation does matter and the second fundamental question must be asked. The second question is what requirements must be met for a cooperative resource management regime to be stable and sustainable over the long run? It might be mentioned, in passing, that the second question raises the issue of equity. Cooperative management regimes that are perceived by one or more players as being inequitable are, by definition, unstable.

Non-cooperative Management of a Shared Fishery Resource

The first question, that of the consequences of non-cooperative management of a shared fishery resource, is addressed, not surprisingly, by bringing to bear the theory of non-competitive games. Consider a two "player" (coastal state) game. Those who have investigated the question usually assume that each of the two players has full and effective resource management powers within it own waters, although we shall want to comment on this at a later point.

A stable solution to a non-cooperative game was defined by John Nash (1951) as situation in which each player has no incentive to change, given the strategies being followed by the other player. Two independent investigations of the non-cooperative fisheries game were published in 1980 (Clark, 1980;Levhari and Mirman, 1980). Both came to the same conclusion. A stable solution to the game would involve, except in unusual circumstances, mismanagement of the resource from society's point of view. Clark (1980) argues that, if the players are symmetric, i.e. identical in all respects, the outcome will be similar to the that encountered in an unrestricted open access domestic fishery, referred to in the economics literature as Bionomic Equilbrium (Gordon, 1954). Bionomic Equilibrium is characterized by overexploitation of the resource, from society’s point of view, and by fleet capacity far in excess of that which would be required, if the resource were exploited optimally.The overall outcome to the game is an example of what is probably the most famous of all non-cooperative games, known as the "Prisoner's Dilemma".

The point of the "Prisoner's Dilemma" game is that the players in the non-cooperative game will be driven to adopt strategies, which each recognizes as being undesirable. The name comes from a story told by the author of the game to illustrate the point (Tucker, 1950). Two men are arrested on suspicion of having committed a major theft. The suspicions are, in fact, entirely valid. The two suspects, A and B, are kept separated from one another. A is interviewed by the chief prosecutor, who admits that the evidence, which he has, is limited. A is told that, if both he and B plead not guilty, they can each expect to receive a six month sentence on a lesser charge. If both A and B plead guilty, they will each receive a five year sentence. If A pleads guilty, but B pleads not guilty, A will be released for having assisted the prosecution. If A pleads not guilty, but B pleads guilty, then it will go very hard with A, and A will get ten years. The chief prosecutor then holds exactly the same interview with B.

A and B are the players. Each player has two alternative strategies: to plead guilty, or to plead not guilty. If A and B could communicate, and enter into a binding agreement, they would both plead not guilty, and would look forward to being out of prison in six months time. They cannot communicate, however. The best strategy for A, regardless of which of the two strategies B might choose, is to plead guilty. What is true for A is true for B. Hence, both plead guilty and end up with the decidedly inferior outcome of serving five year sentences[i].

Now let us apply the concept of the "Prisoner's Dilemma", to a somewhat different fisheries situation. Let A and B be two "symmetric" coastal states sharing a resource, neither of which had, in the past, engaged in serious management of the resource. The resource is, consequently, overexploited, at the common Bioenomic Equilibrium level, a fact, which is recognized by both A and B. A and B are now exhorted by an outside international body to undertake meaningful management of their respective portions of the resource. There is, however, no thought of cooperation between A and B.

Consider A, which has two "strategies" before it: undertake the cost of management, or do nothing. Suppose that A does undertakes the cost of a serious management program, and that the resource, for a time, rises above the Bionomic Equilbrium level. In the absence of cooperation, the outcome is not stable, and the resource will be driven back down to where it started. B would have the pleasure of enjoying some temporary benefits from A's management efforts, at no cost to B. We would refer to B, in these circumstances, as a "free rider". For A, undertaking the cost of management, is, at best, an exercise in futility. If A does nothing, and if B is foolish enough to engage in resource management, A will enjoy the rewards of being a "free rider". Obviously A's best strategy will be to do nothing. B is faced with the same set of strategies. What holds true for A, holds true for B. Thus we can predict that A and B will do nothing, while continuing to recognize the consequences of the absence of effective management.

The predictive power of the theory, with respect to transboundary fisheries, is high. One example, to which reference will be made in the brief case studies, is that of Pacific salmon shared by the United States and Canada. The two countries signed a treaty to manage the resource cooperatively in 1985 (Treaty, 1985).

Both countries have a highly developed capacity for fisheries management systems. Nonetheless, there was a constant threat of the outbreak of damaging "fish wars" prior to the signing of the treaty. Furthermore, it was recognized that both countries had opportunities to enhance the size and strength of the stocks produced in their salmon rivers, through various enhancement projects. Each country held back on initiating such projects, for fear that the other would "free ride" (Munro and Stokes, 1989). Indeed, it was the combined threat of "fish wars" and the continued blocking of enhancement projects, which served as a prod to drive the negotiators on, until they finally achieved (temporary)success.

The Treaty, while initially successful, encountered difficulties in the early 1990s, and came close to foundering. The two countries reverted to destructive competitive behaviour; the "Prisoner's Dilemma" returned with a vengeance. The two sides, eventually "patched up" the treaty by signing an Agreement in 1999. While the Agreement has many critics, even the severest critics, with the thought of "fish wars" in mind, concede that an agreement, however flawed, is better than no agreement at all (Miller, Munro, McDorman, McKelvey and Tyedmers, 2001).

The implication of the analysis is straightforward. Even if coastal States sharing a resource have the capability of managing effectively fishery resources within their domestic waters, one has no justification in assuming that, in the absence of cooperation, the resource management outcome will be "adequate". The risk exists that the outcome will be disastrous. Other than in exceptional cases, cooperation does matter, and is, moreover, to be seen as a prerequisite for effective management, and not merely as a useful supplement to resource management by individual states.

Consider the following example. The FAO has in place an International Plan of Action for the Management of Fishing Capacity (FAO, 1999). The IPOA - Capacity does, *inter alia*, talk about the importance of addressing the problem of excess fleet capacity in the management of shared stocks (FAO, *ibid*., p.2) . One can be confident that, if shared stocks plagued by excess fleet capacity are managed non-cooperatively, the excess capacity problem will continue indefinitely, IPOA or no IPOA

Cooperative Management of Transboundary Fish Stocks: Some Preliminaries

In examining cooperative management of shared fishery resources, one brings to bear, not surprisingly, the theory of cooperative games. Moreover, just as reference was made to Nobel Laureate John Nash's theory of non-cooperative games, so extensive reference will be made to John Nash's theory of cooperative games (Nash, 1953).

The theory of cooperative games is to be seen, first and foremost, as a theory of bargaining. It is, to repeat, assumed that each player is motivated by self interest alone. If the players agree to cooperate, it is because each is convinced that it can gain more from cooperation, than it can by engaging in competitive behaviour.

In cooperative games, numbers are important. Once the number of players exceeds two, the analysis becomes much more complex. One has to allow for the possibility of sub-coalitions forming among the players, and acknowledge the fact that the greater are the number of players, the more difficult it is to achieve a stable solution to the game. For the discussion to follow on transboundary stocks, we can safely restrict ourselves to the more tractable two player games. When we come to discuss the management of straddling stocks, however, we shall be have no choice but to deal head on with games having more than two players, and the complications arising therefrom.

Next, one has to be concerned with whether a cooperative agreement, if it reached, is, or is not, binding. Obviously binding agreements present fewer problems than non-binding ones. Agreements in treaty form can, according to legal experts, be thought of as binding (Owen, 2001). Experience, however, gives us the warning that even agreements in treaty form may be less than fully binding over time.

In the Overview of Shared Fish Stocks section, it was noted that FAO recognized, well before the conclusion of the UN Third Conference on the Law of the Sea, that there is no necessary reason why the states, sharing a fishery resource, should have the same management goals. Hence, the next question is whether those states sharing the resource do, or do not, have identical management goals. If the states are identical, and thus have identical management goals, they are said to “symmetric”. If the states are symmetric, then the theory tells us that the states will attempt to institute a resource management program, which will maximize the global economic returns from the fishery over time, and will then bargain over the division of the returns. If management goals differ, then the added problem has to be faced of developing a compromise resource management program.

Finally, in this list of preliminaries, is the question of so call "side payments". A side payment, in its simplest form, is a type of transfer, which may be either monetary or non-monetary in nature. We shall define, for our purposes, a fisheries cooperative game, without side payments, as one in which one coastal state's return from the shared fishery is determined solely by the harvests of its fleet(s) within it own waters. The importance of side payments, although practitioners will seldom use this term, has become increasingly recognized over the past few years (see: Caddy, 1997). It will be seen that one role that side payments can play is that of helping to resolve the problem, which arises when the relevant coastal states have differing management goals.

Conditions for Stable Cooperative Arrangements: Two Players

There are two basic conditions, which must be met, if there is to be a stable solution to the cooperative game. Both are straightforward, and seem entirely compatible with common sense. The first requires some additional economist's jargon. The early 20th Century Italian economist, Wilfred Pareto, put forth the proposition that in trade, or other dealings between, and among, individuals, the outcome was certain to be less than optimal, if it were possible by a rearrangement of the dealings to make one individual better off, without making the other individual(s) worse off. This gave rise to the concept of "Pareto Optimality", which means that a stage, or situation, has been reached in which it is not possible to make one individual better off, except at the expense of the other individual(s).

The first requirement for a stable solution to the two player cooperative game is that it be "Pareto Optimal". Suppose that the cooperative game consists of two players, coastal states, I and II, and that the "solution" to the cooperative game consists of an agreed upon cooperative resource management regime. If changes could be made to the cooperative management regime that would make both I and II better off, then the "solution" to the cooperative game can hardly be regarded as stable. Once the two states realized that, by altering the cooperative management regime, both would be made better off, the two would, if rational, do just that. What could be more straightforward?

The second requirement for a stable solution to the cooperative game has equal appeal to common sense, although one has no difficulty of finding examples in the real world where this common sense requirement is ignored. This requirement is sometimes referred to as satisfying the Individual Rationality Constraint. It states that a solution to the cooperative game will not be stable, unless the payoffs arising from the solution make each and every player at least as well off as it would be under conditions of non-cooperation.

Those potential solutions to the cooperative game, which satisfy both requirements, are said to constitute the "core" of the game. This immediately raises the question as to whether one can always be certain that such a "core" exists. The answer is no, the "core" can be empty. If that is the case, then there are no solutions, which will satisfy both requirements. Attempts to establish cooperation will prove to be futile, and the players will revert to competitive, non-cooperative, behaviour, with all that that implies.

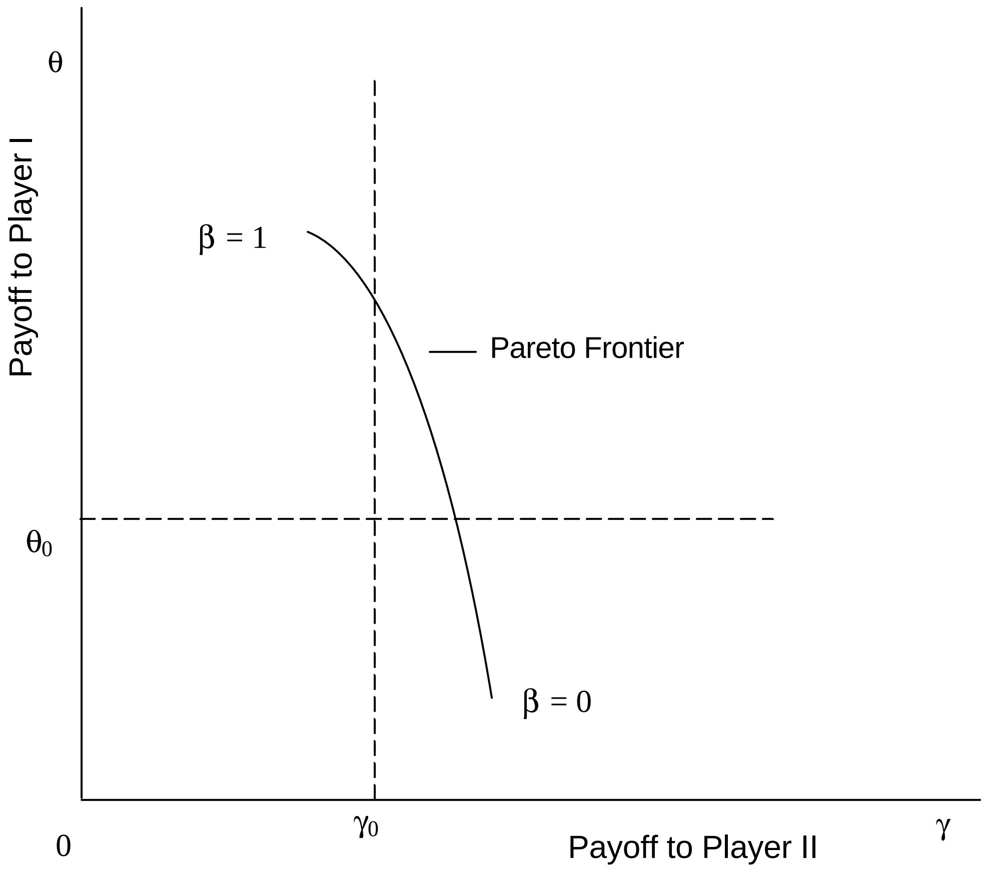
We turn now to a widely used figure illustrating the conditions necessary for a stable solution to the cooperative game. The figure appears in the aforementioned 1997 OECD publication, 1996 World Bank publication, and appears, as well, in the 1997 paper by John Caddy (Agüero and Gonzalez, 1996; Caddy, 1997; OECD, 1997).

The figure is meant to represent a two player, (two coastal states I and II), cooperative fisheries game. The axes show the "payoffs" to the two respective players. A given payoff to player I measures the stream of economic returns through time to player I, arising from given resource management program. Correspondingly, a given payoff to player II measures the stream of economic returns to that player from a given resource management program.

It is assumed, in this example, that: <u>i</u> the two players are not symmetric, they do not have identical management goals; <u>ii</u> if a cooperative arrangement is achieved, it will be binding; and <u>iii</u> there is <u>no</u> allowance for side payments.

The solid curve represents the Pareto Frontier, in that it shows the payoffs from cooperative management regimes, in which it is not possible to make I better of, except at the expense of II, and vice versa. If we commence at the top of the curve at $\beta = 1$, we would have a cooperative management program that would maximize the benefits from the fishery to player I. As we move down the curve, player II would become successively better off, but only at the expense of player I. By way of contrast, if we were at *any* point below the Pareto Frontier, both players I and II could be made better off by adjusting the cooperative resource management program.

Figure 1. A Cooperative Game Without Side Payments



The parameter β, to which we have referred, is, in fact, a bargaining parameter, $0\leq \beta \leq 1$. If $\beta = 1$, then the management preferences of I are wholly dominant, while the management preferences of II count for nothing. If $\beta = 0$, the reverse is true.

The payoffs, θ_0 and $\gamma_{0,}$ are the payoffs, which I and II would enjoy respectively, if there was no cooperation. They might be thought of as the payoffs associated with the solution to a non-cooperative game. John Nash referred to this set of payoffs as the "Threat Point", as they represent the *minimum* payoffs, which each of the two players must receive for the solution to a cooperative game to be stable (Nash, 1953).

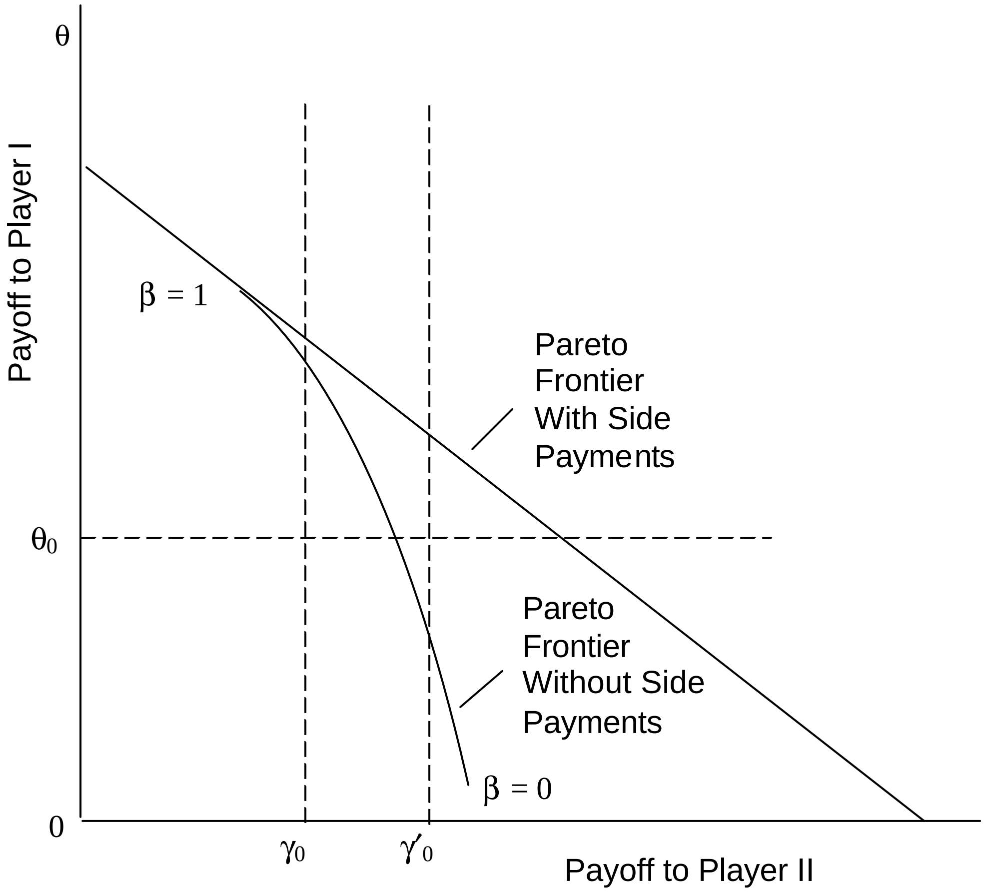
That part of the Pareto Frontier segmented by the dashed lines emanating from the Threat Point payoffs represents the "core" of the game. In the example shown, the "core" is positive, so that a stable solution can be achieved. We shall not discuss the theory underlying the determination of the ultimate solution (see: Nash, 1953). It will only be noted that a unique solution does exist, and that, in this example, the management preferences of both players will play a role, i.e. the solution β lies between 1 and 0. A solution, in which the management preferences of either player are wholly dominant, is not feasible. If, for example, the solution to the game was such that $\beta = 1$, the "solution", the cooperative agreement, could not last, since player II would be worse off than it would be, had it refused to cooperate.

Turn now to Figure 2. In this figure, allowance is made for the possibility of side payments.

When side payments (transfers) are allowed, a particular player's returns from the fishery are not dependent wholly upon its fleets harvest of the resource within its own waters. The Pareto Frontier in this case becomes a 45^0 line, which is tangent to the Pareto Frontier Without Side Payments, at the latter's highest point. The significance of the 45^0 line is that, at any point on the line, the sum of I and II's solution payoffs is equal to the sum of those payoffs at any other point on the line. The implication of all of this is that the players seek to maximize the global returns from the fishery, without regard for differences in management objectives. Bargaining then takes place over the division of the global returns.

It is at this point that a key question must be raised, the question being what benefits from the fishery are in fact being divided between the coastal states sharing the resource. Is it harvested fish per se, or is it the economic (and perhaps social) benefits arising from the fishery? If it is the latter, then sharing the harvest must be seen as only one of several ways of sharing the economic benefits from the fishery. If the relevant coastal states insist that the benefits be divided through harvest shares alone, then they are imposing a constraint upon themselves, a constraint, which in some instances, could prove to be crippling. Side payments serve to relax the constraint.

Figure 2. Cooperative Game With, and Without, Side Payments



Side payments become truly significant when the management goals of the coastal states sharing the resource differ. This author has argued that, when there are differences in management goals, it is invariably the case that one player places a higher value on the fishery than does the other. It might, for example, be that one player has lower harvesting costs than does the other, or it may be that one player discounts the future economic returns from the resource less heavily than does the other. When side payments are possible, then the optimal policy is one in which the management preferences of that player placing the highest value on the resource should be given full reign. That player should, in turn, then proceed to compensate (bribe some might say) its fellow player, or players, through the use of side payments. The side payments can take any number of forms. In another context, I referred to this as the *Compensation Principle* (Munro, 1987).

Consider Figure 2, yet again. In this example, player I places the highest value on the resource. The Pareto Frontier With Side Payments is tangent to the other Frontier at the point where $\beta = 1$, i.e. at the point where the management preferences of I are wholly dominant. The implication is that the global economic returns from the resource through time will be maximized by allowing player I to manage the resource, unimpeded by the management preferences of player II. Player I will then have to compensate player II through side payments, i.e. transfers of some form.

Ignore, for the moment, the payoff γ'_0 on the horizontal axis. II will obviously be better off with side payments, than without. What about I, however? Figure 2 shows that the introduction of side payments makes it possible for *both* players, I, as well as, II, to be better off than they would be in the absence of side payments. In the example, a solution to the game at which $\beta = 1$ is not feasible in the absence of side payments. We would have to end up farther down the Pareto Frontier Without Side Payments curve, with the consequence that the global benefits from the fishery would be less than the maximum. With side payments, the global maximum is achievable, to the mutual benefit of I and II.

Examples of side payments, in various forms will arise in the brief case studies to be considered at a later point. The most striking example, however, comes from an earlier case involving the fur seal fishery in the Northeast Pacific, early in the 20th century. The fishery was shared by four countries, Canada, Japan, Russia and the United States. When the fishery became significant in the late 19th century, there was no cooperative management. The "Prisoner's Dilemma" played itself out, and the resource was subject to severe overexploitation. Fearing the outright collapse of the resource, the four countries came together and transformed the non-cooperative game into a cooperative one, which took the form of the 1911 Convention for the Preservation and Protection of Fur Seals, which was to last, with one lengthy hiatus, until 1984.

The four players were not identical. Two, Russia and the United States, were low cost harvesters, harvesting the seals on land (Pribiloff Islands), while the other two, Canada and Japan, were high cost harvesters, harvesting the seals at sea. Moreover, Russia and the United States received higher prices for their harvested pelts, than did the other two countries. Needless to say, Russia and the U.S. placed a higher value on the resource than did the other two. Under the terms of the Convention, Canada and Japan agreed to reduce their harvests to zero. In return, they were promised by Russia and the U.S. a certain percentage of the annual harvested pelts. The annual transfer of pelts was a straightforward side payment, or compensation. The cooperative game proved to be profitable for all four players. Moreover, it also had beneficial conservation consequences, as well.It was estimated that, between 1911and 1941 (when the hiatus in the Convention, referred to earlier, commenced), the seal herds had increased eighteen fold (FAO, 1992).

Returning once more to Figure 2, we now note that the figure shows two alternative cases. In the first case, the Threat Point payoff for II is γ_0, while in the second case II's Threat

Point payoff is γ'_0 . In the first case, it would be possible to achieve a stable solution to the cooperative game, without side payments. The introduction of side payments has the effect making everyone better off, by allowing superior management. In the second case, if side payments are disallowed, then there is no solution to the cooperative game, because there is no point on the relevant Pareto Frontier at which both I and II would be better off than if they refused to cooperate. The "core" of the game is empty. With side payments, the scope for bargaining is increased, and a stable solution to the game is achievable. Thus, in the second case, side payments make the difference between a successful cooperative arrangement, and attempts to achieve cooperation ending in certain collapse.

An example is provided by the Norwegian Spring Spawning (Atlanto-Scandian) Herring fishery. The resource is managed cooperatively by Norway, Iceland, Russia, the Faeroe Islands and the EU. A recent empirical study on the fishery, conducted by a group of Icelandic economists, makes the point that the global benefits from full cooperation are very large indeed. The study, also concludes that, in the absence of side payments, a full fledged cooperative agreement will be inherently unstable (Arnason, Magnusson, and Agnarsson, 2000).

The *Compensation Principle*, although not labelled as such, found its way into FAO publications a decade ago. In FAO Fisheries Circular No. 853, *Marine Fisheries and the Law of the Sea: A Decade of Change*, 1992, for example, the author cites the case of the North Pacific Fur Seal Convention and states that:

> *The basic principle is the treatment of the fishery resources as resources that have value in situ; a value definable in monetary terms. The model is that of an international regime that achieves stability by the sharing of the benefits deriving from the use of the resource and providing compensation for those members who are less well endowed.* (FAO, 1992, p.41).

Next a comment about the sharing, or allocation, of the benefits arising from cooperative resource management and equity is in order. In the case of a two player game, the answer is straightforward. It is what we shall call the Nash Formula. The surplus arising from cooperation can be expressed as follows. Let the payoffs arising from the solution to the cooperative game be denoted as: θ^* and γ^*, and let the Threat Point payoff for II be γ_0 (i.e. Case 1). We can then say that:

$$\text{Cooperation Surplus} = (\theta^* + \gamma^*) - (\theta_0 + \gamma_0)$$

The Nash Formula is simply that the two players divide the Cooperation Surplus evenly. The rationale is that the two players should be seen as having made an equal contribution towards making cooperation possible. Hence, equity demands that they should share the Cooperation Surplus equally. If we denote the Cooperation Surplus as CS, then the Nash Formula would tell us that for player I, we would have:

$$\theta^* = \theta_0 + 1/2 \text{ CS}$$

Thus, player I receives its Threat Point payoff, plus one half of the Cooperation Surplus. What is true for player I, is true for player II[ii].

If there are more than two players, then the issue becomes somewhat more complex, and a simple Nash type of formula less appealing. We shall comment further on this point, in the section to follow on straddling fish stocks.

In any event, the theory tells us that the allocation of the economic benefits from the fishery, be it in the form of harvests, or other forms, should be determined by the relative bargaining strength of the players, and equity, as perceived by the players. Hence, one cannot safely assume that simple mechanical formulae for allocations will prove to be satisfactory. Thus, for example, allocations based upon the fractions of the resource to be found in each player's EEZ, might seem to provide an eminently sensible basis on which to determine allocations. However, if the resultant formula leads to one player receiving a payoff less than its Threat Point payoff, then application of the formula will lead to the certain collapse of the cooperative arrangement.

Conditions for Stable Cooperative Arrangements: Some Further Considerations

The analysis, which we have examined up to this point, is good enough to get us started, but it is far from complete. Several other considerations have to be taken into account, of which the following two are of particular importance:

1) Non-binding arrangements
2) "Time consistency" of the arrangements

Up to this point, it has been assumed that, if it is possible for the players to enter into a cooperative resource management arrangement, the arrangement will be binding, and that it will, therefore, last forever. This raises the obvious question of what happens if the arrangement is non-binding. The game theoretic aspects then become rather challenging. The reader will be spared the details. Basically, one has to contend with two considerations, the first one being that of cheating. Cheating can be dealt with, if each player is capable of developing a set of credible threats. The object is to ensure that neither player finds that it pays to cheat (see, for example: Kaitala, 1985). When there are only two players involved, the development of credible threats is reasonably straightforward. If there are more than two, then developing credible threats becomes much more difficult, and when the number is large, quite possibly unachievable. This question, however, we leave for the section on straddling fish stocks.

Be that as it may, in the real world, regardless of how binding may be the arrangement, effective enforcement provisions are critical. It is difficult to argue with Gulland's statement that "----without adequate implementation and enforcement the best [fisheries] agreements ----can be useless." (Gulland, 1980, p. 17).

The second consideration is what has been termed "time consistency". If the arrangement is not perfectly binding, then one must allow for the consequences of changes in the underlying conditions, and the fact these changes will, more likely than not, occur in an unpredictable manner. Gulland warned of this possibility in his now much cited 1980 paper.

The chief consequence is that, what may have appeared to have been a perfectly sound and equitable arrangement at the time of initiation, will cease to be so. In terms of Figures 1 and 2, one way to illustrate this problem is to ask what the consequences will be if the Threat Point shifts over time, due to changing conditions, given that the arrangement is non-binding. Kaitala and Pohjola (1988), presented a formal analysis of such case, and showed how cooperative arrangements, meeting all of the requirements for stability outlined in the previous section, can collapse when confronted with changing conditions over time. Cooperative arrangements that cannot withstand the impact of changing conditions through time are said to be "time inconsistent".

It is difficult to overstate the importance of "time consistency", and the concomitant problem of uncertainty. There is probably no binding, let alone non-binding, fisheries arrangement, which is immune to pressures arising from conditions shifting in an unpredictable manner. An example is provided by the cooperative management of Pacific salmon by Canada and the United States, to which we referred earlier. The arrangement is contained within a formal treaty between the two countries (Treaty, 1985), and is consequently about as binding a cooperative arrangement, as one could ask for.

It will be recalled that the Treaty came into force in 1985, and that it appeared to work well for several years. It then broke down, with potentially grave consequences for the resource. While several factors led to the breakdown, unquestionably one very significant factor was an unpredicted, and unpredictable, climatic shift, which had a negative impact upon salmon resources in the southern area covered by the Treaty, and a positive impact upon such resources in the northern area. The Treaty proved, in the end, to lack the flexibility and robustness to withstand the stresses created by the unexpected climatic shifts (Miller, et. al., 2001).

Making a fisheries cooperative arrangement "time consistent" thus means ensuring that the arrangement is robust. Anything, which undermines the flexibility of the arrangement, undermines its robustness. Rigid, unyielding harvest sharing agreements are, in of and by themselves, for example, undesirable. One might add that the need for robustness enhances the importance of side payments, since side payments can increase the scope for bargaining, and thus enhance the flexibility of the arrangement.

A third issue, to which we have alluded, is that of many players, i.e. more than two players. While the issue does arise in the management of transboundary fish stocks, it is of particular importance to the management of straddling fish stocks. We do, therefore, defer the discussion of this issue until the section to follow.

As a final comment, we point out that the model described has now been used in empirical studies, outside of academia. The aforementioned World Bank study by Agüero and Gonzalez is one example. The authors use the model to explore, and to assess, alternative options available to Chile and Peru for cooperative management of shared small pelagic fishery resources (Agüero and Gonzalez, 1996).

A Review of the Basic Economics of the Management of Straddling Fish Stocks

We turn now to the economics of the management of straddling fish stocks. In so doing, we look to the 1982 UN Convention (UN, 1982), and the 1995 UN Fish Stocks Agreement (UN, 1995) for the relevant legal framework. It is, of course, recognized fully that the implementation of the UN Fish Stocks Agreement is at an early stage.

Be that as it may, under the terms of the UN Fish Stocks Agreement, straddling stocks are to be managed cooperatively, on a sub-region by sub-region basis, through Regional Fisheries Management Organizations (RFMOs), which will count among their members distant water fishing nations (or entities) (DWFNs, hereafter), as well as coastal states. Obviously, there is no question that, in the economic analysis of the management of these resources, game theory must be employed. We now confront strategic interaction between/among coastal states *and* DWFNs.

As noted at an earlier point, the economic analysis of the management of straddling fish stocks rests upon a foundation provided by the economic analysis of transboundary fish stocks. The question to be asked is what modifications, if any, must be made to the economics of transboundary fish stock management, in order to accommodate the particular characteristics of straddling fish stocks.

One part of this question can be answered quickly. The economic analysis of the non-cooperative management of straddling fish stocks differs not at all from the economic analysis of the non-cooperative management of transboundary fish stocks. Except in unusual circumstances, non-cooperative management of straddling fish stocks will lead to the resources being mismanaged from society's point of view , and will do so for exactly the same reasons that non-cooperative management leads to the mismanagement of transboundary fish stocks – the "Prisoner's Dilemma" once again.

The pollock resources of the Bering Sea high sea enclave, the Doughnut Hole, which were subject to non-cooperative management prior to 1992, provide an example. It is reasonable to say that, prior to 1992, the resources were not just overexploited; they were plundered (Balton, 2001; FAO, 1994). Indeed, it can be argued that the overexploitation of straddling (and highly migratory) fish stocks worldwide, which provided the motivation for the convening of the UN Fish Stocks Conference, bears testimony to the predictive power of the economic analysis of the non-cooperative management of such resources (Munro, 2000).

It is in cooperative management that distinctions between straddling and transboundary fish stocks appear. There are three features distinguishing the cooperative management of straddling fish stocks, from the cooperative management of transboundary fish stocks, which are particularly striking. They are:

1. Absolute Number of Participants: the number of participants in the typical cooperative transboundary fishery management regimes is relatively small. One can, in analysing the economics of the management of these resources, usually make do with two player models, as was emphasized in the previous section. In the case of straddling fish stocks, involving cooperation among coastal states and DWFNs, one must allow for the possibility that the typical RFMO will have a substantial number of participants. Restricting the economic analysis to two player models is simply not acceptable. Having said this, however, let it be conceded that this distinguishing feature is one of degree.
2. Nature and Number of Participants Through Time: in a cooperative transboundary fishery management regime, the nature and the number of participants can be expected to remain constant through time, except in the most unusual circumstances. In the case of a RFMO, some of the participants are DWFNs, the fleets of which are nothing, if not mobile. Thus, conceivably, a DWFN, originally participant in a RFMO, could withdraw. Of much greater importance, a DWFN, not a founding, or "charter", member of a RFMO may join at later stage. The UN Fish Stocks Agreement does, after all, make specific provision for New Members (UN, 1995, Article 11). It is this feature, which probably most clearly distinguishes the cooperative management of straddling fish stocks from transboundary fish stocks (Munro, 2000).
3. Exploitation of the Resource(s) by Entities Not Party to the Cooperative Arrangement: in the case of a transboundary resource, any attempt by a non-member of the cooperative arrangement to exploit the resource(s) in the EEZ of a member of the arrangement, without the express permission of that member, would clearly be illegal. The member could take vigorous measures to repel the intruder (see: FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU, hereafter), 2001, para. 3.1.1). In the case of a straddling stock a state, or entity, which is a non-member of the RFMO, found to be fishing the stock in the high seas governed by the RFMO, in a manner inconsistent with the conservation and management measures of the RFMO, would be deemed to be engaging, not in illegal fishing, but rather in *unregulated* fishing (IPOA-IUU, 2001, para.3.3.1). The action, which the members of the RFMO could take to deal with the unregulated fishing, is less clear than the action, which they could take if confronted with illegal fishing. The IPOA-IUU attempts to address this problem. It will be argued that, how this issue comes to be

addressed in the future, will have a significant impact on the sustainability of the RFMO regime, through time.

Number of Participants, or Members

When the number of players in a fisheries game is large, one has to be concerned with the possibility, as before, of complete non-cooperation, of players competing with one another on an individual basis. One has also to be aware, however, with the possibility of partial cooperation, of players forming sub-coalitions, and of those sub-coalitions then competing with one another. The full benefits of cooperation are, of course, achieved, when the players form a single coalition, referred to as the Grand Coalition. In order for the Grand Coalition to be stable, it is not enough that each individual player receive a payoff at least as great as it would under competition. There must, in addition, be assurance that no sub-coalition would be better off by standing on its own, and refusing to cooperate with the rest.

In passing, another complication arises from the division of the returns from cooperation. The most widely accepted formula does not involve an equal division of the cooperative surplus among the players, as in two player games. Rather the division is based upon the average of each player's marginal contributions to all possible coalitions, and thus reflects more accurately the relative bargaining power of the players, than would a simple equal division of the cooperative surplus (Kaitala and Lindroos, 1998). It is commonplace to observe, as noted an earlier point, that the larger are the numbers, the more difficult it is to achieve a stable cooperative regime. There is, however, one example, of cooperative fisheries management, involving large numbers, which has proven to be remarkably successful. The case involves the management of transboundary, rather than straddling, fishery resources, and is the exception to the rule that transboundary fishery cooperative arrangements usually involve small numbers. The example is introduced at this stage, because it is likely to hold lessons for the management of straddling, as well as transboundary, fishery resources.

The example consists of the independent Pacific Island Nations, which entered into a cooperative management arrangement for tuna, through the establishment of the South Pacific Forum Fisheries Agency (FFA), in 1979. Fourteen independent Pacific Island Nation "players" were then involved. It can be argued that this arrangement represents one of the most successful attempts at cooperative fisheries management in the world.

Initially, however, there were serious doubts that the endeavour could succeed. A cooperative fisheries "game", consisting of fourteen players, which were spread over a wide geographical area, and many of which were at low levels of development, appeared to be intractable. For the first few years of the FFA's existence, the pessimism seemed to be fully justified (Munro, 1982;1991).

In the end, the cooperative endeavour did succeed. In part, this is due to the fact that the fourteen coalesced into two sub-coalitions, which appears effectively to have turned the game into a de facto two player game. There is also clear evidence of side payments between the sub-coalitions being brought into play, although, needless to say, the term "side payment" was never used in the region (Munro, 1991.).

The New Member Problem

With respect to the issue of New Members, it is this author's understanding that the founders of a RFMO, what we might term the "charter" members, can, under the terms of the UN Fish Stocks Agreement (Articles 8, 10 and 11), exclude would be New Members, claiming a "real interest" in the fishery(ies), only if the would be New Members refuse to abide by the terms of the RFMO management regime (see, as well, the following article by three specialist in the Law of the Sea: Orebech, Sigurjonsson and McDorman, 1998). Otherwise, the prospective New Members are to be admitted. Orebech et. al. (1998) argue further that such New Members "must be offered *just and reasonable* shares of the TAC available under an [RFMO] management plan" (Orebech et al., 1998, p. 123).

The question of the terms and conditions, under which New Members are to be admitted, including, *inter alia*, what constitutes *just and reasonable* shares of the TAC, is of direct relevance to the economics of the management of straddling stocks. The reason is simple. The terms and conditions can affect the stability of the cooperative management regime.

Several years ago, Kaitala and Munro (1997) demonstrated the following. If *just and reasonable* implies that New Members, upon joining a RFMO, should receive, at no further cost as it were, shares of the Total Allowable Catch, or the equivalent, on a pro-rata basis, then, when planning is undertaken for the establishment of a RFMO, prospective "charter" members could well calculate that their expected payoffs from cooperation would fall below their respective Threat Point payoffs. Hence, the RFMO would be stillborn.

The aforementioned interpretation of *just and reasonable* poses the threat described, because it may give rise to a type of "free rider" problem. It is a "free "rider" problem, let it be stressed, which has nothing whatsoever to do with cheating, with flouting the provisions of the RFMO management regime.

The Kaitala-Munro argument can be explained in terms of the following example. Suppose that a hitherto overexploited straddling stock comes under the management of a RFMO consisting of coastal state V, and three DWFNs, W, X, and Y. The four "charter" members undertake the cost and sacrifice of rebuilding the resource over, let us say, a seven year period. In the eighth year, the four are in a position to enjoy a return on their resource investment, through harvesting. At the beginning of the eighth year, a prospective new member, DWFN Z, appears. It demands access to the RFMO, agrees to abide by the resource management rules, but demands, "free of charge", a share of the harvest, and by implication, a share of the net economic returns from the fishery. If DWFN Z's demands were acceded to, Z would effectively be a "free rider." Having incurred none of the costs and sacrifices of investment in the resource, it will enjoy, at no cost, a share of the return on the investment. If "charter" members of a RFMO anticipate extensive "free riding" of the form described, then a straightforward application of game theory demonstrates that one, or more, "charter" members may conclude that it (they) would be better off by refusing to cooperate (Kaitala and Munro, *ibid.*).

Kaitala and Munro (1997) did not discuss the case in which the "charter" members establish a RFMO, expecting the appearance of no New Members, but are then subsequently unpleasantly surprised. Nonetheless, their analysis could readily be extended, and an outcome predicted. The RFMO would be established and might well appear to be successful, initially. When the unpleasant surprise occurs, however, the "charter" members could be expected to reassess their expected payoffs from cooperation, with the possible consequence that the RFMO would disintegrate.

The question, as yet unresolved, is how to ensure that the provisions of the UN Fish Stocks Agreement, pertaining to New Members, are honoured, without at the same time undermining the long term stability of the RFMOs. This paper will not attempt to offer possible solutions, but will respectfully suggest that it is a question, which should be addressed, in detail, during the Expert Consultation.

As an addendum to this section, we raise a further issue, which in terms of the economics, can have consequences similar to that of the New Member problem. This issue pertains to the "real interest", which states and entities have to fisheries governed by a particular RFMO.

As is well known, Article 8(3) of the Agreement states that "---States having a real interest in the fisheries concerned may become members of such organizations [i.e. RFMOs]" (UN, 1995). The term "real interest" is not defined in the Agreement. The Dutch legal expert, Erik Molenaar, (Molenaar, 2000) argues that states/entities having a "real interest" in the relevant fisheries can be taken to include the following categories:

(a) coastal states and DWFNs currently engaged in active exploitation of the fisheries
(b) DWFNs, which are not currently engaged in exploiting the fisheries, but which had done so in the past, and which would now like to re-enter the fisheries.
(c) DWFNs, which had never exploited the fisheries, but which would now like to do so.

Article 8(5) of the Agreement, discusses the establishment of new RFMOs. The paragraph calls upon states falling within Category (a), alone, to commence the establishment. Article 9(2) states that "States cooperating in the formation of a ---regional fisheries management organization [Category (a) states] --- shall inform other States which they are aware have a real interest in the work of the proposed organization [Category (b) and (c) states] ---of such cooperation" (UN, 1995). Molenaar maintains that one can infer from all of this that, upon so informing such Category (b) and (c) states, the Category (a) states would then invite their (b) and (c) colleagues to enter the RFMO negotiations (i.e. become "charter" members) (Molenaar, 2000, n.80). Undoubtedly, the Molenaar position is not accepted by all.

If the Agreement is interpreted, over time, to mean that Category (b) and (c) states must be invited to become "charter" members, then it is easy to see that the same sort of "free rider" problem, threatened by the New Member issue, can readily arise. Return to our New Member problem example, discussed earlier. Now suppose that states V, W, X, and Y are Category (a) states. Suppose, further, that Z is now a Category (c) state, which demands and receives full and undiluted "charter" membership. Z incurs no real sacrifice in the re-building of the resource, because it had not hitherto been engaged in harvesting the resource. Z will simply bide its time over the seven year period, and then, when the eight year arrives, will come to enjoy a share of the return on the resource investment, as the "free rider" that it most certainly is. Once again, the possibility of such "free riding" could undermine the viability of the RFMO.

Unregulated Fishing

Fishing by non-members in the high seas area governed by a RFMO, in a manner contrary to the RFMO management regime, comes under the heading of unregulated fishing. Unregulated fishing can be seen as another form of "free riding". If it is uncontrolled, then it is easy to show, with the aid of game theory, that its existence, or threatened existence, can serve to undermine RFMOs. In a way, it is like a particularly virulent form of the New Member problem.

One can also show, with the aid of game theory that, if the only way that unregulated fishing can be controlled is by persuading the non-members to join the RFMO voluntarily, the stability of the RFMO will be in serious doubt. Recent work has shown the number of players, which a Grand Coalition is likely to be able to support under these circumstances, is depressingly small (often no more than two). With a large number of players, defection, "free riding", becomes too easy, and too attractive. If on the other hand, effective punishment can be meted out to those who refuse to desist from unregulated fishing, then, not surprisingly, the likelihood of achieving a stable cooperative agreement, with large numbers, is greatly enhanced (see, for example: Pintassilgo, forthcoming; Lindroos, 2002).

In the case of straddling stocks, "large numbers" can be expected to be the rule, not the exception. The implications are obvious. If the RFMO regime is to be sustainable through time, effective implementation of the FAO IPOA-IUU is mandatory.

A PostScript

Suppose now that one is examining the economics of the management of a RFMO, the members of which are few in number, and had all been actively engaged in the relevant fisheries at the time of the founding of the RFMO. Suppose further that it is confidently believed, within the RFMO, that the issue of New Members, and the threat of unregulated fishing, are unlikely to arise in the foreseeable future. Then the economic analysis applied to the cooperative management of transboundary fishery resources can be applied with little or no modification.

A case in point is provided by the economics of the management of the Norwegian Spring Spawning Herring. The resource, which has both transboundary and straddling attributes, and which is managed cooperatively by four countries and one entity, has been studied extensively by economists (primarily Scandinavian) over the past few years. Most of these economists assume that the cooperative management regime for the resource is fixed in terms of membership, and is free from the threat of unregulated fishing. They use models, which are but variants of those applied to the study of transboundary fishery resources (see, for example: Arnason, Magnusson and Agnarsson, 2000; Bjørndal, Gordon, Lindroos, and Kaitala, 2000).

Some Comments on the Institutional Aspects of Cooperative Shared Fish Stock Management

This will be a very brief section indeed. The truly useful information on appropriate institutional arrangements can be expected to arise from discussions, and the case studies to be presented, at the Expert Consultation.

Be that as it may, the one paper, which goes into the institutional aspects at greatest depth, is the 1997 John Caddy paper. Let it be conceded that the paper has the limitation, from the perspective of the Expert Consultation, of not discussing RFMOs explicitly.

The first question raised by Caddy is whether a formal body for effecting cooperation is required, or whether an informal committee type of structure will suffice. Caddy points out that formal bodies will often prove to be expensive, and may be seen as a threat to the sovereignty of prospective participants in the cooperative undertaking. There is no clear response that one can give to this question, other than to make the obvious, and rather vague, statement, that in some cases the cooperative management problem is simple enough that an informal committee will do, while in other cases, the complexities involved demand a formal structure. Thus, for example, Canada and the United States co-manage a hake (whiting) resource off their respective Pacific coasts, and find no need to do so on other than on an informal basis. On the other hand, it seems inconceivable that the Pacific Island Nations could effect cooperative management of their immense tuna resources on an informal basis. No one questions that the formal coordinating body, the Forum Fisheries Agency, has, and does, play a critical role. Similarly, it seems inconceivable that the straddling stocks managed under the Northwest Atlantic Fisheries Organization (NAFO) could be managed other than through a formal organization.

The Caddy paper does, however, have a point, under the heading of institutional issues, of considerable substance. The point pertains to scientific cooperation. The point was made earlier that cooperation in research, divorced from resource management, should be relatively easy to achieve (Gulland, 1980), but that once cooperation in research and management become intertwined, research can become a focus of conflict and discord. One example is provided by Pacific salmon. A key factor in the management of the resources, and one, which affects the returns to the players, is the estimated current abundance of various salmon species and stocks. Millar, et. al. (2001), in commenting on the future of the 1999 Agreement, designed to repair the treaty governing the co-management of the resource, state that "-----one of the most pressing needs will be to find a way to prevent the parties from turning abundance estimates into tools of combat" (Miller, et. al., *ibid.*, p.47).

Caddy argues that one way out of such difficulties is to have the scientific research subject to independent reviews. One can, in fact, find examples of where such independent scientific advice is employed. One of the more successful cooperative resource management regimes is to be found in the Barents Sea, involving two players, Norway and Russia. The two players, when negotiating the TACs for the fishery resources within their management purview, turn to ICES for independent scientific advice. ICES does, as well, provide advice in support of other international fisheries agreements in the Baltic and the North Atlantic (e.g. that pertaining to Norwegian Spring Spawning Herring) (Nakken, Sandberg, and Steinsham, 1996).

Some Selected Case Studies

We turn now to a few case studies, several of which have already been referred to in passing, in order to provide some further illustrations of points made in earlier sections. The case studies will be in the nature of very brief sketches, rather than detailed descriptions. An important reason for brevity is that, at the time of writing, it is anticipated that all of the cases discussed here will be presented as complete case studies at the Expert Consultation.

(a) Pacific Island Nations Tropical Tuna Fisheries

The Pacific Islands Region constitutes one of the richest tropical tuna grounds in the world. The tuna resources were, and are, of fundamental economic importance to the Islands. Consequently, it could be maintained that the Pacific Island Nations were, collectively, one of the big "winners" from the advent of Extended Fisheries Jurisdiction (EFJ), in 1982. Having said this, however, it was not at all clear at the time that the economic benefits, which these countries would enjoy from EFJ would be other than ephemeral.

Collectively, the Pacific Island Nations EEZs covered an immense area of 29,000 million km^2, while their collective land mass was but 500,000 km^2. Most of the tuna harvests, within these EEZs, 80 per cent or more, were taken by DWFNs. Finally, the Pacific Island Nations were generally at low levels of development. Hence, these countries faced what appeared to be insurmountable monitoring and surveillance problems.

These difficulties were compounded by the following. First, the Pacific Island Nations effectively faced but one DFWN, one that was a major power in the Asia Pacific region. As a provider of harvesting services, this powerful nation was in the position of a monopolist within the Pacific Islands Region. Secondly, the right of coastal states to assert management jurisdiction over tuna resources was bitterly contested at the close of the UN Third Conference on the Law of the Sea.

The Pacific lsland Nations had an incentive to cooperate. Without cooperation, it was inevitable that the single DWFN would play one Island country off against the other, and that it would do successfully (Munro, 1991). Achieving effective cooperation was, however, very difficult.

We have already noted that the Island nations attempted to cooperate through the formation of the Forum Fisheries Agency (FFA), and have discussed the difficulties to be encountered in attempting to achieve a stable cooperative outcome, when there are large number of players. It will also be recalled that there were fourteen countries involved, which varied enormously in size, and which were spread over vast distances. This author, writing in 1981, expressed the then general pessimistic view about the future viability of the FFA (Munro, 1982).

The tuna resources in the South Pacific are not evenly spread, tending to concentrate around the Equator. The consequence is that there are, in relative terms, "haves" and "have nots", among the Pacific Island Nations. Seven of the fourteen could be regarded as "haves". Concerned about the lack of progress in the FFA, the seven met on the island of Nauru (one of the seven) and signed a formal agreement, the Nauru Agreement, and became known as the Nauru Group thereafter. The Nauru Group made it known, that, while the Group had no wish to see the FFA disintegrate, the Group would go it alone unless the others engaged in serious cooperation. The others decided that serious cooperation was indeed in their best interest.

In the discussion of cooperative games with many players, it was pointed out that, in such games, the formation of sub-coalitions is a common occurrence. In the case of the FFA countries, two sub-coalitions were thus formed, the Nauru Group ("haves"), and the "have nots"'. It helped that there are two major Island nations, Papua New Guinea (PNG) and Fiji, which were in different sub-coalitions. PNG was in the “haves” sub-coalition, and became its leader; while Fiji became the leader of the “have nots” sub-coaltion. An intractable fourteen player game had evolved into what amounted to a two player game (Munro, 1991).

Not surprisingly, the management goals of the two sub-coalitions were not the same. The Nauru Group was much more concerned about the long term stability of the resources, than the less well off sub-coalition. Clearly, the Nauru Group placed the higher value on the resource. The theory tells us that the optimal outcome would be for the management preferences of the sub-coalition placing the higher value on the resource to be made dominant, and for that sub-coalition to compensate its fellow subcoalition.

The predictive power of the theory in this instance proved to be strong. The Nauru Group became the cutting edge in terms of formulating management policy. Various forms of side payments emerged, through which the "have not" sub-coalition was compensated (Aikman, 1987;Munro, 1991). These compensations continue up to the present day. Moreover, the "have nots" sub-coalition has played an increasingly important role in the cooperative management of the resource (David Doulman, personal communication), which attests to the growing strength of the cooperative resource management arrangement.

(b) Pacific Salmon- Canada and the United States

Wild Pacific salmon, as an anadromous species, are produced in fresh water, spend most of their lives in the ocean, and then return to their fresh water origins to spawn and die. In Pacific North America, wild salmon are produced in rivers and streams from California through Oregon, Washington, British Columbia, to Alaska. Historically, the two single most important salmon river systems have been the Columbia, primarily (but not exclusively) in the United States, and the Fraser, wholly confined to Canada.

Some American produced salmon are inevitably “intercepted,” i.e. caught, by Canadian fishers; some Canadian produced salmon are inevitably “intercepted” by American fishers. Hence, the resource is inescapably transboundary in nature. The fish are normally harvested as they approach river mouths on their way to the spawning rounds. They are easy to catch, and thus highly vulnerable to overexploitation. Hence, the consequences of non-cooperative management of the resource can be severe.

Canada-United States Pacific salmon negotiations, initially focussed on the Fraser River, did in the early 1970s, become broadened, with the objective of covering all salmon produced from northern California to southern Alaska. The negotiations proved to be extraordinarily difficult. The negotiators were, however, spurred on by the threatened emergence of a “fish war,” which both sides realized would be highly destructive, and by the blocking of enhancement projects on both sides of the border(Munro and Stokes, *ibid.*).

In 1985, the Canada-United States Pacific Salmon Treaty came into being (Treaty, 1985). The division of returns from the fisheries was incorporated in the Treaty, in the so called Equity Principle, in which each country was to receive economic benefits commensurate with the salmon produced in that country’s rivers and streams. Achieving equity was to be through balancing interceptions alone. No thought was given to the possibility of side payments.

At the time that the Treaty was signed, the Fraser and Columbia Rivers were seen as being at the heart of the cooperative resource management agreement. The Americans intercepted primarily Fraser River salmon; the Canadians intercepted primarily Columbia River salmon. Alaska was essentially a "side show." The interceptions appeared to be roughly balanced (Munro and Stokes, 1989). Initially, the cooperative agreement prospered. While no actual estimates were made, it was agreed that if the Cooperative Surplus, were to be measured, it would prove to be very large indeed.

There were, however, two problems, which were to emerge over time. The first was that, while Canada could be viewed as a single player, the United States was in fact a not particularly stable coalition, in which Washington/Oregon and Alaska were key players. The second problem arose from the fact that a climatic shift was then under way in 1985, which was to prove detrimental to salmon stocks in Washington, Oregon and southern British Columbia, but highly beneficial to salmon stocks in Alaska (Miller, et. al., 2001).

The impact of the climatic shifts became increasingly evident over time. The Columbia River salmon showed signs of severe deterioration, which led, in turn, to declining Canadian interceptions. The booming Alaskan stocks, in turn, resulted in increased Alaskan interceptions of Canadian produced salmon, as Alaskan fishers sought to reap their bounty. Alaskan interception, initially minor from a Canadian perspective, achieved greater and greater importance (Miller, et al., *ibid.*).

The rough interception balance of the early years of the Treaty was upset. The Alaskans were pressed to reduce their interceptions, which they insisted that they could do only by forgoing their bounty (Miller, et al., *ibid*.). By 1993, the Treaty was in disarray. A very real threat of a "fish war," i.e. reversion to destructive competitive behaviour, loomed (Miller, et al., 2001). A fundamental condition for cooperative resource management had now been violated. The Individual Rationality Constraint had become binding. A major player, Alaska, was no longer better off with the Treaty, than without.

The Pacific salmon case illustrates the paramount importance of flexibility and "time consistency" in cooperative fisheries management agreements. As was noted at an earlier point, the Canada-United States Pacific Salmon Treaty was as binding an agreement as one could hope to achieve. Yet, the Canada-U.S. Pacific salmon cooperative game had proved to lack the resilience needed to accommodate changing conditions. The harvest allocation mechanism set in place by the Treaty effectively broke down.One might add that a significant factor, underlying the lack of resilience, and noted by an increasing number of observers, was the absence of the possibility of side payments (Miller, et al. *ibid*.).

In 1999, Canada and the United States signed an Agreement in an attempt, initially successful, to restore cooperation (United States, 1999). It is too early, at this stage, to determine whether the Agreement will lead to a lasting peace, or whether it will prove to be no more than a temporary truce (Miller, et al., *ibid.*). The issue is certain to be discussed in detail at the Expert Consultation in the presentation of the expected case study on Pacific salmon.

(c) Norwegian Spring Spawning Herring Fishery

The Norwegian Spring Herring stock is among the largest and biologically most productive fishery resources in the world. When healthy, the resource has total biomass of 15 to 20 million tonnes, and a spawning biomass averaging 10 million metric tonnes (Arnason et al., 2000). The resource, when in a healthy state, is both a transboundary and straddling stock. The resource, as the name would suggest, spawns in Norway. After spawning, the resource migrates from the Norwegian EEZ through the EEZs of the EU, the Faeroe Islands, and Iceland. The resource does, as well, migrate through a large high seas enclave known by some as the "Ocean Loop", and by others as the "Herring Loop" (Arnason et. al., *ibid*., Bjørndal and

Gordon, 2000). When depressed, the resource is confined to Norwegian waters (Bjørndal, Hole, Slinde and Asche, 1998; Arnason, et. al.,*ibid*.).

The resource has the characteristic, typical of clupeoids, of being an intense schooling species, and is thus highly vulnerable to overfishing. In the pre-U.N. Third Conference on the Law of the Sea era, the fishery was an international open access one. The economic models of non-cooperative management of shared fish stocks proved, by the late 1960s, to have powerful predictive power. The resource collapsed, due to overexploitation, and came within a hair's breadth of extinction (Arnason, et. al., *ibid*.). An international moratorium was declared in 1969.

Through the good fortune of an exceptionally strong year class appearing in the late 1980s, and the continuing harvest moratorium, the resource recovered. The spawning biomass recovered to the healthy state level of 10 million metric tonnes, and the moratorium was lifted. It was recognized that cooperative management of the resources was required, if the health of the resource was to be maintained.

Five countries/entities exploiting the resource - originally Norway, Iceland, Russia, the Faeroe Islands, and later the EU – came together in the mid-1990s to establish a cooperative resource management arrangement. The initial attempt to establish cooperative resource management was disappointing (Bjørndal, Hole, Slinde and Asche, 1998). By 1996, however, the cooperative resource management regime achieved stablity and has apparently remained successful up to the present time. It can be argued that, after December 1995, the UN Fish Stocks Agreement provided the framework required for a successful cooperative resource management regime.

It can be noted in passing that the Norwegian Spring Spawning Herring case provides us with an example of the inadequacy of simple formulae for allocation of benefits from the fishery among the players. There was some suggestion at an early stage of the negotiations that so called "biological zonal attachment" (determined by the amount of the biomass in each EEZ, and high seas zone, and the amount of time spent by the biomass in each EEZ, and high seas zone) be given substantial weight in setting quota shares among the five. Heavy emphasis on "biological zonal attachment" would have given the EU a negligible quota share (Bjørndal, Hole et. al., 1998). The EU's bargaining strength was(is) such that its quota share was not, and is not, negligible.

In any event, the incentive to cooperate is strong. It is obvious to all players that the Cooperative Surplus is large, particularly because a reversion to competitive behaviour would carry with it the distinct threat of extinction of the resource (Arnason, et. al., *ibid*.). There also seems to be some signs of "time consistency", although the cooperative arrangement has not been in place long enough to provide convincing evidence. Nonetheless, it is recognized that the migratory pattern of the resource is certain to vary over time, and that this will necessitate renegotiations of the quotas (Arnason, et. al., *ibid.*). Finally, the cooperative resource management regime has not been tested with respect to New Members, nor is there any likelihood that such testing will arise in the foreseeable future.

Reference has already been made of the game theoretic analysis of the fishery by Arnason et. al. and their conclusion that, in order for the Grand Coalition to be stable, side payments were essential (Arnason. et. al., *ibid.*). There is no evidence of monetary side payments having been made. There are, however, numerous "side arrangements" between players, for example allowing one player to take part of its quota in another player's zone, in exchange for various quid pro quo. To quote Bjørndal and Munro (2000):

> *Whether these side arrangements fit the precise definition of side payments may be open to debate. What is not open to serious debate is the fact that the side arrangements have the flavour of side payments, that they have added to the flexibility of the agreement, and that they have served to broaden the scope for bargaining.*

Norwegian Spring Spawning Herring presents us with what is likely to be the single most important case of straddling fish stock management to come before the Expert Consultation. It is to be hoped that the Expert Consultation will be given the opportunity both to learn, in detail, why cooperative management of the resource has proven to be so successful up to the present time, and to assess the relevance of this experience to the cooperative management of other straddling stocks.

(d) North East Arctic Cod Fishery

We follow with yet another Scandinavian linked example, namely the North East Arctic cod fishery. The resource extends from the west coast of Norway to the Spitzbergen and Novaja Zemliza islands, and has, historically, been the single most important cod stock to the Norwegian fishing industry.

The resource is shared by Norway, with Russia. A cooperative management arrangement was established between Norway and the then U.S.S.R. in the mid-1970s. What is striking is how successful, and resilient, the cooperative management regime has been to date. When cooperation commenced, the two countries were firmly on opposite sides of the Cold War. The cooperative management regime has subsequently withstood the transformation of the U.S.S.R. to the smaller Russia, and the upheavals, occurring in Russia from 1991 onwards.

By the beginning of the 1990s, a further complication was introduced. The resources became a straddling stock as well as a transboundary stock, by virtue of the fact that a significant amount of the resources moved into a high seas enclave, between the Norwegian and Soviet/Russian EEZs, known as the Loophole. This attracted the attention of DWFNs, and one DWFN in particular, Iceland. Extensive Icelandic fishing in the Loophole resulted in several years of acrimonious dispute. The dispute was settled, almost four years after the UN Fish Stocks Agreement had come up for ratification, in 1999. Under the terms of a tri-lateral agreement, Iceland agreed to withdraw from the Loophole, in exchange for cod quota in the Norwegian –Russian EEZs (Stokke, 2001).

A study by Armstrong and Flaaten in 1991 showed the obvious basis for cooperation between Norway and the Soviet Union/Russia. Their study reveals that even though the cooperative regime was less than optimal, the Cooperation Surplus was massive, and that both players were unquestionably better off than they would have been under competition (Armstrong and Flaaten, 1991). A later article by Armstrong (1994) supports this conclusion. Although cod harvests have declined significantly in recent years, there is no reason to believe that the gains from cooperation remain other than substantial at the present time (Munro, 2000).

There are other aspects of the cooperative management arrangement, which add to its strength and resilience. Both the Armstrong and Flaaten and Armstrong papers (1991; 1994) give one the initial impression that the two players refused to consider the possibility of side payments, or the equivalent thereof. This author would suggest that the initial impression is not entirely accurate. First, there is evidence, provided, in fact, by the aforementioned authors, that arrangements have been made to allow U.S.S.R./Russian vessels to harvest part of their quota in the Norwegian EEZ.

Secondly, while the allocation of the TAC has been rigidly determined on a 50:50 basis, since the inception of the cooperative arrangement, the precedent has been set of Norway taking more than 50 per cent of the TAC through quota “swaps.” Norway surrenders part of its quotas in other fisheries, in exchange for a greater share of the North East Arctic Cod TAC (Armstrong and Flaaten, 1991). These two aspects imply added flexibility in the cooperative arrangement. Moreover the quota “swaps” fit all reasonable definitions of side payments, except the most narrow.

Finally, it is worth recalling our earlier comments to the effect that scientific research, certainly including stock assessments can become "weapons of combat" in fisheries management and allocation negotiations. Norway and Russia to their credit (as we noted earlier), do, when negotiating TACs, turn first to ICES for independent, and objective, scientific advice (Nakken et al., 1996).

Conclusions

We are now in a position to draw certain conclusions. The first conclusion is that the management of shared fish stocks continues to be a major issue in world fisheries. There may exist as many as 1,500 transboundary fish stocks alone. One can only guess at the number of stocks to be added to this total, when straddling fish stocks are taken into account. Only a limited number of these shared fishery resources are subject to effective cooperative management. The scope for improved management is, therefore, immense.

The second conclusion is that, with few exceptions, cooperation in the management of shared fishery resources does matter. It is dangerous to assume that non-cooperative management of shared fishery resources will lead to resource management programs, which are adequate.

Cooperative management at the secondary level, involving full joint management, is, admittedly difficult and costly. Nonetheless, there do exist some examples of effective cooperative resource management, which can serve as examples for others.

Stability in cooperative resource management arrangements requires that certain requirements be met. Several of these requirements are obvious. First, for a given arrangement to be stable, it must not be possible to find an alternative arrangement, which is capable of making all "players" better off. Secondly, the so called "individual rationality" constraint must be satisfied. Even if only one "player", or subcoalition of “players”, party to the arrangement, concludes that it can do better, by refusing to cooperate, the full cooperative arrangement will not hold.

Thirdly, where the number of participants in a cooperative management regime is large, it is imperative that the surrounding legal framework be found to have strength. Cooperative management arrangements, which purport to be binding, but which in fact are non-binding, are unlikely to survive the stress created by large numbers. Fourthly, in the case of straddling stocks, means must be found of accommodating New Members, in accordance with the UN Fish Stocks Agreement, that do not, at the same time, undermine the long term viability of RFMOs.

A less obvious, but highly important, requirement, relevant to both transboundary and straddling fish stocks, is that the cooperative management arrangement be "time consistent". The cooperative management arrangement must have the flexibility and robustness to withstand through time the shocks of unexpected and unpredictable changes.

Ensuring that the individual rationality constraint is satisfied, and maximizing the robustness of the arrangement, requires, in turn, that the scope for bargaining be as great as possible. One means of so doing, stressed in this paper, is by making full use of side payments, broadly defined.

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ENDNOTES

[i] We can show the outcome in terms of a Payoff Matrix, in which the payoffs are in terms of prison sentences. Consider the following, adapted from Luce and Raiffa (1957):

Prisoner A\ Prisoner B	**Pleads guilty**	**Pleads not guilty**
Pleads guilty	**5 years each**	**0 years for A, and 10 years for B**
Pleads not guilty	**10 years for A, and 0 years for B**	**½ year each**

Suppose that Player B pleads guilty. Player A would clearly be bettor off pleading guilty. Suppose that player B pleads not guilty. Player A would, once again, clearly be better off pleading guilty. Regardless of what strategy player B may adopt, the best strategy for player A is to plead guilty. Hence, pleading guilty is the dominant strategy for player A. What holds true for player A, also holds true for player B.

[ii] This is not to say that the two players will share the total economic returns from the cooperatively managed fishery equally. Suppose, for the sake of argument, that 90 per cent of the resource lies within player I's EEZ, with the remaining 10 per cent in player II's EEZ. It is reasonable to suppose that player I's Threat Point payoff would be much larger than that of player II. Hence, player I's share of the total economic returns from the cooperatively managed fishery would exceed 50 per cent, probably by an extensive margin.