

The management of transboundary marine resources : recent developments and elements of analysis

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Abstract:

Under the new Law of the Sea, the definition of exclusive zones was considered an important first step towards improved management of the world's fisheries. However, one of the limits¹ to the effectiveness of extended Jurisdictions was the problem of transboundary fish stocks. This question recently appeared at the centre of the international debate on marine resources management. The paper examines these developments and some of the related issues. In particular, two major implications are the evolution of management objectives towards the integration of ecological interactions, and the development of a need for international co-ordination. A discussion of these problems based on the relevant economic theory is presented. This leads to consider the additional issues of uncertainty and the structure of entitlements to marine resources as important determinants of international arrangements, and to underline the particular role played by institutional frameworks in this context.

1. Introduction.

Although the United Nations Convention on the Law of the Sea (UNCLOS) only entered into force in 1994. It has been largely adopted as customary rule by many nations since the early 1980s. Under this comprehensive legal regime for the world oceans, maritime areas and activities are considered as being loosely interrelated, and to be managed as a whole. While one of its main achievements is the expression in legal terms of the Exclusive Economic Zone (EEZ) concept, recognising the sovereign rights of coastal states for exploring and exploiting natural resources within 200 miles of their continental baselines, it stipulates that these rights need to be reconciled with global principles - such as freedom of navigation and overnight improved scientific knowledge of the marine environment, or the protection of its living systems²[2].

The analysis of fisheries management issues builds on the well-known model of free access renewable resources. From this perspective, the EEZ principle has been considered as a way to resolve the model's central problem of free access to marine biological resources, by clearly defining the nature of property rights over these resources, on a geographical basis. Indeed, it placed fish stocks within exclusive zones under the authority of a "sole owner", having a legitimate right to

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[2] During the third Conference on the Law of the sea, the proposal that high seas living resources should be treated like ocean beds as an international commons, and regulated by an international organization, were however rejected by a majority of states (Hey et al., 1991).

regulate the nature and the level of their exploitation, and the capacity to enforce management measures. Since exploited fish populations were considered to be essentially concentrated on the continental shelves, the 200 miles limit seemed to encompass the majority of living resources needing to be managed^{3[3]}. The extension of national jurisdictions over marine areas, in providing a framework for the definition of limited entry programs, was thus considered as an important first step towards a resolution of the "commons dilemma" in fisheries, bound to lead to improved management and result in increased production and global benefits, in the long run (Cunningham et al., 1985).

However, one of the main limits to the effectiveness of EEZs concerned the question of stocks exploited and managed within different exclusive zones and on the high seas. This question has recently appeared at the centre of the international debate on marine resources management. The paper examines these developments, and some related issues. In particular, two major implications are the evolution of management objectives towards the integration of ecological interactions, and the development of a need for international co-ordination. A discussion of these problems based on the relevant economic theory is presented. This leads to consider additional issues of uncertainty and the structure of entitlements to marine resources as important determinants of international agreements, and to underline the particular role played by institutional frameworks in this context. Elements of a case study are presented towards the end of the paper to illustrate these issues.

2. Recent Developments In The Management of Transboundary Resources.

One of the main issues that remained unresolved within UNCLOS III was the status of species spending at least an important part of their life cycle, or moving seasonally, between and outside Exclusive Economic Zones. "Shared" and "straddling" stocks defined as stocks occurring in adjacent waters, between different EEZs and within and outside EEZs respectively, were to be exploited in the limits of international conservation measures established through co-operation of the concerned states. Within its EEZ, each state however retained its sovereign right to define catch levels, and their conditions of allocation. For "highly migratory species", the Convention established the need for states to develop unified management regimes covering their entire range - both within and outside exclusive zones (Meltzer. 1985). Although these general provisions required increased co-operation for the management of transboundary fish stocks, their vagueness as to the rights of coastal states over resources of adjacent high seas or of distant water fishing nations over resources partly occurring in exclusive zones limited their effectiveness in practice. The legal regime was agreed upon at a time when the issue of transboundary fish stocks was considered of limited importance. Particularly, the problem of fishing on the high seas was thought a minor one, given their low productivity in terms of catch per area - the substantial costs of engaging in distant water fishing operations, and the resulting perception that Heels harvesting beyond exclusive zones would also need to have access to the areas under national control for their activity to be economically viable (Munro. 1991).

^{3[3]} "It has been variously estimated that as much as 99% of oceanic fish natural productivity lies in coastal waters, beyond which is a vast area, some 90% of which is almost a 'biological desert'. By the mid 1970s somewhere between 85 and 95% of the world's marine catch (estimates vary) of approaching 70 million tonnes was being taken within the putative 200-mile Exclusive Economic Zone that UNCLOS was beginning to support" (Cunningham et al., 1985).

2.1 The UN Conference on straddling fish stocks and highly migratory fish stocks.

By the end of the 1980s, however, there was renewed debate linked to both a questioning of the perception of high seas as "marine deserts" and the development of fisheries outside exclusive zones. Recent studies produced higher estimates of the ocean's biological productivity than previously thought (Lasserre, 1992), with patterns of concentration that modern technology unable to detect⁴[4]. The exploitation of these concentrations by distant water fishing fleets developed following the extension of exclusive jurisdictions which in many cases limited access to past fishing grounds, and these grounds being submitted to increasingly heavy exploitation (FAO, 1994). Consequently, the current catches of straddling and highly migratory fish appear greater than when the Convention was negotiated. According to the FAO (1994), the total reported landings of highly migratory species increased from 1.7 million tons in 1970 to 4.3 million tons in 1991, and those of species "known to straddle or likely to straddle" from 5.8 million tons to 12.4 million tons over the same period⁵[5]. While knowledge of these fisheries on a global scale remains limited, the problem of their management attracted increased attention due to the development of international conflicts, and growing concern for the impact of fisheries on the state of both target stocks and the associated species assemblages.

This growing concern was addressed in a number of recent international meetings. In particular, the issue was considered during the United Nations Conference on Environment and Development (1992), which called for an international initiative to promote better implementation of UNCLOS provisions regarding transboundary resources⁶[6]. A Conference on Straddling and Highly Migratory Fish Stocks was convened by the United Nations in December 1992 with this intention. Among the questions listed on its agenda, a central item was the definition of *minimum international standards* for the conservation of these resources on the high seas, which could also serve as recommendations for their management within exclusive zones⁷[7]. The negotiations conducted over two years led to a text unanimously agreed upon by the participants in August 1995⁸[8], which has been opened for signature at the UN General Assembly in December 1995.

2.2 Contents of the Agreement.

4[4] These include, for example, upwelling areas and discontinuities between adjacent water masses. The 200 miles boundary also left certain portions of continental shelves and slopes within the high seas, such as the "nose and tail" of the Grand Banks and the Flemish Cap in the Norway Atlantic, and some states have not claimed their exclusive rights to the 200 miles zone, leaving areas of continental shelf beyond 12 miles under high seas regime, such as in the Mediterranean, the South China Sea and the Antarctic (FAO, 1994).

5[5] Annex 1 of the convention lists the species considered highly migratory: these include the most important commercial species of tuna, billfish and swordfish, pomfrets, sauries, dolphinfish, oceanic sharks and cetaceans. The estimate of landings by straddling stock fisheries is given only as "a very order of magnitude" by the FAO (1994).

6[6] The same year, the international conference on responsible Fishing and the FAO Technical Consultation on High Seas Fishing underlined the need for a more precise regime to be defined, and in 1993 the FAO adopted the Agreement to promote compliance with International Conservation Management Measures by Fishing Vessels on the High Sea.

7[7] Doc.A/CONF.164/10

8[8] Doc.A/CONF.164.33 : "Draft Agreement for the implantation of the provisions of the United Nations Convention on the Law of the sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks" ; referred to as the Agreement hereafter.

8[9] The term "by-catch" is usually defined as the catch of non-targeted species by fishery, "discards" being the portion of those catches that are returned to sea. However, the definition of these terms is not universally accepted, especially in multispecies of commercial value and other species, particularly those considered to be endangered (D.L.Alverson et al., 1994).

The Agreement provides a comprehensive framework setting out the principles that should guide the management of transboundary marine resources and the means by which co-operation for the definition of management measures, and compliance to these measures should be achieved. Two major features of the regime are the emphasis it places on an ecosystem-based approach, and the central role it confers to the establishment of international institutions at a regional or sub-regional level.

A first important characteristic of the document is its focus on a holistic approach to the management of marine ecosystems. In line with UNCLOS, the text states that management measures should aim at promoting the optimum utilisation of transboundary fish stocks defined as that allowing to "maintain or restore stocks at levels capable of producing maximum sustainable yield, as qualified by relevant environmental and economic factors" (Art. 5.a-b). In particular, the environmental factors which need to be accounted for in the definition of management objectives comprise the impacts of fishing and other human activities on species dependent on or associated to the target stocks, and the necessity to ensure that the populations of these species are maintained or restored above levels at which their reproduction is threatened (Art. 5-d-e). It follows that management should seek to minimise pollution as well as by catch and discards of both fish and non-fish species⁹[9] and take into account the protection of marine biological diversity (Art. 5.f-g). This preoccupation is also reflected in an annex to the Agreement, which requires that scientific data be collected both on target stocks and on the ecosystem to which they belong¹⁰[10].

Linked to this holistic approach is the explicit recognition of the uncertainty that characterises transboundary resource problems, and the reference by the Agreement to the need for a precautionary approach to their utilisation¹¹[11]. This implies taking management action, even where the available information is inadequate (Art. 6.2), and that issues of scientific uncertainty and risk be explicitly addressed. Again, this is further developed in a second annex to the Agreement¹²[12] requiring that two types of precautionary reference points for management be established through agreed scientific procedures, conservation or limit reference points: selling safe biological standards within which harvesting should be constrained, and larger reference points setting the management objectives. It further requires that where information is lacking, provisional reference points be set by analogy to better know situations, until monitoring allows their revision. In addition to cautiousness in the exploitation of resources, the agreement thus places strong emphasis on the flexibility of management measures, and adaptation to evolving knowledge.

A second important feature of the Agreement is the duty it establishes for states to co-operate in the definition of compatible management regimes. Not only are they required to make their actions consistent throughout the resource's range, but this must be achieved within a "reasonable" period of time (Art. 7.2-3). To this effect, the text provides detailed guidelines for international co-operation which underline the central role to be played by regional and sub-regional organizations or

⁹[10] Annex 1 : "standard requirement for the collection, verification and sharing of data".

¹⁰[11] In the definition of management measures, states are required to "apply the precautionary approach widely to conservation management and exploitation of straddling fish stocks and highly migratory fish stocks in order to protect the living marine resources and preserve the marine environment"(Art.6.1).

¹¹[12] Annex II: "guidelines for application of precautionary reference points".

¹²[13] In line with the terms of UNCLOS and the 1993 FAO Agreement on compliance, this includes in particular the issuing of licenses for any vessel harvesting the seas and the high seas and the monitoring and control of their activities, as well as the execution of speedy investigations and sanctions in case of infraction.

arrangements, comprising states that have a "*real interest*" in the fisheries concerned (Art. 8.3). Furthermore, it explicitly defines limited access TO the resources placed under such international institutions, their exploitation being restricted to members, and countries that accept to comply with the management measures in place (Art. 8.4). In defining these arrangements and organizations, states are required to agree on their object (areas and stocks concerned), functioning (definition of participatory rights, decision-making procedures, standards for the collection and exchange of data, conditions for the acceptance of new members), and relations with other new or existing organizations. The responsibility for the enforcement of management measures rests centrally on states for the vessels flying their flags¹³[13] (Art. 17-19) and a framework for the enforcement of management measures (Art. 20-23) and the settlement of disputes (Art. 27-32) is also defined.

3. Elements of Analysis.

An important part of the literature on fisheries management focuses on situations where a fish stock is placed under the jurisdiction of a single state. In such contexts, the conventional economic approach to their regulation is centred on the identification of the level of efficient harvest, defined as that which provides the maximum net returns to inputs, compared to other sectors of the economy. The analysis seeks to determine the levels of harvest at which economic efficiency will be achieved, and to identify the measures needed to correct the failures of markets to properly guide the fishery towards these levels. Essentially, these failures originate from the lack of definition of rights to the resources, the resulting absence (or imperfection) of markets for them and the externalities that this entails. Where the resources are under the jurisdiction of a central authority, it will have the possibility of correcting these deficiencies, for example through the definition and enforcement of property rights, or through the imposition of taxes on individual harvesters. Following this analysis, the progressive extension of exclusive jurisdictions over oceanic areas can thus be interpreted as a redefinition of national boundaries seeking to give states the capacity to internalize the externalities linked to fisheries exploitation.

However, as shown above, exclusive zones have failed to define complete national control over marine resources. Parallel to their implementation there has been a progressive globalization of the issues considered relevant to fisheries management. In this context, the limitations to the effectiveness of extended jurisdiction result of two sets of problems: those linked to the mobility of fish stocks and the difficulty in assigning exclusive rights to a particular nation over their entire range, and those linked to the interactions between target stocks and the rest of the ecosystem to which they belong, and to the existence of wider transboundary impacts of harvesting activities than were originally considered. Achieving efficient utilisation of marine living resources requires that these "transboundary externalities" are taken into account in the definition of management objectives,

¹³[14] A number of cases have set precedents for the progressive of this doctrine in the international law regarding marine living resources (see birnie et al., 1994).

[15] Sandbag (1991) illustrates this by the example of the Barents Sea jointly exploited by Norway and Russia. He interprets the lack of quota recommendation for the 1991 autumn capelin fishery by the Advisory Committee of the International Council for the Exploration of the Sea as follows: "A quota recommendation for capelin, which is also a food source for cod, will involve a subjective evaluation of whether one should fish capelin or let the capelin be let as a source of food for cod. Such evaluations involve making economic choices, which ACFM is not in a position to do".

[16] Specific applications of game theoretic analysis to transboundary fish stocks are developed in Arnason et al.(1991), Kaitala et al.(1993) Armstrong (1994) and Hannesson (1995).

and that states co-ordinate their actions to this effect.

In the debates that led to the Agreement, two perspectives were opposed on how consistency in the management of marine resources throughout their range should be achieved (Munro, 1986). The first supported the principle of freedom of fishing on the high seas, considering that territorial sovereignty of coastal states was limited to their exclusive zones. According to this approach, specific international regimes would need to be developed for transboundary resources, by which coastal states would have to abide. The second advocated the necessity to preserve the integrity of resources over which coastal states have sovereign rights, and to manage the high seas portion of the fishery in consequence. The Agreement appears to be based on a third approach which has progressively become the guiding doctrine in international law governing the use and allocation of shared natural resources, the principle of equitable utilization 14[14] (Birnie et al., 1994). According to this principle, the interests of states in marine resources should be considered equally legitimate and balanced on a case-by-case basis, taking into account all the relevant factors, with the aim to arrive at specific but stable agreements. The emergence of "transboundary externalities" has thus been considered as a call for necessary co-ordination across jurisdictions, rather than for a redrawing of borders.

3.1 The definition of management objectives.

A first limitation to the effectiveness of exclusive zones is linked to the integration of the ecological interdependence of species across the existing structure of jurisdiction. As shown above, a major focus of the Agreement is on the ecological impacts of harvesting. Indeed, it has increasingly been recognized that in the case of straddling stocks, "only the target species tend to be mentioned when in reality the whole species assemblage is straddling, and all the related by catch species should also be included in any management plan" (FAG./W4). While this concern for technical interactions leading to by-catch and discards in fisheries appears predominant in the Agreement, interactions between species and potential changes in the structure of marine communities resulting from fishing activities are also considered. An important consequence of this approach is the questioning on the single species model as a "sense-giving" metaphor (Pauly, 1994) of the issues at stake in the management of marine living resources. It has been shown in the case of predator-prey interactions (May et al- 1979) that marine communities cannot be managed by applying a maximum sustainable yield concept to each species individually. Rather - if only a predator and a prey are considered - there is a range of harvesting levels for the two species which will be sustainable, and deciding which is preferable will require an explicit *value judgement* as to the relative "importance" of the two species (Clark.1984). This can be interpreted as the existence of a maximum sustainable yield frontier (Flatten. 1988) defining a set of available trade-off between levels of sustainable harvest of the two species. More generally, for cases where a greater number of species interact, Pauly (1994) shows that "the conventional view of how a multi-species resource is fished, i.e. through successive overexploitation of species along a gradient of preference and/or availability (...) can be reinterpreted as a choice between relatively large catches of the preferred species, or of the other species".

Where multi-species interactions have been considered in regulating fisheries, this appears to have changed the role of biological information in the management process, from providing fixed recommendations based on the best available information to defining a set of possible options[15]. This appears to be due to the fact that considering the impacts of harvesting on marine communities opens the management process to the concerns of multiple user groups, deriving benefits from different but interdependent segments of the ecosystem. The selection of an option explicitly involves finding a compromise between the interests at stake, and making trade-off, which can only rest on societal criteria.

The extension of the bio-economic model to this question has provided a useful means to analyze such trade-off. It considers the exploitation of marine communities as the management of a "portfolio" of resources - the objective being to maximize the net present value of the rent derived from harvesting (Flaaten-1988). The optimal utilisation pattern will depend on the relative net present values of harvesting the different species (dependent on relative prices, costs and discount rates), and the degree to which they interact. In the case of predator-prey systems, analysis developed along these lines shows that the individual harvester may lack the incentives to consider important interdependencies between species, due to the absence of clearly defined entitlements to a number of attributes of these resources (such as the value of a fish stock as a source of food for another stock). This may result in the existence of externalities, and a sub-optimal utilisation of the marine community. Hence, some form of regulation may need to be put into place, which would allow, for example the use of *fees and subsidies*, to correct the incentives harvesters, face and guide their actions towards the optimal harvesting plan (Flaaten. 1988). Regulation might for example seek to increase the harvest of the predator above its open access level, in order to increase the harvest of a valuable prey, or conversely, to limit harvest of the prey so as to ensure higher levels of a valuable predator population. Where one or several of the species are transboundary, co-ordination between states will be required for such regulation to be put into place.

Environmental uncertainty.

However, parallel to this integration of ecological interactions in fisheries management, there has been increasing departure from the assumption of stability on which the earlier models of exploited populations rested. For example, the description of tropic systems has evolved from simple and relatively stable food chains (phytoplankton consumed by zooplankton in turn consumed by fish) into complex webs of interactions, which may vary in time and space (Laevatsu et al. 1996). More generally, marine communities have increasingly been perceived as open systems, affected by non-equilibrium and potentially irreversible processes, and characterized by thresholds and discontinuities (Sharp et al., 1983). The resulting complexity makes it difficult to identify general principles guiding the long term evolution of populations and communities, and to predict their response to perturbations such as fishing, modification of habitat or pollution.

Caddy et al. (1995) give a classification of the types of uncertainty that occur in marine resource management. These are essentially error and bias in the measurement of a process: uncertainty about the extent of the process due to the short and long-term variability of marine biological systems, uncertainty about the

nature of the process itself, and "implementation uncertainty". While the last refers to the regulatory process itself, the first three types, or levels, of uncertainty can be related to the amount of experience available on the observed system (Hilborn, 1992): *noise* for predictable fluctuations of well-identified variables, *uncertain states of nature* for identified relations that the lack of experience does not allow to quantify and predict, and *surprise* which results of the misunderstanding of the processes at play. Experience in fisheries shows that the state of understanding of marine ecosystems often fails in the second, and even the third category, usually reflecting a lack of experience on how they respond to varying levels of perturbation, and leading to "a collection of alternative predictions that each appear equally credible based on the data" (Hilborn et al., 1992). The preliminary impact assessment as a condition for an action to be carried out is therefore hindered by the fact that scientific consensus on the underlying valid models may rarely be achieved, even after the collapse of a resource (Ludwig et al., 1993). This is particularly the case for multi-species fisheries, where uncertainty may prevail concerning the extent to which the species composition of harvests can effectively be controlled by management (Sainsbury, 1991).

3.2 The problem of international co-operation.

The second limitation of the exclusive jurisdiction regime is due to the mobility of many fish stocks across jurisdictions. The definition of exclusive zones as a potential solution to excess harvesting relies on the fact that the resources considered are only affected by the coastal state's harvest. This could be the case if the stock is only found in the exclusive zone of that state. It may also be the case if, while it straddles EEZ boundaries, components of the stock in each area are not affected by harvests occurring in other areas. Where these conditions do not occur, the fish stock can be considered transboundary, the allocation of exclusive rights on the resource becomes difficult, and harvesting that occurs within and outside the exclusive zone will lead to reciprocal externalities. The mobility of a number of commercially important fish stocks thus leads to the necessity to manage these resources at an international level. The main problem in such cases is that the allocation of transboundary resources between countries cannot be enforced by a supranational authority or a third party which would have the capability of ensuring an efficient outcome, rather it can only result of negotiation and must be self-enforcing (Barrett, 1993).

This type of problem has been the subject of a number of studies analyzing the nature of international competition and co-operation within the framework of game theory (Barrett, 1993). These studies explain the existence of undesirable collective outcomes in the utilization of a free access natural resource as the result of a non co-operative game in which each "player" acts according to this anticipation of the net discounted benefits derived from the resource. Each country compares its anticipated costs and benefits, the expected benefits also depending on the actions of all other countries. In deciding its level of resource utilisation, it will seek to maximize these benefits, with the expectation that all other countries also do so. The outcome of such a process, defining the total level of resource utilisation, will be stable since no country will have interest in deviating from it as long as the others do not do so. In the case of fisheries, such as outcome will usually be sub-optimal at a collective level, excess harvesting will take place by reference to that which would be achieved under management by a single

authority[16]. Hence, the total gains that would be derived from achieving international co-operation appear generally significant (Munro, 1986), as the duty to co-operate established by the Agreement seems to confirm.

Analysis of this problem has been developed using the theory of co-operative games. Where a limited number of identical players seek to enter in a binding agreement, the theory shows that co-operation will lead to a joint maximization of the discounted net benefits derived from the fishery by both countries. If only two players are considered, the set of feasible allocations of these benefits between the two countries is represented as a Pareto efficient frontier, where a country can not be made better off without benefits to the other country being reduced (Munro, 1991), and the efficient allocation will be that which maximizes the net gains to co-operation for the two countries simultaneously. Such gains will be defined by reference to the outcomes expected by each country in the absence of co-operation, which define the minimum level of benefits each requires to enter into a co-operative agreement.

The analysis then considers a number of difficulties arising from the relaxation of some of the model's hypothesis. In particular, a more realistic situation is when the two countries have differing views of what an optimal utilisation of the resource should be, one country preferring a more conservative policy than the other. In this case, the analysis shows that a compromise solution may be achieved, which favors harvest by the latter in the short term, and harvest by the former in the long term (Munro, 1991). However, the policy implications of this result are not straightforward, and an alternative solution is proposed in which the possibility of operating benefit transfers from one country to the other through the use of *aide-payment* greatly simplifies the policy problem[17]. In such cases, where differences

[17] The benefits derived from the fishery in this case are not only determined by the harvest, but may also derive from various payment by the joint-owners.

[18] The case often cited as an example is the North Pacific Fur Seal Treaty (1911): the United States, Russia, Japan and Canada reached an agreement by which pelagic sealing in open access high seas. By the latter two countries would be banned, against compensation by an annual share of the coastal catch (Munro, 1986; Barrett, 1993).

[19] The problem of more than two participants in an agreement with limited access leads to complex solutions in which the possibility for sub-coalitions must be considered (Kaitala et al., 1993), and a greater number of players may limit the possibilities to reach agreement (Hannesson, 1995).

[20] Examples of this type of problem have been analysed using principal-agent theory applied to the case of climate change (Bromley et al., 1995) and fisheries (Clarke et al., 1987).

[21] Uncertainty is considered here as different from risk, in that probabilities affected to the "states of nature" may remain unknown. However, even where probabilities are available, explaining individual decisions using expected utility theory faces a number of difficulties (Pearce, 1994).

[22] Also, there appears a need to relax the assumption that countries can be considered as displaying a unique set of preferences and objectives (Munro, 1986). Internal divisions that occur at a national level may in fact lead to ill-defined preferences at the international level.

in valuation of the fishery by the joint-owners occur, the optimal solution can be achieved if the joint-owner placing the highest value on the resource in the long run is allowed to decide the optimal harvest level, and to compensate the other joint-owner for the foregone benefits from harvesting, using side-payments[18].

A difficulty will however arise where the number of potential participants to a Fishery remains indeterminate, such as may occur on the high seas, leaving the resource under a status of free access. Achieving co-operation in such cases will be unlikely (Kaitala et al., 1993; Hannesson. 1995)[19]. An answer to this problem seems to be provided by the Agreement, which subordinates access to a resource to participation in its management, either tacitly or through negotiation. Under the new regime, access to fisheries rests on two grounds: countries must prove that they hold a "real interest" in the fishery to become members of an agreement, and they must comply to regulation measures to participate in the fishery. Hence, the effectiveness of this limitation will depend on the basis on which the legitimacy of new claims to resources will be assessed within existing agreements. It will also depend on the degree to which compliance can be ascertained.

Strategic uncertainty.

The latter issue leads to another question addressed by the authors of these models, namely that of the stability of co-operation. Such stability may be in effect limited due to the "loose" nature of an international agreement in the absence of a supra-national authority. If the possibility for participants to "cheat" exists, commitment to a long-term co-operative solution may not be achieved. The analysis of this problem within the bargaining framework shows that a stable compromise will be possible if partners establish as part of the agreement a system of "credible threats", for example the possibility to revert promptly to competition in case of defection. This will limit the incentives TO defect of each partner, such that the anticipated cost of breaching an agreement will exceed the anticipated benefits of doing so for all the parties (Munro, 1991).

However, considering international agreements as non-binding may lead to conceive a number of other important problems. For example, the effectiveness of conditional strategies such as the one just described will be linked to the capacity of each country to detect defection, and its efficiency to the costs entailed by monitoring. While the bargaining model requires that countries have perfect knowledge of each other's preferences, it is thus recognized that they may seek to conceal some of the information concerning their preferences and strategies, and that obtaining this information may prove costly. Moreover, in some cases, arriving at an agreement may change the incentives for the partners to co-operate: for example, the modalities by which transfer payments will be made may affect the outcome of co-operation (Armstrong. 1994). The existence of a degree of strategic uncertainty must thus be taken into account. This uncertainty is due to asymmetries of information, which may be used by the parties to influence the outcome of the game to their advantage. In this case, potential compensation may not be enough for co-operation to develop, in the absence of control by a supra-national authority. Hence, the problem becomes to establish an institutional framework, which will reduce the information asymmetry between partners and

minimize the costs of monitoring and enforcement[20].

4. Further Issues.

The analysis of the problem of transboundary marine resources developed within the theoretical framework previously described provides important insight into the means by which co-operation can lead to a collective optimum. A central element for this is the way in which incentives that different parties to an agreement face may be modified in order to achieve an efficient utilisation of the resources. The role of compensation instruments in this process is central, as they offer a flexible compromise solution. However, other aspects of the problem need to be considered. In particular, two important issues are the fact that countries may face a high degree of uncertainty, and the fact that disagreement may subsist on the acceptability of a co-operative solution.

4.1 Co-ordination under uncertainty.

An important assumption of the economic models developed to explain the possibility of co-operation is that preferences and the "states of nature" are given as independent vectors for the parties to an international agreement. Thus, decisions based on individual preferences relate to an existing set of long term options. The "players" possess true models of the economy which allow them to form rational expectations of the behaviour of others and to grasp the full range of consequences of their actions on the relevant economic variables (Godard. 1992). A degree of imperfection in the information available to them can be introduced such that they only dispose of a partial picture of the game. However, these imperfections result in difficulties in observing the actions effectively carried out, while the set of possible actions remains known by all "players".

To a large extent, the problems considered by the Agreement relate to situations of uncertainty[21]. As shown above, ecosystem-based approaches to marine resources management lead to a lack of consensus on the models which best represent the dynamics and response to exploitation of these resources. Assessment of the economic implications of a decision will change according to the model that is considered relevant. Hence, lack of full knowledge of the available options may lead to difficulties in assessing the potential long-term consequences of commitments to a particular management plan. While this results in a limited capacity to predict changes in the state of the ecosystem, it also appears as a consequence of uncertainty concerning the future evolution of countries' preferences, due for example to progress in knowledge, technology or consumption habits, according to the action chosen[22].

[23] Alverson et al. (1994) note that "The recent evolution of regulation regimes in many regions of the world to deal with bycatch / discarding has obviously already altered fishing practices (...) even in the absence of more quantitative evaluation of benefits and costs (...). Managers are likely to make a number of short term changes without fully recognising how such changes will impact biological economic, ecological and other societal goals".

[24] Such a change is considered to result of a possibility for players to communicate, in co-operative games.

An immediate consequence of this uncertainty is that countries may be expected to refuse agreement where the anticipated benefits of co-operating remain unknown. For example, it may be difficult to reach agreement on the optimal harvest pattern of a multi-species fishery because changes in relative prices of the different species may produce significant modifications in the evaluation of optimality (Jorgensen. 1993). Even in single-species cases, changes in migratory patterns or in the knowledge of stock distribution may lead to a different and unexpected situation, and a need for revisions of the terms of an agreement in the future (Armstrong. 1994).

4.2 The problem of initial entitlements.

A second important difficulty in arriving at international agreements on the management of transboundary resources lies in the definition of the entitlements accepted as a basis for negotiating the allocation of harvest shares or of the resulting benefits between countries. In this regard, the bargaining models previously described provide a solution based on the existing situation. However, there may be cases where countries entering into an agreement will not consider this solution acceptable, if they judge that the initial situation is not legitimate. This in turn may hinder reaching an agreement.

Caddy (1996) points to a number of factors, which would appear relevant under UNCLOS in the definition of acceptable allocations of shared marine resources. For example, a country's contribution to the "wise use" of a fish stock, through voluntary restraint of its catches effort to increase knowledge of the resource's dynamics, or actions taken to avoid damage to critical habitats and enhance the stock, could be taken into account. Another factor to which a special paragraph is devoted in the 1995 Agreement is the special requirements of developing states. Such factors might thus need to be included in the allocation of the gains from co-operation between countries, for an agreement to be judged acceptable by the parties. This work however imply that proper stewardship of marine living resources, as well as the special needs of developing countries, are accepted as common societal norms. Agreement on this may be difficult to achieve, as it would influence the distribution of expected gains from co-operation.

Another example of this problem is the way in which uncertainty is accounted for in the definition of management objectives. Within the Agreement, explicit reference is made to the precautionary approach as a central guide for the definition of management measures. According to this approach, where living systems are considered to be adversely affected by harvesting activities, uncertainty should result in a restriction of exploitation within safe limits. Although the approach has gained increased recognition as a major objective for environmental protection, its practical interpretation remains controversial. Debate over its use as a policy tool center on how safe ecological standards should be set, and preventive

[25] Hey (1991) observes that "The regime to be implemented with respect to marine mammals is a conservation regime; it does not have the dual goal of exploitation and conservation as the other regimes for transboundary marine fisheries resources do. This implies that considerations of a socio-economic nature, which are included in the objective of optimum utilisation and may justify temporary over-exploitation of a fisheries resource in the interest of obtaining a sufficient supply of food.? for example are not to play a role with respect to the exploitation of marine mammals".

conservation measures justified, but also to what extent the cost-effectiveness of these measures should be taken into account (O'Riordan et al., 1994). In its strictest definition, precaution would imply preventing any activity that could entail a negative impact on marine ecosystems, unless scientific evidence proves this impact to be negligible. The practical inconsistency of such an interpretation has been shown in different settings (O.Godard. 1995), including marine fisheries (S.Garcia, 1994). From an economic perspective, precaution has been interpreted as the adoption of "safe minimum standards" requiring a more conservative stance than traditional cost-benefit ratios would advise for (Pearce, 1994). In practice, this would imply avoiding actions on marine ecosystems that could lead to cross safe biological boundaries, unless it is decided that the costs of doing so "are intolerably large, or that other social objectives must take precedence" (Bishop, 1993). The basis for judging the acceptability of such costs however remains unclear, and may prove difficult to agree upon at an international level.

This leads to consider yet another difficulty due to the problem of uncertainty described above. Essentially, where a number of equally plausible models of the impacts of harvests on the ecosystem are available, selecting the model that best represents the current "states of nature" may be a source of conflict (Sainsbury. 1991). This is because it will also entail agreement on the factors considered relevant in the definition of an optimal utilisation of the resources, as well as on the interests considered in the allocation process. This may in turn lead to a necessity to review the existing entitlements to the resources, and in the end, affect the definition of what an optimal utilisation of these resources should be[23].

4.3 The role of international institutions.

As observed by Laurans (1996), bargaining models of international negotiations explain both the existence of undesirable non co-operative outcomes and the possibility to achieve an improved situation through co-operation, based on the same representation of the way countries operate (maximising the net present value of their returns from a resource). But in the absence of a supra-national authority, the emergence of a solution such as one based on compensation will only be possible if countries commit themselves to co-operation. Hence, a change in their attitude is required to move away from stable competitive situations, while the description of their behaviour remains the same. The models, in fact, consider a modification of the conditions in which the game operates[24].

The additional difficulties considered above point to the central role played by the institutional framework in the definition of international agreements. Following Vatn et al. (1995), "It is clear that social norms, conventions, and shared values are necessary components in helping individuals to establish their identity in a community, to provide 'reasonable' solutions in certain situations, and to structure or frame necessary choices". The 1995 Agreement requires that arrangements between states clearly establish their object, the conditions for access to new participants, the economic and environmental factors considered relevant and the decision-making procedures. Thus, nations must not only be considered as agents making decisions within a given set of rules, but also as actors defining the framework of the game, in a context of environmental uncertainty. This bears

similarities with the situations of "controversial risk" that have been analyzed for global environmental problems such as climate change (O. Godard. 1992). The main characteristic of international co-ordination in such situations is that it does not rest on stable social, technical and natural contexts, with a shared representation of the states of the world and of the causal relationships at play. It is thus best represented as a self-organizational process (O. Godard. 1995).

4.4 A case study.

An example of the difficulties considered in this section is the treatment granted to marine mammals in the current international legal system. Under UNCLOS, a special case was made for these species, allowing for stricter regulation (Birnie et al., 1994). This reflected growing claims for their preservation from direct or indirect take for reasons other than the sustainability of commercial harvests[25]. Although it remains unclear whether these claims are accepted as a legitimate basis for managing marine resources in the international law (Birnie et al., 1994), a number of recent cases involving marine mammals illustrate the fact that they are part of the debate. The controversy that surrounds the continuation of the global moratorium set on commercial whaling by the International Whaling Commission (IWC) in 1986 provides a good example. While its justification was originally based on concern for the status of whale populations and lack of adequate information, new factors have emerged to justify maintaining a ban on whaling, in addition to the development of "low-consumptive uses" of sea mammals. A growing view is that these species should be protected for reasons other than their actual or potential use. In this perspective, a permanent moratorium could be based on animal rights or animal welfare considerations (Conrad et al., 1993). While the former would imply the recognition of an "intrinsic value" of marine mammals at an international level[26], the latter would imply the integration of the "non-use" value of species in the definition of their optimal utilisation, thus giving them attributes of a public good (Kuronuma et al., 1993). However, these considerations are far from being shared by all countries member to the IWC[27].

At a regional level, the case of the Eastern-Tropical Pacific purse-seine Fishery for yellow-fin tuna in association with dolphins is a well-known example of such considerations significantly modifying the objectives of fisheries management. Specific regulation measures aimed at reducing the accidental catches of dolphins were developed under the initiative of the United States, and extended at an international level through the Inter-American Tropical Tuna Commission (IATTC) in the mid-1970s[28]. The result has been an important reduction in annual dolphin

[26] Accepting the "intrinsic value" of a species would imply it has a "right" to exist independently of human preferences.

[27] opposition to them is justified, for example, by the special interests of coastal communities and the cultural importance of whaling in certain countries.

[28] The conflict between fishing and the protection of sea mammals has significant economic implications, as tuna is one of the most valuable commercial species harvested in the world, and the ETP is a significant area of production (Strand et al., 1994). It also affects other fisheries: in 1995, the US implemented new regulations which require the annual publication of a list of all US commercial fisheries with a statement of their level and type of impact on marine mammals species. For those where impacts are considered to be significant, vessels must register with the National Marine Fisheries Service and carry observers if requested to (National Marine Fisheries Service, MMPA Bulletin (7), Jan-Feb. 1996).

[29] Although measuring willingness to pay in this case would appear a seriously complex exercise (Strand et al., 1994).

mortality in the tuna fishery (Joseph. 1994). Parallel to this, the United States adopted a "dolphin safe" label and a number of embargoes against states whose fleets continued using the fishing technique in the early 1990s (Joseph, 1994; Strand et al., 1994). Among the elements of conflict, opposition between a complete moratorium on the fishery, and emphasis on the technological improvements seeking to reduce dolphin mortality to minimum levels, were developed as a central issue (Joseph. 1994).

Again, the rationale for protecting dolphin populations could be a recognition of their "intrinsic value", or of their public good characteristic. In the former case, fundamental divergences in ethical norms may hinder reaching agreement on an acceptable level of dolphin mortality. In the latter case, a link would be established between the level of dolphin mortality and the utility of countries concerned with animal welfare. In principle, it would appear possible to apply the bargaining models presented above and identify compromise solutions, based on compensation payments. However, the nature of the compromise would depend on the situation accepted as a starting point for negotiations (Kuronuma et al., 1993). Two situations could be considered, If the right to harvest tuna in association with dolphins is accepted, as an international norm. The problem should be termed as assessing the willingness to pay of countries seeking lower levels of dolphin mortality, in order to compensate the costs of adapted fishing techniques or of a ban of "dolphin-fishing"[29]. If, on the contrary, the fishing technique is judged unacceptable, the problem should be to assess the willingness to accept payment of the same countries, from those seeking to harvest tuna in association with dolphins. Thus, part of the compromise would be to agree on the starting point of the negotiations, and "who bears the costs" of reduced dolphin mortality. The length of the conflict that has opposed the United States to South American countries in the case of the ETP tuna fishery appears to illustrate the difficulties in obtaining such an agreement.

Following this line of analysis also leads to another observation. General and applied valuation studies based on revealed preferences methods have shown that an individual's potential gain and losses for a similar change in the provision of a public good may not be valued equally. Essentially, gains will be granted more importance than losses (Mitchell et al., 1989). If this is the case, the institutional setting in which bargaining takes place may influence the definition of an efficient outcome in the economy: whether or not the "non-use" value of marine mammals is accepted as a relevant factor in the international management of the ETP fishery may influence the definition of their "optimal utilization".

In the case of the ETP tuna fishery, a number of other issues would need to be taken into account. These concern uncertainty about both the ecological and the economic impacts of different management options. Debate has been developed, for example, on the consequences of an international ban of "dolphin-fishing" on the marine ecosystem of the region. This is due to the fact that other fishing techniques induce higher and less well monitored by-catch of other species such as sharks and bill-fish (which are exploited by other commercial and recreational

[30] Catching 'dolphin-safe' tuna has been estimated to imply a 35% to 50% decrease of the vessels potential harvests, in 1991 and 1992. Gross earnings of vessels fishing on dolphins were 88 percent greater than those of vessels that fished "dolphin-safe" (Joseph, 1994).

[31] The "Declaration of Panama" was signed in October 1995 by twelve countries involved in the fishery, including the United States and a number of South American states, and supported by major environmental organisations. It is one of the first international agreements adopted after the Agreement on Highly Migratory and Straddling Fish Stocks.

fisheries) (Joseph. 1994). Moreover, concern has been expressed by the IATTC on the fact that seining for tuna not associated with dolphins would result in catches of lower size and commercial value. This would lead to reduced benefits from fishing operations, and unknown consequences on the tuna stocks[30]. However, the extent of these potential consequences remains uncertain since the reaction of fishing fleets to a ban on "dolphin fishing" may also be to leave the fishery. Finally, the effectiveness of US trade sanctions in reducing "dolphin-fishing" has been questioned, as they have led to the development of alternative markets by countries under embargo, thereby modifying relative bargaining powers (Strand et al., 1994).

No attempt is made here to investigate these questions in detail; this limited characterization of the case study only intends to illustrate some of the issues previously mentioned concerning the problems of achieving international co-operation. The approach taken recently by the countries involved in the ETP tuna fishery has been to agree on an international management system which both defines legal limits to dolphin mortality and sets out a schedule for progressively reducing it, while improving the knowledge of ecological impacts of the different fishing methods, and developing adaptations of the fishing techniques to minimize them[31]. Emphasis is thus placed on a sequential approach to the management problem, and on the means to build up experience about the ecosystem and the fishery. Part of the compromise is a call for the lift of the US ban on "dolphin-fishing" and trade embargoes.

5. Conclusions.

Following the Agreement on Highly Migratory and Straddling Fish Stocks, international institutions may be expected to play an increasingly important role in the regulation of fishing activities. Associated with the globalization of issues considered by the Agreement is a shift of focus from scientific consensus to uncertainty and risk as an element that these institutions should be able to deal with. This leads to a number of questions regarding how co-operation may emerge, while at the same time provide the flexibility required by evolving knowledge and a changing environment.

In the analysis of international co-ordination for the problem of global change, analysts have pointed to possible ways of dealing with these questions (Godard, 1992). In their analysis, institutions are considered as means to "stabilize" the environment in which countries operate through agreement on temporary revisable objectives of co-operation. The long-term stability of such institutions rests on the definition of agreed upon procedures for revising objectives in the future and the progressive construction of a collective experience. Indeed, such a learning process has been considered to explain the emergence of international fisheries agreements, even where the initial possibility of co-operation appeared limited and although it required an extensive period of time (Munro. 1986). Adopting this approach to international co-operation implies considering agreements as sequential, open-ended processes, and emphasis is placed on the value of expected information, the anticipated possibilities of learning and the capacity to adapt to changes not initially considered.

The interpretation of the precautionary principle by the Agreement would appear to be consistent with this approach: it requires in particular that states agree on the procedures for collecting and sharing information, and for revising management reference points when necessary. In the case of the ETP tuna fishery, the recent international agreement seems to be centered on such procedures. Essentially, it focuses on immediate, but transitive, solutions to be adopted, and defines a revisable schedule for the future. While the first action may not be considered the long-term optimal solution from the current perspective of the different parties to the agreement, it could be seen as introducing a degree of flexibility which allowed agreement to be reached.

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