Chapter 3.

Getting the economics and the incentives right:

Instrument choices in rebuilding fisheries

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Abstract

It is now generally agreed that all natural resources, including marine capture fishery resources, are properly regarded as "natural" capital. From this it follows that, when one talks about rebuilding capture fishery resources, one is talking in terms of a "natural" capital investment program. After discussing the basic economics underlying an optimal fisheries capital investment program, the chapter will go on the discuss the incentive structures that are to be in place, at both an intra-EEZ level, and at an international level, if the resource investment program is to be successful. This chapter will draw heavily upon work that the author has been doing for the FAO, in conjunction with The World Bank and FAO study: The Sunken Billions: The Economic Justification for Fisheries Reform.

Introduction

In reviewing the economics of the rebuilding of marine capture fishery resources, we commence with the fundamental proposition that these resources, like all natural resources, constitute capital assets – "natural" capital – from the point of view of society. Consequently, a fishery resource rebuilding program is an investment program, with all that that implies.

In order for such an investment program to succeed, appropriate incentive structures must be in place. All investment in real capital involves a cost that is incurred today in the hope of a return – a payoff – at some point in the future, with the return, or payoff, being very much an expected return/payoff. If the right incentives are not in place, the cost of investment will not be willingly borne.

It will be argued that the relevant incentives have to be viewed, both from an intra-EEZ perspective – incentives involving fishers – and from an international perspective – incentives involving fishing states and entities. It will be further argued that there is a key interrelationship between the two sets of incentives.

This chapter draws heavily upon work that the author has been undertaking for the FAO, in conjunction with the World Bank and FAO study: *The Sunken Billions: The Economic Justification for Fisheries Reform* (World Bank and FAO, 2008).

Fishery resources as capital and the basic economics of rebuilding fishery resources

The Work Bank in its 2005 report, *Where is the Wealth of Nations?* Measuring Capital for the 21st Century (World Bank, 2005), maintains that both the current national income, and the future development, of any nation rest upon that nation's portfolio of real (as opposed to financial) capital assets, where a capital asset can be defined as any asset capable of yielding a stream of economic returns through time. The national real capital portfolio is seen by the World Bank to consist of produced, natural and intangible capital assets, with the latter to be seen, in turn, as a mix of human and social capital. Development is to be viewed as a process of real asset portfolio management through time (World Bank, 2005).

The World Bank 2005 report divides natural capital into two components, exhaustible natural resources, such as hydrocarbons and minerals, and living, or renewable, natural resources. Renewable natural resources, unlike exhaustible natural resources, are capable of growth and are, as a consequence, capable of providing a sustainable flow of net economic benefits (resource rent in common parlance) into the indefinite future. They are, to quote the World Bank, "truly a gift of nature" (World Bank, 2005, ibid.). Marine capture fishery resources constitute a segment of the world's stock of natural capital, in the form of renewable natural resources, and are thus "truly a gift of nature."

Sustainable harvesting of a renewable resource, such as a capture fishery resource, involves, in simplest terms, the skimming off the net natural growth of the resource. Within limits, positive investment in such fisheries capital can be achieved by harvesting less than the net natural growth of the resource, with the maximum rate of resource investment being achieved by setting the harvesting rate equal to zero, i.e. declaring a harvest moratorium.

In examining any proposed real capital investment program, economists have to ask themselves two questions.

- What is the optimal, or target, stock of capital?
- What is the appropriate rate of investment; should one approach the target stock as rapidly as possible, by investing at the maximum rate, or should one approach the target stock at a more gradual rate?

The basic economics underlying these two questions, as they apply to capture fisheries capital, was developed some thirty plus years ago (Clark and Munro, 1975; Clark, Clarke and Munro, 1979). The answer to the first question, which is really just an application of the economist's theory of capital, focuses on the cost of such investment - forgone harvest opportunities today – versus the payoff from such an investment. The payoff is seen in terms of the discounted stream of (expected) additional sustainable resource rent (i.e. the present value of such resource rent), arising from the addition to the resource stock. Resource rent, let it be added, should properly be very broadly defined to include all non-market, as well as market, economic benefits flowing from the resource.

The key investment decision rule just says go on investing in the fishery capital up to the point that the cost of the marginal investment in the resource is just equal to the payoff – the present value of (expected) additional sustainable resource rent arising from the resource investment. Another way of stating the investment rule is to say; invest up to the point that the yield, or rate of return, on the marginal investment in the resource, expressed in percentage terms, is equal to the rate of return on alternative investments of comparable degree of risk[1] (Clark and Munro, 1975). Remember that fisheries capital is just one class of assets in the social manager's real capital portfolio.

What assurance do we have that the attempts at resource investment will, in fact, have a positive resource rent payoff? There are two issues that have to be addressed. The World Bank/FAO report, *The Sunken Billions*, in its estimate of resource rent loss, operates on the assumption that "existing biological overfishing is entirely reversible in the long run" (World Bank and FAO, 2008). The assumption is of questionable validity for a non-trivial number of fishery resources. There is evidence of depleted fishery resources that, either cannot recover to their former levels of abundance, or can be expected to do so, only after several decades (Hutchings, 2000; Clark, Munro and Sumaila, forthcoming). What is required then is investigation into what constitute what we might term a feasible set of fishery resource investment opportunities. This is more of a task for marine biologists, than it is for economists.

Secondly, suppose that we have before us our feasible set of fishery resource investment opportunities, but suppose that our fisheries management regime is such that, should we succeed in rebuilding some of these resources, any resource rent arising from the rebuilt resources will just leak away. The leakage could occur, for example, through uncontrollable build up of excess capacity in the fisheries – a not unknown occurrence.

In terms of our basic economics of investment in fisheries capital, this leakage could undermine the resource investment program. Indeed, we could go further and say that the leakage might be downright dangerous to the investment program.[2]

The answer to our second question on the appropriate rate of resource investment (assuming that we have a resource capital target worth aiming for) is much more complex. It is critically bound up with, to use some jargon, what economists call "malleability" of capital, where the relevant capital in this case is produced capital in the form of fleet capital and processing sector capital, and human capital, in terms of fishers and other workers involved in the fishery. "Malleability" of capital refers to ease with which such capital can be shifted in and out of the fishery, and is analogous to the concept of "liquidity" in the world of finance.

As a general rule of thumb, once the target stock of capital (of any form) is identified, one should move towards the target with all possible speed, unless there are penalties associated with rapid rates of investment. The most rapid rate of resource investment (positive) is achieved, as we have noted, by declaring a harvest moratorium, i.e. setting a TAC equal to zero. If the fleet/processing capital and human capital are highly "malleable" from the perspective of the fishery in question, then a rapid rate of resource investment is generally optimal in economic terms.[3]

If the aforementioned forms of capital are less than perfectly malleable – it is difficult and costly to shift the fleet and the workforce from the fishery – then we know that declaring an outright harvest moratorium will be socially disruptive and costly. It is also turns out to be bad economic policy as well. To achieve the maximum economic returns from the resource through time, a slower, less drastic, rate of resource investment is in order (Clark, Clarke and Munro, 1979).[4]

The prima facie case for a worldwide capture fishery capital investment program

Where do we currently stand in economic terms with respect to the existing stock of capture fishery capital? For answers, we turn to the World Bank/FAO report, The Sunken Billions (World Bank and FAO, 2008). The report argues that the world is losing resource rent from these resources at a rate of USD 50 billion per year, because of less than optimal resource management. It would be one thing, if the report is stating that, while the world capture fishery capital is yielding a positive resource rent return, the return could be higher. A close reading of the report reveals that what it is actually stating is that the current yield on world capture fishery capital is negative (World Bank and FAO, 2008, Table 5). While there are some prosperous capture fisheries, from an overall standpoint, the world capture fisheries capital is to be seen as a set of non-performing assets.

The report also estimates that, in order to achieve an economically optimal outcome, there would have to be a two to threefold increase in the capture fishery biomass (World Bank and FAO, 2008, ibid.). In other words, the report is implying that a major marine fisheries capital investment program is indeed in order.[5] Let it be repeated, however, that some of the implied investments may be infeasible on biological grounds and secondly that, if appropriate fishery management structures are not in place, the resource investment program could prove to be futile from an economic perspective.

To gain a better understanding of the management structures, the incentive schemes, that are required, we need first a better understanding of how we arrived at our current state of affairs. Most know about the problems arising from the "common pool" nature of capture fishery resources, but not all recognize that, until the turn of the 20th century, few, if any, worried about the overexploitation of ocean capture fishery resources.

Origins of the overexploitation of capture fishery resources and the loss of resource rent

It has long been recognized that marine capture fisheries are very difficult to manage effectively. The fish, by and in the large, cannot be seen prior to capture; the fish are, with few exceptions, mobile. There are, moreover, species interactions and the effects of environmental shocks that are unobservable. As a consequence, it was, in the past, difficult, or more to the point costly, to establish effective property rights to the resources, be these property rights private or public. Capture fishery resources were seen as the quintessential "common pool" (open to all) resources.

Up until the 20th century, the inherent, and inescapable, difficulties of capture fisheries management did not seem to matter a great deal. Capture fishery resources were viewed as "free capital," beyond overexploitation. Arguably, one of the greatest of the biologists to emerge in 19th century Britain was Thomas Huxley, who served for a time as Inspector of Fisheries, during the 1880s. While in that position, he stated the following:

The cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all of the great sea fisheries, are inexhaustible: that is to say that nothing we do seriously affects the number of fish. And any attempt to regulate these fisheries seems consequently ... to be useless: (Gordon, 1954).

The belief that the great sea fishery resources are inexhaustible had helped to enshrine the "common pool" nature of high seas ocean fisheries in international law, in the form of the Freedom of the (high) Seas, first set forth in the early 17th century. The high seas were seen to consist of all ocean waters beyond the narrow coastal state territorial seas (historically extending out from shore to only three nautical miles).

Under the Freedom of the Seas doctrine, the resources of the high seas, including fishery resources, were deemed to be res communis. That is to say they were to be seen as the property of all (Orrego Vicuña, 1999). The belief in the inexhaustibility of the ocean fishery resources had an economic basis. When the doctrine of the Freedom of the Seas was propounded in the early 17th century, the state of fisheries technology was such that heavy exploitation of high seas fishery resources was prohibitively costly (not to say dangerous). This remained more or less true until after the mid-19th century.

The economic protection of high seas fishery resources was, in fact, beginning to fray, even as Huxley spoke in the early 1880s. Fishing technology was changing rapidly, bringing with it a fall in harvesting costs. The shift from sail to steam is a prime example.

The vanishing of this economic protection, and the transformation of "free" natural fisheries capital to scarce natural capital, took time to be recognized fully. While there were a few attempts at serious capture fishery resource conservation in the early 20th century, such as in the North Pacific fur seal fishery (1911) and the Pacific halibut fishery (1923), the management of ocean fisheries remained minimal, until after the close of the Second World War (National Research Council, 1999).

Once the economic protection of ocean fishery resources had been stripped away by fisheries technological progress, the perverse (from society's point of view) incentive consequences of the "common pool" nature of the resources then manifested themselves. The primary consequence pertains to investment/disinvestment in this form of natural capital.

From our brief discussion of the economics of capital and investment, it is clear that no rational investor will undertake an investment, unless the expected stream of net economic returns from the investment, (discounted at the appropriate rate of interest) – the present value of the net economic returns – is at least equal to the cost of the investment. In a "common pool" fishery, an individual fisher can count on no positive return on an investment in the resource. If a fisher refrains from harvesting in order to build up the resource, he/she may do nothing more than increase the harvests of his/her competitors.

It can be shown that, in such fisheries, fishers will act as if they are applying a rate of discount (interest) to future returns from the fishery equal to infinity. Tomorrow's returns from the fishery count essentially for nothing (Clark and Munro, 1975). This, in turn, means that the rational fisher is given every incentive to treat the resource as a non-renewable resource, namely as a resource to be mined.

A striking example, to which we shall return again, is provided by the Norwegian Spring-Spawning Herring resource of the North Atlantic. The resource has intense schooling tendencies, which makes it very vulnerable to over-exploitation (Bjørndal, 2008).

Segments of the resource, in the middle of the North Atlantic, were, until the 1960s, protected economically from gross overexploitation. By the 1960s, however, technological developments in fishing led to this economic protection being eliminated.

The International Commission for the Exploration of the Sea (ICES) estimates that the minimum level of spawning stock biomass (SSB) of the resource, below which it should not be allowed to fall, is 2.5 million tonnes (Bjørndal, 2008). In the late 1960s, the evidence of gross overexploitation of the resource, of the clear breaching of this minimum, became overwhelming. A harvest moratorium was declared. The SSB continued to decline, reaching an estimated low of 2 thousand tonnes in 1972, i.e. 0.08%of the ICES declared SSB minimum. In other words, the resource had been mined almost to the point of extinction (Arnason, Magnusson and Agnarsson, 2000). The herring resource, partly through good fortune, was to recover, but only after a 20 year harvest moratorium.

The growing recognition, after the end of World War II, of the fishery resource mining problem led to responses, such as domestic and international controls on harvesting, and the placing of much of the ocean capture fishery resources under coastal state jurisdiction, through the implementation of the EEZ regime under the 1982 UN Convention on the Law of the Sea. That these measures have been less than entirely successful is evidenced by the continued mining of the resources.

The controls on harvesting, domestic and international, did nothing to change the fisher incentives to mine the resources, and did nothing to halt the harvesting cost reducing advances in fishing technology. As harvesting cost fell through time, fishery resources, hitherto enjoying economic protection, became open to exploitation, thereby necessitating yet further harvest controls. Typically, the new controls have been implemented, only after extensive resource overexploitation has already occurred. With the perverse fisher incentives in place, there has, in effect, been a race between harvest control measures and advances in fishing technology.

There is more. Many fishery resources should be viewed as spatially linked sub-stocks (Sanchirico and Wilen, 2005). If the sub-stocks far from shore are commercially un-exploitable, then these sub-stocks constitute natural reserves, which protect the stock

complex from severe overexploitation. With fisheries technological advances, and the ongoing fall in harvesting costs, what was hitherto commercially un-exploitable, becomes profitable to exploit. The natural reserves disappear, and the stock complex becomes vulnerable, for example the Norwegian Spring Spawning Herring.

Even where harvest control measures have been effective in halting the mining of the resources, the control measures, when applied in the past, often had destructive economic consequences. Introducing harvest controls through the implementation of TACs, or the equivalent hereof, and doing nothing else, all but guarantees the emergence of excess fleet capacity and severe economic waste.

As is well known to economists, in these circumstances the restricted season by season harvest becomes the "common pool," with the almost inevitable consequence of the build-up of excess capacity and concomitant reduction of season length. The cost magnifying consequences of redundant capacity and sharply reduced season lengths can easily lead to the full dissipation of resource rent.

The usual response to the competition for shares of the "common pool" harvest – the "race for the fish" - is to introduce measures to restrict the number of vessels allowed to engage in the fishery. These schemes, commonly referred to as limited entry, or license limitation, schemes, are often accompanied by decommissioning schemes designed to remove excess fleet capacity built up before the introduction of license limitation.

Traditionally, under such license limitation schemes, the owners of the licensed fishing vessels are allowed to compete for shares of the TAC, or the equivalent. It seemed clear that, if the fleet was reduced to a size commensurate with the expected TAC, nothing more was required.

The experience in many such fisheries has been that effective fleet capacity is, in fact, very difficult to control. With the fishers competing for harvest shares, capacity continues to grow, even if the number of vessels remains constant. Fishing capacity has many components. Controlling all of them is beyond the capabilities of most resource managers.

An example is provided by the Canadian Pacific halibut fishery. The Canadians share the Pacific halibut resource with Americans, in Alaska. At a very early stage, 1923, Canada and the United States established a cooperative resource management arrangement (International Pacific Halibut Commission), which produced exemplary results, in terms of resource conservation.

In 1979, after Canada had implemented its EEZs, the Canadian authorities introduced a limited entry scheme for its share of the Pacific halibut fishery. The licensed vessels competed for shares of the halibut TAC.

Over the following decade, the number of vessels remained effectively controlled. The actual resource harvesting capacity was not controlled, however. The harvesting season steadily decreased, clearly indicating growing capacity. The Pacific halibut harvest season has a maximum length of about 240 days per year. By the end of the 1980s, the season length had been reduced to 6 days per year.

There was no evidence of resource depletion. Indeed, the TAC was actually increased over the decade because of increased resource abundance. With respect to economic rent, however, such evidence as exists suggests strongly, that, once resource management costs are factored in, the resource rent being generated by the fishery was distinctly negative (Munro, Turris, Clark, Sumaila and Bailey, 2009). The potentially valuable Pacific halibut resource was, from the Canadian perspective, a non-performing natural capital asset.

All of these problems of overexploitation and economic waste have been seriously aggravated by subsidies, often introduced to relieve the economic distress arising from overexploitation and economic waste. Not all subsidies are harmful. It has been estimated, however, that approximately 50% are damaging both biologically and economically (Munro and Sumaila, 2002), by serving to intensify the aforementioned perverse fisher incentives. *The Sunken Billions* report estimates, for example, that subsidies that have a direct impact on fishing capacity, and that are definitely harmful, are in the order of USD 10 billion per year (World Bank and FAO, 2008, Table 1).

There is finally a major source of difficulty in the management of capture fishery resources, and a significant contributor to fishery resource overexploitation, that has come to be recognized fully, only following the advent of the EEZ regime. The establishment of the EEZ regime was seen as placing large amounts of hitherto "common pool" capture fishery resources under coastal state jurisdiction. Most capture fishery resources are mobile, however, with the consequence that the typical coastal state finds that it is sharing some of its EEZ fishery resources with neighbouring coastal states (transboundary stocks) or with distant water fishing states (DWFSs), in the high seas adjacent to the EEZ (highly migratory and straddling stocks). It can be easily be demonstrated that, if states sharing such resources do not cooperate effectively in the management of the resources, the outcome may well be comparable to a classic open access fishery, i.e. resource overexploitation (Munro, Van Houtte and Willmann, 2004; Lodge, Anderson, Løbach, Munro, Sainsbury and Willock, 2007).

Indeed, the lack of effective cooperative management of highly migratory and straddling stocks, and the resultant resource overexploitation following the close of the UN Third Conference on the Law of the Sea in 1982, led to the UN convening another international conference to address the management of these resources, the 1993-1995 UN Fish Stocks Conference. The 1995 UN Fish Stocks Agreement (UNFSA, 1995), arising from the Conference, has led to the now ongoing implementation of the Regional Fisheries Management Organization (RFMO) regime (UN, 1995).

What the 1995 UNFSA does not address are the remaining discrete high seas stocks. Hitherto, most of these stocks had not offered commercially viable fishing opportunities, in other words they had enjoyed economic protection. The history of world ocean capture fisheries provides all but absolute assurance that the protection will prove to be temporary.

The significance of these shared fish stocks, transboundary, highly migratory, straddling and discrete high seas, is not trivial. It is estimated that harvests of these stocks may account for as much as one-third of the global ocean capture fishery harvests (Munro, Van Houtte and Willmann, 2004). Thus, in looking to incentive structures that will lead to successful investment in capture fishery resources, particular attention will have to be given to internationally shared fish stocks.

Getting the incentives right: Intra-EEZ considerations

In this section we shall confine ourselves to a discussion about the incentives necessary for successful investment in capture fishery resources from a strictly intra-EEZ

basis. The resources under consideration are either not shared, or if shared, are such that the sharing is found to lead to no management complications.

The very first step is to introduce a management regime, an incentive scheme that will ensure that the fishery is capable of generating resource rent. The point has now been made that, if a fishery capital investment program is undertaken, in which the additional resource rent proves to be no more than a temporary, the investment program could be fatally undermined from the outset.

We shall illustrate the issues at hand by first discussing two cases, in which rent loss and rent re-capture, were by accidents of history isolated from resource depletion. The author can claim some knowledge of these cases due to a study commissioned by Fisheries and Oceans Canada (Munro, Turris, Clark, Sumaila and Bailey, 2009). These cases will then be followed by reference to two other cases in which there had been resource overexploitation, and in which the correction of incentives brought the resource overexploitation to an abrupt halt.

The two cases to be examined in detail are the Canadian Pacific Halibut fishery and the British Columbia sablefish fishery. The conservation of the Pacific halibut resource has been the joint responsibility of Canada and the United States since 1923. The joint conservation of the resources, which has been exemplary, causes no management difficulties for Canada. The advent of the Canadian and American EEZ regimes in the late 1970s allowed each state to manage its share of the TAC. Canada introduced a then standard limited entry scheme for its share of the halibut fishery, in which the number of vessels in the fishery was strictly limited, with the licensed vessels then competing for shares of the TAC.

The British Columbia sablefish fishery was essentially a post-EEZ fishery for Canada. Strict TACs were introduced, along with a limited entry scheme mirroring that for the Canadian halibut fishery. The resource was effectively conserved (Munro *et al.*, forthcoming).

Several years ago, the FAO introduced the concepts of Incentive Blocking and Incentive Adjusting approaches to fisheries management (FAO, 1999). The former approaches concern measures designed to prevent fishers from responding to the perverse incentives described earlier. Incentive Adjusting approaches are concerned with measures designed to transform perverse fisher incentives into benign ones. Both the imposition of TACs and the limited entry schemes described could be seen as Incentive Blocking approaches. In the case of the two fisheries under consideration, the Incentive Blocking approach in the form of TACs was undoubtedly successful in conserving the resources.

In attempting to analyse the history of the two British Columbia fisheries, the Munro *et al.* study undertaken for Fisheries and Oceans Canada employs two closely related modes of analysis. The authors of the study note one inescapable fact of life in the two fisheries, namely the strategic interaction between and among the fishers, and between the fishers as a group and the resource managers, which in the case of Canada are to be found wholly within Fisheries and Oceans Canada. The obvious mode of analysis then is the theory of strategic interaction, more popularly known as the theory of games, which has been used extensively in the study of international fisheries (Munro, Van Houtte and Willmann, 2004).

There are two broad categories of games: non-cooperative, or competitive, games; and co-operative games. In co-operative games, the "players" are assumed to be coldly rational, with each "player" being prepared to cooperate, only if it believes that it will be better off by cooperating, than it would be by playing competitively. The stability of such co-operative games is always at risk of being undermined by "player" non-compliance (cheating), and by free riding, which can be defined as the enjoyment of the fruits of co-operation by non-participants in the game (i.e. poaching). The concepts of non-cooperative and cooperative games will be seen of relevance to the strategic interaction among the fishers.

Within the theory of games, there is a sub-class of non-cooperative games known as leader-follower games, a version of which is referred to as Principal Agent analysis (PA analysis), used widely by economists, in many fields. PA analysis is of direct relevance to the interaction between the fishers in the two British Columbia fisheries and Fisheries and Oceans Canada.

The principal, be it a person, a firm, a country or a state/province, wishes to see undertaken certain tasks that it is unable to do itself, and so acquires the services of one, or more, agents to undertake these tasks. Classic examples are an owner of a firm hiring a manager, and a landlord leasing farm land to a tenant farmer. The PA analysis has application far beyond these simple examples, e.g. industry regulators and the firms being regulated (Sappington, 1991).

In any event, in the context of Canadian fisheries, Fisheries and Oceans Canada could be seen as constituting the principal, while the fishers constituted the agents. The PA paradigm can be formally described as follows (Clarke and Munro, 1987).

A strict hierarchical relationship exists in which the principal (leader) chooses an incentive scheme (e.g. set of regulations) to be applied to the agents (followers). The principal's incentive scheme, along with the actions taken by the agents, determines both the returns to the agents and to the principal. As seen from the perspective of the principal, a first best situation exists when the principal can, at minimal cost, contractually and enforceably specify the actions of the agents. Wishes, urges and desires of the agents, contrary to the best interests of the principal, are entirely suppressed. The agents are essentially robots.

In the normal second-best situation, the principal lacks the power, or more to the point finds it too costly, to force a set of actions upon the agents. The agents thus have some freedom of choice. The principal can hope to influence the agents' choices, only indirectly through the incentive scheme. This gives rise to the concept of an incentive gap, which is the difference between the actual return to the principal, and what it would receive under a first-best situation. It reflects the insufficiency of the principal's incentive scheme in compensating for its inability to monitor perfectly the agents' actions. At the heart of the PA problem is monitoring imperfection (Clarke and Munro, ibid.).

Consider now these two closely related modes of analysis in the case of the two British Columbia fisheries. The comfortable view of many economists at the beginning of the 1980s was that, while there would be competition among the licensed fishers in a limited entry fishery, the competition (interaction) would be very limited and easily controlled. If the vessels plus crew had been identical, if input substitution in the fishing fleet had been impossible, and if the technology had been frozen, in the two Canadian fisheries, then indeed the competition (interaction) would have been very limited and easily controlled. None of these conditions held. Technology, for example, was anything but frozen in the two fisheries. The result was that circumvention of the intent of the limited entry scheme was feasible, which meant, in turn, that competition among the licence holders was definitely possible. Even if all fishers had been aware that such

competition was mutually harmful, in terms of their economic returns from the fishery, each and every fisher would, in the absence of scope for meaningful co-operation, have had no option but to compete. Any fisher, who held back from competing, was all but guaranteeing the loss of a part, if not all, of his/her share of the TAC.

One of the most famous of all non-cooperative games is known as the Prisoner's Dilemma, which derives its name from a story told by the author to illustrate his point. The author's point is that, in a non-cooperative game, the "players" will be driven to adopt strategies that they know are harmful. In the situation described in the two fisheries, the fishers were engaged in what might be described as a non-cooperative sub-games, which provided, in turn, almost text book examples of the Prisoner's Dilemma.

In both fisheries, season lengths declined to small fraction of their potentials, indicating severe excess capacity. While no precise estimates were possible, one could conjecture, as has been noted, that the resource rents, from a national perspective, were negative and that the Pacific halibut and sablefish resources were properly classified as non-performing natural capital assets. The authors of the report state that, in PA terms, the non-cooperative sub-games among the fishers had led to a yawning and unsustainable incentive gap. Out of desperation, Fisheries and Oceans Canada, with industry support, shifted to an Incentive Adjusting approach in the form of IQs, later to become ITQs (Munro, *et al.*, ibid.).

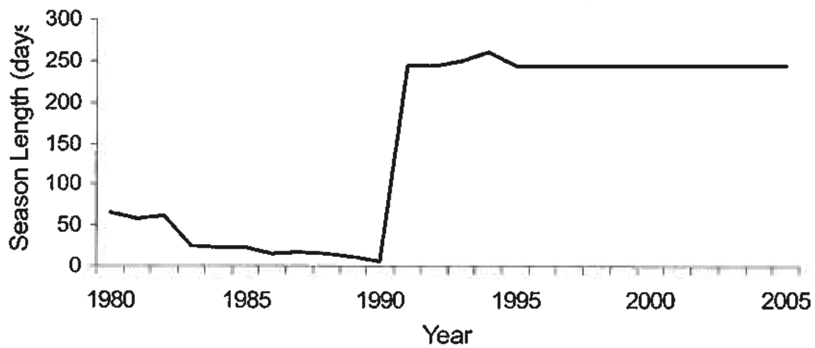
The authors of the study then ask, if there was any evidence that the ITQs eliminated strategic interaction among the halibut fishers, or the among the sablefish fishers. The answer is that there was no such evidence. They conclude that, if the IQ schemes do no more than re-establish non-cooperative games among the two sets of fishers, perhaps under a different guise, then little or nothing is to be gained. Success will be achieved (the incentive gap reduced to tolerable proportions), they argue, if and only if, the IQ scheme lead to the fisher sub-game being transformed from a competitive to cooperative one.

In order for there to be a cooperative game, there must first be in place a workable mechanism for the sharing of the economic benefits among the "players". IQ schemes were seen to provide such a mechanism. The existence of the sharing mechanism, in of and by itself, is, however, not sufficient.

A fundamental condition that must be satisfied, if a cooperative game is to have a stable solution, is that each and every player must be convinced that it will receive a return – a payoff – at least as great as it would under competition (FAO, 2002). If non-compliance (cheating) is left unchecked, or, if free riding (poaching) is rampant, this condition, known as the Individual Rationality Constraint, will not be met, even if the allocated shares appear to be "fair".

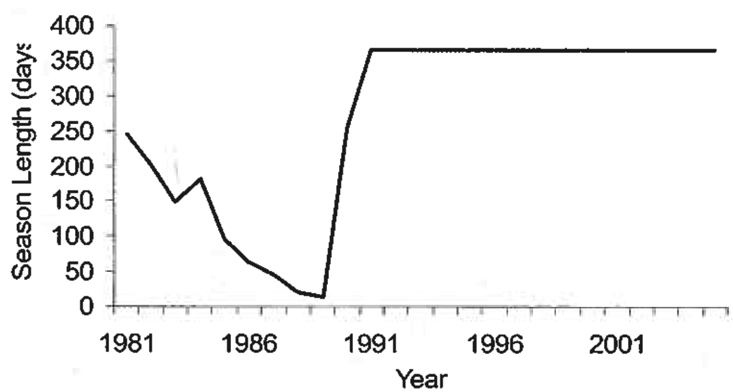
The evidence that exists, while not absolutely conclusive, suggests that effective cooperative fisher games have replaced the destructive non-cooperative games in these two fisheries. Consider first the season lengths in the two fisheries, before and after the introduction of ITQs.

Figure 3.1. Canadian pacific halibut season length: 1980-2005.



Source: Munro, Turris, Clark, Sumaila and Bailey, 2009, Figure 1.

Figure 3.2. British columbia sablefish season length: 1981-2005.

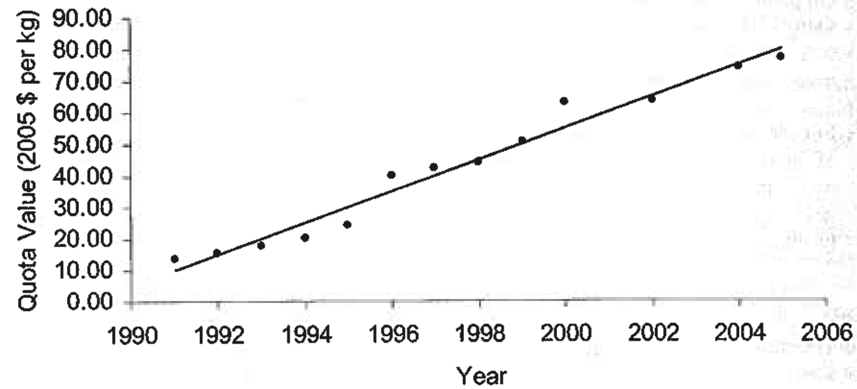


Source: Munro, Turris, Clark, *et al.* 2009, Figure 4.

Excess capacity, if not eliminated in physical terms, was "defanged". In the case of both fisheries, season length rose rapidly to the maximum, after the introduction of ITQs.

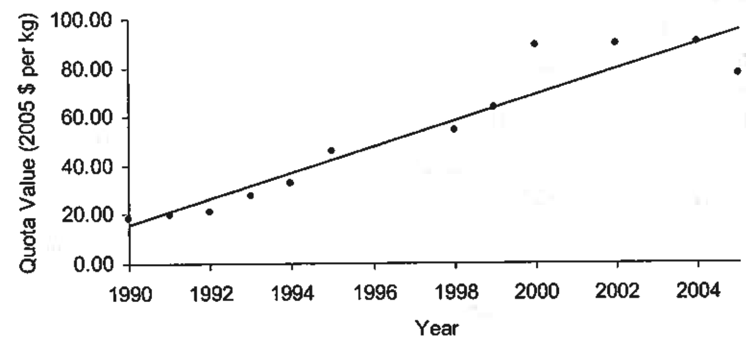
Adequate fleet cost data were not available to the authors of the study. The harvest quotas were and are actively traded. Quota price data are available. Since the quotas are de facto long term (Munro, *et al.*), the quota prices could be seen as reflecting the market participants' estimates of future private sector net returns from the fisheries.

Figure 3.3. Canadian pacific halibut quota values and trend lines.



Source Munro, Turris, Clark, *et al.*, 2009, Figure 3.

Figure 3.4. British Columbia sablefish: quota values and trend line.



Source: Munro, Turris, Clark, *et al.*, 2009, Figure 6.

The authors note that the ITQ schemes involve higher management costs, and accompany the figures with tables showing substantially increased licence fees received by the government. Overall the evidence suggests that significant positive rent is flowing from the fisheries. In other words, the relevant natural capital assets are now seen to be yielding positive economic returns.

From this experience, one can conclude the following:

- The Incentive Blocking approach to resource management, as it pertained to fleet and human capacity, was completely ineffective. The inability to control capacity led to rent destroying non-cooperative games among the fishers.

- The introduction of ITQs did, in these instances, lead to a resource rent creating cooperative games among the fishers. If the key lies in transforming destructive non-cooperative fisher games into cooperative ones, then it is obvious that instruments other than ITQs could be used to achieve the same results, such as community based fisheries management (TURFs) or fisher cooperatives. The choice of instrument should be made on a fishery by fishery basis.

- In order to effect this transformation, substantial management capacity was demanded of the resource managers. To take one example, if the resource managers had proven to be incapable of establishing an effective monitoring scheme, the ITQ schemes would have degenerated into non-cooperative fisher games, with consequences that require no further elaboration.

The two additional fisheries to be mentioned in passing are the Icelandic cod fishery and the hake fishery off Namibia. Both fisheries had experienced resource overexploitation. Both fisheries were reformed through the introduction of Incentive Adjusting management measures (ITQs), which helped bring the resource overexploitation to a halt and to lead to the generation of resource rent. Interestingly, the resources have not been restored in either case (Arnason, 2008; Sumaila and Marsden, 2008).

It is easy enough to see why the ITQ schemes should have helped to bring the resource exploitation to a halt. With the individual fishers/vessel owners/companies having the promise of enjoying future returns from the resource they should no longer have the incentive to mine the resource, i.e., they will no longer discount future returns at a rate equal to infinity.[6]

The next question, and the truly important question, is the following. Once a management is in place that makes rent generation feasible, what further modifications must the Principal (resource managers) make to the incentive scheme in order for the Agents (fishers) to be willing to invest the resource, or at least not impede the progress of resource investment programs? The question does not arise in the halibut and sablefish cases cited, but does very much so in the cod and hake cases.

This is a question, let it be admitted, that cannot be fully answered at this stage. Much more thought and research is required.

Since all investment involves a cost, the first part of the question is who is to bear the cost of investment in the fishery capital? If the relevant produced/human capital is highly malleable, then the problem is minimal, as the produced/human capital can be shifted to equally remunerative undertaking. Return to the example of Norwegian Spring Spawning herring. After the resource crashed in the late 1960s – early 1970s, the remnants of the resource were confined to Norwegian waters. The Norwegian authorities found it easy to declare an outright harvest moratorium, in part because the relevant fleet/human capital could be readily shifted to other fisheries, and was thus highly malleable from the perspective of the herring fishery (Gréboval and Munro, 1999). The cost of the resource investment, such as it was, was borne by the state.

In many cases, in which the fleet/human capital is less than perfectly malleable, one could, in the first instance, think of a scheme in which the state bore the cost of investment, by compensating the fishers for temporary reduced harvest opportunities (Grafton, Kompass and Hillborn, 2007). That such schemes could be accompanied by the threat of possibly severe moral hazard problems is obvious.

If the fishers are to bear part, or all, of the resource investment cost, then the following incentive requirements are straightforward enough. The fishers must be assured of a share of the future returns from the investment, which means, in turn, that they must not be given the incentive to discount heavily future returns from the fishery, e.g. as a result of seemingly capricious resource management policies . Secondly, the future returns accruing to the fishers should be contingent on the success of the resource investment program. Thus, for example, within the context of an ITQ scheme, one would want quotas that are long term, de facto if not de jure, and which are expressed as percentages of the TAC, or equivalent thereof.

One of the case studies commissioned by The World Bank and the FAO to accompany The Sunken Billions study does provide us with a developing fishing state example of a fishery, in which a state of pure open access and resource overexploitation was transformed into one in which a successful resource investment program could be undertaken. The case is that of the Indonesian Arafura shrimp fishery. The author of the study deems the optimal, or target, stock level to be that associated with maximum sustainable resource rent (Purwanto, 2008).

Up until early in this decade, the fishery was plagued with rampant non-compliance and poaching by Indonesians and foreigners, with consequent overexploitation of the resource and dissipation of resource rent. It is estimated that in 2000 the biomass was no more than 50 % of the optimal level. The resource rent was positive, but was equal to less than 6 % of the optimal level (Purwanto, 2008, Table 4.1). Under the new Indonesian fisheries legislation, promulgated in 2004, surveillance and enforcement were greatly strengthened, the right incentives were created by devolving management authority upon the relevant provincial government, which, in turn gained the active support and co-operation of the relevant fishing communities. By 2005, the biomass had increased to almost 75 % of the optimal level. The resource rent was estimated to be equal to more than 90 % of the optimal level (Purwanto, 2008, Table 4.1).

Two points need to be made about this example. First, the principle of subsidiarity appears to be at work here, a point worth noting in devising other resource investment supportive incentive schemes. Secondly, since shrimp is a rapidly growing resource, the waiting period for the payoff was very short. Obviously, the longer one has to wait for the payoff, the greater the difficulty in designing the appropriate incentive scheme.

Beyond this, the author can say little about the optimal incentive scheme at this stage, other than to say that Icelandic cod and Namibian hake might present interesting case studies on what is required to get an effective resource investment program underway, given that a well working Incentive Adjustment management scheme is in place. Clearly, the issue will require a great deal of further research, planning and thought.

Getting the incentives right: international considerations

We turn now to international fisheries, where the needed incentives involve, in the first instance, fishing states, as opposed to fishers. It will be recalled that internationally shared fishery resources account for as much as one-third of the harvest of marine capture fisheries (Munro *et al.*, 2004).

The economics of the management of internationally shared fish stocks is reasonably well understood. It does, by necessity, draw upon the theory of strategic interaction (theory of games), due to the fact that strategic interaction between and among the states exploiting the resources lies at the heart of the problem.

The economics of non-cooperative management of shared fishery resources, based upon the theory of competitive games, is straightforward. Non-cooperative management carries with it the high risk of overexploitation of the resources. This is a manifestation of the famous "Prisoner's Dilemma," discussed at an earlier point. In other words, non-cooperative management of shared fish stocks carries with it the high risk that fishing state incentives will be exactly wrong, leading not to positive fishery resource investment, but rather to ongoing fishery resource disinvestment.

The truly complex part of the management of internationally shared fishery resources is focussed on the means of ensuring stable cooperative management of these resources through time. The economics, not surprisingly, draws upon the theory of cooperative games. A cooperative game, subject to instability that remains uncorrected, soon degenerates into a competitive game, accompanied by resource destroying state incentives.

The economics informs us that the ease of achieving stability through time depends, in the first instance, upon the number of "players," *i.e.* the number of states involved in the exploitation of the resource. Where the number of "players" is only two, achieving stability is relatively easy. Thus, for example, it is no surprise that the cooperative management of Pacific halibut, and the cooperative management of groundfish resources in the Barents Sea, have proven to be stable over time. In each case, two states are dominant. Once the number of "players" exceeds two, difficulties arise, with the difficulties increasing almost exponentially as the number of "players" increases.

The greatest difficulties are to be found in the management of internationally shared fishery resources to be found in all, or in part, in the high seas, i.e. outside of the coastal state EEZs, namely highly migratory and straddling stocks that are to be found in the EEZs and the adjacent high seas, and discrete high seas stocks. Highly migratory and straddling stocks are, under the terms of the 1995 Fish Stocks Agreement, to be managed through Regional Fisheries Management Organizations (RFMOs) that are to have both coastal states and relevant distant water fishing states (DWFSs) as members (Lodge, Anderson, Løbach, Munro, Sainsbury and Willock, 2007; UN, 1995). The Northwest Atlantic Fisheries Organization (NAFO), the Northeast Atlantic Fisheries Commission (NEAFC), and the Western and Central Pacific Fisheries Commission (WCPFC) are all examples.

Achieving the stability through time of the cooperative fishery games that are the RFMOs is aggravated by the fact that the number of "players" is typically large, and by the fact that the high seas portions of areas under RFMO jurisdiction are, in many instances, plagued with "unregulated" fishing, i.e. free riding by non-RFMO members. An additional source of instability arises from the fact that RFMOs are required, by the 1995 UN Fish Stocks Agreement (U.N., 1995), to accommodate new members, which are typically DWFSs, which could not, or did not, see fit to become "charter" members of the RFMO. The so-called "new member" problem is one of the most difficult confronting the emerging RFMO regime (Lodge *et al.*, 2007).

Two of the case studies commissioned by The World Bank and FAO, in conjunction with The Sunken Billions study, illustrate well the issue of incentives confronting fishing states sharing fishery resources. One involves a tuna resource, the Northeast Atlantic and Mediterranean bluefish tuna resource, which has been seriously overexploited, and where

a major resource investment program has been called for. The prospects for success of the investment program are not encouraging. The other is a case study on Norwegian Spring Spawning Herring, a resource to which we have referred many times. A massive investment program has occurred, which to date has been strikingly successful. The author of the case studies assumes, in each case, that the optimal stock level is that associated with maximum sustainable resource rent (Bjørndal, 2008; 2009).

To begin with Northeast Atlantic and Mediterranean bluefin tuna, the RFMO for these bluefin tuna fisheries takes the form of the International Commission for the Conservation of Atlantic Tunas (ICCAT). The bluefin tuna resource, when in a healthy state ranges from the Canary Islands to Norway, through the Mediterranean to the Black Sea. The harvested fish are some of the most valuable in the world, with an individual fish being able to command a price of up to USD 100 000 (Bjørndal, 2009).

At the present time, some 25-30 states are involved in the fishery. At the peak of the fishery, up to 50 states were involved. The fact that the number of active states involved in the fishery has been substantially reduced is due, argues Bjørndal, to the fact that the resource has been severely depleted (Bjørndal, 2009). Bjørndal maintains that the resource rent maximizing spawning stock biomass is in the order of 800 000 tonnes. The current spawning stock biomass is estimated to be in the order of 100 000 tonnes. This is the lowest spawning stock biomass for the resource in recorded history. Indeed, the resource faces a significant risk of outright collapse (Bjørndal, 2009; MacKenzie, Mosegaard and Rosenberg, 2009).

The root of the problem is easy to identify. The cooperative fishery game in the form of the ICCAT based RFMO governing the tuna resources has degenerated into a competitive game. ICCAT management advice is largely ignored (Bjørndal, 2009). The economics of non-cooperative management of shared fishery resources predicts that the competitive shared fishery can readily take on all of the characteristics of a pure open access one. Bjørndal maintains that the bluefin tuna fishery is to all intents and purposes, just that. The steady, almost inexorable, decline in the spawning stock biomass over the past 30 years is entirely consistent with a pure open access fishery (Bjørndal, 2009, ibid.)

ICCAT, with the support of the EU, has called for the implementation of a program of resource investment. Consider the difficulties to be faced. Given the seriously reduced state of the biomass, argue MacKenzie *et al.*, recover may take many years, if not decades, even if fishing mortality is drastically reduced (MacKenzie *et al.*, 2009). In other words, the states currently exploiting the resource will be called upon to bear heavy investment costs.

The economics of cooperative fisheries management makes it abundantly clear that the needed co-operation will be forthcoming, only if compliance is ensured. If a moral and otherwise law abiding, member state of the RFMO is convinced that cheating by other RFMO members will go unchecked, this otherwise law abiding member state will likely conclude that it would be no better off under co-operation, and probably less well off, than it would be under competition. Co-operation will founder. Ensuring compliance in a cooperative fisheries game with 25-30 "players" is a formidable undertaking.

There is yet another problem. Suppose that somehow the compliance problem is effectively resolved, and suppose that substantial resource investment is achieved. The fishery at its peak had up to 50 participating states. What is to prevent the 20-25 states that left the fishery demanding re-admission to the club, once the resource investment program has achieved success? If those returning states were readmitted and granted significant shares of the TAC, they would effectively be free riders, having borne none of the cost of investment. It is not at all clear that, under the 1995 UN Fish Stocks Agreement, the would-be returning states could be denied re-admission.

If the would-be returnees cannot be denied re-admission, then it would be foolish to suppose that the current members of the RFMO could not anticipate the future free riding. The anticipated free riding cold lead many current members to conclude that they would, in fact, be better off under competition. Once again, the proposed cooperative resource investment program would be stillborn (Kaitala and Munro, 1997; Munro, Van Houtte and Willmann, 2004). It can be argued that, without a resolution of the so called "new member" problem, the outlook for the future of the resource is bleak. The fishing state incentives will be incompatible with a program of preventing ongoing resource disinvestment, let alone a program of encouraging positive resource investment.

A stark contrast is provided by Norwegian Spring Spawning Herring. The RFMO involved with the management of the resource operates under the aegis of the Northeast Atlantic Fisheries Commission (NEAFC).

The herring resource, when in a robust state, has historically been one of the largest and most valuable in the Northeast Atlantic. The resource, when robust, migrates from its spawning grounds in Norwegian waters as far west as Iceland. In so doing, the resource passes through international waters, which means that it is to be classified as a straddling stock (Bjørndal, 2008, ibid.).

It will be recalled that the resource crashed in the late 1960s-early 1970s, and that spawning stock biomass (SSB) of the resource was reduced to 2 000 tonnes, 0.08 % of the critical minimum level of 2.5 million tonnes. Absolutely massive resource reinvestment was called for. The massive resource investment did, in fact, occur. Today the resource is healthy, with the SSB at 6.5+ million tonnes (Bjørndal, 2008, ibid.). So what went right?

First, the remnants of the resource were confined to Norwegian waters. Thus, it ceased, for the time being, to be a shared fishery resource. Secondly, as indicated at an earlier point, the Norwegian fleet and human capital involved in the fishery was highly malleable, with respect to the fishery. It was politically easy for the Norwegian resource managers to declare a harvest moratorium, which more or less remained in place for 20 years. Finally, there was an element of luck, in that environmental conditions allowed for a recovery of the resource from its desperately low state.

By 1994, there were signs that the recovered resource was recommencing its migratory pattern, and was thus becoming once again a shared stock. There was a realization among the relevant states that cooperative resource management was required, if another disaster was to be averted. Indeed, the states undoubtedly recognized that, if the stock were to crash again, the crash might be irreversible.

The first attempts to develop a cooperative regime involved Norway, Iceland, Russia and the Faroe Islands. These attempts were largely unsuccessful, with an important reason being that an important player, in the form of the EU, had been left out. The EU can claim a very small coastal state interest in the resource, but more importantly, its fleets were able to operate in the high seas through which the resource passed in its migration – the typical free rider problem.

By late 1996, the EU was brought in to the cooperative resource management arrangement. The recently concluded 1995 UN Fish Stocks Agreement provided a useful framework for the now inclusive agreement (Munro, 2001).

For several years, the cooperative game in the form of the Norwegian Spring Spawning Herring cooperative resource management arrangement seemed to be stable and to be effective, both in terms of conservation and resource rent generation. In contrast to the Northeast Atlantic/Mediterranean bluefin tuna cooperative resource management arrangement, the number of "players" was small (a cooperative straddling stock fishery game with only five "players" is small indeed). There were no troublesome would be new members appearing on the horizon. One can conjecture that the lack of a new member problem was not unconnected with the fact that two of the "players" were, and are, politically very powerful – the EU and Russia.

Then a problem arose in 2002, which was of a type that can afflict any RFMO. When one talks about the stability of the RFMO cooperative fisheries game, it is not sufficient to talk about current stability. One has to be concerned with the stability of the RFMO through time, with what economists refer to as the "resiliency," or more technically the time consistency, problem. Any RFMO can be expected to be subject to unpredictable shocks, which may be political, economic or environmental in nature. If the RFMO lacks the resilience and flexibility to respond to and absorb these shocks, the RFMO may founder (Miller and Munro, 2004; Munro, 2009).

The harvest sharing rule among the "players" in this herring fishery game is based upon the perceived migratory pattern of the resource. In 2002, the Norwegians insisted that the resource migratory pattern was markedly different from what had thought to have been the case in 1996, and that they were not, as a consequence, receiving their "fair" share of the TAC. The Norwegians demanded a larger share of the TAC, and were met with an outright refusal by their fellow "players". The cooperative resource management arrangement, while not being formally terminated, seized up. In short, the cooperative resource management arrangement displayed a lack of resilience, in that there was no mechanism in the arrangement to deal with shocks such as those arising from shifting migratory patterns. The cooperative herring fishery game began to show worrying signs of degenerating into a competitive one.

A new cooperative resource management arrangement was finally agreed upon, but only after three dangerous years of paralysis. During the hiatus, the collective harvests began exceeding by a considerable margin the hitherto agreed upon TAC, holding out the threat of another resource crash (Bjørndal, 2008).

The interrelationship between intra-EEZ and international incentive structures

We have discussed the intra-EEZ incentives that must be in place, if intra-EEZ resource investment programs are to be successful. We have stressed the fundamental importance of fishing states sharing fishery resources having the incentive to cooperate in the management of the resources through time, if programs to rebuild such resources are to have any hope of success. It is now appropriate to ask, if there is any interrelationship between the two sets of incentives. The answer is very straightforward, namely that there is, of course, an interrelationship.

Let us take as an example a relatively simple case of a shared fishery resource having no high seas complexities, a transboundary stock, shared by two or more coastal states.

Let it be supposed that the states sharing the resource have ineffective intra-EEZ management of their respective shares of the resource, so that the intra-EEZ rent from the resource is completely dissipated. In the theory of strategic interaction (theory of games), there is the concept of the cooperative surplus, which is the difference between the sum of the payoffs to the players under co-operation and the sum of the payoffs to the players under competition. If the intra-EEZ rent from the resource is completely dissipated, the prospective cooperative surplus may be negligible, which means in turn that the incentive to establish a cooperative management regime will be at a minimum (Munro, 2007).

Conversely, suppose that each state sharing the fishery resource is attempting to establish an intra-EEZ effective harvesting rights scheme, but suppose further that the states are unsuccessful in establishing a stable cooperative resource management regime. It is easy to show that this lack of international success can readily undermine the attempts to establish intra-EEZ effective harvesting rights schemes – the Prisoner's Dilemma once again.

Conclusion

Captures fishery resources, like all natural resources, are to be seen from the perspective of society as capital assets. Calls for the rebuilding of such resources are, therefore, to be seen, in turn, as calls for an investment program, with all that that implies, in particular the fact that there is no such thing as a costless investment.

That such an investment program is required is no longer in dispute. Beyond the admonitions from the 2002 World Summit on Sustainable Development, The World Bank and FAO report that world capture fishery capital is, overall, providing the world economy with a rate of return, which at best is equal to zero, and that, if these resource assets are even to approach the goal of yielding maximum sustainable resource rent, the resource assets will have to be at least doubled in size (World Bank and FAO, 2008).

There will not be a capture fishery resource investment program that is successful from an economic standpoint, unless the correct incentive structures are in place, at both the intra-EEZ and international levels. Within the EEZs, there must, at a minimum, be incentive structures that will ensure ongoing generation of resource rent. Inter alia, this calls for the removal harmful fisheries subsidies, which currently are immense. If intra-EEZ resource rent is continuously dissipated, then there will be no promise of positive payoffs on fishery resource investments.

The major question, as yet unanswered, is what incentives need to be in place to cause fishers to willingly invest in the resources, or at least not impede the investment program. If the fishers are to be called upon to bear all, or part of the cost of investments, then obviously, they must be assured of a share of the future resource investment payoffs. There are aspects of this question, however, which are as yet not fully answered. Substantial further thought and research is required.

At the international level, there must be a set of incentives in place to drive the relevant fishing states to engage in cooperative management of shared stocks through time. The issue of cooperative resource management arrangements resiliency over time was stressed.

The needed intra-EEZ and international incentive structures are, of course, interrelated. If we do not get these two interrelated sets of incentive structures right, the

risk is that, rather than having an effective fishery capital investment program in place, we will be faced with ongoing fishery capital disinvestment.

Notes

1. There are many additional complications that we shall not attempt to discuss here in detail. For example, suppose that there is extensive species interaction. Then one has to talk, not about the return on one species, but rather about the return on a sub-portfolio of species assets.

2. The anticipation of the resource rent leaking away to zero could lead to it being optimal, in economic terms, to turn around and *deplete* the resource. The importance of ensuring the sustainability of the additional resource rent, generated by the resource investment, cannot be overstated. See Clark and Munro, 1975, particularly Part 3 on so called non-autonomous models, for further details.

3. There is an important qualification to this rule. Suppose that the producer/human capital is perfectly malleable, but suppose further that the price of harvested fish is a function of the amount harvested – the more that is harvested and sold, the lower is the price – and/or that the unit cost of what is referred to as fishing effort varies with the amount of fishing effort employed in the fishery. Then the most rapid rate of resource investment is not optimal, since there will be penalties associated with rapid rates of resource investment or disinvestment. See Clark and Munro, 1975, for details.

4. There is an exception to this rule. If the resource has been severely depleted, a temporary harvest moratorium might be in order. It would *not* be appropriate, however, to maintain the moratorium until the target biomass has been achieved. See Clark, Clarke and Munro, 1979, for further details.

5. The report's target or optimal stock (biomass) levels are those that would be associated with maximum sustainable resource rent. By implication, the report is assuming that the appropriate rate of interest, or discount, is zero (Clark and Munro, 1975).

6. See the earlier discussion on the incentive consequences of a pure open access fishery, and Clark and Munro, 1975.

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Chapter 4.

Economic considerations and methods for evaluating fishery rebuilding strategies

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Abstract

Many fish stocks throughout the world have declined to levels that are believed to reduce their sustainable yield and/or create a risk of economic or even biological collapse. Most OECD nations have legislation and regulations requiring that these "overfished" fisheries be rebuilt -- generally to the biomass levels associated with maximum sustainable yield. The timing of catch reductions and increases during rebuilding and the specific management tools used to achieve those catch targets may have substantially different impacts on the net benefits generated by the fishery during rebuilding and beyond. We discuss some key economic considerations for evaluating rebuilding strategies including how they may affect gross value and harvest costs over time. We discuss a variety of factors that often are not, but perhaps should be, considered when determining rebuilding targets and deadlines including: issues with multispecies fisheries and changes in fishery productivity that may relate to climate cycles or climate change. Finally we discuss how management strategy evaluations can be used to design rebuilding strategies that are robust to uncertainty and address economic and social, as well as biological objectives.