

Unclassified

ENV/EPOC/GEEI/BIO(97)14/FINAL



Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

OLIS : 08-Oct-1998
Dist. : 12-Oct-1998

Or. Eng.

ENVIRONMENT DIRECTORATE
ENVIRONMENT POLICY COMMITTEE

**Group on Economic and Environment Policy Integration
Expert Group on Economic Aspects of Biodiversity**

**INDIVIDUAL TRANSFERABLE QUOTAS AS AN INCENTIVE MEASURE
FOR THE CONSERVATION AND THE SUSTAINABLE USE OF MARINE
BIODIVERSITY**

70254

Document complet disponible sur OLIS dans son format d'origine
Complete document available on OLIS in its original format

ENV/EPOC/GEEI/BIO(97)14/FINAL
Unclassified

Or. Eng.

This study was written for the OECD Expert Group on Economic Aspects of Biodiversity by Mr. Jon Sutinen, Professor at the Department for Environmental and Natural Resource Economics of the University of Rhode Island, Mr. Eyjo Gudmundsson, also Department for Environmental and Natural Resource Economics of the University of Rhode Island, and Mr. Jan Horst Keppler of the Environment Directorate of the OECD Secretariat. It is part of the project "Experiences with the Implementation of Incentive Measures for the Conservation and the Sustainable Use of Biodiversity".

Drafts of this study have been discussed at the meetings of the OECD Expert Group on 20-21 January 1998 in Paris and on 28-29 July 1998 in La Paz, Mexico. The present version has been revised in the light of comments received by Member countries during the meetings and through written procedure. Mr. Paul Wallis of the Fisheries Division of the OECD Directorate for Food, Agriculture and Fisheries has also provided helpful and extensive comments.

TABLE OF CONTENTS

1. GENERAL DESCRIPTION..... 4

2. IDENTIFICATION OF CAUSES AND SOURCES OF PRESSURES 6

 2.1 Identification of sectoral activities and resulting pressures 6

 2.2 Identification of underlying causes of biodiversity loss 7

 2.3 Identification of adverse incentives with negative impacts on biological diversity 10

3. IMPACTS ON ECOSYSTEMS 11

4. IMPACTS ON ECONOMY AND WELFARE..... 16

5. THE IMPLEMENTATION OF THE INCENTIVE MEASURE AND CONTEXT 20

 5.1 Identification of the incentive measure: ITQs 20

 5.2 Process of implementation and distributional effects 24

 5.3 The role of information and the importance of ecosystem management 27

 5.4 Resource rents and the institutional framework 29

6. POLICY RELEVANT CONCLUSIONS..... 32

 6.1 Lessons learned..... 32

 6.2 Transferability of experience 33

 6.3 Possible policy advice for implementation 34

REFERENCES 35

INDIVIDUAL TRANSFERABLE QUOTAS AS AN INCENTIVE MEASURE FOR THE CONSERVATION AND THE SUSTAINABLE USE OF MARINE BIODIVERSITY

1. GENERAL DESCRIPTION

Description of the ecosystem and main impacts

Marine ecosystems and coastal zones are ecosystems in which individual transferable quotas are used to regulate commercial fisheries. There exist two different impacts on biodiversity through commercial fisheries: first, the overfishing of the commercially valuable target species and the resulting stock depletion; and, second, the damage to the wider ecosystems of which the target species is a part through by-catch, discard, destruction of habitat and pollution. Marine ecosystems and coastal zones are also impacted through land-use (sewage release), agriculture (nutrient release), tourism and shipping. However, in this context the emphasis is on impacts on marine ecosystems and coastal zones from commercial fisheries.

Identification of incentive measure and economic sector targeted

Individual transferable quotas (ITQs) give individuals the right to catch a specified quantity and species of fish in a specific location during a specific period of time. The actual individual catch quota in any year is equal to the individual's share of each year's total allowable catch (TAC). The quota share is assured from year-to-year, but the catch entitlement associated with that quota varies with the total allowable catch that is determined by a central authority. The TAC is usually set at a level which will move the fish stock towards a size, or maintain it at a size, which will support the maximum sustainable yield.

ITQs are property and can be traded, exchanged or mortgaged. The duration, transferability, flexibility, quality of title and divisibility of a transferable quota varies across management programmes (OECD, 1997c). While the introduction of some form of private property rights over fish stocks is a characteristic of all ITQs, the name 'ITQ' is actually applied to a wide variety of different systems. These differences relate to the form and the distribution of the property or harvesting rights as well as to the objectives connected with the introduction of an ITQ system. In many countries ITQs are introduced in order to increase the economic efficiency and profitability of fisheries.

This study of individual transferable quotas has to be seen in context: first, ITQs are not the only instrument available for the management of fishery resources; however this report concentrates on ITQs as an instrument with attractive conceptual properties (economic efficiency, sustainable use of the target resource) which increasingly is also able to prove its viability in practice. Second, while ITQs constitute a widely used instrument¹, they are not necessarily the preferred instrument of Member countries' governments for the management of fisheries in all circumstances, in particular if objectives other than economic efficiency, such as employment creation, regional development or the maintenance of

1. See Table 4.3. *Fisheries Managed with Individual Quota Programmes*, OECD (1997c), pp. 81-82.

traditional fishery practices are pursued. The *de facto* privatisation of a formerly public resource, even if under continued administrative supervision, is also sometimes seen as problematic. Third, as will be argued throughout this report, also the use of ITQs for the sustainable use of biodiversity beyond the commercial target resource requires the implementation of complementary incentive measures such as gear restrictions in order to assure sustainability.

Individual transferable quotas have economic and environmental consequences. In principle, economic consequences are the restriction of supply and the achievement of efficiency, as incentives are created for the most efficient producers to eventually own all the quotas. The conversion of an open access regime into a private property or limited access regime, depending on the actual form of the ITQ scheme, creates winners and losers and can thus lead to resistance to the introduction of ITQs. Total income from the use of the fishery can, however, be maximised.

Environmental consequences concern the commercially valuable target species, whose yield is maximised as well as the conservation and the sustainable use of the wider ecosystem of which the target species is a part of. Impacts on ecosystems depend on the extent to which the commercial species is a 'keystone species', the amount and treatment of by-catch and high-grading (the discarding of the target species if it is, e.g., too small), the damage through the use of inappropriate gear (e.g., dredging) or the loss of gear (e.g., 'ghostfishing' by lost nets) and the pollution from at-sea processing activities (e.g., disposal of fish waste).

2. IDENTIFICATION OF CAUSES AND SOURCES OF PRESSURES

2.1 Identification of sectoral activities and resulting pressures

Pollution

Pollution threatens marine biodiversity in several ways. Run-offs from agriculture, toxic chemicals that pile up through the food chain and air pollution affect biodiversity in coastal waters as well as on the open oceans. Marine fisheries and coastal zones are also affected from pollution of commercial fisheries through the discarding of by-catch and high-grading, inappropriate gear, the loss of gear and disposal of waste from at-sea processing. Lost gear, such as nets, continues to entrap fish and leads to so-called 'ghost fishing'. Other forms of pollution are caused by destructive harvesting methods such as poison or dynamite fishing. Finally, on a global level, climate change due to anthropogenic emissions can affect marine biodiversity in a number of different ways.

Discards: by-catch and high-grading

Discards in the form of by-catch and high-grading are inevitable in most multi-species fisheries. Discarding is believed to be a major problem in many fisheries, even though the levels of discards are usually not well known. Dumped catch can raise nutrient levels and lead to oxygen depletion. A recent FAO study provisionally estimated that global commercial discards amounts to 27 million metric tons annually, totalling 27 per cent of the world catch (OECD, 1997b). This preliminary estimate should, however, be treated with caution and can be considered an upper bound rather than a median estimate. In another estimate 3 000 tonnes of by-catch were generated for every 500 tonnes of prawns (Young, 1995). Common policies to control and reduce discards include such observers, mandatory landings, improved gear selectivity, by-catch quotas and prohibitions.

Non-sustainable use of biological diversity

In the past, fisheries were frequently left unmanaged as open-access goods; i.e., fishers attempted to maximise their personal benefit by equating private marginal cost with the marginal benefit to be had from an additional unit of fish caught. As no consideration to stock depletion and its effect on other fishermen is given, this creates the 'problem of the fisheries', also referred to as the 'tragedy of the commons'.² In this situation, each fisher imposes negative externalities on all other fishers by reducing through his or her own efforts the return on other fishers' fishing effort. In final instance, all positive profits to be garnered as rent from the natural resource are dissipated. This constitutes a non-sustainable use of biological diversity in two ways:

2. There exists a large and growing literature on both the 'problem of the fisheries' and the 'tragedy of the commons'. Many authors insist on a clear distinction between unmanaged open-access goods and communally managed common property goods, such as the pastures traditionally known as the 'commons'. Only unmanaged open-access goods do indeed display the negative efficiency results, erroneously named 'tragedy of the commons', whereas there exist a large number of successfully managed common property goods.

- the commercially valuable target species is depleted through overfishing;
- no regard to elements of the surrounding ecosystem is given.

In practice, unmanaged open access regimes for fisheries are increasingly rare in OECD countries. Most commercially valuable fisheries are regulated through total allowable catch (TAC) provisions. TACs can in principle maintain stocks at the size that produces the maximum sustainable yield. However, fishers have an incentive to maximise their catch within the TAC. This results in wasteful 'races-to-fish', as fishers attempt to extract the maximum amount of fish in the shortest possible time. The over-investment in faster and bigger boats, the reduced concerns for safety and quality, gear conflicts and periodic gluts at processing centres again dissipate the obtainable rents for all participants.

The losses from unregulated access to fishery resources concern private as well as public goods such as the environment or biodiversity. The private good is, of course, the value of the sales from the target species. The public goods are the existence values of the target species *and* of the surrounding ecosystem, as well as the option, recreational and aesthetic values connected with it. An example of a case, in which the existence value of a non-target species was threatened by unregulated commercial fisheries was constituted by the by-catch and mortality of seabirds. A particular case, in which not the existence value of a species was threatened, but in which single specimen of a species had high existence values attached to them, was constituted by the highly publicised Tuna-Dolphin case between the United States and Mexico.

2.2 Identification of underlying causes of biodiversity loss

Missing markets or non-existent property rights

Missing markets and the non-existence of property rights are clearly the underlying cause of the depletion of stocks for commercially valuable fish. In principle, well defined property rights can avoid such depletion by giving owners an interest in the long-run maximisation of the yields from their assets. However, such reasoning presupposes that property rights can be defended at reasonable cost and that owners have an interest in the long-run maximisation of the profits from *each* single fishery. The first point depends on the accessibility of a fishery to international fishing fleets and the ability to prevent encroachment on fishing rights from outsiders.

The second point depends on issues such as the mobility of capital, the time horizon of owners-investors and the transparency and efficiency of the market of fishing rights. As an example, one can imagine the owner of a fishing fleet who also owns several quota shares in different fisheries. With a sufficiently short time horizon and a sufficiently mobile fleet, such a company might be interested in increasing the short-term return on its working capital by rotating between fisheries and by fishing each one *beyond* the maximum sustainable yield. A countervailing effect could be constituted by an efficient market for ITQ shares, as fishers interested in the long-run maximisation of the yield of each ITQ share would be willing and able to bid higher prices and would eventually be able to acquire the ITQs from the owner of the rotating fishing fleet. This example shows, however, that issues such as market structure, information and transparency can be crucial in determining the success of an ITQ system.

Things are even less straight-forward concerning the surrounding ecosystem at large. The extent to which the establishment of private property rights in the form of ITQs contributes also to the conservation of the surrounding ecosystem depends largely on the fishing methods used and the interaction of the target species and the ecosystem.

The economic as well as the ecological functioning of ITQ systems depends on the determination and enforcement of total allowable catch (TAC). The ITQ share of the TAC determines the actual catch of every individual fisher or fishing unit. While trading of ITQ shares is allowed, their total supply is determined through the TAC set by a central authority. In theory, also the determination of a TAC alone could achieve the reaching of an economically and ecologically sustainable level of catch. In practice, however, the establishment of TACs has led to the 'races-to-fish' referred to above (see OECD, 1997c, for more detail).

Markets based on ITQs alone can under certain conditions, see above, achieve economic efficiency and resource sustainability in terms of the commercial target resource. However, in order to assure contributions to the conservation and the sustainable use of the whole of biodiversity supplementary measures are needed. Such measures include: banning of certain fishing methods (e.g., drift nets); the requirements for certain fishing methods (e.g., setting tuna longlines with bird scaring devices); the use of independent observers to record by-catch of non-target species; area closures to protect certain marine habitats; mandatory landings of by-catch; improved gear selectivity and by-catch quotas.

Information, institutional and enforcement failure

By definition, open access regimes, imply the absence of any centralised functions concerning management, information and enforcement. It is thus not possible to talk directly of an institutional 'failure'. While TAC provisions constitute an institutional imperfection, they are, however, a first step to improve over open access. They might thus be regarded as an insufficient measure rather than an outright failure. In most OECD countries, the problems connected with over-fishing and stock depletion are usually relatively well-known and researched. There exists, however, much less information on the impacts of commercial fisheries on wider marine ecosystems.

The institutional problem connected with open access-fisheries relates to the conceptual and political difficulties of transferring a traditionally 'common' resource into private property, even if it is a private property under semi-public management. The privatisation of a public good enfranchises some and disenfranchises others, and hence creates winners and losers. Even when the allocation of property rights reflects established use rights as closely as possible, e.g., when quotas are distributed on the basis of historical catch rates, the impediments are frequently formidable in an environment with strong social cohesion and a resistance to change.

Enforcement problems exist in all management systems. Nevertheless, with the allocation of ITQs one important positive incentive is created. The willingness to co-operate and engage in mutual supervision will increase to the extent that the ITQ share is perceived as a real asset that provides a stake in the smooth working of the whole system. Non-compliance and illegal behaviour are perceived as diminishing the value of the ITQ share, and its owners are more likely to assist in its protection.

Failure to adequately consider the lifestyles of indigenous and local communities

Indigenous people have in many cases pursued life-styles that involved the long-term sustainable use of natural resources. An example that highlights the difficulties, but also the possibilities, of integrating these life-styles with the mix of natural resource policies typical for OECD Member countries, is that of the Maori people in New Zealand.

In the traditional Maori view fish play a large role in social gatherings and the demonstration of hospitality to guests, a function which has close links to the central concept of *mana atua* (the prestige and power of the gods). Marine management was organised on the basis of communal property rights that belonged to *whanau* (extended family), *hapu* (sub-tribe) or *iwi* (tribe). Knowledge of fishing grounds and their properties was extensive, closely guarded and carefully transmitted. Management was administered by the *Rangatira* (head of *iwi*) who delegated authority to special custodians of the resource, *kaitaki* (Te Puni Kokiri, 1993). Management involved the forbidding of the gutting of fish on the shoreline, the interdiction of dragging nets, the establishment of fishing seasons, and limitations on bait and gear. Ecosystem management included the transplanting of shellfish beds and the active intervention when predator-prey relationships were out of balance.

There has long been some form of recognition in New Zealand law that Maori retained traditional fishing rights under the 1840 Treaty of Waitangi. However, the nature and extent of those rights were never defined. Therefore, from a situation of being the main suppliers of seafood to European settlers in the 19th century, the situation for Maori fishers was degraded due to the erosion of their property rights by government legislation, pollution and encroachment by recreational and commercial fishers to a point where seafood for annual gatherings had to be purchased. The allocation of ITQs finally brought this issue to head with a threatened injunctions by Maori against further ITQ allocations through the government. As a result of ensuing negotiations, the government agreed in the Maori Fisheries Act 1989 and the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992 to the following:

- to buy back 10 per cent of existing ITQs and to provide assistance to the development of Maori fishing;
- provision of funds to buy a 50 per cent share in New Zealand's largest commercial fishing company;
- to allocate 20 per cent of all quota from the introduction of new species into the ITQ system to Maori;
- to establish a regulatory framework for the Maori customary, non-commercial fishing interests.

The history of the Treaty of Waitangi shows that the absence of adequate incentive measures such as, well defined, property rights, can constitute a threat to the lifestyles and development capabilities of indigenous and local communities. However, it also shows that with innovative policy approaches combining a mix of private property transfers and government regulation solutions can be found.

2.3 Identification of adverse incentives with negative impacts on biological diversity

Substantial support in a variety of forms is transferred to fisheries industries. They include:

- market price support through tariffs, quotas and other forms of import restrictions;
- output subsidies such as minimum landing prices and price premiums for locally caught fish;
- input subsidies, in particular for the building and modernisation of fishing boats;
- technical barriers to trade in form of processing requirements such as 'hazard analysis' and 'critical control point'-analysis);
- infrastructure provision in form of ports and docking facilities; and
- government services dedicated to the fisheries sector such as research and forecasting.

There exists currently no reliable information about the detailed form, amount and impacts of subsidies to the fisheries sector. However, two overall estimates of the total amounts for global subsidies to the fishery sector do exist. An FAO calculation from 1992 arrives at a figure of US\$ 54 billion (FAO, 1993); a more recent study by Milazzo provides a range of US\$ 11-20 billion (Milazzo, 1997). Several efforts in different international fora are currently under way in order to arrive at a more detailed overview of the subsidies to the fishery sector. The OECD Fisheries Committee is currently conducting a detailed study to examine the impact of subsidies on fisheries resource sustainability.

3. IMPACTS ON ECOSYSTEMS

In the absence of appropriate incentive measures such as individual transferable quotas (ITQs) biodiversity in marine ecosystems can be affected by unsustainable human activities in a number of different ways. Impacts on marine ecosystems can be classified into the following categories:

- biomass shifts,
- impacts from the introduction of alien species,
- impacts from pollution,
- habitat destruction, and
- global environmental impacts.

The examples below provide information on different parameters of ecosystem impacts such as impacts on genetic and species diversity, the role of keystone species, the impacts on ecosystem resilience and on damages to the resource base. While ITQs cannot address all of the underlying causes of these impacts, it is necessary to discuss them as an ensemble, as they interact and mutually re-enforce each other in achieving the final impacts.

General characteristics of marine ecosystems

Before discussing different causes for ecosystem impacts some general characteristics of marine ecosystems should be considered. Marine ecosystems have frequently a high level of resilience, i.e., they frequently adapt quickly to changes in environmental conditions. Most species under stress can quickly rebound under favourable conditions. However, species at the top of the food chain (marine mammals and sharks) often have low fecundity rates. The combination of unsustainable catch rates and low fecundity rates, such as in the case of certain whale or shark species, constitutes a particular threat to marine biodiversity (NMFS, 1993; Williams, 1996).

Marine ecosystems also display particularly clear interactions between different species and heavily rely on single keystone species. One such keystone species is the capelin in the Barents Sea ecosystem. Barents Sea capelin feeds on zoo-plankton, particularly krill and amphipods. Capelin, along with herring, is the main food source for groundfish, such as cod and haddock. Cod and haddock on the other hand are food source for marine mammals, such as seals and some whale species. After the introduction of cold and low salinity water into the Barents Sea in the late 1970s and early 1980s, due to the melting of the Greenland ice cap, zoo-plankton biomass dropped to record low levels. At the same time capelin was harvested commercially, up to 2,5 million metric tons a year in the early 1980s (Skjoldal et al., 1992; Jakobsson, 1992). The cod stock was increasing at the same time, preying on capelin. Due to this triple pressure, the capelin stock collapsed in 1986.

In combination with a reduced herring stock that was still recovering from collapse in the late 1960s, the collapse of the capelin stock caused a severe decrease of the cod stock between 1986 and 1990. The continuing harvesting of the declining cod stock forced marine mammals that rely on cod, such as the Arctic harp seal, to search for food as far away as the Norwegian coastal waters. Only the recovery of the zoo-plankton biomass, in combination with favourable environmental conditions in 1988-1990 and the reduced pressure from cod, allowed the capelin stock to start recovering. And in the early 1990s larger

stocks of capelin eventually also allowed for a recovery of the cod stock. The example highlights the strength and immediacy of interaction between different species in marine ecosystems and the necessity of the sustainable use of keystone species.

Biomass shifts

The Food and Agricultural Organisation of the United Nations (FAO) warned that over 70 per cent of fish stocks are fully exploited, over exploited, depleted or recovering (FAO 1995). Since FAO published its findings the world has taken a closer look at widespread potential crises in commercial fisheries which have occurred frequently since World War II. The following are just a few of many examples that show how unsustainable harvesting of wild species affects the abundance of fish stocks and either cause a shift of biomass or a reduction in total biomass of the ecosystem.³

- The collapse of the herring stocks in the Northeast Atlantic in the late 1960s (Dragesund 1980, Devold, 1968).
- The collapse of Peru's anchoveta stock off the west coast of South America in the early 1970s (Glantz, 1979).
- Reduction in fish stocks in many of European Union fisheries in the late 1980s (OECD, 1997c).
- Collapse of the Canadian groundfish stocks in the late 1980s/early 1990s (Parsons, 1993)
- Collapse of the US groundfish stocks off New England in the early 1990s (Anthony, 1993).

Over-harvesting of commercially valuable species has particularly dramatic consequences in ecosystems with low biological diversity. The Grand Banks fishery off the coast of New England and the Canadian Atlantic groundfish fisheries are prime examples of the different effects over-harvesting can have on low-biodiversity ecosystems. Both are groundfish fisheries that historically were dependent on species like cod, haddock, pollock and flounder (principal groundfish species) but also caught skates, dogfish and other groundfish species (secondary species). Over-harvesting has reduced the principal groundfish species in both fisheries during the last decade, as well as total biomass. Fortunately, the overall carrying capacity of the Grand Bank ecosystem, however, is not believed to have changed significantly (Sherman, 1994, National Research Council, 1995).

In the case of the Canadian groundfish fishery off Newfoundland a collapse of the principal groundfish species and a collapse in overall biomass has been observed. The cod fishery has been under a commercial moratorium since 1992 and a complete moratorium since 1994, interrupted only briefly in 1997. The main cause for the collapse is thought to be overestimation of stock size in the 1980s and consequently over-harvesting of cod. The ecosystem seems to have changed as well, and contributed to the decline in principal groundfish species. It is not possible to determine if the cause of the collapse was deliberate overfishing, overestimation of stock size, environmental factors, or all of them combined (Schrank, 1997). The gap left by the collapse of one species does not seem to be filled with other species, suggesting that the resilience of this particular ecosystem differs from the resilience of, for instance, the Grand Bank's groundfish fishery. Depending on local circumstances, unsustainable use of commercial target species can thus have different ecological impacts.

3. Steele (1984) defines a biomass shift as a sudden decline or collapse in a dominant resource stock, followed by an increase in another species in the same ecosystem. The shift may be due to an exogenous environmental event, over-exploitation or a combination of both.

Impacts from the introduction of alien species

The introduction of alien species can threaten existing biodiversity resources, as has happened in the cases of wild salmon fish stocks and shrimp. In the Northwest Pacific Ocean many salmon stocks are endangered, in combination with habitat changes, due to competition from introduced Atlantic salmon. Atlantic salmon is used in aquaculture in the Northwest Pacific and considerable numbers of Atlantic salmon are thought to have escaped hatcheries. Intensive aquaculture has also led to new viral diseases in wild and farmed salmon. In the United States exist several viruses connected with aquaculture shrimp. These viruses are considered to be a potential threat to wild stocks of shrimps in coastal waters (NMFS, 1997).

One of the most important ways of introducing alien species into ecosystems is through ballast water in cargo ships. The following three examples provide an indication of the different effects the introduction of such alien species can have. For instance in the Black Sea Odessa Gulf, a soft shelled clam, *Mya arenaria*, was found for the first time in the late 1960s. Its larvae had been brought to the Black Sea by ballast water in cargo ships from either the Atlantic or the North Sea. This clam species out-competed the local small bivalve *Lentidium mediterraneum* in the first years of the invasion. It is now an important component of the ecosystem as a major food source for bottom-living fish (Zaitsev and Mamev 1997). In another case, the jellyfish, *Mnemiopsis leidyi*, probably introduced to the Black Sea in the same way, caused the collapse of the commercial anchovy fishery in the Azov Sea.

In 1986, the Chinese Clam *Potamocorbula amurensis* was discovered in San Francisco Bay, California. It is believed that the species was introduced to the bay by ballast water in ships. In addition, in 1986 natural conditions changed. First there was a flood which introduced low salinity water into the bay and thus caused a decline in the Northern Bay Fauna. The flood was followed by a severe drought that led to increases in salinity above normal level. This hindered the previous fauna from coming back but favoured the *Potamocorbula amurensis* clam. The clam now makes up more than 95 per cent of the biomass and is expected to heavily impact local fish populations (National Research Council 1995).

Impacts from pollution

Pollution threatens biodiversity in the ocean in several ways. In coastal zones, nutrition-rich run-off from agriculture is thought to be responsible for toxic algae blooms that cause major disturbances. Toxic chemicals, like PCB, have been shown to pile up, through the food chain, both in fish and bird species, especially in the temperate oceans. Air pollution releases chemicals into marine ecosystems both on coastal waters and on open oceans.

The effects of run-off to the oceans are most apparent in semi-enclosed oceans like the Black Sea, where mass mortality of benthos and bottom living fish have been reported. As a result of increased human activities the frequency of water blooms has risen 10 to 30 fold compared to the 1950s. These water blooms consist of increased primary production in marine plants, and phytoplankton reactions to these blooms. The reasons for these blooms are increased run-offs of nitrogen, phosphorus, other nutrients from agricultural activities, and other chemicals (Zaitsev and Mamev, 1997).

One important effect of the increases in phytoplankton is decreased transparency of the surface water which affects the organisms that depend on sunlight for their survival such as algae. In 1950s the largest concentration of red agar-bearing algae in the world, an area of 11 000 km² (Zernov's *Phyllophora* field) was found in the Black Sea. This algae field was harvested commercially for extraction of agaroid

and also provided an important ecosystem service as an oxygen generator at depths between 20 and 60 metres for a large number of species (118 invertebrates and 47 species of fish). The lack of sunlight due to increased phytoplankton favoured by pollution has reduced the size of the field to 500 km² today.

There is contradictory evidence on the effects of pollution on increased zoo-plankton. Tsai et al. (1991), for instance, hypothesise that the abundance of zoo-plankton in the Potomac River estuary due to the discharge of sewage plants in the area actually favoured juvenile striped bass. Hence when treatment of sewage improved and the zoo-plankton population declined, also the abundance of striped bass decreased despite the improved in water quality in the estuary.

Increased pollution in combination with coastal development and introduced disease agents have caused the population of oysters in the Chesapeake Bay to almost disappear. The oysters of the species *Crassostrea virginica* were once a major fishery. Historic descriptions of the oyster reefs in the Chesapeake Bay area suggest that the abundance of oysters was so great that the amount of seawater filtered by Oysters for nutrition in one week came close to the total volume of water in the Chesapeake Bay (Hargis and Haven, 1988). Today's oyster stock would require one year to filter a volume of water equal to the volume of the bay corresponding to a 98 per cent decline in the population of the species (National Research Council, 1995).

Habitat destruction

Destructive fishing methods such as bottom trawling or dynamite fishing can have significant effect on the flora and fauna of marine ecosystems. Watling (1994) found evidence that in untrawled areas diversity of epibenthic invertebrates, infaunal burrows and tubes, as well as diversity and abundance of young fish, was greater than in trawled areas. Jones (1992) reviewed evidence for the environmental impact of trawling on the seabed. He concludes that bottom trawling affects the environment, but the extent of the effect depends on the size of the gear and the exact physical conditions it is used in. Despite the so-far sketchy evidence, the United States National Research Council has identified bottom trawling as an factor in extensive change of the marine habitat (National Research Council 1995). The destruction of coral reefs by destructive fishing practices (dynamiting, poison fishing) and the destruction of mangroves through intensive shrimp aquaculture are further examples of habitat loss (McNeely et al., 1990).

Global environmental impacts

Global warming and increased ultraviolet radiation are the main global environmental threats to marine ecosystems. Global warming threatens marine ecosystems in two ways: first, by changing ocean temperatures, and second through raising sea levels. Increased UV-B exposure due to the depletion of the ozone layer has already lead to increases in certain algae with negative impacts on coral reefs in Florida and the Caribbean. Rising sea levels, on the other hand, threaten estuaries, mangroves, and coral reefs and the many species that depend on them as nursery grounds for spawns and juveniles.

The main global impact, however, is expected from climate change, as marine life is highly sensitive to water temperatures. The boundaries of nutrition-rich cold water and warm ocean currents create some of the most productive ecosystems in the oceans (e.g., in the Bering Sea, the Northeast Atlantic, and the Southwest Pacific). Permanent changes in ocean temperature therefore have the potential of imposing large changes on these often highly diverse ecosystems.

The impact of changes in water temperature is demonstrated by the following example. In the 1960s, an unusual high-pressure cell over Greenland gave rise to northerly winds over the Greenland Sea. This created a big bowl of cold and fresh water in the East Greenland current known as the 'Great Salinity Anomaly'. The water mass travelled through most of the North Atlantic over the next 25 years. Temperatures in this water mass were 0,5 to 2 degrees Celsius lower than average and salinity anomaly was 0,1 to 0,15 units (Jakobsson, 1992).

The change in ocean temperatures had significant effects on the Norwegian spring spawning stock, the West Greenland cod stock and the blue whiting stock. For the Norwegian spring spawning stock, major changes in migratory patterns were observed. The West Greenland cod stock suffered a drastic decline from 400 000 metric tons in 1968 to 30 000 metric tons in 1976 due to the cold water mass and heavy fishing pressure (Blindheim and Skjoldal, 1993). The example illustrates the potential impacts of global warming in the North Atlantic: with warmer temperatures more ice in the Northern Hemisphere would melt, leading to increased inflow of fresh cold water to the North Atlantic. Such a change would be felt throughout the North Atlantic with a dramatic effect on fisheries.

However, it is difficult to evaluate the precise impacts of global environmental impacts on the economic profitability of commercial fisheries. For instance in the case of the 'Great Salinity Anomaly', the thermic front around the cold bowl has generated a temporary *increase* in the productivity of fish stocks, notably cod. When the cold water mass arrived in the extreme North, the return of the productivity of fish stocks to its normal level was perceived as a crisis. Suffice it to say that global environmental change, in particular global warming, is likely to have a noticeable impact on the size and location of fish stocks. While the direction of productivity changes is difficult to predict, the variability of stock sizes is likely to increase.

4. IMPACTS ON ECONOMY AND WELFARE

The absence of appropriate incentive measures such as ITQs has significant impacts not only on marine biodiversity but also on the economic performance of the fishery industry and the welfare of the communities that depend on it. One of the main benefits of ITQs is the stabilisation and the maximisation of the income of the remaining participants in the fishery industry. While additional incentives have to be implemented in order to maximise the ecological benefits of ITQs, their economic benefits are largely realised without any modifications. Below is presented briefly the economic damage caused by the absence of incentive measures, i.e., a description of the situation that ITQs are designed to address.

Direct economic impacts of biodiversity loss in fisheries

The absence of fishery management systems and incentives for sustainable use such as ITQs have resulted in the over-exploitation of fishery resources. Sudden declines of major stocks have occurred in at least 10 of the world's major fisheries (Beverton, et al. 1984). The following three examples, two from OECD countries, one from a non-OECD country, demonstrate the economic effects of such stock collapses.

Canadian Northern cod

In 1992, Canada's northern cod fishery collapsed and a moratorium was imposed on fishing. Originally, the moratorium was supposed to last two years, but the stocks continued to decline and the moratorium is expected to stay in place until the late 1990s, despite a brief lifting of the moratorium in 1997. The moratorium has had severe effects on income and employment in Newfoundland, which relied heavily on the fishery. Official policy to diversify the basis for income in Newfoundland had largely failed and fishing remains the backbone for the Newfoundland economy and the employment of last resort. When the Northern cod stock of the Newfoundland coast was closed to fishing, tens of thousand of fishers and fish processing plant workers were put out of work and, in the absence of alternative employment, became dependent on government assistance (40 000 fishers in 1995).

As with previous crises in the Atlantic groundfish fisheries, the Canadian government responded by implementing a social welfare programme in order to ease the social effect of the collapse of the northern cod fishery. This programme, named the Atlantic Fisheries Adjustment Program, was funded with over C\$ 500 million Canadian dollars to ease the economic impacts on the communities (Schrank, 1997). Later the Northern Cod Adjustment Program and Recovery Program (NCARP) replaced the AFAP programme. While the aid programmes were intended to encourage people to leave the fishing industry, flaws in design changed its character to a financial aid for fishers waiting for the fishery industry to rebound (Schrank, 1997).

In order to emphasise the need for people to leave the fishing industry a new programme was developed when the NCARP came to an end in 1994. This new programme was aimed directly at the over-capacity in the industry and was called The Atlantic Groundfish Strategy (TAGS). The programme with a budget of C\$ 1,9 billion aims at capacity reduction and reallocation of labour through vessel and license buyback programmes, education, job training, community work, early retirement and mobility assistance. In 1995 the TAGS provided income support, training and other adjustment measures to

14 000 fishers and 26 000 plant workers (OECD 1997d). While the programme was intended to continue until 1999, by mid-1996 funds were nearly depleted and an additional C\$ 500 million has been provided to fulfil its objectives (Schrank, 1997).

United States Northeast groundfish

The United States North-east groundfish fishery is a multi-species fishery exhibiting complex biological and technological interactions. Cod, haddock and yellowtail flounder, the traditional commercial mainstays of the fishery, are subject to predation by dogfish, skates, silver hake and mackerel, among others. The composition of stocks on Georges Bank, the principal fishing grounds for the fishery, has shifted dramatically during the last three decades. The proportion of dogfish and skates in Georges Bank trawls surveys has increased from 25 per cent in the early 1960s to nearly 75 per cent in the early 1990s (NOAA, 1992).

In 1994, the US National Marine Fisheries Service announced that the stocks of yellowtail flounder and haddock had collapsed, defined as a condition of chronic low recruitment due to reduced spawning biomass, truncated age structure, and prolonged periods of fish stocks being less than 25 per cent of the size that would produce their maximum sustainable yields. A determination made late in 1994, based on new assessments, indicated that the cod fishery in this region had also collapsed (NMFS 1996).

The crisis in the Northeast groundfish fishery has resulted in economic hardship. It is evident that past management and harvesting practices have not provided a long-term sustainable fishery for these species. Rebuilding the groundfish stocks and recovering the economic health of the industry is expected to be difficult and time-consuming. In 1996, a vessel buyback programme was instituted in the Northeast groundfish fishery with the objective of reducing fishing capacity. US\$ 23 million was appropriated with the expectation it was anticipated that this level of funding would be sufficient to retire 75 to 80 groundfish and scallop trawlers (OECD 1998).

Peruvian anchoveta

One of the best known cases of a large biomass shift with dramatic impacts on the economy and welfare followed the collapse of Peru's anchoveta stock in 1972. The fishery had been, until then, the world's largest fishery in weight terms. The stocks of South American sardine increased substantially following the anchoveta collapse, filling the niche in the ecosystem left by the anchoveta (Patterson, Zuzunaga and Cardenas, 1992).

The shift from a high volume fishery based on anchoveta to a low volume mixed species fishery had a large impact on the whole Peruvian economy of which the anchoveta fishery had been an important component. Catches fell from 10,4 million metric tons in 1971 to 4,7 million metric tons in 1972. When the collapse was apparent in 1973 the anchoveta industry was nationalised in order to save jobs. It was denationalised again in 1976. These changes in property rights regimes caused considerable political unrest (Glantz, 1979 and 1980).

This biomass shift was the result of a very strong El Niño event bringing warm, nutrient-poor water into an area that is normally cold and nutrient-rich. The depletion of nutrients adversely affects plankton production, which is the primary food source for anchoveta larvae. The strong El Niño effect was accompanied by heavy fishing pressure. In the five years preceding the collapse in 1972, catches had

exceeded maximum sustainable yield, with especially heavy fishing on younger fish. Whether El Niño or excess fishing pressure was the dominant cause of the collapse is still not clear. Each may have been sufficient to cause the collapse, or they may have 'acted in catastrophic harmony to produce a severe ... dislocation of the anchoveta fishery' (Thompson, 1981).

The above discussion suggests that there was some indication prior to 1972 that the harvesting of the anchoveta was at unsustainable levels. However, some have contended that due to political pressures these warning signs were ignored. Gulland (1980) notes that it would have been politically very difficult to call for reduction in catch when the fleet was only operating at half of its capacity (but still harvesting 10 million metric tons). While a reduction might have caused political unrest already prior to 1972, the problem was compounded by postponing the implementation of possible solutions to the future.

Damages to public goods resulting from biodiversity loss in fisheries

Total economic welfare consists of the sum of the utilities derived from the consumption of private goods and of public goods. Commercially valuable fisheries can be considered as private goods (at least as soon as they are sold on markets), whose existence values also have the characteristics of public goods. The collapse of a commercial fishery thus reduces welfare in two ways: first, less fish is caught, sold and eaten and hence the utility from private goods is reduced; second, the utility derived from the existence of the fish stock in question and hence its public good value is reduced.

A third impact on economic welfare is derived from the interactions of the commercially valuable target species with the surrounding ecosystems. As Chapter 3 has shown, certain commercially valuable fish stocks are keystone species and their collapse negatively affects other species. Consequently, the existence values from these other species are reduced as well. Furthermore, some recreational and leisure activities in the marine environment rely on healthy marine ecosystems. Should their pursuit be negatively affected by the collapse of a fish stock, the resulting negative impacts on utility form also part of total welfare losses. Therefore, in order to assess the total damage to the economy and welfare from the absence of an appropriate incentive measure such as an ITQ system, consideration must be given to not just the losses in private good terms of the commercially valuable target species. The existence values of the target species as well as those of the surrounding ecosystem affected by its collapse also have to be taken into account.

The measurement of the existence values of public goods such as marine ecosystems is difficult but not impossible. Economic theory has developed a series of methods aiming at deriving approximate answers. Probably best researched are the existence values for marine mammals such as whales and dolphins. The measurement of the travel costs of tourists wanting to see whales and dolphins in their natural environments can give *some indication* of the economic value of the existence of these species. Similarly, the payments to environmental advocacy groups that undertake efforts to save whales, dolphins, seals or turtles can, properly separated from general contributions, help to estimate the public good value of these species.⁴ Partly in response to these expressions of preferences, national and international regulations have been implemented, such as the bans on commercial whaling or the legal pressures to abolish certain techniques in tuna fishing which endanger dolphins and seabirds.

4. Public good arguments can apply also to the defense of a continued utilisation of fish stocks. Examples are constituted by the cultural value of whale meat as part of a national cuisine or the value of whale whiskers or bones used for artistic purposes.

The question with regard to ITQs is, of course, to which extent can ITQs preserve not only the economic value of the target species but also the wider existence values of the surrounding ecosystem and its relevant species. ITQs can contribute to the wider ecosystem, in particular, if they are applied to the management of keystone species. However, as discussed at length in Chapters 5 and 6, ITQs alone can preserve the target species and its ecosystem functions, but cannot, in the absence of complementary measures, address problems such as by-catch, discarding and marine pollution that affect the wider marine biodiversity. Hence the need for complementary incentive measures which also preserve the public good value of marine resources affected negatively by the absence of incentive measures.

Economic impacts of adverse incentives

The harvesting sector of the world's fishing industry is heavily subsidised. The UN Food and Agriculture Organisation (FAO) estimated global operating and capital costs in the late 1980s were in the region of US\$ 132 billion. Catches at the same time were worth US\$ 70 billion. The FAO reports concludes that governments subsidise their fishing industries by US\$ 54 billion per year (FAO, 1993). More recently, Milazzo estimates global subsidies to the world fisheries to be between US\$ 11 billion and US\$ 21.5 billion (WWF, 1997; Milazzo, 1997). Fisheries subsidies contribute to over-capacity and overfishing problems in three ways: first, by raising profits per unit of fish produced; second, by providing income support for fishermen who are thus encouraged to stay in the industry; and third, by reducing the cost of investing in new and more efficient technologies (Porter, forthcoming).

Most, if not all, fishing nations have subsidised their fishing sectors to various extents. With the establishment of 200-mile exclusive economic zones, optimism about the future of the fisheries increased as well. The nations with coastal access increased the capacity of their fleets dramatically between 1976 and late 1980s (FAO, 1992). This capacity increase was supported by direct and indirect subsidies. The direct subsidies included low interest loans, grants, uncollected user fees and subsidies to operate the fishing vessel. Indirect subsidies included price supports, tax incentives (deferred tax on investment savings) and the provision of tax-financed infrastructure in the form of ports and docking facilities. Subsidies aimed at modernising fishing fleets have been especially damaging. Today governments spend large amounts of money buying out vessels that, in some cases, they helped to build by direct or indirect subsidies (Gates et al. 1997).

Currently, very little quantitative data about subsidies to commercial fisheries is readily available, but several efforts to remediate this situation are under way.

5. THE IMPLEMENTATION OF THE INCENTIVE MEASURE AND CONTEXT

5.1 Identification of the incentive measure: ITQs

ITQs are incentive measures that can simultaneously address the ecological and economic sustainability of commercial fishery resources. ITQs alone are not, however, well-suited for dealing with pollution, discards, by-catch, destructive fishing methods and problems related to the introduction of alien species. Methods similar to ITQs are used to control air and water pollution and to allocate the prospecting and the extraction of certain natural resources such as oil and gas. ITQs are thus part of a wider class of incentive measures which can be referred to as 'market creation through the allocation of private property rights' and which have been subsumed under 'Indirect Incentives' in *Saving Biological Diversity* (OECD, 1996).⁵

An ITQ gives an individual fisher the right to harvest a specified quantity of fish for a specified period of time. ITQ programmes have used different ways to specify the units of individual quota: in terms of weight of fish, numbers of fish, and shares or units of the total harvest. Most commonly, each fisher's ITQ specifies the percentage of the total allowable catch (TAC) he or she is permitted to catch in any given fishing season. For example, if a TAC is set at 25 000 tonnes, and a fisher holds an ITQ equal to one tenth of one per cent of the TAC, the fisher is then allowed to harvest 25 tonnes during the season.

ITQs convey exclusive rights to individuals. The property may be assigned, traded, and exchanged, i.e., the owner has the right to transfer ownership (by sale or gift) to others. The ITQs can differ, however, in characteristics such as their duration, flexibility, quality of title, and divisibility (Scott, 1988; Muse and Schelle, 1989). For example, in the San Francisco Bay herring sac roe fishery, a fisher's quota can only be transferred in whole to other licensed fishers, whereas in the Mid-Atlantic surf clam fishery any part of a quota can be transferred to any US citizen or corporation. In the Australian southern bluefin tuna and abalone fisheries there is no limit on the total quantity of quota that any one owner can possess, while in other fisheries there are limits on the share of the total that any one person can own.

ITQs avoid the costs of the race-to-fish

The reasons for choosing an ITQ-system vary widely across fisheries. Many fishery management authorities have chosen to use ITQs after experiencing the deleterious economic consequences from using TACs without individual harvest rights. While, in theory, TACs too should avoid the overfishing of commercial fish stocks, in practice this is far from evident. A study by the OECD Committee for Fisheries reported that TACs have been observed to perform poorly in terms of resource conservation.

TACs are also connected with substantial costs, the study of the Committee for Fisheries reported that TACs resulted in races-to-fish with important negative side-effects, such as capital stuffing and increased harvesting costs. Notable cases include the US and Canadian Pacific halibut and sablefish

5. The potential problems and benefits of ITQs are examined in detail in *Towards Sustainable Fisheries: Economic Aspects of the Management of Living Marine Resources* (OECD, 1997c, pp. 61-122). The study analyses the experiences of 42 ITQ-managed fisheries in 10 countries.

fisheries, the Alaskan king crab, groundfish, and more recently tanner crab fisheries, US wreckfish, Canadian geoduck, Australian Southern bluefin tuna and gemfish (OECD, 1997c).

In these cases races-to-fish resulted in shortened seasons, increased costs and lower profits. Fishing seasons became shorter than optimal for maximum economic returns, landings were too small and of inferior quality, and excessive investment in vessels and gear was stimulated. In particular, increases in vessels and capacity (bigger boats and faster engines) were common. This 'capital stuffing' occurs as investment is profitable in the immediate term from a private point of view but imposes negative externalities on the industry as a whole, leading to over-investment and misallocation of resources. Other side-effects included increased gear losses, gear conflicts, and decreased safety, since two or more fishers often competed for the same stocks at the same time and place.

Processors, distributors, wholesalers, retailers and consumers also lost, as the races-to-fish resulted in periodic peak loads, requiring the build-up of excessive processing, storage and distribution facilities. Wholesalers, retailers and consumers were swamped with large amounts of supplies for short periods and found themselves without adequate supplies for the remainder of the season. This resulted also in changes in product characteristics, as fish were processed for long shelf life, which, in general, reduced the quality of the end-product.

Increasing the economic sustainability of fisheries

While ITQs can contribute to the long-term ecological sustainability of commercial fish stocks, there is also evidence that they increase the long-term economic sustainability of the use of commercial stocks. In those cases in which careful analyses have been done, there are significant positive net benefits from the implementation of ITQs. In the Australian southern bluefin tuna, the net benefits to the industry are estimated to be in excess of A\$ 6,5 million compared to a quarter of this sum for the same catch under alternative management schemes (Geen and Nayar, 1988).

A cost-benefit analysis of ITQs for the British Columbia halibut fishery estimates the programme will generate C\$ 7 million per year which constitutes a 65 per cent increase over the revenue generated by the previous management regime (Fagan, 1990). In the plan document for Alaskan sablefish, the Management Council estimated a clear gain in economic benefits to be expected from managing the fishery under ITQs. Not included for in the above estimates are the benefits to consumers of being offered higher quality fish and have fresh fish available for longer periods.

While there have been problems implementing ITQs in some fisheries such as the Bay of Fundy herring and New Zealand groundfish fisheries, industry strongly endorsed the ITQ programmes in the Wisconsin Green Bay yellow perch fishery and the British Columbia black cod and geoduck fisheries (Muse and Schelle, 1989; Muse, 1991; Clark, Major and Mollett, 1988). Despite initial problems, a majority of fishers in one of New Zealand's inshore fisheries viewed ITQs as better than other forms of management, and a majority reported their condition to be better under ITQs (DeWees, 1989). In the herring roe fishery of Yaquina Bay, Oregon, fishers are voluntarily using a private ITQ system (Muse, 1991). In Iceland, where the industry was initially sceptical of ITQs, soon enough support emerged in order to implement the system permanently.⁶

6. Further reports exist for the New Zealand inshore fishery (Deweese, 1989), Lake Winnipeg gillnet fisheries (Muse, 1991), Ontario (Muse and Schelle, 1989), Australian abalone (Muse and Schelle, 1989), Bay of Fundy herring (Muse, 1991), and the Canadian Atlantic groundfish (Muse and Schelle, 1989).

Overview of potential problems of ITQs

- *High-grading*: ITQs present added incentives to high-grade (i.e., to discard less valuable fish and to keep only the most valuable fish to count against one's quota). High-grading has been a problem in some fisheries and not in others (see OECD, 1997c).
- *Underreporting of catch and data degradation*: ITQs provide an added incentive to underreport actual catches. Fish not reported is not counted against one's quota. The tendency to misreport actual catches reduces the veracity of reported landings. Evidence on reporting and data degradation is mixed (OECD, 1997).
- *Enforcement costs and problems*: ITQs do present serious problems with enforcement and compliance. However, where enforcement costs increased under ITQs, fishers were often able and willing to pay these increased costs. As non-compliance is perceived by other fishers as an act that diminishes the value of their assets, assistance can also be more forthcoming.
- *Social cohesion and inequities*: There is a concern that ITQs create groups of 'haves' and 'have-nots' by giving an elite class of fishers exclusive rights to exploit the fishery. In many fisheries, ITQs have been assigned with little or no fee being paid to boat owners with a historical record in the fishery. Unless the ITQs are auctioned off, or a resource rental or royalty is paid, recipients receive a windfall gain at the expense of other participants in the sector (e.g. crews) potential newcomers and the general public who previously enjoyed unrestricted access to a public resource.
- *Elimination of small-scale fishers*: Concerns exist that ITQs eliminate small-scale fishers, and smaller, more remote fishing ports as tradable quotas would be purchased by the larger, more profitable fishing operations. The actual outcome in any given fishery depends on the most efficient scale of operation, and programme policy.⁷ There is little evidence that smaller fishers were eliminated where ITQs were introduced.
- *Reduced employment and crew income*: Employment and crew incomes may decline because of the reduced number of vessels. Since total income is maximised and fewer vessels operate for longer periods during the year, the remaining crew will have more full-time employment opportunities and more stable income. OECD (1997c) reports strong evidence of reduced employment in ITQ fisheries.
- *Industry resistance*: The above problems, both perceived or real contribute to resistance to adopting ITQs as a management tool. An additional fear is that the system is irreversible; once it is in place and money has been exchanged for quota, it would be difficult to revert to a more open system of access. While these fears may not be always justified, they are real and evidence exists for both industry resistance to and support for using ITQs.
- *Biodiversity conservation*: While ITQs can protect the economic value and the existence value of the commercial target species, they need complimentary incentive measures, in order to also conserve and sustainably use the surrounding ecosystem. Nevertheless, where the commercial target species is a 'keystone species', the ability of the ITQ to create incentives to conserve this species can be considered to have positive impacts on the surrounding ecosystem,

7. In the Mid-Atlantic surf clam and the Atlantic Canada offshore groundfish fisheries large companies own the quota because they were initially given the quota. However, both fisheries were dominated originally by a few large, vertically integrated companies before ITQ management was introduced. In some fisheries (specifically the Australian pearl oyster and Newfoundland cod fisheries), ITQs have helped smaller operators (Muse and Schelle, 1989, Muse, 1991). In Iceland, built-in constraints on trading quota protect local and regional fishing interests (Muse and Schelle, 1989).

Overview of potential benefits of ITQs

- *Elimination of race-to-fish:* Since each producer is assured a given quantity of fish, the race-to-fish among producers is eliminated. The evidence clearly shows that TAC management results in a race-to-fish with all its attendant effects.
- *Maximised resource rent:* Since an ITQ is an asset and a form of wealth, each owner is motivated to maximise its value. If the underlying TAC is properly set, the resource rent from the fishery can be maximised. The availability of resource rent offers government the opportunity to capture some of the rent to cover the costs of managing the fishery (e.g., enforcement, research), and to compensate other parties and the general public for the loss of certain rights over the resource..
- *Increased profits:* Assured of a given quantity of fish, each fisher can plan operations to minimise the costs of catching a given quantity of fish. Also, the fisher can plan to catch and land fish when they are in the best condition for market and when the market price is highest. This results in greater revenue and lower cost. OECD (1997c) reports strong evidence that ITQs increase profits.
- *Greater economic stability:* Because ITQs provide fishers the opportunity to smooth production over the fishing season, to respond to market and stock conditions, and to avoid costly and dangerous fishing conditions, there is greater stability in the fishery.
- *Improved product quality:* Fish are caught, handled and processed to best suit the market, thus improving the quality of the product available to consumers. OECD (1997c) reports significant empirical evidence of improved product quality.
- *Safety:* The incentives to fish during dangerous weather conditions, and with inadequate or unrepaired equipment, are reduced. Fishers can forego fishing in unsafe conditions, and wait to fish when it is safe, secure in the knowledge that no 'race-to-fish' will reduce their entitlements.
- *Reduced gear conflicts:* With the introduction of ITQs, the fleet size is likely shrink in over-capitalised industries. The remaining vessels will spread their fishing effort over a longer period of time during the season. Both facts reduce the potential for congestion and conflict.
- *By-catch and waste reduction:* Fishers operating under ITQs have the time to target, sort, handle, and, as a result, by-catch will tend to decline. If the by-catch species are managed under ITQ programmes, and are adequately monitored, fishers have an additional incentive not to discard by-catch. As a result, the waste or loss of product as well as the resulting impacts on biodiversity are reduced.
- *Reduced gear losses:* Since the amount of effort is less, and fishers tend to fish during more favourable fishing conditions and with better-maintained equipment, fewer losses of gear can be expected.
- *Market gluts are mitigated:* Since fishing and landings are smoothed out over the season, market gluts are avoided and the average quality of the product is improved which results in higher average prices. There is strong evidence supporting this outcome (OECD, 1997c).
- *Wealth creation and compensation:* An ITQ is a valuable asset. Owning rights to catch fish is similar to owning other property and, as such, contributes to the individual's wealth position. Fishers, who want to leave, or otherwise reduce their participation in the fishery, may be compensated by the sale or leasing of their quota.
- *Sense of responsibility:* Other than through the conservation of the target species, biodiversity and the surrounding ecosystem can gain through an increased sense of responsibility from fishers who have become stakeholders in the viability of the whole system through the owning of a quota.

5.2 Process of implementation and distributional effects

Implementation of an ITQ fishery management programme includes determining how to design the many components of the programme. These components include specifying the rules for the initial allocation of quota shares, setting the TAC(s), determining the characteristics of the individual quotas, specifying supplementary management regulations, and the nature and extent of enforcement and compliance.⁸

Initial allocation determines winners and losers

The problem of initially allocating shares of the TAC is perhaps the greatest difficulty in implementing ITQs in fisheries. As indicated in OECD (1997c), 'The initial allocation of quota shares is often problematic and controversial because it determines who will receive many of the benefits from the programme, creating a valuable asset for some and excluding others.' The initial allocation problem is, whether to sell or give away the rights and how to distribute the shares among the recipients.

There are many ways that ITQs can be initially distributed among recipients. In practice, most ITQ programmes have chosen to allocate quotas to boat owners who have a historical record of participation in the fishery. Other programmes have developed formulas that assign distributed weights to historical catches, investment, and other factors in order to determine fishers' shares. The use of equal shares also has been quite common. Another alternative is to auction off the ITQs.

Another option is to allow fishers to decide among themselves how to allocate TACs. This method has been used, for instance, by the Canadian government. In the offshore groundfish, Nova Scotia trawler, and Gulf of St. Lawrence shrimp trawl fisheries, fishers chose to base the initial allocation of ITQ on historical catches. In some areas of the Gulf of St. Lawrence groundfish fishery, vessels were divided into length categories, and each vessel in a category received an equal allocation. In another area of the fishery, fishers tried to assure that everyone was given an allocation with which they could at least break even.

Different allocation formulas create different problems. Where ITQs are assigned on the basis of historical catch records with little or no fee being paid, recipients receive a windfall gain. New entrants to the fishery, as well as the general public which enjoyed certain ownership rights over the resource, lose. Frequently, the fairness of assigning catch rights to a privileged few, especially to the owners of capital in the fishery, is questioned.

Other concerns are that ITQs eliminate small-scale producers and contribute to the decline of small, remote fishing ports, as quotas will eventually be purchased and controlled by large fishing corporations. There is, however, no evidence so far that the concentration of ownership that often exists at the primary buying and processing level is being vertically extended backwards to the harvesting sector as well. The most efficient scale for a fishing unit may be a large corporation or a small family-owned operation; it depends on the nature of the fishery.

The prime concern of all arrangements for the allocation of quotas is its acceptability to the industry and its operators. From a theoretical point of view any initial allocation will work; that is, the

8. More details on the design and implementation of ITQ programs can be found in NOAA (1992), and in Anderson (1994).

initial allocation does not affect the long-term economic performance of an ITQ programme. Acceptability, however, is the key to assure the working of the ITQ programme and to keep monitoring and enforcement costs at reasonable levels.

Setting the TACs

The TAC must be set each year for each species, location, and season. Determining the unit or units of a fishery stock is a critical step in any fishery management programme. There are two important considerations when defining the appropriate management units (Anderson, 1994). The first is how many and which species to include. Species that are biologically related, e.g., as predator and prey, or are caught jointly, may each need a separate TAC. The second consideration is how to group the included species. Several stocks or distinct units of a single species may exist in proximate geographic areas. A separate TAC may or may not be appropriate for each area. In many fisheries, the appropriate unit is the species throughout its geographic range. In other fisheries, such as Alaskan halibut and sablefish, there are several appropriate management units, one for each area.

Once the stock management unit is determined, the next step in the TAC-setting process is to assess the status of the fish stock. The main outputs of the stock assessment process are: estimates of the current size of the stock; estimates of current fishing mortality rates; and forecasts of the likely biological consequences of continuing to fish at current rates or of reducing or increasing the catch according to specified target rates. Catch forecasts vary depending on the rate of fishing, and the size, productivity, age composition and expected pattern of exploitation of the stock.

Typically, the stock assessment authority subjects its assessment to peer review by other scientists. In some countries these peer reviews are funded by different stakeholder groups such as environmental NGOs or fishing industry groups. Special boards or committees are often established for this purpose. In most cases, the TAC-setting authority takes account of this stock assessment which is based on biological considerations, as well as of a range of other considerations such as economic objectives, social constraints, interactions with other commercial or recreational fisheries, interactions with marine mammals and other protected or endangered species. In general, TACs are set below the expected maximum sustainable yield for stocks that require rebuilding, and above the expected maximum sustainable yield for relatively new fisheries. However, even in a fishery exploited at near-optimal rates, the TAC levels vary in response to fluctuations in recruitment and stock size.

Characteristics of ITQs

ITQs confer property rights which differ in their transferability, duration, flexibility, quality of title and divisibility (Scott, 1988). Often, the two most controversial characteristics are transferability and duration of the quota share. Concerning transferability, allowing owners the unrestricted sale, lease or otherwise exchange of quota shares increases the economic efficiency of the fishery. It also provides fishers with a valuable asset once they choose to leave the fishery. Full transferability allows participants to optimally adjust their portfolio of species and to operate at their desired scale. An ITQ provides incentives to find the most efficient ways to harvest fish and to maximise the value of quota.

In a fully flexible trading system, quota prices reflect the present discounted value of expected future profits (expected revenue minus costs) from fishing. Therefore, fishers with more profitable operations will tend to purchase quota from those with less profitable operations. If the fishery is very

heterogeneous, i.e., with a wide range of profitability among fishers, then less profitable fishers can expect to sell their quota for more than what they can earn by fishing it and the more profitable fishers can expect to earn more than what they have to pay for additional quota. Bargaining power and bargaining skills will determine the final distribution of the rent gained from a more efficient allocation of the resource.

Concerning the durability of title, some ITQ programs assign quota shares that are permanent. Others assign the right for a fixed term. Permanent rights are expected to generate greater economic returns than shorter-term rights. Thus permanent ITQ rights are generally considered superior to fixed-term ITQs. Short-term rights breeds a 'get rich quick' mentality, reflecting uncertainty about the future. Long-term rights, instead, allow fishers to invest in their businesses. The longer the duration of rights, the greater is the value of fishers' stake in the fishery and stronger the incentive to conserve and protect the resource.

In order to achieve successful ecosystem management ITQs have to be combined with other management measures. There are many circumstances where controlling total catch alone is an insufficient conservation measure. Quota holders will fish to maximise the value of their quota. Since the quota is fixed, profit maximising fishers have the incentive to select only the most valuable fish to count against their quota. This can result in the practice of high-grading in which fishers discard the less valuable fish they do not want to count against their quota. High-grading can have two effects. First, it results in under-reporting of true total catch. Second, it can lead to increased loss of smaller fish thus harming the spawning potential of the fish stock.

Complementary incentive measures designed to protect fish below a certain size, e.g., through the imposition of a minimum mesh size, can help to address the problem of high-grading. Other conditions on gear and vessels serve to minimise gear conflicts and collateral damage to ecosystems. Limits on days at sea, number and size of gear units, etc., can reduce the cost of enforcement and monitoring of fishing practices. Such supplementary regulations can thus contribute to the conservation of biodiversity beyond what ITQs alone could achieve. While imposing certain restrictions on fishing activities, such regulations usually do not interfere with the efficiency improvements expected from ITQ systems. In fact, it can be argued that by preserving the wider marine ecosystem such measures ensure the long-term sustainability also of the commercial target species and thus contribute to the maximisation of the value of ITQ rights.

Enforcement and monitoring

Enforcement problems and costs are relatively high in ITQ-managed fisheries compared with other management systems. The OECD (1997c) reports that rights based systems such as ITQs, may generate increased enforcement and administration costs. However, while enforcement costs usually increase under ITQ programmes, fishers are often able and willing pay at least part of the increased costs. The specific enforcement and monitoring strategy for ITQ programmes typically consists of three related sets of activities: (1) at-sea patrols, (2) on-shore monitoring, and (3) auditing. At-sea patrols are needed to detect smuggling, poaching, illegal discarding and to monitor fish transfers from fishing vessels to processing vessels and carriers. On-shore monitoring of landing operations is needed to inspect the holds of vessels to detect smuggling, and to verify compliance with quota and by-catch requirements. Auditing is required to check the records of quota holders, vessels, processors, fish buyers, and shipping companies. For reasons of cost-effectiveness, some fisheries authorities require each vessel to use a designated landing port where it must land its catch unless otherwise authorised.

Participation of the fishers in fisheries management decision making can lower the enforcement costs. In this context also education of stakeholders about impacts of ITQs can have an important role to play. Information on actual experiences with ITQs and early stakeholder involvement are essential for the success of ITQ programmes. The Netherlands, for instance, rely on extensive user participation in some of its fisheries. Co-incidentally, ITQ systems lend themselves well to co-management, here understood as arrangements in which governments share decision-making powers and responsibilities with user groups. As ITQs are property rights, they provide incentives for fishers to maintain the overall system that establishes and protects these rights. Furthermore, the fishery resource forms the basis of the property right, ITQs provide an incentive for fishers to conserve the resource.

There exists some empirical evidence for the importance of monitoring and enforcement for the working of ITQ systems, as well as for the importance of social cohesion in order to allow for stakeholder involvement: ITQs have worked well in relatively isolated fisheries such as in Iceland or in New Zealand, where social cohesion and personal knowledge are high and where consequently a degree of social control exists. Conversely, the costs of monitoring and enforcement are higher in more open and accessible fisheries, such as the fisheries in Eastern Canada.

5.3 The role of information and the importance of ecosystem management

The lack of information and uncertainty complicate the implementation of ITQs and the conservation of biodiversity in fisheries. One of the principal sources of uncertainty and imperfect information is the status of the stocks. The size and composition of fish stocks routinely fluctuate from year to year. This uncertainty presents difficulties for managers whose target TAC depends on the precision of stock assessments. In addition, stock assessments are based on data that are one or more year old (Sissenwine and Kirkley, 1982). Other management-relevant sources of uncertainty and lack of information include weather, equipment performance, product quality, market prices, regulatory policy and unforeseen events, such as, for instance, an oil spill which can severely harm the resource in question.

A specific form of lack of information arises with respect to the management of marine biodiversity. Preventing the continuing loss of biodiversity requires an approach that manages ecosystems in an integrated fashion.⁹ This regards ITQ systems as well as other management approaches. Ecosystem management must be able to cope with the uncertainty associated with the complexity of ecosystems as natural systems, and the organisational and institutional complexity of the implementation environment (Hennessey, 1997). Ecosystem management thus necessitates the co-ordination of all policies concerning the use of an ecosystem's resources, as well as the formation of partnerships with non-governmental agencies and private sector stakeholders.

The ecosystem paradigm, recognising that plant and animal communities are interdependent and interact with their physical environment to form distinct ecological units, is emerging as the dominant approach to managing natural resources. The *Convention on Biological Diversity*, for instance, explicitly embraces an ecosystem approach. As another example, the United States administration and legislation are increasingly requiring an ecosystem approach to natural resource research and management. The 1993

9. Ecosystem management is defined as a system "driven by explicit goals, executed by policies, protocols, and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem structure and function" (Ecological Society of America, 1995).

Report of *The National Review: Creating a Government That Works Better and Costs Less* recommended to establish ecosystem management policies across the federal government.¹⁰

With respect to fisheries, this movement toward ecosystem management is reflected in the following initiatives:

- In the United States, habitat loss was one of the key concepts added into the reauthorization of the 1996 Magnuson-Steven's Conservation and Fisheries Management Act. This new Act recognises that habitat destruction, through development, pollution and unsustainable and destructive fishing methods, might have caused reduction in productivity of the ecosystems, requiring stricter control of ocean resources in the future. Ecosystem approaches are mandated in the NOAA's Marine Sanctuaries Program, the National Estuary Program, the National Estuarine Research Reserves System, the 1990 Amendment to the Coastal Zone Management Act; and also in the actions of federal agencies with resource management responsibilities.¹¹
- In South Korea, habitat and environmental protection will be integrated into future plans for developing harbours (Hong and Chang, 1997).
- In New Zealand, the 1996 Fisheries Act provides for the utilisation of fisheries resources while ensuring sustainability. This legislation defines sustainability as maintaining fishing activity at a level to support the maximum sustainable yield and avoiding or mitigating any adverse effects of fishing on the aquatic environment. The Act requires all decision makers to maintain the range of aquatic ecosystems and their genetic diversity and protecting habitats of particular significance to fisheries management.
- In Australia, a By-catch Task Force has been established to develop policy directions on the issue of by-catch.
- In Canada, the 1997 Oceans Act focuses on the conservation and protection of the oceans as an ecosystem. The Act provide for the implementation of a Oceans Management Strategy which give the Minister of Fisheries and Oceans the ability: to establish marine protected areas for the conservation and protection of marine resources and habitats; develop and implement in co-operation with stakeholders, plans for integrated management of estuaries, coastal and marine waters; and to develop measures to protect marine ecosystem health.

Based on the existing knowledge and institutional structures, successful ecosystem management approaches will have to address step-by-step the existing information gaps. These gaps regard the basic

10. The policies are based on the following principles: 1) managing along ecological boundaries; 2) ensuring co-ordination among federal agencies and increased collaboration with state local and tribal governments, the public and congress; 3) using monitoring, assessment and the best science available; and 4) considering all natural and human components and their interactions.

11. Since 1992 all four of the primary land management agencies (the National Park Service, the Bureau of Land Management, the Fish and Wildlife Service and the Forest Service) have independently announced that they are implementing or will implement an ecosystem approach to managing their natural resources (GAO, 1994). Several other agencies, including the Soil Conservation Service, the Department of Defense, Department of Energy, Bureau of Indian Affairs, Bureau of Mines, Bureau of Reclamation, Minerals Management Service, USGS, EPS, and NASA, have engaged in significant ecosystem management activities (CRS, 1994).

functioning and interdependence of ecosystems, as well as their reaction to exogenous pressures such as harvesting or pollution. Integrated work programmes within and between institutions should assign responsibilities in a co-ordinated fashion. Issues that have to be considered in such a process are co-ordination costs, the costs of transferring information, the costs of scientific resources, and the strategic costs of free riding and rent seeking. The latter are particularly important in the context of ITQ systems. Based on a sound understanding of the wider marine ecosystem, the working of ITQ systems can be optimised to contribute to the conservation and the sustainable use of biodiversity.

5.4 Resource rents and the institutional framework

In addition to the controversial issue of the initial allocation of quota, one of the most serious problems (political and legal) in connection with the implementation of ITQs in fisheries is the collection of resource rent. Since ITQ management programmes endow fishers and others with the rights to valuable property, many people question whether those rights should simply be given away without the government collecting some or all of the resource rent in the fishery.

Resource rent is the residual income ('excess profit') earned by the owner of a natural resource such as an ITQ after deduction of all operating and capital costs associated with production and management of the resource. A rent accrues to the owner of an ITQ, if the annual gross sales value of harvested fish exceeds operating costs, fixed and capital costs, and normal return to management associated with the harvesting activity. Necessary costs associated with regulation and enforcement of fishery regulations would also have to be subtracted from this value. The rent can vary widely over time as fish prices, catch rates, and operating costs vary.

Despite the apparent simplicity and widespread use of the term 'rents', the concept as applied to fisheries remains confusing and controversial. The three main issues concerning fishery rents are: How can resource rent generated under an ITQ system be measured? Should some or all of the rent be collected by the government from owners of ITQs? And, what fiscal mechanisms are best for collecting rents? Decisions in all three areas can influence both the efficiency of the ITQ programme and the distribution of benefits from the programme.

Various authors (e.g. Campbell and Haynes, 1991) have reviewed means of measuring the economic rents based upon market sales and costs derived from fishing firm's financial accounts or income tax returns. They note that the calculation is confounded by ambiguities concerning reported depreciation, accounting for opportunity costs of other scarce inputs to fishing, and costs of labour inputs.

Also, the existence of two notions of rent adds to the confusion. These are: (1) long term resource rent equal to gross revenue from landings minus all costs; (2) short-term, or quasi-rent, equal to gross revenue minus short-run variable costs (i.e. not deducting fixed or capital costs which are unrelated to level of fishing effort). Any economically sustainable rent collection system must focus on the long term resource rent. However, continuing differences in the estimates of resource rents plague efforts to collect a portion of annual resource rent from ITQ owners, as the experience in New Zealand has shown (Pearce, 1991). New Zealand charged fishers in ITQ fisheries resource rents between 1986 and 1994, but discontinued the practice when cost recovery was introduced in 1994.

There are essentially two rationales for government to collect some of the residual resource income from ITQ holders: (1) to compensate the public at large for relinquishing their open access fishing rights to the limited number of ITQ holders; (2) to recover the government costs of fishery research and

administration. While the two rationales emanate from two different sets of policy objectives, they are in practice difficult to distinguish. The charging of resource rents is a form of compensation from fishers who have been given the ability to earn rents at the expense of others who may have used the fish stock if it had been managed under an open access regime.

The objectives of cost recovery are the efficient provision of government fisheries research and management services with little or no government expenditure. In the absence of cost recovery, fisheries research and management services are provided free of charge and hence they are demanded even when their costs exceeds their benefits. With cost recovery, fishers' knowledge that they will be paying for, say, research services, provides an incentive to prioritise, and, in theory, optimise, requests. Of course, arguments remain to which extent research and management services, such as weather forecasts, are public goods and should be financed from general revenue, or to which extent they are specialised services which have the character of production inputs.

Australia, New Zealand and Canada operate policies of cost recovery for government fisheries services. In New Zealand costs incurred in relation to research, monitoring, quota management systems, some enforcement activities and some government policy activities are recovered from fishers. These costs are recovered from ITQ and non-ITQ managed fisheries. This point highlights the difference in underlying policy principles of cost recovery compared to those underpinning the policy of charging resource rents. In New Zealand, active consideration was given to having a system of cost recovery running in parallel to the charging of resource rents.

Concerning the mechanism for rent collection, there are two basic options: first, the use of a tender mechanism to auction off the rights. This option is attractive in that it enables the government to obtain at the outset the discounted value of expected future profits from the ITQ system; and second, the use of a periodic or transaction charge on the ITQ right. Such periodic charges could be collected as a share of net proceeds from the sale of products, landings taxes, a fee per ton landed payment, or as a percentage of the value of any transaction at the first point of fish (i.e., an *ad valorem* tax). Alternatively, annual lump-sum license fees could be used to extract rents (Huppert et al., 1992).

An important consideration with respect to periodic or transaction charges is timing. Once an ITQ system is initiated, the market in quotas will capitalise the future expected rents into the price. Proper accounting for asset values held in quota shares will then treat the 'rent' as an opportunity cost of investment in the harvest right. That is, there will be no excess profit in the fishing industry attributable to resource rent after the cost of quotas is subtracted. If the government later decides to collect rent, the price of quota shares will decline and firms having purchased quotas shares at the initial prices would be left with negative equity. It is therefore important that governments state clearly from the outset its intention to collect resource rents so that this is built into expectations regarding the ITQ values.

Final decisions on rent allocation and collection tend to be political rather than economic. They depend on the implicit and explicit ownership arrangements in individual countries. In many countries there seems to be an implicit consensus that part but not all of the resource rents in fisheries should belong to the active members of the fishery industry. The recovery of all costs of the management, monitoring and enforcement of an ITQ programme frequently indicates an acceptable portion of the rent that should accrue to the government and the public at large. Other than providing incentives for efficient service provision, cost recovery can thus in some cases also constitute an acceptable form of rent distribution.

However, the issue of rent extends beyond the rental values extractable from the commercial target species. Integrated resource management should strive for the joint maximisation of economic and ecological rent, which implies the full realisation also of the non-market values of natural resources. Such

policies could also ease problems of distribution and acceptance. The contribution of ITQ holders to the conservation of marine ecosystems could be interpreted as a form of compensation for the transfer of property rights. In this perspective, the implementation of additional incentive measures that complement ITQs such as, for instance, conditions on gears and vessels, strict monitoring and enforcement, is therefore part of achieving distributional equity and social acceptability.

6. POLICY RELEVANT CONCLUSIONS

6.1 Lessons learned

As ITQs are an internationally widely applied economic instrument within OECD countries, questions of transferability therefore seem moot at first sight. But ITQs are not the only instrument available for the management of fishery resources and while positive outcomes are often associated with the use of ITQs, there are nevertheless two important constraints on the use of ITQs have to be considered when assessing the usefulness of this incentive measure:

- ITQs are restricted to the species which have commercial value; and
- their social and environmental compatibility has to be assured by additional instruments.

First, ITQs are restricted to those biodiversity resources that have a commercial value. The creation of ITQs implies the creation of a market and the privatisation of a public resource. Such a mechanism will, if implemented and enforced properly, assure the maximum sustainable yield and enable profit maximisation. Incidentally, ITQs also realise the existence value of the target species as a public good and, to the extent that the ITQ target species is a 'keystone' species, its conservation contributes also to the wider ecosystem.. ITQs seem thus at first sight an ideal instrument for the conservation and the sustainable use of biodiversity.

However, frequently the contribution of ITQs is limited to the commercially valuable target species itself. Without complementary incentive measures and effective management, ITQs will not contribute to the conservation of other species or the surrounding ecosystems. Discarding, by-catch, destructive fishing methods and pollution have to be addressed by additional instruments. ITQs have thus to be implemented in a framework that makes their assignment conditional on the use of sustainable practices in order to support not only the sustainable use of the target species but also the conservation of the wider marine ecosystem. When such additional requirements or instruments are implemented, ITQs can be an effective instrument to achieve the conservation and the sustainable use of biodiversity.

A second issue is that a closer look at existing experiences reveals that the success or failure of an ITQ depends to a large extent on the ability of the policy makers to take local social and environmental issues into account. In particular, attention has to be paid to the following two areas:

- distributional issues, quota allocation and rent collection;
- enforcement of compliance with quotas, monitoring of underreporting and discarding.

ITQs display one important characteristic that allows to proceed towards a resolutions of these problems: ITQs maximise privately extractable resource rents. There exists thus an accessible source of funding for the solution of the accompanying framework that is necessary to render the use of ITQs ecologically and socially sustainable. The taxing of quota holders, or the auctioning off of quota rights, can be used to finance research, monitoring and enforcement of quotas and to ensure sustainable use practices, as well as, to some extent, compensate those who lost out upon the introduction of quotas. To render ITQs an instrument not only for sustainable fishery management but for truly sustainable

development including social and environmental components does create increased costs, but fishers that remain in the industry after the introduction of ITQs are able and often willing to pay for them.

6.2 Transferability of experience

The transferability of the results of ITQs to other situations can be discussed in two contexts: transferability to other parts of the marine ecosystem; and, transferability to other forms of natural resource use. Concerning the transferability of the results of ITQs to other parts of the marine ecosystem, the limited experience so far would encourage an extension of the use of ITQs, as long as there exists a definable and measurable target species with commercial value. Pure existence values that cannot be realised in private property terms do not lend themselves well to ITQ type systems. Perhaps the only adequate way is to tie the conservation of such components of the ecosystem to the utilisation of its commercially valuable components. As discussed above, this can be done through carefully chosen regulatory means which reflect the particular technologies, customs and circumstances of the industry.

The transferability of the results of ITQs to the management of other forms of natural resource seems to require the same conditions. The use of ITQs for other natural resources is equally dependant on the extent to which the resources in question have a realisable private value. If a direct use of a natural resource is already taking place (e.g., hunting, logging of indigenous forests), then this question is answered in the positive. Provided the conditions discussed above are adequately dealt with, there exists no principal reason why ITQ systems should not be applicable also for the conservation and the sustainable use of other environmental resources.

Even in cases where there exist resources with definable private values, the same problems are likely to occur as with the use of ITQs in the marine ecosystem. In an indigenous forest it may be possible to allocate cutting rights for the valuable commercial species, but problems relating to conservation of other parts of the ecosystem would persist and would require additional measures for their existence values to be protected. Examples of natural resource use where consideration could be given to an ITQ-type application include: access to land for cultivation purposes; the hunting of animals; and the access to tropical forests for the prospecting of genetic resources or the harvesting of forest products.

However, the formidable difficulties relating to the implementation of ITQs which were discussed in this report are likely to be larger rather than smaller in connection with the use of natural resources other than fisheries. Fishers constitute a relatively homogenous group of users, frequently living together in geographically clearly delineated areas. In addition, the target resource is usually comparatively easily defined, measured and monitored. Furthermore, declining fish stocks and the easily observable costs of the races-to-fish created a sense of urgency and a willingness to try new instruments. The implementation for ITQs for other natural resources will depend on the ability to bring together very diverse and geographically dispersed stakeholders and the capability to define and monitor resource use. With progress in research and information technology such developments are not impossible. However, only further detailed research on the use of ITQs for natural resources other than marine resources will allow to answer the question of transferability with more certainty.

6.3 Possible policy advice for implementation

Policy advice thus includes the following elements:

1. ITQs should be studied as a highly interesting incentive measure for the management of commercially valuable natural resources.
2. There are far-reaching economic, social, legal and ecological consequences which have to be carefully considered before and during the implementation of an ITQ system.
3. Information, education and early stakeholder involvement on social, economic, legal and ecological issues is crucial.
4. Attention has to be paid to the interactions between the commercially valuable target species and the surrounding ecosystems.
5. Careful research, including research on ecological impacts, monitoring, and effective enforcement are needed in order to ensure the greatest possible benefit of ITQs for economic development and wealth creation as well as for the conservation and the sustainable use of biodiversity.
6. ITQs have to be augmented by complementary incentive measures (financial or regulatory) that assure the compliance with these public good objectives through insistence on sustainable practices, e.g., gear controls to avoid by-catch or fish below a certain size.
7. The financing of the increased costs of monitoring and enforcement, as well as of the necessary complementary measures can be accomplished at least to some extent through the funds that are generated by the ability of fisher to gain maximum rents from fishing the maximum sustainable yield of the commercially valuable target resource.
8. Commercial fishers are not the only users of the particular fish stock. Consideration should be given on how to integrate the values that other users derive from an ITQ managed fish stock. An absence or inefficient integration of different access rights can lead to suboptimal decisions regarding the use of the fish stock.
9. Consideration should be given into the potential, and existing, application of ITQ-like measures to the use of other forms of biodiversity while paying attention to the integration of social and ecological constraints; such as: tradable permits for exotic and indigenous forests; tradable licenses for hunting of animals; tradable access rights to government-owned grazing land.

REFERENCES

- ANDERSON, L. (1994), "Fundamental Issues in the Design of ITQ Programs", in M. ANTONA, J. CATANZANO, J. G. SUTINEN (eds.), *Proceedings of the Sixth Conference of the International Institute of Fisheries Economics and Trade*, Volume II: 787-794.
- ANDERSON, L. (1989a), "Conceptual constructs for practical ITQ management policies", in NEHER, ARNASON, and MOLLETT, *Rights Based Fishing*, Kluwer Academic Publishers, Dordrecht.
- ANDERSON, L. (1989b), "Property rights in fisheries: lessons from the New Zealand experience", Working Paper 89-22, Political Economy Research Center. Bozeman, Montana. 52 p.
- ANDERSON, L., and P.J. HILL (1991), "Privatizing the Commons: An Improvement?" *Southern Journal of Economics* 50:438-450.
- ANTHONY, V. C. (1993), "The State of Groundfish Resources Off the Northeastern United States" *Fisheries* 18(2):12-17.
- BERKES, F. and D. POCOCK (1987), "Quota Management and 'People Problems': A Case History of Canadian Lake Erie Fisheries," *Transactions of the American Fisheries Society* 116: 494-502.
- BEVERTON, R., J. COOKE, J. CSIRKE, R. DOYLE, G. HEMPEL, S. HOLT, A. MACCALL, D. POLICANSKY, J. ROUGHGARDEN, J. SHEPHERD, M. SISSEWINE and P. WIEBE (1984), "Dynamics of Single Species – Group Report", in R. MAY (ed.), *Exploitation of Marine Communities Dahlem Konferenzen*, New York: Springer.
- BINKLEY, M. (1989), "Nova Scotian offshore groundfish fishermen," *Marine Policy*: 274-284.
- BLINDHEIM, J. and SKJOLDAL H.R. (1993), "Effects of Climatic Changes on the Biomass Yield of the Barents Sea, Norwegian Sea, and West Greenland Large Marine Ecosystems." In SHERMAN, K. et al. (ed.) *Large Marine Ecosystems: Stress, Mitigation, and Sustainability*. AAAS Press, Washington DC, USA.
- CAMPBELL, DAVID and JOS HAYNES (1991), "Resource rent in fisheries", *Australian Fisheries* 50(2):6-7.
- CAPPS, O. and J.A. LAMBREGTS (1991), "Assessing Effects of Prices and Advertising on Purchases of Finfish and Shellfish in a Local Market in Texas", *Southern Journal of Agricultural Economics* (July 1991): 181-194.
- CHENG, H. and O. CAPPS (1988), "Demand Analysis of Fresh and Frozen Finfish and Shellfish in the United States", *American Journal of Agricultural Economics* 70: 533-542.
- CHEUNG, S. N. S. (1970), "The Structure of a Contract and the Theory of a Nonexclusive Resource", *The Journal of Law and Economics* 13: 49-70.

- CLARK, I., P. MAJOR and N. MOLLETT (1988), "Development and Implementation of New Zealand's ITQ Management System," *Marine Resource Economics* 5:325-349.
- CONGRESSIONAL RESEARCH SERVICE (1994), *Ecosystem Management: Federal Agency Activities*, Congressional Research Service, Library of Congress, Washington, DC.
- COUNCIL ON ENVIRONMENTAL QUALITY (1992), *Linking Ecosystems and Biodiversity*, Washington, DC.
- CROWLEY, R.W. and H. PALSSON (1991), "Rights Based Fisheries Management in Canada", Department of Fisheries and Oceans, Ottawa, Canada.
- DEVOLD, F., and JAKOBSSON, J. (1968), "The Formation and Disappearance of a Stock of Norwegian Herring." *Fiskiridir. Skr. Ser. Havunders.* 15:1-22.
- DEWEES, C. M. (1989), "Assessment of the Implementation of Individual Transferable Quotas in New Zealand's Inshore Fishery," *North American Journal of Fisheries Management* 9(2):131-139.
- DOF (1991), *1991 Halibut Management Plan*, Department of Fisheries and Oceans, Vancouver, British Columbia.
- DRAGESUND, O., HAMRE, J., and ULLTANG, O. (1980), "Biology and Population Dynamics of the Norwegian Spring-spawning Herring." *Rapp. P.-v. Reun. Cons. Int. Explor. Mer* 177:43-71.
- ECOLOGICAL SOCIETY OF AMERICA (1995), *The Scientific Basis for Ecosystem Management*, ESA Ad hoc Committee on Ecosystem Management, Washington, DC.
- FAGAN, S. (1990), "Halibut Individual Quotas: A Benefit Cost Analysis." Unpublished report, Canadian Department of Fisheries and Oceans, Vancouver, B.C.
- FAO (1995), Invitation by the Director general of FAO to Prepare for the 1996 Meeting of the UN Commission on Sustainable Development, Rome.
- FAO (1993), "Marine Fisheries and the Law of the Sea: A Decade of Change - Special Chapter of the State of Food and Agriculture 1992." Rome.
- FAO (1992), *World Fisheries Situation*, Rome.
- FRASER, C. and J. JONES (1989), "Enterprise Allocations: The Atlantic Canadian Experience," in P. NEHER, R. ARNASON, and N. MOLLETT (eds.) *Rights Based Fishing*, Dordrecht: Kluwer Academic Publishers; 267-288.
- GAO (1994), *Ecosystem Management: Additional Actions Needed to Adequately Test a Promising Approach*, GAO Report GAO/RCED-94-111, General Accounting Office, Washington, DC.
- GARDNER, M. (1988), "Enterprise Allocation System in the Offshore Groundfish Sector in Atlantic Canada," *Marine Resource Economics* 5(4):389-414.

- GATES, J., HOLLAND, D. and GUDMUNDSSON, E. (1997), "Theory and Practice of Fishing Vessel Buyback Programs." in *Subsidies and Depletion of World Fisheries: Case Studies*. World Wildlife Fund - U.S., Washington, D.C.
- GAUVIN, J., WARD, J. and BURGESS, E. (1994), "Description and Preliminary Evaluation of the Wreckfish (*Polyprion Americanus*) Fishery under Individual Transferable Quotas", Unpublished Paper.
- GEEN, G. and M. NAYAR (1988), "Individual Transferable Quotas in the Southern Bluefin Tuna Fishery: An Economic Appraisal," *Marine Resource Economics* 5(4):365-388.
- GLANTZ, M.H. (1980), 'El Niño: Lessons for Coastal Fisheries in Africa?', *Oceanus* 23(Jan):9-17.
- GLANTZ, M.H. (1979), "Science, Politics and Economics of the Peruvian Anchoveta Fishery." *Marine Policy*.
- GLANTZ, M., and J. THOMPSON (1981), *Resource Management and Environmental Uncertainty*. New York: John Wiley & Sons.
- HAHN and HESTER (1989) "Marketable Permits: Lessons for Theory and Practice," *Ecology Law Quarterly* 16(36):361-406.
- HARGIS, W.J. and HAVEN, D.S. (1988), "Rehabilitation of the troubled oyster industry of the lower Chesapeake Bay", *Journal of Shellfish Research* 7:271:279.
- HENNESSEY, T. M. (1997) "Ecosystem Management: The Governance Dimension," Paper prepared for the Western Social Science Meeting, Albuquerque, New Mexico, April 23-26, 1997.
- HIDE, R.P. and P. ACKROYD (1990), "Depoliticizing Fisheries Management: Chatham Islands Paua (Abalone) as a Case Study", Unpublished report, Centre for Resource Management, Lincoln University, New Zealand.
- HONG, S-Y and CHANG, Y-T (1997), "Integrated Coastal Management and the Advent of New Ocean Governance in Korea: Strategies for Increasing the Probability Success", *The International Journal of Marine and Coastal Law* 12(2):141-161.
- HUPPERT, Daniel D. (1991), "Managing the Groundfish Fisheries of Alaska: History and Prospects", *Reviews in Aquatic Sciences* 4(4): 339-373.
- JAKOBSSON, J. (1992), "Recent variability in the fisheries of the North Atlantic." *ICES - Marine Science Symposia* 195:291-315.
- JOHNSTON, R. and J. G. SUTINEN (1996), "Uncertain Biomass Shift and Collapse: Implications for Harvest Policy in the Fishery," *Land Economics* (November).
- JUDA, L. (1993), "Ocean Policy, Multi-use Management, and the Cumulative Impact of Piecemeal Change: the Case of the United States Outer Continental Shelf," *Ocean Development and International Law* 24: 355-376.

- LAL, P. and BROWN, D. (1993), "Individual Transferable Quotas in Fisheries Management", in ABARE, *Use of Economic Instruments in Integrated Coastal Zone Management*, Canberra.
- MACE, P.M. (1985), *Catch rates and total removals in the 4WX herring purse seine fisheries*, Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 85/74.
- MCKINNEY, David A. (1991), *The Individual Transferable Fishing Quota Management System: A review of recent programs from an enforcement perspective*, National Marine Fisheries Service, Office of Law Enforcement, Silver Spring, MD.
- MCNEELY J.A., MILLER, R.K., REID, W. V., MITTERMEIER, R. A., and WERNER T.B. (1990), *Conserving The World's Biological Diversity*. International Union for Conservation of Nature and Natural Resources, World Resource Institute, Conservation International, World Wildlife Fund-US and The World Bank. Gland, Switzerland and Washington DC.
- MILAZZO, M.J. (1997), "Reexamining Subsidies in World Fisheries" Unpublished working document, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, May 1997.
- MITCHELL, R., and R. CARSON (1989), *Using Surveys to Value Public Goods: The Contingent Valuation Method*, Washington, DC: Resources for the Future.
- MUSE, B. (1991), "Survey of Individual Quota Programs." Alaska Commercial Fisheries Entry Commission, Juneau, Alaska.
- MUSE, B. and K. SCHELLE (1989), "Individual Fishermen's Quotas: A Preliminary Review of Some Recent Programs." Alaska Commercial Fisheries Entry Commission, Juneau, Alaska.
- NEHER, P.A., R. ARNASON, and N. MOLLETT (Eds.) (1989), *Rights Based Fishing: Proceedings of a Workshop on the Scientific Foundations for Rights Based Fishing*, Reykjavik, June 27-July 1, 1988, NATO ASI series, Series E (Applied sciences), no. 169, Kluwer Academic Publishers.
- NMFS (1994), "Special Advisory: Groundfish Status on Georges Bank", Northeast Fisheries Science Center, Woods Hole, Massachusetts.
- NMFS (1993), *Fisheries Management Plan for Shark of the Atlantic Ocean*. NMFS, Silver Spring.
- NMFS (1996), *Our Living Oceans: Report on the Status of US Living Marine Resources 1995*, United States Department of Commerce, Washington, D.C.
- NMFS (1997a), *An evaluation of potential shrimp virus impacts on cultured shrimp and wild shrimp populations in the Gulf of Mexico and southeastern US Atlantic coastal waters: A report to the joint subcommittee on Aquaculture*. Shrimp Virus Work Group, National Marine Fisheries Service, U.S. Department of Commerce. Animal and Plant Health Inspection Service, U.S. Department of agriculture, National Center for Environmental Assessment, U.S. Environmental Protection Agency, Fish and Wildlife Service, U.S. Department of Interior. NMFS, Silver Spring, USA.

- NOAA (1997b), Strategic Plan, A Vision for 2005. US Department of Commerce, National Oceanic and Atmospheric Administration. (May, 1997).
- NOAA (1992), *The National ITQ Study Report*, US Department of Commerce, National Oceanic and Atmospheric Administration. Washington, DC.
- NOAA (1992), "Status of Fishery Resources off the Northeast United States for 1992", NOAA Technical Memorandum NMFS-F/NEC-95. 133pp.
- NORSE, E., (1993), *Global Marine Biological Diversity: A strategy for Building Conservation into Decision Making*. Center for Marine Conservation, World Conservation Union (IUCN), World Wildlife Fund, United Nations Environmental Programme and The World Bank. Island Press, Washington DC., 1993
- NPFMC (1991), Environmental Impact Statement, Regulatory Impact Review, Initial Regulatory Flexibility Analysis for Proposed Individual Fishing Quota Management Alternatives for the Halibut Fisheries in the Gulf of Alaska and Bering Sea/Aleutian Islands, North Pacific Fishery Management Council, Anchorage, Alaska.
- OECD (1993), *Iceland*, OECD Environmental Performance Reviews Series, Paris
- OECD (1996), *Saving Biological Diversity: Economic Incentives*, Paris.
- OECD (1997a), "Incentive Measures to Promote the Conservation and the Sustainable Use of Biodiversity: Framework for Case Studies", Report by the Expert Group on Economic Aspects of Biodiversity, Environment Directorate (free document), Paris.
- OECD (1997b), *Investing in Biological Diversity: The Cairns Conference*, Paris.
- OECD (1997c), *Towards Sustainable Fisheries: Economic Aspects of the Management of Living Marine Resources*, Paris.
- OECD (1997d), *Review of Fisheries in OECD Countries*, Paris.
- OECD (1998), *Review of Fisheries in OECD Countries - 1998 edition* (in press), Paris.
- OSTROM, E. (1995), "Designing Complexity to Govern Complexity," in S. HANNA and M. MUNASINGHE (eds.), *Property Rights and the Environment: Social and Ecological Issues*. The Beijer Institute of Ecological Economics and the World Bank, Washington, DC.
- PARSONS, L.S. (1993), "Management of Marine Fisheries in Canada." *Canadian Bulletin of Fisheries and Aquatic Sciences*. 225:763 p.
- PATTERSON, K., J. ZUZUNAGA and G. CARDENAS (1992), "Size of the South American Sardine (*Sardinops sagax*) Population in the Northern Part of the Peru Upwelling Ecosystem after Collapse of Anchoveta (*Engraulis ringens*) Stocks," *Canadian Journal of Fisheries and Aquatic Sciences* 49:1762-69.

- PEARSE, Peter (1991), *Building on Progress: Fisheries Policy Development in New Zealand: A report prepared for the Ministry of Fisheries*, Wellington, New Zealand.
- PERRINGS, C., MALER, K.G., FOLKE, C., HOLLING, C.S. AND JANSSON, B.O. (1995), *Biodiversity Loss: Economic and Ecological Issues*. Cambridge University Press. Cambridge, England.
- PORTER, G. (Forthcoming), *Fishing Subsidies, Trade and the Environment*, UNEP Environment and Trade Series.
- RAIZIN, M. (1994), "Individual Transferable Quota Management of the Surf Clam and Ocean Quahog Fishery of the Northwest Atlantic", Unpublished Paper.
- RHODES, V. J. (1987), *The Agricultural Marketing System*, Third Edition. New York: John Wiley & Sons.
- SAFMP (1991), "Amendment 5 (Wreckfish)", Regulatory Impact Review, Initial Regulatory Flexibility Determination and Environmental Assessment for the Fishery Management Plan for the Snapper-Grouper Fishery of the South Atlantic Region, South Atlantic Fishery Management Council, Charleston, SC.
- SCHRANK, W. (1997), "The Newfoundland Fishery: Past, Present and Future." in *Subsidies and Depletion of World Fisheries: Case Studies*. World Wildlife Fund - U.S., Washington, D.C.
- SCOTT, A. (1988), "Development of Property in the Fishery," *Marine Resource Economics* 5(4):289-313.
- SHERMAN, K. (1994). "Sustainability, biomass yields, and health of coastal ecosystems: an ecological perspective," *Marine Ecology Progress Series*, Vol. 112:277-301.
- SHERMAN, K. (1995), "Achieving regional cooperation in the management of marine ecosystems: the use of the large marine ecosystem approach," *Ocean & Coastal Management*, Vol. 29, Nos. 1-3: 165-185.
- SHERMAN, K., and L. ALEXANDER (Eds.) (1986), *Variability and management of large marine ecosystems*, AAAS Selected Symposium 99. Westview Press, Boulder, Colorado.
- SHERMAN, K., L. ALEXANDER and B. GOLD (Eds.) (1993), *Large Marine Ecosystems: Stress, Mitigation, and Sustainability*, AAAS Press, Washington, DC.
- SHERMAN, K., N. JAWORSKI and T. SMAYDA. (1996), *The Northeast Shelf Ecosystem: Assessment, Sustainability and Management*, Blackwell, Cambridge, Mass.
- SISSENWINE, M. P. and J. E. KIRKLEY. (1982), "Fishery Management Techniques - Practical Aspects and Limitations". *Marine Policy* (1:82): 43-57.
- SKJOLDAL, H.R., GJOSAETER, H. and LOENG, H. (1992), "The Barents Sea Ecosystem in the 1980s: Ocean Climate, Plankton, and Capelin Growth." *ICES - Marine Science Symposia* 195:278-290.
- STEELE, J. (1991), "Marine Functional Diversity", *Bioscience* 41(July/August):470-74.

- STEELE, J. (1980), "Kinds of Variability and Uncertainty Affecting Fisheries," in R. May (ed.), *Exploitation of Marine Communities Dahlem Konferenzen*. New York: Springer Verlag.
- SUTINEN, J.G., P. MACE, J. KIRKLEY, W. DUPAUL, and S. EDWARDS (1992), "Consideration of the Potential Use of Individual Quotas in the Atlantic Sea Scallop Fishery," Volume 5 of *The National ITQ Study Report*, NOAA, Washington, DC.
- SUTINEN, J.G., A. RIESER, AND J. GAUVIN (1990) "Measuring and Explaining Non-compliance in Federally Managed Fisheries," *Ocean Development and International Law* 21:335-372.
- TE PUNI KOKIRI -- MINISTRY OF MAORI DEVELOPMENT (1993), *Nga Kai O Te Moana: Kaupapa Tiakina -- Customary Fisheries: Philosophy and Practices, Legislation and Change*, Wellington.
- THOMPSON, J. (1981), "Climate, Upwelling, and Biological Productivity: Some Primary Relationships," in GLANTZ, M., and J. THOMPSON (eds.), *Resource Management and Environmental Uncertainty*. New York: John Wiley & Sons.
- UNESCO (1980), *Proceedings of the Workshop on the Phenomenon Known as 'El Niño,' Guayaquil, Ecuador, 4-12 December 1974*. Paris: United National Educational, Scientific, and Cultural Organization.
- WATLING, L. and LANGTON R. (1994), "Fishing, Habitat Disruption, and Biodiversity Loss." *EOS, Trans. Amer. Geophys. Union* 75(3):210, 1994.
- WILLIAMS, T. (1996), "Attack on the Sharks", *Audubon*, July-August 98(4):30-8.
- WHITE, G.N. and P.M. MACE (1988), "Models for cooperation and conspiracy in fisheries: changing the rules of the game", *Natural Resource Modelling* 2: 499-530.
- WWF (1997), *Subsidies and Depletion of World Fisheries: Case Studies*, World Wildlife Fund, Washington, D.C.
- YOUNG, M.D., GUNNINGHAM, N. et al. (1996), *Reimbursing the Future*, Canberra: Department of the Environment, Sport and Territories.
- ZAITSEV, Y. and V. MAMEV (1997), *Marine Biological Diversity in the Black Sea: A Study of Change and Decline*. United Nations Publications, New York.