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RIVO report

Number: C062/04

Outstanding Environmental Issues in relation to European Fisheries

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Commissioned by: Milieu- en Natuurplanbureau – RIVM
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Project number: 3.16.12685.01

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Date: 18 August 2004

Number of copies: 18
Number of pages: 21
Number of tables: 1
Number of figures: 1

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Summary/Conclusions

- Overexploitation has severely diminished commercially exploited fish stocks in European waters. A steadily increasing number of stocks is exploited outside safe biological limits and present exploitation rates are not sustainable. Some are even threatened by 'economic extinction', requiring stringent recovery plans before exploitation should be resumed (e.g. North Sea cod, northern hake).

- Commercial fisheries are targeted on specific (groups of) species, but may take a by-catch of others that are also seriously affected (in particular marine mammals, sharks and rays). Moreover, the removal of large quantities of fish has measurable secondary effects on the structure and functioning of ecosystems.

- Effects of other human activities in the marine environment are generally considered subordinate to the effects of fishing, although locally they may have devastating effects on specific components of the ecosystem (e.g. oil spills). Eutrophication is largely restricted to coastal areas and semi-enclosed seas (e.g. Baltic) where it may affect productivity of commercial stocks. Effects of global warming are largely unpredictable, but may restrict the management potential to reverse historic trends in species abundance.

- With the possible exception of pelagic stocks targeted by specific fisheries with relatively small by-catches of other species, the CFP toolbox of catch quota, capacity control and technical measures has not been effective in meeting the long-term strategic objective of sustainable fisheries in EU waters without challenging the quality of the marine environment. The main problem relates to mixed fisheries that can continue fishing until the quota for the last species exploited has been exhausted as long as catches of the others are discarded. Therefore, quota regulations effectively don't limit exploitation rates of demersal species and other regulatory measures seem required. However, the CFP reform process showed that the political will to change the management system is severely limited.

- The main problem faced in fisheries management is the short-term need to reduce fishing mortality for most stocks and the overcapacity of the fleets. Although initiatives within the sector such as gear changes may alleviate ecosystem effects caused by the gears presently in use, these cannot be expected to resolve the problem for the target stocks, because they are based on effort replacement, not effort reductions.

- Although management of marine resources based on clear property rights for fishermen (limited entry, ITQ) and co-management has shown to be effective in other parts of the world, these approaches are difficult to implement in EU waters because of the complex national interests and political infrastructure.

- To restore fish stocks in EU waters, more effective measures are required to control mixed fisheries. The potential of direct effort control and/or economic incentives as effective alternatives for TAC management should be explored further.

- The major challenge facing the rapidly growing European aquaculture is to provide solutions for increasing conflicts for space and water use. The limited space available, especially in highly populated coastal areas where competition between human activities becomes extremely tense, makes this a critical issue. Investment in innovative technologies to reduce environmental impact in combination with economic feasibility is essential.

Introduction

Background

The impact of European fisheries on marine fish stocks has been an issue of great concern for more than 100 years. In the late 19th century, fishermen reported declining catch rates and asked governments to take remedial actions against overfishing. These requests led to the establishment of national fisheries research institutes to study the impact and to advise on appropriate management measures. The scientists employed immediately realised that different countries were all fishing in the same pond and that the overfishing problem could only be evaluated in close cooperation among nations. Also, they understood that tackling population dynamics of individual stocks required a sound knowledge of their biology in relation to the variable environment in which they live, and of the fisheries exploiting them. Specifically, they realised the importance of reliable international catch statistics. The early establishment of the International Council for the Exploration of the Sea (ICES) in 1902 to coordinate this research is indicative of the great concern at that time about resource exploitation, while its name indicates the awareness that the fisheries problem was imbedded in a wider environmental setting (Rozwadowski, 2002).

One century later, the situation has only deteriorated, even though several international conventions were established with the best of intentions (International Overfishing Convention in 1946; North-East Atlantic Fisheries Convention in 1959). Since 1977 when the exclusive fishing zones were extended to 200 miles, many resources fall entirely under EU jurisdiction, but also the Common Fisheries Policy (CFP) agreed in 1983 has not been able to reverse the trend of continued overexploitation (EC, 2001). Indeed, the recent need for developing stock recovery plans for several stocks (e.g., North Sea cod and northern hake) indicate that things have only become worse, not only biologically, but also economically (EEA, 2003). Despite a forest of international regulations, the Tragedy of the Commons appears to persist.

The description of outstanding environmental issues in relation to European fisheries presented here draws heavily on the ICES (2003a) report on the "Environmental Status of the European Seas, which itself is based on the Quality Status Reports produced in 1993 and 2000 by the Oslo-Paris Convention for the Protection of the Marine Environment of the Nort-East Atlantic (OSPAR, 2000).

Relevant policies

The most important restriction on international fishing rights has been the ratification of the extension of exclusive national fishing zones by the United Nations Convention on the Law of the Sea (UNCLOS) in 1977. Many of the important fishery resources inhabit shelf regions and therefore, this extension gave individual countries more responsibility and reduced the scope for international management conflicts caused by opposite interests of different fleets. However, in European waters these exclusive fishing zones rarely represent natural borders for fish stocks and for shared stocks multilateral agreements are obviously required to implement effective management measures. Therefore, the management responsibility for stocks in waters of EU countries has been largely transferred to the European Commission (EC), within the constraints laid out in the CFP. While the CFP defines the broad regulations, implementation and enforcement remains a national responsibility and different rules may be applied depending on national jurisdiction. One exception applies to resources exclusively inhabiting the coastal zone (within 12 miles), for which individual countries have retained full responsibility.

Sustainable development has been defined by FAO in 1988 as “the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such development conserves land, water, plant genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable”, while the Rio Declaration of the UN Conference on Environment and Development in 1992 states that “In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation” (FAO, 1995). The precautionary approach has been widely adopted also in fisheries, as exemplified by the FAO International Code of Conduct for Responsible Fisheries (1995), and since 1997, ICES has formally implemented this approach in producing advice to its customers (ICES, 1997a).

OSPAR is more generally tasked with the protection of the marine environment in European waters. Originally, OSPAR dealt specifically with effects of pollution (e.g., shipping, oil and gas exploitation) and eutrophication (atmospheric nutrient deposition and river effluents) as well as measures to restrict these effects. However, OSPAR is increasingly involved in the conservation of marine biodiversity (including habitat protection). For instance, by developing a range of ecosystem quality objectives [EcoQO’s] for 10 broad ecological issues and by pursuing the establishment of marine protected areas, the road is being paved for an ‘ecosystem approach to fisheries management’. In the Ministerial Declaration of the Fifth International Conference on the Protection of the North Sea in Bergen, 2002, four EcoQO’s have been identified for implementation with high priority. These include those related to spawning stock biomass of North Sea commercial fish species and by-catch of harbour porpoises in the North Sea. Thus, although OSPAR is not responsible for fisheries management, there is a direct link with fisheries management issues and the integration is being pursued. However, in practice there remain many scientific and political stumbling blocks that, for the time being, prohibit its general application.

Advice on fisheries management

In seeking independent scientific advice on marine fisheries management, the EU as well as other international and national management agencies (International Baltic Sea Fishery Commission, NEAFC, North Atlantic Salmon Conservation Organisation, Iceland) put out detailed requests on an annual basis to ICES. The primary analyses are delegated to a large number of working groups dealing with specific issues, in which only scientists with interests and knowledge of those issues participate. The working group reports are reviewed (quality assurance) internally by the ICES Advisory Committee on Fisheries Management (ACFM) and Advisory Committee on Ecosystems (ACE) before the scientific advice to the various customers is formulated. These committees are based on national representation, complemented with experts from within the ICES organisation and observers as felt appropriate.

Fisheries scientists may largely be seen as county clerks responsible for recording births and death of the various fish species. These records of the size and age composition of the catches are processed in complex models to derive historic estimates of stock size and mortality induced by fishing and allow short term predictions of stock trends and expected catches, which are then used by managers to decide on appropriate Total Allowable Catches (TAC). However, the reliability of the predictions depends critically on the accuracy of the catches recorded and since the introduction of the TAC management regime in the 1980s, concern has been expressed increasingly that catch statistics have deteriorated owing to large-scale mis-reporting and illegal landings (e.g., ICES, 2003b). This clearly undermines the value of science-based management and may be the source of the conflicting views about the status of the stocks among scientists basing their conclusions on the official statistics and fishermen knowing how large the discrepancy between their actual catches and their legal landings may be.

The EC has also established its own Scientific, Technical and Economic Committee on Fisheries (STECF) for providing advice. However, this committee is mainly tasked with the more technical and economic management issues. In addition, it deals with all questions about Mediterranean fish stocks, because this area is not covered by the ICES advice.

Based on the ICES advice, the EC formulates TAC proposals in the light of socio-economic considerations. The proposals for the next year are then considered at the meeting of the Council of Ministers held annually in December, where the final decisions are taken. The TAC agreed may deviate considerably from the advice and the proposals. Only in a few cases, harvest control rules have been set, particularly in bilateral agreements between the EU and Norway. These harvest control rules define exactly how the ultimate TAC relates to the stock status as assessed by ICES, thus severely restricting the scope for further negotiations within the Council of Ministers.

Fisheries impact

Developments in fish stocks

Commercial stocks

Out of 113 stocks in the Northwest Atlantic assessed by ICES in 2001 and based on the data available, 31 were outside safe biological limits (recruitment impaired because of overexploitation), 16 were harvested outside safe biological limits (although recruitment not yet impaired, exploitation not sustainable because of a high probability that recruitment will be impaired in the near future, if present level of exploitation is maintained), 18 were (harvested) within safe biological limits, and 48 could not be evaluated because of lack of data (ICES, 2003a). Although these figures include a limited number of stocks around Iceland and in the Barents Sea that fall outside the responsibility of the EU and comparable information for the Mediterranean are lacking, it is clear that the situation under the CFP (since 1983) has deteriorated for the majority of stocks and is still deteriorating further (figure 1).

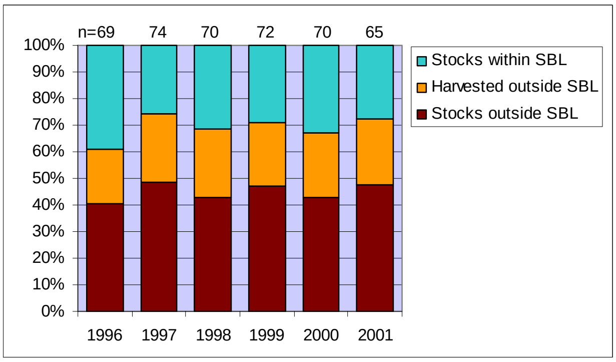

Figure 1. Percentage of stocks in the Northeast Atlantic assessed by ICES that are within safe biological limits (SBL), outside SBL or harvested outside SBL by year (excluding stocks that could not be evaluated because of lack of data; data from ICES 2003a).

In general, pelagic fish stocks (living free in the water column) are in a better state than demersal stocks (living near or on the bottom). The North Sea herring went through a serious decline in the 1970s as a consequence of extreme overexploitation, but, failing international agreement on appropriate conservation measures, had to become economically extinct before the fishery was closed in 1977. After a closure of 3 years, some recovery was seen and a TAC regime was put in place that effectively restricted the catch. Since a harvest control rule has been agreed between the EU and Norway in 1996, the stock has expanded to a safe biological level. The Atlanto-Scandian herring went through a similar cycle, although the recovery was much slower. In contrast, many of the demersal stocks have gone down throughout the Northeast Atlantic and cannot be considered exploited sustainably.

For instance, the advice for North Sea cod and northern hake since 2001 has been to stop fishing altogether, but this advice has not been followed by the Council of Ministers, because it would seriously limit all mixed fisheries taking cod as a by-catch in these areas.

Although available data do not allow an evaluation of the status of deep-water stock, catches of most species are rapidly declining. So far, however, no steps have been taken to restrict these fisheries. A coherent picture of the status of the Mediterranean stocks does not exist. The high diversity of the species exploited, the large number of local fisheries and lack of data inhibits quantitative assessments. However, the situation is improving and the General Fisheries Council for the Mediterranean does report on the state of key stocks. In a recent report of the European Environment agency (EEA, 2003), 65-75% of the Mediterranean stocks are considered overexploited.

Non-target stocks

Fisheries generally target specific species or assemblages, but all kind of other species may end up in the nets. In case they represent a commercial value, they may be landed but the sheer number of species involved (and thus the costs) prohibits scientific sampling and therefore formal assessments. Moreover, trying to control the fishery impact on all these species individually by TAC could only further overload a management system that might already be stretched too far (regulations apply to over 100 stocks!). In addition, many species caught have no market value at all. These go back into the sea, often dead, as discards without further notice. Because commercial fishing gears are designed to catch target species and are employed where these target species are most likely to be caught, the general expectation is that the impact on non-target species in quantitative terms is less (Pope *et al.*, 2000). However, some species may be more sensitive to the extra mortality caused by fishing because of deviant life-history characteristics.

An evaluation of long-term trends in non-target stocks is largely restricted to information obtained from research vessel surveys. However, in contrast to stock assessment of target-species, the impact of the fisheries cannot be evaluated directly, and only circumstantial evidence can point to the cause of observed trends. There is an increasing body of evidence suggesting that most shark as well as ray species in the Northeast Atlantic are on the decline and a few have already become locally extinct. Both sharks and rays are characterized by a low fecundity (on an annual basis they produce a relatively small number of offspring) and a low natural mortality, which explains why they are more sensitive to fishing pressure (Walker, 1999). This view is supported by evidence provided by fisheries elsewhere in the world, where sharks represent the target species. Therefore, if the observed trends are to be reversed, specific management measures may be required. ICES (1997b) advised to close the area in the North Sea where the last representatives of an originally large ray population still survives, but as yet no action has been taken.

A problem in interpreting long-term trends is that many fish species exhibit large natural variations in abundance. Thus, over the last 30 years some stocks have decreased while others have remained stable or increased. In particular, there has been an influx of 'southern' species into the North Sea, coinciding with a general rise in sea temperature. If this positive relationship is a causal one, one might equally expect a negative effect on resident species. Therefore, a negative trend may not necessarily be explained by fishing impact.

Developments in environmental pressure

Different fisheries exert different pressures on the environment. Marine mammals, sharks and turtles become entangled in drift nets and gill nets or caught in large pelagic trawls to the extent that the EU has taken steps to phase out the use of certain gears in European waters, whilst for others the use of deterrents is being prescribed ('pingers'), even though their effectiveness is by no means ensured. Bottom trawls and dredges affect the benthic habitat.

The wide scale use of heavy beam trawls in particular is seen as detrimental to benthic life, because of both physical disruption of the top layers by the use heavy chains and the large amounts of marine life that is brought on deck and returned to the sea dead (Hall, 1999). While beam trawls are effective in catching flatfish buried in the sediment, the environmental pressure is huge, if only because of the horsepower required to tow the gear at over 6 knots over and through the bottom. On average, 0.7 kg of marketable fish is landed for each litre of fuel used (Salz & Daan, 1999)! Dredges have similar effects, but their use is much more restricted to areas of high shellfish abundance. Traditional otter trawls exercise less environmental pressure, but their use in sensitive habitats may also lead to unacceptable effects. For instance, the cold-water coral reefs (Lophelia) present in deep water around Norway and Scotland may be easily degraded (ICES, 2003c) and steps are being taken to close these areas for trawl fishing.

Bottom trawls in general considered non-selective gears and result in large quantities of unmarketable and unwanted catches. It is estimated that in the North Sea alone 700 thousand tonnes of fish and offal goes back into the sea compared to a landed catch of 2.5 million tonnes (Camphuysen *et al.*, 1995). These discards partly consist of juveniles of commercially important species, reducing future profits, partly of species of no interest. Thus, trawling may lead to changes in the entire fish and benthic communities and increasingly evidence of such changes is becoming available. There may be also secondary effects. Many of the dead fish float at the sea surface and represent an easy prey for various seabird species, while those that sink may attract scavenger species. It is perhaps revealing that populations of many seabirds have increased considerably over the last century ()!

There are likely to be other secondary effects. Animal populations are governed largely by predation. Large fish eat small fish, but large fish have become scarce in heavily exploited ecosystems. Thus, also predation on small fish must have been reduced. While there is evidence of such changes, in practice it is extremely difficult to investigate to what extent fishing is responsible, because secondary changes are integrated with other (anthropogenic) causes (Daan et al., 2003).

Conclusions

The impact of fisheries on commercial fish stocks can be readily measured as the chance that a fish will die in a net (fishing mortality) relative to natural causes (natural mortality). In virtually all commercial fish stocks, fishing mortality is at least two times higher than natural mortality and this has large and measurable consequences on the quantities of fish present in the seas. Effects on non-target stocks are likely to be smaller, because they are caught incidentally rather than purposefully. When it comes to ecosystem effects, the situation becomes inherently complicated, because effects of fishing become totally integrated with the effects of natural variations as well as of other anthropogenic factors. In this case, causes and effects are by no means always clear. However, given the established impact of fishing on most fish stocks, it is generally taken for granted that the impact of all fisheries combined on ecosystem structure and functioning is larger than of any other human activity in the marine environment.

- Overexploitation has severely diminished commercially exploited fish stocks in European waters. A steadily increasing number of stocks is exploited outside safe biological limits and present exploitation rates are not sustainable. Some are even threatened by ‘economic extinction’, requiring stringent recovery plans before exploitation should be resumed (e.g. North Sea cod, northern hake).

- Commercial fisheries are targeted on specific (groups of) species, but may take a by-catch of others that are also seriously affected (in particular marine mammals, sharks and rays). Moreover, the removal of large quantities of fish has measurable secondary effects on the structure and functioning of ecosystems.

Other anthropogenic impacts

Global warming

Although it is generally accepted by scientists that there is clear evidence of global warming, it remains difficult to establish clear trends at a local scale (Kok *et al.*, 2001). This is not unexpected, because global warming does not mean that it becomes warmer everywhere. Indeed the available models suggest that there may be restricted areas that actually become cooler. In the marine environment, predictions are even more difficult, because the strength of current systems may be affected by changes in climate. Recently, evidence has been presented that melting of the ice cap of the North Pole may reduce the strength of the Gulf Stream, thereby bringer less warm water to northwest Europe. Nevertheless, for the time being, seawater temperatures appear to have been above average during the last decade. Also, preliminary data on species composition of catches during monitoring surveys suggest an influx of species of southern origin in the North Sea during this period, which might well be related to climate change.

Whatever the consequences of global warming on the oceanographic conditions in the North Atlantic, the effects on marine ecosystems may be complex and large. Overall productivity is likely to change as well as biodiversity. Specifically, the largest effects may be expected in the survival of eggs and larvae, and therefore in recruitment patterns. This would affect the traditional fisheries in unpredictable ways. Some target species may decline, while new target species may be enhanced. However, it is virtually impossible to advance an appropriate management policy because of the unpredictability of the effects of global warming on individual species. Also, it seems likely that changes will be gradual and that fisheries and management can largely follow these changes (Kok *et al.*, 2001).

Contaminants

Contaminants in the marine environment fall into four main groups: trace metals, organic compounds, oil and radioactive elements. They all differ in the way they reach marine areas (directly into the see, via rivers or via the atmosphere), in their behaviour (in solution, deposition in sediments or biological uptake), and in their ecological effects (ICES, 2003a).
Trace metals occur naturally in seawater, but concentrations may be enhanced through atmospheric input or locally near rivers and industrial harbours. They may affect physiological functions of biota. Discharges from industrial sources have been generally reduced over the past decade owing to stricter regulations and tighter controls based on OSPAR recommendations.

A wide range, and large quantities, of organic compounds is being produced for human use. Most of these are easily broken down before or after entering the sea, but the persistent ones may spread over large areas and taken up by organisms. The list of chemicals of concern is long and growing and there are many documented reports of serious harm to specific organisms. Many of these substances are taken up readily by marine animals. Some are known to accumulate in fat tissue, particularly in blubber deposits of marine mammals where they may cause infertility. Although steps have been taken to phase out the use of specific harmful compounds, the industry is continuously exploring, and exploiting, new substances and therefore, vigilance remains needed.

Oil is directly input into the sea from two sources, the offshore oil and gas industry, and shipping. In the past, oil-based drilling fluids were used resulting in large piles of contaminated cuttings near the platforms and associated environmental disorder. However, their use has been phased out and the use of various chemicals in the production process is strictly controlled. Overall, the environmental impact of this industry is probably less than of the input of oil from shipping.

A distinction may be made between operational discharges and illegal or accidental spills. Based on the proportion of oiled seabirds washed ashore on North Sea beaches, small operational discharges pose a chronic but declining threat to marine life. The impact of illegal spills and catastrophic accidents is more temporal and their impact depends largely on time and location. The most obvious victims are seabirds and marine mammals, but the extent to which the various biota living below the surface may be also affected remains largely unknown.

While the different contaminants may pose a threat to various ecosystem components, they often pose a threat to the fishery before the ecosystem is at risk itself, because of concentration limits for selling fish and shellfish for reasons of human health. In this respect, the recent accident with the “Prestige” off northwest Spain has had a major impact on the local fishery, in addition to temporarily ruining local resources.

Eutrophication

Nutrients, in particular nitrogen and phosphorous, and light are essential for the growth of phytoplankton that forms the basis of the marine food chain. Generally, marine waters in the photic zone are relatively void of nutrients during summer, because everything has been used for primary production. During winter, light is the limiting factor in temperate waters and nutrients are released in the water column because of decomposition of organic material. In addition to the nutrients naturally available in seawater, river runoff, atmospheric deposition and human activities such as fish farming represent an additional source of nutrients. Eutrophication is a term reserved for excessive nutrient enrichment from domestic, industrial and agricultural activities. Although the North Atlantic is the major source of nutrients for the North Sea (90%), concentrations in river runoff may be a factor 50 higher leading to eutrophication in coastal waters. Also, in a semi-enclosed system such the Baltic, exchange with Atlantic water is limited and the loading is largely determined by land-based input. Eutrophication may lead to increased productivity, algal blooms, decreased water transparency, reduced oxygen concentration in bottom waters and consequently kills of fish and benthos (ICES 2003a).

Under normal conditions, nitrogen is the limiting nutrient in the marine environment, while there is a surplus of phosphorous. In recent years, this situation has been reversed in some coastal areas, because loading with land-based phosphorous has drastically declined as a consequence of wastewater treatment and the use of phosphorous-free detergents. Nitrogen inputs are more difficult to control. This nutrient imbalance is seen as the main cause of the observed increase of ‘harmful algal blooms’, which can be either toxic or otherwise perceived as a nuisance.

Although eutrophication leads, at least initially, to a higher primary production, its consequences on components higher up the food chain remains unclear. There is no a priori reason why a higher productivity should lead to increased yields of target species, because there are many other potential recipient components in any ecosystem than just the intermediate ones between phytoplankton and fish.

Conclusions

The effects of other anthropogenic activities on marine ecosystems are generally elusive, because there is not a clue how to measure them. Scientists are searching intensively for good indicators of ecosystem quality that could be directly linked to these activities, but so far this search has met little success. The problem is that effects are not necessarily negative. Global warming may selectively favour some components, while being detrimental to others. Pollution is generally believed to affect top predators first. However, seals and seabirds are generally on the increase, suggesting that pollution has presently less impact, although its effects have been strong in the past. Under extreme circumstances, eutrophication may lead to anoxia and fish kills, but this is not easily detected because it happens primarily in bottom waters. And enhanced primary production may be good for specific components.

Overall, it is not quite clear to what extent eutrophication has affected target resources or ecosystems relative to other anthropogenic factors.

- Effects of other human activities in the marine environment are generally considered subordinate to the effects of fishing, although locally they may have devastating effects on specific components of the ecosystem (e.g. oil spills). Eutrophication is largely restricted to coastal areas and semi-enclosed seas (e.g. Baltic) where it may affect productivity of commercial stocks. Effects of global warming are largely unpredictable, but may restrict the management potential to reverse historic trends in species abundance.

Limitations of CFP and alternative solutions

TAC regulation

Overall, the tactic tool available to adjust exploitation rate on an annual basis through TAC has mostly failed for various reasons. One important reason is that, even though the proposals of the EC generally followed closely the scientific advice, TAC often have been set higher by the Council of Ministers for socio-economic and political reasons. However, there are other fundamental drawbacks of the TAC system.

The TAC system requires reliable scientific advice on the present state of the stocks as well as reliable predictions of their development two years ahead. Scientific assessments depend critically on information on the total catch by all international fleets combined. This presents the core of the problem, because information is only available on legally landed catches (corrected for malversation as far as detected by national inspectorates. The history of the CFP has clearly shown that the TAC regime is an incentive for fishermen to misreport catches as belonging to a different species or originating from a different region, thus undermining the quality of the catch statistics, and thereby the reliability of predicted catches. Although for obvious reasons the extent of this problem cannot be evaluated, it is considered the most important source of error in most stock assessments (ICES, 2003). An associated problem is that, even if fishermen obediently follow the national quota regulations, they may decide legally to continue fishing while discarding over-quota catches of one or more species. These 'catches' do not enter the catch statistics and therefore bias the assessments quantitatively, because they are not included in the estimated removals. When predicted catches are unreliable and these are then translated into TAC that are too low, this system progressively leads to ever increasing discrepancies between stock abundance as perceived by scientists and the actual catches obtained by fishermen during their operations. Therefore, the TAC system – or rather Total Allowable Landings system - bites its own tail and appears to be fundamentally flawed. While in principle, catches may be predicted for various levels of fishing effort, Total Allowable Landings do not necessarily control future effort (Daan, 1997).

Capacity control

In a recent evaluation, the EC (2001) has drawn the conclusion that so far the CFP has failed to meet its overall objective of maintaining sustainable fisheries in sustainable ecosystems and that its main cause is the overcapacity of the existing fleets, which was estimated 40% higher than required to exploit the resources in a sustainable way. Although a strategic Multiannual Guidance Programme was set up in 1993 to reduce the overcapacity of individual countries by scrap subsidies, this has not led to an effective reduction because of technological improvements in fishing gear used by the remaining fleet. Although the policy may have helped to halt a further increase in overcapacity, its objectives have not been met and its effectiveness relative to the costs involved must be questioned.

Technical regulations

There is a forest of regulations aimed to control the performance of fishing gear and to reduce apparent negative impacts on target and non-target stocks. Minimum mesh sizes and other gear restrictions and prescriptions, often area-specific, minimum landing sizes, closed areas and seasons, they all may have some positive effect on a specific aspect. However, they do not address the problem that there is simply too much effort for the fisheries to be sustainable.

Marine Protected Areas

Increasingly, Marine Protected Areas (MPA) are being suggested as a means to protect marine ecosystems against human impacts. However, their effectiveness depends on the specific management goals to be achieved and on their design in relation to these goals. Of course, a specific habitat may be protected against a harmful human activity. Also, a population may be protected if the MPA is sufficiently large relative to the area over which the population is distributed. However, in contrast to many terrestrial ecosystems, marine ecosystems have essentially open borders that may be easily crossed by most fish. Also, different species prefer different areas and any MPA is most effective if it covers the area of highest abundance. Thus, if one had to design a MPA that would effectively protect all species inhabiting the Northeast Atlantic against overexploitation, one might end up with a marginal area where the remaining vessels would have to compete for the remaining limited resource. In that case, one might as well stop fishing completely, because such a fishery could not be considered sustainable in economic terms, which is also one of the fundamental objectives of the CFP.

In relation to fisheries management, MPA have been, and still are, used. The Plaice box covering a large area along the continental coast was established in 1989 to protect juvenile plaice by prohibiting large beam trawlers to fish there. This fleet now concentrates just around its borders, where every plaice leaving the box is caught immediately. Overall, the expected increase in recruitment has not come off and both scientists and fishermen have doubts about its effectiveness, partly because the distribution of juvenile plaice has changed for unknown reasons (Pastoors *et al*., 2000). Within the framework of a recovery plan for North Sea cod in 2001 that also fell short of expectations, the EU temporarily closed a large area during the latter part of the spawning season for all cod fishing, thereby forcing the fleets to exploit other areas where they may have done more damage to other stocks than there was gain to the cod stock (Rijnsdorp *et al*., 2003). The Shetland box is meant to safeguard all sandeel present for the local breeding populations of seabirds, but this measure was entirely of a precautionary nature and there is no evidence that the local industrial sandeel fishery was actually a threat to the breeding success (Wright, 1996).

These examples show that large-scale conservation effects of MPA are difficult to predict, but may have unexpected effects on other components of the ecosystem, unless it can be reassured that the fishing effort expelled is removed from the entire system. This is not to say that MPA cannot have predictable effects on specific habitats or species of concern, but they should be integrated in an overall management plan.

Effort regulation

Since 2003, the CFP allows for direct effort control, but this is optional rather than prescribed. Effort control has its own limitations, because different gears have different impacts and transfer of effort among different fisheries must be controlled if this system is going to be effective. On the other hand, it has many advantages, because days at sea can be easily counted, particularly since the introduction of automatic satellite-based recording of vessel positions. Enforcement should be relatively easy and cheap. Furthermore, days at sea are directly correlated with the chance that a fish may be caught (fishing mortality) and therefore is much more likely to be effective than a TAC regime that only controls the chance that a fish is landed, not that it is caught.

However, scientifically it is by far the preferred option, because if landings are no longer controlled, the incentive for misreporting and illegal landings disappears: the quality of international landings statistics can be expected be restored, thereby improving the basis for all management advice.

One of the main principles underlying the CFP is to maintain relative stability among the nations exploiting the various fish stocks. The TAC system provides for this by having the variable TAC split in shares by a constant key based on historic landings. With effort regulation, this is not quite so simple, because the different fleets must be managed individually based on their share in the total impact on the stock. If for instance, one fleet develops technological advances that increase its share, the effort must be reduced accordingly to meet the relative stability principle. However, in the elaboration, this is not quite so different from the TAC regime, where this should also happen. In practice, there is even a virtue in moving to effort management, because under the TAC system, illegal landings above the TAC by one country violates the relative stability principle, while its effects on future TACs represent a shared burden for all nations. Irrespective of such injustice, one may wonder whether the development during the last twenty years of large fleets of re-flagged vessels fishing for foreign quota (quota-hopping; Hatcher *et al.*, 2002) while landing their catch on their original home market is in agreement with the principle.

Economic incentives

A major factor responsible for the overcapacity of the European fleets has been the EU policy on subsidy for landing excess fish on the markets and building new vessels, because this masked the economic performance of the various fleets. While subsidies have been largely abandoned, one might consider other economic incentives to help controlling fleet capacity. The race for ever more powerful and larger vessels in many fisheries has been induced by the relatively low costs of oil (no tax levies) for sea-going vessels. Also, the considerable costs of international fisheries management are not charged to the fishermen. As a consequence, the break-even point of the fisheries is artificially increased and lay off of inefficient vessels postponed accordingly. Appropriate tax levies on input (oil) or output (catches) might be expected to lead to effectively reduce the overcapacity to a level that is in accordance with appropriate profit margins at a higher stock biomass (Van der Burg, 2000).

Conclusions

- With the possible exception of pelagic stocks targeted by specific fisheries with relatively small by-catches of other species, the CFP toolbox of catch quota, capacity control and technical measures has not been effective in meeting the long-term strategic objective of sustainable fisheries in EU waters without challenging the quality of the marine environment. The main problem relates to mixed fisheries that can continue fishing until the quota for the last species exploited has been exhausted as long as catches of the others are discarded. Therefore, quota regulations effectively don't limit exploitation rates of demersal species and other regulatory measures seem required. However, the CFP reform process showed that the political will to change the management system is severely limited.

- The main problem faced in fisheries management is the short-term need to reduce fishing mortality for most stocks and the overcapacity of the fleets. Although initiatives within the sector such as gear changes may alleviate ecosystem effects caused by the gears presently in use, these cannot be expected to resolve the problem for the target stocks, because they are based on effort replacement, not effort reductions.

Comparison with other areas

Introduction

Overfishing is not a typical European but a worldwide problem. While traditional resources are becoming smaller, fleets move to exploit new resources elsewhere, of which there are fewer and fewer left. Based on FAO catch statistics, total international landings are no longer increasing, but only their composition changes. In many underdeveloped countries, fish stocks are exploited by foreign fleets that pay for their fishing rights. The more these countries can sell, the better it is for their national budget. This clearly exacerbates the overfishing problem. In contrast, many developed countries have become aware of the detrimental effect that fisheries may have on their national marine resources and they are ardently trying to develop an appropriate management system. What can we learn from countries like Australia, New Zealand, South Africa, Canada, USA.?

The common view is that the overfishing problem is an example of the 'Tragedy of the Commons'. Free access to a resource means essentially 'catch as catch can', because any fish one does not catch may be caught next by others. The only remedy to this is to introduce property rights over the resource to individual fishermen, so that they may build up a long-term perspective of resource use. This requires a limited entry policy, by some licensing system for individual boats or by giving out Individual Transferable Quota (ITQ). The value of the license or ITQ obviously depends on the stock conditions and good management will increase the value. To achieve this, the 'owners' should be able to take part in developing an appropriate management policy, rather than leaving this to a governmental agency, supported by scientists. This has led to Regional Management Authorities, in which all stakeholders in a healthy marine environment should be represented. These not only are fishers, but also other user groups, non-governmental organisations, scientists, and the general public (often represented by one or more government representatives). The shared responsibility will ensure that at least part of the costs can be recovered from the industry.

When the outline of the management organisation is decided, there are still many ways to manage a fish stock. Increasingly, it is understood that there is not one single scientific solution to the problem, but rather an array of approaches that all may have specific advantages and disadvantages. Crucial here is the awareness that science is never perfect: the systems that we are trying to manage are too complex to be known in all aspects. Rather, scientific uncertainty should be the basis of any system that is not going to present us with unexpected flaws in its functioning. The way to proceed then is to define a variety of alternative management policies and to investigate how these different systems would work under alternative scientific assumptions for crucial population dynamic processes. This helps to select the management system that is least risk prone to collapse under the present range of scientific uncertainties (Payne [ed], 1999). Of course, scientific knowledge expands over time and appropriate adjustments may have to be made regularly.

Although the specific approaches vary among the different countries mentioned – and even within countries as one might expect if Regional Management Authorities have full responsibility for their choices-, there is a common acceptance of the measures taken and a positive attitude to the collection of new data to improve the systems. The experience has learnt that there are fewer antagonists and less severe overfishing problems.

Specific problems in European waters

The situation in Europe is quite different from the one described above. Fishers always blame fishers from other countries for causing the problem, they blame scientists for giving the wrong advice and they blame managers for listening to the wrong advisers. The causes are obvious.
The EU has chosen for one CFP that is applicable in all areas, irrespective of regional structural problems.

Although an overall objective has been formulated in broad terms that all countries could agree to, there has never been an agreement on a common long-term strategy to achieve this objective. The regulations merely allow tactical short-term decisions on the level of the TAC, but even these decisions are not delegated to the EU. The Council of Ministers takes the final decisions after days of intensive lobbying to reach compromise votes. The shear number of ministers, countries, and fisheries do not permit full stakeholder representation or even a transparent management process. Stakeholders, whether representatives of the EC, national governments, fisheries organisations, scientists, or non-governmental organisations appear to operate from their own ivory towers to enhance their influence on the decision-making process. Moreover, every effort to change the CFP – which requires unanimity among the EU countries – is frustrated by the fallback position that the present system is maintained, if the countries fail to reach agreement on appropriate changes.

There is also another difference that complicates a change in the management systems. When the new systems were introduced in Australia and New Zealand, the stocks were not yet severely overexploited and drastic measures were not required. In contrast, the stock condition in European waters is so bad – as a consequence of failing management measures – that the implementation of a new and effective system to reduce overexploitation is bound to have large socio-economic consequences. That makes it hard to reach agreement on such a system.

During the last CFP reform in 2003, a few changes have been agreed on. The decision was taken to establish Regional Management Councils (RMC) consisting of stakeholders from the industry and from Non-Governmental Organisations (NGO) addressing environmental issues. Recently, the Council of Ministers has taken further steps towards this goal (Symes, 2004). However, these RMC will only have an advisory role to the EU and no management authority. Also direct effort control is now listed as a management option, but its application is confined to stock recovery plans (Brown, 2004). The TAC system will remain the backbone until the new revision in 2013.

Conclusions

- Although management of marine resources based on clear property rights for fishermen (limited entry, ITQ) and co-management has shown to be effective in other parts of the world, these approaches are difficult to implement in EU waters because of the complex national interests and political infrastructure.

- To restore fish stocks in EU waters, more effective measures are required to control mixed fisheries. The potential of direct effort control and/or economic incentives as effective alternatives for TAC management should be explored further.

Aquaculture

Introduction

Aquaculture production has increased at an annual rate of 19% over the last 30 years. In 2001, aquaculture produced 48 million tonnes, representing 27% of the total aquatic production (FAO, 2002). Worldwide, 42% consists of fish raised in freshwater systems, mainly cyprinids that are cultured under extensive management in Asia (specifically China). The production of feed organisms by these systems, often increased by fertilization, contributes to the overall production. In Europe, molluscs and diadrocfmous fish (mainly species that spawn in freshwater, but spend most of their life in the marine environment), represent the bulk of the aquaculture production (see table).

Molluscs and carp in central Europe are also produced in extensive systems, but otherwise production is mainly derived from intensive systems. Intensive means that feed is derived from external sources and that the system does not contribute to the production of feed organisms. An important ingredient of fish feed is fish meal and fish oil. Thus, overfishing of stocks used for industrial purposes to produce fish feed is a serious environmental impact of intensive aquaculture systems.

In 1980, aquaculture in Europe produced 240 000 tonnes. Since then, production has grown by about 10% annually. However, recently the increase appears to have slowed down (2% in 2000, 6% in 2001).

	Europe		World	
	Ktonnes	%	Ktonnes	%
Seaweed	3	0,1	10562	21,8
Molluscs	855	40,4	11267	23,3
Crustaceans	+	0,0	1986	4,1
Freshwater fish	308	14,6	20799	43,0
Diadromous fish	834	39,4	2543	5,3
Marine fish	116	5,5	1091	2,3
Miscellaneous			165	0,3
Total	2086	100	48413	100

Table 1. Aquaculture production in Europe and overall by main components (FAO, 2003).

Intensive fish culture

Salmon (*Salmo salar*) production increased from almost nil in 1985 to around one million tonnes in recent years. Over 50% is produced in Europe, Norway being the main producer, followed by Scotland an Ireland. In Mediterranean countries, aquaculture of European seabass (*Dicentrarchus labrax*) and gilt head seabream (*Sparus aurata*) took off after 1990 producing 130 thousand tons in 2001, with Greece as the main producer (FAO, 2001). These species are kept in cages floating in the marine environment during the main part of the production cycle. This system allows high densities to be maintained within the cage, while the water flowing through provides the fish with oxygen and discharges the metabolic products.

Site selection is a crucial issue in cage culture because of direct interactions with the local environment. Sheltered locations are favoured to restrict damage by storms, but this may enhance negative impacts through discharge of nutrients and chemicals used for pest control and/or improving energy uptake because of limited dilution. Also, conflicts with other potential uses for these sites are common, and increase with the number and extent of the fish farms. Other negative impacts refer to spread of parasites and diseases.

Every tonne of salmon production requires a feed input containing 22 kg of phosphorus and 116 kg of nitrogen, but only 18% and 26%, respectively, is recovered in the fish production. For the rest, these minerals settle on the bottom under the cages or end up in soluble form in the water column. Seabed conditions around fish farms show increased levels of organic carbon and nitrogen and changes in the benthic fauna: in general, number of species is reduced while biomass is increased. To avoid severe impacts, new cage locations are regularly selected. In some operations, the solid waste under the cages is collected for further processing. However, the dissolved fraction (particularly nitrogen) may still lead to eutrophication effects.

Contaminant levels associated with cage culture, for example copper and zinc from anti-fouling compounds, may be elevated in sediments adjacent to fish farms, but the risks posed by these are not well understood. From a nutritional point of view, the use of copper coatings may not affect the quality of seafood products either within or around cages (Solberg *et al*, 2002).

Fish escapees from cages can never be completely avoided, and may result in the introduction of non-indigenous species or domesticated strains. There is evidence that escaped farmed fish negatively impact wild salmon through genetic introgression and other ecological interactions (Whoriskey and Carr, 2001). Interactions between wild and farmed fish may not be limited to escapees. Mass rearing and transport of live fish always increase the risk of disease and parasite spreading, as exemplified by increased sea trout mortality in a wild population from stress linked with sea lice infection from farmed fish (Bjorn et al, 2001).

Land-based re-circulation systems are also used in Europe for aquaculture of various species, although the production is only a fraction of the cage production. In these intensive systems based on culture feed, water is also used as a medium to deliver oxygen and discharge metabolic products. The main difference is that the water is reused after filtering and oxygenation and only a small volume of water is exchanged. Water inlet and effluent discharge can be completely controlled, and environmental impact kept to a minimum. Water can be treated, buildings insulated and effluents processed. When water is sourced from bore holes, re-circulation systems can be constructed without contact with open water, greatly limiting the risks of escapes from fish, parasites and diseases. Environmental aspects relate to the facilities, energy requirements for pumping and water treatment, effluent processing, and of course the dependency of feed.

Extensive shellfish culture

Shellfish are produced extensively along the Atlantic and Mediterranean coasts of Europe. Important product groups are mussels, with a production of 450 000 tons and oysters with 250 000 tons. In contrast to fish, shellfish filter their food from the surrounding natural waters and culture does not depend to external feed, causing a minimum impact on the environment. Recent studies have focused on the potential of shellfish culture to reduce the environmental impact of cage culture. Although there is not always a direct relation between nutrient input in cage farming and nutrient output through shellfish, the net loss of nutrients at the culture site is less when mollusc and finfish culture are integrated.
Concerns about shellfish farming relate to a reduced availability of plankton for other filter organisms, changes in the structure and composition of the benthic fauna, increased turbidity, the spreading of introduced organisms (e.g., Japanese oyster), and nature conservation in general (food resource for seabirds).

Scope for extension

Further extension of the present intensive aquaculture systems increases associated risks and the challenge is to increase production without increasing the negative impact on the environment. Alternatives for fish meal and fish oil as ingredients for feed do exist and can be developed further. However, it is economically not feasible to use these alternatives at present.

Discharges of nutrients from cage culture may be reduced by improving feed efficiency, or by collecting waste products. Diluting discharges by moving cages further out into the open sea may help to reduce the local impact, but increases the chance of accidental losses through storm events. Discharges could then be adjusted to the carrying capacity of the environment. By using land-based re-circulating systems complete control over inputs and outputs may be obtained, thus controlling to a maximum extent possible the impact on the environment.

All these solutions are technically feasible, but at an increased cost price. Aquaculture has to remain competitive with imports, wild catches and alternative food on the market. Given the current economic situation for the European aquaculture sector, major investments to reduce environmental impact at an increased cost price are hardly feasible.

Conclusion

- The major challenge facing the rapidly growing European aquaculture is to provide solutions for increasing conflicts for space and water use. The limited space available, especially in highly populated coastal areas where competition between human activities becomes extremely tense, makes this a critical issue. Investment in innovative technologies to reduce environmental impact in combination with economic feasibility is essential.

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