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Review Article

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Adopting a Wider Approach for Fisheries Management

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Abstract

Many marine and freshwater fisheries are now in a very poor state, and many fish stocks are close to collapse. There is a need to manage fisheries more carefully, especially since fishing can affect other aspects of the environment. It is also important to reduce the adverse effects of climate changes upon the marine and freshwater environments, fishes, and other animals, and the need to manage other human activities taking place in the sea, to improve the marine environment and protect the wildlife and the fishing activities. Marine pollution, includes human waste materials, chemicals and plastics, and there is also noise and substrate vibration, from industrial and other activities that may affect both the abundance and quality of fishes and other marine animals. This paper deals with fisheries management, and environmental protection, and concludes that fishermen, fisheries scientists, fisheries managers and environmental interests must work closely together, if fishes are to be adequately protected, and fisheries are to be better managed. It describes current systems of management. It especially draws attention to the importance of moving towards an ecosystem-based approach to fisheries management. Such an approach aims to manage all those human activities that have an impact upon the marine environment and its life forms.

Introduction

Fishes are a healthy protein foodstuff, with a low carbon content compared with many other food sources. Fisheries are therefore very important in supplying food. However, many fisheries around the world are now in a state of crisis. Some fish stocks are close to collapse and catches are falling. However, at the same time, fishing for some species is able to expand, and the level of exploitation of some fish stocks does continue to increase. With free access to a fishery, then the number of fishing boats can increase, and fish catching and efficiency measures may increase, and the fishes can come under severe pressure. Often, there are many boats chasing very few fishes. Fishes are then removed at a rate faster than they can reproduce themselves. There is now a need to manage fisheries more effectively.

Some fisheries are managed by international organisations that receive advice from both national and international groups of scientists. Within the eastern North Atlantic, the Baltic, and the Mediterranean seas, the fisheries are managed by the European Community and are governed by a Common Fisheries Policy (CFP). This has established a programme for monitoring and conserving fish stocks, regulating fishing, sharing out the resource, policing, restructuring fleets and maintaining employment within fishing communities. The UK has recently left the European Community (Brexit), and has begun to manage its own fisheries independently, but with some cooperation with Norway and the EU. In some cases, the UK fishers have thought that there is only poor science and that leads to quota catch recommendations that are not related to the numbers of fish that are available. However, in some countries, including the United States, Australia, New Zealand, and Norway, the fisheries are actually well managed nationally.

Environmental protection has to be integrated into Community policies. There is an obligation to protect and conserve living marine aquatic resources, and to provide for their rational and responsible exploitation. Scientific advice is required on the state of fish stocks and the impact of fishing upon them. In addition, ecological advice is needed on the state of marine ecosystems, the interactions between fish stocks and other key species, and the impact of fishing and other activities upon non-target species and the wider environment. The advice required is not just limited to scientific issues, however. It is important for fisheries managers to have advice available on the appropriateness and practicality of management measures, and, in addition, on the economic and social impact of those measures upon fishers and fishing communities. This paper deals with fisheries management, and later draws attention to the importance of adopting an Ecosystem approach for fisheries management. It considers the arguments for adopting an Ecosystem approach, and considers how it might be implemented. Natural marine resources whose state needs to be considered include the air, water, adjacent land, flora and fauna and especially representative samples of natural ecosystems. These must be safeguarded for the benefit of present and future human generations through careful and appropriate management.

Determining the State of Fish Stocks

World-wide, many fisheries are in a state of crisis. Catches are falling and in some cases there is an ever greater dependence on younger, smaller fishes. Many fish stocks are outside safe biological limits. Landing statistics and details of the fishing fleet must be obtained from the different ports in each country. Sampling of fish landings is necessary to determine the size, age and condition of the fishes. Voyages on commercial fishing vessels by scientific observers must be carried out to monitor the fishes which are being caught (some of which may be discarded). Also, research vessels must be used to conduct surveys of the abundance of fishes. Most of these activities can only be carried out by large and well-equipped fisheries research institutes. Such facilities have to be established within all the relevant coastal countries, and need to be funded directly by their governments. It is necessary to bring together the results of research and monitoring from several adjacent countries in order to fully assess the state of fish stocks and their aquatic environments.

Fishing also has a wider impact upon the ecosystems. Trawling and dredging may degrade habitats and destroy flora and fauna. The removal of fish and other organisms, either deliberately or as a by-catch, may affect their abundance and diversity. Fishing may also have an adverse impact upon other animals, such as seabirds, seals, and cetaceans.

Therefore, as well as conserving fish stocks, there is a need to consider the effects of fishing upon the wider ecosystems, to protect the economic viability of the fishing industry, and preserve social and cultural values within coastal communities. Any management system should involve all the stakeholders and, wherever possible,

should pass management down to a local level. Fishermen, fisheries scientists, fisheries managers, and environmental interests, must work closely together if fisheries are to be well managed.

The main advice provided to fisheries managers is in the form of assessments of the state of individual fish stocks in different areas. These assessments involve examination of the catches, and of the changes which take place in the age composition of fish over time. The data are slow to be collated and analysed and the assessments require long data series. The assessments are inherently long-term, and their ability to predict the future state of fish stocks is limited. Although there is a progressive increase of confidence in the assessments after years have elapsed, there is always uncertainty about the current and future state of the stocks. This uncertainty poses particular problems in assessing the effects of management measures. The effects of major changes to the management regime cannot be assessed until three or four years have elapsed. Often, new measures are introduced before any assessment has been made of the effectiveness of previous measures.

Fish stock assessments would benefit greatly from improvements in the capacity for collecting data from the fishery and analysing it immediately. The assessments would also be improved by the incorporation of up-to-date information from fishers themselves on their recent catches and on changes in the behavior and distribution of the fishing fleets. There is a need to develop new paradigms for the more rapid and up to date assessment of fish stocks. New and independent assessments made using different methods would help to validate those obtained by the current methods. They would also enable more prompt evaluation of the efficacy and impact of management measures.

Currently, there is a lack of attention being paid to multi-species factors. Each fish stock is evaluated separately, although it has to be recognised that different species interact with one another in a complex way. For example, cod are predators of herring, sandeels and Norway lobsters. Changes in one fish stock can affect other stocks. Moreover, fish are part of a wider ecosystem, supporting predators (like seabirds and sea mammals) and in some cases also providing food for other fish species. The wider ecosystem may be adversely affected by changes to the fish stocks. For example, seabirds may be deprived of food through heavy fishing on their prey fishes, and charismatic organisms may be affected directly by fishing activities, such as the destruction of deep-sea corals by trawls, or the incidental capture of cetaceans in drift nets. The growth of predator populations such as seals, whales, and dolphins, may also have an adverse effect upon fish stocks. It is now widely accepted that there must be a move towards an ecosystem-based approach to fisheries management.

Fish stocks can be adversely affected by changes in the environment, though these changes are often not taken into account in the assessments. The assessments often assume that the biological reference points for the stocks remain stable with time. However, recent major changes in the ocean climate, and harmful human environment activities within the sea, and pollutants along the coast, have resulted in changes in species composition within areas like the North Sea. Clupeid fish species like the anchovies, herring and pilchards are especially vulnerable to facing extinction, as the warming seas are reducing their size, damaging their ability to move to more suitable environments, and affecting their survival. Some of the fishes that we like to use for our food may become more scarce. The effects of climate and environmental changes upon fish stocks need to be taken into account in setting biological reference points. There is little point in setting a target for spawning stock biomass based on earlier levels, as it is unlikely to be reached under changing climate conditions.

Examining Climate Change

It is necessary to examine all the problems that are affecting fishes in the sea. Climate change is having an

especially adverse effect, with changes taking place in the sun's intensity, rising sea levels, and also "greenhouse" changes. The impacts include changes in the water temperature, the level of acidification, lower oxygen content, and changes in the wind and ocean currents. Because the water temperature has risen in some southern areas a number of fishes have moved further north, including the Atlantic mackerel. Global temperature rises are expected to increase even more over the next few years. The "greenhouse" effects involve warming, that results when the atmosphere receives heat radiating into the air space, especially from the burning of fossil fuels, including oil, gas and coal. Gases released into the atmosphere, such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), actually trap heat; and they allow direct sunlight to reach the Earth's surface. The natural occurrence of these gases in the atmosphere is in part responsible for the Earth's climate change. It is human activities have caused some of the changes in the natural cycles of these gases. The increases in greenhouse gases in the atmosphere have led to significant changes in the Earth's climate since the start of the industrial revolution. The revolution has involved rapid major changes in economies, marked by the general introduction of power-driven machinery or by major changes in the prevailing types and methods of use of machines, as well as the oil, gas and coal industries. It has been pointed out [1] that the oceans are absorbing much of the carbon dioxide and excess heat resulting from a changing global climate. This absorption results in ocean acidification, and the increasing temperatures contribute to a loss of oxygen from the sea. Warming of the waters in areas like the North Atlantic is believed to be taking place and may be a significantly adverse factor for some fish species. There have been changes in the distribution of Atlantic mackerel since 2007, and the mackerel have moved further North, because the sea temperatures are rising. The North Sea cod populations have also been especially badly affected, with fewer juvenile cod. There is some concern about skates and rays, which are being poorly managed. There is also concern about the overfishing and poor management of brown crabs and lobsters, although sardines are currently doing well in the North Sea. It seems that low-lying coastal regions and estuaries are especially threatened by global warming and a concomitant rise in the sea levels. They are also affected by pollutants, including sewage, some of which enters from the rivers that flow into the sea. These processes can have an especially adverse impact on coastal marine life. However, it is mainly areas in the Tropical Oceans and in Polar Seas that are expected to experience the largest changes in fish species, and therefore the fisheries that target them in these regions are likely to be more vulnerable to climate change.

Climate change may result in changes in the water within the sea, lakes and rivers. Global warming is now increasing even faster, with overall temperatures expected to be higher. It is resulting in more water entering the sea, and increases in the seawater temperature leading to lower levels of oxygen. The floods that are generated on land can affect rivers and lakes adversely. There is particular warming of the shallow Mediterranean Sea at the moment. These changes may affect the prey of fishes detrimentally, as well as the fishes themselves. Sea levels around the World have risen in recent years, owing to the melting of glaciers and ice-sheets, and thermal expansion in the oceans, where sea levels increase in volume as a result of the higher temperatures. It has been pointed out [1] that climate warming over several decades has been linked to changes in the large-scale hydrological cycle including: increasing atmospheric water-vapor content; changing precipitation patterns, intensity and extremes; reduced snow cover and widespread melting of ice; changes in soil moisture; and water runoff into rivers and the sea. Over the 20th century, precipitation of rain and snow has mostly increased over land and on the sea in some of the high northern latitudes, while decreases have dominated in southern areas. Water stored in glaciers and snow cover areas are expected to decline, reducing water availability in some areas. In some coastal areas and

islands, volcanic eruptions take place, and they are expected to create climate change problems. However, they are being reduced by the current rises in sea levels in some areas, and are more likely to take place in areas where the sea levels have been reduced. Some creatures may be improving the quality of water by purifying it. For example, oysters and other invertebrates, which are filter feeders, may be removing particles and water pollutants from the water in some areas, enhancing its quality.

There is a real need to deal with the climate change that is currently taking place, as it is damaging to both humans and fishes. Fishes within the sea may be adversely affected by the temperature changes, increasing levels of water movement and ocean acidification. Some human deaths may be associated with storm surges and flooding on land, and warmer temperatures may also affect peoples' health, but it seems that fishing vessels and their fishermen still appear to be able to operate quite well. However, it is clearly necessary to carry out long-term monitoring of the environmental and climate changes, and their effects upon fish populations, habitats and communities. All of the changes taking place require big commitments from governments. The use of wind power, direct current power, solar power, and energy from other sources may reduce the damage being done by the earlier energy sources, including fossil fuels, by reducing greenhouse gas emission. Renewable energy sources are now playing an increasing role in providing electrical energy, and they involve wind, solar, hydropower, tidal and other green sources. Such sources are intended to provide low-carbon energy that can significantly reduce dependence on fossil fuels, thereby reducing impacts upon the environment. However, in some cases, these new energy sources may impede water movement and put in place barriers preventing free access of migrating fishes to their essential habitats. It is important to examine the possibility of some damage perhaps being done in the sea through the installation and presence of some of the renewable energy sources, like wind farms [2] and direct current generators, including tidal power systems. The wind farms can be rather large and can restrict access to some of the coastal fishing grounds. The tidal turbines used to harvest energy may help to meet the challenge of global warming, but they can especially injure and kill fishes. The wind farms that are now being installed in coastal waters can consist of many spaced wind turbines, mounted upon the seabed. They are initially connected to the seabed using pile drivers, which generate high level impulsive sounds in the water and also generate substrate vibration. Once these wind turbines are operational, each of them vibrates internally, and generates vibration within the substrate. A new generation of wind farms has now been created, which float at the surface. These wind farms may generate sound in the water, near the surface, but do not generate substrate vibration. However, these floating wind farms are all interconnected with electrical power cables suspended below the surface. So what has been an open ocean is transferred into a forest of obstacles – that may impose risks upon animals. For example, whales, dolphins and fishes may collide with the cables and floating structures. The electrical power cables may also affect some animals adversely, as they can change the local magnetic fields that may be used to guide migrations [2]. There is a need to avoid building large wind farms within coastal areas that normally include large numbers of healthy fishes.

Fisheries Scientific Studies

At the heart of fisheries management is the need for expert advice. Scientific advice is required on the current state of the fish stock populations and the impact of fishing upon them. In addition, ecological advice is needed on the state of marine ecosystems, the interactions between fish stocks and other key species, and the impact of fishing upon non-target species and the wider environment. Fisheries science is extremely important for supporting fisheries management. It includes stock assessment, the evaluation of impacts, and even examining the allocation of resources. However, fisheries science is not always perfect, and the fishing industry and fishery

managers do not always trust what is provided by the scientists. There are often complaints about the science, especially when there are likely to be adverse impacts on the fishing industry.

The main advice provided by scientists to fisheries managers is in the form of assessments of the state of individual fish stocks in particular areas. These assessments involve examination of the catches, and of the changes which take place in the age composition of fishes over time. The data are slow to be collated and analysed and the assessments require long data series. The assessments are inherently long term, and their ability to project the future state of fish stocks is limited. Although there is a progressive increase of confidence in the assessments after years have elapsed, there is always uncertainty about the current and future state of the stocks. This uncertainty poses particular problems in assessing the potential effects of management measures. Currently, the effects of major changes to the management regime cannot be assessed until three or four years have elapsed. Often, new measures are introduced before any assessment has been made of the efficacy of previous measures.

The advice required on fisheries management should not be limited to scientific questions. It is also important for fisheries managers to have advice available on the appropriateness and practicality of management measures, and, in addition, on the economic and social impact of those measures upon fishers and fishing communities. Fishers, fisheries scientists, fisheries managers and environmental interests must work closely together, if fisheries are to be better managed. This was achieved within the European Union through the establishment of the North Sea Regional Advisory Council (NSRAC). Anthony Hawkins initially set up the North Sea Commission Fisheries Partnership (NSCFP), starting in the year 2000 [3]. The partnership brought together fishermen, fisheries scientists, and environmental experts from around the North Sea, and it included personnel from Norway as well as the EU. The Partnership was effective, and organised a joint study group on fishers' information with the International Council for the Exploration of the Sea (ICES). It also suggested that a fisheries management council should be established for the North Sea to provide a wide group of stakeholders with the opportunity to participate in governance of the fisheries. When the European Commission proposed in 2002 that Regional Advisory Councils should be established, the Partnership was the first organisation to pick up on this proposal, and it established the North Sea Regional Advisory Council (NSRAC). The first meeting took place in November 2004, and other RACs were later established for other regional seas. The RACs have been very successful and have greatly improved fisheries management policy.

The procedures now used for collecting scientific data are generally rigorous and comprehensive. Landings are monitored, the sizes and ages of fishes examined at fishing ports, research vessels measure the abundance of young fishes and spawners, and sampling also takes place on board commercial fishing vessels to determine what is caught but discarded at sea. However, this rigour cannot be applied to all stocks. Inevitably, for some fish stocks, the availability of data falls short of what is required for a full assessment.

Fishermen and other stakeholders often mention within the RACs that they wish to take part in providing the information on which the scientific assessments are based. They believe that they hold information which is potentially valuable for fish stock assessment and they have their own views on the state of the stocks. Such information should certainly be used to validate and extend the scope of the scientific assessments. Fishermen are more likely to be convinced by the assessments if they understand them, and have contributed to them.

There are many questions over how scientific data is best obtained. For example, in monitoring catches, should use be made of human observers or should video/ electronic apparatus be used for data gathering? On-board observer information is often accurate, but it is expensive to organise and coverage can be limited. Electronic monitoring can produce a tremendous amount of data – but it is necessary to ensure that there are adequate

resources to store the data and then to process it. Ideally, real-time or near real-time processing of data is desirable. Data collection by the industry can be especially valuable in this respect, especially in relation to catches and discards. Information from fishers can play an important role in the scientific process, although fishers may need to be familiarised with the science, perhaps through training workshops. Fishers are often frustrated that their knowledge and experience is ignored. They have to fight against the belief of scientists that fishers' knowledge is anecdotal, and cannot easily be utilised within the models, tables, and graphs that they are being prepared. This lack of attention to fishers' views undermines support for the whole process of stock assessment, and for the conservation measures subsequently adopted. Thus, biologists and social scientists must get together with fishermen to develop new ways of collecting relevant information on the fisheries. That information can consist of measurable quantities, like the catch of fish fished per hour, or it can be information which is less easily quantified, like information on the location of spawning grounds or nursery areas. The collection and analysis of these data presents a real challenge.

Protection of the Aquatic Environment

Fishing and other human activities can have an adverse impact upon marine ecosystems. Fisheries management needs to be extended to integrate environmental protection aspects into policy-making, not only to protect vulnerable species and habitats, but because the fisheries themselves can affect the ecosystem adversely. Trawling and dredging as a result of fishing may especially degrade habitats and destroy flora and fauna. The removal of the fishes and other organisms, either deliberately or as a by-catch, may affect their abundance and diversity. Fishing may also have an impact upon charismatic fauna, such as seabirds, seals, and cetaceans, evoking strong public concern. A balance has to be struck between fisheries and environmental interests.

However, not all the problems in the marine environment result from fishing. Pollution from industrial and other activities may affect both the abundance and quality of fish. Pollutants can originate from the land and rivers, including industrial wastes, sewerage, fertilizers, pesticides. Oil spills, and negligent acts of the transporters of oil, also have a hazardous impact on marine life. Use of plastics is also contributing to marine pollution, and currently poses a threat to fish and invertebrates, as well as the many other pollutants. Activities such as: seismic surveys for oil exploration; the construction of harbours, oil and gas farms, and wind turbines; the use of tidal turbines; and even the operation of vessels in the sea, may generate noise in the water and even substrate vibration, and this can affect the distribution and health of fishes and other organisms.

Fishes make use of particular sensory cues during their migrations and other activities, including responses to water currents, electro-magnetic cues, sounds including infrasound, and olfactory cues (involving the sense of smell). Alterations to those environmental cues as a result of human activities may have effects upon both migratory, residential and spawning fish. Delays in migrations and the accumulation of fish at locations where they are vulnerable to predation by other fishes, mammals and birds, may result in high mortality rates. Fishes must not be exposed to poor water quality or unacceptably high levels of pollutants, and their access must be maintained to habitats of suitable quality. Migratory fishes are especially vulnerable to high temperatures, low flows and de-oxygenation of the water.

The generation of noise in the sea can create particular problems. Sounds and vibrations provide a great deal of important information to aquatic animals about their environment, potential mates, competitors, predators, and prey. Sound is an essential communication channel for aquatic vertebrates and many aquatic invertebrates [reviewed by 4 and 5]. Sounds are produced by fishes and invertebrates in different behavioral contexts and are emitted almost continuously by some of them, including the cod and haddock, especially throughout the spawning season (in Feb - May). The distinctive characteristics of these sounds make it possible to locate spawning cod and haddock, and also some other

fish species, at their marine spawning grounds, and to map the spawning areas. Fishing and other human activities in the vicinity of spawning concentrations of fishes may have deleterious effects upon their stocks. Man-made sounds in water do have an adverse effect upon fishes. Listening for the fish sounds provides a reliable, non-invasive technique for detecting their locations, including spawning fishes, and enables them to be protected well. Anything that interferes with the ability of animals to detect sounds of biological relevance to them has the potential to significantly impair survival of individuals and populations [6].

There are currently substantial gaps in our understanding of the potential effects of sounds and substrate vibration on fishes and aquatic invertebrates. These gaps currently preclude assessment of potential cumulative impacts from offshore human activities. In particular, there is little data from field studies conducted under real-world conditions to examine behavioral and/or other effects with possible fitness consequences. Research is needed to deal with some of the most critical gaps in our current knowledge, to enhance our understanding of possible impacts of noise upon populations and ecosystems.

In some areas, natural and anthropogenic effects have led to changes in the numbers of sea-mammals and seabirds, which may prey on commercial species of fishes. There is rather limited ability to engage with these environmental issues. It is evident that the current scientific systems for setting reference points for exploited fish stocks should be extended to habitats, and conducted for non-target species. For this to be possible, an improved knowledge of the relevant ecosystems is required, and more work needs to be done to identify indices, baseline levels and limits for important ecological parameters. it is important to strengthen the role of marine science, since this underpins all management systems. The marine science organisations must receive stronger funding and they need to become more flexible, responsive and communicative. Along with this strengthening, there must also be a longer term view of management measures. Work must be put in hand to prepare for multi-annual marine environment management strategies.

The Management of Fisheries

Fishing is characterised by heavy investment in vessels and other facilities and by rapidly rising costs, often adversely affected by shrinking biological resources. Fishing enterprises can show poor profitability, and fishing communities can show declining employment. Problems with fishing develop where there are simply too many boats chasing too few fishes. Fishes can then be removed through fishing at a rate faster than they can reproduce themselves. Fishermen are living off the natural capital of the resource, rather than the interest.

To maintain fisheries in a sustainable state, governments and international agencies have often intervened to place strong controls upon the operation of the fisheries. Output controls are imposed to regulate the quantities and sizes of fishes landed through quotas and minimum landing sizes. Input controls are introduced to restrict access to the fishery through licences which limit the number of boats, gear regulations, restrictions to the capacity of vessels, limitations on days spent at sea, and the closure of areas of sea. Imposition of these controls can bring problems. Fisheries managers may be pressured into setting quotas which are too high, while fishermen may catch more than their quota allocations, leading in both cases to heavy fishing mortality and over-exploitation of the resource. Quota allocations can encourage the race for fishes as individual skippers seek to maximise their track records which qualify them to receive quota allocations. Restrictions on landings can also result in the release of large quantities of captured fish at sea. Controls on fishing vessels can influence their design, with implications for safety, while many of the technical measures which regulate fishing gears can be overcome by fishermen, or can be difficult to enforce. In contrast, with output controls, including quotas, sensible harvest control rules need to be developed. Ideally, industry should be involved in the setting of those rules, although harvesting decisions must be based on scientific

assessments and science-based advice, and not on politics. Management procedures must be transparent and accountable.

Successful management of fisheries especially requires a heavy investment in the collection of scientific data on the state of the fish stocks. Moreover, enforcement of the management controls requires heavy policing. The result can often be the development of a complex, centralised and expensive system of fisheries management which is inflexible, resistant to change, and which can fail in its main objective of conserving the fish stocks. Management in the past has often been based on single fish stocks, but management of multi-species fisheries and the wider ecosystem is considered to be especially important, given the mixed-species nature of fisheries and the interactions of species in a dynamic marine environment. In considering management measures, the relative merits of quota control and effort control also need to be considered. Input controls (which directly regulate the amount of effort which can be put into a fishery) might work as an adjunct for output controls, but never as a substitute. They may involve restrictions on fishing gears and limitations on the number of commercial fishing vessel licences issued (called limited entry).

International fisheries agreements, which set catch limits for shared stocks, are complicated, require cross-boundary liaison and should not be left to the last minute during any major political transition changes (like Brexit). Industry should take a lead in these negotiations to ensure a pragmatic solution is reached. Governments need to involve stakeholders in making their operational decisions. Managers have to be held to account, especially when they are taking decisions outside the scientific advice. It is also important to get the balance right between primary legislation that sets out the legal framework for management, and the need for flexibility within the management plans.

Inshore fisheries, within rivers and lakes, tend to have poorer data, as they are rather local and are not always subjected to international management.

Management of Fisheries by the European Union (EU)

Many fisheries within the eastern North Atlantic and the Mediterranean fall within the jurisdiction of the European Union. The Treaty which established the European Union (the Treaty of Rome 1957) made no specific reference to fisheries. Within the European Union (EU), fisheries were later managed under a Common Fisheries Policy (CFP). This established a programme for monitoring and conserving fish stocks, regulating fishing, sharing out the resource, policing, restructuring fleets and maintaining employment within fishing communities. Europe assigned to the Common Fisheries Policy (CFP) the same general objectives as the Common Agricultural Policy (CAP). These were mainly to:

1. Increase productivity by promoting technical progress;
2. Ensure a fair standard of living for the (fishing) community;
3. Stabilise markets;
4. Assure the availability of supplies;
5. Ensure the principle of non-discrimination

The CFP was later subjected to review and there was some initial criticism of its institutions and the way its power was exercised. Increasing thought was then given to the development of a more comprehensive, holistic system of fisheries management. Within the CFP procedures were also developed for policing catches and landings, for restructuring fleets, for marketing fishes and for maintaining employment within fishing communities. Community waters are mainly open to all member states. However, the policy operates with provisions which limit access to the coastal waters around a state (within 6 and 12 nautical miles from the shore) and which exclude new member states from waters they have not traditionally fished. Each member state is responsible for administering fishery management within the coastal zone, in line with the overarching CFP.

In northern waters like the North Sea, where resources are shared, fish stock conservation and allocation of the resource is mainly achieved through a

system of Total Allowable Catches (TACs), supplemented by technical conservation measures. The latter include minimum mesh sizes, minimum landing sizes and the definition of areas where fishing is prohibited. The system of TACs tends to predominate, largely as a result of the need to allocate resources between EU member states and between the EU and adjacent third party states like Norway and more recently the UK, which are not EU members. The TACs are determined on the basis of independent scientific analyses undertaken by an Advisory Committee on Fishery Management (ACFM) under the supervision of the International Council for Exploration of the Sea (ICES). The advice is based solely on scientific considerations. Data is collected through national and international surveys, and analyzed by a series of ICES Working Groups. The establishment of the Regional Advisory Councils (RACs) has enabled scientists and fishers to discuss management together and provide advice to the ACFM.

In the Mediterranean, a different system of management prevails. Many of the fisheries take place around the relatively narrow shallow fringe and are essentially local. They are very diverse in terms of fleet structure, species caught, and fishing methods used. Management is mainly through technical measures, including minimum landing sizes, mesh regulations, closed seasons and areas and restrictions on fishing gears. Trawling is prohibited within 3 nautical miles of the coast or in depths of less than 50m. Here, there has been great resistance to the introduction of TACs. Only the fisheries for bluefin tuna, and other large pelagic fishes, are subject to quotas. There are some regulations which are applicable over the whole of the Mediterranean but these are not universally complied with or enforced. The General Fisheries Commission for the Mediterranean (GFCM) promotes 'the development, conservation, rational management, and best utilisation of living marine resources' and is advised by its own Scientific Advisory Committee. However, assessment of the fish stocks is hindered by a shortage of reliable statistics and data series.

Management of Fisheries by the United Kingdom (UK)

Originally, the UK's accession to the EU in 1973 created an international framework within which to manage fisheries and set strategic objectives for all EU members. The UK was already a member of the EU when exclusive economic zones were declared, extending out to two hundred nautical miles (or the midline between countries). It was the EU rather than UK law which drove the shape of the developing fisheries policy. However, there were opportunities to shape British law even within the EU framework, for matters such as quota distribution and inshore management, which remained within the UK's authority. The UK also played a key role in managing fisheries under the CFP.

Leaving the European Union through Brexit has involved the UK leaving the Common Fisheries Policy (CFP). Post-Brexit fisheries policies have now been adopted by the UK (7). Sharing the management of the UK fisheries and maintaining good relations with the EU and other relevant countries was considered to be essential for ensuring sustainability and maintaining favourable trade in seafood. For fisheries, the seafood industry and the marine environment, Brexit offered an opportunity to re-think governance, improve transparency, respond better to the views of stakeholders and strengthen environmental protection. An agreement between the UK and EU permits non-UK vessels access to fishes in UK waters under certain conditions, and EU vessels still have full access to many UK fishing grounds. However, the UK is not part of the EU's Common Fisheries Policy. It is a sovereign independent coastal state with the right to manage the resources in its own waters. The UK government is responsible for managing the UK's territorial waters (out to 12 nautical miles) and the Exclusive Economic Zone (out to 200 nautical miles or the median line with other states). The UK Single Issuing Authority (SIA) has been set up to issue licences to both UK and non-UK vessels authorising access to UK waters to fish. Non-UK vessels, including EU registered vessels, are not permitted to fish in UK waters, unless they have the appropriate licence from SIA. Such vessels do not have

automatic rights to land in any UK ports unless there is a case of distress or an unexpected event. The UK government has signed continuity agreements with Norway and the Faroe Islands to allow UK fishermen to continue to access and catch fishing quotas in Norwegian and Faroese waters.

The UK has never had full legislative responsibility for its exclusive economic zone. It has not been able to revert to a pre-existing system following Brexit. Legislative building blocks are now put in place to house decision-making in the appropriate places and for those decisions to be taken in the right way. However, there is still a need to engage in dialogue and consensus with key governments and industries in other countries, as they are all engaged in fishing within areas like the North Sea. The UK will need to continue to work with ICES with regard to its scientific work, and on the assessment of fish stocks. UK scientists have played an important role within ICES in the past, and should continue to do so in the future. There are a number of important fish stocks that are shared with European neighbours from the EU, Norway and other coastal states, and discussion can take place through membership of the North East Atlantic Fisheries Commission (NEAFC), with decisions on how to allocate the catches. There is a need to allocate catches both within the UK, and between the UK and relevant neighbouring countries. The management plans must also include provisions for monitoring catches and the implementation of reasonable control and enforcement measures. There has to be be a level playing field between countries. Zero to low tariff trade in both exported and imported seafood was accepted as essential for ensuring the profitable sale of the fishes that the UK catches, and the affordability of the seafood that the UK inhabitants consume.

Management in Other Areas

Fisheries management is said to have improved significantly [8] in some countries such as the United States, Australia, New Zealand and Norway, and all four can point to strong examples of stock recovery because of effective management, but they still have some way to go. Nevertheless, in all four countries, marine conservation has been more integrated into the fisheries management system than in the UK or EU. Each country has its problems but these four can point to strong examples of stock recovery because of effective management. This is heartening in a world where many environmental problems seem to have no obvious solution. In all these countries, national or federal governments have controlled the offshore fisheries. There have been good examples of regional government co-operation over coastal fisheries. A science-based approach was advocated by all four countries, but different methods of assessing maximum sustainable yield were adopted, with the US, New Zealand and Norway using deliberately conservative methodologies. In New Zealand and Australia, the industry paid for the science, whereas in the US it was the government. It is important to note that management can be enhanced at all locations if fishers work closely with scientists.

Allocating the Costs of Fisheries Management

The costs of fisheries management can be very high. Consideration needs to be given on whether the industry should take on most of the costs, or share them with the government. One of the advantages of industry bearing some of the costs is that fishers become more engaged in the science and in management. In New Zealand, the fishing industry pays for much of the scientific research and monitoring. Fishers attend the scientific working groups and they buy into the results, which has an impact of strengthening management. In Australia, commercial fishers also pay significant fees. Their response has been to increase efficiency, adopt new techniques, use on board video cameras, introduce vessel monitoring schemes (VMS) and supply data directly to government agencies. As a result, the cost is dropping each year. The US system is very different; there, the bulk of the costs are borne by the government, not by the industry.

It is important to assess the impact of management decisions and actions, upon both fishers and fish processors. There has to be some knowledge of the impact that management measures have upon people and

communities. It is possible to control the fisheries, but it is not easy to cope with shifting demand and changing prices. Income and profitability is important to both the fishing and fish processing industry and to communities, and this must be kept in mind. However, it is possible for fish producers to add to their income by promoting sustainability and achieving accreditation, so that there is full public confidence in seafood products.

Applying an Ecosystem Approach to the Fisheries

An ecosystem approach is the management of human activities based on scientific knowledge about the ecosystem and its dynamics, in order to identify and deal with influences which are critical to the health of marine ecosystems. It is important to take action on influences which are critical to the health of the marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity. The ecosystem approach aims to manage all the human activities that have an impact on the environment and its life forms. It involves a set of procedures for attaining ecosystem objectives which involves setting indicators and reference points. To many stakeholders, whether these are fishers or environmental NGOs, it is protecting the animals themselves which is most important, especially the protection of seabirds, marine mammals, fishes and invertebrates.

Marine fisheries involve the direct exploitation of wild fishes, lobsters, and shellfish populations. Those populations are inherently dependent upon the environment which contains them, and are supported by a wide range of other living organisms. It is clear that fisheries have a direct effect not only on the species they exploit but also upon non- target species and habitats. Information is needed on the effects of fishing on non-target species such as benthic organisms, sharks, rays, turtles, seabirds, and marine mammals, and also on their midwater and benthic habitats.

Fisheries depend on the productivity of the ecosystems which underpin them. It is evident that responsible fisheries management should take account of all the interactions between the fisheries and the "ecosystem" which supports the fish stocks. However, one of the difficulties in adopting an ecosystem approach is the weakness of the different concepts being applied by international agencies. Some of those agencies have failed to realise that the ecosystems themselves cannot be managed. The management must actually be applied to human activities. There are problems in defining the ecosystem approach itself, and wide use is made of terms like "ecosystem health" or "ecosystem integrity". It is almost impossible to delimit the extent of large marine ecosystems, and most ecosystems themselves are made up of smaller ecosystems. A search has begun for "ecosystem indicators" but these may have limited utility in the management of real fisheries. The so-called "precautionary approach" is often invoked, but again is of limited value unless it is carefully defined.

The best approach is to adopt measures to protect vulnerable habitats, species and biological communities. It is important to introduce measures to promote biological diversity, identify feeding links between species, and take account of the life histories of different organisms in developing more balanced harvesting strategies. It is especially important to take account of climate change and its effects. The need for an ecosystem approach has clearly been recognized and accepted by politicians, bureaucrats, fisheries management agencies and environmental interest groups throughout the world. There has been a strong commitment to adopt the approach, especially in relation to the management of fisheries. In practice, however, few steps have been taken towards its implementation.

The ecosystem approach to fisheries is essentially concerned with ensuring that fishery management decisions do not adversely affect the environment or other forms of life. It requires scientific support in terms of knowledge of how the different organisms within an ecosystem interact with each other and with the physical environment. Not only must the harvesting of the target fish stocks themselves be sustainable in the long-term, the whole environment and the animals and plants that depend upon it must be taken into account in deciding

upon fisheries management measures. An ecosystem monitoring system needs to be designed and implemented to ensure that the information necessary for tracking the sustainability indicators is collected in a reliable and timely manner. Fisheries must be conducted in a manner that does not threaten by-catch species, and minimises the impact of fishing operations upon the ecosystem itself. There are of course problems in identifying the extent and location of particular ecosystems.

Stakeholders and other key interests must be allowed to participate in ecosystem management if it is to be successful. These include not just fishermen and those with a commercial investment in fisheries, but also those with an interest in the marine environment, its habitats, and its flora and fauna, and those from the wider community. Such participation is best achieved by a regional system of management. The regions are those defined for fisheries management purposes and within which a common fisheries management regime is already maintained. Thus, areas like the North Sea, the Baltic, the Mediterranean, and even the Northwest Atlantic can be selected – although there may be scope for further subdivision within such areas. In the United States, the Ecosystem Principles Advisory Panel, in its 1995 Report to the US Congress, considered how to implement "ecosystem principles" and subsequently the Ecosystem Approach Task Force of the United States Marine Fisheries Advisory Committee defined the essential elements of the ecosystem approach. Within the European Community, a Working Group on Ecosystem Approach to Human Activities (EAM) prepared a draft "Roadmap". Although all these organisations may have carried out valuable groundwork the principles they have outlined have yet to be adopted in the management of the actual fisheries.

To assist in managing fisheries, the ecosystem management procedures might include the need to:

1. Identify vulnerable habitats and introduce measures to protect them from damage including area closures and appropriate choice of fishing method;
2. Identify key species and biological communities and introduce measures to conserve them;
3. Adopt measures to promote biological diversity, in its broadest sense (including ecological, species and genetic diversity);
4. Identify trophic links between fish species and consider the effects of the fisheries and management measures upon the predators and prey of targeted species, implementing a balanced harvest policy which retains important features of ecosystem structure;
5. Monitor the effects of environmental change and consider the implications of these changes for fisheries and their management;
6. Consider the life-history characteristics of targeted and non-targeted species in deciding upon management measures;
7. Assess the impact of new fisheries before they begin.

Discussion

Many fish stocks in the sea are currently outside safe biological limits. They are too heavily exploited, and exposed to adverse environmental changes, both as a result of climate change and human activities. If the current trends continue some fish stocks will collapse.

Successful management of the fisheries requires heavy investment in the collection of scientific data on the state of the fish stocks, in addition to examining the numbers being caught. Landings need to be monitored, the sizes and ages of fish examined at fishing ports, research vessels need to measure the abundance of young fishes and spawning fishes, and sampling must also take place on board commercial fishing vessels to determine what is being caught but discarded at sea. Control can then be imposed upon the fishing activities, and even other human activities. Fish stock conservation is mainly achieved through a system of Total Allowable Catches (TACs), supplemented by technical conservation measures. The latter include minimum mesh sizes, minimum landing sizes and the definition of areas where fishing is prohibited. These management features include the development of management plans; setting measurable target limits and reference points; controlling access to

the fishery; and limiting fishing capacity and fishing mortality.

However, as well as conserving fish stocks, there is a need to consider the wider ecosystem, as environmental protection must be integrated into the management policies. Harvesting of a fish must take into account effects upon the environment and other species. Fishing activities can have an adverse impact upon the wider ecosystem, and management needs to be extended to integrate environmental dimensions into policy-making, to protect vulnerable species and their habitats. Not all the problems in the marine environment result from fishing. Pollution from industrial and other activities may affect both the abundance and quality of fishes, and climate change is also having detrimental effects, and is influenced by on land and aquatic human activities.

An ecosystem-based approach should include two key elements. The first is a need for greater understanding of marine food webs, and the development of management models which include all the species affected by the fishery, whether directly or indirectly. The second is a need for ecosystem objectives, indicators and reference points which might be used to trigger management action.

An ecosystem approach aims to manage all those human activities that have an impact upon the marine environment and its life forms. The approach recognizes that humans are a part of the ecosystem and aims to make both economic activities and the environment that supports these activities more sustainable, in terms of their capacity to absorb the impact of human activities without fundamental change.

There is also a need to protect the economic viability of the fishing industry and preserve social and cultural values within coastal communities. Any new system should involve all the stakeholders and, wherever possible, should pass management down to a local level. It is especially important to build a series of partnerships between fishers, scientists, environmentalists and the fisheries managers, so that they work together to ensure that fish and invertebrate stocks, and their environments, are fully examined, and managed more widely in a sustainable way.

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