5 Getting stock management right

> Overexploited stocks, unemployed fishermen, short-sighted structural policy – it is impossible to ignore that fisheries management has failed in many respects. Nonetheless, we can all learn from the positive approaches being taken in some regions. These aim to conserve fish species and ecosystems and take account of the social dimension – objectives which the European Union has yet to achieve with its current reform of fisheries policy.

Fishing at its limit

> The size of fish stocks can fluctuate considerably from one year to the next. Setting catch limits at sustainable levels is therefore a challenging task. Although there have already been some good scientific approaches to the problem, these have not translated into fisheries policy. Now, at last, a new fisheries management regime should safeguard the long-term sustainability of global fisheries.

The coming and going of fish

Fish stocks increase and decrease, with or without fishing activity. We have been aware of this natural phenomenon for hundreds of years. In the past it has spelled disaster for many people when fish stocks have suddenly declined. For instance, in 1714 and 1715 the cod inexplicably failed to appear along the barren west coast of Norway. In the poor region of Søndmør the fishermen, to avoid starvation, were forced to sell their most important possession – their boats.

For a long time it was unclear what triggered such fluctuations in fish stocks. Many fishermen and scientists believed that in some years the fish simply migrated to other maritime regions. Finally in 1914 the Norwegian fisheries biologist, Johan Hjort, produced a comprehensive statistical analysis of data he had gathered over numerous research expeditions. One of his most important findings was that variability in the number of fish and offspring is largely dependent on environmental factors – including the salinity and the temperature of the water.

Hjort's work dates back almost 100 years. Since then, our knowledge about the growth and decline of many fish stocks has increased tremendously. Today we know that many factors impact on the natural development of stocks. We still do not fully understand how everything interacts, however.

The natural factors with the greatest impact include the biotic environment with its species interactions, and also the abiotic environment, particularly the salt and oxygen content, temperature and quality of the water. The latter are also changed by long-term climate fluctuations – a further complicating factor in reaching an understanding of stock development. Of course, the size of fish stocks is not affected only by nature but also by human fishing activity. The condition of an exploited stock can be described by the following three factors:

STOCK BIOMASS (B) is the total weight of all large and small, juvenile and adult fish in a stock. This figure is estimated with the aid of mathematical models using fisheries' catch data and scientific samples and is quoted in tonnes. But even these mathematical estimates are riddled with uncertainty. Biomass can also fluctuate greatly from year to year. Of particular significance is the number of adult, sexually mature fish – the spawners – because they are responsible for producing offspring. This section of the stock is known as the "spawning biomass" which is also stated in tonnes. The spawning biomass level is crucial for fisheries scientists because they use it to derive vital benchmarks, known as reference points, used in fishery management. The total biomass of a stock is made up of the spawning biomass and the biomass of the juveniles, which have not yet reached sexual maturity.

THE FISHING MORTALITY RATE (F) is a somewhat abstract measure of fishery pressure. It can be converted to a relative value which indicates the proportion of the stock biomass which is removed by the fisheries.

THE PRODUCTIVITY of a stock is calculated by subtracting the number of fish which have died of natural causes from the increase in mass resulting from offspring and natural growth of the fish. This correlation makes it clear that the productivity of a stock is highly dependent on the spawning biomass. It follows that the stock declines when the natural mortality rate and the fishing mortality rate together are greater than the productivity.

When things get too tight for the offspring

When the spawning biomass – the number of sexually mature parent fish – of a stock increases, then the number of juveniles or so-called recruits swells accordingly, but only up to a certain limit. Even if the spawning biomass continues to increase, the number of recruits remains at a certain level. The habitat has reached its maximum carrying capacity for offspring. The reason for this is that the more juveniles there are, the greater the competition for food. Many die. The habitat can therefore only support a certain number of offspring. In theory, this maximum carrying capacity stays the same for a long period of time. In reality, however, it fluctuates from year to year, mainly depending on how many predators are in the area and how much food is available. The amount of food, on the other hand, depends on the environmental conditions. The findings of scientific fish counts show that recruit numbers fluctuate accordingly. The figure below shows measurements taken over several years, which indicate that certain spawning masses are quite capable of producing different numbers of recruits (blue dots). In this respect, the maximum carrying capacity for offspring can be considered a type of median value. On the other hand, the point at which the spawning biomass is so reduced by fishing activity that the number of recruits falls below this maximum carrying capacity is known as the limit biomass (B_{LIM}).

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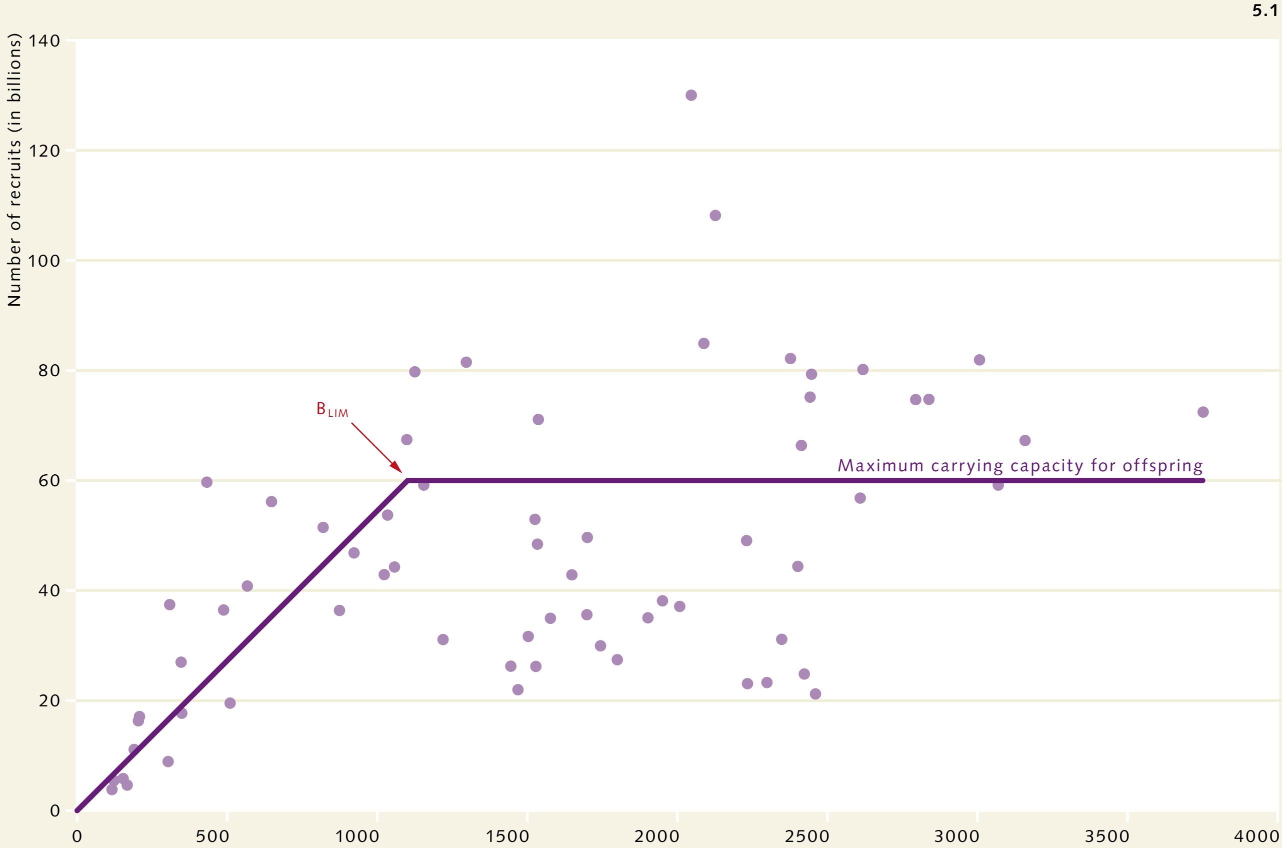


5.2 > > Barren land, poor fishermen: In the Søndmør region of western Norway people's livelihoods used to depend almost exclusively on fishing, and particularly on the development of fish stocks.

The offspring production of a fish stock is limited. If the spawning biomass is large, the habitat at some stage reaches its maximum **carrying capacity**. Even if the spawning biomass then continues to grow, the number of juvenile fish remains at a certain level. At this stage the amount of offspring depends entirely on the environmental conditions. Various factors come into play here: eggs and larvae may be eaten by predators, for example, or starve because insufficient food is available. In addition there can be competition for suitable spawning sites to deposit eggs. The Baltic Sea herring, for example, deposits its adhesive eggs on aquatic plants. When there are too many spawners, they deposit the eggs on top of each other, and those underneath die from a lack of oxygen. As these conditions can fluctuate from year to year, so too does the number of offspring when spawning stocks are high. There can be strong but also very weak years for offspring.

If a stock is exploited too intensively the following can occur. The spawning mass is at some stage so small that few offspring can be produced. In such a case the number of offspring depends directly on the number of spawners. It is no longer capable of reaching its carrying capacity, even when good environmental conditions prevail. The value at which the spawning biomass is so small is called limit biomass (B_{LIM}). The corresponding fishing mortality rate is described as F_{LIM}.

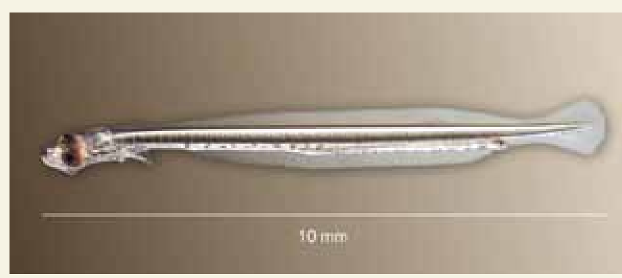
The failure of the precautionary approach

The massive overfishing of many stocks by the industrial fishing industry in the 1970s, 1980s and 1990s made the importance of limiting catch volumes abundantly clear. In 1995, the international community adopted a more cautious approach to fishing with the United Nations Straddling Fish Stocks Agreement (UNFSA). In the same year

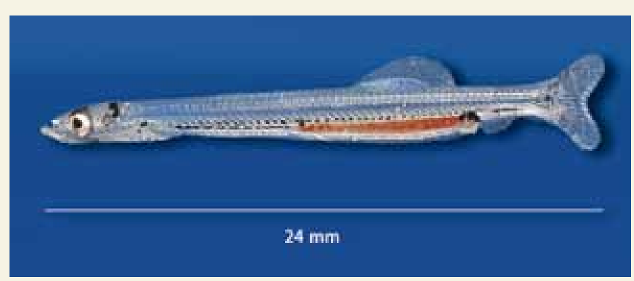
When does a fish become a fish?

The annual reproduction of fish is quite different from that of mammals. After they have hatched from the egg, fish pass through a larval stage. The larvae of many fish species spend this time in shallow waters away from the parent stock. In a manner of speaking, they live in a different world. At this stage, their numbers can reduce significantly because they are a food source for many other marine fauna. Many can die due to poor environmental conditions. Most fish larvae become juvenile fish in the first year. In fishery biological terms, however, they are only considered offspring or included in stock numbers when they join the parent stock and are large enough to land in fishermen's nets: in other words when they can be counted. These juvenile fish are known as recruits.

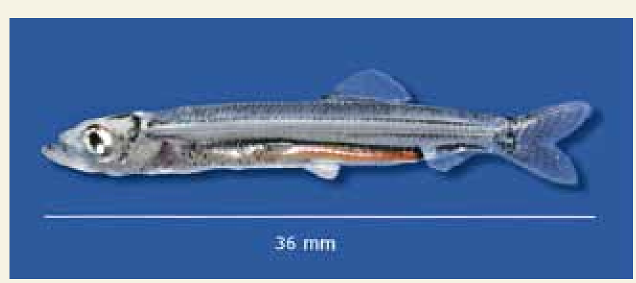
5.3a > Twelve hours before hatching: the large, well-pigmented eyes of the transparent herring larvae are particularly striking.



5.3b > Eat or be eaten: at eight days old, herring larvae feed mainly on the larvae of smaller crustaceans. They are themselves the prey of larger fish. Only about 1 per cent of herring larvae survive this stage.



5.3c > After 30 days the larvae have all the fins of adult fishes. The gills and scales are formed at this stage. The swim bladder is partially formed, so that the larvae can move up and down the water column following the food.



5.3d > Still almost scale-free. At 60 days the larvae look like fully-grown herring, but the stomach is not yet fully developed and they have few scales. However, the swim bladder is now fully functional. The larvae can swim strongly and flee from predators.

the Food and Agriculture Organization of the United Nations (FAO) published its Code of Conduct for Responsible Fisheries. The overriding aim of this precautionary approach (PA) is to prevent a stock from being reduced to such an extent that it can no longer produce sufficient offspring and becomes overexploited. It also stipulates that fisheries should err on the side of caution: the less that is known about a stock and its development the more carefully that stock should be managed, and the less it should be exploited. In principle, therefore, the precautionary approach aims to avert the risk of harm to fish resources. Limits were accordingly set for many commercially exploited fish species, in order to minimize fishing mortality and prevent severe depletion of stock biomass. For example, each year the EU Council of Ministers sets the total allowable catch (TAC) for stocks in the waters of the European Union, thus stipulating how many tonnes of a fish species may be caught in a specific area.

The precautionary approach also takes the dynamics of the stocks into account, because environmental conditions can change the size of a stock. If there is little food available, for instance, the productivity of the stock declines accordingly. The biomass shrinks. If there is plenty of food, the productivity rises and the stock grows. The fishing industry must take these stock fluctuations into account and adjust catch volumes accordingly, not continue to catch the same amount of fish. Such adjustment should be achieved using several benchmarks and limit reference points, terms which are still used for fishing according to the precautionary approach:

BIOMASS PRECAUTIONARY APPROACH (B_{PA}): It is difficult to predict the status of a fish stock, for several reasons. One is that the current fishery and research data used to calculate fish abundance is unreliable. Another is that all mathematical analysis programs are to a certain extent inexact. There is no 100 per cent certainty. The Limit Biomass (B_{LIM}) is therefore too risky as a reference point. The probability is too great that the biomass does actually fall below this limit in any given year, threatening population growth. In line with the precautionary approach, therefore, it was decided to stipulate a limit reference point which takes such uncertainties into account. This limit is known as the Biomass Precautionary Approach (B_{PA}). It is designed to guarantee that the biomass does not inadvertently fall below the B_{LIM}-threshold. The area between B_{LIM} and B_{PA} is therefore a buffer zone, as it were. Today it is still the most important benchmark used to ascertain the health of many stocks.

PRECAUTIONARY FISHING MORTALITY RATE (F_{PA}): As the biomass is a fundamentally unreliable and changeable variable which cannot be directly influenced by human activity, it is not practical to stipulate a limit reference point for the fisheries which takes only the biomass as its parameter. Therefore there is an additional limit reference

Guidelines against overexploitation

Fisheries science is geared to two parameters: the fishing mortality rate (F) and spawning biomass. If fishery is to be sustainable, F should be sufficiently low, and the spawning mass sufficiently large. Experience has shown that functioning fisheries management systems need limit reference points and target reference points. An adequately low F_{Target} should achieve a low mortality rate. An additional limit reference point (F_{MSY}) should prevent the fishing mortality rate from ever rising to critical levels, indicating that catches are too high. In future the F_{MSY} should replace the conventional F_{PA}-value. In practice these F-values are extremely important points of reference for the fisheries. In terms of total biomass, however, only a target reference point, the B_{MSY}, is specified. B_{LIM} is the crucial lower threshold for spawning stock which should never be reached. In this event the stock would be overfished.

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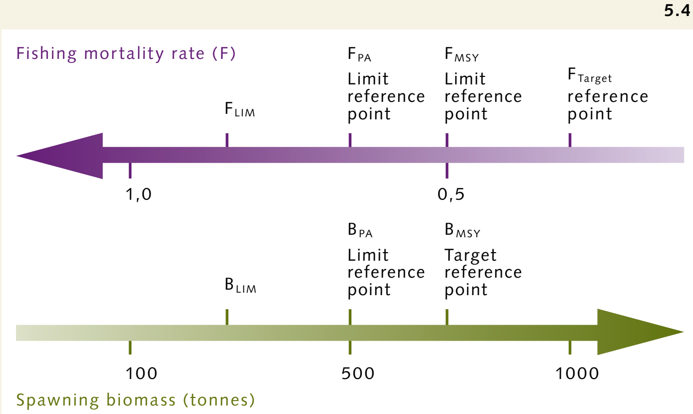

point which is derived from the B_{PA}. This is known as the F_{PA}. This point specifies the maximum fishing mortality rate permissible to stay below the B_{PA}. Scientists use the F_{PA} to calculate the maximum annual catch tonnages for the next season. However, this is only possible when the current status of the stock is known. For this purpose the researchers use the catch data of past years, which provides information on the long-term development of the stock. They then add the catch data from the current season along with the data gathered by research vessels. Finally, they must make assumptions for the current year for which no fisheries data is yet available. From these figures they use mathematical models to estimate the status of a stock for the next season, which forms the basis of their catch recommendations for the fisheries. Adhering to these maximum catch tonnages ensures that fishing remains within the F_{PA}.

Fishing to the limits

In principle the precautionary approach was a good idea. In practice, however, it failed because Fisheries Ministers consistently took the limit reference points to mean the target reference points. Instead of ensuring that limits were not exceeded, they all too often set catch volumes as close as possible to the limit. In hindsight we know that the limits – because of the uncertainties already mentioned – were often violated, meaning that in certain years more fish was caught than the stock could cope with. Moreover, authorities, mainly for political reasons, are even today allowing fishermen to catch more than researchers recommend. The B_{PA} and the F_{PA} were therefore entirely misconstrued by both the fishing industry and the political establishment. The result is common knowledge. In too many cases too many fish were removed, resulting in weakened stocks, particularly in poor years with low numbers of offspring.

MSY – the new route to responsible fishing?

After only a few years, it became clear that the precautionary approach did not work. For this reason, shortly after the turn of the millennium, a different concept was developed which aimed to improve the regulation of fisheries. This traces back to the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002. The summit declared its intention that global fish stocks should be fished to sustainable and responsible limits, the objective being the maximum sustainable yield (MSY). This concept goes further than the precautionary approach which was only designed to protect stocks from overfishing. MSY is designed to manage fisheries efficiently with the aim of preserving stocks and ensuring the highest long-term yields. In other words, the MSY is the largest possible catch volume which can be removed from the sea on a long-term basis without reducing the productivity of the stock. The crucial reference point is the B_{MSY}, or Biomass$_{MSY}$. This is the total biomass which allows long-term fish yields in accordance with the MSY concept. It is large enough that neither strong fluctuations in offspring production and individual fish growth, nor years of very weak recruitment will threaten the stock. There are already some fisheries around the world which are guided by the

The MSY – harshly criticized and yet established

The term maximum sustainable yield (MSY) was developed in the 1930s. It is based on two findings. Firstly, there is a maximum size which the stock of an animal group can achieve within an ecosystem. Secondly, the net growth of the stock, resulting from reproduction and increased size and weight of individuals, is highest at 30 to 50 per cent of the maximum stock size. This stock size therefore allows the maximum long-term yield. However, such a maximum withdrawal is only achievable when the maximum stock size and the growth rate have been accurately determined. The current stock size must also be known. If the stock was already smaller than 30 to 50 per cent of the maximum size, the stock would be overfished. For this reason there has been much criticism of this concept, and there were recommendations that it should be abandoned. Nonetheless the term was taken up by the United Nations Convention on the Law of the Sea in 1982. With one important condition, however – that ecological and economic factors as well as the special needs of developing countries should be taken into account. For this reason the MSY concept is no longer applied in the theoretical, mathematical terms in which it was originally defined. It now also takes particular account of the above-mentioned uncertainties, species interactions and economic aspects.

Why fishing at MSY levels delivers more

The maximum sustainable yield (MSY) is achieved at a certain level of biomass (B_{MSY}). This differs in size from fish stock to fish stock. At B_{MSY} the annual production of new biomass is at its maximum – firstly because the fish grow particularly well and increase their weight, and secondly because more eggs and larvae survive to develop into fish.

Above or below B_{MSY}, the stock is less productive. At about 200,000 tonnes biomass, for example, the stock provides only 15,000 tonnes of new biomass per year. This is because there are more fish in the stock to compete for food, and they each put on less weight. Also, more eggs and juvenile fish are cannibalized. A stock of only 50,000 tonnes biomass experiences a similar level of biomass growth. Although this smaller stock contains fewer spawners, the total achieved from the increase in weight of the individual fish (as a result of reduced competition for food) and the biomass of the offspring (which have a greater chance of survival within a smaller stock) is the same as for a large stock.

It is interesting that sustainable fishing is also possible with larger or smaller sized stocks than the B_{MSY}, but the annual fish yield is lower.

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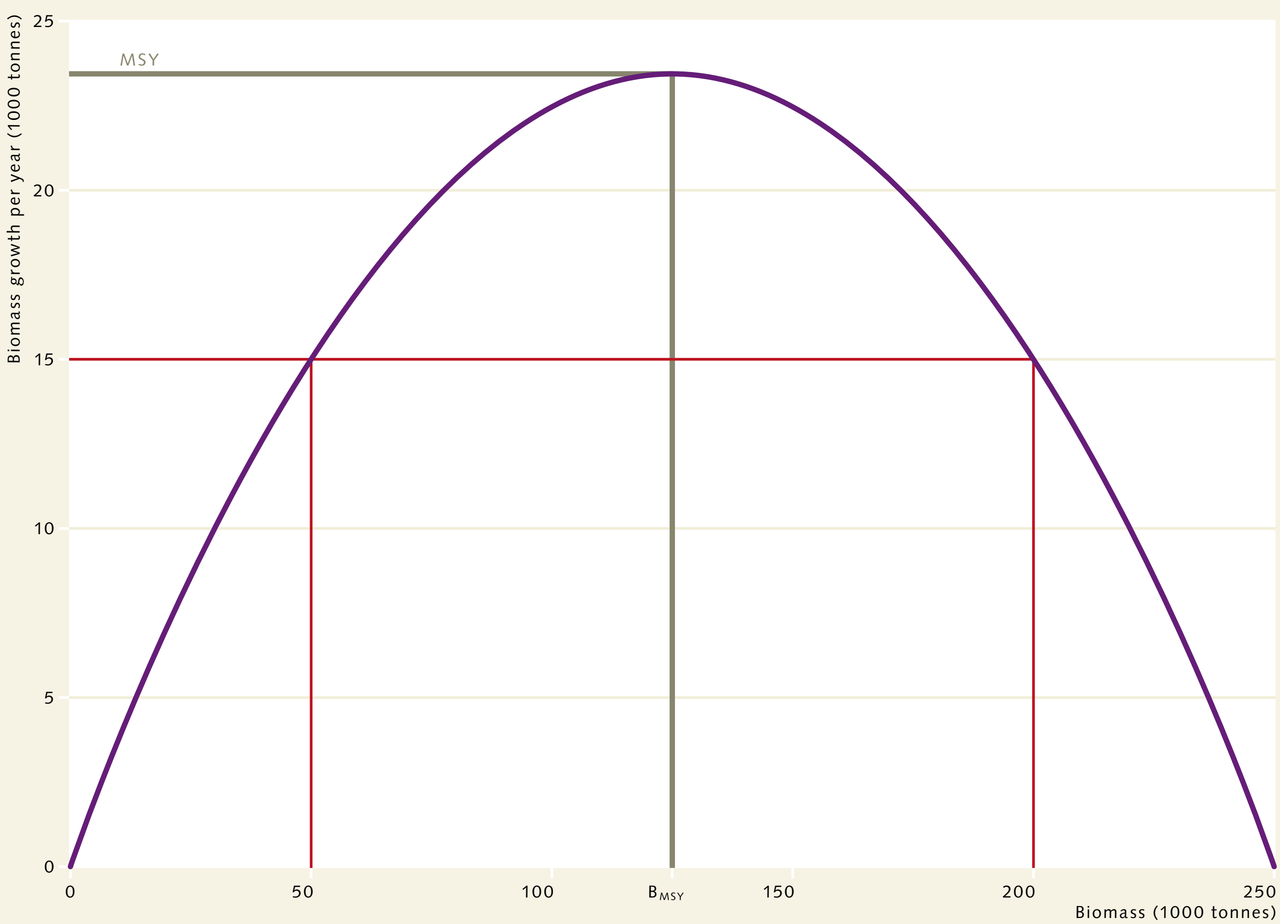


MSY concept – off Australia and New Zealand, for example. In most cases the B_{MSY} value is higher than the B_{PA} value used previously, simply because the MSY concept is geared towards the optimal use of a usually larger stock. The B_{PA}, in contrast, was a minimum level. For this reason, the biomass which can deliver the MSY is often larger than the biomass according to the precautionary approach (B_{PA}). Similarly, F_{MSY} is smaller than F_{PA}. Here too, however, there are differences from fish stock to fish stock. The reason why a fishery produces the highest yield with MSY is that there is neither too much nor too little fishing activity. An MSY catch is the happy medium, as it were. If the stock is too small, however, the stock growth is also poor because few offspring can be produced. If the stock is too large it will at some stage reach the carrying capacity of the ecosystem. This happy medium means that the right amount of biomass is produced to replace the amount that dies. With the medium-sized stock aimed for under the MSY concept, there is much less competition for food than in larger stocks with more individuals. The fish find more food, must expend less energy to find it and increase their body weight vigorously. The losses from fishing are offset by the faster growth of the animals. Fishing with MSY also means that more eggs survive and more fish can develop, due in part to the fact that there is cannibalism among predator fish such as the cod: the adult fish partially feed on eggs and larvae. Where there are large numbers of adults, the young are decimated to a much greater extent than occurs with fishing in accordance with MSY. All in all, this means that fishing to MSY levels results in more biomass being available. This is known as excess or surplus production. Surplus production is greatest with MSY.

Unbeatable team: limit and target reference points

The fishing industry and fishing ministries have abused limit and target reference points for far too long. If they had adhered strictly to the scientists' recommendations, one single point of reference would have been sufficient. A successful fisheries management system based on the MSY concept would consequently need only the B_{MSY} or the F_{MSY} as the limit reference point. But the precautionary approach has shown that this does not work: B_{PA} and F_{PA} were fixed limit reference points, but the fishing industry and policy-makers did not apply them properly – in other words, not in the sense of sustainable fisheries. For this reason the MSY concept today uses a target reference point which the industry can be guided by, and a limit reference point as a safeguard.

This type of approach has already been introduced in Australia and New Zealand. In these countries the F_{MSY} is the limit reference point. In addition, there is a lower target reference point, the F_{Target}. The fisheries are accordingly required to fish only until this target reference point is achieved as closely as possible. On the other hand, the F_{MSY} in this model, along the lines of the old B_{PA}, is the limit reference point, which should be avoided as far as possible. The essential difference between this and the conventional precautionary approach is that the fisheries no longer align themselves towards a limit reference point but to a lower target reference point (F_{Target}), which safeguards the F_{MSY}. These values are extremely important for the fisheries because it is from this that clear catch recommendations are derived.

In the greater context of the MSY concept, the stock biomass B_{MSY} is often the desired ideal, so to speak. But here too, because determination is uncertain, the B_{MSY} is in many cases taken as the limit, not the target. In Australia, for example, the biomass target is specified along with a correspondingly higher B_{Target}. The USA and New Zealand have developed similar models. Although the limit and target reference points in some cases have different names, all the current MSY approaches work with limits and targets and have thus abandoned the precautionary approach which used only the lower biomass limit.

The MSY concept in practice

The MSY concept is of course a theory, an ideal which still needs to be put into practice. For many fish stocks, the problem is that they have been so severely exploited that it is impossible to know the optimal values for biomass,

5.6 > Fishermen on the deck of the trawler "Messiah" sort cod that they have caught in the Pacific near the Aleutian Islands.

mortality and yield. We do not know the maximum spawning biomass of an unexploited stock, nor can we derive the B_{MSY} with any degree of certainty. For those stocks which were already depleted and recovered after catch limits were set, the best that can be hoped for is the B_{LIM}.

One example is the cod in the eastern Baltic Sea, which occurs mainly between Sweden and Poland. The stock was overfished for years, but in recent years it has been able to recover, particularly in Poland, as a result of improved environmental conditions and better controls of catch quotas. For the past two years, however, the stock has hardly grown at all. Apparently the carrying capacity of the habitat has been reached with its current 300,000 to 400,000 tonnes spawning biomass. Although the stock was much larger in the mid-1980s, current food shortages have apparently prevented further growth. This example shows that carrying capacities can change and do in fact fluctuate strongly over the years. For this reason the BMSY cannot be stipulated with any degree of certainty. Furthermore, this biomass analysis does not take into account the age structure of the fish stock. This information is crucial, however, for any assessment of offspring numbers and weight increases in individuals.

It is also impossible to stipulate B_{MSY} reference levels for many other intensively exploited fish stocks. For these cases we must continue to rely on the old PA values or determine a corresponding fisheries mortality rate F_{MSY} in the coming years. These values can be ascertained even if the B_{MSY} is unknown. The PA values would indeed be meaningful from a purely scientific point of view. They were set on the basis of many years' experience, catch and recruitment data, and scientific sampling. They have proved to be ineffectual for fisheries management, however.

The original aim of the PA concept was to allow fish stocks to slowly grow as a result of catch limits and then, as with the cod, to observe how a stock develops. To do this, however, policy-makers must set clear targets and limit catches accordingly. In a joint European research project involving more than 10 universities and institutes, researchers are now developing concepts to establish fishing on a sustainable footing in accordance with MSY while fishing continues. Fisheries off Alaska, Australia and New Zealand are already showing that fishing based on the MSY concept is possible. But the starting conditions there were better than in Europe. As industrial fishing only began about 20 years ago, the maximum stock size is known – and this could be used to reliably assess such levels as the B_{MSY}. It is also much easier to manage fisheries in nation states such as Australia and New Zealand than in a union of states such as the EU with its many conflicting opinions.

The aim of the World Summit on Sustainable Development in 2002 was to fish all worldwide fish stocks according to MSY guidelines by the year 2015. This target will not be achieved – mainly because many nations have been too hesitant and have not yet adequately limited fishing. It will therefore still take some years until all European stocks are fished in this way.

One fish species seldom comes alone

Until now fisheries management systems have in most cases examined each species separately. Catch volumes have been stipulated for individual species without considering that these are part of a food web in which the catch of one species also impacts on other species and their development. This applies in equal measure to the initial MSY management approaches. Fisheries should in future pay more attention to these interrelationships between the species. The following two interrelationships can be identified:

MULTI-SPECIES APPROACH: The multi-species approach takes account of the fact that removing one species by fishing also affects other interrelated species within the ecosystem – as predators and prey for example. The multi-species approach takes account of all these interrelationships when calculating catch volumes. For instance, a fish stock should only be exploited to the extent that sufficient food remains for its predators. Depending on how many species occur in a marine area, this multi-species approach can be implemented with different degrees of success. In the Baltic Sea, only 3 protagonists are interrelated as predator and prey – cod, herring and sprat. Scientists believe fisheries management according to the multi-species principle should be possible in the Baltic Sea within the next few years. By contrast, 17 species interact in one complex system in the North Sea. For this area, therefore, it is difficult to develop a multi-species concept. Although scientists have learned a lot in recent years about how species fundamentally interact and prey on each other, little is known about the volumes involved.

Analysing the stomach contents of fish or the faeces of sea birds and marine mammals is one way of determining how much of a given species is eaten. If these analyses are combined with data on speeds of digestion, a rough estimate can be made of how much fish is being consumed. But in most cases the required data is only available for certain years, as individual research projects tend to be time-limited. The data is, therefore, very unreliable. With the aid of mathematical models, however, efforts can be made to reduce these uncertainties and make a better assessment. Various projects are currently attempting to do this. The researchers hope to be capable of making a more reliable evaluation within the next 10 to 15 years.

CONCEPTS FOR MIXED FISHING: Fish of several different species are often caught in fishing nets at the same time – whether or not they are closely linked within the ecosystem. This is called mixed fishing.

One example is cod and haddock. Both cod and haddock are predators, but they do not prey on each other. Their similar size and habits mean that when one species is caught, the other inevitably ends up in the net too. This makes it difficult to optimize the catch volume for a single species. Cod is more valuable than haddock but occurs in smaller numbers and is classed as overexploited in the North Sea. If we concentrate on catching cod, we can catch very little without placing the stock under further pressure. But at the same time we forgo a large volume of haddock. If, alternatively, we rely on the cheaper, more

5.7 > Stomach content analysis shows what marine fauna feed on – in this case a crustacean, snails and a bullhead, a bony fish.

5.8 > Natural beauty against an urban backdrop: for the citizens of Seattle, orcas in the Puget Sound are a common sight.

freely available haddock, cod will also end up in the net as bycatch. Intensive haddock fishing will cause the cod stocks to dwindle. There are many such interdependencies which complicate mixed fishing, especially in the North Sea. Although not all the details are yet known, researchers are hoping to establish an initial pragmatic concept for the North Sea at last, within the next two to three years. This will take the problems of mixed fishing into account and simultaneously optimize the multi-species catch in terms of the MSY.

The ecosystem-based approach – the ultimate discipline

The situation becomes even more complicated if we look at the entire ecosystem – all the fish along with all the other marine dwellers. Currently there is controversy among the experts about whether it is better use of the expensive, time-consuming fishery research expeditions to find out more about the development of individual fish species – or whether all species in the ecosystem should be recorded as a whole in order to increase our understanding of the food web. Although our knowledge of these interrelationships has increased enormously, particularly over the past 20 years, we are still a long way from implementing an ecosystem-based fisheries management regime.

US researchers have developed a concept for ecosystem-based fisheries management in the Puget Sound off Seattle on the west coast of the USA, and are showing how this could perhaps function. Although not yet introduced by the US authorities, this concept is considered by other experts to be viable and could serve as a model for other parts of the world. The researchers analyse the extent to which a certain species may be exploited without causing any damage to the environment. They also take into account other human impacts on marine life such as construction work, shipping and tourism.

Towards better fisheries management

> For many years, fishing around the world has been organized on the basis of management plans. And yet stocks have been overexploited and thousands of fishermen have lost their livelihoods. Future-proof fisheries management must master both these challenges: it must support sustainable fishing while achieving high long-term yields. The Alaskan fishing industry is one example of how this can work.

Conflict over a living resource

The importance of establishing clear regulatory arrangements for fishing activity was demonstrated with particularly dramatic effect by the Cod Wars in the Northeast Atlantic in the 1950s and 1970s. At the time, many foreign trawlers used to fish close to the Icelandic coast, for unlike today, there was no exclusive economic zone (EEZ) extending 200 nautical miles out from the coastal baseline. This led to a conflict over access to fish stocks, mainly between Iceland and Great Britain. At the peak of the conflict in 1975/1976, Britain even sent in warships. The situation was not defused until 1982, when the **United Nations Convention on the Law of the Sea** (UNCLOS) was adopted, establishing exclusive economic zones.

This example shows the high level of demand for fish, a lucrative and highly tradable commodity. It also shows how serious the consequences of a poorly regulated fishery can be. Even today, there are periodic conflicts between countries over fishing rights or the allocation of fishing quotas. A much greater challenge at present, however, is the overexploited status of many stocks. The primary task of modern fisheries management is therefore to limit catch volumes to a biologically and economically sustainable level and ensure equitable access to fish as a living resource.

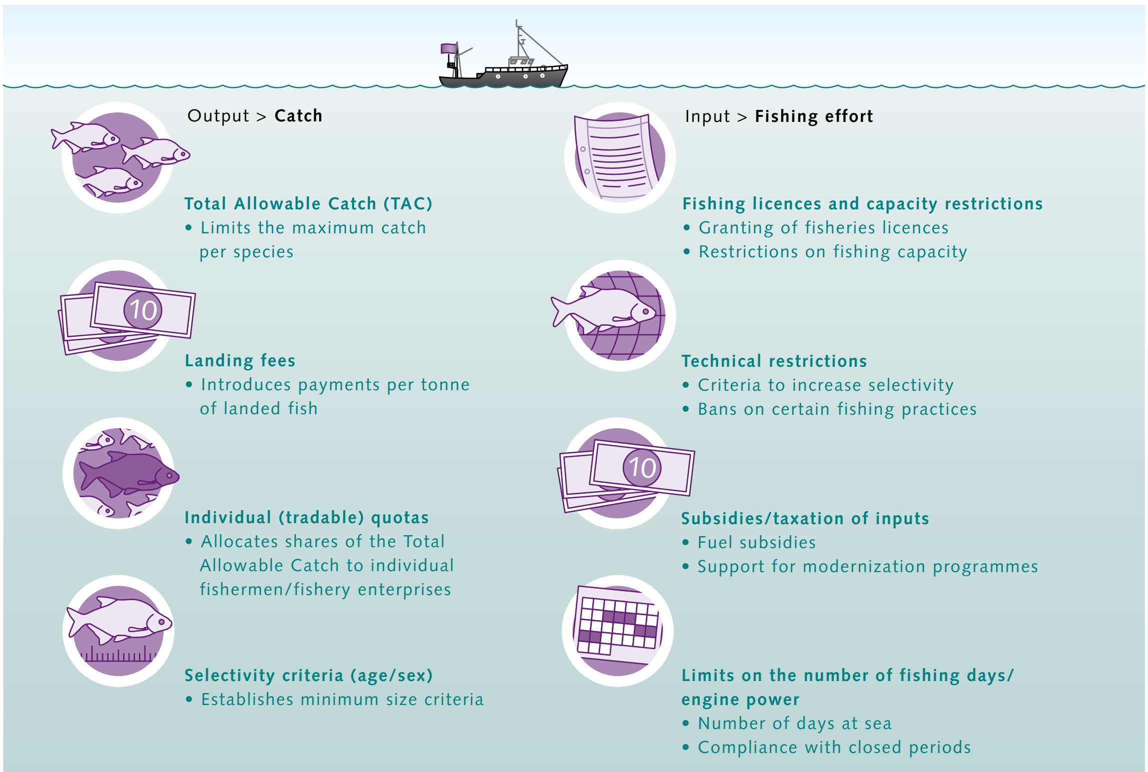
5.9 > A scene from the Cod Wars: the Icelandic vessel "Ver" (left) attempts to cut the fishing lines of the British trawler "Northern Reward" (right). The British tugboat "Statesman" intervenes.

Fisheries policy or centralized fisheries management therefore focuses either on catch volumes (direct approach) or fishing effort (indirect approach):

- Fishing volume: To prevent too many fish being caught, the authorities can limit catch volumes (output). In most cases, this means setting a total allowable catch (TAC). This defines the maximum quantity of a given species that may be caught in a specific area, generally the EEZ, in any year.
- Fishing effort: To prevent too many fish being caught, the authorities can also limit fishing effort (input). For example, their effort-based management measures can include limiting the number of fishing days, fishing vessels' engine power, or the size of the fleet, or setting minimum mesh size for nets.

Fishing quotas – equal rights for all?

In fact, it is quite possible to regulate fishing effectively with the aid of fishing quotas. To that end, a total allowable catch (TAC) is set for a specific marine area. The TAC is then broken down into separate national fishing quotas for the various countries which border this maritime region. For example, each Baltic Sea state has a national fishing quota. Of course, for this system to function effectively, more is required than a single national quota:



5.10 > Classic approaches to fisheries management either focus on restricting catches or attempt to limit fishing effort. The term "fisheries management" encompasses a variety of methods which can be used to regulate the fishing industry. Their suitability in any given context depends on the fish stock and region.

otherwise, fishermen within a single country would find themselves in direct competition with each other and would attempt to catch as many fish as possible at the start of the season in order to fulfil a large share of the quota. This would lead to a glut of fish on the market for a short period, pushing down prices and ultimately harming the fishermen's livelihoods.

So in order to give fishermen a measure of security to plan their fishing activities for the entire season, the total allowable catch is generally allocated to individual fishing vessels, fishermen or cooperatives.

Fisheries policy strategies in which fishermen are allocated long-term fishing rights in some form are known as rights-based fisheries management. Individual transferable quotas (ITQs) are the prime example.

In an ITQ system, fishermen are allocated individual fishing quotas as a percentage share of the total allowable catch. As a rule, the ITQs are allocated for a period of several years, giving the fishermen the stability they need to plan ahead. The fishermen can trade their ITQs freely with other fishermen, which often results in relatively unprofitable enterprises selling their quotas to more efficient companies. Less economically efficient companies would be inclined to sell, and more profitable companies would be likely to buy the ITQs. The main goal of the ITQs is to achieve the greatest possible economic efficiency and sustainability. There is less focus on social objectives. In extreme cases, the quotas become concentrated in the hands of a small number of companies.

One example is the New Zealand hoki fishery, which is now dominated almost completely by a small number of large fishery enterprises.

Another example is the Icelandic fishery. The management of Iceland's cod stocks is considered to be fairly good nowadays as regards sustainability. Following the introduction of ITQs, however, many family-owned companies left the fishing industry and sold their quotas to other enterprises.

An end to discards?

Fishing quotas are generally allocated for individual fish stocks. In fisheries in which individual species can be caught on a targeted basis – in the main, these are schooling fish such as herring or mackerel – this works well. Often, however, various species of fish end up in the net. Fishery experts call this a **mixed fishery**. In the North Sea sole fishery, for example, large quantities of plaice, another flatfish species, are caught as bycatch. This causes problems because fishermen can only land the species for which they have been allocated a quota. All the other fish and marine fauna caught as bycatch are dumped overboard. Most of the discards are already dead when they go back into the water. This discarding of bycatch has been practised for decades. The European Union (EU) is keen to prohibit the practice of discarding under its new Common Fisheries Policy (CFP). A frequent criticism is that it is almost impossible to monitor compliance with a ban. For that reason, various measures and strategies are currently being discussed to reduce bycatch on a general basis in future and make monitoring more effective. They include:

- Use of sealed CCTV cameras to monitor activity on deck. This type of system is now being trialled on a number of fishing vessels in the North Sea and the Baltic Sea.
- More intensive onboard deployment of government observers.
- Counting of non-quota species against the quota. A shrimp fisherman, for example, who catches plaice as bycatch must then count this species against his shrimp (prawn) quota, based on a specific formula. This reduces the quantity of shrimp that may be caught under his remaining quota. The purpose of this measure is to exert gentle pressure on fishermen to switch to more sophisticated fishing gear that fishes more selectively and minimizes bycatch. For prawn fishing, for example, new nets are now being developed that use a mild electric pulse to disturb the prawns while the flatfish remain on the seabed.

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The new Common Fisheries Policy (CFP) will probably allow a transitional period of several years for the introduction of the new technology. Based on the current stage of the discussions, it seems likely that the possibility of counting non-quota species against the quota will also be introduced on a progressive basis. The aim is to carry out fewer checks and compel fishermen to take more responsibility – in other words, to increase their ownership of the process. On the Faroe Islands in the North Atlantic, an attempt has been made to solve the problem of discards as follows. Instead of allocating fishing quotas, restrictions are imposed on fishing effort. The fishermen can only spend a limited number of days at sea. However, they can land their entire catch, so there is no need for them to discard any fish. This approach does not solve the problem of high-grading, however; this term describes fishermen's practice of sorting out the most valuable components of the catch, such as the largest and heaviest individuals from a given species, because large fish bring in more money per kg of body weight. Smaller or damaged fish are then dumped overboard. This is a waste of resources. High-grading is already banned in the EU, Iceland and Norway but is still practised despite the bans, so properly functioning controls are vital.

5.11 > In the North Sea, a typical bycatch is likely to include small flatfish and a great many crabs, such as shore crab *(Carcinus maenas).*

ITQs are traded like stocks and shares. High ITQ prices are therefore an indicator of good fisheries management: the higher the yield from the fish stock, the more valuable the fishing rights become. In Iceland, fishing rights were initially distributed free of charge to the fishermen based on their average catches at the time (grandfather rights). In other words, rights of access to this natural resource were allocated on the basis of historic fishing privileges, which in some cases go back many generations. As fisheries management has steadily improved, however, and fishing fleets became more efficient as a result of the rationalization measures described, the fishing rights – which are now very valuable – have become concentrated in the hands of a small number of enterprises.

In Iceland, this development is viewed very critically. The preferred situation is more equitable distribution of profits from fishing. Some experts are therefore proposing that rather than granting permanent fishing rights, annual quotas should be auctioned instead. The advantage of this system, it is argued, is that smaller or recently established fishing companies could enter the trading scheme and acquire quotas at any time, without having to hand over extremely large sums of money.

There are frequent demands at political level for small-scale coastal fishing to be protected, prompting calls for separate quotas to be allocated on the basis of fleet segment. This would mean that quotas allocated to small vessels could only be sold on to other small vessel owners and could not be used to increase a large vessel's fishing quota. The expert view is that the ITQs are an effective tool for the management of fisheries, but as soon as social goals come into play, it is essential to rethink the basic principles.

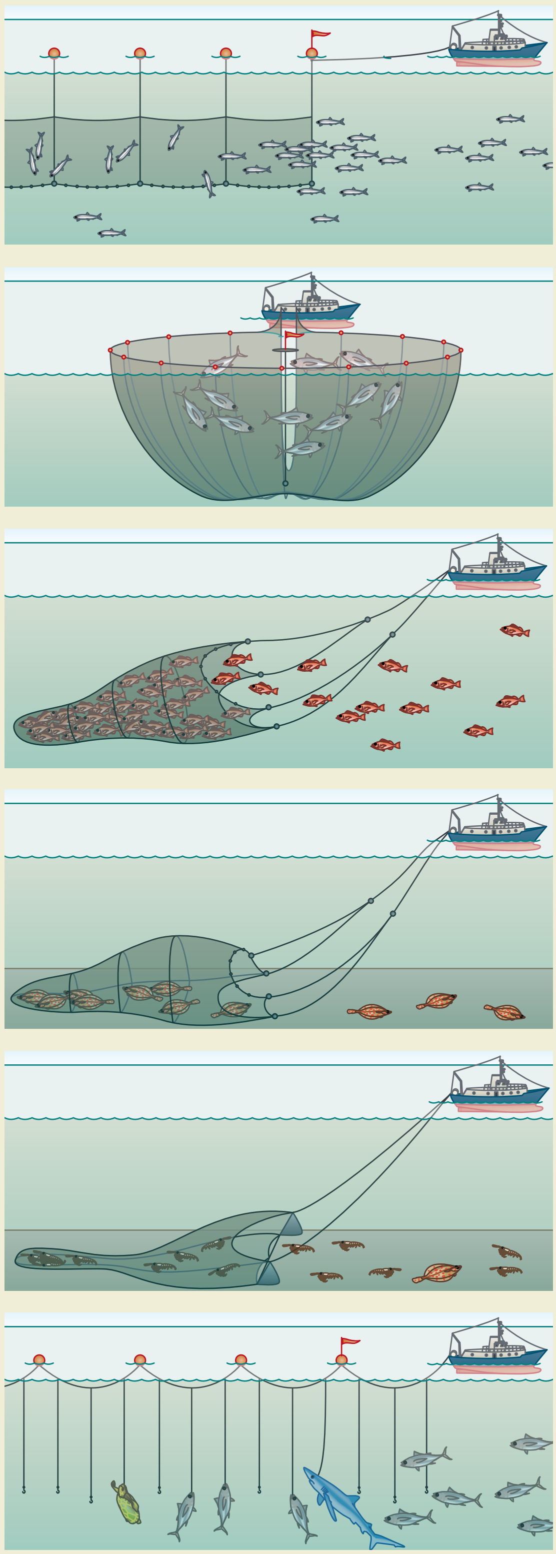
Effort-based management – fewer days, fewer ships

In addition to the use of quotas, fishing can also be regulated by restricting the fishing effort. For example, fishing capacity can be limited by capping the number of licences available for allocation to fishing vessels or by restricting the engine power or size of vessels. It is also possible to limit the duration of fishing, e.g. by capping the number of days that may be spent at sea. These restrictions on fishing effort are more common than ITQ schemes in some regions. However, effort-based management also has its shortcomings and is sometimes taken to absurd extremes by fishermen themselves. One example is the Pacific halibut fishery, where at the end of the 1980s, fishing was only permitted for three days a year in order to conserve stocks. In practice, during this very short fishing season, a vast fishing fleet was deployed and caught the same quantity of fish as had previously been harvested in an entire year. Another even more extreme example of a time limit is the fishing derby in Sitka Sound in the Gulf of Alaska. Here, the herring fishery is regulated by limiting fishing activity to a few hours a year. Rather like a horse race, all the fishing vessels line up and, as soon as they hear the signal, they set off at the same time. While fishing is monitored by an observer ship, the fishermen try to catch as much fish as possible in the very short time available. After a few hours, another signal tells the fishermen that it is time to stop fishing.

5.12 > Hot competition for limited resources: in Sitka Sound in Alaska, the herring fishery is only open for a few hours a year. Dozens of boats then compete for the catch.

Selective fishing with the aid of electric nets and LED lights

Various types of fishing gear are utilised, depending on the species or habitat. Bottom-living species are caught using



5.13 > Different fishing techniques and their impacts on the environment

> **GILLNETS** are anchored at a fixed position in the water. There is a low level of bycatch of other species because of the specific sites selected for the setting of gillnets. However, turtles, marine mammals and seabirds can become entangled in these nets.

> **PURSE SEINE NETS** are used to encircle a school of fish. The net is then drawn together to retain the fish by using a line at the bottom, allowing the net to be closed like a purse. There is a low level of bycatch of other species as purse seines target schools of one species. However, dolphins or turtles are often caught as bycatch. Modern purse seines therefore have escape mechanisms.

> **PELAGIC TRAWLS** are funnel-shaped nets that are towed by one or two vessels. The fish are scooped up and captured in the “cod end”, i.e. the trailing end of the net. Bycatch of other species can be a problem in some areas, depending which species is being targeted for trawling.

> **BOTTOM TRAWLS** work in a similar way to the pelagic trawl, but are dragged along the seabed. They are one of the most important techniques used in deep-sea fishing. The nets can damage underwater habitats such as cold-water coral reefs.

> **BEAM TRAWLS** are bag-shaped bottom trawls that are mounted on a heavy metal beam and towed along the seabed. This destroys many fauna living in and on the seabed

> **LONG-LINES** consist of a long main line, up to 100 km in length, with a large number of short lines (called snoods) carrying thousands of baited hooks. Bycatch is a problem. Dolphins, sharks, turtles and seabirds become trapped on the hooks

bottom trawls, whereas fish living in open waters are caught using pelagic nets. Steel long-lines – carrying hundreds of thin lines and baited hooks – are often used to catch tuna.

Some of these fishing techniques have considerable disadvantages. A prime example is the beam trawl, a type of net that is dragged across the seabed. Beam trawls are often equipped with iron chains that disturb the flatfish on the seabed and drive them into the net. The beam trawl is the subject of considerable controversy because it ploughs its way along the seabed and destroys numerous bottom-living creatures.

Long-lines, in turn, are notorious for their bycatch harvest of dolphins and turtles, which are attracted by the bait on the hooks. Seabirds such as albatross are also frequent casualties: they dive for the bait when the lines are thrown from the ship into the water and are briefly suspended near the surface. Over recent years, various alternative and gentler fishing techniques have therefore been developed:

- the Danish seine, a specific form of towed net. Conventional trawl nets are generally equipped with weights to help them sink. However, these weights can kill other marine fauna or damage sensitive seabed habitats. With a Danish seine, contact with the seabed is minimized due to its specific geometric structure, consisting of diamond knotted netting turned 90° from its usual orientation;
- pelagic trawl nets with escape hatches for turtles;
- long-lines with additional lead weights that cause the lines to sink rapidly, taking them out of seabirds' reach;
- unusually shaped hooks for long-lines that avoid turtle bycatch;
- electric fishing nets which produce a mild electric pulse to disturb the flatfish and drive them into the net, instead of using heavy chains (tickler chains) for this purpose;
- gillnets equipped with fishing lights (LED markers or lightsticks), which scare away turtles or alert them to the presence of the net.

For some years, the development of gentler (i.e. more selective) fishing technologies has been promoted by an international environmental organization through the Smart Gear initiative. It is noteworthy that it is not only researchers and engineers who are involved in the initiative; so too are professional fishermen. The many different solutions offer hope that gentler forms of fishing will come to the fore. Many fishermen, especially in Northern Europe, have already switched from beam trawling to alternative fishing techniques for pragmatic reasons. With rising oil prices, dragging a heavy beam trawl along the seabed is no longer economically viable. In many areas, lighter fishing gear such as Danish seines is being used instead.

Generally speaking, effort-based management must be constantly adapted to the latest technological advances. Increasingly efficient technology is available to locate fish, for example, making it possible to detect and catch a given amount of fish in ever shorter periods of time. Experts estimate that industrial fishing is achieving a 3 per cent increase in efficiency year on year, so fishing effort must be reduced.

Another way of protecting fish stocks is to establish designated marine protected areas, where fishing is restricted or subject to a total ban. In some areas, bottom trawling, for example, is prohibited altogether in order to protect seabed habitats. In other cases, specific areas are protected, notably those where fish come to spawn and juveniles grow to maturity. This approach can only be successful, however, if very accurate information is available about the whereabouts and reproduction habits of fish or marine fauna in relation to the protected areas. Furthermore, a protected area must be the right size. If it is too small, the stock will not be adequately protected. If it is too large, the fishermen will lose access to stocks that they could in fact catch without putting stocks at risk.

Sustainable, high-yield fishing is possible

Despite the numerous problems, well-organized fisheries management can work, as the examples of Alaska, Australia and New Zealand show. Most stocks in these regions are fished sustainably and are in a good state. In many cases, TACs and ITQs have been set in accordance with the maximum sustainable yield (MSY) principle, i.e. the maximum annual catch that can be taken from a species' stock over an indefinite period without jeopardizing that stock.

In some fisheries, the limit reference points and target reference points for the maximum annual catch are even more stringent than the MSY. The following factors contribute to successful fisheries management:

- The fishing industry and policy-makers comply with researchers' recommendations on catch volumes and with limit reference points and target reference points.
- Various interest groups are involved in the management process at an early stage. Researchers' expertise plays a key role in the setting of quotas. In addition to commercial fishing companies, recreational fishing associations and non-government organizations are involved in the allocation of fishing rights, in measures to avoid bycatch, and in other aspects of fisheries management.
- Responsibilities for the various aspects of fisheries management are clearly defined and hierarchically structured. Fishing in international waters is regulated by one of the Regional Fisheries Management Organizations (RFMOs). Fishing in the exclusive economic zone is managed by national authorities, while fishing in coastal waters falls within the jurisdiction of local authorities.
- Government observers are deployed and their operating costs are covered by the fishery enterprises, generating funds for the research community. The entire Alaska pollock *(Theragra chalcogramma)* fishery, for example, is monitored by onboard observers. Landings in port are also monitored by CCTV.
- The focus is not only on individual fish species: efforts are also made to manage fishing in a way which protects the ecosystem as a whole. Experts call this the ecosystem approach. Among other things, it means that no heavy fishing gear can be used that would potentially damage the seabed.
- The management authorities are willing to learn from others' mistakes and, from the outset, target their measures towards avoiding overfishing. This is the case in both Alaska and New Zealand, where industrial fishing began only around 20 years ago.

In the USA, the Magnuson-Stevens Fishery Conservation and Management Act adopted in 1976 contains the main legal provisions applicable to fishing. The Act has been revised several times over the years, most recently in 2007. The latest amendments introduce measures for the USA as a whole which are very much in line with some of those already in place in Alaska. For example, fishing should now take greater account of environmental conservation aspects and protect important fish habitats. The objectives defined in the Act are to be achieved with the aid of fishery management plans (FMPs) which incorporate the economic, ecological and social dimensions. Although there is some opposition to these stringent rules in the USA, they are now established in law and non-governmental organizations can bring legal actions in the event of violations.

The right management regime for each stock

So which management measures are most appropriate to generate a high but sustainable yield over the long term while protecting fish stocks and marine habitats? This will ultimately depend on the fish stock and the local situation. In industrial fishing, which is carried out using vast vessels and provides employment for around 500,000 fishermen worldwide, the fishing activity could, in theory, be monitored by onboard observers, although this is associated with high costs. However, in countries where artisanal fishing involving hundreds of small boats is the norm, as in West Africa, this type of surveillance measure cannot possibly work. With an estimated 12 million artisanal fishermen worldwide, it is quite impossible to monitor all of them at work. Nonetheless, there are some promising strategies for monitoring the catches of small and medium-sized coastal fisheries as well. In Morocco, for example, the authorities have introduced automated systems to

5.14 > Fishing without bycatch: stilt fishermen in Sri Lanka's coastal waters wait patiently for their prey, which they haul out of the water with rods and landing nets.

monitor coastal fishing. Machines are installed in port or in the coastal villages and fishermen are allocated a chip card which they insert into the machines to register their departure and arrival times. This gives the authorities an ongoing overview of which particular fishermen are at sea at any given time. If a ship does not return to port on time, the authorities can run preventive checks. This system also allows fishing effort to be estimated very accurately. The catches are recorded by the authorities on landing. At present, the system is used to record vessels of trawler size, but from next year, smaller motor boats will also be monitored using this system, with spot checks on these smaller vessels' catches also being carried out. Penalties are imposed on fishermen who provide false information about their catch. These penalties depend on the severity of the offence, but in some cases can include the confiscation and scrapping of the boat.

More regional responsibility

Territorial use rights in fisheries (TURFs) are an alternative to centralized approaches to fisheries management. Here, individual users or specific user groups, such as cooperatives, are allocated a long-term and exclusive right to fish a geographically limited area of the sea. Catches and fishing effort are decided upon by the individual fishermen or user groups.

This self-organization by the private sector can also help to achieve a substantial reduction in government expenditure on regulation and control. Users also have a vested interest in ensuring that they do not overexploit the stocks, as this is necessary to safeguard their own incomes in the long term. However, a use right for a stock of fish or other living resource in the ocean is exclusive only for non-migratory species such as crustaceans and molluscs.

One example of successful management by means of TURFs is the artisanal coastal fishery in Chile, which mainly harvests bottom-living species, particularly sea urchins and oysters. Fishermen here have shown that they have a vested interest in pursuing sustainable fishing once they have the prospect of obtaining secure revenues from these fishing practices over the long term. Similar approaches are being pursued in the lobster fishery

Mauritania, Senegal and the difficult path towards good fisheries management

The waters off West Africa are among the most heavily fished in the world and the irresponsible approach to fishing there is heavily criticized. Mauritania is a good example of how difficult it is to move towards sound and sustainable fisheries management. Mauritania is not a traditional fishing nation, so fish is not a staple food here. Instead of engaging in fishing activity itself, Mauritania has, for many years, granted licences to foreign fishing companies – an important source of income for this desert state. However, the licences have until now been granted solely on the basis of vessel size (tonnage) – a very imprecise measure for targeted management of fish stocks. Mauritania, with support from various other nations and development projects, therefore decided to establish a more effective fisheries management system. In 2006, it adopted its first management plan, which focused on octopus fisheries. Then on 1 August 2012, a comprehensive new fisheries protocol entered into force on a provisional basis with the aim of regulating many other fisheries as well. Among other things, the protocol sets precise quotas for each species and defines the number of ships and maximum catch per species. This type of arrangement makes it much easier to manage fishing activity. The licence fees were also increased. In order to monitor compliance with the various quotas, catches of demersal fish (bottom-living species including shrimp and deep-water crab) must be landed in Mauritania's only fishing port, namely Nouadhibou. Pelagic fish, of which up to 1 million tonnes are caught off Mauritania annually, cannot be landed here due to capacity limitations, however. The transshipment of the catches from the trawlers to the large refrigerated transport ships must therefore take place just outside the port of Nouadhibou so that random checks can be carried out at any time.

5.15 > Worried about their livelihoods, Senegalese fishermen held protests in March 2012. The President in office at the time intended to sell more fisheries licences to foreign fishing companies.

With the new fisheries protocol, an effective management regime is available – in theory. However, it is currently being boycotted by most owners of the foreign fishing fleets on the grounds that it is too stringent. These are just some of their complaints:

- Spanish octopus fishermen are no longer permitted to fish for octopus as the stocks are overexploited;
- the fishing ban area for pelagic fish has been extended from 12 to 20 nautical miles, thus reducing yields;
- 2 per cent of the catches of pelagic fish must be handed over to the Government, which intends to distribute these fish to the poor at low cost or free of charge;
- 60 per cent of crew members working on international vessels operating in the exclusive economic zone must come from Mauritania, even though an appropriately skilled workforce for the industry is virtually non-existent in that country;
- licence fees have increased sharply.

As a result of the boycott, virtually no new licences have been purchased and many international fishing companies have withdrawn their vessels from Mauritanian waters. As an expression of solidarity with the Spanish octopus fishermen, for example, the Spanish shrimp fishermen have also pulled out. Only the French tuna fishermen and the Spanish hake fishermen have acquired licences. This is resulting in a substantial loss in licence revenue for Mauritania. There is a strong possibility that Mauritania will bow to international pressure and amend the protocol in the near future. This highlights a wider problem in Mauritania, namely that sound rules and good management regimes are often implemented in a half-hearted manner by the Government, or are circumvented by means of exemptions. If in doubt, the Government invariably opts to make a quick profit instead of protecting fish stocks.

As well as the difficulties of establishing a sound management regime, a further sobering fact is that Mauritania is currently experiencing setbacks with regard to its fisheries control system. In order to curb illegal fishing far out in the EEZ, but also to monitor vessels operating legally, Mauritania has, over the past 10 years, established a fisheries inspectorate with international assistance. Monitoring vessels were deployed to patrol the 200 nautical mile zone and the country also has an aircraft for this purpose. Radar systems were installed to monitor the coastal areas. These measures have done much to curb

5.16 > Artisanal fishing is pursued very intensively in some areas, as is apparent from the large number of pirogues moored on this beach in Senegal.

illegal fishing. But now, aid organizations are lamenting the growing disinterest on the part of the Government. The surveillance aircraft has not been in operation for some time, and the fisheries inspectorate's vessels are generally in such a poor state that they cannot be operated safely. The only vessel which is still seaworthy is often seen in dock, tied up by the quay, due to a shortage of fuel. When it does take to the seas, its surveillance activities are generally confined to coastal waters. As a consequence of this situation, the fisheries inspectorate's deterrent effect has recently decreased.

Unlike its neighbour Mauritania, Senegal has a long tradition of fishing. The Senegalese have for generations relied on long narrow wooden boats, around 14 metres in length, known as pirogues, which can carry more than 10 tonnes of fish. As Senegal is a much more impoverished country than Mauritania, however, it cannot afford a fisheries inspectorate. Foreign fleets from China, Russia and even Spain, operating under flags of convenience, are therefore engaged in illegal fishing on a massive scale in Senegal's waters. What's more, as the Government under former President Abdoulaye Wade allocated a very large number of fishing licences to foreign companies, the Senegalese people have been complaining for years that their once abundant fishing grounds have been ravaged. When Wade was about to sell even more licences to Russian trawlers in spring 2012, the Senegalese people took to the streets in protest. Already heavily criticized for his political power games, Wade lost the presidential election. The new President, Macky Sall, has now cancelled 29 of the 44 fisheries licences allocated during Wade's presidency – thus honouring one of his key election pledges.

This example highlights the close bond felt by people in countries with a strong tradition of fishing towards this natural resource. It is also clear that it is essential to take their concerns and interests seriously and to involve them in fisheries management. It is hoped that the new Government of Senegal will take this to heart and continue with its vigorous measures to combat what has been, in effect, the sell-off of the country's fishing grounds.

5.17 > Generous subsidies, large fleets: the Spanish fishing fleet in particular – part of which is seen here in the port of Muros – was dependent on state subsidies for many years.

in Canada. Experts use the term "co-management" to describe this trend towards more individual responsibility for fishermen (ownership).

Economic benefits of sustainable fisheries management

Overfishing of stocks is not only an ecological problem. It is also uneconomic. As fish stocks decline, the effort required to catch a given quantity of fish increases. The fishermen spend more time at sea and use more fuel to catch a given quantity of fish. So it makes sense to manage stocks in accordance with the MSY principle. One problem is that even now, many countries are still heavily subsidizing their fishing industry. Government subsidies allow the fishery to be maintained even when the direct costs of the fishing effort, in the form of wages or fuel costs, have already exceeded the value of the fishing yield. Fishermen's individual operating costs are reduced in many cases by direct or indirect subsidies. Every year worldwide, around 13 billion US dollars is paid to fishermen in the form of fuel subsidies or through modernization programmes, with 80 per cent of this in the industrialized countries. A recent study concludes that restructuring of subsidized fisheries would pay off because it would put an end to overfishing. Stocks would recover, leading to higher yields in future. Restructuring would mean that fishing would have to be suspended for a time or substantially reduced in certain regions. Instead of subsidizing the fishing industry, the money would be used to support fishermen who were unemployed, even if only temporarily, as a result of these measures. The great importance of social protection schemes is shown by the closure of the herring fishery in the North Sea between 1977 and 1981. Although stocks were able to recover, small coastal fishing companies did not survive this enforced break, and today, the North Sea herring fishery is dominated by a small number of major companies. However, if periods when restrictions on fishing activity are in force can be managed in a socially equitable manner and stocks recover, fishing can then be resumed. Of course, the fishing industry loses revenue as a result of the closure of a fishery or a reduction in fishing activity. However, the study concludes that this type of restructuring measure would only take around 12 years to pay for itself and would generate as much as 53 billion US dollars in additional revenue for the fishing industry annually. These calculations are very much in line with older estimated figures produced by the World Bank. It estimates the loss of net benefits due to overfishing, inefficiency and poor management to be in the order of 50 billion US dollars annually worldwide – a substantial figure compared with the total annual landed value of fish globally, i.e. around 90 billion US dollars. Admittedly, this global analysis is based on generalizations to some extent, as there are strong variations between countries' fishing industries, but experts regard the estimated figures as sound.

Certificates increase the appeal of sustainable fishing

Overall, the status of fish stocks worldwide still gives cause for concern. On a positive note, however, sustainable fisheries management is becoming increasingly attractive to many fishing companies. The reason is that fishing companies that fish sustainably can now market their products under an ecolabel. For many food retailers in Europe and North America, the most important importing regions worldwide, these labels are now a key prerequisite for including a given fishery product in their ranges. Various certification schemes are now in operation. Two of the best-known schemes are run by the Marine Stewardship Council (MSC) and the Friend of the Sea initiative. The MSC was established by a well-known environmental organization and an international food corporation in 1997 and became fully independent in 1999. There are currently 133 MSC-certified wild capture fisheries worldwide, harvesting more than 5 million tonnes of MSC-certified fish and shellfish annually. This represents almost 6 per cent of the total global wild capture catch. The Friend of the Sea initiative was also established by an environmental organization. Both schemes aim, among other things, to support the sustainable management of fish stocks in accordance with the MSY principle.

As a rule, certificates are granted to individual fisheries, not to individual species, and certification is contingent on compliance with various criteria. The condition of the fish stock, the impacts of fishing activity on the marine ecosystem, and the management of the fishery are all factors that are considered in the assessment. Certification to MSC standard, for example, is based on 31 separate criteria, and fisheries are required to meet a specific number of them. They include the following:

- Fishermen should utilize modern and improved fishing gear that reduces bycatch to a minimum.
- The fishing operation should implement appropriate fishing methods designed to minimize adverse impacts on habitat. For example, instead of heavy bottom trawls which churn up the seabed and destroy bottom-living fauna, rockhopper trawls should be used. These are fitted with large rubber tyres or rollers that allow the net to pass fairly easily over the seabed.
- The fishing operation should minimize operational waste such as lost fishing gear, oil spills, etc.
- The fishing operation should be conducted in areas where fisheries management systems are in place and in compliance with these systems. Areas where industrial fishing would compete with traditional coastal fishing should be avoided.
- The fishing industry should engage in intensive dialogue with scientists. Comprehensive data relating to the current status of fish stocks should be collected for use in fisheries science.

The fishery should also prevent illegal, unreported and unregulated fishing. The certificates also state which ports are to be used. Landings are limited to a specific number of ports where there is proper monitoring of catch landings. A certificate is awarded for 5 years and can be renewed. Checks are carried out at intervals to ascertain whether the rules are being complied with. This takes the form of logbook checks and perusal of records, as well as onboard inspections. These audits may also be attended by observers from non-governmental organizations or environmental associations. Observers also travel out with the ships in order to carry out random checks to determine how much fish is being caught and from which species. In the case of the South African hake fishery, the South African Deep Sea Trawling Industry Association provides the funding for the deployment of observers. These are experts from various environmental organizations and South African ornithological associations with a particular interest in seabird bycatch. The catch is also subject to video camera surveillance. In the cod and pollock fisheries in the Barents Sea, observers commissioned by a government-funded Polar Research Institute of Marine Fisheries and Oceanography have an onboard presence on 5 per cent of all fishing expeditions. Critics argue that the certification procedures are not stringent enough as only a proportion of the criteria must be fulfilled. They claim that certificates are in some cases awarded to stocks that are in a less than optimum condition or that have not yet fully recovered. This applies to stocks with biomass growth lower than the level needed to supply a maximum sustainable yield. The critics are therefore calling for even more restrictive certification. From the certifiers' perspective, however, ecolabelling is entirely justified, as it imposes obligations on companies to fish in a manner that enables stocks to recover. The certificate establishes clear targets and objectives for the companies, which must be achieved within a specific timeframe.

Turning the tide in fisheries policy?

> In 2013, the European Union will agree a new Common Fisheries Policy (CFP), which will establish the regulatory framework for the management of fisheries in future. The European Commission has made numerous proposals for improving the disastrous fisheries policy pursued over recent decades. Discussions are still ongoing, but it is hoped that the ambitious goals can be translated into effective legislation.

High ambitions, clear goals

The EU's fisheries policy has failed. Many fish stocks are overexploited. The fishing fleet is too large: there are too many boats out fishing, and not enough fish. For decades, catches have regularly exceeded the levels recommended by scientists. But this situation is about to change. The European Commission has resolved to overhaul the EU's fisheries policy and management at long last. A reform of its Common Fisheries Policy (CFP) – the regulatory framework applicable to all the EU Member States – is scheduled for 2013 and aims to achieve the following goals:

- In future, fish stocks in the EU will no longer be fished in accordance with the precautionary approach; instead, stocks must be exploited at levels that produce the "maximum sustainable yield" (MSY) (i.e. the amount that can be harvested with a view to protecting stocks).
- Fleet overcapacity is to be reduced.
- The amount of unwanted bycatch is to be reduced and discards eliminated.
- Fishing should not only exploit fish stocks sustainably, but should also have minimum impact on marine habitats, the aim being to ensure that fisheries management follows the ecosystem approach.
- There should be a stronger focus on regionalization. Fishermen in the various countries and regions should be involved to a greater extent in fisheries management, with Brussels merely establishing the general policy framework.

Many of these goals have already been achieved in other countries. In Europe, however, a sustainable and economically efficient fishing industry is still far from being a reality. It has become apparent that in a union of states like the EU, reconciling highly diverse national interests is a difficult process. However, the mere fact that the European countries were able to agree on a Common Fisheries Policy in the first place should be viewed as a success in itself. The Treaty of Rome, which created the European Economic Community (EEC) – the precursor to the EU – in 1957, contained a commitment to the formulation of a common fisheries policy. In those days, however, the fisheries sector was still relatively small and industrial fishing fairly rare. Furthermore, the scope of European fisheries policy extended only to the 12 nautical mile zone then in force.

Much has changed since then. Firstly, as time went on, major fishing nations such as Denmark, the United Kingdom, Portugal and Spain joined the EEC. And secondly, the scope of application of European fisheries policy increased with the introduction of the exclusive economic zone (EEZ), which extends to a distance of 200 nautical miles out from the coastal baseline. As a result, individual Member States acquired exclusive rights to fish in much larger areas of the sea. A Common Fisheries Policy was first adopted in 1982, and was accompanied by the introduction of the quota system. Under this system, the EU sets a total allowable catch (TAC) for the various species of fish and then allocates a fishing quota (based on a percentage of the catch) to each fishing nation, calculated according to a specific formula.

Fewer vessels, more efficiency

Whereas Denmark and Germany have already substantially reduced their fishing fleets, the Dutch, Portuguese

5.18 > Brussels: animal rights activists protest about overfishing.

and Spanish fleets in particular are still too large. In regions such as Galicia, the fishing industry is still an important source of income, as very few jobs exist in other sectors. Politicians therefore shy away from any reduction in the fishing fleet, which is also heavily subsidized for structural policy reasons. In the structurally weak fishing regions, EU funding has been – and is still – accessed in order to put new fishing vessels into service or refurbish older ships. The welfare of the region as a whole thus takes precedence over the greater goal of sustainable fishing. But generous subsidies create a vicious circle for the fishing industry. Government loans for fleet development have to be repaid, which compels fishermen to fish intensively with no regard for the welfare of fish stocks. This is one of the reasons why the Fisheries Ministers, who form the Fisheries part of the EU's Agriculture and Fisheries Council and are responsible for setting the new Total Allowable Catch (TAC) every year (in tonnes), have regularly set TACs which are far higher than recommended by fishery scientists – in extreme cases, up to 48 per cent higher.

An oversized fishing fleet also makes fishing inefficient, as there are far too many vessels in pursuit of the available stocks. In order to achieve even approximate compliance with the fishing quotas, each individual vessel can only harvest a small percentage of the Total Allowable Catch. It would be more sensible to reduce the number of vessels in operation and utilize their capacity to the full. One possible solution for reducing overcapacity is to introduce tradable quotas – initially at country level and later EU-wide. Fishing companies could sell these individual transferable quotas (ITQs) to others at a profit. Less economically efficient companies would be inclined to sell, and more profitable companies would be likely to buy the ITQs. In this way, the industry gradually sheds the less profitable companies, and the number of fishing vessels is reduced.

A system of catch quotas has already been introduced in Denmark. Here, in order to prevent the formation of monopolies and the bulk purchasing of quotas by a handful of fishing companies, no more than four vessels may be operated by a fishing company. The European Commission

Tradable quotas
Tradable quotas are a fisheries management tool used by various countries around the world. In 1986, New Zealand became the first country to incorporate a tradable quota system into national legislation. These tradable quotas are often known as „individual transferable quotas (ITQs)“.The term preferred by the EU is „transferable fishing concession“ (TFC).

is proposing to subdivide ITQ trading according to vessel size (i.e. vessels longer than 12 metres, and vessels under 12 meters in length). Owners of smaller vessels would not be permitted to sell their quotas to owners of ships in the larger-vessel category. This measure is intended to protect artisanal coastal fishing using smaller boats.

Doing battle against discards

In its current draft of the new CFP, the European Commission also makes a number of proposals for dealing with the problem of discards. All over the world, millions of tonnes of freshly caught fish and marine fauna are dumped back in the sea every year. Most of the discards are already dead when they go back into the water. This practice is a massive waste of natural resources. What's more, the discards are not systematically recorded, creating a large gap in the data that fishery scientists need to estimate the size of fish stocks accurately. In North Sea sole fishery, for example, large quantities of plaice and other flatfish, such as dab, are caught as bycatch. In some cases, this unwanted bycatch amounts to 70 per cent of the catch. As many plaice are too small to be landed legally and other flatfish are unpopular as eating fish, the bulk of this bycatch – with the exception of a few high-grade individuals – is dumped overboard. As the discards are not recorded, researchers find it almost impossible to make an accurate assessment of the status of flatfish stocks other than sole and plaice.

There are various reasons why fish are discarded:

- For some species, such as crustaceans, starfish and smaller fish such as the European eelpout and the family of gobies, there is simply no market.
- The fishermen sort out the high-grade components of the catch, such as the largest and heaviest individuals from a given species. The rest is dumped overboard. This high-grading has been prohibited in the EU since 2010 but is still practised.
- The fish are too young or too small. The rules currently in force prohibit the landing of these undersized fish.
- Fishermen are not permitted to land species for which they have not been allocated a quota. Nor can they land species for which their quota is already fulfilled. This problem occurs in mixed fisheries, where several species of a similar size occurring in a single habitat are sometimes netted together. A haddock fisherman, for example, is not permitted to land any cod caught as bycatch. Under the current rules, the cod must be discarded.

Due to the rules currently in place under the existing CFP, this type of prohibition on landings means that discarding still takes place on a large scale within the EU. As one possible solution, the European Commission is proposing a reform of the old quota allocation system. At present, individual quotas are still allocated for many species, even though these species are only caught in mixed fisheries. In future, it would be possible or even obligatory to acquire additional bycatch quotas, for example for cod and haddock. These bycatch quotas would be allocated in a flexible and straightforward manner. For example, rather than automatically being allocated for an entire year, they could be assigned on an ongoing basis throughout the course of the fishing season, depending on the status and development of stocks. The aim is to encourage fishermen to avoid bycatch of unwanted species – for example, through the use of better and more selective fishing gear. If they failed to achieve an appropriate reduction in the amount of bycatch, they would be obliged to apply for a bycatch quota. A fisherman would then have to demonstrate that he had been allocated a separate quota for each species likely to occur in the fishing grounds. In a mixed fishery, his fishing activities would then be oriented towards the stock with the smallest population.

In the North Sea, for example, the haddock stock is in a good state but the status of cod is less favourable. At present, a fisherman can catch as much haddock as he needs to fulfil his quota. Inevitably, though, some cod are caught as bycatch in the net and must be discarded. If the fisherman had two quotas, he could land both haddock and cod. However, he would have to stop fishing – for both haddock and cod – as soon as he had met his cod quota. This

5.19 > Pot fishery: a form of artisanal fishing still practised in Denmark.

is intended to protect cod from overfishing and avoid discards. Furthermore, the European Commission is keen to encourage the use of more selective fishing gear in future, as more sophisticated fishing technology can also help to reduce the amount of bycatch. A further proposal aims to reduce bycatch by obliging fishermen to avoid certain areas of the sea with large stocks of bycatch species at certain times of the year. A further possibility being discussed with a view to reducing discards is to equip the EU's fishing vessels with electronic surveillance systems, including CCTV, in future. This would enable checks to be carried out to determine whether any fish had been discarded, and if so, of which species. More intensive deployment of observers is a further option. However, the advantage of CCTV, compared with observers, is that it is far less expensive.

5.20 > Discarding of bycatch is a problem worldwide, not just in the EU. This Mexican prawn fisherman is dumping fish with no market value overboard.

More power for fishermen

At present, the EU's fisheries policy is still largely a top-down policy. The rules are agreed in Brussels at the highest level and must be adhered to by every fisherman in the same way. National or, indeed, regional approaches to fisheries management are virtually non-existent at present. As a result, conflicts are inevitable. Many of the sometimes contradictory rules agreed in Brussels are viewed by fishermen themselves as excessive or impractical. Indeed, some are ignored altogether. The Commission is proposing to defuse the situation by involving fishermen in fisheries management and decision-making to a greater extent, in the hope that this will increase their acceptance of the rules.

There is to be stronger regionalization of fisheries policy, as the Agriculture and Fisheries Council explains in its proposal on CFP reform. The proposal envisages that Member States would be able to devolve decision-making to the regional level. In recent years, a number of Regional Advisory Councils (RACs) have been established by various EU Member States, e. g. for the Baltic Sea and for the waters in the Arctic and around Iceland. These RACs have produced a number of proposals for CFP reform. Up to two-thirds of the members of the RACs are experts from the fisheries sector, with experts from other interest groups, such as nature conservation organizations and trade unions, comprising the remaining one-third. In future, the RACs, in conjunction with the relevant national authorities, could potentially undertake the management of fisheries in their specific region and submit their proposals to Brussels. Provided that there were no objections from the European Parliament or individual countries, the proposed fisheries management strategy would then enter into force.

Open-ended

Only time will tell which of the European Commission's reform proposals will be implemented; that will become clear when the new CFP is adopted in 2013. Ultimately, it is up to the Council and the European Parliament to decide which of the Commission's proposals will be incorporated as rules and provisions in the new CFP. We can only hope that the two institutions manage to agree on a fisheries policy which is good for both the economy and the environment. In fact, there is cause to be reasonably optimistic here: with the Marine Strategy Framework Directive, the European Union, in 2002, imposed an obligation on all Member States to take the necessary measures to protect and conserve the marine environment and achieve or maintain its good environmental status by the year 2020 at the latest. The Council is therefore obliged not only to ensure, with the new CFP, that fisheries are exploited at levels which produce the maximum sustainable yield (MSY); it must also minimize the impact of fishing on the marine environment at the same time.

Conclusion

Learning from bitter experience?

Today, many fish stocks are in a poor state because they were badly managed, or not managed at all, for many years. One reason for their parlous condition is that policy-makers and fishing companies have often disregarded scientists' recommendations on Total Allowable Catch. From the scientists' perspective, the TACs were meant to be upper limits which should not be exceeded; their aim was to ensure that stocks were not put at risk. However, policy-makers and the fishing industry viewed these upper limits as recommendations on the maximum amount that could be caught. With disastrous results: in years when stocks were already in an unhealthy state due to poor environmental conditions, fishing activities often exceeded the level that stocks could reasonably sustain. Quick profits or short-term protection of jobs were often viewed as more important than the recovery of stocks and the creation of a sustainable, high-yielding fishing industry for the long term.

There now appears to be a willingness to learn from past mistakes, with alternative and more sustainable fisheries management strategies slowly coming to the fore all over the world. These strategies are based on the concept of maximum sustainable yield (MSY), i.e. the amount that can be harvested with a view to maintaining abundant stocks for the long term. This concept can be easily adapted to diverse local conditions and allows countries to tailor their approach, also taking account of the social dimension.

In future, fisheries management strategies based on the MSY principle should also consider the interaction between the various species and the impact of fishing on the ecosystem. These modern fisheries management strategies also aim to promote more stakeholder involvement in order to identify solutions which are acceptable to everyone. The stakeholders concerned are fishermen, relevant authorities, professional associations and environmental organizations at regional and local level. But how can all these various aspects be reconciled within the framework of the Common Fisheries Policy (CFP)? That is currently the subject of intense debate in Europe. The problem with the previous fisheries policy was that outdated provisions constantly had to be revised and improved upon. This led to a plethora of rules which were often ignored, and made compliance extremely difficult to monitor.

One problem which is still largely unresolved is the issue of discards: unwanted bycatch is simply dumped overboard. This causes the wastage of millions of tonnes of fish and marine fauna all over the world every year. Fish which cannot be landed because they do not make the grade in terms of size, or because no quota is in place for the species, are very likely to be discarded. The practice of high-grading is also a problem: this means that fishermen pick out the most valuable parts of the catch and dump the rest overboard. Various methods are currently being discussed to reduce the quantity of discards, such as more intensive deployment of government observers or onboard surveillance using CCTV. This type of system is now being trialled on some fishing vessels in the North Sea and the Baltic Sea. The European Commission is also keen to use the CFP as an opportunity to demand more industry responsibility, which turns the spotlight on fishermen themselves. Anyone whose fishing practices result in several species being netted simultaneously will be required to obtain a licence for each of the relevant species. This is intended to encourage fishermen to set their nets in areas where only one species of fish is likely to be caught, or to use nets which are designed to catch one specific species.

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