3 Plenty more fish in the sea?

> Ocean fish are not in particularly good shape. At least a quarter of the world's fish stocks are overexploited or depleted. In recent decades the search for new fishing grounds has taken fleets into ever-deeper waters. Stocks are further undermined by illegal fishing. It is now clear that overfishing is wreaking havoc on our marine environment and is economically unsustainable. For this reason many nations are adopting a more precautionary approach to fishing.

The global hunt for fish

> Within a few short decades, industrial fishing has expanded from the traditional fishing grounds of the Northern Hemisphere to include all the world's oceans and seas. Many stocks have been overexploited and are depleted. But the situation is not without hope. Some countries have shown that fish stocks can in fact recover when sustainable fisheries management systems are implemented.

The art of counting fish

No other group of animals is as difficult to monitor as fish. Spotting scopes and radar equipment are used to locate and count migratory birds along their flight paths. Bats can be monitored by placing ultrasound detectors and photoelectric sensors at the entrance of their caves. But what about fish?

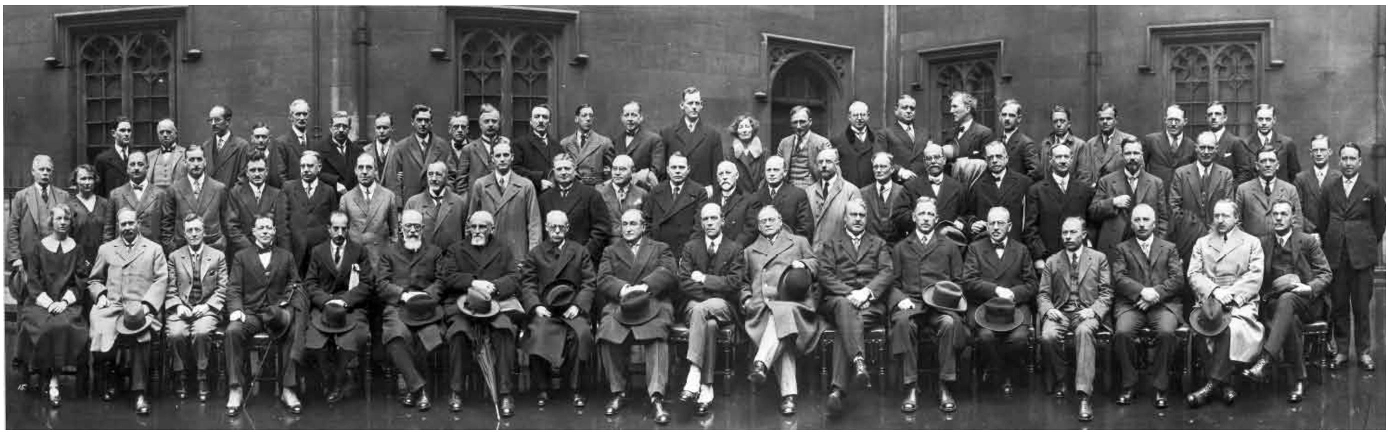
Humans are not capable of looking into the ocean and counting the fish they see. Instead, they must try to estimate the size of fish stocks as accurately as possible. The Food and Agriculture Organization of the United Nations (FAO) uses various sources to estimate global fish stocks and trends as accurately as possible. The results are published every two years in the SOFIA Report (The State of World Fisheries and Aquaculture). The latest report was released in 2012 and reflects the developments to 2009/2010. Fish is the means of subsistence for billions of people around the world. Accordingly, the report is an important document on which UN decisions, international agreements and treaties are based. The data used for the SOFIA Report is taken from the following sources:

FISHERIES – Fishermen report their catches to their government authorities, such as the Ministries of Agriculture and Fisheries. The authorities are obliged to send this data to the FAO. The data is also forwarded to scientists in their own country.

THE SCIENTIFIC COMMUNITY – Fisheries' data is often incomplete or incorrect. For instance, fishermen only report the amounts of those fish which they are officially permitted to catch. They do not include any unwanted "bycatch" – all the fish and marine fauna which are caught inadvertently and until now have mostly been thrown back overboard. An quantitative assessment of bycatch levels would, however, be crucial as this could provide a more realistic estimate of the actual status of fish stocks. In order to improve the flawed basic data, fishery scientists therefore gather their own data.

1. Fishery-dependent data: Fishery scientists regularly accompany fishing vessels. They collect catch samples and detailed data including the age, size, length and number of adult fish. The volume and composition of the catch are of particular interest. They also record the effort expended, such as how long a net is dragged behind the vessel before it is full. This establishes the exact amount of effort involved in catching a certain amount of fish. Researchers call this the "catch per unit effort" (CPUE). It is the only way of ascertaining the stock density, or the number of fish found in a certain area.

2. Fishery-independent data: Scientists also conduct research projects using their own vessels. They take numerous sample catches – not only in the abundant areas highly sought after by the fishermen, but in many different parts of a maritime region. The sampling locations are either chosen randomly or according to a certain pattern. The objective is to obtain a comprehensive overview of the entire maritime region as well as the distribution of fish stocks. During these expeditions it is important that all the marine fauna caught are counted and measured, to enable a reliable assessment of the entire ecosystem to be made. The scientists are also interested in the age of the fish. Using close-meshed nets, therefore, they catch young fish (juveniles) which are not usually taken by the fishermen. The age distribution of the fish is an extremely important aspect of stock predictions. It shows how many of the fish will grow to sexual maturity and thus how populations are



3.1 > Venerable gentlemen of fisheries science: ICES researchers held their statutory meeting at the House of Lords in London in 1929. Upon its foundation in 1902, the ICES had 8 member nations: today it has 20.

likely to develop in future years. How many research expeditions are undertaken differs from country to country. Researchers sample individual fish stocks up to five times a year. Information on the eggs and larvae of some stocks is also recorded. These numbers indicate the parent stock and the numbers of young to be anticipated.

The researchers utilize both the fishery-dependent and the fishery-independent data to adjust and augment the fisheries' official catch numbers. For instance, from their own sample catches they can estimate the approximate volume of bycatch in the fishing grounds. In many cases catches from illegal fishing are also shown up. For instance, double logbooks are frequently used – one for the authorities showing the official figures, and another for the scientists showing the higher but genuine catch numbers. Comparing these two allows a more accurate estimation of how many fish were actually caught in a maritime region.

How does the data reach the FAO?

The catch data from both the fishermen and the scientists is initially forwarded to higher scientific institutions which utilize it to estimate the current stocks of the various fish species and maritime regions. One objective is to generate a supra-regional overview from the national data. For example, the International Council for the Exploration of the Sea (ICES) in Copenhagen is responsible for the Northeast Atlantic. Its working groups use both the fisheries' official catch data and the scientific results to calculate the current stocks of the different species of fish and fauna. The ICES then sends these stock estimates to the FAO.

Data about stocks in other maritime regions reaches the FAO in a similar way. For example, the Northwest Atlantic Fisheries Organization (NAFO) is responsible for the Northwest Atlantic. It collates data from Canada, the USA, France (for the Atlantic islands of St. Pierre and Miquelon) and the foreign fleets from Russia and the EU which operate in this region. The NAFO then forwards the data to the FAO. The Canadian and US national fisheries institutes also report directly to the FAO.

The FAO does not re-evaluate this information, but merely summarizes, edits and ultimately publishes the data for the various maritime regions of the world.

Disagreement on the condition of fish stocks

Around 1500 fish stocks around the world are commercially fished, with the various stocks being exploited to different extents. Comprehensive estimations of abundance currently exist for only around 500 of these stocks. In most cases these are the stocks which have been commercially fished for many decades. For many years, exact records have been kept of what and how much is caught:

ICES CIEM

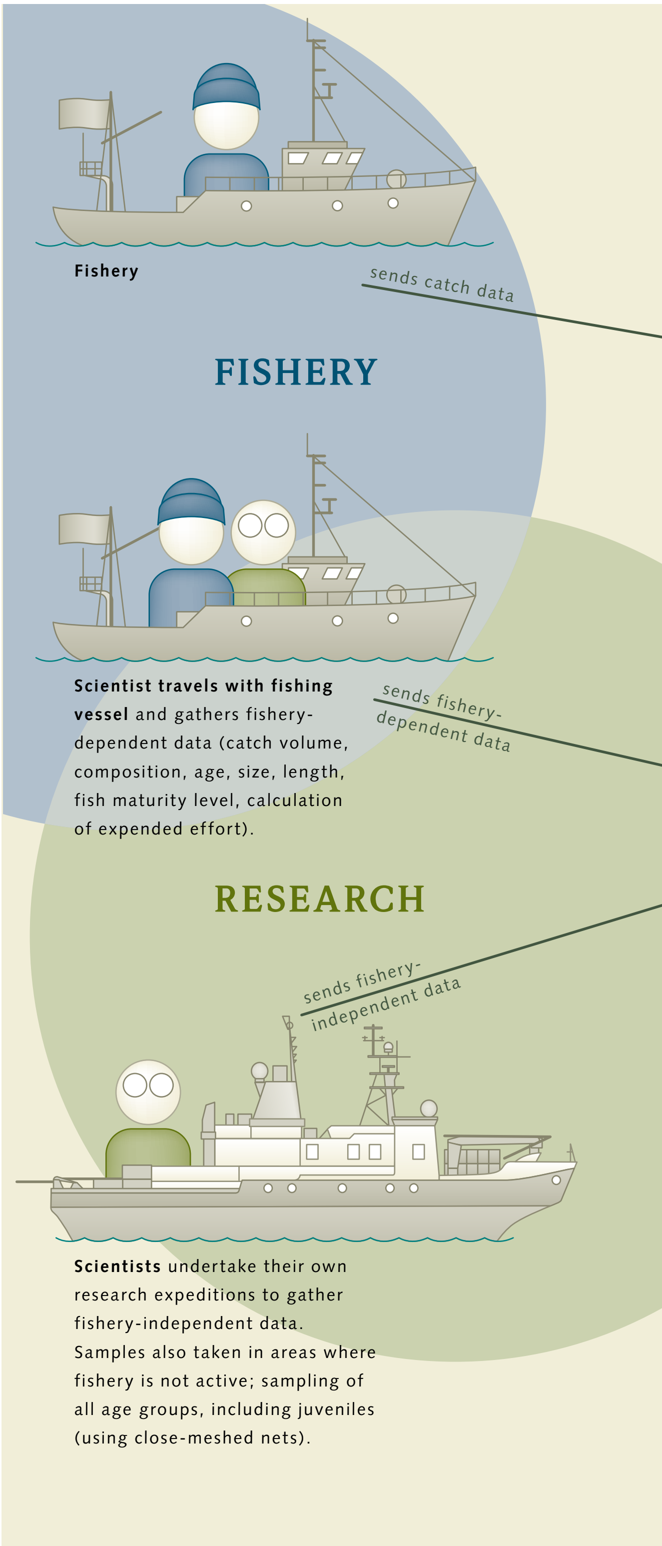
ICES
The International Council for the Exploration of the Sea (ICES) was founded in Copenhagen, Denmark, in 1902 and is the world's oldest intergovernmental organization. At that time there was a growing awareness in some European fishing nations that the long-term management of migratory fish stocks depended on a coordinated approach. Today the ICES acts on behalf of the EU and other fishing nations such as Canada, Iceland and Russia. It is responsible for all the living marine resources in the Northeast Atlantic, a total of 120 species. The ICES recommends the maximum fish catches within a specific maritime region.

the tonnages and also the age and size of the fish. Datasets for cod off the coast of Norway, for example, go back as far as the 1920s. Very little is known about other fish species and maritime regions – particularly the Exclusive Economic Zones of some developing countries. Many developing countries provide catch data alone, without any scientific assessment. The FAO makes limited use of such data. There are also some maritime regions for which not even simple catch data is available. The FAO believes that it is impossible to make any reliable estimation of such stocks.

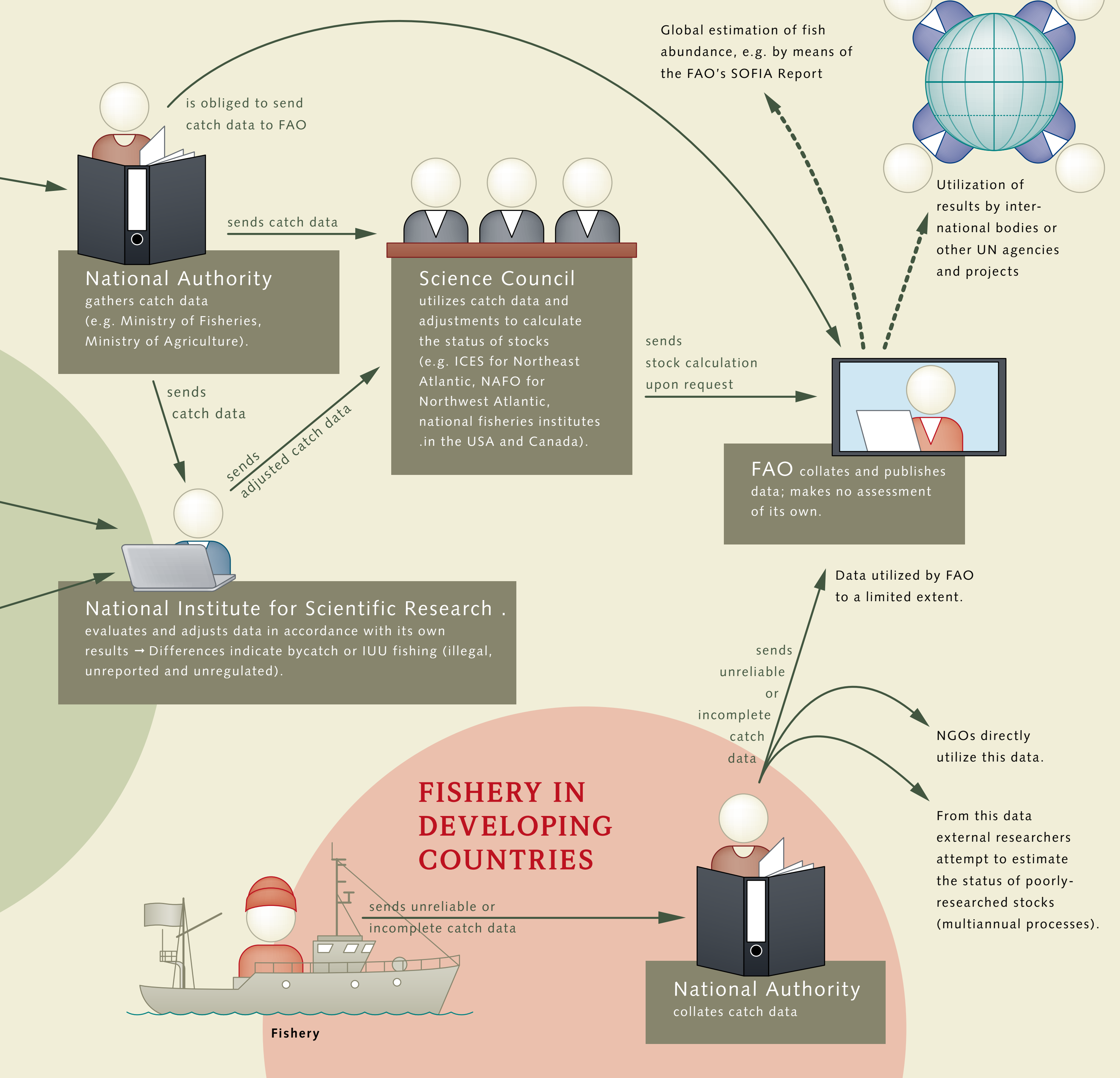
Therefore no reliable data exists for many of the world's fish stocks. Moreover, fisheries biologists are even unable to confirm how many fish stocks there actually are. If any data is available, it applies only to commercially exploited species. Naturally an overall survey of all the world's fish would be desirable – but the cost would be exorbitant. Hundreds of research expeditions would be required, making the exercise unaffordable.

Critics point out, therefore, that the FAO statistics do not take a large proportion of stocks into account. A joint American-German research group has therefore developed its own mathematical model to estimate the status of all populations from the catch amounts reported by the fisheries alone, without the fishery-independent data from the scientists. These researchers are also investigating how stock catches have developed over time. According to this model, a fish stock is depleted when the catch decreases conspicuously within a few years. Attempts are being made to circumvent the lack of stock calculations by simply interpreting catches over the course of time. The researchers have meticulously requested information from the authorities of the countries responsible for regions with no catch data at all. Based on the model, which takes 1500 commercially exploited stocks and around 500 other stocks into account, the fish are in even worse shape than assumed by the FAO: 56.4 per cent of the stocks are overexploited or depleted, not 29.9 per cent as claimed by the FAO. But the work of this American-German research group is itself under fire, with claims that its data is inconsistent and still unreliable. It presents a distorted picture of the reality, say other researchers. Which of the methods better illustrates the state of the

3.2 > Global estimation of fish abundance: Data on the status of fish stocks is provided by the fisheries and scientists. The FAO collates this information and then attempts to draw up a picture of the worldwide situation. The problem is that reliable data exists for only about 500 stocks. Experts do not agree on the status of other fish stocks.



How the data reaches the FAO



world's fisheries is currently a subject of heated debate. Despite the uncertainties, the researchers and the FAO agree on one thing: over the years the situation has deteriorated. Recovery will only be possible if the endangered stocks are fished less intensely for a number of years.

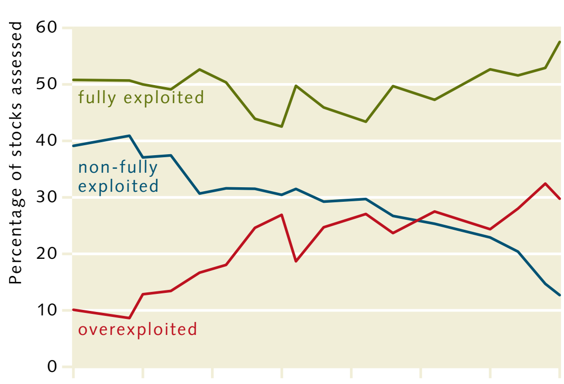
Things are gradually getting worse

The results are alarming, because the pressure on fish populations has been escalating for years. According to the current SOFIA Report, the proportion of overexploited or depleted stocks has increased from 10 per cent in 1974 to 29.9 per cent in 2009. After temporary fluctuations, the proportion of fully exploited stocks rose during the same period of time, from 51 per cent to 57 per cent. The proportion of non-fully exploited stocks, in contrast, has declined since 1974 from almost 40 per cent to only 12.7 per cent in 2009.

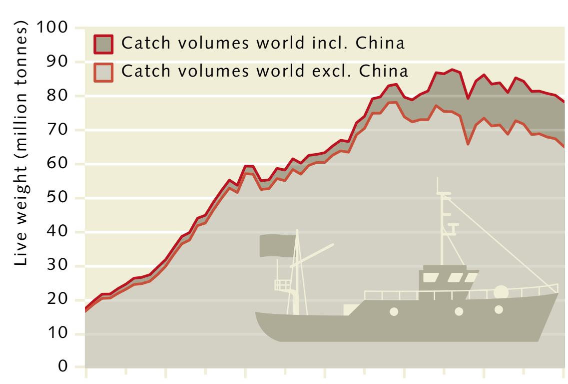
A clear trend is therefore emerging: as far as overfishing and the intensive exploitation of the oceans are concerned, the situation is not improving; it is slowly but steadily deteriorating. It is interesting that the total annual fish catch has been fluctuating for about 20 years between a good 50 and 60 million tonnes. It peaked in 1994 at 63.3 million tonnes. In 2011 a total of 53.1 million tonnes was landed – about four times more than in 1950 (12.8 million tonnes). The FAO, however, records the catches of not only fish but also other marine species such as prawns, mussels and squid. If these numbers are added to those for fish, total catches are much greater. Accordingly, for the past 20 years the total marine catch has been a steady 80 million tonnes annually. The peak was reached in 1996 with 86.4 million tonnes. In 2011 it was 78.9 million tonnes.

The reason why fish catches have remained fairly stable is because over time the coastal maritime regions were fished out, prompting the fisheries to spread out into new areas. They have expanded in geographical terms, from the traditional fishing grounds of the North Atlantic and North Pacific further and further south. They have also penetrated into ever-deeper waters. Only a few decades ago it was virtually impossible in technical terms to drop nets deeper than 500 metres. Today the fisheries are operating at depths of up to 2000 metres. Moreover, once the stocks of the traditional species had been exhausted, the fishing industry turned to other species. Some of these were given new names in an effort to promote sales and make them more attractive to consumers. For instance the "slimehead" went on sale as "orange roughy".

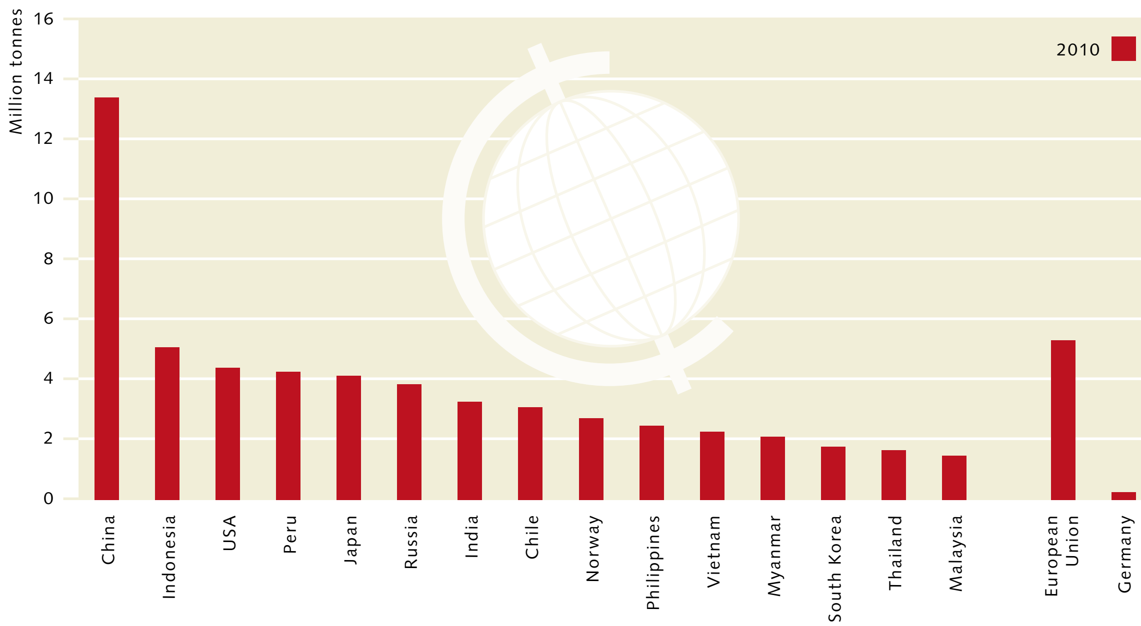
It is still possible to remove virtually the same amounts of fish from the oceans, therefore, but the composition of the global catch and the stocks themselves have changed. Consistent catches are no indication that fish stocks have remained stable.



3.3 > The number of overexploited stocks has soared since the 1970s, while the number of non-fully exploited stocks has decreased. Fully-exploited stocks are not, in principle, problematic. It is important to manage them sustainably, however.



3.4 > The development of catch volumes of world marine capture fisheries since 1950. Catches in China might have been adjusted upwards for many years, in order to comply with the government's official output targets.



3.5 > Top producer countries based on catch

China catches the most fish

Taking catch volumes as the benchmark, China has been the most important fishing nation for years now. However, the data available is extremely unreliable. A large number of experts believe that catches have been adjusted upwards for many years, in order to comply with the government's official output targets. Therefore the figures have presumably been too high for some time. Only recently has this practice begun to change in China.

Peru, until 2009 the second most important fishing nation, has slipped to fourth place. This is due to the low catches of anchovies which can be ascribed to climate change in particular, but also to a complete closure of the fishery designed to protect future anchovy stocks. Indonesia is currently the second and the USA the third most important fishing nation.

Developments in Russia are interesting. Since 2004, its catches have increased by about 1 million tonnes. According to the Russian authorities, this growth is a result of changes to the comprehensive documentation of catches. Until now some local catches were registered in the home port as imports and not as domestic catches. Russia plans to further expand its fishing industry in the coming years, the goal being to land 6 million tonnes by the year 2020. This would amount to slightly more than the combined catches of all EU nations, which totalled 5.2 million tonnes in 2010.

A new way of thinking

The situation is grave, but not without hope. The days of rampant overfishing are over in many regions. After stocks began to collapse in the 1970s, 1980s and 1990s, leading to the loss of many jobs, it gradually became clear to the fishing industry and policy-makers in various countries that overfishing is not only an environmental but also an economic problem. Some nations took the necessary steps to avoid any repeat of the situation. Australia, Canada, New Zealand and the USA, for example, developed fisheries management plans which limit catches to the extent that overfishing will be largely avoided in future. Europe has also learned from some of its mistakes. After massive overexploitation of the North Sea herring in the 1970s the fishery was completely closed for several years. The stocks recovered. Here too a fisheries management regime was introduced to prevent any renewed collapse. Even today, however, many other maritime regions and stocks

3.6 > A net bulging with herring is pulled on board the Norwegian trawler "Svanug Elise". The last good herring year off the coast of Norway was 2004.

are still not fished sustainably. One such area is the Bay of Biscay where the European hake *(Merluccius merluccius)* remains under heavy fishing pressure. Many stocks in the Mediterranean are also overfished.

Currently, therefore, the overall picture is mixed. Attempts are being made to maintain stocks in some regions through good management and sustainable fishing practices. In others, short-term profits still take priority over the precautionary approach to ensure the long-term productivity of stocks. It is therefore likely that stocks will continue to collapse. It is true that depleted stocks can recover when fishing is closed or drastically limited, but this can sometimes take many years. The herring stocks off the coast of Norway took about 20 years to recover from overfishing. Luckily, however, stocks of North Sea herring increased after just a few years, so that the fishing ban could be revoked. Nonetheless the effect of overfishing on the fishing industry is the loss of previously productive stocks for an extended period of time.

Around the world – the FAO fishing areas

The FAO divides the oceans into 19 major fishing areas. This regional classification has evolved over time. It simplifies the collection of data on fish catches, because the regional authorities and fishery associations work closely together. Other divisions – based on large-scale marine ecosystems, for example – might appear to make more sense today. Nonetheless, the FAO's traditional division is still an effective way of making a global comparison. The 19 regions are in turn divided into three categories. The first comprises areas where the catches have been fluctuating since 1950. The second consists of areas where catches have fallen over the years, and the third category covers areas where catches have continuously increased. Here again the FAO bases its analysis on the roughly 500 fish stocks for which reliable stock calculations are available. However, four of the 19 areas – the Arctic and the three Antarctic areas – are not considered in more detail below, either because there is little fishing in these regions or because few of the stocks are exploited for commercial purposes.

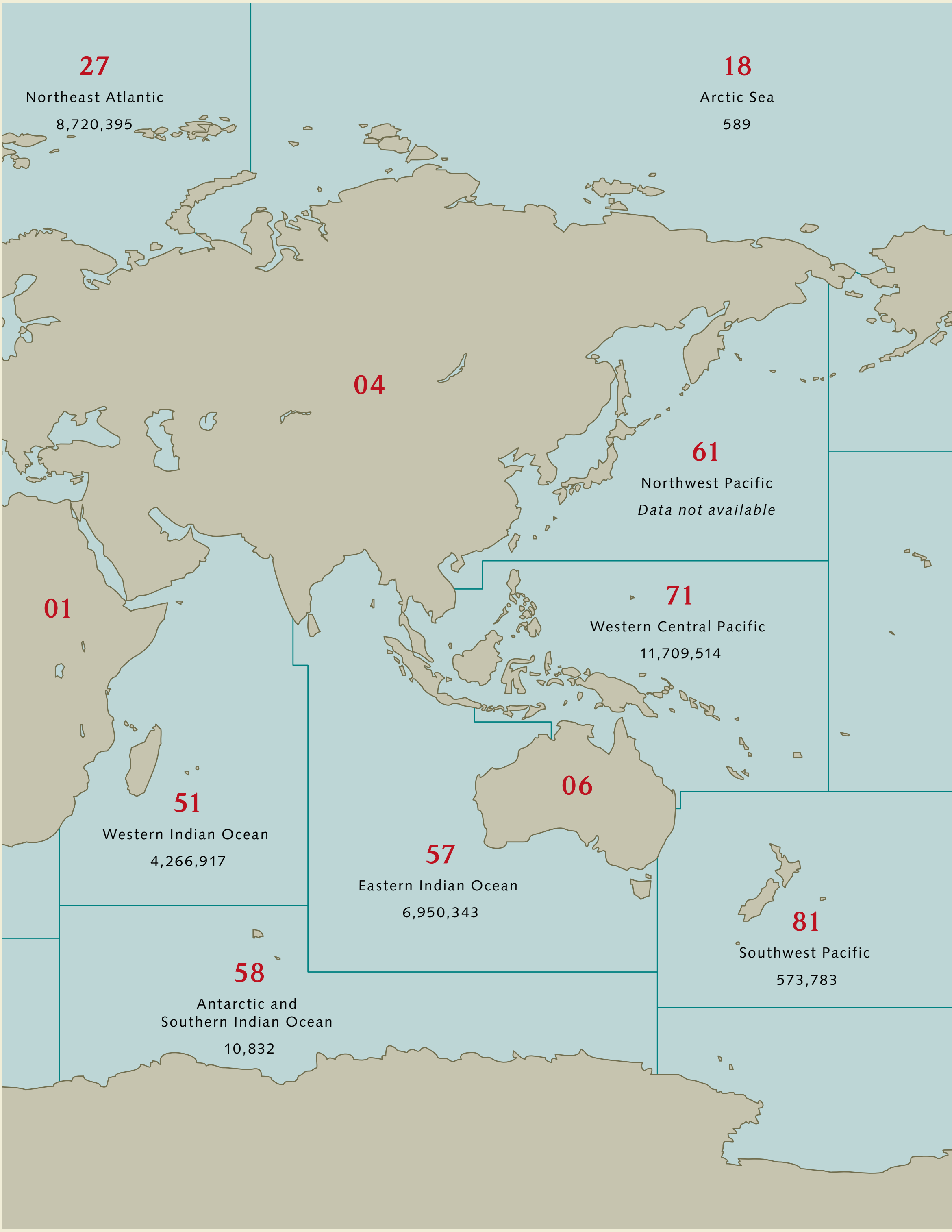
Areas with fluctuating catch volumes

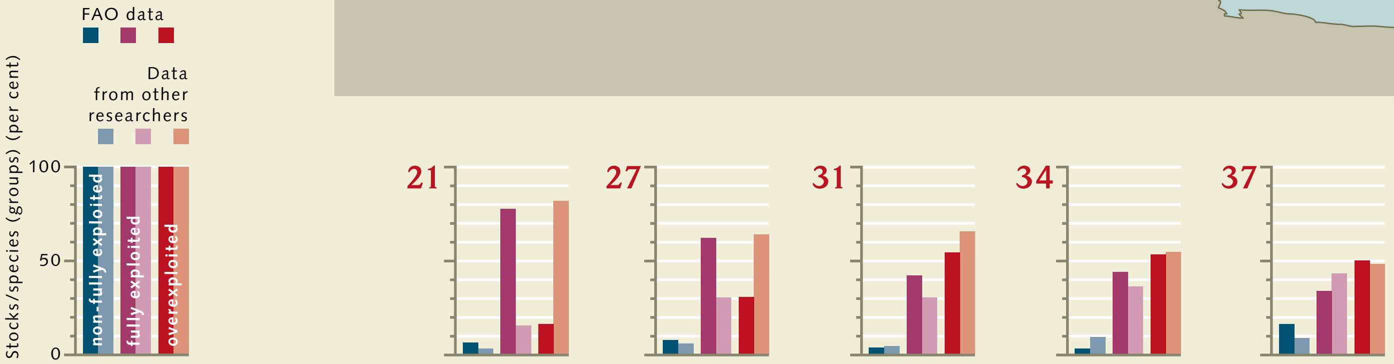
The first group includes the Eastern Central Atlantic (FAO fishing area 34), the Southwest Atlantic (41), the Northwest Pacific (61), the Northeast Pacific (67), the Eastern Central Pacific (77) and the Southeast Pacific (87). In the past five years these areas provided, on average, 52 per cent of the total global catch volume.

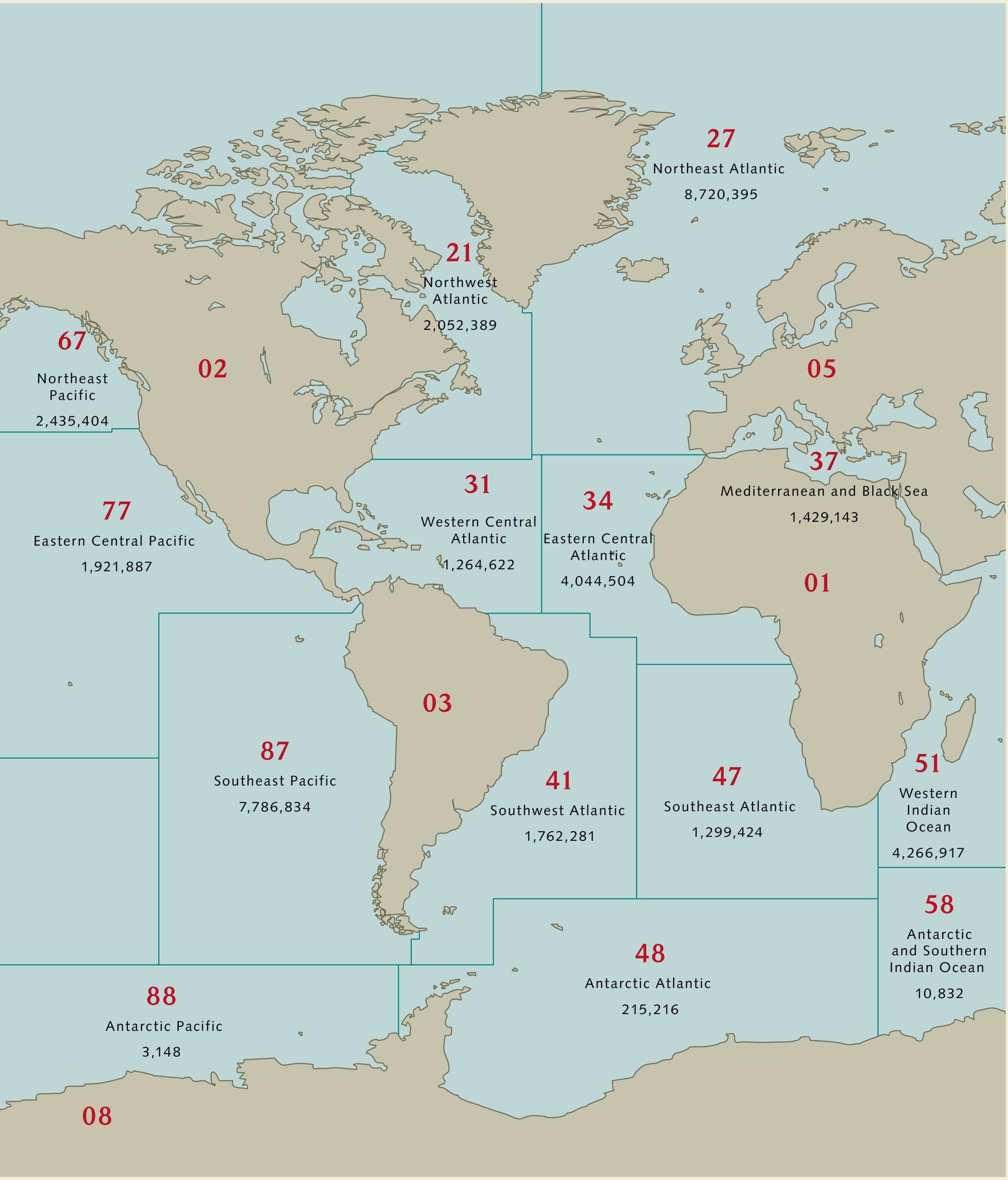
The most important area today is the Northwest Pacific. In 2010 a total of 21 million tonnes of fish were caught in this region – more than a quarter of the world's total marine catch. Small pelagic fish such as the Japanese anchovy make up the largest proportion of the total catch. The Eastern Central Pacific and the Southeast Pacific are also prolific due to the nutrient-rich upwelling areas off the coast of South America. Catches are prone to huge fluctuations, sometimes from one year to the next. One reason for this is the large numbers of small schooling fish (sardines and anchovies), stocks of which rely heavily on the current in the upwelling areas. Nutrient-rich water rises to the surface from the depths, stimulating the growth and reproduction of the plankton on which fish feed. When the current weakens due to climatic fluctuations, there is less plankton and thus less food for the fish.

Compared with the general situation of world fish stocks, things are looking particularly grim in the Eastern Central Atlantic: 53 per cent of stocks in this area are considered overexploited, 43 per cent fully exploited and only 4 per cent non-fully exploited – off the coast of Senegal for example. The sardine *(Sardina pilchardus)* is the dominant species here. The Southwest Atlantic is also under heavy pressure. Important fish species are the Argentine hake and the anchovy off Brazil. Both are thought to be overfished. However, according to experts, the latter appears to be recovering. In this area, 50 per cent of stocks are considered overexploited, 41 per cent fully exploited and 9 per cent non-fully exploited. In contrast, the FAO data for the Northeast Pacific is comparatively positive. The annual catch peaked here in the 1980s. The largest proportion of the catch is made up of Alaska pollack, cod and hake. Today 80 per cent of the stocks in this region are considered fully exploited and 10 per cent each are overexploited and non-fully exploited.

3.7 > The FAO divides the oceans into 19 major fishing areas which differ markedly in their annual catches (in tonnes living weight). The bar charts show the conditions in the corresponding maritime regions. The FAO figures (based on about 500 stocks) are compared with those of an American-German research group (based on about 2000 stocks). Despite the fact that the stock conditions were ascertained using different methods, it is still possible to compare the datasets. The Arctic is not shown in detail due to its limited catches. The red figures show the FAO number of the corresponding area. These areas differ considerably in their level of productivity. The coastal areas, or more accurately the continental shelves, are usually much more productive than the open seas. In FAO area 81, for example, there are few shelf areas, and the catch is correspondingly low, but the fish stocks are in a good condition (according to FAO data). Therefore, a low catch is not necessarily indicative of poor stock condition.



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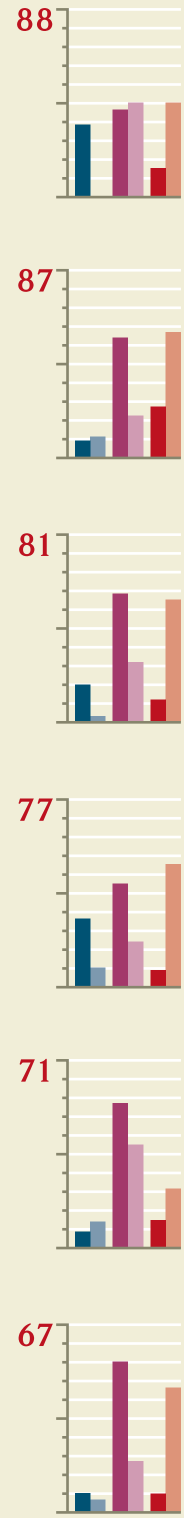
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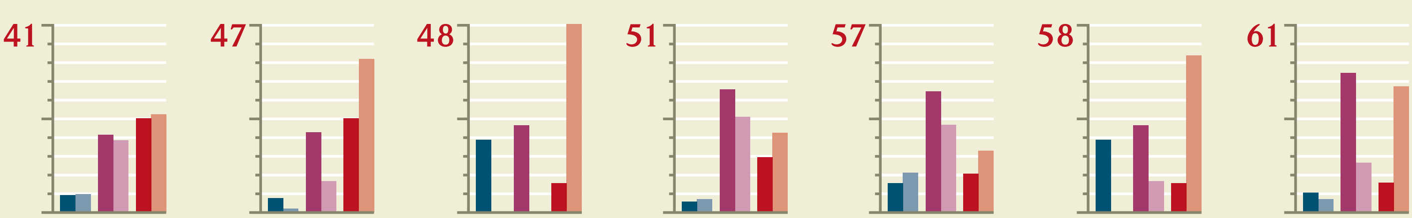
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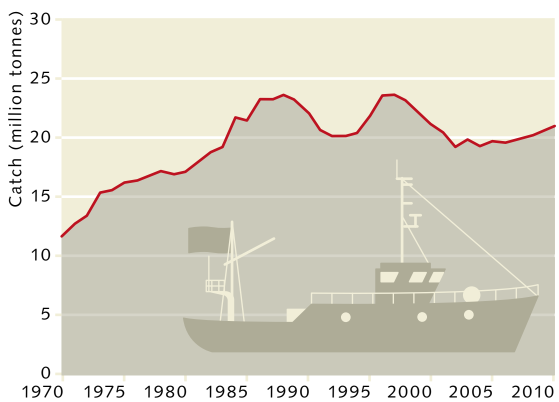


3.8 > The FAO includes the Northwest Pacific among the areas with fluctuating catch volumes.

Areas with falling catches

The areas in which catches have decreased over the years include the Northwest Atlantic (FAO fishing area 21), the Northeast Atlantic (27), the Western Central Atlantic (31), the Mediterranean and the Black Sea (both 37), the Southeast Atlantic (47) and the Southwest Pacific (81). In the past 5 years these areas provided an average 20 per cent of the world's total catch. In some areas reduced catches were a result of fisheries management regulations, and stocks are expected to recover here. If the annual statistics indicate diminished catch volumes, this does not always mean that a stock is being depleted or has been overfished.

In the Northeast Atlantic, for instance, the pressure on cod, plaice and sole has been reduced. Management plans are in place for the most important stocks of these species. Fortunately the spawning stocks of the Northeast Arctic cod have increased again here – particularly in 2008. Apparently the stocks have recovered following the low levels of the 1960s to 1980s.

The future is looking a little brighter for the Northeast Arctic pollack and the Northeast Arctic haddock, but other stocks of these species continue to be overexploited in some regions of the Northeast Atlantic.

Catches of blue whiting have decreased dramatically – from 2.4 million tonnes in 2004 to 540,000 tonnes in 2010 and 100,000 tonnes in 2011. This decline can be ascribed to the fisheries reacting too slowly to a sudden change in reproduction. Between the years of 1997 and 2004 the blue whiting for unknown reasons produced masses of young. During this period the species was fished intensively. But following a sudden drop in reproduction rates after 2004, the fishing industry continued to exploit the species at the same rate as before. The marked reduction of catch volumes in recent years, however, has helped the stocks to regenerate. In 2012 a harvest of almost 400,000 tonnes is expected.

The situation of some deep-sea fish species is critical. All in all, 62 per cent of the stocks assessed in the Northeast Atlantic are fully exploited, 31 per cent overexploited and 7 per cent non-fully exploited.

Fish stocks also remain in a poor condition in the Northwest Atlantic. Cod and ocean perch, for example, have not yet recovered from the intensive fishing of the 1980s, despite the Canadian authorities having completely banned the commercial fishing of these species. Experts ascribe the situation to adverse environmental conditions and competition for food (Chapter 1). Other stocks which are protected by fisheries management regimes appear to be regenerating. These include the spiny dogfish, the yellowtail flounder, the Atlantic halibut, the Greenland halibut and the haddock. Stocks in the Northwest Atlantic are considered 77 per cent fully exploited, 17 per cent overexploited and 6 per cent non-fully exploited.

Catch volumes in the Southeast Atlantic have declined considerably since the 1970s, from a previous 3.3 million tonnes to only 1.2 million tonnes in 2009. This can be ascribed partially to overfishing, and partially to catch reductions as a result of sustainable fisheries management. This applies in particular to the hake which is particularly important in this area. Thanks to the fishery measures introduced in 2006, some stocks of hake such as the deep sea *Merluccius paradoxus* off South Africa and the shallow water *Merluccius capensis* off Namibia appear to be recovering. In contrast, stocks of the formerly prolific South African sardine appear to be overexploited following a phase of intensive fishing. In 2004 the stock was classified as fully exploited. In the years since then, however, it has declined again as a result of adverse environmental conditions. This example highlights the speed at which a fully exploited stock can become overexploited, and the importance of forward-looking and sustainable

Spawners
"Spawners" is the term used for sexually mature male and female fish which help to maintain stocks by producing young. If spawner numbers decrease as a result of intensive fishing or adverse environmental conditions, insufficient young are produced and stocks can collapse.

fisheries management plans. The condition of the mackerel off the coast of Angola and Namibia has also deteriorated, since 2009 being considered overexploited.

The Mediterranean and the Black Sea are combined into a single FAO fishing area. Similarly, its situation is not particularly good. Of the stocks analyzed by the FAO, 50 per cent are overexploited, 33 per cent fully exploited and 17 per cent non-fully exploited. All stocks of the European hake *(Merluccius merluccius)* and the red mullet *(Mullus barbatus)* are classified as overexploited. Too little information is available about the condition of the sea breams and sole to categorize, but these are also suspected to be overexploited. The most significant stocks of small pelagic fish (sardines and anchovies) are considered fully exploited or overexploited.

Areas with increasing catches

In only three of the FAO major fishing areas have catches been continuously increasing since the 1950s. These are the Western Central Pacific (FAO fishing area 71), the Eastern Indian Ocean (57) and the Western Indian Ocean (51).

Catch volumes in the Western Central Pacific have constantly increased since 1970 to a peak of 11.7 million tonnes in 2010 – about 14 per cent of the total global catch. The situation has changed in the meantime, however, and stocks are now in a critical condition. Most are assessed as fully exploited and overexploited – particularly in the western regions of the South China Sea. It is thought that the high annual catches are due to China's intensive fishing industry expanding into this area where there was little commercial fishing in the past. But the FAO points out that the high catch numbers could be misleading. For many years China's catch statistics were adjusted upwards to comply with official output targets. It is assumed that fish were counted twice during transportation. For this reason it is conceivable that flawed data is masking an actual trend reversal – i.e. a reduction of fish stocks in the Western Central Pacific region.

The annual catch in the Eastern Indian Ocean has also escalated over the years, and this trend is continuing. Between 2007 and 2010 alone, the catch volume increased by 17 per cent. In the Bay of Bengal and the Andaman Sea catch volumes are steadily increasing. About 42 per cent, however, is not ascribed to any specific species and simply registered as "marine fishes not identified". This practice gives cause for concern because it is then impossible to assess the stocks of the different fish species in this heavily exploited region.

Each of the FAO's 19 major fishing areas comprises numerous sub-areas which are developing in different ways. Even when the total catch is increasing in one particular area, the trend for stocks of individual sub-areas can be the exact opposite. For instance, the catch volume in the Eastern Indian Ocean is increasing overall, but that

The end of the line?

At times over recent years researchers and the media have issued dire warnings about the state of ocean fish. According to some 2006 announcements, the oceans will be completely empty by 2048. This statement was strongly criticized at the time. Firstly the researchers had assumed that collapsed stocks would not recover in future decades. They failed to take into account the successful fisheries management measures aimed at stock recovery in the USA, New Zealand, Australia and other countries. Secondly, data from the past was projected 30 years into the future. Claims covering such a long time-frame are, however, riddled with uncertainty. Today the scientific community is agreed that the status of worldwide fish stocks calls for a differentiated approach.

The European Commission provided more bad news: 88 per cent of EU fish stocks are overfished, it declared in 2009. This number has now reduced to about 50 per cent, partly as a result of stricter catch limits. However, these figures are incomplete because the European Commission based its calculations on only about one fifth of the European fish stocks for which extremely good scientific data and reliable reference values were available. Overall, about 200 different stocks are exploited in the EU. But even bad news contains an element of good. In this case it has significantly helped to publicize the problem of global overfishing. Leading fisheries scientists for a long time took the view that they knew too little to assess the actual status of fish populations, and the fishing industry generally reacted by continuing to fish at the same rate of intensity. Despite a lack of knowledge, the scientists are now more prepared to make recommendations on the sustainable management of individual stocks. Furthermore, in many places the opinion is gaining ground that we must exercise more caution in our fishing practices. Sustainable, precautionary fishing is the aim. Some nations have already enshrined this objective in law, but many others still need to do so.

What shape are tuna stocks in?

Tuna is popular both in Western Europe and Japan where it is often prepared as sushi. At Japanese fish auctions in particular, prices in excess of 1000 euros per kilogram are paid for certain species of tuna. Visitors to high-class restaurants are quite prepared to pay top prices for the right product. The trade in tuna is therefore extremely lucrative.

As a result of strong demand, in 2009 stocks of seven important species of tuna were overexploited by a third, 37.5 per cent were fully exploited and 29 per cent were non-fully exploited. In the case of tuna the status of the species is often defined but not the populations, because it is difficult to define individual regional stocks of these fast-moving, highly migratory species. The most important species (as a proportion of total 2010 catch) are:

- Skipjack tuna: 58 per cent
- Yellowfin tuna: 26 per cent
- Bigeye tuna: 8 per cent
- Albacore tuna: 5 per cent
- Southern bluefin tuna *(Thunnus maccoyii):* 1 per cent
- Pacific bluefin tuna *(Thunnus orientalis):* 1 per cent
- Atlantic bluefin tuna *(Thunnus thynnus):* 1 per cent

Skipjack stocks are slightly increasing, meaning that in principle it should be possible to catch more of them. The problem with skipjack fishery, however, is that young bigeye and yellowfin tuna become caught in the net as bycatch. As several species often occur together it is difficult to catch only one species at a time. Accordingly, experts advise that any expansion of the skipjack fishery should be very closely monitored. There are also fears that all tuna stocks will further decline in the medium term if commercial fishing continues at the intensive rate of today. The bluefin tuna in particular is under threat. For this reason, in 2010 attempts were made to protect this species in accordance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This convention governs the import and export of endangered plants and animals. More than 170 nations have joined the convention since it came into effect in 1974.

Non-governmental organizations in particular have called for CITES to protect the bluefin tuna. The species is so popular, they claim, that commercial fishing is still economically viable even if only a few of them are caught in the net each time. The bluefin could become completely extinct. Opponents counter that overexploitation cannot be compared with extinction, that fishermen would stop fishing if it were no longer in their economic interests to continue. Even then, sufficient fish would remain to ensure the survival of the species. Whether CITES requirements can be used at all for ocean fish is doubtful, they say. So far, no international agreement has been reached on strict protection based on CITES criteria. It currently appears that the future protection of the bluefin tuna will be governed by the International Commission for the Conservation of Atlantic Tunas (ICCAT). Whether this will work remains to be seen.

3.9 > Catching yellowfin tuna used to involve backbreaking manual labour, as seen here off the Galápagos Islands in the 1930s.

of one sub-area, Australia's Exclusive Economic Zone (EEZ), is decreasing in response to management plans. As far as the protection of fish stocks goes, Australia and New Zealand are now regarded as models of best practice. The trigger was a 2005 ministerial decision which ended overfishing in the EEZ and made it possible for stocks to recover.

The Western Indian Ocean has long been considered an area in which the catches have increased appreciably. A temporary peak was reached in 2006. Since then, catch volumes have slightly decreased. The volume for 2010 was 4.3 million tonnes. Current investigations show that the widespread Narrow-barred Spanish mackerel *(Scomberomorus commerson)* found in the Red Sea, the Persian Gulf, the Gulf of Oman and off India and Pakistan, is overfished. Catch figures from these areas are incomplete, making it difficult to estimate the population. Attempts are being made to gather valid data in other regions. The Southwest Indian Ocean Fisheries Commission responsible for the southwestern sub-area of the Western Indian Ocean carried out a systematic estimate of 140 species in 2010. Although there are some gaps in the data, the attempt to assess the region's stocks deserves recognition. Overall, 65 per cent of the stocks in the Western Indian Ocean are fully exploited, 29 per cent overexploited and 6 per cent non-fully exploited.

Alien species add to the pressure

Already weakened fish stocks in some maritime regions are faced with the additional threat of alien species. Predators which feed on the fish, eggs and larvae of weakened stocks are particularly problematic, and competitors for food can play further havoc with depleted stocks. The situation becomes critical when the alien species thrives under its new living conditions and begins to reproduce vigorously. For example, alien species migrate from the Red Sea and through the Suez Canal into the Mediterranean. Some of them are apparently supplanting the native species of the eastern Mediterranean. The anchovy and sprat stocks of the Black Sea collapsed in the 1990s. This was due partly to overexploitation and partly to a type of fist-sized comb jellyfish introduced in the **ballast water** from ship tanks further undermining the already low fish stocks. The swarms of jellyfish ate the fish eggs and larvae en masse, biologists believe. Stocks have still not fully recovered. They are considered either fully exploited or still overexploited.

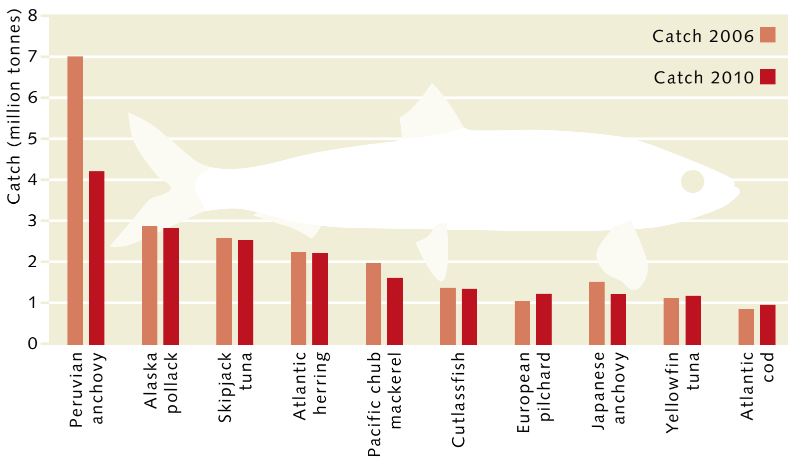
A closer look at the different species

Taking a closer look at the individual fishing areas of the world, it becomes clear that there is no simple response to the question of how the fish are faring. It's a complex situation. Without doubt many stocks are overexploited or have collapsed. But others are recovering thanks to sustainable fisheries management regimes. By way of illustration, the following section describes some individual fish species and their status – including the most important species with the highest total catch volumes. These fish species make up about 25 per cent of the world's total fish catch. Most of their stocks are considered fully exploited or overexploited.

3.10 > Tins of tuna generally contain the flesh of widespread species such as the skipjack tuna. Nonetheless, consumers should ensure that the products they buy are from sustainable fisheries.

The Peruvian anchovy – sometimes more, sometimes less

The development of the Peruvian anchovy *(Engraulis ringens)* is interesting. In terms of catch, it is the most important fish in the world. Large amounts are processed into fishmeal and fish oil to be fed to larger farmed fish in aquaculture operations. The largest volume ever caught, around 13 million tonnes, was landed in 1971. Today this would equate to a quarter of the global fish catch – excluding catches of other marine fauna such as mussels and squid. In the 1980s, the stocks crashed to about a tenth of this record level, not only as a result of intensive fishing but probably also because of a lack of food caused by the El Niño climatic phenomenon. The stocks later recovered. A new annual record of 12.5 million tonnes was reached in 1994. Since 2004, catch volumes have been dropping again, once more mainly due to El Niño. This anchovy example clearly shows the extent to which stocks can fluctuate. It also illustrates the vast amounts of fish which humans are removing from the seas; when adverse environmental conditions are added to the equation even vast



3.11 > The ten most important ocean fish species and their worldwide catch totals. As a result of the El Niño climatic phenomenon, catches of the Peruvian anchovy in particular fluctuate from year to year.

stocks can be decimated. This example also teaches us that a stock can regenerate rapidly due to the ability of the fish to reproduce profusely.

Other species of fish and stocks, however, are not capable of recovering so quickly from overfishing. One example of this is the Northeast Atlantic mackerel.

The Northeast Atlantic mackerel – departure from the North Sea

The Northeast Atlantic mackerel *(Scomber scombrus)* fishery comprises three components: the western, the southern and the North Sea stock. Each has its own spawning grounds. The North Sea mackerel spawn along the east coast of Britain, the southern component in the Bay of Biscay and off the Iberian Peninsula and the western component to the west of the British Isles and Ireland.

In spring, when the plankton proliferates in response to rising temperatures, the mackerel of all three stocks gather in large hunting schools and migrate to the region between the Shetland Islands and Norway. They later gradually leave this nutrient-rich summer feeding area to spawn in the three regions mentioned above. They display an amazing swarming instinct: by no means all the first-time spawners return to their traditional spawning grounds, but often follow the majority of the mackerel. The North Sea mackerel used to be the largest component, so many first-time spawners were attracted to the North Sea. However, stocks of this component collapsed in the 1970s due to overfishing.

Although the fishery was completely closed, the component has still not recovered. The western stock component then became the most prominent. The repercussions are clear: many mackerel which today begin their lives in the North Sea follow the main flow of fish towards the west when they first spawn. This occurs even in good years. Even when there are plenty of young fish in the North Sea most of them migrate westwards to spawn. The fact that there are still mackerel in the North Sea presumably means that a certain proportion of them continue to frequent the spawning grounds on England’s east coast. The question is whether a major mackerel stock will ever again be able to establish itself in the North Sea.

It is interesting that the Northeast Atlantic mackerel has apparently been increasingly orienting itself towards the west in recent years. The early-summer migration has been taking them more regularly into Icelandic waters. As a result, Iceland’s mackerel catches have soared from 4000 to 200,000 tonnes in only three years. Scientists are worried about the development because for years now too many mackerel have been caught. The reason is that the littoral states – the Faroes, Iceland, Norway, Russia and the European Union – cannot agree on lower catches. Each nation sets its own limits. When added together the total catch far exceeds the annual tonnage recommended by scientists. Fears that Northeast Atlantic mackerel stocks will be completely overexploited in the coming years are therefore justified.

The European hake (southern stock) – haggling over catch numbers

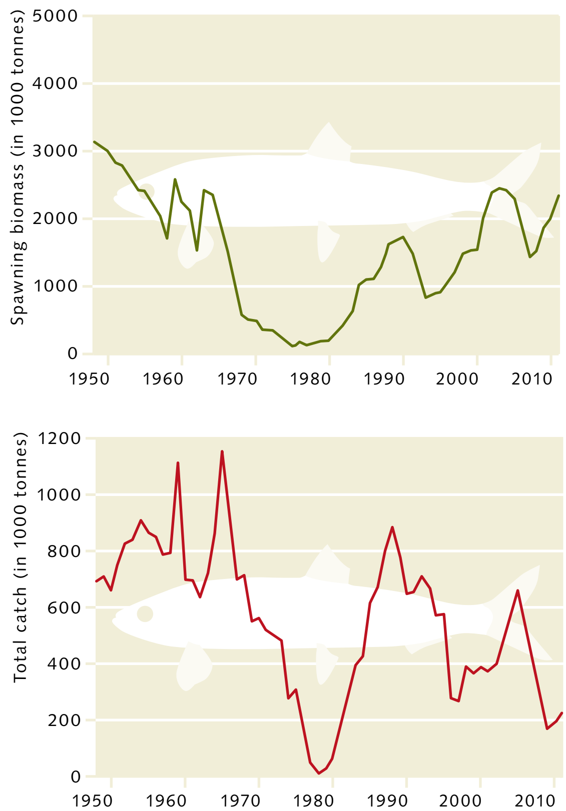
The future of the European hake (southern stock) in the Bay of Biscay and west of the Iberian Peninsula is also uncertain. This is a classic example of how difficult it is to accurately assess a stock. And it also shows that if in doubt, a fishing nation tends to continue fishing rather than protect a fish population.

The hake debate is difficult, mainly because the species seems to have been proliferating more rapidly over the past two years than had been observed previously. Its spawning biomass levels are increasing. ICES scientists, however, believe that for some time now, probably since the turn of the century, the stock has been overfished. The ICES fish abundance estimates have revealed that three times more hake has probably been caught than the stock can sustain over the long term. After tough and protracted negotiations with Spain, the European Commission in 2005 finally succeeded in establishing a management plan. But the ICES experts consider this inadequate, because it aims to reduce catches very slowly. In purely arithmetical terms, the stock could, at some stage, recover. However, the scientists claim that such an increase in the hake population would be so minimal as to be scarcely perceptible. Accordingly, it would be impossible to predict any stock recovery within the next ten years.

For this reason, many experts consider the management plan absurd, providing the hake with little protection. Nonetheless, Spain is persisting with it based on the evidence of the current increase in spawning biomass. The ICES believes that too many fish are still being caught, and it is simply a matter of luck that spawning stocks are expanding. They claim that hake numbers are growing in spite of and not because of the management plan. Spain is unlikely to back down. The data it has submitted to the ICES for 2012 is incomplete and is of little use in this form. This has led to the current heated debate taking place between the ICES and Spain.

The North Sea herring – recovery is possible

The example of the North Sea herring shows that a stock can recover if it is given a chance. Within a few years of the introduction of seine fishing in the 1960s, the stocks collapsed. The herring fishery was therefore completely closed between 1977 and 1981 – a measure which was both logical and correct. The stock recovered. In the early 1990s the spawning biomass level reached a new high. The next crisis followed not long after. This time many juvenile fish were captured in the nets as bycatch, leaving fewer fish to grow to maturity and rebuild depleted populations. As a result the spawning biomass dropped markedly once again, and stocks reached another low point in the mid-1990s. But this time reaction was swift. In mid-season 1997 catch amounts were again cut back drastically, and stocks recovered.



3.12 > Resolute fisheries management can ensure the recovery of a fish stock. After the North Sea herring was overfished in the 1960s (as revealed by the drop in spawning biomass), the fishery was completely closed. The stock, particularly the numbers of sexually mature fish (spawners), regenerated. After renewed over-fishing in the 1990s a management plan was agreed in 1997, which once again limited catches. The spawning stock was able to recover. The reduction of spawning biomass since 2002 can presumably be ascribed to climatic changes.

This example shows that the development of a stock can be very specifically controlled by restrictions and bans on fishing, resulting in positive change. Since 2002 the spawning biomass has again been dropping – most probably due to natural climatic fluctuations. Apparently the reproduction of the herring is partially connected to the North Atlantic Oscillation (NAO), a large-scale fluctuation in atmospheric pressure which occurs at regular intervals. This is leading to more differences of opinion between the ICES which makes the recommendations, and the EU Council of Ministers which is responsible for fisheries management in the North Sea. The positive stock development prompted the Council of Ministers in 2011 to set higher catches than envisaged in the management plan and recommended by ICES. The ICES is urging that catches should remain as they were, in spite of the good spawning stocks. Especially in good times a management plan should be complied with, it claims, so that stocks can further regenerate and cushion years with poor reproduction.

Purse seine
A purse seine is a net that is 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.

The deep sea – remote and endangered

> People have been fishing in the deep sea for over half a century. Over time, ever deeper ocean regions have become accessible to deep-sea fisheries. These hidden habitats are doubly endangered, because they are home to rare as well as sensitive organisms. Fortunately, the knowledge that these ecosystems require special protection is gradually becoming accepted.

Fishing in the dark

The assertion that the moon has been more thoroughly researched than the deep sea is still true. The deep sea refers to the totally dark layers of the ocean below around 800 metres.

Submersible robotic vehicles that can penetrate to the deepest parts of the ocean, the deep-sea trenches, have been in use for some time, but expeditions with these are expensive and complex. So our knowledge of life at great depths is still fragmentary. At best, submersible vehicles provide only highlights in the vast darkness, and sea-floor samples obtained with grab samplers or trawls deployed from research ships allow only isolated snapshots of the deep-sea ecosystems.

Although the impact of human encroachment on these systems is largely unknown, the deep ocean regions have been fished since the end of the Second World War. At first, fishing mostly targeted species of *Sebastes,* at depths of only a few hundred metres. Now fish are being caught from depths around 2000 metres, where the living conditions are fundamentally different from those in shallow regions. The Food and Agriculture Organization of the United Nations (FAO) defines deep-sea fisheries as those conducted between the depths of 200 and 2000 metres.

Flourishing life in the darkness

Off northwest Europe the transition from land to the sea bottom is a gradual slope. Off the coast lies a sprawling continental shelf. The North Sea is situated here as a shallow, offshore marginal sea. A similar situation is found off the coast of China with the South China Sea. The wide continental shelf ends at the break to the continental slope, which falls more steeply to greater depths. There are also coasts, however, where the transition from the land to deep sea is more abrupt. Here the wide continental shelves and marginal seas are absent. An example of this is the coast of Japan, where the sea floor descends abruptly and steeply into the depths.

Distinctive structures rise from the sea floor all around the world: submarine banks, ridges and seamounts. A bank is defined as a sea-floor elevation that can be several hundred kilometres long or wide. Banks are composed of sandy material or massive rock.

The kind of fish that predominate in an area depends in part on the bottom characteristics. Individual fish species have different modes of life. Some live close to the bottom. They are demersal. Other species swim in the open water column and are called pelagic. There are also species that live near the bottom, but rise into the water column to hunt for food. These are benthopelagic species.

It is amazing that special biological communities have developed in the deep sea in spite of the darkness. Most of them have only been superficially investigated and biologists are constantly discovering new species that have not yet been described. In recent years researchers have been focussing on cold-water corals in particular, as well as the ecosystems around seamounts and at deep-sea hydrothermal vents and cold seeps. The great biological diversity discovered here was completely unexpected because the deep sea had long been considered to be a dead and muddy desert. The species diversity in the deep sea was sensational for researchers.

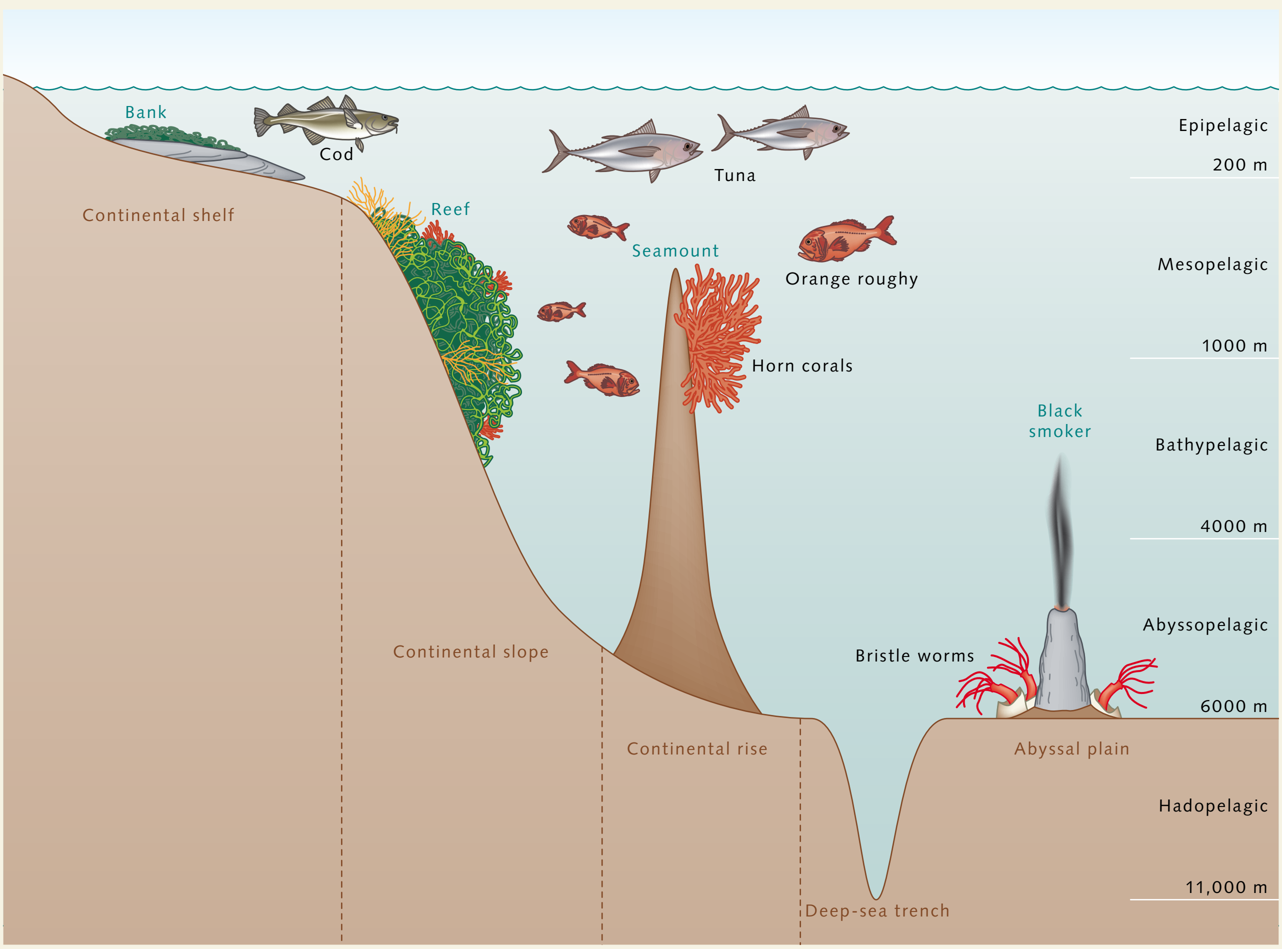
Seamounts

Seamounts are underwater mountains that are formed by volcanic activity and rise at least 1000 metres above the

Depth zones of the ocean

The ocean is divided into different depth zones. The epipelagic extends from the water surface down to a depth of 200 metres. The word comes from the Greek terms *pélagos* (open sea) and *epí* (upon). This upper layer, which is influenced by light, is especially productive because the primary producers (algae, cyanobacteria and seagrass) produce biomass here through photosynthesis. This primary production is the foundation of life in the sea.

Below the epipelagic zone lies the mesopelagic, extending down to around 1000 metres (Gr.: *mésos* = middle). Below this, the bathypelagic zone encompasses depths from 1000 to 4000 metres (Gr.: *bathýs* = deep). Many deep-sea species live within this zone, including fish, crustaceans and snails. And even deeper, between 4000 and 6000 metres, lies the abyssopelagic (Gr.: *ábyssos* = bottomless), where the prevailing temperatures are near the freezing point. Even here specialized animal species can be found, including crustaceans. The deepest regions of the sea are called hadopelagic (Gr.: *hades* = underworld). The hadopelagic extends into the deep-sea trenches, down to a depth of 11,000 metres. The inhabitants of this deepest marine region include bristle worms. The ambient pressure here is around 1000 times greater than at the water surface.



3.13 > The depth zones in the ocean. Diverse habitats such as black smokers or cold-water coral reefs have formed in these zones. Where different species settle depends on the depth and structure of the sea floor among other factors.

sea floor. Some are 3000 or even 4000 metres high. Their peaks often rise up into the upper layers of the mesopelagic zone. Seamounts can be regarded as islands or volcanoes that do not reach up to the sea surface. It was long believed that these were rare occurrences. Today it is known that seamounts are present in all oceans. The total number is estimated in the thousands.

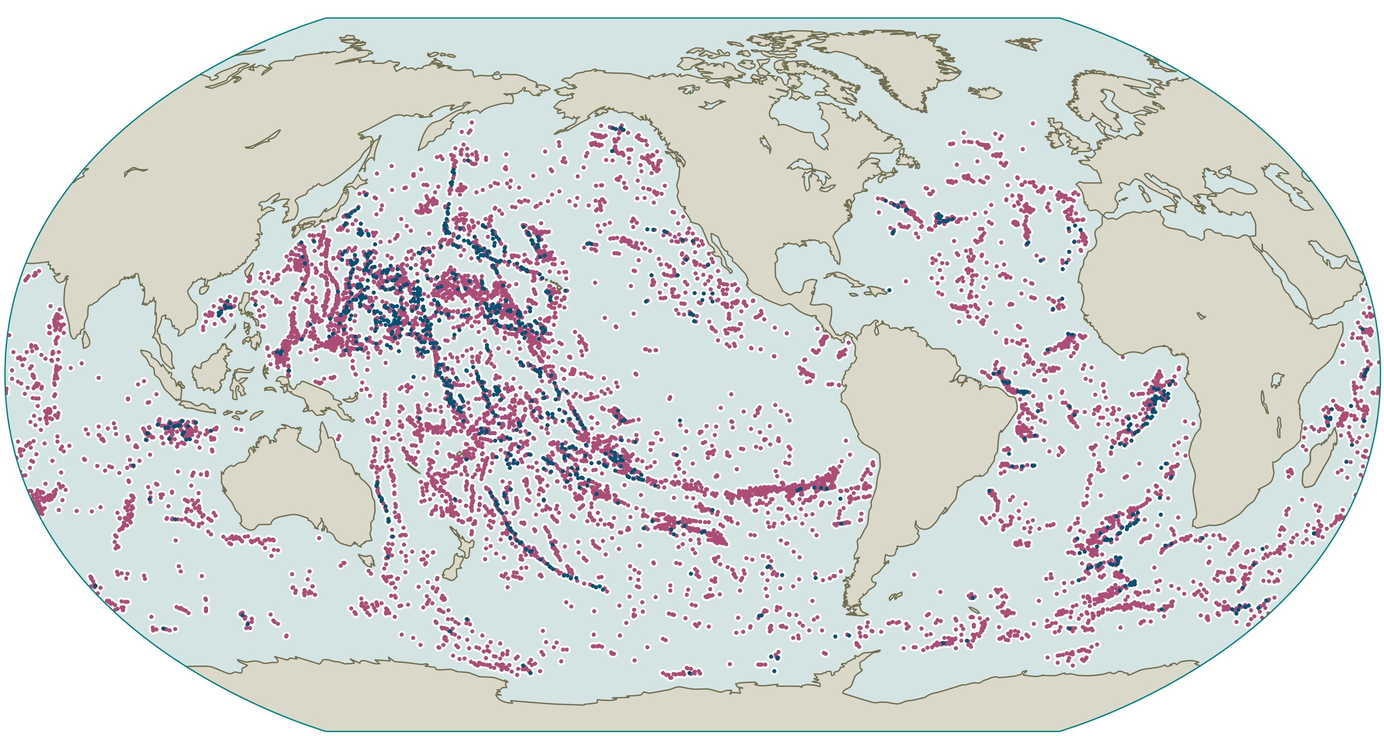
Research has shown that some seamounts are home to communities of unique, **endemic** species. These include lower animals like sponges and sea cucumbers, relatives of the starfish, but also vertebrates such as fish, which can occur in large schools around seamounts with high species diversity. This makes the seamounts especially interesting for fisheries.

There are still many unanswered questions regarding the significance of seamounts. Many scientists believe that seamounts act like gigantic stirring rods in the ocean, where small-scale eddies break off from the large ocean currents. It is presumed that nutrients and dead plant and animal remains from the epipelagic are trapped in these eddies and attract fish. That would be a logical explanation for the high diversity at seamounts and the sometimes very high fish densities. It is also known that migratory birds on their transoceanic flights and large predatory fish like sharks commonly hunt and feed in marine regions with seamounts.

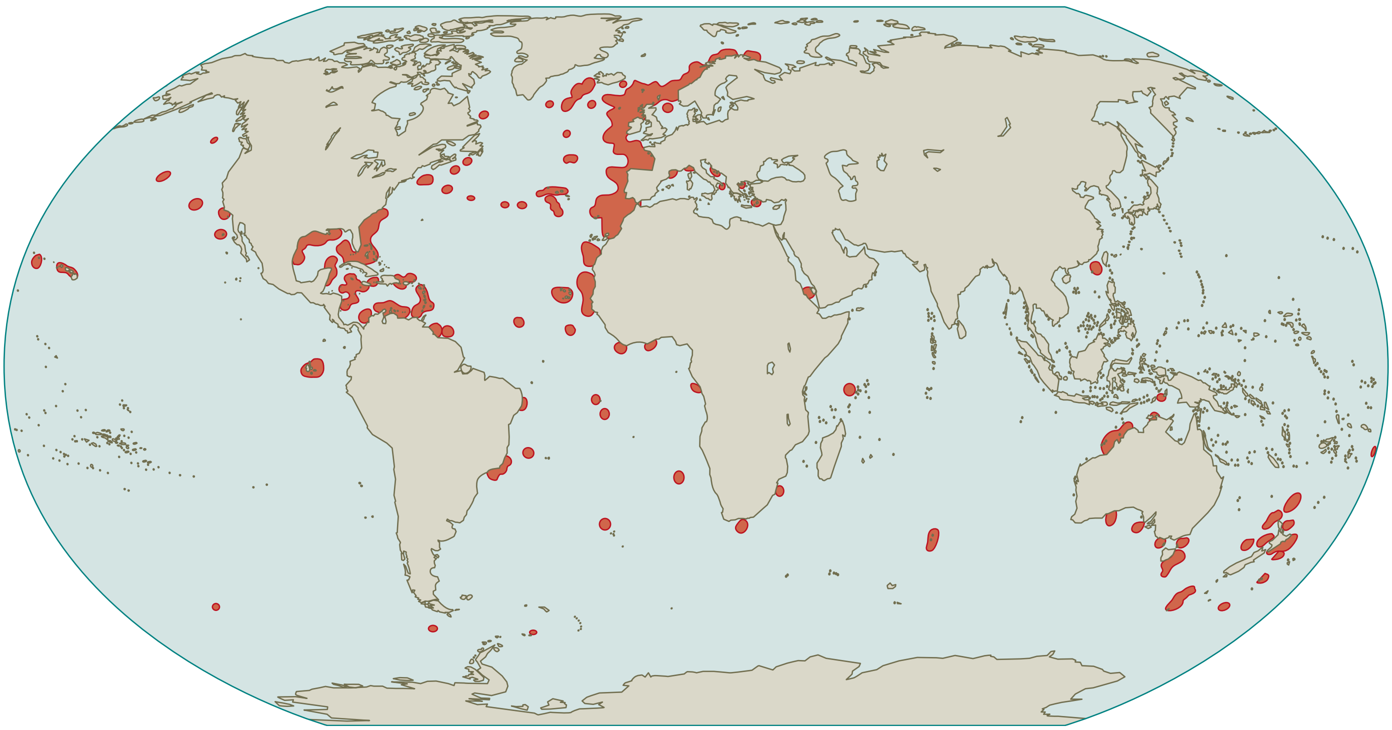
Furthermore, sharks apparently use seamounts as geomagnetic orientation points and sometimes mate there in large groups. Elsewhere, bigeye tuna may converge to hunt among the dense schools of prey fish. An example of this hunting is seen in eddies over the Hawaiian seamounts.

Cold-water corals

Corals usually evoke a mental picture of idyllic South Sea Islands, white palm beaches and swarms of colourful luminescent fish darting through clear waters suffused with light. Actually, however, some coral species also live in cold, deep water layers. They occur primarily in the Atlantic, off the coast of Norway or northwest of Ireland, but they are also found in the Pacific near Australia and New Zealand.



3.14 > Seamounts are commonly located at volcanic structures such as the ocean ridges, and sometimes form long chains along the sea floor. Seamounts with a height between 1000 and 3000 metres are marked in red, those higher than 3000 metres in blue.



3.15 > **Cold-water corals occur worldwide. They can even flourish at depths of 2000 metres.**

It has been known for centuries that there are corals living in deeper waters because fishermen have often found pieces of them in their nets. Until 20 years ago, however, no one had any idea of the areal extent of cold-water coral reefs. While searching for an ideal route for a pipeline in 1982, workers for the Norwegian energy company Statoil discovered large populations of the cold-water coral *Lophelia pertusa*. The underwater photographs caused a sensation at the time.

Today it is known that the Norwegian coral reef has an area of around 2000 square kilometres and, in terms of size, exceeds even the warm-water coral reefs in the diving grounds of the Seychelles. A great number of rare and even unique species live on the Norwegian coral reef. Furthermore, these reefs serve as a nursery ground for fish, providing an effective retreat and protection area for the offspring.

The term "cold-water coral" does not refer to a particular species. It includes around 1000 species that thrive in cold water at temperatures between 4 and 12 degrees Celsius. Many of them occur in the mesopelagic zone between 200 and 400 metres of water depth. Some species, such as the Antarctic deep-sea coral *Flabellum impensum*, can live at depths down to 2000 metres – at a water temperature of around 1 degree Celsius.

Hydrothermal vents and cold seeps on the sea floor

Hydrothermal vents on the sea floor are found primarily in regions of volcanic activity, most commonly in areas where continental plates drift apart. **Mid-ocean ridges** have formed at these plate boundaries over thousands of years as fresh magma continuously rises from the Earth's interior. They have built up over time to form high mountain chains thousands of kilometres long. Water seeps 2 to 3 kilometres down into the Earth's crust through fractures and cracks in the rocks and is heated by the magma chambers. Because the heated liquid has a lower density, it rises again. At some locations minerals stain the water black. For this reason the vents are also called black smokers. The minerals are an elixir for bacteria, primary producers that generate biomass. Experts refer to this process as chemosynthesis, an allusion to the photosynthesis carried

Reefs
Reefs are narrow, elongated elevations on the sea floor. Coral reefs are composed of the carbonate skeletons of corals, which have built up to form reefs several metres high over thousands of years. Mussels can also build reefs. In addition, there are reef-like sand banks and rocky reefs.

Exclusive economic zone
The Exclusive Economic Zone (EEZ) is also referred to as the 200-nautical-mile zone. Here, coastal states have sovereign rights to the exploration and exploitation of living and non-living resources. This includes the exclusive use of fish stocks in one's own EEZ. Furthermore, within its own EEZ a state may erect offshore drilling rigs or wind farms.

out in sunlight. The bacterial biomass provides the foundation for higher life forms. The black smoker sites are also populated by shrimp, fan-shaped gorgonian corals, or tube worms.

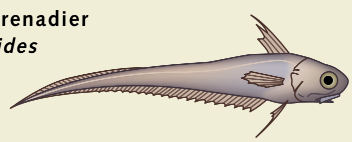
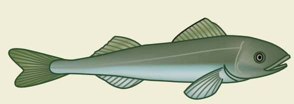
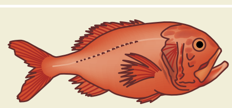
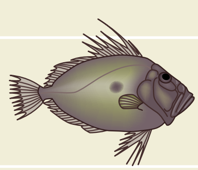
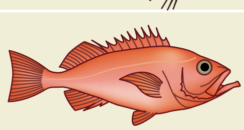
Today there are around 300 known black smoker sites worldwide. Most of them are in the Pacific. There are, however, almost no commercially important fish species living in these extreme habitats. It has only been known for a few years that cold seeps in the deep sea are special and important habitats. Cold nutrient-rich water flows out of the sea floor here.

During an expedition off the coast of Pakistan in 2007 scientists discovered densely populated cold seeps. There are mussel banks, crabs, snails and sea cucumbers. Although experts had long known about heavily populated cold seeps in the Gulf of Mexico, they were believed to be an exceptional case. Actually, however, cold seeps are found in numerous ocean regions. Off the coast of Pakistan, for example, the Arabian continental plate is being pushed beneath the Eurasian plate. In the process, water contained in the sediments is pressed out. It flows back into the ocean through fissures in the bottom. Substances contained in the water provide nutrition for bacteria and small animals, which in turn become food for higher organisms such as crustaceans.

The fish of the deep sea

In the nutrient-rich and highly productive coastal regions, massive reproduction is typical of many species, and this ensures their survival. Many deep-sea fish species, on the other hand, are characterized by slow growth, late sexual maturity, long life, and the production of fewer offspring. They are adapted to life at great depths, to a habitat in which unchanging environmental conditions prevail. The strong temperature fluctuations that can impact the repro-

3.16 > Many fish species of interest to fisheries occur in the deep water layers. Some do not reach sexual maturity until a relatively late age.

Species	Habitat	Age at sexual maturity	Maximum age
Roundnose grenadier ***(Coryphaenoides rupestris)*** 	Continental slope and sea floor; Northern Atlantic; 600–800 m	10	54
Sablefish ***(Anoplopoma fimbria)*** 	Continental slope and sea floor; Northern Pacific; 300–2700 m	5	65
Orange roughy ***(Hoplostethus atlanticus)*** 	Seamounts and banks; Atlantic, parts of the Pacific; 180–1800 m	20–40	>100
Smooth oreo dory ***(Pseudocyttus maculatus)*** 	Seamounts and banks; Southern Atlantic and Pacific; 400–1500 m	20–30	100
Pacific ocean perch ***(Sebastes alutus)*** 	Seamounts and banks; Northern Pacific; 180–640 m	10	100

duction of fish in shallow coastal regions are absent here. However, the deep sea is not as rich in nutrients as the coastal waters. The carrying capacity is almost exhausted and competition for food is great. Most species have therefore adapted by producing fewer, but highly competitive offspring. This reproduction strategy is called K-strategy (K refers to the carrying capacity of the environment). There is a high parental investment in the offspring. The eggs of many deep-sea fish are relatively large and rich in nutrients so that the larvae have a good chance of developing well.

One example of this is the deep-sea orange roughy *(Hoplostethus atlanticus),* which does not reach sexual maturity until the age of around 25 and can live to be 125 years old. The orange roughy lives at seamounts and builds up very large stocks over time. These fish grow slowly and can survive periods of scarce food supply. Furthermore, thanks to the long life expectancy of the individual fish, the stock can compensate for times of low offspring production. Fish species of the K-strategy type are especially threatened by deep-sea fisheries. When the older fish are continuously removed by fishing, at some point there will be too few sexually mature animals remaining to sustain the population.

However, not all fish living in the deep sea are K-strategists. The blue whiting *(Micromesistius poutassou),* for example, occurs on the continental slopes at depths from 100 to 1000 metres. It is, however, a species that produces great numbers of offspring. The reason for this is that the immature fish spend most of their time in the shallow shelf areas in water depths around 100 metres, where there are numerous predators and food competitors. Massive reproduction is therefore the ideal strategy for the blue whiting.

Fisheries in the deep sea

Commercial fishing has only been carried out in deep waters over the past few decades. Although longline fishing has been practised since the 18th century, industrial fishing far out in the ocean first became practicable in the 1950s with the availability of seaworthy refrigeration ships. Deep-sea fishing received a boost in the early 1970s with the introduction of the 200-nautical-mile zone, or Exclusive Economic Zone, which made it impossible for foreign ships to fish close to the coasts of another country. The high seas, including the deep sea, were an alternative fishing area. The Soviet Union and Japan in particular were soon specializing in the deep-sea regions. In the beginning the catch amounts were enormous – especially around structures such as seamounts and banks.

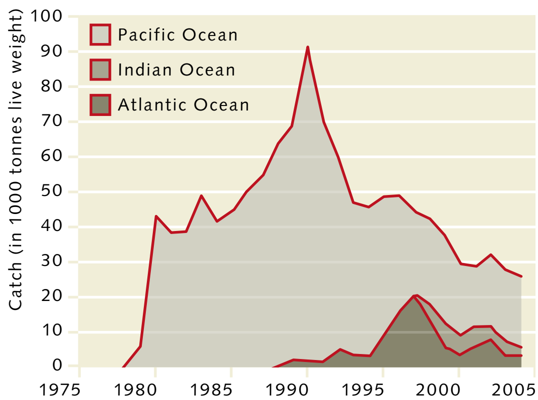
To the extent that fish stocks were gradually shrinking in the coastal areas, deep-sea fishing became increasingly interesting for other countries as well. According to a survey by the FAO, there were 27 countries conducting deep-sea fishing in the year 2008, with Spain, South Korea, New Zealand and Russia at the forefront. Around 70 per cent of the ships employ trawl nets, and these are often demersal-trawl nets. Today these can be deployed to a depth of 2000 metres.

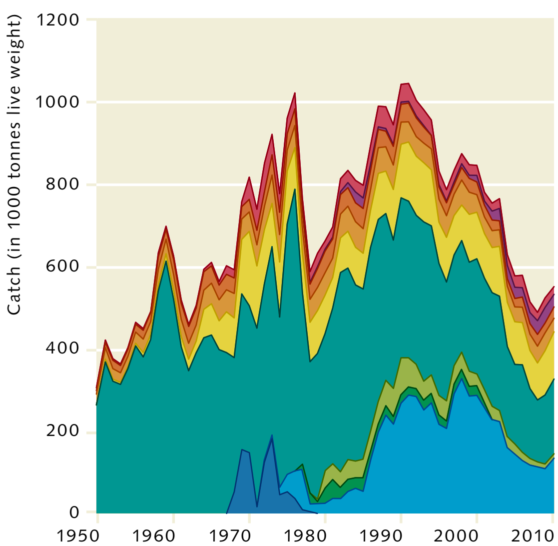
It soon became obvious that deep-sea fishing is problematic in two respects. For one, valuable habitats such as cold-water corals or the ecosystems at seamounts are destroyed when nets come in contact with the bottom. Secondly, fish species are quickly decimated, particularly

3.17 > The orange roughy lives at depths down to 1800 metres.

High seas
The "high seas" are the areas of the ocean to which all states have free access. No country may claim sovereignty over any part of the high seas. The high seas, where freedom of navigation, research and fishery are internationally recognized, begin at the boundary of the 200-nautical-mile zone. Much of the deep-sea region lies outside the EEZ, and is therefore part of the high seas. All nations have the right to exploit fish stocks there.

3.18 > The catches of many deep-sea fish, like the orange roughy shown here, declined rapidly within just a few years because of overfishing.





3.19 > Over the years, the total catches of deep-sea fisheries have remained high. However, this was only possible because new species have replaced the overfished stocks of other species. The figure shows the total amounts for different species in each year. An example of overfishing of a deep-sea species is provided by the armourhead, which had been fished by Japanese and Russian trawlers at Pacific seamounts since the 1960s. Within 10 years the stocks were so strongly reduced that the species was commercially depleted and abandoned by fisheries.

the K-strategists. For example, newly discovered stocks of orange roughy were reduced to 15 to 30 per cent of their original size within just 5 to 10 years. In many areas the species was commercially depleted. This "boom and bust" kind of fishery is typical in the pursuit of deep-sea fish species. The reason for this is that species like the orange roughy not only produce a small number of offspring, their reproductive performance is also very erratic and episodic. Several years can pass with low production of offspring before a strong season occurs again. It is still not known what controls or triggers these fluctuations. Investigations at the Great Meteor Seamount west of Madeira have indicated an influence of changes in the winds affecting eddy currents above the seamount.

It is a certainty that the deep-sea species cannot compensate for heavy fishing activity. Deep-sea fishing is also both ecologically and economically questionable. For one thing, it is very destructive, and for another the catch levels are relatively low because most deep-sea fish stocks are comparatively small due to their K-strategy. Thus, taken as a whole, the deep-sea fisheries represent only a small proportion of the worldwide catch amounts. Basically they can only be maintained because of the high subsidies, since the costs for fuel are high for the great distances ships often have to cruise out.

Again and again over the years, new species that previously were not considered by fisheries have become interesting, usually to replace species that were overfished. The pursuit of various species of *Sebastes* is a striking example of the substitution of an overfished species by a new one. The total catch has dropped since the 1970s, but it has still remained at a comparatively high level. This has been possible because new species have been targeted.

In the northeast Atlantic, starting in the 1950s, *Sebastes marinus* (golden redfish) was initially caught. In 1980 it still made up more than 40 per cent of the catch of *Sebastes* species. But then the stocks declined. In the 1990s *Sebastes marinus* made up less than 20 per cent of the total catch of *Sebastes* species in the northeast Atlantic. In lieu of *Sebastes marinus*, fishing of the Greenland stocks of *Sebastes mentella* (deepwater redfish) intensified. In this region the species is mainly demersal. As these Greenland stocks shrank, the focus shifted to the more pelagic-living *Sebastes mentella* stocks in the open Atlantic. Due to restraints on fishing, it has been possible for some time now for the *Sebastes mentella* stocks off Greenland to recover.

Destruction of unique habitats

Many species of deep-sea fish build up large stocks, especially at structures like seamounts, banks and cold-water coral reefs. Fishing for these species represents a potential threat to the environment, especially when demersal trawls are used that can destroy fragile corals. The prob-

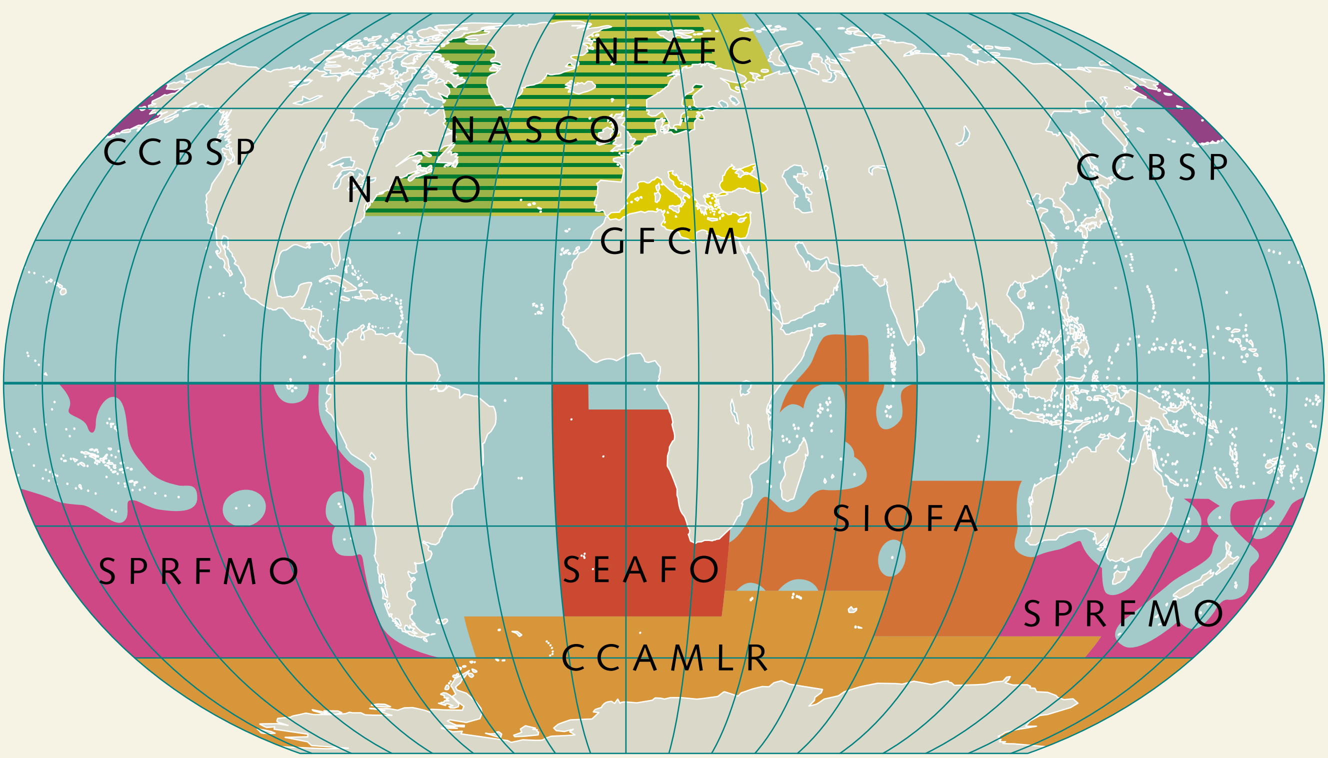
3.20 > In Norway's Trondheimsfjord the red bubble gum coral *(Paragorgia arborea)* occurs beside the white stony coral *Lophelia pertusa.* There are around 1000 cold-water coral species worldwide.

Catching fish in international waters

The fish catch in international waters outside the EEZ is regulated by the Regional Fisheries Management Organizations (RFMOs) and their member countries. These members include not only the bordering states, but also countries that are heavily involved in fishing in a given marine region. For example, China and Japan also fish in the northeast Atlantic. This is consistent with international maritime law and completely legitimate according to the principle of freedom of access to the high seas. The European countries, in turn, are represented in numerous RFMOs through the European Commission. Annual negotiations are held to determine which countries are allowed to catch how much of a species. Almost all commercially relevant fish species are covered by the RFMOs.

There are specific RFMOs for the management of certain fish species, for example, salmon and pollock. The catch of highly migratory species, above all tuna, is also regulated by special RFMOs. In these, the countries that carry out tuna fishing are represented as are the bordering and coastal states whose Exclusive Economic Zones are adjacent to the fishing ground. This also takes into consideration the fact that tuna, in contrast to most fish species, do not live in geographically defined stocks. Sharks are covered, in part, as a subgroup of the ICCAT.

There are only a few remaining marine regions today that are not supervised by RFMOs, or that are insufficiently supervised due to a political situation. These include the Indian Ocean around the Horn of Africa. Although the area is covered by the IOTC, fishing cannot be regulated due to piracy. Illegal, unreported and unregulated fishing (IUU fishing) is common there. The Arctic, on the other hand, is not yet managed by RFMOs because fishing there is rare. With the growing worldwide demand for fish, however, this region could become more interesting for fisheries in the future.



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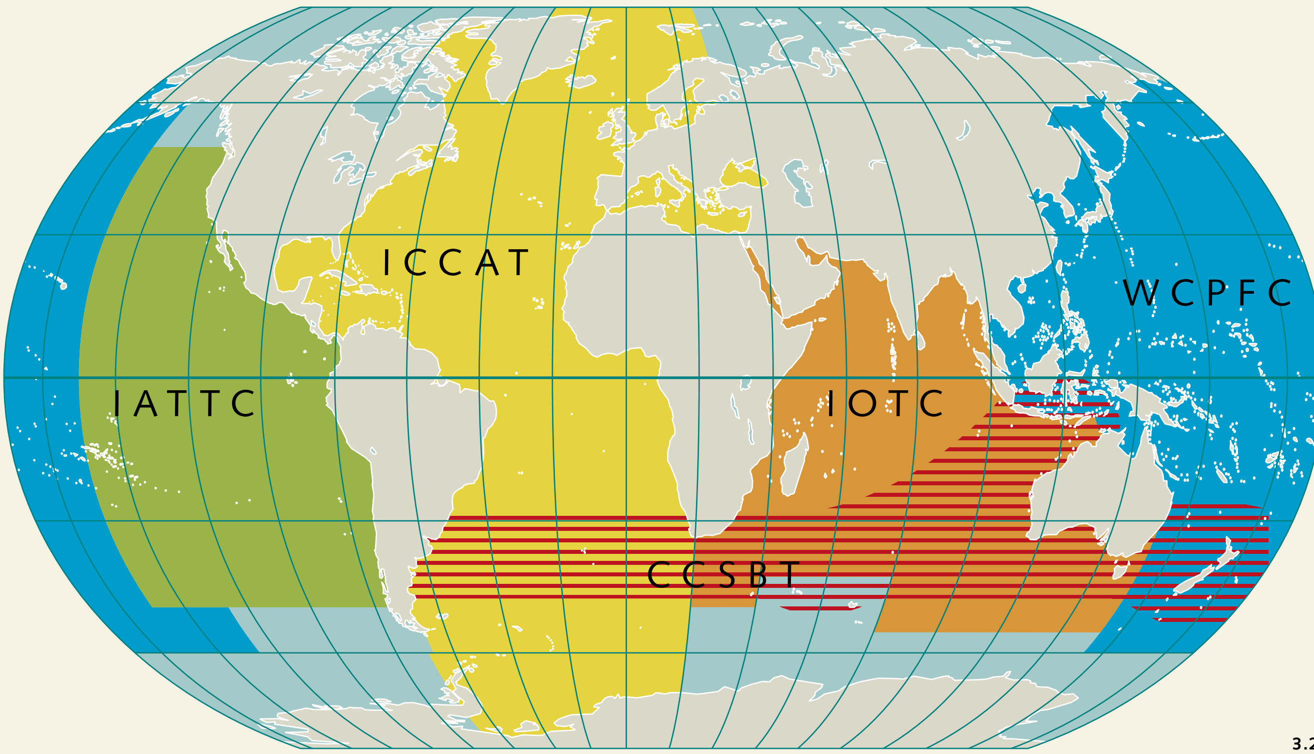


3.22

3.21 > RFMOs that manage fish stocks by region:

- North East Atlantic Fisheries Commission (NEAFC)
- Northwest Atlantic Fisheries Organization (NAFO)
- North Atlantic Salmon Conservation Organization (NASCO)
- South East Atlantic Fisheries Organisation (SEAFO)
- South Indian Ocean Fisheries Agreement (SIOFA)
- South Pacific Regional Fisheries Management Organisation (SPRFMO)
- Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)
- General Fisheries Commission for the Mediterranean (GFCM)
- Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea (CCBSP)

3.22 > RFMOs that manage highly migratory fish species, mainly tuna:

- International Commission for the Conservation of Atlantic Tunas (ICCAT)
- Indian Ocean Tuna Commission (IOTC)
- Western and Central Pacific Fisheries Commission (WCPFC)
- Inter-American Tropical Tuna Commission (IATTC)
- Agreement on the International Dolphin Conservation Program (AIDCP)
- Commission for the Conservation of Southern Bluefin Tuna (CCSBT)

3.23 > Rockall, off Ireland. At its base is a marine area considered to be one of the most species-rich and deserving of protection in the northeast Atlantic.

lem is that corals grow very slowly, usually only a few millimetres each year. So it can take decades for the habitats to recover. Studies at several neighbouring seamounts off Tasmania have shown that 43 per cent of the species were previously unknown and thus could be unique. In areas where demersal trawls were used, the total number of species was diminished to 59 per cent of the original number. 95 per cent of the surface was reduced to bare, stony bedrock. It is thus highly conceivable that endemic species that only exist at a single seamount could be completely exterminated.

Is it possible to protect the deep sea?

In 2008, in response to the growing knowledge that deep-sea habitats are especially threatened by fisheries, the FAO established the International Guidelines for the Management of Deep-sea Fisheries in the High Seas. These guidelines are not legally binding. They do, however, contain clear recommendations for the protection of fish species that are vulnerable to overfishing. They relate to methods by which the fishing gear comes into contact with the sea floor. These guidelines, by definition, should regulate protection in international waters outside the Exclusive Economic Zone (EEZ), where freedom of the seas and fishing is recognized. The FAO refers to areas deserving protection as vulnerable marine ecosystems (VMEs). In addition to banks, seamounts and cold-water coral areas, these include large species-rich sponge communities as well as densely populated undersea hydrothermal vents and cold seeps. The following criteria are used to determine whether a marine area is given the status of a VME:

1. UNIQUENESS OR RARITY:
Ecosystems that are unique or contain rare species. The loss of the ecosystem cannot be compensated for by similar ecosystems. These include: habitats with endemic species, habitats with endangered species, breeding or spawning areas.

2. FUNCTIONAL SIGNIFICANCE:
Habitats that are important for the survival, reproduction or recovery of fish stocks, or are significant for rare or threatened species, or various development stages of these species.

3. FRAGILITY:
An ecosystem that is highly susceptible to destruction or weakening by anthropogenic activities.

4. SIGNIFICANCE FOR SPECIES WITH SPECIAL LIFE-HISTORY TRAITS:
Ecosystems that are characterized by species or assemblages with the following traits: slow growth rates, late sexual maturity, low or unpredictable reproduction, long-lived.

5. STRUCTURAL COMPLEXITY:
An ecosystem that is characterized by complex structures, for example, by corals or isolated rock outcrops. Many organisms are specially adapted to these structures. Such ecosystems often have high diversity.

The designation of an international marine area as a vulnerable marine ecosystem according to the FAO guidelines is decided, as a rule, by the Regional Fisheries Management Organizations (RFMOs). It is the task of the RFMOs to apportion the catch of fish stocks or individuals of migrating species such as tuna in their area among the member countries. In addition, they are responsible for ensuring that the protection measures and catch limits are complied with. RFMOs develop management plans and announce sanctions in cases of non-compliance. Critics claim that many fish stocks in areas managed by the RFMOs are still not fished with sufficient restraint, and that vulnerable areas are not adequately protected.

A number of regional fisheries management organizations have now placed certain VMEs within their areas under special protection, particularly those at several seamounts off southwest Africa. Fishing is either completely banned there or demersal trawl fishing is prohibited. Pelagic fish that swim in the upper water layers may still be fished. Fishing for demersal species, however, which live near the bottom, is halted. There are other protected areas with VMEs northwest of Ireland, including Hatton Bank and the Rockall Bank, which is several hundred kilometres long. Here the responsible RFMO has established Marine Protected Areas (MPAs), whose primary objective is to protect overfished stocks. The relatively small vulnerable marine ecosystems are located within these much larger MPAs. Demersal trawl fishing has been banned here to protect the cold-water corals.

Incidentally, one of the first protected areas in VME terms was established long before the FAO published its guidelines. In 1995, after the publication of studies on the devastating effects of demersal trawl fishing at seamounts, the Australian government established a deep-sea protected area of 370 square kilometres on the continental slope off Tasmania. There are 15 seamounts here and large stocks of orange roughy. The objective was to protect slow-reproducing fish species as well as their vulnerable habitats on the sea floor. The Australian officials only allow fishing down to a depth of 500 metres. This should prevent the overfishing of deep-sea fish and the fragile bottom from net contact. With this decision the Australian officials were more than 10 years ahead of their time and the FAO guidelines. On the other hand, in the region south of Tasmania there are a total of 70 seamounts and only 15 are protected. The question of whether the protected area is large and representative enough to preserve all of the species indigenous to the Tasmanian seamount region is still being discussed today.

The FAO guidelines for deep-sea fishing on the high seas were developed to protect vulnerable habitats in international waters. Of course, they also apply to equivalent deep-sea areas inside national waters that fulfil the criteria for a VME. In this respect, the guidelines are also an important orientation point for the countries themselves. Many nation-states have now designated valuable areas as VMEs and placed them under special protection. Norway, for example, protects parts of its cold-water coral regions in this way. Critics claim, however, that the extent of these areas is far from sufficient to preserve the full diversity of the cold-water coral systems.

Species and genus
A species is designated by a two-part name. The first part (for example, *Sebastes*) indicates the genus. Usually many closely related species belong to one genus. The second part indicates the species *(marinus)*. Although species can often be very similar to one another, such as, in birds, the blue tit and great tit, they still remain clearly separated, either by a large distance (continent) or because they no longer interbreed. Around 100 species belong to the genus *Sebastes*.

Illegal fishing

> In many maritime regions of the world, illegal fishing has massively contributed to the depletion of fish stocks, especially in developing countries' coastal waters. Better international cooperation to control fishing vessels is now being launched. The aim is to eliminate illegal fishing in future.

Unscrupulous fishing worsens the problems

Nowadays, the world's fish stocks are not only under threat from intensive legal fishing activities; they are also at risk from illegal, unreported and unregulated (IUU) fishing. It is difficult to estimate precisely the total catch from pirate fishing. Researchers are engaged in the painstaking process of collating data from various countries' fisheries control agencies, experts' estimates, trade figures and the findings of independent research expeditions in order to arrive at an approximate figure for the total IUU catch. As this is a black market, however, estimates are bound to be unreliable. Some experts put the annual figure at around 11 million tonnes; others suggest that it may be as high as 26 million tonnes – equal to 14 or 33 per cent respectively of the world's total legal catch (fish and other marine fauna) in 2011. These catches are additional to the world annual catch of fish and other marine fauna, currently 78.9 million tonnes.

For many years, however, too little account was taken of IUU fishing in estimates of fish stocks. This is problematical, for unless the IUU share is factored into the calculations, the legal catch quotas for a given maritime region cannot be determined correctly. Based on the assumption that less fish is being caught than is in fact the case, experts overestimate the size of the stock and set the following year's catch quotas too high, potentially entrenching and accelerating the overexploitation of the stock.

IUU fishing also exacerbates the problem of overfishing because IUU vessels even operate in marine protected areas where a total fishing ban has been imposed. It also pays little or no heed to fisheries management plans which are intended to conserve overexploited or depleted stocks.

However, the main reason why IUU fishing is a particularly critical issue today is that many fish stocks have already been overexploited by legal fishing activities. IUU fishing therefore puts fish stocks under additional pressure. If stocks were being managed sustainably, on the other hand, IUU fishing would no longer exacerbate an already difficult situation to the extent that it does today.

The Food and Agriculture Organization of the United Nations (FAO) defines three categories of IUU fishing:

ILLEGAL FISHING refers to fishing activities conducted by foreign vessels without permission in waters under the jurisdiction of another state, or which contravene its fisheries law and regulations in some other manner – for example, by disregarding fishing times or the existence of the state's protected areas. For example, some IUU vessels operate in waters under the jurisdiction of West African states. As these countries generally cannot afford to establish effective fisheries control structures, the IUU vessels are able, in many cases, to operate with impunity.

UNREPORTED FISHING refers to fishing activities which have not been reported, or have been misreported, by the vessels to the relevant national authority. For example, some vessels harvest more tonnage than they are entitled to catch under official fishing quotas. In 2006, for example, several Spanish trawlers were inspected by the Norwegian Coast Guard near Svalbard (Spitsbergen). The trawlers were found to hold not only the reported catch of headed and gutted cod but also a total of 600 tonnes of cod fillets which had not been reported to the Norwegian authorities. The Norwegian authorities subsequently imposed fines on the Spanish trawler company equivalent to 2 million euros.

3.24 > A chase at sea near South Korea: an entire fleet of illegal Chinese fishing vessels attempts to evade the South Korean Coast Guard. The fishermen were arrested by armed units soon afterwards.

UNREGULATED FISHING refers to fishing activities in areas where there are no applicable management measures to regulate the catch; this is the case in the South Atlantic, for example. The term also applies to fishing for highly migratory species and certain species of shark, which is not regulated by a Regional Fisheries Management Organization (RFMO). And finally, the term applies to fishing activities in international waters in violation of regulations established by the relevant RFMO.

Although unregulated fishing is not in fact illegal under the law of nations applicable to the high seas, it is nonetheless problematical. It results in additional fish being caught over and above the maximum catches agreed by RFMO member states for their respective regions. As a result, fully exploited stocks can easily become overexploited. Furthermore, IUU fishermen often ignore the existence of marine protected areas established by the Regional Fisheries Management Organizations to support the recovery of overexploited stocks.

Why does IUU fishing exist?

From the fishermen's perspective, IUU fishing is highly attractive as they pay no taxes or duties on these catches. A further reason why IUU fishing takes place on such a large scale is that it can often be practised with impunity. This is mainly the case in the territorial waters or exclusive economic zones of countries which cannot afford to set up costly and complex fisheries control structures such as those existing in Europe.

The situation is especially difficult in the developing countries. In a comprehensive analysis of IUU fishing worldwide, researchers conclude that IUU fishing is mainly practised in countries which exhibit typical symptoms of weak governance: large-scale corruption, ambivalent legislation, and a lack of will or capacity to enforce existing national legislation.

The Sub-Regional Fisheries Commission (SRFC), comprising seven member states in West Africa (Cape Verde,

3.25 > Transshipment is typical of IUU fishing. As seen here off the coast of Indonesia, smaller fishing vessels transfer their illegally caught fish onto larger refrigerated transport ships (reefers). The fishing vessels are restocked with fuel and supplies at the same time, enabling them to remain at sea for many months.

Gambia, Guinea, Guinea-Bissau, Mauritania, Senegal and Sierra Leone), has produced a detailed list of the various causes of IUU fishing:

- There are insufficient and inadequately trained personnel in the relevant authorities.
- The authorities' motivation to invest in relevant personnel is poor. Financially weak states set other priorities.
- Salaries are low, and vessel owners take advantage of this situation to make irregular payments to observers/ fisheries administrators to cover up their activities.
- The purchase, maintenance and operational costs of patrol boats and aircraft are very high. For effective control, there must be sufficient time spent out at sea or in the air. However, in some states, even though they are available, they are not operational due to logistical problems – lack of fuel, proper maintenance regime, etc.

Where does IUU fishing take place?

The situation off the coast of West Africa is particularly critical. Here, IUU fishing accounts for an estimated 40 per cent of fish caught – the highest level worldwide. This is a catastrophe for the region's already severely overexploited fish stocks. Confident that as a rule, they have no reason to fear any checks by fisheries control agencies or prosecution, some IUU vessels even fish directly off the coast – in some cases at a distance of just one kilometre from the shore. A similar situation exists in parts of the Pacific. Indonesian experts report that it is extremely difficult to track the whereabouts of IUU vessels around the country's islands and archipelagos. The volume of the illegal catch here is correspondingly high, amounting to 1.5 million tonnes annually. The Arafura Sea, which lies between Australia and Indonesia, is also very severely affected. After West Africa, the Western Central Pacific Ocean is the region with the highest rate of IUU fishing worldwide. In the Western Pacific, IUU fishing accounts for 34 per cent of the total catch.

A similar situation exists in the Northwest Pacific Ocean, especially in the West Bering Sea. Here, IUU fishing is mainly practised by China and Russia and amounts to 33 per cent of the catch.

Figures for the Southwest Atlantic are unreliable, but experts estimate that IUU fishing here amounts to 32 per cent.

What's the catch?

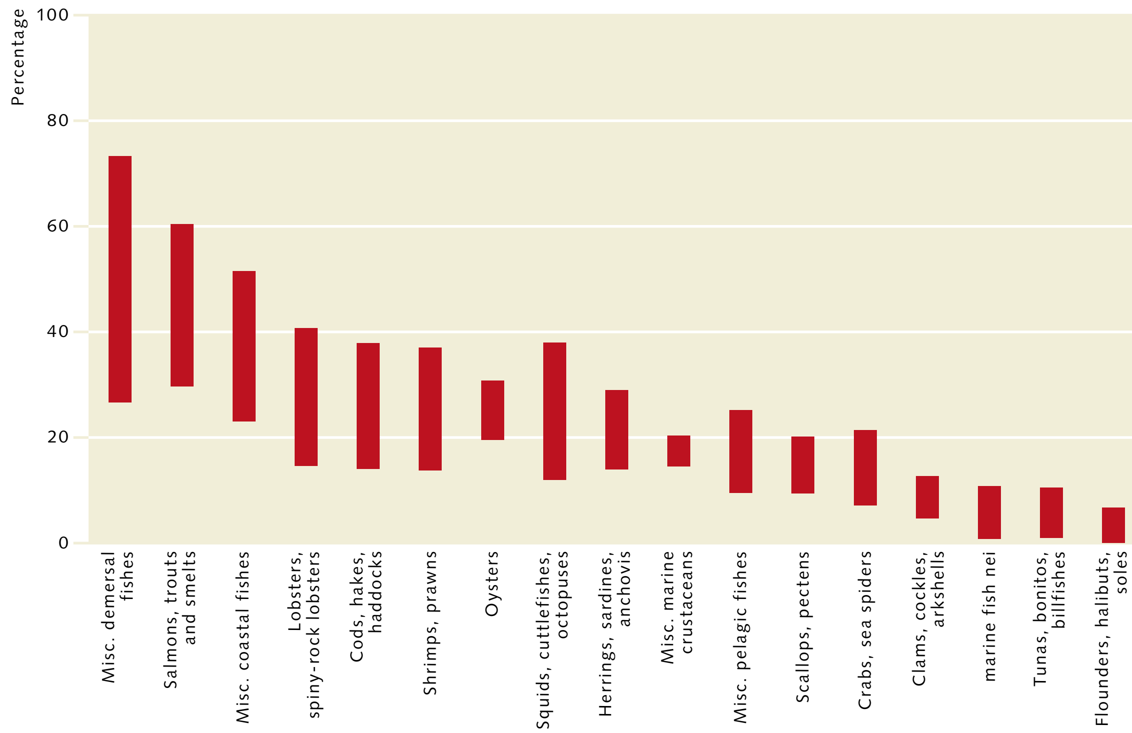
IUU fishing often targets high-value demersal species (i.e. those which live and feed on or near the bottom of the sea) such as cod, as well as salmon, trout, lobster and prawns. It is mainly interested in species which are already overexploited by legal fishing or which are subject to restrictions for fisheries management purposes. As these species can only be traded in small quantities, demand and prices are high – making this a lucrative business for IUU fishermen.

Too many loopholes

Combating illegal, unreported and unregulated fishing at sea is generally extremely expensive and very complex. Affluent countries such as Norway can afford to enforce stringent controls in the waters under their jurisdiction and deploy a large fleet of vessels and a great many personnel for this purpose. An effective and possibly less costly alternative is to carry out rigorous checks in port. However, this only helps to curb IUU fishing if all ports cooperate.

In the European Union (EU), regulations in force since 2008 and 2009 contain uniform provisions on the type of controls to be carried out in EU ports. Since then, it has become very difficult for IUU vessels to land their catches in EU ports.

Nonetheless, there are still ports in other regions where IUU fishermen can land their illegally caught fish with no repercussions. Here too, it is mainly the developing countries, with their absence of controls, which are particularly suitable for illegal transshipment. However, examples such as the Spanish trawlers near Svalbard



3.26 > Different species groups (fish and other marine fauna) are affected by IUU fishing to varying degrees. One particular study has shown that from 2000 to 2003, IUU fishing mainly targeted demersal species (i.e. those which live and feed on or near the bottom of the sea). The figure shows the illegal and unreported catch, as a percentage of reported catch, by species group.

show that even fishermen from EU countries are not immune to temptation and that the prospect of a healthy profit may persuade them to fish illegally.

The problem is exacerbated by the fact that not every IUU vessel needs to put into port in order to land its catch immediately. In many cases, especially off the coast of West Africa, the smaller fishing vessels load their catch onto larger refrigerated ships (known as reefers) while at sea. During this transshipment, fishermen on board are also resupplied with food and fuel, enabling them to remain at sea for many months.

The Sub-Regional Fisheries Commission (SRFC) concludes that some IUU vessels off West Africa are in operation 365 days of the year, putting massive pressure on fish stocks. The refrigerated ships then make for ports in countries with lax controls, enabling them to land their catches unhindered.

The practice of using a flag of convenience (FOC) also makes it easier to engage in IUU fishing activity. Instead of registering the ships in the shipping company's home state, IUU fishers operate their vessels under the flag of another state, such as Belize, Liberia or Panama, with less stringent regulations or ineffective control over the operations of its flagged vessels.

By switching to a foreign register of ships, restrictive employment legislation and minimum wage provisions in the home country can also be circumvented, allowing the shipping companies to pay lower wages and social insurance contributions for their crews than if the vessel were registered in Germany, for example. Furthermore, fisheries legislation in "flag-of-convenience" states is often extremely lax. These countries rarely, if ever, inspect their vessels for illegal catches.

Monitoring of onboard working conditions is also inadequate, and conditions are correspondingly poor. The fishermen work for low wages on vessels whose standards of accommodation are spartan in the extreme, and which rarely comply with the current safety standards applicable to merchant shipping under the International Convention for the Safety of Life at Sea (SOLAS regulations). The Convention contains exact details of equipment that must be available to ensure safety on board.

Combating IUU fishing

Today, IUU fishing is a global problem, with vast amounts of fish being caught illegally. Nonetheless, the worst seems to be over. IUU fishing was at its peak in the mid 1990s. Since then, according to the FAO, it has declined in various maritime regions, partly due to more stringent government controls. In Mauritania, for example, fisheries control structures have been established with support from German development assistance, with ships now being tracked by a satellite-based vessel monitoring system (VMS).

Other countries are now more inclined to comply with the relevant laws and agreements. Poland is a good example. For many years, Polish fishermen were constantly in breach of the EU's quotas for cod fisheries for the eastern Baltic, routinely catching far more fish than the total allowable catch. This was tolerated by the Polish government of the day. With the change of government in November 2007, however, the situation changed, and Poland is now complying with the quotas.

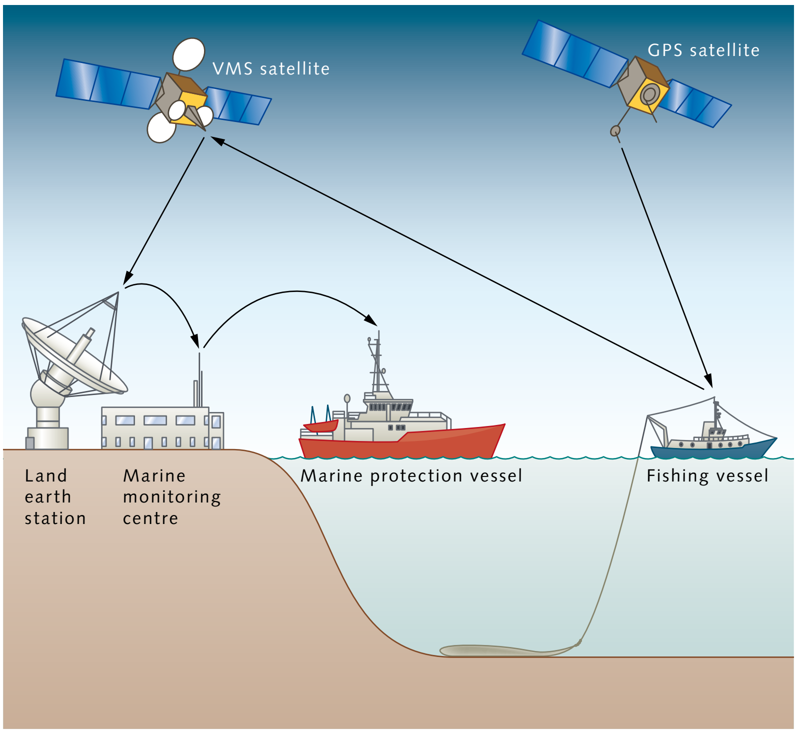
World population growth is likely to drive up the demand for fish even further. IUU fishing will therefore continue to be an attractive option, and can only be curbed with more stringent controls. To that end, controls and sanctions must be coordinated and consistently enforced at the international level. The FAO therefore adopted the Code of Conduct for Responsible Fisheries (CCRF) in 1995, which was endorsed by around 170 member states. Although the CCRF is voluntary and non-binding, a number of countries, including Australia, Malaysia, Namibia, Norway and South Africa, have incorporated some of its provisions into national law. Predictably, IUU fishing has decreased in these regions.

In order to prevent landings of illegally caught fish in the EU, Council Regulation (EC) No 1005 on IUU fishing was adopted in 2008; this was followed by Council Regulation (EC) No 1224 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy in 2009. These regulations describe in precise detail which vessels may land fish in the EU, which specific documents they must produce, and how the catch is to be controlled. The aim is to prevent IUU fishing EU-wide and close any loopholes. The current procedure for landing catches in an EU port is therefore as follows:

A Before the vessel lands its catch, it must provide reasonable advance notice.

B Once the vessel has docked,
- the fishing licence is checked. This includes the vessel's operating licence issued by the flag state and information showing who is authorized to operate the vessel.
- the fishing authorization is checked. This contains detailed information about the vessel's permitted fishing activity, including types of fish, times, locations and quantities.
- the catch certificate is checked. This contains information about the catch currently on board, including where and when it was caught.
- the logbook in electronic format is checked. The master of the vessel must record on a daily basis when and where the fish was caught, and in which quantities.

3.27 > An armed unit of the South Korean Coast Guard arrests Chinese fishermen who have been fishing illegally in South Korean waters. Very few countries can afford such effective fisheries control structures.



3.28 > Nowadays, fishing vessels must be equipped with electronic devices, or "blue boxes", which form part of the satellite-based vessel monitoring system (VMS). The blue box regularly sends data about the location of the vessel to the fisheries monitoring centre (FMC). Vessels are also equipped with GPS transmitters which track the ship's speed and position.

If a ship lacks any of the relevant documentation, it is not permitted to land its catch and must head instead for a port outside the EU. Permission to land the catch is also refused if there are any discrepancies between the figures given in the catch certificate and the daily entries in the electronic logbook. In this case, the fisheries control agency – in Germany, this is the Federal Office for Agriculture and Food – may require vessel monitoring data to be produced. Nowadays, electronic devices, or "blue boxes", are installed on board fishing vessels and form part of the satellite-based vessel monitoring system (VMS). The blue box regularly sends data about the location of the vessel to the fisheries monitoring centre (FMC) responsible for the area where the vessel is currently fishing. If the vessel enters territorial waters or fishing grounds where it is not permitted to fish, the master of the vessel can be prosecuted.

In suspicious cases, the state in which the fish is to be landed may request the VMS data from the state in whose waters the vessel has been fishing. Furthermore, the landing procedure is observed in each EU port. The fisheries control agency checks how much is being landed and which species comprise the catch. Random checks are also carried out periodically. Relevant measures have been agreed by the EU and the other countries belonging to the North East Atlantic Fisheries Commission (NEAFC), including Iceland and Norway, putting this region beyond the reach of IUU fishermen.

The same applies to the Northwest Atlantic, ports in the US, Canada and other member states of the Northwest Atlantic Fisheries Organization (NAFO), such as Denmark, Iceland and Norway.

The example of Mauritania shows that more stringent controls can be introduced to good effect in developing countries as well. VMS-based monitoring of vessels and controls of landings in port have largely eliminated IUU fishing here.

The FAO has been lobbying for many years for stringent and uniform controls worldwide and is a firm advocate of close cooperation among ports. It takes the view that a concerted approach by ports will make it more difficult for IUU fishing vessels to find a port where they can land their catches without fear of repercussions. However, ports derive an income stream from the charges they impose on vessels using their facilities. Ports which are used by a large number of vessels generate very large amounts of revenue, and for some ports, this takes precedence over the protection of fish stocks. Although a draft Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing has existed for a good three years, based on the FAO Code of Conduct, no specific measures to enforce global action have been adopted yet.

A further initiative to combat IUU fishing consists of the blacklists held by the RFMOs. These include details of vessels which have attempted at some point to land IUU fish at an RFMO port. Port and fisheries control authorities regularly refer to these blacklists. This "name and shame" policy is intended to make it even more difficult for IUU vessels to find ports where they can land their catches. However, here too, states must be willing to cooperate in order to combat IUU fishing effectively. As long as the lack of international coordination allows loopholes to exist, IUU fishing will continue.

Conclusion

Slow but steady improvement

More than a quarter of the world's fish stocks are now classed as overexploited or depleted. Since 1950, the world annual fish catch has increased five-fold. In light of these statistics, it has often been claimed in recent years that overfishing will soon empty our oceans. However, the situation is by no means the same in all maritime regions. Although it is often the short-term profits that count, some countries such as Australia, New Zealand and the U.S. are now structuring their fishing industries towards sustainability. Here, the aim is to establish a future-proof fishing industry which yields abundant harvests while maintaining fish stocks.

What is worrying is that much of the information provided by many countries about their fish stocks and catches is still very patchy or inaccurate. As a result, the status of stocks is almost impossible to verify in many cases. In the past, many fishing companies therefore simply continued to fish as before, resulting in overfishing. For the future, then, there is only one solution: where there is a question mark over the future of fish stocks, fishing companies must reduce their catch.

In the past, scientists' recommendations on the total allowable catch (TAC) were often ignored. This situation is now changing to some extent, notably in the USA, although not in the case of tuna: the International Commission for the Conservation of Atlantic Tunas (ICCAT) is still setting larger total allowable catches for high-value and overexploited species of tuna than scientists recommend.

A gradual improvement can be observed in deep-sea fishing. From the 1970s to the 1990s, it was above all the Japanese, Russian and Spanish fleets which penetrated into ever-deeper waters and extended their fishing operations to shoals of fish which inhabit cold-water corals or seamounts (undersea mountains). This was highly problematical for two reasons. Firstly, many species of deep-sea fish are very slow to reproduce, so stocks were overexploited within just a few years. Secondly, bottom trawling inflicted severe damage on sensitive deep-sea habitats. Many countries, including Australia and New Zealand, have learned from past mistakes and have now established protected areas where fishing has either stopped completely or bottom trawling, at least, is now banned. And although critics claim that the number of protected areas falls a long way short of what is needed, it is at least a start.

Experts are also concerned about illegal, unreported and unregulated (IUU) fishing, which is still widespread and puts extra pressure on already overexploited stocks. The volume of illegally caught fish is estimated to be equal to 14 to 33 per cent of the world's total legal catch. Combating IUU fishing is difficult as IUU vessels often operate in the territorial waters of developing countries which cannot afford to establish complex and expensive monitoring, control and surveillance systems. Some years ago, the FAO produced a catalogue of measures to prevent, deter and eliminate IUU fishing which envisages closer international cooperation between port States. The aim is to prohibit IUU vessels from landing the fish, thus preventing the illegally caught fish from reaching the markets. Implementation of these joint "port State measures" has only recently begun, however, and progress is slow. The introduction of blacklists of all IUU vessels already identified is a promising step and is intended to make it more difficult to land IUU catches. Furthermore, a number of international assistance projects have helped developing and newly industrialized countries such as Mauritania to establish radar-based vessel monitoring systems or effective fisheries control structures.

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