Cod: a challenge for sustainable fisheries

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Cod: A Challenge for Sustainable Fisheries

Cod is one of the world's most important demersal fish. It has great economic value. This species has been in demand ever since the sixteenth century. Initially, cod stocks seemed to be inexhaustible. But concentration of fishing on this species caused a serious decrease of stocks from the beginning of the nineteenth century. Fishermen tried to overcome the problem of reduced catch rates with the help of vessels with improved gear and higher catch capacities and in consequence with higher catch effort. Stocks were depleted to a level that impaired their natural reproductive capacity. In some areas, continued fishing of these stocks caused extinction.

Nowadays, several international and regional organisations like the International Council for the Exploration of the Sea (ICES), the Northwest Atlantic Fisheries Organisation (NAFO), the Common Fisheries Policy (CFP) of the EU, the World Trade Organisation (WTO) or the Food and Agriculture Organisation of the United Nations (FAO) try to enforce sustainable fisheries management. The common aim is to counteract overexploitation and to achieve long-term conservation of stocks and sustainable utilisation of fishery resources. Without conservation of stocks there will be no long-term profitable fishery in future.

Overexploitation of fish stocks

The world-wide demand for fish is increasing and thus a high volume of landings is needed. Fishery resources are endangered. For example, according to studies by the World Wide Fund for Nature (WWF), almost all cod stocks are overfished.[1]

But there are several influences apart from fishing activities that can lead to the reduction of a population. First of all, it is necessary to focus on the ecosystem within which a fish population lives. Ecosystems contain a species, its environment and their interactions. Environmental influences like pollution or natural diseases can disturb the biological equilibrium. This is due to the fact that ecosystems have only restricted possibilities of self-regulation.[2]

According to ICES/GLOBEC Cooperative Research Report No. 252, 'Workshop on the Dynamics of Growth in Cod', there are several reasons for variations in the growth of cod stocks. These stocks are dependent on the optimal temperature and the abundance of food in the ecosystems they live in. Furthermore, natural mortality is another aspect of the reproductive capability of cod stocks. High mortality of recruits means a decrease or stagnation of growth because they do not reach maturity and are not able to reproduce.[3]

Scientific evaluations relating to the North Sea and the Wadden Sea show that human activities affect the biodiversity of the sea. For example, tourism flourishes on the coastline and high human fluctuations affect the living space of species in or near the water. In consequence, fish populations may be destroyed. Moreover, industrial waste causes pollution of the sea water.[4]

Natural resources like fish will only develop well – with the possibility of conservation through reproduction – if environmental conditions are optimised. For this reason management of sustainable fisheries also has to counteract pollution.[5] Iversen emphasises that fisheries management should take into account reproduction rate, growth, habits of the fish stocks like migration and interactions with other stocks, and environmental influences. Those influences include not only diseases, mortality rates, changes in temperature or toxicological matters, but also human influences such as the construction of seawalls, the draining and filling of wetlands, pollution, and intensive fishing.[6]

Taking all these facts together, it is clear that natural stocks can be endangered even without intensive fishing taking place. It is therefore necessary to ensure the presence of a sustainable surplus of a population before it is harvested.

Biological aspects of overfishing

The maximum economic revenue and therefore the economically efficient utilisation of fishing resources are not the same thing as the maximum sustainable harvest, according to biological advice.[7]

Edwin S. Iversen states that overexploitation of a population is taking place when 'more than a surplus production is being taken from a stock'.[8] This means that the reproductive capacity of a population is reduced to a minimum because too many fish are being harvested.

In the literature, the model of the Maximum Sustainable Yield (MSY) is used to illustrate how a healthy population can be harvested at a sustainable level without overexploitation, as shown below. The aim is to maintain the stocks at high levels so that the yield that is harvested from a stock, in terms of weight, does not reduce the population size and is therefore sustained.[9]

The curve describes the growth of a fish population over a period, measured in weight of its biomass. K represents the carrying capacity level, which is the maximum level of a population that a stock can achieve. The population size would grow to this level if no fishing were taking place. To apply full utilisation of the resource, the annual harvest can be kept at H_{MSY} if the population is maintained at the X_{MSY} level. Harvesting above H_{MSY} would cause overfishing and finally extinction because there is more fish taken from a stock than it is able to reproduce.[10]

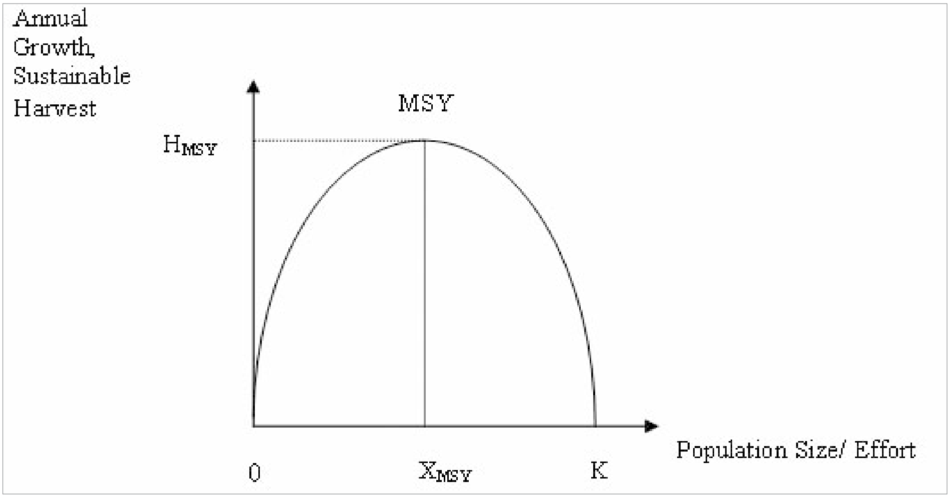


Fig. 1 Maximum sustainable yield. (Source: Jari Kuuluvainen and Olli Tahvonen, 'The Economics of Natural Resource Utilisation:' 680, in: Henk Folmer, Landis H. Gabel and Hans Opschoor (eds.), *Principles of Environmental and Resource Economics* (Aldershot, 1995): 665-699)

The MSY model is a highly simplified yet useful model. In practice there are several environmental influences, causing variations in the growth of stocks, that are not taken into account in the MSY model. Furthermore, this model presupposes that prey, predators, and competitors are not affected by the fishery.[11]

To determine the optimum harvesting population size, fisheries management usually adopts the precautionary approach. The ICES uses biological data samples relating to the spawning stock biomass (SSB), exploitation rates (fishing mortality coefficient F), landings and recruitment in order to advise on the annual total allowable catch (TAC) for each fishing area. An example of the problem of overfishing related to the MSY model in connection with precautionary management will be given later in the text.

Economic aspects of overfishing

Economic analyses for fisheries depend on biological data samples. It has to be pointed out that there are difficulties in ascertaining the data because there are too many unknown aspects that affect fluctuations within populations, as described above.

From the economic point of view, there is a discrepancy between long-term maximum sustainable harvests of fish stocks and economically efficient utilisation policy.[12] On the one hand, fish populations have to be protected in order to be sustained from the biological point of view. On the other hand, the resources should be utilised so as to achieve a maximum economic yield on a sustainable level. Because fishermen normally try to maximise their profits, they do not observe biological restrictions on fisheries, since these often lead to short-term losses.[13]

Figure 2 illustrates the relationship between the total revenue and the total costs of an open-access fishery by means of a yield-effort curve. The maximum economic yield (MEY) marks the point where the difference between total costs (TC) and total revenue (TR) is greatest. The effort and the TR increase until the MSY level is reached. Afterwards, TR still increases but at a decreasing rate. The average yield per unit effort falls as the size of the fish stock declines, and the number of fishermen rises because of the higher fishing effort that is needed. The level of fishing continues to be profitable until the TC line crosses the TR, where total costs equal total revenues, the open-access equilibrium (NP). If the TC line exceeds the TR line, losses occur and overexploitation follows.[14]

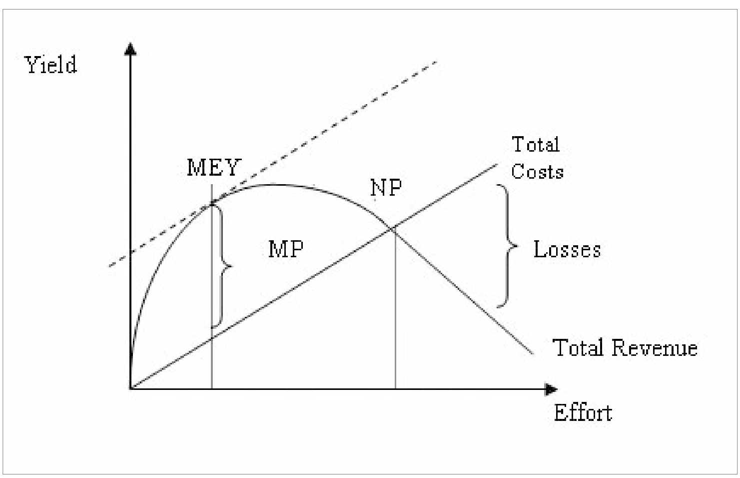


Fig. 2 Yield-effort curve. (Source: Based on Bowen and Hancock (1989) as cited in Iversen, *Living Marine Resources: Their Utilisation and Management* (New York, 1996): 254)

In comparison to the point of the maximum sustainable yield, the maximum economic yield is reached at a level of fishing effort below the crossing line of H_{MSY} and X_{MSY}. For this reason, MEY is the preferred point because it is possible to achieve more profits from the fishery with less fishing effort than by reaching MSY.[15]

According to the MSY model, a fish population should be increased to its maximum sustainable level, independent of the catch effort. By contrast, following the MEY model means that the effort is diminished by harvesting at a level that brings about the maximum economic yield and therefore the maximum utilisation of the resource.

Development of cod stocks in selected divisions

Cod stocks are endangered in the Irish Sea, North Sea, Kattegat and Eastern Channel. As already mentioned, working and study groups of the ICES carry out annual assessments of the current population size to define a precautionary management plan for fishing effort limitations or catch recommendations.

Precautionary management:
The assessments are based on different reference points. They indicate the spawning stock biomass (SSB) and the fishing mortality (F) in relation to the precautionary approach. Both parameters normally have two reference points each.

- Limit-reference-point: B_{lim} or F_{lim}, whereas for reproduction capacity B must not fall below B_{lim} and F must not exceed F_{lim}.
- Precaution-reference-point: B_{pa} or F_{pa}, which indicates a buffer area up to the limit reference point to guarantee that in a case of statistical uncertain calculation B does not fall below B_{lim} and F must not exceed F_{lim}. The higher the uncertainty in data samples, the higher has to be the buffer area and the TAC is set down.

If the SSB falls below B_{pa}, the stock shows a reduced reproduction capacity. Below B_{lim}, it has no sufficient reproduction capacity. If this description is modelled on the mortality of fish, F over F_{pa} means "endangered sustainable harvesting" and F over F_{lim} "non sustainable harvesting". This assessment is endorsed by the target reference points B_{target} and F_{target}. These points shall show the biomass and fishing intensity in relation to the optimum utilisation.

Precautionary Management. (Source: Christopher Zimmermann and Tomas Gröhsler, 'State and development of selected fish stocks. Assessment and advice by ICES in 2004:' 43-48, in: Federal Research Centre for Fisheries Hamburg (ed.): *Information on Fisheries Research*, Vol. 51 (2-4) (2004): 46)

If all the required data are available, a full analytical assessment can give information about the spawning stock biomass, recruitment, landings, current exploitation rates and future harvesting possibilities. If there are no satisfactory data, e.g. because of unknown amounts of by-catches or insufficient data samples, it is only possible to publish trends regarding landings and population sizes.[16]

It is interesting to see that in several fishing areas the SSB decreases and fishing mortality rises even though management plans had been implemented to maintain the stock size at a sustainable level.

The following considerations of cod stocks are significant for the non-sustainable development of fisheries. The selected areas refer to Subarea IV (North Sea), Division VIId (Eastern Channel), and Division IIIa (Skagerrak), which belong to the convention areas of the International Council for the Exploration of the Sea. In addition, Divisions 3L, 3M, 3NO, the Labrador-Newfoundland area, are relevant to show the dynamics of growth in population sizes of cod stocks. The latter are managed by the Northwest Atlantic Fisheries Organization.

Furthermore, the development of cod stocks in Iceland is of special significance because it is governed by a fisheries management plan of its own, the so-called Harvest Control Rule (HCR). To illustrate the trends in cod stocks during recent decades, figures for the SSB and the fishing mortality are considered.

Cod stocks in the North Sea (Subdivision IV), the Eastern Channel (Division VIId) and Skagerrak (Division IIIa)

According to the ICES, cod stocks in Subdivision IV, Division VIId and Division IIIa are suffering reduced reproductive capacity.[17]

Landings declined from 300,000 t in the 1980s to 50,000 t counted in the year 2001. This is due to the falling SSB, which has decreased by about 90 per cent between 1970 and 2002, from 280,000 t to 40,000 t.[18] But removal from this stock still continues. As stated by the ICES, the official landings in 2004 were 33,600 t, including the discards of 6,400 t. It has to be mentioned that during 2002 to 2004, 90, 80, and 75 per cent of the international landings in number were accounted for by juvenile cod aged 1-3.[19]

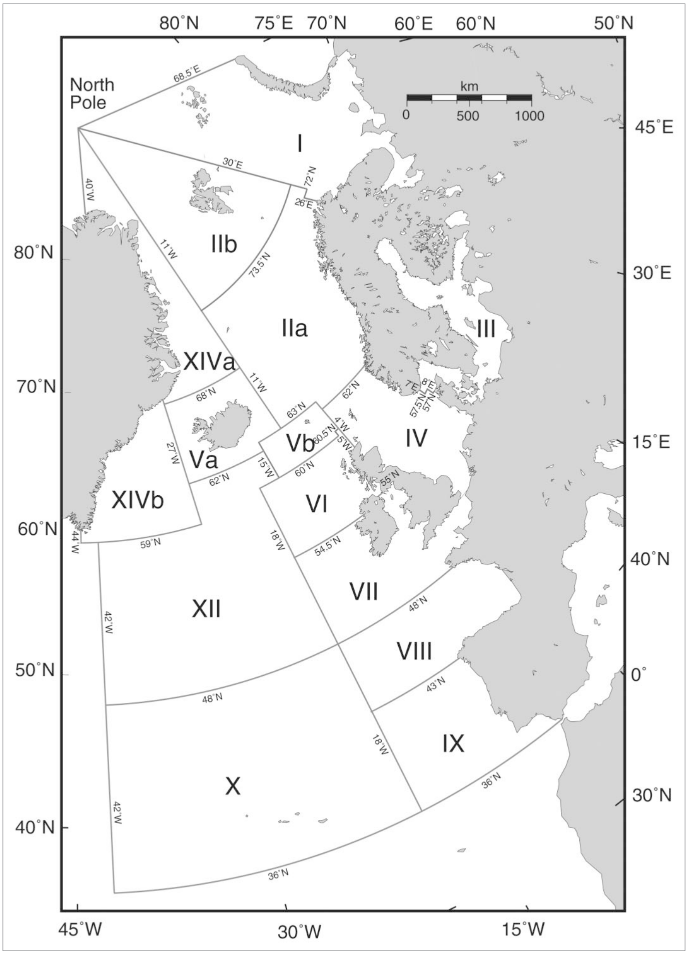


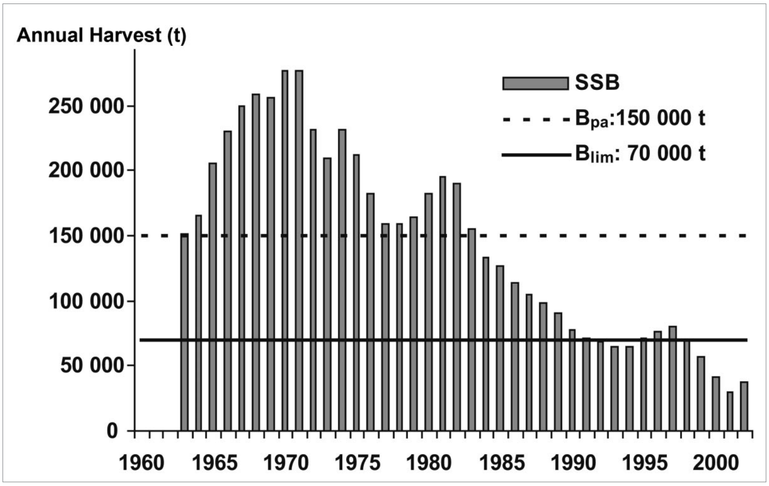
Fig. 3 ICES areas of the Northeast Atlantic: North Sea (IV), Skagerrak (IIIa), Eastern Channel (VIId) and Iceland (Va). (Source: R. Schöne, 'Assessment of some commercially important demersal fish stocks in the Northeast Atlantic:' 5, in: Federal Research Centre for Fisheries Hamburg (ed.): *Information on Fisheries Research*, Vol. 51 (1) (2004): 3-8)

To ensure the reproductive capacity of a stock, juvenile cod must be able to spawn at least once. If this issue is not considered, the biomass decreases because of a reduced reproductive capacity.

As mentioned above, the sustainable development of a stock according to the precautionary management plan is dependent on reference points. Figure 4 shows the development of cod stocks in the North Sea, Skagerrak and Eastern Channel between 1963 and 2002. By 1983, the SSB falls below B_{pa} and by 1998 it is even below B_{lim}.

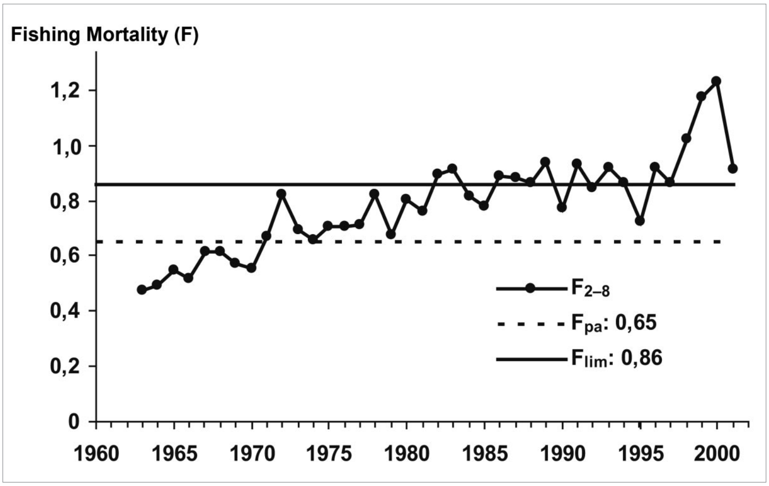
For the last two decades the SSB has fallen below B_{pa} = 150,000 t. The SSB has to be restored to at least B_{lim} = 70,000 t for a recreation of the stock. The ICES has therefore advised a zero catch for 2006 in all fisheries in order to reach B_{lim} in 2007.[20]

Fig. 4 Cod in the North Sea, Skagerrak and Eastern Channel (SSB). (Source: Hans-Joachim Rätz, 'Crisis of cod in the North Sea requires new conservation measures,' in: Federal Research Centre for Fisheries Hamburg (ed.): *Information on Fisheries Research,* Vol. 50 (2) (2003): 46)



As shown in Figure 5, the exploitation rate, measured in the fishing mortality coefficient F, has increased above the sustainable level of F_{pa} = 0.65 since the beginning of the 1970s and has risen to the limit reference point of F_{lim} = 0.86 in the 1980s.

Fig. 5 Cod in the North Sea, Skagerrak and Eastern Channel (F). (Source: Hans-Joachim Rätz, 'Crisis of cod in the North Sea requires new conservation measures,' in: Federal Research Centre for Fisheries Hamburg (ed.): *Information on Fisheries Research,* Vol. 50 (2) (2003): 46)



If both parameters are combined, the MSY model can be used to illustrate the development of cod stocks in the North Sea, Skagerrak and the Eastern Channel, as shown below. The curve illustrates the maximum sustainable yield as a function of increased exploitation rates (F) between 1963 and 2001. All points within the curve imply sustainable harvesting. As one can see, the cod stocks have been overfished since the year 1970. The maximum sustainable yield was set at 300,000 t per year. Landings accounted in 2001 were only about 50,000 t. This indicates losses of about 250,000 t of the annual yield in weight.[21]

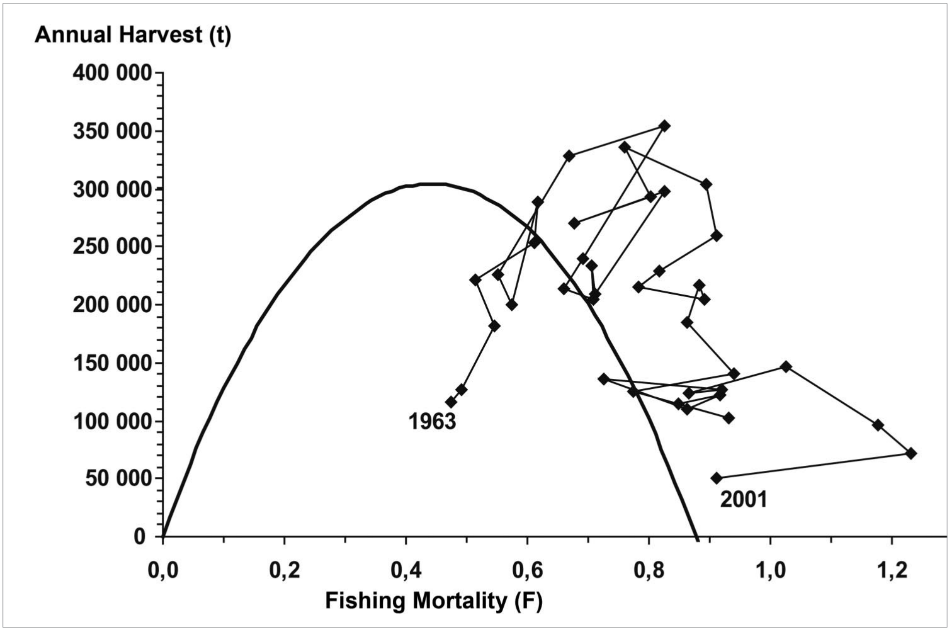


Fig. 6 Cod in the North Sea, Skagerrak and Eastern Channel (MSY as a function of increased exploitation). (Source: Hans-Joachim Rätz, 'Crisis of cod in the North Sea requires new conservation measures,' in: Federal Research Centre for Fisheries Hamburg (ed.): *Information on Fisheries Research,* Vol. 50 (2) (2003): 47)

Although several steps have been taken to control sustainable fisheries, the SSB of these cod stocks has continued to fall in recent years. Fishing bans will be necessary to conserve the stocks. According to the ICES, 'management of cod fisheries must deal with the combined effects of unreliable catch data and the inability of management to control catch. As long as these two interrelated conditions persist for fisheries which catch North Sea cod, rebuilding cannot be achieved.'[22]

Cod stocks in Iceland (Division Va)

In contrast to the other stock developments shown above, the ICES did not define precautionary reference points for the cod stocks in Iceland. This is because of the utilisation of a different fisheries management plan, the Harvest Control Rule (HCR), which was implemented in 1995 for the Icelandic stocks. According to this, the TAC is set as a fraction of 25 per cent of the total biomass, 'computed as the biomass of age 4 and older fish averaged over two adjacent calendar years.'[23] But the TAC exceeded the 25 per cent limit. This is due to the fact that stock size assessments were overestimated and fishing mortality underestimated. In consequence, the Icelandic Government added to the 25 per cent catch rule the further restriction that annual catches must not diverge from the TAC by as much as 30,000 t. If this plan is observed, the ICES will expect landings of about 187,000 t in the fishing year 2006/2007[24], 11,000 t less than in the fishing year 2005/2006.

As shown in Figure 7, the SSB fell from 941,000 t in 1955 to below the long-term average of 304,000 t in the 1980s. It is expected to stay below this level. The estimated SSB for 2005 was 262,000 t, for 2006/2007 it is expected to be 229,000 t.[25]

Figure 8 illustrates the fishing mortality between 1955 and 2005. Current fishing mortality is high (F5-10 = 0.6 in the last three years) and above the mean level of F = 0.4 that would provide for long-term yields. Because the SSB leaves many ages of fish out of account and includes relatively high proportions of younger fish, reproductive capacity is affected.

According to the ICES, the stock is overexploited when fishing mortality is considered in relation to the highest yield.[26] The total allowable catch is laid down but there is no indicator for a zero catch advice.

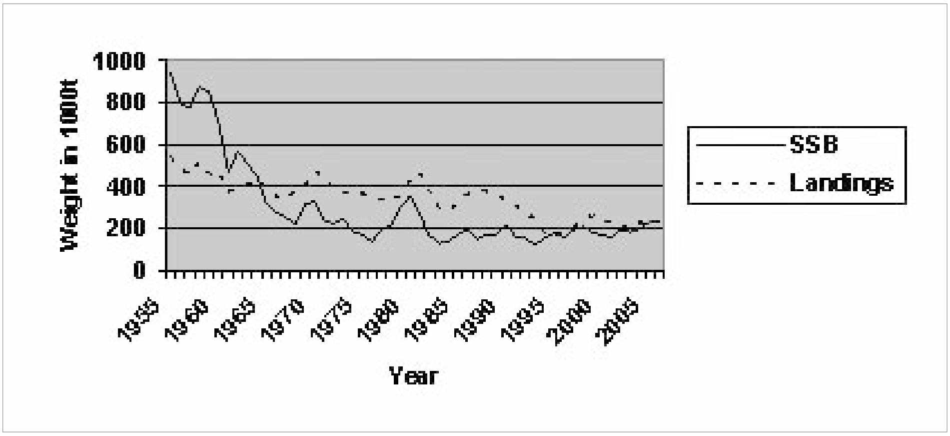


Fig. 7 Icelandic cod (SSB and landings). (Source: ICES Advice, *Icelandic Cod in Division Va* (www, accessed 18/07/2006), (hereafter ICES/Va): 32)

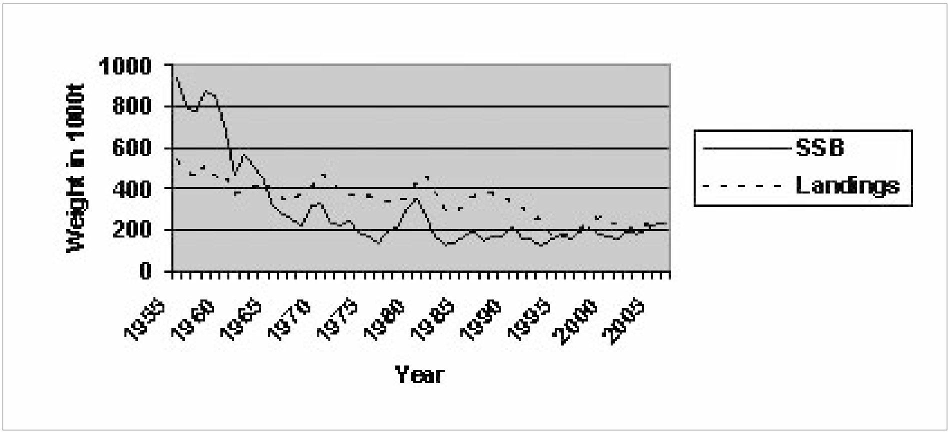


Fig. 8 Icelandic cod (F). (Source: ICES/Va: 32)

Cod stocks in Newfoundland (Divisions 3NO)

The Labrador-Newfoundland area is divided into the southern half of the Grand Banks (Divisions 3N and 3O), the St. Pierre Bank (Subdivision 3Ps), the southern areas off the coast of Labrador (Division 2J) and the eastern side off Newfoundland (Divisions 3K and 3L). All Divisions exhibit an extraordinary decline in cod stocks.[27] This is attributed to the intensive foreign fishing activities in the 1970s. Between 1962 and 1977, stock sizes decreased by about 82 per cent.[28]

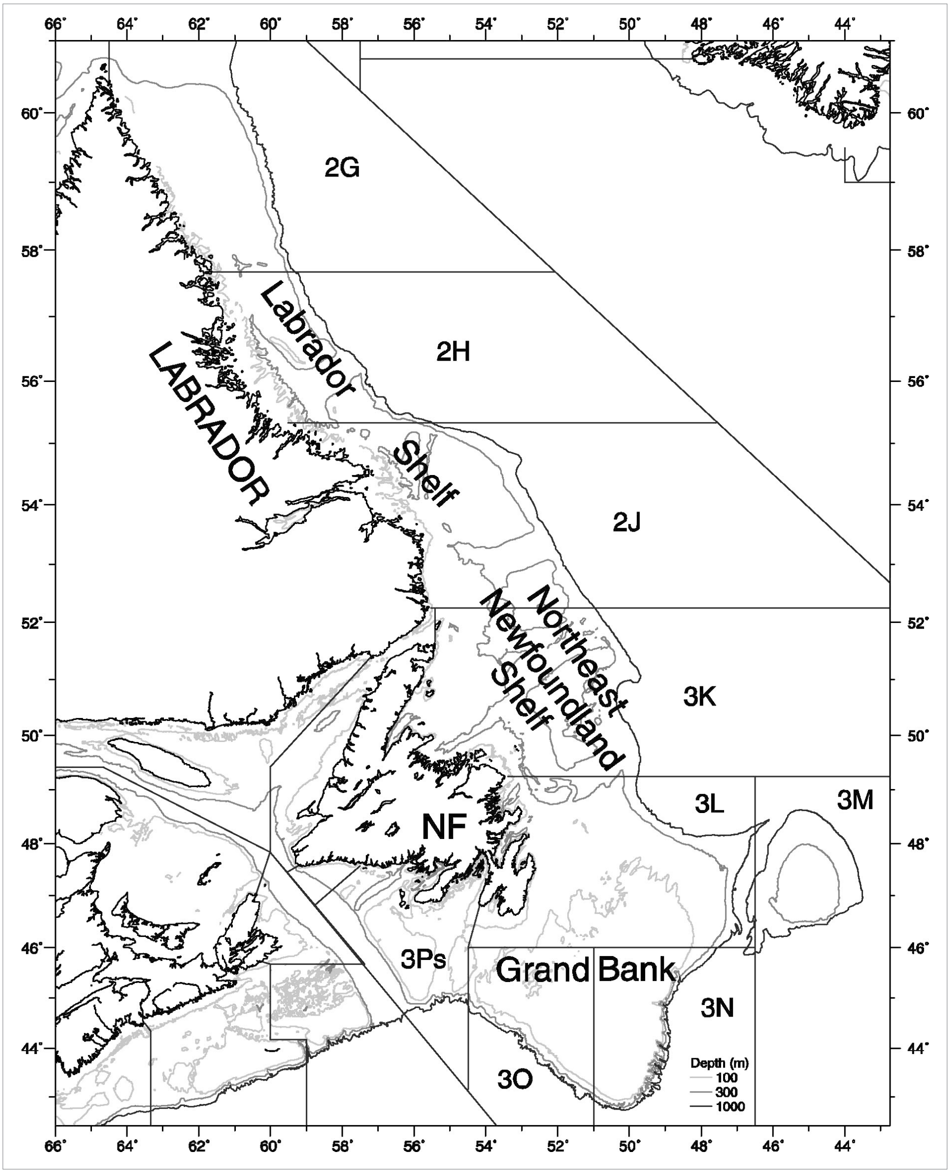


Fig. 9 Cod stocks in the Labrador-Newfoundland area. (Source: ICES Cooperative Research Report, *Spawning and Life History Information for North Atlantic Cod Stocks* (www, 2005), No. 274 (hereafter ICES No. 274): 138)

To measure the size of the population, it is divided into different age categories. Figure 10 shows the development of the 3+ biomass and the SSB in Divisions 3N and 3O.

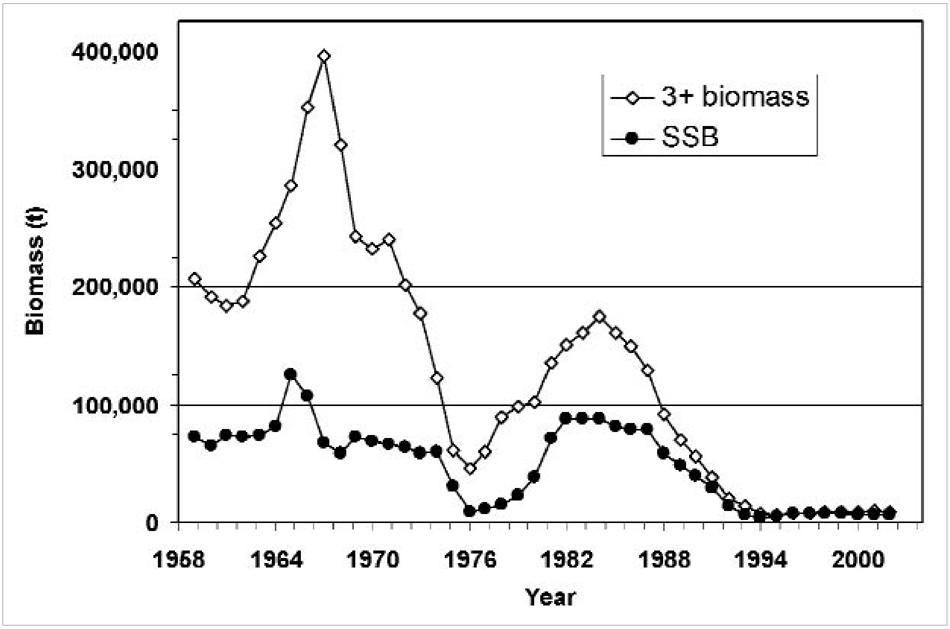


Fig. 10 Cod divisions in 3NO. Total (3+) biomass and SSB. (Source: ICES No. 274: 115)

In the 1950s, the estimated size of the total biomass (3+) was 200,000 t. The highest peak was counted in 1967, with 400,000 t. There was a dramatic decline in 1976, down to 46,000 t, and again in 1993, to 14,000 t. From that time, the population size hit rock bottom and has not yet recovered.[29] At present, the reference point of the SSB is set at B_{lim} = 60,000 t and the reference point of fishing mortality at F = 0. If the recruitment rate falls steadily, there is an indication that B_{lim} would have to be set at half the B_{lim} level.[30]

Because of the falling population size, and continued intensive foreign fishing with reported landings above the TAC, the NAFO imposed fishing bans on Divisions 3L, 3M, and 3NO in 1994 that are still in place. Thus, the scientific advice suggests that there should be no directed fishing for cod in the years 2006 and 2007 in Divisions 3N and 3O. Furthermore, by-catches of cod should be reduced and kept at the lowest level to ensure the reproduction of the cod populations.[31]

Sustainable fisheries and fisheries management

Sustainable fisheries are based on the issues of sustainable development in general. The definition is found in the Brundtland Report, published in 1987 by the World Commission on Environment and Development (WCED). 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'[32]

The Fisheries Department of the FAO has published the Code of Conduct for Responsible

Fisheries.[33] It transfers all aspects of sustainability to the fishery. Although it is a voluntary Code, some elements refer to relevant rules of international law.

As shown above, cod stocks in the Labrador-Newfoundland Area, Skagerrak, the Eastern Channel, the North Sea, and Iceland are overexploited. Therefore fisheries management has to deal with the challenge of the reproduction of aquatic resources by devising suitable regulations that create a balance between maximised long-term profitable fishing yields on the one hand and conservation of stocks on the other. For this, fisheries management has various possible means by which to regulate fishing intensity and support responsible practices in relation to aquatic resources and the ecosystem they live in.

The resolutions of the three United Nations Conferences on the Law of the Sea (UNCLOS I-III), which were held between 1958 and 1982, reshaped fisheries policy, and the third conference finally provided solutions to the question of a common international fisheries policy. Territorial waters were expanded to a 200-mile zone, the exclusive economic zone (EEZ), off the coast of every coastal state. Each state is obliged to control its own fisheries and has sovereign rights for the purposes of exploiting marine resources.[34]

In co-operation with the European Commission for Fisheries and Maritime Affairs, the International Council of the Exploration of the Sea (ICES) and the Northwest Atlantic Fisheries Organisation (NAFO) try to ensure the optimum utilisation of fisheries and maritime resources. From them, local fishery authorities receive advice on dealing with marine ecosystems and their resources, technical regulations on mesh sizes or fishing vessels, minimum landing sizes for cod, or effort limitations for fishing within the EEZ.[35] European member states established the Common Fisheries Policy (CFP) to manage international relations in fisheries. The CFP is effective for the fishing nations of the EU. It imposes limits on access to European waters.[36]

Thus, controlling fishing activities is one of the main tasks in sustainable fisheries management. A general problem for fisheries management is the enforcement of regulations and in consequence the existence of illegal fisheries. The implementation of regulations is often linked with costs for technical reorganisation.[37] The relationship between fishing expenditure and fishing revenue is worsened as a result. Fishermen therefore often try to recoup their losses by means of illegal landings. For example, the estimated number of non-reported cod-landings in the Barents Sea was 80,000 t in the fishing year 2002/2003.[38] Illegal fishing is one of the main causes of overexploitation. Particularly outside the EEZ, illegal fishing is on the rise. The ability to process caught fish on fishing plants at sea makes control more difficult. It is not possible to ensure that fish products come from a sustainable surplus.

Catch rights regulations

In an open-access system like a fishery, fisheries management has to achieve the optimal allocation of resources and therefore the optimal planning of resource management.[39] There are various limitations on catch effort to counteract overfishing and to prevent overexploitation of healthy stocks.

The Advisory Committee on Fishery Management (AFCM) of the ICES gives advice on the TAC for each fishing area. The data are based on biological calculations of the SSB, recruitment, fishing mortality and landings of a stock, as explained above.[40] The aim is to fix the quantity of fish that can be harvested in a given period to sustain the population at a level that prevents extinction.[41]

The TAC System is one of the current fishing limitations that try to guarantee a properly protected resource. It is only a guideline and not an obligatory regulation. Territorial fisheries management can decide whether to accept the advice. But there is the problem of giving incentives to regional fisheries management and fishermen to observe the advised TAC. Because of the high demand for fish, real landings often exceed the TAC and biological reference points are exceeded. On the one hand, fisheries management sometimes sets TACs that are above the advised limit. On the other hand, illegal fishing takes place if fishermen are not satisfied with their catch rates. For these reasons, the implementation of TAC is not enough to protect natural resources from overexploitation.[42]

In the context of the TAC advice, fisheries management of most fishing areas transfers so-called Individual Transferable Quotas (ITQ) to fishermen. Fishermen buy certificates that give them the right to catch and sell a fixed quantity of harvested fish, measured in tonnes. The fishing effort is measured by the catch per unit effort (CPUE) index. It represents the amount of fish caught per time period (boat day or week, for example).[43]

Once the TAC has been landed, the whole fleet receives a fishing ban for the period. It is obvious that fishermen try to catch as many fish as possible to achieve the full amount of their quotas before fishing bans are enacted.[44]

In some fishing areas, the Individual Transferable Share Quota system (ITSQ) is used. These catch quotas are shares in the total allowable rate of catch and can be traded on an internal market. The ITSQ holder is allowed to fix the share in the TACs in perpetuity. This differs from the ITQ system in that changes in TAC are linked with quota increases or decreases for individual firms. Holders of shares have an incentive to enlarge their shares and, in consequence, to sustain basic stocks, because the higher the TAC, the higher the share in the TAC.[45]

Both the ITQ and the ITSQ systems also have a bearing on the problem of illegal fishing. In order that the regulations are complied with, fishermen have to be monitored and directed by an overall authority, a system that possesses legislative and executive power.

Another way of limiting the exploitation of fish stocks is to impose closed fishing seasons to protect spawning fish. While fisheries management in Newfoundland has implemented a moratorium on the Labrador-Newfoundland area for years, spawning areas in Iceland, for example, are closed for 2-3 weeks during the spawning seasons.[46] But, as Kuuluvainen and Tahvonen have noted, closed seasons for fishing increase fishermen's costs, and they would try to raise their harvest yields outside the closed seasons.[47] Illegal fishing would be intensified as a result.

Selectivity in fishing gear

For every kind of fish there are regulations governing fishing vessels and mesh sizes to ensure the harvest of the target species. For demersal fisheries trawl nets are normally used. By the way, the impact of fishing gear on the seabed and therefore on the ecosystem is often overlooked, but has to be noted.

Limits on the minimum landing size for fish are linked with minimum mesh opening sizes. The aim is to reduce the landings of juveniles to let them grow and spawn and in consequence to increase the reproductive capacity of a stock. According to the ICES, the minimum size for cod in Subarea IV and Divisions IIIa and VIId is 35 cm.[48] For Division Va it is about 55 cm.[49] Fishermen normally accept this limitation as long as the desirable market sizes and prices are above the minimum sizes.[50]

For Division Va, Iceland, mentioned above, the minimum mesh opening allowed for cod is 135 mm[51], and for the North Sea the basic minimum mesh opening was 120 mm in 2002.[52]

Concentration on harvesting the target species is difficult due to the fact that several species with similar fish sizes live in the same areas and may be caught as well.[53] It is therefore almost impossible to avoid by-catches of cod. In addition, juvenile cod often cannot escape from the nets because of older fish blocking the inner side of the nets. Thus, fishing gear cannot always ensure selectivity.[54]

Iversen points out that all management programmes must be to the benefit of fishermen.[55] But an improvement in the selectivity of fishing gear is linked with decreased catch rates. Thus fishermen will try to use fishing gear that allows as high a catch as possible. The fishing capacity of vessels is intensified, and this may lead to the problem of overcapacity.[56] Furthermore, mesh sizes can be manipulated quite easily and because of unsatisfactory control over fishing activities at sea, the problem of illegal fishing increases.[57] Provided that fishermen observe the regulations, employment of modern technology can help to improve the reproductive capacity of fish populations by protecting juveniles.

The main focus of the regulations mentioned is on the reduction of fishing mortality and consequently on the reduction of fishing effort to protect stocks from biological overfishing. But reducing fishing effort is not necessarily desirable from the economic point of view. This is because less effort is linked with reduced landings and less yield.

Bethke suggests a management plan that could lead to a long-term solution to overfishing. His researches relate to cod fishing in the Baltic Sea. The idea is to increase the current mesh size openings and the age of fish when first caught without affecting the fishing effort.

If mesh sizes are enlarged and younger fish can escape, they have the ability to grow and spawn at least twice. Therefore, the age at which a fish is first caught is increased and the reproductive capacity of a population at a sustainable yield will be ensured. Instead of limiting the total catch rate, in theory fishermen could harvest as much as they like from the older members of the target species. In consequence, even the same or a higher yield in weight could be achieved even though fewer fish are caught, because the target members of the species are older and heavier than before.[58]

Of significance in relation to this issue is the age composition of the fish that are taken from a stock. If juvenile fish are caught, the recruitment rate will fall and the population is not able to reach its biomass maximum. If the age of fish caught is too high, most of the rest of that target group will have died from natural mortality. Therefore, fish has to be caught near its biomass maximum.[59]

As long as the economic limit of overfishing is not exceeded, biological overfishing is also avoided. The aim of biological conservation and profitable long-term fishing is achieved.[60]

It has to be mentioned that this solution to overfishing would have to be implemented gradually. Although fishermen would have the incentive of making long-term gains that exceed the previous yields, it is not certain that they would accept the new idea. In the context of this management plan, controls would have to be intensified.

Selectivity in fishing gear can be supported by responsible consumption of fish products. Here consumers have an important role. They have to be sensitized to sustainable practices with living aquatic resources. But for this to happen, information about the origin and environmental influences of aquatic resources needs to be available.

For frozen products there is an eco-label that brands fish products from sustainable fisheries, the Marine Stewardship Council (MSC) label.

In cooperation with the WWF, Unilever founded the Marine Stewardship Council in 1997. This organisation is supported by NGOs worldwide. 'The MSC is seeking to harness consumer purchasing power to generate change and promote environmentally responsible stewardship of the world's most important renewable food source.'[61] The MSC accordingly requires branding of fish products from sustainable fisheries. Fisheries companies can be certified by the MSC label if they meet the conditions of environmental and sustainable fishing.

When buying fish at a sales counter, the consumer has secondly to note the minimum landing size of fish. According to the Fish Information Centre, Germany, the mean length of cod is

60 cm with a mean weight of 2.5 kg.[62] The marine biologist Rainer Froese, Germany, refers to a fish ruler, produced by the Department of Agriculture of the Philippines, that indicates the permitted minimum size of full-grown species. This provides the consumer with the possibility of selective consumption.[63]

Conclusion

Although fisheries management has been in force since the beginning of the twentieth century, and a huge number of regulations are implemented by local governments, overexploitation of aquatic resources, especially of cod, is still taking place.

As described above, precautionary management did not achieve the target of sustaining the population at a satisfactory size. Cod stocks in the North Sea, the Eastern Channel and Skagerrak are overfished. The Labrador-Newfoundland area exhibits an extinction of cod which led to a moratorium in 1994 that has lasted to the present day. Iceland shows an increasing fishing mortality rate and a decline in the SSB to a mean level of about 150,000 t in the early 1990s. It seems to have remained stable at that level. The HCR was implemented in Icelandic fisheries management in 1995, and it appears that this management system is preferred to the precautionary principle. In this context, it has to be mentioned that Icelandic management has advantages in implementing homogeneous management systems because it is independent of other fishing nations and therefore executive power is easier to enforce.

As pointed out above, the implementation of regulations is linked with reduced fishing effort. Bethke´s approach of increasing the mesh sizes while maintaining stable or even increased fishing effort seems to be a possible way of counteracting both biological and economic overfishing. But the overall problems of enforcing regulations and also of reducing illegal fishing activities have to be considered.

The challenge for sustainable fishing of cod stocks is to make sure that regional fisheries and fishermen observe the regulations for conservation of the natural resource. But overregulation in fisheries management does not give an acceptable solution. There are too many different regulations implemented by different regional fisheries managements. International organisations have to strengthen controls by creating a homogeneous management plan similar to the CFP.

For the improvement of sustainable fisheries management, it is necessary to take into account information about biological stock developments and also economic matters, namely the livelihoods of fishermen and the aims of fishing industries. There is a need not only for improved biological science research but also for public discussion of the problem of the limited nature of natural resources. There are many steps that need to be taken to solve the dilemma of sustaining cod stocks.

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21 Rätz, 'Crisis of cod in the North Sea:' 47.
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26 ICES/Va: 24-25.
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Kabeljau – Eine Herausforderung für eine nachhaltige Fischereiwirtschaft

Zusammenfassung

Fast die Hälfte aller Nutzfischbestände befindet sich auf einem nicht-nachhaltigen Niveau. Das bedeutet, dass die von einem Fischbestand abgefischte Menge die Anzahl der Jungfische in diesem Bestand so stark vermindert hat, dass die eigene Reproduktionsrate nicht ausreicht, um die Populationsgröße langfristig zu erhalten. Wenn die starke Befischungsintensität über einer zugelassenen nachhaltigen Höchstmenge bestehen bleibt, wird es zukünftig keine gewinnbringende Fischerei mehr geben. Besonders bezeichnend sind die Auswirkungen der Fischerei auf Kabeljaubestände. Innerhalb der letzten Jahrzehnte sind Kabeljaupopulationen auf ein Minimum gesunken, und Überfischung stellt heute eine ernstzunehmende Bedrohung dar.

Dieser Aufsatz setzt sich mit dem Problem der Überfischung der Nutzfischart Kabeljau in den Regionen Neufundland, der Nordsee und Island auseinander. Die Leitfragen sind: Wie haben sich die Kabeljaupopulationen über die letzten Jahrzehnte entwickelt? Aus welchen Gründen trat die Übernutzung hauptsächlich auf? Welche Regulationen wurden eingeführt, um Überfischung vorzubeugen?

Der Kabeljau stellt eine Herausforderung für ein nachhaltiges Fischereimanagement dar, da die Befriedigung der anhaltend hohen Nachfrage, verbunden mit unzureichendem Wissen über die Reproduktionsfähigkeit der Bestände, die Schwierigkeit der Überfischung mit sich bringt. Das Fischereimanagement entwickelte verschiedene Maßnahmen, um diesem Problem entgegenzuwirken. Während sich die Fischereiforschung auf die langfristige Erhaltung der Fischbestände konzentriert, versuchen Berufsfischer kurzfristig Gewinne zu erzielen. Das Ziel des nachhaltigen Fischereimanagements ist es hierbei, sowohl die Reproduktion des Bestandes zu sichern als auch die Bedürfnisse der Fischer zu befriedigen.

Le cabillaud – un défi pour une économie halieutique durable

Résumé

Presque la moitié des fonds halieutiques se trouve à un niveau non durable. Ce qui signifie que la quantité pêchée dans un stock a tellement réduit le nombre de ses petits poissons que le taux de reproduction de celui-ci ne suffit plus à assurer la densité des populations de l'espèce à long terme. Si l'intensification de la pêche continue au-delà de la quantité maximale autorisée, la pêche lucrative va disparaître à l'avenir. Particulièrement significatifs sont les effets de la pêche sur les stocks de cabillauds. Au cours des dernières décennies, les populations de cabillauds ont chuté à un minimum et la surpêche présente aujourd'hui une menace à ne pas négliger.

Cet article aborde le problème de la surpêche de l'espèce cabillaud dans les régions de Terre-Neuve, de la mer du Nord et de l'Islande. Les questions fondamentales sont les suivantes: comment les populations de cabillauds se sont-elles développées ces dernières décennies? Quelles sont les raisons principales de la surpêche? Quelles sont les régulations introduites afin de prévenir de la surpêche?

Le cabillaud représente un enjeu pour la gestion halieutique durable, car la demande en permanence élevée, liée à des connaissances insuffisantes sur la capacité de reproduction des stocks, a entraîné les problèmes de la surpêche. La gestion de la pêche a mis au point différentes mesures afin de combattre ce problème. Tandis que la recherche halieutique se concentre sur la restauration durable des stocks, les pêcheurs tentent d'obtenir un gain à court terme. Le but de la gestion halieutique durable est autant d'assurer la reproduction du stock que de satisfaire les besoins des pêcheurs.