Why has the cod stock recovered in the North Sea?

Summary

The expansion of European fisheries during the 1970s and 1980s resulted in high fishing pressure on stocks of cod, haddock, whiting and saithe caught in the mixed fisheries of the North Sea. This resulted in above optimal exploitation levels for these stocks for most of the period from the 1970s until the 2000s. As a result, these stocks, most notably cod, have been either at risk of being, or outside safe biological limits, during much of this period. The need to curb this high fishing pressure in order to avoid stock depletion and bring these stocks back to a level which they can be sustainably harvested, was recognized by the European Union and Norway under their agreement to manage these stocks.

However, because these stocks are caught in mixed fisheries, where productivity varies between stocks, simply introducing restrictive catch limits on depleted stocks would not always result in reduced fishing pressure on those stocks that are either at risk or depleted, because fishers would continue to fish for the more productive stocks, and discard fish from those stocks for which they did not have available quota. So the EU cod management plans; the recovery plan in 2004 and the long term management plan in 2008 had to include measures to control and reduce fishing effort, as well as introducing restrictions on catches of cod and other stocks.

Effort reduction, through vessel decommissioning schemes and days at sea restrictions were therefore an important part of the management plans implemented in the 2000s. National governments were able to devise cod avoidance schemes in which fishers were incentivized to avoid cod through increased effort allowances. The UK devised schemes avoid concentrations of cod by monitoring catches in real time and closing areas which contained high concentrations of the species. The UK also devised the ‘catch quota’ scheme in which catches are monitored using cameras, and fishers have to land all the cod they catch, stopping fishing when the catch limits are reached, although there was additional quota for those vessels participating in the scheme, thus incentivizing more selective fishing.

Whilst it is difficult to assess the relative importance of these various schemes on cod recovery, there has clearly been an effect on the cod and other whitefish populations in the North Sea, resulting in reduced fishing mortality and recovery of spawning stock. This is in a natural environment which is considered not conducive to cod recovery. Environmental change is believed to affect food supplies and hence survival of cod larvae, together with increased predation pressure on the young cod.

Contents

Introduction

European fisheries experienced expansion and technological advance in the 1970s and 1980s, which resulted in high fishing mortality on the stocks of cod, haddock, whiting and saithe caught in the mixed fisheries of the Northern North Sea. By the early 2000s, there was a clear need to introduce management measures to curb the high fishing mortality on these stocks to allow them to recover so they could be sustainably harvested.

However, simply trying to limit catches by introducing restrictive Total Allowable Catches (TACs) for depleted stocks would have been unlikely to result in a decrease in catch and hence a reduction in fishing mortality, because the North Sea demersal fisheries catch a mixture of species, where stock status and catch limits varied. Catches of cod, therefore, continued but were discarded or landed illegally, whilst the fishers pursued other species such as haddock.

Control of fishing effort

The imperative was to reduce fishing effort, as well as catch, in order to reduce mortality on these stocks. Therefore, the two management plans for cod, the cod recovery plan initiated in 2004 (Council Regulation (EC) No 423/2008) and the long term management plan in 2008 (Council Regulation (EC) No 1342/2008) included elements for a reduction in fishing effort, as well as 'Harvest Control Rules', which stipulated the way in which managers should set TACs in response to changes in stock status.

Reductions in fishing effort have been achieved:

1. By decommissioning schemes, these effectively rewarded owners for removal of fishing capacity through decommissioning of older vessels. These reductions occurred predominantly in the early 2000s.

2. By controlling the numbers of days the vessels can spend at sea in the areas where scientific advice indicated the highest reductions in catches of cod were required.

Figure 1 shows trends in effort in the main towed-gear fisheries which catch cod in the North Sea;

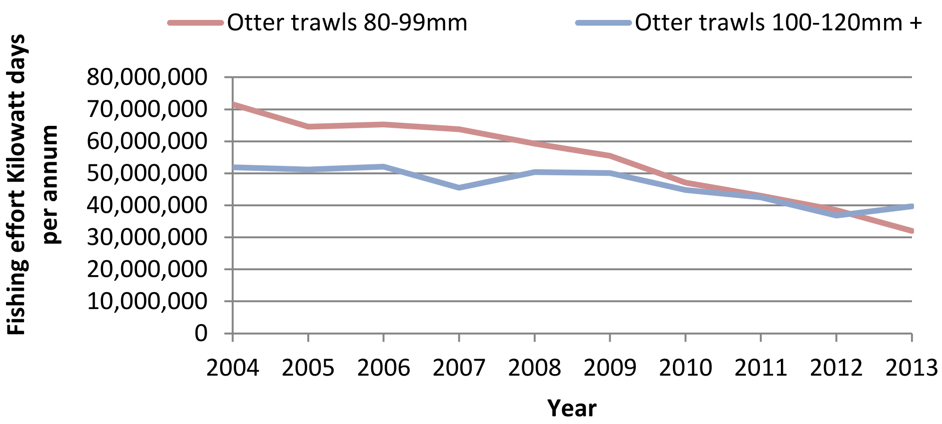

Figure 1. Trends fishing effort levels for the period 2004 to 2013 main otter trawl gears, North Sea, Skagerrak and Eastern Channel; Otter trawls 80-99 mm predominantly targeting *Nephrops* but also species such as whiting; Large mesh 100-120+mm otter trawls targeting cod, haddock and whiting (Source; Scientific Technical and Economic Committee for Fisheries (STECF) data 2015).

EU Member States were permitted to 'reclaim' fishing effort allowances under the restrictive days at sea scheme described in 2 above. The UK Governments (Scotland and England) initiated the Conservation Credits Scheme which was based on the closure of areas of high concentrations of cod (determined by monitoring catches on a 'real time' basis). In parallel there was a tightening up of measures against illegal landing and selling of fish. In the UK this was through the implementation of the registration of the Fish Buyers and Sellers and Designation of Fish Auction Sites regulation 2005, which re-enforced earlier European legislation (Council Regulation (EC) 2847/93).

Other measures used include the 'catch quota' scheme introduced by UK governments which account for around 24% of UK cod landings. Participating vessels use independent electronic monitoring devices (video recordings which monitor fishing activities using sensors) to ensure that all caught fish is recorded, and all caught cod is retained on-board, landed and counted against quota (including undersized fish). In return, additional quota and days at sea are allowed, although vessels had to stop fishing when they used up their quota.

These measures aim to reduce wasteful discarding, and incentivise fishers to fish more selectively, and improve information on catches. However, it is difficult to quantify the effects of the individual measures (Kraak et al., 2013).

Effects on whitefish stocks

Figure 2 and Figure 3 overleaf, show historical trajectories of the main North Sea demersal stocks since the 1960s. Figure 2 shows the rate of fishing mortality relative to optimum levels, that is F_{MSY} = fishing mortality for Maximum Sustainable Yield (MSY). Figure 3 shows the level of spawning stock biomass (the total weight of fish capable of spawning in the stock and therefore an indication of the stock's reproductive capacity) relative to MSYBtrigger, this is the level below which management action should be taken to conserve stocks.

For the period from the 1960s until 2000 all these stocks experienced fishing mortality much higher than optimal levels (F_{MSY}), and there was a corresponding reduction in spawning stock biomass. Spawning stock biomass for cod showed clear declines from the early 1970s to 2006, and for saithe from the early 1970s to 1994, with cod having been below the MSYBtrigger level, from the early 1980s until 2016. Similar trends are evident in haddock and whiting, but these results are much more variable because there is much more variation in the level of recruitment of young fish into these stocks and hence much more variation in spawning stock biomass.

After 2000 there is a clear downward trend in fishing mortality for cod with a corresponding rise in the spawning stock biomass, which has increased during the period from 2006 to 2016. There are similar trends for the other three stocks, though variability is evident, particularly in whiting and haddock.

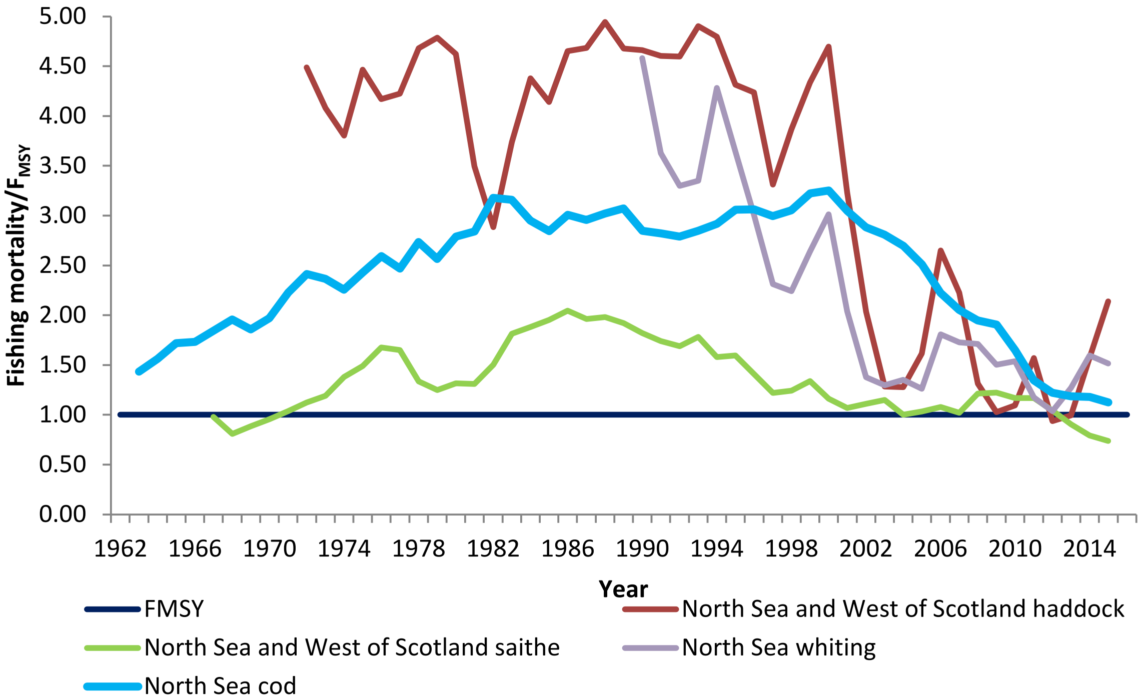

Figure 2. Trends in fishing mortality/F_{MSY} in the main North Sea demersal whitefish stocks 1962-2015. This references current fishing mortality (F) against optimal fishing mortality F_{MSY}; Dark Blue line F_{MSY} (source ICES data).

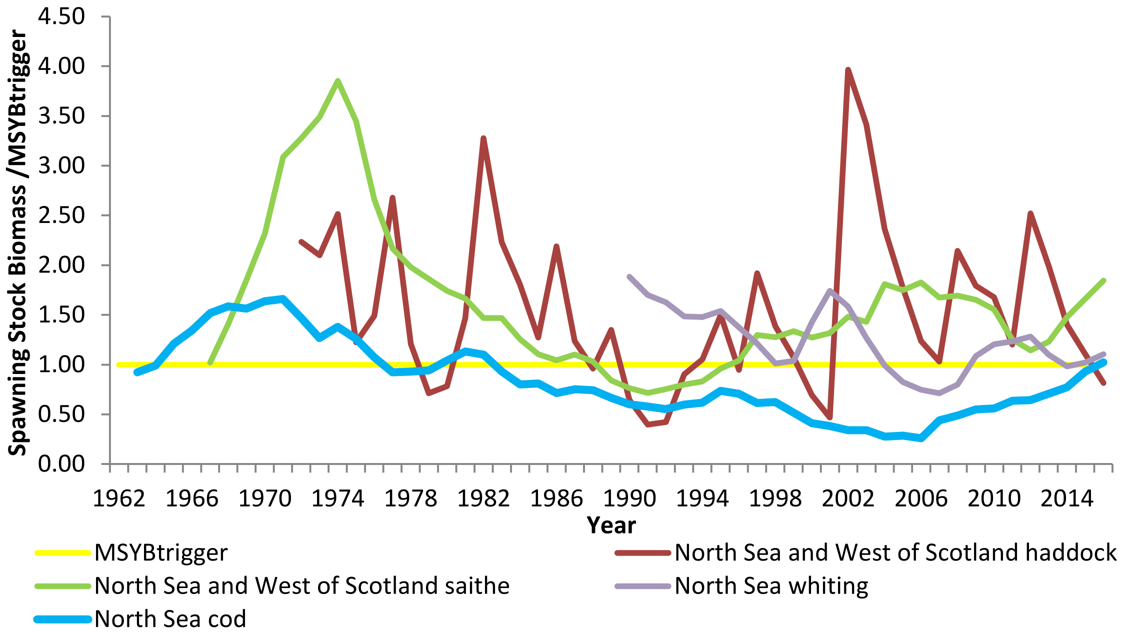

Figure 3. Trends in spawning stock biomass/MSYBtrigger of the main North Sea demersal whitefish stocks during the period 1962-2016. This references current spawning stock biomass against the MSYBtrigger action level; (Yellow line; MSYBtrigger). When the spawning stock biomass is below this level the stock action should be taken to reduce Fishing mortality (source ICES Data).

Recruitment and growth

Recruitment is the process by which young fish enter the stock of fish. Beaugrand et al, (2003) showed that the mean size of prey for cod larvae and the seasonal timing of the hatching of the eggs in relation to the food supplies for the larvae, all have effects on larval survival and hence recruitment into the North Sea cod stock. During the period 1963-83, there was a period of very high recruitment into this stock which coincided with favourable planktonic conditions for cod larvae. Other stocks of cod like species (Gadoids); haddock, whiting and saithe had similar high recruitment levels, hence the period is known as the 'Gadoid outburst'.

Since then, it is believed that survival of larvae has decreased due to poorer feeding conditions; there has been a lower survival of eggs produced by younger cod (which formed a higher proportion of the depleted cod spawning stock) and an increasing predation pressure from predators such as seals on young cod. These are all factors that are considered to have reduced recruitment into the stock (ICES 2016) particularly in the period since 1983 when recruitment has been relatively low in this stock (Figure 4).

Young fish enter the stocks as recruits after which they grow and mature until they are big enough to spawn and hence contribute to reproduction and become a part of the spawning stock biomass of the stock. When recruitment is relatively constant, as is currently the case with the North Sea cod, spawning stock biomass can only be increased by reducing mortality on the stock. Since fishing mortality is the only source of mortality that fisheries' managers can control, a reduction in fishing mortality using such measures as described above is the measure used to recover depleted stocks.

So how can we account for nearly four (3.9) fold growth, from 43,002 to 168,552 t, in cod spawning stock biomass over the period since 2006?

Figure 5 shows how the number of 5+ year old fish has over the years, along with the percentage survival of 1 year old fish to age 5. The percentage survival of fish to age 5 has shown steady increase in the period after 2000, with these fish contributing to the numbers of 5+ fish. This increased survivorship to age 5 is consistent with reduced mortality over the period since 2000. Because the percentage survival relates to the survival of recruited fish, it is independent of variations in recruitment. The main source of mortality on this stock is considered to be fishing mortality, so the results point to the success of the fisheries management measures in bringing down fishing mortality on this stock.

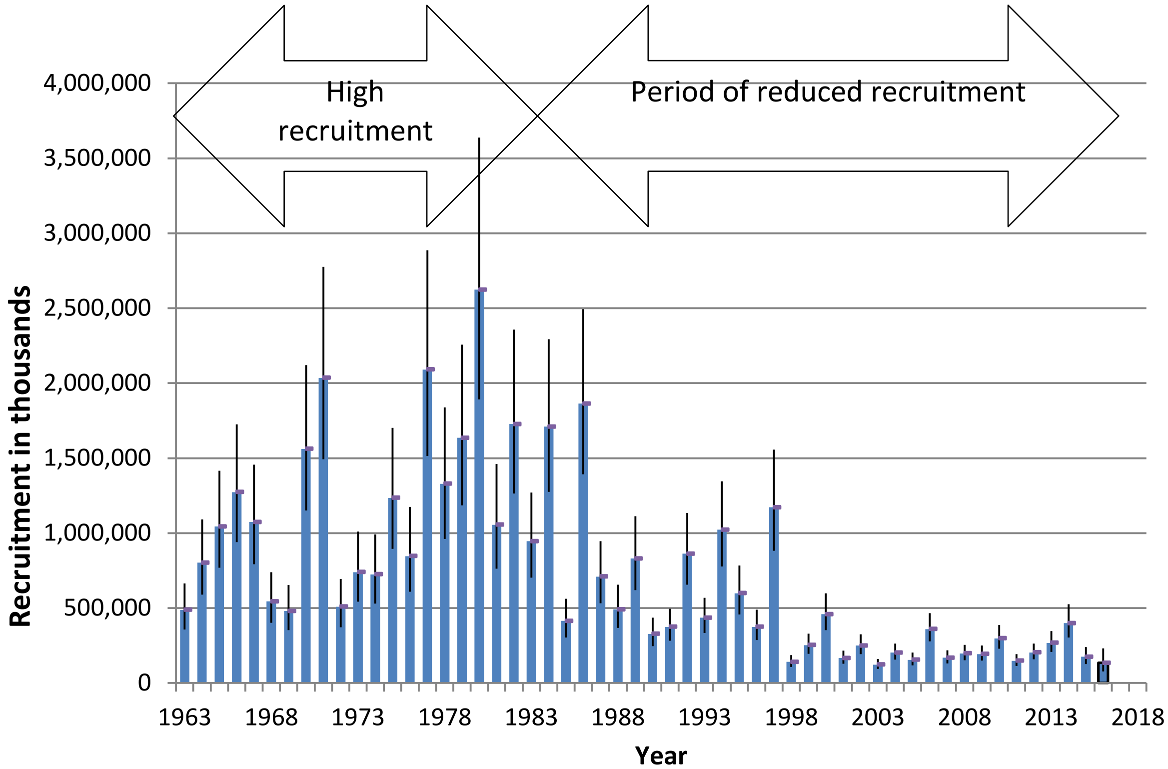

Figure 4. Estimated recruitment to the North Sea cod stock from 1963-2016in numbers at age 1 ± 95% confidence intervals. Arrows show periods of changes in the recruitment level; see text for discussion (source ICES Data)

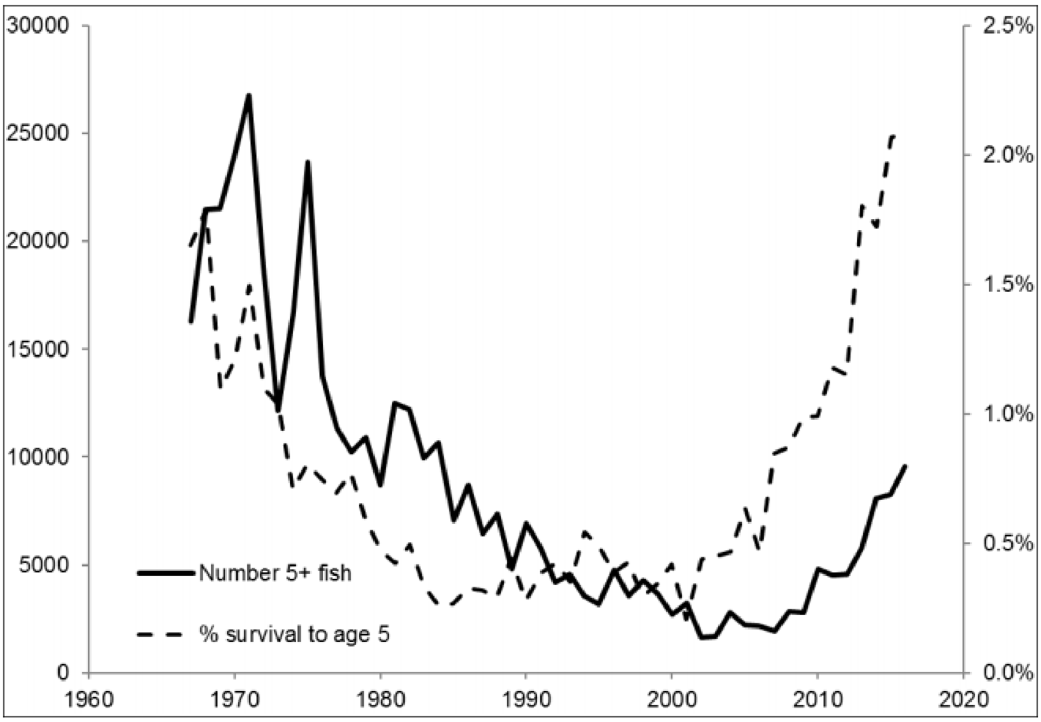

Figure 5. Estimates of the number of 5-year-old and older cod in the population (solid line; thousands, left hand axis) and the percentage of 1-year-olds by number that have survived to age 5 (right hand axis) in the given year (dashed line); from ICES (2016).

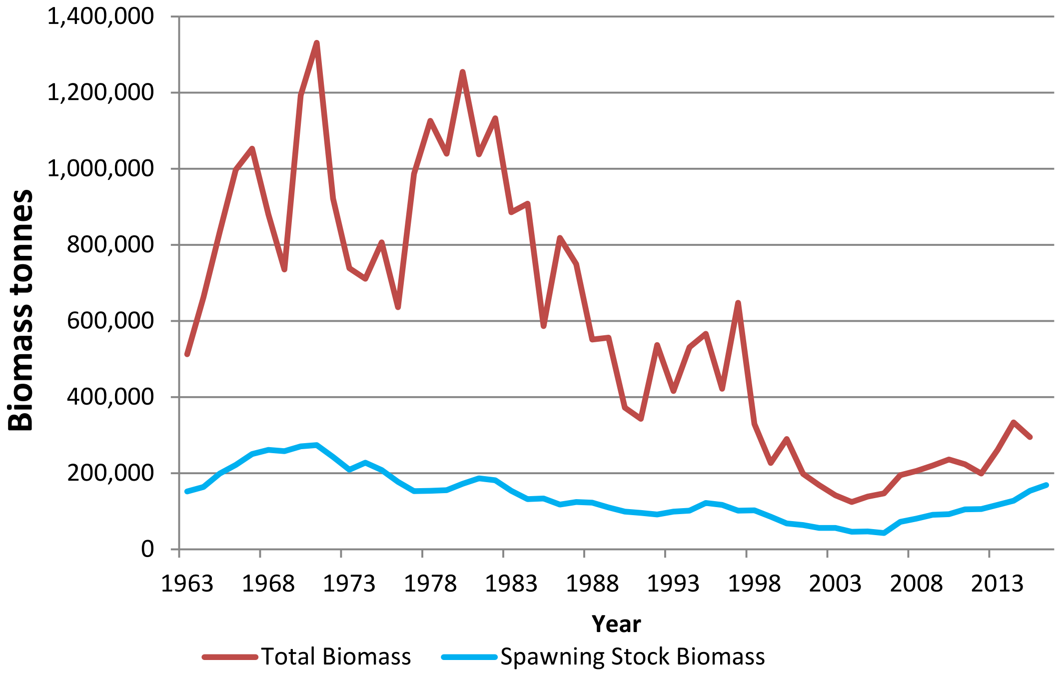

Figure 6. Total biomass compared with spawning stock biomass for North Sea cod 1963-2015 (Source ICES data)

Cod stock composition

Figure 6 shows the trajectory of the total biomass of the recruited stock of cod compared with the spawning stock biomass over the period 1963 until 2016. These results show that in although the levels of spawning stock biomass is now similar to that which prevailed in 1963, the total biomass is very much smaller. This is because in recent years there is an increased proportion of cod maturing at a younger age than in the 1960s. Hence the spawning stock is currently composed of younger fish than in the 1960s and there is a much smaller overall biomass of cod. This is likely to affect the resilience of the stock.

Another factor is the uneven distribution in the improvements in North Sea cod. The improvements in cod stock status have largely occurred in the northern and northwest North Sea and the northern Skagerrak, with the recovery of cod in the southern North Sea and eastern English Channel lagging behind the Northern areas (ICES 2016).

These factors, along with the changes in the environment, which are believed to affect the recruitment of young fish into the North Sea cod stock (see page 6), mean that although the spawning stock biomass is restored to levels which are considered inside safe biological limits, and fishing mortality is close to optimal, the composition of the stock and the environmental conditions are different from those prevailing in the 1960s and 1970s. So there should be an element of caution in judging the recovery of this stock and we may not expect the high yields experienced during the 1960s and 1970s in the future.

Catches

Improvements in catches tend to lag behind improvements in stock status, because the fish take time to grow large enough to catch. Figure 7 shows historical catches of North Sea cod, illustrating the extent to which catches have declined over the years since the early 1980s. However, the recent increase in landed catch since 2007 has been accompanied by a reducing trend in the proportion discarded, which is consistent with the efficacy of the management measures discussed above.

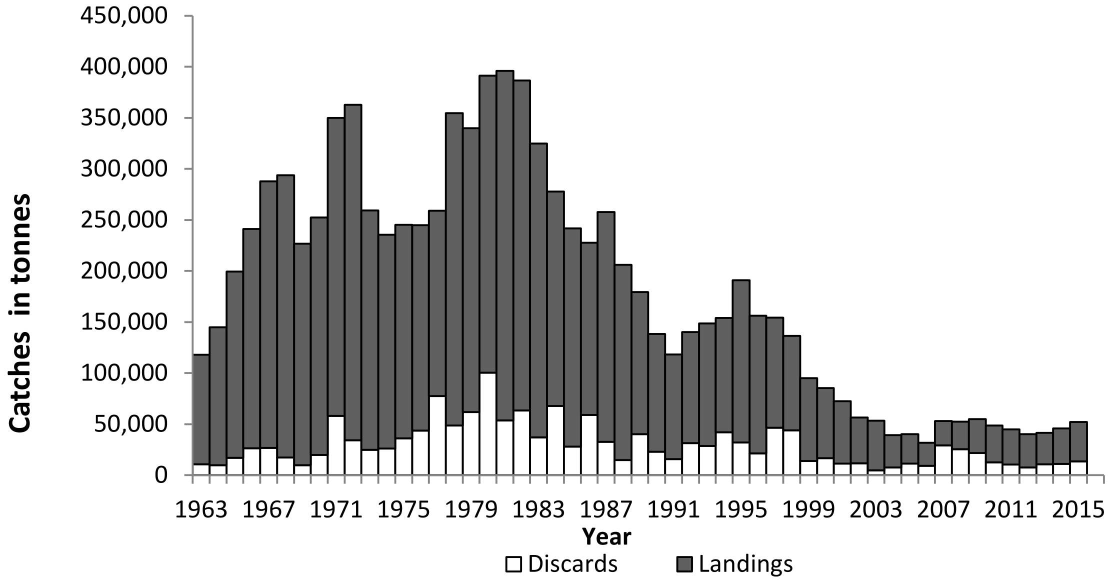

Figure 7. Estimated landings and discards for cod for the period 1963 until 2015 (Source ICES data).

Conclusion

The significant reductions in fishing effort and other measures to control catches under the cod management plans (agreed by the EU with Norway), as discussed above are likely to be the main drivers behind the reduction in fishing mortality that has enabled the young cod to live longer and grow larger and contribute to the spawning stock.

Other North Sea stocks have also shown improvements over this period consistent with reduced fishing pressure. Therefore recovery of cod and other demersal stocks in the North Sea has been largely due to the fisheries management measures, although it is difficult to assess the relative importance of the various measures.

The indications are that the environment for cod recruitment into the North Sea is not as favourable as it was in the 1960s and 1970s. This implies that future growth and maintenance of sustainable yields will be dependent on control of fishing mortality and that catches are not likely to reach levels seen in the 1970s when recruitment was higher.

Authors

William Lart, Alex Caveen, March 2017

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