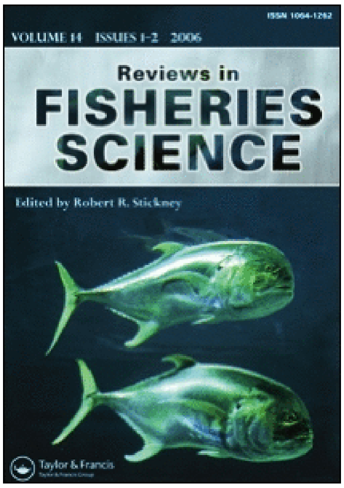

Reviews in Fisheries Science
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713610918

Fisheries Discards in the North Sea: Waste of Resources or a Necessary Evil?

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First published on: 20 June 2011

To cite this Article Diamond, Ben and Beukers-Stewart, Bryce D.(2011) 'Fisheries Discards in the North Sea: Waste of Resources or a Necessary Evil?', Reviews in Fisheries Science, 19: 3, 231 — 245, First published on: 20 June 2011 (iFirst)
To link to this Article: DOI: 10.1080/10641262.2011.585432
URL: http://dx.doi.org/10.1080/10641262.2011.585432

Reviews in Fisheries Science, 19(3):231–245, 2011

ISSN: 1064-1262 print
DOI: 10.1080/10641262.2011.585432

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Fisheries Discards in the North Sea: Waste of Resources or a Necessary Evil?

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Fisheries discards are often seen as a waste of resources and an impediment to the management of fish stocks. However, many traditional fisheries management measures have effectively encouraged discarding. This controversial dichotomy has recently prompted the European Commission to review its approach to managing discards, particularly in the North Sea, where discard rates are among the highest in the world. The European Commission jointly manages North Sea fisheries with Norway; however, in Norwegian waters, discarding is banned. To assess the effectiveness of this Norwegian policy, this study examined its effect on biologically isolated stocks of cod, haddock, saithe, and herring in the Northeast Arctic. Trends in stock status and economic performance showed that the Norwegian approach in the Northeast Arctic has been more successful than the joint approach in the North Sea. After considering the economics and current status of stocks, it is concluded that a discard ban throughout the North Sea for the above species could also offer substantial benefits. Implementation of this policy would be complicated by the more mixed nature (both politically and biologically) of North Sea fisheries, but the use of real-time area closures, gear modifications, and electronic monitoring systems could help ensure compliance and effectiveness.

Keywords fisheries management; common fisheries policy; Norwegian discard ban; by-catch; sustainability

INTRODUCTION

Global per capita consumption of fishery products has increased by more than 80% in the last 40 years. Combined with an ever increasing human population, the demand for fish continues to grow at a significant rate (FAO, 2009b). However, 77% of ocean fisheries are either fully or over-exploited, and there is little room for expansion (FAO, 2009b). Despite this insatiable demand for fish, it is estimated that 8% of the fish caught each year are subsequently discarded (Kelleher, 2005). This equates to some 7.3 million tonnes of fish (Kelleher, 2005). Discards refer to any animal material that is caught during commercial fishing operations that is then subsequently returned to the sea (Kelleher, 2005). They include organisms that are alive as well as those that are dead (Kelleher, 2005). Despite covering just 0.2% of the world's oceans, between 1992 and 2001, the North Sea fisheries were estimated to be responsible for the discarding of over 13% of the estimated total global discards (Kelleher, 2005).

The North Sea is in the Northeast Atlantic and is bordered by seven different countries (Belgium, Denmark, France, Germany, the Netherlands, Norway, and the United Kingdom), all of which have significant fishing interests in the region. Effective management of this area thus becomes extremely difficult. The introduction of the European Union (EU) Common Fisheries Policy (CFP) in 1983 simplified the situation slightly, since it meant that the six countries belonging to the EU were all managed under one policy. However, Norway maintains national control over its fisheries, and its policies are somewhat different to that of the CFP. A major discrepancy in the two policies lies in their approach to discards. For vessels operating under Norwegian authority or in the Norwegian Exclusive Economic Zone (EEZ), it is illegal to dump fish into the sea (Government of Norway, 2008), whether the vessel holds a licence for the catch or not. For vessels operating under EU authority, however, it is illegal to keep on board any fish for which the vessel does not hold a licence or have quota or which is below the minimum legal landing size (EU, 2009). Perhaps surprisingly, there do not appear to

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have been any previous quantitative studies examining the effectiveness and impact of the Norwegian ban on discards. However, isolating the effects of the Norwegian discard ban in order to examine its effectiveness is not straightforward. The management of Norwegian fisheries underwent a series of changes at the same time as the discard ban was introduced in late 1980s (Eliasen et al., 2009, Johnsen and Eliasen, 2011). Some fish species may also move between the North Sea and Norwegian waters (e.g., mackerel) and, hence, are exposed to both different management regimes. Furthermore, little or no direct data was collected on compliance with the Norwegian discard ban until recently, making it difficult to know how effective it may have been. To help overcome these challenges, we undertook a series of complimentary analyses of direct and indirect evidence in order to assess compliance with the Norwegian discard ban and how it may have benefitted Norwegian fish stocks relative to those in the North Sea. Such an analysis would seem especially timely, given that the EU is currently reviewing the CFP (Anon., 2009) and has recently proposed plans to phase-in a discard ban in European waters (Anon., 2011). The issue of discards in the North Sea is also receiving considerable coverage in the media and among policy makers and campaign groups at present (e.g., Anon, 2010; Hugh's Fish Fight, www.fishfight.net).

This study first introduces the problem of discards in the North Sea (ICES sub-area IV) and then assesses the impacts of the Norwegian discard policy in the Norwegian Sea and around Spitzbergen (ICES sub-area II) and in the Barents Sea (ICES sub-area I). ICES sub-areas I and II will be referred to as the Northeast Arctic throughout this study. See www.ices.dk/aboutus/icesareas.asp for the geographic locations of all of these areas. It is then asked if the Norwegian approach to discards should be transferred to the North Sea EU fisheries in order to make management of the North Sea more effective and harmonious.

Initially, the Norwegian discard ban only applied to commercial species (Wåge, 2007), and it is the effects of discarding commercial species of fish that will be addressed in this study. The particular focus is on cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), saithe (*Pollachius virens*), and herring (*Clupea harengus*). These species are considered for four main reasons. First, they are found in both the Northeast Arctic and the North Sea but form two distinct stocks. This allows the effects of different management approaches on these species to be compared in isolation. Second, these species were the first to receive bans on discarding within the Norwegian EEZ (cod and haddock in 1987 and saithe and herring in 1988; Wåge [2007]), and as such, relatively substantial time series on the status of these stocks are available. The third point relates to the distribution of the Northeast Arctic stocks. Northeast Arctic saithe is found almost exclusively within the Norwegian EEZ (Kaschner et al., 2008). Northeast Arctic herring (Norwegian spring spawning herring) was so overfished in the 1970s and 1980s that, at the time Norway implemented the discard ban, it was also found almost exclusively within the Norwegian EEZ (Churchill and Ulfstein, 1992). Northeast Arctic cod and haddock migrate between the Norwegian EEZ and the Russian Federation EEZ (Kaschner et al., 2008). However, cod and haddock have been managed under a bilateral agreement since 1976, and Russia also has a discard ban on these species within its EEZ (Hallenstvedt, 1995; Hønneland, 2000). Therefore, it is illegal to discard the Northeast Arctic species for almost the entirety of their range, and they are likely to prove a good indicator as to the ecological effects of the Norwegian discard policy. Finally, in 1987, cod, haddock, saithe, and herring made up 62% of the Norwegian catch by value[1]. Therefore these species will also provide a good indicator as to the economic effects of the Norwegian discard policy.

The North Sea Fisheries

Discarding in the North Sea

The North Sea roundfish otter trawl fishery (targeting cod and haddock) is responsible for 24% of North Sea discards (Enever et al., 2009). It is estimated that 20–50% of the cod and haddock catch (by weight) is discarded each year (Anon., 2002; Cotter et al., 2002; ICES, 2010b). For haddock, this has equated to more than 100,000 tonnes of discards in recent years (Kelleher, 2005). In these fisheries discards mainly consist of small-sized specimens of the target species (ICES, 2008a); therefore, the proportions discarded by number are much higher. For example, approximately 75% of all cod caught in 2007 were discarded (ICES, 2010c). There are no discard estimates for the North Sea saithe fishery, but the volume discarded in this fishery is considered to be small compared to the total catch (ICES, 2008c). However, there are reports of large hauls of saithe being discarded in other whitefish fisheries due to a lack of quota (Cappell, 2001). In general, pelagic fisheries are considered to suffer from much smaller bycatch and discard rates than the bottom trawl fisheries, since they are largely single-species fisheries (Alverson et al., 1994). However, Pierce et al. (2002) found that about 11% of the herring caught in the Scottish "maatje" herring fishery were subsequently discarded, mainly as a result of being too small.

A Waste of Resources

It is widely accepted that the dumping of fish at sea is unethical and represents a substantial waste of resources. There are a number of international statements and agreements, including United Nations (UN) resolutions, that call for states and regional organizations to develop and implement techniques to reduce bycatch and discards (e.g., FAO, 1995; UN, 1996).This culminated in UN resolution 57/142 of 2002, which urged action to reduce or eliminate bycatch and fish discards (UN, 2002). The direct loss of potential income through discarding in the North

[1]Calculated using data obtained from Statistics Norway (2008).

Sea has been estimated at 42% of the value of the total annual landings for the UK roundfish fishery (Cappell, 2001). In 1999, this equated to £11 million of cod and £31 million of haddock (Cappell, 2001). More recently, the North Sea Scottish fishery alone was estimated to have lost over £30 million from discarding of cod and haddock in 2009 (Anon., 2010). As well as direct losses, discards also result in foregone potential future yield. In the otter trawl fishery, discard mortality for cod and haddock is estimated at 100% (Lindeboom and de Groot, 1998; Cappell, 2001). As such, these fish can neither be caught later nor do they contribute to stock recruitment. Discards, therefore, are seen as a serious impediment to the management and rebuilding of stocks (ICES, 2008c).

Discarding not only results in a waste of natural resources but also in the loss of valuable scientific information. The provision of sound scientific advice relies heavily on accurate fish stock assessments, which in turn, rely on accurate estimates of fishing mortality. Discard information is included in relatively few stock assessments due to the inaccuracy of the data (Kelleher, 2005). As a result, estimates of fishing mortality can be substantially lowered, leading to inaccurate conclusions and poor management decisions (Casey, 1996).

Furthermore, discarding also has wider ecosystem effects (Lindeboom and de Groot, 1998; Groenwold and Fonds, 2000; Votier et al., 2004). The direct impacts of continuing to discard, or reducing discards, are not fully understood (Lindeboom and de Groot, 1998; ICES 2000). There are indications that some seabird species may have benefitted from discards (Votier et al., 2010). However, the European Commission (EC) considers that bycatches and discarding have a negative effect, both from ecosystem and economic perspectives, and is now committed to reducing unwanted bycatch and eliminating discards in European fisheries (Anon., 2007, 2009, 2011).

Reasons for Discarding in the North Sea

The volume of fish that is thrown back into the sea is initially influenced by the composition of the catch, which is determined by social (gear regulations and fishermen's behavior), environmental, and biological factors (Maynou and Sarda, 2001; Bergmann et al., 2002). The decision to discard is then ultimately controlled by the fishermen who are further influenced by regulations as well as by economic forces (Gillis et al., 1995; Catchpole et al., 2005). Once the catch is onboard, reasons for discarding fall into three main categories—exclusion discarding, capacity discarding, and high grading (Gillis et al., 1995). Exclusion discarding occurs because there is no market for the species or because there are regulations that prohibit the retention of any amount of the species, e.g., protected species. Capacity discarding occurs because there is either no physical room in the hold of the vessel or because the vessel has filled its quota, whereas high grading is the decision to discard marketable fish before the vessels capacity is filled. High grading is ultimately at the discretion of the fisherman and is based on whether the fisherman believes that they stand a good chance of catching a more profitable haul later in the trip. This is often related to size. Individual catch quotas (IQs) issued under the total allowable catch (TAC) system restrict the total weight of fish that can be landed. This creates an incentive for fishermen to throw back the smaller fish and retain the larger fish that have a higher value per kilogram (Turner, 1997). On the other hand, exclusion and capacity discarding occurs largely because of external pressures from markets or from management authorities. The CFP has come under public criticism because it requires member-state vessels to discard all catches that they are not legally allowed to catch, thus placing external pressures on fisherman to exclusion and capacity discard (Booker, 2007; www.fishfight.net). The EU's reasons for maintaining this policy are not widely discussed.

In the late 1970s, it was realized that fishing pressure was so high that simply using technical measures, such as mesh size regulations, was not enough to conserve fishery resources (Karagiannakos, 1996). New measures, such as TACs, bycatch regulations, and small fish restrictions, that controlled the output of fisheries were put in place (Gezelius, 2008). Under EU law, each of its 27 member states is individually responsible for penalizing violators of EU regulations through "criminal proceedings in conformity with their national law" (EU, 2002, Article 25). In many European states, confiscation of goods or fines can only be issued as the consequence of a punishable act (Gezelius, 2008). This means that in order to impose a penalty or confiscate fish, the EU state has to prove the fisherman has acted without "due care." Due to the isolated nature of a vessel at sea and the fishermen's lack of complete control over their catch composition, this can be extremely difficult to prove, greatly reducing the risk of penalty and, thus, reducing deterrents to pursue illegal catch or fish carelessly. The EU simplifies the legal problems of enforcing catch regulations by regulating acts that the fishermen can control. The EU's quotas are set for the catch landed and not for the fish caught (EU, 2002). This simplifies the question of "due care"', clarifies the criteria for criminal liability, and makes enforcement much simpler to implement. The downside to this approach is that it not only allows fishermen to discard any catch that they feel is not economically worth keeping, but it also forces them to discard potentially valuable fish if they are not licensed to catch them. EU discard policy thus focuses on indirect technical measures that try to reduce the initial capture of fish that are likely to be discarded. There are currently no direct measures in place that address the issue of discarding in EU fisheries (MRAG, 2007).

The Norwegian Discard Policy

When TACs were first introduced, fisheries law in Norway was similar to many European laws in that fish could only be confiscated if it resulted from a punishable act (Gezelius, 2008). As a result, Norwegian fishermen were also expected to discard illegal catch to get around the problem of incidental catch and the random nature of fisheries (Government of Norway, 1955). Shortly after the introduction of TACs, discussions began on how to manage the unintentional exceeding of quotas. Norwegian sales organizations were given the power to confiscate all catch that exceeded the vessels quota without having to prove the fisherman's liability (Government of Norway, 1983). This was thought to be an acceptable action on the grounds that fishermen do not own the catch they are not legally permitted to take (Gezelius and Raakjaer, 2008). It was not seen as a penalty, and no fines were implemented for the landing of illegal catch. Further, although fishermen did not receive any financial gain from the "illegal" catch, it was not deducted from the vessels quota (Gezelius, 2006). This reduced the incentive for fisherman to pursue illegal catches without forcing the fisherman to discard their catch. This change in approach allowed Norway to introduce a ban on discards. In 1987, Norway introduced a ban on the discarding of cod and haddock (Wåge, 2007). This was followed by a ban on the discards of six other species, including saithe and herring, in 1988 (Wåge, 2007). The EC has raised the possibility of moving toward this strategy in several recent communications (Anon., 2007, 2009, 2011). In this study, therefore, the impacts of the Norwegian policy on the Northeast Arctic fisheries were assessed in order that the lessons learned may be applied to the North Sea stocks.

In order to assess the impact of the Norwegian discard policy on the Northeast Arctic stocks, a three-pronged approach was taken. First, evidence was sought that the fishermen were complying with the ban. Second, the impacts on the fish stocks were assessed, and finally, impacts on the fishing industry were considered. The first prong tests the hypothesis that due to the remoteness of a vessel at sea, the low chance of being observed discarding and, thus, the difficulty in proving that a vessel has been involved in illegal discarding, the discard ban would have been extremely difficult to enforce and compliance would have been low. The second prong tests the hypothesis that a discard ban may not reduce fishing mortality. The unwanted fish will still be caught, whether they are thrown back into the sea or they are landed. Further, allowing fishermen to land everything may reduce the incentive for them to fish selectively. It may generate new markets for undersized fish, and as a result, a discard ban may actually increase pressure on the fish stocks. The third prong aims to test the hypothesis that since some discarding occurs for economic reasons, a discard ban will reduce the profitability of the fishing fleet. The fishing fleet will be constrained to land catches of lower value and its competitiveness in what is an international fish market will be reduced.

A Comparison of Fisheries and Stocks

The technological level of the fishing gear used by European fleets is similar to Norwegian fleets (MRAG, 2007). Bycatch and discards in the North Sea roundfish fishery (cod, haddock, and saithe) mainly consist of small or undersized roundfish (ICES, 2008a), and the North Sea herring fishery is largely a single-species fishery (Pierce et al., 2002). The Northeast Arctic roundfish fishery is also mixed with the cod fishery taking bycatch of haddock and saithe (Ingólfsson et al., 2007; ICES, 2008b), and the Northeast herring fishery is also a single-species fishery, although small bycatches of saithe are sometimes recorded (Norwegian Ministry of Fisheries and Coastal Affairs, 2006). Thus, it can be concluded that the North Sea and Northeast Arctic fisheries for these species are relatively similar. The final question that this study asks is whether the present-day North Sea fish stocks are in a comparable state to the late 1980s Northeast Arctic stocks and, therefore, whether similar effects are likely to be observed if a discard ban is implemented in the North Sea.

METHODS

Compliance

Estimates of discard rates have not been considered until fairly recently and are not available over the period of time with which this study is concerned. Instead, a more indirect approach to assess whether fishermen have reduced discards since the introduction of a discard ban was required.

Age Composition of Catches of Northeast Arctic Cod

If the discard ban was enforced effectively and fishermen were complying with the ban (and no longer high grading), then it would be expected that the fish being landed by the Norwegian fleet would consist of smaller fish shortly after the implementation of the discard ban. It is difficult to assess how policies or measures may have influenced catch composition over time, since the data are likely to be heavily distorted by strong year classes or other environmental changes that may effect the composition of the fish stocks. It would, therefore, be useful if the catch composition of two fleets, operating under different policies but fishing the same fish stocks, could be compared.

Under the Norwegian Sea-Water Fisheries act, it is illegal for Norwegian vessels to discard fish (Government of Norway, 1983). Russia has a similar discard ban, and it is also illegal for Russian vessels to discard (Hallenstvedt, 1995; Hønneland, 2000). Since the Northeast Arctic cod stocks are shared between the Norwegian and Russian EEZs, it is important that fishermen from both countries comply with the discard ban. If Russia continues to discard while Norway complies or vice versa, then the effects of the policy on the stocks may be masked. For this reason, the Norwegian and Russian catches are aggregated in this section, and compliance is assessed in the Northeast Arctic as a whole.

Norway and Russia may trade some of their TAC with other countries in order to obtain quotas for other fisheries. EU vessels are allocated some of the Northeast Arctic TAC, and so also are allowed to fish within the Norwegian and Russian EEZs.

However, it is only illegal for EU vessels to discard fish within the EEZs of Norway or Russia (Government of Norway, 1983). As a result, it can be assumed that EU vessels that leave the bounds of these EEZs in order to land their fish will continue to act as though no discard ban was put into place. In fact, upon re-entering EU waters, it becomes illegal not to discard any fish for which the vessel does not have a licence to catch (EU, 2009).

If the Norwegian and Russian fleets are adhering to the discard ban, then it would be expected that EU fleets would be discarding at a higher rate, since at least some of the EU vessels can be assumed to continue to discard. High grading involves throwing back the smaller, less valuable fish to make room for the larger, more valuable ones. If the Norwegian and Russian fleets are complying with the discard ban and discarding to a lesser extent than the EU fleets, then this should be apparent in the age composition of the catch. This provides a testable hypothesis for compliance within the Norwegian and Russian fleets. After the implementation of the discard ban, the Norwegian and Russian fleets should be landing a larger proportion of the younger, smaller fish and a smaller proportion of the older, larger fish than the EU fleets. By comparing the age composition of the Norwegian and Russian fleets to the EU fleets at specific points in time, the problems of temporal fluctuations in stock composition can be avoided.

The need to keep the stock compositions the same for the different fleets highlights a second reason why it is important to combine the Norwegian and Russian landings in this section. The EU fleets catch fish in both the Norwegian and Russian EEZs. The Russian EEZ is mainly an area for young cod, while the majority of cod found within the Norwegian EEZ are mature adults (Garrod, 1977). By combining the Russian and Norwegian data, the landings come from the whole of the Northeast Arctic, and the stock compositions can be assumed to be the same as experienced by the EU fleet.

The Arctic Fisheries Working Group (AFWG) provides commercial catch data on the number of Northeast Arctic cod that were landed from 1946 (ICES, 2007). These data are available by age and nationality up until 1998 for ICES sub-areas I and II. The data were split into two groups—catches landed by the Norwegian and Russian fleets and those landed by the Spanish, German, and Polish fleets (EU fleets). Landed catches for each group were then totaled for six three-year periods spanning from 1981 to 1998. The mean ages and age distributions of the cod landed in each period were then calculated and plotted. The age distributions of the Norwegian and Russian catches were compared to that of the EU fleets for each three-year period. Q-Q plots and Shapiro-Wilk tests were used to test for normality, and Levene's test looked for homogeneity of variance (Field, 2005). Since the data were non-normally distributed and had un-equal variances, a Kolmorgorov-Smirnov Z-test was used to test if the distributions were significantly different from one another (Field, 2005). The distributions were then plotted to show where the differences in distribution occurred.

Temporal Trends in the Status of Stocks

Temporal trends in the health of the fish stocks were considered prior to and after the implementation of the different management policies in order to try to assess the impacts of the different strategies. Time series data on the spawning stock biomass (SSB) and the biomass at which the probability of recruitment failure is deemed high (B_{lim}) for the North Sea and Northeast Arctic stocks of cod, haddock, saithe, and herring were taken from ICES (2008b,c). Table 1 shows the time span of each series included in the analysis.

Optimum levels of SSB vary between species and stocks such that directly comparing SSBs of different species would not be valid. The SSB was therefore divided by its associated B_{lim} value in order to obtain a normalized value that would allow for the status of different stocks to be compared (Garcia and Staples, 2000; Sparholt et al., 2007). Combining the status of the stocks enables general trends to be seen more easily than if they are considered on a stock-by-stock basis (Myers, 2001). For this reason, the normalized SSB values for the four Northeast Arctic stocks were plotted on the same chart and the North Sea stocks on another chart. To keep the analysis as transparent as possible, means of the stocks by year and simple linear regression were used to explore the temporal trends. For the Northeast Arctic stocks, the regression was run once for the data points prior to and once for the data points after the discard ban in order to assess whether the ban had any effect on the status of the stocks. Similarly, for the North Sea stocks, the regression was run once for data points prior to and once for data after the implementation of the CFP in 1983 in order to assess what effect this had had on the status of the fish stocks. Significance levels and confidence intervals were not calculated because the data are strongly autocorrelated. However, a leave-one-stock-out sensitivity analysis was conducted (Mosteller and Tukey, 1977).

Effects on the Fishing Industry

As discussed above, after the implementation of the discard ban, the Norwegian fleets should be landing a larger proportion

Table 1 Stocks included in the analysis and the time spans for which data were utilized

Species	ICESstock area	Time series span	
		Start	End
Cod	I and II	1946	2008
Cod	IV, VIId, and IIIa	1963	2007
Haddock	I and II	1951	2008
Haddock	IV and IIIa	1963	2008
Saithe	I and II	1961	2008
Saithe	IV, IIIa, and VI	1967	2007
Herring	I and II	1950	2008
Herring	IV, VIId, and IIIa	1960	2006

of younger, smaller fish and a smaller proportion of older, larger fish. Since larger fish are of a higher value than smaller fish, this will have reduced the value of the fish landed. However, the lower value of the fish landed may have been offset by greater catch per unit effort (CPUE), since fish were no longer being thrown back into the sea.

Time series data on the CPUE in ICES sub-areas I, IIa, and IIb were taken from ICES (2008a). Data are available for Norwegian, Spanish, and Russian trawls for Northeast Arctic cod and for the Norwegian trawls for Northeast Arctic saithe from 1983 until 1995. The units used differ for some fleets, so the CPUEs are not directly comparable. Instead temporal trends in CPUE for the fleets were considered.

Comparison of Historic Northeast Arctic Stocks with Present North Sea Stocks

In order to test if late 1980s Northeast Arctic fish stocks were in a comparable state to present North Sea stocks, three major components need to be considered: SSB, the fishing mortality rate (F), and the proportion of juveniles. SSB is the biomass of mature individuals in the stock, and F gives an indication of the fishing pressure on the stock. SSB and F give an indication of the stocks ability to replenish and are considered below. The proportion of juveniles is also important since the discards in the fisheries with which this study is concerned consist primarily of juveniles or undersized fish (ICES, 2008c). Thus, a larger proportion of juveniles in the stock will result in larger proportions of bycatch. Therefore, the proportion of juveniles in the Northeast Arctic and the North Sea stocks were also compared.

Precautionary Plot

A precautionary plot allows SSB and F to be compared at the same time. Data for the Northeast Arctic stocks of cod and haddock (1987) and saithe and herring (1988) were taken from ICES (2008b). Data for the North Sea stocks (2006) of the same species were taken from ICES (2008c). The choice of 2006 data was intentionally conservative because, in this year, North Sea cod stocks were at a historical low and, therefore (hopefully), represented a "worse-case scenario" for North Sea stocks. Data on the SSB, F, the biomass at which the stock is regarded as potentially depleted (B_{pa}), and the F at which there is a high probability of it being sustainable (F_{pa}) were used for this analysis. The SSB and F were normalized by dividing them by their reference values (Garcia and Staples, 2000; Sparholt et al., 2007). B_{pa} and F_{pa} were used as the reference values because ICES does not provide F_{lim} information for either of the herring stocks (ICES, 2008b,c). The normalized SSB of the Northeast Arctic stocks for the year that the Norwegian discard ban was introduced (1987 for cod and haddock, 1988 for saithe and herring) were plotted against normalized F values to form precautionary plots similar to those used by ICES (e.g., ICES, 2008c, p. 154). The normalized SSB of the North Sea stocks in 2006 and their corresponding normalized F values were added to the plots for comparison. The mean normalized SSB and F values were calculated for the North Sea stocks and for the Northeast Arctic stocks. A Shapiro-Wilk test was used to check for normality, and Levene's test was used to test for homogeneity of variance (Field, 2005). Since there was no evidence of non-normality or heterogeneity, one-way ANOVA was used to test for differences between the means of the two stocks (Field, 2005).

Stock Maturity

Data were taken from ICES (2008b,c). The percentage of juvenile fish in the stocks was calculated for Northeast Arctic cod and haddock (1987); Northeast Arctic saithe and herring (1988); and North Sea cod, haddock, saithe, and herring (2006). The percentage of juvenile fish in the stocks was calculated using the following equation:

$$\text{Juvenile fish}\,(\%) = \frac{TSB - SSB}{TSB} * 100,$$

where *TSB* is the total stock biomass.

The proportions of juvenile fish in each fish stock were arcsin $\sqrt{x}$ transformed (Underwood, 1991). A Shapiro-Wilk's test and Levene's test found no evidence of non-normality or heterogeneity (Field, 2005). One-way ANOVA was used to test if there was a difference between the proportions of juvenile fish in the pre-discard ban Northeast Arctic stocks and the 2006 North Sea fish stocks (Field, 2005).

RESULTS

Compliance

Age Composition of Catches of Northeast Arctic Cod

Figure 1 shows the mean age of Northeast Arctic cod that was landed between 1981 and 1998 for the Norwegian and Russian fleets and for the EU fleet. Figure 2 shows the age distributions of the cod landed by the different fleets for this period with the corresponding Kolmorgorov-Smirnov Z statistic. Prior to the introduction of the discard ban, the mean age for the Northeast Arctic cod landed by the Norwegian and Russian fleets was older than for the fish landed by the EU fleet (Figure 1). The distributions of the ages for the cod landed by the different fleets were significantly different ($p < 0.001$), with the Norwegian and Russian landings consisting of smaller proportions of young fish and larger proportions of older fish (Figures 2A,B). After the introduction of the discard ban on cod in 1987, Norway and Russia started landing fish that were, on average,

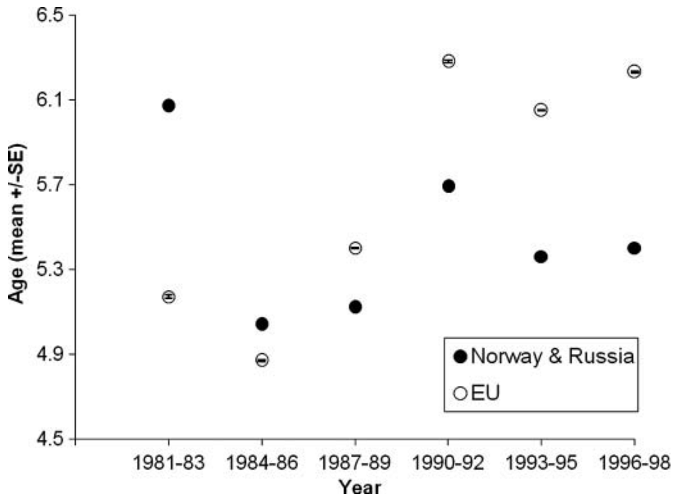

Figure 1 Mean age of Northeast Arctic cod that were landed by the Norwegian and Russian fleets (closed circles) and the EU fleet (open circles) between 1981 and 1998.

younger than the EU fleet (Figure 1). Norway and Russia's cod landings now consisted of proportionally more young fish and proportionally less older fish than the EU fleet ($p < 0.001$) (Figures 2C–F).

Temporal Trends in the Status of Stocks

The temporal trends in the normalized SSB for the Northeast Arctic and North Sea stocks of cod, haddock, saithe, and herring are shown in Figure 3. The normalized SSB of the Northeast Arctic stocks (Figure 3A) declined at a rate of 7% per year up until the discard ban was implemented. Post-discard ban, the normalized SSB of the Northeast Arctic stocks increased at a rate of 18% per year. The normalized SSB of the North Sea stocks (Figure 3B) declined at a rate of 6% per year until 1983 when the CFP was implemented. After this date, the normalized SSB of the North Sea stocks began to increase at a rate of 3% per year. The rates of change from the leave-one-stock-out sensitivity analysis are shown in Table 2. For the Northeast Arctic stocks, the largest range in the rate of change occurred for the post-discard ban data. Increases in normalized SSB ranged from 12% (if saithe are excluded) to 23% (if cod are excluded) per year, compared to 18% if all stocks are included. For the North Sea stocks, the largest range in the rate of change occurred for the post CFP data. Increases in normalized SSB ranged from 2% (if haddock are excluded) to 6% (if cod are excluded) per year, compared to 3% if all stocks are included. Therefore, the results are relatively robust

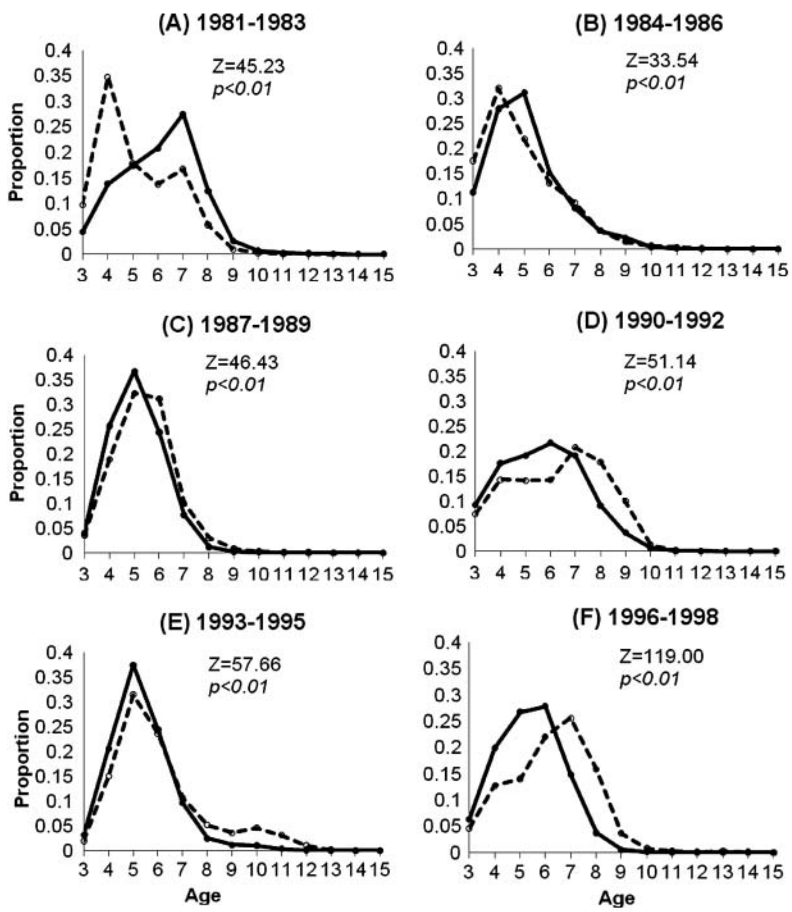

Figure 2 Age composition of Northeast Arctic cod landed by the Norwegian and Russian fleets (closed circles/solid lines) and the EU fleet (open circles/dashed lines) between 1981 and 1998. The Kolmorgorov-Smirnov Z statistic and corresponding *p*-values are shown in each panel.

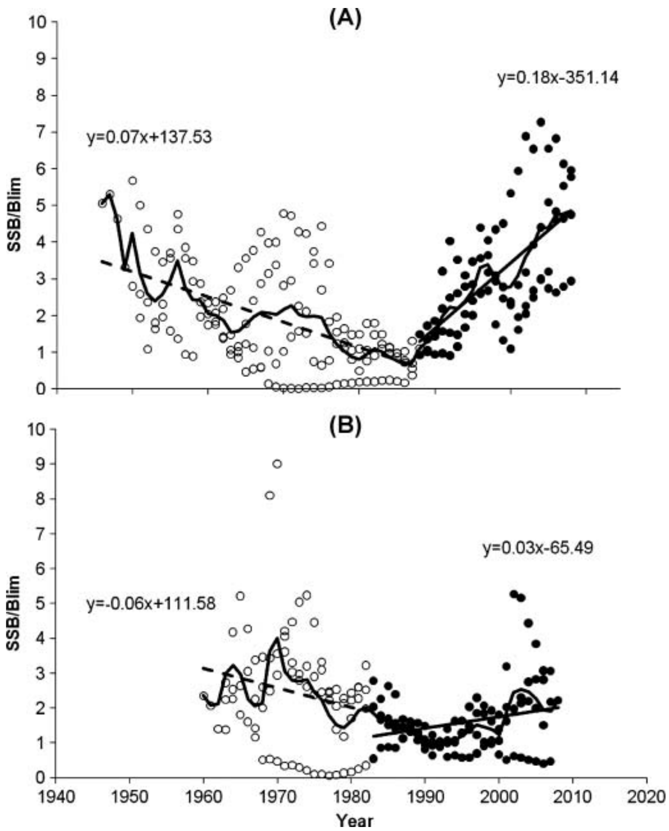

Figure 3 Normalized SSB (B_{lim}) for: (a) the Northeast Arctic and (b) the North Sea stocks of cod, haddock, saithe, and herring by year. The undulating lines represent the mean values by year, and the straight lines are the linear regressions (parameters are given in each panel). The open circles/dashed lines are the pre-discard ban (a) CFP (b) and the closed circles/solid lines represent the subsequent periods.

to this sensitivity analysis, and it can be concluded that the observed temporal trends are not driven by just one species in the analysis.

Effects on the Fishing Industry

The temporal trends in CPUE for various fleet's catch of Northeast Arctic cod are shown in Figure 4. The Norwegian total CPUE for cod began to decrease in 1987 and had declined by 75% before reaching a low in 1991 (Figure 4A). The fastest rate of decline occurred between 1987 and 1988, during which time the CPUE was reduced by 42%. By 1993, the total Norwegian CPUE was back above the 1987 total CPUE. CPUE in ICES sub-areas IIa and IIb showed much greater rates of change than ICES sub-area I. The Spanish trawls targeting cod in ICES sub-area IIb displayed a very different trend in CPUE (Figure 4B). The Spanish CPUE continued to rise after 1987, increasing by 173% by 1991. By 1994, the Spanish CPUE was back at similar levels to those experienced in 1987. No temporal trends were apparent in the Russian CPUE for cod (Figure 4B). Russian CPUE ranged from a low of 0.23 t/hr (1992 ICES sub-area IIb) to 1.14 t/hr (1986 ICES sub-area IIa and 1994 ICES sub-area IIb).

The temporal trends in the Norwegian CPUE for Northeast Arctic saithe are shown in Figure 4C. Between 1988 and 1990, CPUE decreased by 16%. However, by 1992, CPUE was above late 1980 levels peaking in 1993 at 1 t/hr.

Table 2 Rate of change of the standardized SSB for the Northeast Arctic and North Sea stocks when certain stocks are excluded from the regression analysis

	Rate of change (% per year)			
	Northeast Arctic		North Sea	
Species	Pre-discard ban	Post-discard ban	Pre-CFP	Post-CFP
None	−6.9	17.7	−5.5	3.4
Cod	−7.8	23.0	−6.3	6.4
Herring	−4.9	18.6	−6.9	3.0
Haddock	−8.0	18.0	−3.3	1.5
Saithe	−7.3	11.5	−7.1	2.4

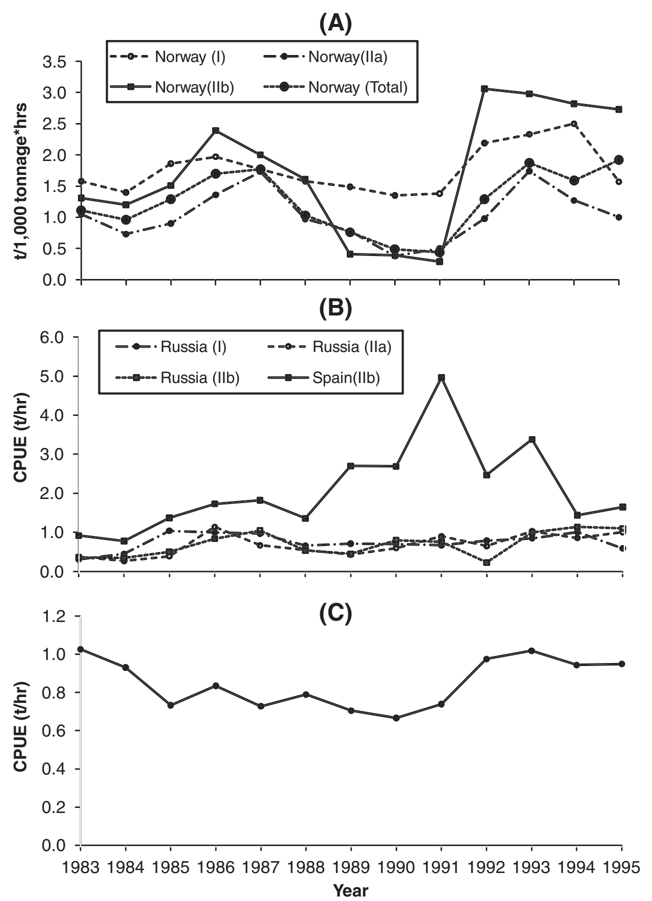

Figure 4 Northeast Arctic CPUE in ICES sub-areas I, IIa, and IIb in: (a) the Norwegian trawl fishery for cod and (b) the Spanish and Russian trawl fishery for cod, and (c) the Norwegian trawl fishery for saithe.

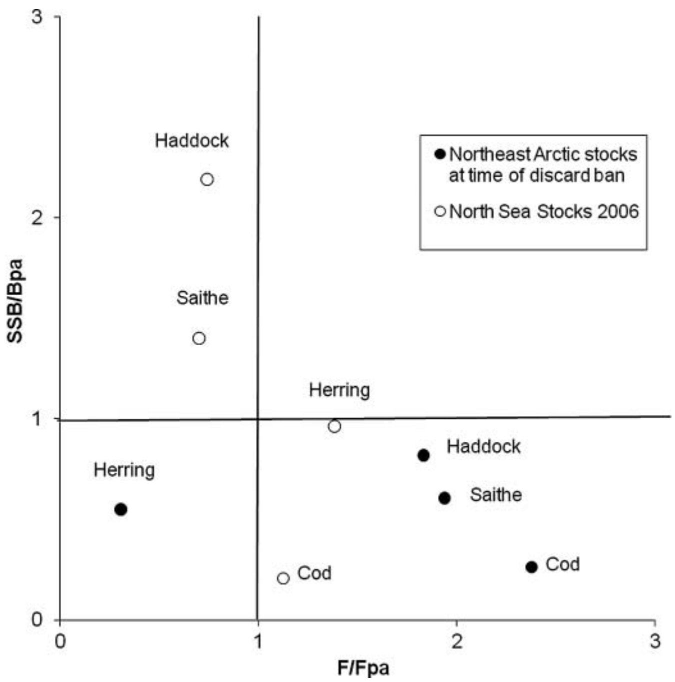

Figure 5 Normalized SSB (B_{pa}) against normalized fishing mortality (F/F_{pa}) for Northeast Arctic cod and haddock in 1987, Northeast Arctic saithe and herring in 1988 (before discard ban), and North Sea cod, haddock, saithe, and herring in 2006.

Comparison of Historic Northeast Arctic Stocks with Present North Sea Stocks

Precautionary Plot

The status of present North Sea stocks and Northeast Arctic stocks at the time that the Norwegian discard ban was introduced is shown in Figure 5. Present North Sea stocks of haddock and saithe are in much better condition than any of the Northeast Arctic stocks were in when the Norwegian discard ban was implemented. Generally, the North Sea stocks have higher levels of normalized SSB than the historic Northeast Arctic stocks and experience lower levels of fishing mortality. Only present North Sea stocks of cod contain lower levels of normalized SSB than the Northeast Arctic stocks. The mean normalized SSB for the North Sea stocks (1.2) was higher than that of the historic Northeast Arctic stocks (0.6). However, this was not statistically significant ($t_6 = -1.465$, $p = 0.19$). The mean fishing mortality rate for the North Sea stocks (1.0) was also lower than the Northeast Arctic stocks (1.6), though again this was not statistically significant ($t_6 = 1.3$, $p = 0.18$).

Stock Maturity

The percentage of juvenile fish in each stock is shown in Figure 6. The mean arc sine $\sqrt{x}$ transformed proportion of juvenile fish was very similar in the present North Sea stocks (0.91) to the historic Northeast Arctic stocks (0.94). There was no statistical evidence to suggest that these proportions were different from one another ($t_6 = 0.13$, $p = 0.90$). However, the mean proportion of juvenile fish in the Northeast Arctic stocks was strongly influenced by the low proportion of juvenile fish in the Northeast Arctic herring stocks. The historic Northeast Arctic stocks of cod, haddock, and saithe all contained a larger percentage of juveniles than their equivalent present-day North Sea stocks (Figure 6).

DISCUSSION

After the introduction of the discard ban, the Norwegian and Russian fleets started landing larger proportions of small fish and smaller proportions of large fish than the EU fleet. However, this was followed by substantial stock recovery rates in the Northeast Arctic. The Norwegian fleet initially began landing smaller fish, which were of lower value, and Norwegian CPUE declined, but the period of decline lasted just four years. Most present-day North Sea stocks have higher SSBs and lower F than the pre-discard-ban Northeast Arctic stocks, with similar proportions of juveniles present in both areas. It is felt, therefore, that a discard ban similar to that implemented by the Norwegian system could also have substantial benefits for North Sea fisheries.

Compliance

Within the EEZs of Norway and Russia, minimum mesh size and gear regulations are set for the operating area and not by the vessels flag state (UN, 1982). Comparing the catch composition of two different groups of fleets fishing the same stocks under the same technical regulations, one of which is assumed to be continuing to discard to at least some extent,

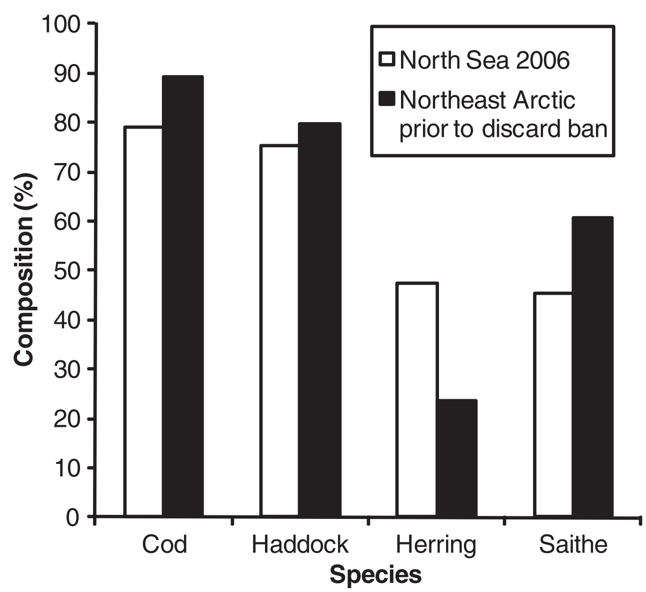

Figure 6 The percentage of juveniles in the present (2006) North Sea and pre-discard ban Northeast Arctic stocks of cod, haddock, herring, and saithe.

enabled the check for a reduction in discarding behavior in the other fleet. Prior to the discard ban, the Norwegian and Russian fleets were landing significantly smaller proportions of young and significantly larger proportions of old cod than the EU fleets (Figure 2). This suggests that, prior to the discard ban, the Norwegian and Russian fleet's discarding rates were actually greater than those of the EU fleet. After the ban on the discarding of cod was put into place in 1987, the Norwegian and Russian fleet began landing greater proportions of younger, smaller cod and smaller proportions of older, larger cod (Figure 2). This supports the idea that the Norwegian and Russian fishermen were at least partly adhering to the ban on discards and high grading to a lesser extent than the EU fleet. Exclusion discarding and capacity discarding occur mainly for legislative reasons, which are removed if a ban on discards is introduced, whereas high grading occurs mainly in order for fishermen to maximize the profitability of their catch. This makes high grading much more difficult to enforce. For this reason, a reduction in high grading in the Norwegian and Russian fleets indicates that other forms of discarding are also likely to have been reduced.

The Norwegian government enforced the discard ban largely through on-board inspectors from the Directorate of Fisheries and through Coast Guard patrols of fishing grounds (MRAG, 2007). However, due to the vast area covered by the Norwegian EEZ and the small number of inspectors involved, it was extremely difficult to monitor activities at sea. As a result, the number of reported infringements that were later prosecuted is small (Gezelius, 2006; MRAG, 2007). With no penalties or fines in place for the landing of illegal catch, the discard ban appears to have been adhered to largely on a voluntary basis. This is supported by the fact that violations of Norwegian fisheries policy are no more frequent in the protection zone around Svalbard than in the Norwegian EEZ, despite the fact that violations within this zone cannot be punished due to Svalbard's unsettled jurisdictional status (Hønneland, 2000). Part of the voluntary compliance may be explained by the fact that representatives of the fishermen are directly involved in the regulatory decision process with the explicit aim of enhancing the legitimacy of regulations (Hønneland, 2000; Eliasen et al., 2009; Johnsen and Eliasen, 2011).

Recent discard estimates for Norway are relatively low and are between 2–8% (Valdemarsen and Nakken, 2002), but a ban on discards has not completely eliminated the problem of discarding in the Norwegian and Barents Seas. In order to increase compliance, soft enforcement schemes, whereby fishermen would be paid 20% of the value of any unlicensed fish that they landed, were experimented with in the late 1990s but with mixed success (Gezelius, 2008). These schemes reduced incentives to discard and eased enforcement but increased the incentives to target "illegal" fish. For pelagic fisheries, this incentive proved too lucrative and was later removed, but it is still in place for demersal fisheries.

There would be a number of challenges for the enforcement of a discard ban in the North Sea area. Fish caught and landed in the North Sea are landed and sold in at least six EU countries, all with different legal systems, as opposed to just six sales organizations in Norway. This makes monitoring of the catch composition and prosecution of offenders much more difficult. One encouraging option is the development of electronic monitoring systems involving GPS and CCTV cameras, currently being tested to monitor discarding in Scottish and Danish fisheries (WWF, 2009; Anon., 2010); see below. As well as the problems with hard enforcement, voluntary compliance is also unlikely to be as high as experienced in the Northeast Arctic. Unlike the Norwegian system, which is largely supported by fishermen (Hønneland, 2000; Eliasen et al., 2009; Johnsen and Eliasen, 2011), dissatisfaction with the current CFP is widespread among EU fishers (Ritchie, 2003). However, although there was little support from fishermen for a discard ban in the North Sea in the past (Cappell, 2001), the position of the industry appears to be changing, with support emerging for a gradual move toward a discard ban (NSRAC, 2009) at least in some sectors.

Comparison of Stocks and Fisheries

One of the main objections against the implementation of a discard ban is that allowing fishermen to land everything removes the incentive for fishermen to try to fish selectively or for them to adhere to their allocated quotas. Fishermen may deliberately target smaller fish if they are much more abundant than their larger counterparts, and the pressure on fish stocks may actually increase. However, since the implementation of the discard ban in Norway, the SSB of cod, haddock, saithe, and herring has improved at a rate of 18% per year (Figure 3A). In comparison, the North Sea has experienced a much slower rate of recovery (Figure 3B).

It is important to note here that the increase in stock health may have been influenced by a variety of natural and anthropogenic factors (e.g., environmental change; Stenevik and Sundby, 2007). The ban on discards was introduced alongside various other changes in Norwegian fisheries management. These included the proper enforcement of TACs for the inshore fishery (which were allowed to exceed TACs until 1989) (Mikalsen and Jentoft, 2003), the first regulations for an effective catch monitoring regime (introduced in 1990), which made it much more difficult to trade unregistered fish (Gezelius, 2006), and drastic reductions in allocated TACs (introduced in 1990) (Mikalsen and Jentoft, 2003). Further, the Norwegian and EU management policies differ in other ways than their position on discarding. Historically Norway has set TACs much more closely to the recommended scientific advice than the EU, and this is also likely to have had a positive effect on the Northeast Arctic stocks (Cardinale and Svedäng, 2008) . It is not possible to control for all of these variables and the increase in stock health, which was observed, cannot therefore be attributed solely to the Norwegian discard ban. In reality, it is likely to have been down to a combination of these factors. However, a ban on discards greatly improves estimates of fishing mortality. This will have helped make effective management decisions and is likely to have contributed strongly to the recovery of the fish stocks. At the very least, the implementation of the discard ban does not seem to have hindered the recovery of these stocks and suggests that fisherman have remained selective in their targeting of these species.

In order to ensure that fishermen remain selective, Norway has combined the discard ban with two other main instruments. After the introduction of the discard ban, "unlicensed" fish were confiscated, and the fishermen received either no compensation (in pelagic fisheries) or a small proportion of the true value (in demersal fisheries after 1999) (Gezelius, 2006). The value of the fish accrued directly to the sales organization, and so fishermen had no incentive to target them. The fishermen still faced costs associated with the hold space and processing of the fish, so this acted as a disincentive to target them. Further, a system of real-time closed areas was established (Graham et al., 2007). If the catch to undersize and bycatch ratio is above a certain limit, then the surrounding area is immediately closed. The vessel must then steam five miles before it is allowed to resume fishing (Graham et al., 2007). In combination with technical measures (e.g., fitting grids in trawls; see below), this system is also credited with having had a large influence on the recovery of Northeast Arctic fish stocks (WWF, 2008; Eliasen et al., 2009; Johnsen and Eliasen, 2011).

There are a number of similarities between the North Sea and Northeast Arctic areas. The North Sea fisheries for cod, haddock, and saithe consist mainly of discards of small-sized roundfish (ICES, 2008c). Similarly, the Northeast Arctic roundfish fishery is also mixed, with hauls targeting cod containing by catches of haddock and saithe (Ingólfsson et al., 2007; ICES, 2008b), although perhaps not to the extent of the North Sea fisheries (Anon., 2010). Like the Norwegian herring fishery, the North Sea herring fishery is a single-species fishery, with the bycatch nearly completely consisting of herring that are too small (Pierce et al., 2002). The two fishing fleets are also comparable with the European fishing fleet and the Norwegian vessels using similar technology (MRAG, 2007). The potential also exists for a faster rate of stock recovery in the North Sea. Most North Sea stocks currently have larger normalized SSBs and experience lower rates of fishing mortality at present than the pre-discard-ban Northeast Arctic stocks (Figure 5). Further, cod in the North Sea have been shown to grow faster than those living at higher latitudes, and North Sea haddock reach maturity at age 2–3 years compared to 4–5 years elsewhere (FAO, 2009a). The use of real-time closures to reduce discards of cod has also been experimented with in the Scottish fishery in the North Sea since 2007 (Scottish Government, 2007) and has received considerable support from the fishing industry, scientists, and conservation groups (WWF, 2009). Project 50%, a Fisheries Science Partnership (FSP) with beam trawlers in Devon, United Kingdom, has also demonstrated the potential of gear modifications by achieving significant discard reductions in that fishery (Armstrong and Revill, 2010). Most recently, a catch quota scheme, in conjunction with remote electronic monitoring (using the CCTV cameras mentioned above), has been tested by a small number of English and Scottish boats in 2010 (Scottish Government, 2010; Pasco et al., 2010). In this scheme, all catch (whether undersize or not) counts against a set quota. Early analysis suggests this has encouraged boats to fish more selectively and has reduced discard rates dramatically (Scottish Government, 2010; Pasco et al., 2010).

Effects on the Fishing Industry

In the late 1980s, the SSB of the Northeast Arctic stocks were below the precautionary limits set by ICES (Figure 5), and they contained high proportions of juveniles (Figure 6). The discard ban and the associated closed area regulations, thus, will have initially resulted in a large number of closed areas within Norway's EEZ. Fishermen will have had to fish much more selectively to ensure that they could continue fishing in that area. This will have reduced Norwegian CPUE, as is shown by the steep decline in Norwegian CPUE for Northeast Arctic cod after the discard ban was introduced (Figure 4A). Similarly, CPUE for saithe decreased after the introduction of a ban on discards in 1988 (Figure 4C). A decrease in CPUE may also be a result of decreasing quantities of fish in the stock. However, it is interesting to focus on ICES sub-area IIb. Unlike the Norwegian CPUE (Figure 4A), CPUE for Spanish cod trawlers within this area continued to increase (Figure 4B) over this period, suggesting that decreasing quantities of fish in the stock was probably not the reason for this decline. Further, the SSB for Northeast Arctic cod actually increased over this period from 121,243 tonnes in 1987 to 704,744 tonnes in 1991 (ICES, 2008b), which suggests that there were actually increasing quantities of fish in the stock. A reduction in CPUE combined with lower values of fish being landed caused operating costs to exceed operating revenues (Figure 7), and for a short period, the industry was reliant on government subsidies. Government subsidies to the fishing industry peaked at 1.1 billion kroner in 1990 (Milazzo, 1998).

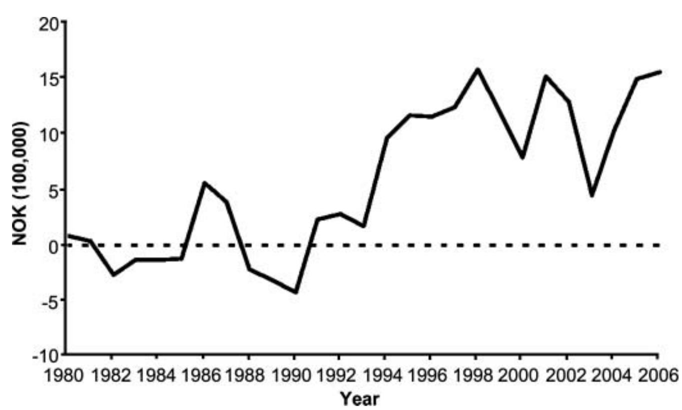

Figure 7 Operating margin of whole year operated fishing vessels 8 meters and above over the period 1980–2006. Converted to 2006 value by means of consumer price index (Statistics Norway, 2008).

This equates to about £100 million at today's exchange rate. An interesting side point here is that the Norwegian CPUE for cod did not decrease as significantly in ICES sub-area I as it did in sub-area II. Since compliance with the ban seems to have been largely voluntary, there is no reason to suggest that compliance should be lower in sub-area I than in II. It is more likely that this is as a result of the different minimum catch sizes (MCS) in the two areas. In the Norwegian EEZ (sub-area II), the MCS for cod is 47 cm, whereas in the Russian EEZ (sub-area I), the MCS for cod is 42 cm (Cappell, 2001). Thus, the smaller MCS in the Russian EEZ appears to have reduced the costs to the fishing vessels operating in sub-area I.

The lack of profitability created strong incentives for fishermen to find technical ways in which they could enter the closed areas. In the early 1990s, investigations began into the use of grid technology to improve the selectivity of cod trawls (Graham et al., 2007). These were demonstrated to improve compliance with catch composition regulations and gave fishermen access to areas that would previously have been closed. The decline in CPUE lasted for just four years; the fishing fleet was profitable again by 1991, and by 1993, the CPUE was back above pre-discard-ban levels. By the mid 1990s, more than 100 Norwegian vessels were using the grid technology on a voluntary basis (Løbach and Veim, 1996). The use of these sorting grids are now mandatory for cod and shrimp trawls in Norway's EEZ north of 62ºN (WWF, 2008).

As already highlighted, most current North Sea stocks are in better condition and also have the potential to recover much more quickly than the Northeast Arctic stocks were in the 1980s. At 35 cm and 30 cm for cod and haddock respectively, the minimum landing sizes (MLS) in the North Sea are also much smaller than the Norwegian and Russian MCS's (47 cm and 42 cm) (Cappell, 2001). Therefore, the short-term cost of a discard ban to the industry is likely to be much smaller and economic recovery much quicker than that experienced by Norway. The economic reliance on the fishing industry is also much smaller in the EU than it was in Norway. In 1987, 1.5%[2] of Norwegians were employed in the fishing industry. This compares to current rates of 0.14%,[3] 0.13%,[4] 0.01%,[5] and 0.04%[6] for Denmark, France, Germany, and the United Kingdom, respectively. Further, North Sea fisheries are made up of a wide variety of alternative species (Sustainable Development of European Coastal Zones, 2009), whereas cod, haddock, saithe, and herring dominate Norwegian fisheries, accounting for 62% of the total by value.[7] Therefore, should it be deemed that additional governmental support would be required during the early stages of a discard ban; this amount would likely be proportionally much smaller than the amount required from the Norwegian government.

A problem previously raised by the EC (and others) in a communication on the subject (Anon., 2002) was what to do with all the excess, undersized, and low-value fish that would be retained if discards are banned. There is a clear and achievable need to reduce the currently high catches of juvenile fish in the North Sea (see above). It has also been long recognized that one of the main options for reducing discards is to ensure that more of the fish is used for human consumption (Clucas, 1997). This would improve fisheries management and reduce the current waste of resources, thereby increasing income for fishers and the availability of fish protein for consumers. The EC now acknowledges the need for as much fish as possible to be marketed for human consumption, with the conversion of any excess catch into fishmeal seen only as a last resort (Anon., 2011). In the United Kingdom, a number of public and private schemes and campaigns have recently been set up to help encourage more diverse fish-eating habits and, hence, create a market for previously under-utilized species (e.g., Hugh's Fish Fight, www.fishfight.net; Fishing for the Market [Torney, 2010]; Fishing Credits Scheme [Pritchard and Luk, 2010]). These efforts have already achieved considerable success within a short space of time (Smithers, 2011).

CONCLUSION

It has been shown that since its implementation in 1987, the discard ban has received at least partial compliance within the EEZs of Norway and Russia. Discarding still occurs but at a significantly lower level than in the North Sea (Kelleher, 2005). Allowing fishermen to land everything does not appear to have increased pressure on the fish stocks. On the contrary, combined with a system of real-time area closures the discard ban appears to have generated an incentive for fishermen to install gear modifications and fish more selectively. This, combined with greater scientific knowledge about the status of the stocks, is likely to have contributed to the relatively fast stock recovery rates experienced in the Northeast Arctic. Initially, the economic cost to the fishing industry was relatively high with fishermen experiencing catches comprised of greater proportions of small fish with lower values and lower CPUE. However, the period for which the fishing sector remained unprofitable lasted for just four years. Today, the Norwegian and Barents Sea fisheries are some of the most prosperous in the world. The SSB for Northeast Arctic cod is now near its record high, and the 2010 TAC amounted to 607,000 tonnes (ICES, 2010a).

In comparison, the TAC for North Sea cod has declined from a peak of 250,000 tonnes in 1985 (ICES, 1992) to just 20,000

[2]Calculated using data obtained from Statistics Norway (2008).

[3]Calculated using data obtained from Eurostat (2007) and Danmarks Statistiks (2009).

[4]Calculated using data obtained from Eurostat (2007) and Statistiches Bundesamt Deutschland (2009).

[5]Calculated using data obtained from Eurostat (2007) and the Institut National de la Statistiques et des Études Économiques (2009).

[6]Calculated using data obtained from the Marine and Fisheries Agency (2008) and the UK Office for National Statistics (2009).

[7]Calculated using data obtained from Statistics Norway (2008).

tonnes in 2007 (EU, 2009), and the North Sea stocks as a whole have performed poorly since the introduction of the CFP in 1983. The North Sea fisheries for cod, haddock, saithe, and herring are relatively similar to those in the Northeast Arctic, and the potential exists for rates of stock recovery exceeding those experienced by Norway since the late 1980s. The economic reliance on these fisheries in the North Sea is also smaller, and the short-term negative impacts on the industry of a discard ban are likely to be significantly less than that experienced by Norway in the late 1990s. The potential also exists to expand the seafood market to make use of those fish that are currently under-utilized for human consumption.

The main obstacle to a discard ban on these species in the North Sea would be that of enforcement. Hard methods of enforcement are extremely difficult and expensive to carry out, especially in six different legal systems. Soft strategies that create incentives to land "illegal" catches can also generate incentives to target them. However, new developments to monitor fishing activity, such as remote electronic monitoring systems (e.g., on-board CCTV), are showing great promise.

Norway's positive experience with the discard ban provides evidence that a ban on the discarding of cod, haddock, saithe, and herring would also produce positive results if transferred to trawl fisheries in the North Sea. Gaining support from the fishing industry and voluntary compliance from the fisherman will now be crucial if a discard ban is to be successfully implemented.

ACKNOWLEDGMENTS

Much of this research was completed by Ben Diamond in partial fulfilment of an M.Sc. degree in Marine Environmental Management at the Environment Department, University of York. The authors wish to thank the staff and students involved with the degree that helped support and stimulate the work. The authors are also grateful to the editor and an anonymous reviewer whose comments improved an earlier version of this manuscript.

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