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Money Overboard

Why discarding fish is a waste of jobs and money

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Executive summary

Fish are a renewable resource. If well managed, they can provide endless benefits to society in terms of revenue, food, and jobs. Yet, the problems with fisheries are endemic in Europe and around the world. Discarding – the throwing away of fish – is a problem that has gone on too long.

Each year millions of fish are discarded in European waters, an environmental tragedy that does nothing to help the struggling fishing industry or the fish populations upon which they depend. In one species studied in this report, cod living in the North Sea, Eastern Channel, and Skagerrak, almost 7.5 billion cod have been discarded since 1963; that's a staggering 1.4 for every cod landed. In cold, hard cash, this adds up to £2.7 billion lost at sea. We can ill afford to squander our environmental and economic wealth; especially given the current economic climate. The scale of this problem has inspired recent action running up to the reform of the Common Fisheries Policy (CFP), such as the *Fish Fight* television series channelling public outrage into over 700,000 signatories to a petition against discards to date.[1]

But it's not simply about waste. It's also about how we manage our increasingly precious natural environment. Discarding is a symptom of poor management and practice. These two factors are also responsible for overfishing this public resource far below its economic potential. European fisheries management continues to use blunt policy tools, such as single-stock quotas, that do little to accommodate the impacts of fishing on the wider ecosystem. Fishing technology is not yet sophisticated enough to avoid catching fish that have not had the chance to grow or reproduce and thus support the future of the stock and of the fishing industry – a loss which we estimate at £7.5 billion since 1963. In essence, the fishing industry is biting the hand that feeds it. Both management and fishing practice need to be smarter and streamlined to respect the dynamic and complex ecosystems they impact and depend upon. Discarding has no place in a sustainable future where we must reconcile runaway consumption with collapsing ecosystems.

So what are the alternatives? Huge emphasis has been placed on creating markets for new species as a solution. Due to the poor health of many European stocks buckling under consumer demand, we strongly caution against this, particularly the sale of undersize and undervalue fish (as discards tend to be). Instead, we should opt for never catching these discarded fish in the first place, allowing them to grow in the sea to re-build the fish population and support a healthy ecosystem. Remarkably, we find that even if total catches were *reduced* by banning discards, landings could actually *increase* and the stock would benefit too, getting 13 per cent larger each year. And, fewer catches mean more fish in the sea, and as they grow in size, they grow in economic value. This potential can be realised with smarter initiatives[2] and practice, such as highly selective gear and seasonal fishing in minimal by-catch areas.

In this report we focus on a single species – cod. More specifically, we look at cod living in the North Sea, Eastern English Channel, and Skagerrak. From 1963 to 2008, 8.24 million tonnes of cod were landed from this stock, typically by trawlers and gillnetters from many European countries (including Denmark, the Netherlands and Germany), with the UK catching the single most. This activity has provided economic benefits to fishermen, their communities and economies, as well as nutritional value to consumers. But, this British favourite is both overfished and suffers high discard rates, and is now even considered a species threatened with extinction.[3]

We find that discarded cod in the period 1963–2008:

a **had a total landing value of £2.7 billion, £935 million to the UK, and supporting 711 additional UK jobs**

b but this depends on creating new markets for undersize, undervalue fish, which would **not help the stock and would hamper future profitability of fishermen**.

If discards had instead been banned during this period, and **left in the sea**:

c revenue from the stock would have risen by £414 million, £144 million to the UK supporting 219 more UK jobs

d the cod population would be have been an average 13.2 per cent larger year-on-year.

With completely selective gear sparing the small cod, discarded fish, **with time to grow**:

e could have weighed up to 9.26 million tonnes, **almost five times the weight at which they were actually discarded** (2.14 million tonnes)

f could have been worth £7.5 billion **(£2.6 billion to the UK), compared to being thrown away for nothing**.

These results show that fish are simply too valuable to throw away. At the time of writing this report, the European Commission has presented its proposal for CFP reform, including a Discard Ban for "quota" species. Ministers from EU Member States and Members of the European Parliament now have an opportunity to build on this and see an end to this waste.

Photos: © OCEAN2012 and Corey Arnold

Introduction

Every year, millions of pounds in fish are discarded – literally thrown overboard – instead of being landed and sold. Why are they wasted?

The list of reasons is long, owing both to the fishing industry's practices and its regulation, including unselective fishing, lack of quota,[4] high-grading,[5] undersized fish,[6] ecosystem characteristics, inadequate by-catch management,[7] and fishing effort controls.[8]

Despite substantial investment in fishing gear, there is still no way for fishermen to be entirely selective with their catch: non-target species (by-catch) are discarded as collateral damage. Many fish are of a similar size and live in similar habitats, making them vulnerable to gear that is being used to target just one particular species. In aggregate, the waste is staggering, often outnumbering those that are landed at port, particularly in the case of cod in the North Sea, Eastern English Channel and Skagerrak (Figure 1).

These discards are the result of fishing by many countries using a variety of gear types. The main countries fishing cod in this area are the UK (landing approximately 38 per cent of total cod), Denmark (approximately 27 per cent), Netherlands, Germany, France, Belgium, Norway and Sweden (together approximately 33 per cent) (Figure 2). The area – the North Sea, Eastern English Channel and Skagerrak – is also illustrated (Figure 3).

The value of the discards from this area depends on how they otherwise could have been used. In Scenario 1, we estimate the real value of these discards had

Figure 1. Population and catch numbers of cod in the North Sea, Eastern Channel and Skagerrak (1963-2008). Cod population (green), cumulative total catches (landings and discards; red+blue), and landings (blue). The red shaded area (above the blue area) represents total discards. We use cod as a case study because of the excellent data available, which is amenable to modelling techniques.[9]

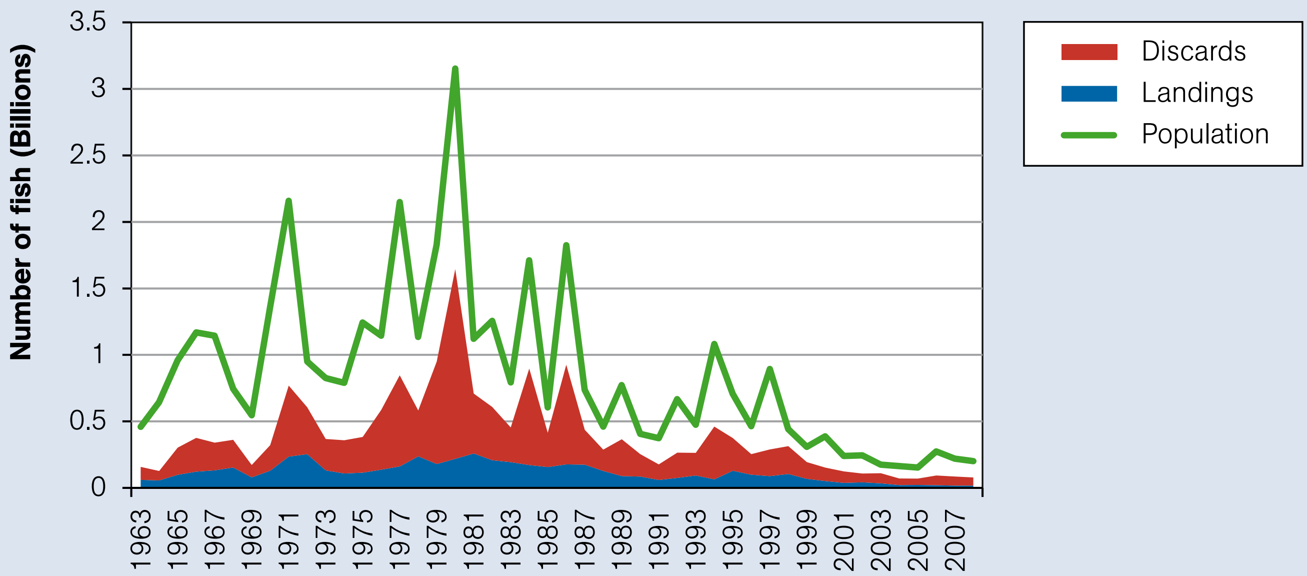


Figure 2. Landings (tonnes) by country of cod in the North Sea, Eastern Channel and Skagerrak (1963–2008)[10]

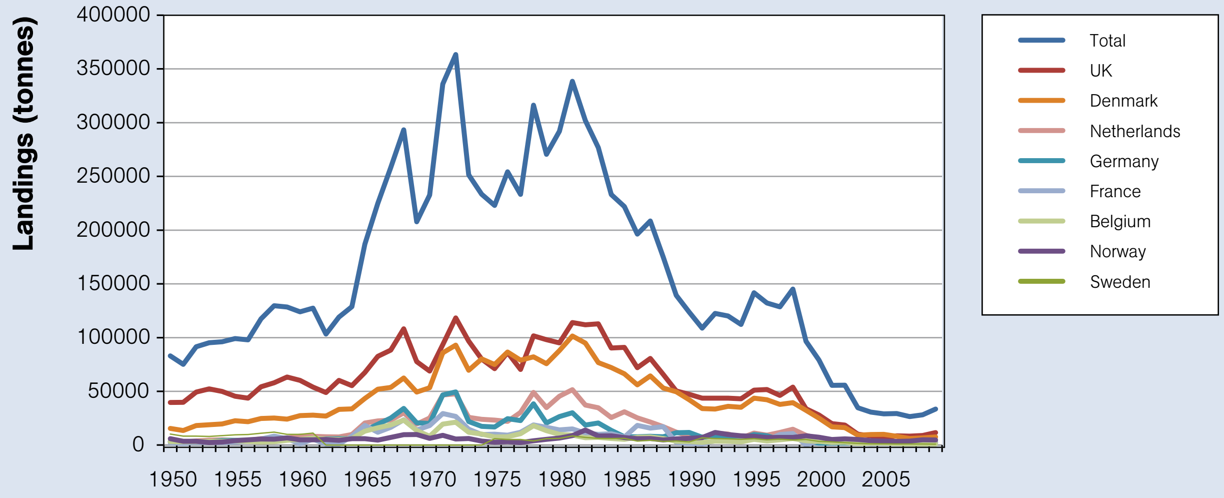
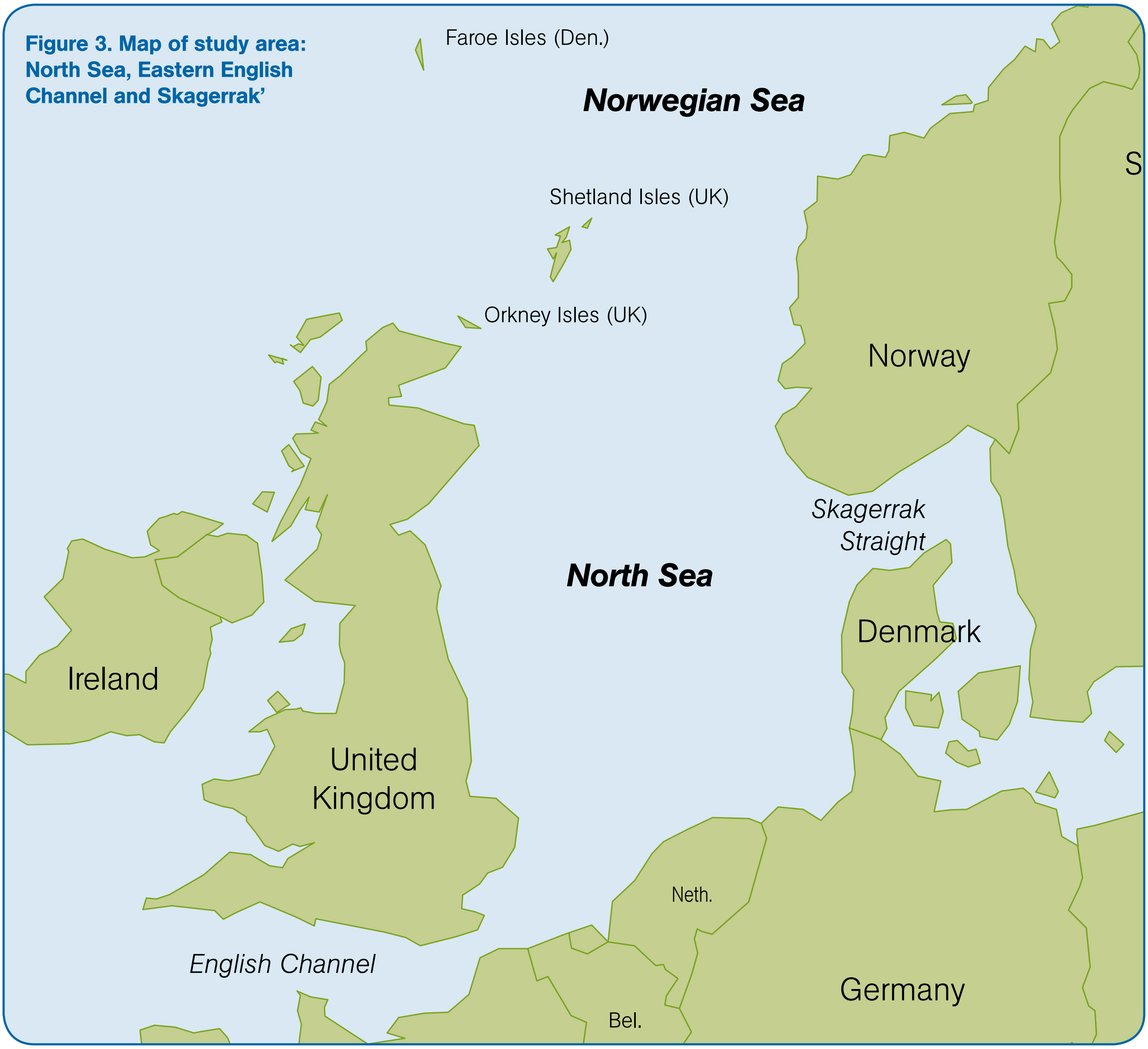


Figure 3. Map of study area: North Sea, Eastern English Channel and Skagerrak'



they been landed (though we are not arguing that these undersize, undervalue fish *should* be marketed from now on, since in the future these fish could be left in the sea). Admittedly, this is highly simplified: boat-capacity dictates that landing these fish would likely have displaced many of the fish which were *actually* landed. We mitigate this by allowing flexible prices, which drop as the amount landed increases.

To address this issue more accurately in terms of quantity landed, we explore another discard ban scenario – Scenario 2. This time the mortality associated with landings is maintained at the original level. This also means that the population swells in each year (by a range of +1 per cent to +60 per cent, and an average of +13.2 per cent) because many of the fish that were once discarded now remain in the sea (though some are caught and landed). Finally, in Scenario 3, we explore what the maximum value of a discarded fish would have been over the years if fishing gear were perfectly selective, looking at the trade-off between natural mortality and somatic growth.

In each scenario we provide reasonable and detailed estimates of the economic value the discards would have had, but caution that these results, because of the dynamic and often difficult-to-predict behaviour of fish populations, are not definitive. A full analysis of discards, their potential, and how they impact on landings and fleet behaviour, however, remains to be done by expert fisheries scientists.

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Methodology

At the core of our analysis is the *age cohort*. An age cohort constitutes all fish recruited into the stock at the same time (and, obviously, of the same age), and fished successively each year. In any single year, the stock will comprise overlapping cohorts, so that the population has fish of all ages in different proportions.

The fish population, number of discards, number of landings, and natural deaths are all studied on a cohort basis, specific to the age of fish and the year. *Recruitment* is the number of fish in the youngest cohort now vulnerable to fishing gear, usually because of their size. In cod, recruitment occurs at the age of one. An example to illustrate the structure of a cod population, and help visualise a cohort, is shown in Table 1.

The number of fish in any particular cohort diminishes over time because of natural mortality (e.g. predation, carnivorous behaviour of cod) and fishing mortality (partitioned into mortality associated with landed cod, and discarded cod).

To model the changing population sizes, illustrated by the arrows in Table 1, the following difference equation is used (**Equation 1**):

$$N_{i+\Delta t,t+\Delta t} = e^{-\sum_{j=0}^{\Delta t}[Z_{i+\Delta t-j,t+\Delta t-j}]} \times N_{i,t} \quad (1)$$

where N_{t+1} is the number of fish in the next period, N_t the number of fish in the current period, and Z the total mortality of the fish of age i between periods t and $t + \Delta t$. The total population at any one time, therefore, is a mixture of cohorts (**Equation 2**):

$$\sum_{i=1}^{l=7} N_{i+\Delta t,t+\Delta t} = \sum_{i=1}^{l=7} \left[e^{-\sum_{j=0}^{\Delta t}[Z_{i+\Delta t-j,t+\Delta t-j}]} \times N_{i,t} \right] \quad (2)$$

The number of fish killed in a year is determined using the Baranov catch equation (**Equation 3**):

$$X_{i,t} = \frac{F_{x_{i,t}}}{Z_{i,t}} \times (1 - e^{-Z_{i,t}}) \times N_{i,t} \quad (3)$$

Table 1. Example matrix of cohorts: recruits in 1980 aging to age +gp (aged seven and over, aggregated into one cell) in 1986. Figures are rounded.[11]

Age \ Year	1980	1981	1982	1983	1984	1985	1986
1	3 x 10^9	6 x 10^8	1 x 10^9	5 x 10^8	1 x 10^9	3 x 10^8	2 x 10^9
2	2 x 10^8	4 x 10^8	1 x 10^8	3 x 10^8	1 x 10^8	3 x 10^8	7 x 10^7
3	7 x 10^7	7 x 10^7	1 x 10^8	4 x 10^7	6 x 10^7	4 x 10^7	6 x 10^7
4	3 x 10^7	2 x 10^7	2 x 10^7	2 x 10^7	8 x 10^6	2 x 10^7	1 x 10^7
5	4 x 10^6	9 x 10^6	7 x 10^6	6 x 10^6	7 x 10^6	3 x 10^6	6 x 10^6
6	3 x 10^6	2 x 10^6	4 x 10^6	2 x 10^6	2 x 10^6	3 x 10^6	1 x 10^6
+gp	2 x 10^6	2 x 10^6	1 x 10^6	2 x 10^6	2 x 10^6	1 x 10^6	2 x 10^6
Total	3 x 10^9	1 x 10^9	1 x 10^9	8 x 10^8	2 x 10^9	6 x 10^8	2 x 10^9

where $X_{i,t}$ is the number of killed fish associated with $X\varepsilon$ *(natural deaths, landings, discards)* within year, t = *1963, 1969…2008* and age, i = *1,2,…+gp*, and $F_{X_{i,t}}$ is the mortality associated with $X_{i,t}$ and $F_{Z_{i,t}} = \Sigma_X F_{X_{i,t}}$. Equation 3 can be manipulated to help model the likely effects of reducing partial mortality, such as discard mortality. More information on such methods can be found in the literature.[12,13,14]

While some fishing gear is more selective than others in catching particular sizes of fish (note: size directly correlates to age), others are not. In this study we look at all fishing gear. The selectivity characteristics of the gear *en masse* mean there is no age when the cod are safe from fishing, i.e. cod of all ages over one are fished. While the use of some gear leads to higher discards than others, we study only the aggregate discard rates. A sample table of the different kinds of mortality a cohort is exposed to is shown in Table 2.

***Table 2.* Total, natural, landing and discarding-associated mortalities for the 1980–1986 cohorts (1980 cohort = age 1 in 1980, age 2 in 1981, etc).**[15]

TOTAL MORTALITY				***Year***			
Age	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**
1	1.910067	1.450632	1.354564	1.161619	1.696633	1.307353	1.614346
2	1.319248	1.415246	1.350703	1.452439	1.377942	1.461743	1.311744
3	1.295193	1.318318	1.530726	1.484353	1.302048	1.267528	1.355372
4	1.013592	1.013829	1.146607	1.144845	1.051134	0.99446	1.174981
5	0.966086	0.911618	1.073343	1.035342	1.002296	0.960913	1.033342
6	1.0616	1.0512	1.2202	1.2015	1.0986	1.0508	1.1746
+gp	1.0216	1.0112	1.1802	1.1515	1.0486	1.0008	1.1146
FBAR (2-4)	1.209344	1.249131	1.342679	1.360545	1.243708	1.241244	1.280699
NATURAL MORTALITY							
Age	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**
1	0.91	0.9	0.890001	0.869997	0.85	0.830003	0.81
2	0.420003	0.409998	0.409989	0.399994	0.390003	0.380003	0.379984
3	0.359986	0.360003	0.359987	0.360006	0.360024	0.360048	0.359986
4	0.23	0.230036	0.23003	0.230076	0.229948	0.230024	0.22999
5	0.219876	0.220011	0.219972	0.220089	0.219772	0.23028	0.22981
6	0.24	0.24	0.24	0.25	0.25	0.25	0.26
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2
LANDING MORTALITY							
Age	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**
1	0.049995	0.06303	0.123963	0.092405	0.09053	0.058233	0.121063
2	0.768895	0.849856	0.832951	0.968492	0.830488	0.824767	0.790757
3	0.935207	0.956118	1.168824	1.12305	0.941874	0.902019	0.986564
4	0.783592	0.783793	0.916577	0.914769	0.821186	0.764435	0.944991
5	0.74621	0.691607	0.853372	0.815252	0.782524	0.730633	0.803531
6	0.8216	0.8112	0.9802	0.9515	0.8486	0.8008	0.9146
+gp	0.8216	0.8112	0.9802	0.9515	0.8486	0.8008	0.9146
DISCARD MORTALITY							
Age	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**
1	0.950072	0.487602	0.340601	0.199217	0.756103	0.419116	0.683283
2	0.13035	0.155392	0.107762	0.083953	0.157451	0.256973	0.141004
3	0	0.002197	0.001915	0.001296	0.000151	0.005461	0.008822
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0

The value of discards: scenarios and results

In this section we look at the value of discards in three scenarios. In scenario 1 all discarded fish are ascribed a price similar to (but lower than) the fish that actually were sold during this period. In scenario 2 we look at their value had they been left in the sea, along with more conservative assumptions of fishing effort by the fleet. In scenario 3, we study the value of discards had they been caught with more selective gear.

Scenario 1: The value of discarded fish 1963–2008

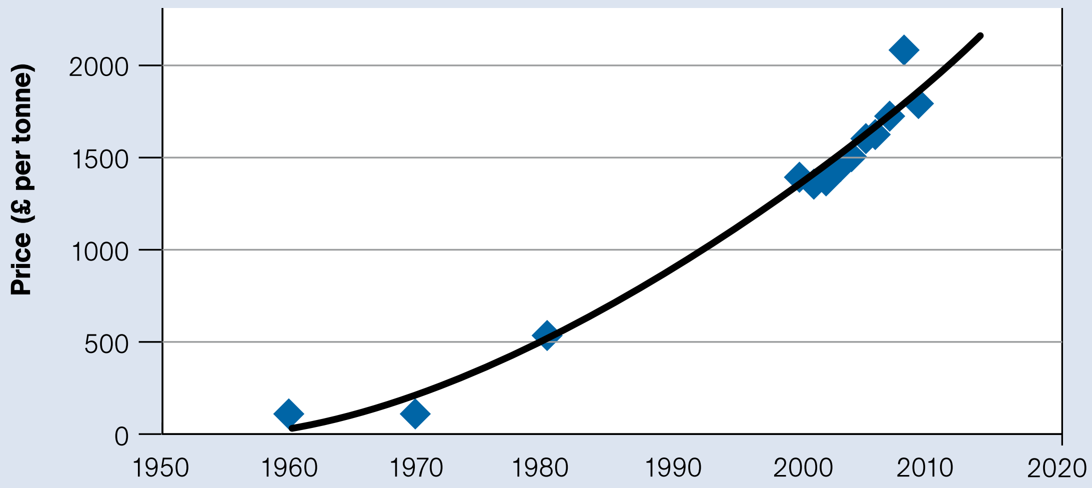
Our most realistic estimate of the total value of the fish discarded in the North Sea, Eastern Channel and Skagerrak cod fisheries over the period 1963–2008 is £2.702 billion in real terms. The scenario assumes that all fish that were discarded could instead have been landed. This illustrates the value of discards, but does not argue that they *should* be landed; this will depend on how the fishing industry would have reacted to a ban on discards (Scenario 2), and the implications on the fish population – creating new markets for these undersized, low value fish would not relieve pressure on such an overexploited stock. Nonetheless, these fish still had a very real value and yet were thrown away dead.

It is also worth noting that this scenario does not study how total landings and revenue of the fishing fleet would be affected by landing previously discarded fish. By landing discarded fish, some of the fish that had been landed in the 1963–2008 period would not have been caught, since boats would have filled their hold more quickly and returned to port (though they may, of course, have gone out again to increase their catches and revenue). How costs react is difficult to predict: they may rise due to additional trips, but may fall since fewer hauls are required to fill the holds (since no fish are thrown away). The estimate of £2.702 billion is, therefore, only for the value of the discarded fish, but may not be in addition to the value that was actually made in the 1963–2008 period – some of this value would have been displaced by discarding. The total revenue of the cod fishery under a discard ban is more realistically looked at in Scenario 2.

We begin by estimating the number of discards of each age of fish in each year of the period 1963–2008. The number of discards is provided by the International Council for the Exploration of the Sea,[16] but this excludes unaccounted removals, which we must correct for. Unaccounted removals, in simple terms, are the estimated number of fish removed from the population but not declared either in landings or discards. While mortality associated with these removals could in part be attributed to natural mortality, a lack of data justifying how to apportion these removals between different causes has meant that we attribute them fully to fishing activity. Correcting for the unaccounted removals requires adjusting the mortality rates by a series of multipliers.[17] Mortality rates are specific to each cohort's age and to each year – they are in no way constant across years or across cohorts. The adjusted mortality rates for total, natural, landing, and discard mortalities are then used to estimate the discard numbers, using the Baranov catch equation (Equation 3), where X is discards, so that: $X_{i,t}$ = *discard number of age i in time t.*

We then estimate the value of the discards using a price per tonne of cod, and multiplying it by the average weight of the average discarded fish of that age in that year. We then sum these weights across discards of all ages (cohorts) in that year. The weight of a discarded cod tends to be lower than the weight of one that is landed, even if both are of the same age.

Figure 4. Scatter plot of nominal prices of cod 1960–2008, fitted with a second degree polynomial trendline. Full equation of fitted line is [Price = (0.451828196085899*Year^2) – (1755.73003483164*Year) + 1705490.40308173]. R^2=0.965.[19]



The nominal price per tonne is obtained from the Marine Management Organisation[18] for a number of years for 1963–2008 (Figure 4). The real price is calculated by using 2008 as the base year and inflating past prices according to inflation in that year and all intermediary years (Figure 5). The intuition of this is simply that while prices were far lower in the past, cod may have had an equivalent value relative to other products. To make previous values comparable to current prices, we inflate them using retail price index (RPI)[20] inflation rates excluding housing, as sourced from the Office of National Statistics.[21]

The price per kilogramme of landed cod is then varied to reflect the typical laws of supply and demand; we assume that original landings are unaffected, so that landing each discarded fish is now an additional one to be sold, and further assume that this would lead to a fall in price of all landings. The supply side might be sensitive to market price changes, but because we are looking at the scenario where all discards are landed in addition to the original landings, we assume supply to be perfectly price inelastic.

Instead, we focus on the demand side, and ask how much price would have to fall in order for demand to meet the new, higher supply of landings. In this scenario, landing all discards is equivalent to an average increase in tonnes landed of 28 per cent each year (or +140 per cent more fish landed each year). The price elasticity of demand (PED) – the responsiveness of demand to changes in price and vice versa – is varied from perfectly inelastic ($\varepsilon_d = 0$) to unitary ($\varepsilon_d = -1$) and elastic ($\varepsilon_d = -2$).

When $\varepsilon_d = 0$ then any change in demand does not change prices. Incidentally, this leads to the same estimate of the value for discards as if original landings *were* displaced by discarded fish now being landed, on a tonne-by-tonne basis, since in either case the price of fish is unchanged. In both of these cases, discarded fish have a value of £3.29 billion.

Varying the PED from $\varepsilon_d = -1$ to -2 means that a 10 per cent increase in landings (and consumption) leads to a drop in price of 10 per cent and 5 per cent, respectively, relative to original landing value.[22] These PEDs were adopted simply for illustrative purposes, though they are within the reasonable limits found by other research.[23,24]

A unitary PED ($\varepsilon_d = -1$), will mean that total revenue remains unchanged even if fish that were originally discarded are now landed in addition to the original landings; the drop in price completely negates any additional revenue or jobs

Figure 5. Data used for adjusting nominal values to real terms (using 2008 as the base year and year end values). Inflation measured using the Retail Price Index (RPI; a measure of prices in a single year), excluding housing.[25]

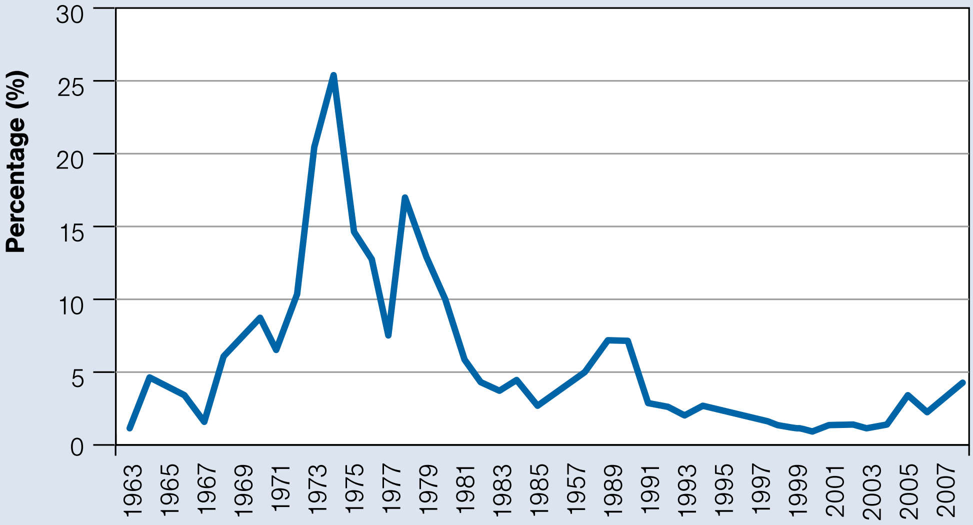


Table 3. Results of landing all once-discarded cod in this region, with ε_d = 0,-1, and -2. Standard deviation in brackets; £m=million GBP. Own calculations using source data.[26,27,28]

		Number of cod 1963–2008 (million)		*Weight of cod 1963-2008 (million tonnes)*		*Total value of cod 1963–2008 (£m)*			*Value of discards to the UK**	
		Discards	**Landings**	**Discards**	**Landings**	**Discards (now landed)**	**Landings (original)**	**All landings**	**Revenue (£m)**	**Jobs**
Original - with discarding		7,479	5,310	2.15	8.24	0	12,960	12,960	0	0
No Discarding	**Most value:** Value of an increase in landings met with no fall in price ($\varepsilon_d = 0$)	0	12,790	0	10.4	3,294	12,960	16,254	1,138 (26.7)	1,732 (1,872)
No Discarding	**Mid-point:** Value of an increase in landings only partially offset by semi-proportionate fall in price ($\varepsilon_d = -2$)	0	12,790	0	10.4	2,702	11609	14311	935 (18.9)	1,422 (1,324)
No Discarding	**Most conservative:** Value of an increases in landing discards completely offset by a fall in price ($\varepsilon_d = -1$)	0	12,790	0	10.4	2,331	10,628	12,960	807 (17.5)	1,228 (1,034)

'Original – with discarding' shows that discards had no value when they were thrown overboard. When discarding is banned ('No Discarding') we study three cases, where the price of cod is varied. In the 'Most value' case, all discards are additional value and there is no drop in the price of cod, or, alternatively, that discards now landed displace the original landings on a tonne-by-tonne basis. In the 'Mid-point' and 'Most conservative' cases, discards are landed in addition to those landings in the 1963-2008 period. When $\varepsilon_d = -2$ there is a 5% fall in price for every 10% more landed. When $\varepsilon_d = -1$ there is complete compensation, so that an increase in landings reduces the price of all fish by the same proportion, and total revenue remains unchanged (though the portion of this attributable to discards is still significant).

* The fifth column shows the value of discarded fish to the UK, but note that this is not necessarily a net gain since this depends on the price changes. Net gains are calculated as the difference between original landing values and new total landing value.

(even if they would have value to consumers). These once-discarded fish make up 18 per cent of the £12.96 billion in total landing value, or £2.331 billion (Table 3).

With $\varepsilon d_d = -2$, these fish have a value of £2.702 billion (£935 million to the UK), pushing up the value of all landings to £14.3 billion. The net impact (after the price drops) is an additional £1.351 billion, worth to the UK specifically[29] a *net* gain of £467 million over this 46-year period and an additional 711 UK jobs.[30]

This scenario maximises fish landings in the short term, i.e. all discards that were once thrown away are now landed. In the long-term, however, this scenario would do little to relieve the pressure on stock, to address the inefficiency of the fishing industry, or to help transition to sustainable and well-managed fisheries. By landing additional fish, previously discarded, the fishing mortality must increase. This approach, leading to the £2.702 billion value of discards, £1.351 billion of which is additional, sees no relief for the fish stock. The next scenario, therefore, looks at the consequences of maintaining fishing pressure (strictly, the mortality associated with landed fish), and allowing the fish population of each age in each year to increase.

Scenario 2: Never catching discards in the first place

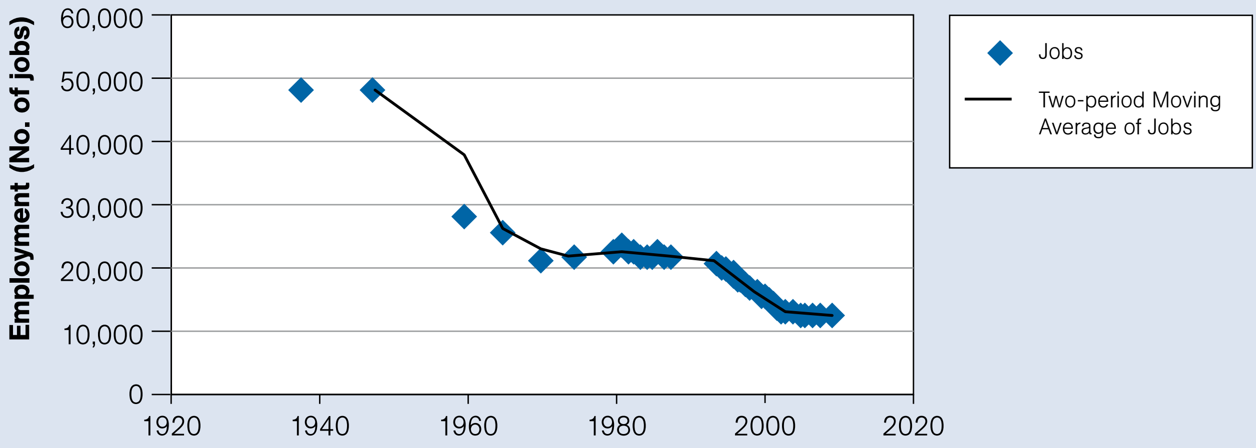
In Scenario 1, we assumed that all discarded fish could have been landed, and we make no attempt to see how this would affect total landings. Landing all discarded fish may have substituted or complemented the fish that actually were landed to varying degrees. To explore this further in Scenario 2, we assume that discarded fish were left in the sea. In fact, strictly speaking we assume that the rate at which fish are discarded is set to zero. While it may seem intuitive to put discarded fish back into the sea, this would not reflect the increased catchability of fish in a population that is now larger yet subject to fishing by the same boats. Therefore, we assume instead that the mortality associated with those fish that were landed (the rate at which they were removed from the population by fishing gear) is maintained as it was before.

This difference is intuitively explained by the change of context: the landing of 8.24 million tonnes of cod that actually took place during the 1963–2008 period were made by a certain number of boats, fishing a certain population size, and discarding heavily to select just a fraction of fish to be landed. Now, we change this context. The population is larger, since the once-discarded fish are now left in the sea, making it easier for more fish to be caught even if the effort put into fishing is kept the same. We formally do this by keeping constant the mortality of fish associated with landings, and applying this to a larger population: If the rate of landings is a constant proportion of the total population, then as the population grows landings must also increase to maintain this proportion.

We begin by setting the mortality associated with discarding to zero, and assume that the discarded fish re-enter the population and grow in size. This re-constructed population is larger by an average of +13.2 per cent over the period, and a range of +1 per cent to +60 per cent, and an average of 15.1 per cent larger in each age. To this larger population we then apply the same landings mortality, and as already explained, this will show an increase in actual numbers of landed fish, some of which are fish that would have been discarded, and others that would have remained in the sea.

These landings must then be weighed in order to estimate the revenue that they bring in. First, we compare these hypothetical landings to actual landings in the period 1963–2008. As an example, suppose that 100 fish were originally caught, and now 120 are caught. We assign the same weight per fish (in kg) of the 100 fish that were caught in the 1963–2008 period to 100 of the 120 fish that are now caught. To the remaining 20 landed fish, we assign typical stock weights of fish in the stock, which tend to be somewhere between the average weight of landed fish and discarded fish. Using the same pricing methodology as in Scenario 1 (and $\varepsilon_d = 0$ because of the relatively small increase in landings compared to total cod landings), this scenario yields an *additional* £413.65 million above the original landing value, which we take as the best estimate in this study. (To help grasp the impact of using different weights per fish, if we were to assume that all landings in this scenario weighed the same as those which were actually landed during this

Figure 6. Time series of number of UK fishermen 1938–2009, with some data values missing. Trendline is a two-period moving average.[31]



period, we would estimate £485.92 million in *additional* landing value, an extra £72.27 million which can be viewed as a rough estimate of the extra value that more selective gear would have brought – though truly selective gear would bring even more, as will be seen in Scenario 3.)

We can also convert this difference in landing revenue into an equivalent number of fishing-related jobs, albeit simplistically. To do this, we use figures produced by Seafish,[32] an advocate of the fishing industry, that state an increase of £1 million worth of landings of demersal fish, of which cod is one, would result in 70 additional full-time equivalent jobs (on top of baseline employment;[33] Figure 6), an increase in UK output of £6.29 million, and in UK GDP of £2.01 million.

We take these figures – particularly jobs – as equally representative of the value of discards across other countries, partly because of the general homogeneity of the product and fishing gear used, and the industry profitability, and partly because the UK is the single largest catcher of cod in this area. Based on the aggregate value of discards, we estimate their value to the UK. To do this, we estimate the proportion of all cod landings from the region accounted for by the UK, and assume that discard rates are equally proportional (since data for this is not directly available for the years we study). This, we believe, is defensible because the UK cod fleet is not very different from that of other countries fishing in this region. The UK is the single largest catcher of cod (by landings) over the period, which we use to justify a UK price and inflation rate for the landings as a whole. For year-specific proportions of total landings that the UK is accountable for, see Table 4 (note that age-specific landings data for the UK alone is not available).

Looking across all years in the period 1963–2008, we obtain the results shown in Table 5.

We can also compare aggregate values of the 40 cohorts (1963–2003), adjusted to real terms. While actual landing value from these cohorts was £11,912 million, had there been no discards this could have been £12,306 million, following a cohort estimate. In addition to this extra value, the population is on average 13.2 per cent higher over the period 1963–2008 even if we assume constant recruitment (i.e. an absence of higher-spawning stock biomass). Using the same approach of converting increased revenue to estimate the impact on jobs, we estimate that an increase of £394.10 million in landing value from all cohorts of the stock, of which the UK would have a share of £136.1 million sustaining 232 more UK jobs.

Scenario 3: Using selective gears to maximize the potential of discarded fish

The vast majority of discarded cod tend to be smaller, younger fish (aged 1–3). In a hypothetical world where fishing gear is completely selective, and fishermen can

Table 4. Tonnes of cod landed from the North Sea, Eastern English Channel and Skagerrak by all countries and by the UK alone. In the fourth column, the fraction of total landings from this stock by the UK is shown. This proportion is used as a proxy for the proportion of discards the UK is responsible for (for which data is not directly available for the years shown). Source data.[34]

Year	*UK cod landings from region (tonnes)*	*Total cod landings from region landings (tonnes)*	*UK fraction of total landings*
1963	60,215	119,053	0.506
1964	55,228	128,737	0.429
1965	67,469	186,837	0.361
1966	82,572	224,927	0.367
1967	88,341	258,310	0.342
1968	108,151	293,359	0.369
1969	77,693	207,733	0.374
1970	68,834	232,608	0.296
1971	93,416	335,986	0.278
1972	118,410	363,375	0.326
1973	96,682	251,411	0.385
1974	80,049	233,427	0.343
1975	71,063	223,005	0.319
1976	86,202	254,314	0.339
1977	70,273	233,265	0.301
1978	101,650	316,306	0.321
1979	98,082	270,542	0.363
1980	95,157	291,940	0.326
1981	113,988	338,489	0.337
1982	111,891	301,985	0.371
1983	112,799	276,863	0.407
1984	90,246	233,095	0.387
1985	90,949	221,948	0.410
1986	71,939	196,275	0.367
1987	80,675	208,574	0.387
1988	65,745	174,904	0.376
1989	50,426	139,291	0.362
1990	47,209	123,748	0.381
1991	43,652	108,825	0.401
1992	43,604	122,534	0.356
1993	43,669	120,084	0.364
1994	43,107	112,223	0.384
1995	51,175	141,736	0.361
1996	51,697	132,149	0.391
1997	46,238	128,682	0.359
1998	53,997	145,152	0.372
1999	33,815	96,568	0.350
2000	27,937	79,151	0.353
2001	19,976	55,526	0.360
2002	18,673	55,706	0.335
2003	10,186	34,664	0.294
2004	8,643	30,629	0.282
2005	6,390	29,049	0.220
2006	8,616	29,416	0.293
2007	8,285	26,543	0.312
2008	8,882	28,113	0.316
2009	11,573	33,584	0.345

Table 5. Estimating the impacts of no discards in the period 1963–2008 on stock population, landings, revenue and jobs to all countries and to the UK. Never catching discarded fish but maintaining the mortality rates associated with landing fish (similar to fishing pressure) during the period 1963–2008 leads to increases in landings by number and weight, and increases in revenue and jobs to the UK. Standard deviation in brackets; £m=million GBP. Own calculations using source data.[35,36,37]

	Total impact									*UK impact*	
	Number of cod 1963-2008 (million)		*Weight of cod 1963-2008 (million tonnes)*		*Value of cod 1963-2008 (£m)*			*Cod Population*		*Value of discards to the UK*	
	Discards	Landings	Discards	Landings	Discards (now landed)	Landings (original)	All landings	Average annual numbers (million)	Average annual increase (%)	Revenue (£m)	Jobs
Original – with discarding	7,479	5,310	2.15	8.24	0	12,960	12,960	860	0	0	18,635 (4,244)
No Discarding: Maintaining fishing mortality ($\varepsilon_d = 0$)	0	5,807	0.27	8.24	413.7	12,960	13,373	954 (673)	13.23 (0.128)	143.8 (2.17)	+218.8 (152)

catch only the largest fish, we could maintain the tonnage of fish landed with fewer fish. Working against this, fish die naturally over time, so that the maximum biomass of an entire cohort is determined by the rate of growth in weight of each fish and the rate of decline in numbers.

In Scenario 3, we play this out for every cohort between 1963 and 2002 (the last fully lived cohort). We find the discrete maximum biomass of each cohort, at which point we imagine that these fish are caught using completely selective gear (such that they do not affect the other cohorts in the population that have not reached their maximum biomass). To do this we combine two opposing factors: the natural mortality (applied to the population using Equation 1), and the somatic growth of the fish, according to stock weights (data on discards weights only exist up to age three, while stock weights allow us to study their potential up to age seven, though it is debatable which weights-at-age are more applicable to discards left in the population).

This maximum biomass, we find, is on average six times greater than the biomass of the cohort when it enters the fishery. Aggregated over the period 1963–2002 (full cohort years), the total biomass of all discarded fish cohorts was 1.908 million tonnes at age one; that is 1.908 million tonnes of fish that had the potential to grow to 8.90 million tonnes. This contrasts with their actual discarded weight of 2.15 million tonnes, which we valued in Scenario 1. Had the discarded fish never been caught, this huge potential could have been realised. The glaring implication here is that a ban on discards, combined with the use of more selective gear, could further increase the benefits we estimate in Scenarios 1 and 2. Also, let's not forget that the future stock population would also have increased because of the reproductive potential of the discarded fish.

For example, in Scenario 1, if the almost 7.5 billion cod that had been discarded were instead landed when they were just one year older and weighed of comparable weights to those that *were* landed (if the gear selected more narrowly and not the smallest fish), then they would be worth £3.55 billion (£1.24 billion to the UK) instead of the £2.702 estimated (or, indeed, the £0 worth discarded). For all cohorts in the 1963–2008 period (including incomplete ones), if they had been landed at their maximum cohort biomass (usually around age 6–7), the value of discards would balloon to £7.533 billion (£2.592 billion to the UK), even with price falling ($\varepsilon d = -2$) in both cases. While speculative, this provides a taste of the potential of fish resources and the value of using more selective gears. Of course, this simplified model does not take into account any negative environmental feedback, such as resource use by a large cod biomass.

Discussion

In this report, we have estimated the value of discards under different scenarios. We offer realistic estimates of the value of discards, first by looking at their value had they been landed (Scenario 1: £2.702 billion over 46 years), and then by assuming the mortality associated with landed fish is kept constant (Scenario 2: £413.65 million over the same period, and a larger fish population). Their value also increases with gear selectivity (Scenario 3: maximum of £7.533 billion over the same period).

Scenario 1 would certainly have required more fishing effort, the development of new markets for smaller fish, and would not have increased the health of the fish stock. Scenario 2, on the other hand, is likely to have decreased fishing effort and fishing costs, because of the increased catchability of fish in larger populations, while also improving the health of the fish stock. Higher selectivity requires more investment in technology, but improves profitability of trips. Even small improvements in selectivity, so that once-discarded fish are close to the weight of those landed, would see their value increase to £3.55 billion. But, this is still far from their maximum: their value could be up to £7.533 billion if they reach their maximum cohort weight.

We do not try to estimate the costs of landing all these discards. In the short term, it is likely that even as gross revenue rises, the fall in value per fish associated with landing small fish – which were once thrown away – could mean a short-term fall in profitability for fishermen. Yet, in the long term, fishermen could expect those fish that were not caught to re-enter the population, grow in size and also feedback on recruitment in the next year because of their enormous spawning potential. In this regard our results are conservative; they do not reflect any changes to recruitment from lowering the pressure on the stock. Moreover, the fall in value per fish in the short term, as once-discarded fish make up part of the landings, would be mirrored across the EU in the event of a pan-European ban on discards under the CFP. Competition between fishermen to gain the highest value catch would therefore depend far more on fishing gear selectivity. Issues remain, however, on how certification schemes or tariffs could be used to reduce unconstructive competition from outside the EU. Yet these measures may only be temporary, lasting only the time needed for the benefits of a discard ban to come to fishermen in terms of growing landings by size and number. Without a change of direction, EU fisheries will continue to waste fish, prolonging the ill-health of stock and promoting inefficiency in an industry whose very survival is uncertain.

Short-term losses vs long-term gain: should discards be banned?

There is no good reason why the practice of discarding should be allowed to continue. In fact, there are many reasons why a ban on discarding could bring substantial benefits, both environmental and economic. It should be noted, however, that this report does not include all the factors that would come into play if discards were banned, such as enforcement costs, fishing costs and so on. For example, how much we could expect the stock to recover is an extremely difficult question to answer. In the Grand Banks, off the east coast of Canada, where fishing was banned following the collapse of the stock, there has been little recovery of the population.[38] It is logical, however, that a reduction of fishing pressure on the stock due to a discard ban would only improve the chances of the cod population recovering.

The potential of the North Sea, Eastern Channel and Skagerrak to rebuild to its record levels may be hampered by many factors other than the size of the spawning stock biomass (SSB), such as environmental factors and indirect human activity.[39] For example, climate change has led to a warming of the North Sea and a likely fall in recruitment levels, possibly indefinitely.[40,41]

A discard ban is a straightforward solution that could help the prospects of the stock in the face of such difficulties, and meet the insatiable consumer demand for fish. But can the fishing industry survive such a ban? While we have estimated the value of landings had there been a discard ban in place, we have not looked at the profitability of the fishing fleet. It seems reasonable that this profitability might face a short-term decline because fishermen would now be forced to land all of their catch, including the smaller, less valuable fish. A recent study compares several stocks in the North Sea and the Northeast Arctic where access to fish resources is shared between countries that have banned discards (Norway and Russia), and those that have not (EU countries). It finds that following a discard ban, the subsequent unprofitability associated with landing smaller fish lasted just four years.[42] These fisheries are now amongst the most prosperous in the world, with the cod SSB near record highs and quotas in 2010 at 607,000 tonnes.[43] The quota in the North Sea has continued to decline from 250,000 tonnes in 1985 to 20,000 tonnes in 2007.[44,45] The discard ban also appears at least partially responsible for encouraging more responsible fishing and the use of more selective gear.

nef (new economics foundation) has argued that more sustainable, innovative solutions are needed if we, as a society, are to survive and thrive in a future of diminishing natural resources and the increasing environmental pressures of human activity. Our programme, the Great Transition,[46] is an attempt to create a blueprint for a fair society that operates within environmental constraints. Such a blueprint does not just require the elimination of environmental waste but seeks to re-connect our society with the value of the environment. The threats to the common environment are very real, and it is no exaggeration that they are taking their toll on our future.[47] Radical changes to our environmental management and practice are needed; changes such as eliminating the enormous waste of discarded fish. The reform of the CFP offers a unique opportunity to be much smarter about how we fish.

Photos: © OCEAN2012 and Corey Arnold

Endnotes

1 *FishFight*. http://www.fishfight.net/ (2011).

2 Revill, A. & Armstrong, S. Devon beam trawlermen reduce discarded juvenile fish by over 50 per cent. Final project report 2010. (The Centre for Environment, Fisheries and Aquaculture Science, 2010).

3 IUCN. *Red List*, http://www.iucnredlist.org/apps/redlist/details/8784/0 (2010).

4 A quota is an allowance established at European level designed to ensure sustainable exploitation of the stock.

5 Where low value fish of the same or different species are thrown overboard in order to free up space for higher value fish, therefore increasing profits.

6 Fish are deemed too small for landing as a disincentive to catch younger fish upon which a healthy future fish population depends.

7 Non-target species caught as collateral and often thrown away dead.

8 Fishing effort is simply the amount of effort, often measured in days at sea, that is expended catching a certain amount of fish. Controlling effort is often an alternative to quota management, and is less restrictive with what fishermen catch or throw away.

9 ICES. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. (International Council for the Exploration of the Sea 2010).

10 ICES. (ICES, Copenhagen, 2010).

11 ICES. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. (International Council for the Exploration of the Sea 2010).

12 Darby, C. *et al.* Vol. Contract report C2465 (ed Fisheries & Aquaculture Science (CEFAS) The Centre for Environment) (2005).

13 Lassen, H. & Medley, P. Vol. FAO Fisheries Technical Paper - 400 (ed Food and Agriculture Organisation of the United Nations) (FAO, 2001).

14 Clark, C. W. *Mathematical bioeconomics : the optimal management of renewable resources*. 2nd edn, (Wiley-Interscience, 2005).

15 ICES. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. (International Council for the Exploration of the Sea 2010).

16 *Ibid.*

17 *Ibid.*

18 MMO. (2009). *UK Sea Fisheries Statistics 2009.*

19 *Ibid.*

20 The RPI is available for all years of this study, having been used as the main inflation measure by the UK government for most of this period. We did not use the Consumer Price Index (CPI) because it is only partially available from the ONS from 1975 to 2011.

21 ONS. (Office for National Statistics, 2011).

22 The price of all landings are reduced, not just the discards that are now landed.

23 Gallet, C. A. The demand for fish: A meta-analysis of the own-price elasticity. *Aquaculture Economics & Management* **13**, 235-245 (2009).

24 Baldursson, F. M., Danielsson, A. & Stafansson, G. On the rational utilization of the Icelandic cod stock. *ICES Journal of Marine Sciences* **53**, 643-658 (1996).

25 ONS. (2011) *Op. cit.*

26 ICES. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. (International Council for the Exploration of the Sea 2010).

27 MMO. (2009). *Op. cit.*

28 Sea Fish Industry Authority. (2006). *Op. cit.*

29 That is, after taking the proportional share of UK landings from this stock

30 See scenario 2 for methods on jobs creation

31 MMO. (2009). *Op. cit.*

32 Sea Fish Industry Authority. (2006). *Seafish. The economic impacts of the UK sea fishing and fish processing sectors: An input-output analysis.* (SFIA: Edinburgh).

33 MMO. (2009). *Op. cit.*

34 ICES. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. (International Council for the Exploration of the Sea 2010).

35 *Ibid*.

36 MMO. (2009). *Op. cit.*

37 Sea Fish Industry Authority. (2006). *Op. cit.*

38 Myers, R. A., J.A., H. & N.J., B. Why do fish stocks collapse? The example of cod in Atlantic Canada. *Ecological Applications* **7**, 91-106 (1997).

39 Olsen, E. M. *et al.* Spawning stock and recruitment in North Sea cod shaped by food and climate. *Proc Biol Sci* **278**, 504-510, doi:rspb.2010.1465 [pii] 10.1098/rspb.2010.1465 (2011).

40 Clark, R. A., Fox, C. J., David, D. & Livermore, M. North Sea cod and climate change – modelling the effects of temperature on population dynamics. *Global Change Biology* **9**, 1669-1680 (2003).

41 Brander, K. M. *et al.* Cod and future climate change. *International Council for the Exploration of the Sea (ICES) cooperative research report* **305**, 92 (2010).

42 Diamond, B. & Beukers-Stewart, B. D. Fisheries Discards in the North Sea: Waste of Resources or a Necessary Evil? *Reviews in Fisheries Science* **19**, 231–245 (2011).

43 ICES. *Report of the ICES Advisory Committee, 2010.* Vol. Book 3 (2010).

44 EU. Council Regulation (EC)No 43/2009 of 16 January 2009 fixing for 2009 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required., (2009).

45 ICES. Vol. 179 (ed ICES Headquarters) (Copenhagen, Denmark, 1992).

46 Spratt, S., Simms, A., Nietzert, E. & Ryan-Collins, J. The Great Transition. (New Economics Foundation (**nef**), London, 2009).

47 Rockstrom, J. *et al.* A safe operating space for humanity. *Nature* **461**, 472-475, doi:461472a [pii] 10.1038/461472a (2009).

The Great Transition

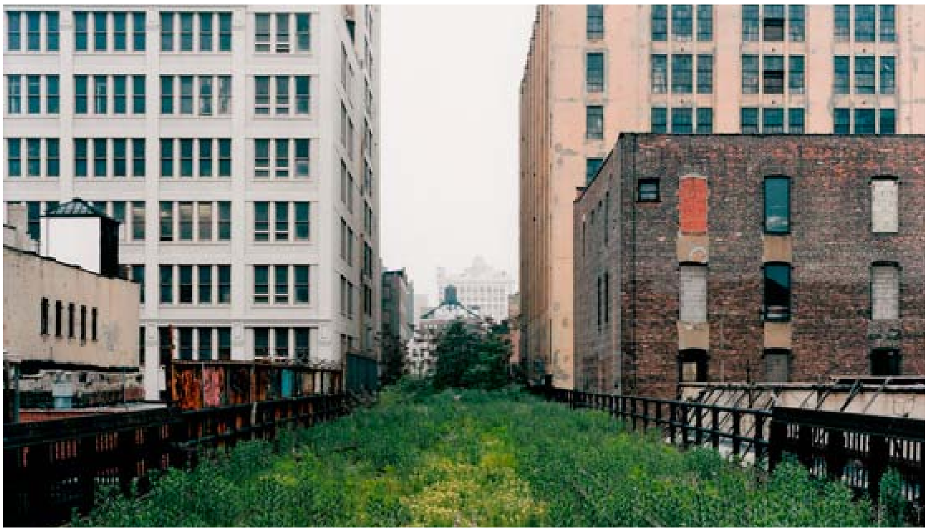


Photo: Joel Sternfeld

The Great Transition is a growing movement finding new ways for everyone to survive and thrive through financial crises, recession, climate change and the end of the oil age.

Securing the Great Transition is at the heart of all of **nef**'s work. But meeting the challenges we have identified needs new approaches. The Great Transition is a growing movement of individuals and organisations who recognise that creating a different world is necessary, desirable and possible.

At its heart is an emerging new economy built on well-being, social justice and the inescapable need to learn to live within our available biosphere. This calls for experiment, innovation and bold action by government, business and civil society. By working together to make change happen we believe we can make the Great Transition.

For more information please call
020 7820 6300

Author: Rupert Crilly

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Cover image: Aniol Esteban

If you have any feedback, comments or suggestions to improve this report we would love to hear from you.

E-mail: info@neweconomics.org

new economics foundation
3 Jonathan Street
London SE11 5NH
United Kingdom

Telephone: +44 (0)20 7820 6300

Facsimile: +44 (0)20 7820 6301

E-mail: info@neweconomics.org

Website: www.neweconomics.org

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