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Using inferred drivers of discarding behaviour to evaluate discard mitigation measures

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Abstract:

Discards refer to the part of the catch not retained on board during commercial fishing operations, but returned to the sea. The proposed European Union Common Fisheries Policy reform, to be implemented in 2014, sets out a gradual elimination of discards by reducing unwanted catches and ensuring that all catches are landed. To develop successful discard mitigation measures, it is necessary to identify the reasons for discarding. Here, we have developed a simple model that can be applied to data from observer programmes (ObsPs) to establish the contribution of different drivers of discarding behaviour. The analysis makes inferences on the causes of discarding by partitioning discards into four categories based on the length of the fish and the associated regulatory restrictions. The drivers are defined as: fish discarded below the legal minimum landing size; fish for which there is no market and that do not have a minimum landing size; fish for which there are inconsistencies in market and sorting practices; and discards that can be attributed to fishers' responses to quota restrictions. The approach is applied to data generated from ObsPs from five European Member States. All the inferred drivers contribute to the total discard quantity. Their relative contributions vary widely across countries, areas, gears, and species.

Keywords: CFP ; Discards ; fishers market ; quota

1. Introduction

Discards refer to that part of the catch not retained on board during commercial fishing operations, but returned to the sea. Discarding of marine organisms is a widespread feature of commercial fishing operations. Discard patterns are affected initially by catch compositions, which are determined by environmental factors, the fishing gear used, and fishing tactics, and ultimately by fishermen themselves, when they decide which parts of the catch to retain. This decision is influenced by both market and regulatory conditions, and constrained by space and time – storage space onboard the vessel, and sorting time.

Currently, under the European Union (EU) Common Fisheries Policy (CFP) it is illegal to land catch that does not match prescribed catch compositions, legal Minimum Landing Sizes (MLS) or Total Allowable Catches (TACs). These components of catch, and catch with low or no market value, are thrown back to the sea and most of these fish do not survive being caught and subsequently discarded (Revill, 2012).

In recognition of the economic and ecological consequences of discarding, and the growing public belief that the practice is socially unacceptable, the elimination of discards in European fisheries has been identified as a specific objective of the reform of the EU CFP. The proposed CFP reform regulation, to be implemented in 2014, sets out a gradual elimination of discards by reducing unwanted catches and ensuring that catches are landed (COM, 2012).

Quantifying the levels and composition of discards, to identify what is being discarded, when and by whom, is a necessary first step in developing a strategy to eliminate discards. Since 2002, there has been a legal requirement for all EU Member States to collect biological data on fisheries (COM, 2008), and it is from Member State fishery observer programmes that discard estimates have been derived for many European fisheries (e.g. Enever et al., 2007; STECF, 2008; Borges et al., 2005; Borges et al., 2008). Data generated by these programmes have provided estimates of the scale, composition and variability in discard patterns. The estimates have been applied to stock assessments to improve estimates of fishing mortality and scientific advice (e.g. ICES, 2012).

To develop successful discard mitigation measures it is necessary to identify the reasons for discarding. A number of studies have investigated discarding behaviour, and these have focussed on specific quota limited species in specific fisheries (Vestergaard, 1996; Gillis et al., 1995; Stratoudakis et al., 1998). The general approach in the reformed CFP proposes the implementation of an obligation to land all catch at the level of fisheries. Therefore, all discards associated with a fishery need to be considered and the dominant drivers identified. Social data has been used to determine drivers of discards (Catchpole et al., 2005; Crean and Symes, 1994), but there has been little attention on quantifying the relative importance of drivers at a fishery level.

Here we have developed a simple approach that can be applied to data generated from discard sampling programmes to establish the relative contribution of different drivers of discarding behaviour. The specific reasons for discarding individual fish have generally not been recorded as part of sampling programmes so far; therefore, we have made inferences, based on the lengths of fish discarded and landed combined with associated regulatory restrictions, to identify the likely reasons for discarding. The analysis is applied to all data from the English observer programme and case study fisheries from four other European observer programmes. The output is used to discuss on a fishery specific basis approaches that fishermen could take to comply with the new obligation to land policy.

2. Method

The analysis (Figure 1) makes inferences on the main causes of discarding by partitioning the discards into four categories based on the length at which the fish were discarded and the regulatory restrictions associated with each species-area-gear combination. The first category includes fish discarded below the MLS. The inferred driver for these discards is the mismatch between the selectivity of the fishing practices and the minimum length at which these fish can be legally landed. This driver is called 'Under MLS'.

The second category includes fish discarded below a minimum marketable size (MMS) combined with species that have no market outlet (non-commercial species). The MMS was defined as the minimum length at which fish were landed; this category includes only species for which there was no MLS. To account for variability in marketing opportunities and practices, the MMS was calculated to each gear-area and year combination. The driver behind these discards was inferred to be a mismatch between the selectivity of fishing practice and the market demand for these fish. This driver is named 'No market'.

The third category of discards included species with no associated quota and discarded above either the MMS or MLS, so these discards were all of commercial species. These fish, at the length discarded were also landed by some fishermen at least some of the time. The inferred reasons for discarding these fish included inconsistencies in market opportunities, inconsistent sorting, poor condition of the fish and/or damage to the fish. This category represents the amount of discards attributed to inconsistencies in sorting and in the marketing opportunities, and the driver is named 'Inconsistencies'.

The fourth category of discards is named 'Quota restriction' and describes fish with an associated quota which were discarded above the length normally landed. This length was taken as the MLS in most cases but in instances where species-area combinations had associated quotas but no MLS, the length normally landed was taken as the minimum length landed (MMS). The 'Quota restriction' category describes discards generated through fishermen's responses to quota restrictions and includes high graded fish as well as those discarded once a vessel had exhausted its quota. High graded fish are those discarded in preference for larger, higher-value individuals; high grading might occur at the trip level but also at the year level when fishermen have a limiting quota for a valuable species. Notice that without specifically asking the fishermen who sorted the catch, the precise reasons for discarding cannot be known. Therefore our categories are presumptions, and the amounts of fish per category might be overestimates, or underestimates, of the fish actually discarded for each reason. For example, there are likely to be instances when quotas are not restrictive, yet fishermen chose to discard fish above the MLS. This may be due to market factors or adherence to catch composition regulations, for example. As a result, it may be that the amount of fish discarded for quota reasons is lower than the amount we report under the 'Quota restriction' category, and could fall either in the 'No market' or 'Inconsistencies' categories.

For each species in each gear-area combination a hierarchical decision tree was used to assign the discards to one of the four driver categories (Figure 1). The output was discard numbers or weights of each discarded species by category, and the equivalent proportions. The four categories ('Under MLS', 'No market', 'Inconsistencies' and 'Quota restriction') can also be used in combination to determine the contribution to the total discarded volume generated by broader pressures (Figure 2). Combining 'Under MLS' and 'No market' categories produced the total of fish discarded due to employing fishing practices which catch fish for which there was never an opportunity to sell during the study period. 'No market' and 'Inconsistencies' in combination, estimate the total quantity of discards

generated through market forces; and 'Under MLS' combined with 'Quota restriction' provide an estimate of the total quantity of discards generated by regulatory drivers.

2.1. The data

The approach was applied to the dataset from the English Cefas Observer Programme for the years 2002-10, and also to five area-gear combinations from French, Danish, Greek and Spanish fisheries (Table 1). The English Observer Programme (ObsP) has monitored catches of fishing vessels registered in England since 2002, during which scientific at-sea observers sampled ~200 trips and ~1200 hauls per annum and measured ~350,000 fish per year. Details of the sampling schemes developed in France, Spain, Denmark and England are described in ICES (2011).

The selection of species, gear types, and areas sampled in the observer programmes are determined by EU Data Collection Framework (DCF) requirements (Council Regulations (EC) 1639/2001 and 199/2008). The estimated number and weight of retained and discarded fish from each of the sampled trips were raised at each length by the effort exerted for each area-gear combination. Overall, the total number of sampled trips in the English ObsP equated to around 0.5% of the total fishing effort and 0.2% in the French ObsP, 2.2% in the Spanish ObsP, 0.15% in the Greek ObsP and 0.3% in the Danish ObsP for the selected fisheries. Estimates from sampled trips were raised to the fleet level using total fishing activity (fishing days) by area-gear combination (ICES, 2007; ICES, 2004) using an approach consistent with previous estimates (Catchpole et al., 2011). Days-at-sea is a metric easily obtained from the observer programme and official log books. Using days meant that if observed trips were of different durations to the population of trips, the raising factor applied would still be appropriate. However it is acknowledged that any discard pattern dependent on trip duration is not accounted where observed trips were not of representative duration. In the case study fisheries, one gear-area combination was selected. For the English ObsP, the data were raised across the five gear-groupings (beam trawl, shrimp beam trawl, otter trawl, *Nephrops* trawl and gill/trammel nets) and across four ICES fishing grounds (IV&VIId, VIIe, VIIfgh and VIIa) and by two vessels length classes ('10m and under' and 'over 10m') in nine years (2002–2010). This covers all the metiers included under the DCF requirements, but not all the metiers in the English fleet. The metiers assessed to generate few discards, owing to either the scale or method of fishing, are not sampled.

The data were raised by spatial areas that broadly reflected the distribution of the English fleet. Potential sources of bias were considered minimized by having sampling effort proportional to fleet effort with a randomized vessel selection protocol (Catchpole et al., 2011). The results are presented with fishing gear descriptions merged into three general populations in accordance with DCF descriptors: beam trawl (TBB) gill/trammel nets (GNS) and otter trawl (OTB), which for the English data is further subset into otter trawlers targeting Nephrops (*Nephrops norvegicus*) (NEP) and other otter trawlers (OTB).

An effort variable was used as the raising metric to enable the incorporation of non-commercial species. Consequently, the absolute estimates of discards may not be consistent with those generated in the stock assessment process, which generally apply a landings metric. Estimates of discard quantity are presented only for the English case study at the national fleet level; all other results are presented as proportional contributions of each driver in each year. The proportional contributions are used to investigate differences between areas, gears and species. Only selected species are presented here for the English data and European case studies. The results give single point estimates, although, the analysis could incorporate confidence intervals (e.g. by bootstrap (Catchpole et al., 2011)). Some temporal changes in the contributions from each of the drivers for different gear-area-species combinations are also commented on.

3. Results

3.1. English data

The mean contributions to the total discard weight from each of the four drivers remained relatively constant between 2002 and 2010; 17% were 'Under MLS' discards, 37% were 'No market' discards, 24% were attributable to 'Inconsistencies' in markets and sorting, and 22% of discards were attributed to 'Quota restriction' category (Table 1). Each of the four drivers therefore made a substantial contribution to the total discard quantity when examined at a national fleet level. The weight of discards generated by the observed component of the English fleet ranged from 23 to 45.5 thousand tonnes (Figure 3). The quantity of discards decreased during the period, attributed in a previous study to the falling levels of fishing effort and to a lesser extent, diminishing catch weights (Catchpole et al., 2011).

In the English observer data, three main patterns in discard drivers are observed in the four fishing grounds investigated (Figure 4). In ICES IV&VIId it is the regulatory pressures, 'Under MLS' 26% and 'Quota restriction' 33%, which generated most of the discards (Table 1). Whereas in ICES VIIa, it was the mismatch between the selectivity of the gear and the opportunity to sell the catch that was inferred as the main influence; 'Under MLS' 32% and 'No market' 50%. The dominant fishery in this area for English vessels is a *Nephrops* targeted trawl fishery and the results observed reflect the discarding of mostly small dab, (*Limanda limanda*) which are below marketable size and small plaice (*Pleuronectes platessa*), which are below the MLS.

The contributions of the discard drivers in the fishing grounds of ICES Western Channel and Celtic Sea are similar to one another but different to the other two fishing grounds (Figure 4). Here the main drivers relate to the markets, with discards driven either by 'No market' or 'Inconsistencies' in the market and sorting of the catch. The 'No market' driver was inferred to generate a mean 38% and 48% of the total weight of discards in these two areas respectively; a mean 46% and 30% of discards were attributed to 'Inconsistencies' (Table 1). In general, the spatial effect was more important in identifying the relative importance of discard drivers than the gear type or vessel length (Table 2). In England, vessels over 10m in length operate within a different quota management regime to vessels under 10m, however, the relative importance of the factors driving discards are comparable. Moreover, because species with quotas usually also have MLSs, regions in which regulated species dominate catches have a higher proportion of discards ascribable to legislation as opposed to market forces.

3.2. Five European case study fisheries

The main drivers of discarding in the Danish otter trawl fishery in the eastern Baltic were the 'Under MLS' and 'Inconsistencies' in the markets and sorting (Figure 5). A substantial proportion of cod and flounder (*Platichthys flesus*) below MLS is caught because the selectivity is too low in relation to the MLS (Madsen, 2007). Species contributing most to the weight of discards included flounder, which have associated MLSs but no quota and whiting (*Merlangius merlangus*) which has neither MLS nor quota in this region (Table 1).

The French *Nephrops* targeted otter trawl fishery in the Bay of Biscay illustrates a discard pattern driven by the mismatch between MLS and the selectivity of the gear, Under MLS',and to a lesser extent by 'Quota restriction' (Figure 5). Here the species contributing most to the discard weight were hake (*Merluccius merluccius*), horse mackerel (*Trachurus trachurus*) and *Nephrops* all of which have associated MLSs and quotas (Table 1).

In the Spanish otter trawl fishery in the western Mediterranean the main driver of discards was from the category 'Inconsistencies', the inconsistency in the market opportunities and sorting practices (Table 1, Figure 5); whereby at least some fishermen during at least some period of the year are landing fish of particular species and lengths that they are discarding at other times. There are no quotas associated with Mediterranean stocks and therefore no 'Quota restriction' category discards. Along with lesser spotted dogfish (*Scyliorhinus canicula*), hake and horse mackerel contributed substantially to the discarded fraction, and discards were above their MLSs due to variable market demand.

The results from the Greek otter trawl fisheries in the Ionian Sea and Aegean Sea are given separately in Table 1. Both areas demonstrate a substantial and similar contribution from three drivers. The influence of the discard drivers for the main species of hake, horse mackerel and the deep-water rose shrimp (*Parapenaeus longirostris*) were comparable between the two fisheries (results for the Aegean are shown in Figure 5). Hake discards were a consequence of the poor selectivity of the gear ('Under MLS'), while deep-water rose shrimp and horse mackerel are low/medium value species that are discarded when the catch exceeds local market demand ('Inconsistencies'). There was also a considerable proportion of discards (~30%) that corresponded to species with no commercial value ('No market'), as noted previously (Damalas and Vassilopoulou, 2011).

There were few evident examples of temporal trends in the overall proportional contributions of the four drivers and interannual fluctuations were not wide, indicating that in most instances the factors driving discard patterns have had a consistent level of influence. However, the influences on discarding at the level of area-species-gear can sometimes change. In the English fisheries operating in ICES IV&VIId there was an increase in the contribution of cod discarded as a response to quota restrictions which correlated with an increase in stock but maintained quota levels (ICES, 2011). This suggested that fishermen were discarding an increasing proportion of over MLS cod. In the English fisheries operating in ICES VIIa, an increase in the proportion of Under MLS whiting discards (Figure 4b) coincided with restrictions on the use of larger codend mesh sizes of 100-119mm and a switch by fishermen to smaller mesh codends (70-99mm). There were also examples of reductions in the contribution of those discards driven by an absence of a market. Cuttlefish (*Sepia officinalis*), caught by vessels in the Western Channel, are an unregulated species; this species showed a declined 'No market' category and increasing 'Inconsistencies' category indicating that more of the catches are being utilised in recent years and there are fewer length classes for which there is never a market.

4. Discussion

This analysis demonstrates that, with some rudimentary information on MLSs and the presence or absence of quota restrictions, the length information generated in European observer programmes can be used to infer the main drivers of discarding. With the application of simple conditions the data can be interrogated at different scales to gain an understanding about the likely causes of discarding and the differences in the importance of those causes between fisheries, gears, areas and species.

The results from the English programme demonstrate that all of the inferred drivers contribute substantially to the total discard quantity; therefore, there is not one principal cause for discarding at the national level. Examination of the English data identified clear differences in the relative importance of the four drivers at the scale of fishing ground. In the fisheries investigated, the spatial effect was generally more important in identifying the relative importance of discard drivers than the gear type or vessel length. The five European case studies, also demonstrated different combinations of primary drivers. Discards were

reckoned to be driven mostly by legislation (MLS and quotas) in the French *Nephrops* trawl fishery, by MLS and market inconsistencies in the Danish demersal trawl fishery, by market inconsistencies almost exclusively in the Spanish demersal trawl fishery and by a combination of MLS, an absence of market and market inconsistencies in the Greek trawl fishery. Uhlmann et al. (online), found that discard rates were more homogeneous across fisheries than between regions. Both results support the notion that implementing discard mitigation measures at a regional level would be appropriate.*

In the data examined, only a few trends in the relative importance of drivers were observed. This suggested that there was consistency in the inferred mechanisms that bring about the overall pattern of discards. However, more subtle spatial and temporal changes could have been missed owing to the coverage of the sampling. The analysis is based on a substantial number of observed trips, nonetheless these account for only around 0.15-2.2% of the total effort exerted by these fleets. Therefore, we assume that observed and unobserved trips are statistically interchangeable. There are reasons why this may not be so: non-random distribution of observers among sampling units and the presence of observers altering fishing practices or location (Benoit and Allard, 2009). The first of these is minimised through the random selection of vessels but the second is more difficult to account for.

This analysis uses inferred reasons for discarding based on fish length and regulatory restrictions rather than data generated directly during observations at sea. Other factors may also be influencing discard patterns. For example, fishermen's responses to market demands may be more important than legal minimum landing sizes. In the Mediterranean case studies, the low level of discarding of MLS-regulated species is considered to be due to a lack of compliance with the MLSs. Damalas and Vassilipolou (2013) demonstrated a high market demand for undersized fish, as well as the low control of MLSs in the Greek Aegean Sea demersal trawl fishery. Similarly, the relative importance of high grading, quota exhaustion, catch composition regulations and damaged fish in influencing fishermen's decisions during catch sorting cannot be determined from this approach. Konigson (2009) demonstrated that between 6-22% of cod caught in the Baltic Sea gillnet fishery were damaged by grey seals and these were over the MLS and made up the majority of discards.

The analysis does demonstrate that discards are the consequence of both market and regulatory drivers. Moreover, the findings reiterate that the current objective to eliminate discards in European fisheries is inconsistent with the Common Fisheries Policy as it stands prior to the reforms to be introduced in 2014. The objective of MLSs and landing quotas are to discourage the catching of juvenile fish and to control fishing mortality. These regulations are unlikely to meet their objectives in the absence of other measures such as effort control, particularly, in fisheries that catch more than one species simultaneously. In most European fisheries, a mix of species are caught together, some of which are regulated by landings quotas and have associated MLSs. In these fisheries, there has been little incentive to avoid catching fish that are under the MLS, only to avoid landing them. Similarly, once the landing quota is fully utilised for one or more species, fishermen have legitimately continued catching and discarding those species while targeting unregulated species and other species for which quota is available. Catch composition regulations have also resulted in fish over the MLS being discarded even when there is sufficient quota to land it. These regulations have inadvertently increased fishing mortality of non-target species and are recognised by the fishing industry to introduce perverse incentives and inefficiencies for fishing businesses (Park, 2012; Graham et al., 2007).

An alternative approach, to be introduced into European fisheries as part of the CFP reform in 2014, is the move from landings quotas to catch quotas. The principle of which is to limit total catch for a single or group of species and when any one of the catch quotas in a fishery are met, fishing activities cease. To maximise the revenue from allocated catch quota, fishermen are incentivised to avoid catching fish that would otherwise result in curtailing the

fishing season and avoid catching undersized, juvenile, low value fish, which would be deducted from their quota for little or no profit. The catch quota approach is designed to put an end to discards generated by the regulatory drivers of landings quota and MLSs and create an incentive to catch only the fish fishermen want.

The strength of the incentive for fishermen to change the selectivity of their fishing practices will be dependent on i) the proportion of the catch previously discarded; ii) the proportion of undersized fish in those discards; iii) the level of increase in the landings quota to transform it to a catch quota; iv) the variability in discard patterns within the affected fleets and v) the distribution of any additional quota amongst the fleet (Condie et al., 2013). This analysis identifies the fishermen who would most likely need to change fishing practices to maximise their revenue under the new system and also how they would need to alter their fishing operations. It is the North Sea *Nephrops* trawlers who would most need to alter their catch compositions, they would need to avoid fish under MLS and species for which they have insufficient quota to land, whereas *Nephrops* trawlers in the Irish Sea would need only to avoid fish under the MLS in order to maximise revenue (Table 2).

The approaching new European discard policy is likely to be less relevant to fishing businesses for which discards are driven by market rather than regulatory pressures. For example, discards generated by English beam trawlers operating in ICES the Western Channel and Celtic Sea may change little with a move to catch quotas (Table 2). In these fisheries, other technical measures (gear/spatial) and the development of new and more consistent markets could offer a better strategy to minimise discards. It should be noted that here we indicate which fleets are most likely to be impacted; however the exhaustion of quota for only one species could bring a premature end to the fishing operations for any fleet even when that species makes up only a small component of the catch and discards.

We have demonstrated that by using a simple analysis of scientific fisheries observer data it is possible to infer the main drivers of discarding at species, gear type and regional scales. Moreover, the outputs from the approach can be used to indicate the relative importance of the main drivers of discarding in different fisheries. In turn, these can be linked to an evaluation of strategies to assist in meeting management objectives to minimize discard mortality whilst maximising the economic returns for the fishing industry.

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Figure 1. The decision tree used in the analysis to categorize the at-length discard estimates to the four inferred drivers of discarding. MLS, minimum landing size; MMS, minimum marketable size.

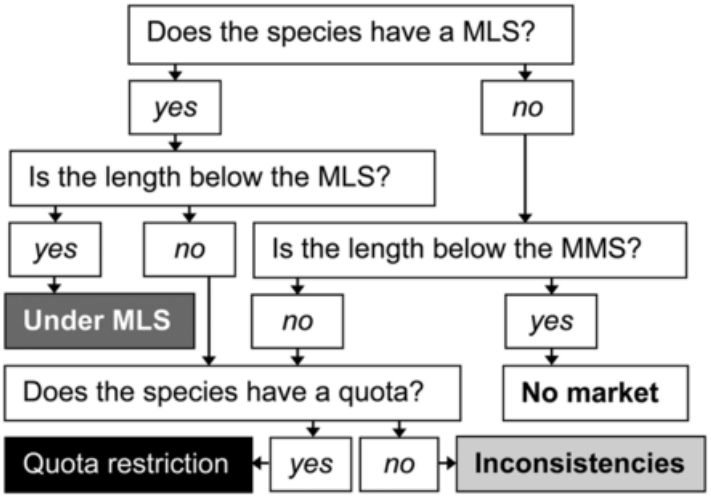

Figure 2. The four categories of inferred discard drivers and how these drivers combine to inform broader influences on discard patterns.

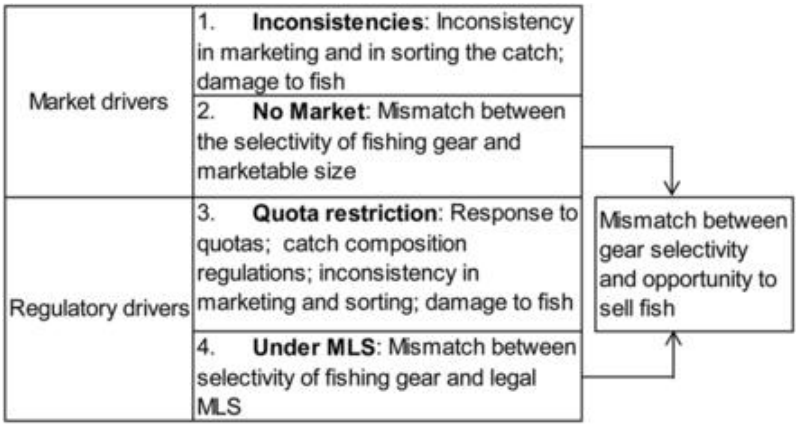

Table 1 Mean proportional contributions of the four inferred drivers to the total discard quanitity for selected combinations of area, country, gear and species;.

Country	Unit	Period	Sampled trips	Species	Gear	Fishing area	Under MLS	No market	Inconsistencies	Quota restriction
EN	weight	2002-10	1125	all	TBB, OTB, GNS	IV, VIIa,d-h	0.17	0.37	0.24	0.22
EN	weight	2002-10	369	all	OTB, GNS	IV,VIId	0.26	0.3	0.12	0.33
EN	weight	2002-10	103	all	OTB	VIIa	0.32	0.5	0.1	0.09
EN	weight	2002-10	515	all	TBB, OTB, GNS	VIIe	0.03	0.38	0.48	0.11
EN	weight	2002-10	138	all	TBB, OTB, GNS	VIIfgh	0.09	0.46	0.3	0.15
EN	weight	2002-10	138	*Sepia officinalis*	TBB, OTB, GNS	VIIfgh	-	0.4	0.6	-
EN	weight	2002-10	367	*Gadus morhua*	OTB, GNS	IV,VIId	0.65	-	-	0.35
EN	weight	2002-10	103	*Merlangius merlangus*	OTB	VIIa	0.71	-	-	0.29
EN	weight	2002-10	515	all	TBB>10m	VIIe	0.02	0.4	0.51	0.07
EN	weight	2002-10	515	all	GNS>10m	VIIe	0.22	0.51	0.15	0.12
EN	weight	2002-10	515	all	GNS<10m	VIIe	0.18	0.47	0.12	0.23
EN	weight	2002-10	515	all	OTB>10m	VIIe	0.04	0.23	0.56	0.16
EN	weight	2002-10	515	all	OTB<10m	VIIe	0.09	0.54	0.25	0.12
DK	number	2002-08	346	all	OTB	25-32	0.47	0	0.47	0.06
DK	numb	2002-08	346	*Gadus morhua*	OTB	25_32	0.94	-	-	0.06

	er									
DK	number	2002-08	346	*Platichthys flesus*	OTB	25_32	0.31	-	0.69	
DK	number	2002-08	346	*Pleuronectes platessa*	OTB	25_32	0.37	-	-	0.63
DK	number	2002-08	346	*Merlangius merlangus*	OTB	25_32		0.12	0.88	
FR	weight	2003-10	458	all	OTB	VIIIab	0.67	0.03	0.02	0.28
FR	weight	2003-10	458	*Merluccius merluccius*	OTB	VIIIa,b	0.91	-	-	0.09
FR	weight	2003-10	458	*Trachurus trachurus*	OTB	VIIIa,b	0.03	-	-	0.97
FR	weight	2003-10	458	*Nephrops norvegicus*	OTB	VIIIa,b	0.65	-	-	0.35
ES	number	2004-07	188	all	OTB	37.1	0.04	0.02	0.95	0
ES	number	2004-07	188	*Merluccius merluccius*	OTB	37.1	1	-	0	-
ES	number	2004-07	188	*Scyliorhinus canicula*	OTB	37.1	-	0.6	0.4	-
ES	number	2005-07	188	*Trachurus trachurus*	OTB	37.1	0.07	-	0.93	-
GR	number	2003-06,2008	562	all	OTB	G3720	0.19	0.34	0.47	-
GR	number	2003-06,2008	562	*Boops boops*	OTB	G3720	0	-	1	-
GR	number	2003-06,2008	562	*Merluccius merluccius*	OTB	G3720	1	-	0	-
GR	number	2003-06,2008	562	*Parapenaeus longirostris*	OTB	G3720	0.17	-	0.83	-
GR	number	2003-06,2008	562	*Trachurus trachurus*	OTB	G3720	0.46	-	0.54	-
GR	number	2003-06,2008	990	all	OTB	G3722	0.28	0.42	0.31	-

GR	number	2003-06,2008	990	*Illex coindetii*	OTB	G3722	-	0	1	-
GR	number	2003-06,2008	990	*Merluccius merluccius*	OTB	G3722	1	-	0	-
GR	number	2003-06,2008	990	*Parapenaeus longirostris*	OTB	G3722	0.76	-	0.24	-
GR	number	2003-06,2008	990	*Trachurus trachurus*	OTB	G3722	0.69	-	0.31	-

Figure 3. The estimated weight of discarded fish, and commercial cephalopods and crustaceans generated by the English fishing fleet (2002-2010). Annual estimates are divided into discards derived from each inferred driver 'Under MLS', 'No market', 'Inconsistencies' and 'Quota restriction'.

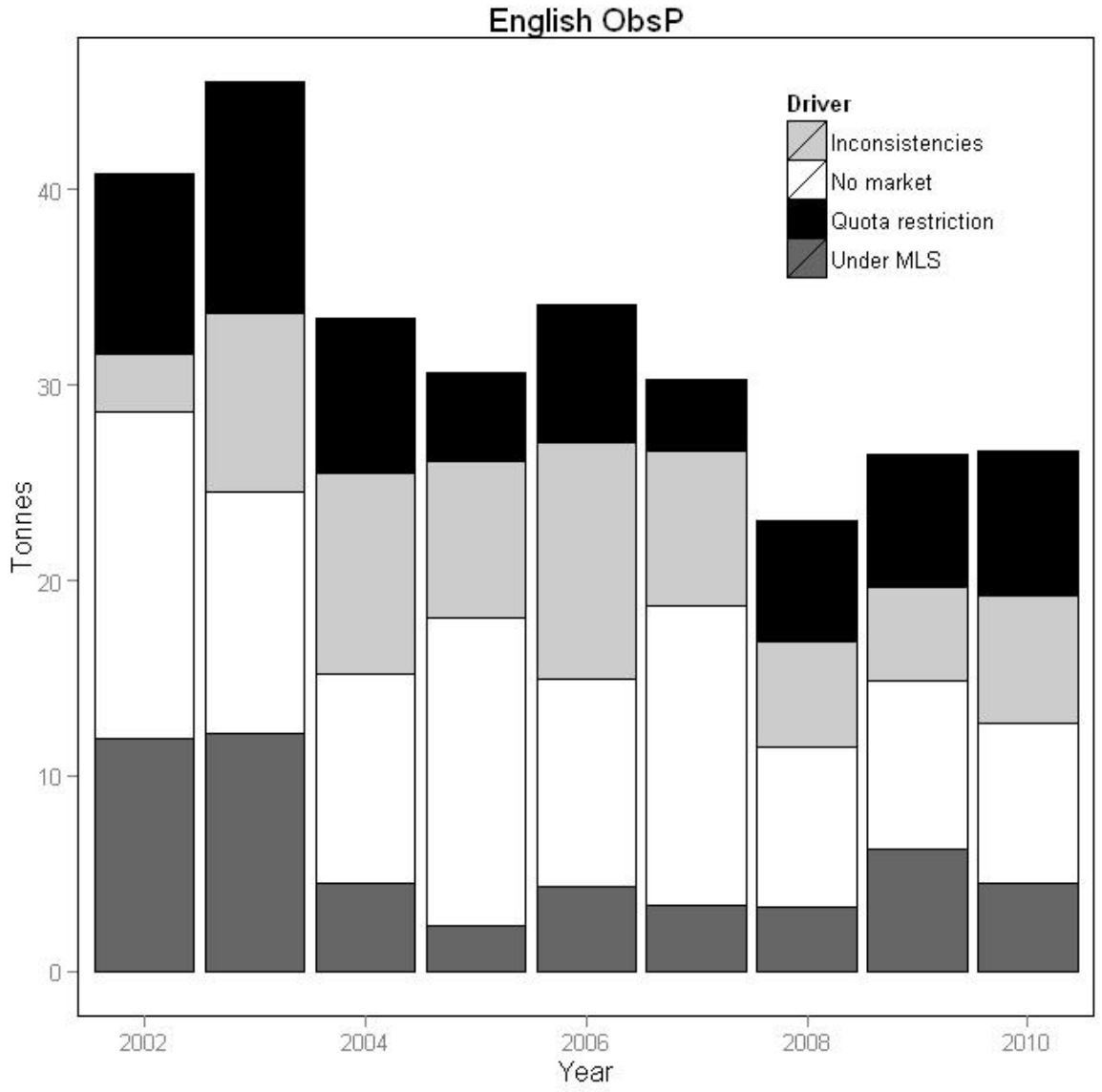

Figure 4. Annual proportional contributions to the total of fish and commercial cephalopods and crustaceans discarded by the English fleet in four fishing grounds attributed to each of four inferred drivers: ‘Quota restriction’ (black), ‘Under MLS’ (dark grey), ‘No market’ (white) and ‘Inconsistencies’(light grey).

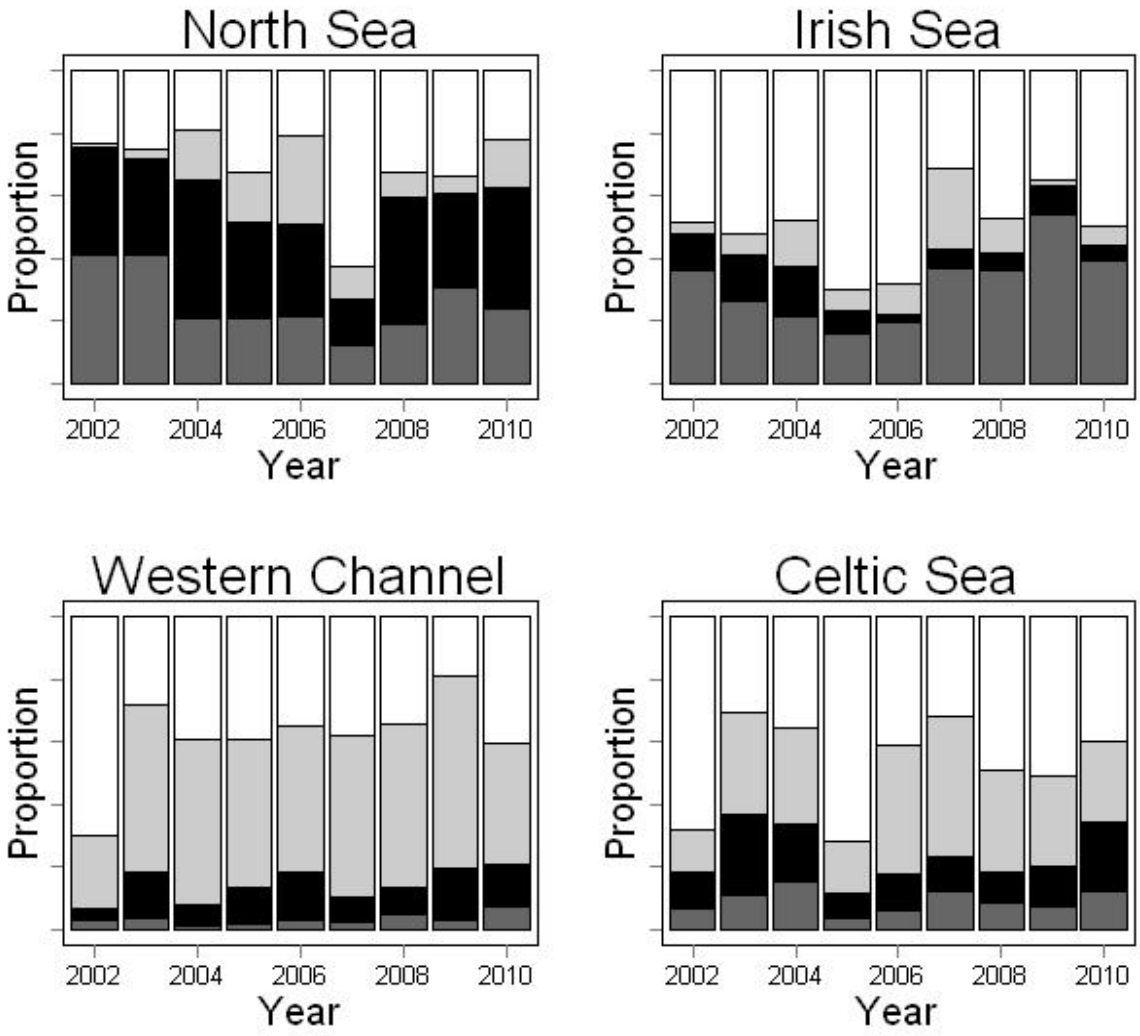

Table 2 Mean estimated contributions by discard driver to the total discard weight for each of the English metiers (2001-2010) ranked by regulatory pressures.

	Regulatory		Market	
English Metier	Quota restriction	Under MLS	No market	Inconsistencies
ICES IV & VIId Nephrops trawl u10m	44%	34%	21%	2%
ICES IV & VIId Nephrops trawl o10m	42%	35%	16%	7%
ICES IV & VIId Otter trawl o10m	45%	28%	12%	15%
ICES IV & VIId Otter trawl u10m	41%	26%	29%	4%
ICES IV & VIId Gill Trammel nets o10m	18%	44%	38%	0%
ICES VIIa Nephrops trawl u10m	4%	49%	46%	1%
ICES VIIa Nephrops trawl o10m	8%	44%	42%	6%
ICES IV & VIId Gill Trammel nets u10m	31%	20%	29%	20%
ICES VIIa Gill Trammel nets u10m	50%	0%	50%	0%
ICES VIIfgh Gill Trammel nets o10m	23%	24%	36%	17%
ICES IV & VIId Beam trawl DEF o10m	23%	20%	45%	12%
ICES VIIe Gill Trammel nets u10m	23%	18%	47%	12%
ICES VIIfgh Gill Trammel nets u10m	18%	22%	51%	9%
ICES VIIa Otter trawl u10m	9%	28%	48%	15%
ICES VIIa Beam trawl DEF o10m	6%	30%	59%	5%
ICES VIIe Gill Trammel nets o10m	12%	22%	51%	15%
ICES VIIa Otter trawl o10m	9%	25%	54%	13%
ICES VIIfgh Otter trawl u10m	10%	15%	56%	19%
ICES VIIfgh Otter trawl o10m	10%	12%	34%	43%
ICES VIIe Otter trawl u10m	12%	9%	54%	25%
ICES VIIe Otter trawl o10m	16%	4%	23%	56%
ICES VIIfgh Beam trawl DEF o10m	15%	4%	50%	30%
ICES VIIe Beam trawl DEF o10m	7%	2%	40%	51%

Figure 5. Annual proportion contribution to the total of fish and commercial cephalopods and crustaceans discarded by the four case study European fleets attributed to each of four inferred drivers: 'Quota restriction' (black), 'Under MLS' (dark grey), 'No market' (light grey) and 'Inconsistencies' (white).

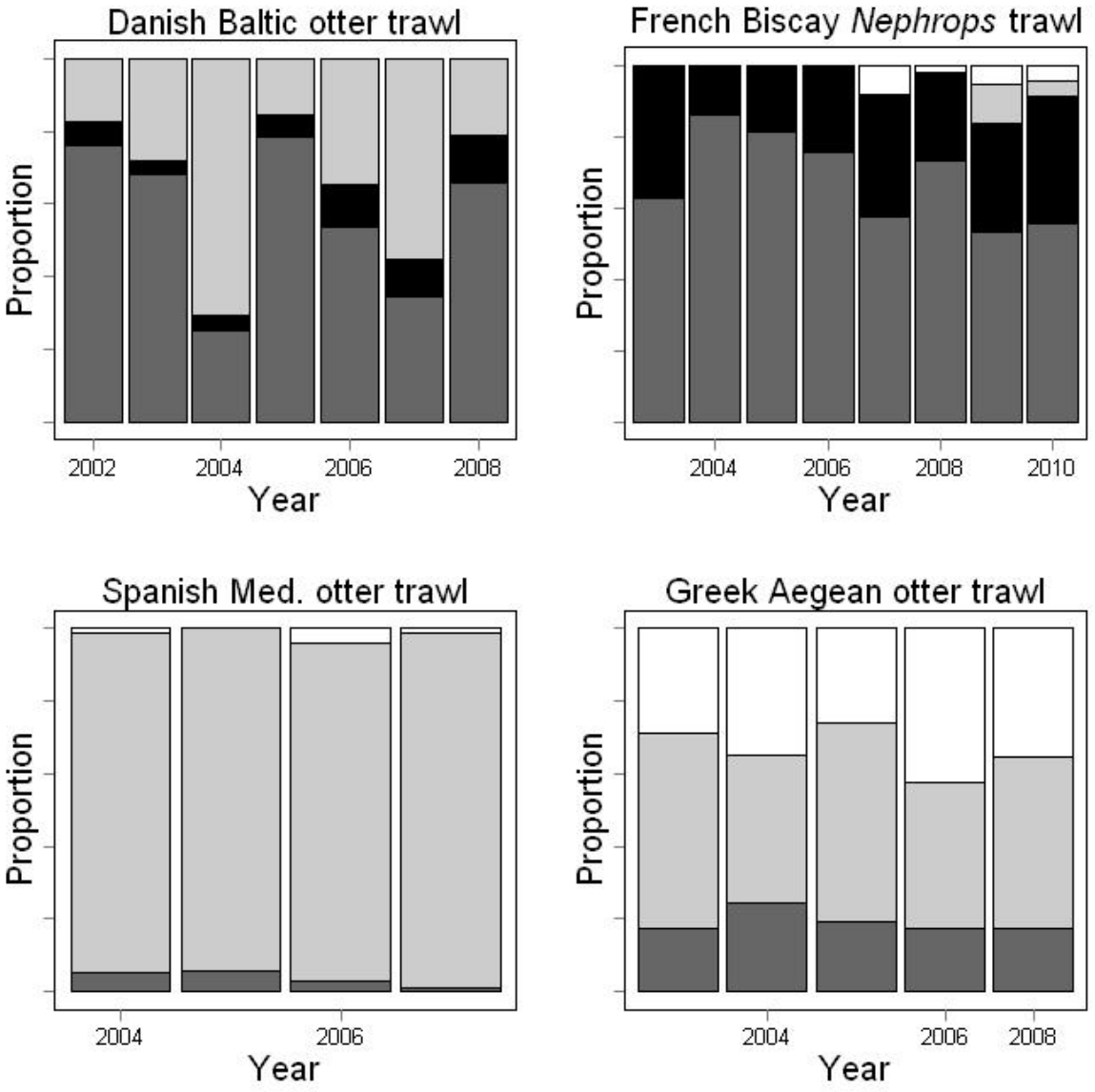

Figure 6 The proportion contribution of the inferred drivers to the discard quantity generated by English vessels for cod in North Sea, whiting in Irish Sea; 'Quota restriction' (black), 'Under MLS' (dark grey).