Fishing Industry Science Alliance (FISA)

Collection of Data to Inform the Implementation of a Discards Ban

Scottish Marine and Freshwater Science Vol 7 No 12

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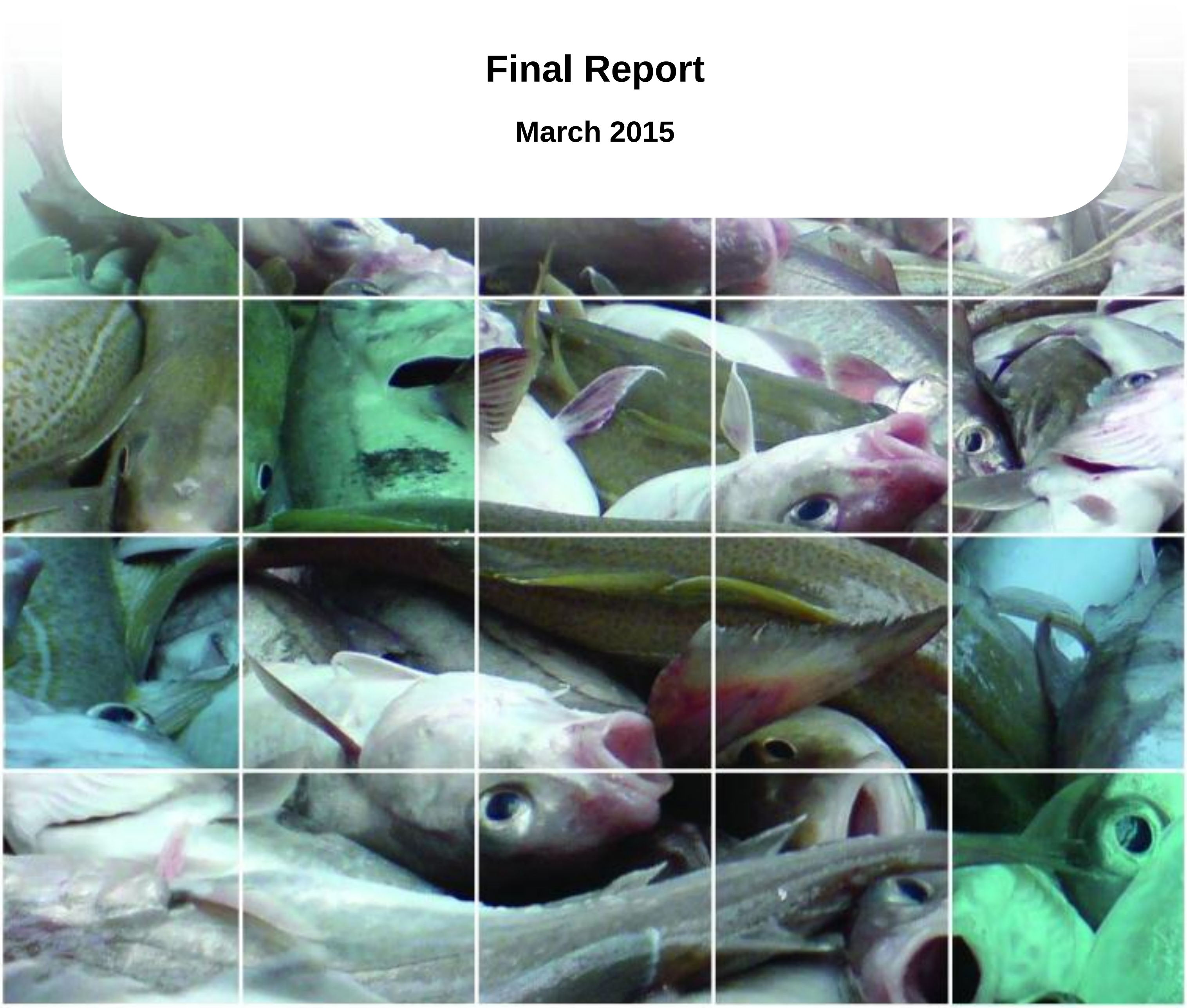

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Collection of Data to Inform the Implementation of a Discards Ban

Final Report

March 2015

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The Shetland Fish Producer Organisation is thanked for making available data on quota availability and on the weight and value of landings by Shetland whitefish vessels.

[*] See: www.gov.scot/Topics/marine/science/FISA

Contents

1 Summary

This project has trialled self-sampling by fishermen as a means of collecting information on discards. In the process a significant quantity of additional information has been collected on the nature and scale of discarding in the Scottish mixed whitefish fishery in the northern North Sea.

The results have confirmed species such as hake, saithe and cod as some of the biggest components of whitefish discards. They have also indicated that the vast majority of discard fish in this area are potentially marketable; that is, larger than the minimum landing size (the primary reason given by Shetland fishermen for discarding is lack of quota over the course of the year). The principal exceptions were rays (there is little market demand for small rays) and ling (where most discarded fish are below the minimum landing size). The results have also identified small, but regular, discards of pelagic species such as herring and mackerel in the whitefish fishery.

In the absence of observers it was not possible to directly verify the results obtained from the analysis of the samples, but comparison with data from other sources and the internal consistency of the self-sampling data has suggested a reasonable level of confidence in them.

An analysis has also been carried out of the potential implications of the discards ban for fishermen in the Scottish mixed whitefish fishery, including an estimation of the potential costs of handling, landing and disposing of unmarketable discards, and an evaluation of the potential impacts of quota limits on individual species.

2 Introduction

The European Union has agreed to implement a discard ban ('landing obligation') under the reformed Common Fisheries Policy*. This ban came into force for pelagic species at the beginning of 2015. For whitefish species the ban will be phased in from 2016 to 2019. The implementation of the discard ban represents a substantial challenge to the Scottish fishing industry, and especially to the mixed whitefish fishery.

A key problem is a lack of basic information needed to inform the development of a practical and proportionate discard management regime for the Scottish mixed whitefish fleet that can achieve the objectives of a discard ban without imposing unreasonable requirements on fishermen. In particular, detailed information on the quantities and nature of the fish being discarded and information on the potential practical implications of implementing a discards ban are lacking.

Knowledge of the nature and scale of these issues could help inform the development of a practical and proportionate discard management regime and would also help fishermen better understand the issues likely to arise from a discard ban and how these might best be managed.

The traditional means of collecting discards (and other fisheries) data has been through the deployment of scientific observers on-board commercial fishing vessels. Observers tend to be preferred because of the high level of control they provide over the sampling process and the resultant high level of scientific confidence in the resulting data.

However, deploying scientific observers on-board commercial fishing vessels is expensive and recruiting suitably qualified and experienced persons willing to undertake this work can be difficult. For these reasons the availability of observers is usually limited and there can be conflicting demands on their time from different sampling programmes.

Self-sampling – where fishermen themselves collect samples of their catches for analysis ashore – offers a potential alternative to the use of on-board observers for the collection of discards and other fisheries data from commercial fishing vessels. Self-sampling has been successfully used elsewhere, for example in Dutch fisheries (van Helmond *et al*., 2012; Kraan *et al*., 2013; Uhlmann *et al*., 2013).

The Dutch programme has used a reference fleet of 23 vessels, distributed across nine different métiers (gear, mesh-size combinations), to collect discard samples

* See, for example:
EU: ec.europa.eu/fisheries/cfp/fishing_rules/discards/index_en.htm
Scottish Government: www.gov.scot/Topics/marine/Sea-Fisheries/discards
Seafish: www.seafish.org/responsible-sourcing/conserving-fish-stocks/discards

during their commercial fishing operations. The Dutch crews collected a sample of two boxes of discards (~80kg) from two catches during each trip. These samples were landed for on-shore analysis. The self-sampling has been backed up by observers who independently sampled discards during some of these vessels' fishing trips to provide a means of verifying the data collected through the self-sampling programme.

Given the fishing industry's desire to obtain more information on the nature and scale of discarding by fishing vessels in the waters around Shetland, and the difficulties associated with the use of observers (outlined above), the Dutch self-sampling model was adapted and trialled in the northern North Sea mixed whitefish fishery as a means of obtaining additional information on discards.

The objectives of the project were:

- to implement a discard self-sampling programme in this fishery (based on methods developed and used in the Netherlands) as a cost-effective means of increasing the quantity of discards data from Scottish whitefish fisheries.
- to use this programme to collect quantitative information on the amount and nature of fish currently being discarded in the mixed whitefish fishery around Shetland.
- to assess the practical implications of implementing a discard ban on fishing vessels in the mixed whitefish fishery.

It was agreed by the FISA Steering Committee that this project would work cooperatively alongside industry and other observer programmes to assist with verification of the data obtained through the self-sampling programme, and to collect other information relevant to an assessment of the implications of the discards ban. As a means of verifying the data collected through this self-sampling scheme, comparisons were made with available discards data collected through various other programmes.

3 Methods

This project used self-sampling by fishermen to collect samples of the fish being discarded by vessels in the Shetland whitefish fleet. The self-sampling methodology was based on that developed and used in Dutch fisheries (van Helmond *et al*., 2012; Uhlmann *et al*., 2013).

3.1 Data Collection

3.1.1 Vessel Self-Sampling

Fishing crews willing to participate in the self-sampling programme were identified by the Shetland Fishermen's Association. Participating crews were asked to retain a representative sample of the fish that they were discarding from some of their tows; ideally two catches each week.

Members of each crew were briefed on the objectives of the project and about what they were being asked to do. Each vessel was issued with sample record sheets (an example record sheet is included in the Appendix) on which to record information about each discard sample and the tow from which it was taken. Each sheet bore a random number between 1 and 10 and the crew were asked to sample the tow that corresponded to that number. (For example, if the first sheet bore the number '7' they should sample the 7^{th} tow of their trip. If the next sheet bore the number '3' they should then sample the 3^{rd} tow after that). Despite this protocol being laid out, the randomised sampling methodology was not followed by the fishermen in a high proportion of cases.

For each sampled tow the crew were asked to collect two boxes of the fish that were being discarded (stress was laid on the importance of the sample being as representative of the discards as possible). These boxes were to be iced, labelled and tagged and stored in the vessel's fish hold.

Derogations were provided by Marine Scotland Compliance (MSC) for each participating vessel to cover any undersized or other fish, the retention of which on-board would normally be prohibited. MSC also provided numbered tags to mark the boxes of samples.

Fishermen were asked to record relevant information on the sample record sheet, including the date and fishing ground, and the number of boxes retained and discarded from the sampled tow.

The samples were landed with the rest of the vessels' catches to the fish markets in either Lerwick or Scalloway.

A provisional target of 72 samples was set at the beginning of the programme, with 24 each to come from seine net, single trawl and twin trawl vessels.

3.1.2 Sample Processing

Samples were processed at the fish market where they had been landed. Each sample was sorted by species; the principal commercial species were individually measured (overall length); and each species was weighed (Table 1).

Following processing the material from the samples was bagged and disposed of at the Energy Recovery Plant (incinerator) in Lerwick. During periods when this plant was closed they had instead to be disposed of at the Gremista Waste Management Facility landfill site, also in Lerwick.

Table 1. Summary of sampling protocol for fish species in the fishermen's discard samples.

Species		Sampling Protocol
Cod Haddock Hake Lemon Sole Ling Megrim Monk Plaice Saithe Whiting Witch Rays Common Skate		Total weight Lengths
Other Species	-	Total weight

3.2 Data Analysis

All data collected were entered into Excel spreadsheets for collation and analysis. Statistical analyses were carried out in Excel using the Real Statistics Resource Pack add-in[*].

[*] Real Statistics Resource Pack software (Release 3.5). Copyright (2013 – 2015), Charles Zaiontz. Available at: www.real-statistics.com.

The Kruskall-Wallis test was used to compare the discard composition between fishing gear types.

3.2.1 Estimation of Discard Rates

Overall discard rates for the sampled catches (for all species) were determined using the information recorded by the fishermen on each sample record sheet. This included the number of boxes that were retained (landed) and discarded from the sampled catch. The discard rate was calculated as the quantity of fish discarded divided by the total quantity caught (retained + discarded).

It was not possible to directly determine discard rates for individual species as the quantities of each species caught in the sampled catches was not known. The total quantity of each species discarded could be estimated by raising the weights in each discard sample to the level of the catch (the size of the sample and the total quantity discarded from the catch were known). However, the composition of the retained portion of the sampled catches was not recorded. (Whilst this information would have been desirable it was decided not to risk overloading fishermen by asking them to record too much information. This was information that observers would have collected had they been available).

However, although the composition of the retained portions of each catch were not known, the composition of the landings from each sampled trip were available (from data provided by the Shetland Fish Producer’s Organisation, covering to the end of December 2014). Overall discard rates for individual species were therefore estimated for each sampled trip by raising the sample data to the level of the trip, as follows:

The total quantity of fish landed at the end of the trip was known (from the SFPO data), as was the total quantity of fish retained (landed) from the catches sampled during that trip (from the sample record sheets). From these, the percentage of the total landings that came from the sampled catches could be calculated, as well as a raising factor.

This raising factor was then used to raise the estimated total quantities of each species discarded from the sampled catches (see above), to an estimate of the total quantities discarded during the trip. The total quantity of each species caught during the trip could then be determined as the sum of the total quantity landed (known) and the quantity discarded (estimated). The discard rates for each species were then estimated from these values.

These estimates of the discard rates for individual species are based on the assumption that the catches sampled, and the discards from them, are representative of all the catches made during the trip. In the absence of observers, or of any other sources of information, it is not possible to verify this assumption of the estimated discard rates for individual species. These estimates therefore need to be treated with some caution, but remain the best possible from the available data.

3.2.2 Comparison with Other Discards Data

In the absence of observers, no data were available to allow for direct verification of the discard sample data. Instead these data were compared to data from two other programmes:

3.2.2.1 Discard Tally Book Data

Between June 2013 and July 2014 the Shetland Fishermen's Association (SFA) in conjunction with the NAFC Marine Centre used tally books to collect information from Shetland whitefish vessels on the nature and scale of their discards (Napier, 2014). Participating vessels were asked to record, for each catch, estimates of the total quantities of each species retained and discarded. This information was used to estimate the composition of the discards and the discard rates for each species.

The tally book scheme recorded information on 1,513 catches over 422 days of fishing, by eight fishing vessels (2 seine net, 3 single trawl & 3 twin trawl) over varying periods between June 2013 and July 2014, during which about 46,000 boxes of fish of more than 24 different species were caught. Several of the vessels that participated in the tally book scheme also collected discard samples in this project.

The composition of the fishermen's discard samples were compared to those estimated through the discard tally book scheme using the Spearman Rank Correlation test, while the discard rates were compared using the Mann-Whitney U test.

3.2.2.2 Observer Data

Observer data on discards were available from an ongoing project to collect information on data-limited species in the northern North Sea[*]. This project used fisheries observers on commercial fishing vessels to collect fisheries and biological data on selected whitefish species (hake, lemon sole, ling, megrim, monk and plaice). Of relevance to this study, these data included the quantities of each species retained and discarded (from which discard rates could be estimated), and the lengths of discarded fish.

[*] This project is being carried out by the NAFC Marine Centre received funding from the Scottish Government via Marine Scotland Science, the European Fisheries Fund, and the Shetland Fishermen's Association. The project is due to be completed in June 2015.

Data collected during the period from June to December 2014 were used for comparison with the results of the analyses of the fishermen's discard samples. These included data on 571 catches during 18 trips (usually only one or two species were sampled from each catch). To avoid the effects of any possible seasonal variations in the discards data comparisons between the fishermen's discard sample and observer data were made by quarter.

The size distributions of the fish in the fishermen's discard samples were compared with those measured by the observers using the Kolmogorov-Smirnov test.

3.3 Implications of the Discards Ban

Two potential implications of the discards for fishermen were considered.

Firstly, the potential costs of handling and disposing of fish that fishermen would be required to land under a discards ban, but which they could not sell (because it fell below minimum landing sizes). The discards data collected through this study together with landings data for the Shetland whitefish fleet[*] were used to estimate the total quantity of unmarketable discards caught by the fleet in 2014. (The quantities estimated from the fishermen's discard samples were raised to the level of the fleet for the year). The potential costs of disposing of this quantity of material were then calculated.

Secondly, the potential impact of the discards ban on quota uptake; in particular how much quota for other species might remain uncaught if fishing had to stop when one quota runs out. The potential magnitude of such uncaught quota was assessed by estimating the dates that quotas available to the Shetland whitefish fleet for selected species might have run out in 2014 under a discards ban, and the total quantities of quota that would have remained uncaught on those dates (based on actual landings data and quota availability for the fleet*).

[*] Landings data and quota information provided by the Shetland Fish Producers Organisation Ltd. Available quotas include in-year, swaps, trades and transfers.

4 Results

4.1 Sample Collection

A total of six vessels were enlisted in the self-sampling programme, representing about one-quarter of the Shetland whitefish fleet. These included two vessels using seine nets, two using single trawls and two using twin trawls*.

The vessels returned a total of 72 samples of discards between May 2014 and February 2015, with a total weight of 5,885 kg (Table 2). Most of the samples were collected in the waters around Shetland (Figure 1), with almost half (46%) of the samples coming from the two ICES statistical rectangles east of Shetland.

Two vessels returned samples dependably throughout the programme and accounted for the majority (61%) of the discard samples returned. Other vessels enlisted in the programme tended to return samples initially, but failed to continue doing so in the longer-term. As a result, the majority of the fishermen’s discard samples were received from vessels using single or twin trawls; only nine samples were received from seine net vessels.

All but three of the samples (96%) comprised two boxes of fish, with a mean box weight of 41.2 kg (± 0.7 kg).

From the information recorded on the sample record sheets, the discard samples represented about 25% of the total quantity of fish discarded from the sampled catches, on average (Table 2). This percentage tended to be slightly higher for the seine net and single-trawl fishing vessels and slightly lower for the twin-trawl vessel, and especially the twin-trawl vessels with cameras.

Slightly more than one-third (36%) of the samples came from the tow indicated by the random number on the record sheet issued to the vessel. For the remaining samples (64% of the total) the tow number recorded on the record sheet did not match the random number.

* This included one twin-trawl vessel operating under the Cod Catch Quota Scheme (CCQS) (see www.gov.scot/Topics/marine/Licensing/FVLS/catchquota). Under the CCQS a vessel receives an additional allocation of cod quota in return for an obligation to retain on-board and land all cod that are caught, regardless of size or marketability. CCTV cameras are fitted to the participating vessels to allow monitoring of compliance with this requirement. This vessel is referred to in this report as Twin-Trawl (cameras).

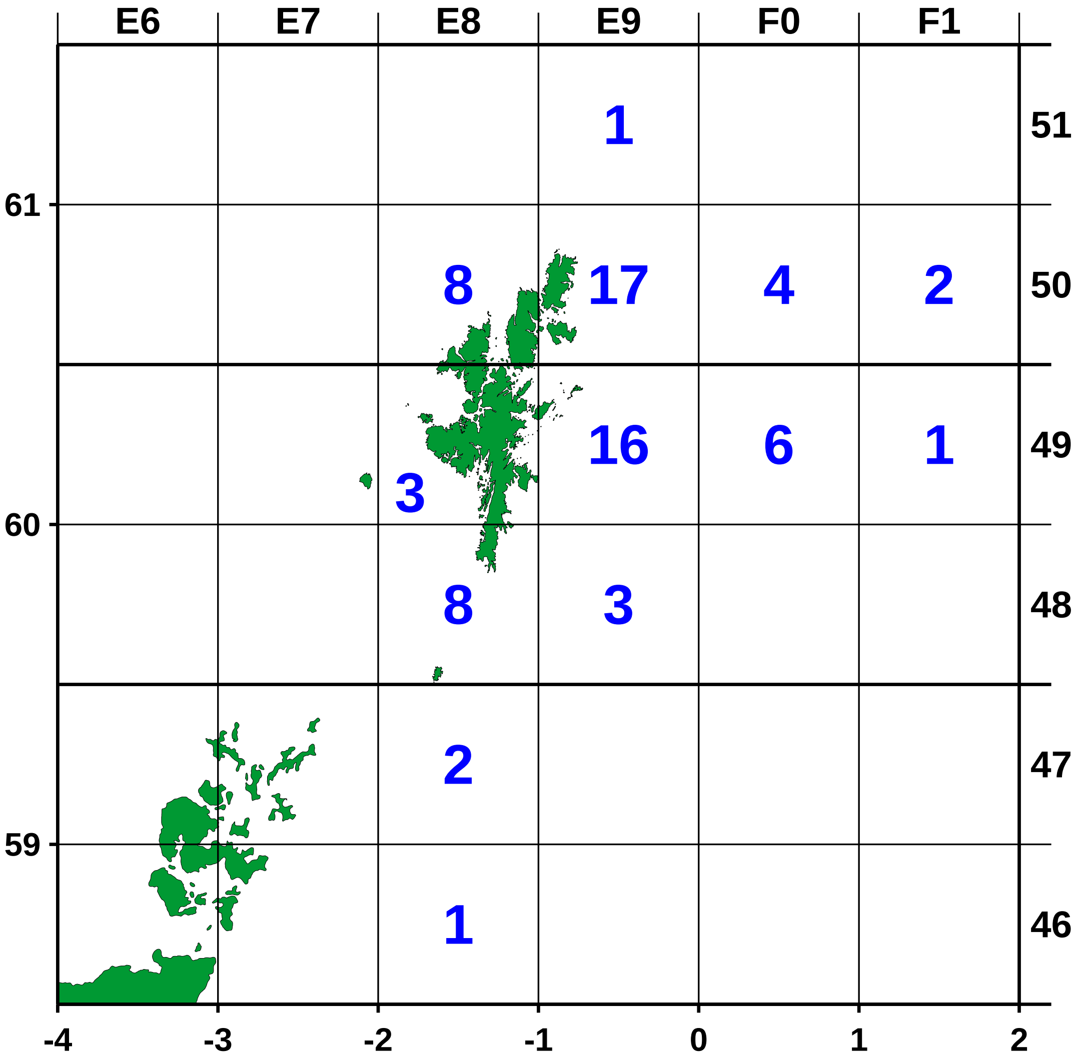


Figure 1. Distribution of the fishermen's discard samples collected during this study. Numbers indicate the total number of samples collected in each ICES statistical rectangle.

Table 2. The number of samples returned, and the total sample weight, by fishing gear type and overall. Also shown are: the mean sample weights, the mean box weights, and the mean percentage of the discards from the catch that were included in the samples (± the standard error of the means in each case). Most samples comprised two boxes.

	Seine Net	Single Trawl	Twin Trawl	Twin Trawl (cameras)*	ALL Gears
No. of Samples	9	31	23	9	72
Total Sample Weight (kg)	797	2,485	1,862	742	5,886
Mean Sample Wt. (kg)	88.6 ± 2.5	80.1 ± 1.4	84.2 ± 3.1	77.2 ± 2.9	82.1 ± 1.4
Mean Box Wt. (kg)	44.3 ± 2.5	40.1 ± 0.7	42.5 ± 1.5	38.9 ± 1.3	41.2 ± 0.7
Sample as % of Discards	27% ± 7%	28% ± 5%	22% ± 3%	16% ± 2%	25% ± 2%

* Vessel operating under the Cod Catch Quota Scheme. See footnote on page 9.

4.2 Composition of Discards

More than 25 species of fish were recorded in the fishermen's discard samples (Table 3). The samples were dominated by three species; hake, saithe and cod, which together accounted for two-thirds of the total sample weight (Figure 2, Table 5). Hake was the most abundant single species, accounting for about one-third of the sample weight on its own, while saithe and cod accounted for similar percentages.

Other species that were present in the samples in relatively large quantities included gurnards, rays and ling (Figure 2). Together, eight species accounted for more than 90% of the discard sample weight (Figure 2).

Based on discussions with fishermen, and the analysis of the fishermen's discard samples, several principal reasons for discarding were identified (Table 4), of which lack of quota was perhaps the most important (in that it accounted for the greatest quantity of fish discarded). 'Lack of quota' in this context refers to a lack of quota over the course of the year, not during an individual fishing trip; most skippers try to manage their available quota so that it last the whole year. (Available quota includes in-year swaps, trades and transfers).

The other principal reasons for discarding were lack of market demand and size limits (for fish below or close to minimum landing sizes).

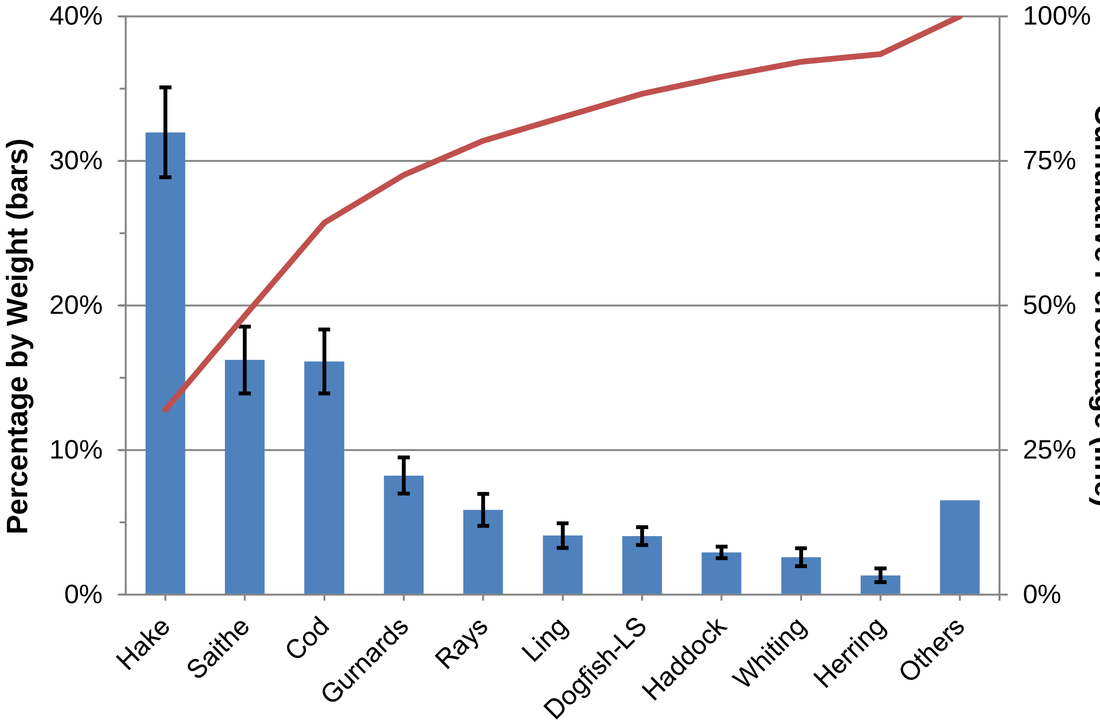


Figure 2. Discard sample composition: the average proportion (by weight) of the principal species in the fishermen’s discard samples (all gear types). Error bars show the standard error of the mean. The line shows the cumulative percentage (on the right-hand axis).

Table 3. The species recorded in the fishermen's discard samples, with the average weight of each per sample by fishing gear type and overall.

		Fishing Gear				
		Seine Net	Single Trawl	Twin Trawl	Twin Trawl (cam's)[1]	ALL Gears
	No. of samples:	**9**	**31**	**23**	**9**	**72**
Species		kg / sample				
Hake	*Merluccius merluccius*	33.3	20.9	28.2	27.8	25.6
Cod	*Gadus morhua*	20.0	11.0	20.4	0.0	13.8
Saithe	*Pollachius virens*	0.1	10.7	12.1	41.0	13.6
Gurnards	*Chelidonichthys cuculus* *Eutrigla gurnardus*	7.6	7.7	6.0	2.5	6.5
Rays[2]	*Raja naevus* *Raja clavata*, etc.	10.4	5.5	1.5	4.6	4.7
Ling	*Molva molva*	0.6	4.6	2.5	4.2	3.4
Dogfish-Lesser-Spotted	*Scyliorhinus canicula*	7.0	3.5	2.3	0.9	3.2
Haddock	*Melanogrammus aeglefinus*	1.1	3.6	2.0	0.5	2.4
Whiting	*Merlangius merlangus*	0.7	4.4	1.0	0.2	2.3
Plaice	*Pleuronectes platessa*	1.1	1.4	1.0	0.0	1.1
Herring	*Clupea harengus*	0.1	1.6	1.0	-	1.0
Skate-Common	*Dipturus batis*	0.9	1.7	0.5	-	1.0
Horse Mackerel	*Trachurus trachurus*	1.4	1.2	0.4	0.4	0.9
Mackerel	*Scomber scombrus*	0.0	0.4	1.1	-	0.6
Dabs	*Limanda limanda* *Hipploglossoides platessoides*	1.0	0.3	0.1	0.0	0.3
Megrim	*Lepidorhombus whiffiagonis*	0.0	0.1	0.3	0.0	0.2
Witch	*Glyptocephalus cynoglossus*	0.0	0.2	-	0.0	0.1
Red Fish	*Sebastes spp.*	-	0.2	0.0	0.1	0.1
Lemon Sole	*Microstomus kitt*	-	0.1	0.0	-	0.1
Blue Whiting	*Micromesistius poutassou*	-	0.1	0.0	-	0.1
Monk	*Lophius piscatorius* *Lophius budegassa*	-	0.1	0.1	-	0.1
Wolffish	*Anarhichas lupus*	-	0.1	-	-	0.0
Tusk	*Brosme brosme*	-	-	-	0.1	0.0
Other Fish[3]		2.6	0.5	0.1	0.0	0.6
Non-Fish[4]		0.5	0.1	0.2	0.0	0.2
Total		88.6	80.1	81.0	82.4	81.7

Notes

1 Vessel operating under the Cod Catch Quota Scheme. See footnote on p. 9

2 Rays were not identified to species, but included cuckoo rays (*R. naevus*) and thornback rays (*R. clavata*).

3 'Other fish' commonly included Argentines (*Argentina sphyraena*) and Norway pout (*Trispoterus esmarkii*).

4 Non-fish included cephalopods, echinoderms, crustaceans and molluscs.

Table 4. The assumed primary reasons for discarding the principal species discarded (based on discussions with fishermen and others, and analysis of the fishermen's discard samples).

Species	Main Reason for Discarding
Hake	Lack of Quota[1]
Saithe	Lack of Quota[1]
Cod	Lack of Quota[1]
Gurnards	No Market
Rays	No Market (small fish)
Ling	Size Limit[2] / Lack of Quota[1]
Lesser-Spotted Dogfish	No Market
Whiting	Size Limit[2]
Haddock	Size Limit[2]
Herring	Lack of Quota[1]

[1] Lack of quota over the course of the year (including in-year swaps, trades and transfers).
[2] Fish below or close to the minimum landing size.

4.2.1 Comparison of Fishing Gears

The composition of the fishermen's discard samples was broadly similar between the different types of fishing gear (Figure 3, Table 5), with a few exceptions. In particular, relatively few ling and almost no saithe were encountered in the samples from seine net vessels, while saithe accounted for a relatively high proportion of the discards from the camera-equipped twin-trawl vessel. As would have been expected, cod was almost entirely absent from the discards of the latter vessel (a single cod was recorded).

Overall, there was a significant difference between the discard compositions of the four gear categories (Kruskal-Wallis, H = 8.21, $P < 0.05$). However, this can be explained by the absence of cod from the discard samples from the camera-equipped twin-trawler. There was no significant difference between the discard compositions of the other three fishing gear types (Kruskal-Wallis, H = 3.01, $P > 0.05$), or between the four gear types if cod is excluded from the analysis (Kruskal-Wallis, H = 7.22, $P > 0.05$).

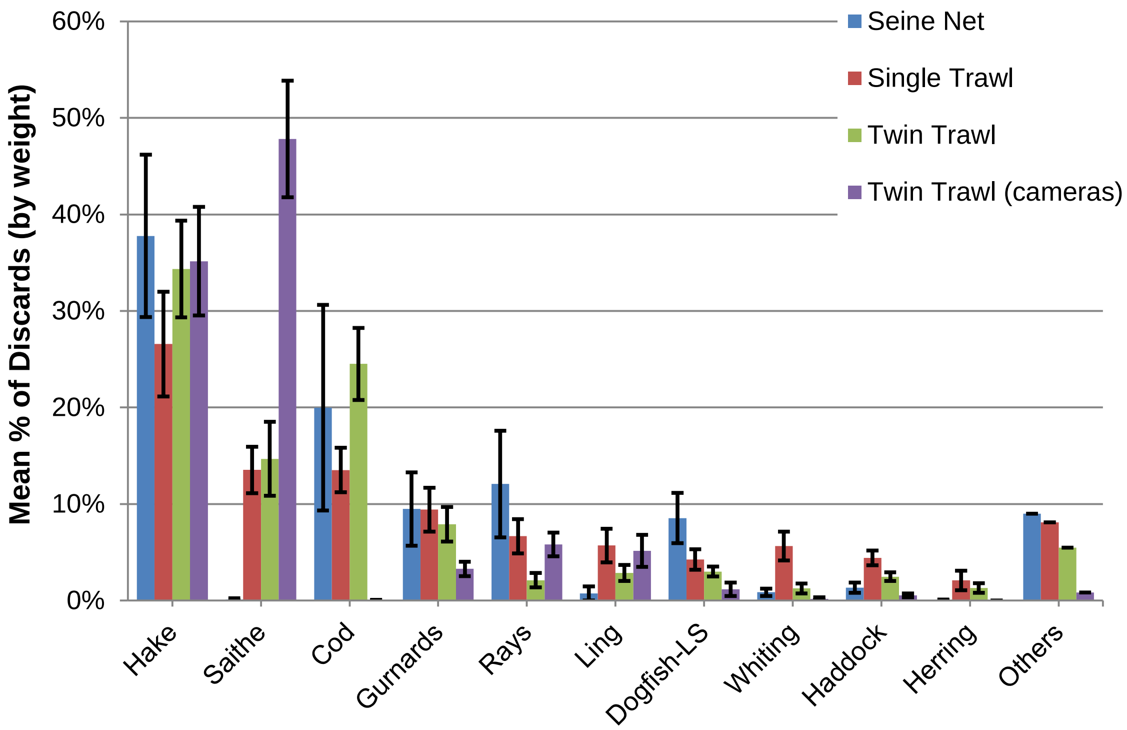


Figure 3. Discard sample composition by fishing gear type: the average percentage (by weight) of the principal species in the fishermen's discard samples by fishing gear type. Error bars show the standard error of the mean.

Table 5. Discard sample composition by fishing gear type: The average percentage (by weight) of each species in the fishermen's discard samples by fishing gear type and for all gears combined, and the standard error of the mean (SE) in each case. Species are ranked in decreasing order of their percentage in all the fishing gears combined.

	Seine Net		Single Trawl		Twin Trawl		Twin Trawl (camera)		ALL Gears	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Hake	37.8%	8.4%	26.6%	5.4%	34.3%	5.0%	35.2%	5.6%	31.5%	3.1%
Saithe	0.1%	0.1%	13.5%	2.4%	14.7%	3.8%	47.8%	6.0%	16.5%	2.3%
Cod	20.0%	10.6%	13.5%	2.3%	24.5%	3.7%	0.0%	0.0%	16.2%	2.2%
Gurnards	9.5%	3.8%	9.4%	2.3%	7.9%	1.8%	3.3%	0.7%	8.2%	1.2%
Rays	12.1%	5.5%	6.7%	1.8%	2.1%	0.7%	5.8%	1.2%	5.8%	1.1%
Ling	0.7%	0.7%	5.7%	1.7%	2.9%	0.8%	5.1%	1.7%	4.1%	0.8%
Dogfish-LS	8.6%	2.6%	4.3%	1.1%	3.0%	0.5%	1.2%	0.7%	4.0%	0.6%
Whiting	0.9%	0.4%	5.7%	1.5%	1.3%	0.5%	0.2%	0.1%	3.0%	0.7%
Haddock	1.3%	0.5%	4.4%	0.8%	2.5%	0.4%	0.5%	0.2%	2.9%	0.4%
Herring	0.1%	0.1%	2.1%	1.0%	1.3%	0.5%	0.0%	0.0%	1.3%	0.5%
Plaice	1.2%	0.7%	1.7%	0.6%	1.3%	0.6%	0.0%	0.0%	1.3%	0.3%
Skate-Common	1.0%	0.5%	2.1%	0.6%	0.7%	0.5%	0.0%	0.0%	1.2%	0.3%
Horse Mackerel	1.8%	0.9%	1.5%	0.5%	0.6%	0.2%	0.5%	0.3%	1.1%	0.3%
Mackerel	0.0%	0.0%	0.5%	0.3%	1.8%	1.6%	0.0%	0.0%	0.8%	0.5%
Other Fish	3.0%	2.3%	0.6%	0.4%	0.1%	0.1%	0.0%	0.0%	0.7%	0.3%
Dabs	1.3%	0.5%	0.3%	0.1%	0.1%	0.0%	0.0%	0.0%	0.3%	0.1%
Non-Fish	0.6%	0.2%	0.2%	0.1%	0.2%	0.1%	0.0%	0.0%	0.2%	0.1%
Megrim	0.0%	0.0%	0.2%	0.0%	0.4%	0.1%	0.0%	0.0%	0.2%	0.0%
Witch	0.1%	0.1%	0.3%	0.3%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%
Red Fish	0.0%	0.0%	0.2%	0.1%	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%
Lemon Sole	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Blue Whiting	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%
Monk	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Wolffish	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Tusk	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%

4.2.2 Comparison with Tally Book Data

The composition of the fishermen's discard samples was broadly similar to the estimates of discard composition made by fishermen on similar vessels through the SFA's discard tally-book scheme* (Figure 4). Hake dominated the discards in both cases, accounting for almost identical proportions of the discards (32% in the fishermen's discard samples compared to 31% in the tally-books), followed by saithe and cod.

The percentages of cod and saithe in the discards reported through the tally-books tended to be higher than those recorded in the fishermen's discard samples (these two species made up 50% of the discards reported through the tally-books compared to 33% of the discard samples). For other species the percentages reported through the tally-books tended to be somewhat lower than in the fishermen's discard samples.

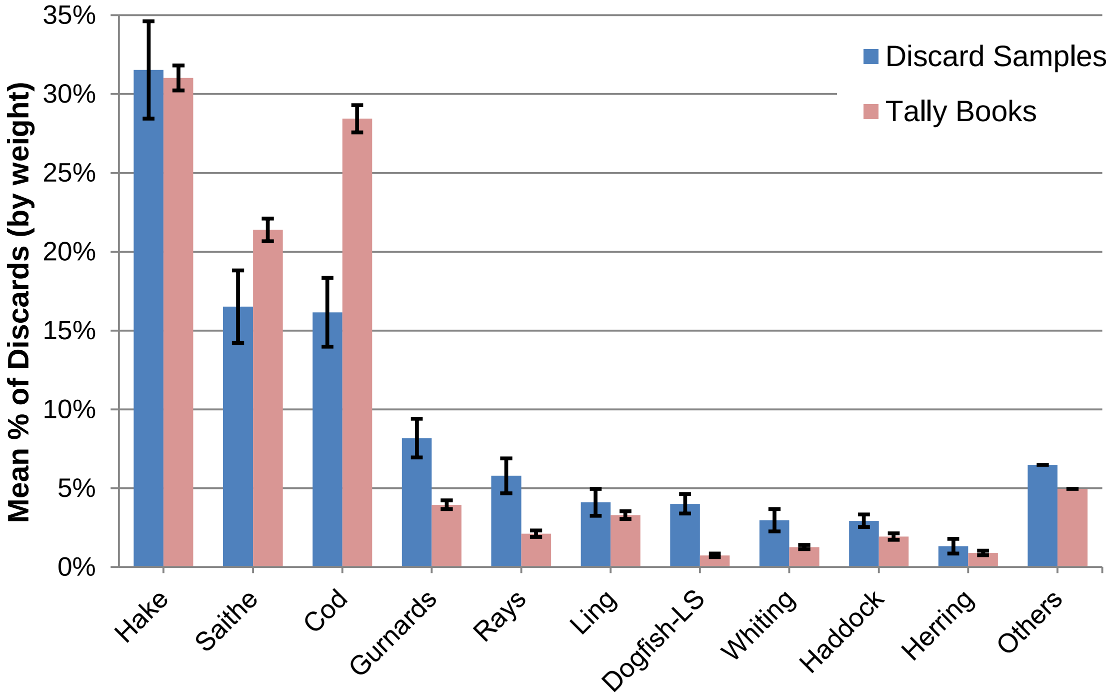


Figure 4. Comparison of composition of the fishermen's discard samples and the composition of the discards reported through the SFA's discard tally-book scheme (all fishing gears): The average percentages (by weight) of the principal species in the fishermen's discard samples and the mean percentage of each species in the discards recorded in the tally-books. Error bars show the standard error of the mean.

* The composition of the participants in the tally book scheme was similar to that of the self-sampling scheme, and included some of the same vessels (the two vessels that accounted for the majority of the discard samples also accounted for the majority of the tally book returns).

Despite these differences there was a close agreement between the composition of the fishermen's discard samples and the composition of the discards reported through the tally-book scheme). The top-six species recorded in the fishermen's discard samples, and nine of the top-10 species, were the same as those reported through the tally-books.

There was a significant relationship between the composition of the fishermen's discard samples and the composition of the discards reported through the tally-books (Spearman Rank Correlation: $\rho = 0.91$, $P < 0.05$)[*]. For the individual fishing gears the relationship was strong for single trawl vessels (Spearman Rank Correlation: $\rho = 0.89$, $P < 0.001$) and twin trawl vessels (Spearman Rank Correlation: $\rho = 0.73$, $P < 0.001$). For seine net vessels the relationship was weaker (Spearman Rank Correlation: $\rho = 0.48$, $P < 0.05$), possibly a result of the smaller amount of data from these vessels. A comparison of data from two individual vessels that participated in both projects showed a strong correlation in one case and a somewhat weaker relationship in the other (Spearman Rank Correlation: $\rho = 0.86$ & 0.60, $P < 0.001$ in both cases).

4.3 Discard Rates

4.3.1 All Species

The sample data sheets completed by the skippers indicated that 42% (by weight) of the fish caught in the sampled catches were discarded (Figure 5). This is very similar to the overall discard rate of 40% reported through the SFA's discards tally book scheme.

For the individual fishing gear types the discard rate for all species varied from 34% (twin-trawl with cameras) to 57% (seine net) (Figure 5). Again these rates were similar to those calculated from the tally book data.

There was no significant difference between the overall discard rates recorded in this study and those recorded through the SFA's discards tally book scheme, either for all gears combined or for individual gear types (Mann-Whitney U Test; all gear U = 44,858, seine net U = 635, single trawl U = 7,699, twin trawl U = 5,454; $P > 0.05$ in all cases).

[*] Where ρ (rho) = 1 would indicate a perfect match and ρ = 0 no agreement.

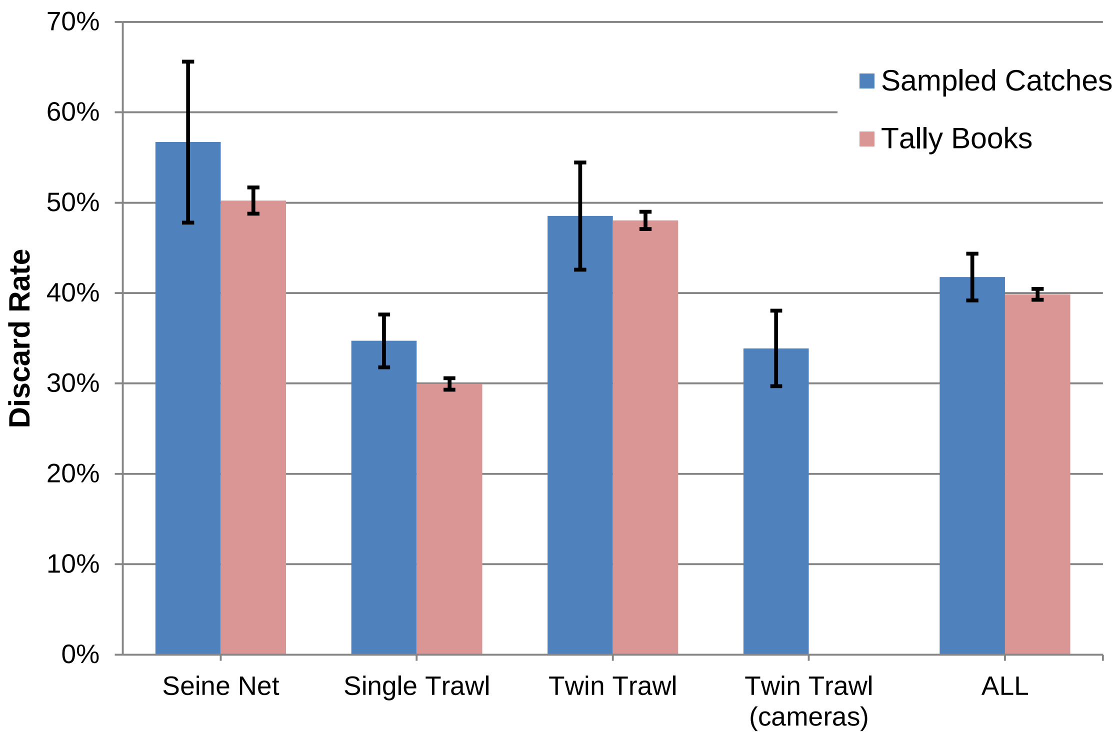


Figure 5. Discard rates by fishing gear type: the average percentage (by weight) of the sampled catches that were discarded. Discard rates derived from the SFA discard tally book scheme are shown for comparison (no tally book data were available for camera-equipped vessels). Error bars show the standard error of the mean.

4.3.2 Individual Species

Hake had the highest discard rate overall, with an estimated 80% of the hake caught being discarded (Figure 6, Table 6). For individual fishing gear types the estimated discard rate for hake was as high as 96% (Figure 7, Table 6).

Other commercial species with high discard rates were rays, saithe, ling and cod (Figure 6, Table 6).

A number of non-target species (that is species not usually landed by whitefish fishing vessels) also had very high discard rates; 100% in many cases (Figure 6, Table 6).

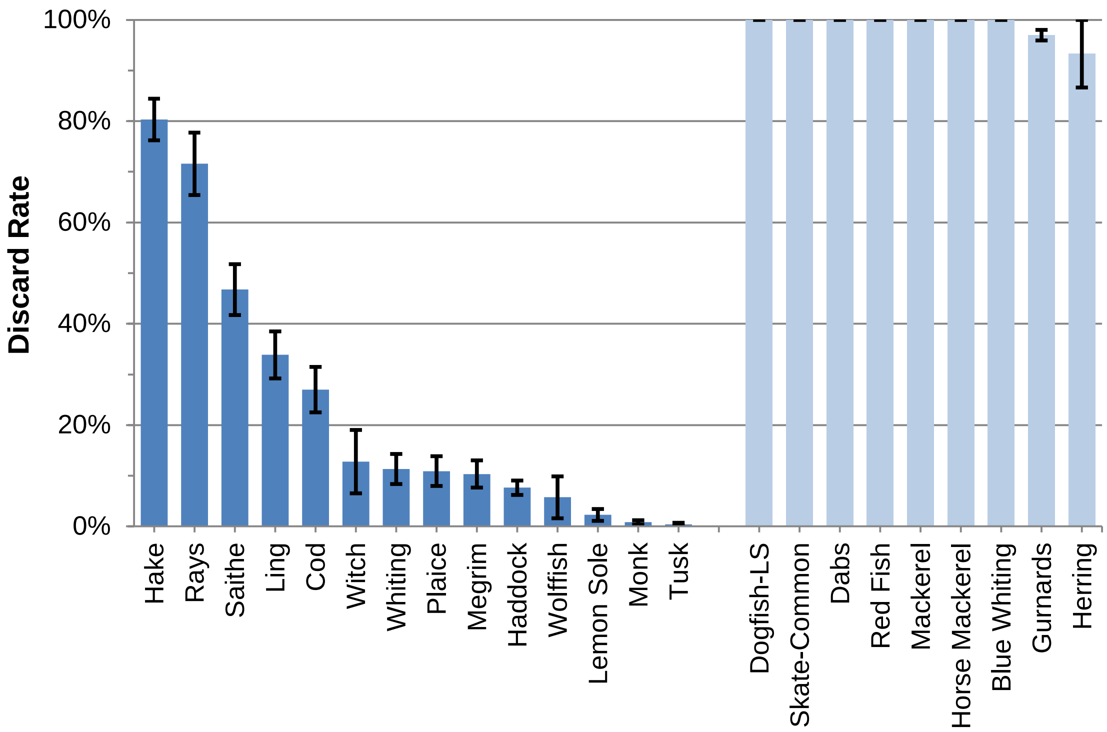


Figure 6. Discard rates: the average estimated discard rate of each species (for all fishing gears). Species are grouped into 'target' species at left (those normally landed by whitefish fishing vessels) and 'non-target' species at right (not normally landed), and ranked by decreasing discard rate within each group. Error bars show the standard error of the mean.

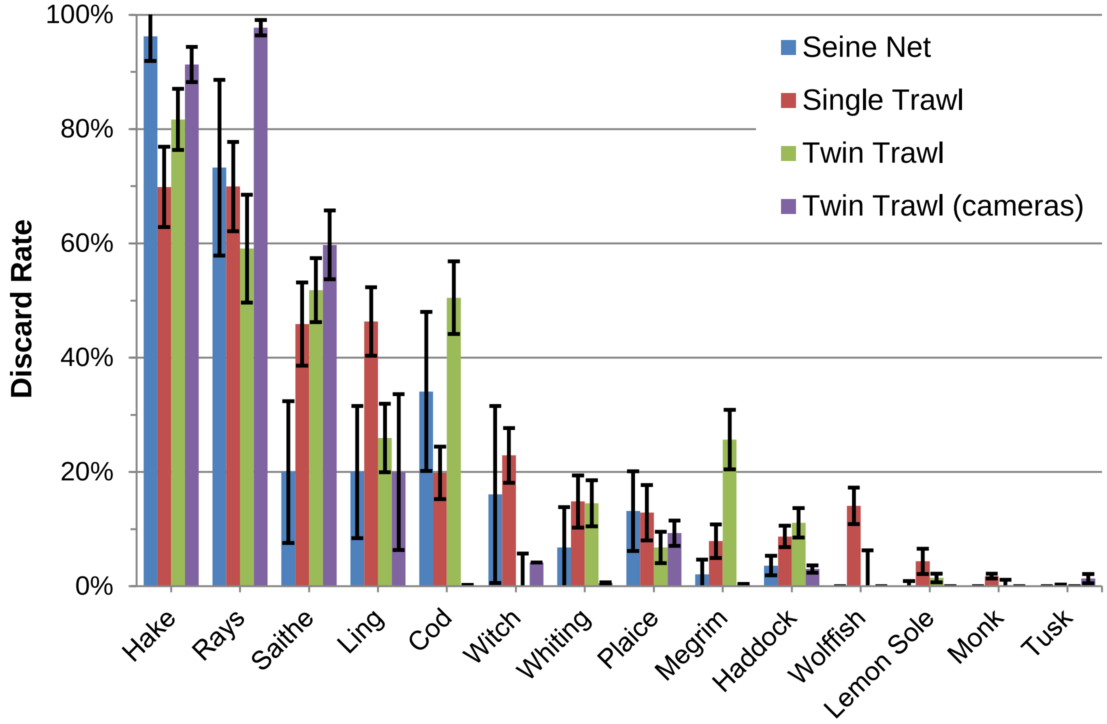


Figure 7. Discard rates by fishing gear type: the average estimated discard rate of each species. Error bars show the standard error of the mean.

Table 6. Discard rates by fishing gear type: The average estimated discard rate of each species by fishing gear type and for all gears combined, and the standard error of the mean (SE) in each case. Species are grouped into 'target' species (those normally landed by whitefish fishing vessels) and 'non-target' species (not normally landed), and ranked by decreasing discard rate within each group.

	Seine Net		Single Trawl		Twin Trawl		Twin Trawl (camera)		ALL Gears	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
TARGET SPECIES										
Hake	96%	4%	70%	7%	82%	5%	91%	3%	80%	4%
Rays	73%	15%	70%	8%	59%	9%	98%	1%	72%	6%
Saithe	20%	12%	46%	7%	52%	6%	60%	6%	47%	5%
Ling	20%	12%	46%	6%	26%	6%	20%	14%	34%	5%
Cod	34%	14%	20%	5%	50%	6%	0%	0%	27%	4%
Witch	16%	15%	23%	5%	0%	6%	4%	0%	13%	6%
Whiting	7%	7%	15%	5%	15%	4%	1%	0%	11%	3%
Plaice	13%	7%	13%	5%	7%	3%	9%	2%	11%	3%
Megrim	2%	3%	8%	3%	26%	5%	0%	0%	10%	3%
Haddock	4%	2%	9%	2%	11%	3%	3%	1%	8%	1%
Wolffish	0%	0%	14%	3%	0%	6%	0%	0%	6%	4%
Lemon Sole	0%	1%	4%	2%	1%	1%	0%	0%	2%	1%
Monk	0%	0%	2%	0%	0%	1%	0%	0%	1%	0%
Tusk	0%	-	0%	0%	0%	0%	1%	1%	0%	0%
NON-TARGET SPECIES										
Dogfish-LS	100%	0%	100%	5%	100%	0%	100%	0%	100%	0%
Skate-Common	100%	0%	100%	6%	100%	0%	0%	-	100%	0%
Dabs	100%	0%	100%	6%	100%	0%	100%	-	100%	0%
Red Fish	0%	-	100%	8%	100%	0%	100%	0%	100%	0%
Mackerel	100%	-	100%	7%	100%	0%	0%	-	100%	0%
Horse Mackerel	100%	-	100%	5%	100%	0%	100%	0%	100%	0%
Blue Whiting	0%	-	100%	9%	100%	-	0%	-	100%	0%
Gurnards	100%	5%	96%	4%	94%	1%	100%	0%	97%	1%
Herring	100%	-	89%	7%	100%	7%	0%	-	93%	7%

4.3.3 Comparison with Tally Book and Observer Data

The discard rates for individual species estimated from the fishermen's discard samples were broadly similar to those recorded through the SFA's discard tally book scheme, and by observers in the Data-Limited Stock project (Figure 8). Hake had the highest discard rates in all three cases.

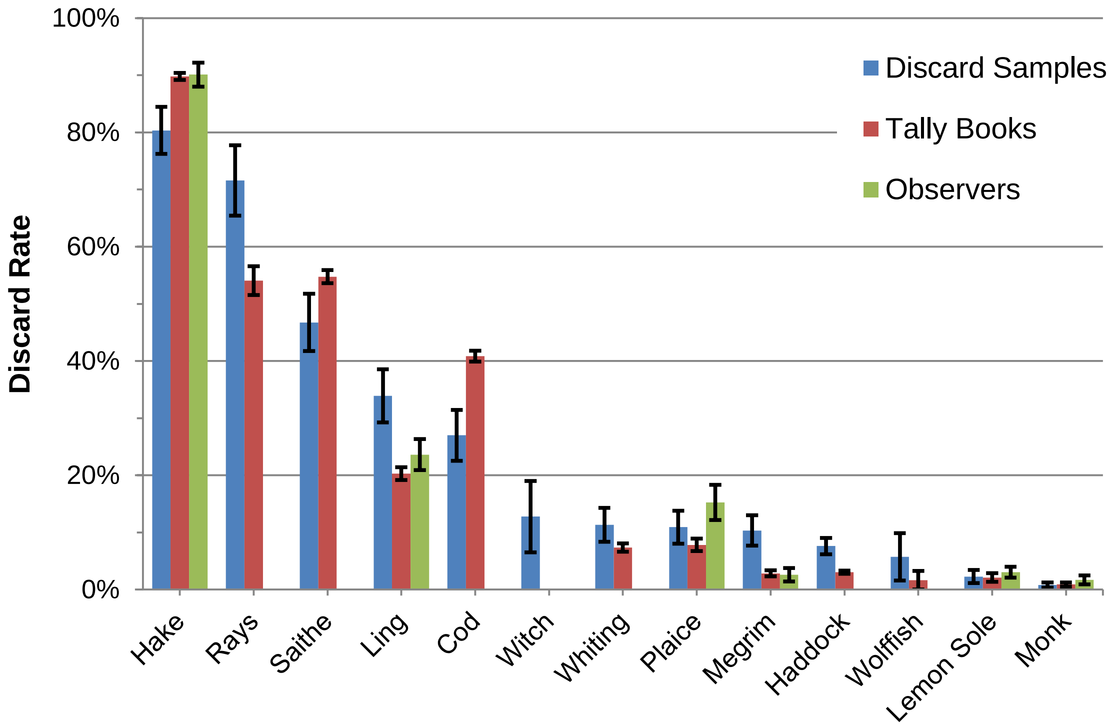


Figure 8. Comparison of discard rates (all gears) estimated from the fishermen's discard samples with those recorded through the SFA's discard tally books and by observers in the Data-Limited Stock project. Error bars show the standard error of the mean. (Note: observer data were only available for hake, ling, plaice, megrim, lemon sole and monks).

There was a significant relationship between the discard rates estimated from the fishermen's discard samples and those recorded through both the discard tally books (Spearman Rank Correlation, $\rho = 0.96$, $P < 0.001$) and via observer data (Spearman Rank Correlation: $\rho = 0.94$, $P < 0.005$) (Table 7) for all fishing gears combined. For the single and twin trawl vessels the relationships were also significant but they were weaker for the seine net vessels.

Although the statistical test showed a strong relationship between the discard rates from the fishermen's discard samples and those measured by the observers they were not significant (Table 7) for the individual fishing gears. This may reflect the relatively small sample size (observer data were available for only six species).

Table 7. Correlations between the discard rates for individual species estimated from the fishermen's discard samples and those recorded through the SFA's discard tally book scheme and by observers in the Data-Limited Stock project: Results of the Spearman Rank Correlation test between the data sets for each fishing gear type and for all gears combined. The value of rho (ρ) indicates the strength of the relationship between the two data sets on a scale from 0 (no correlation) to 1 (a perfect match). The significance levels (P) indicate the level of confidence in the results.

	Samples v. Tally Books	**Samples v. Observers**
	rho (ρ)	**rho (ρ)**
Seine Net	0.634*	0.365
Single Trawl	0.939***	1.000
Twin Trawl	0.952***	0.700
ALL Gears	0.964***	0.943**

Significance Levels: * $P<0.05$, ** $P<0.01$, *** $P<0.001$

4.4 Quantities Discarded

In 2014 Shetland whitefish vessels landed a total of 13,277 tonnes of fish from North Sea stocks (Table 8). Based on the discard rates estimated in this study, and assuming that these are representative of the whole Shetland whitefish fleet, it is estimated that a total of 6,629 tonnes of fish were discarded (implying an overall discard rate of 33%) (Table 8).

Hake is estimated to have accounted for the largest quantity of discards (Figure 9, Table 8), reflecting its relatively high discard rate. Other species estimated to be discarded in relatively large quantities included: saithe, cod, gurnards, lesser-spotted dogfish and rays.

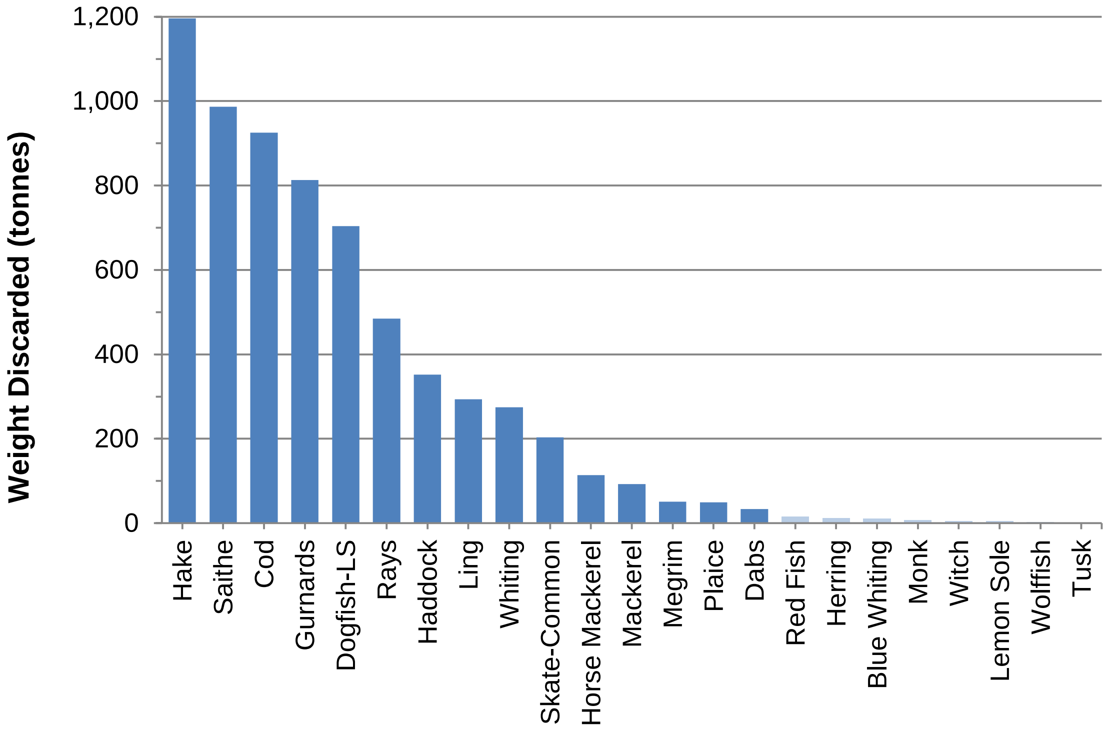


Figure 9. Estimates of total quantities discarded: The estimated total weight of each species discarded by Shetland whitefish vessels in 2014, based on total weights landed and estimated discard rates. (North Sea stocks only).

Table 8. Estimates of total weights discarded in 2014. For Shetland whitefish vessels, the total weight of each species landed, the estimated total weight discarded and the discard rate. (Weights landed are from data provided by the Shetland Fish Producer's Organisation).

Species	Weight Landed (tonnes)	Weight Discarded (tonnes)	Discard Rate (%)
Hake	292.6	1,196.2	80%
Saithe	1,123.5	986.3	47%
Cod	2,501.9	925.1	27%
Gurnards	25.2	813.0	97%
Dogfish-LS	0.0	703.6	100%
Rays	192.5	485.0	72%
Haddock	4,255.2	351.8	8%
Ling	573.3	293.8	34%
Whiting	2,147.4	274.6	11%
Skate-Common	0.0	203.7	100%
Horse Mackerel	0.0	113.6	100%
Mackerel	5.7	92.3	94%
Megrim	438.6	50.6	10%
Plaice	405.2	49.6	11%
Dabs	0.0	33.8	100%
Red Fish	0.2	15.0	99%
Herring	0.8	11.5	93%
Blue Whiting	0.0	10.4	100%
Monk	927.2	7.6	1%
Witch	34.4	5.0	13%
Lemon Sole	185.5	4.3	2%
Wolffish	35.4	2.2	6%
Tusk	18.2	0.1	0%
ALL Species	**13,277**	**6,629**	**33%**

4.5 Size Distributions

A total of 5,957 fish from the fishermen's discard samples were measured. Numbers at length of cod, haddock and hake are shown in Figure 10; of lemon sole, ling and megrim in Figure 11, of monks, plaice and saithe in Figure 12, of whiting and witch in Figure 13; and of rays (all species) and common skate in Figure 14.

The total numbers of each species in the samples and the estimated total weights above and below the minimum landing size (MLS), where there is one, are shown for each fishing gear in Table 9. The proportions of each species above and below the minimum landings size are summarised in Figure 15.

With the exception of lemon sole and ling, the vast majority of the fish discarded were above the minimum landing size, where it existed (Figure 15); that is, they could legally have been landed and marketed. Of the other species, with the exception of haddock, the proportion of the discarded fish above the minimum landing size generally exceeded 95%. For hake and megrim no fish below the minimum landing size were recorded in the fishermen's discard samples. For most species this pattern tended to be similar across the different types of fishing gear (Table 9).

For some species, such as haddock and whiting, the size distribution of the discarded fish tended to be fairly narrow and concentrated around the minimum landing size (Figure 10 and Figure 13). For some others, such as cod, hake and saithe the size distribution was much wider with a high proportion of the fish above the minimum landing size (Figure 10 and Figure 12).

4.5.1 Marketable and Unmarketable Fish

Based on the proportions of each species above and below the minimum landing sizes (where relevant)[*] the total weight of the discards of each of the principal discarded species (Figure 9) were divided into potentially marketable and unmarketable (Figure 16). This indicates that most, if not all, of the discards of species such as hake, saithe, cod, haddock and ling are potentially marketable. That is, they could legally have been landed and marketed (no consideration has been given to what effect additional landings of these species might have on market demand and prices).

The largest quantities of unmarketable discards would have been of gurnards and lesser-spotted dogfish. But as these are not quota species fishermen will not be prohibited from discarding them. The largest quantities of discards of unmarketable

[*] For gurnards it was assumed that the discard rate reflected the proportions of marketable and unmarketable fish in the discards. For lesser spotted dogfish it was assumed that there was no market. For rays it was assumed that there was no market for fish < 50 cm.

quota species (which fishermen will not be allowed to discard) are probably of rays and ling, with an estimated 260 tonnes or so of each discarded by the Shetland whitefish fleet in 2014. The figure for rays could be affected significantly by the marketability of smaller fish.

Overall, excluding non-quota species (gurnards & lesser spotted dogfish) and species that cannot legally be landed (common skate) to which the discard ban will not apply, and based on the assumptions outlined above, it was estimated that the Shetland whitefish fleet could have discarded some 959 tonnes of unmarketable fish in 2014. This would represent about 14% of the total quantity discarded by the fleet in 2014, or 5% of the total quantity caught.

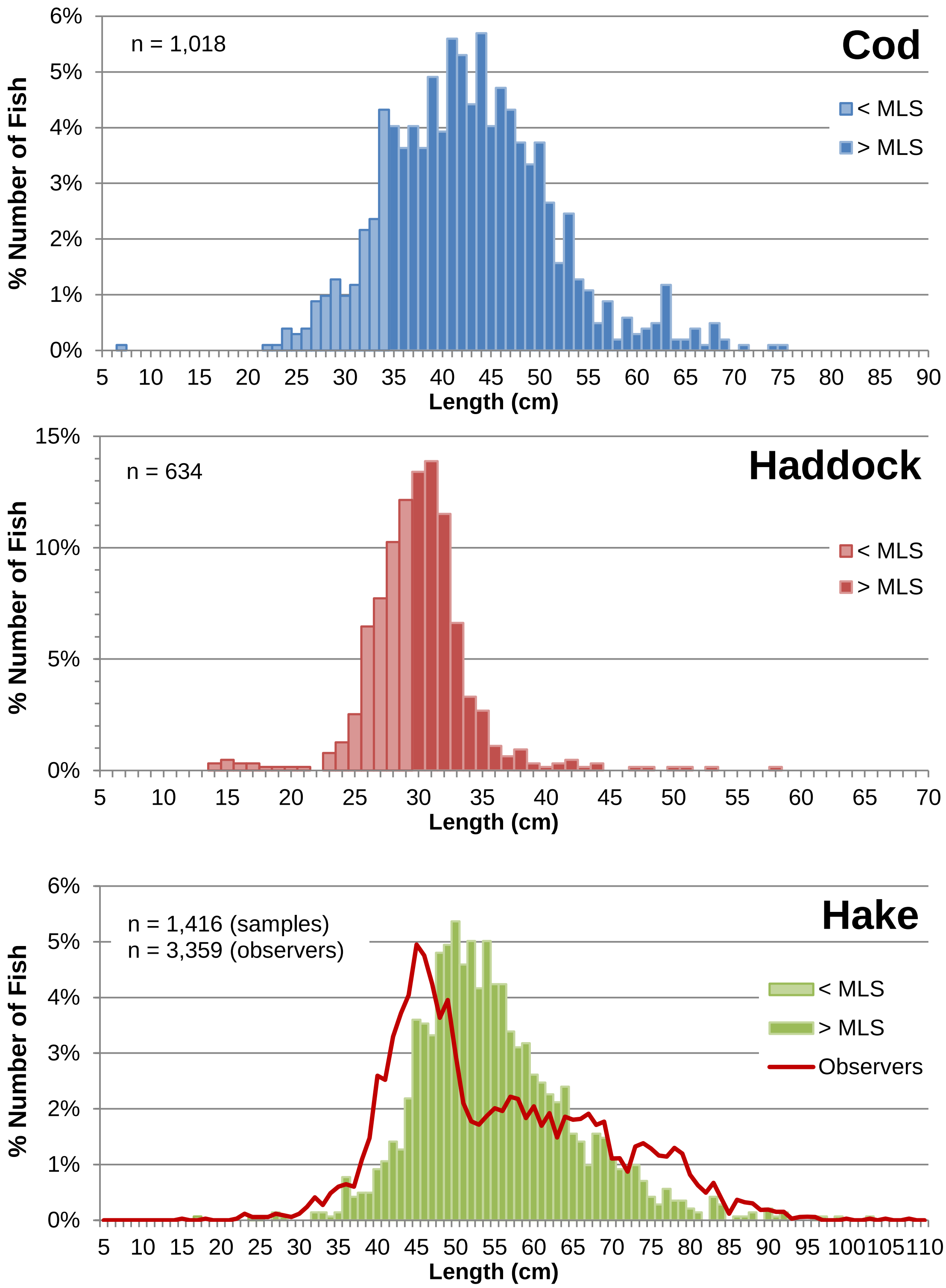


Figure 10. Percentage numbers at length of cod, haddock and hake in the fishermen's discard samples for all fishing gears combined. The percentage numbers at length of discarded hake measured by observers under the data-limited stock project are also shown (all fishing gears, to end of 2014).

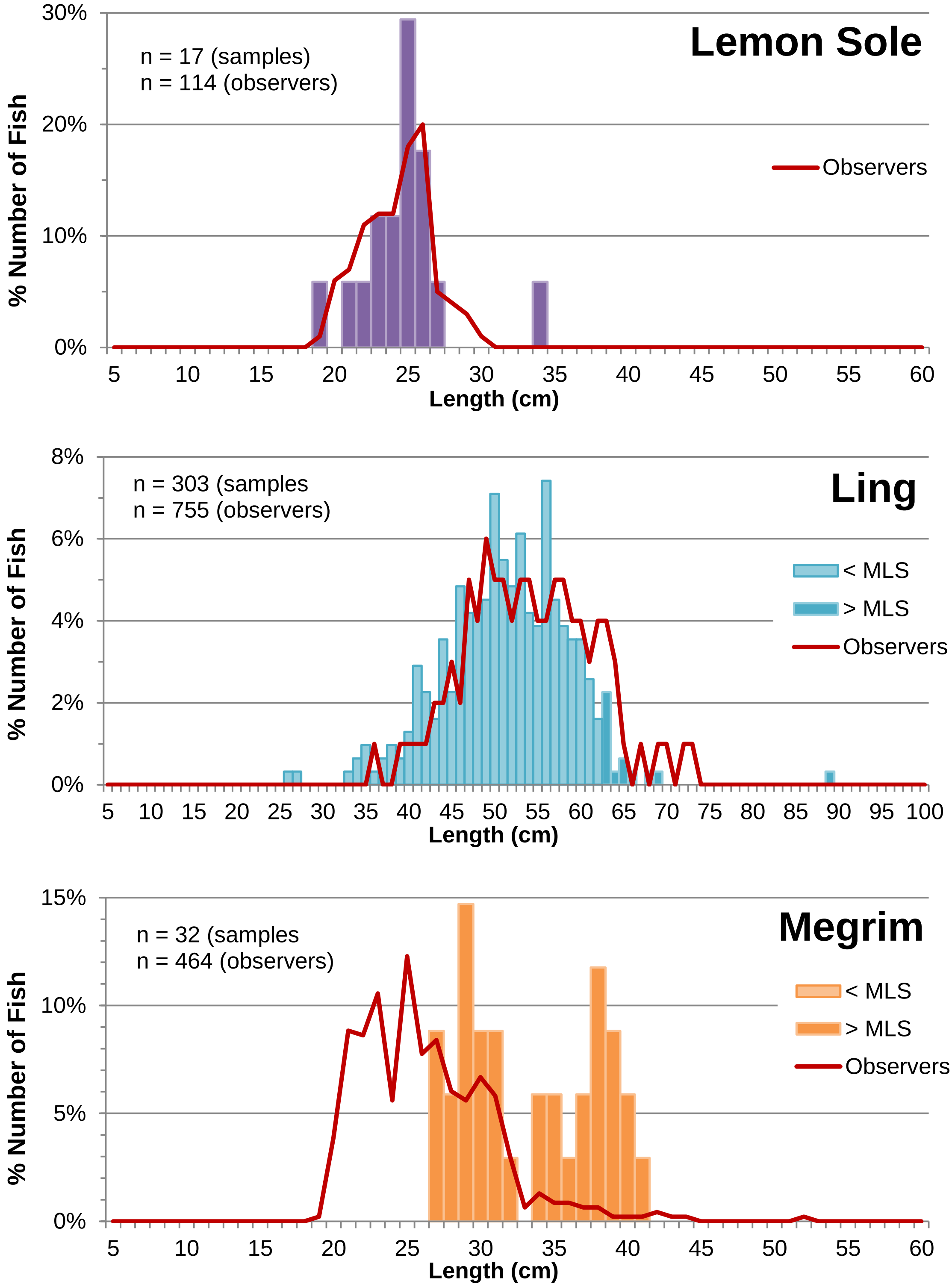


Figure 11. Percentage numbers at length of lemon sole, ling and megrim in the fishermen's discard samples for all fishing gears combined. The percentage numbers at length of discarded fish measured by observers under the data-limited stock project are also shown (all fishing gears, to end of 2014).

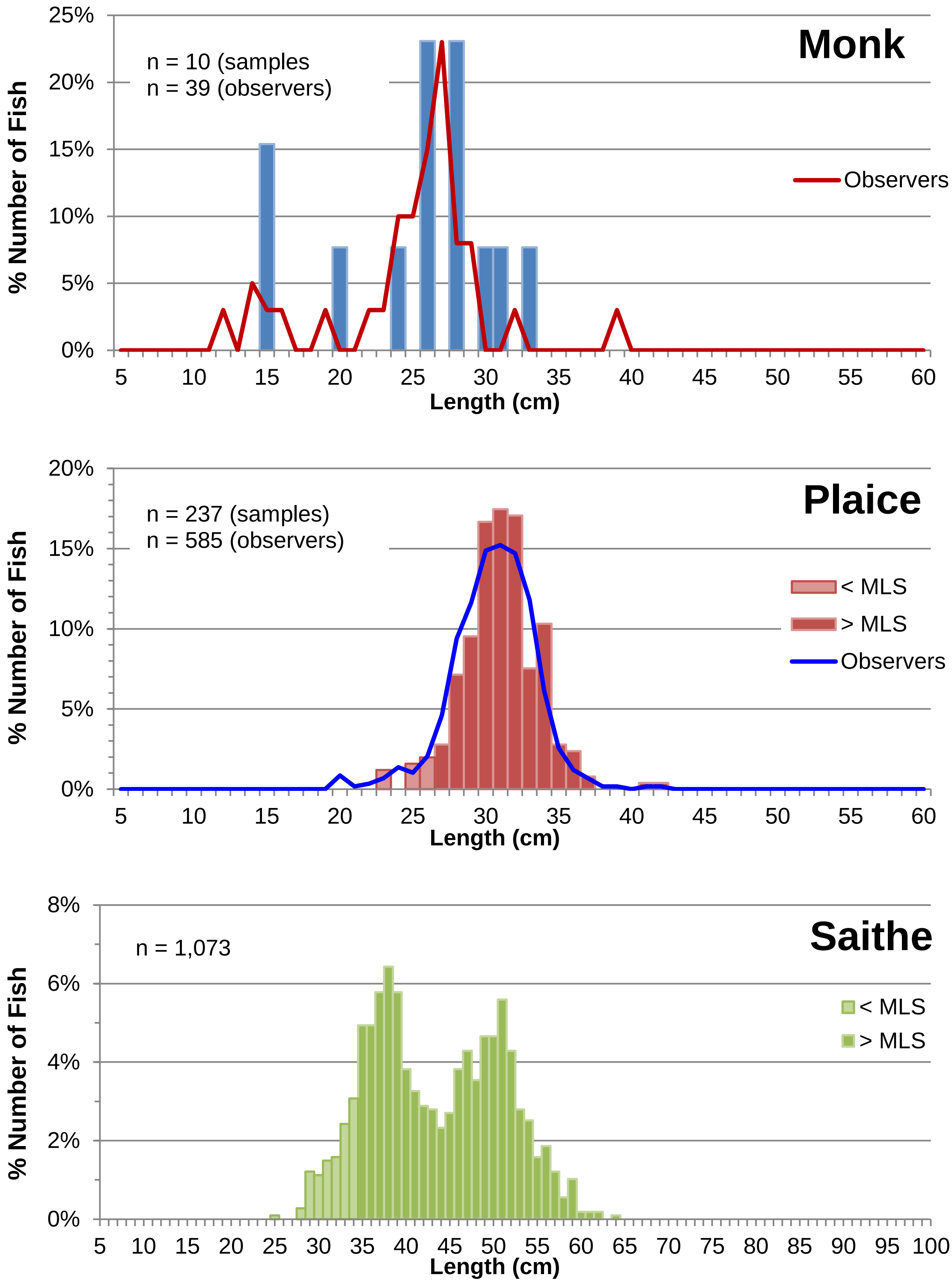


Figure 12. Percentage numbers at length of monks, plaice and saithe in the fishermen’s discard samples for all fishing gears combined. The percentage numbers at length of discarded monk and plaice measured by observers under the data-limited stock project are also shown (all fishing gears, to end of 2014).

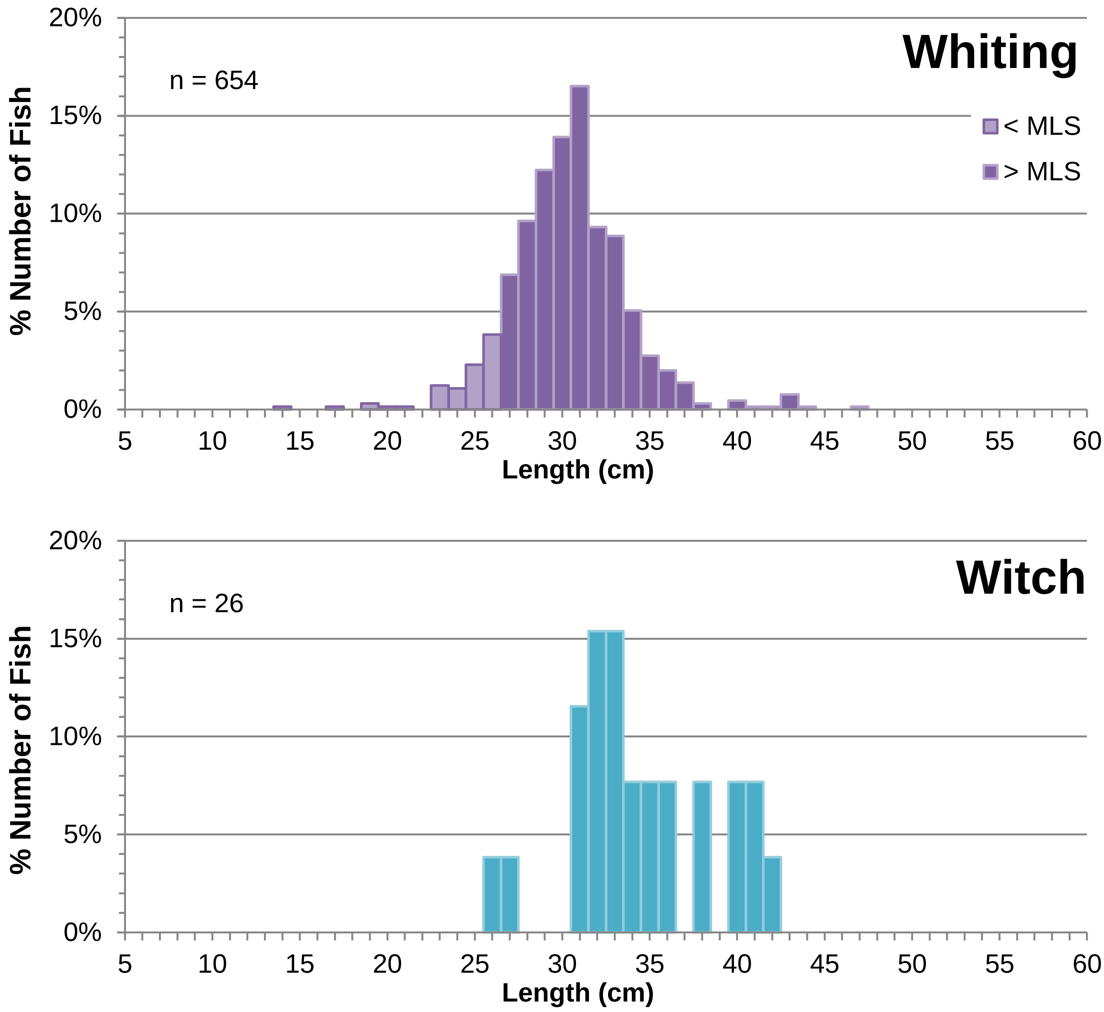
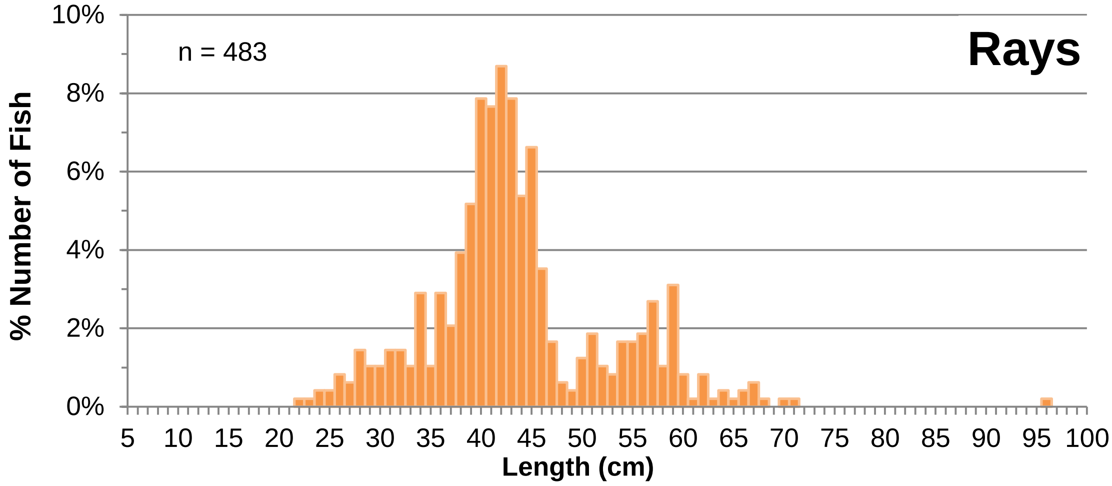


Figure 13. Percentage numbers at length of whiting and witch in the fishermen's discard samples for all fishing gears combined.



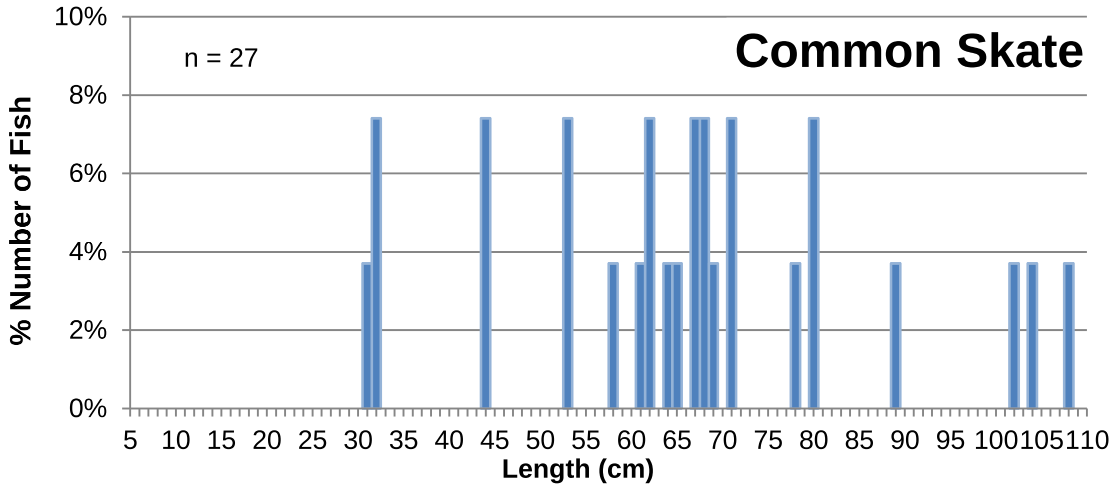


Figure 14. Percentage numbers at length of rays (all species) and common skate in the fishermen's discard samples for all fishing gears combined.

Table 9. The numbers and estimated weights of fish in the fishermen's discard samples above and below the minimum landing size for each type of fishing gear and for all gears combined and the percentages in each case. Minimum landing sizes (MLS) are shown for each species. Where there is no MLS only total numbers caught are shown. Weights are in kg.

	Seine Net		Single Trawl		Twin Trawl		Twin Trawl (cameras)		ALL Gear	
Cod			**MLS = 35 cm**							
No. < MLS	22	12%	107	24%	28	7%	1	100%	158	16%
No. > MLS	166	88%	330	76%	364	93%	0	0%	160	84%
Wt. < MLS	7.3	4%	32.5	11%	8.9	2%	0.2	100%	48.8	6%
Wt. > MLS	155.2	96%	264.0	89%	408.5	98%	0.0	0%	827.7	94%
Haddock			**MLS = 30 cm**							
No. < MLS	15	45%	183	44%	67	40%	9	56%	274	43%
No. > MLS	18	55%	235	56%	100	60%	7	44%	360	57%
Wt. < MLS	2.2	24%	38.0	31%	14.2	30%	1.8	40%	56.2	31%
Wt. > MLS	7.0	76%	84.2	69%	33.3	70%	2.7	60%	127.2	69%
Hake			**MLS = 27 cm**							
No. < MLS	1	0%	1	0%	1	0%	0	0%	3	0%
No. > MLS	278	100%	532	100%	435	100%	168	100%	1,413	100%
Wt. < MLS	0.1	0%	0.0	0%	0.1	0%	0.0	0%	0.2	0%
Wt. > MLS	326.7	100%	663.4	100%	689.4	100%	253.3	100%	1,933	100%
Lemon Sole			**No MLS**							
No.	0	---	14		3		0		17	
Ling			**MLS = 63 cm**							
No. < MLS	5	83%	193	98%	71	96%	27	79%	296	95%
No. > MLS	1	17%	3	2%	3	4%	7	21%	14	5%
Wt. < MLS	4.7	76%	148.2	97%	58.7	93%	26.6	66%	238.2	91%
Wt. > MLS	1.5	24%	5.1	3%	4.5	7%	13.5	34%	24.6	9%

cont./

Table 9 cont.

	Seine Net		Single Trawl		Twin Trawl		Twin Trawl (cameras)		ALL Gears	
Megrim			**MLS = 20 cm**							
No. < MLS	0	0%	0	0%	0	0%	0	0%	0	0%
No. > MLS	2	100%	14	100%	17	100%	1	100%	34	100%
Wt. < MLS	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Wt. > MLS	0.3	100%	3.9	100%	6.2	100%	0.2	100%	10.6	100%
Monk			**No MLS**							
No.	0		12		1		0		13	
Plaice			**MLS = 27 cm**							
No. < MLS	0	0%	11	7%	1	1%	0	0%	12	5%
No. > MLS	25	100%	138	93%	76	99%	1	100%	240	95%
Wt. < MLS	0.0	0%	2.0	4%	0.1	1%	0.0	0%	2.2	3%
Wt. > MLS	9.5	100%	47.7	96%	26.0	99%	0.3	100%	83.5	97%
Saithe			**MLS = 35 cm**							
No. < MLS	0	0%	109	20%	12	4%	0	0%	121	11%
No. > MLS	1	100%	434	80%	255	96%	262	100%	952	89%
Wt. < MLS	0.0	0%	40.5	12%	4.9	2%	0.0	0%	45.4	5%
Wt. > MLS	1.0	100%	300.7	88%	276.8	98%	367.1	100%	945.6	95%
Whiting			**MLS = 70 cm**							
No. < MLS	3	13%	30	6%	28	26%	0	0%	61	9%
No. > MLS	21	88%	490	94%	79	74%	3	100%	593	91%
Wt. < MLS	0.4	6%	3.9	3%	3.7	16%	0.0	0%	8.0	5%
Wt. > MLS	6.8	94%	129.6	97%	19.9	84%	1.7	100%	158.0	95%
Witch			**No MLS**							
No.	2		22		0		2		26	
Rays			**No MLS**							
No.	145		231		44		63		483	
Common Skate			**No MLS**							
No.	3		18		6		0		27	
ALL Species										
No.	708		3,107		1,591		551		5,957	

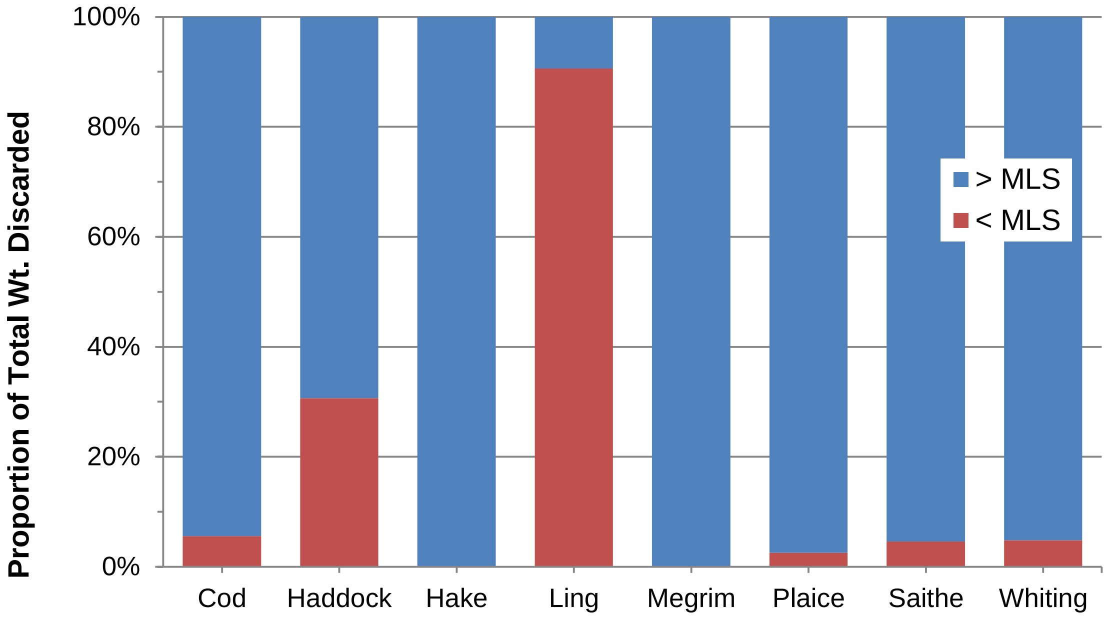


Figure 15. The proportions (by weight) of the fish in the fishermen's discard samples that were above and below the Minimum Landing Size.

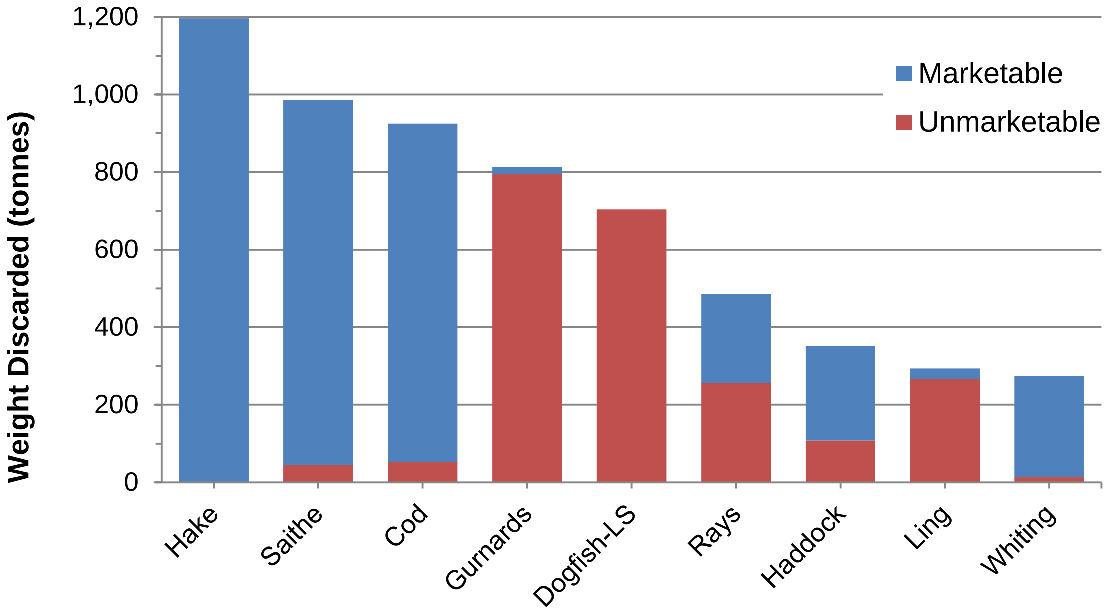


Figure 16. Total quantities discarded of marketable and unmarketable fish: The estimated total weights of the principal species discarded by Shetland whitefish vessels in 2014 that would have been marketable and unmarketable. Based on total weights landed, estimated discard rates, and proportions above and below the minimum landing size (where relevant). (See foot note on page 28 for some assumptions made).

4.5.2 Comparison with Observer Data

The length frequency distributions of discarded hake, lemon sole, ling, megrim, monk and plaice measured by observers under the data-limited stock project to the end of 2014 are shown on Figure 10, Figure 11 and Figure 12.

The results of statistical comparison of the discard sample and observer data, broken down by quarter and by fishing gear, are summarised in Table 10 and Table 11. Overall, the length distributions of the hake, ling and megrim in the fishermen’s discard samples were significantly different from those measured by the observers, while those of the lemon sole, monk and plaice were not. (For lemon sole, megrim and monk the number of measured fish in the fishermen’s discard samples was relatively small. The same was true of the numbers of discarded monks measured by the observers).

Hake was the only species for which the length distributions were consistently significantly different for all quarters and for all fishing gears. This difference is apparent from Figure 10, with the hake in the samples tending to be larger than those measured by the observers (the difference between the peaks of the two size distributions is about 5 cm).

The length distributions of ling were significantly different overall and for each fishing gear separately, but not by quarter. In this case Figure 11 suggests that the ling in the samples tended to be smaller than those measured by the observers, although the difference is relatively small.

Overall, there was no statistically significant differences between the length distributions from the fishermen’s discard samples and the observer measurements for about two-thirds of the species-quarter combinations (10 of 16 = 63%) and about half of the species gear combinations (6 of 13 = 46%).

Table 10. Results of statistical comparison of length frequencies of fish in the fishermen's discard samples and those measured by observers under the data-limited stock project, by quarter in 2014 (all fishing gears): D values from two-sample Kolmogorov-Smirnov Test. Shaded cells indicate statistically significant differences. (--- indicates no data).

	Quarter			
Species	**2**	**3**	**4**	**ALL**
Hake	0.260***	0.141***	0.348***	0.165***
Lemon Sole	---	0.333	0.268	0.071
Ling	0.684	0.214	0.112	0.141***
Megrim	0.677*	0.184	0.242	0.578***
Monk	---	0.563	0.644*	0.395
Plaice	0.188	0.258**	0.118	0.094

Significance Levels: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 11. Results of statistical comparison of length frequencies of fish in the fishermen's discard samples and those measured by observers under the data-limited stock project, by fishing gear (in 2014): D values from two-sample Kolmogorov-Smirnov Test. Shaded cells indicate statistically significant differences. (--- indicates no data).

	Fishing Gear			
Species	**Seine Net**	**Single Trawl**	**Twin Trawl**	**ALL**
Hake	0.136***	0.194***	0.407***	0.165***
Lemon Sole	---	0.121	0.500	0.071
Ling	---	0.145**	0.413***	0.141***
Megrim	---	0.188	0.680***	0.578***
Monk	---	0.349	---	0.395
Plaice	0.474**	0.067	0.307	0.094

Significance Levels: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

4.6 Implications of the Discards Ban for Fishermen

4.6.1 Costs

It was estimated that the Shetland whitefish fleet could have discarded about 959 tonnes of unmarketable fish in 2014 (see Section 4.5.1). Under a discards ban, fishermen would in general be required to retain these fish on-board and land them.

The principal costs of handling and disposing of such unmarketable fish were assumed to be those associated with storing the fish on-board fishing vessels (boxes and ice), landing it (harbour dues), transporting it from the landing place to a place of disposal, and the disposal of the fish.

4.6.1.1 Options for Disposal

In Shetland there are three potential options for the disposal of fish waste: The Shetland Energy Recovery Plant incinerates waste with the resulting heat used to power a district heating scheme. However, this plant can only handle small quantities of fish waste (no more than about 1 tonne per week), so is probably not an option for the disposal of discards.

The landfill site operated by Shetland Islands Council is licensed to accept fish waste[*]. (The charge for disposal to landfill includes a landfill tax of £80 per tonne).

The fishmeal factory operated by Shetland Fish Products Ltd processes waste material from the salmon and pelagic fish processing industries. While this factory might be able to accept some unmarketable discards this would depend on the quantities and characteristics of the material involved and whether or not the plant was operating.

It was concluded, therefore, that while processing for fish meal might be an option for some discards, disposal to landfill represents the only guaranteed outlet for this material in Shetland at the present time.

4.6.1.2 Costs of Disposal

Based on the costs of disposal to landfill, and other known costs and charges for these elements (summarised in Table 12) it was estimated that the total cost of disposing of 959 tonnes of unmarketable fish could be about £177,000. That is less than 1% of the total gross value of landings by the Shetland whitefish fleet in 2014.

The cost of disposal is the largest single element of these estimated costs, accounting for 81% of the total. Disposal for fish meal production would avoid this disposal cost but, as outlined above, does not represent a certain outlet.

[*] It should be noted that the Waste (Scotland) Regulations 2012 will impose a ban on biodegradable waste going to landfill from 2021.

Table 12. Summary of the assumed principal costs of disposing of unmarketable fish under the discards ban.

Item	Calculation	Charge	Total
Boxes	959 tonnes @ 40 kg / box = 23,979 boxes	£0.43 / box	£10,311
Ice	23,979 boxes @ 5 kg / box = 120 tonnes	£52.00 / tonne	£6,234
Landing Dues	959 tonnes	£2.35 / tonne	£2,254
Skip Hire	959 tonnes @ 6 tonnes per skip = 160 skips	£25.00 / skip	£3,996
Transport	160 skips @ 1.5 hours per skip	£45.00 / hour	£10,790
Disposal (Landfill)	959 tonnes	£149.30 / tonne	£143,000
Total			**£176,787**

4.6.2 Quota Uptake

Cod, hake and saithe were selected to illustrate the potential impacts of the discards ban on quota uptake by the Shetland whitefish fleet as these were the most abundant species in the fishermen's discard samples. Hake had the highest discard rate of the commercial species landed by the fleet; cod and saithe also had high discard rates and are some of the most important commercial species landed. It might be expected, therefore, that the effects of the discards ban on quota uptake would be larger for these species than for others.

The cumulative total landings of each of these species by the fleet in 2014 and the cumulative total estimated catch of each (landings + discards) based on the discard rates calculated above are shown in Figure 17. Based on the total estimated catches it is estimated that the available quota (including in-year swaps, trades and transfers) for cod would have run out on 15th October, that for saithe on 8th August, and that for hake on 10th July.

These dates are shown in relation to the total cumulative landings of all species by the fleet in Figure 18. If it was assumed that all fishing had had to stop when a quota ran out (as it would under a discard ban) then significant quantities of the total potential catch would have remained uncaught. For example, if fishing stopped on 15th October – the date the cod quota would be estimated to run out – about 21% (by weight) of the fleet's total catch of remaining species would have remained uncaught. If fishing stopped on 8th August – the date the saithe quota was estimated to run out – then about 46% of the total catch would have remained uncaught, while on 10th July – the date the hake quota was estimated to run out – 53% of the total would have remained uncaught. The value of the uncaught catches ranges from about £5.0 million on 15th October, to £12.4 million on 10th July.

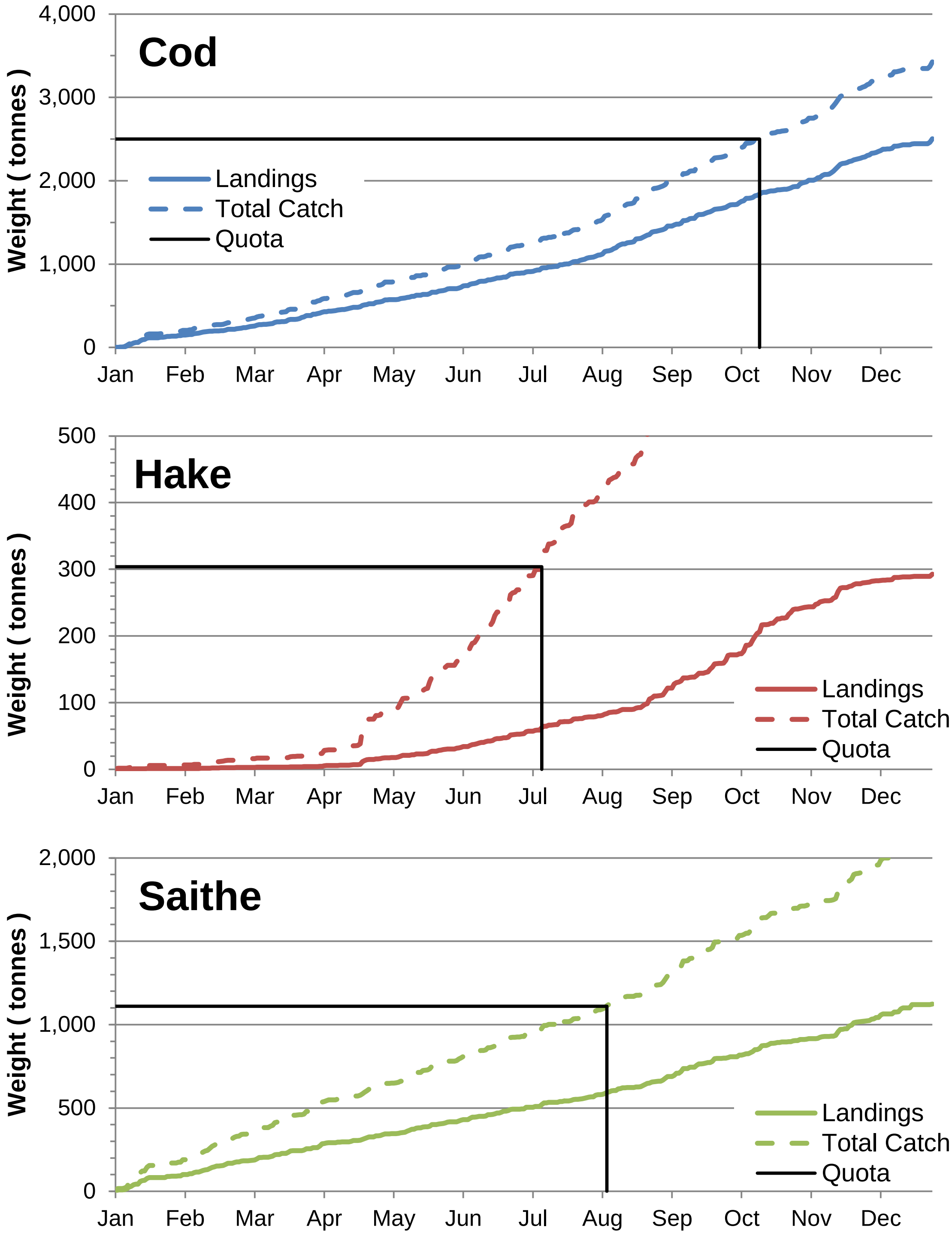


Figure 17. The cumulative landings and estimated cumulative total catch (landings + discards) of cod, hake and saithe by the Shetland whitefish fleet in 2014. For each species the total available quota (including in-year swaps and trades) is shown along with the estimated date that this quota would have run out under a discards ban. (Landings and quota data provided by the SFPO).

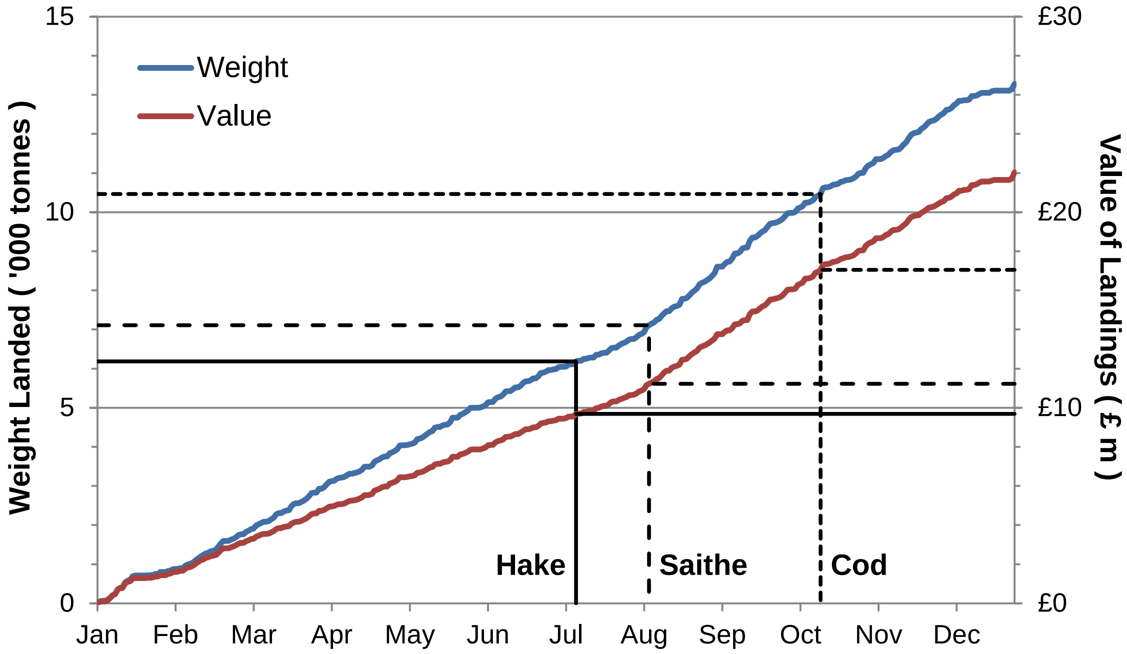


Figure 18. The total cumulative weight and value of landings (all species) by the Shetland whitefish fleet in 2014, in relation to the estimated dates that cod, hake and saithe would have run out under a discards ban. The horizontal lines indicate the total weight and value of landings made by the critical dates. (Landings data provided by the SFPO).

5 Discussion

The primary aims of this project were to collect quantitative information on the amount and nature of the fish currently being discarded in the mixed whitefish fishery around Shetland, and to implement and evaluate a discard self-sampling programme in this fishery as a means of increasing the quantity of discards data from Scottish whitefish fisheries. Although direct verification was not possible, the results of the analysis of the fishermen's discard samples were compared to other available observer data to evaluate their reliability.

The following discussion first considers the information that was collected through the self-sampling programme on nature and scale of discarding, then considers self-sampling as a means of collecting such data, and finally considers some of the potential implications of the discard ban for fishermen.

5.1 The Nature and Scale of Discarding

5.1.1 Composition of Discards

With a few exceptions, the composition of the fishermen's discard samples was broadly similar between the different fishing gears. One of the most obvious differences was that while saithe was one of the dominant species in the discards from the trawl net vessels (single and twin) it was almost entirely absent from the discards of the seine net fishing vessels. This probably reflects the fact that seine net vessels tend to catch less saithe because it is generally less common on seine net fishing grounds. Anecdotal information from fishermen indicates that saithe tend to be associated more with areas of harder (rougher) sea-bed where seine net vessels cannot operate. In 2014 saithe accounted for only 3% of the total landings of the seine net vessels involved in this trial, compared to 12% for the trawlers.

The variability in discard composition between the fishermen's discard samples was relatively small, both overall and for individual fishing gear types. This suggests that the composition of discards does not vary widely over time or between fishing vessels. It also gives some confidence in the reliability of the self-sampling of discards by fishermen (in that inconsistencies in the sampling might result in large variability between the samples).

The composition of the fishermen's discard samples broadly agreed with the composition of the discards reported through the SFA's discard tally book scheme (which included several of the same vessels). The same species dominated the discards in both cases and their relative proportions matched closely overall (despite some differences in detail).

5.1.2 Discard Rates

The overall discard rate of 42% by the vessels sampled in this study was very close to the figure of 40% reported through the SFA's discards tally book scheme. The discard rates varied for the different fishing gears, being highest for the seine net vessels and lowest for the single-trawl and camera-equipped twin trawl vessels, but again matched closely with the rates derived from the tally books. The variability in the discard rates calculated for the individual samples was relatively small.

Hake had the highest estimated individual discard rate, with some 80% of the catch being discarded overall. Rays, saithe, ling and cod also had relatively high estimated discard rates (above 20%). Other commercially important species had lower discard rates. (Note: these estimated discard rates for individual species are based on a number of assumptions, in particular that the sampled catches are representative of the catches of the Shetland whitefish fleet, and so should be treated with caution).

A number of non-target species also had very high estimated discard rates (100% in many cases). These included species of little or no commercial value (such as dogfish or gurnards), species that cannot be landed (such as common skate), but also included several pelagic species (including herring and mackerel). Although the quantities of the pelagic species being discarded were not large (perhaps a few hundred tonnes per year) they will be covered by the discards ban. However, whitefish fishing vessels generally lack the quota needed to land these species.

There was some variability in the estimated discard rates of individual species between the different fishing gear types, although there was broad agreement in the overall pattern.

The discard rates estimated for individual species from the fishermen's discard samples matched well with the those determined from the SFA's discard tally books, and with those measured by observers (from the Data Limited Stock project). There was also good agreement between the discard samples and the discard tally books for the individual fishing gear types (the agreement with the observer data for individual gears was not statistically significant). Again, this agreement gives some confidence in the reliability of the self-sampling of discards by fishermen, and of the tally book scheme (in that inconsistencies in either scheme would be expected to result in differences between the results).

The general pattern of the discard rates estimated from the fishermen's discard samples for cod, haddock, hake, monk, saithe and whiting was also similar to published discard rates (Needle *et al*., 2014; Figure 19), especially those collected through two other Scottish observer programmes. Differences between these data (higher discard sample rates for hake and lower rates for haddock and whiting) might be due to differences in the geographical areas covered by the different programmes. While the discard samples in this study were collected from vessels working in the northern North Sea, the Scottish observer programmes covered vessels fishing throughout the North Sea. The match between the discard sample rates and the published CCQS (camera) rates was less good, but no worse than difference between the CCQS and published observer programme rates.

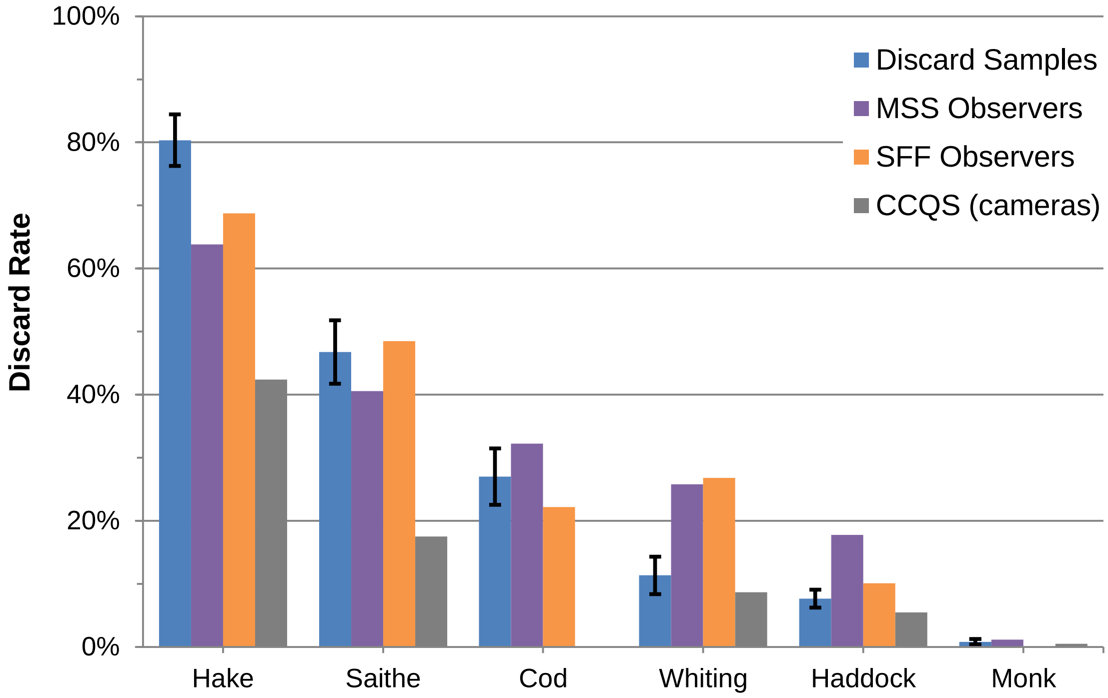


Figure 19. Comparison of discard rates estimated from the fishermen's discard samples (all gears) with published rates (from Needle *et al*., 2014). MSS Observers = Marine Scotland Science observer programme; SFF Observers = Scottish Fishermen's Federation observer programme; CCQS (cameras) = analysis of CCTV footage from vessels equipped with cameras under the Cod Catch Quota Scheme (which are prohibited from discarding cod; see footnote on p. 9). MSS, SFF and CCQS data are overall means for Scottish whitefish vessels fishing in the North Sea during Q4 of 2012 and Q1 – 3 of 2013. Error bars on the Discard Sample estimates show the standard error of the mean (not available for the published data.

5.1.3 Quantities Discarded

The quantity of any particular species discarded is a function of both the discard rate and the quantity caught. Thus, even if a species has a high discard rate the amount actually discarded may not be large if the quantity caught is small. Conversely, a species with a low discard rate may actually be discarded in large quantities if it is caught in large quantities. Overall, the data collected from the fishermen's discard samples suggest that Shetland whitefish fishing vessels may have discarded a total of some 6,600 tonnes of fish in 2014, compared to landings of about 13,300 tonnes. (Given that this estimate is based on a number of assumptions it should be treated with caution).

5.1.4 Size Distributions

The vast majority of the fish in the fishermen's discard samples were above the minimum landing size. For most species more than 95% of the measured fish exceeded the minimum landing size, for some (such as hake) it was 100%. This contrasts with the conclusion by Heath & Cook (2015) that the majority (60-65%) of the fish discarded in mixed demersal fisheries in the North Sea were below the minimum landing size. However, their estimate is based on modelling of historical data collected over the period from 1978 to 2011 for the whole North Sea and so may not be comparable with the results of this study.

Several broad patterns were evident in the size distributions of the discarded fish. For some species, such as haddock and whiting, the size distribution tended to be fairly narrow, with most discarded fish close to the minimum landing size. This suggests that discarding of these species primarily resulted from the grading of fish and the discarding of fish close to the minimum landing size (lack of quota is not generally an issue for species like haddock and whiting).

For some other species, such as cod, hake and saithe, the size distribution of the discarded fish is much wider, with most (in some cases all) of the discarded fish above the minimum landing size. This suggests that these species are primarily being discarded due to a lack of quota (over the course of the year), rather than size limits.

A third pattern was evident for plaice, with the majority of the discarded fish above the minimum landing size although plenty of quota was available. This is believed to reflect discarding of sizes for which there is little market demand.

There was some agreement between the size distributions of the fish in the fishermen's discard samples and those measured by observers under the Data Limited Stock project, with the exception of hake where there was a consistent difference. Even where there were statistically significant differences the magnitude of the differences tended not to be large (< 10 cm for hake; perhaps a few cm for ling).

5.1.5 Discard Data: Conclusions

The results obtained from this analysis of fishermen's discards samples should be treated with some caution: As is discussed below (Section 5.2.1), the majority of the samples were returned by a small number of vessels and the randomised sampling protocol was not followed in all cases.

Nevertheless, the discard self-sampling programme has provided a substantial amount of new information on the nature and scale of discarding by vessels in the Scottish mixed whitefish fishery in the northern North Sea. The results obtained were internally consistent (variability between samples was relatively small) and agreed well with those from other sources (in particular the SFA's discard tally book scheme). They also agreed well with published discard rates from other Scottish observer programmes (Needle *et al*., 2014).

Thus, it is suggested that the data obtained through the self-sampling of discards in this project can be regarded with some confidence, although the absence of observers in this project precluded any direct verification.

The discard self-sampling has confirmed the high levels of discarding of hake, saithe and cod in the northerly component of the Scottish mixed whitefish fishery and has shown that the vast majority of the discards of these species are of marketable size. These species arguably represent the biggest discard 'problem' for the Shetland whitefish fleet, due to the relatively large quantities being discarded and the difficulty of reducing their catches. (Hake, saithe and cod are all relatively large fish so reducing their catches without losing smaller, valuable species with lower discard rates, such as haddock and whiting is a particular challenge).

A related point that can be taken from these results is that very few of the fish being discarded are 'undersized' (that is, below the minimum landing size). Overall, only 8% (by weight) of the discarded fish were below the minimum landing size (and if ling are excluded the figure is less than 4%). The vast majority of the commercial species in the fishermen's discard samples could have been landed and sold if the vessels had had sufficient quota to allow this (and if there was sufficient market demand).

The discard sampling has also highlighted relatively high discard rates for some other species, both commercial and non-commercial. These included rays, gurnards and lesser-spotted dogfish, where discarding was probably mainly a result of lack of market demand. The discarded rays tended to be relatively small and there is little market demand for small rays. Similarly, although gurnards are sometimes landed in small quantities anecdotal information suggests that there is not a strong market demand for them, again especially for small sizes (although the gurnards were not measured in this study most of those in the fishermen's discard samples were relatively small).

A final point worth noting from the fishermen's discard samples is that pelagic species such as herring, mackerel, horse mackerel and blue whiting are regularly being caught and discarded by whitefish vessels. The quantities involved are not large, amounting to perhaps 200 to 300 tonnes for the entire Shetland whitefish fleet in 2014, but they pose a further problem for whitefish vessels which typically do not have quota for pelagic species.

5.2 Evaluation of Self-Sampling

The result of this study have shown that self-sampling – where fishermen themselves collect samples of their catches for analysis ashore – offers a potential alternative to the use of on-board observers for the collection of fisheries data from commercial fishing vessels.

Although the use of observers would tend to be a preferred option, as in this case they are not always available. In their absence, self-sampling provided a potential means of collecting some data on the nature and scale of discarding by whitefish vessels in the waters around Shetland.

Both the use of observers and self-sampling have other potential advantages and disadvantages, some of which are summarised in Table 13. Amongst other things, it might be said that while observers allow for the controlled, intensive sampling of a small number of vessels, self-sampling potentially allows for the less intensive (but less controlled) sampling of a larger number of vessels.

A key question is whether the data collected through self-sampling is reliable and dependable; whether the advantages outweigh disadvantages.

Although the absence of observers in this trial precluded direct verification of the data collected through self-sampling, analyses indicated that these data agreed closely with equivalent data from other sources (tally books and observers engaged in a separate project). This suggests that self-sampling of catches by fishermen can be a credible means of collecting fisheries data and can provide useful information.

As discussed above, self-sampling should probably not be viewed as a substitute for scientific observers, but rather as a potential alternative when observers are not available (or not available in sufficient numbers). An optimum sampling strategy might be a combination of the two techniques; with self-sampling allowing simultaneous coverage of a number of vessels and observers providing verification and additional data.

Table 13. A summary of some of the potential advantages and disadvantages of using observers on-board commercial fishing vessels, as opposed to self-sampling by fishermen as a means of collecting discard information.

Observers	**Fishermen's Self-Sampling**
High level of control over sampling protocol.	Low level of control over sampling protocol.
Requires sea-going staff (capable of working at-sea on board commercial fishing vessels).	Does not require sea-going staff.
Observer can only sample one vessel at a time.	Same staff can process samples from multiple vessels.
Limit on the amount of time that an observer can spend at sea / number of vessels that can be covered.	Limited only by the number of vessels willing to undertake sampling, and the availability of onshore staff.
Observers are occupied full-time.	Staff not required full-time.
Observer can sample all (or most) tows made during a trip.	Samples can probably only be collected from a few of the tows made during a trip.
Observer can analyse all (or a high proportion) of a catch.	Only a sample of the catch is available.
Observers' priority is to collect samples / data.	Fishermen have other priorities that may interfere with sample collection.

5.2.1 Practical Aspects of Self-Sampling

Self-sampling ultimately depends on the cooperation and assistance of the fishermen who are asked to undertake the sampling. The experience of this study showed that fishermen's responses could be 'patchy'. Some skippers and crews returned samples on a regular basis over an extended period of time, but others seemed to 'lose interest' after returning some samples. The reasons for the failure of some crews to return samples on a regular basis were unclear; no crew ever directly refused to provide samples or expressed any unwillingness to do so. Reasons given failing to return samples were generally either that they had 'forgotten' or been 'too busy'.

It needs to be borne in mind that for commercial fishermen sample collection will not be their primary priority during fishing trips. Nevertheless, if self-sampling is to be successful it will be necessary to find ways of maintaining fishermen's commitment to the sampling programme. One possible option might be more proactive engagement with the fishermen on a regular basis; for example, contacting them directly and asking them to collect a sample from their next tow. Another option might be to offer some form of recompense (such as a small payment, to fishermen for each sample landed).

It was notable that the majority of the samples returned did not come from the catch indicated by the random numbers on the sample record sheets. This could indicate a bias by fishermen in the selection of the catches sampled, but the general agreement between the results derived from the analysis of the discard samples and those derived from other sources (including observers and tally-books) provides no evidence that this was the case. (Although most samples did not come from the randomly indicated catch that does not necessarily mean that the sampling was 'non-random', in the sense that the fishermen were deliberately selecting which catches to sample, or not sample). Other than bias, possible reasons for the fishermen's failure to sample the randomly indicated catch could include practical reasons or a lack of awareness of the importance of the random numbers.

The sampling protocol, and how best to ensure that samples are collected randomly (so far as is reasonably practical), would need to be addressed in any future self-sampling programme.

The experience of this study has also highlighted some practical issues with the shore-based reception and analysis of samples that need to be considered: Firstly, it is desirable to have some means of monitoring or checking landings for samples. Whilst the fishermen in this study did usually provide notice when they intended to land their samples, or after they had done so, they did always do so. The other main point that needs to be considered is that staff need to be available, often at short notice, to deal with the samples when they area landed. Furthermore, these staff need to have access to necessary equipment such as vehicles. Finally an appropriate means is required for disposing of the material from the discard samples.

5.3 Implications of the Discards Ban for Fishermen

5.3.1 Costs

A common concern for fishermen is that under the discard ban they will be required to handle, box, store and land (and perhaps dispose of) substantial quantities of unmarketable fish. As well as the extra labour involved this could impose additional costs on fishermen in the form of charges for additional boxes, ice, etc.

The results of this analysis, however, suggest that the vast majority of the fish being discarded, of the species that will be covered by the discards ban, are potentially marketable. That is, they are of a size that could legally be landed and sold. So while fishermen might have to handle, box, ice and land more fish under the discard ban, they could expect a commercial return for that fish (all else being equal). This assumes, firstly, that fishermen are allowed to land the extra fish (see below), and that the markets can absorb the extra fish without there being a substantial adverse effect on prices.

Overall, it was estimated that the quantity of unmarketable fish discarded by the Shetland whitefish fleet in 2014 amounted to approximately 5% of the total quantity caught. The total cost of landing and disposing of these fish was estimated to be about £177,000, or less than 1% of the gross value of the fleet’s landings.

That cost is based on the disposal of the unmarketable fish to landfill. It should be noted that although this disposal option is available in Shetland it probably will not be an option elsewhere. Most landfill sites in the UK are not licensed to accept fish waste (the site in Shetland is so licensed). Furthermore, from 2021 the disposal of biodegradable waste (including fish) in landfill will be prohibited under the Waste (Scotland) Regulations 2012.

Processing for fish meal represents a possible alternative disposal route for unmarketable discards but this is likely to depend on the quantities and characteristics of the material involved and so probably cannot be depended on.

Substantial questions remain to be answered about how unmarketable fish landed under the discards ban are to be disposed of and where the responsibility for this will lie. Consideration may also need to be given to the disposal of marketable fish that cannot be sold (due to lack of market demand).

5.3.2 Quota Uptake

If fishermen are compelled to stop fishing when any one of their quotas has run out this would prevent them from catching their full quotas of other species in the mixed whitefish fishery and could result in substantial loss of income.

While this analysis suggests that the cod quota would not run out until about October, that would still leave almost one quarter of the Shetland whitefish fleet's total quotas of all species uncaught. Hake and saithe quotas would likely run out much earlier, (July / August) resulting in the loss of about half of the fleet's potential catch of all species. Losses of income on this scale would have a significant impact on the financial viability of the fishing vessels involved. The disruption to fishing patterns implied would also have substantial impacts on fish markets and other industry infrastructure.

Fishermen (and Producer Organisations) can increase the available quota by buying, swapping, leasing or otherwise transferring it, and the figures presented here for 'total available quota' include in-year transfers. In 2014 the Shetland Fish Producer's Organisation and its member vessels transferred in some 1,000 tonnes of additional quota for cod, hake and saithe; accounting for one quarter of the final total available quota for these species (Table 14). For hake, in-year transfers accounted for almost two-thirds of the available quota. However, the availability of quota for such transfers is limited and in-year transfers were not sufficient to cover all of the fish caught. The industry view is that there is simply not enough quota in the system to meet the needs of all fishermen.

This problem with quota availability, and the difficulties of avoiding catches of species for which quota is limited, were highlighted by a trial carried out by Marine Scotland in 2013 (Marine Scotland, 2013) during which a pair of Scottish whitefish vessels attempted to fish under full discard ban conditions. Despite the vessels receiving additional allocations of quota from Marine Scotland the trial had to be terminated early because the skippers were unable either to obtain sufficient quota for the fish they were catching or to avoid catching species for which quota was limited.

Table 14. The basic allocation of quota for selected species to SFPO member vessels in 2014, total in-year transfers and the final total available quota for the year. The in-year changes are shown as percentages of the final available totals. (Data from the SFPO).

Species	**Basic Allocation (tonnes)**	**In-year Change (tonnes)**	**Total Quota Available (tonnes)**	**Change as % of Final**
Cod	1,794	+705	2,499	+28%
Haddock	4,796	-399	4,397	-9%
Hake	111	+192	304	+63%
Saithe	1,000	+110	1,109	+10%
Whiting	1,885	+243	2,128	+11%
Cod, Hake & Saithe	2,905	+1,007	3,912	+26%

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7 Appendix

Example of the Sample Record Sheets issued to skippers.

Ian: 077 869 711 87 Leslie: 077 866 563 98

Discards Self-Sampling

See over for information

Vessel:	
Skipper:	

PLN:	

Trip Start Date:		**End Date:**	

Haul to be Sampled:	

Hauls:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Haul Information

Haul No.	
Date:	
Tow Duration:	
Haul Time:	

ICES Square:	
Fishing Ground:	

No. of Boxes Kept:		**No. of boxes Discarded:** (including sample)	

Sample Information

	Box 1	**Box 2**	
SFPA Tag No:			

Please write any comments or other information in the space below:

continue on the back if necessary

Further Information

- Please collect a sample consisting of two boxes of discards from the specified haul.
- If you are unable to sample the specified haul please sample the next one.
- Fill three boxes at intervals with whatever is being discarded from the catch.
- Please ensure that the samples include all the fish being discarded as they come off the end of the belt (do not just pick out certain species or sizes of fish).
- Space the samples out so that the discards from all parts of the catch are sampled (for example, fill one box after 1/3 of the catch has been processed and one box after 2/3).
- Put NAFC Sample labels in each box.
- Attach an SFPA tag to each box and record the tag numbers on the front of this sheet.
- Ice the boxes and store them in the hold.
- The sample <u>should not</u> be recorded in your log book.
- If you are using the SFA's Discard Tally Book please record the sampled catch in the tally book as normal, and mark that the catch was sampled.
- Please let us know when you will be landing your catch.
- When you land please place your sample separately from the rest of your catch.

If you have any queries, please contact:

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