International Council for the Exploration of the Sea

CM 1998/O:11 Paper
Deepwater Fish and Fisheries

ESTIMATES OF DISCARDS FROM TWO DEEPWATER FLEETS IN THE ROCKALL TROUGH

T Blasdale and A W Newton

FRS Marine Laboratory, PO Box 101, Victoria Road,
Aberdeen, AB11 9DB, Scotland, UK

SUMMARY

Since the late 1980s a fishery has developed in deep water west of the British Isles targeting a variety of species, many of which were formerly unknown to European markets. At present there are two distinct fleets operating in deep water and landing into Scotland; A fleet of five French vessels of 45 to 50 m total length capable of fishing to depths of over 1,500 m and a second of Scottish trawlers of between 24 and 30 m mainly targeting gadoids and *Lophius* spp. on the continental shelf but occasionally fishing down to about 1,000 m depth. Both fleets divide their fishing effort between the deep water fishery and traditional fisheries on the continental shelf.

Discards from both fleets were sampled at sea between 1996 and 1998 and marked differences were observed between the two fleets in terms of the species composition of their discards. It is thought that this can be accounted for to a large extent by differences in the depth range fished.

INTRODUCTION

Commercial exploitation of deep water fishes in the Rockall Trough began in the late 1980s when French vessels, which had traditionally targeted gadoid species on the continental shelf west of Scotland, began to develop markets for previously unexploited species from deeper water. In the mid 1990s several of the larger Scottish trawlers also began to direct some of their effort to deep water, principally in search of monkfish (*Lophius* spp.) but also landing significant quantities of deep water species.

As part of the EC funded project CT 95-0655 "Developing deep water fisheries: data for their assessment and for understanding their impact on a fragile environment" the Marine Laboratory, Aberdeen has undertaken sampling of the discards of vessels landing deep water species into Scotland.

Discards can be defined as fish that are brought onto the deck of fishing vessels and subsequently returned to the sea. Discards from trawlers can generally be divided into two categories; fish of commercially valuable species which are below the minimum size that is acceptable to the markets or which are damaged, and fish of species with no commercial value. Estimates of the former are vital in the assessment of commercial fish stocks, however with

growing interest in the wider ecosystem effects of fisheries, it is also desirable to obtain, where possible, estimates of the latter, non-commercial discards.

For commercial species, discarding rates are strongly influenced by minimum landing size and market conditions and are usually expressed as a proportion of the total catch, however for non-commercial species, 100% of the catch of each species is discarded and hence discard must be expressed as weight or numbers of fish discarded. Thus for non-commercial species discard rate is equivalent to total catch rate while for commercial species it is influenced by catch rate, size distribution and selection by the crew.

In view of the limited sampling opportunities, the only *a priori* stratification applied to sampled trips was the division into French vessels landing in Scotland and Scottish vessels. In the absence of any hard statistical evidence that discarding rates differ significantly between the two fleets there are good intuitive reasons to make this distinction, namely that the two fleets are targeting different species using different gear and different sizes of vessels.

MATERIALS AND METHODS

Deep water fisheries are defined, for the purpose of the study as fisheries conducted at depths greater than 400 metres. During the period covered by this study, all French landings of deep water species into Scotland could be attributed to a fleet of five French trawlers of 45 to 50 metres length, all owned by the same company and landing their catches into Lochinver, a small port on the west coast of Scotland. These vessels divide their fishing effort between deep water species and traditional shelf fisheries, particularly for saithe (*Pollachius virens*), and typically fish both in deep water and on the shelf during the course of a single fishing trip. They are capable of fishing to depths in excess of 1,500 metres.

The Scottish fleet in deep water consists of vessels between about 24 and 30 metres in length which exploit a variety of demersal fisheries around Scotland and are capable of fishing to depths of around 1,000 m. The number of Scottish vessels involved in this fishery is difficult to determine because some vessels spend much of their time in deep water while others make only occasional trips.

The target level of sampling effort was one vessel, selected at random from either of the two fleets to be sampled, in each quarter. In the early part of the project difficulties were encountered in identifying vessels which were both intending to fish in deep water and prepared to carry an observer and as a result two quarters were missed. However, these problems were overcome and subsequently sampling was carried out in every quarter. Table 1 lists sampling coverage to date.

The sampling protocol followed was similar to that used by the Marine Laboratory in its demersal discard sampling programme. For every haul, the total bulk was estimated as the catch was brought on board and total discard estimated by subtracting the weight of retained catch from the estimated total bulk. Two baskets (approximately 60 kg) of mixed discarded material were sampled from every haul. All the fish in this sample were identified and measured and otoliths were taken from a sub-set of the sample. Weight of each species in the sample was calculated by application of appropriate weight/length equations to measured lengths. Numbers and weight of each species in the samples were multiplied by the ratio total discard weight/sample weight to give an estimate of discard of each species from each haul and these were summed over the trip to give total trip discard of each species. A full description of the method used can be found in Jermyn and Hall (1978), Jermyn and Robb (1981) and Jermyn (1989).

RESULTS

A total of 85 species have been recorded in discard samples. A complete species list is given in Table 2 together with indications of their occurrence in the two fleets and two depth strata. Figures 1 and 2 show the species composition of discards on observed trips from the two fleet by weight and numbers. These have been further broken down by extracting discards from hauls at depths greater than 400 metres (Figs 3 and 4). Species which account for less than 1% of the total discard by weight or numbers have been aggregated as "others".

To test whether observed differences in discarding rates were statistically significant, t-tests were performed on discarding rates, expressed as discard per hour fishing over an entire trip, for each of the 15 species which individually accounted for more than 1% of the total observed discard (Table 3). Taking $p = .05$ as the cut off level of probability for significance it was shown that the two fleets differed significantly in discarding rates of 4 of the 15 species including *Alepocephalus bairdii* and *Argentina silus* which are the two most abundant species, together making up 47% of the total discard and *Phycis blennoides* and *Helicolenus dactylopterus* which are the most abundant commercially valuable species in the discards.

DISCUSSION

A complicating factor in the study of this fishery is the wide range of depths fished, with vessels dividing their fishing effort to a greater or lesser extent between continental shelf and deep water fishing grounds. The continental slope in this area is very steep so that as little as five miles may separate the deep water and continental shelf fishing areas. This mean that vessels can move very easily from one fishery to the other and, as fishing positions are reported only to within a specific statistical rectangle (30 by 15 nautical miles), vessels may have fished at a wide range of depths within a single reported area.

Figure 9 shows the depth distribution of fishing effort on observed trips. It can be seen that a clear distinction can be made between the continental shelf fishery between 100 and 400 metres and the deep water fishery below 400 metres. Within the deep water fishery, Scottish vessels concentrated their fishing effort between the 600 and 900 metre isobaths while the French fleet fished over a much wider depth range from 500 to 1,400 metres. These observed differences in fishing depth reflect differences in target species. In the 400 to 900 metre range, both fleets target blue ling (*Molva dypterygia*), monkfish (*Lophius* spp.), black scabbardfish (*Aphanopus carbo*) and squalid sharks (*Centroscymnus coelolepis* and *Centrophorus squamosus*) with limited catches of roundnose grenadier (*Coryphaenoides rupestris*), while in the 900 to 1,400 metre range the main target species for French vessels were roundnose grenadier and *C. coelolepis.*

It can be seen from Figures 1 to 4 that considerable differences in species composition were observed between the discards of the two fleets. Species compositions of discards (by number) of the two fleets from hauls at depths greater than 400 metres were compared using Pearson's product moment correlation on log transformed data (Fig. 8) and were found to have a correlation coefficient of $r = .54$. The most obvious differences between the discards of the two fleets were the relatively high proportions in the discards of the French vessels of *Alepocephalus bairdii, Trachyrhynchus murrayi* and *Coryphaenoides rupestris*, species which are mainly associated with depths of greater than 900 metres. When discards from depths greater than 900 metres are separated out (Figs 5, 6 and 8), it can be seen that species compositions of discards from the two fleets within the 400 to 900 metre depth range were more similar ($r = .74$) while those of French vessels fishing at depths greater than 900 metres were very different.

This seems to confirm that much of the variation between the two fleets can be accounted for by differences in the range of depths fished.

Even within the shared depth range of 400 to 900 metres there are noticeable differences between the discards of the two fleets (Fig. 5). Comparison of discards over a narrower depth range (Figs 7 and 8) shows that within a depth range of 100 metres species compositions were very similar (r = .82). It can therefore be concluded that when fishing at similar depths, the discards of Scottish and French vessels were similar and that the differences in species composition observed between the total discards of the two fleets can be accounted for to a large extent by differences in the depth range fished.

This is further illustrated by Figure 10 which shows that many of the most abundant non-commercial species have narrow depth distributions relative to the total depth range of the fishery. Thus even a relatively small difference in fishing depth could produce a large difference in species composition. The extent to which the depth range fished on observed trips is representative of the two fleets as a whole is uncertain and it must be noted that considerable variation was observed beween trips (Table 1).

It should also be noted that like all fisheries, but perhaps more than most, this fishery is in a continuous state of development. This is particularly apparent for Scottish fishermen who are relative newcomers to the fishery and are in a continual process of adapting vessels, gear and fishing practices. Recent developments within the fishery have seen many Scottish deep water vessels change from traditional single rig trawls to twin rig, and the addition to the fleet this year of two new vessels of over 40 metres length. These could be expected to be more similar to the french vessels in their fishing depth range and hence catch composition.

While further development in the future is likely, the results of this study indicate that the fishery can be divided into three sub-categories based on depth: a shelf fishery from 100 to 400 metres, an upper slope fishery from 400 to 900 metres and a deep slope fishery below 900 metres. Since the fishermen are not required to record fishing depth in their official logbooks depth would not provide a practical basis for stratification. If sampled vessels can be assumed to be typical of their respective national fleets with respect to depth distribution of fishing effort then nationality would appear to be the best practical basis for stratification.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance given by the staff of Jégo Quéré and the skippers and crews of all the vessels sampled, the financial support given by the EC FAIR Project CT 95-0655, and the advice and comments of Mr Stuart Reeves.

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TABLE 1

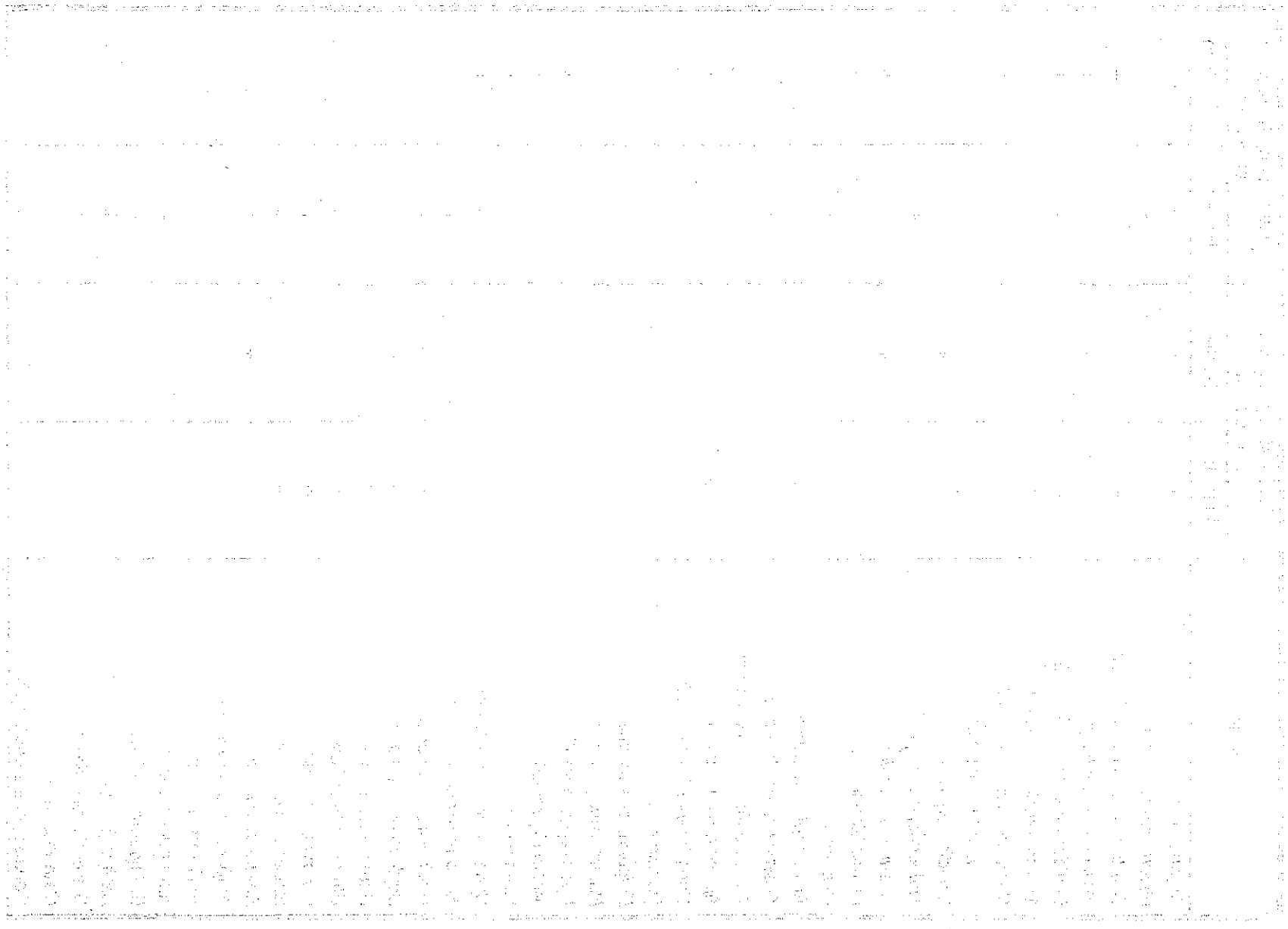
Discard sampling trips 1996 to 1998

Year	Quarter	Vessel nationality	Tows sampled >400 m depth	Tows sampled <400 m depth
1996	2	Scottish	19	0
1997	1	Scottish	9	12
1997	2	Scottish	36	16
1997	3	French	18	7
1997	4	French	17	12
1998	1	French	20	4
1998	2	French	37	0
Total			156	51

TABLE 2

Occurance of species in discard samples from French and Scottish vessels

Species	Hauls at depths less than 500 m		Hauls at depths greater than 500 m	
	French	Scottish	French	Scottish
Argentina silus	+	+	+	+
Galeus melastomus	+	+	+	+
Glyptocephalus cynoglossus	+	+	+	+
Helicolenus dactylopterus	+	+	+	+
Lepidorhombus whiffiagonis	+	+	+	+
Micromesistius potassou	+	+	+	+
Centroscymnus crepidater	+		+	+
Chimaera monstrosa		+	+	+
Lepidion eques		+	+	+
Malacocephalus laevis		+	+	+
Nezumia aequalis		+	+	+
Phycis blennoides		+	+	+
Raja fyllae		+	+	+
Alepocephalus bairdii			+	+
Anarhichas denticulatus			+	+
Antonogadus macrophthalmus			+	+
Apristurus laurussoni			+	+
Coryphaenoides rupestris			+	+
Deania calceus			+	+
Epigonus telescopus			+	+
Halargyreus johnsonii			+	+
Hydrolagus mirablis			+	+
Molva dypterygia			+	+
Mora moro			+	+
Synaphobranchus kaupi			+	+
Xenodermichthys copei			+	+
Merluccius merluccius	+	+	+	
Scyliorhinus canicula	+	+	+	
Squalus acanthias	+	+	+	
Etmopterus spinax	+		+	
Ommastrephidae	+		+	
Sebastes viviparus	+		+	
Anarhichas lupus		+	+	
Alepocephalus rostrata			+	
Antimora rostrata			+	
Aphanopus carbo			+	
Bathypterois dubius			+	
Bathyraja spp			+	
Breviraja caerulaea			+	
Cataetyx laticeps			+	
Centoscymnus coelolepis			+	



Species	Hauls at depths less than 500 m		Hauls at depths greater than 500 m	
	French	Scottish	French	Scottish
Centrolophus niger			+	
Chauliodus sloani			+	
Coelorhynchus coelorhynchus			+	
Coelorhynchus labiatus			+	
Cottunculus thomsonii			+	
Etmopterus princeps			+	
Galeus murinus			+	
Hariotta raleighana			+	
Macrourus berglax			+	
Melanostomiidae			+	
Nematonurus armartus			+	
Notacanthus chemnitzii			+	
Notocanthus bonapartei			+	
Raja bathyphila			+	
Raja kreffti			+	
Unidentified Raja spp.			+	
Serrivomer beani			+	
Trachyrhynchus murrayi			+	
Eutrigla gurnardus	+	+		+
Lophius piscatorius	+	+		+
Pollachius virens	+	+		+
Brosme brosme		+		+
Gadiculus argenteus		+		+
Clupea harengus	+	+		
Gadus morhua	+	+		
Melanogrammus aeglefinus	+	+		
Microstomus kitt	+	+		
Molva molva	+	+		
Raja clavata	+	+		
Raja fullonica	+	+		
Raja naevus	+	+		
Scomber scombrus	+	+		
Trachurus trachurus	+	+		
Trisopterus esmarki	+	+		
Callionymus lyra	+			
Cyclopterus lumpus	+			
Hexanchus griseus	+			
Loligo spp	+			
Raja batis		+		
Raja montagui		+		
Raja nidarosiensis		+		
Raja radiata		+		

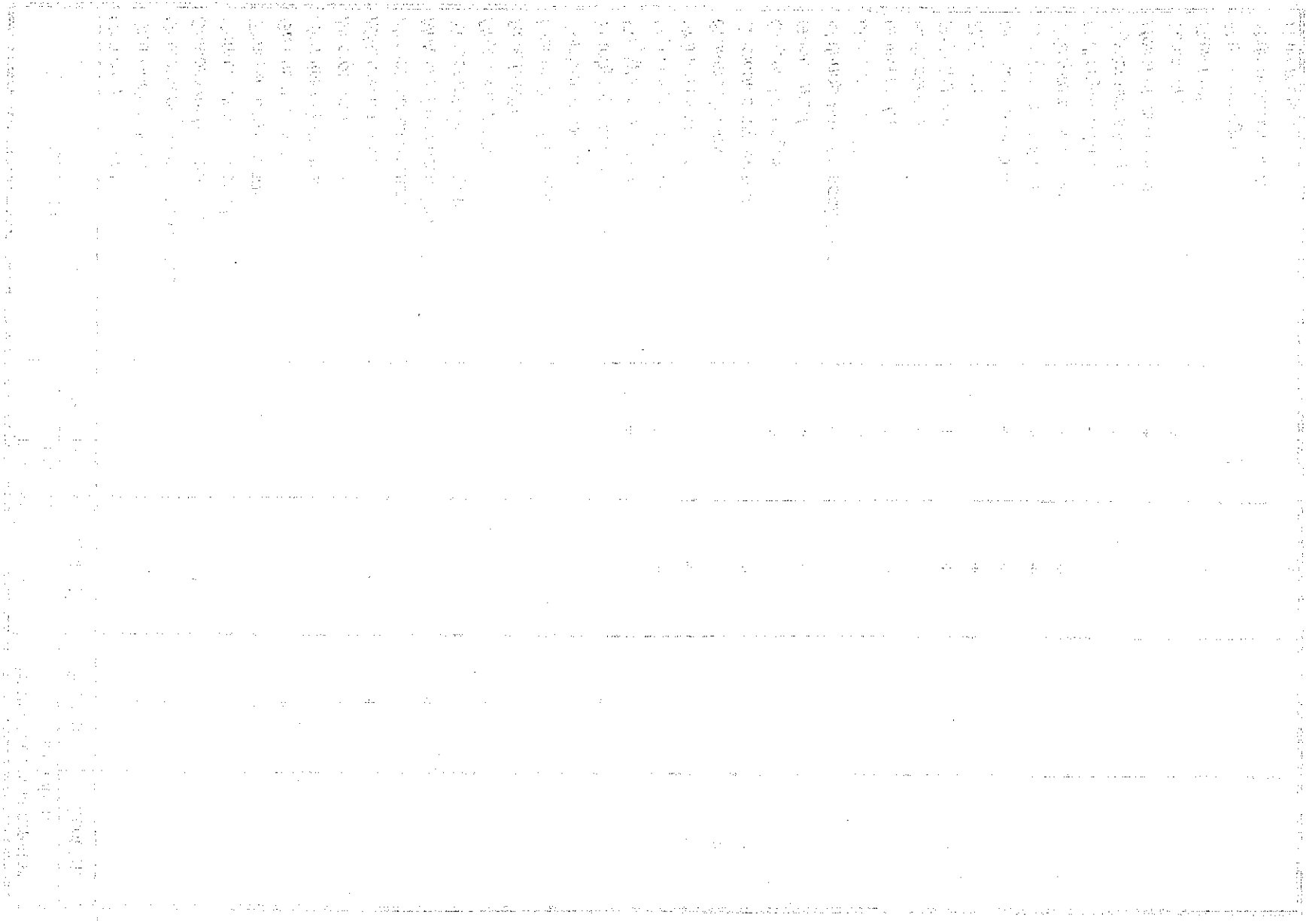


TABLE 3

Results of t-test on discard rates of species accounting for <1% of total discard

Species	Mean discarding rate (kg/hour)		t	p
	Scottish vessels	French vessels		
Alepocephalus bairdii	0.21	49.34	2.93	<.05
Argentina silus	42.71	7.46	3.62	<.02
Lepidion eques	23.07	7.73	0.99	<.4
Coryphaenoides rupestris	2.76	15.55	1.54	<.4
Chimaera monstrosa	4.44	6.79	0.83	<.5
Trachurus trachurus	6.1	4.67	0.22	<.9
Pollachius virens	4.39	0.9	1.57	<.3
Micromesistius potassou	6.53	0.17	1.7	<.2
Phycis blennoides	6.13	0.25	3.06	<.05
Trachyrhynchus murrayi	0	4.72	1.14	<.4
Scomber scombrus	6.04	0.9	1.05	<.4
Raja fyllae	1.82	2.4	0.24	<.9
Helicolenus dactylopterus	2.91	0.5	4.64	<.01
Deania calceus	2.03	2.12	0.1	<.9
Molva dypterygia	3.26	0.08	1.43	<.4

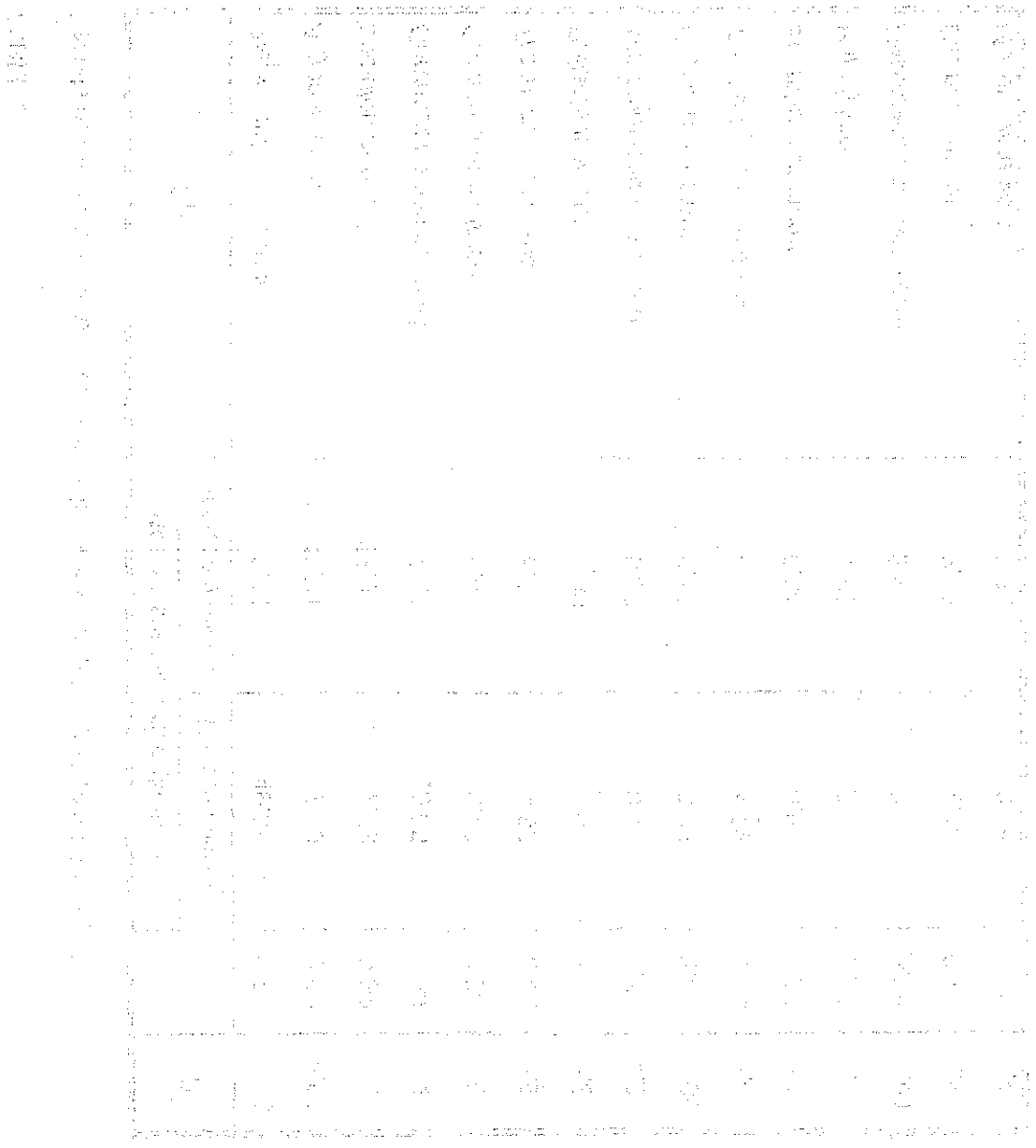
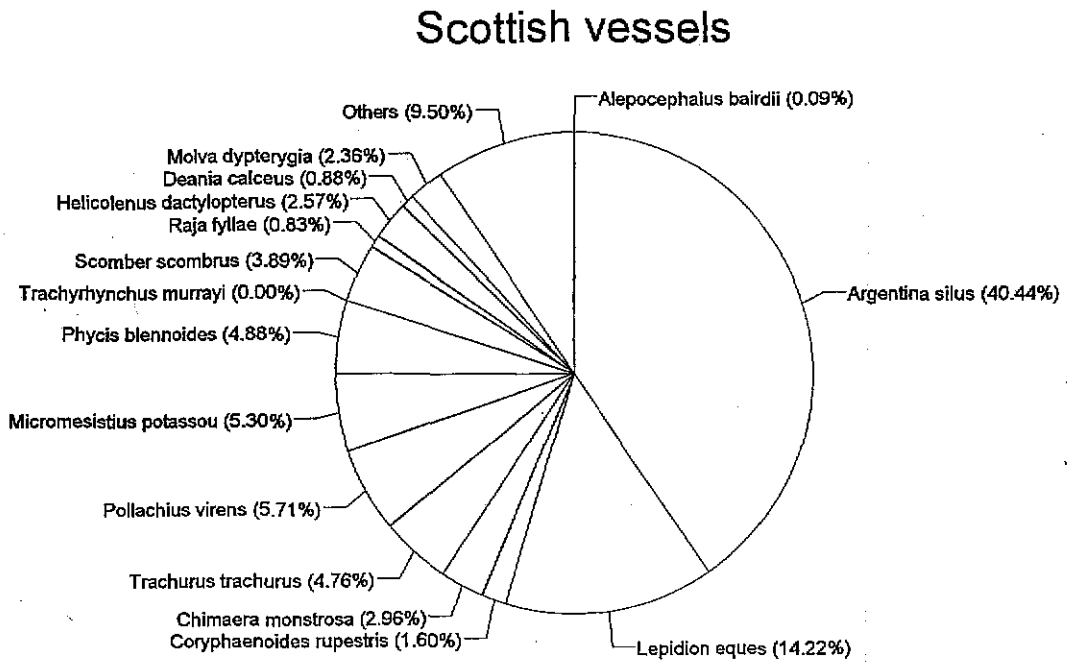
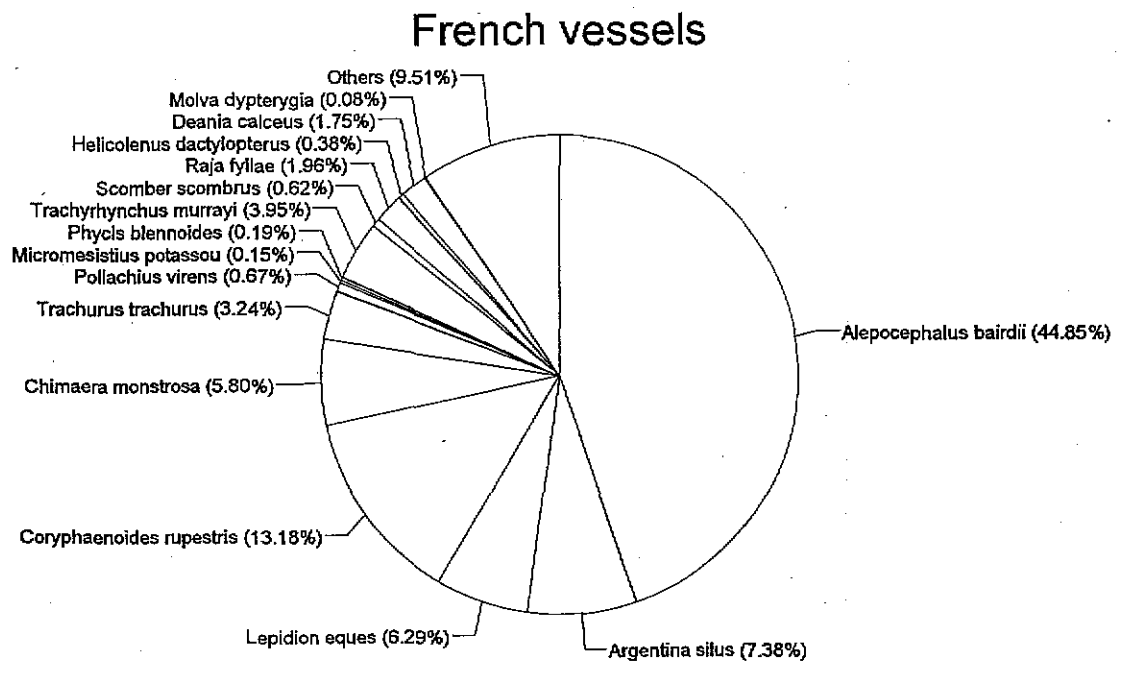


Fig 1. Discards by weight.

All depths





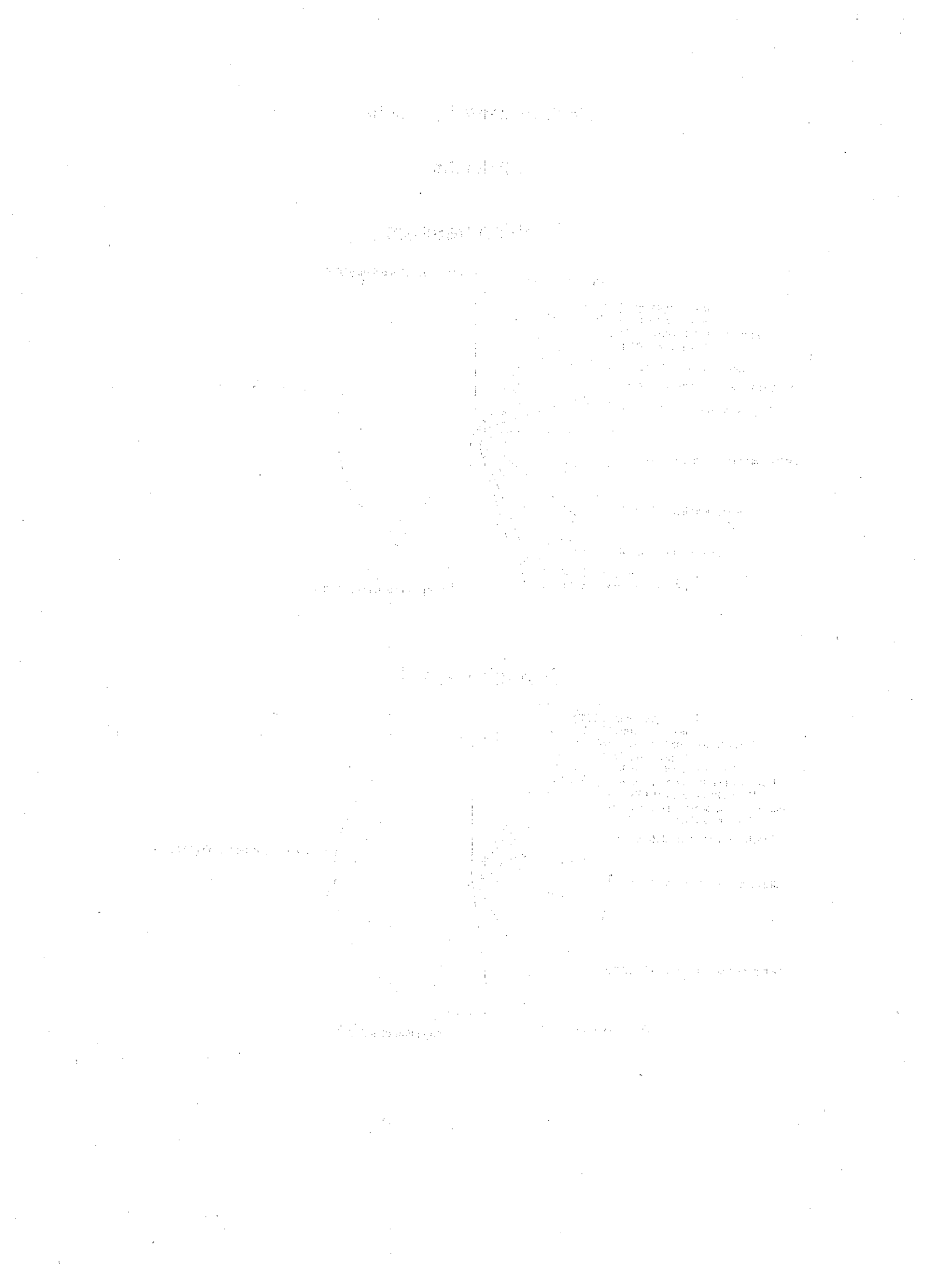
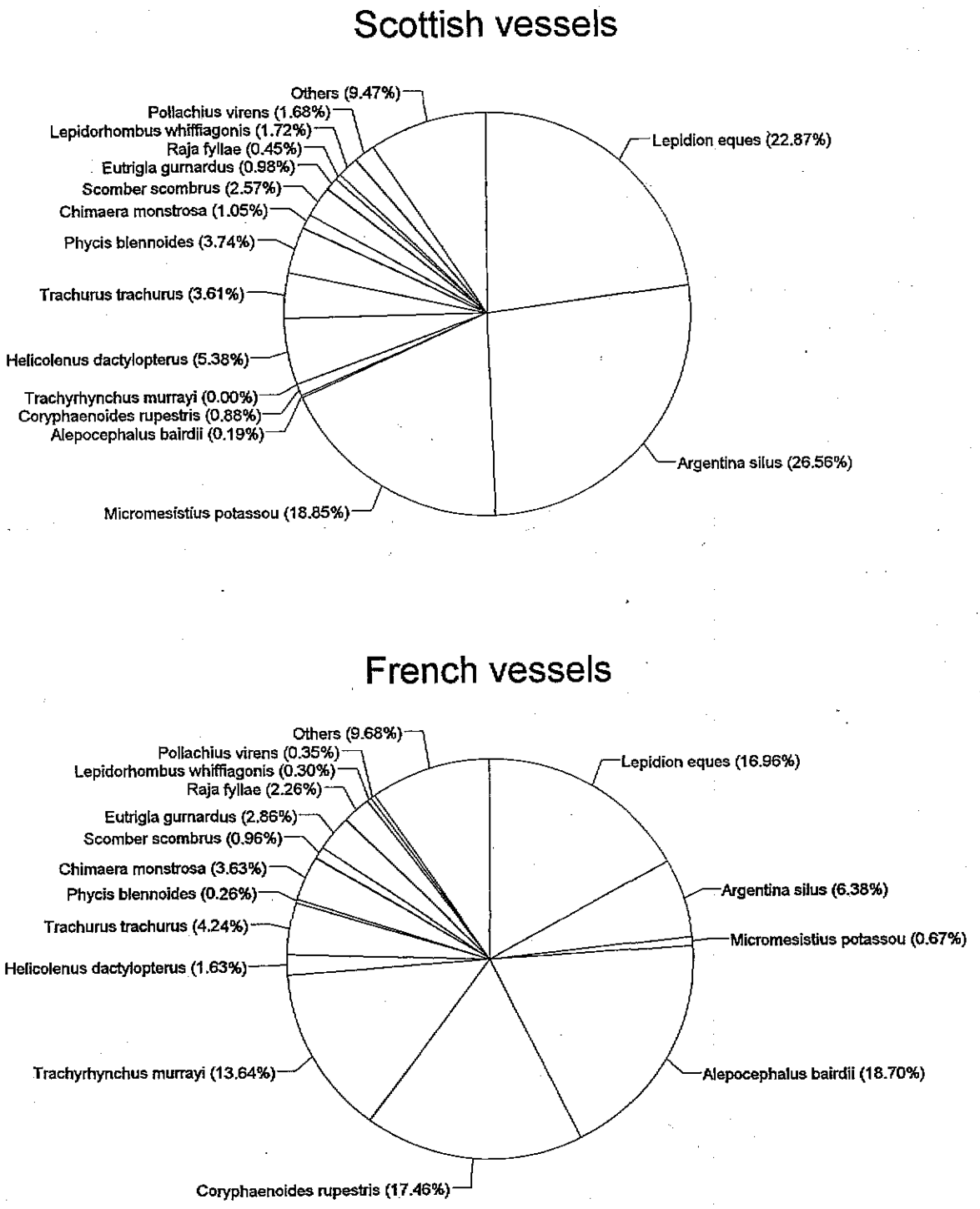


Fig. 2. Discards by numbers.

All depths.



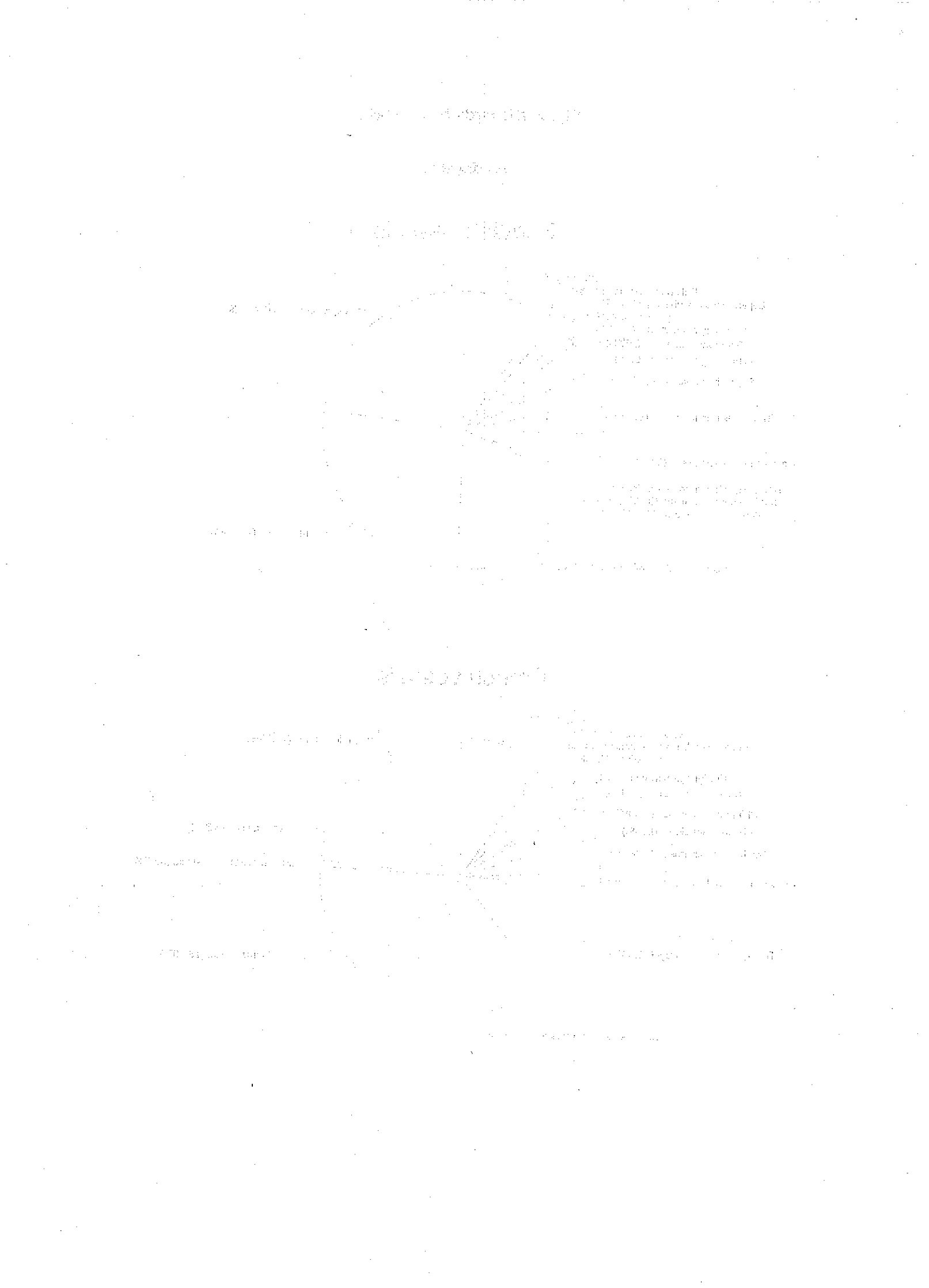
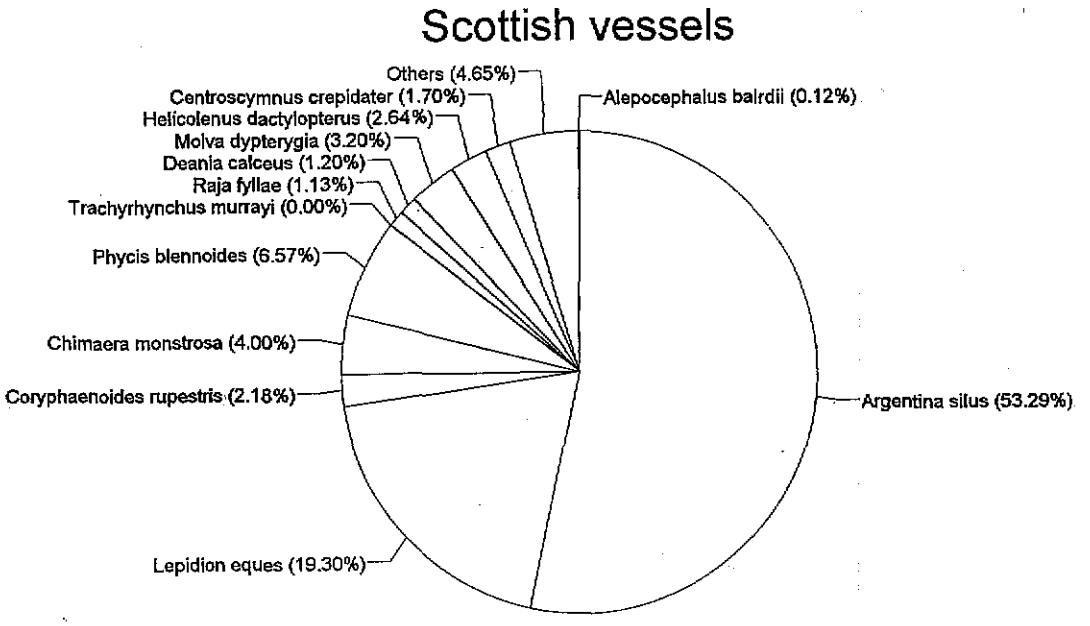
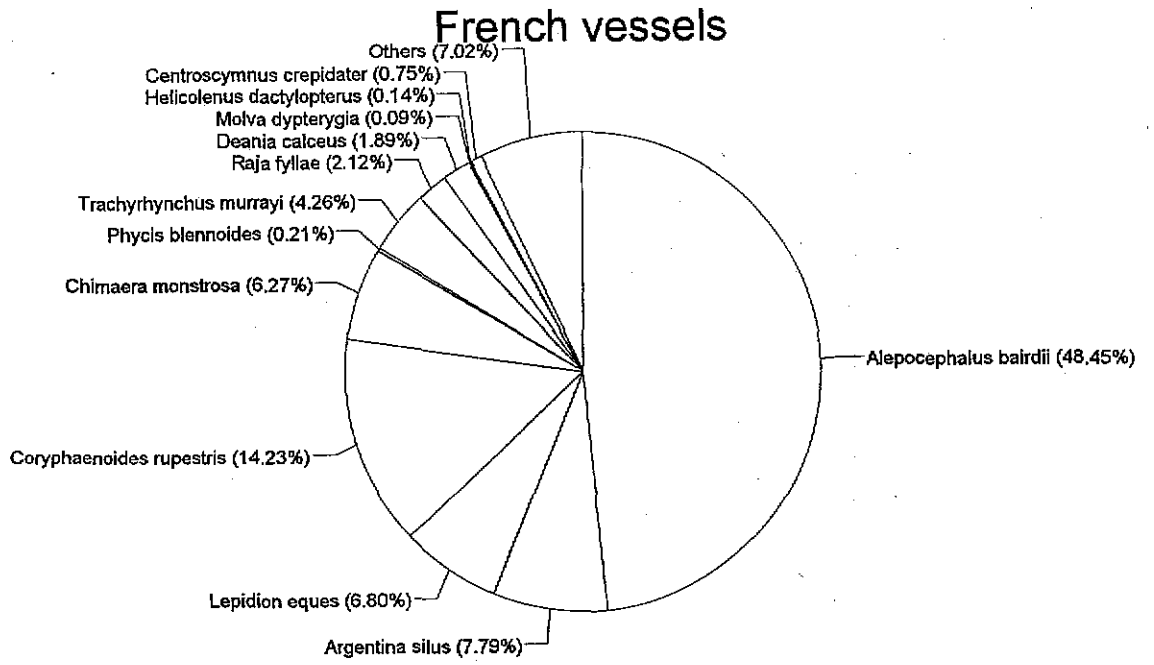


fig 3. Discards by weight.

Hauls at depths greater than 500m





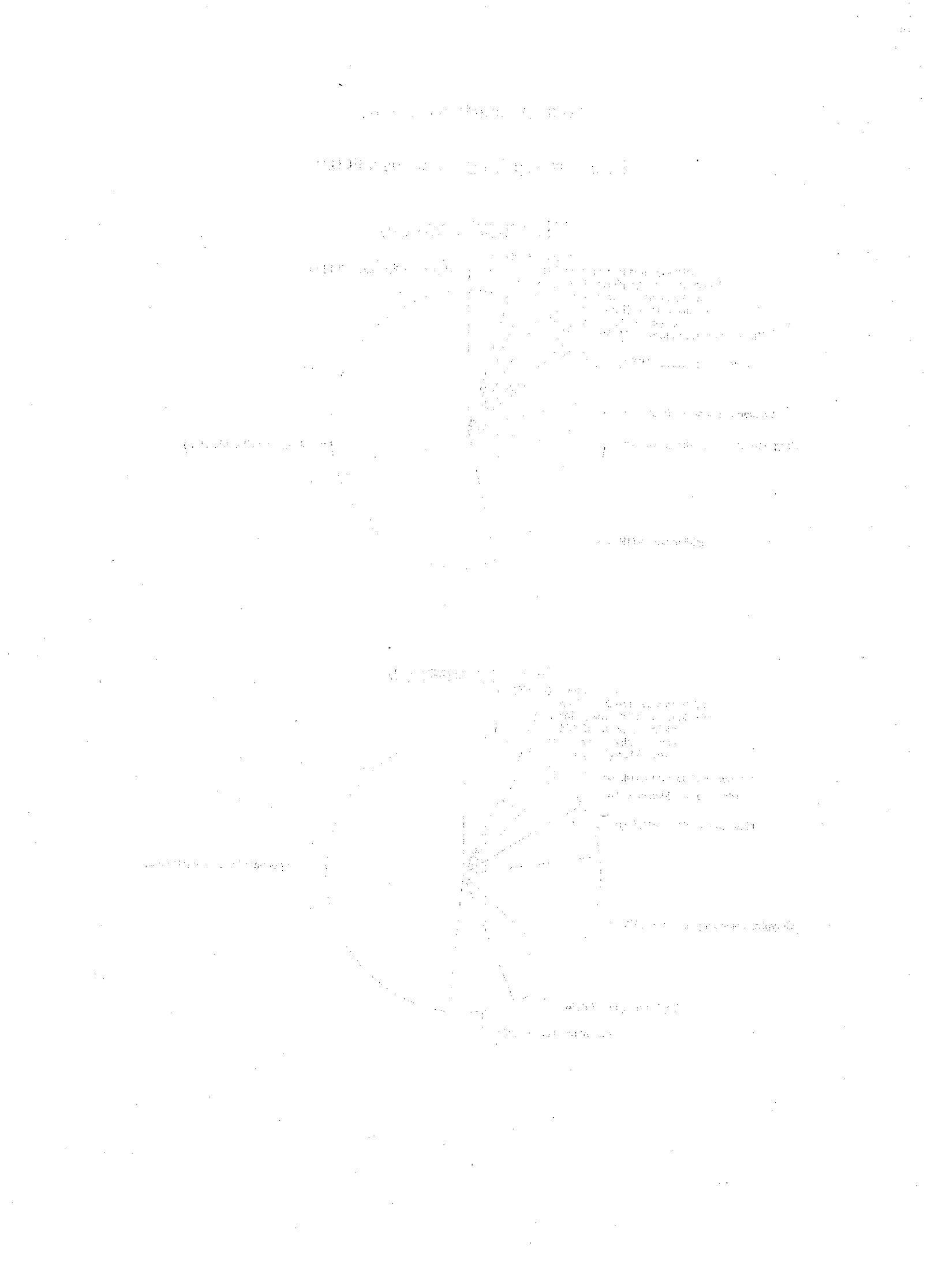
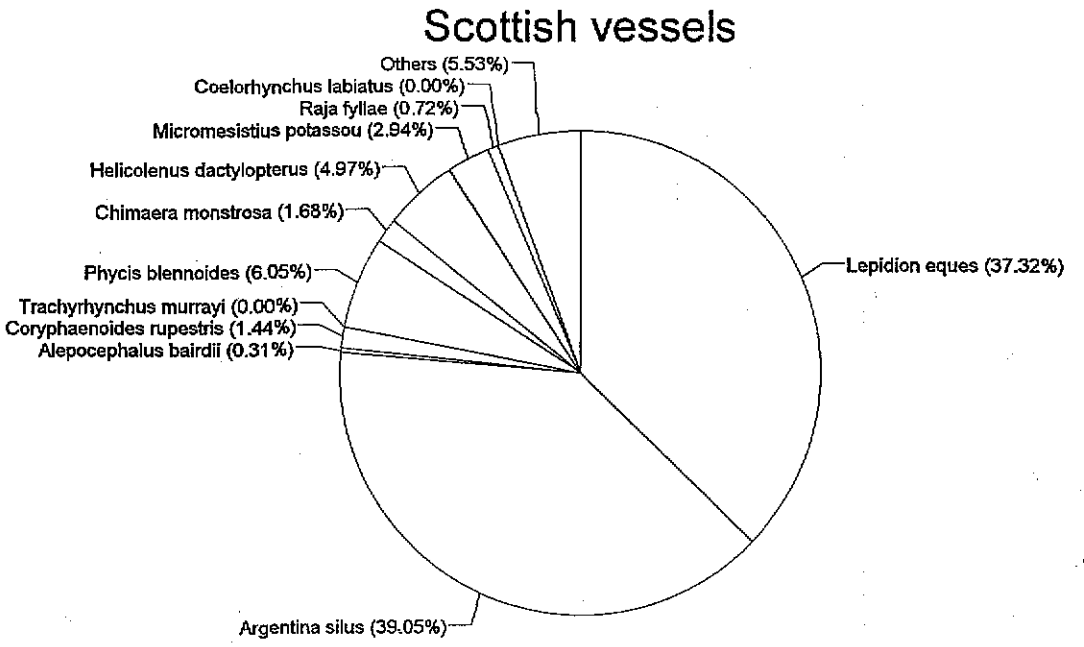
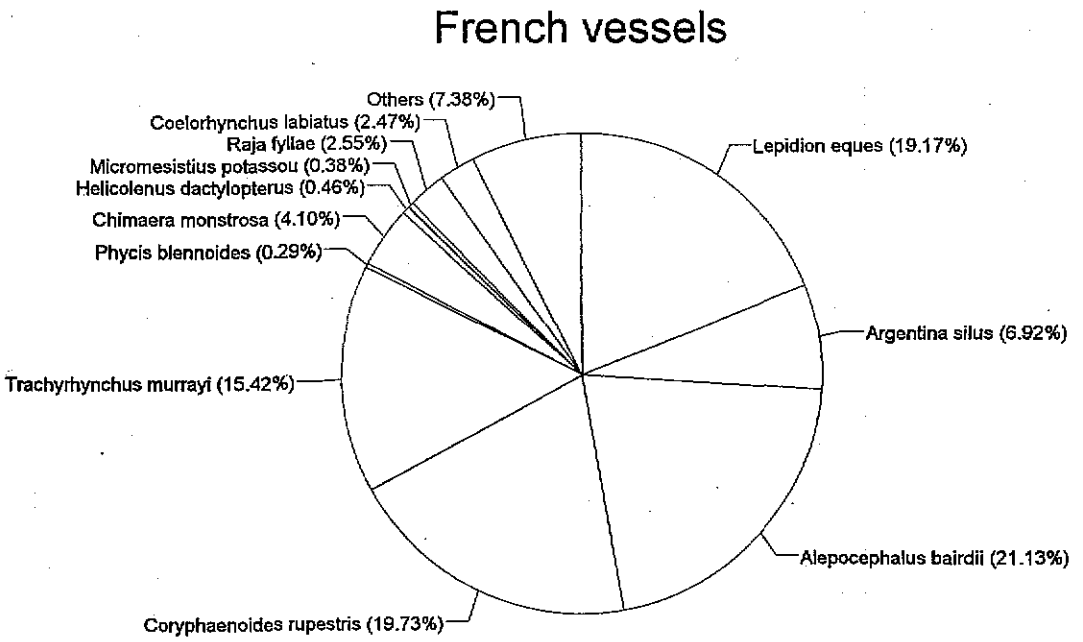


Fig 4. Discards by numbers.

Hauls at depths greater than 400m.





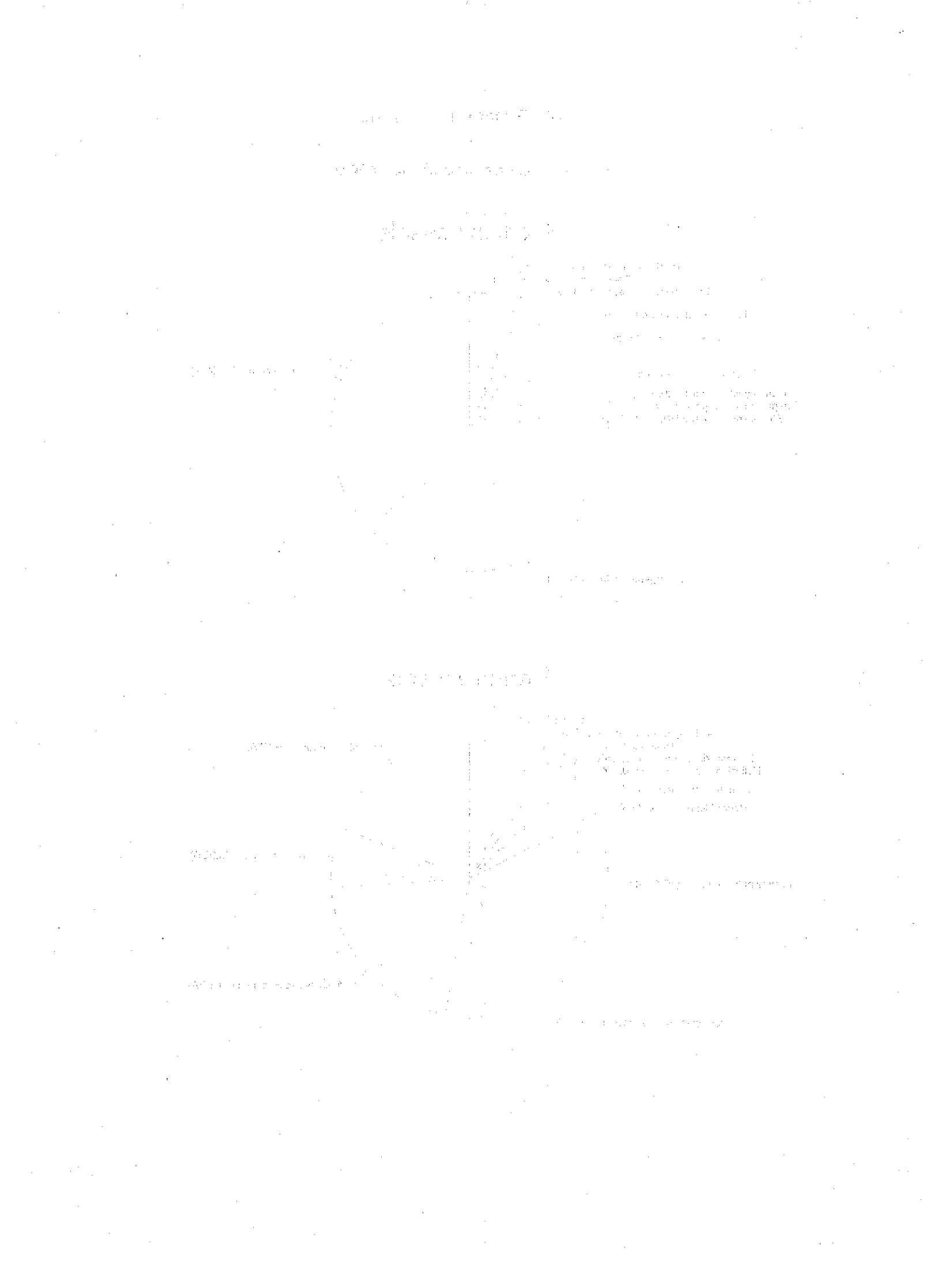
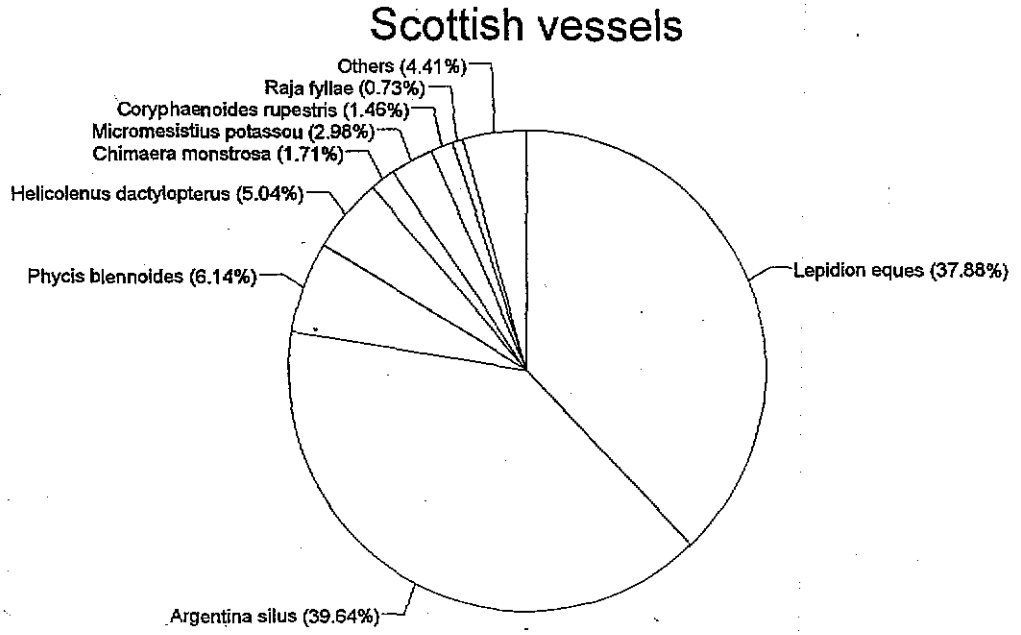


Fig. 5. Discards by number.

Depths between 400 and 900m.



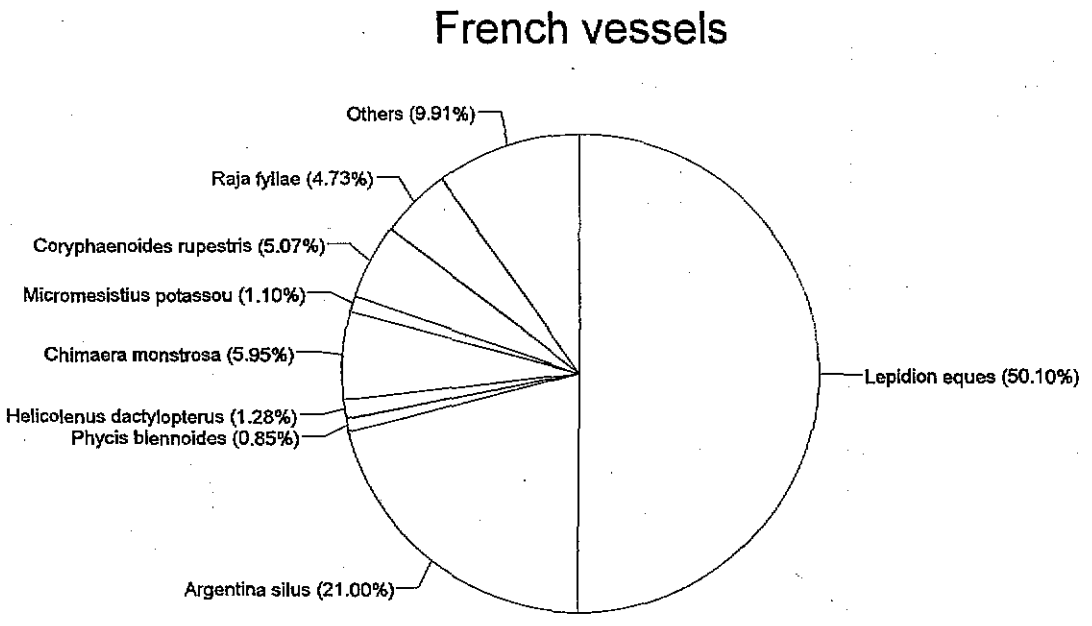


Fig. 6. Discards by number.
Hauls at depths greater than 900m.
French vessels

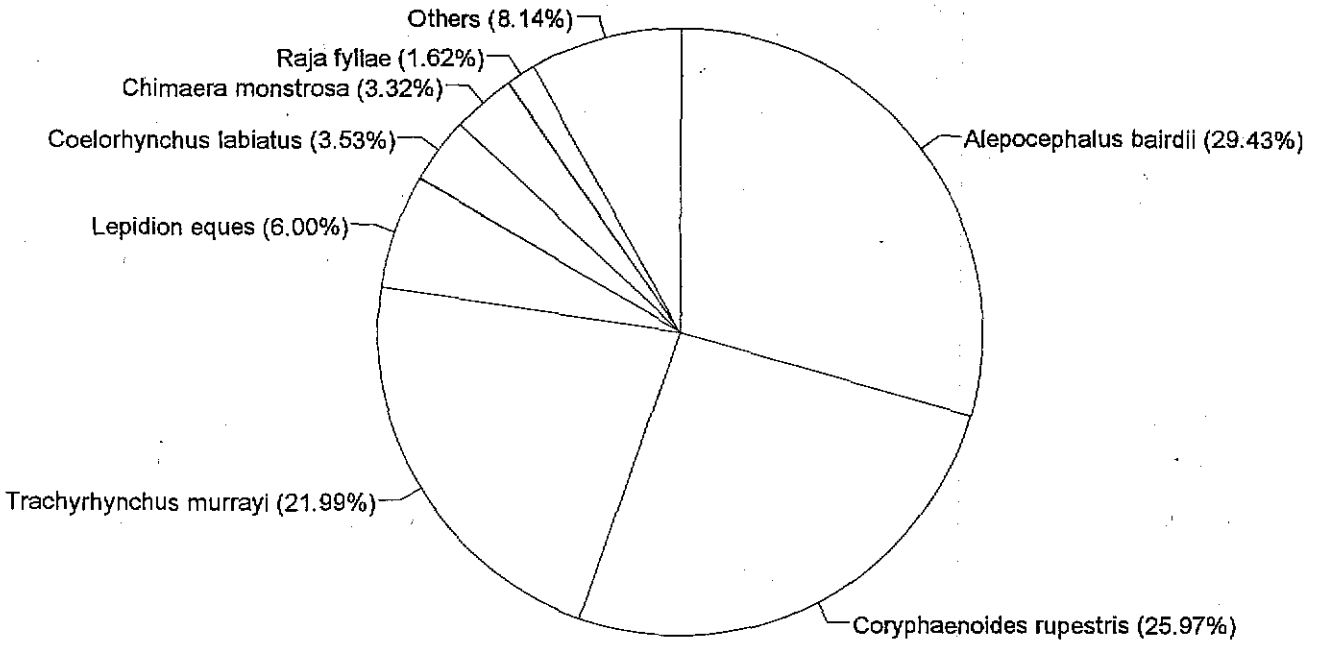
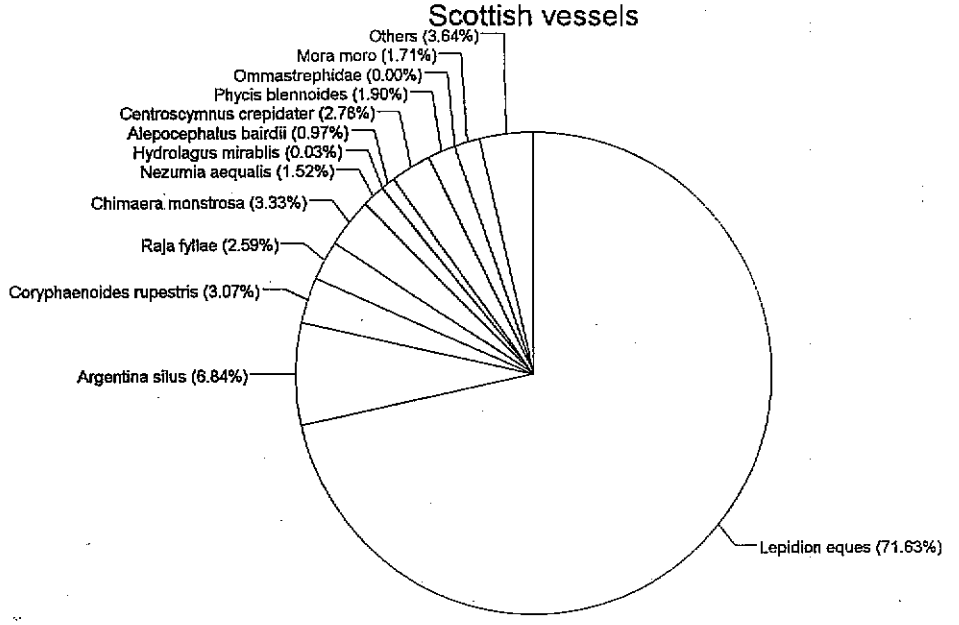


Fig.7. Discards by numbers.

Hauls between 800 and 900m



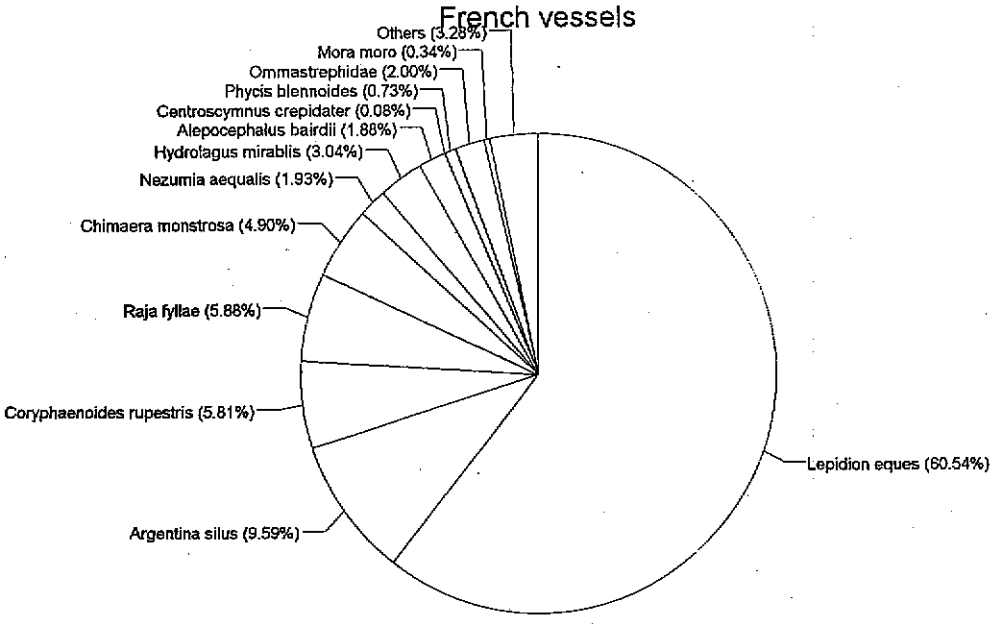
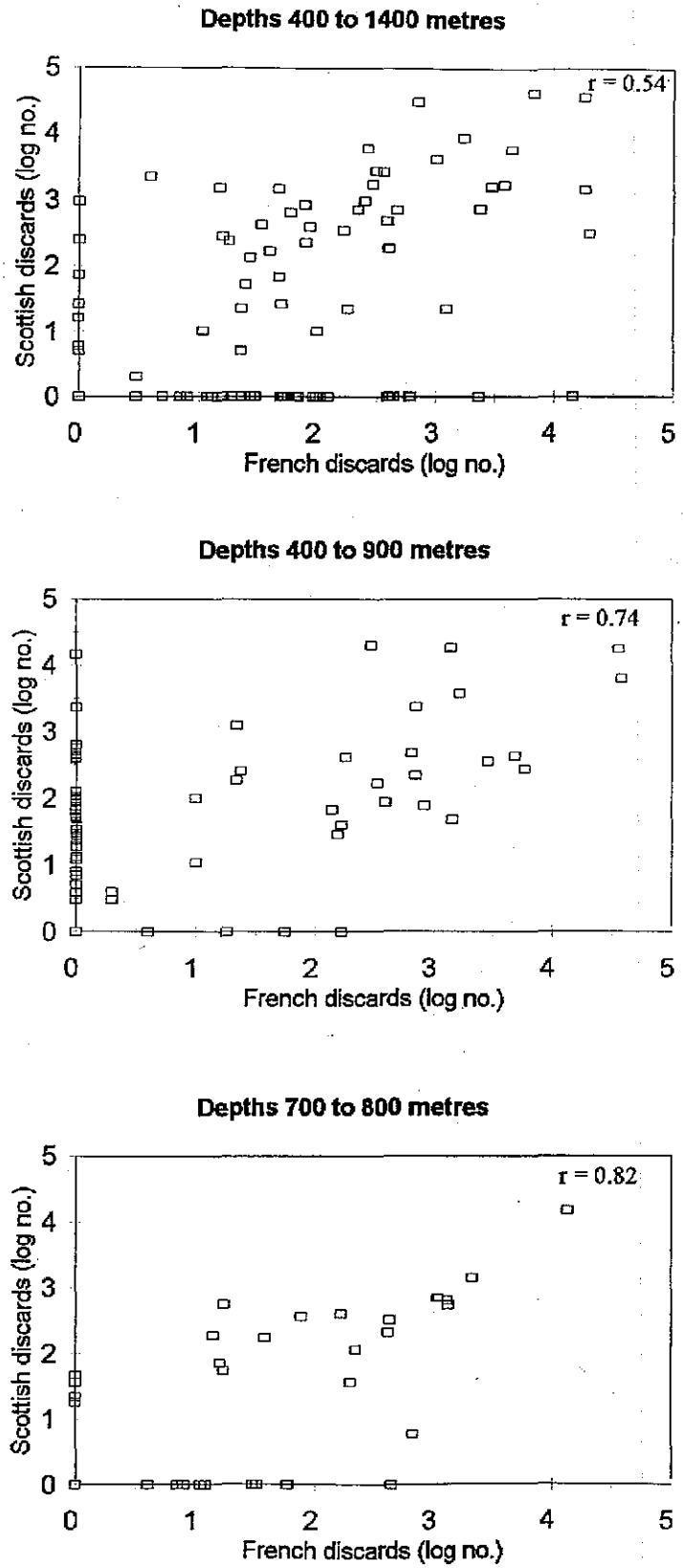
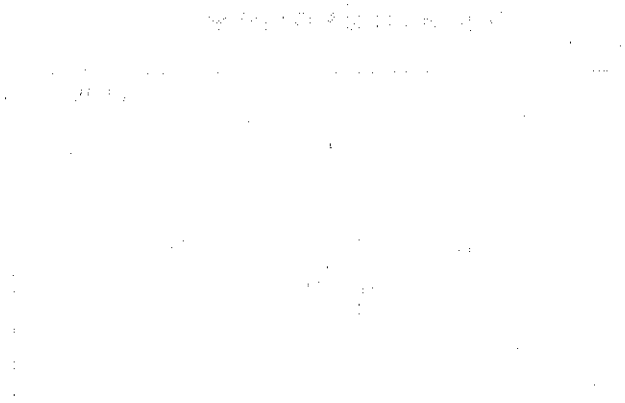


Fig. 8. Correlations between French and Scottish discards of all species.





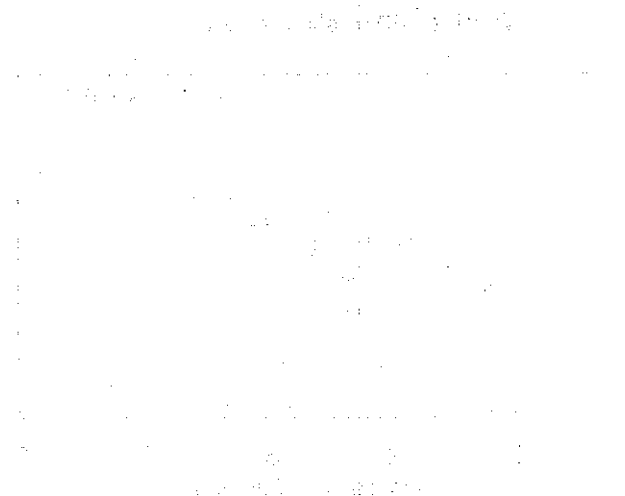
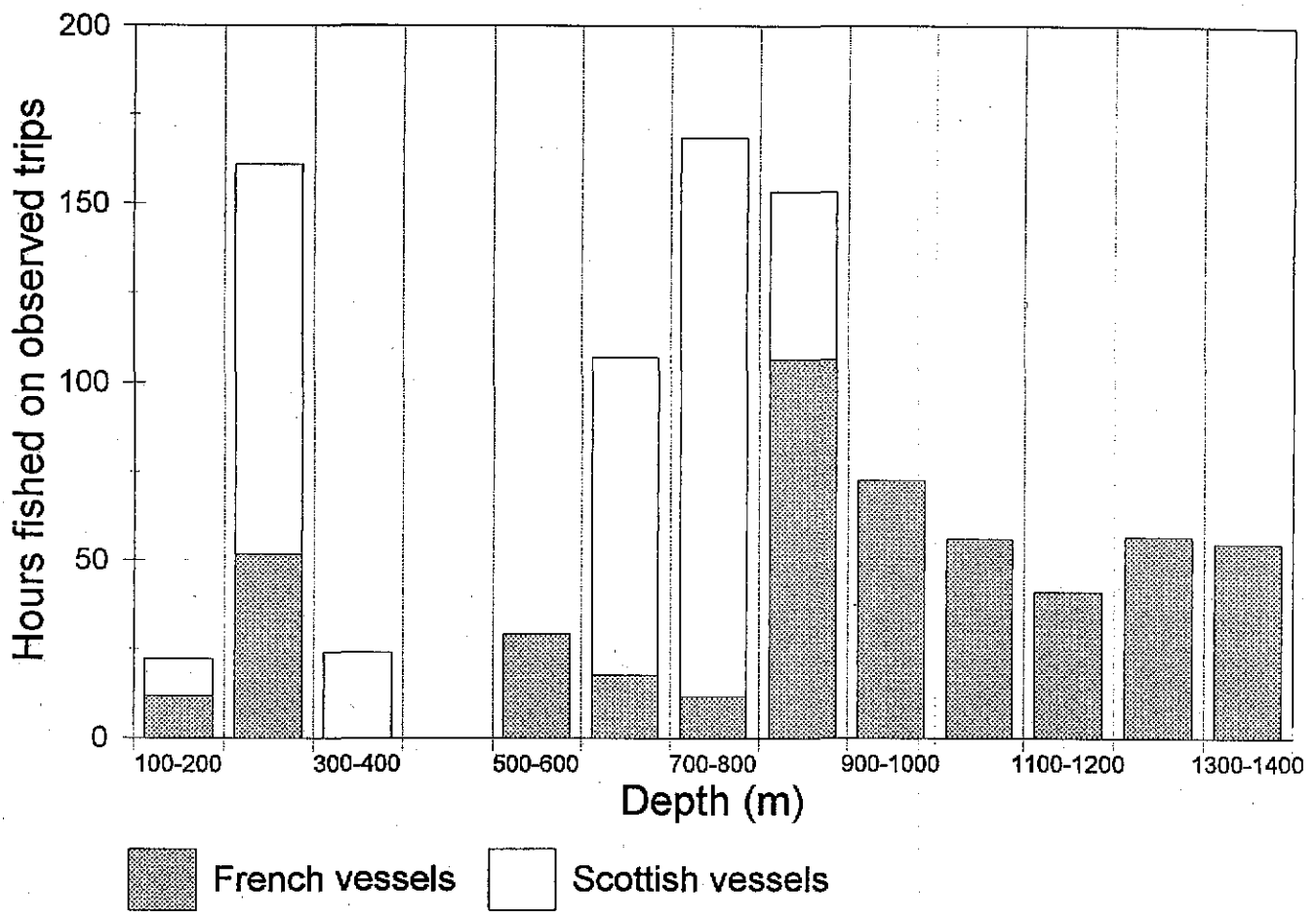


Fig 9. Depth distribution of fishing effort on observed trips.



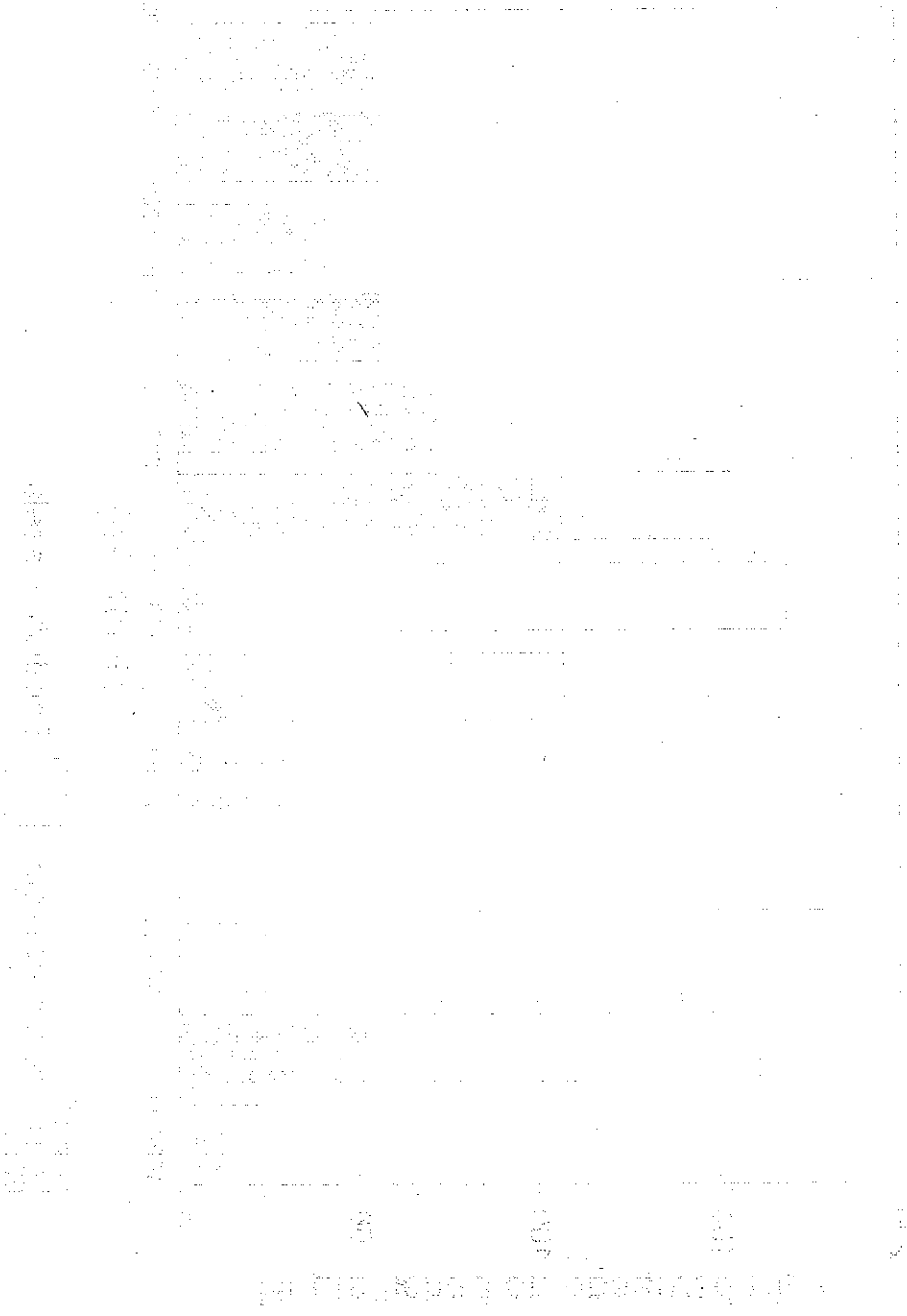


Fig 10 Discarding rates of the 9 most abundant species. Fleet data combined.