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Comparisons of Trawl and Longline Catches of Deepwater Elasmobranchs West and North of Ireland

(Elasmobranch Fisheries - Oral)

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Abstract

A comparison was made between catches from deepwater trawl and longline surveys (1993-2000) in the NE Atlantic. Longline catches were dominated by elasmobranchs, particularly squalid sharks and species diversity was low. Trawl catches had higher species diversity, with more teleosts, though elasmobranchs were still an important component. Species composition of the catch is depth dependent. Comparative trawl and longline surveys of the eastern and southern slopes of the Rockall Trough were used to examine size-selectivity. Trawls and longlines selected for significantly different (KS test $p < 0.05$) size frequency distributions of *Centroscymnus coelolepis* and *Deania calceus*, though not *Centrophorus squamosus*. These data highlight some important aspects of behavior of the species under study. Longlines selected for smaller *Centroscymnus coelolepis* than trawls, suggesting that smaller sharks were present at a considerable height above the seabed, out of reach of trawls, but attracted to baited hooks. In the case of some species, larger females were selected by hooks, but not present in trawl catches, possibly indicating their ability to escape towed gears. Trawl selectivity ogives were constructed for *Deania calceus* and a simulated for *Centroscymnus coelolepis*, using available data. Results suggest that longline is not as selective for *C. coelolepis* as trawl. Selectivity ogives for *D. calceus* were similar in form, but longline selected bigger individuals. Unvalidated age estimates (for two species), and reproductive studies suggest that these species can not sustain high fishing pressures. The implications of these results for the management of fisheries taking elasmobranchs are discussed.

Introduction

There are several fisheries for deepwater sharks in the northeast Atlantic, but most activity takes place in the Rockall Trough, and on the slopes of the Porcupine Bank. Two species of sharks are routinely landed for their flesh and livers; the leafscale gulper shark *Centrophorus squamosus* (Bonneterre, 1788) and the Portuguese dogfish *Centroscymnus coelolepis* (Bocage and Capello, 1864). These species are collectively called "siki" in French fishery records (Gordon, 1999) though they are marketed elsewhere under this name too. French vessels catch these species in the mixed-species trawl fishery. Spanish longliners target deepwater sharks too (Pineiro *et al*., 2001) but it is difficult to quantify landings as separate statistics for deepwater shark species are not collected from these vessels. More recently, longliners from Norway and Ireland and trawlers from Scotland and Ireland are catching these species. Other, smaller species of deepwater sharks are now being landed, or in some cases livers or fins are retained and the carcasses discarded. In addition to trawl and longline, there are fisheries for deepwater sharks using gillnets and tangle nets, but there are no catch or effort data available for these gear types. These species are *Centroscyllium fabricii* and *Centroscymnus crepidater* (Lorance and Lespagnol, 2000). Considerable progress has been made by some countries in collecting deepwater shark data, though data are still incomplete. Table 1 presents landings data for large squalid deepwater sharks, mainly *C. squamosus* and *C. coelolepis* and other sharks, some of which are deepwater species.

Relatively few studies on deepwater elasmobranchs exist in the scientific literature. The majority deal with members of the Squalidae, but little attention has focussed on the impacts of fisheries on these species, despite their commercial importance in several regions. The ICES Working Group on the Biology and Assessment of Deep-sea Fisheries Resources and Study Group on Elasmobranch Fish have run some preliminary assessments of these species since 2000 and the results to date are presented in (Anon., 2000; 2002a; b) and Clarke *et al*. (this conference). Given that these species are taken by several gears, it would seem prudent to examine the properties of each so that rational management decisions can be made concerning these fisheries. This paper presents information on comparative size distributions of some deepwater elasmobranchs taken by commercial trawl and longline.

Materials and Methods

This study is based on 3 trawl and 3 longline surveys on the Rockall Trough and Porcupine Bank, between 50°N and 59°N in the depth range 500 to 2,000 m (Table 2). Fishing was carried in eight fixed areas (Fig. 1) of the continental slope in 200 m depth strata from 500 m to 1,300 m. Some deeper settings were made during longline surveys. Commercial fishing gears were used in these surveys. Trawl surveys used a "bobbin" trawl (Gundry's© Ltd.) with 105 mm mesh cod-end, with 25 mm liner, foot-rope length 23 m, with bobbins of 40 cm, the bridles comprised of 92 m of singles and 46 m of doubles. Hauls ranged in duration from 135 minutes to 380 minutes. Longline surveys used the "Autoline" system with main lines of 9 mm or 11.5 mm, with Mustad© size 13/0 EZ, and smaller numbers of size 7/0 EZ hooks. Snoods were of 40-70 cm in length attached to the main line at 1.4 m intervals. Bait consisted of squid (60%) and mackerel (40%).

Specimens were identified according to Compagno (1984) and McEachran and Branstetter (1984). Total length (cm), taken as the length from the snout tip to the posterior tip of the caudal fin depressed along the anterior-posterior axis of the fish, was measured to the nearest centimetre below the actual length of the fish. All specimens caught were measured and weighed except during the 1996 trawl survey, when the weight of a sub-sample was recorded, and using a raising factor the total weights for that haul of *Deania calceus* and *Centroscymnus crepidater* were estimated (Connolly and Kelly, 1996).

The ratio of elasmobranchs to teleosts was calculated for each area. The percentage of total catch by 200 m depth interval was calculated from comparative trawl and longline surveys of the eastern and southern slopes of the Rockall Trough in 1997. The discard rates for the two most abundant non-commercial squalid sharks, longnose velvet dogfish *Centroscymnus crepidater* and the birdbeak dogfish *Deania calceus* were calculated as a percentage of the total catch for each haul and also as kg per ton of target species for the corresponding ICES Sub-area (VI). The latter rate enabled the estimation of the total weight discarded by raising the overall discard rate to the reported landings of the target species. The target species were the commercially important species leafscale gulper shark *Centrophorus squamosus* and Portuguese dogfish *Centroscymnus coelolepis*. Estimates of total weight discarded from trawlers were calculated from official landings data for these sharks as reported to ICES (Anon., 2002).

Length frequency distributions (5 cm groups), separated by sex, for *C. squamosus*, *C. coelolepis* and *D. calceus* were pooled by gear type (survey-trawl, long-line). The Kolmogorov-Smirnov (K.S.) Two Sample Test (Sokal and Rohlf, 1995) was used to test for significant differences between length frequencies from trawl and longline catches.

Comparative selectivity ogives for trawl and longline were constructed for *Deania calceus* and *Centroscymnus coelolepis*. Selectivity ogives were estimated using the method of Sparre *et al*. (1989) where the descending limb of a catch curve is extrapolated backwards to achieve an estimate of the non-fully selected age groups. The difference between these expected catch numbers and the observed values provide an estimate of the combined effect of recruitment and selectivity of the gear for these age groups. This approach assumes that mortality of fish, not fully recruited to the fishery is the same as that estimated from the catch curve. This assumption is probably not valid in the case of sharks, where mortality of juveniles is usually considered higher. However the approach offers a simple means to obtain first estimates of the selectivity patterns for these species for teleost deepwater species. The logistic model was assumed to describe the selectivity pattern for each species. Input data for *D. calceus* were age based catch curves from the August 1997 trawl survey and the December 1999 longline survey. Initial runs displayed little difference in ogives for male and female, so data by sex were combined. For *C. coelolepis* age estimation has not been possible to date, so length frequency distributions from these surveys were used to produced length converted catch curves (Pauly, 1984) using the hypothetical parameters of the von Bertalanffy growth function: $K = 0.09$, $t_0 = 0$, $L_\infty = 115$ cm.

Results

Depth distribution of the species is illustrated by catch rates in kg per 1,000 hooks, from longline surveys (Fig. 2). The habitual depth range (300 m-1,800 m) of each species was sampled. *Centrophorus squamosus* and *Deania calceus* were most abundant between 700 m and 900 m. *Centroscymnus coleolepis* was more abundant deeper (1,300 m). Table 3 shows the relative proportions of elasmobranchs and teleosts in trawl and longline catches by area (Fig. 1). In longline catches, the elasmobranchs outnumber teleosts in all areas, except 4, where shallower hauls took the dominant species shallower than 500 m, ling and tusk, in large proportions. In trawl catches elasmobranchs were still well represented, but ratio favoured teleosts. Clearly, species diversity is greater in trawl, and though elasmobranchs are present, they are a less important component of the catch. In longline catches, elasmobranchs dominate. There is also a trend for greater numbers of species in catches, moving southwards.

Fig. 3 shows the percentage catch composition by species from comparable trawl and longline surveys of the continental slopes of the Rockall Trough in 1997. Squalid sharks dominate longline catches, deeper than 500 m, in this area. Elasmobranch dominance increases with depth, with catches deeper than 1,300 m almost totally composed of squalid sharks (98%). The non-commercial species, *Deania calceus*, is the largest component of the catch between 500 and 700 m and squalids are the dominant species at all depths in longline catches. In contrast, trawl catches display a greater diversity of species, with less dominance. The roundnose grenadier, *Coryphaenoides rupestris*, a teleost, dominated below 700 m, but the remainder of catches at these depths comprised a diversity of species, both chondrichthyan and teleost. The large, commercial squalids, *C. squamosus* and *C. coelolepis*, were the most abundant in trawl catches. Whilst teleosts comprise a higher component of trawl catches than elasmobranchs, it is clear that the latter group are well represented in catches from towed gears. The percentage species composition on the continental slopes of the Porcupine Bank, from longline catches, is illustrated in Fig. 4. The differing species composition in this more southern region is evident. *Deania calceus* is dominant over a range of depths here, comprising more than 60 % of the catch between 700 and 900 m.

An important aspect is the absence of smaller specimens of these species from the study area (Fig. 5). Trawls and long-lines selected for significantly different (Kolmogorov-Smirnov two-sample test $p<0.05$) size ranges of *Centroscymnus coleolepis* and *Deania calceus*, though not *Centrophorus squamosus* (Fig. 4). Large female *Deania calceus* were well represented in long-line catches, but less well represented in trawls, indicating that large, mature females can avoid these nets.

Based on the 1999 longline survey (Table 4) it can be seen that the percentage discard rate of these sharks depends on depth fished. The highest discarding occurred on the southern slopes of the Rockall Trough, where over 60% of the catch was *Deania calceus*. Indeed it accounted for over 30% of the total catch on the long-line survey of December 1999. However catch rates are depth dependent. Thus long-lining in waters deeper than 1,200 caught only small amounts of *Deania calceus*. However when long-liners are targeting *Centrophorus squamosus*, *Mora moro* and *Phycis blennoides*, in waters less than 800 m, discarding may be higher. In the case of *Centroscymnus crepidater*, discards will be higher at depths around 1,200 m, as this species occurs deeper.

Selectivity ogives for *D. calceus* (Fig. 6) display similar shapes for both gears. The model predicts that longline selects for older (larger) sharks than trawl. Age_{50} for trawl was estimated at 11 years whilst for longlines was estimated at 15 years. Results of the simulated ogive analysis for *C. coelolepis* (Fig. 7) suggest different selectivity patterns for trawl and longline. In the case of females, longline appears to be less selective for younger (smaller) sharks. The ogive for longline caught females displayed a lower Age_{50}, and only slight increases in proportions selected with increasing age. In contrast the trawl ogive for females displayed a sudden increase in proportion selected around age 25. This suggests that longline is less selective for female *C. coelolepis* than males, and takes a higher proportion of smaller sharks. This effect is also illustrated in the comparative length frequencies (Fig. 5), smaller females being selected by hooks, but absent from the towed gear. There is less difference in the ogives for male *C. coelolepis*, for which longlines did not attract greater numbers (Fig. 5). When both sexes are combined the differences are masked, however the longline ogive is slightly less steep than that of the trawl.

Discussion

This study illustrates some important differences between trawl and longline with respect to catches of deepwater elasmobranchs. Clearly the catch composition of deepwater sharks is depth dependent, as also described by Gordon (1999). The present data show the composition of elasmobranch species in the total catch for commercial gears, by depth. Of the two commercial species, *C. squamosus* occurs in maximum abundance shallower, between 800 and 1,000 m and *C. coelolepis* is more abundant deeper being the dominant species in longline catches below 1,100 m. *D. calceus* is not commercially exploited, but dominates longline catches in intermediate depths on the slopes of the Porcupine Bank, being slightly less important a component further north in the Rockall Trough. Because this species tends to occupy hooks that could otherwise attract commercially valuable species, longline fishermen tend to avoid these depths. Therefore two completely separate longline fisheries can be defined in this area, one on the upper slopes targeting ling *Molva molva* and tusk, *Brosme brosme* with by-catches of greater forkbeard *Phycis blennoides*, mora *Mora moro* and blue ling *Molva dypterygia*. Deeper than 1,000 m there is a target fishery mainly for the two commercially important large sharks, *C. squamosus* and *C. coelolepis*.

Trawl catches are not dominated by elasmobranchs. On the slopes of the Rockall Trough roundnose grenadier dominates trawl catches from 700 m and deeper. However deepwater sharks are the next most important species in terms of weight, after this teleost. Discards from trawling in this region are high, and are composed of up to 30 different species, whilst species diversity of discards from longlining is lower, but dominated by sharks (Connolly and Kelly, 1996). Trawl discards are composed of small individuals of commercial species such as C*. rupestris, M. dypterygia* and *P. blennoides*. Some teleost species are taken mainly on longline, being mainly absent from trawls, notable *M. moro* and *B. brosme*. Small specimens of the squalid sharks are not present in this region (see below). Trawl discards are also composed of a large range of non-commercial species, such as blue antimora *Lepidion eques*, Murray's longsnout grenadier *Trachyrhynchus murrayi* and Baird's smoothhead *Alepocephalus bairdii*. In contrast, longline discards are mainly composed of non-commercial shark species such as blackmouth dogfish, *Galeus melastomus*, greater lanternshark *Etmopterus princeps*, *D. calceus* and *Centroscymnus crepidater*. Few small teleosts are taken on longline, less than 5 % of the catch of ling or blue ling below minimum legal landing size were caught on a subsequent longline survey (Clarke and Moore, 2002). In contrast, longlines take many small shark species, and smaller specimens of some of the larger species of shark than the trawls.

An estimated 533 t of *D. calceus* was discarded during trawling operations in the Rockall Trough and slopes of the Porcupine Bank in 1996 (corresponding to ICES Sub-areas VI and VII) were provided by Clarke *et al*. (2002). Clearly there are significant levels of discarding of this and the other non-commercial sharks from trawling in this area. It is more difficult to estimate discarding levels from longlining, because landings data are less complete. However from the species composition data it can be seen that non-commercial sharks will dominate the discards. In shallower settings the main species are *D. calceus* and *G. melastomus*, whilst in the deepest settings (commercial viability decreases below 1,500 m) *C. crepidater* and *E. princeps* are most important. In intermediate depths *D. calceus* is the most abundant species, as mentioned above, taking up most of the baited hooks. Therefore fishermen tend to avoid fishing in this depth range. However it is possible that markets for this and other non-commercial species may become available in the future and this would lead to increased exploitation of these sharks.

The absence of small specimens of the large squalid sharks from this region has been well documented (Clarke *et al*. 2002; Girard and DuBuit, 1999). In the case of *D. calceus* and *C. squamosus* this is probably explained by migratory behaviour. Smaller D. calceus, absent from the area west of Ireland are present off Portugal (Machado and Figueiredo, 2000). Gravid *C. squamosus*, totally absent from west of Ireland are found in Madeira and off Portugal (Hareide and Garnes, pers. comm.; Figueiredo, pers. comm.). Interestingly, neither gear selected for larger *C. squamosus* (Fig. 5), providing further evidence that the larger gravid *Centrophorus squamosus* are absent from the study area, and that gear selectivity is not the reason for their absence from samples. It seems clear that smaller sizes of these species do not escape through the cod-end of trawls, since a fine-mesh liner was used. Nor is it likely that the baited hooks used do not select the smaller specimens, since small specimens of E. princeps (27 cm TL) were taken in these surveys (Connolly *et al*. 1999).

Certain aspects of the behaviour of these species are highlighted by comparison of the size-frequencies from trawl and longline. The greater numbers of large female *D. calceus* taken on longline may suggest that this species is capable of making quick movements that allow it to escape towed gears. Evidence for a more pelagic distribution of smaller specimens of this species may be found by comparison of length frequencies for trawl and long-line. Longlines took smaller specimens of *Centroscymnus coelolepis* than trawls. This result suggests these smaller sharks occur at some distance from the seabed, out of the range of trawls (headline height around 4 m), but attracted to the baited hooks. It also known that gravid females of this species are found in shallower waters (Clarke *et al*., 2001; Yano and Tanaka, 1988). This is an important factor in considering the impact of fishing in waters shallower than 1,000 m, on *C. coelolepis*, as mainly mature and gravid females will be taken.

Millar and Fryer (1999) define three categories of size selection in fish:

1. Population selection: The probability that a fish of a given length is captured from the population.
2. Available selection: The probability that a fish of given length is captured given that it is available to the gear.
3. Contact selection: The probability that a fish of given length is captured given that it contacted the gear.

In the present study, the logistic model was considered to represent both trawl and longline selectivity. This model has enjoyed wide usage for trawls (Millar and Fryer, 1999). However authors are divided on whether it can be applied to longlines. But very little is known about longlines selectivity. Some authors consider that longlines have bell-shaped functions, like gill nets (Sparre *et al*., 1989). This type of curve would imply that the largest size classes must escape the gear after contact. However, given the typical scarcity of large fish in commercial fisheries it is difficult to estimate the right hand limb of such a curve (Millar and Fryer, 1999). Whilst there may be some tendency for reduced selectivity of largest, most powerful sharks, it is not possible to quantify this at present. The choice of the logistic model for hook selectivity in the present study was based on the need to describe the left-hand limb of the curve, to investigate the effect of selectivity and recruitment to the fishery. A recent selectivity study for deepwater fish, off Portugal, found the logistic to be a versatile model which adequately described the pattern observed (Sousa *et al*., 1999).

It seems reasonable to assume that contact selectivity of trawl for these sharks is unity, since they are very unlikely to escape through the meshes. Thus trawls are selective for these sharks in the sense that a) some sharks avoid trawls and b) a part of the population of these sharks is beyond the range of the trawl. It seems clear from comparisons of length frequencies from trawl and longline in the present study that some sharks (probably larger specimens) can avoid trawls, and that some size ranges are not present in the area where they would be vulnerable to trawls. From the composition of elasmobranchs in trawl catches it can be seen that there is considerable mortality of small sharks from trawling (Clarke *et al*., 2002; Connolly and Kelly, 1996).

Longlines may be selective for sharks in the sense that some sharks may take the baits, but subsequently break the hook or snood and escape. Observations on-board show that this does occur, but it is difficult to quantify the extent to which this takes place. Thus there may be some contact selection, though the small number of broken snoods on these surveys suggests that this is not common. Longlines may also display population selection, in that smaller sharks may be out-competed by large sharks for available hooks. However this will only take effect over the size ranges of the sharks that are actually present in the region, since smaller sharks are totally absent. In contrast to trawls, available selection is likely to be unity, since it is unlikely that a shark, being available to a bait, would actually avoid it, or fail to take it.

The selective properties of trawl and longline for deepwater fish have been discussed by several authors. They are fundamentally different fishing methods, trawls herd fish into the opening of the net while longlines attract fish from a wide area by the odour of the baits (Hareide, 1995). This difference explains why longlines have been found to capture larger fish than trawls. According to Bjordal and Lokkeborg (1996) the swimming speed of a fish is proportional to its body size, larger fish being able to swim faster than smaller ones. In addition, bigger fish often frighten smaller fish from baits. The consequence of these differences is that the exploitation patterns of the two gears will be different. For teleosts, this effect has been illustrated by yield per recruit analyses. Jorgensen (1995) showed that for Greenland halibut *Reinhardtius hippoglossoides*, maximum yield per recruit and yield per recruit corresponding to $F_{0.1}$ are reached at lower rates of fishing mortality for longlines than trawls. Jorgensen concluded that longline offered a better means of exploiting this teleost species, since a larger biomass will remain in the sea if a given quota is fished with longlines. Moreover, a given tonnage of this species taken by longline will consist of fewer, larger individuals than trawl. Heavy exploitation of a stock of fish by longline may result in damage to the spawning stock, though as a general rule this will involve less risk of over-exploitation than fishing of younger age groups according to Hareide (1995). Longlines have other advantages too; they are less destructive of benthic habitats, longline vessels have lower energy consumption rates, they produce fish of higher market value and there is little effect of ghost fishing (Bjordal and Lokkeborg, 1995). However these authors point out that longlines do have the propensity to select for smaller fish, if there are few large fish on a fishing ground.

Results of the present study show that longlines select for larger *D. calceus* than trawls. These results are in agreement with those found *for R. hippoglossoides*. However results of the simulations for female *C. coelolepis* suggest that longlines are not always more selective that trawl. Indeed, trawl displayed almost “knife-edge” selectivity for females of this species. These differences highlight an important property of longlining. This method can capture fish from a wider area than trawl. This simulation predicts that exploitation of a stock of *C. coelolepis* by longlines will involve the removal of greater numbers of smaller females than exploitation by trawl. This suggests that longlines may be less size-selective for some deepwater sharks. This effect would suggest that a fishery for deepwater sharks, prosecuted solely by longline could result in greater removals of younger sharks, opposite to what has been observed for teleosts.

Studies of the life history parameters of these species suggest that they are slow growing, mature relatively late in life and have low fecundities (Clarke, 2001; Clarke *et al*., 2002a, 2002b; Girard and DuBuit, 1999). These characteristics imply that they can’t sustain high levels of fishing pressure. Yet they are subject to considerable and increasing exploitation in the NE Atlantic. The present study presents some properties of the two main gear types used to exploit these species. There are also gill-net fisheries for deepwater sharks, but there are no data available on these activities. There has been great debate both within ICES and European fisheries management agencies on appropriate management measures for deepwater species. The European Commission has proposed a series of TAC’s to be introduced in 2002, and later a series of proposals surrounding effort control and licencing of deepwater vessels was brought forward by the Council for the European Union. In June 2002, the Council agreed a series of TAC’s for a limited number of species. It remains unclear whether a single management measure such as this will be successful and the ICES Advisory Committee on Fisheries Management has advised that a range of management measures may be required. However the Council of the European Union also announced its intention to implement the effort control regime on a wider range of deepwater species. The debate is now being carried to the Northeast Atlantic Fisheries Commission (NEAFC), which deals with management of fisheries outside coastal jurisdictions in the region.

Fig. 8 illustrates the species interactions in the deepwater fisheries west of Ireland and Britain. It can be seen from this that there are several separate fleets/metiers. It would be useful for managers of fisheries, to consider the characteristics of the metiers involved in deepwater fisheries, in terms of fleet profile, gear used and time spent targeting deepwater species. Then the biological characteristics of the various species should be considered, and the most recent management advice. The next step might be to take account of the species that are caught by more than one gear type so that knowledge of technical interactions can be incorporated into management measures. Reliable reports from the fishery show that the average autoline longliner can catch 3-6 tons of commercial squalid sharks per day, in comparison to 1-2 tons for an average trawler. This confirms that longlines are more efficient at catching sharks than trawl. This information suggests that days at sea may provide a simple means of regulating the relative fishing capacities of the various gear-types in deepwater fleet. Based on a life history approach, the deepwater squalid sharks were found to be the most vulnerable to overexploitation, with lowest predicted recovery rates (Anon. 2001; Clarke *et al*., in press). These sharks are taken by all demersal deepwater gear-types in the area, and given their vulnerability, it would seem prudent to incorporate what is known about their biology, life history, and the technical aspects of the fisheries that capture them, into a unified management regime for deepwater fishing. Such an approach should proceed as quickly as possible.

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Table 1. Official landings data for deepwater sharks as reported to ICES (Anon. 2002) for Sub-areas VI and VII. Data for deepwater sharks represents landings of large deepwater squalids (mainly C. squamosus and C. coelolepis). Landings of other sharks included some deepwater species.

Year	Deepwater sharks		Other sharks	
	VI	VII	VI	VII
1990				
1991	944	265	944	265
1992	1953	878	1953	878
1993	2454	857	2454	857
1994	2198	1363	2198	1363
1995	1784	991	1784	991
1996	2374	754	2374	754
1997	2222	571	2222	571
1998	2081	673	2081	673
1999	2123	440	2371	440
2000	3010	621	3704	789
2001preliminary	3679	1032	4102	1353

Table 2. Details of surveys from which samples and information for this study were obtained.

Vessel	Type	No. of Hauls	Month and Year	Depths (m)
Mary M	Trawl	26	November, 1995	740-1400
Sea Sparkle	Long-line	22	November/December 1995	542-1332
Mary M	Trawl	26	September, 1996	560-1102
Skarheim	Long-line	32	August, 1997	292-2925
Mary M	Trawl	22	October/November 1997	520-1158
Loran	Long-line	38	December, 1999	514-1974

Table 3. Relative numbers of elasmobranchs and teleosts from trawl and longline surveys of the same areas of the eastern and southern slopes of the Rockall Trough in 1997.

Gear	Area	No. hauls	Depth	No. elasmobranchs	No. teleosts	Ratio elasmobranchs: teleosts
Longline	1	4	691-1350	9	3	3.0
	2	4	684-1166	10	8	1.3
	3	4	775-1401	11	9	1.2
	4	9	353-1357	12	13	0.9
	5	7	637-1418	15	7	2.1
Trawl	1	4	654-1159	5	14	0.4
	2	3	880-1105	6	18	0.3
	3	4	550-1150	7	28	0.3
	4	7	520-1100	7	34	0.2
	5	3	1100-1174	8	20	0.4

Table 4. Percentage of total catch during long-line surveys in August 1997 (Areas 1-5) and December 1999 (Areas 5-8) for *Deania calceus and Centroscymnus crepidater*.

Area (1997)	**Depth** m	***Deania calceus*** %	***Centroscymnus crepidater*** %	**Area** (1999)	**Depth** m	***Deania calceus*** %	***Centroscymnus crepidater*** %
1	1044	1.9	1.0	5	988	47.4	4.8
1	762	2.3		5	748	54.8	
				5	557	47.8	
2	1288	2.0	5.3	5	1277	19.3	10
2	1143	3.1	2.2	5	745	62.6	
2	905	0.8	0.2				
				6	585	3.7	
3	1300	0.5	1.1	6	765	60.1	
3	1099	0.9		6	944	34.1	1.9
3	954	0.9	0.8	6	1097	39.8	0.3
3	775	4.2		6	1304	2.5	2.4
				6	1378	1.8	7.8
4	1275	3.1	11.5				
4	969	5.4	3.1	7	1227	6.6	7.4
4	723	4.2	2.0	7	1038	26.6	5.4
4	1218	5.3	3.7	7	907	34	0.8
4	902	18.1	2.2	7	1403	1.2	8.7
4	740	40.8	0.1	7	695	1.4	2.5
4	545	11.7		7	1209	7.1	2.4
5	1404	1.2		8	1251	51.2	2.7
5	1134	17.0	1.9	8	610	57.7	0.6
5	806	28.5	0.0	8	883	75.8	
5	637	75.2		8	1444	7	11.9
5	1178	8.4	3.8	8	1032	15	1.4
5	968	36.5	0.6	8	849	5.7	
5	688	40.7		8	995	10.6	5.7
				8	988	30.4	2
				8	1105	38.4	4.1
				8	1071	14.3	1.6
				8	1071	24	5
				8	1125	48.9	4.1

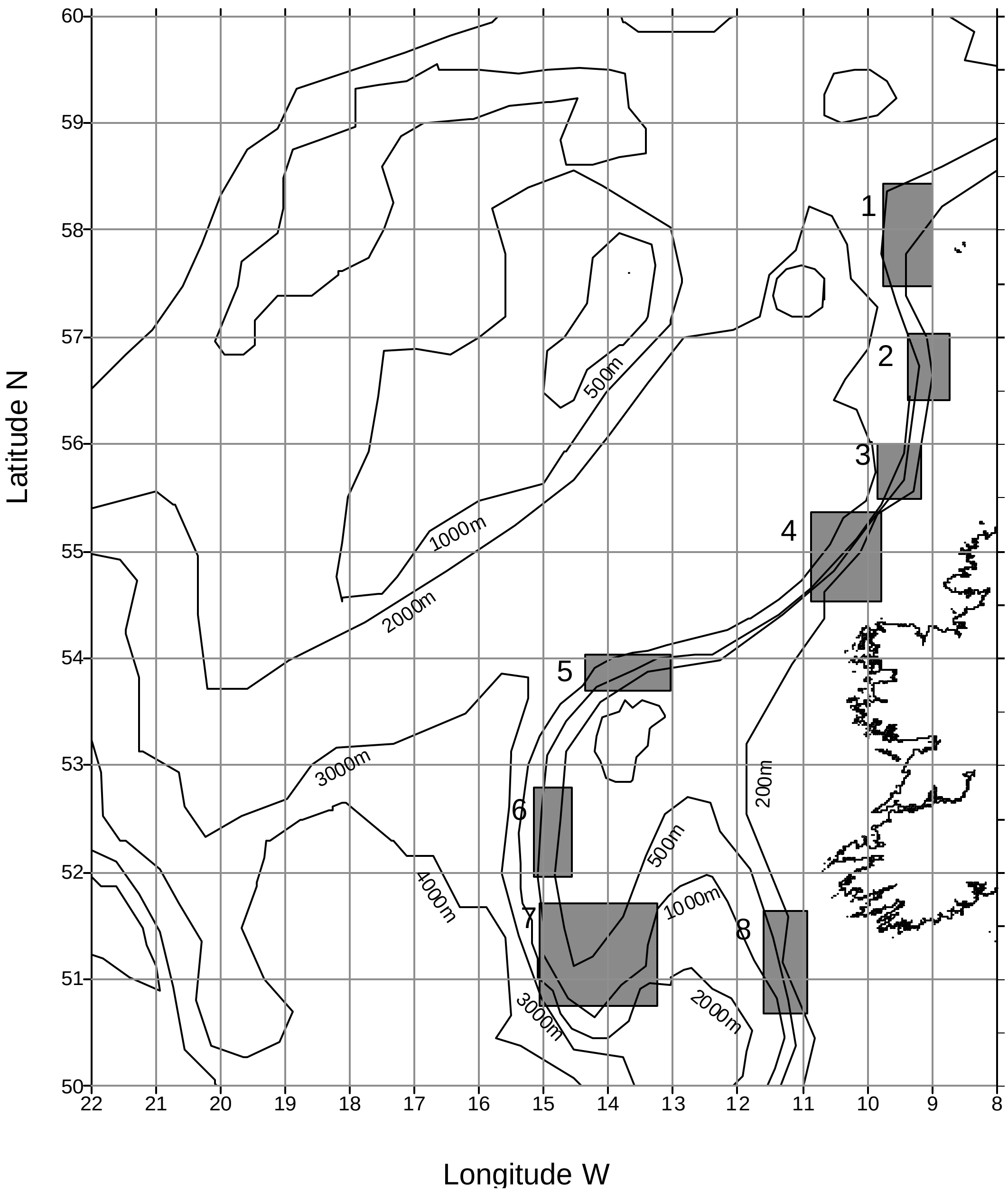

Fig. 1. The 8 areas where stations were completed and shark sampling carried out.

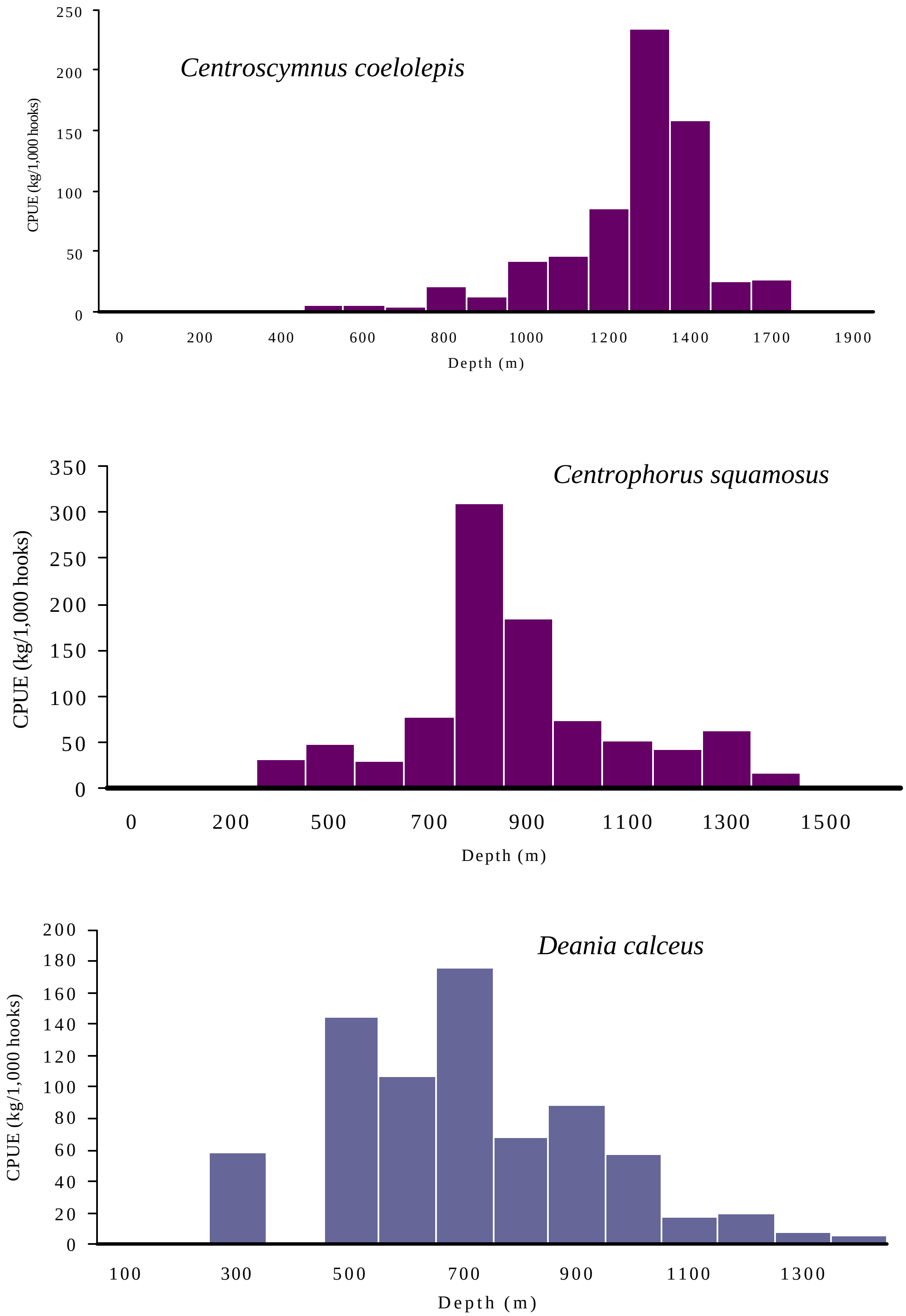

Fig. 2. Catch rates (kg/1,000 hooks) from longline surveys 1995-2000. Each 100 m interval indicated by its lower value.

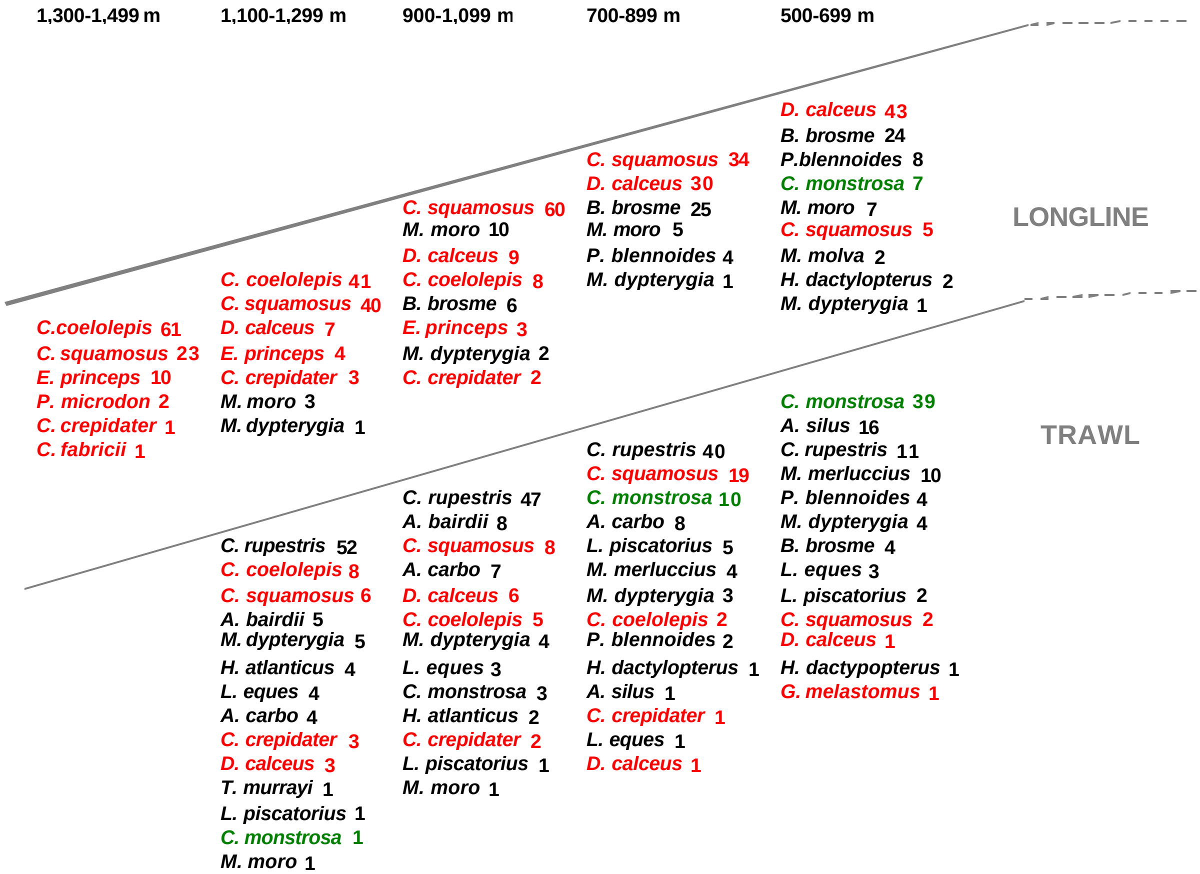

Fig. 3. Percentage composition of total catch by species in trawl and longline catches from the continental slopes of the Rockall Trough. Data presented by 200 m depth interval. Elasmobranchs indicated in red, teleosts in black and chimaeras in green.

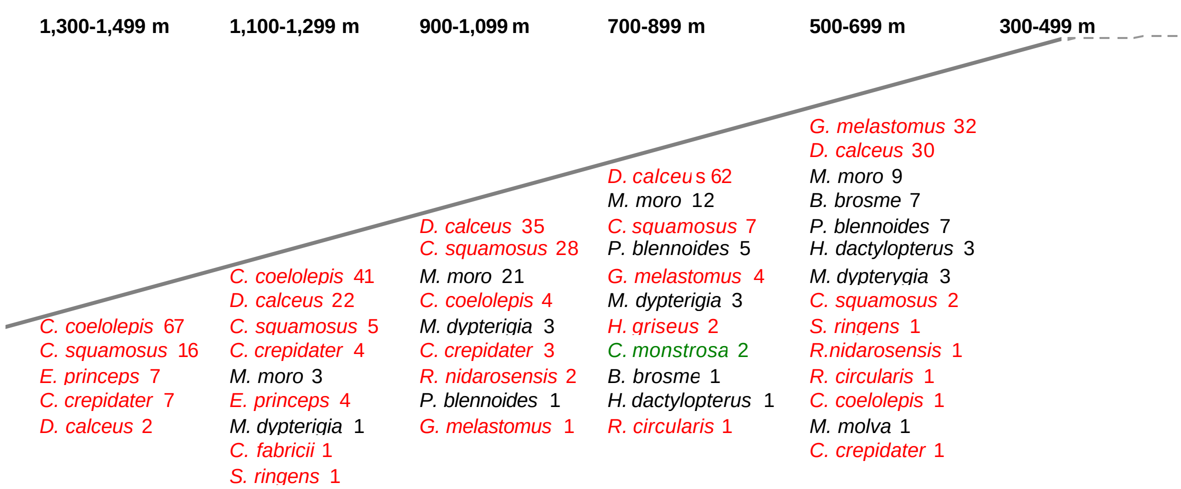

Fig. 4. Percentage composition of total catch by species longline catches from the continental slopes of the Porcupine Bank. Data presented by 200 m depth interval. Elasmobranchs indicated in red, teleosts in black and chimaeras in green.

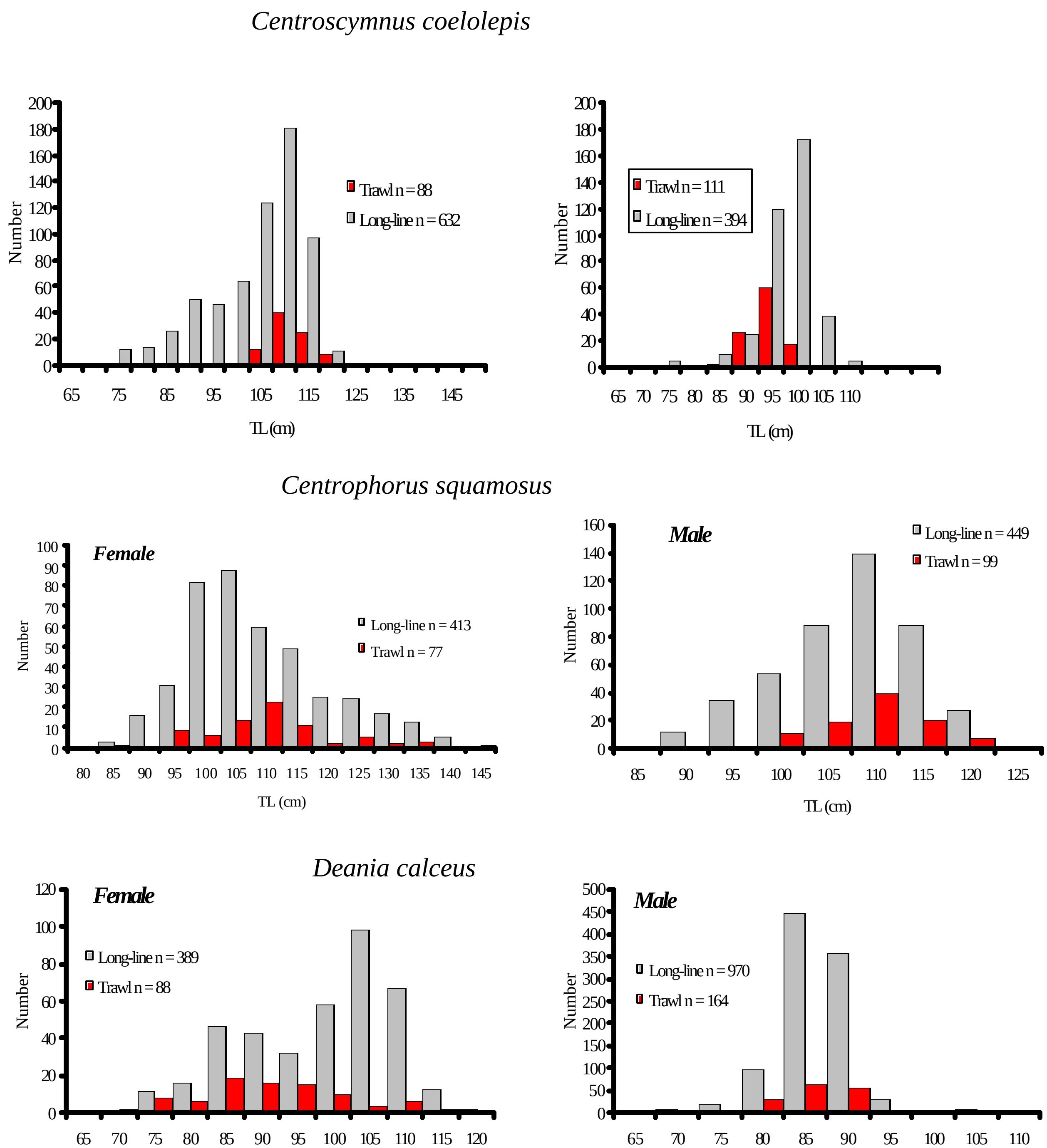

Fig. 5. Comparison of length frequencies from trawl and longline surveys of the Rockall Trough in 1997.

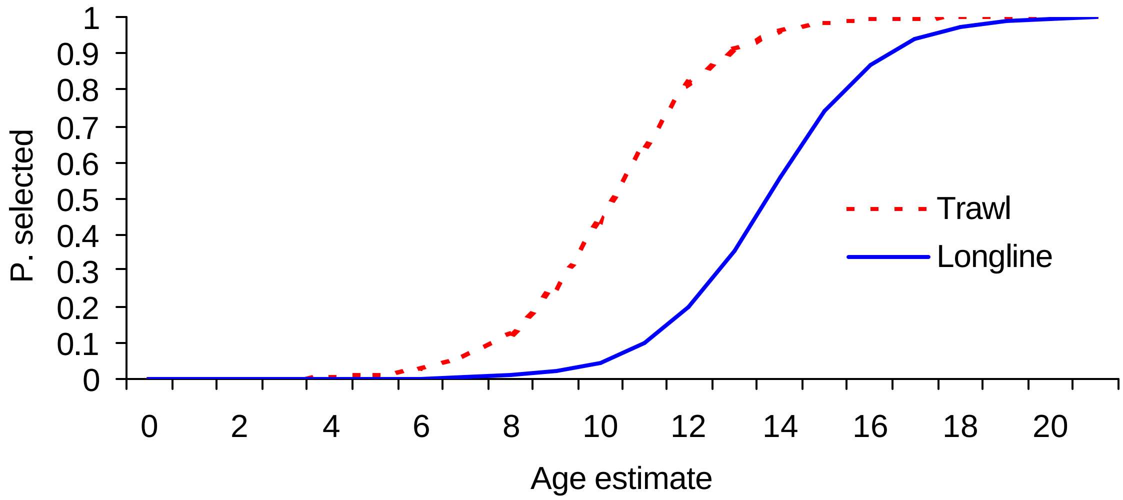

Fig. 6. Estimated selectivity ogives for *Deania calceus*, combining both sexes, derived from catch curve analyses. Estimated Age_{50} (trawl) = 11 and Age_{50} (longline) = 15.

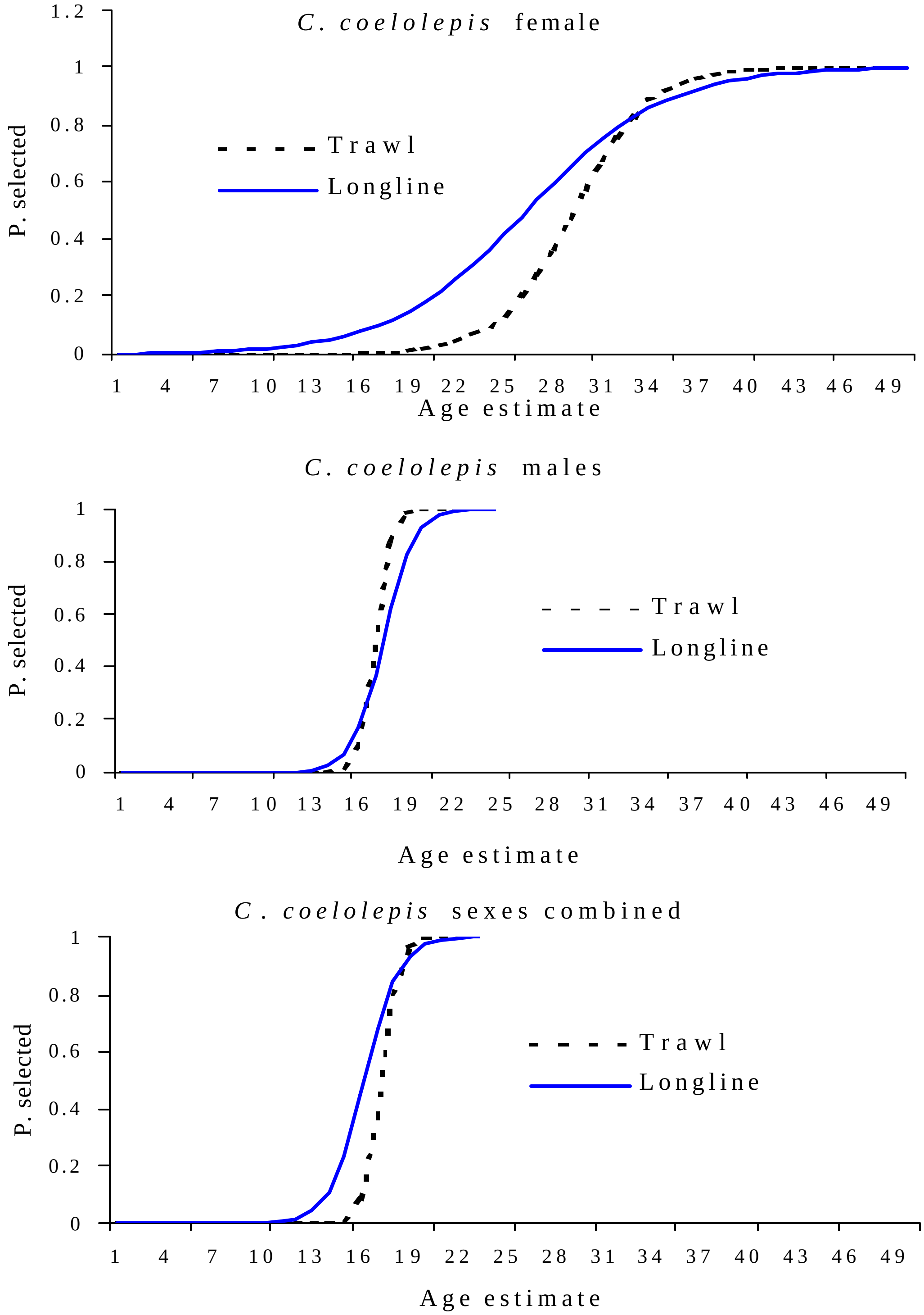

Fig. 7. Estimated selectivity ogives for *C. coelolepis*, derived from length-converted catch curves developed with hypothetical von Bertalanffy growth parameters.

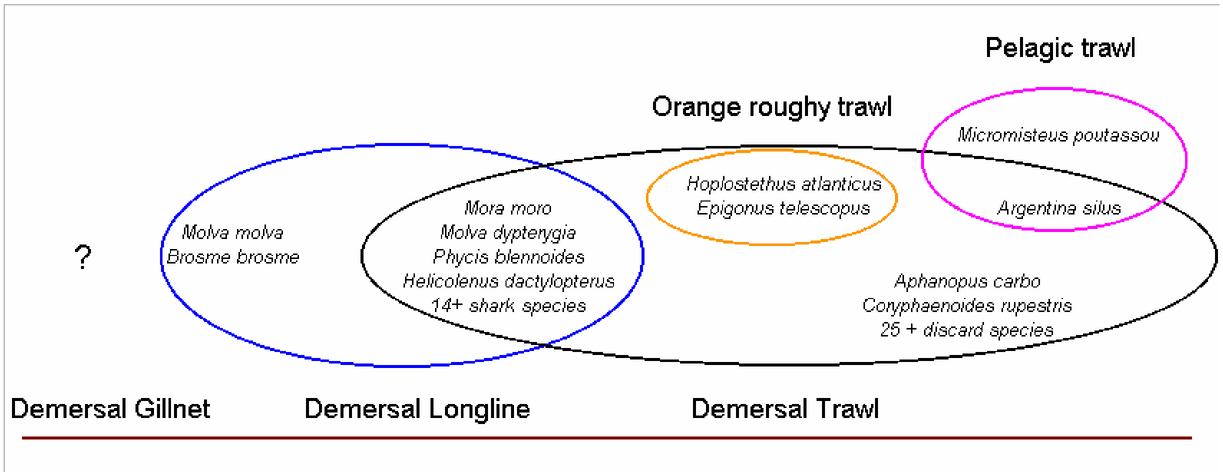

Fig. 8. Schematic representation of the interactions between the main deepwater fishing gear types in the area west of Ireland and Britain. Some species are caught by more than one gear. Data on by-catch in the pelagic trawl fishery for greater argentine *Argentina silus* are lacking. No data are available for gill net fisheries.