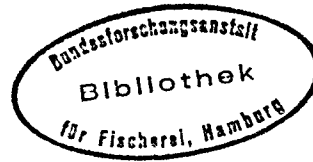


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**Introduction on the finfish by-catches and discards in
the Belgian Norway lobster (*Nephrops norvegicus*) fishery**

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ABSTRACT

In June and September 1993 two sampling campaigns were carried out on board of a commercial *Nephrops* trawler operating in the Botney Gut - Silver Pit area (central North Sea), to investigate fishermen's selection and discarding of whiting, cod, gurnards, dab, plaice and sole.

In general, the numbers of undersized cod, plaice and sole returned to the sea were very low, with figures hardly exceeding 30 individuals per species per day. Conversely, the numbers of whiting and dab discarded were sometimes extremely large, depending on the season and the area fished.

Fishermen's selection curves are presented for each species, and discussed in relation to the main factors which drive size selection and discarding on the *Nephrops* trawlers. A tentative estimate of the total numbers of undersized and unmarketable whiting discarded by the Belgian *Nephrops* trawler fleet is given, and the implications with respect to the conservation of juvenile whiting are discussed.

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INTRODUCTION

Although the *Nephrops* fisheries are often considered as being focused on one particular target species, many of them are in reality of a much more mixed nature, with important round- and flatfish by-catches, both in terms of quantities landed and return to the fishermen.

The legal minimum mesh size in the *Nephrops* fisheries in the North Sea is 70 mm, as opposed to 80 or 100 mm for most other fisheries targeting round- or flatfish. In fisheries with "smaller" mesh sizes, the by-catches of undersized protected fish species (such as cod, haddock, whiting, hake, plaice and sole) can be quite large, and discarding may pose a problem, in the sense that it may cause considerable damage to the juvenile fish stocks. For some time, the possible impact of the *Nephrops* fisheries on the stocks of juvenile whiting and hake has been a reason for concern in areas such as the Irish Sea and the Bay of Biscay (see e.g. ICES, 1984 ; BENNETT, 1985). Several, mostly technical solutions, including separator trawls (see e.g. MAIN and SANGSTER, 1982, 1985 ; HILLIS, 1983 ; ICES, 1984) and square mesh windows (see e.g. THORSTEINSSON, 1991 ; ULMESTRAND and LARSSON, 1991 ; BRIGGS, 1992), have been explored, to reduce the by-catches of these species and the overall levels of their discard mortalities.

Data on the catch composition and the discarding practices in the *Nephrops* fisheries in the North Sea are extremely scarce, except for the Scottish *Nephrops* fisheries, where the ongoing discard sampling programmes also cover finfish species such as whiting (REEVES, pers. comm.).

The present paper summarizes the results of preliminary investigations on finfish catch composition and discarding in the Belgian *Nephrops* fishery in the Botney Gut - Silver Pit area (central North Sea). Particular attention was paid to whiting, *Merlangius merlangus* ; cod, *Gadus morhua* ; gurnards, *Trigla spp.* ; dab, *Limanda limanda* ; plaice, *Pleuronectes platessa* ; and sole, *Solea solea*. The results with respect to *Nephrops* itself are discussed in another paper (REDANT and POLET, 1994).

LANDINGS COMPOSITION of the BELGIAN *Nephrops* TRAWLERS

Trends in landings and auction sales figures

Until recently, the Belgian otter trawler fleet comprised 25-30 vessels which, either full-time or part-time, were targeted towards *Nephrops*. Roughly two-thirds of these could be considered as *Nephrops* specialist trawlers, fishing

almost year-round for *Nephrops*, mostly in the central and southern North Sea (ICES Sub-areas IVb and IVc). The others fished for *Nephrops* during part of the year only, usually between April and September, when the catch rates of *Nephrops* are highest.

Recent trends (1984-93) in the species composition and the auction sales figures of the landings by the Belgian *Nephrops* directed trawler fleet currently operating in the central and southern North Sea, are shown in Figures 1 and 2 ; their landings-per-unit-effort (LPUEs, by species, in kg/hour trawling), and their proceeds-per-unit-effort (in BEF/hour trawling), in Figures 3 and 4. The top-10 species in terms of quantities landed and sales figures (data for 1993 and averages for 1984-93) are listed in Tables 1 and 2.

Until 1992, the landings of the *Nephrops* trawler fleet (all species combined) have fluctuated between 1,700 and 2,300 tons, with peak values of 2,272 tons in 1985, and 2,293 tons in 1990 (Figure 1). In 1993, however, the landings fell to just under 1,560 tons, the lowest figure in the data series.

In general, the contribution of *Nephrops* to the landings has been fairly stable, at a level of 25-30 %, with an exceptional low of only 21 % in 1986, and a record share of up to 35 % in 1993 (Figure 1). Roughly 90-95 % of these were landed from the Botney Gut - Silver Pit area (ICES statistical rectangles 37F1-F4 ; 36F1-F4 and 35F2-F3), together with much smaller quantities from the Farn Deep (off the English east coast) and, since about 1990, the Witte Bank (north of Terschellinger Bank) (ICES, 1994a).

Rather surprisingly, the most important species in terms of quantities landed, appears to be plaice, with relative contributions ranging from 25 up to 45 % of the annual landings by the *Nephrops* trawlers (Figure 1 and Table 1). Since about 1990, there has been a marked increase in the "by-landings" of sole, from less than 100 tons per year in the mid- and late 1980s, to over 225 tons in the early 1990s. An important part of these were taken on the Witte Bank, which has become increasingly popular amongst Belgian *Nephrops* fishermen, particularly because of the valuable by-catches of sole.

It should be noticed, however, that not all landings by the Belgian *Nephrops* trawlers are from actual *Nephrops* grounds, such as the Botney Gut - Silver Pit, the Farn Deep or the Witte Bank. Depending on various factors (market demand, auction prices, *Nephrops* catch rates, etc.), vessels may direct part of their effort towards other fishing grounds or other species, even during the same voyage. Landings and effort data for the Belgian *Nephrops* trawlers are recorded by voyage, but precise information on the directedness of their voyages towards *Nephrops* or on the origin of their catches is usually lacking. The "by-landings" of cartilaginous fish are a typical example : most of these are not taken in the Botney Gut - Silver Pit area, but on more westerly fishing grounds, which are visited by the vessels particularly during summer time,

when the catch rates of *Nephrops* are highest and their shelflife relatively short. In these months, vessels often start their voyages fishing for cartilaginous fish with a finfish trawl (with a 90 or a 100 mm codend mesh size); then steam to the Botney Gut or the Silver Pit, change their gear, and go on fishing for *Nephrops*.

In terms of financial outcome, *Nephrops* is the most important species to the fishery, with relative shares ranging from 40 to 55 % of the total sales figures (Figure 2). It should be emphasized that nearly half of the annual sales figures of the *Nephrops* fishery is made up by round- and flatfish, with sole, plaice, cod and turbot being the most important contributors (Figure 2 and Table 2).

Trends in LPUEs and proceeds-per-unit-effort

The LPUEs of the *Nephrops* trawlers (all species combined) show a clear downward trend, from almost 40 kg/hour trawling in 1984, to 24 kg/hour in 1991 and 1992, i.e. a 40 % decline (Figure 3). Most recently, the LPUEs increased again, to just over 26 kg/hour trawling. The almost continuous decline in the LPUEs, from 1984 to 1992, is not attributable to one single species, but appears to be the combined effect of an overall decrease in the LPUEs of cod, whiting and plaice (the latter especially since 1988).

The proceeds-per-unit-effort (all species combined) remained fairly constant from 1984 to 1990, then fell off rapidly from 3,500 BEF/hour trawling to only 2,500 BEF/hour in 1992, i.e. a drop of almost 30 % (Figure 4). In 1993 they slightly recovered again, to just over 2,600 BEF/hour trawling. The dramatic decline in proceeds-per-unit-effort largely explains why the owners of several *Nephrops* trawlers decided to cease their activities and to have their vessels decommissioned.

MATERIALS and METHODS

Size compositions of landings and discards

Data on the finfish by-catches and discards were collected during two voyages, viz. in June and September 1993, with a Belgian *Nephrops* trawler currently fishing in the Botney Gut - Silver Pit area.

The finfish "by-landings" (i.e. fish retained by the crew for marketing) and discards were sampled after the catch had been sorted by the ship's crew. As a rule, all whiting, cod, gurnards, dab, plaice and sole retained by the crew were measured, together with the discards from 2-4 baskets of "trash" (viz. 1 or 2

baskets from each side of the sorting table ; see REDANT and POLET, 1994). Fish were measured with a ruler, to the nearest cm below. The numbers measured per species and per haul are shown in Tables 3 (June voyage) and 4 (September voyage).

Data processing

The numbers-at-length in each sample were first raised to total numbers landed and discarded per standard haul of 3½ hours, using raising factors based on the ratios between the total volume of the landings and the discards, and the volume of the corresponding samples. These data were then grouped into so-called "data sets" of six standard hauls each (taken within a time span of approximately 48 hours), which were chosen so as to cover a full period of 24 hours. The numbers thus obtained give an idea of the total numbers of fish landed and discarded per fishing day. The groupings of standard hauls into "data sets" are also shown in Tables 3 and 4.

All subsequent calculations (e.g. the proportions retained by the crew, etc.) were then based on the numbers-at-length, obtained by summing the numbers landed and discarded at length across each "data set" of six standard hauls.

Fishermen's selection curves

Fishermen's selection curves were calculated using ConStat's "CC" package. Depending on the expected shape of the selection curves, as suggested by the overall appearance of the observed retention rates, different combinations of selection ogives were calculated : two symmetrical ones (Logit and Probit), together with one or two asymmetrical ones (Log Log and/or Complementary Log Log, also called C Log Log). Retention rates which were way out of the curves (usually because the number of animals in that particular size class was too small to produce a sensible retention rate) were excluded from these calculations.

For whiting, the data base was sufficiently large to allow the calculation of fishermen's selection curves for each "data set" separately. For the other species, however, either the numbers landed (dab and gurnards), or the numbers discarded (cod, plaice and sole), were generally too small to produce reliable fishermen's selection curves on a 24 hours' basis. Therefore, the data for cod, gurnards, dab, plaice and sole were pooled into one large data set, including all 36 hauls analyzed during the two voyages.

Details on the "CC" package, and on the criteria used to evaluate the goodness of fit of the selection curves, are given in POLET and REDANT (1994).

RESULTS

Numbers landed and discarded per day

The total numbers of whiting, cod, gurnards, dab, plaice and sole landed and discarded per fishing day are shown in Figures 5-10.

As for *Nephrops* (REDANT and POLET, 1994), the quantities of by-catch fish taken varied considerably from one haul to another, depending on the season, the time of the day and the location of the hauls.

It should be stressed that, in general, the numbers of undersized cod, plaice and sole discarded per day were very small, viz. < 40 for cod, < 70 for plaice and < 40 for sole (Figures 6, 9 and 10). Conversely, the numbers of whiting and dab discarded sometimes were extremely high, depending on both the location of the hauls and the time of the year. For whiting, values exceeding $3.5 \cdot 10^3$ discards per day were observed throughout the September voyage (Figure 5) ; for dab, values exceeding $8.0 \cdot 10^3$ discards were noted during both voyages, particularly in the north-western part of the Botney Gut (Figure 8). For gurnards too, the numbers discarded exceeded by far the numbers landed (Figure 7), largely because in Belgium there is almost no market for "small" gurnard (say < 27 or 28 cm).

Size compositions of landings and discards

The length frequency distributions of the whiting landings and discards are shown in Figure 11 (all June "data sets" combined) and Figure 12 (all September "data sets" combined) ; those for dab in Figures 13 and 14.

Particular attention should be drawn to the occurrence of relatively large numbers of 0-group whiting (with a size of 5-10 cm) in the September catches (Figure 12).

Fishermen's selection

The fishermen's selection curves for whiting are plotted in Figures 15-18 for the June voyage, and in Figures 19-22 for the September voyage. The curves for all individual "data sets" are compared in Figure 23.

As already pointed out in the Materials and Methods' section, the numbers landed and/or discarded of cod, gurnards, dab, plaice and sole, were too small to yield reliable fishermen's selection curves for each "data set" separately. The

curves for these species were calculated from the data for all hauls in the six "data sets" combined, and are given in Figures 24-28.

For cod, dab, plaice and sole, where the observed retention rates suggested a very sharp and (almost) symmetrical selection pattern, only the Logit and Probit curves were calculated. For whiting, where the retention rates suggested a clearly asymmetrical selection pattern, the calculations were complemented with a C Log Log curve ; those for gurnard, with both a Log Log and a C Log Log curve. The selection curves which best fitted the observed retention rates are shown as bold, solid lines ; alternatives, which gave a more or less equally good fit, as thin, solid lines ; the others as dashed lines. The parameters α and β , and the L_{50} 's for each selection curve are summarized in Tables 5 (whiting) and 6 (cod, gurnards, dab, plaice and sole).

The selection curves for cod, dab, plaice and sole are very steep, with an L_{50} close to (cod, plaice and sole) or clearly above (dab) the legal minimum landing size (MLS) (Figures 24-28 and Table 6). Size selection on particularly cod, plaice and sole was almost knife-edged, with very few animals below the MLS being retained, and almost none above the MLS being discarded (Figures 24, 27 and 28).

The curves for gurnards are slightly smoother than those for the other species, with an L_{50} of ≈ 27.5 cm (there is no MLS for gurnards in ICES Sub-area IV) (Figure 25 and Table 6).

The selection curves for whiting were mostly asymmetrical, with a gentle curvature between the lengths at 0 and 25 % retention, and a sharp bend in the area just below the length at 100 % retention. It is especially worth noting that all selection curves had an L_{50} at least 5 cm, and sometimes even as much as 10 cm above the MLS of 23 cm (Figures 15-22).

As for *Nephrops* (REDANT and POLET, 1994), the selection curves for whiting clearly shifted to the right from June to September (Figure 23). In this case, however, the shift could not be explained by an increase in the catches of marketable animals. The numbers of whiting actually landed were even lower in September than in June (on average 150 per day in September as opposed to 320 in June) (Figure 5).

The discarding of whiting was clearly driven by a combination of factors, including both market demand and work load. In June, when the auction price for whiting was at "normal" levels, and the *Nephrops* catch rates were low, relatively large quantities of "small" whiting were retained by the crew ($L_{25} \approx 29$ cm and $L_{50} \approx 30-31$ cm ; Figures 15-18). In September, however, both the poor demand for whiting on the local market (which resulted in low auction prices during most of the summer of 1993), and the increased work load on board of the vessel (with sometimes several hundreds of kilogrammes of raw

catch to be sorted per haul), made that the crew retained the largest, most valuable whiting only ($L_{25} \approx 31-32$ cm and $L_{50} \approx 34-35$ cm ; Figures 19-22).

DISCUSSION

Fishermen's selection

In the absence of data on other *Nephrops* trawlers or other seasons, it is difficult to speculate on how the results of the present study compare to the situation in the Belgian *Nephrops* fishery as a whole.

For species such as cod, plaice and sole, where fishermen's selection is almost knife-edged at the legal minimum landing size (MLS), it can be assumed that all *Nephrops* trawlers have very similar and consistent discarding practices. The same probably holds for gurnards and dab, where the landing size largely depends on (fairly stable) local market requirements. For both dab (MLS 23 cm) and gurnards (no MLS in the North Sea area), there is no market for animals below a size of 27-28 cm.

For whiting, however, the situation appeared to be much less straightforward. Particularly during the second voyage, there were strong indications that the discarding practices on the vessel sampled differed from those on the other *Nephrops* trawlers fishing in the area.

Indirect evidence on these differences in discarding practices was obtained from comparative investigations on the size composition of the whiting landings by a number of *Nephrops* trawlers. Since all *Nephrops* trawlers investigated had been fishing on the same grounds, it seemed reasonable to assume that they also had been fishing the same whiting population, and hence that the size compositions of their whiting catches were identical, or at least very similar. If fishermen's selection on these vessels had taken place according to the same standards, the size distributions of their landings too could be expected to be roughly similar. Similarities (or differences) in the size composition of the landings could thus be considered as indirect evidence for similarities (or differences) in fishermen's selection and discarding practices.

Data on the size composition of the whiting landings by *Nephrops* trawlers were collected throughout the summer of 1993, at the auctions of Oostende and Zeebrugge. In total 12 data series were collected, viz. one in June, four in July, three in August, and four in September. The cumulated relative frequency distributions of the whiting landings are shown in Figure 29. In this figure, the vessel which was engaged in the sea sampling programme, is referred to as Vessel A ; the others as Vessels B to K. The dates refer to the dates of auctioning.

The results of these investigations clearly show that the size composition of the whiting landings by Vessel A in June and early August was roughly comparable to the size composition of the landings by the other *Nephrops* trawlers (Figure 29, top). In September, however, Vessel A landed much less "small" whiting than the other vessels, and this resulted in a cumulative size distribution which was clearly shifted to the right (Figure 29, bottom).

The obvious conclusion of this comparative study is that the discarding pattern observed during the September voyage cannot be considered as being representative for the Belgian *Nephrops* trawler fleet as a whole. The one observed during the June voyage, however, seems to be much closer to the discarding practices on the other vessels (including those sampled in September), and therefore can be considered as being a fair approximation of the "average" discarding pattern for whiting.

In order to obtain an estimate of the numbers of whiting discarded per day and per hour fishing by an "average" Belgian *Nephrops* trawler, the data for September were re-calculated, starting from the original numbers-at-length in the unsorted catches, but using the fishermen's selection curve observed in June. The results of these re-calculations are shown in the text table below.

| | June | September | September re-calculated |
|---------------------|------|-----------|-------------------------|
| Nos. discarded/day | 925 | 4,760 | 4,335 |
| Nos. discarded/hour | 44 | 227 | 207 |

The resulting figures (viz. 44 whiting discards/hour fishing for June, and 207 for September) are of the same order or smaller than the figures reported for the Scottish *Nephrops* fisheries (viz. 305 for the 1st quarter of 1993, 513 for the 2nd, 174 for the 3rd, and 134 for the 4th) (REEVES, pers. comm.).

General considerations on the finfish discards by the Belgian *Nephrops* directed trawler fleet

For now, it is impossible to accurately quantify the impact of the Belgian *Nephrops* directed fishery on the stocks of undersized cod, plaice and sole in the North Sea.

Moreover, there are no comprehensive estimates of the numbers of cod, plaice and sole discarded in the North Sea as a whole (see e.g. ICES, 1994b), to which the estimates for the Belgian *Nephrops* fishery could be compared.

Bearing in mind, however,

- (a) that the average numbers of cod, plaice and sole discarded per day by the *Nephrops* trawlers (Figures 6, 9 and 10) are substantially smaller than the numbers discarded by Belgian flatfish directed beam trawlers (POLET, unpublished data), and
- (b) that the total fishing effort by the Belgian *Nephrops* trawler fleet in the North Sea ($\approx 59,600$ hours trawling in 1993) is small as compared to the effort by e.g. the Belgian beam trawler fleet ($\approx 272,700$ hours),

it can reasonably be assumed that the impact of this particular *Nephrops* fishery on juvenile cod, plaice and sole is almost negligible.

A rough estimation of the total number of undersized and unmarketable whiting discarded by the Belgian *Nephrops* trawlers, based on the average number of whiting discarded per hour fishing (≈ 125 for all "data sets" combined), and the total effort by the Belgian *Nephrops* trawler fleet in 1993 ($\approx 59,600$ hours trawling), gives a figure of $\approx 7.5 \cdot 10^6$ discards.

At the time this paper was written, the data for 1993 on the numbers of whiting discarded in the North Sea as a whole were not yet available. Last year's whiting assessment, made by the Working Group on the Assessment of Demersal Stocks in the North Sea and the Skagerrak, however, includes a prediction of the total *biomass* of the discards for 1993, viz. 46,700 tons (ICES, 1994b, Table 3.4.18). This figure was converted to expected *numbers* discarded, using the relationship between the numbers and the biomasses of the whiting discards, derived from the historical data series (1960-92) given in this year's report of the North Sea Working Group (Figure 30, after ICES, 1994b, Table 3.4.2). The figure thus obtained was $\approx 325 \cdot 10^6$ discards.

Although these estimates are rather crude, they seem to indicate that the impact of the Belgian *Nephrops* fishery on the juvenile whiting stock in the North Sea is relatively small. Indeed, only $\approx 2\%$ of all (expected) whiting discards in 1993 would be attributed to the Belgian *Nephrops* directed trawler fleet.

The introduction of a square mesh window in the top panel of the *Nephrops* trawls is generally considered to be an effective means to reduce the by-catches of protected roundfish species, such as cod, haddock and whiting (see e.g. THORSTEINSSON, 1991 ; ULMESTRAND and LARSSON, 1991 ; BRIGGS, 1992). In the case of the Belgian *Nephrops* fishery, however, this may not bring much of a solution to the "by-catch problem". Comparative experiments, also carried out in 1993, have shown that the extra escapes through the window concern mostly whiting of marketable sizes, and that the escapement of undersized whiting is not substantially improved by the insertion of a square mesh window (POLET and REDANT, 1994).

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LITERATURE CITED

BENNETT, D. (1985) : The problem of small mesh *Nephrops* trawls in the Irish Sea - are separator trawls the answer ?
ICES, Shellfish Comm., C.M. 1985/K:38 (mimeo).

BRIGGS, R.P. (1992) : An assessment of nets with a square mesh panel as a whiting conservation tool in the Irish Sea *Nephrops* fishery.
Fisheries Research, 13, 133-152.

HILLIS, J.P. (1983) : Experiment with a double codend *Nephrops* trawl.
ICES, Fish Capture Comm., C.M. 1983/B:29 (mimeo).

ICES (1984) : Report of the *Nephrops* Working Group.
ICES, Shellfish Comm., C.M. 1984/K:4 (mimeo).

ICES (1994a) : Report of the Working Group on *Nephrops* and *Pandalus* Stocks.
ICES, C.M. 1994/Assess:12 (mimeo).

ICES (1994b) : Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak.
ICES, C.M. 1994/Assess:6 (mimeo).

MAIN, J. and SANGSTER, G.I. (1982) : A study of separating fish from *Nephrops* in a bottom trawl.
Scottish Fisheries Research Report, 124.

MAIN, J. and SANGSTER, G.I. (1985) : Trawling experiments with a two-level net to minimise the undersized gadoid by-catches in a *Nephrops* fishery.
Fisheries Research, 3, 131-145.

POLET, H. and F. REDANT (1994) : Selectivity experiments in the Belgian Norway lobster (*Nephrops norvegicus*) fishery.
ICES, Fish Capture Comm., C.M. 1994/B:39 (mimeo).

REDANT, F. and H. POLET (1994) : Results of a discard study on the Belgian *Nephrops* fishery in the central North Sea.
ICES, Shellfish Comm., C.M. 1994/K:44 (mimeo).

THORSTEINSSON, G. (1991) : Experiments with square mesh windows in the *Nephrops* trawling off South Iceland.
ICES, Fish Capture Comm., C.M. 1991/B:3 (mimeo).

ULMESTRAND, M. and P.O. LARSSON (1991) : Experiments with a square mesh window in the top panel of a *Nephrops* trawl.
ICES, Fish Capture Comm., C.M. 1991/B:50 (mimeo).

| Table 1 - Top-10 species in the landings of the Belgian Nephrops fishery, in terms of quantities landed | | | | | |
|---|------|------|----------------------|------|------|
| Data for 1993 | | | Averages for 1984-93 | | |
| Species | Land | % | Species | Land | % |
| Nephrops | 552 | 35.2 | Plaice | 655 | 33.3 |
| Plaice | 421 | 26.9 | Nephrops | 529 | 26.9 |
| Whiting | 153 | 9.8 | Whiting | 239 | 12.2 |
| Sole | 115 | 7.3 | Cod | 156 | 8.0 |
| Cod | 80 | 5.1 | Sole | 119 | 6.0 |
| Rays | 44 | 2.8 | Turbot | 37 | 1.9 |
| Turbot | 42 | 2.7 | Whelk | 36 | 1.8 |
| Grey gurnard | 35 | 2.2 | Dab | 33 | 1.7 |
| Dab | 29 | 1.9 | Rays | 31 | 1.6 |
| Whelk | 16 | 1.0 | Haddock | 28 | 1.4 |

Land : Landings in tons.

% : Percent of total landings for all species combined.

| Table 2 - Top-10 species in the landings of the Belgian Nephrops fishery, in terms of auction sales figures | | | | | |
|---|-----|------|----------------------|-----|------|
| Data for 1993 | | | Averages for 1984-93 | | |
| Species | ASF | % | Species | ASF | % |
| Nephrops | 774 | 49.7 | Nephrops | 905 | 45.7 |
| Sole | 241 | 15.4 | Plaice | 318 | 16.1 |
| Plaice | 212 | 13.6 | Sole | 309 | 15.6 |
| Turbot | 136 | 8.7 | Turbot | 148 | 7.4 |
| Cod | 47 | 3.1 | Cod | 108 | 5.5 |
| Whiting | 41 | 2.6 | Whiting | 78 | 3.9 |
| Rays | 27 | 1.8 | Rays | 21 | 1.1 |
| Brill | 24 | 1.6 | Brill | 17 | 0.9 |
| Dab | 7 | 0.5 | Spurdog | 11 | 0.6 |
| Anglerfish | 7 | 0.4 | Lemon sole | 11 | 0.6 |

ASF : Auction sales figures (in million BEF).

% : Percent of total ASF for all species combined.

| Table 3 - Groupings of hauls into "data sets" of six hauls each, and numbers of fish measured during the June voyage (17-29.06.1993) | | | | | | | | | |
|--|----------|----------|---------------|---------|------|------|------|----------|------|
| Data set | Haul no. | Date | Hour at start | Whiting | | Cod | | Gurnards | |
| | | | | Land | Disc | Land | Disc | Land | Disc |
| Jun S1 | 3 | 18.06.93 | 16.30 | 26 | 23 | 4 | 1 | 11 | 15 |
| | 5 | 19.06.93 | 0.30 | 26 | 17 | 9 | 1 | 2 | - |
| | 6 | 19.06.93 | 4.30 | 26 | 17 | 5 | 1 | 1 | 14 |
| | 8 | 19.06.93 | 12.30 | 66 | 22 | 13 | 2 | 2 | 3 |
| | 10 | 19.06.93 | 20.30 | 37 | 18 | 1 | 2 | 4 | 12 |
| | 13 | 20.06.93 | 8.30 | 25 | 24 | 7 | 5 | 4 | 76 |
| Jun S2 | 14 | 20.06.93 | 12.30 | 13 | 74 | 23 | 1 | 1 | 13 |
| | 16 | 20.06.93 | 20.30 | 58 | 220 | 2 | - | - | 1 |
| | 18 | 21.06.93 | 4.30 | 18 | 32 | 14 | - | 10 | 9 |
| | 19 | 21.06.93 | 8.30 | 31 | 41 | 15 | 1 | 3 | 12 |
| | 21 | 21.06.93 | 16.30 | 38 | 134 | 18 | 1 | 2 | 6 |
| | 23 | 22.06.93 | 0.30 | 61 | 28 | 8 | 5 | 9 | 19 |
| Jun S3 | 45 | 26.06.93 | 1.30 | 156 | 234 | 27 | 2 | 9 | 30 |
| | 47 | 26.06.93 | 11.00 | 35 | 99 | 19 | - | 4 | 35 |
| | 52 | 27.06.93 | 8.30 | 103 | 126 | 9 | 2 | 2 | 15 |
| | 55 | 27.06.93 | 20.30 | 76 | 106 | 26 | 12 | 3 | 53 |
| | 57 | 28.06.93 | 4.30 | 64 | 98 | 21 | 3 | 4 | 42 |
| | 60 | 28.06.93 | 17.00 | 154 | 176 | 21 | 2 | 3 | 48 |

Land : Nos. in the landings.

Disc : Nos. in sample of the discards.

| Table 3 - Continued. | | | | | | | | | |
|----------------------|----------|----------|---------------|------|------|--------|------|------|------|
| Data set | Haul no. | Date | Hour at start | Dab | | Plaice | | Sole | |
| | | | | Land | Disc | Land | Disc | Land | Disc |
| Jun S1 | 3 | 18.06.93 | 16.30 | 6 | 245 | 76 | 4 | 3 | 1 |
| | 5 | 19.06.93 | 0.30 | 9 | 178 | 68 | 7 | 6 | 10 |
| | 6 | 19.06.93 | 4.30 | 10 | 202 | 46 | - | 5 | 12 |
| | 8 | 19.06.93 | 12.30 | 13 | 195 | 205 | 5 | 5 | 2 |
| | 10 | 19.06.93 | 20.30 | 4 | 172 | 37 | 1 | 2 | 3 |
| | 13 | 20.06.93 | 8.30 | 7 | 156 | 17 | 1 | 5 | - |
| Jun S2 | 14 | 20.06.93 | 12.30 | 3 | 70 | 31 | 4 | 5 | - |
| | 16 | 20.06.93 | 20.30 | 1 | 126 | 18 | 10 | 4 | 1 |
| | 18 | 21.06.93 | 4.30 | 1 | 107 | 82 | 3 | 19 | 3 |
| | 19 | 21.06.93 | 8.30 | 3 | 104 | 52 | 6 | 12 | 1 |
| | 21 | 21.06.93 | 16.30 | 7 | 137 | 16 | 4 | 7 | 2 |
| | 23 | 22.06.93 | 0.30 | 3 | 186 | 15 | 2 | 13 | - |
| Jun S3 | 45 | 26.06.93 | 1.30 | 3 | 143 | 37 | 1 | 4 | - |
| | 47 | 26.06.93 | 11.00 | 2 | 129 | 101 | 15 | 9 | - |
| | 52 | 27.06.93 | 8.30 | 3 | 140 | 43 | - | 4 | - |
| | 55 | 27.06.93 | 20.30 | 8 | 248 | 27 | 1 | 6 | - |
| | 57 | 28.06.93 | 4.30 | 2 | 117 | 71 | 6 | 8 | - |
| | 60 | 28.06.93 | 17.00 | 11 | 198 | 52 | 2 | 3 | - |

Land : Nos. in the landings.

Disc : Nos. in sample of the discards.

| Table 4 - Groupings of hauls into "data sets" of six hauls each, and numbers of fish measured during the September voyage (28.08-09.09.1993) | | | | | | | | | |
|--|----------|----------|---------------|---------|------|------|------|----------|------|
| Data set | Haul no. | Date | Hour at start | Whiting | | Cod | | Gurnards | |
| | | | | Land | Disc | Land | Disc | Land | Disc |
| Sep S1 | 21 | 01.09.93 | 14.15 | 7 | 182 | 10 | 2 | 2 | 4 |
| | 23 | 02.09.93 | 22.30 | 22 | 63 | 7 | - | 3 | 9 |
| | 25 | 02.09.93 | 6.30 | 33 | 168 | 19 | 3 | - | 6 |
| | 26 | 02.09.93 | 10.30 | 12 | 149 | 15 | - | - | 11 |
| | 28 | 02.09.93 | 18.30 | 8 | 196 | 9 | 2 | - | 2 |
| | 30 | 03.09.93 | 2.30 | 9 | 97 | 7 | - | 3 | 9 |
| Sep S2 | 31 | 03.09.93 | 7.00 | 12 | 210 | 8 | - | 2 | 15 |
| | 33 | 03.09.93 | 15.00 | 47 | 303 | 8 | - | - | 8 |
| | 35 | 04.09.93 | 23.00 | 18 | 185 | 10 | - | 1 | 3 |
| | 36 | 04.09.93 | 3.00 | 16 | 183 | 8 | - | - | - |
| | 38 | 04.09.93 | 11.00 | 21 | 204 | 13 | - | - | 6 |
| | 40 | 04.09.93 | 19.00 | 9 | 86 | 9 | - | - | - |
| Sep S3 | 44 | 05.09.93 | 11.00 | 67 | 269 | 5 | 1 | 2 | 7 |
| | 46 | 05.09.93 | 19.00 | 53 | 278 | 3 | - | - | 3 |
| | 48 | 06.09.93 | 3.00 | 74 | 250 | 10 | 3 | 1 | - |
| | 49 | 06.09.93 | 7.00 | 24 | 233 | 21 | - | 1 | 4 |
| | 51 | 06.09.93 | 15.00 | 8 | 102 | 8 | 2 | 1 | 1 |
| | 53 | 07.09.93 | 23.15 | 20 | 94 | 5 | 3 | 2 | 1 |

Land : Nos. in the landings.

Disc : Nos. in sample of the discards.

| Table 4 - Continued. | | | | | | | | | |
|----------------------|----------|----------|---------------|------|------|--------|------|------|------|
| Data set | Haul no. | Date | Hour at start | Dab | | Plaice | | Sole | |
| | | | | Land | Disc | Land | Disc | Land | Disc |
| Sep S1 | 21 | 01.09.93 | 14.15 | 7 | 245 | 40 | - | 37 | 4 |
| | 23 | 02.09.93 | 22.30 | 4 | 143 | 19 | - | 24 | 1 |
| | 25 | 02.09.93 | 6.30 | 4 | 102 | 64 | 2 | 16 | - |
| | 26 | 02.09.93 | 10.30 | - | 46 | 49 | 1 | 4 | - |
| | 28 | 02.09.93 | 18.30 | 1 | 36 | 68 | 1 | 13 | - |
| | 30 | 03.09.93 | 2.30 | - | 46 | 23 | 5 | 5 | - |
| Sep S2 | 31 | 03.09.93 | 7.00 | 2 | 63 | 26 | 1 | 8 | - |
| | 33 | 03.09.93 | 15.00 | 1 | 102 | 85 | 9 | 9 | - |
| | 35 | 04.09.93 | 23.00 | 1 | 26 | 30 | 2 | 5 | - |
| | 36 | 04.09.93 | 3.00 | 3 | 44 | 14 | - | 13 | - |
| | 38 | 04.09.93 | 11.00 | 1 | 38 | 16 | - | 4 | - |
| | 40 | 04.09.93 | 19.00 | - | 33 | 21 | 2 | 1 | - |
| Sep S3 | 44 | 05.09.93 | 11.00 | 5 | 90 | 13 | - | 8 | - |
| | 46 | 05.09.93 | 19.00 | 2 | 165 | 15 | 4 | 11 | 2 |
| | 48 | 06.09.93 | 3.00 | 1 | 33 | 83 | 2 | 14 | 2 |
| | 49 | 06.09.93 | 7.00 | 1 | 131 | 196 | 3 | 12 | - |
| | 51 | 06.09.93 | 15.00 | - | 75 | 102 | 3 | 10 | - |
| | 53 | 07.09.93 | 23.15 | 2 | 152 | 113 | 1 | 11 | - |

Land : Nos. in the landings.

Disc : Nos. in sample of the discards.

| Table 5 - Fishermen's selection curves for whiting | | | | | |
|--|-----------------------|------------------|--------------|----------------|-------------|
| Species | Voyage and data set | Curve | α | β | L50 |
| Whiting | Jun S1 | <i>Logit</i> | 0.747 | -22.231 | 29.8 |
| | | <i>Probit</i> | 0.402 | -12.004 | 29.8 |
| | | <i>C Log Log</i> | 0.572 | -17.483 | 29.9 |
| Whiting | Jun S2 | <i>Logit</i> | 0.846 | -25.059 | 29.6 |
| | | <i>Probit</i> | 0.491 | -14.537 | 29.6 |
| | | <i>C Log Log</i> | 0.720 | -21.743 | 29.7 |
| Whiting | Jun S3 | <i>Logit</i> | 0.769 | -22.873 | 29.8 |
| | | <i>Probit</i> | 0.443 | -13.158 | 29.7 |
| | | <i>C Log Log</i> | 0.699 | -21.118 | 29.7 |
| Whiting | Jun All sets combined | <i>Logit</i> | 0.774 | -23.028 | 29.7 |
| | | <i>Probit</i> | 0.440 | -13.080 | 29.7 |
| | | <i>C Log Log</i> | 0.674 | -20.441 | 29.7 |
| Whiting | Sep S1 | <i>Logit</i> | 0.780 | -26.476 | 34.0 |
| | | <i>Probit</i> | 0.372 | -12.746 | 34.3 |
| | | <i>C Log Log</i> | 0.738 | -25.287 | 33.8 |
| Whiting | Sep S2 | <i>Logit</i> | 0.813 | -26.368 | 32.4 |
| | | <i>Probit</i> | 0.392 | -12.853 | 32.7 |
| | | <i>C Log Log</i> | 0.772 | -25.263 | 32.3 |
| Whiting | Sep S3 | <i>Logit</i> | 0.687 | -22.860 | 33.3 |
| | | <i>Probit</i> | 0.375 | -12.524 | 33.4 |
| | | <i>C Log Log</i> | 0.618 | -20.894 | 33.2 |
| Whiting | Sep All sets combined | <i>Logit</i> | 0.732 | -24.369 | 33.3 |
| | | <i>Probit</i> | 0.371 | -12.443 | 33.5 |
| | | <i>C Log Log</i> | 0.682 | -22.960 | 33.1 |

(*) Curves giving the best fit to the observed retention rates are shown in bold ; alternatives, giving a more or less equally good fit, in normal script ; and the others in italics.

| Table 6 - Fishermen's selection curves for cod, gurnards, dab, plaice and sole. | | | | | |
|---|---------------------|------------------|--------------|----------------|-------------|
| Species | Voyage and data set | Curve | α | β | L50 |
| Cod | All sets combined | Knife-edg | ... | ... | 35.0 |
| | | Logit | 1.741 | -60.970 | 35.0 |
| | | Probit | 0.822 | -28.745 | 35.0 |
| Gurnards | All sets combined | Logit | 0.927 | -25.342 | 27.4 |
| | | <i>Probit</i> | <i>0.505</i> | <i>-13.800</i> | <i>27.3</i> |
| | | <i>C Log Log</i> | <i>0.836</i> | <i>-23.213</i> | <i>27.3</i> |
| | | <i>Log Log</i> | <i>0.593</i> | <i>-15.713</i> | <i>27.1</i> |
| Dab | All sets combined | Logit | 2.104 | -56.960 | 27.1 |
| | | Probit | 1.133 | -30.606 | 27.0 |
| Plaice | All sets combined | Knife-edg | ... | ... | 26.5 |
| | | Logit | 1.502 | -40.010 | 26.6 |
| | | Probit | 0.884 | -23.496 | 26.6 |
| Sole | All sets combined | Knife-edg | ... | ... | 24.0 |
| | | Logit | 2.580 | -62.028 | 24.0 |
| | | Probit | 1.513 | -36.167 | 23.9 |

(*) Curves giving the best fit to the observed retention rates are shown in bold ; alternatives, giving a more or less equally good fit, in normal script ; and the others in italics.

**Species composition of the landings by
Belgian *Nephrops* directed trawlers
from ICES Sub-areas IVb+c**

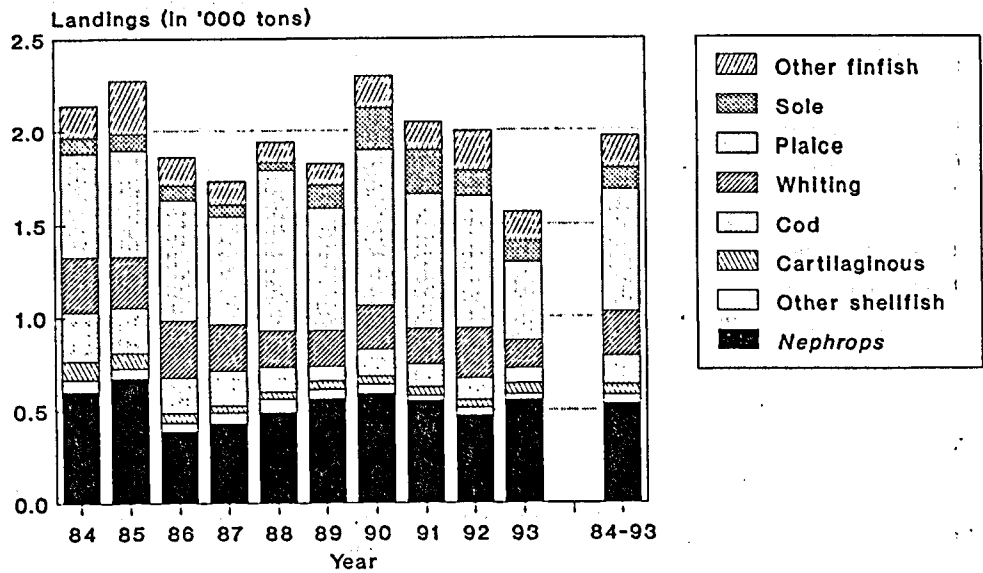


Figure 1

**Auction sales figures of the landings by
Belgian *Nephrops* directed trawlers
from ICES Sub-areas IVb+c**

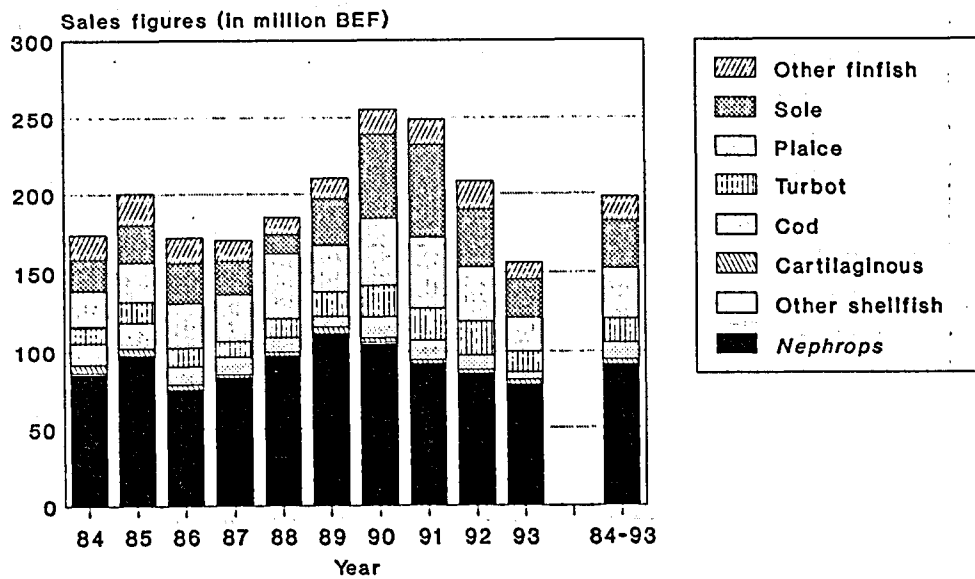


Figure 2

Landings-per-unit-effort of
Belgian *Nephrops* directed trawlers
operating in ICES Sub-areas IVb+c

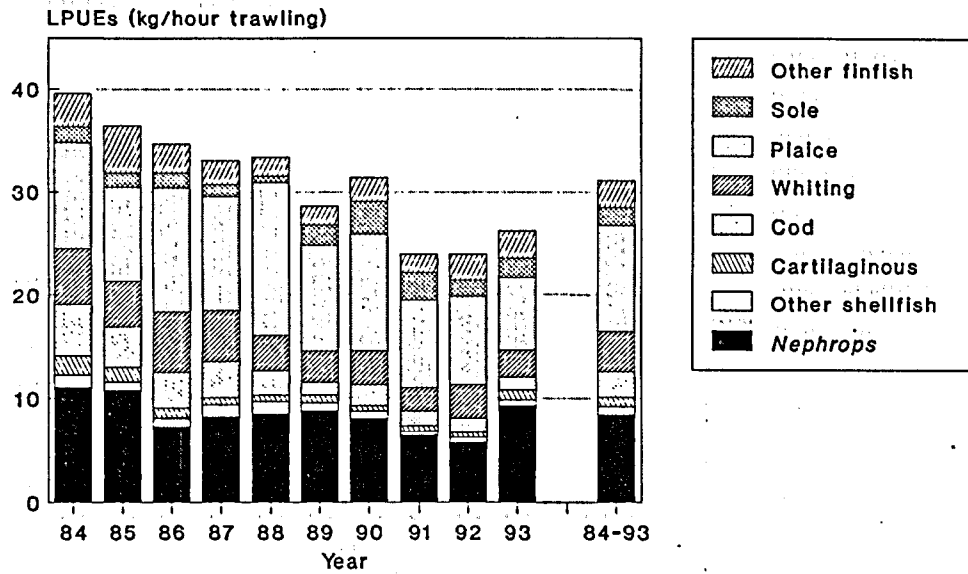


Figure 3

Proceeds-per-unit-effort of
Belgian *Nephrops* directed trawlers
operating in ICES Sub-areas IVb+c

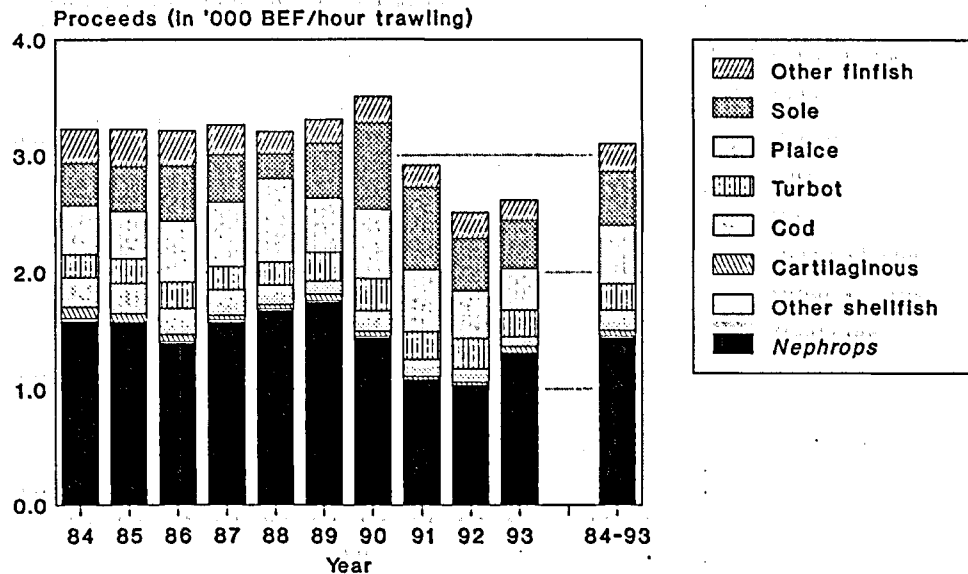


Figure 4

Whiting : Numbers landed and discarded per day
All "data sets"

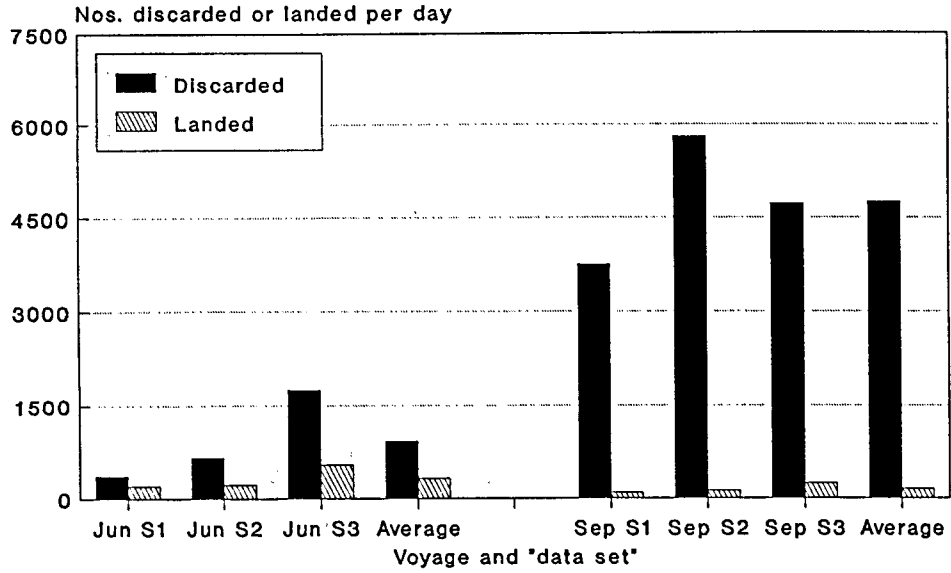


Figure 5

Cod : Numbers landed and discarded per day
All "data sets"

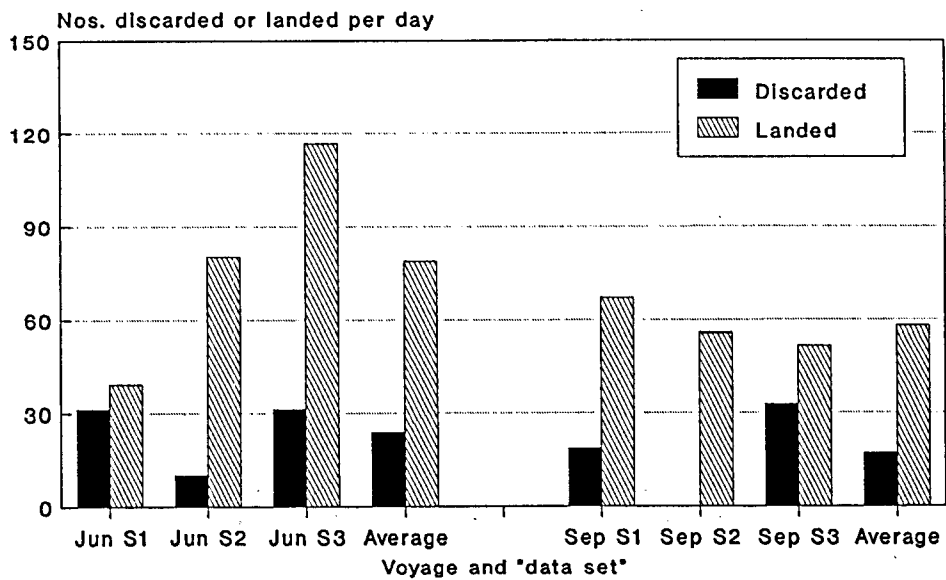


Figure 6

Gurnards : Numbers landed and discarded per day
All "data sets"

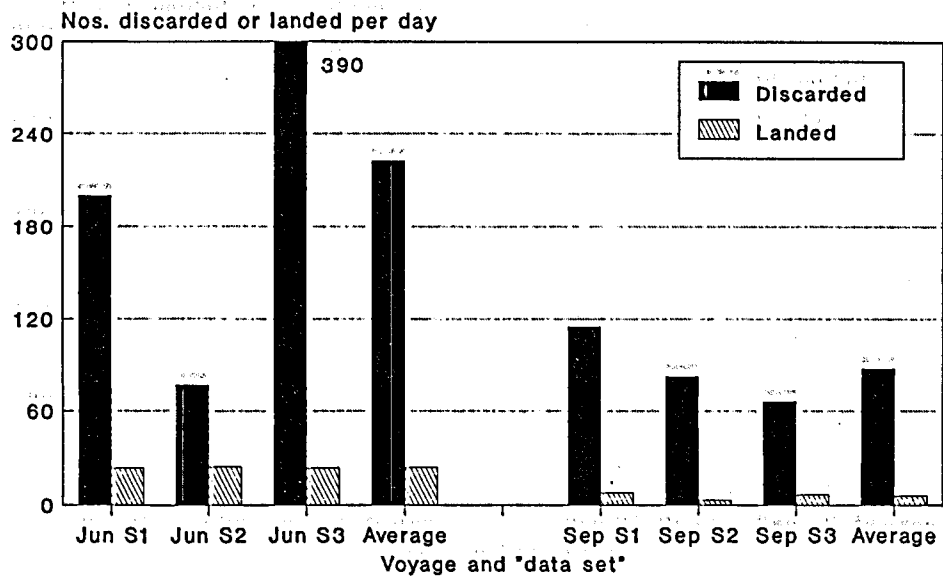


Figure 7

Dab : Numbers landed and discarded per day
All "data sets"

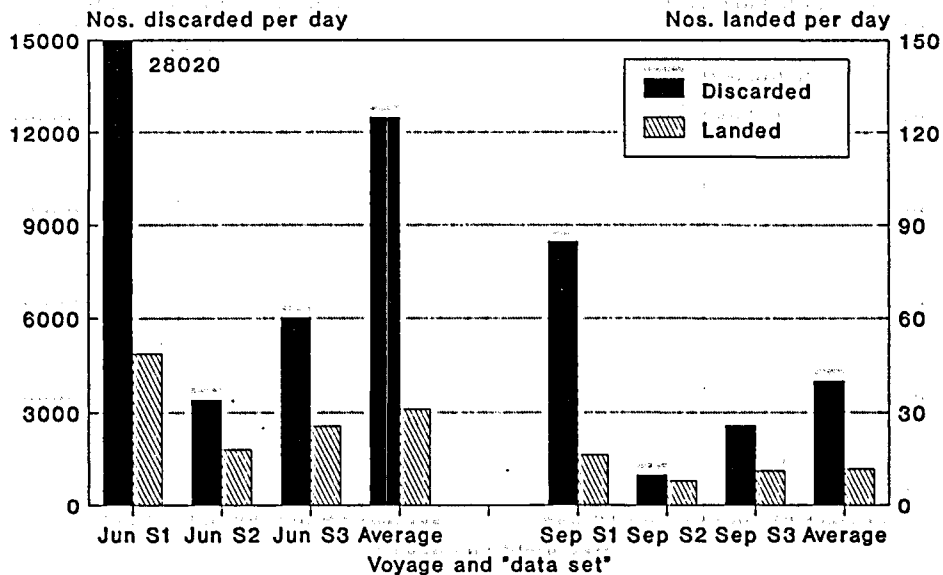


Figure 8

Plaice : Numbers landed and discarded per day
All "data sets"

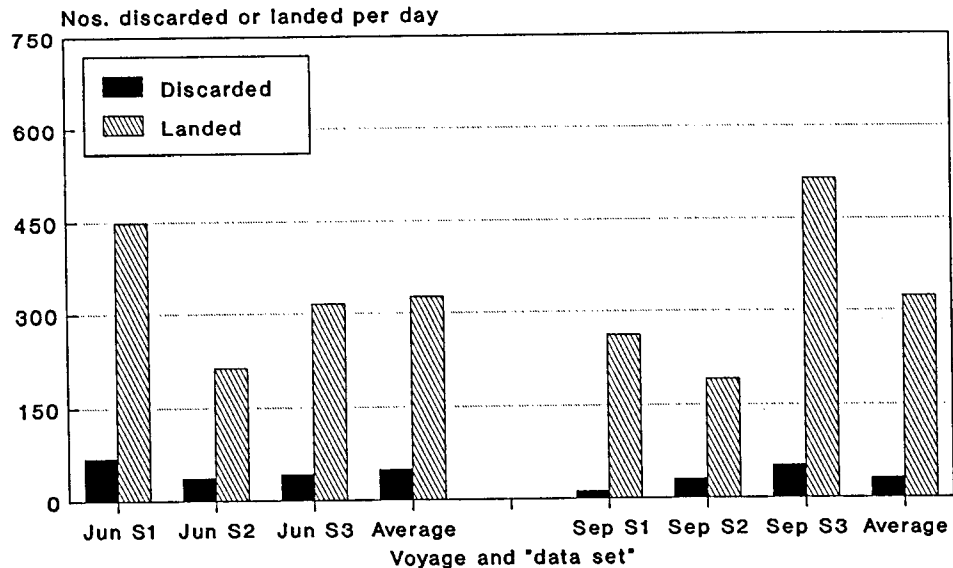


Figure 9

Sole : Numbers landed and discarded per day
All "data sets"

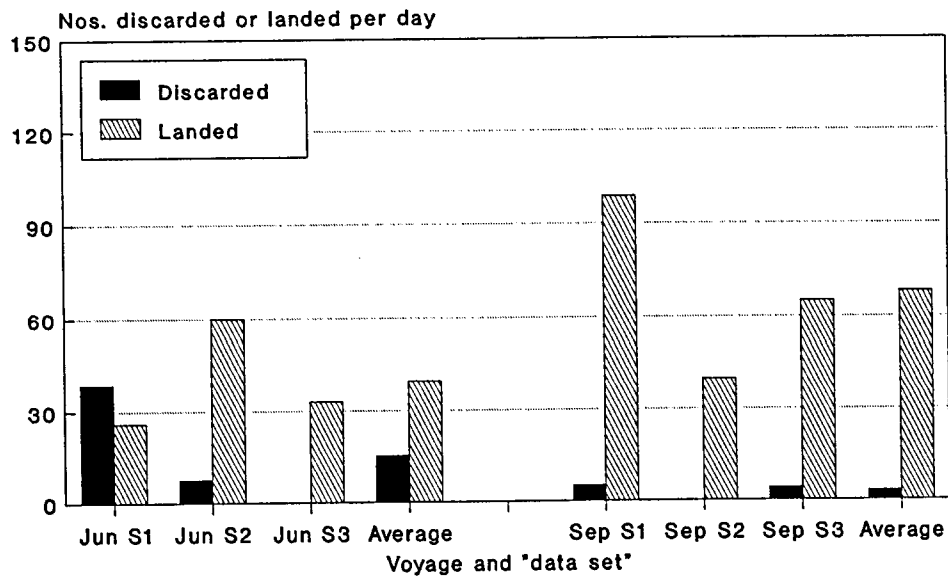
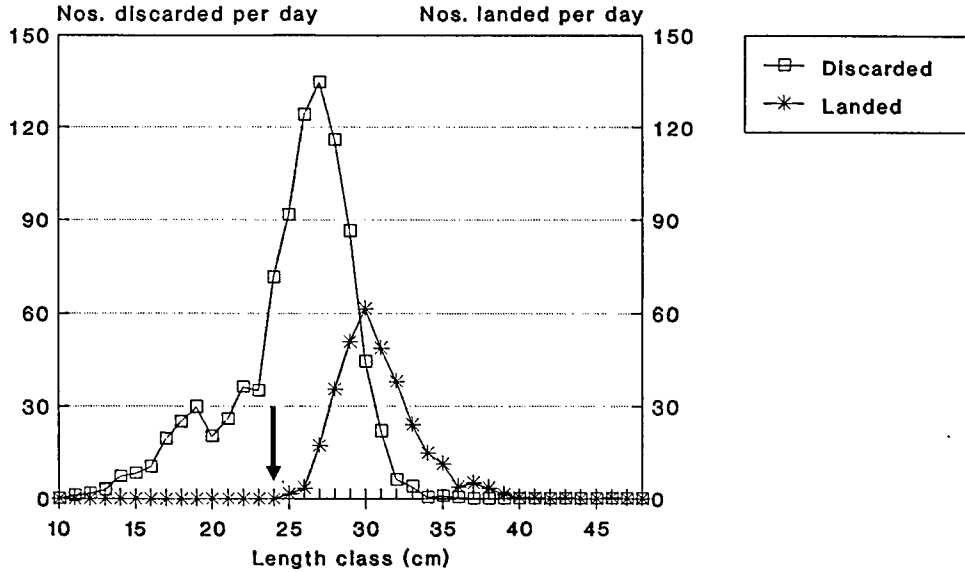


Figure 10

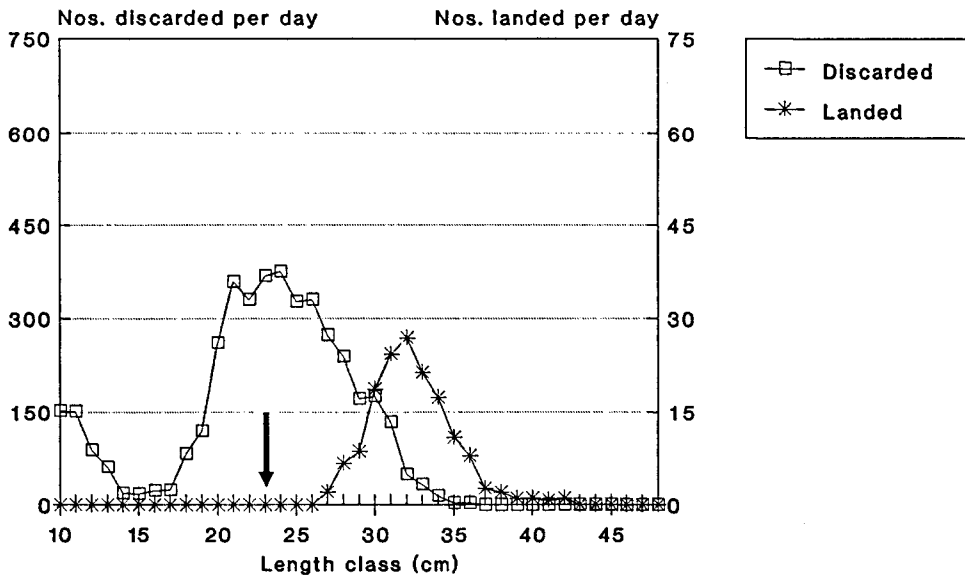
Whiting : Size composition of landings and discards
 June : All "data sets" combined



Arrow indicates minimum landing size

Figure 11

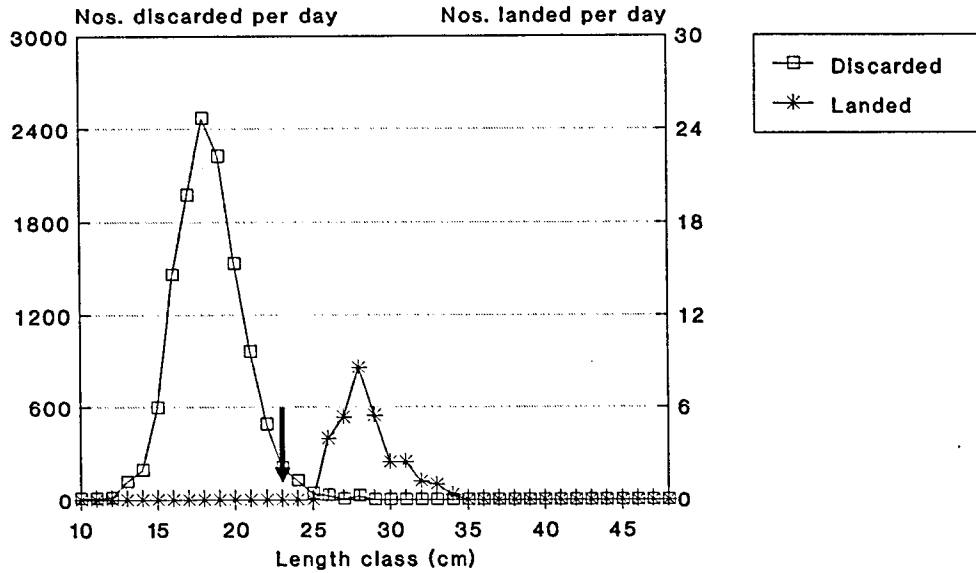
Whiting : Size composition of landings and discards
 September : All "data sets" combined



Arrow indicates minimum landing size

Figure 12

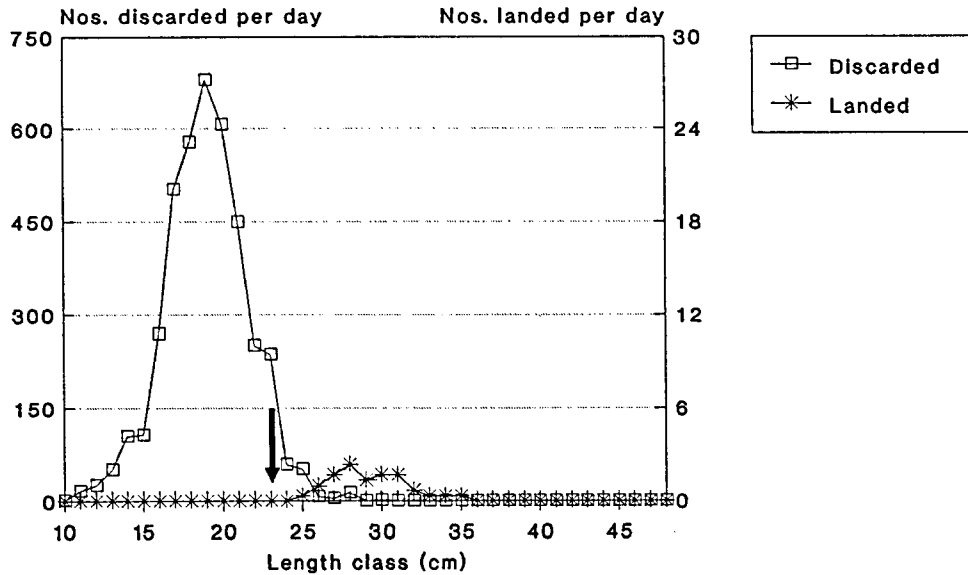
Dab : Size composition of landings and discards
 June : All "data sets" combined



Arrow Indicates minimum landing size

Figure 13

Dab : Size composition of landings and discards
 September : All "data sets" combined



Arrow Indicates minimum landing size

Figure 14

Whiting : Fishermen's selection
June : Data set 1

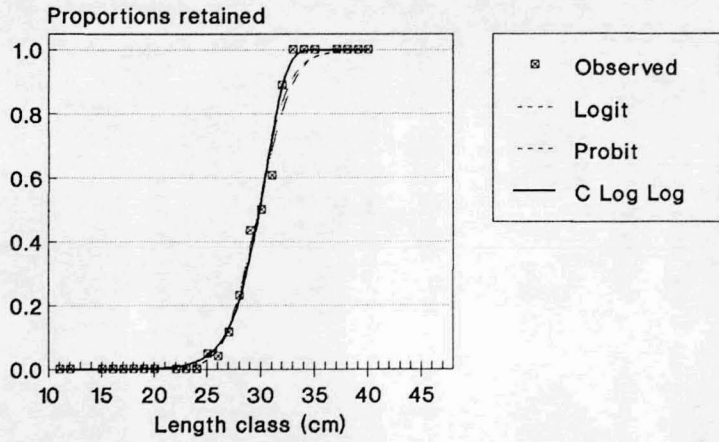


Figure 15

Whiting : Fishermen's selection
June : Data set 2

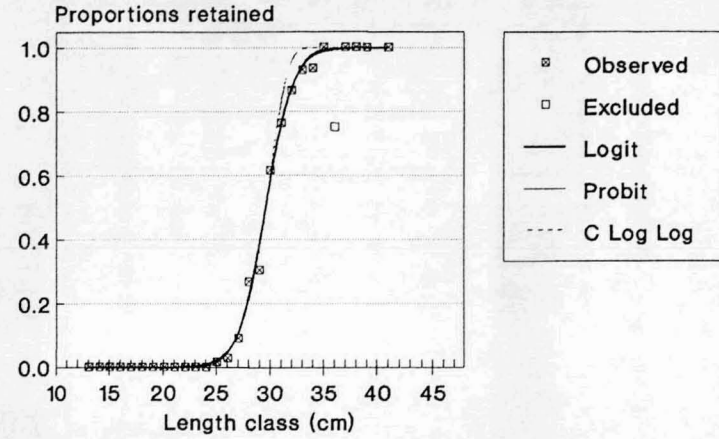


Figure 16

Whiting : Fishermen's selection
June : Data set 3

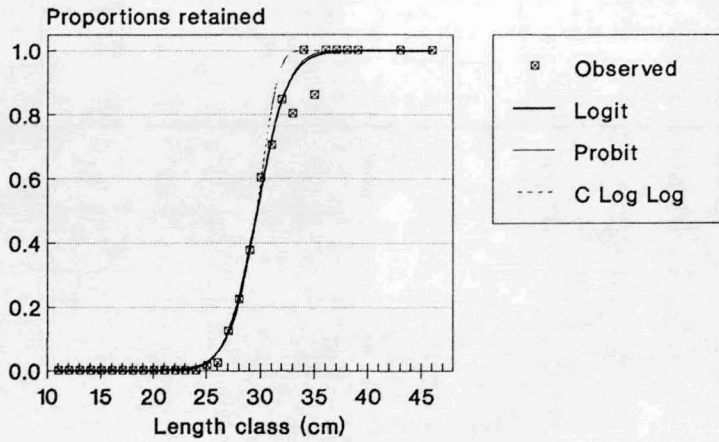


Figure 17

Whiting : Fishermen's selection
June : All "data sets" combined

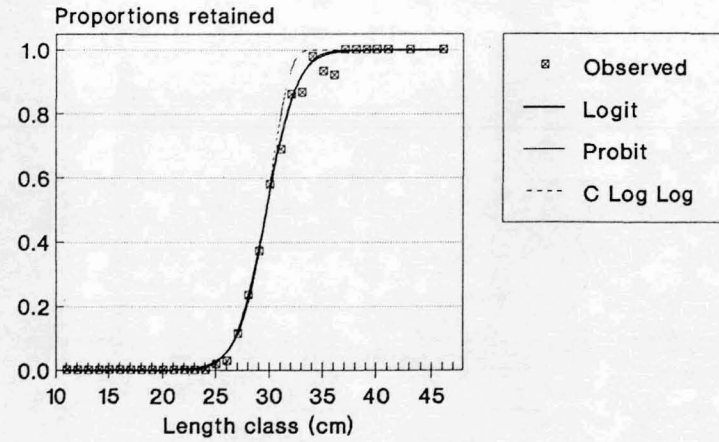


Figure 18

Whiting : Fishermen's selection
September : Data set 1

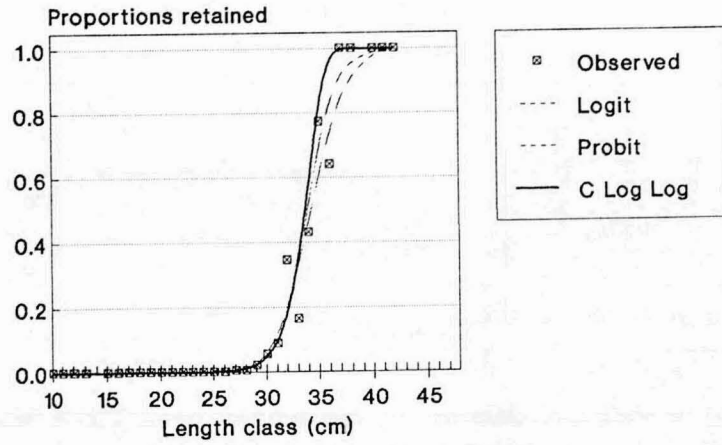


Figure 19

Whiting : Fishermen's selection
September : Data set 2

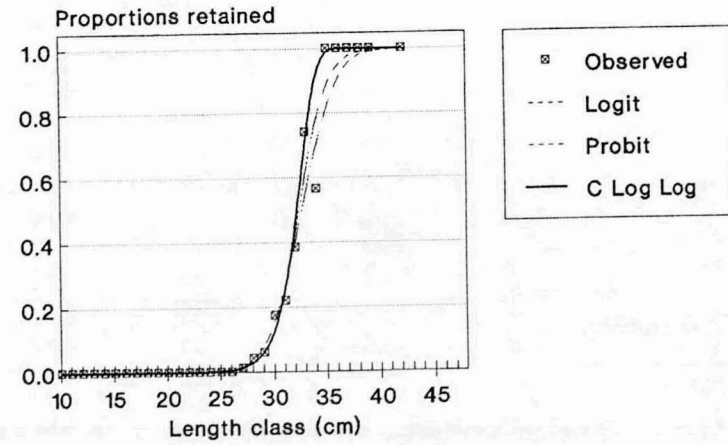


Figure 20

Whiting : Fishermen's selection
September : Data set 3

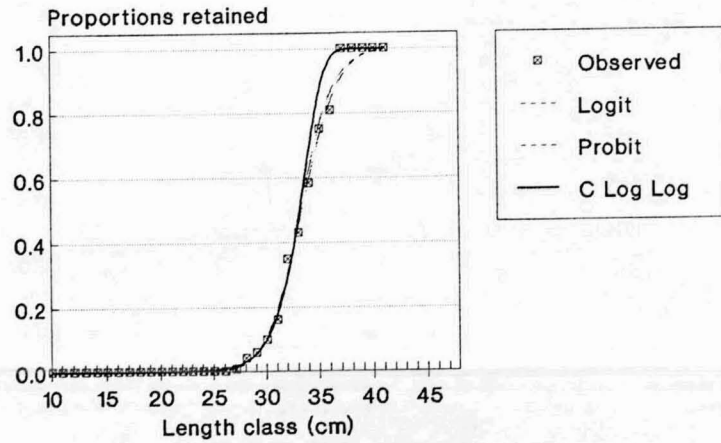


Figure 21

Whiting : Fishermen's selection
September : All "data sets" combined

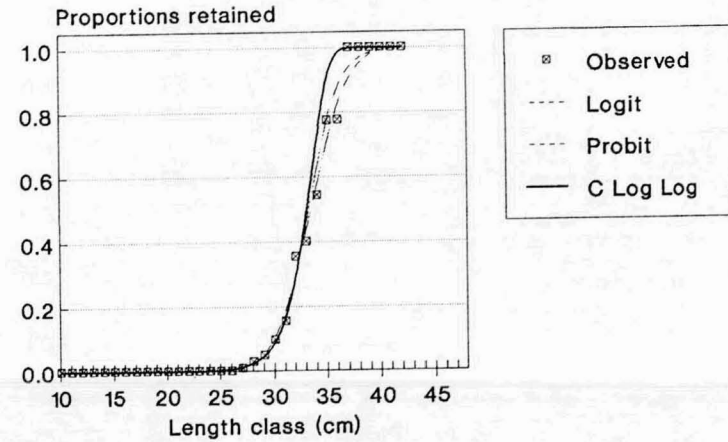
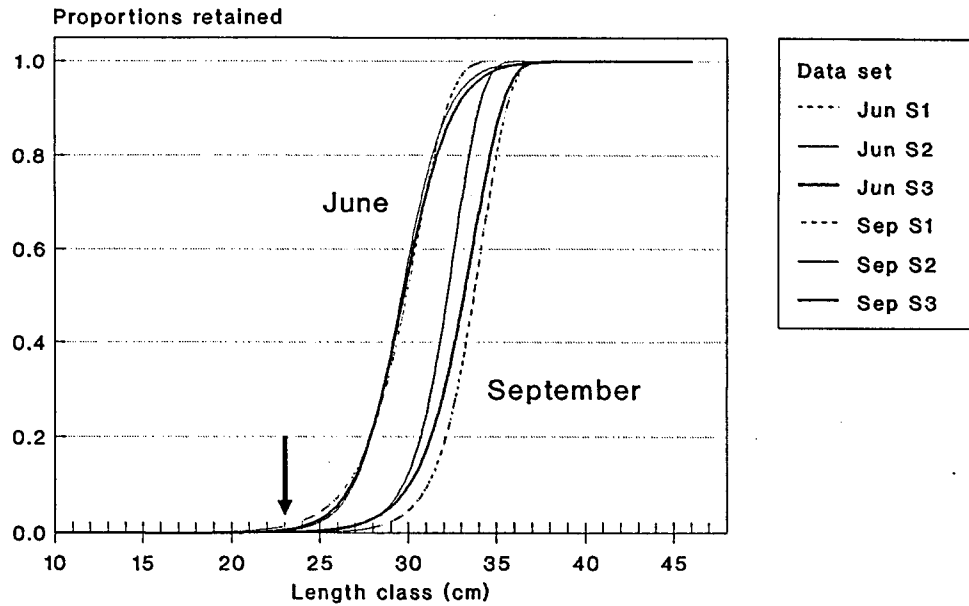


Figure 22

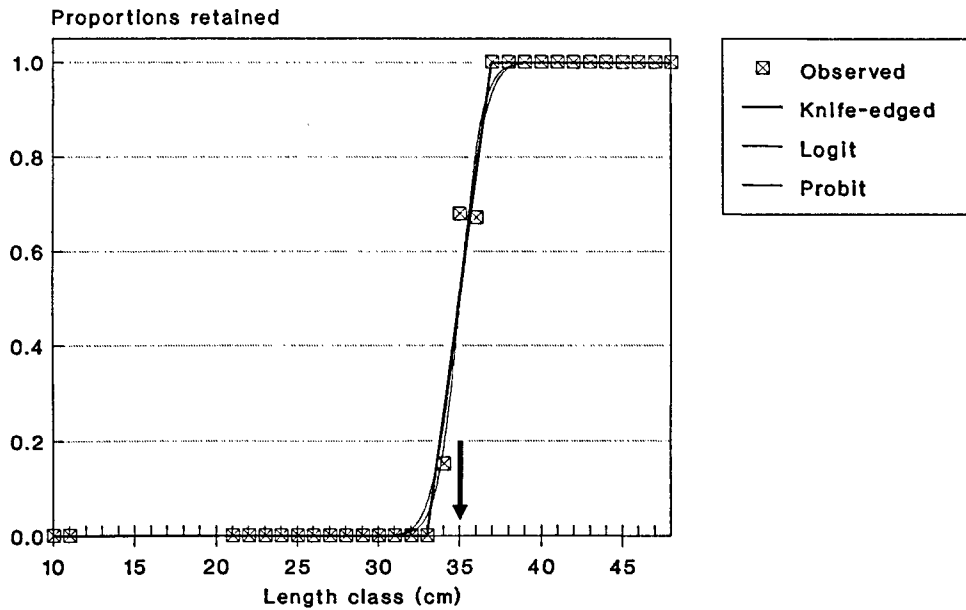
Whiting : Fishermen's selection
Comparison June vs. September



Arrow indicates minimum landing size

Figure 23

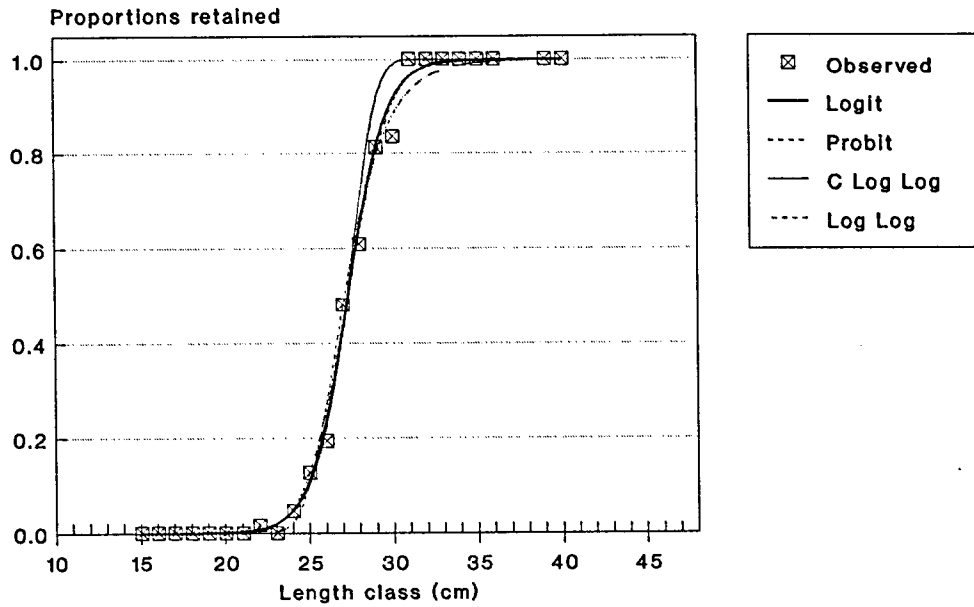
Cod : Fishermen's selection
All "data sets" combined



Arrow indicates minimum landing size

Figure 24

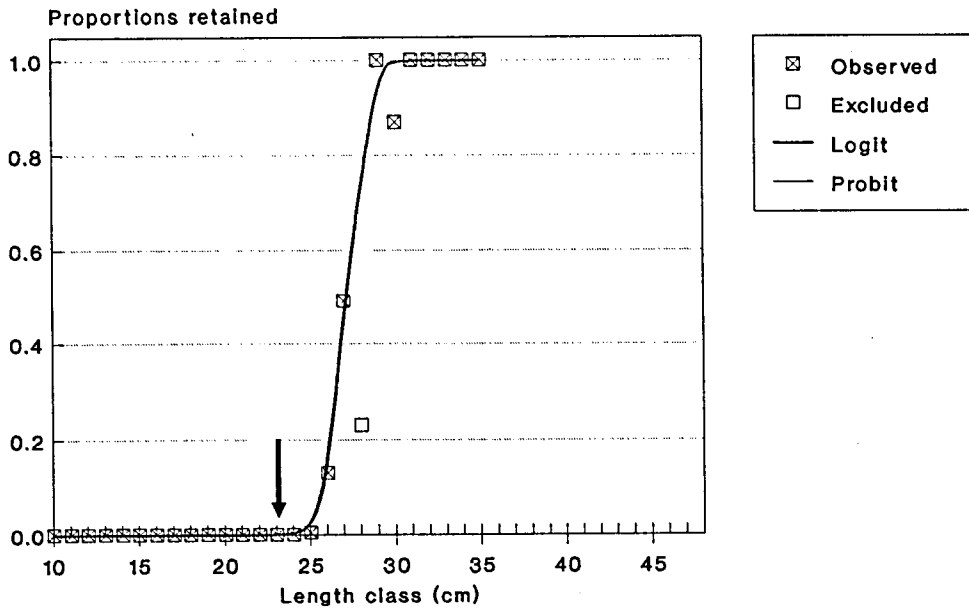
Gurnards : Fishermen's selection
All "data sets" combined



There is no MLS for gurnards

Figure 25

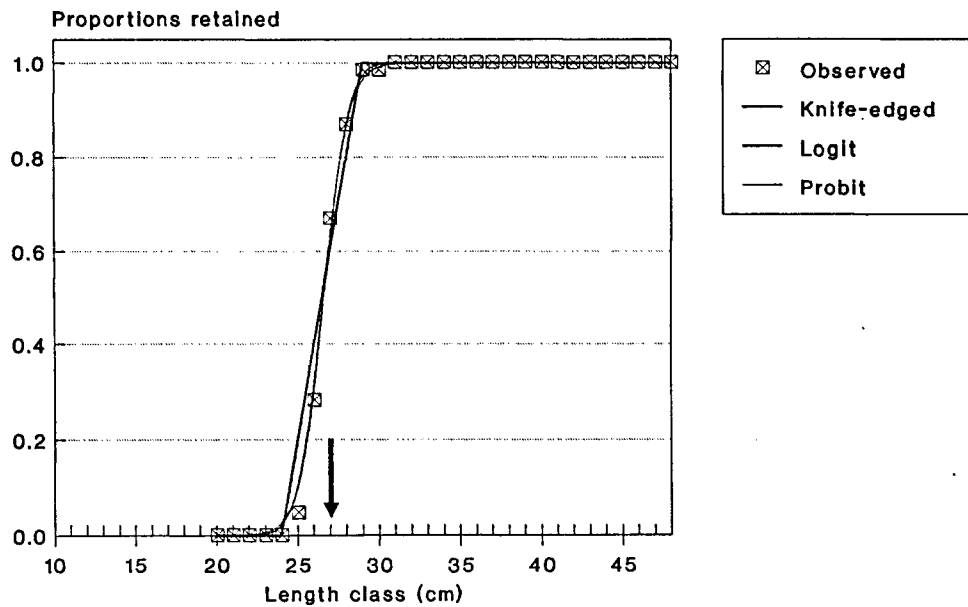
Dab : Fishermen's selection
All "data sets" combined



Arrow indicates minimum landing size

Figure 26

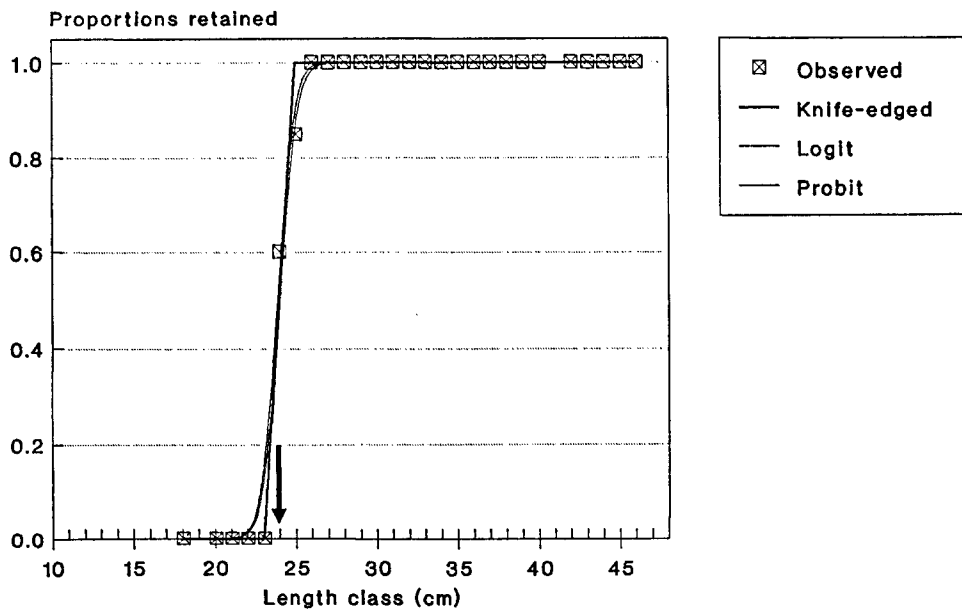
Plaice : Fishermen's selection
All "data sets" combined



Arrow Indicates minimum landing size

Figure 27

Sole : Fishermen's selection
All "data sets" combined



Arrow Indicates minimum landing size

Figure 28

Whiting : Cumulated size compositions of the landings by *Nephrops* trawlers

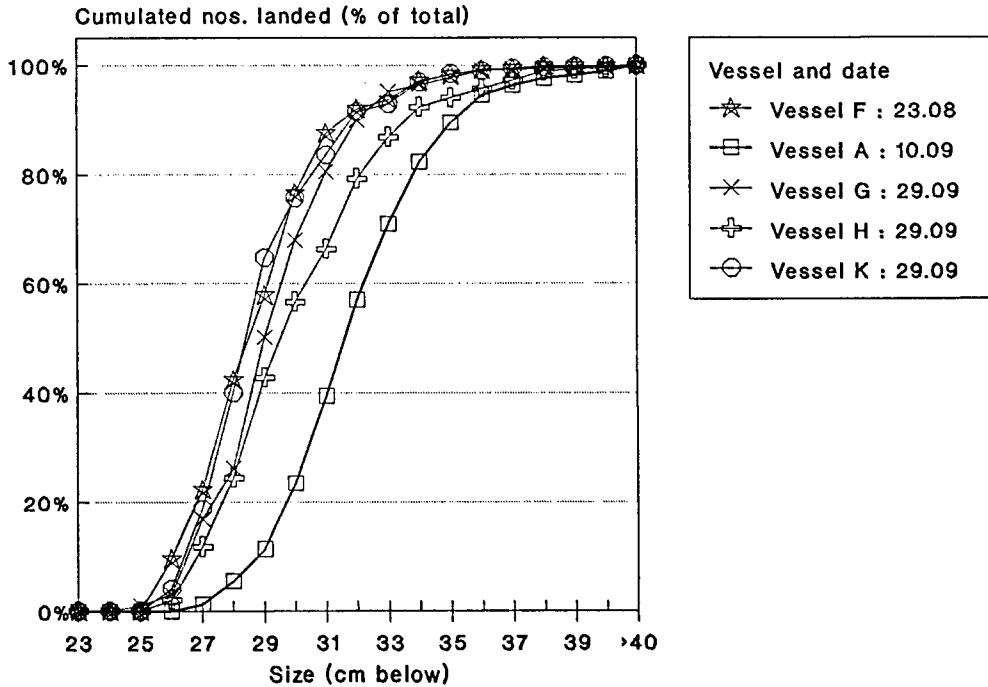
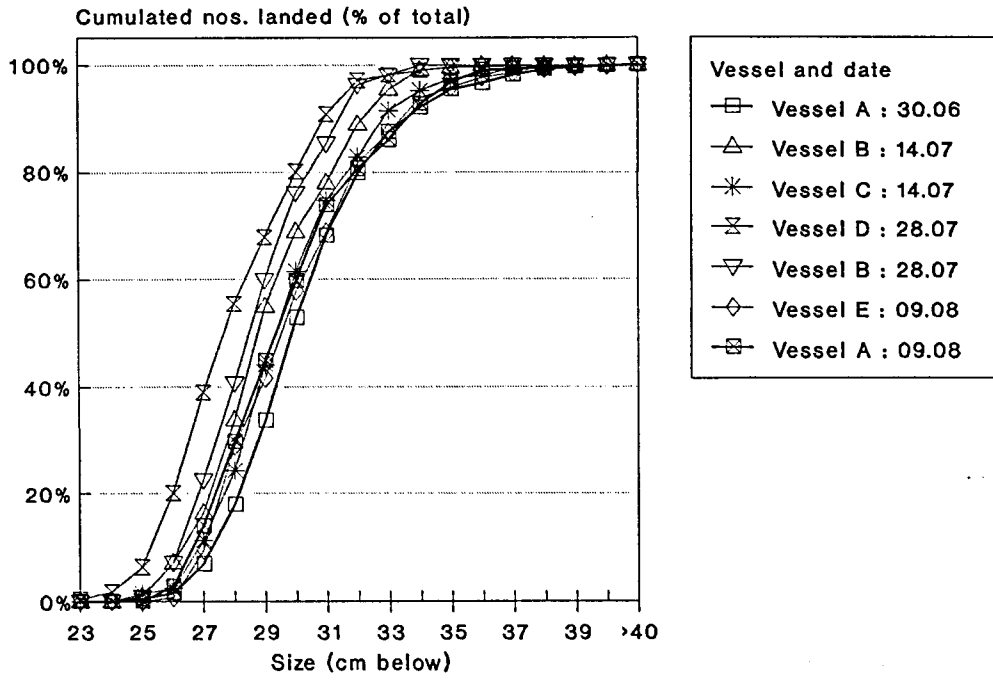
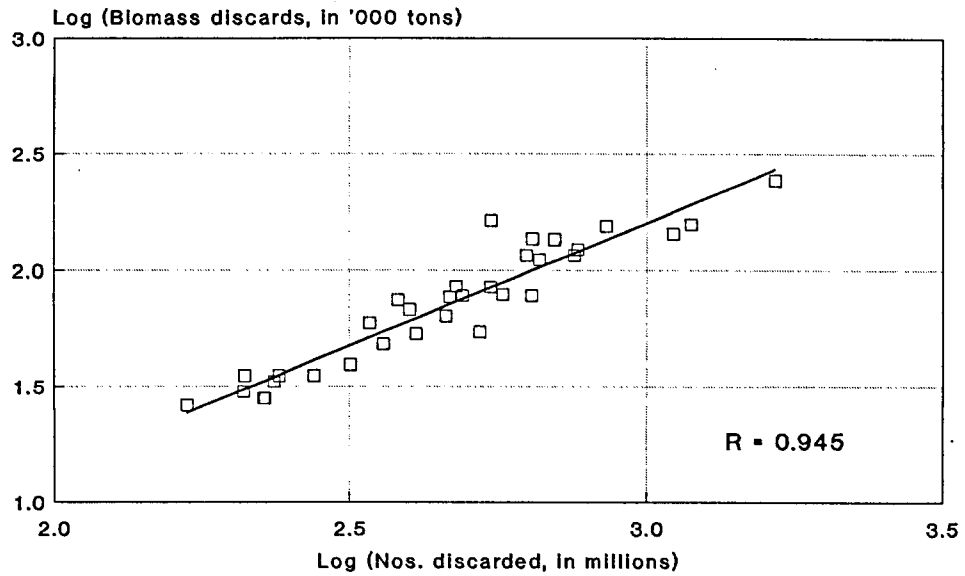


Figure 29

Whiting : Relationship between numbers
and biomass of discards in the North Sea
Data for 1960-92



Based on data taken from ICES (1994b)

Figure 30