Irish Sea Finfish and Nephrops Discard Study 1993/94

MAFF R&D Commission
Consultancy Report No.99
October 1995

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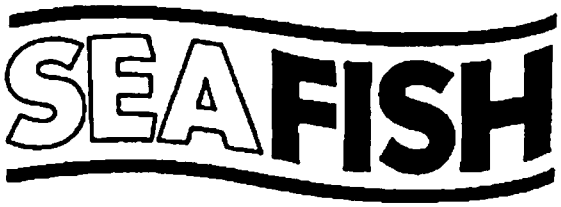
Sea Fish Industry Authority

Technology Division



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Summary

The study of discard rates in commercial fisheries is intended to estimate the component of fishing mortality accounted for by discarded fish; these fish are not landed and so would not appear in market sampling. Discard surveys are intended to describe the discarded fish as a percentage of the total catch. These data, when used in conjunction with landings data could be used to improve estimates of fishing mortality.

This report describes the results of a study to assess the feasibility of longer term monitoring of discarding practices in the towed gear fisheries of the Irish Sea (ICES Area VIIa) carried out during the period June 1993-August 1994. The report describes the development of methods considered suitable for assessing discard rates in these fisheries and discusses factors affecting the variation in discard rates.

Earlier studies and initial investigations here used a technique which sampled the marketable and discarded fish separately after sorting by the crew. This proved unsuitable for use in this fishery due to the sorting practices used and the requirement to obtain estimates of between haul variation in discard rates.

A technique was therefore developed which sampled the total catch prior to sorting. This had the merits of being adaptable to all the vessels being sampled in the fishery and enabling between haul variation to be studied.

The factors affecting variation in the discard rates obtained from this study are described in hierarchical terms. Samples were taken from **hauls** within **trips** aboard various **boats** working from various **ports** using different **gears** over many **grounds** in pursuit of various **species**. For plaice and sole, few of which were discarded above the minimum landing size (MLS), spatial factors appeared to be most important in determining discard rates. In particular it was observed that the discard rate was higher in the shallower inshore grounds than in the deeper offshore grounds.

For whiting, market forces predominated; there was considerable between port variation and much discarding above the MLS. The study of discard rates for Nephrops was hampered by the apparent difference between two methods used for obtaining samples. A lower discard rate was obtained for samples obtained from an officer accompanying a vessel for a whole trip as compared with sampling when boarding from a fishery patrol vessel. The report discusses this phenomenon and makes recommendations for improving the boarding technique.

The report also tabulates the effort and landings of the boats sampled by statistical rectangle. These may be compared with reported effort and landings data to assess the degree to which these two data are consistent.

The study concludes that there is scope for further development of sampling methods for discard assessment.

Acknowledgements

We would like to thank all of the many owners, skippers, crews and shore staff without whose goodwill and support this study would not have been possible. In addition, we also thank the skipper (Mr. Dave Dobson) and crew of the Cumbria Sea Fisheries Committee Protection Vessel *Solway Protector* for their enthusiastic help during Nephrops sampling.

We would also like to thank Dr. M. G. Pawson of the Directorate of Fisheries Research (DFR) Lowestoft who initiated this project and who provided information, including the age at length keys for adult fish, along with help and advice. Dr. D. Bennett and Mr. A. Lawler initiated and provided valuable help with the Nephrops part of this study. The otolith reading staff at DFR - Mr. Ian Holmes and Mr. Gary Howelett - were helpful in reading our otoliths.

Lastly, we also thank Dr. Duncan Tamsett of the University of East Anglia (UEA) for his valuable guidance on sampling strategy and statistical analysis.

1. Introduction

1.1 Discards - A Definition

Discards are those marine organisms in the catch which are brought onto the deck of fishing vessels and then returned to the sea. The discards quantified in this report are finfish and shellfish which are rejected by fishermen when catches are sorted.

1.2 The Discarding Environment

The discarding of fish is one function in the interaction between commercial fishing boats and the marine environment. Although discarding is ubiquitous, its characteristics may vary according to the influences of the fishing environment. These influences can be grouped into four main factors:-

Environment and biology

Weather, season, year class strengths, distribution of juveniles, growth rates and mixture of species.

Fishery

Chosen fishing grounds, gear specifications, duration of tow (possible inverse relationship between length of tow and catch marketability), size of catch, length of trip and crew motivation.

Regulatory

Minimum landing sizes, minimum mesh sizes and quota entitlements.

Market

Relative strengths of supply and demand, prices, size requirements.

Many of these factors are associated and interact with each other.

1.3 The Purpose of Discard Data

Possible yield loss

All fish discarded dead or moribund represent a potential loss of yield. This may be a direct short term loss of commercial species or a loss of system productivity. The loss is particularly important if the discarded fish are immature from over-exploited stocks and with considerable growth potential.

Fisheries management

When stock assessment and advice for management do not, or cannot accommodate accurate discard data then the relation between effort and fishing mortality will be imprecise. Discarding in finfish fisheries can vary widely. The worst cases always attract the most attention, but the recent North Sea Intergovernmental Quality Status Report (QSR) used ICES data to show that between 40-50% of the demersal catches of commercial species in the North Sea are discarded. When added to an already high catch level, this is the basis for poor PR for the fishing industry as a whole.

Studying discards

The main aim of a discard study is to estimate from the catch, both the numbers of fish retained as landings and those rejected and discarded, and to express these numbers as a Percentage Discard Rate for each species observed within a given fishery:-

$$Percentage\ Discard\ Rate = \left(\frac{No.\ of\ Discards}{Total\ Catch} \right) \times 100\%$$

Where Total Catch = No. of Landings + No. of Discards

This figure can then be used in conjunction with landings data to improve estimates of fishing mortality within the fishery for stock assessment purposes. In addition, a discard study can also collect otoliths (for age), sex, length frequency and location data to be used to assess fish stock structure and distribution.

Finally, port, market, boat, gear and crew information is necessary to identify any correlations between discarding patterns and legislative, economic, technological or human factors.

For discard studies to be of value in increasing our understanding of this interaction, to develop appropriate sampling protocols and to identify opportunities to introduce more effective fisheries management, it is fundamental that the discarding which is observed and measured is an accurate reflection of commercial practice. Consequently, sampling should take place aboard ordinary fishing trips, and be designed so as to interfere as little as possible with normal fishing activities.

1.4 Study Aims

This contract required Seafish to asses the feasibility of studying finfish and Nephrops *(Nephrops norvegicus)* discards in the towed gear fisheries pursued in the Irish Sea (ICES Area VIIa). This required the development of suitable techniques to produce data from which the patterns of discarding for the major species in the main fishing fleets could be estimated and discussed. It was also intended to assess the utility of the sampling techniques in describing these patterns.

1.5 Study Objectives

The objectives were identified as follows:-

- To develop techniques for assessment of discard rates and raising factors.
- To assess factors affecting variation in the results.

1.6 Study Period

The study period was from June 1993 to September 1994 and followed on from a similar project undertaken by Seafish in the Irish Sea during the period January-December 1992 (Hepples 1993).

2. Method

2.1 Manpower

Fishing boats operate in a potentially dangerous environment, and it was considered important that scientific staff should be competent, safe and unobtrusive workers when at sea. Two graduate research assistants with sea-going experience were recruited to undertake the sampling.

Preliminary training included familiarisation with previous studies and a practical demonstration of both sampling and otolith removal at sea.

2.2 Hauls

Shoot and haul times and positions were fixed when brakes were applied on the winch during shooting and when the clutch was engaged during hauling.

Hauls were considered void if interrupted by coming fast shortly after shooting, or if upon hauling the trawl was found to be damaged or otherwise seriously impaired in its ability to fish normally.

2.3 Trips

For the purposes of this study, a sampling trip was defined as one or more hauls sampled aboard a particular vessel during the same voyage (or consecutive days using the same gear if day tripping), using the same fishing gear and codend mesh size.

2.4 Boats

Boats differ mainly in size (horsepower) and in the gears they work. Their size is the main factor which limits their ability to fish offshore grounds and/or during poor weather. Boats were largely chosen on an opportunistic basis, but for each study quarter efforts were made to sail with a wide variety of boat sizes.

2.5 Gears

There are several different towed gear types used in the Irish Sea (Area VIIa): beam trawling, otter trawling, nephrops trawling and anchor seining, and these in turn can use different codend mesh sizes depending on fishermen's choice and/or controls on catching target species in that area and at that time.

The towed gears chosen for the study were beam trawl, otter trawl, Nephrops trawl and anchor seine.

2.6 Grounds

Preliminary enquiries showed traditional links between certain ports and fishing grounds. These are in the main local grounds, except where deep water ports with good infrastructure are able to support larger boats working offshore in nearly all weathers. This was taken into account when targeting effort. Based upon MAFF fleet structure and landings statistics (see Appendix 1) it was decided to concentrate the study between the ports of Holyhead and Maryport, allocating effort to each port so as to reflect the recent patterns of fishing activity.

For analysis purposes, fishing grounds were defined by Statistical Rectangles.

The study was also commissioned to examine discard rates in the Nephrops fishery to the east of the Isle of Man. The Nephrops fishery to the west is sampled by the Irish and Northern Irish. The main Nephrops ground for this study was in the ICES Statistical Rectangle 37E6 adjacent the Cumbrian coast. Whitehaven (the major Nephrops landing port) became the centre of sampling effort.

2.7 Temporal Factors

The recording of dates and times for all hauls facilitated analysis of diurnal and seasonal patterns in discarding. Where it was not possible to sample all the hauls during a long trip efforts were made to ensure that an equal number of daytime and nighttime hauls were sampled.

2.8 Species

The species recorded in the study were those with commercial value within the fishery. However only four species were recorded in sufficient quantity for a full analysis to be carried out - plaice *(Pleuronectes platessa)*, sole *(Solea solea)*, whiting *(Merlangius merlangus)* and Nephrops *(Nephrops norvegicus)*. The other species recorded are on the database which will be made available on disc.

The non-commercial species observed tended to be small fish with low bulk volumes.

2.9 Targets

Targets for each port and sub-fleet were planned quarterly, based on a general target of 14 trips per quarter derived from the results of the previous study. It was hoped that this could be exceeded where weather allowed. The target number of trips with each gear was chosen to reflect expected landings based upon historical landings data (Appendix 1). Based upon this principal, otter and beam trawler targets were equal and anchor seiners and Nephrops trawlers were sampled in line with seasonal activity. The targets and achievements are shown in the results section (Tables 3.2.1 & 2 and Fig 3.2.1).

The main Nephrops fishing is prosecuted in the summer with the best catches usually occurring during neap tides. The study planned to sample this fishery during the period April-September, concentrating sampling effort around neap tides. Regular discussion with the Fishery Officer at Whitehaven ensured that sampling effort was directed as effectively as possible.

Access to boats

In order to gain access to normal commercial fishing trips on a voluntary basis, it is essential to win the confidence and goodwill of owners, skippers and crew. This project was fortunate in being able to build upon the good relations pioneered during the previous study. The current economic and legal constraints facing the industry, coupled with the traditionally competitive nature of fishing, meant that it was very important to stress the confidentiality of the data collected and that the Seafish staff had only a scientific, and not a regulatory, interest in the activities of the boat.

Weather

In view of the travelling time involved between Hull and the Irish Sea ports, the vagueries of weather, tidal constraints and the short trips made by most of the target fleets, it was felt that pre-arranged trips were often impractical and might lead to skippers making promises which they might not have been able to keep. Consequently, most port visits were made on a speculative basis without prior arrangement. On arrival in the port the Discard Officers arranged suitable trips with skippers. In the event of delayed sailings due to poor weather, the Discard Officers remained in port on stand-by for a few days. This meant that they were ready to sail at short notice and the waiting time provided valuable opportunities to meet new fishermen and extend the range of vessels supportive to the study.

2.10 Sampling Hauls at Sea

When a demersal trawl is hauled and the catch is brought aboard, the unsorted catch is composed of a mixture of marketable fish, discards and detritus. The relative proportions of these components will vary according to such factors as the variety and abundance of species encountered during the tow, the characteristics of the particular gear employed, the nature of the substrate, and prevailing tidal and weather conditions (Fig 2.10.1). This can lead to wide variations in catch composition. In addition, fish behaviour and the flow of water through the codend during towing and hauling may tend to 'sort' the catch (to varying degrees according to circumstances), so that when the codend is opened and the catch is released into a pound or onto the deck, it is unlikely that the fish and detritus are completely mixed. Lastly, because of differences in relative shape, density, size and vigour between species, some further 'sorting' may occur on deck before sampling can be commenced. As a result, sampling procedures need to be carefully designed to overcome the problems of 'self-sorting'.

2.11 Catch Sampling

The towed gear fisheries pursued from these ports can suffer from substantial by-catches of weed, shells, starfish, jellyfish and mud. Such catches are generally more viscous and less suitable to box than catches predominantly composed of fish. Consequently, the initial sorting to select the marketable content of the haul is done as the fish is cleared off the deck, the discards being dumped through the scuppers as work progresses. Generally, there is only sufficient room for one or two crew to do this, access by scientists at this early stage is somewhat restricted by space and the fishermen's need to prepare the catch for the fish-room as quickly and efficiently as possible.

In general, Nephrops trawlers use a table when sorting the catch. The unsorted catch is shovelled on to the table from the pound. The Nephrops are then sorted from the finfish and trash and either tailed or kept whole, depending on their size and quality. The sorted Nephrops are then washed, put below into the fishroom, boxed and iced. The discarded Nephrops and/or unwanted parts thereof are dumped over the side.

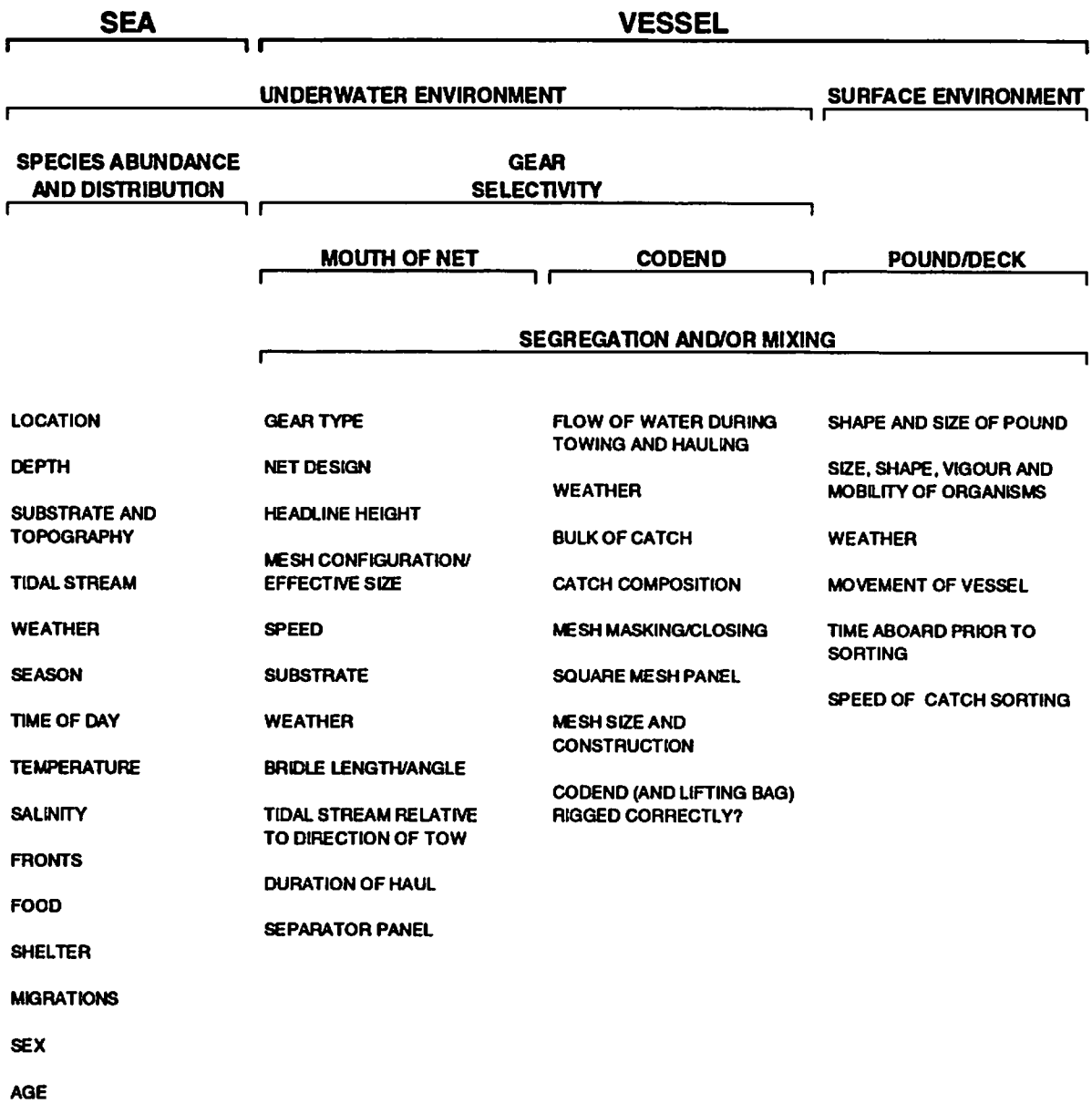


Fig 2.10.1 - Factors which could affect the abundance and distribution of organisms within a trawl catch prior to, and during, sorting by the crew.

2.11.1 Catch sampling : materials and methods

The two catch sampling methods
The sampling procedure changed during the course of the study and is divided into Method 1 and Method 2. For the first study quarter (June-Sept 1993) the sampling method precluded the estimation of between-haul variation of Discard Rates. This was seen as a limitation and the sampling procedure amended accordingly. Thus the procedure described as Method 2 was evolved. Both methods required the same sampling equipment listed in Table 2.11.1.1 and the same basic data collected from each trip and haul listed in Table 2.11.1.2 and 2.11.1.3, and the differences in data collected at the haul level are shown in Table 2.11.1.3. The two sampling methods are described below.

Method 1
This sampling regime was used by previous Seafish studies and was largely based upon the method developed by SOAFD. The catch was sorted into landed and discarded fish by the fishermen. Sub samples of both discarded and landed fish were taken and the length/frequency (wingspan/frequency for rays) distribution of these samples of fish obtained. The samples of discards were taken on a haul basis and the landings on a trip basis.

Appropriate raising factors were estimated for each of these components. The raising factors for discards were obtained by estimating the volume of the sample of discards and the total volume of discards for that haul. There were two methods available for estimating this quantity:-

i. All the unsorted catch from the haul was containerised and its total bulk obtained. The volume of marketable fish was subtracted from the total bulk to obtain the volume of discards.

ii. The discards from the haul were containerised and the total volume of discards obtained.

However, it was not the practice to containerise the catch on most of the vessels sampled so visual estimates of the total bulk had to be made. It was difficult to implement method (ii) because the discarded fish were discarded through the scuppers as sorting progressed (2.11). Visual estimates were relied upon.

The raising factor for the landed fish was obtained by estimating the theoretical weight of the sample from the length/weight relationship (Coull 1989) and dividing this quantity into the tally as reported at the end of the trip (RFD in section 3.4).

Method 2 (trip 10 onwards)
This is described pictorially in Fig 2.11.1.1. Initially the total bulk of the whole catch was estimated visually. Then prior to any sorting by the crew, a sub-sample was taken from the whole, and as yet untouched catch. This was done using a shovel, by vertically sampling each horizontal quarter of the catch until the required sample size was obtained

(based upon experience 3 to 4 baskets were considered necessary to obtain a sufficiently large sample of marketable fish).

The sample was then sorted by the crew (or by the discard officer under close supervision of an experienced crew member) into landings and discards/trash (any sorted Nephrops were then stored in separate polythene bags to be sexed, weighed and measured on return to the laboratory).

The volume of the landed and discarded fish and other components described as trash (see below) from the sub-sample was estimated using the calibrated baskets. (When finfish and Nephrops were observed the volumes of these were estimated separately). Length/frequency distributions of the landed and discarded fish by species were obtained for the fish in the sub-sample.

The trash (sorted from sub-sample) ranked by volume and the components of the trash were coded for database entry and are listed below to help with future use of the archive data:

No trash present	N	Mud	MUD
Coal	COA	Sand	SAN
Crab	CRB	Shells (dead)	SHE
Whelk egg cases	EGG	Starfish	STA
Jellyfish	JEL	Hydroids and algae	WEE

Where the volume of discarded fish was too high to be processed in a reasonable time (approximately half a 6 stone basket per haul was the normal quantity) the amount of discards was reduced by Dutch shuffle and an additional raising factor obtained for these discards.

The volume of total landings as retained by the fishermen was also noted. Thus the results could be raised by (see section 3.4 for equations):

i. Dividing the total volume of landed fish retained by the volume of the sample either on a haul basis (RFA) or a trip basis (RFC).

ii. Dividing the estimated bulk volume by the volume of the sub-sample (RFB).

iii. Dividing the tally weight for the trip by the theoretical weight of the sub-samples (as obtained from the length/weight relationship [Coull 1989]) or actual weight for Nephrops. (RFD for fish and RFN for Nephrops).

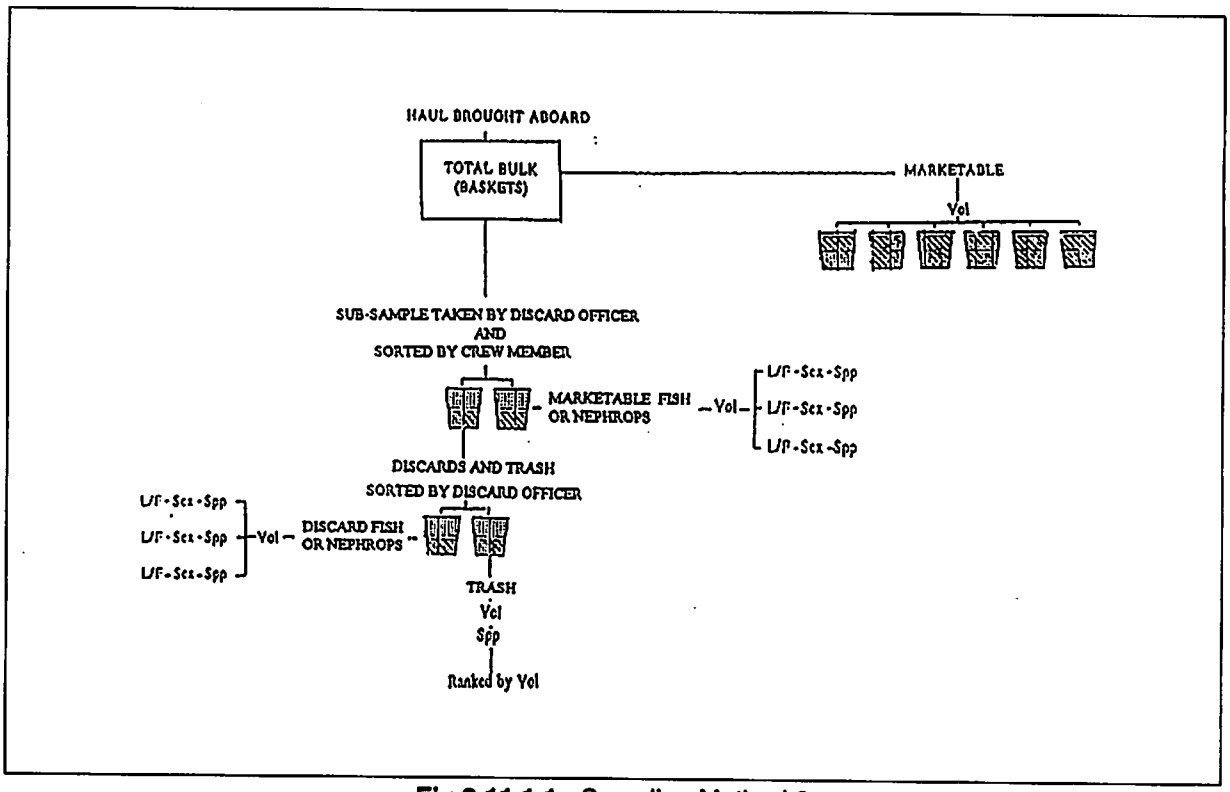


Fig 2.11.1.1 - Sampling Method 2

Table 2.11.1.1 - Equipment Used for Discard Studies

Measuring board
Data recording forms
Pencil
Otolith knife
Otolith storage board
Calibrated fish baskets - nominally 6 stone (37kg) but actual capacity dependent upon species marked in tenths
Shovel
Sample bags, ties and labels
Calipers
Insulated fish boxes

Table 2.11.1.2 - Data Collected for Each Trip

Sailing and Landing Details
Date of sailing and landing
Port of landing
Landing tally by species (boxes or stones)
Boat Details
Port of sailing
Number of crew available to process catch
Engine horsepower
Box size (stones)
Basket size (stones)
Gear Details
Gear type (beam trawl, otter trawl, Nephrops trawl or anchor seine)
Beam/fishing line length (metre) - not measured but informed by skipper
Codend mesh size (mm) - as above
Codend twine size (mm) as above
Codend twine construction - as above
Codend becket fitted correctly (Y/N)?*
Codend lifting bag fitted (Y/N) and if so, fitted correctly (Y/N)?*
Square mesh panel fitted (Y/N) and if so, fitted correctly (Y/N)?*

* as assessed by the Discard Officer

Table 2.11.1.3 - Data Collected for Each Haul

Date	Shoot time	Shoot position
Shoot depth (fathoms)	Haul time	Haul depth (fathoms)

Table 2.11.1.4 - Measurements Taken by Haul in Methods 1 and 2 Compared

Method 1	**Method 2**
Total bulk of unsorted catch estimated by the skipper or another experienced member of the crew.	Total bulk of unsorted catch estimated by the skipper or another experienced member of the crew.
Estimated total bulk of discards (baskets).	Not required.
Total volume of landings.	Total volume of landings.
Volume of sample of discards.	Volume of discards in sub-sample.
Not required; volume or weight of landings estimated on a trip basis.	Volume of landings in sub-sample.
Length/frequency distribution of discards in sample.	Length/frequency distributions of discards in sub-sample.
Not required; length/frequency distributions of landed fish measured on a trip basis.	Length/frequency distributions of landings in sub-sample.

An example of a typical data sheet used in Method 2 is shown in Fig 2.11.1.2.

Nephrops Boarding Method
Personnel were transferred from the Cumbrian Sea Fisheries Protection vessel *Solway Protector* using her inflatable tender. This procedure could only be carried out during daylight hours and good weather; operation of the inflatable was limited by sea conditions and wind strength.

Where possible the boarding was timed to ensure that the gear had been recently hauled; thus the complete haul was available in the pound. On boarding the fishing vessel a sample was taken of the haul currently being processed. A sample of Nephrops was taken from the pound. Efforts were made to acquire a representative sample by taking Nephrops from as many parts of the pound as possible. The sample size was approximately ⅓ of a 3.5 stone (22.2 kg) basket.

NOTE: The bulk density of Nephrops was very much lower than for fish. Consequently, the weight of a full nominal 6 stone (37 kg) basket of Nephrops was 3.5 stone (22.5 kg) resulting in a sample of around 6-9 kg.

This was then sorted into marketable and discards by the crew and placed in labelled polythene bags. The crew were asked not to tail any Nephrops which would normally be tailed; this to enable all the carapace lengths of the sample to be measured. The sample was then purchased from the skipper at slightly higher than the market price (to foster goodwill and future co-operation).

Records were made of the approximate location and time of haul and the mesh size used (as informed by the skipper).

Nephrops Laboratory Work
Samples from both boarding and trip samples were returned to the laboratory. The landings and discards were separated by sex and weighed; any incomplete Nephrops which could not be sexed were also weighed and their weights apportioned in proportion to the weight of each category. The standard measurement of carapace length of each individual Nephrops was taken to the nearest mm below using calipers.

2.12 Data Management
The raw data were processed using Borland Paradox, NAG Genstat and Microsoft Excel.

2.13 Age Structures
Age structures for discards were obtained by the application of age/length keys made from otoliths collected on the discard trips. For landings age/length keys were obtained from DFR Lowestoft (see Appendix II).

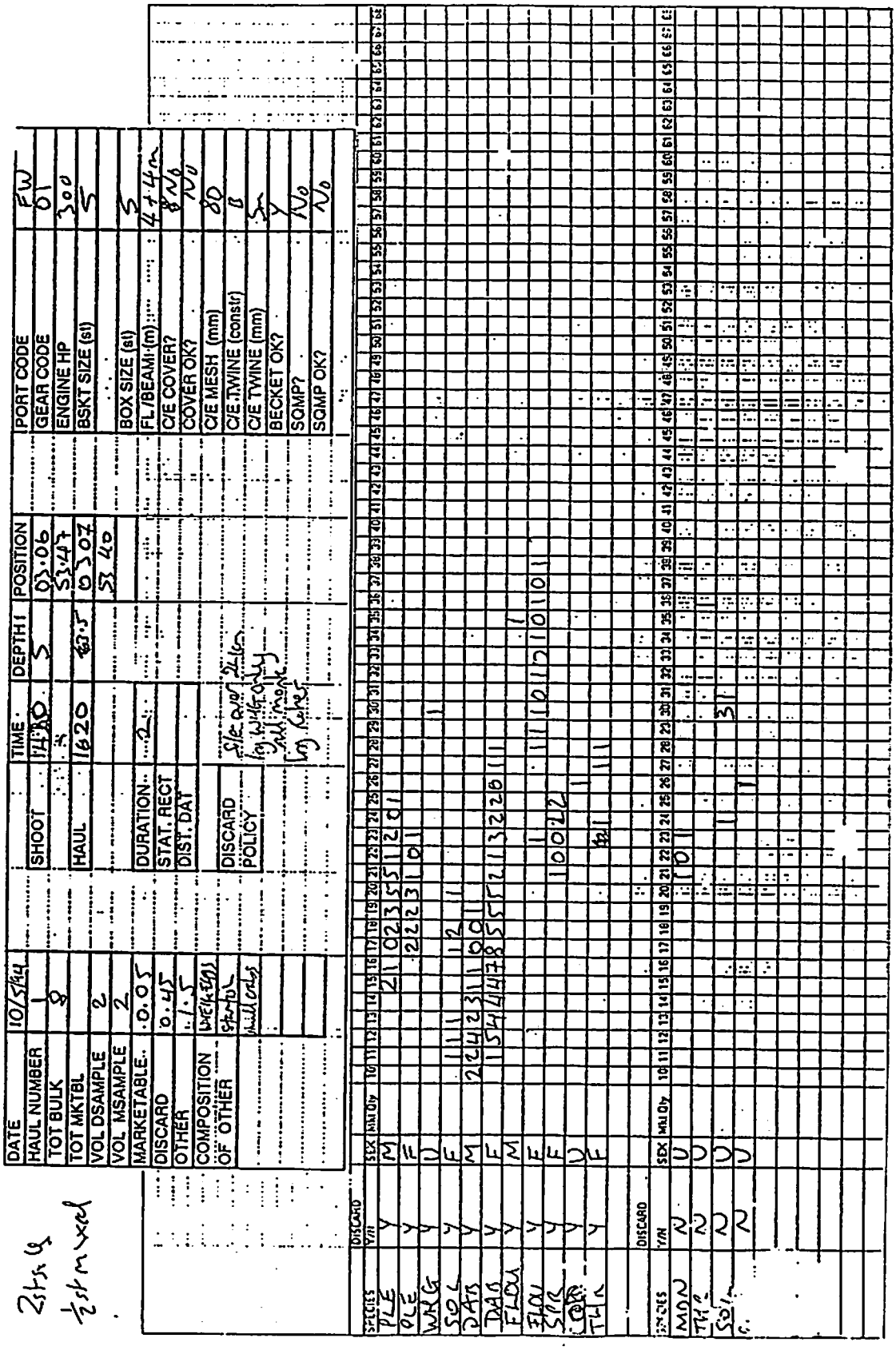


Fig 2.11.1.2 - A typical data recording sheet

3. Results

3.1 The Sampling Hierarchy

The sampling environment can be described hierarchically as being composed of samples of catch taken over the duration of the study in Baskets, from Hauls, within Trips, aboard various **Boats**, working from various **Ports**, using different **Gears**, over many **Grounds**, in pursuit of various commercial species. This provided a framework within which to examine the results of the study. The results were analysed by strata in order to examine possible sources of bias and indicate the likely levels of variation at each stratum. The framework is shown below.

Stratification of Sampling Environment
Time : targets and achievements
Seasonal variation in discarding
Between basket variation (subject of an EC study and not reported here)
Between haul variation
Between trip variation
Between boat variation
Between port variation
Between gear variation
Variation between grounds

The results are presented and discussed in the following sections.

3.2 Targets and Achievements

The main limitations to achieving trips were access to vessels and poor weather.

Access to boats
This project benefitted from the goodwill and relationships established during the previous study. The Nephrops sampling by boarding was helped greatly by the excellent relationship existing between the fishermen and Dave Dobson (skipper of the *Solway Protector*).

Generally access was not a problem with the major exception of Liverpool. This port serves a seasonal fleet of itinerant beamers of various Flag States. Despite sincere efforts by agents and PO's, we were refused outright by Continental vessels (who would not sail with anybody from a UK authority) and failed to connect with willing UK vessels. However, we did gain access to local beamers fishing from Fleetwood. Apart from Liverpool, refusals were rare and usually found to be due to genuine lack of accommodation space.

Weather
Weather was a serious limitation to operating from the exposed tidal ports of the Irish Sea. However, this was really only a logistical obstacle making planning difficult. At times it was difficult to connect with the few (generally larger) boats going to sea (often at very short notice). On the other hand, the reduced sampling during poor weather directly reflects the reduced fishing effort at these times.

Wind speed and sea state also restricted use of the inflatable tender used to board Nephrops trawlers from the *Solway Protector.* At such times efforts were made to sample by trip instead.

Achievements

The results shown in Tables 3.2.1a and b in terms of hours trawled by gear and statistical rectangle show the extent of the sampling achieved.

Table 3.2.1a - Details of Finfish Sampling Trips Planned and Achieved

STUDY AREA	GEAR	PLANNED	ACHIEVED	TRIP CODE	BOAT CODE	PORT	CODEND MESH (mm)	ENGINE HP	CREW SIZE	NUMBER OF HAULS	HOURS TOWED	STATISTICAL RECTANGLE
1993 QUARTER 3 (JUN-SEP)												
N Wales & L'pool	Otter trawl	1	1	3	C	Bangor	100	150	1	3	5	35E5
Lancashire	Beam trawl	3	3	1	A	Fleetwood	80	300	N/A	15	30	36E6
	"			7	A	"	80	300	2	4	5	36E6
	"			8	A	"	80	300	2	12	22	36E6
	Otter trawl	3	2	9	G	"	80	230	4	5	23	36E6
	"			5	E	"	80	150	2	6	29	37E6
Cumbria	Anchor seine	1	1	6	F	Whitehaven	120	95	2	4	5	37E6
	Nephrops trawl	1	1	4	D	"	70	120	2	3	7	37E6
	Otter trawl	2	1	2	B	Maryport	80	160	2	11	39	38E6
TOTALS:		11	9							63	165	
1993 QUARTER 4 (OCT-DEC)												
N Wales & L'pool	Beam trawl	1	0									
	Otter trawl	1	0									
Lancashire	Beam trawl	3	1	15	A	Fleetwood	80	300	3	2	4	36E6
	Otter trawl	3	3	13	G	"	80	230	4	6	30	37E6
	"			14	H	"	80	127	2	4	20	37E6
	"			16	B	"	80	150	2	4	18	36E6
Cumbria	Anchor seine	2	3	10	H	Whitehaven	80	172	3	4	4	37E6
	"			11	H	"	120	172	3	1	1	38E7
	"			12	F	"	120	95	3	4	6	37E6
	Otter trawl		0			"						
	Nephrops trawl	2	0			"						
TOTALS:		13	7							25	82	
1994 QUARTER 1 (JAN-MAR)												
N Wales & L'pool	Beam trawl	2	1	17	1	Holyhead	80	1500	5	67	134	36E4
Lancashire	Beam trawl	2	0									
	Otter trawl	3	0									
Cumbria	Anchor seine	1	0									
	Otter trawl	1	0									
TOTALS:		9	1							67	134	
1994 QUARTER 2 (APR-JUN)												
N Wales & L'pool	Beam trawl	1	0									
	Otter trawl	1	0									
Lancashire	Beam trawl	3	2	21	J	Fleetwood	80	300	3	13	24	36E6
	"			27	N	"	80	500	5	11	19	36E6
	Otter trawl	3	2	18	G	"	80	230	4	3	12	37E6
	"			20	B	"	80	114	2	3	17	37E6
	Nephrops trawl	6	3	19	E	"	70	114	2	3	13	37E6
Cumbria	Anchor seine			25	F	Whitehaven	120	95	3	4	6	37E6
	Otter trawl			29	O	"	80	170	2	1	3	37E6
	Nephrops trawl			24	K	"	70	110	3	8	39	37E6
	"			28	O	"	70	170	2	6	21	37E6
TOTALS:		17	9							52	152	
1994 QUARTER 3 (JUL-AUG)												
Lancashire	Beam trawl	1	0									
	Otter trawl	2	2	32	G	Fleetwood	80	230	4	2	15	37E6
	"			33	E	"	80	114	2	4	16	37E6
Cumbria	Anchor seine	1	1	30	F	Whitehaven	120	95	3	2	3	38E6
	Otter trawl	0	2	31	P	"	80	70	1	2	5	38E6
	"			35	P	"	80	70	2	2	6	37E6
	Nephrops trawl	12	2	34	Q	"	70	230	3	7	28	37E6
	"			36	K	"	70	110	3	4	18	37E6
TOTALS:		16	7							23	90	

NOTE: Boat code letters were allocated as each new vessel entered the study, to allow repeat trips aboard the same vessel to be identifed and compared.
Only Nephrops trips not boarding samples are recorded here.

Table 3.2.1b - Study Totals

STUDY AREA	GEAR	PLANNED	ACHIEVED	NUMBER OF HAULS	HOURS TOWED
N Wales & L'pool	Beam trawl	4	1	67	134
	Otter trawl	3	1	3	5
Lancashire	Beam trawl	9	6	57	104
	Otter trawl	14	9	37	180
	Nephrops trawl	0	1	3	13
Cumbria	Anchor seine	7	6	19	25
	Otter trawl	5	4	16	53
	Nephrops trawl	21	5	28	113
TOTALS:		63	33	230	627

There are seasonal differences in the spatial extent of sampling; since the strategy required that the sampling activity followed the activity of the fleet, this should reflect the overall commercial effort. Comparison should therefore be made with reported effort.

The planned and achieved Nephrops sampling trips can be seen in Fig 3.2.1 and Table 3.2.2. The planned sampling weeks of the 4/4/94 and 2/5/94 were unfulfilled due to adverse weather. However, sampling in the weeks of 30/5/94, 13/6/94 and 4/7/94 was cancelled because information gained from Cumbrian Sea Fisheries Committee indicated that the fishing activity at these times was very low due to poor catches of Nephrops.

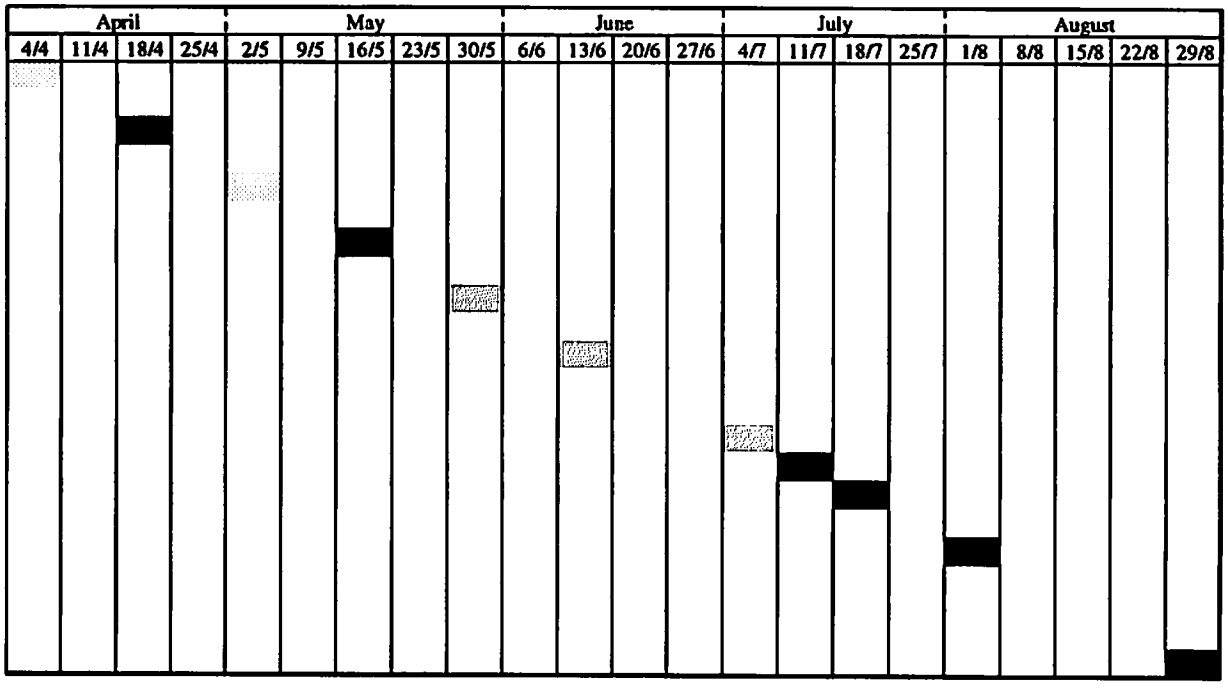


Fig 3.2.1 - Record of Nephrops Sampling 1994

Table 3.2.2 - Details of Nephrops Sampling Trips

STUDY AREA	DATE	SURVEY TYPE	BOAT CODE	PORT	NUMBER OF HAULS
1993 QUARTER 3					
Cumbria	15/06/93	B	A	Whitehaven	1
	"	B	B	"	1
	"	B	C	"	1
	27/07/93	B	C	"	1
	"	T	D	"	2
	18/08/93	T	E	"	3
1994 QUARTER 2					
Cumbria	20/04/94	B	F	Whitehaven	1
	"	B	G	"	1
	17/05/94	T	G	"	8
1994 QUARTER 3					
Lancashire	13/07/94	T	H	Fleetwood	2
Cumbria	19/07/94	B	D	Whitehaven	1
	"	B	I	"	1
	"	B	J	Heysham	1
	"	B	K	Whitehaven	1
	"	B	F	"	1
	"	B	L	"	1
	"	B	G	"	1
	"	B	M	"	1
	02/08/94	B	N	"	1
	"	B	O	"	1
	"	B	L	"	1
	"	B	C	"	1
	03/08/94	T	N	"	4
	31/08/94	T	G	"	7
TOTAL:					44

KEY: B: Boarding survey
T: Trip survey

NOTE: *The Nephrops Boat Code letters were allocated independently of the finfish trips and are not comparable.*

3.3 Temporal Variation in Discarding

The quarterly discarded and landed components are displayed as raised length frequency histograms and age structures for plaice, sole and whiting (Figs 3.3.1 to 6).

Plaice

The length frequency distributions for the first study quarter (Fig 3.3.1) are quite different from the subsequent quarters. The distribution shows a huge proportion of discards to landings. This distribution was obtained using Method 1, where the aggregate sample discards had to be raised to haul level in order to obtain a discard rate. It is considered that these results are invalid, and are probably due to gross errors in estimating the total bulk component for raising. Method 2 was developed in response to this and other problems with Method 1. As a result of this deficiency, the subsequent analysis in this report is restricted to data gathered after Method 2 was introduced at the start of the second sampling quarter (Trip 10 onwards).

The length/frequency histograms of plaice for October-December 1993 onwards (Fig 3.3.1) show very similar distributions across the seasons. Within these distributions it can be seen that the age structure varies. Overall, two year classes dominate the discarded fish - 1991 and 1992. The 1991 year class was the modal year class for autumn 1993. By the spring of 1994 the modal year class were the 1992 fish, of which the majority were discarded. The following quarter heralds the appearance of the 1993 year class within the catches. These results suggest that the discarding pattern for plaice varies little throughout the seasons and that the age classes succeed each other in a well defined and orderly manner.

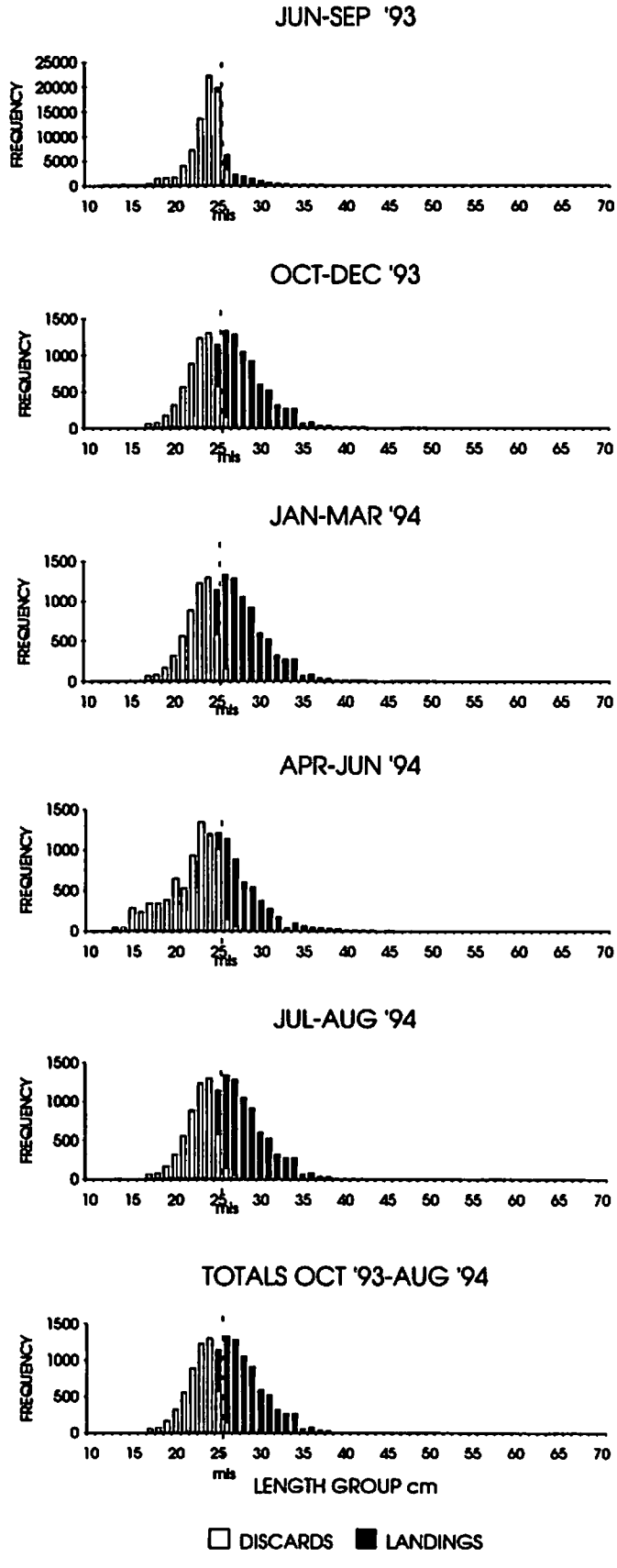


Fig 3.3.1 - Plaice length/frequency distributions by quarter.

NO DATA

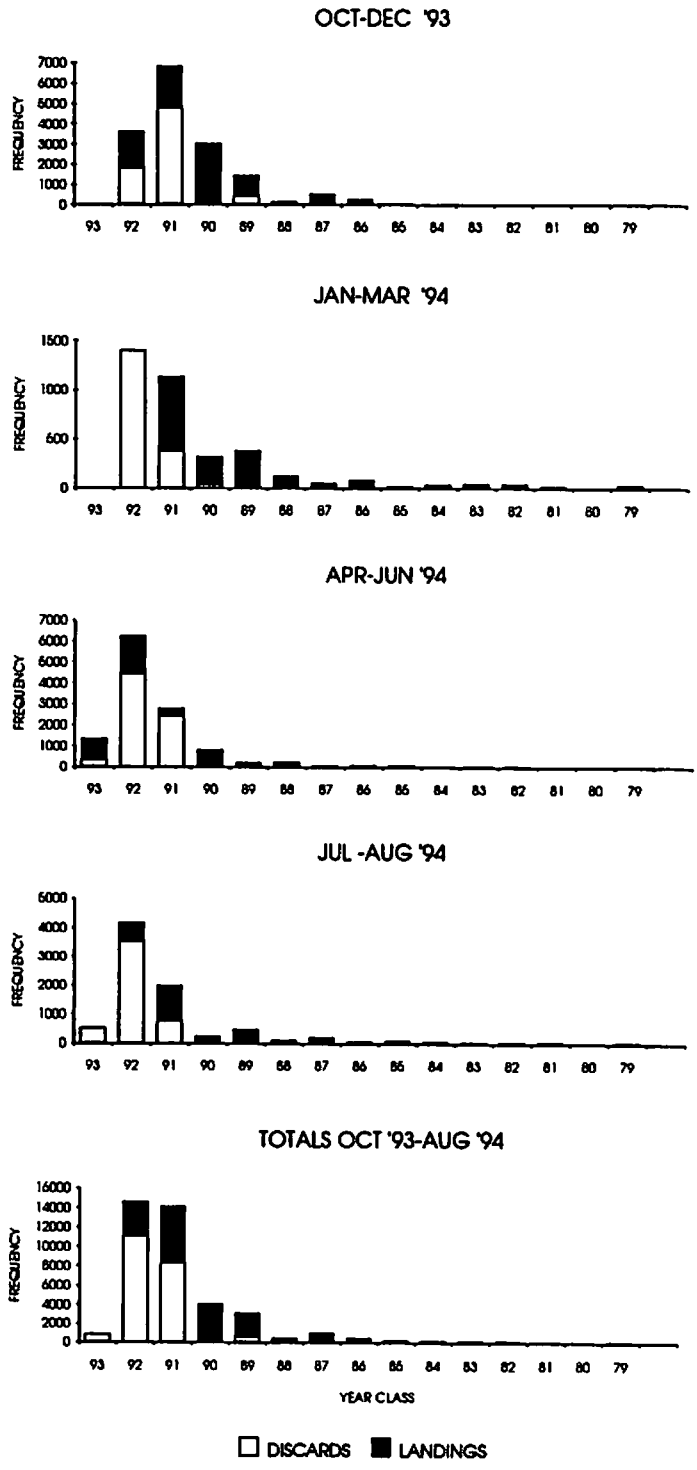


Fig 3.3.2 - Plaice age structures by quarter.

Sole

Analysis of the sole data is somewhat limited due to the low numbers of observations with the exception of spring 1994 which consisted of one 1600hp beamer trip (Table 3.2.1).

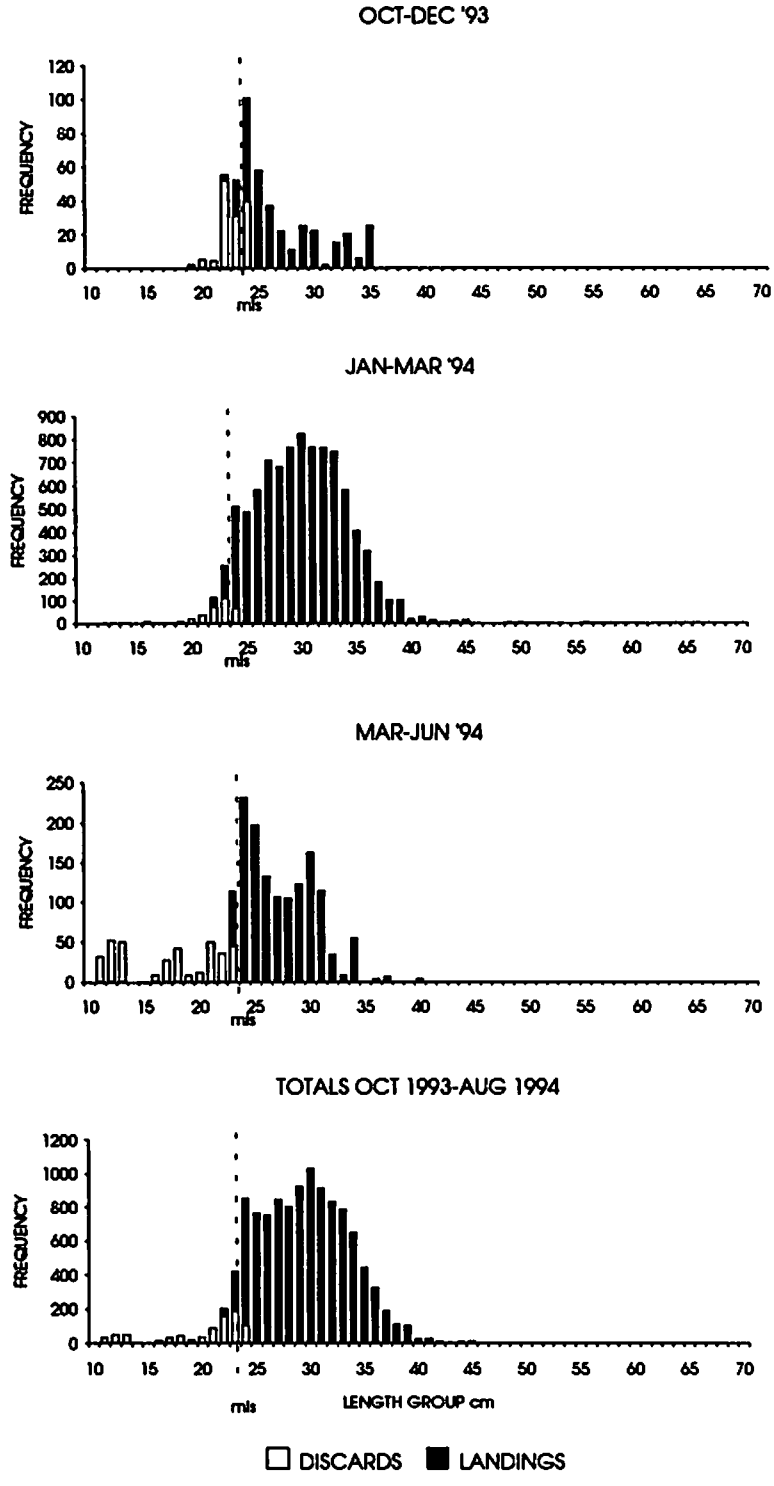


Fig 3.3.3 - Sole length/frequency distributions by quarter.

Despite this, it can be seen that discarding is generally very low throughout the seasons and limited to fish smaller than the minimum landing size and hence of the more recent year classes.

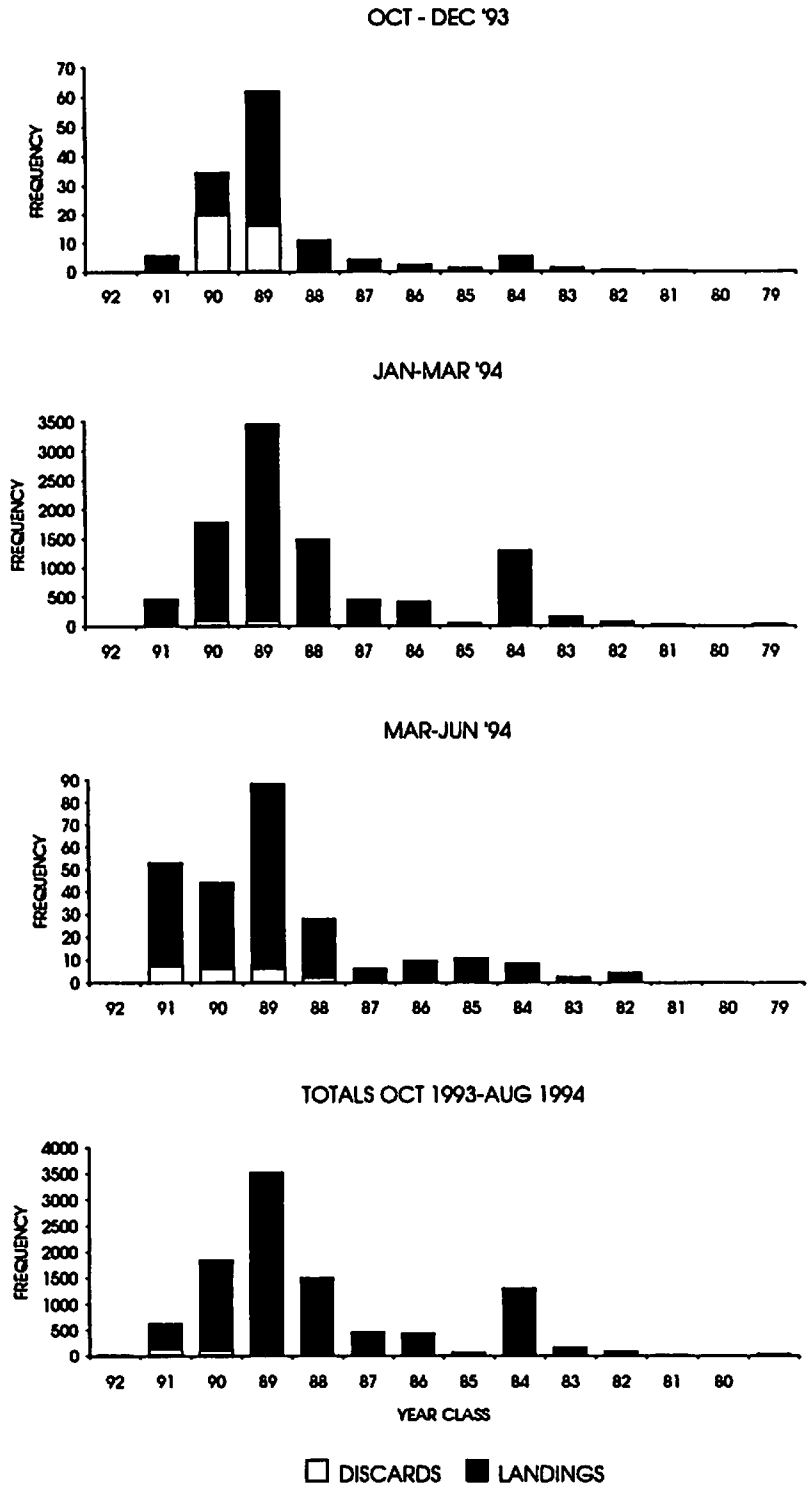


Fig 3.3.4 - Sole age structure by quarter.

Whiting

The whiting length frequency distributions (Fig 3.3.5) vary somewhat through the seasons and overall show heavy discarding both above and below MLS (27 cm). Almost all of the whiting caught during the summer of 1994 were discarded. At this time, sampling was concentrated within the seasonal Nephrops fishery south of St. Bees Head.

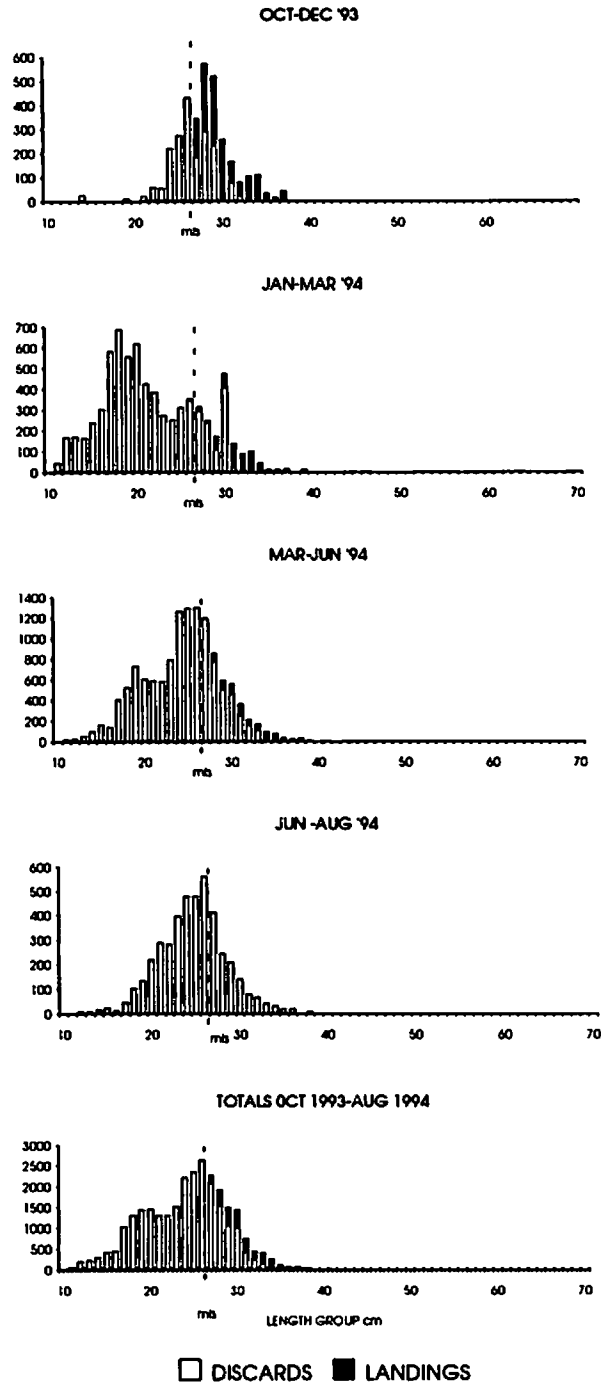


Fig 3.3.5 - Whiting length/frequency distributions by quarter.

OCT-DEC '93
Insufficient data

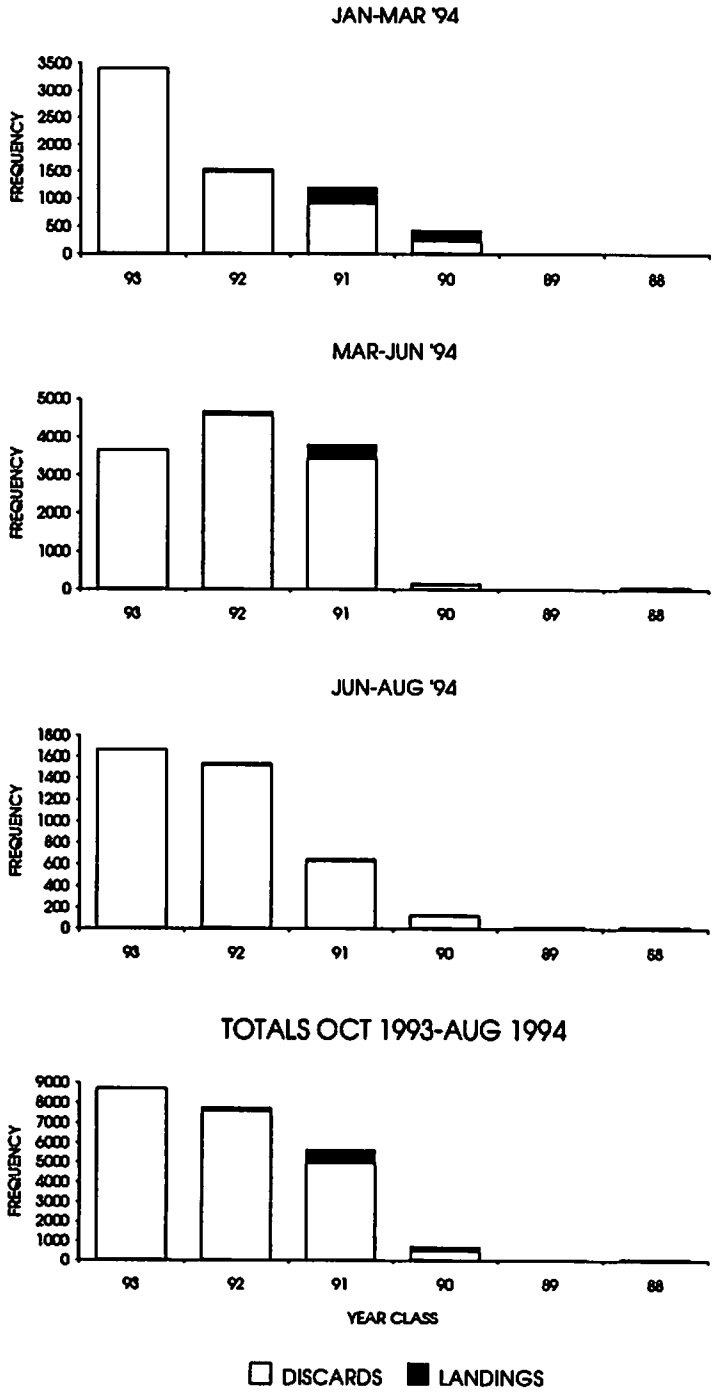


Fig 3.3.6 - Whiting age structures by quarter.

Nephrops

The main fishing activity for Nephrops occurs during the summer months. This is governed by the availability of Nephrops which fluctuates throughout the year. This fluctuation could be related to the Nephrops's life-cycle (Figure 3.3.7). In the summer months the catch ability of the Nephrops increases because both males and females are more readily available for exploitation, but for the rest of the year the females become unavailable to the fishery because they are in their burrows (Farmer, 1975).

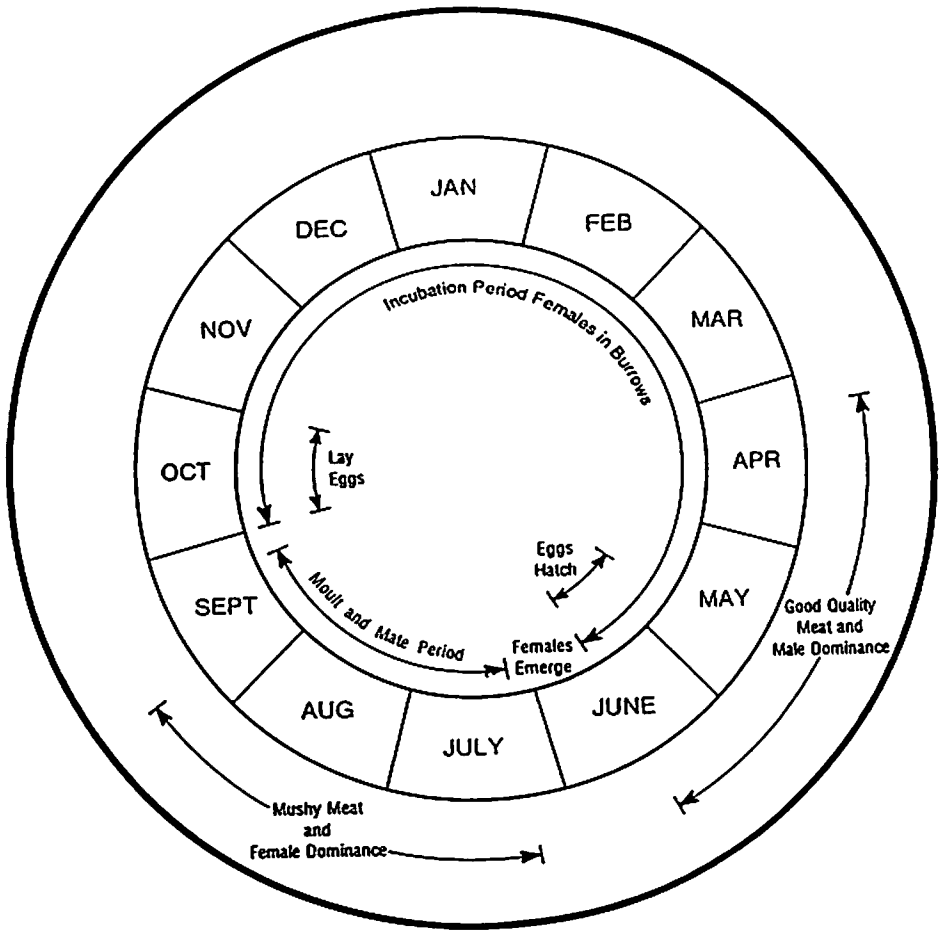


Fig 3.3.7 - Suggested life cycle of *Nephrops norvegicus* in the Irish Sea based on Farmer (1975).

The proportions of males throughout the sample period can be seen in the length/frequency distributions in Figures 3.3.8 & 9. These show that in April and May the males dominate the catches, whereas in June, July and August the females dominate. Between these times (in 1994) the fishery for Nephrops diminished, making sampling not worthwhile (Table 3.2.2.). Overall, the number of boats exploiting Nephrops was highest in late July 1994.

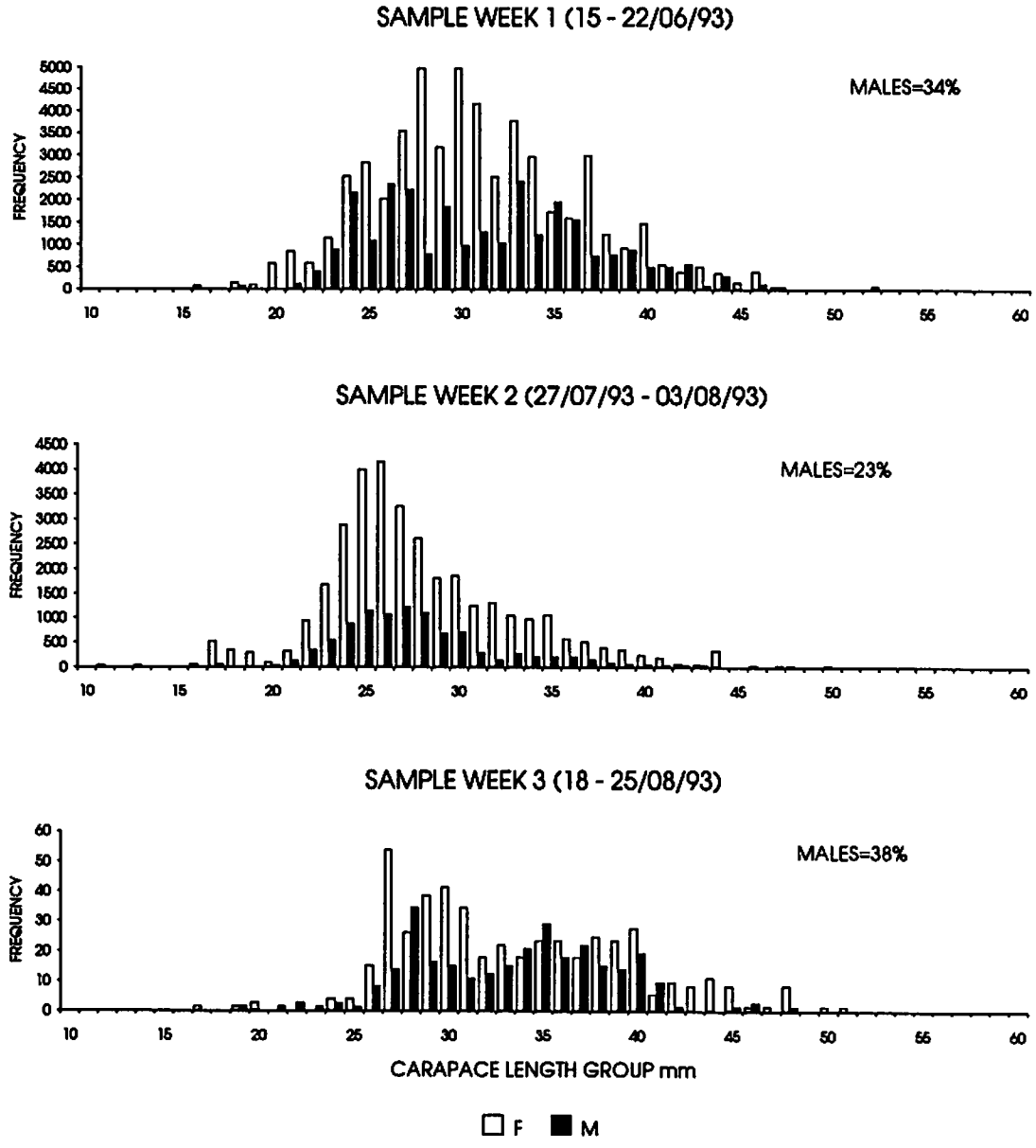


Fig 3.3.8 - Carapace length/frequency distributions of male and female Nephrops 1993.

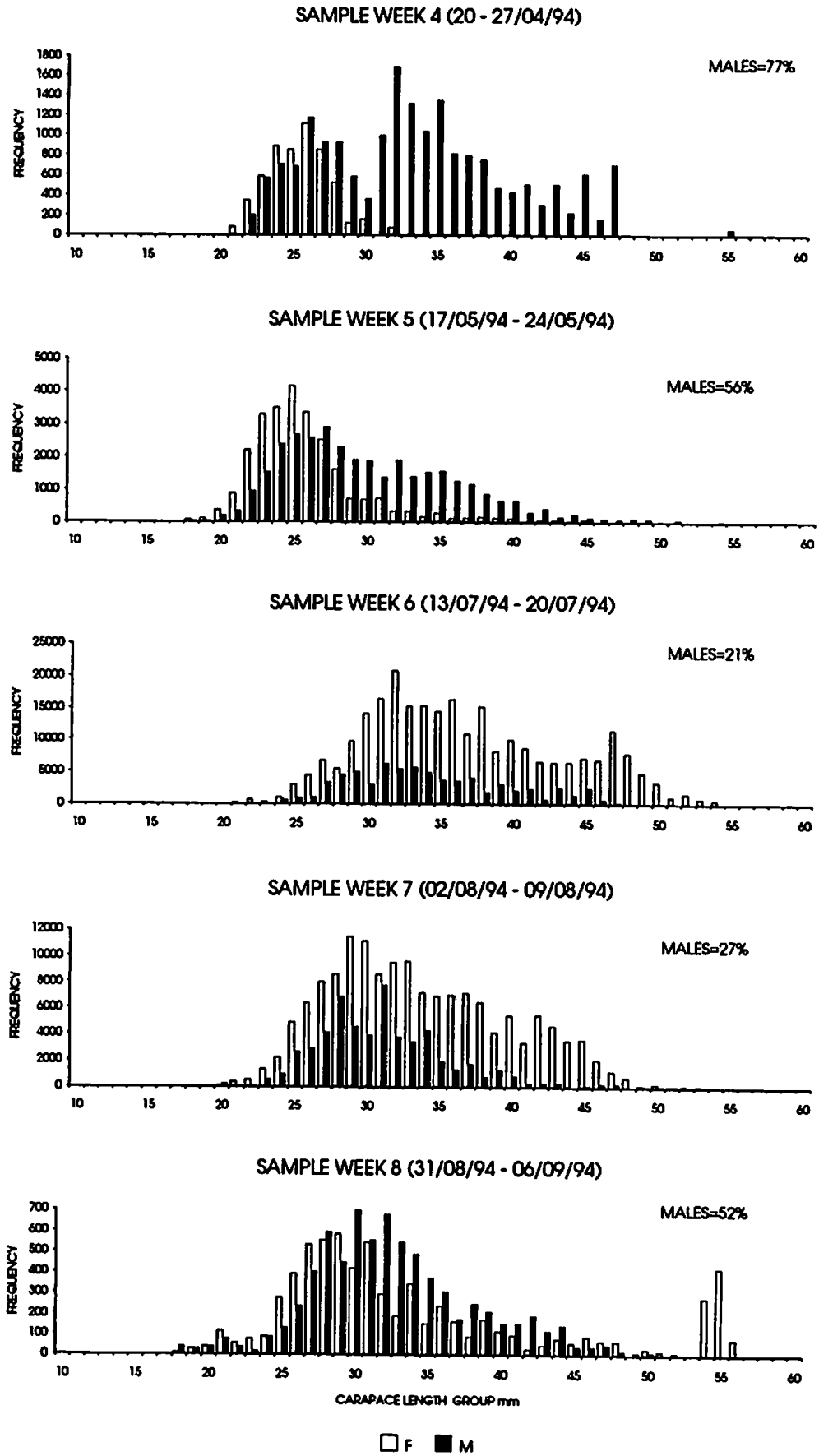


Fig 3.3.9 - Carapace length/frequency distributions of male and female Nephrops 1994.

Farmer (1975) describes the life cycle of Irish Sea Nephrops. In June, July and August the Nephrops moult and mate. Subsequently the females undergo a period of incubation between September, when they lay their eggs, and late May when the eggs hatch. This occurs within the burrows, thus making them inaccessible to fishing gear. Farmer's description (Fig. 3.3.7) is consistent with the seasonal fluctuation in sex ratio observed within trawl catches during the study. It is suggested that in April and May the females are still incubating and are consequently less available to fishing, but by June (in 1993), July and early August (1993 & 1994) they emerge and can be caught. The females outnumber the males in the catches during this period. However, the overall sex rate for the Nephrops stock may favour the females.

The overall length/frequency distributions for the two sample years are shown in Fig 3.3.10. The total discard rate varies between years (42% for 1993 and 8% for 1994). This could be as a result of changing market or other conditions, but it may be an artifact of the sampling. Sample weeks 5 and 6, which were both trip samples, exhibited the lowest discard rate. Only one trip (sample week 8) was undertaken in 1993. These effects are further discussed below.

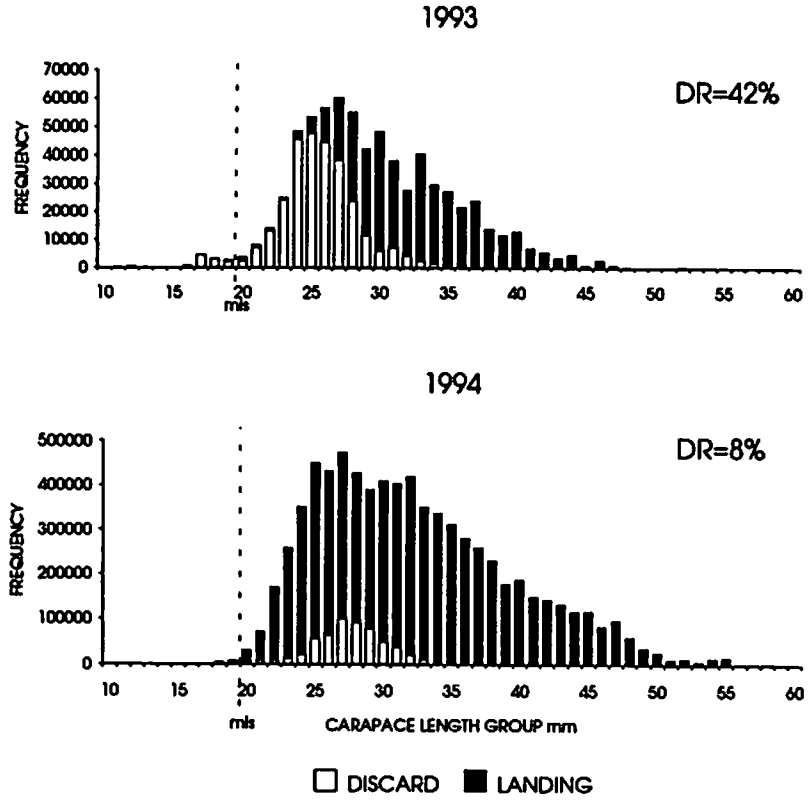


Fig 3.3.10 - Nephrops length/frequency distributions for 1993 and 1994.

At certain times of the year the quality of the Nephrops can deteriorate and their flesh becomes a slightly mushy consistency. These are usually tailed irrespective of size because they are not of a high enough standard for the head-on market and if their quality is very poor they are discarded completely. It was observed that the quality of the Nephrops meat deteriorated in the later summer months (July and August) after the period of quiescence in June, and became soft and mushy. This coincides with the suggested Nephrops moulting period as outlined in Figure 3.3.7 and may have been responsible for the quite high levels of discarding above MLS at this time. It is difficult to discern any wider seasonal trends in the changes in percentage discards over the course of the study.

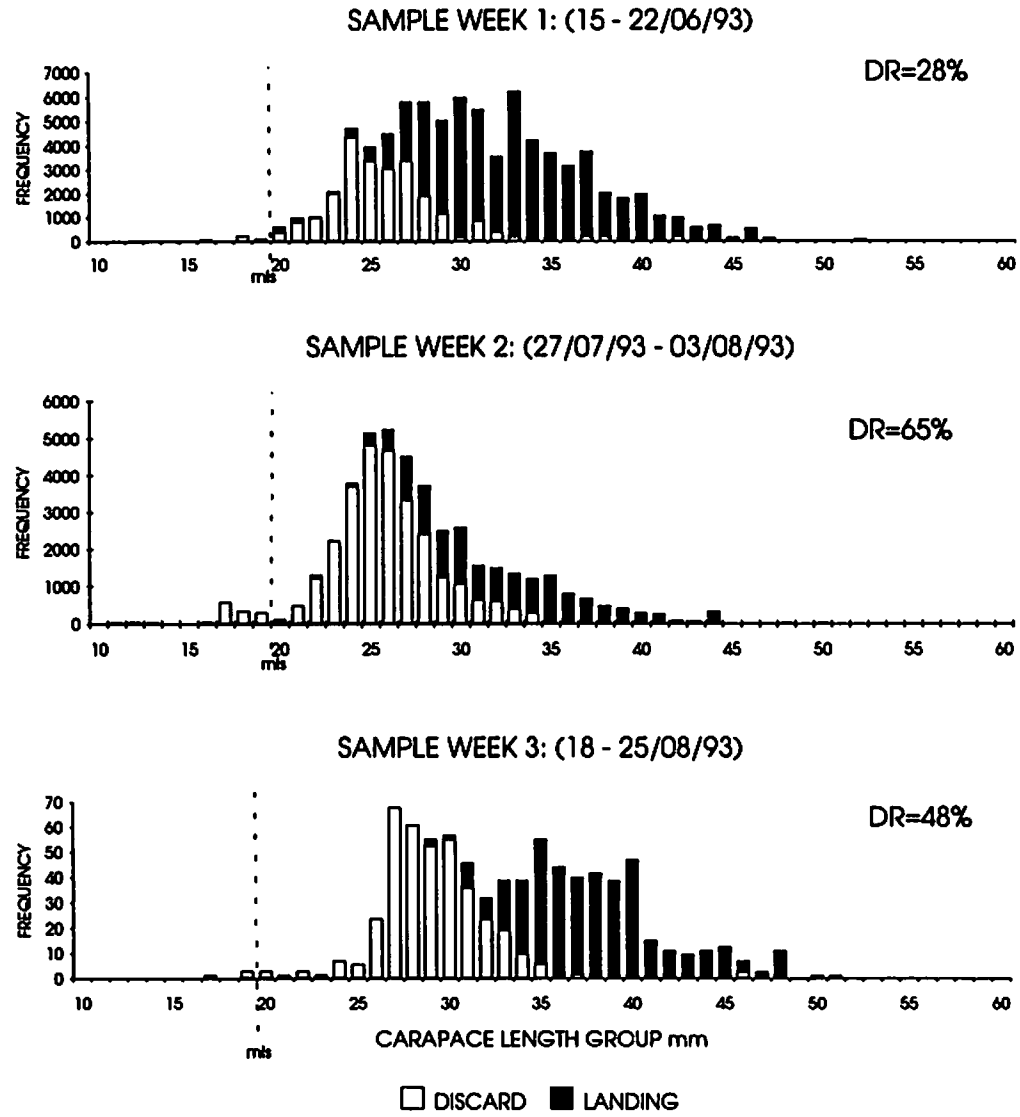


Fig 3.3.11a - Nephrops length/frequency distributions by sample week 1993

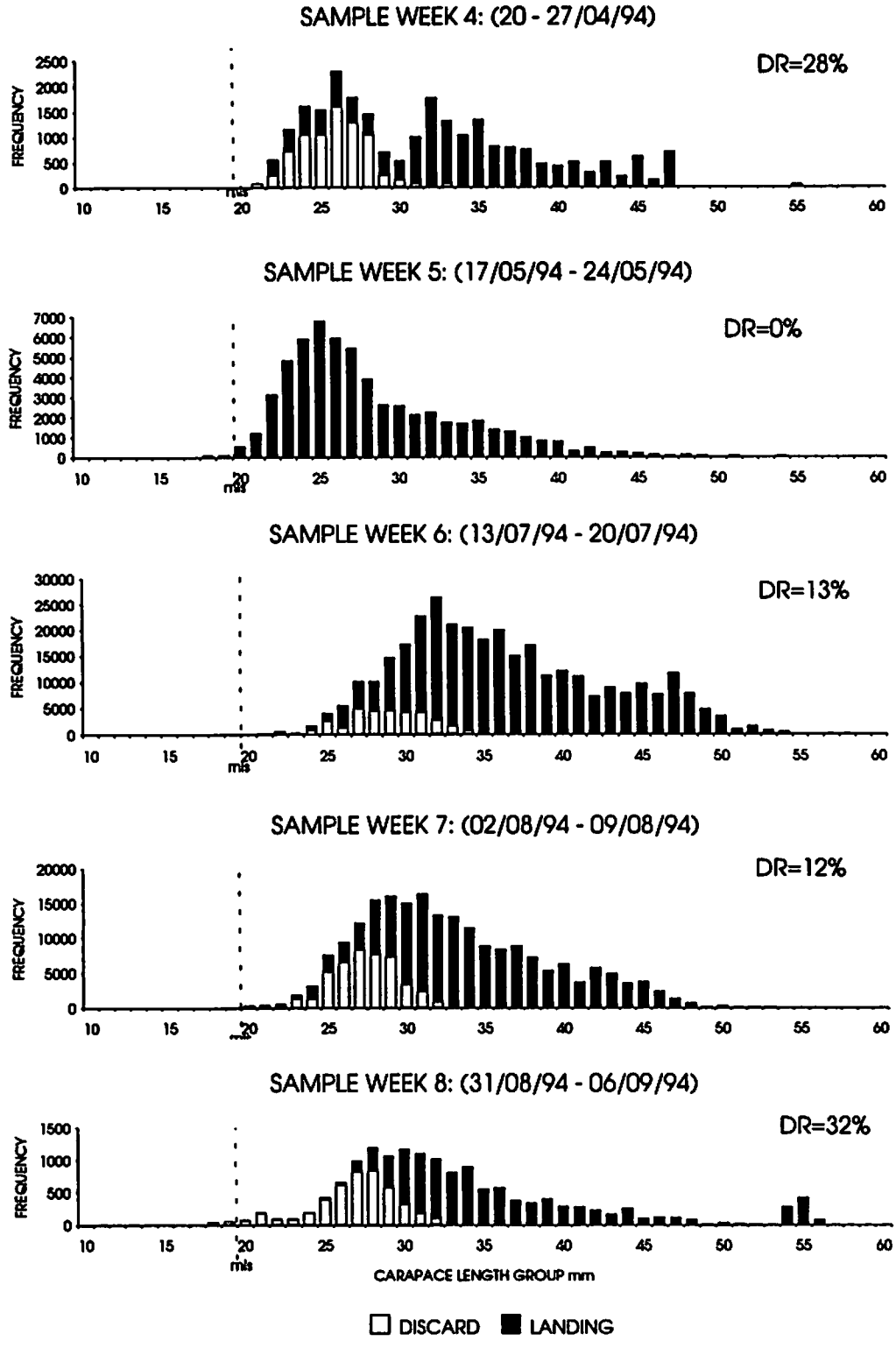


Fig 3.3.11b - Nephrops length/frequency distributions by sample week 1994

Diurnal Effects

For trip samples efforts were made to confound any diurnal variation by ensuring that an equal number of night and day time samples were taken (Section 2.7). However the sampling of Nephrops by boarding could only take place during the day. Therefore it is important to assess any evidence of diurnal variation in discard rates for Nephrops.

When questioned about diurnal effects, most fishermen said that they thought the dawn and dusk hauls yielded the higher Nephrops catches. This suggests that the Nephrops were responding to some change in light intensities, leaving their burrows and so becoming available to the fishermen at these times of the day. Such habits may have an effect upon the population length frequency distributions throughout the day. Lastly, the fishermen's sorting efficiency may deteriorate as the working day progresses. Consequently, the data were examined for any diurnal trends in discard rate as follows:

Only data sampled by the Trip method were used in order to avoid bias towards the day time. The trip hauls were grouped by time of hauling, and the mean, maximum and minimum percentage discard rates are presented in Table 3.3.1. The main discard rates are very similar for day and night hauls and the range of discard rates of between 0% and 83% indicate that the between-haul variation was considerably higher than the variation between times of day. Consequently, for this study, these results suggest that there is not likely to be any bias in the estimates of discard rate due to diurnal factors and that boarding samples, which are only taken during the day, are not likely to be biased by this factor.

Table 3.3.1 - Diurnal Fluctuations in % Discard Rates (Trip Samples Only)

Haul Time		No. of Hauls	Mean	Min	Max
NIGHT	(20:00 - 08:00)	5	16	0	50
DAY	(08:00 - 20:00)	18	15	0	83

3.4 Between Haul Variation

Haul by Haul Raising Factors

Method 2 enabled comparison between two raising factors for each haul to be made. The two raising factors available are as follows:-

$$RFA = \frac{\textit{Total landed volume retained for haul (baskets)}}{\textit{Total landed volume derived from sample (baskets)}}$$

$$RFB = \frac{\textit{Total bulk of haul (baskets)}}{\textit{Total sample volume (baskets)}}$$

Comparisons between the two haul by haul method for estimating raising factors are shown in Figure 3.4.1.

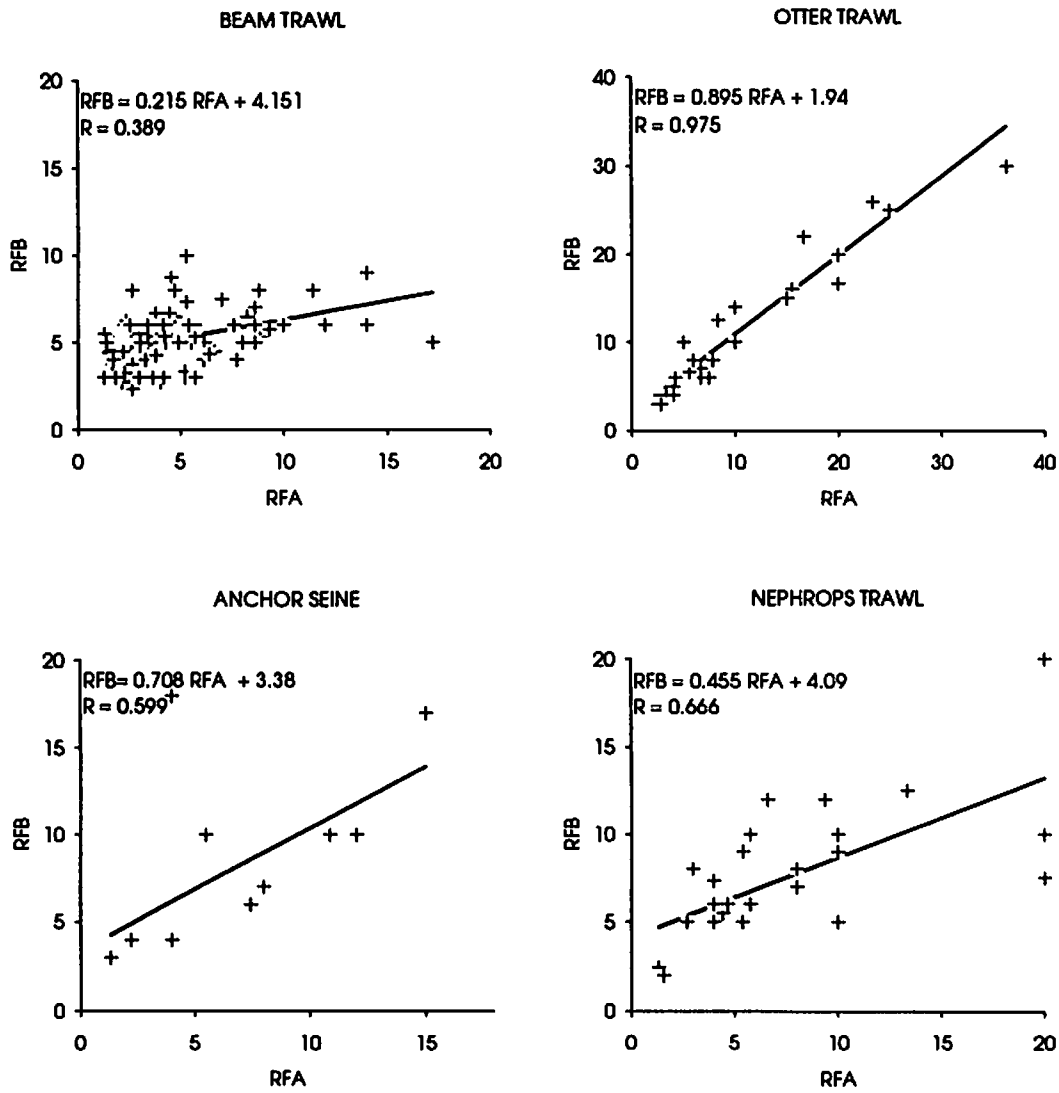


Fig 3.4.1 - Raising factors RFA and RFB compared between gears

These results indicate that the relationship and degree of variation between these two raising factors differ for the four gears studied. The results for otter trawl indicate that there is a good correspondence between the two raising factors. On the other hand, beam trawl results show considerable variation and a poor correspondence between the raising factors.

Beam trawl catches are usually divided into reasonably equal halves when brought aboard, which helps greatly in estimating bulk. Samples were taken from alternate sides at each haul, and the removal of a measured number of baskets for sampling enabled a fair estimate of the remaining material to be made.

However, the percentage volume of landed fish (which is used in the estimate of RFA) within beamer catches was found to be significantly lower than in otter trawling and anchor seining ($p<0.001$), Table 3.4.1. The table shows a significantly higher proportion ($p< 0.001$) of trash (includes stones, sand, mud, shell and weed) in beam trawling than the other gears. Consequently, the smaller numbers of fish observed could lead to greater variation when calculating RFA. Further, the significantly higher percentage of trash in beam trawl hauls also leads to a more viscous catch which is generally less easy to sample effectively. (For significance tests see Appendix 3).

Table 3.4.1 - Mean percentages volumes of landed fish and trash compared by gear type

Gear Type	% Volume of Landings (± 95% conf.)	% Volume of Trash (± 95% conf.)
BEAM TRAWL	15 ± 2.5	75 ± 3.5
OTTER TRAWL	27 ± 4.5	37 ± 6.2
NEPHROPS TRAWL	13 ± 4.8*	54 ± 6.5**
ANCHOR SEINE	56 ± 6.8	0 ± 9.0

NOTE: * Excludes Nephrops
** Includes Nephrops

3.5 Between Trip Variation

Trip by Trip Raising Factors

Two methods are available for estimating raising factors on a whole trip basis.

1. By totalling the volume of marketable fish measured during the trip from each of the haul by haul samples. This was divided by the total volume of marketable fish as estimated on a haul by haul basis:

$$RFC = \frac{\textit{Total landings retained for trip (baskets)}}{\textit{Total volume of landings derived from samples during trip (baskets)}}$$

2a. By estimating the total weight of landed fish measured during the trip using the length/weight relationship from Coull 1989 (theoretical weight) and dividing that into the reported landing tally (SOAFD method):

$$RFD = \frac{\textit{Tally weight (kg)}}{\textit{Aggregate theoretical weight of landed samples for trip (kg)}}$$

2b. The Nephrops were raised similarly, but as the samples were actually weighed, theoretical weights were unnecessary:

$$RFN = \frac{\textit{Tally weight (kg)}}{\textit{Aggregate weight of landed samples for trip (kg)}}$$

Comparison between the two raising factors is complicated by the fact that it was difficult to obtain reliable tallies for all species. This was because some species, particularly if caught in small quantities (e.g. soles caught by otter trawl), would often be landed as components of boxes of 'mixed fish', or not reported at all. The only species for which sufficient tallies were available was plaice.

The two raising factors are compared for plaice (Trips 10 to 36) in Fig 3.5.1. This figure shows that over the course of the study there is good correspondence between these raising factors, providing that the raising factor does not exceed 8.0. Higher raising factors result in increased variation.

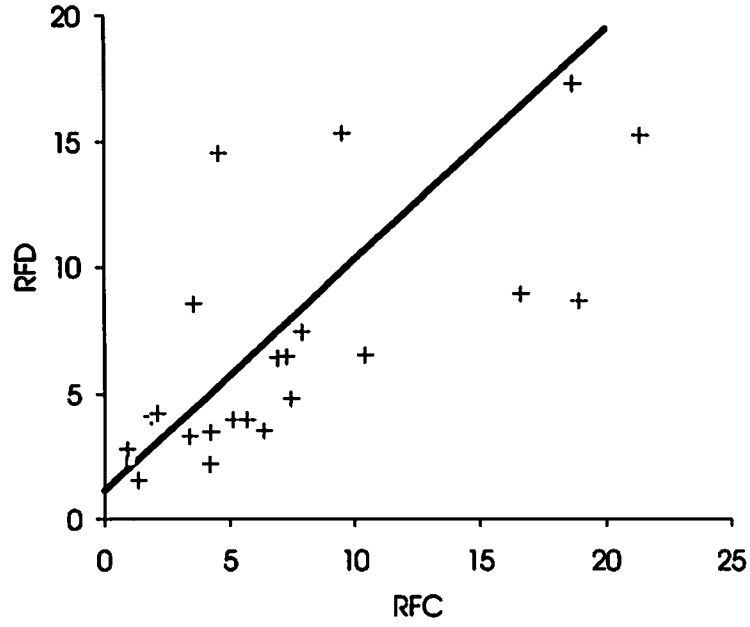


Fig 3.5.1 - Raising factors RFC and RFD compared for plaice for trips 10-36

Table 3.5.1 - A Comparison Between RFC and RFD for 3 Selected Sampling Trips

		SPECIES						
		Plaice	Sole	Whiting	Cod	Monk	Brill	Turbot
Trip Code	RFC	RFD	RFD	RFD	RFD	RFD	RFD	RFD
4	1	1	0.999	0.99	*	*	1	*
17	3.55	6.37	5.266	1.863	60.7	6.36	11.13	21.63
28	6.54	10.43	7.613	8.101	15.7	*	9.13	9.26

NOTE: *no data

Trip 4 (a small otter trawl) was carried out with two Discard Officers and this made sub-sampling unnecessary and enabled all of the fish caught to be measured. The landing tally for this trip was considered to be reasonably accurate. In this instance the results of the different raising factors are very similar and indicate that the length/weight relationships used in RFD for the study are appropriate.

The raising factors by species for Trip 17 (beam trawl) for which reliable tallies are available, are compared in Table 3.5.1. Comparison between species for a single trip suggests that variation between RFC and RFD is highest for cod, and thus there may be some bias against cod inherent in the sampling technique. The larger average size of the individual fish which may make estimates of basket proportions difficult, combined with the relatively few observations, may lead to errors when raised.

Figure 3.5.2 shows the percentage of whiting discarded above MLS, by haul, for Trip 17, a large beamer fishing from Holyhead for the continental markets. There is a slight but fluctuating tendency towards higher discarding towards the end of the trip.

This could be due to dwindling crew stamina reducing the perceived marginal benefit of processing a relatively low value species. The fluctuations in policy could be due to watch changes through the working day.

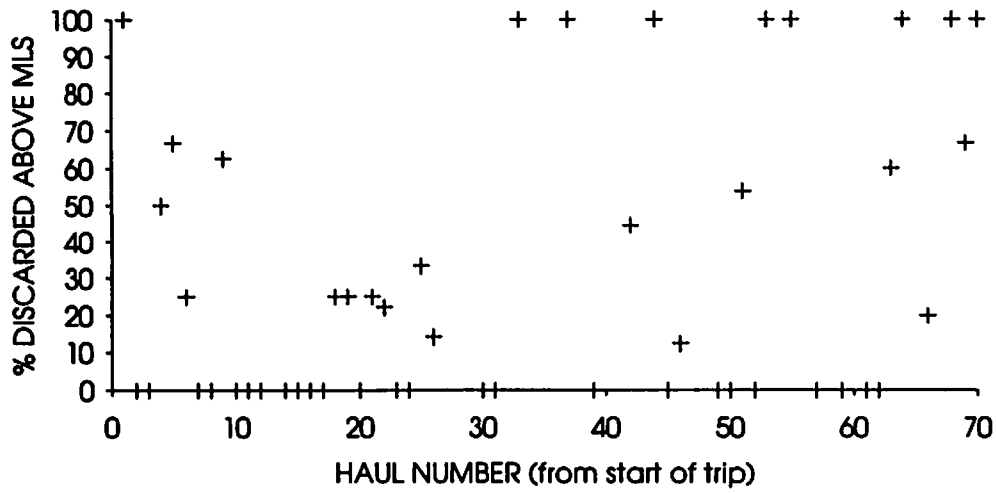


Fig 3.5.2 - Variation in percentage discards of legal sized whiting over the course of a beamer voyage (Trip 17)

Between trip variation in discard rates

The haul was the unit of sampling effort used in most of the analysis. However, to enable trip information to be read into the main MAFF database, the haul data has been totalled by trip and is available on disk.

Comparison between percentage discard rates by trip and haul for plaice, sole and whiting are shown in Figs 3.5.3 to 3.5.5. These results indicate that analysis by trip would yield the same mean values for discard rates for these species, though the standard errors and consequent confidence intervals are smaller for the haul by haul results.

Analysis by trip masks important spatial variations, and was consequently considered less useful than analysis by haul. As a result, all subsequent analysis was carried out by haul where possible.

DISCARD RATE	MEAN	S.E OF MEAN	NUMBER OF OBS.	95% CONF. INTERVAL
HAUL	55	2	162	51-59
TRIP	56	4	24	47-64

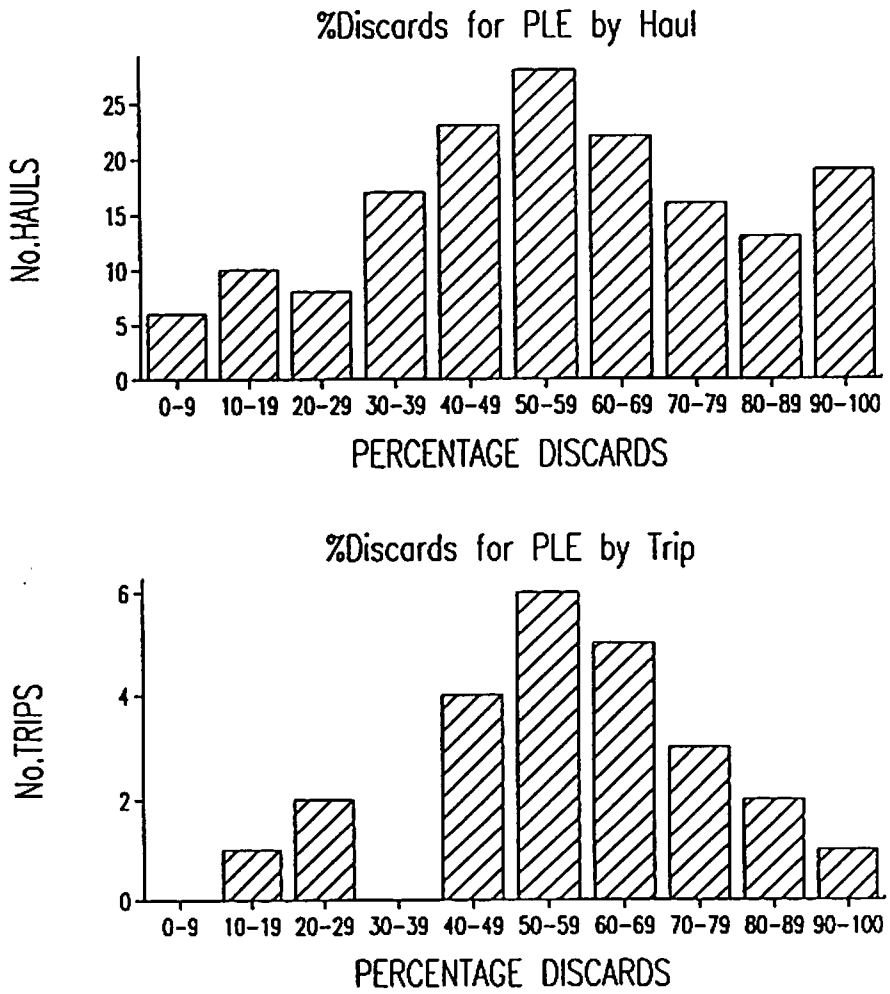
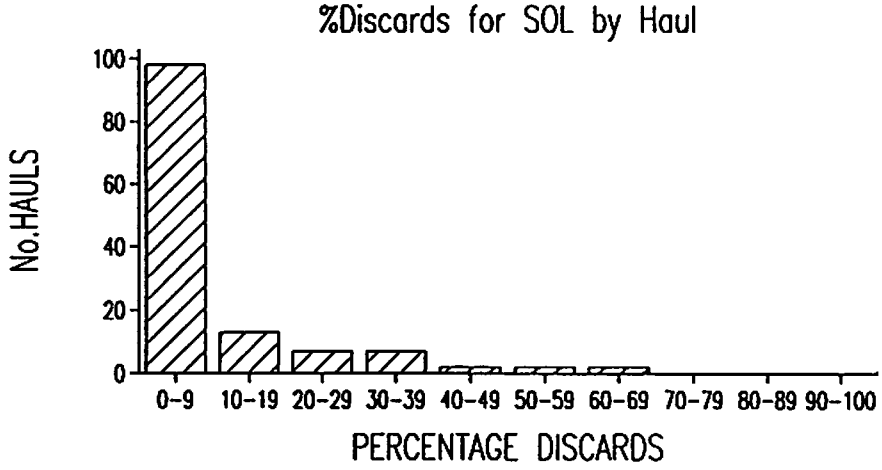


Fig 3.5.3 - Percentage discard rates by haul and trip compared for plaice

DISCARD RATE	MEAN	S.E OF MEAN	NUMBER OF OBS.	95% CONF. INTERVAL
HAUL	8	1.2	131	6-10
TRIP	7	3	18	1-13



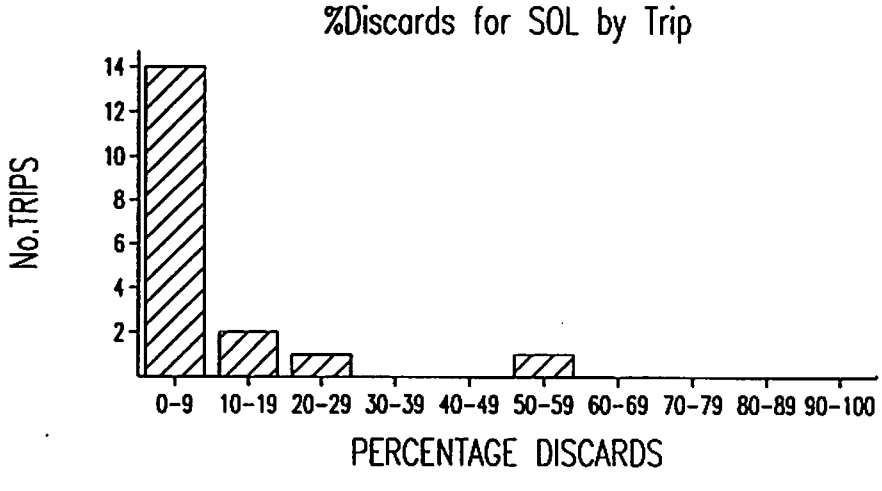


Fig 3.5.4 - Percentage discard rates by haul and trip compared for sole

DISCARD RATE	MEAN	S.E OF MEAN	NUMBER OF OBS.	95% CONF. INTERVAL
HAUL	88	1.9	147	84-92
TRIP	86	5.8	20	74-98

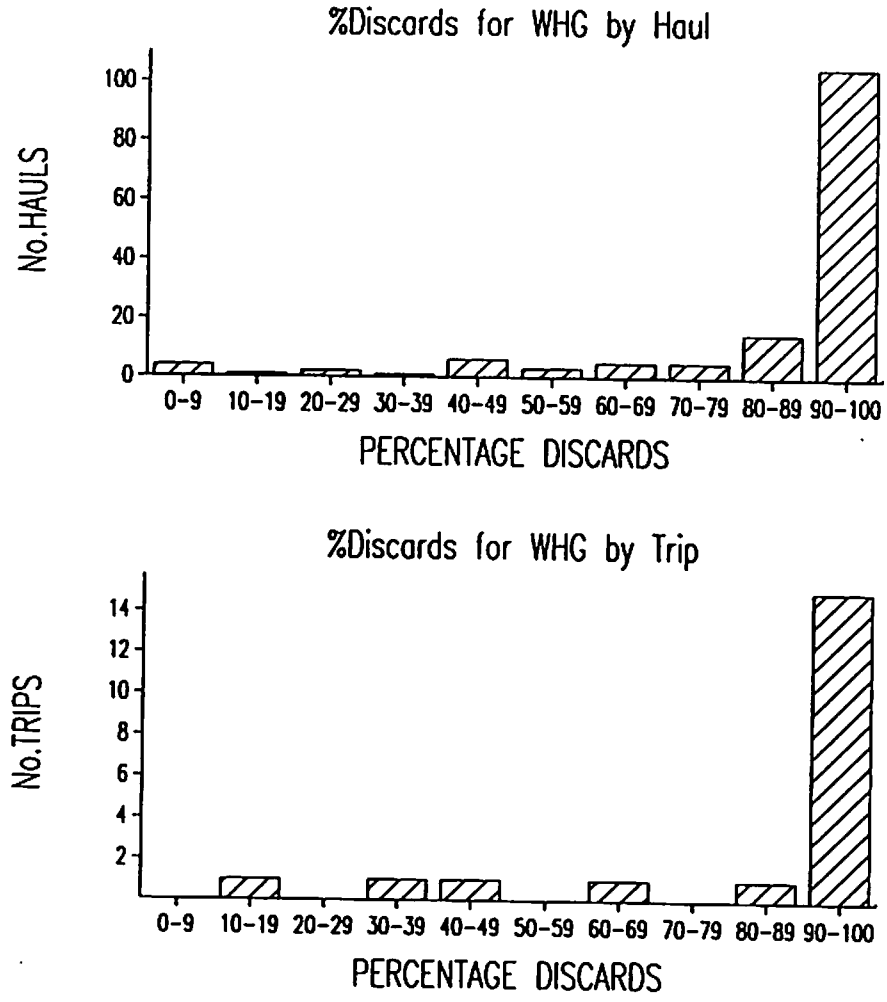


Fig 3.5.5 - Percentage discard rates by haul and trip compared for whiting

Nephrops sampling: variation between the trip and boarding methods

By comparing boarding and trip samples undertaken on the same vessel in the same season, any difference between the two methods can be identified in Figures 3.5.6.

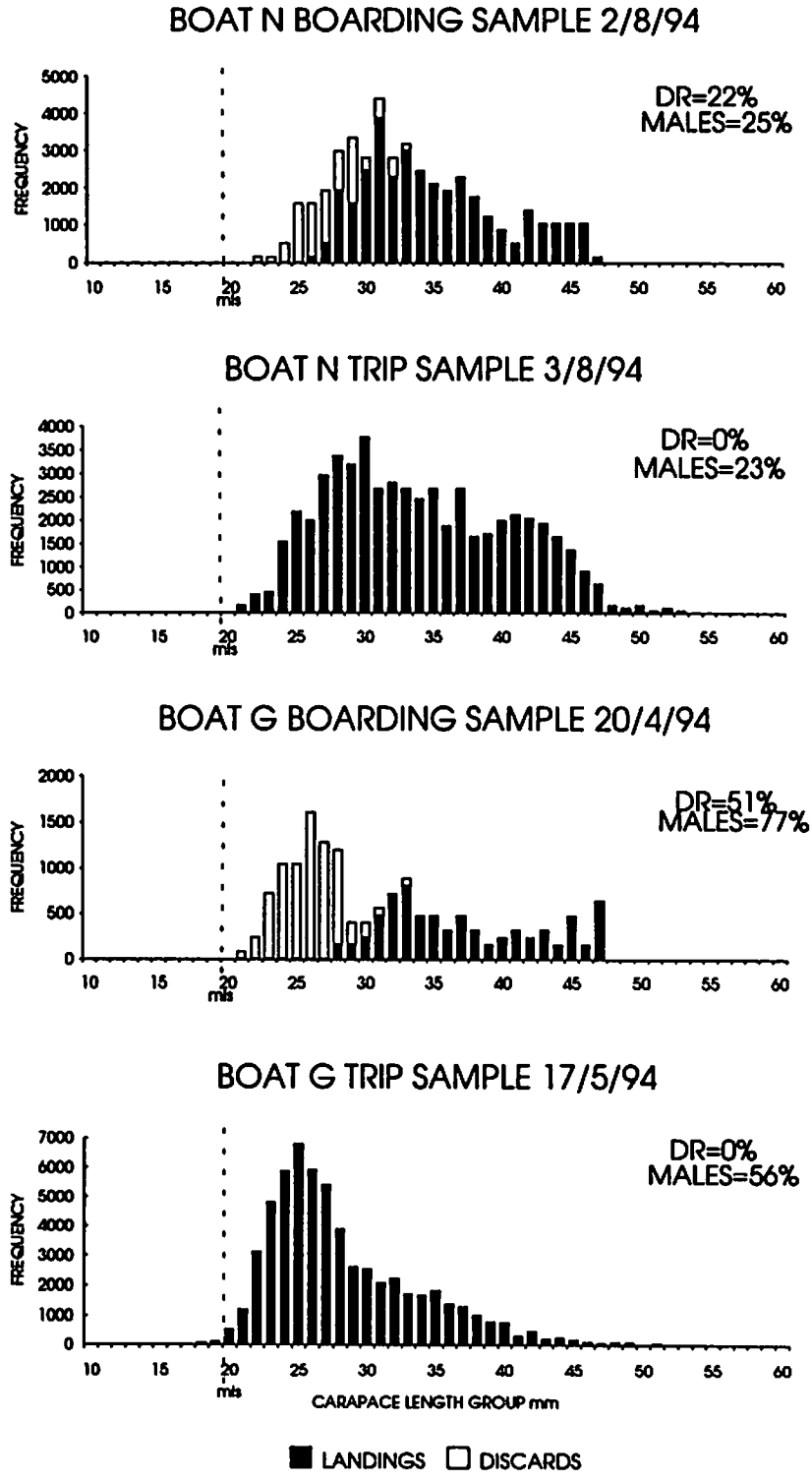


Fig 3.5.6 - Comparison of Nephrops length/frequency distributions between boarding and trip samples

In the two available cases, the trip sample produced a very different result from the boarding sample, with 0% discards compared with 22% and 51% for the boarding samples. Fig. 3.5.6 shows a lower discard rate for the boarding sample. The most striking contrast is for Boat N which was sampled by boarding and trip on successive days and it shows that there is a change in discard practice. It was thought that the presence of a Cumbrian Sea Fisheries Committee Officer (who accompanied the sampling officer during boarding) may have caused the crew to discard the smaller sized Nephrops. The use of a monetary incentive, which was higher than the current market price, may also have influenced discarding, as skippers may have thought that they would not be sampled if they did not discard. Boat G shows a similar pattern but the time interval between the samples may mean that different populations were being fished and different market conditions were prevailing.

These results suggest that boarding by this method, as it stands, may cause bias in the results.

3.6 Between Boat Variation

Variation in discard rates by boat

Discard rates by haul and by boat for plaice, sole and whiting, and Nephrops by trips and boat are shown in Fig 3.6.1. These results reflect the composition of the stocks fished and the discarding policies of the boats sampled. These two components are examined further in Table 3.6.1.

For plaice, sole and whiting, two discard rates are calculated on a haul by haul basis:

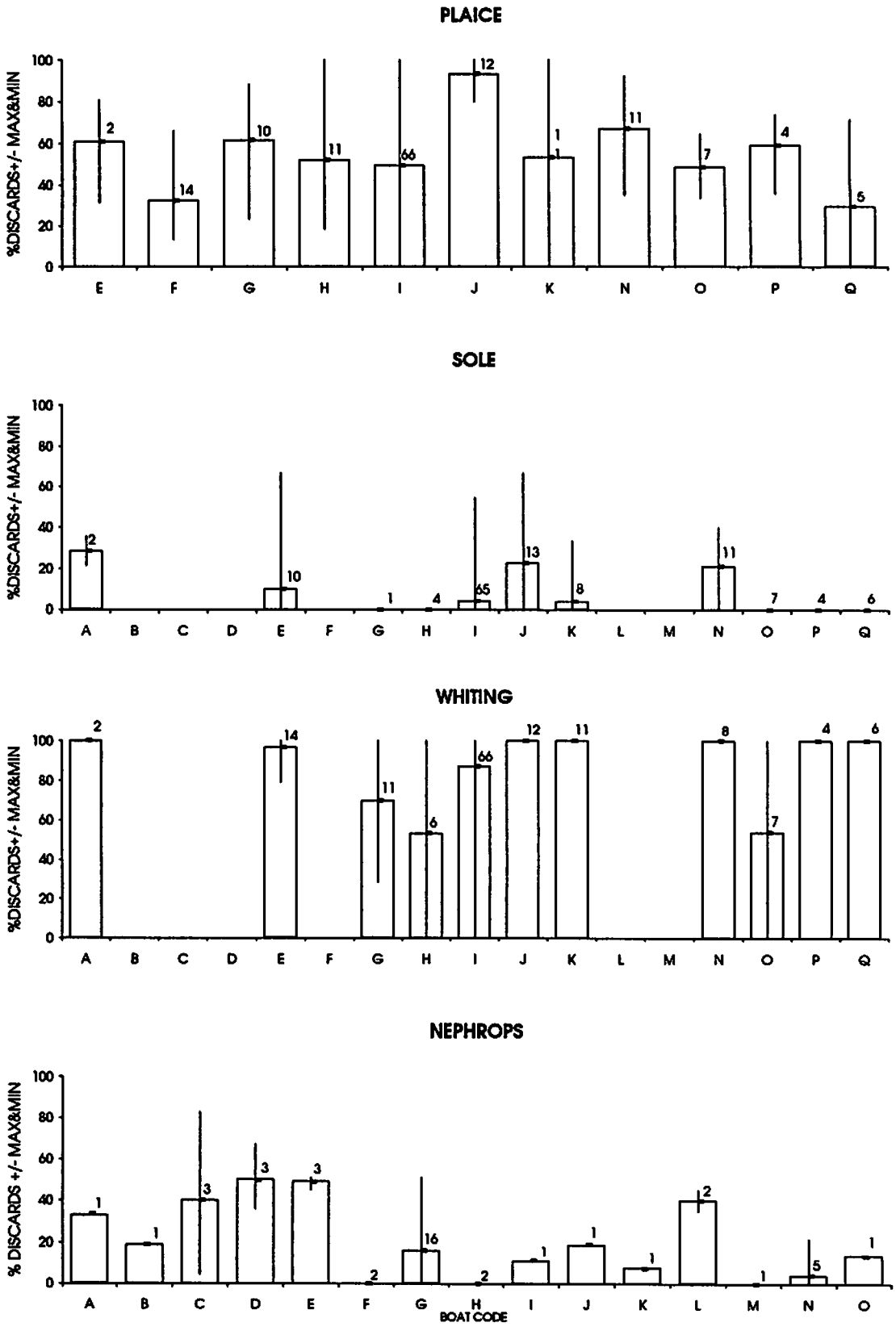
$$\textit{Discard rate below MLS} = \left(\frac{\textit{No. of fish discarded below MLS}}{\textit{Total Catch}} \right) \times 100\%$$

$$\textit{Discard rate above MLS} = \left(\frac{\textit{No. of fish discarded above MLS}}{\textit{Total Catch}} \right) \times 100\%$$

With the exception of boat A for plaice (where only two hauls were sampled), and boat E for soles, the mean discard rate above MLS for these two species did not exceed 5% and was mostly between 0 and 3%. In contrast, the percentage discarded above the MLS for whiting is much more variable between boats. In order to investigate this further the percentage of whiting discarded above MLS was calculated:

$$\textit{Percentage discarded above MLS} = \left(\frac{\textit{No. of whiting discarded above MLS}}{\textit{Total catch of whiting above MLS}} \right) \times 100\%$$

These results are shown in Table 3.6.1.



NOTE: Numbers above columns indicate the number of hauls sampled
Boat codes for nephrops trips were allocated independently of those for finfish trips and are not comparable

Fig 3.6.1 - Percentage discard rates - variation between boats (Nephrops boat codes were different from other boat codes)

Table 3.6.1 - Percentage discard rates above and below MLS by boat, for plaice, sole and whiting

		WHOLE CATCH		CATCH >MLS
BOAT CODE	HAULS OBSERVED	% DISCARDED < MLS	% DISCARDED > MLS	% DISCARDED > MLS
PLAICE				
A	2	43	19	n/a
E	14	60	1	n/a
F	10	32	0	n/a
G	11	59	3	n/a
H	9	48	4	n/a
I	66	48	1	n/a
J	12	93	0	n/a
K	11	50	4	n/a
N	11	67	0	n/a
O	7	48	1	n/a
P	4	59	0	n/a
Q	5	30	0	n/a
SOLE				
A	2	26	3	n/a
E	10	3	7	n/a
I	65	3	1	n/a
J	13	23	0	n/a
K	8	4	0	n/a
N	11	21	0	n/a
WHITING				
A	2	36	7	100
E	12	51	27	83
G	9	61	2	14
H	6	22	3	21
I	59	72	5	30
J	5	81	11	100
K	10	69	13	100
N	11	100	0	0
O	7	29	14	30
P	4	41	50	100
Q	6	78	11	100

It would appear that discard policies for plaice and sole were reasonably consistent between boats; fish are discarded if they are below MLS with very little discarding of legal sized fish. Consequently discard rates for these two species are likely to be most affected by such factors as gear selectivity and fish population structure. The higher between boat variation for whiting both in terms of the discard rate above MLS and the percentage of marketable whiting discarded suggests that market forces and other factors were influencing discarding.

The mean discard rates for Nephrops by boat are shown in Fig 3.6.1. Most boats were only sampled for one haul during the boarding sampling method, so it is difficult to separate 'between haul variation' from 'between boat variation'. The results are highly variable and

because different boats were sampled using the two different methods (boarding and trip), they are difficult to interpret fully. However, the results suggest considerable variation between boats, but since the same boats were not sampled on each sampling week, seasonal and other factors mean that it is difficult to elucidate between boat variation.

3.7 Variation Between Ports and Markets

The mean percentage discard rate for plaice, sole, and whitings by port calculated on a haul by haul basis is shown in Table 3.7.1. In addition, for whiting, the percentage of legal sized fish discarded is shown, since this was found to vary between vessels. The differences between port for plaice and sole are likely to be mainly due to the different grounds fished and gears used from these ports.

Table 3.7.1
Percentage discard rates above and below MLS by port, for plaice, sole and whiting

		WHOLE CATCH		CATCH >MLS
PORT	HAULS OBSERVED	% DISCARDED OVERALL	% DISCARDED > MLS	% DISCARDED > MLS
		PLAICE		
Fleetwood	54	66	2	n/a
Whitehaven	42	44	2	n/a
Holyhead	66	48	1	n/a
		SOLE		
Fleetwood	40	15	2	n/a
Whitehaven	26	1	0	n/a
Holyhead	65	3	1	n/a
		WHITING		
Fleetwood	32	87	52	68
Whitehaven	29	89	83	85
Holyhead	59	87	30	56

For whiting, market forces are likely to dominate discarding patterns. The high whiting discard rates observed from Whitehaven are mostly due to the Nephrops fishery where the whiting by-catch is of poorer quality and commands lower prices.

The smaller vessels in the study area tend to land to markets at their home ports, whereas larger boats operating from Holyhead and Liverpool generally send fish overland to continental markets. During the study period, whitings fetched very poor prices on local markets, with the result that many boats either retained only larger fish, or in some cases did not retain any at all. However, Boat I, the large beamer fishing from Holyhead for the continental markets, landed a higher proportion of marketable whiting, despite the fact that she had been at sea for ten days (markets usually prefer fresh whiting). It is also worth noting that the same vessel discarded large numbers of marketable rays as they could not find a market for them on the continent.

Most of the Nephrops boats sampled, landed to Whitehaven. However, there were exceptions. Irish boats on a final trip would return to Ireland to land. One of the visiting boats landed to her home port of Fleetwood and another was a twin-rig vessel (and as such is banned from landing to Whitehaven) which chose to land at Heysham. The resulting small

amount of information from ports other than Whitehaven make it difficult to examine these data for between-port differences.

However, some general observations concerning markets were made which might have a bearing on discarding practices. The most lucrative market is for whole Nephrops to supply the restaurant trade. Tails are sold on for end-use as breaded scampi, frozen prawns, or are rendered down to prawn paste.

Head-on Nephrops are selected, larger, good quality individuals, whereas tails can be of any size and can include Nephrops under the MLS of 20mm carapace length. Products such as prawn paste can use any and all prawns. The tailing of these undersize Nephrops makes it virtually impossible to enforce the statutory MLS because the heads and carapace are discarded at sea.

The MLS of 20mm had very little influence on the discarding practices observed in this study as very few Nephrops under 20mm were caught (Fig 3.3.10). Thus the market possibly has the most influence on the discard rate of Nephrops.

In order to examine changes in the discard rate with size, Figs. 3.7.1 and 3.7.2 show the percentage discard rates for different carapace length groups by trip for the two study years.

There were very few Nephrops caught below 20mm carapace length so it is difficult to define a discard rate for this length group. The discard rate for the 20-24mm and 25-29mm groups are also poorly defined, although it is clear that some discarding takes place although at a higher level than the 30 and 60mm group. Discarding above 30mm is low in both sample years and any discarding that did occur can probably be attributed to poor quality or damaged Nephrops.

Although these results show an inverse relationship between length and discard rate, it would be difficult using them to estimate a discard rate on a year-by-year or size-by-size basis.

SIZE GROUP mm	MEAN % DISCARD RATE	95% CONF. INTERVAL
10-19	91	69-100
20-24	94	89-99
25-29	68	42-94
30-60	14	0-35

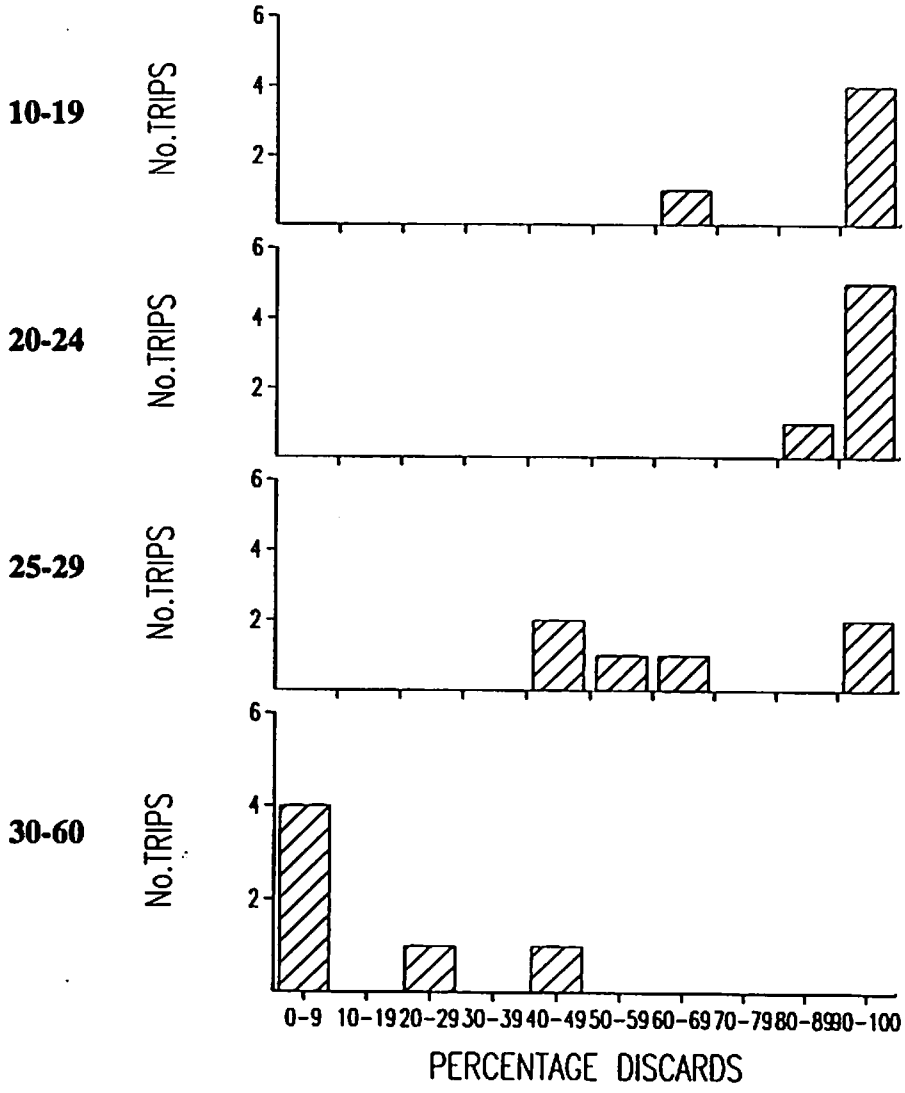


Fig 3.7.1 - Percentage discard rates by carapace length group for Nephrops 1993

SIZE GROUP mm	MEAN % DISCARD RATE	95% CONF. INTERVAL
10-19	50	0-100
20-24	66	43-89
25-29	45	22-68
30-60	5	1-7

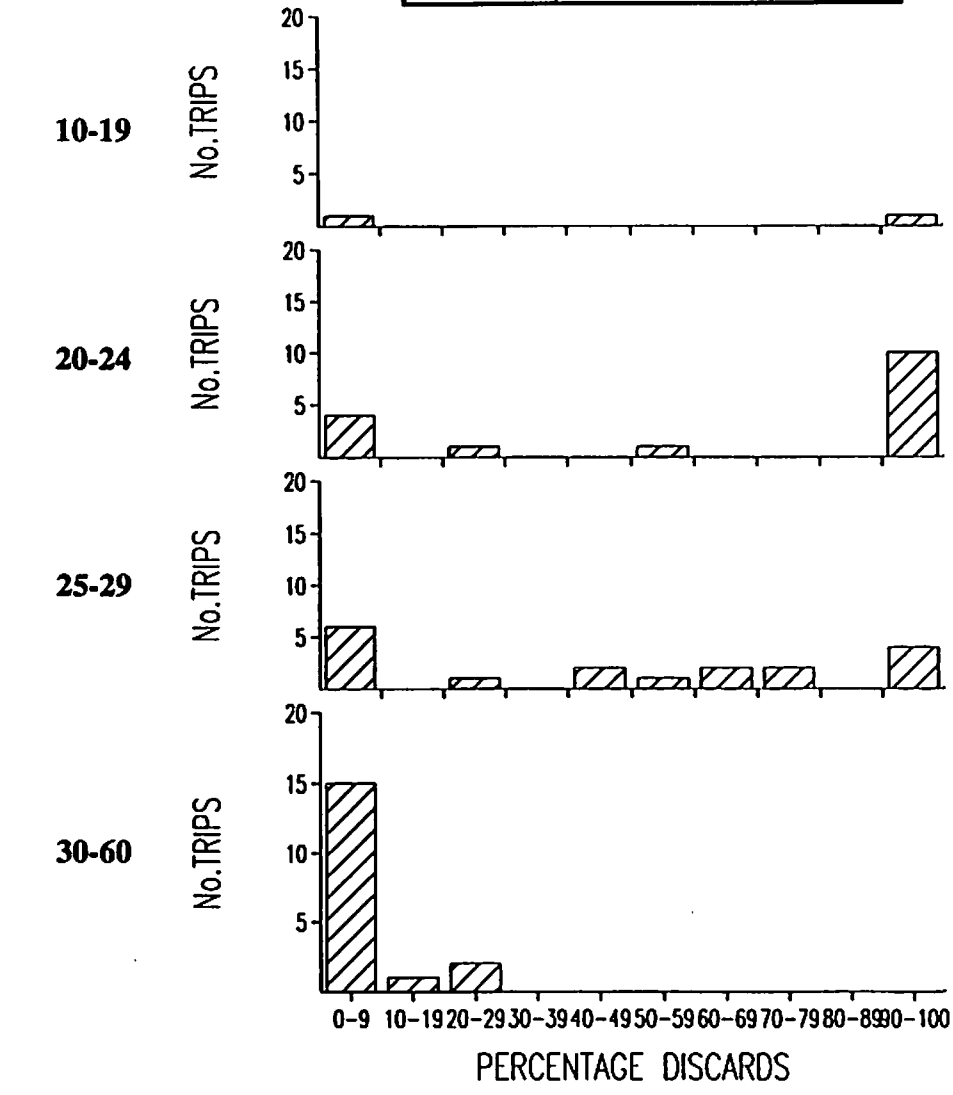


Fig 3.7.2 - Percentage discard rates by carapace length group for Nephrops 1994

3.8 Between Gear Variation

Discard rates for the major species by gear

The length/frequency distributions for plaice, sole, and whiting were obtained for different gear types and mesh sizes. This was achieved by raising the numbers sampled by RFA and totalling them by gear and mesh size. These are displayed in histograms Figs. 3.8.1 to 3.8.4 which show the discarded and landed fish as well as the minimum landing size (MLS) for each species.

Plaice

Fig 3.8.1 shows similar length frequency histograms and similar percentage discard rates (56-67%) for all of the trawls of various meshes studied, which appear to impact upon the local plaice stocks in the same way.

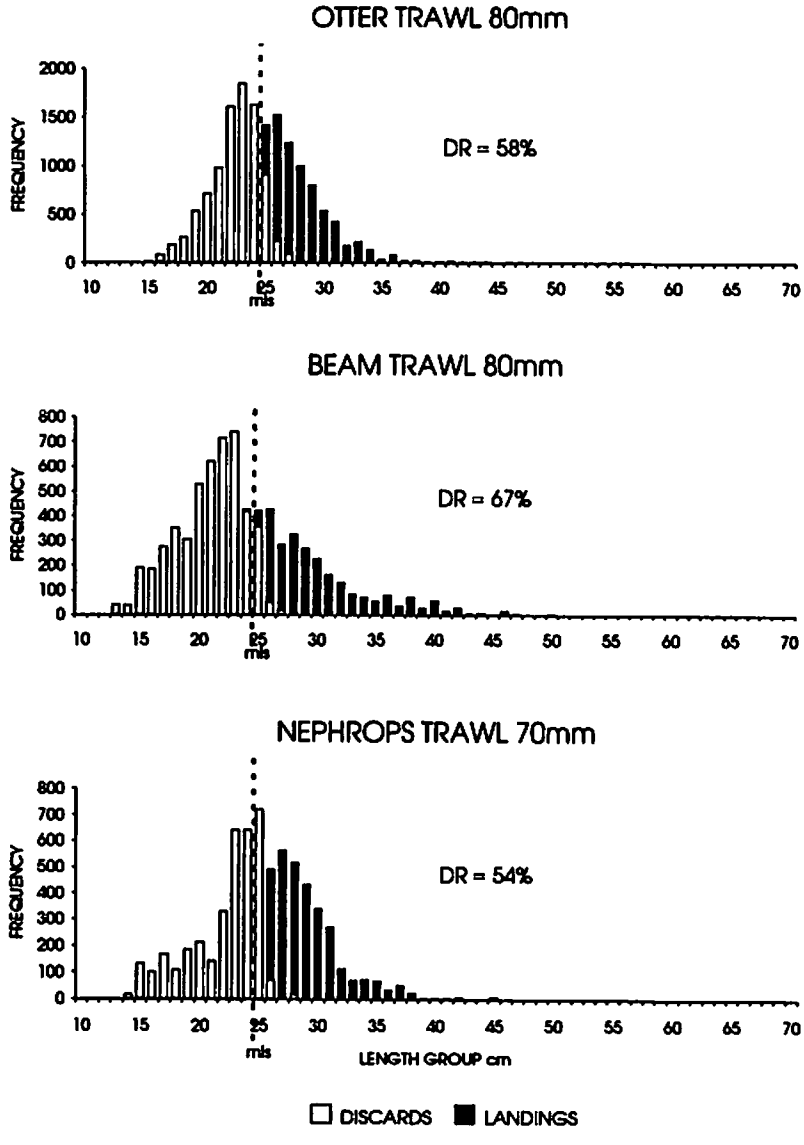


Fig 3.8.1 - Plaice length/frequency distributions for different mesh sizes and gear types

Anchor seining is a species selective method of fishing and catches within the study area are almost exclusively composed of plaice. Consequently, mesh sizes can be fine-tuned to minimise discarding without encountering the losses of other species which restrict this in the other gears. The study sampled two mesh sizes in this gear (80 and 120mm) and the results in terms of length/frequency distributions and age structures are shown in Fig 3.8.2. The seine employing 120mm mesh reduced the discard rate from 56% to 33%. A mesh of 120mm virtually eliminates all plaice below 22cm.

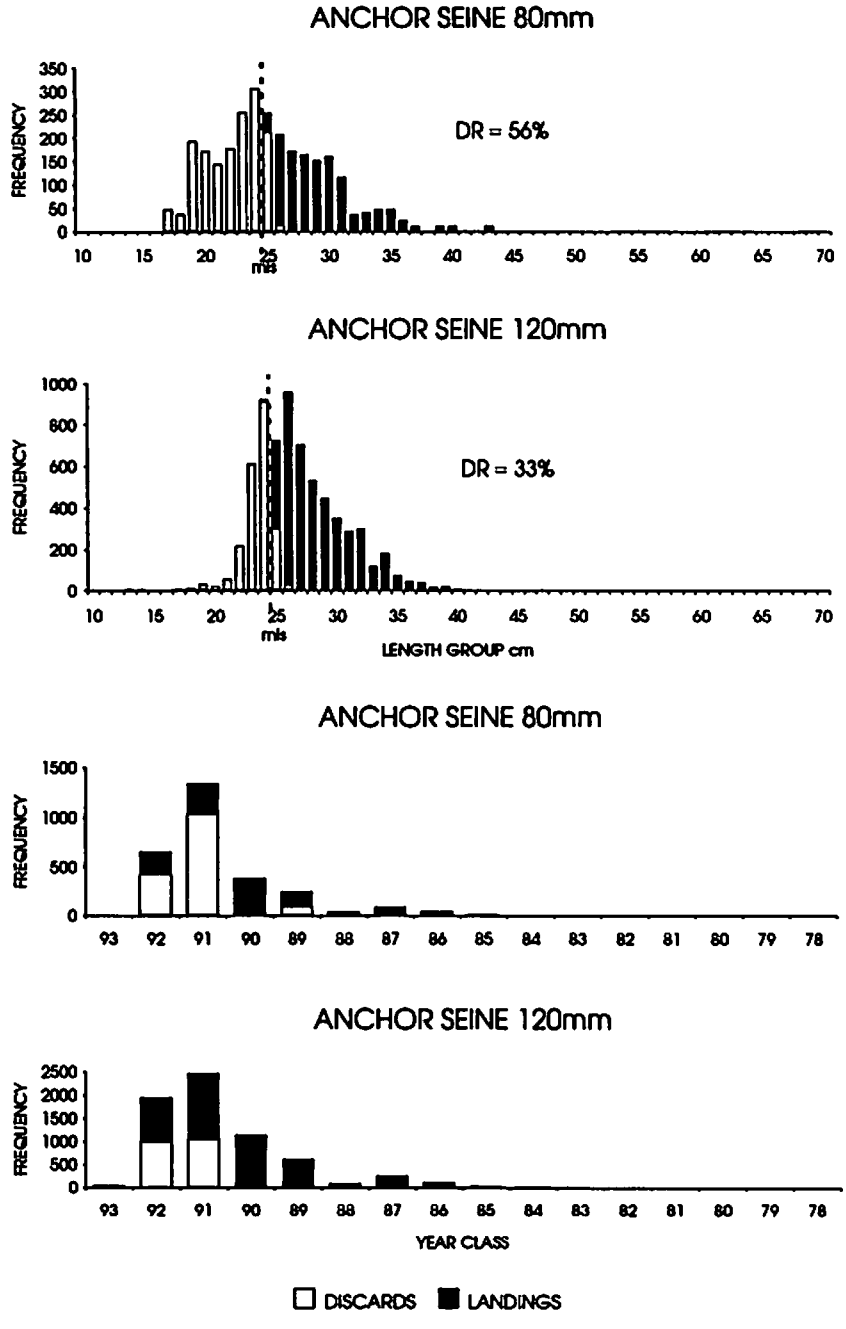


Fig 3.8.2 - Length/frequency distributions and age structures compared - plaice within 80mm and 120mm anchor seine catches.

Sole

Fig. 3.8.3 shows that the trawls studied which do catch soles (beam 80 mm, otter 80 mm and Nephrops 70 mm) all have low discard rates (3%, 5% and 0.01% respectively) and their selectivities appear to be well matched to the fishery.

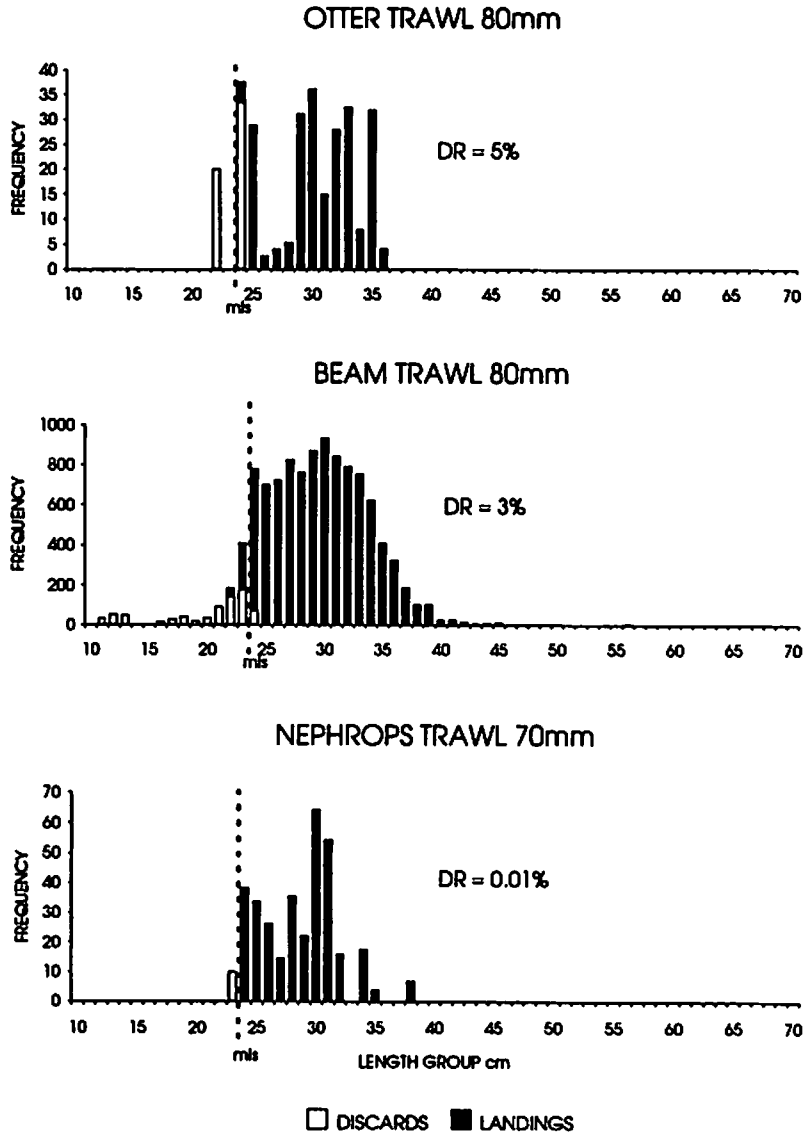


Fig 3.8.3 - Sole length/frequency distributions for different mesh sizes and gear types

Whiting

Fig. 3.8.4 shows length frequency histograms for the different trawl gears and meshes, all of which caught large numbers of small whiting. Though the Nephrops trawls studied were fitted with a statutory square mesh panel, the study observed considerable numbers of whitings below MLS, but with no control it is impossible to quantify how effective the panels were.

Fig. 3.8.4 shows that Nephrops trawl 70mm caught high numbers of whiting yet very few were landed. Otter trawl 80mm on the other hand caught the least numbers overall but retained the most marketable sized fish. In all three fishing methods whiting of marketable size were discarded. This is most likely to be due to the market forces affecting whiting at the time of the trip, i.e. sometimes its price is higher than at others or there may be a scarcity of other species at the time making it more profitable to land whiting (see Ports). Perhaps the high value of Nephrops contributed to the fact that virtually all of the low value whiting are discarded in this fishery because fishermen thought it not worthwhile to waste time handling these fish. On the other hand, in the plaice and sole histograms for Nephrops trawling, virtually all marketable sized fish of these higher value species are landed.

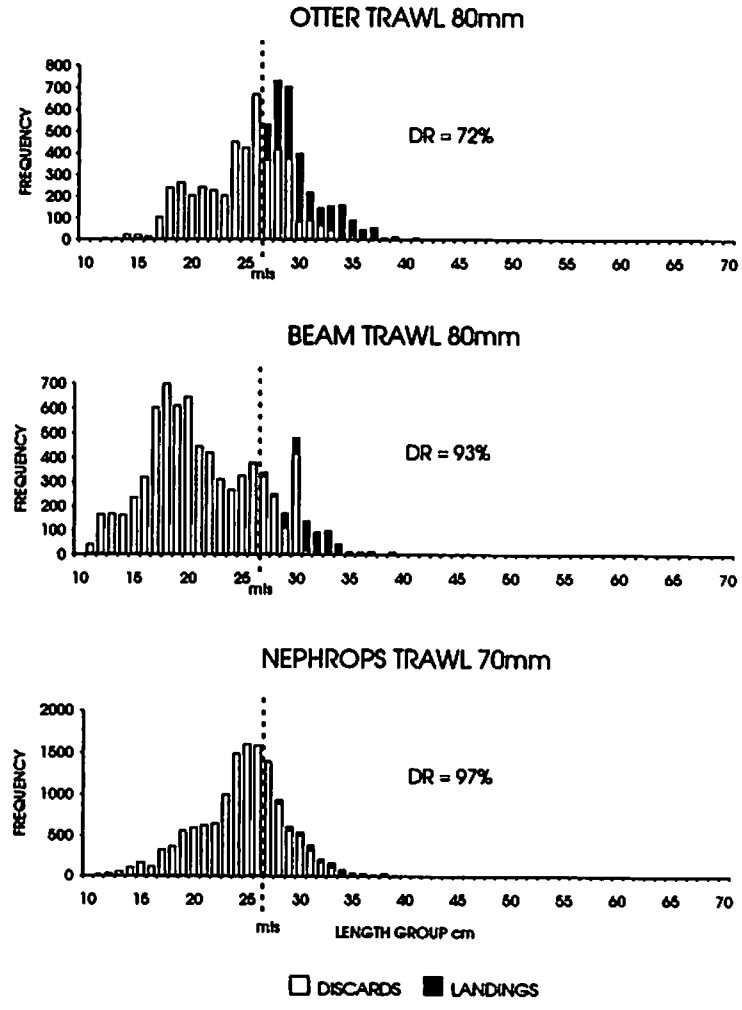


Fig 3.8.4 Whiting length/frequency distributions for different mesh sizes and gear types

The maximum number of discarded whiting in both otter trawling and Nephrops trawling occurs at about 24-26cm, whereas in beam trawling this is at 18cm. This would indicate that for a given mesh size, gear type (beam trawl as opposed to otter/Nephrops trawl) produces different catch length/frequency distributions. However, this difference may be more dependent on the different grounds, depths, and distances to chart datum that these gear types concentrate their fishing effort on. These factors will be discussed later in 'Variation Between Grounds' Section 3.9).

Thus the characteristics of whiting discarding with respect to gear type are:

1. Percentage discard rates are high and variable (Fig. 3.8.4).

2. A large variation between gear type in terms of catch composition (Fig. 3.8.4).

3. The variation in catch composition suggests that the three gears impact on the population in different ways.

It would seem that the length frequency distributions of all three species of fin fish studied can not be attributed to difference between gears alone. Other factors such as depth, and grounds need to be considered in conjunction with any relevant biological information, e.g. spawning/nursery grounds. To try and establish more fully the effects upon discard rates due to gear or mesh size in other fisheries, especially the sole fishery, more data are needed.

3.9 Variation Between Grounds

The hauls observed during the course of the study are shown by gear, in Figs. 3.9.1 to 3.9.4.

Discard rates (mean, maximum and minimum), number of hauls observed and hours fished were tabulated for the major species by statistical rectangle. The results are shown in Figs. 3.9.5. to 3.9.14.

Discard rates against depth and distance to chart datum were plotted by gear type for plaice and sole. The results are shown as scatter plots in Figs. 3.9.15 a-b.

Length frequency distributions and age structures plotted as histograms at depths above and below 15m for plaice and 20m for soles are shown in Figs 3.9.16 a-b. The age structures were derived by applying the age at length keys obtained for the whole sample to the length/frequency distributions observed above and below these depths. Thus it is assumed that growth at all depths is equal.

Plaice and Sole : Environmental gradients
Examination of the graphs (Figs. 3.9.15 a-b) showing beam trawl percentage discard rates for plaice and sole with depth and distance from chart datum, suggest that there are two groups of discard rates - inshore in shallow water and offshore in deeper water. In order to investigate these phenomena further, the histograms depicted in Figs. 3.9.16 a-d were plotted. For sole and plaice, smaller fish predominate in shallower water. This is in accordance with the known characteristics of flatfish populations (Heinkes' Law in Harden Jones, 1968) where the larger and older individuals tend to be found in deeper waters. These results could be due to other factors such as gear type, but it could be interesting to look for correlations with known nursery areas.

Plaice and Sole : Statistical rectangles
It was decided to examine whether the above results could also be described in terms of ICES Statistical Rectangles.

Figs 3.9.5-3.9.8 shows that the highest mean percentage discard rates for both species occurred in beam trawling within 36E6, and for plaice high levels were also observed in 35E6. Broadly, these areas are the shallow areas of Morecambe and Liverpool Bay, however fishing was not evenly distributed over these areas, as can be seen in the haul distributions (Fig. 3.9.1 to 3.9.4). Most of the fishing took place along the coastal margins of Lancashire.

Whiting
Discard rates for whitings by statistical rectangle for the various gears are shown in Figs 3.9.11 to 3.9.13. Market forces and gear selectivity confound spatial analysis of these data in terms of environmental gradients. For example, market prices and their influence upon individual boats' discard policies mean that unlike plaice and sole, there is no reasonably consistent landing size (see 3.7 'Between Port Variation'). Further, there appear to be differences in the length frequency distributions of whiting catches between the different gears (see 3.8 'Between Gear Variation').

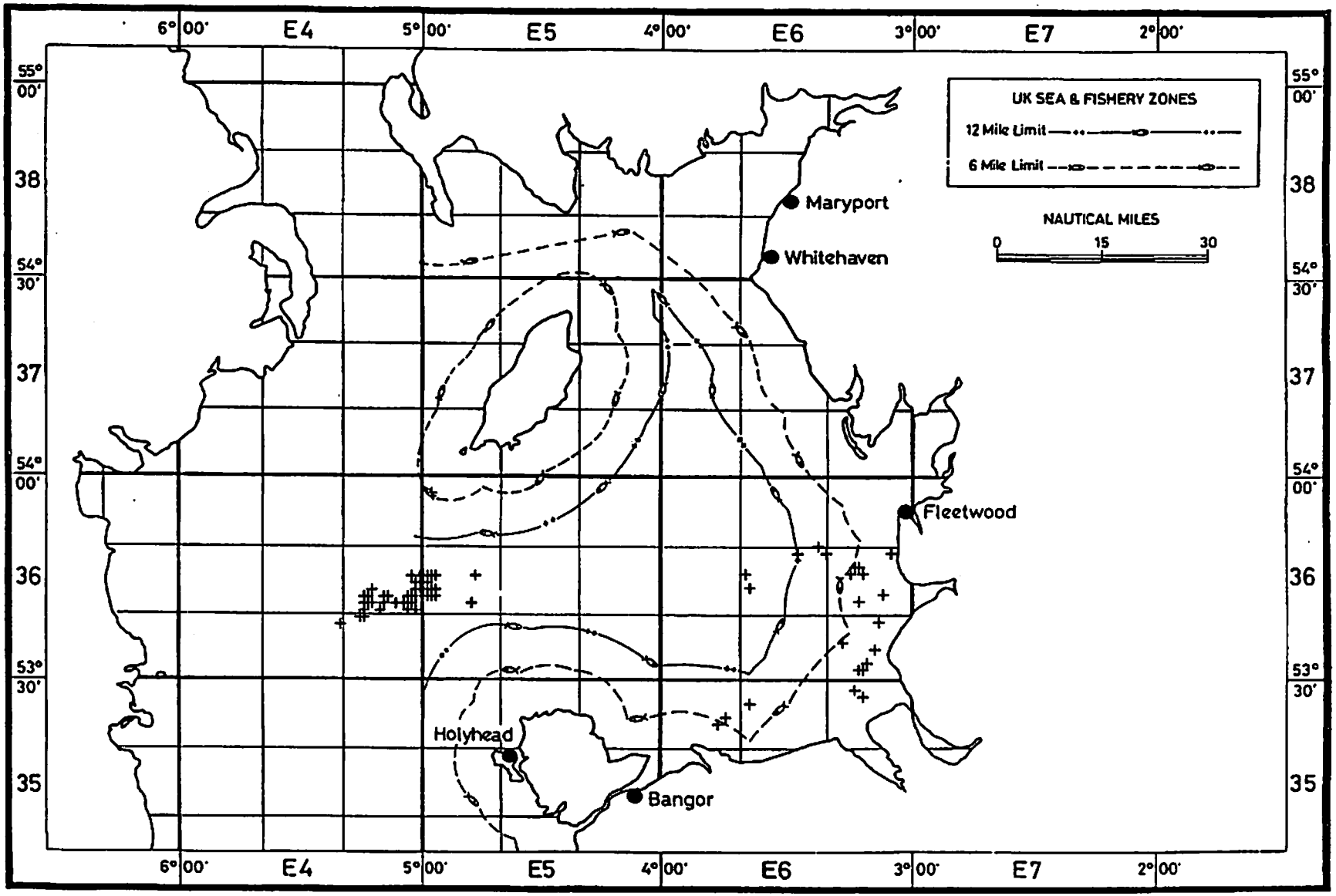


Fig 3.9.1 - Location of beam trawl hauls observed (October 1993 - June 1994)

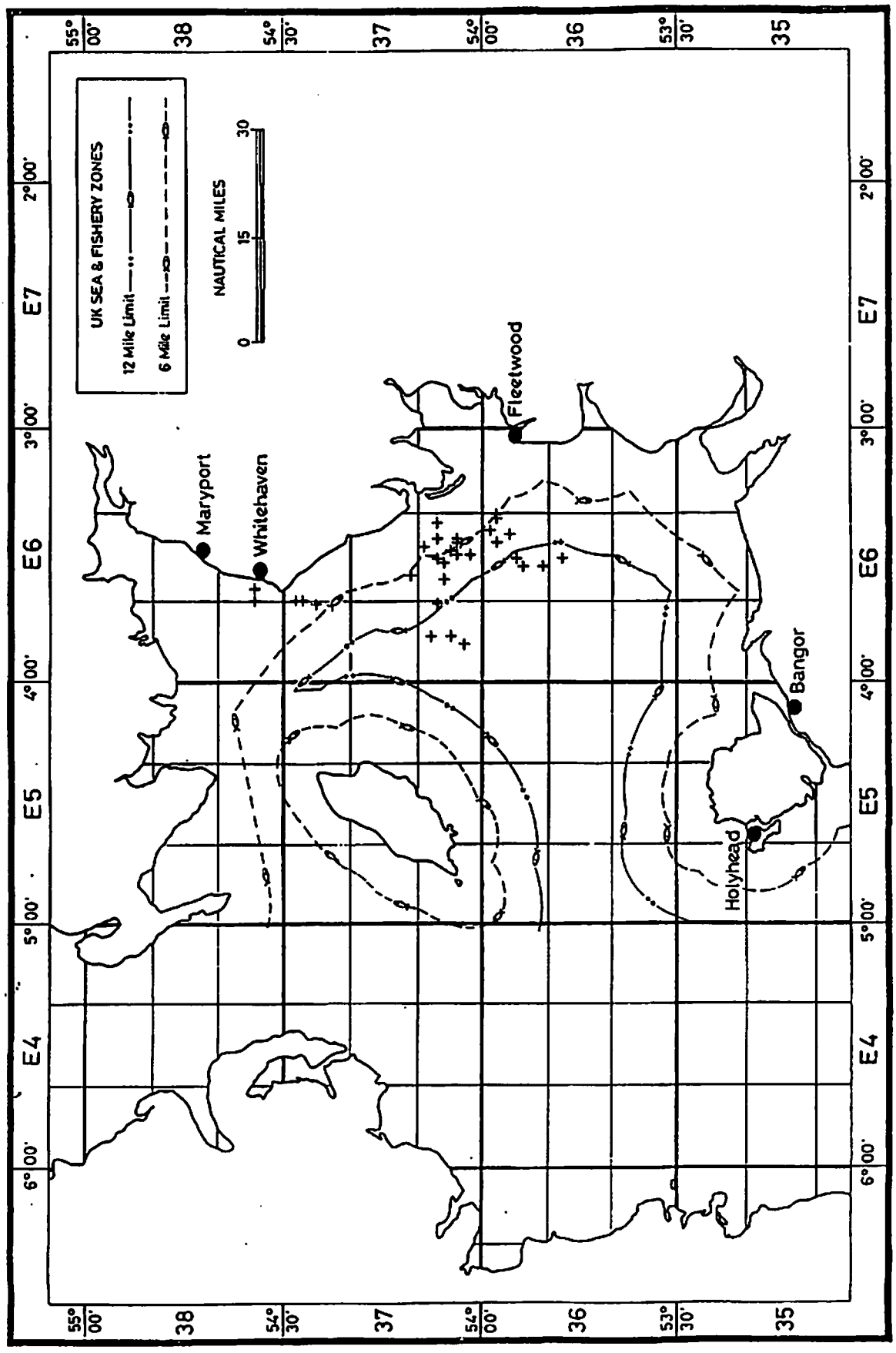


Fig 3.9.2 - Location of otter trawl hauls observed (October 1993 - June 1994)

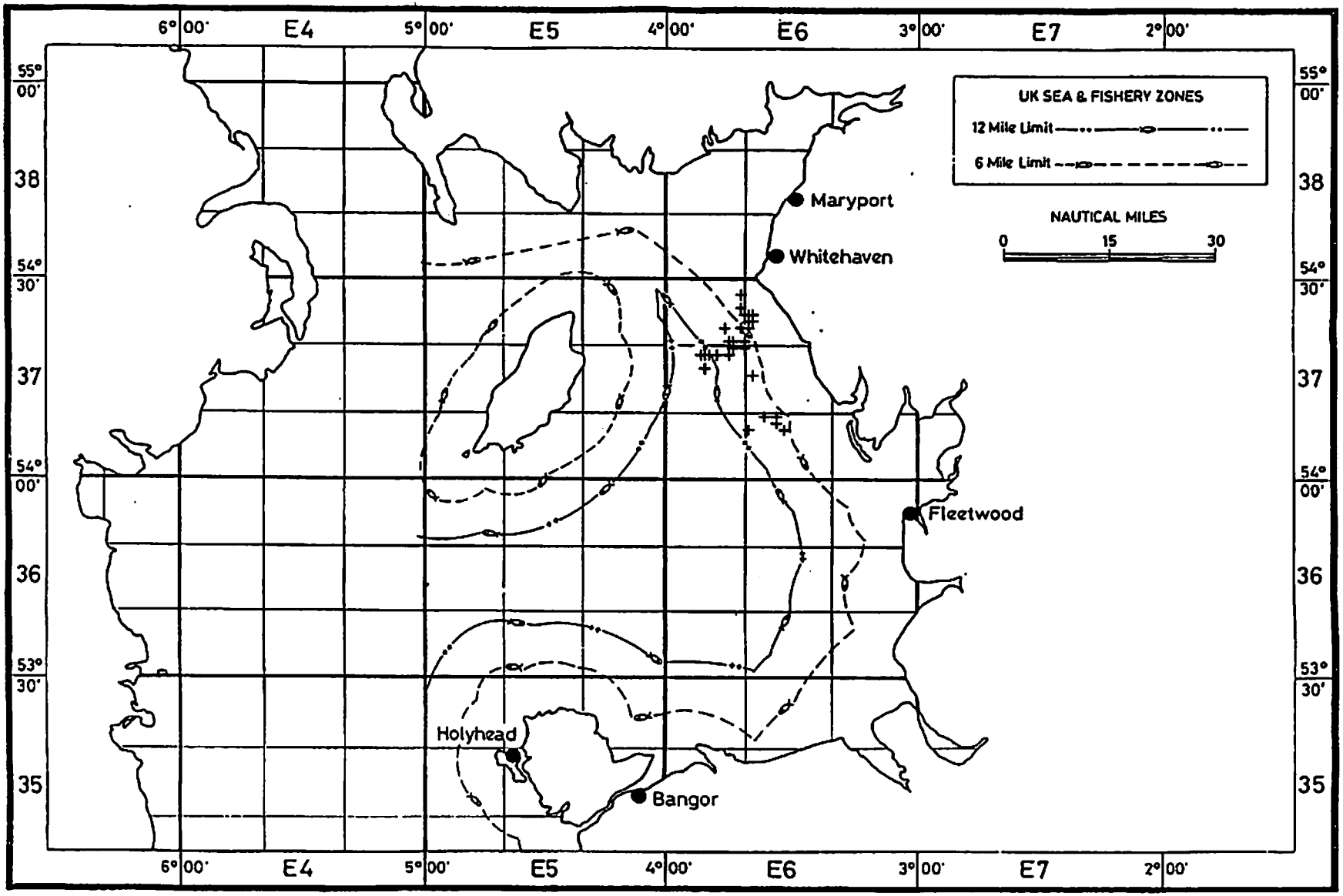


Fig 3.9.3 - Location of Nephrops trawl hauls

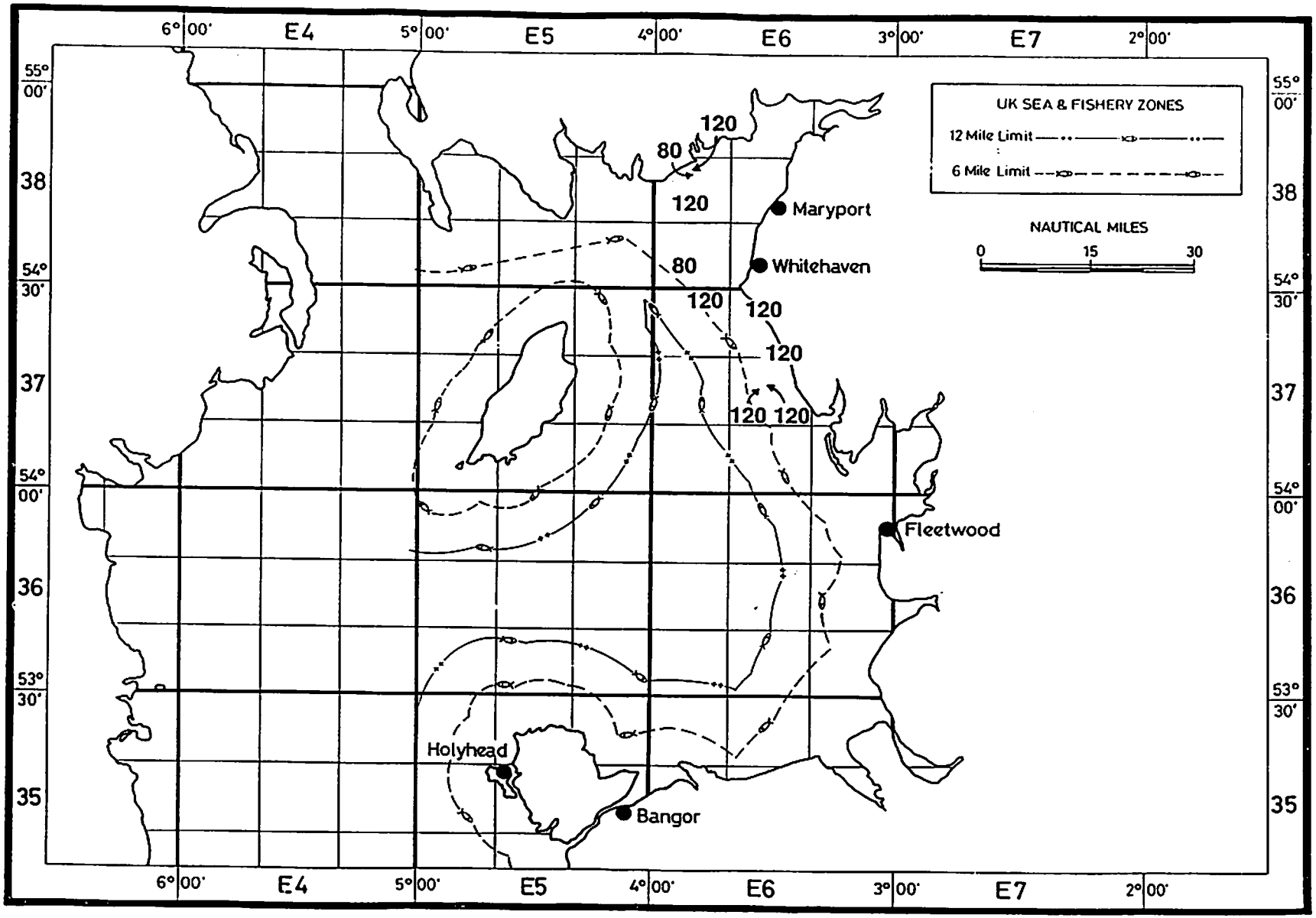


Fig 3.9.4 - Location of anchor seine hauls (by mesh size mm)

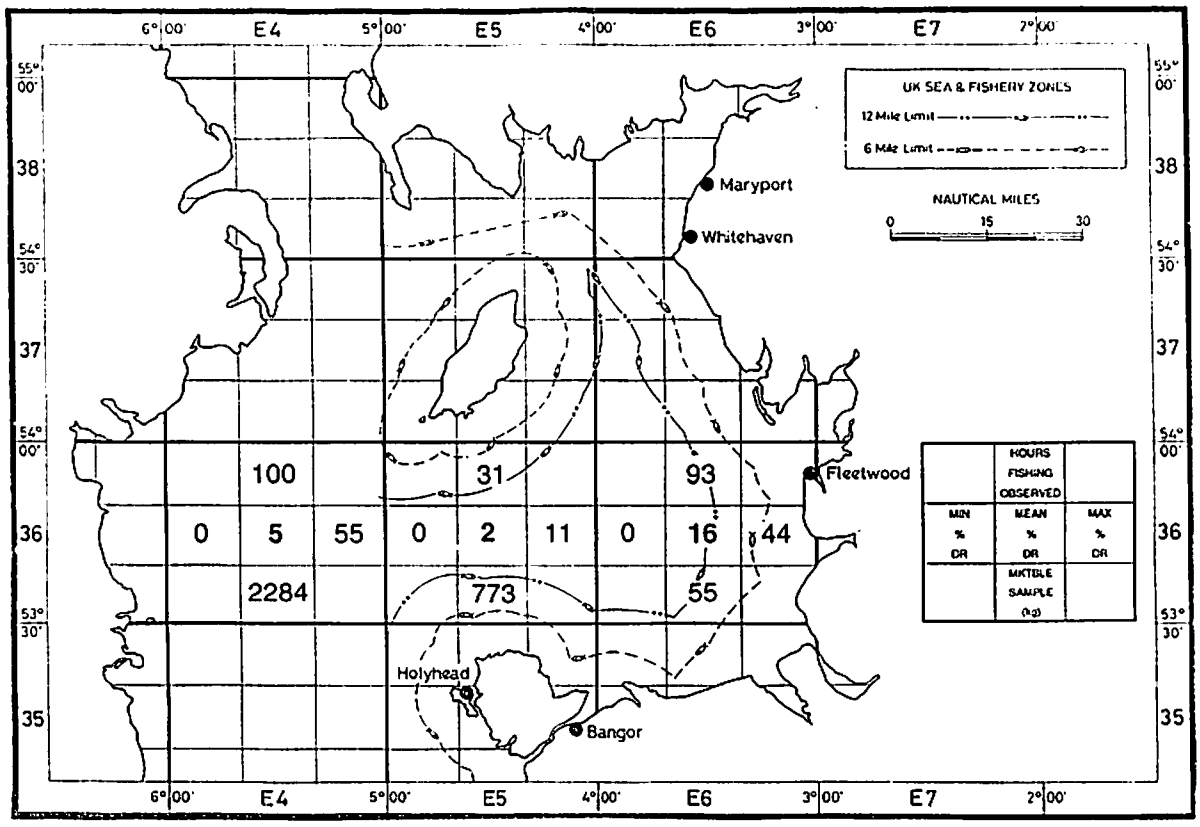


Fig 3.9.5 - Discard tabulations by statistical rectangle : sole - beam trawl

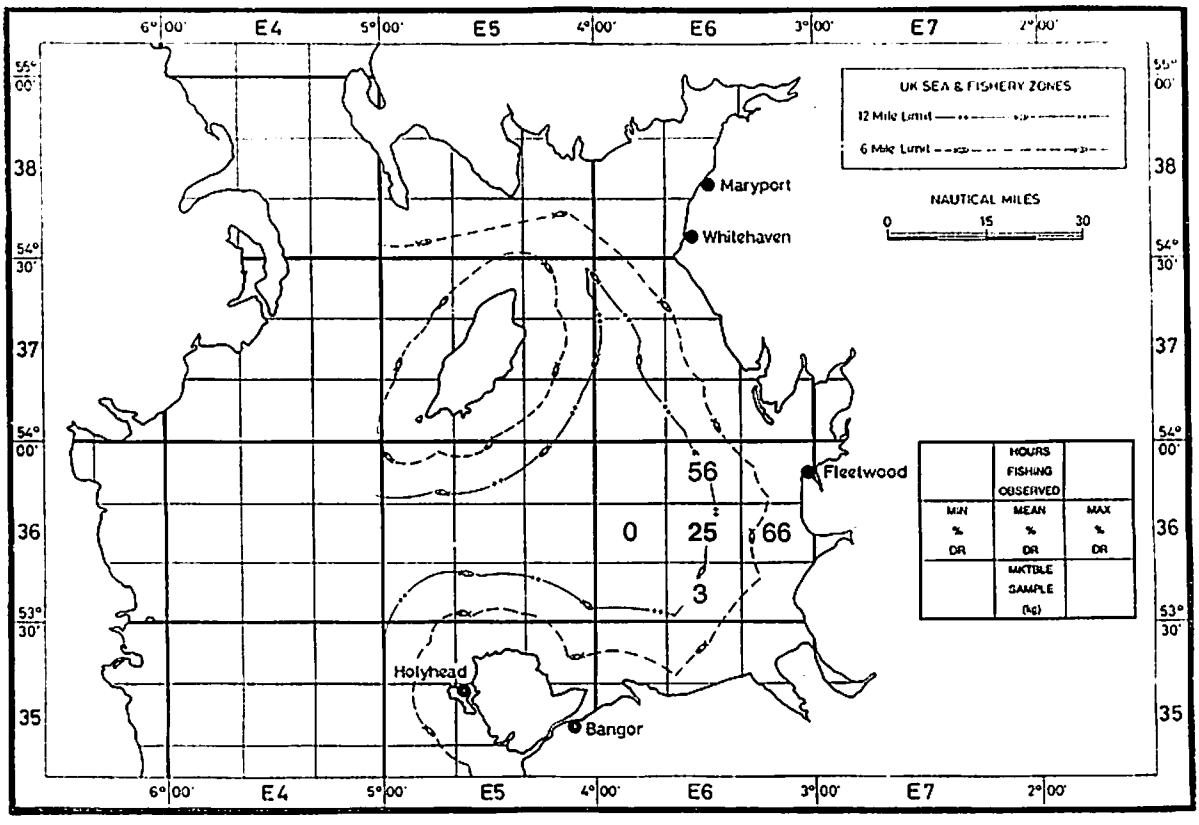


Fig 3.9.6 - Discard tabulations by statistical rectangle : sole - otter trawl

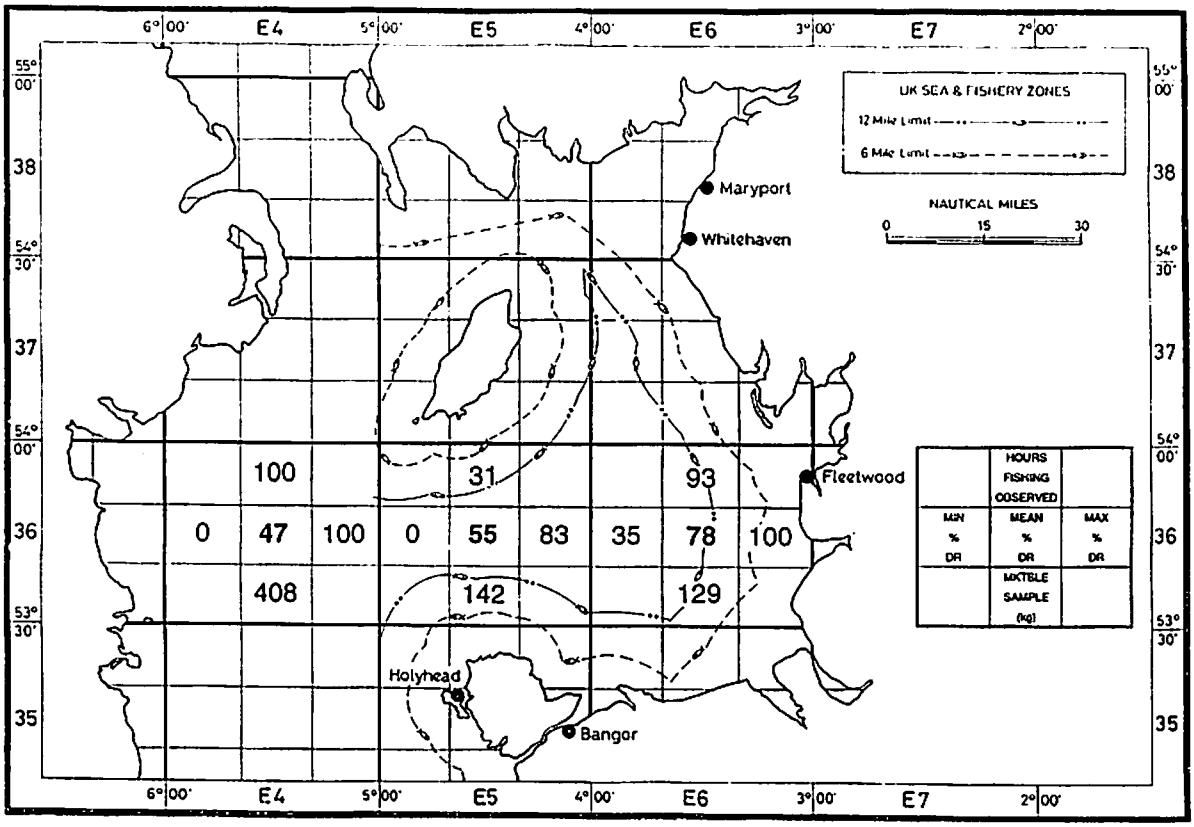


Fig 3.9.7 - Discard tabulations by statistical rectangle : plaice - beam trawl

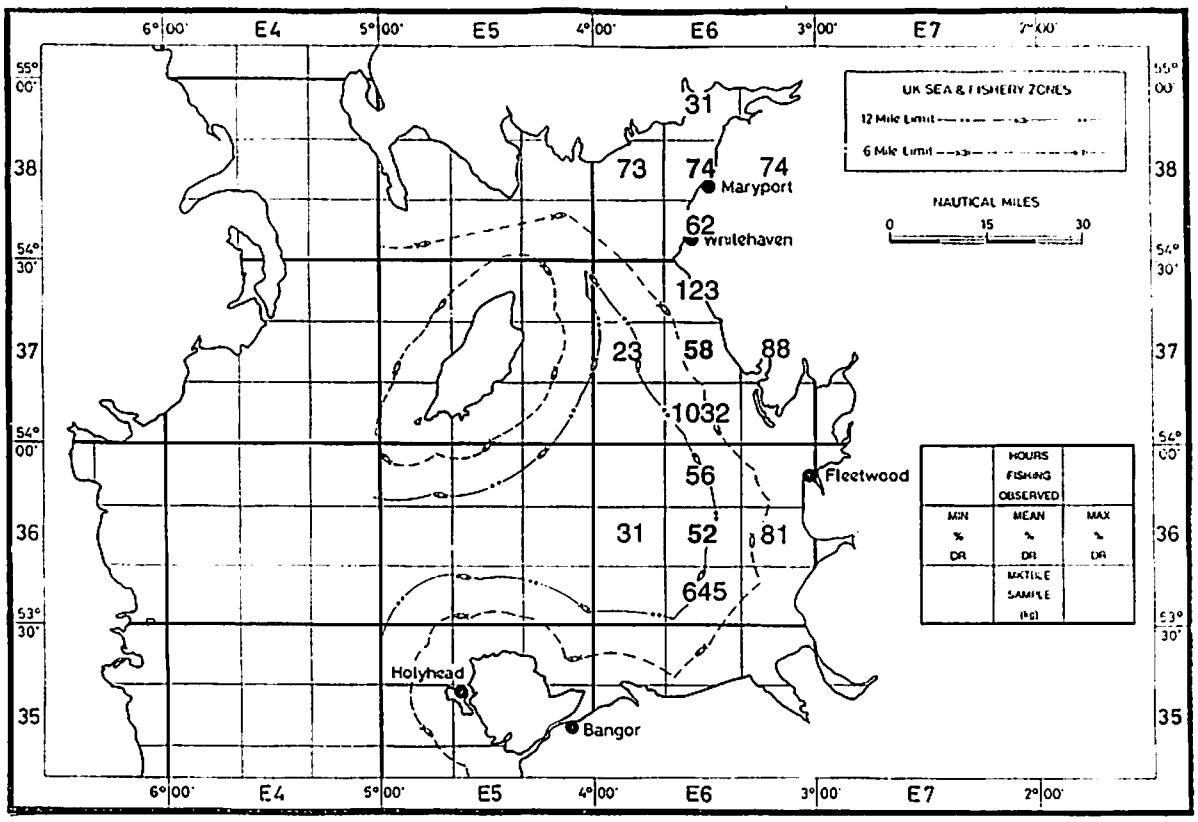


Fig 3.9.8 - Discard tabulations by statistical rectangle : plaice - otter trawl

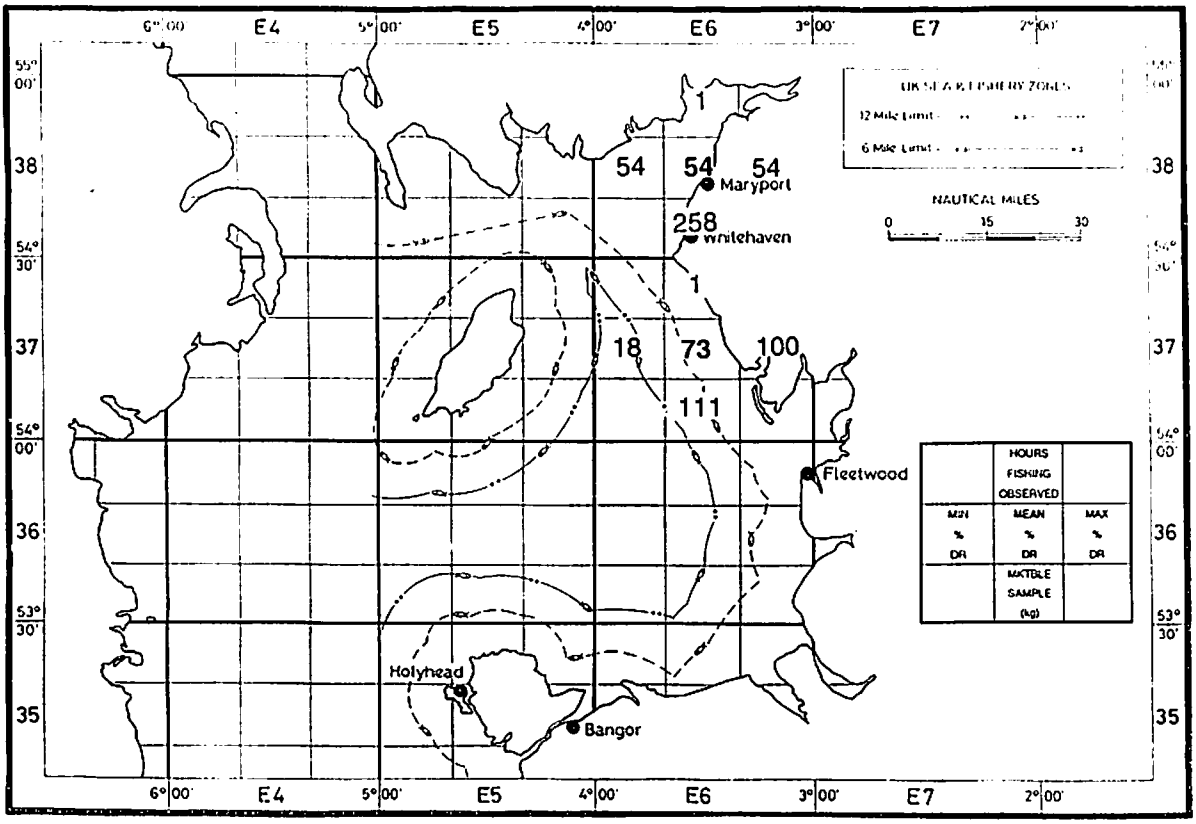


Fig 3.9.9 - Discard tabulations by statistical rectangle : plaice - anchor seine (80mm)

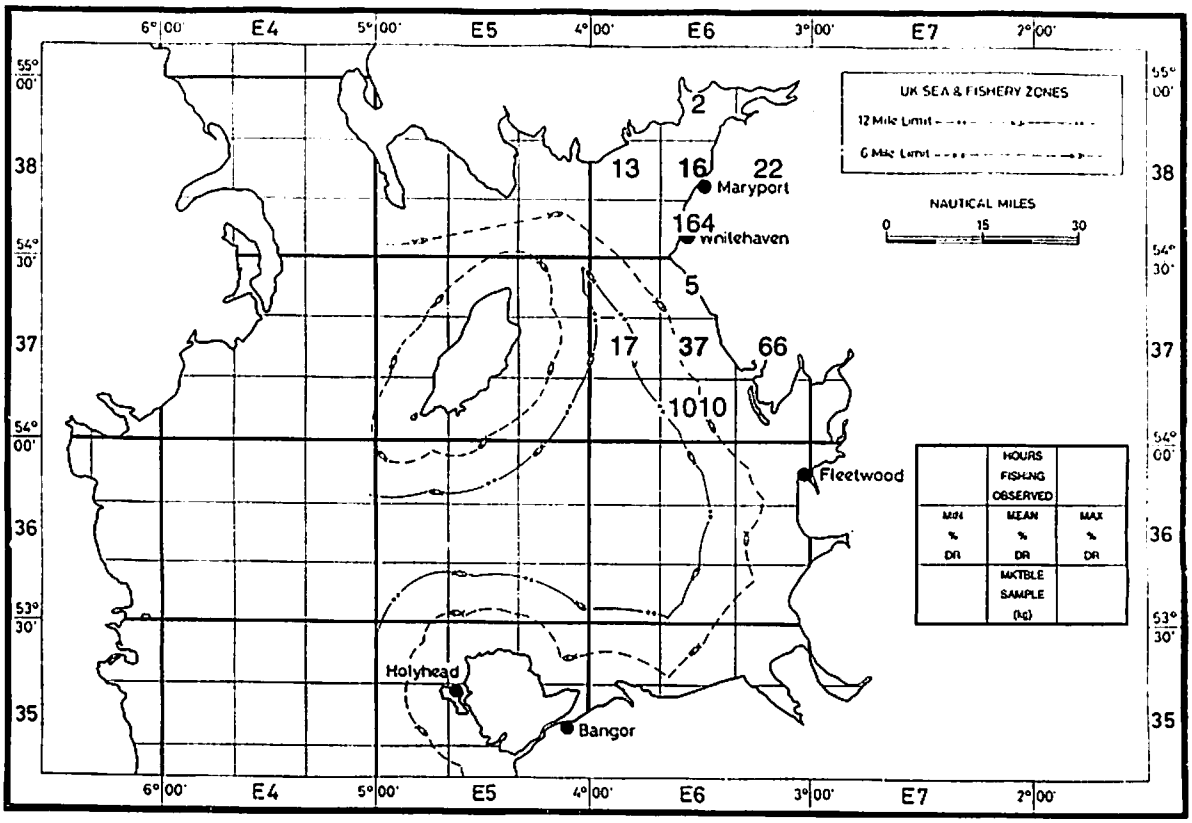


Fig 3.9.10 - Discard tabulations by statistical rectangle : plaice - anchor seine (120mm)

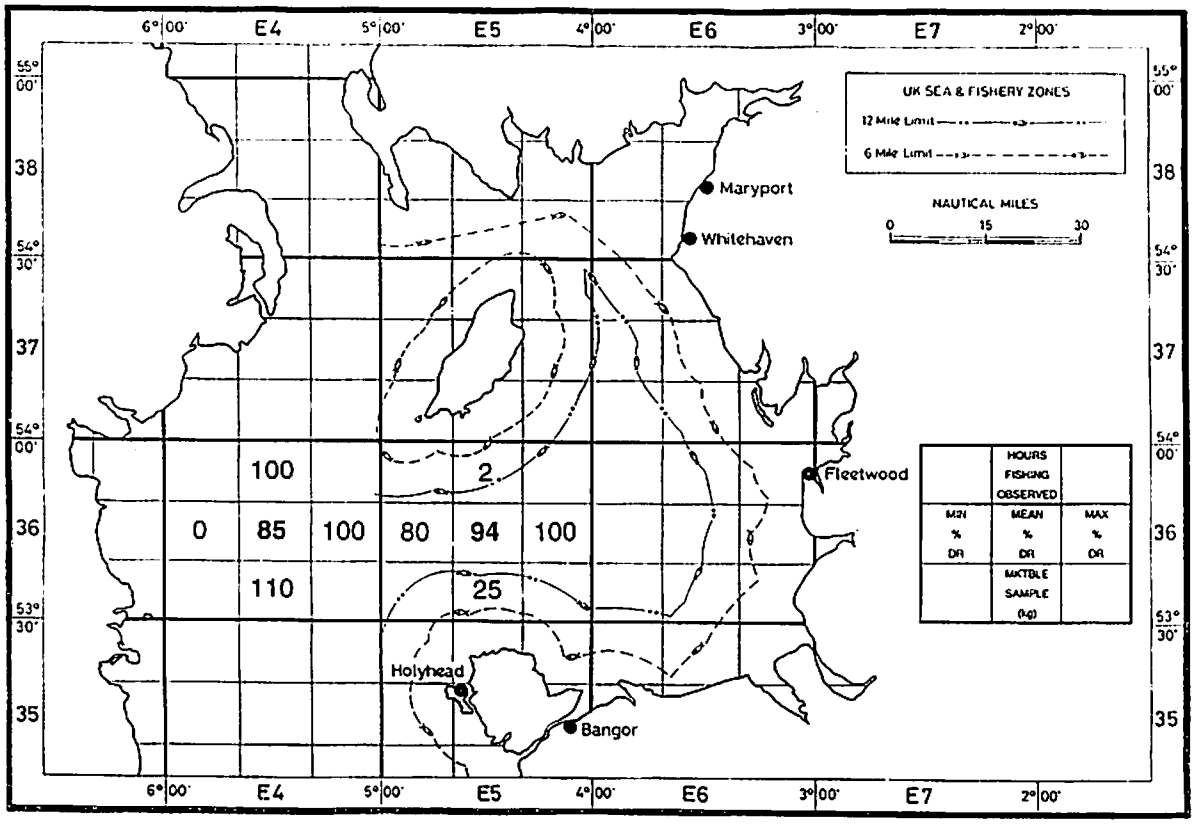


Fig 3.9.11 - Discard tabulations by statistical rectangle : whiting - beam trawl

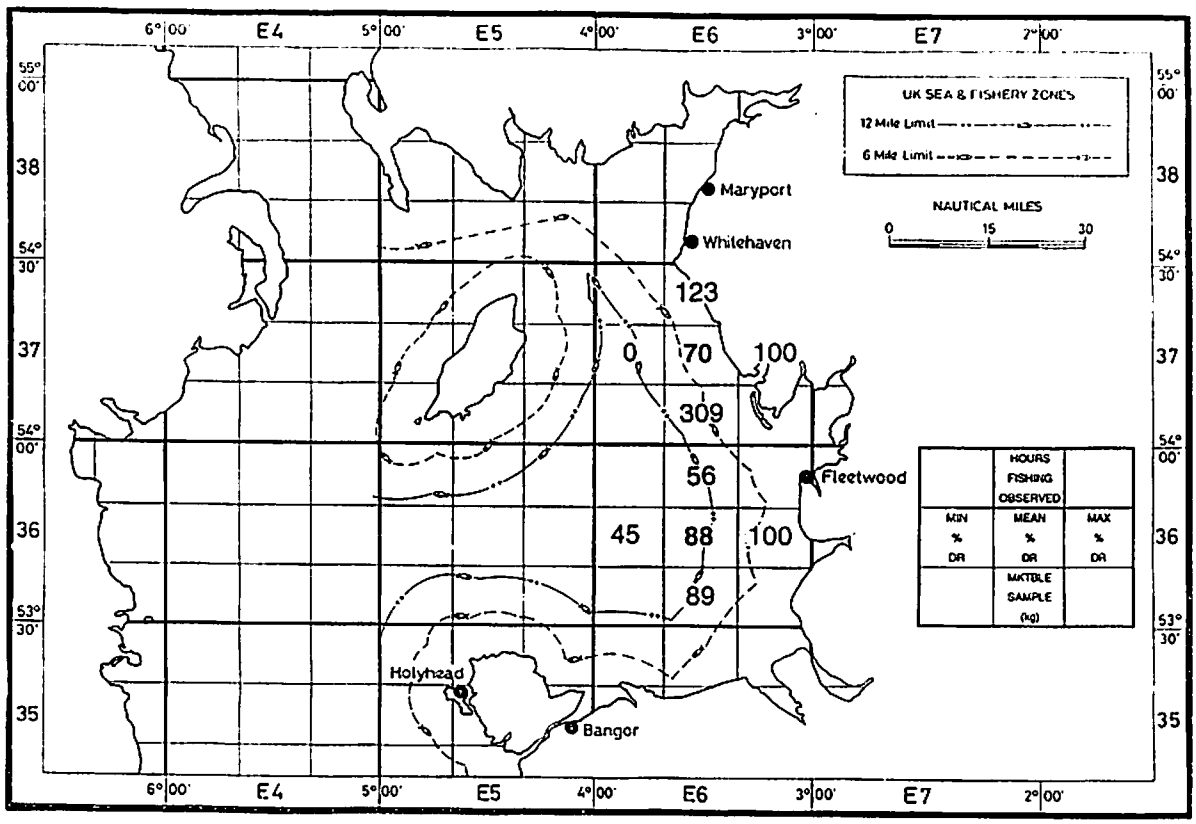


Fig 3.9.12 - Discard tabulations by statistical rectangle : whiting - otter trawl

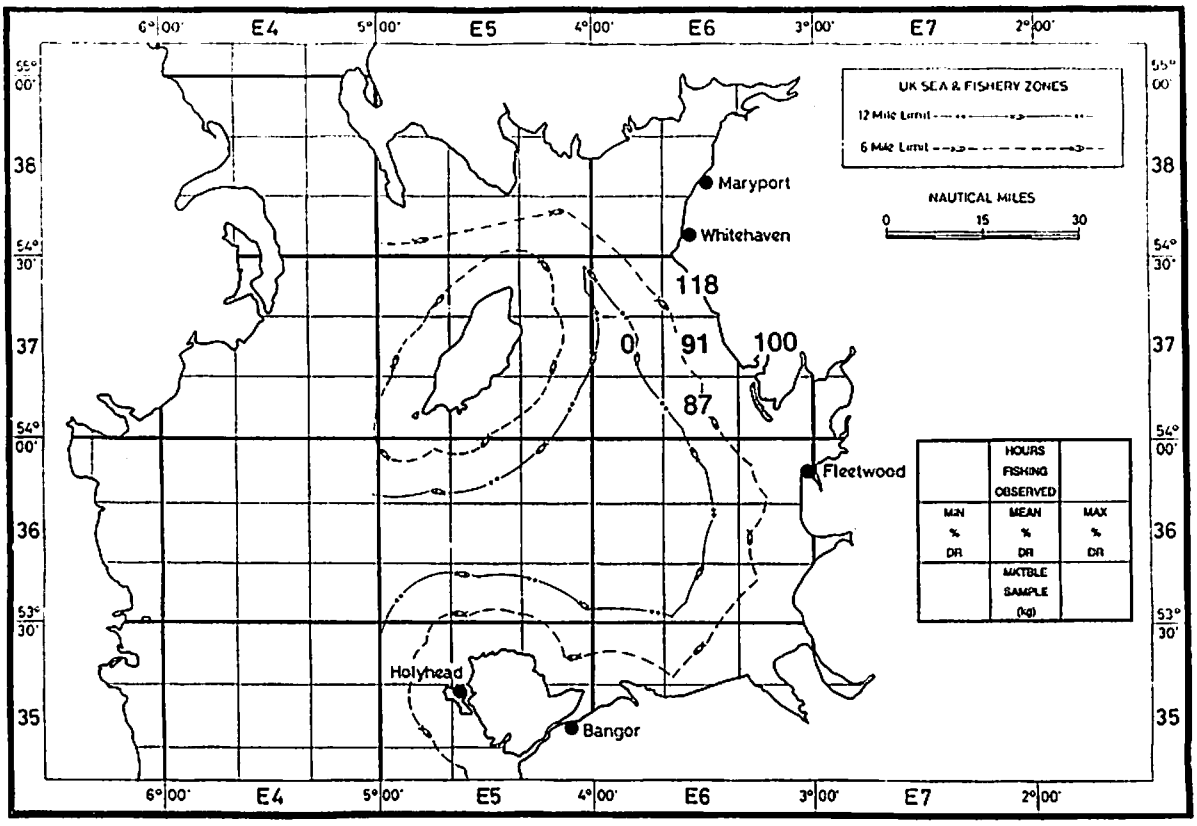


Fig 3.9.13 - Discard tabulations by statistical rectangle : whiting - Nephrops trawl

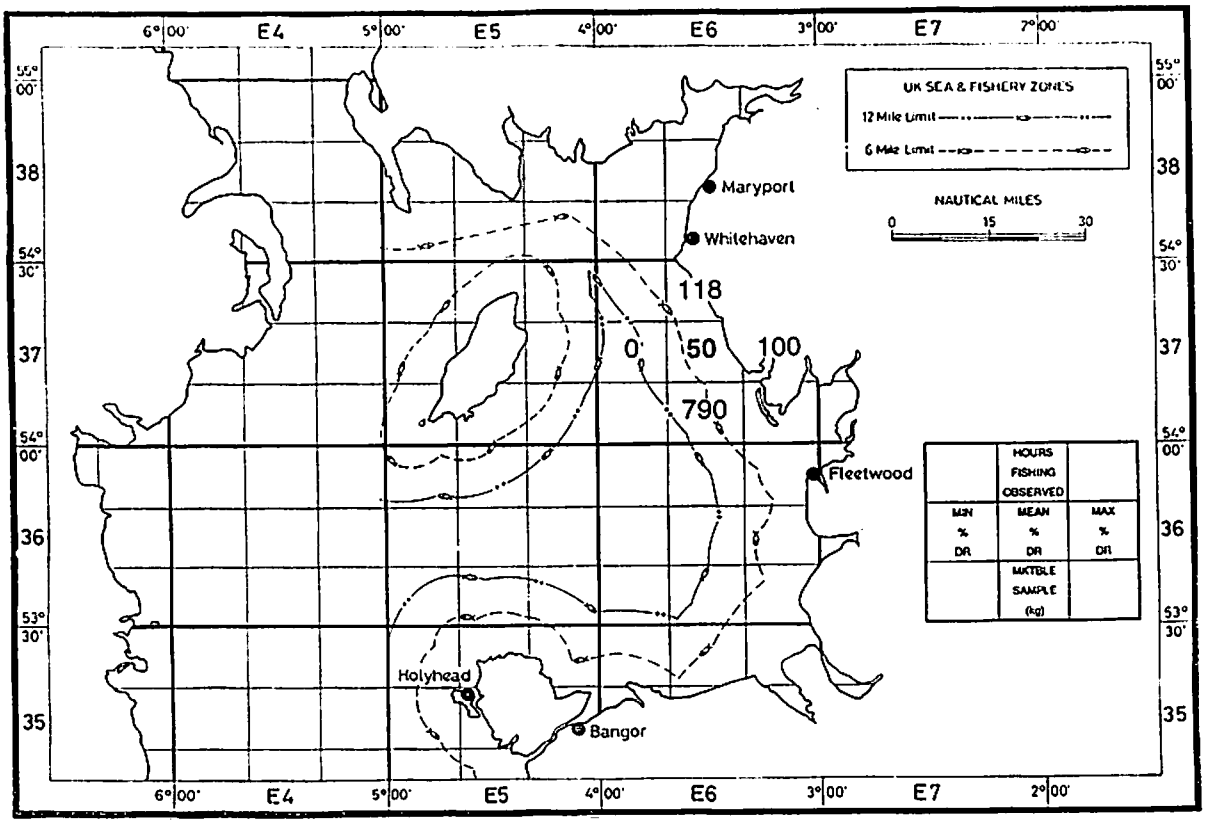


Fig 3.9.14 - Discard tabulations by statistical rectangle : plaice - Nephrops trawl

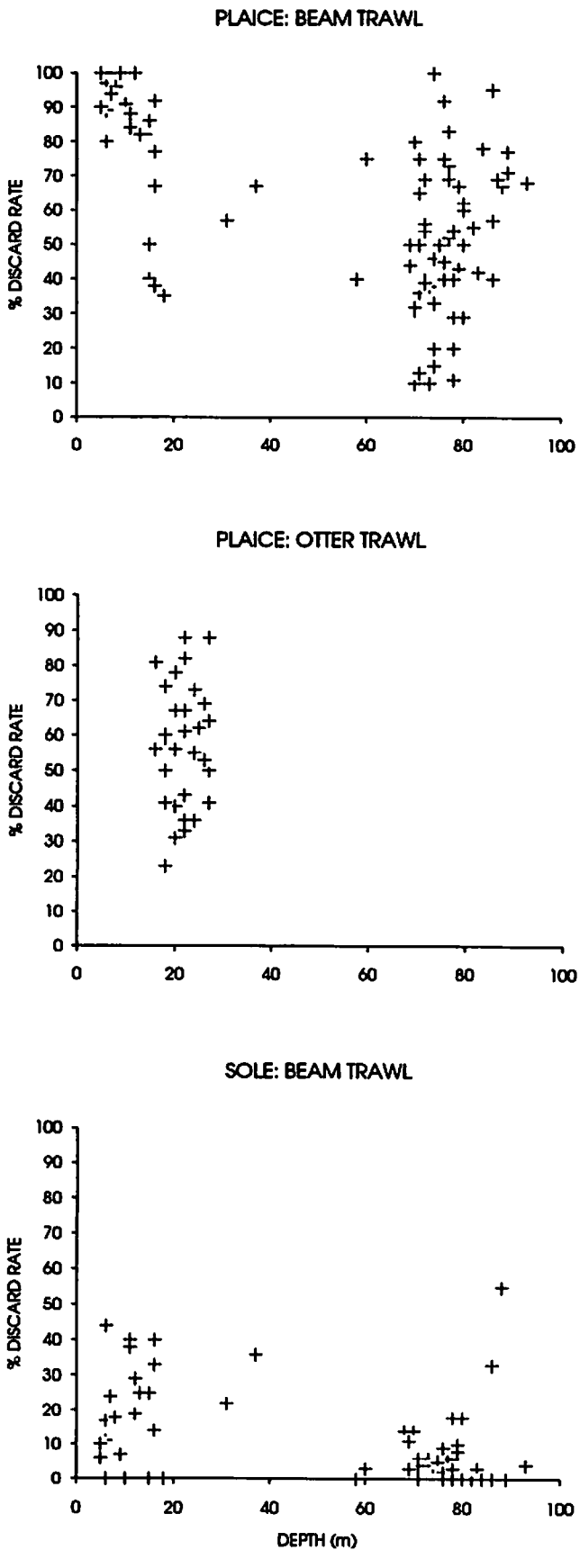


Fig 3.9.15a - Percentage discard rates for plaice and sole compared by gear with depth

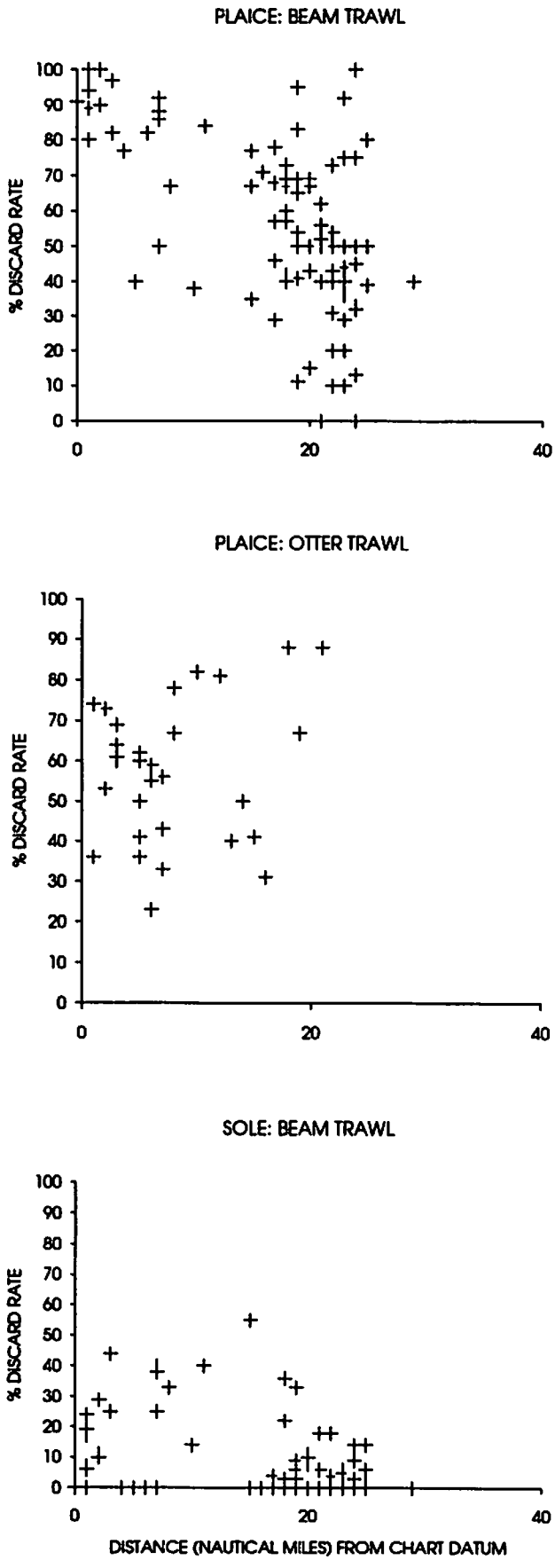


Fig 3.9.15b - Percentage discard rates compared by gear with distance from chart datum

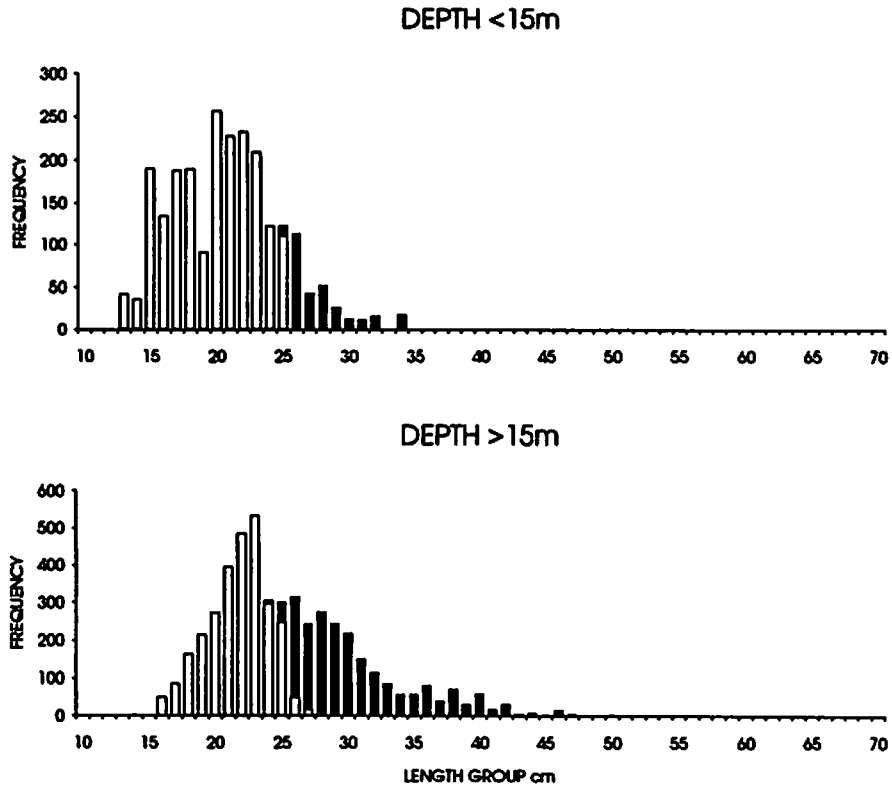


Fig 3.9.16a - Comparison between length/frequency distributions: plaice catches in beam trawlers below and above 15m depth

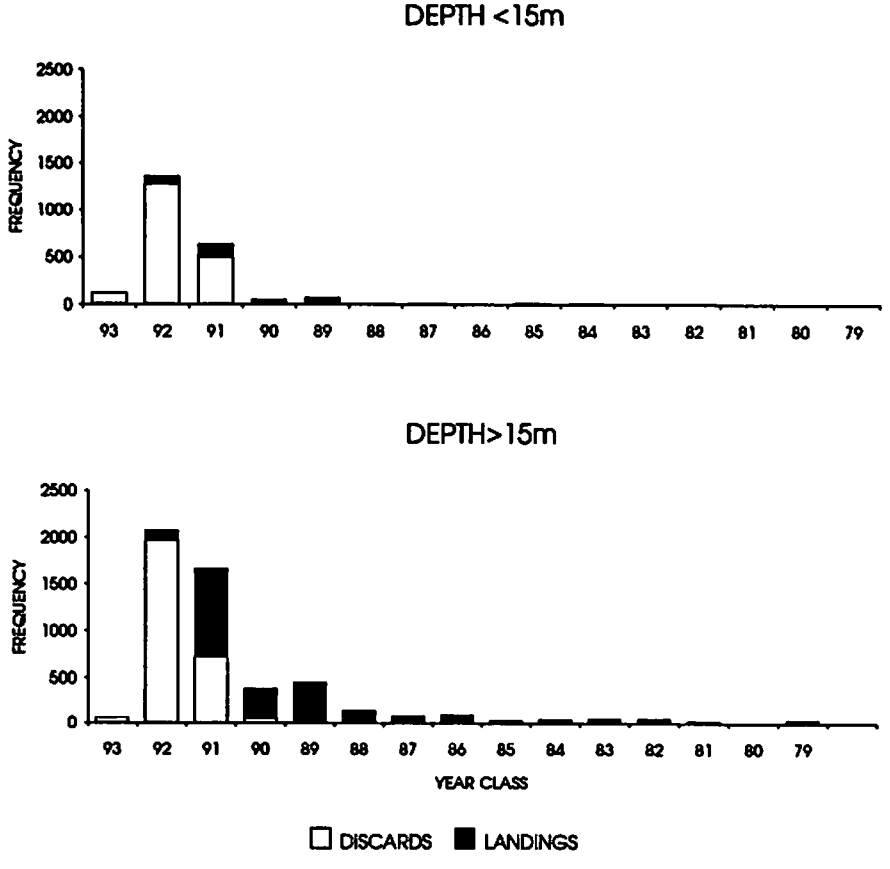


Fig 3.9.16b - Comparison between age structures: plaice in beam trawlers below and above 15m depth

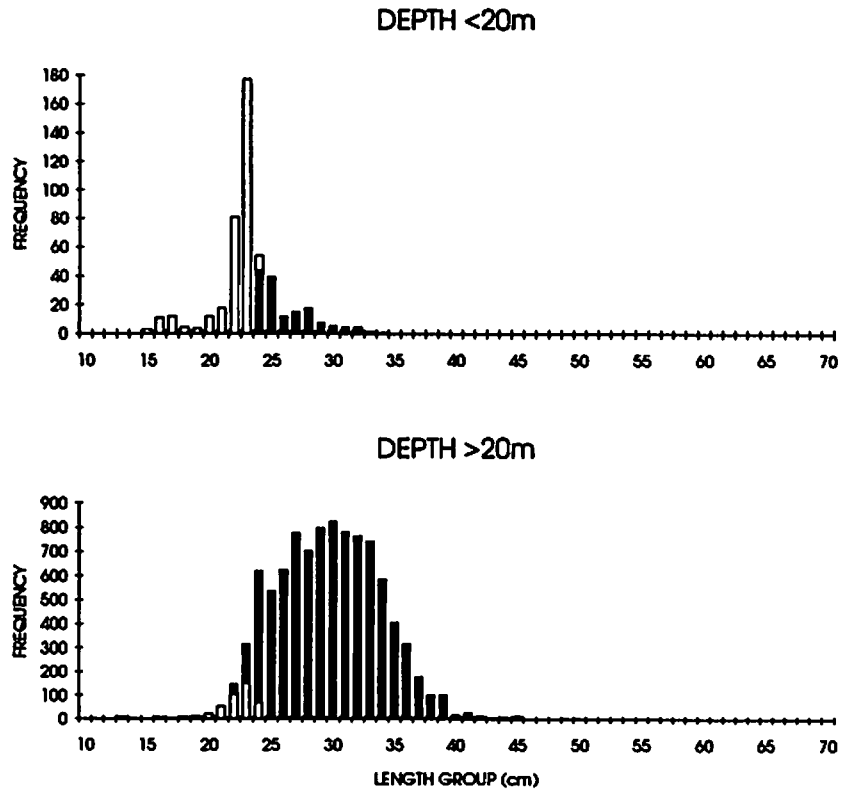


Fig 3.9.16c - Comparison between length/frequency distributions: sole catches in beam trawlers below and above 20m depth

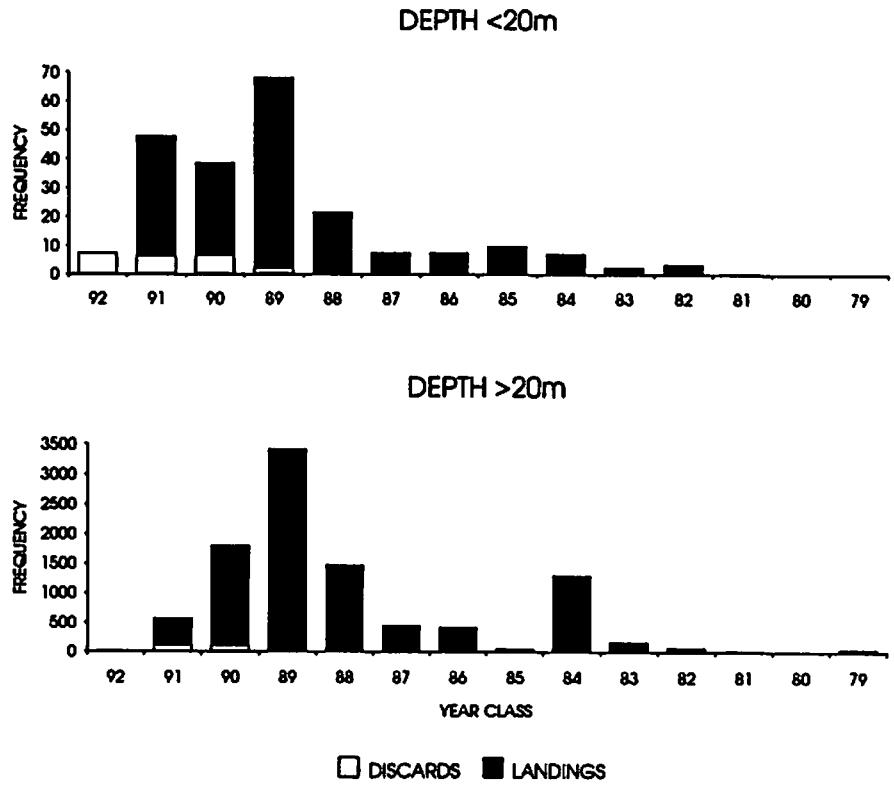


Fig 3.9.16d - Comparison between age structures: sole catches in beam trawlers below and above 20m depth

4. General Discussion

The hierarchical approach to analysis has proved to be useful and will be of use in both planning and analysing future work.

4.1 Sampling Techniques

Method 1, based broadly on the technique used by SOAFD, proved inadequate for the following reasons:

1. This method is best suited to fisheries where the catch is boxed prior to sorting, because boxing enables accurate measurement of total bulk to be made.

2. Efforts were made to retain all of the fish discarded at sorting to quantify their bulk, but this proved to be awkward to achieve without impairing the activities of the crew.

3. Computation of discard rate depends upon raising components by factors derived from visual estimates, and is consequently vulnerable to gross errors.

4. Method 1 could only provide a trip (rather than haul-by-haul) percentage discard rate. Trips are too large a unit with which to adequately measure spatial variations in discarding. Further, the marketable fish measured can only be attributed to the trip, and consequently any spatial differences in their length frequency distribution and/or age structure at haul level are unobtainable.

5. No information was collected regarding the trash component of each haul.

Method 2 has the following advantages:

1. An estimate of total bulk is no longer an essential component of calculation.

2. There is no longer any need to try to retain all of the discards prior to sub-sampling.

3. The haul becomes a discrete sampling unit and also has its own integrity because the relative proportions of the various catch components remain intact. Each haul is sub-sampled and analysed for marketable, discards and trash enabling a haul-by-haul discard rate to be obtained.

4. The haul is a better unit for the measurement of spatial patterns of both discards and retained fish than the trip.

However, there are disadvantages to this technique. It is possible that a shovel discriminates against larger fish in that they tend to slide off the top of a sample before it is deposited in a basket. There is scope for developing an improved sampling tool and /or procedure to reduce this problem.

Catches with larger proportions of trash (often from beamers or Nephrops trawls), contain fewer fish overall. The catches tend to be more viscous than those which contain little trash, and the associated 'clumping' within these catches calls for more careful sub-sampling practice and this is an area which could benefit from closer study and development.

Although a large amount of data was collected from one 1600 hp beamer trip, there can be no comparison with similar vessels. Access to larger visiting beamers proved difficult and this also limited the amount of sole data collected.

During the course of the study, limitations were found in the use of tallies for raising the numbers of certain species. The retained fish from any haul considered void from a sampling point of view have to be deducted from the landing tally for the particular trip. Tallies are usually measured in boxes or stones, and as the landed fish by haul are often reported in baskets or stones, there is scope for inaccuracy if conversions have to be estimated.

Although tallies can be innaccurate in themselves, a particular problem was found when certain species were commonly landed as components of boxes of 'mixed fish'. Unfortunately, this was often the case for trawled soles which are generally not caught in sufficient quantities to justify landing as a separate species and are often mixed with brill, turbot or cod to fill a box and save on landing costs. This can make raising of total discards to trip level difficult.

It appears that attitudes changed during the Nephrops boarding sampling (despite the best efforts of Discard Officers to explain that the catch should be sorted normally) and discarding was considered to be markedly higher than normal. Perhaps future boardings could be conducted without a Fishery Officer present on deck and greater efforts made to explain the need for 'normal' sorting and the confidentiality of the data.

4.2 Factors Affecting Variation in the Results

These results represent the interactions of many variables (see Fig 2.10.1), of which only a few were taken into account in this analysis, and it is recognised that some variables may confound analysis.

In analysis of these data, depth and geographical location were found to be the dominant strata influencing discard rates for plaice and sole.

In the case of whiting, discarding policies appear to be more market driven and many more legal sized whitings are caught and discarded than are retained and landed. Market forces or enforcement problems reduce the influence of the MLS upon fishermen's discarding policy, e.g. within the whiting and Nephrops fisheries respectively. In these circumstances, discarding policy may vary between boats due to differences in fishermen's attitudes. It is beyond the scope of this study to identify and measure the subtle factors involved.

The Nephrops results fitted broadly with the known features of their life cycle in the Irish Sea. This suggests that the sampling regime was adequate to obtain biological information on the fishery. Although variation in the quality of Nephrops was observed there is little evidence of these changes being reflected in the discard rate.

5. Conclusion and Further Work

The following conclusions have been made.

The study identified shortcomings in finfish sampling using Method 1. In response, Method 2 was developed and was found to be an improvement. In particular, the discard rate could be determined at haul level and this aided the analysis of spatial influences. However, despite the improvements upon the original technique, there is scope for further refining Method 2:-

1. Replicate sampling can measure the extent of variation between baskets, and assess the validity of sample selection from the catches of the different gears studied, particularly those which catch higher proportions of trash (beam trawl and Nephrops trawl).

2. Any sub-sampling technique will suffer from raising inaccuracies if the quantities used are estimates rather than empirical measurements. If a suitable method for weighing at sea could be employed, then there would be considerably less reliance upon estimates.

3. It may be possible to develop a better sampling tool than the shovel and minimise discrimination against larger fish.

Spatial factors have been identified as important influences upon the discarding of the main flatfish species. It is also clear that the discard rate has to be determined at haul rather than trip level in order to study spatial influences properly.

Both methods of Nephrops sampling yielded length frequency and biological information. However, only the trip method is considered to be a reliable source of discard rates as the boarding method appears to be corrupted.

The boarding method can be improved by clearer communication with fishermen regarding the scientific need for normal practices, and also the absence of a Fishery Officer on deck.

6. References

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APPENDICES

APPENDIX I

MAFF Landing Statistics

Table A1.1 shows the reported landings for the period January to December 1992 from ICES Area VIIa at the major ports used in this study. These figures were used to approximately weight the ports and gears for the quarterly targets for sampling.

	SPECIES							
PORT & GEAR	SOLE	PLAICE	LEMON SOLE	DAB	COD	WHITING	HADDOCK	TOTAL
HOLYHEAD								
Beam Trawls	12437	18388	221	274	12160	1479	432	45391
Otter Trawls	3232	11205	1198	110	219989	21809	3122	260665
Pair Trawls	0	0	0	0	0	0	0	0
Fixed Nets	13	0	0	0	129	0	0	142
Seines	0	0	0	0	0	0	0	0
LIVERPOOL								
Beam Trawls	26118	36825	474	1191	8333	5451	665	79057
Otter Trawls	0	56	0	0	0	0	0	56
Pair Trawls	0	0	0	0	0	0	0	0
Fixed Nets	0	0	0	0	0	0	0	0
Seines	0	0	0	0	0	0	0	0
FLEETWOOD								
Beam Trawls	66911	57802	257	4977	8439	10404	48	148838
Otter Trawls	63393	554398	8811	34762	539648	548488	5852	1755352
Pair Trawls	0	0	0	0	0	0	0	0
Fixed Nets	0	0	0	0	0	0	0	0
Seines	3	4695	43	0	110	0	0	4851
WHITEHAVEN								
Beam Trawls	459	332	3	6	82	10	0	892
Otter Trawls	5169	61156	177	167	14359	78159	1043	160230
Pair Trawls	0	0	0	0	0	0	0	0
Fixed Nets	0	0	0	0	0	0	0	0
Seines	98	67035	45	0	15323	23280	22	105803
MARYPORT								
Beam Trawls	107	272	0	38	0	0	0	417
Otter Trawls	13841	109031	272	56	28308	32668	48	184224
Pair Trawls	0	0	0	0	0	0	0	0
Fixed Nets	1	51	0	0	0	0	0	52
Seines	0	0	0	0	0	0	0	0

APPENDIX II

Age/Length Keys

The otoliths from discarded fish were sent to DFR Lowestoft for ageing. The resultant age/length keys are shown in tables A2.1-A2.5. For plaice and sole age/length keys for landed fish (these age/length keys for were derived from 1024 otoliths for plaice and 1273 otoliths for sole) were obtained from DFR Lowestoft; for whiting the same age/length keys were used for discarded and landed fish. The numbers of otoliths collected from cod and lemon sole discards were not adequate for further analysis.

The age/length keys for plaice discards were applied by sex and by quarter. The sexes were then summed. Landed fish were not sexed so the age/length keys were combined before application by quarter.

For both marketable and discarded sole the age/length keys for both sexes were combined before application because of the uncertainties involved in sexing small soles and the fact that marketable soles were not sexed. The age/length keys were applied by year for both discarded and landed fish. The low numbers of otoliths from discarded fish of this species means that results must be considered with caution.

Although no age/length keys were avalaible for landed whiting the size range of discarded and landed whiting was similar thus enabling the otoliths collected from discarded fish to be used for both landings and discards. Age length keys were applied by quarter.

Table A2.1 - Age/Length Keys for Plaice

3rd QUARTER 1993

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE 0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6
JUL-SEPT 93	PLE	F	Y	16-20	0	7	3	0	0	0	0
				21-25	0	7	18	2	0	0	0
				26-30	0	1	15	3	1	0	0
JUL-SEPT 93	PLE	M	Y	16-20	0	13	20	1	0	0	0
				21-25	0	5	25	9	1	0	0
				26-30	0	0	16	5	0	0	0

4th QUARTER 1993

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE 0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6
OCT-DEC 93	PLE	F	Y	16-20	0	2	3	1	0	0	0
				21-25	0	8	11	0	0	0	0
				26-30	0	1	4	0	0	0	0
OCT-DEC 93	PLE	M	Y	16-20	0	5	6	0	0	0	0
				21-25	0	4	16	0	2	0	0
				26-30	0	3	6	1	0	0	0

1st QUARTER 1994

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6
JAN-MAR 94	PLE	F	Y	15-19	0	0	3	3	0	0	0
				20-24	0	0	4	1	0	0	0
				25-29	0	0	3	1	0	0	0
JAN-MAR 94	PLE	M	Y	15-19	0	0	4	1	0	0	0
				20-24	0	0	6	1	0	0	0
				25-29	0	0	2	2	1	0	0

2nd QUARTER 1994

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6
APR-JUN 94	PLE	F	Y	15-19	0	0	10	0	0	0	0
				20-24	0	0	15	6	0	0	0
				25-29	0	0	4	5	0	0	1
APR-JUN 94	PLE	M	Y	15-19	0	2	15	2	0	0	0
				20-24	0	2	16	12	1	1	0
				25-29	0	0	5	5	0	0	0

3rd QUARTER 1994

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6
JUL-SEPT 94	PLE	F	Y	15-19	0	6	1	0	0	0	0
				20-24	0	0	10	0	0	0	0
				25-29	0	0	5	1	0	1	0
JUL-SEPT 94	PLE	M	Y	15-19	0	2	6	0	0	0	0
				20-24	0	1	10	4	0	0	0
				25-29	0	0	4	2	0	0	0

Table A2.2 - Age/Length Keys for Sole

YEAR 1993

SEASON	SPECIES	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5
JUL-SEPT 93	SOL	Y	16-17	0	3	0	0	0	0
			18-19	0	3	2	0	0	0
			20-21	0	0	6	0	0	0
			22-23	0	0	3	5	0	0
			24-25	0	0	9	0	0	0

YEAR 1994

SEASON	SPECIES	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5
JAN-MAR 94	SOL	Y	16-17	0	0	6	0	0	0
			18-19	0	0	3	3	1	2
			20-21	0	0	0	5	0	0
			22-23	0	0	0	2	5	1
			24-25	0	0	0	5	0	0

Table A2.3 - Age/Length Keys for Whiting

3rd QUARTER 1993

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6
JUL-SEPT 93	WHG	U	Y	15-19	2	12	2	0	0	0	0
				20-24	0	15	18	0	0	0	0
				25-29	0	0	14	7	1	0	0
				30-34	0	0	1	1	1	0	0
				35-39	0	0	0	0	0	0	0
				40-44	0	0	0	0	0	0	0

4th QUARTER 1993

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6
OCT-DEC 93	WHG	U	Y	15-19	29	12	0	0	0	0	0
				20-24	2	28	2	0	0	0	0
				25-29	0	4	30	0	0	0	0
				30-34	0	0	8	4	0	0	0
				35-39	0	0	0	0	0	0	0
				40-44	0	0	0	0	1	0	0

1st QUARTER 1994

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6
JAN-MAR 94	WHG	U	Y	15-19	0	46	0	0	0	0	0
				20-24	9	22	18	1	0	0	0
				25-29	0	0	20	19	3	0	0
				30-34	0	0	1	22	12	0	0
				35-39	0	0	0	0	5	0	0
				40-44	0	0	0	0	0	1	0

2nd QUARTER 1994

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6
APR-JUN 94	WHG	U	Y	15-19	0	14	0	0	0	0	0
				20-24	0	12	14	1	0	0	0
				25-29	0	0	11	11	0	0	0
				30-34	0	0	0	0	0	0	1
				35-39	0	0	0	0	0	0	0
				40-44	0	0	0	0	0	0	0

3rd QUARTER 1994

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6
JUL-SEPT 94	WHG	U	Y	15-19	0	0	0	0	0	0	0
				20-24	0	0	8	2	0	0	0
				25-29	0	0	0	7	3	0	0
				30-34	0	0	0	0	1	1	1
				35-39	0	0	0	0	0	0	0
				40-44	0	0	0	0	0	0	0

Table A2.4 - Age/Length Keys for Lemon sole

3rd QUARTER 1993

SEASON	SPECIES	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5
JUL-SEPT 93	LEM	Y	16-17	0	0	1	0	0	0
			18-19	0	0	3	0	0	0
			20-21	0	0	3	0	0	0
			22-23	0	0	3	1	0	0
			24-25	0	0	0	0	0	0

4th QUARTER 1993

SEASON	SPECIES	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5
OCT-DEC 93	LEM	Y	16-17	0	0	0	0	0	0
			18-19	0	0	1	0	0	0
			20-21	0	0	3	0	0	0
			22-23	0	0	0	0	0	0
			24-25	0	0	0	1	0	0

1st QUARTER 1994

SEASON	SPECIES	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5
JAN-MAR 94	LEM	Y	16-17	0	0	0	0	0	0
			18-19	0	0	0	1	0	0
			20-21	0	0	0	0	0	0
			22-23	0	0	0	0	0	0
			24-25	0	0	0	0	0	0

2nd QUARTER 1994

SEASON	SPECIES	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5
APR-JUN 94	LEM	Y	16-17	0	0	0	0	0	0
			18-19	0	0	0	1	0	0
			20-21	0	0	0	0	0	0
			22-23	0	0	0	0	0	0
			24-25	0	0	0	0	0	0

Table A2.5 - Age/Length Keys for Cod

3rd QUARTER 1993

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5
JUL-SEPT 93	COD	U	Y	16-20	1	0	0	0	0	0
				21-25	0	0	0	0	0	0
				26-30	0	0	0	0	0	0
				31-35	0	0	0	0	0	0

4th QUARTER 1993

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5
OCT-DEC 93	COD	U	Y	16-20	1	0	0	0	0	0
				21-25	0	0	0	0	0	0
				26-30	0	0	0	0	0	0
				31-35	0	0	0	0	0	0

2nd QUARTER 1994

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5
APR-JUN 94	COD	U	Y	15-19	0	2	0	0	0	0
				20-24	0	4	0	0	0	0
				25-29	0	1	0	0	0	0

3rd QUARTER 1994

SEASON	SPECIES	SEX	DISCARD	LENGTH GROUP cm	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5
JUL-SEPT 94				15-19	0	0	0	0	0	0
				20-24	0	1	0	0	0	0
				25-29	0	0	0	0	0	0

APPENDIX III

Statistical Tests

Although the study did not to carry out a full statistical analysis of these data (this has been along with other discard data from previous studies the subject of an EC Project BIOECO 93/3) there were some statistical tests carried out, the details of which are presented here.

1. Comparison between gear types - % trash and % landed fish

Comparison was made in the mean differences in the % trash and in the % landed fish between beam trawling and the other gear types on a haul by haul basis. This was carried out by Generalised Linear Regression (GLM) treating the propotion as continuous variates. The results of this analysis shows that both models account a high propotion of the variance. The proportion of trash in the beam trawl samples was significantly higher than the other three gears. In the case of % landed fish there was a signicantly propotion of fish in the anchor seining and otter trawling but no significant difference between beam trawling and nephrops trawling, however for these purposes the Nephrops themselves were treated as trash.

Gear codes; BT=beam trawling,NT=nephrops trawling, OT=otter trawling.

```
 43 MODEL %Trash
 44 FIT GEAR_CODE
```

```
44.....

***** Regression Analysis *****

 Response variate: %Trash
    Fitted terms: Constant, GEAR_CODE


** Summary of analysis ***

             d.f.      s.s.       m.s.     v.r.
Regression      3     92476.    30825.2   106.59
Residual      163     47137.      289.2
Total         166    139613.      841.0

Percentage variance accounted for 65.6
```

*** Estimates of regression coefficients ***

	estimate	s.e.	t	Sig. of Difference from BT
Constant (GEAR_CODE BT)	75.38	1.76	42.75	
GEAR_CODE NT	-21.33	3.67	-5.82	P>0.001
GEAR_CODE OT	38.24	3.53	-10.84	P>0.001
GEAR_CODE AS	-75.38	4.73	-15.93	P>0.001

45 MODEL %landed fish
46 FIT GEAR_CODE

46.....

***** Regression Analysis *****

Response variate: %RESMARK
Fitted terms: Constant, GEAR_COD

*** Summary of analysis ***

	d.f.	s.s.	m.s.	v.r.
Regression	3	24011.	8003.8	51.63
Residual	163	25269.	155.0	
Total	166	49280.	296.9	

Percentage variance accounted for 47.8

*** Estimates of regression coefficients ***

	estimate	s.e.	t	Sig. of Difference from BT
Constant (GEAR_CODE BT)	15.70	1.29	12.16	
GEAR_CODE NT	-2.42	2.68	-0.90	Not significant
GEAR_CODE OT	11.47	2.58	4.44	P>0.001
GEAR_CODE AS	40.47	3.46	11.68	P>0.001