Advisory Committee on Fisheries Management **ICES CM 2001/ACFM:13**

REPORT OF THE

STUDY GROUP ON DISCARD AND BY-CATCH INFORMATION

ICES, Headquarters
26–29 March 2001

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 INTRODUCTION

1.1 Participants

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Lisa Borges	Ireland
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Wolfgang Müller	Germany
Henrik Svedang	Sweden
Els Vanderperren	Belgium
Dave Kulka	Canada

Apologies were received from France, Scotland, and the Netherlands.

Before the meeting, France circulated a paper entitled 'An analysis of discards from the French trawler fleet in the Celtic Sea' by Rochet *et al*.

1.2 Terms of Reference

It was decided at the 88th Statutory Meeting in 2000 (C. Res. 2000/2ACFM05) to call a second meeting of the Study Group on Discard and By-catch Information (SGDBI) under the chairmanship of J. Cotter (UK) at ICES Headquarters from 26-29 March 2001 to:

a) compile estimates including a measure of their accuracy of discards and/or by-catches of fish and shellfish by fleet and fisheries using protocols defined at the 2000 meeting;

b) where possible, allocate these estimates to stock units. The Group shall give priority to commercial fish and shellfish stocks.

A copy of the justification for the establishment of this group was given in the report (ICES CM 2000/ACFM:11) of the first meeting of the SGDBI (20-22 March 2000).

1.3 Approach

Members of the Group brought available raw data from national and international catch sampling programmes conducted by sea-going observers in European and Canadian waters. Details of these programmes may be found in the first report of SGDBI. Data by haul (=set in Canada) or by fishing trip were raised to estimates of discarding by fishing fleets using methods discussed at the first meeting of the SGDBI. The method chosen in each case depended upon the type and perceived quality of information available about the fleet and the fishing effort, as well as on the principles discussed in the first report of the Group. In some cases, different raising methods were compared on the same data set but, to prevent possible confusion, only the preferred set of estimates is tabulated; the relative values of the other estimates are mentioned in accompanying text together with reasons (not necessarily very strong) for preferring one raising method over others. Fleet estimates are given as numbers-at-age when suitable age-length keys (ALKs) were available. Otherwise, only numbers-at-length or uncategorised numbers or weights are given. The estimates are separated by stock and grouped in chapters corresponding to the main ICES stock assessment working groups, i.e. the North Sea and Skagerrak, the Baltic, the Northern Shelf, the Southern Shelf, the Northwestern Shelf, the Northern Pelagic and Blue Whiting, and the Mackerel, Horse Mackerel. For shellfish, only data for the Kattegat were available but there was insufficient time to present them.

Results are tabulated in the forms proposed in section 5 of the first SGDBI report, slightly modified. They include estimated raised weights discarded, numbers-at-length, and numbers-at-age by species, fishery, gear, marine area, and quarters or years. Results for discarding by Baltic countries only are presented differently from others, being raised 'per thousand tonnes landed' and being in a slightly different format. This happened because of the existence of a computer

programme to achieve this directly from the raw data. Tables also show the raising method used, mean lengths and mean weights-at-age. To avoid giving spurious impressions of accuracy and in accordance with recommendations of other groups, the Group (with one or two exceptions, noted in the data tables) did not attempt to estimate missing ALKs or other data by interpolation or by adoption of results from adjoining areas or time periods. We felt that it is usually better for users of the data to make such calculations for themselves. The data tables therefore contain many empty spaces.

Results are separated nationally. No attempts were made to estimate total quantities discarded internationally in specific marine areas because (i) this task is already being undertaken as part of European Community projects for the Baltic and North Seas, (ii) complete data for all fisheries were not available to the Group, and (iii) the raising of partial estimates of discarding is in some cases already carried out by the stock assessment working groups using their own preferred methods.

The high degree of disaggregation chosen for presentation of the estimates was thought necessary to avoid masking features of the data thought to be relevant to stock assessment working groups, e.g indications of the effects of gear on discarding. It had the disadvantage of creating many tables and these have therefore been presented in electronic form on CD. They are in a spreadsheet format which can be used directly for computation. The Group attempted fairly successfully to maintain the tables in a uniform format to assist this.

Iceland supplied the Group with length distributions for haddock as determined for catches by sea-going observers, and for the landed portions by samplers in fish markets. The data covered a time period when mesh size regulations changed. The Group took the opportunity to investigate the effects of this and other factors on catch and landings compositions. Results are given in the chapter for the North Western Shelf.

1.4 Measures of accuracy

The terms of reference request measures of the accuracy of the fleet-level estimates of discarding. Technical reservations about each set of tabulated estimates are stated in accompanying text to assist users to place an appropriate degree of confidence in the results.

Statistical estimates of variance have been given in papers on discarding, e.g. Rochet *et al*. However, it should be noted that these (and standard errors, and coefficients of variation) are no less vulnerable to small sample sizes and bias than the estimates of total quantities discarded. Also, for some sampling schemes, variance formulae are not readily available, may not include all sources of variability, and may overlook reduction of effective sample size due to covariances, e.g. between age-groups or species in the same catch samples. Since many of the estimates presented in this report are based on unrandomised sampling with restricted sampling resources, other measures of accuracy were used in preference to variances.

It has been reported for European trawl fisheries (Rochet *et al.*; Allen *et al.*) that variance between-trips is generally higher than between-hauls-within-a-trip. Therefore, the variance of estimated discarding can reasonably be expected to reduce more or less in proportion to the number of independently selected, observed trips. Increasing the number of hauls or total fishing time by selecting long trips for observation has a less beneficial effect on estimation variance because the observed fishing would often be conducted in the same way within the same grounds and therefore represent only a small part of the total activities of the fishing fleet. For these reasons, the number of observed trips was preferred as a simple measure of the accuracy of raised estimates of discarding. However, we also tabulate the number of hauls from which samples of fish were measured since they are a guide to the reliability of length frequency distributions. Further, since fishing trips may vary in length from one to many days, the number of observed hours fishing was thought relevant for inclusion in some data tables. The accuracy of age-length keys depends strongly on the number of otoliths collected, so this information is given with tables of numbers-at-age.

To assist in gauging the effect of number of trips on accuracy of estimation, note that:

- Rochet *et al.* reported coefficients of variation (CVs) between 19 and 46% for numbers or weights discarded of various demersal species given 26 trips sampled in the Celtic Sea.

- Stratoudakis *et al.* (1999) reported CVs between 20 and 30% given 45 to 65 trips sampled annually in the North Sea, and between 50 and 60% given 15 to 35 trips sampled annually to the West of Scotland.

- Cotter *et al.* reported CVs between 20 and 50% given 17 to 25 trips sampled per period using a 'probability proportional to size' scheme in the North Sea

Data made available to the Group by Canada provided an additional opportunity to gauge the effects of numbers of observed trips on accuracy of estimation of discarding by a fishery, in this case that for shrimps (*Pandalus sp*) off the Canadian Atlantic coast. Due to 100% coverage of vessels fishing in Canadian waters by sea-going observers, catch by species was recorded for every haul and trip made by the offshore (large trawler) fleet since 1987. Two years of these data (1988, 1991) were available for analysis. The total weights caught by trip of *P. borealis*, the main target species, and turbot, redfish and cod, the main discard species, were calculated along with the number of sets made, and the number of hours fished. The column sums in this data table therefore gave the true annual totals of the catches and of the effort measures by the whole fleet. Trips were randomly selected 1000 times in a boot-strapping procedure intended to see whether different raising methods affected precision or accuracy, and to estimate how many trips would have to be observed to achieve a given CV assuming that observer coverage were less than 100%, as in European waters. Catches of each selected trip were raised to fleet estimates using (i) trips, (ii) fishing time, (iii) hauls, and (iv) landings of shrimp. Two CVs were calculated in each case, one to estimate precision in terms of deviations from the sample mean, the other to estimate accuracy in terms of deviations from the true values. If the second is considerably larger than the first, bias arising from the raising method is implied.

Results are shown in table 1.4.1. The following summary is not intended to suggest that sampling of any fishery would give similar results. Assuming independent sampling of trips, the CV obtained from a sampling programme making n trips (n<<total number of trips made by fleet) can be found by dividing the tabulated CV by $\sqrt{n}$. For example, with a CV of 100% for one trip and an available sample size of 20 observed trips, the estimated total discards would have a CV of $100/\sqrt{20} = 22\%$. This result may be compared with CVs estimated by Rochet and Stratoudakis, cited above. Other results which may be of interest are that the CVs for shrimp were smallest, presumably because that species was caught most regularly in large numbers. In both years, raising by fishing time and hauls usually gave best precision and accuracy which is not surprising because more information about fishing operations is being incorporated into the estimation. None of the raising methods caused noticeable bias.

Table 1.4.1. Coefficients of variation (CVs as %) for bootstrap estimates (1000 samples) of total annual fleet catch in two years of four species made from observed catches on one trip raised to fleet level with four different methods. CV precision based on sample mean. CV accuracy based on true value. True total catches are in tonnes.

a) 1988

Raising by:	Shrimp	Turbot	Red-fish	Cod	Shrimp	Turbot	Red-fish	Cod
	CV precision				CV accuracy			
Trips	54	111	103	184	54	111	103	184
Fishing time	37	87	75	175	37	88	77	175
Hauls	38	97	76	192	37	97	77	193
Shrimp land'gs	0	101	85	537	0	101	85	544
True totals	57814	1809	2996	1026				

a) 1991

Raising by:	Shrimp	Turbot	Red-fish	Cod	Shrimp	Turbot	Red-fish	Cod
	CV precision				CV accuracy			
Trips	90	165	158	262	90	166	158	262
Fishing time	59	111	89	211	59	112	95	211
Hauls	54	120	86	242	54	121	93	243
Shrimp land'gs	0	117	106	283	0	118	107	287
True totals	58350	3436	5148	1843				

1.5 Abbreviations

The following abbreviations may be found in this report:

AZTI	Fundación AZTI Instituto Tecnologico Pesquero y Alimentario (Spain)
WGBFAS	ICES Baltic Fisheries Assessment Working Group
CEFAS	Centre for Environment, Fisheries, and Aquaculture Science (England)
DIFRES	Danish Institute for Fisheries Research
DvZ	Departement voor Zeevisserij (Belgium)
EC	European Commission
EU	European Union
FRS	Fisheries Research Services (Scotland)
IEO	Instituto Español de Oceanografia (Spain)
IFREMER	Institute français de recherche pour l'exploitation de la mer.
IMR (Norway)	Institute of Marine Research
IMR (Sweden)	Institute of Marine Research
ISH	Institut für Seefischerei, Hamburg
MHSA	ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy.
MI	Marine Institute (Marine Fisheries Services Division) (Ireland)
NEPH	ICES Working Group on *Nephrops* Stocks
NSDS	ICES Working Group on the Assessment of Northern Shelf Demersal Stocks.
NSSK	ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak.
NWWG	ICES North-Western Working Group.

RIVO	Rijksinstituut voor Visserijondersoek (The Netherlands)
SEAFISH	Sea Fish Industry Authority (England)
SSDS	ICES Working Group on the Assessment of Southern Shelf Demersal Stocks.
WGNBBW	ICES Working Group on Northern Pelagic and Blue Whiting Fisheries

1.6 References:

Allen, M., Kilpatrick, D., Armstrong, M., Briggs, R., Course, G., and Pérez, N. (submitted). Multi-stage cluster sampling design and optimal sample sizes for estimation of fish discards from commercial trawlers. Fisheries Research.

Cotter, A.J.R., Course, G., Buckland, S.T., and Garrod, C. (in press). A PPS sample survey of English fishing vessels to estimate discarding and retention of North Sea cod, haddock, and whiting. Fisheries Research.

Rochet, M-J., Péronnet, I., and Trenkel, V.M. (submitted). An analysis of discards from the French trawler fleet in the Celtic Sea. ICES Journal of Marine Science.

Stratoudakis, Y., Fryer, R.J., Cook, R.M., and Pierce, G.J. (1999). Fish discarded from Scottish demersal vessels: estimators of total discards and annual estimates for targeted gadoids. ICES Journal of Marine Science, **56**: 592-605.

2 THE BALTIC SEA

2.1 Overview

Routine discard collection has been going on in the Baltic Sea since second half of 1995. All countries around the Baltic Sea are involved. At present the work is funded by the EC and national governments.

For sea sampling two different strategies are applied among countries. Germany and Latvia use a strategy where few recurrent vessels are selected. These vessels are assumed to be representative for a larger group of vessels concerning catches and fishing pattern. The rest of the countries (Sweden, Poland, Estonia, Russia, Finland and Denmark) more or less randomly select the vessels for sampling of a given fishery among a large number of vessels. In addition some considerations are made in order to assure that different vessel sizes and various duration of the fishing trips are covered. There are not in any of the participating countries authority in law, which give the possibility to enforce the observers participation on a fishing trip. Therefore, the vessels are not sampled randomly among all vessels performing a given fishery but only among the vessels where the skipper beforehand has agreed in having observers on board. It is the objective to include as many different vessels as possible in the sampling scheme.

The national sampling schemes are organized in a way that the sampling efforts are distributed according to the fishing intensities in the different strata –a relative large number of landings imply heavy sampling effort and relative smaller numbers of landings imply less sampling effort. This assures that the biological data are directly applicable to the national landing statistics.

The sampling of commercial vessels is normally done on board during normal active fishery by observers employed at the national institutes. Sampling are made in harbour during landing only in fisheries where it is verified that no advantages are obtained by sampling on board (e.g. fisheries where no discards are obtained), in fisheries where the vessels are to small to carry an extra person or where sampling on board for various reasons are impossible to organize. When possible and when the observers are confident with the skipper and crew, the part of the catch, which normally are discarded, are landed separately from the normal landing part of the catch and worked up and recorded. In this case the same information are collected as if the observer has been on board. It is indicated if the data are sampled at sea or in harbour. Typically a fishing trip consists several stations defined as a haul or a gill-net set depending of the type of gear.

At each station the following catch data are collected:

- Total weight of discard and landing by species.
- Separate length distributions of discard and landings by all species caught.
- Otoliths and individual mean weight per cm-length group of selected species.

In addition all relevant vessel, gear and geographical information is recorded.

The weight measurements are all recorded as un-gutted fish and the measurements are preferably made on un-gutted fish, but if gutted fish are used a weight conversion factor is applied.

The data collection is stratified on:

- Country
- ICES Sub-division
- Gear
- Purpose of the landing (consume or industrial)
- Quarter

The sampling procedure is defined in a common agreed sampling manual.

The number of trips sampled covers approximately 0.5% of the total number of commercial trips made in the period.

All participating have on request full access to all data collected if the data are used for scientific purposes.

All data are stored in a common database, which are in the process of being reorganised into a web-based base, which can be accessed through a web browser.

It is the ambition that the database besides providing discard information shall provide the basis for central calculation of age aggregated catch in numbers per e.g. 1000 tons landed for all countries fishing in the Baltic Sea. Presentation in relative terms was chosen because landings figures are not included in the database. This will assure that the input to the assessment model used by the Baltic Fish Assessment Working Group will be calculated in a consistent and well-documented way. A prototype of this program has been used to produce the discard figures in the present report. The program raise from the sampling level to discard per 1000 tons of cod landed by stratum. The format of the tables are a bit different from the agreed for practical reasons.

Danish data for Baltic discarding of cod can be found in tables 2.2.1.1.2a through to 2.2.1.9.3a. Swedish data for cod is in tables 2.3.1.1.2a to 2.3.1.13.3b, and German data for cod is in tables 2.4.1.1 to 2.4.2.3c. Data for other Baltic countries is not presented in this report because they were not represented at the Study Group. However, all tables covering all countries and all fisheries during the period 1995-2000 will be presented at the WGBFAS this year.

2.2 Germany

2.2.1 German investigations in the Baltic Sea

Under the EU-project 98/024 „International Baltic Sea Sampling Program“(IBSSP II) investigations on discards and bycatch in the commercial fisheries are carrying out by all Baltic countries since 1999.

Amongst the German fishery cod is the main species, with yearly catches of 15.308 tons in 1999 and 12.977 tons in 2000.The fishing areas are the Kiel- and Mecklenburg Bight (ICES-Division IIIc, Sub-division 22) with about 60% of the catches, followed by the Arkona Sea (ICES-Division IIIc, Sub-division 24) with round 30%. The Bornholm Bassin (ICES-Division IIId, Sub-division 25) in recent years plays a minor role with descending shares of about 10%.

The most common fishing method in the German cod-fishery is trawling in different variants (otter-and pair trawls on the bottom, otter trawls in midwater especially in the Bornholm Bassin). They harvest up to 95 % of the yearly catches. In order to minimize the discard rates, codends of 120 mm mesh size or 105 mm mesh size with exit windows to be used since 1994.

For the data collection there exist contracts with 10-12 vessels , that are a representative fraction for the German fleet in regard to vessel size (11-32 m length), engine power (80-900 HP) and fishing intensity. The sampling takes place in two steps: Monthly trips with onboard measurements in different fishing areas results in length compositions and rates of retained and discarded fish including cod and bycatch species. Another data source are samples of unsorted fish (250 kg) taken to the lab, to produce age-length-keys and to gain individual weights.

These data are summarized from all Baltic countries in a common database, with different file types on specific parametres from the vessels, the gears, the fishing process and the numerous biological data for each haul. German data for discarding of cod in the Baltic are given in tables 2.4.1.1 to 2.4.2.3c of this report.

3 NORTHERN SHELF

3.1 Ireland

The Irish discard data was produced as part of the Irish work program for the FIEFA Project (EU Study Contract 97/059) and SAMFISH Project (EU Study Contract 99/099).

Raised total discards, length frequencies, numbers, mean length and mean weight-at-age are presented for 7 demersal stocks between the years 1995 to 2000. There were no *Nephrops* discards observed in the areas, fleets (including *Nephrops* trawlers) and years sampled. The data are presented by year since quarterly discard age length keys were not available. The age length keys used were only provided by the discard program.

An exploratory analysis was carried out where discard values were raised to fleet level by landings in kg, landings in numbers and effort (total hours fished). Landings in kg was chosen to raised discards to fleet level because it is considered to be the most reliable of the three auxiliary variable studied. 2000 discard and all landings are provisional data. 2000 age length keys were not available and therefore only raised length frequencies are presented.

3.1.1 Haddock VIa and VIIb-k

Haddock in Division VIa (tables 3.1.1.1a - 3.1.1.3a) presents a general decrease in discarding. However, 2000 has poor sampling coverage (only 1 trip). Mean lengths and weights at age are consistent between ages and years. There is an age increase on the discard mode over time: from age 1 in 1996 to age 2 in 1998.

Regarding Divisions VIIb-k, haddock (tables 3.1.1.1b - 3.1.1.3b) had an increase in discards until 1997, decreasing in recent years. Mean lengths and weights at age are consistent between ages and years, except for ages 3 to 5 in 1996 where there is an apparent overestimation of both variables. Nevertheless, it can be observed an increase on the discard mode over time: from age 0 in 1995 to age 2 in 1998.

3.1.2 Megrim VI

Megrim (tables 3.1.2.1 - 3.1.2.3) presents a general increase in total discards. Mean weights and lengths at age are underestimate in older ages (>7 years) due to poor sampling of those ages. Furthermore, 1999 presents discrepancies between ages. Discards were mainly composed of 3 year old individuals.

3.1.3 Whiting VIa

Whiting (tables 3.1.3.1 - 3.1.1.3) presents a variable total discard pattern between years. Mean weights and lengths at age are consistent between ages and years. Discards were mainly composed of 1-2 year old individuals.

3.1.4 Plaice VI and VIIa

Plaice in Division VI (tables 3.1.4.1a - 3.1.4.3a) presents a general increase in discarding. Discarding of plaice in Division VIIa (tables 3.1.4.1b - 3.1.1.3b) has steadily increased. In both Divisions mean lengths and weights at age are underestimate for older ages (>7 years) due to poor sampling of those ages. Also, in both Divisions the mode of the age distribution was located between 2-3 years of age.

3.1.5 Sole VIIa

Sole discarding (tables 3.1.5.1 - 3.1.5.3) has increased between 1995 till 1999. However sampling levels are low regarding number of trips sampled and number of otoliths aged which might justified the discrepancies observed in mean lengths and weights at age.

4 NORTH SEA AND SKAGERRAK

4.1 Germany

North Sea

Data collection onboard German commercial vessels has been carried out since 1995. Some fleets were sampled also in earlier years. The data sets included at this meeting are the most recent ones only; they cover catches from the North Sea. Catches from the Skagerrak are negligible and are not sampled. The complete data set on discards (in tonnes), by length and by age for the beam-trawl, otter-trawl, pair-trawl and fly-seine fleet are available for the period Quarter1/1999 to Quarter 2/2000. They cover the species cod, saithe, haddock, whiting, plaice and sole.

Discard data for the years 1997 and 1998, however, having gaps, partly in sampling, partly just in fitting age distributions, are not included. Additionally, discard data for the period Quarter 2/1995 to Quarter 4/1996 were sampled in the same way, but they were not available in the agreed format.

The missing sampling data in the period 1999/2000 are kept as blanks, whereas missing ALKs are tried to be filled by those of adjacent quarters. An explaining remark in the table is given accordingly. ALKs were taken from all available sources. See tables 4.1.1.1.1 to 4.1.6.2.3c.

4.2 England

Data provided by England were collected through the jointly funded (national government and EC) EC Project 98/097 "Monitoring discarding and retention on fishing vessels towing demersal fishing gears in the North Sea and Skagerrak." England had no fishing effort in the Skagerrak so all data presented are for the North Sea only (ICES Areas 4a,b and c, combined). Discard data for cod, haddock, female and male plaice, saithe, sole and whiting can be found in tables 4.2.1 to 4.2.7 respectively.

Raw data collected were numbers at length and these were converted to weights using length weight relationships provided by the CEFAS biological-sampling programme. This allowed the total weights discarded shown in tables whose last digit is 1 to be estimated for each species, gear type and quarter sampled. They were also raised to fleet level and presented as raised numbers at length discarded in tables whose last digit is 2.

Officially reported fishing effort data were available from the 1st quarter 1999 to the 4th quarter 2000 and these were used to raise sampled data using officially reported hours fishing hours divided by sampled fishing hours, to obtain a raising factor. The total amounts of sampling effort for each gear type and quarter are shown at the foot of Table 2.

Age data for the main species were available from the 3rd quarter 1999 to the 2nd quarter 2000, from this project, the exceptions being plaice and saithe, where age data were only available for 1999. Where enough fish were caught, numbers of fish at age, mean weight and mean length at age, are presented in tables whose last digit is 3. These are split into gear type sampled (a,b,c etc.) and quarter. Given more time, data from previous discard studies could be used to provide age, length, and weight data from the 1st quarter 1996 to the 2nd quarter 2000 inclusive. The value for total number of fish-aged shown at the foot of this table for each quarter was a combination of otoliths collected from discard trips and market sampling. These were aggregated to form a combined Age Length Key (ALK) that used discard otoliths for ageing fish below the Minimum Landing Size (MLS) and market sampled otoliths for the those above or equal to the MLS for each species.

4.2.1 Data Limitations

Although it would have been preferable to supply complete data for all quarters in both 1999 and 2000, this was not possible in the time available. For the 3rd and 4th quarters 2000, no otoliths had been read to allow numbers and weights at age to be presented. This was also the case for plaice and saithe in the 1st and 2nd quarters 2000.

Data collected on a previous study (EC Project 95/094) from 1994 to 2nd quarter 1999 could also be presented in this format but, for this meeting, only that of the 1st quarter 1999 is shown. This excludes age data. No sampling occurred in quarter 2 1999 due to lack of funding.

For some quarters and gear types high hours sampling at sea were achieved. However this was often from one or two trips only. For example, only one Scottish fly seining trip was carried out in the 3rd quarter 1999 but this resulted in 52 hauls and 116.58 hours being sampled, respectively. Alternatively, some data that has been raised to fleet level may be

based on very low sampling levels and with few fish measured. Therefore the reader should take care when using any of this information and also consider the sampling effort and its stratification.

To avoid too many strata, some gear types have been grouped together under general gear type headings. For example:

- "Otter" trawl contains the gear types twin, triple, light, heavy and unspecified otter trawls because the gear types fish in similar ways and generally in the same areas.

- "Beam" trawl contains offshore plaice beam, inshore sole beam, and shrimp beam trawl, which although fish completely differently can not easily be distinguished from each other when extracting officially reported effort and landings.

- "Seine" combines anchor and Scottish fly seine and

- "*Nephrops*" trawl contains single, twin and triple rig *Nephrops* trawls.

Although this is not ideal it was necessary to try and avoid a large number of gear types for which information was unlikely to be obtained for all quarters.

Despite these problems, the data does provide some useful indications of quantities and patterns being discarded by vessels fishing from the NE coast of England.

The accuracy of the data is hard to quantify but it is thought that fishers do not react differently when research staff are aboard and that most trips sampled were typical for the fleet. However comparing the sampling effort to that actually fished by the fleet can give an indication of sampling levels and possible precision. In England's case most gears were sampled at levels less than 1% of the fleet's total fishing effort, with the exception of seine trawling where over 3% of effort was sampled. An English paper has recently been accepted by Fisheries Research that includes analysis for accuracy and estimates coefficients of variation e.g. cod numbers of discarded and retained between 10and 50% (Cotter *et al.*, 2001).

4.2.2 References

Cotter, A.J.R., Course, G.P., Buckland, S.T. and Garrod, C., 2001. *A PPS sample survey of English fishing vessels to estimate discarding and retention of North Sea cod, haddock and whiting.* Fisheries Research (in press).

4.3 Denmark

No text provided. Data for cod, haddock, and plaice for 1999-2000 may be found in tables 4.3.1.1.2.a to 4.3.3.4.2c.

4.4 Sweden

The Swedish participation in the EC project 98/097: "Monitoring discarding and retention on fishing vessels towing demersal gears in the North Sea and Skagerrak" is administrated from Institute of Marine Research, Lysekil, Swedish National Board of Fisheries.

Since the third quarter of 1999, Swedish fishing vessels operating in the North Sea and Skagerrak have been monitored by onboard measurements of discards and retention of, in particular, six TAC-species; i.e. cod, haddock, saithe, whiting, plaice and sole. Data for cod are given in tables 4.4.1.1.1 to 4.4.1.2.3e.

The selected fishing vessels, according to log-books, have been fishing in previous years in the North Sea and Skagerrak, using otter bottom trawls, Danish seines or pair trawl. From this population of fishing vessels, study objects have been picked at random. As the sampling was stratified according to quarter, the population of fishing vessels have been updated at every quarter.

In order to raise estimates of discarding and retention to fleet level, a factor based on fishing effort has been used. The effort of the Swedish fishing fleet towing the demersal gears has been compiled for six different quarters, i.e. from the third quarter in 1999 to the last quarter in 2000. Because the present intention was to separate fishing effort and catches into fishery, an *ad hoc*-stratification was made. For the Swedish fishing fleet, the following gear or rather fishery stratification was made: fish otter trawl, shrimp otter trawl, *Nephrops* otter trawl, pair trawl, and Danish seines.

The level of accuracy is given as the total fishing effort sampled. For the dominating Swedish demersal fisheries in the North Sea and Skagerrak, it was easily recognized that the percentage of sampled fishing effort was small. Due to the high number of "cells", i.e. the rather high degree of stratification, the sampling scheme was unable to cover all kinds of fisheries in both areas in every quarter. However, the detailed information for some specific and important fisheries given by this stratification might be more relevant both for assessment purposes and *per se* studies of discarding rates.

The amount of discarded and cod in numbers was estimated for the Swedish demersal fishery. Length frequency distribution were converted into age classes according to otolith subsampling of the discarding. According to the obtained estimates, it is obvious that the discarding rate of cod was high in the Skagerrak, especially for fishing vessels using either *Nephrops* or fish otter trawl.

5 SOUTHERN SHELF

5.1 Ireland

The Irish discard data was produced as part of the Irish work program for the FIEFA Project (EU Study Contract 97/059) and SAMFISH Project (EU Study Contract 99/099).

Raised total discards, length frequencies, numbers, mean length and mean weight-at-age are presented for 3 demersal stocks between the years 1995 to 2000. There were no *Nephrops* discards observed in the areas, fleets (including *Nephrops* trawlers) and years sampled. The data are presented by year since quarterly discard age length keys were not available. The age length keys used were only provided by the discard program.

An exploratory analysis was carried out where discard values were raised to fleet level by landings in kg, landings in numbers and effort (total hours fished). Landings in kg was chosen to raise discards to fleet levels because it was considered to be the most reliable of the three auxiliary variables studied. 2000 discard and all landings are provisional data. 2000 age length keys were not available and therefore only raised length frequencies are presented.

5.1.1 Hake VI & VII

Hake discard data (tables 5.1.1.1-5.1.1.2) are presented only for otter trawl because gillnets were not sampled. Also, hake is not aged thus the data presented comprise only of length frequency. Discarded tonnes between the study period have been variable with maximums in 1998 and 2000.

5.1.2 Megrim VII

Discard data for megrim in area VII are presented in tables 5.1.2.1 - 5.1.2.3. 2000 presents the highest total discards of the time series studied. Mean weights and lengths at age are underestimate in older ages (>6-7 years) for 1996 till 1998 due to poor sampling of those ages. Furthermore, 1999 presents discrepancies between ages. Discards were mainly composed of 2 year old individuals.

5.1.3 Whiting VIIe-k

Discard data for whiting in area VIIe-k are presented in tables 5.1.3.1 - 5.1.3.3. Whiting had an increase in discards until 1998, decreasing in recent years. Mean lengths and weights at age are consistent between ages and years. Discards were mainly composed of individuals corresponding to age 1 until 1996 with a shift to age 2 in the following years.

5.2 Spain

Spanish discard estimates for the trawling fleet operating in the North and Western part of Ireland (Sub-area VI and VII) and in the Central and Western part of the Cantabrian Sea (Divisions VIIIc and IX a) are presented in this section.

Information about discards came from different EC Projects: Discards of the Spanish fleet in ICES Divisions, EC Project: Pem/93/005. On-board sampling of fish landed and discarded by commercial vessels, EC Project: 95/094, and Monitoring of discarding and retention by trawl fisheries in Western Waters and the Irish Sea in relation to stock assessment and technical measures, EC Project: 98/095.

Trawling discard data are presented annually by stock. Raised total discards, length frequencies, numbers and mean length and weight at age are presented for 4 demersal stocks in 1994, 1997 and 1999. Discard data are available for 2000, but no results are presented in this report as no effort and landing statistics for that year are already available. Data are presented annually since some quarters lack of discard sampling. Also for many species, no quarterly discards Age Length Keys were available.

Discard data are available for Hake and Megrim in Sub-area VI and VII, both areas together, for 1994 and 1999. Information are available for Hake and Four Spot Megrim, from Divisions VIIIc and IXa, for years 1994, 1997 and 1999. Data for Megrim in 1997 from Divisions VIIIc and IXa is also presented. All these discard data will be provided to the group assessing these species: the Southern Shelf Demersal Stock Working Group.

In Sub-area VI & VII, only one gear and two fisheries targeting two different species were studied separately. In Divisions VIIIc & IXa, where there are two different modalities, "Baka" trawls and Pair trawls with Very High Vertical opening nets, raising was done individually for each of the modalities and then to the total of the trawl fleet landings.

During 1994, in ICES Divisions VIIIc and IXa and due to the scarce sampling deployed in VHVO Pair trawls, discards obtained in both modalities where analysed together. No random sampling was deployed because just a determined number of fishing vessels was available for boarding. The Age Length Keys of the landings were applied to the discard length composition. No sampling of discard otoliths was carried out on board and consequently no Discard Age Length Keys were obtained for this year.

Exploratory analysis of discard data of 1997 was carried out. Different raising methods were used: by weight landed, number landed and effort (fishing hours) (ICES CM 2000). The results of the raising carry out by landings in weight produced more realistic outcomes when comparing to those obtained using the other methods.

From 1997 and 1999, the monitoring of the discards was carried out under a randomised sampling program by vessel and stratified by gear and area.

During 1999, sampling discards was carried out during the second half of the year, this is when the recruitment of the major part of the species take place. Thus, comparatively to other years the amount of discarded estimated was rather high.

5.2.1 Discard estimations of Megrim (*Lepidorhombus whiffiagonis*) in Sub-area VI & VII and Divisions VIIIc and IXa

In 1999, the discard estimations were around 8 times greater than estimates in 1994 (Table 5.2.1.1). It has to be pointed out that the sampling was deployed during the second half of the year when the major recruitments take part.

In 1994, looking at the length distributions (Table 5.2.1.2a), the bulk of the discards was around 18 cm. However, for 1999 the mode was around 20 cm and even large fish were also discarded in relatively large amounts.

In Table 5.2.1.3a. and looking at the numbers by age, in 1994 the largest number of fish discarded belong to ages 3 and 4. It has to be pointed out that in this case an Age Length Key of the landings was used to obtain numbers at age. However, in 1999 a discard Age Length Key was used and more discards correspond to fish of ages 2 and 3.

In 1997, a total of 143 tons of Megrim in Division VIIIc and IXa were discarded (Table 5.2.1.1). Discards were mainly composed of individuals (Table 5.2.1.2b) corresponding to age 2 (Table 5.2.1.3b).

5.2.2 Discard estimations of Hake (*Merluccius merluccius*) in Sub-area VI & VII and Divisions VIIIc and IXa

In 1999, the discard estimations were around 4 times greater than estimates in 1994 (Table 5.2.2.1). As same as for Megrim in this Sub-areas, discard sampling was deployed during the second half of the year when the major recruitments take part.

In 1999, looking at the length distributions (Table 5.2.2.2a), the bulk of the discards is around 27 cm. However, for 1994 the mode is around 18 cm and no such big fish as in 1999 were discarded.

In Table 5.2.2.3a. and looking at the numbers by age, in 1994 the largest number of fish discarded belong to age 1. Age Length Key of the landings was used to obtain numbers at age. However, in 1999 a discard Age Length Key was used and more discards correspond to fish of age 2.

Hake discards in Division VIIIc and IXa are presented in Table 5.2.1. Discards were mainly composed by small individuals (Table 5.2.2.2b) corresponding to ages 0 and 1 in 1994 and 1997 and age 1 in 1999 (Table 5.2.2.3b).

5.2.3. Discard estimations of Four Spot Megrim (*Lepidorhombus boscii*) in Divisions VIIIc and IXa

Four spot megrim discard estimations were very similar, around 350 tons, during 1994, 1997 and 1999 (Table 5.2.3.1).

Discards length distributions are presented in Table 5.2.3.2. In Table 5.2.3.3 numbers at age, mean length and weight at age are displayed.

5.2.3 References

ICES CM 2000/ACFM:11 Report of the Study Group of Discards and By-catch Information. Copenhagen 20-22 March 2000.

6 NORTH WESTERN SHELF

6.1 Iceland - Haddock

Systematic collection of data with the specific aim of estimating discards, has not been carried out in Icelandic waters so far. In recent decades, however, sea-going observers have length measured large numbers of fish on board commercial vessels, basically with the aim of preventing excessive catch of undersized fish. On the other hand, systematic data collection from landings has been carried out as input for stock assessment models.

These two sources of data, length measurements at sea and from landings, are used to estimate discards of haddock in 1988-2000 for the bottom trawl fishery. Length distributions of landings, obtained by sampling in port in a given year, are calculated conventionally as a product of numbers landed and the proportion of fish numbers measured at each length. This gives length distributions in number of fish.

The length distributions at sea are found by sampling the catch prior to discarding. This gives length distributions at sea as proportions of fish numbers measured at each length. However, the numbers or weight of the discards are, obviously, not known and, therefore, numbers caught at sea must be estimated by other means than numbers landed. In principle, this is done by matching the heights of the two distributions. To do this, it must be assumed that discarding is nil above a given length. The values in this length interval are then used to calculate a raising factor, which raises the proportions measured at sea to numbers. For haddock this length is set at 49 cm, in view of the available data. Under this assumption the raising factor (k) can be calculated as follows:

$$k = \frac{SUM(L_l: l > 49)}{SUM(c_l: l > 49)}$$

where,
L = numbers landed
c = proportions measured at sea
l = length

Thus, two length distribution have been produced. One for numbers at length landed (excluding discards) and the other for numbers at length caught at sea (including discards) Discard, in numbers, is then calculated as the difference of the two distributions below their first point of intersection, i.e. while numbers at length caught at sea remain larger than numbers at length landed. Discard in numbers is converted to weight by a length-weight relationship.

Discard rate by length (DL) is modeled as a reversed logistic curve:

$$DL = 1 - \frac{1}{1 + \exp(-b(L - DL_{50}))}$$

where,
L = length
DL_{50} = length at which discard is 50%
b = constant (slope)

Input data and main results are summarized in Tables 6.1.1 and 6.1.2, and fig. 6.1.1. Length measurements from landings were limited during the first years but increased to more than 10 thousand fish measured in recent years. A plot of numbers measured ashore versus the regression coefficient (r_2) of the fit between numbers landed and number caught (for length > 49 cm, to calculate the raising factor k), indicates a certain gain in increasing the numbers measured in landings to 10 thousand fish a year. The calculated numbers and weights discarded vary between years, with a maximum numbers discarded in 1996 (10 million fish) and maximum weight in 1997 (5852 tons). The overall trend indicates an increase until 1996-97, followed by a decrease in recent years. A similar trend is seen when discards are expressed as proportions of the landings, with maxima in 1997 (49.8% by numbers and 21.2% by weight). The DL_{50} is also variable and is seen to fit significantly with the discard rate (% numbers). Furthermore, there appears to be a rather strong inverse relationship between discard rate and stock size. Year class strength of haddock at age 2, however, does not reveal a significant relation to discard rate.

Mesh size in bottom trawls was decreased in Icelandic waters as of March 1 1998 from 155 mm to 135 mm. A marked decrease in discards was observed in 1999 and 2000, although this would not necessarily be explained by the change in mesh size. Further data are probably needed in order to verify the effect of this technical change as well as for a better understanding of the underlying causes for discards.

Raised annual length distributions for haddock in Area V are shown in table 6.1.3a - c for comparison with other tables in this report.

Table 6.1.1. Haddock measurements and landings in the Icelandic bottom trawl fishery 1988-2000

Year	Numbers measured		Landings	
	At sea	Ashore	(tons)	(numbers)*
1988	29511	2909	39088	24.8
1989	27998	2610	44215	26.4
1990	32700	4506	47158	31.0
1991	39364	2282	34661	18.3
1992	40194	4235	29093	17.7
1993	51730	8046	30132	24.1
1994	68837	6302	39474	30.1
1995	Data not available			
1996	50833	9946	39466	25.8
1997	29631	7802	27643	16.3
1998	53571	13285	24191	15.6
1999	70268	10992	25960	18.0
2000	51257	12510	22990	15.6

*Numbers in millions

Table 6.1.2. Haddock discards in the Icelandic bottom trawl fishery 1988-2000

Year	Discards by numbers		Discards by weight		DL_{50}	Year class	Stock size
	(millions)	(%)*	(tons)	(%)*	(cm)	(age 2)**	(age 3+)***
1988	3.0	12.3	1592	4.1	40.3	47	151
1989	2.5	9.5	1447	3.3	40.7	24	168
1990	1.3	4.3	474	1.0	37.7	22	145
1991	6.8	37.3	3260	9.4	43.7	79	120
1992	7.9	44.5	3208	11.0	39.5	169	106
1993	3.9	16.1	1444	4.8	37.1	37	129
1994	8.7	29.1	4062	10.3	40.6	41	127
1995							
1996	10.0	38.6	4391	11.1	41.1	38	108
1997	8.1	49.8	5852	21.2	44.4	89	89
1998	5.6	36.1	2612	10.8	40.5	18	96
1999	2.4	13.5	1220	4.7	38.8	80	91
2000	3.2	20.8	1759	7.7	40.5	80	86

* With reference to numbers landed. **Millions. ***Thousand tons.

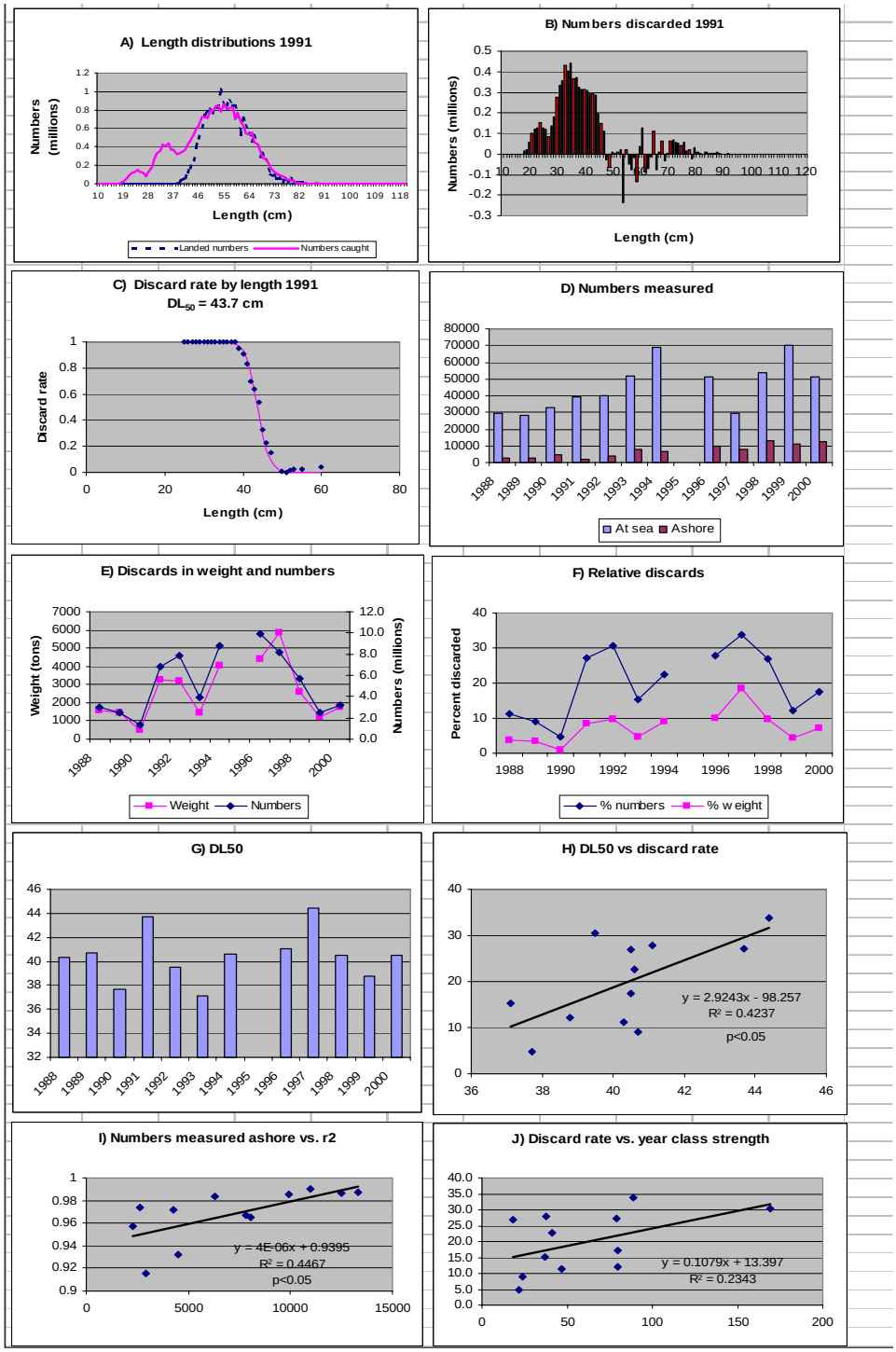

Figure 6.1.1. Discards of Iceland haddock in the demersal trawl fishery 1988-2000

(Figs a-c are shown as examples of output for the year 19

7 NORTHERN PELAGIC AND BLUE WHITING WORKING GROUP

7.1 Spain

Spanish discard estimates for the trawling fleet operating in the Central and Western part of the Cantabrian Sea (Divisions VIIIc and IX a) are presented in this section. Please see tables 7.1.1 through to 7.1.3.

As mention in section 5.2, information about discards came from different EC Project: *Discards of the Spanish fleet in ICES Divisions*, EC Project: Pem/93/005. *On-board sampling of fish landed and discarded by commercial vessels*, EC Project: 95/094, and *Monitoring of discarding and retention by trawl fisheries in Western Waters and the Irish Sea in relation to stock assessment and technical measures*, EC Project: 98/095.

Trawling discard data are presented annually by stock. Raised total discards, length frequencies, numbers and mean length and weight at age are presented for the stock of Blue Whiting in 1994, 1997 and 1999 in Divisions VIIIc and IXa. Raising was done individually for each of the modalities ("Baka" trawls and VHVO Pair trawls) and then to the total of the trawl fleet landings. Discard data are available for 2000, but no results are presented in this report as no effort and landing statistics for that year are already available. As for the same reasons mentioned in section 5.2, data are presented annually. These discard data will be provided to the Northern Pelagic and Blue Whiting Fisheries Working Group.

During 1994 and due to the scarce sampling deployed in VHVO Pair trawls, discards obtained in both modalities where analysed together. Landings Age Length Keys was applied to the discard length composition as no sampling of discard otoliths was carried out on board.

An exploratory analysis of 1997 discard data was carried out. Different raising methods were used: by weight landed, number landed and effort (fishing hours). The results of the raising carry out by landings in weight produced more realistic outcomes when comparing to those obtained using the discard rate.

For 1997 discard data, raising was done individually for each of the trawl modalities ("Baka" and VHVO Pair trawls) and then to the total of the trawl fleet landings. The monitoring of the discards was carried out under a randomised sampling program by vessel and stratified by gear and area.

During 1999, sampling discards was carried out during the second half of the year, this is when the recruitment of the major part of the species take place. Thus, comparatively to other years the amount of small fish discarded estimated was slightly higher.

Blue Whiting discards were very similar between 1994, 1997 and a slight increment was observed in 1999 (Table 7.1.1). Discards length distributions and numbers, mean weight and mean length at age are presented in Table 7.1.2 and Table 7.1.3, respectively. No discards Age Length Keys were available and thus, Age Length Keys of the landings were used.

8 WORKING GROUP ON THE ASSESSMENT OF MACKEREL, HORSE MACKEREL, SARDINE AND ANCHOVY

8.1 Spain

In this section, Spanish discard estimates for the trawling fleet operating in the Central and Western part of the Cantabrian Sea (Divisions VIIIc and IX a) are presented. Please see tables 8.1.1.1 to 8.1.2.3 for 1997.

As stated in Section 5.2 and Section 7.1, discards information came from different EC Project: *Discards of the Spanish fleet in ICES Divisions*, EC Project: Pem/93/005. *On-board sampling of fish landed and discarded by commercial vessels*, EC Project: 95/094, and *Monitoring of discarding and retention by trawl fisheries in Western Waters and the Irish Sea in relation to stock assessment and technical measures*, EC Project: 98/095.

Trawling discard data are presented annually. Raised total discards, length frequencies, numbers and mean length and weight at age are presented for Mackerel and Horse mackerel in 1997 in Div. VIIIc and IXa. Discard data are available for 2000, but no results are presented in this report as no effort and landing statistics for that year are already available.

Discard data will be provided to the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy.

The monitoring of the discards was carried out under a randomised sampling program by vessel and stratified by gear and area. Exploratory analysis of discard data of 1997 was carried out. Different raising methods were used: by weight landed, number landed and effort (fishing hours).

The results of the raising carry out by effort in hours produced more realistic outcomes when comparing to those obtained using the landings in weight. In Divisions VIIIc & IXa, raising was done individually by "Baka" and VHVO Pair trawls and then to the total of the trawl fleet landings.

8.1.1 Discard estimations of Mackerel (*Scomber scombrus*) in Divisions VIIIc and IXa

In 1997, around 1500 tons of Mackerel in Division VIIIc and IXa were discarded (Table 8.1.1.1) . Discard length distribution are presented in Table 8.1.1.2. Numbers at age were obtained by means of semestral Age Length Keys (Table 8.1.1.3). No enough otoliths of large discarded individuals were sampled and so a 4 plus group was used in the Age Length Keys.

8.1.2 Discard estimations of Horse mackerel (*Trachurus trachurus*) in Divisions VIIIc and IXa

In 1997, around 1000 tons of Horse mackerel were discarded in Division VIIIc and IXa (Table 8.1.2.1). All sizes and ages were discarded (Table 8.1.2.2 and Table 8.1.2.3).

9 DISCUSSION

Preparation of comments on the significance to the management and assessment of fisheries of the data presented in this report and accompanying CD would have been outside our terms of reference and beyond our resources. We merely note that discarding is responsible for a significant proportion of mortality in many fisheries, and that strong yearclasses sometimes confer much less benefit to the yields of a fishery than they might, due to high levels of fishing mortality when the fish are large enough to be vulnerable to commercial gear but not large enough to be landed legally or to contribute to future spawning stock biomass.

The need to monitor discarding depends on:

- continued management of fisheries by the setting of Total Allowable Catches, as in the EU;
- the need to assess effects of changing technical measures, e.g. new mesh size regulations, closed areas, minimum landing size regulations, stock recovery plans;
- the amount of variation over time of discarding.

Discarding can be expected to vary over time because of changing fishing strategies in response to declining stock sizes and improving technology, and because of widely varying yearclass strengths of many stocks from year to year. Evidence for increased discarding rates on large yearclasses is available from discard studies in the Baltic, around Ireland, and from published German and Canadian studies (Kulka, 1995; Weber, 1995; Bagge, 1987), although, unfortunately, not all seagoing studies can claim small enough sampling error to show the effect. Stock assessments which do not allow for variable discarding mortality are at risk of being significantly in error.

If discard monitoring is to continue it will benefit from reliable funding so that experience may be built up and resources not wasted on repeated training of sea-going staff. In Canada, 100% coverage of trips by major fisheries is funded by the fishing industry. In this situation, sampling error is not a consideration. The data have been used to improve stock assessments and to confirm the benefits of discard reduction measures such as the Nordmore grate fitted to shrimp gear. In European waters, many nations typically only find resources to observe of the order of 20 to 200 trips per year. This amounts to less than 1% of trips made. Given the many types of fishery, and the many area, seasonal, and species effects on discarding, the findings of such programmes are severely restricted by statistical sampling errors. Access to vessels to observe fishing is not always available within the EU and presents particular problems in certain countries. There is a need to consider more use of other techniques of estimating discarding, e.g. sampling of catches by fishers ('self-sampling').

Continuing monitoring of discarding would greatly benefit from continued international collaboration. This allows nations to pool data for marine areas and major fish stocks thereby greatly increasing effective sample size and precision. It also allows exchange of experience, techniques, and ideas. In the Baltic, the collaboration has gone even a step further as all discard data are stored in a common database which allows data to be processed centrally. At the time of this meeting, major discard sampling programmes funded by the EC as scientific projects with resources for international collaboration were coming to an end, and a change to funding of individual nations for sampling was being implemented. The Group were not clear whether resources would be available for continuing collaboration. Ideally, there will be collaboration among nations sampling in each marine area, e.g. Baltic, North Sea, Mediterranean, and occasional joint meetings of representatives from each. The latter is a possible role for the SGDBI in future.

9.1.1 References:

Bagge, O., 1987. Danish discards in the Baltic. ICES CM 1987/J:9, 13 pp.

Kulka, D. W., 1995. Bycatch of commercial groundfish species in the northern shrimp fisheries, 1980-1994 DFO Atlant. Fish. Res. Doc. 95/48. 16p.

Weber, W., 1995. Estimation of cod discards caused by the fishery on roundfish in the German Bight, 1982 - 1994. ICES CM 1995/B+G+H+J+K:6, 14 pp.