

Stichting DLO Centre for Fishery Research (CVO)

P.O. Box
1970 AB IJMUIDEN
Phone: 0255 564600
Fax: 0255 564765
Visitor address: Haringkade 1, IJmuiden

CVO report 04.024

Number:

Discard sampling of the Dutch beam trawl fleet in 2003

Ir. O. A. van Keeken, drs. M.A. Pastoors

Commissioned by: Ministerie van Landbouw, Natuur en Voedselkwaliteit
Drs. R.J.T. van Lint
Postbus 20401
2500 EK DEN HAAG

Project number: 3.22.12130.01

Approved by: Drs. F.A. van Beek
Head WOT, Centre for Fishery Research

Signature: _____

Date: November 2004

Number of copies:	10
Number of pages:	55
Number of tables:	27
Number of figures:	14
Number of annexes:	1

Stichting DLO
Centre for Fishery Research

We are registered in trade
register of the Chamber of
Commerce Centraal Gelderland
Nr. 09098
VAT nr. NL 8089.32.184.B01

This report is drafted at the request of the commissioner indicated above and is his property. Nothing from this report may be reproduced and/or published by print, photoprint microfilm or any other means without the previous written consent from the commissioner of the study.

Table of Contents

Table of Contents	2
Summary	3
Samenvatting	4
1. Introduction	5
2. Methods	6
2.1 Sampling procedures	6
2.2 Raising procedures	6
3. Results	7
3.1 Sampling	7
3.2 Numbers and weight	7
3.3 Species	8
4. Discussion	10
Acknowledgements	12
References	13
Appendix I	15
Tables and Figures	19

Summary

The Dutch beam trawl fishery is one of the main fisheries in the southern North Sea, targeting plaice and sole. It has been recognized that sampling of discards is an important element of fisheries statistics and therefore discards sampling schemes have been set up in a European context.

This report contains results of the discards sampling program on the Dutch beam trawl fishery in the North Sea in 2003, which was instigated as part of the EC regulations 1543/2000 and 1639/2001 on data collection in European fisheries. 10 trips with beam trawl vessels were sampled, of which nine were with vessels larger than 300 HP and one with a vessel of 300 HP. Samples of the discards and landings were counted and measured and raised to catches per hour, per trip, per quarter and per year. The sampling is carried out as a pilot-survey (see annex of EC 1639/2001, chapter III, E1c).

The sampled fleet segment (beam trawlers with engine power larger than 300 HP fishing with 80 mm mesh size) is responsible for most plaice and sole landings. This indicates that the most important fleet segment has been covered by the discard sampling program. The spatial distribution of fishing effort of the Dutch beam trawl fleet larger than 300 HP and fishing with 80 mm mesh size is similar to the effort distribution in the discard sampling, except for the area in the centre of the southern North Sea.

The major fish species in the discards were dab and plaice. The percentage plaice discards in 2003 was around 83% in numbers and 58% in weight for large vessels. The percentage discards for sole in weight was around 14% for large vessels and 22% for eurocutters. The variation in the discard rates between trips was relatively low.

The percentage discarding of plaice in 2003 appeared to be higher than in earlier periods, e.g. 2002 (77% in numbers, 51% in weight), 1999-2001 (73% in numbers, 46% in weight) and 1976-1990 (42%-53% in numbers, 18%-31% in weight). There was no apparent trend in discard percentages of sole compared to 2002 (13%), 1999-2001 (8%) or 1976-1990 (3%-13%).

Length frequency distributions showed that smaller plaice were being caught in recent periods compared to the 1970s and 1980s. This could be caused by a shift in spatial distribution of small plaice to more offshore areas, whereby they become vulnerable to the beam trawl fleet. The high amount of discards was mainly caused by a relatively strong 2001 year class, in 2003 at the age of 2.

Samenvatting

De Nederlandse boomkor visserij is één van de belangrijkste visserijen in de zuidelijke Noordzee. De belangrijkste doelsoorten zijn schol en tong. Jonge vissen die kleiner zijn dan de minimum aanvoermaat worden hierbij weer overboord gezet, hetgeen discarding genoemd wordt. Het is algemeen erkend dat het bemonsteren van discards een belangrijk onderdeel is de visserij statistiek en om die reden zijn programma's voor de bemonstering van discards in een Europese context opgezet.

Dit rapport bevat de resultaten van het discardsbemonsteringsprogramma van de Nederlandse boomkorvisserij in de Noordzee in 2003, dat is opgezet als invulling van EC regelingen 1543/2000 en 1639/2001 voor gegevensverzameling in Europese visserijen. 10 reizen aan boord van boomkorschepen werden bemonsterd; negen aan boord van schepen met een motorvermogen groter dan 300 PK en één aan boord van een eurokotter met een motorvermogen van 300 PK. De discards en de aanlandingen werden geteld en gemeten en vervolgens opgewerkt tot vangsten per visuur, per reis, per kwartaal en per jaar. De bemonstering werd uitgevoerd als een "pilot-survey" (zie annex van EC 1639/2001, hoofdstuk III, E1c)

Het bemonsterde vlootsegment (boomkorschepen met een motorvermogen groter dan 300 PK met 80 mm maaswijdte) is verantwoordelijk voor de meeste schol en tong aanlandingen. Dit geeft aan dat het belangrijkste Nederlandse vlootsegment is bemonsterd. De ruimtelijke verdeling van de visserij-inspanning van de boomkorvisserij groter dan 300 PK vissend met 80 mm maaswijdte is vergelijkbaar met de verdeling van de visserij-inspanning in het bemonsteringsprogramma, met uitzondering van het centrale gedeelte van de zuidelijke Noordzee.

De discards in de boomkorvisserij bestaan voornamelijk uit schol en tong. Het percentage discards van schol was in 2003 rond de 83% in aantallen en 58% in gewicht voor grote schepen. Voor tong was het percentage discards in gewicht ongeveer 14% voor grote kotters en 22% voor eurokotters. De variatie in percentages discards tussen de verschillende reizen was relatief laag.

Het percentage discards van schol lijkt hoger te zijn dan in eerdere periodes, bijvoorbeeld 2002 (77% in aantal, 51% in gewicht), 1999-2001 (73% in aantal, 47% in gewicht) en 1976-1990 (42%-53% in aantal, 18%-31% in gewicht). Er was geen duidelijke trend in percentage discards van tong vergeleken met 2002 (13%), 1999-2001 (6%) of 1976-1990 (3%-13%).

De lengteverdelingen van schol laten zien dat in recente periodes gemiddeld kleinere schol werd bijgevangen dan in de periode 1976-1990. Deze verandering hangt mogelijk samen met een verandering in de ruimtelijke verspreiding van ondermaatse schol, waardoor deze nu verder uit de kust voorkomt en daarom beschikbaar is voor de visserij. Mogelijk is het aantal discards hoog door een relatief sterke 2001 jaarklas, die in 2003 2 jaar oud waren.

1. Introduction

Most demersal fisheries are mixed fisheries, targeting a limited number of species and sizes. In general other catches will be thrown overboard, a practice called discarding (Van Beek, 1998). Alverson et al. (1994) estimated that worldwide between 17.9 en 39.5 million tonnes fish is discarded annually. As a comparison, worldwide the annual fish catch was estimated at 84 million tonnes for that period (FAO, 1997).

There are four main categories of discards:

- specimens of commercial species below the minimum legal landing size
- over-quota fish which is not allowed to be landed when this result to exceeding legal quota
- bycatch species of no commercial value
- fish with an undesired quality, high-grading

Discarding leads to lower profits from fish stocks, because a large part of the discards will not survive the sorting process (Van Beek et al., 1990; Jennings and Kaiser, 1998). However, discards also form an important food item for other organisms like birds (Camphuysen and Garthe, 2000) and benthic invertebrates (Lindeboom and De Groot, 1998). Discarding, and most important variation in discarding, may result in bias in fish stock assessments when these assessment are based only on landings numbers at age (Pastoors et al., 2000). To date discards are only incorporated into a few stock assessments (ICES, 2002) but the intention is to incorporate discards estimates for all stocks where relevant information becomes available.

One of the main fisheries in the southern North Sea is the Dutch beam trawl fishery, targeting mainly sole (*Solea solea*) and plaice (*Pleuronectes platessa*). Trips made on beam trawl vessels between 1976 and 1990 showed great variation in the quantity of plaice discarded (18-31% by weight)(Van Beek, 1998). Recent sampling in 1999-2001 suggested that the percentage discarded has increased (average 47% by weight, range 8%-73%, Netherlands Institute for Fisheries Research, unpublished data). These higher discard rates could be caused by changes in the growth rate of plaice such as the slower growth of the strong 1996 year class. The slower growth rates could extend the period the fish are susceptible to discarding (ICES, 2002). Also a shift in the distribution of smaller plaice (ICES, 1999) could make them more susceptible to commercial fishing (Pastoors et al., 2000). The proportion discarded could also increase because the biomass of marketable fish declines (Pastoors et al., 2000; ICES, 2002).

From 1999 to 2001 discarding practices of the Dutch beam trawl fleet in the North Sea have been monitored within an EC funded international research project (Anon., 2002). From 2002 onwards discards data are collected under the EC Data Collection Regulations 1543/2000 and 1639/2001 (EC., 2000, 2001; Anon., 2002; ICES, 2003). This report gives an overview of the Dutch demersal discard sampling program for 2002, which was carried out as a pilot-survey (see annex of EC 1639/2001, chapter III, E1c).

2. Methods

2.1 Sampling procedures

Selection of the vessels is quasi-random and based on co-operative sampling (ICES, 2000). This means that co-operation of a skipper with the project is on voluntarily basis. On forehand it is difficult to predict the sampling location, since this depends on the fishing strategy of the skipper. However vessels from different regions are selected during a quarter to obtain widespread coverage. During 2003 a total of 9 trips were made on board beam trawl vessels with engine power larger than 300 HP (221 kW). In addition one trip was conducted with a eurocutter with engine power up to 300 HP.

For a discard sampling trip, two observers went onboard a vessel, sampling at least 60% of the hauls (Van Beek, 2001). For each sampled haul, a sub-sample of the discards was measured. All fish were counted and measured. Benthic invertebrates were only counted. Total and sampled volume of discards was recorded. A sub-sample of the fish landed was measured, and total and sampled landings weight was recorded. If possible otoliths were collected from the major discarded fish species (plaice, sole, dab, cod, whiting) for age readings. All data was entered into a computer program on haul-by-haul basis and later transported into the central database.

2.2 Raising procedures

This paragraph gives a short description of the raising procedures used. A more mathematical description is given in Appendix I.

Sampled numbers of fish per haul were raised to numbers at length and at age for both discards and landings. Different raising procedures were used for discards and landings because different sources of information were available for these catch components. For the landings the total landed weight per species was available, while such data was not available for discards.

Discards were raised from sampled numbers in a haul to total numbers in a haul with the ratio of estimated haul volume to sampled haul volume. Total numbers per haul were summed over all sampled hauls in a trip and divided by duration of the sampled hauls to obtain total numbers discarded per hour per trip. Total weight in the trip was calculated from total numbers using length-weight relationships.

Landings were raised from sampled numbers per haul to total numbers per trip with the ration of total landings weight in the trip to sampled landings weight. Total numbers landed were calculated by dividing total numbers in the trip by the trip duration. Landings weight per hour was calculated by dividing total landings weight by trip duration.

Numbers landed and discarded at length were calculated per period (quarter or year) by multiplying total numbers at length in a trip over the trips in this period and dividing this by total duration of the trips in this period. Numbers at age were calculated from numbers at length using age-length keys, which calculates the proportion of fish at length (l) with age (a). Numbers at age landed and discarded by the fleet were calculated by multiplying total numbers at age in the sampled trips with the ratio of total fleet effort to effort of sampled trips, both measured in effort corrected for engine power.

3. Results

3.1 Sampling

A total of 10 trips were sampled, all using 80 mm mesh size. Nine trips were carried out on vessels with engine power between 1467-1489 KW (1991-2021 HP) and one on a beam trawl vessel of 221 KW (300 HP) (Table 3.1.1).

The total number of hauls in the trips varied between 36 and 51, with an average fishing duration of 77 hours per trip (Table 3.1.2.). 79% of the hauls were sampled for discards and 72% for landings. Otoliths were collected from the discards samples for plaice (269 otoliths) and sole (94 otoliths).

Per quarter between 0.11% and 0.17% of the Dutch beam trawl fleet with engine power larger than 300 HP was sampled in HP effort (Table 3.1.3a). Fleet coverage by year was 0.14% in HP effort for the beam trawl fleet larger than 300 HP (Table 3.1.3a) and 0.09% for the beam trawl fleet with engine power of 300 HP (Table 3.1.3b).

The spatial distribution of fishing effort of the Dutch beam trawl fleet larger than 300 HP fishing is shown in Figure 3.1.1a, the segment of this fleet fishing with 80 mm mesh size is shown in Figure 3.1.1b. Figures 3.1.2a and 3.1.2b show the spatial distribution for beam trawl vessels of 300 HP. Effort of the beam trawl fleet larger than 300 HP is mainly distributed off-shore from the Dutch coast, while the effort of the smaller vessels is mainly distributed along the Dutch coast. The effort distribution in the discard sampling of vessels larger than 300 HP (Figure 3.1.1c.) and of vessels of 300 HP (Figure 3.1.2c.) can be compared to the spatial distribution of fleet effort. The comparison of the beam trawl fleet larger than 300 HP indicate that the overall pattern in effort distribution in the discard sampling is similar to the whole fleet, with exception of the areas above 53.5 latitude and between 2-4 longitude. Because only one vessel of 300 HP was sampled, effort distributions could only be compared for 3 rectangles.

3.2 Numbers and weight

The average weight of all discards (both fish and invertebrate discards) during a trip was 34 tonnes (CV 56%, Table 3.2.1) for vessels larger than 300 HP. Of the catch in weight, 17% consisted of fish landed and 28% in fish discards (Figure 3.2). Dab and plaice were the most abundant species in the discards (Table 3.2.2, Figure 3.2) Brittle stars, common starfish, swimming crab, hermit crab and masked crab were the most abundant benthos species.

The number discarded per rectangle per hour varied for vessels larger than 300 HP between 611-2464 for plaice and 0-120 for sole (Figure 3.3.1a) and for the vessel of 300 HP between 228-392 for plaice and 26-37 for sole (Figure 3.3.1b).

The total landings weight by trip for vessels larger than 300 HP varied for plaice between 1313 and 7622 kg and for sole between 513 and 3085 kg (Table 3.2.3a). The landings weight for the vessel of 300 HP was 778 kg for plaice and 772 kg for sole. Sampled landings weight for vessels larger than 300 HP varied for plaice between 40 and 224 kg and for sole between 96 and 203 kg (Table 3.2.3b).

3.3 Species

Plaice

On average 5200 kg of plaice were discarded per trip (CV 50%, Table 3.2.1). The average number of discards per hour was 936 to 189 individuals landed for vessels with engine power larger than 300 HP and 334 discarded to 26 individuals landed for the vessel with engine power of 300 HP. This resulted in an average discard percentage of 83% in numbers and 58% in weight for large vessels and 93% in numbers and 70% in weight for the vessel with engine power of 300 HP (Table 3.3.1). The average discard percentage per quarter for large vessels varied between 81% and 85% in numbers and 49% and 62% in weight (Table 3.3.2).

The peak of the discard length distribution for large vessels was around 19 cm (Table 3.3.3, Figure 3.4.1) and 20 cm for the vessel of 300 HP (Table 3.3.3, Figure 3.4.2), whereas the minimum landing size is 27 cm. Plaice were discarded up to 31 cm.

Most discards were between ages 1 to 4, with most of the discards being age 2 (yearclass 2001) (Table 3.3.4). Plaice from the strong 1996 yearclass, now at the age of 7, were still being discarded in small numbers.

Landings and discards in numbers at age were raised to fleet level for vessels larger than 300 HP (Table 3.3.5) using an effort multiplier (Table 3.1.3a).

Sole

On average 240 kg of sole were discarded per trip (CV 120%, Table 3.2.1). For all trips, landings were higher than discards both in numbers and in weight per hour (Table 3.3.6). The average discard percentage was 25% in number and 14% in weight for large vessels and 43% in number and 22% in weight for the vessel of 300 HP. Per quarter the discard percentage in number varied between 21 and 27% in number and 11% and 22% in weight for large vessels (Table 3.3.7).

The peak of the discard length distribution was around 22 cm for large vessels (Table 3.3.8, Figure 3.4.1) and 21 cm for the vessel of 300 HP (Table 3.3.8, Figure 3.4.2) Sole were discarded up to 29 cm.

Most sole discards were between ages 1 and 4, with most discards being age 2 (Table 3.3.9). Landings and discards in numbers at age were raised to fleet level for vessels larger than 300 HP (Table 3.3.10) using an effort multiplier (Table 3.1.3a).

Dab

On average 4800 kg of dab were discarded per trip (CV 76%, Table 3.2.1). On average 64 kg were discarded to 8 kg landed per hour for large vessels while 10 kg was discarded to 1 kg landed for the vessel of 300 HP (Table 3.3.11). The average discard percentage was 95% and 97% in numbers and 89% and 88% in weight for large vessels and the vessel of 300 HP respectively. Per quarter the discard percentage varied in weight between 84% and 90% in weight for large vessels (Table 3.3.12).

Cod

On average 24 kg of cod were discarded per trip (CV 95%, Table 3.2.1) and per hour less than 1 kg were landed and discarded (Table 3.3.13). The average discard percentage was 15% in weight. The estimate however is highly uncertain because of the low catches, expressed by the discard percentage in weight per quarter varying between 0% and 55% for large vessels (Table 3.3.14).

Whiting

On average 215 kg of whiting were discarded (CV 114%, Table 3.2.1). For large vessels discards were higher than landings with less than 1 kg whiting landed to 3 kg discarded per hour (Table 3.3.15). Landings and discards per hour for the vessel of 300 HP were lower than 1 kg per hour. The average discard percentage, taking discards from all trips into account, was 96% in number and 86% in weight for large vessels. Per quarter the discard percentage in weight varied between 68% and 96% (Table 3.3.16).

4. Discussion

The discards sampling programme for the Dutch beam trawl fleet in 2003 was instigated as part of the EC regulations 1543/2000 and 1639/2001 on data collection in European fisheries. Results of the discard sampling on Dutch beam trawl vessels in 2003 were presented. A total of 10 trips were sampled, of which nine were on vessels with engine power larger than 300 HP and one on a vessel of 300 HP. The mesh size used during all trips was 80 mm. The sampling was carried out as a pilot-survey (see annex of EC 1639/2001, chapter III, E1c).

The discard sampling program of vessels larger than 300 HP covers the most important fleet fishing for North Sea plaice and sole. The fleet of vessels larger than 300 HP fishing with 80 mm mesh size is responsible for most of the plaice and sole landings. The spatial distribution of fishing effort of the Dutch beam trawl fleet larger than 300 HP and fishing with 80 mm mesh size is similar to the effort distribution in the discard sampling, except for the area in the centre of the southern North Sea.

Plaice is one of the two important target species of the Dutch beam trawl fishery. The average discard percentage of plaice in 2003 was around 83% in numbers and 58% in weight. These discard rates are higher than the rates observed in 2002 (77% in numbers and 51% in weight), 1999-2001 (73% in numbers and 47% in weight) and 1976-1990 (51% in numbers and 27% in weight, Table 4.1). The discard fraction in 2003 was dominated by the strong 2001 yearclass, at the age of 2. This strong yearclass also dominated the discard fraction in 2002.

Since the late 1990's a shift in spatial distribution of plaice is apparent, whereby relatively small plaice move towards deeper, more offshore water (Pastoors et al., 2000; Van Keeken et al., 2004), making the fish more vulnerable to the fishery. The recent discard trips were carried out outside the plaice-box. Nevertheless the size of the smallest plaice corresponded to those lengths at which plaice in the 1970s and '80s were only caught inside the 12-mile zone and the plaice box (Figure 4.1) (Rijnsdorp and Van Beek, 1991; ICES, 1999).

Changes in plaice discard rates in the recent period could also be caused by the decrease in landings due to quota restrictions or by gear modifications. Plaice landings per hour were lower (50 kg/hour) than in 2002 (63 kg/hour) and 1999-2001 (56 kg/hour), and substantially lower than in the 1970s and 1980s (around 110 kg/hour) (Table 4.1). On the other hand, discards per hour fishing in recent periods were either the same or higher compared the 1970s and 1980s. The historical length frequency distribution over 1976-1990 (Figure 4.1) showed more landings of larger plaice compared to recent period (Figure 3.4, Figure 4.2). The mean weight per fish landed was also higher (0.36 kg per fish in 1970 and 1980s, around 0.25 kg in recent years). Illegal gear modifications like double cod-ends and liners could also result in higher discard percentages. However, given that the beam trawl fishery is a mixed fishery for plaice and sole, and that the discard rates for sole seemed to be relatively stable over time (see below), changes in gears are unlikely to be the major source for the higher discard rates of plaice.

The discard percentage of sole in 2003 was within the range of discard percentages in earlier periods (Table 4.2). The length frequency distributions showed no apparent trends 1999-2002 compared to the 1970s and 1980s.

The catches of cod in 2003 were very low. It is very clear that the absolute numbers caught per hour has decreased substantially compared to the 1970s and 1980s. It is also clear that the length distribution of the landings has been reduced from a maximum length around 80 cm to a maximum length of around 60 cm in recent years (Van Keeken et al., 2003b).

Due to the absence of sufficient discards data on most stocks in the North Sea, discards have only been included into the stock assessments of haddock and whiting (ICES, 2002). For these two species the Scottish discards sampling program has been used to estimate discards of these species for all international fleets. Estimates of discards for other species have started to be collected from 1999 onwards for all countries involved in the EU study project (Anon., 2002). Some countries have started their sampling programs even before 1999 (e.g. Denmark, England) or have historical sampling programs (e.g. The Netherlands). When discards are included into the stock assessment process, it is essential that estimates of discards are available for the whole time series of catch data. This implies, that for years where no samples are available, discards need to be estimated from other sources of data (e.g. survey data, growth data).

An exploration of the consequences of including discards into the assessment of plaice was presented at the ICES Annual Science Conference 2003 (Van Keeken et al., 2003a). The exploration was based on a reconstruction of discards based on growth and selectivity characteristics of the gears. The exploration indicated that the perception of stock trends could be different when discards were included, especially in periods of high recruitments and associated slow growth, which could lead to high discard rates. It is therefore important to put effort in sampling discards onboard vessels to obtain sufficiently long discard time-series so that these data can be included in the stock assessments and that they can be used to validate discard-models that aim to fill the gaps of unsampled years. In this way, stock assessments for those stocks that suffer from substantial discarding are thought to become more reliable (and less biased).

Acknowledgements

We would like to thank the skippers for their co-operation with the project. We would also like to thank Ronald Bol, Kees Groeneveld, Simon Rijs, Gerrit Rink, Mario Stoker, Andre Dijkman-Dulkes, Rob Grift, Jan Jaap Poos and Floor Quirijns for their hard work on board of the vessels. This project is funded under EU funding 2000/439; collection of fisheries data under the Common Fisheries Policy.

References

- Anon. 2002. Monitoring discarding and retention on fishing vessels towing demersal gears in the North Sea and Skagerrak, EC Project:98/097: 143 p.
- Camphuysen, C. J. and S. Garthe (2000). Seabirds and commercial fisheries: population trends of piscivorous seabirds explained? Effects of fishing on non-target species and habitats, biological conservation and socio-economic issues. M. J. Kaiser and S. J. De Groot, Black Well Science: 163-184.
- EC. 2000. COUNCIL REGULATION (EC) No 1543/2000 of 29 June 2000 establishing a Community framework for the collection and management of the data needed to conduct the common fisheries policy. No. 1543/2000.
- EC. 2001. COUNCIL REGULATION (EC) No 1639/2001 of 25 July 2001 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. No. 1639/2001.
- FAO. 1997. Review of the state of world fishery resources: Marine fisheries. FAO Fisheries Circular No 920 FIRM/C920.
- ICES. 1999. Workshop on the evaluation of the plaice box, IJmuiden, 22-25 June 1999. ICES CM 1999/D:6.
- ICES. 2002. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, Copenhagen, Denmark, 11-20 June 2002. ICES CM 2003/ACFM:02.
- ICES. 2003. Report of the planning group on commercial catch, discards and biological sampling, Rome, Italy, 4-7 March 2003. ICES CM 2003/ACFM:16.
- Jennings, S. and M. J. Kaiser. 1998. The effects of fishing on marine ecosystems. *Advances in Marine Biology* 34: 201-352.
- Lindeboom, J. J. and S. J. De Groot. 1998. The effects of different types of fisheries on the North Sea and Irish Sea benthic ecosystems., Z-Rapport 1998-1/RIVO-DLO Report C003/98: 408 p.
- Pastors, M. A., A. D. Rijnsdorp and F. A. Van Beek. 2000. Effects of a partially closed area in the North Sea ("plaice box") on stock development of plaice. *ICES Journal of Marine Science* 57: 1014-1022.
- Rijnsdorp, A. D. and F. A. Van Beek. 1991. The effects of the "plaice box" on the reduction in discarding and on the level of recruitment of North Sea sole. *ICES C.M.* 1991/G:47.
- Van Beek, F. A. 1998. Discarding in the Dutch beam trawl fishery. *ICES CM* 1998/BB:5.
- Van Beek, F. A., P. I. Van Leeuwen and A. D. Rijnsdorp. 1990. On the survival of plaice and sole discards in the otter-trawl and beam-trawl fisheries in the North Sea. *Netherlands Journal of Sea research* 26(1): 151-160.
- Van Keeken, O. A., M. Dickey-Collas, S. M. B. Kraak and M. A. Pastors. 2003a. The use of simulations of discarding to investigate the potential impact of bias, due to growth, on the stock assessment of North Sea plaice (*Pleuronectes platessa*). *ICES C.M.* 2003/X:17.

Van Keeken, O. A., J. J. Poos and M. A. Pastoors. 2003b. Discarding in the Dutch beam trawl fleet in 2002. IJmuiden, CVO report 04.010: 46 p.

Van Keeken, O. A., F. J. Quijijns and M. A. Pastoors. 2004. Analysis of discarding in the Dutch beamtrawl fleet. IJmuiden, RIVO report C034/04: 96 p.

Appendix I

Table I. Explanation of the abbreviations used in the formulas in appendix I.

explanation		sub-script	explanation
n	sampled number	l	length
N	total number	h	haul
w	sampled weight	o	hour
W	total weight	t	trip
v	sampled discards volume	p	period
V	total discards volume	y	year
u	sampled duration	s	species
U	total duration	f	fleet
wt	sampled landings weight		
WT	total landings weight		
e	sampled fleet effort		
E	total fleet effort		
T	Number of trips		
DN	total discard number		
LN	total landings number		
CN	total catch number (landings and discards combined)		

Raising discards per trip

The sampled number per length and haul were raised per species to total number per length and haul

$$DN_{l,h,s} = \frac{V_h}{v_h} Dn_{l,h,s}$$

where $DN_{l,h,s}$ is the total number discarded at length (l) in haul (h) for species (s), V_h is total volume of haul (h), v_h is sampled volume of haul (h) and $Dn_{l,h,s}$ sampled number discarded at length (l) in haul (h) for species (s).

The total number discarded at length per haul and species was summed over the sampled hauls to obtain the total sampled number discarded at length (l) for species (s) over all sampled hauls (h). The total number discarded ($DN_{l,t,s}$) at length (l) per trip (t) and species (s) was calculated by multiplying the total number discarded ($DN_{l,h,s}$) over all sampled hauls with the ratio of total trip duration (U_t) and duration of all sampled hauls ($\sum u_h$).

$$DN_{l,t,s} = \frac{U_t}{\sum u_h} \sum_{h=i}^h DN_{l,h,s}$$

The number discarded at length per hour and species ($DN_{l,o,t,s}$) was calculated by dividing the total number at length per trip ($DN_{l,t,s}$) by total trip duration (U_t).

$$DN_{l,o,t,s} = \frac{DN_{l,t,s}}{U_t}$$

The obtained number discarded at length per hour ($DN_{l,o,t,s}$) was summed over length to obtain the number discarded per hour ($DN_{o,t,s}$):

$$DN_{o,t,s} = \sum_{l=i} DN_{l,o,t,s}$$

Discarded weight per hour per species at length was calculated using length-weight relationships:

$$DW_{l,o,t,s} = \sum_l \left(\frac{DN_{l,o,t,s} * A_s * l^{B_s}}{U_t} \right)$$

where $DW_{l,o,t,s}$ is the weight per length, per hour and per species, $DN_{l,o,t,s}$ is the number discarded at length, per hour and per species and A_s and B_s species specific constants.

The variance over the total weight of all discards combined per trip $VAR(DW_y)$ was calculated per year (Anon. 2003):

$$Var(DW_y) = \sum_t VAR(DW_{t,y})$$

where $DW_{t,y}$ is the total weight of all discards in a trip.

Second the variance over the total weight per species per trip $VAR(DW_{y,s})$ was calculated per year:

$$Var(DW_{y,s}) = \sum_t VAR(DW_{t,y,s})$$

where $DW_{t,y,s}$ is the total weight of a species discarded in a trip.

Raising landings per trip

The sampled number landed at length per haul and species ($Ln_{l,h,s}$) were summed over all sampled hauls (h) to calculate the sampled number at length for the trip ($ln_{l,t,s}$). The total number landed at length for the entire trip ($LN_{l,t,s}$) was calculated by multiplying the sampled number at length for the trip ($ln_{l,t,s}$) with the ratio of total trip weight obtained from auction or VIRIS data ($WT_{t,s}$) to sampled landings weight of the trip ($wt_{t,s}$):

$$LN_{l,t,s} = \frac{WT_{t,s}}{wt_{t,s}} \left(\sum_{h=i}^h Ln_{l,h,s} \right)$$

Number landed at length per hour per species ($LN_{l,o,t,s}$) was calculated by dividing total number landed at length per trip ($LN_{l,t,s}$) by the trip duration (U_t).

$$LN_{l,o,t,s} = \frac{LN_{l,t,s}}{U_t}$$

The obtained total number at length per hour ($LN_{l,o,t,s}$) was summed to calculate number per hour per species ($LN_{o,t,s}$):

$$LN_{o,t,s} = \sum_{l=i} LN_{l,o,t,s}$$

Total landings weight per hour ($LW_{o,t,s}$) was calculated per species by dividing total landings weight ($WT_{t,s}$) per species by total trip duration (U_t).

$$LW_{o,t,s} = \frac{WT_{t,s}}{U_t}$$

Numbers at length, per quarter and year

The number of discards and landings ($CN_{l,o,p,s}$) at length per hour was calculated per quarter/year by summing the total number landings or discards at length per trip ($CN_{l,t,s}$) over all trips in that period (p) and then dividing this by the sum of the duration of all trips (U_t) in this period:

$$CN_{l,o,p,s} = \left(\sum_p CN_{l,t,s} \right) / \sum_p U_t$$

Confidence limits around length-frequency distributions show weighted standard deviation ($VAR(CN_{l,o,p,s})$):

$$VAR(CN_{l,o,p,s}) = \sqrt{\left[\left(T_t / (T_y - 1) \right) * \frac{\sum_l [(N_{l,o,t} - N_{l,o,y})^2 * (U_t)^2]}{U_y} \right]}$$

where T_y is the number of trips per year, $N_{l,o,t}$ the number at length per hour and trip, $N_{l,o,y}$ the number at length per hour and year, U_t trip duration and U_y total duration over all sampled trips in the concerning year (Sokal & Rohlf, 1981).

Total numbers discards or landings ($CN_{o,p,s}$) were calculated by summing over length. Trip duration data was excluded from calculation numbers per hour per period if landings were not measured during a trip, but auction records existed for this species.

$$CN_{o,p,s} = \sum_{l=i} CN_{l,o,p,s}$$

Numbers at age, per quarter and year

The age structure of both plaice and sole discard and landings was calculated by distribution of numbers at length over age groups using age-length-keys (ALK). The number landed and discarded ($CN_{l,a,t,s}$) at length and age per trip and species was calculated by distribution of the proportion ($f_{l,a}$) of fish at length (l) with age (a) over the number ($CN_{l,t,s}$) at length per trip and species. Because $f_{l,a}$ is dependent on the period, ALK were taken from discards and market samples from the quarter where discards were sampled.

$$CN_{l,a,t,s} = f_{l,a} * CN_{l,t,s}$$

The number landed and discarded ($CN_{a,t,s}$) at age per trip and species was calculated by multiplying the number landed and discarded ($CN_{l,a,t,s}$) at length and age per trip and species over length:

$$CN_{a,t,s} = \sum_{l=i} CN_{l,a,t,s}$$

The number of discards and landings ($CN_{a,o,p,s}$) at age per hour was calculated per quarter/year by summing the total number landings or discards at age per trip ($CN_{a,t,s}$) over all trips in that period (p) and then dividing this by the sum of the duration of all trips (U_t) in this period:

$$CN_{a,o,p,s} = \left(\sum_p CN_{a,t,s} \right) / \sum_p U_t$$

The variance of the numbers at age per species per trip $VAR(DN_{a,y,s})$ was calculated per year (for the major species) as:

$$Var(DN_{a,y,s}) = \sum_t VAR(DN_{a,y,s,t})$$

where $DN_{a,y,s,t}$ is the total weight of a species discarded in a trip.

Numbers at age, per quarter and year per fleet

Total landings en discards ($CN_{a,p,s,f}$) at age per quarter/year were calculated for the entire fleet by multiplying the total numbers of discards and landings ($N_{a,p,s}$) at age per quarter/year with the ratio effort of the entire fleet ($E_{p,f}$) per quarter/year measured in Hpeffort (proportion fishing duration per day multiplied with engine power) to the effort of the sampled part of the fleet in Hpeffort per quarter ($e_{p,f}$).

$$CN_{a,p,s,f} = \frac{E_{p,f}}{e_{p,f}} CN_{a,p,s}$$

Trip duration data was excluded from calculation numbers per hour per period if landings were not measured during a trip, but auction records existed for this species.

Tables and Figures

Table 3.1.1. Characteristics per trip. For each vessel the engine power in KW, the mesh size and sampled rectangles are presented.

Vessel	Quarter	KW	Mesh size	Sampled rectangles
R41	2	221	80	34/F4, 35/F4, 35/F5, 36/F5
R37	1	1471	80	33/F3, 33/F4, 34/F2, 34/F3, 34/F4, 35/F2, 35/F3
R38	1	1469	80	33/F3, 34/F3, 34/F4, 35/F3
R39	2	1471	80	38/F6, 39/F7,
R40	2	1470	80	36/F4, 36/F5,
R44	3	1489	80	33/F2, 33/F3, 34/F2, 34/F3, 35/F2
R45	2	1471	80	32/F3, 33/F3, 34/F3, 35/F3
R48	3	1471	80	34/F2, 34/F3, 35/F2, 35/F3
R49	4	1467	80	37/F5, 37/F6, 38/F6
R50	4	1471	80	36/F0, 37/F0, 37/F1, 38/F0, 38/F1

Table 3.1.2. Sampling effort per trip. For each trip the duration and number of hauls sampled for landings and discards and total duration and number of hauls for the total trip are given, and the number of plaice and sole otoliths taken from the discard fraction.

HP class	Vessel	Number of hauls			Duration (hour)			Plaice Otolith	Sole Otolith
		Land	Disc	Tot	Land	Disc	Tot		
300	R41	31	26	51	57	49	96	30	
>300	R37	21	31	36	37	54	63	25	22
	R38	18	41	44	32	72	78	41	
	R39	28	29	39	50	52	70	28	
	R40	25	30	44	44	53	80	19	16
	R44	23	37	45	39	63	76	36	22
	R45	17	33	39	34	67	79	35	21
	R48	34	40	45	58	69	78	25	13
	R49	20	31	39	41	64	81		
	R50	21	34	40	38	60	71	30	
	Total	238	332	422	430	603	772	269	94
	% Total	72%	79%		71%	78%			

Table 3.1.3a. Sampling effort in days at sea (D.A.S.) and hp-effort (HPeff, days at sea corrected for engine power) per trip, and per quarter for the sampled trips and for the fleet larger than 300 HP and fleet coverage by the sampled trips in 2003.

Quarter	Vessel	Sampled effort		Fleet effort		Fleet coverage	
		D.A.S.	HPeff	D.A.S.	HPeff	D.A.S.	HPeff
1	R37	4	8.000				
	R38	3	5.991				
	Total	7	13.991	5.465	12.449.672	0.13%	0.11%
2	R39	3	6.000				
	R40	4	7.996				
	R45	4	8.000				
	Total	11	21.996	5.591	12.681.939	0.20%	0.17%
3	R44	4	8.000				
	R48	5	10.000				
	Total	9	18.000	5.329	11.975.298	0.17%	0.15%
4	R49	4	7.980				
	R50	4	8.000				
	Total	8	15.980	5.727	12.913.554	0.14%	0.12%
All	Total	35	69.967	22.112	50.020.463	0.16%	0.14%

Table 3.1.3b. Sampling effort in days at sea and hp-effort (days at sea corrected for engine power) per trip, and per quarter for the sampled trip and for the fleet larger than 300 HP and fleet coverage by the sampled trip in 2003.

Quarter	Vessel	Sampled effort		Fleet effort		Fleet coverage	
		D.A.S.	HPeff	D.A.S.	HPeff	D.A.S.	HPeff
1	Total			898	269.259	-	-
2	R41	5	1.500				
	Total	5	1.500	2.320	695.184	0.22%	0.22%
3	Total			1.523	456.879	-	-
4	Total			636	190.834	-	-
All	Total	5	1.500	5.378	1.612.156	0.09%	0.09%

Table 3.2.1. Total weight (kg) of all discards and of plaice, sole, dab, cod and whiting for beam trawl vessels larger than 300 HP by trip and summed over trips with the CV in 2003.

HP class	Vessel	All discards	Plaice	Sole	Dab	Cod	Whiting
300 HP	R41	19.489	1.845	214	952	-	17
>300 HP	R37	21.161	2.788	177	1.001	-	229
	R38	22.289	5.073	202	2.930	3	71
	R39	51.714	10.345	7	12.243	-	1
	R40	37.445	3.548	256	4.706	-	241
	R45	18.631	3.956	80	1.970	21	71
	R44	67.506	4.600	970	7.054	-	393
	R48	37.458	2.697	30	2.358	-	29
	R49	67.326	8.676	218	2.917	-	121
	R50	42.432	5.302	222	7.906	49	780
	Average		33.720	5.220	240	4.787	8
CV		56%	50%	120%	76%	216%	114%

Table 3.2.2. Numbers per hour discarded per species in 2003 in descending order for beam trawl vessels larger than 300 HP and a beam trawl vessel of 300 HP.

Fish species	>300 HP	300 HP	Benthic species	>300 HP	300 HP
Dab	1166	238	<i>Astropecten irregularis</i>	2421	316
Plaice	936	334	<i>Ophiura ophiura</i>	2107	4195
Solenette	89	167	<i>Asterias rubens</i>	1411	2743
Grey gurnard	69	24	<i>Liocarcinus holsatus</i>	721	106
Scaldfish	60	37	<i>Echinocardium cordatum</i>	443	
Dragonet	46	28	<i>Corystes cassivelaunus</i>	346	125
Whiting	40	3	<i>Anthozoa</i>	241	3
Sole	32	29	<i>Macropipus sp.</i>	189	
Lesser weever	12	5	<i>Pagurus bernhardus</i>	120	
Lemon sole	12	<1	<i>Liocarcinus depurator</i>	115	
Hooknose	8	3	<i>Pagurus sp.</i>	112	262
Long rough dab	6		<i>Aphrodita aculeata</i>	77	
Four-bearded rockling	5		<i>Echinocardium sp.</i>	33	
Tub gurnard	5		<i>Nephrops norvegicus</i>	28	
Ammodytes sp.	3		<i>Psammechinus miliaris</i>	24	2
Starry ray	2		<i>Buccinum undatum</i>	11	
Pomatoschistus sp.	2		<i>Crangon sp.</i>	10	
Striped red mullet	2		<i>Liocarcinus marmoreus</i>	8	
Greater sand-eel	2	41	<i>Acanthocardia echinata</i>	7	
Horse mackerel	2		<i>Spisula sp.</i>	7	
Raitt's sand-eel	1		<i>Ascidacea</i>	6	
Sprat	1		<i>Lunatia alderi</i>	6	
Haddock	1		<i>Lanice conchilega</i>	6	
Bull-rout	1	4	<i>Arctica islandica</i>	5	
Herring	1		<i>Cancer pagurus</i>	5	3
Flounder	1	3	<i>Alloteuthis subulata</i>	2	1
Viviparous blenny		1	<i>Aequipecten opercularis</i>	2	
Five-bearded rockling	<1		<i>Necora puber</i>	1	
Red gurnard	<1		<i>Echinidae</i>	1	
Roker	<1		<i>Mactra corallina</i>	1	
Cod	<1		<i>Alcyonidium diaphanum</i>	1	
bib	<1	<1	<i>Luidia sp.</i>	1	
Cuckoo ray	<1		<i>Pilumnus hirtellus</i>	<1	

Table 3.2.2. Continued.

Name	>300 HP	300 HP	Name	>300 HP	300 HP
Poor cod	<1		<i>Sepia officinalis</i>	<1	
Lesser spotted dogfish	<1		<i>Ensis sp.</i>	<1	
Reticulated dragonet	<1		<i>Colus gracilis</i>	<1	
Norwegian topknot	<1		<i>Gele spons</i>	<1	
Brill	<1		<i>Portumnus latipes</i>	<1	
Syngnathus sp.	<1		<i>Eledone cirrhosa</i>	<1	
John Dory	<1		<i>Alcyonium digitatum</i>	<1	
Raja sp.	<1		<i>Loligo sp.</i>	<1	
Turbot	<1		<i>Macropodia rostrata</i>	<1	
Lumpsucker	<1		<i>Spisula solida</i>	<1	
Mackerel	<1		<i>Donax vittatus</i>	<1	
Snake pipefish	<1		<i>Crangon crangon</i>	<1	
Twaite shad	<1		<i>Thia scutellata</i>	<1	
Anglerfish	<1		<i>Hagfish</i>	<1	11
Garfish	<1		<i>Nereis sp.</i>	<1	
Spotted ray	<1		<i>Atelecyclus rotundatus</i>	<1	
Blonde ray	<1		<i>Ensis siliqua</i>		60
Spotted dragonet	<1		<i>Carcinus maenas</i>		15
			<i>Lunatia catena</i>		11
			<i>Hyas sp.</i>		4

Table 3.2.3a. Total landings weight per trip for the plaice, sole, cod, whiting, dab, turbot and brill for beam trawl vessels larger than 300 HP and for a beam trawl vessel of 300 HP (vessel R41).

HP class	Vessel	Quarter	Plaice	Sole	Cod	Whiting	Dab	Turbot	Brill
300 HP	R41	2	778	772	8	5	129	192	43
>300 HP	R37	1	6539	1279	201	124	224	190	233
	R38	1	1625	1789	53	17	535	243	445
	R39	2	7622	513	0	0	2230	592	43
	R40	2	1689	1163	13	90	215	221	68
	R45	2	1728	1008	40	25	575	241	81
	R44	3	1313	1489	46	26	487	186	109
	R48	3	4053	3085	38	0	568	152	114
	R49	4	3871	1328	0	4	67	574	164
	R50	4	5142	2143	40	35	520	301	293
>300 HP	Total		33582	13797	431	321	5421	2700	1550

Table 3.2.3b. Sampled landings weight per trip for the plaice, sole, cod, whiting, dab, turbot and brill for beam trawl vessels larger than 300 HP and for a beam trawl vessel of 300 HP (vessel R41).

HP class	Vessel	Quarter	Plaice	Sole	Cod	Whiting	Dab	Turbot	Brill
300 HP	R41	2	56.6	62.3	6	0	4	36.3	0
>300 HP	R37	1	39.4	179.9	0	0	1.1	0	0
	R38	1	92.1	115.4	0	0	0	0	0
	R39	2	224	96	7	0	107	0	0
	R40	2	88.5	104.5	1.5	4	0	45	5.5
	R45	2	40	152	0	0	69	0	0
	R44	3	58.5	146	0	0	38	0	0
	R48	3	126	203	29.5	0	41	0	0
	R49	4	61	109.5	0	0	3.5	3	2
	R50	4	81.5	100.5	0	0	0	0	0
>300 HP	Total		811	1206.8	38	4	259.6	48	7.5

Table 3.3.1. Plaice. Landings (L), discards (D) and percentage discards (%D) per hour in numbers (left) and weight (right) for a beam trawl vessels of 300 HP and beam trawl vessels larger than 300 HP.

HP class	Vessel	Quarter	Numbers			Weight		
			L	D	%D	L	D	%D
300	R41	2	26	334	93	8	19	70
	Mean		26	334	93	8	19	70
>300	R37	1	300	668	69	104	44	30
	R38	1	76	1210	94	21	65	76
	R39	2	549	2384	81	110	149	58
	R40	2	77	682	90	21	44	68
	R45	2	120	724	86	22	50	70
	R44	3	87	688	89	17	61	78
	R48	3	134	367	73	52	35	40
	R49	4	191	1046	85	48	107	69
	R50	4	230	737	76	73	75	51
	Mean		189	936	83	50	70	58

Table 3.3.2. Plaice. Landings (L), discards (D) and percentage discards (%D) per hour and per quarter in numbers (left) and weight (right) for beam trawl vessel larger than 300 HP.

Quarter	Numbers			Weight		
	L	D	%D	L	D	%D
1	176	967	85	58	56	49
2	236	1215	84	48	78	62
3	110	525	83	35	48	58
4	210	902	81	59	92	61

Table 3.3.3. Plaice. Number landed and discarded per hour per length class (with weighted standard deviation between brackets) for beam trawl vessels larger than 300 HP (≥ 300 HP) and for a beam trawl vessels of 300 HP.

Length (cm)	>300 HP		300 HP	
	Discards	>300 HP Landings	Discards	300 HP Landings
10	0.07	(0.1)		
11	0.2	(0.1)	1.5	
12	1	(1.1)	8.2	
13	4	(2.0)	29.4	
14	9	(4.4)	32.9	
15	25	(11.5)	32.7	
16	56	(22.6)	30.6	
17	101	(34.9)	16.3	
18	135	(49.7)	25.3	
19	136	(46.7)	29.2	
20	111	(28.6)	38.2	
21	91	(14.7)	0.03	(0.0)
22	77	(17.9)	0.05	(0.1)
23	66	(18.9)	0.2	(0.1)
24	51	(15.9)	0.4	(0.2)
25	37	(9.9)	1	(0.6)
26	23	(5.2)	7	(2.1)
27	8	(2.6)	28	(7.3)
28	2	(0.6)	30	(9.0)
29	0.6	(0.2)	30	(9.2)
30	0.5	(0.2)	20	(6.5)
31	0.07	(0.1)	16	(5.3)
32			14	(4.8)
33			9	(2.9)
34			7	(2.5)
35			6	(2.3)
36			5	(2.3)
37			3	(0.8)
38			3	(0.7)
39			3	(0.9)
40			1	(0.3)
41			2	(1.5)

Table 3.3.3. Continued.

Length (cm)	>300 HP Discards	>300 HP Landings	300 HP Discards	300 HP Landings
42		0.8 (0.3)		0.3
43		0.6 (0.2)		
44		0.2 (0.1)		0.1
45		0.1 (0.1)		
46		0.3 (0.3)		
47		0.05 (0.0)		
48		0.1 (0.1)		
49		0.08 (0.1)		
50				
51		0.05 (0.05)		
58		0.05 (0.05)		

Table 3.3.4. Plaice. Numbers landed (L) and discarded (D) at age per hour and per quarter and year, and discard coefficient of variation (CV) at age per year.

Age	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Year		
	L	D	L	D	L	D	L	D	L	D	CV
0	0	0.3	0	0	0	0	0	0	0	0.1	300%
1	0	117	0.4	97.1	4	159	13	3	4	94	90%
2	0.6	767	58	1075.2	40	347	68	767	44	776	69%
3	25	45	51	41.9	25	13	50	97	39	48	72%
4	62	34	50	0.4	18	5	37	19	42	13	121%
5	40	0	28	0.3	14	0.9	17	15	25	4	179%
6	22	0	21	0.3	4	0.3	8	0.0	15	0.2	136%
7	21	3	20	0	5	0.2	15	0.2	16	0.7	184%
8	0.3	0	2	0	0.8	0	1	0	1	0	-
9	0.7	0	0.6	0	0.1	0	0.2	0	0.4	0	-
10	4	0	4	0	0.3	0	0.6	0	2	0	-

Table 3.3.5. Plaice. Landings (L) and discards D) raised estimates of total fleet numbers (*1000) and mean length (left), total weight (*1000) and mean weight (right) at age per quarter.

Quarter	age	Numbers (*1000)		Mean length		Weight (*1000)		Mean_weight	
		L	D	L	D	L	D	L	D
1	0	0	41	-	10.0	0	0	-	0.009
	1	0	14684	-	14.7	0	414	-	0.028
	2	81	96053	25.5	18.4	12	5506	0.147	0.057
	3	3118	5684	28.7	23.5	667	662	0.214	0.116
	4	7780	4247	30.6	20.4	2022	351	0.260	0.083
	5	5006	0	33.3	-	1714	0	0.342	-
	6	2790	0	34.1	-	1028	0	0.368	-
	7	2693	350	36.3	27.0	1201	62	0.446	0.176
	8	36	0	39.6	-	20	0	0.569	-
	9	83	0	42.8	-	60	0	0.722	-
	10	445	0	40.9	-	277	0	0.623	-
	all	22032	121059	32.3	18.3	7003	6995	0.318	0.058
2	1	56	12782	26.0	15.9	9	465	0.157	0.036
	2	7677	141600	28.6	19.1	1618	9029	0.211	0.064
	3	6680	5521	29.9	25.0	1634	776	0.245	0.141
	4	6553	51	30.4	27.0	1698	9	0.259	0.176
	5	3657	34	30.7	27.0	980	6	0.268	0.176
	6	2808	41	30.8	27.0	762	7	0.271	0.176
	7	2625	0	31.9	-	801	0	0.305	-
	8	320	0	32.7	-	109	0	0.340	-
	9	80	0	40.5	-	50	0	0.618	-
	10	566	0	33.6	-	225	0	0.397	-
		all	31024	160028	30.1	19.1	7885	10291	0.254
3	1	427	16240	27.5	19.0	80	1038	0.188	0.064
	2	4060	35389	28.4	22.1	845	3480	0.208	0.098
	3	2544	1283	30.6	26.6	673	216	0.264	0.169
	4	1804	550	32.0	26.4	556	90	0.308	0.164
	5	1400	90	30.9	28.8	390	19	0.279	0.214
	6	433	26	32.9	28.7	150	5	0.345	0.213
	7	481	25	33.6	28.7	178	5	0.370	0.211
	8	77	0	42.7	-	56	0	0.726	-
	9	7	0	40.9	-	4	0	0.619	-
	10	32	0	31.0	-	9	0	0.267	-

Table 3.3.5. Continued.

	all	11266	53602	30.3	21.3	2939	4854	0.261	0.091
4	1	1557	337	27.0	17.9	275	21	0.177	0.063
	2	8295	94203	28.0	22.0	1654	9087	0.199	0.096
	3	6181	11913	29.0	23.8	1379	1471	0.223	0.124
	4	4526	2330	31.4	27.1	1304	416	0.288	0.179
	5	2099	1853	31.0	26.1	585	295	0.278	0.159
	6	1025	6	33.9	29.0	372	1	0.363	0.218
	7	1801	24	32.7	29.0	605	5	0.336	0.218
	8	147	0	36.5	-	67	0	0.458	-
	9	20	0	39.8	-	12	0	0.577	-
	10	68	0	41.9	-	46	0	0.674	-
	all	25718	110665	29.7	22.3	6299	11296	0.245	0.102
all	0		33		10.0		0		0.009
	1	1906	45396	27.1	16.8	341	2043	0.179	0.045
	2	21285	374114	28.3	19.9	4387	27397	0.206	0.073
	3	18991	23331	29.6	24.3	4505	3028	0.237	0.130
	4	20319	6127	30.8	23.3	5482	758	0.270	0.124
	5	11918	1777	31.6	26.3	3528	289	0.296	0.162
	6	7096	83	32.4	27.7	2260	16	0.319	0.191
	7	7528	329	33.5	27.3	2685	60	0.357	0.181
	8	639		35.1		271		0.424	
	9	192		41.2		125		0.650	
	10	1155		36.2		551		0.478	
	all	91028	451191	19.9	30.5	24135	33591	0.074	0.265

Table 3.3.6. Sole. Landings (L), discards (D) and percentage discards (%D) per hour in numbers (left) and weight (right) for a beam trawl vessels of 300 HP and beam trawl vessels larger than 300 HP.

HP class	Vessel	Quarter	Numbers			Weight		
			L	D	%D	L	D	%D
300	R41	2	38	29	43	8	2	22
	Mean		38	29	43	8	2	22
>300	R37	1	75	33	31	20	3	12
	R38	1	90	29	24	23	3	10
	R39	2	28	1	4	7	<1	1
	R40	2	72	39	35	15	3	18
	R45	2	70	10	13	13	1	7
	R44	3	115	113	50	20	13	39
	R48	3	187	4	2	40	<1	1
	R49	4	63	28	31	16	3	14
	R50	4	152	28	16	30	3	9
	Mean		95	32	25	20	3	14

Table 3.3.7. Sole. Landings (L), discards (D) and percentage discards (%D) per hour and per quarter in numbers (left) and weight (right) for large vessels.

Quarter	Numbers			Weight		
	L	D	%D	L	D	%D
1	83	31	27	8	2	22
2	58	17	23	22	3	11
3	152	58	28	12	2	11
4	104	28	21	30	7	18

Table 3.3.8. Sole. Number landed and discarded per hour per length class (with weighted standard deviation between brackets) for beam trawl vessels larger than 300 HP (≥ 300 HP) and for a beam trawl vessels of 300 HP.

Length (cm)	>300 HP Discards		>300 HP Landings		300 HP Discards	300 HP Landings
10						
11						
12					0.5	
13	0.1	(0.1)			0.5	
14	0.2	(0.2)			0.9	
15	0.3	(0.2)				
16	0.2	(0.1)				
17	0.2	(0.1)			1.7	
18	0.6	(0.2)	0.07	(0.1)		
19	2	(0.6)			4.6	
20	4	(1.2)	0.04	(0.0)	7.3	0.1
21	6	(1.4)	0.1	(0.1)	7.7	0.1
22	7	(3.0)	0.5	(0.4)	4.6	0.3
23	6	(2.5)	3	(1.0)	1.5	4.5
24	4	(2.5)	11	(1.9)		7.2
25	1	(1.0)	16	(3.6)		5.8
26	0.4	(0.3)	13	(3.7)		4.5
27	0.2	(0.1)	11	(3.0)		2.8
28			9	(1.8)		1.4
29	0.01	(0.0)	7	(1.0)		1.7
30			5	(0.6)		1.4
31			5	(0.5)		1.2
32			4	(0.3)		1.5
33			3	(0.3)		1.4
34			2	(0.3)		0.8
35			2	(0.3)		0.9
36			1	(0.2)		0.9
37			0.7	(0.2)		0.8
38			0.6	(0.1)		0.3
39			0.4	(0.1)		0.3
40			0.3	(0.1)		
41			0.2	(0.1)		0.3

Table 3.3.8. Continued.

Length (cm)	>300 HP Discards	>300 HP Landings	300 HP Discards	300 HP Landings
42		0.07 (0.0)		
43		0.04 (0.0)		
44		0.05 (0.0)		
45		0.05 (0.0)		
46		0.02 (0.0)		
47				
48		0.06 0.0		
49				
50		0.02 0.0		

Table 3.3.9. Sole. Numbers landed (L) and discarded (D) at age per hour and per quarter and year, and discard coefficient of variation (CV) at age per year.

Age	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Year		
	L	D	L	D	L	D	L	D	L	D	CV
0	0	0	0	0	0	0	0	0	0	0	-
1	0	0.3	0	2	3	0.4	5	1	2	1	154%
2	9	29	5	15	86	50	45	18	33	26	109%
3	19	0.3	12	0.3	25	8	21	7	19	3	161%
4	29	0.5	16	0.9	24	0.1	14	1	20	0.7	108%
5	7	0.1	9	0.1	5	0	9	0.1	8	0.1	142%
6	10	0.1	7	0	2	0	8	0.1	7	0.1	180%
7	8	0.1	6	0	4	0	2	0	5	0	246%
8	0.2	0	1	0	0.4	0	0	0	0.6	0	-
9	0.4	0	0.3	0	0.2	0	0	0	0.3	0	-
10	0.5	0	1	0	0.8	0	0.3	0	0.7	0	-

Table 3.3.10. Sole. Landings (L) and discards D) raised estimates of total fleet numbers (*1000) and mean length (left), total weight (*1000) and mean weight (right) at age per quarter.

Quarter	age	Numbers (*1000)		Mean length		Weight (*1000)		Mean_weight	
		L	D	L	D	L	D	L	D
1	0								
	1	0	36		13.3	0	1		0.019
	2	1155	3669	23.9	20.8	155	316	0.134	0.086
	3	2418	37	27.4	24.6	524	5	0.217	0.149
	4	3663	62	29.0	24.6	974	9	0.266	0.147
	5	820	14	28.6	24.6	218	2	0.266	0.147
	6	1236	18	30.8	24.3	419	2	0.339	0.141
	7	1010	6	31.4	26.4	366	1	0.362	0.187
	8	30	0	39.7		22	0	0.717	
	9	52	0	48.9		81	0	1.549	
	10	60	0	47.9		87	0	1.451	
	all	10444	3841	28.7	20.9	2845	337	0.272	0.088
2	1	0	196		15.0	0	6		0.028
	2	630	1919	25.0	21.0	100	169	0.159	0.088
	3	1644	35	27.2	24.1	345	5	0.210	0.137
	4	2136	115	28.3	24.2	524	16	0.245	0.141
	5	1164	13	29.6	24.3	336	2	0.288	0.142
	6	974	2	30.2	26.0	306	0	0.314	0.176
	7	728	0	31.5		258	0	0.354	
	8	153	0	31.0		53	0	0.345	
	9	44	0	35.1		22	0	0.496	
	10	127	0	30.7		43	0	0.341	
	all	7601	2281	28.7	20.7	1987	198	0.261	0.087
3	1	332	36	22.1	18.0	34	2	0.103	0.052
	2	8797	5062	25.8	22.6	1518	570	0.173	0.113
	3	2567	796	28.2	22.8	622	91	0.242	0.115
	4	2462	8	29.8	27.0	720	2	0.293	0.199
	5	520	0	30.1		155	0	0.298	
	6	179	0	33.3		76	0	0.423	
	7	442	0	29.4		127	0	0.288	
	8	45	0	37.0		26	0	0.571	
	9	24	0	39.3		18	0	0.733	
	10	79	0	37.8		52	0	0.655	

Table 3.4.10. Continued.

	all	15447	5903	27.2	22.6	3349	665	0.217	0.113
4	1	655	188	24.3	17.0	92	9	0.140	0.046
	2	5534	2228	26.6	22.0	1077	231	0.195	0.104
	3	2567	853	28.0	22.9	599	98	0.233	0.115
	4	1668	161	27.6	20.4	378	13	0.227	0.081
	5	1058	10	27.9	27.0	250	2	0.236	0.199
	6	1000	10	27.8	27.0	229	2	0.229	0.199
	7	291	0	29.7		82	0	0.281	
	8	2	0	38.0		1	0	0.617	
	9								
	10	43	0	34.2		19	0	0.436	
	all	12818	3451	27.2	21.9	2726	356	0.213	0.103
all	0								
	1	937	478	23.4	15.8	118	17	0.126	0.036
	2	16059	12738	25.9	21.8	2833	1282	0.176	0.101
	3	9010	1683	27.7	22.9	2048	196	0.227	0.116
	4	9713	343	28.8	22.8	2542	41	0.262	0.119
	5	3596	36	29.1	25.1	979	6	0.272	0.157
	6	3278	26	29.9	25.4	999	4	0.305	0.165
	7	2446	5	30.9	26.4	823	1	0.336	0.187
	8	264		32.9		111		0.422	
	9	123		40.7		111		0.906	
	10	329		35.4		196		0.595	

Table 3.3.11 Dab. Landings (L), discards (D) and percentage discards (%D) per hour in numbers (left) and weight (right) for a beam trawl vessels of 300 HP and beam trawl vessels larger than 300 HP.

HP class	Vessel	Quarter	Numbers			Weight		
			L	D	%D	L	D	%D
300	R41	2	6	238	97	1	10	88
	Mean		6	238	97	1	10	88
>300	R37	1	16	344	96	4	16	82
	R38	1		740		7	38	85
	R39	2	237	2434	91	32	176	85
	R40	2		1343		3	59	96
	R45	2	51	441	90	7	25	77
	R44	3	36	1971	98	6	93	94
	R48	3	29	432	94	7	30	81
	R49	4	4	901	100	<1	36	98
	R50	4		1976		7	111	94
	Mean		60	1166	95	8	64	89

Table 3.3.12. Dab. Landings (L), discards (D) and percentage discards (%D) per hour and per quarter in numbers (left) and weight (right) for large vessels.

Quarter	Numbers			Weight		
	L	D	%D	L	D	%D
1	16	563	97	1	10	88
2	138	1364	91	5	28	84
3	32	1192	97	13	83	86
4	4	1403	100	7	61	90

Table 3.3.13. Cod. Landings (L), discards (D) and percentage discards (%D) per hour in numbers (left) and weight (right) for a beam trawl vessels of 300 HP and beam trawl vessels larger than 300 HP.

HP class	Vessel	Quarter	Numbers			Weight		
			L	D	%D	L	D	%D
300	R41	2	<1	0	0	<1	0	0
	Mean		<1	0	0	<1	0	0
>300	R37	1		0		3	0	0
	R38	1		<1		<1	<1	6
	R39	2	0	0	0	0	0	0
	R40	2	<1	0	0	<1	0	0
	R45	2		<1		<1	<1	34
	R44	3		0		<1	0	0
	R48	3	<1	0	0	<1	0	0
	R49	4	0	0	0	0	0	0
	R50	4		2		<1	<1	55
	Mean		<1	<1	68	<1	<1	15

Table 3.3.14. Cod. Landings (L), discards (D) and percentage discards (%D) per hour and per quarter in numbers (left) and weight (right) for large vessels.

Quarter	Numbers			Weight		
	L	D	%D	L	D	%D
1		<1		2	<1	1
2	<1	<1	63	<1	<1	28
3	<1	0	0	<1	0	0
4	0	<1	100	<1	<1	55

Table 3.3.15. Whiting. Landings (L), discards (D) and percentage discards (%D) per hour in numbers (left) and weight (right) for a beam trawl vessels of 300 HP and beam trawl vessels larger than 300 HP.

HP class	Vessel	Quarter	Numbers			Weight		
			L	D	%D	L	D	%D
300	R41	2		3		<1	<1	77
	Mean			3		<1	<1	77
>300	R37	1		63		2	4	65
	R38	1		11		<1	<1	81
	R39	2	0	1	100	0	<1	100
	R40	2	5	48	90	1	3	73
	R45	2		9		<1	<1	73
	R44	3		83		<1	5	94
	R48	3	0	7	100	0	<1	100
	R49	4		34		<1	1	97
	R50	4		115		<1	11	96
	Mean		2	40	96	<1	3	86

Table 3.3.16. Whiting. Landings (L), discards (D) and percentage discards (%D) per hour and per quarter in numbers (left) and weight (right) for large vessels.

Quarter	Numbers			Weight		
	L	D	%D	L	D	%D
1		34		1	2	68
2	3	20	88	<1	1	73
3	0	44	100	<1	3	94
4		71		<1	6	96

Table 4.1. Plaice. Landings (L), discards (D) and percentage discards (%D) per hour and per period in numbers (left) and weight (right). Results over 1976-1983 and 1989-1990 from Van Beek (1998), 1999-2001 from Netherlands Institute for Fisheries Research unpublished data.

Period	N trips	Numbers			Weight		
		L	D	%D	L	D	%D
1976-1979	21	253	185	42%	104	24	18%
1980-1983	22	336	380	53%	107	49	31%
1989-1990	6	392	330	46%	136	40	23%
1999-2001	20	214	575	73%	56	47	46%
2002	6	241	816	77%	63	66	51%
2003	9	189	936	83%	50	70	58%

Table 4.2. Sole. Landings (L), discards (D) and percentage discards (%D) per hour and per period in numbers (left) and weight (right). Results over 1976-1983 and 1989-1990 from Van Beek (1998), 1999-2001 from Netherlands Institute for Fisheries Research unpublished data.

Period	N trips	Numbers			Weight		
		L	D	%D	L	D	%D
1976-1979	21	116	8	6%	38	1	3%
1980-1983	22	84	23	21%	27	3	9%
1989-1990	6	286	83	22%	72	11	13%
1999-2001	20	92	21	19%	22	2	8%
2002	6	124	37	24%	18	3	13%
2003	9	95	32	25%	20	3	14%

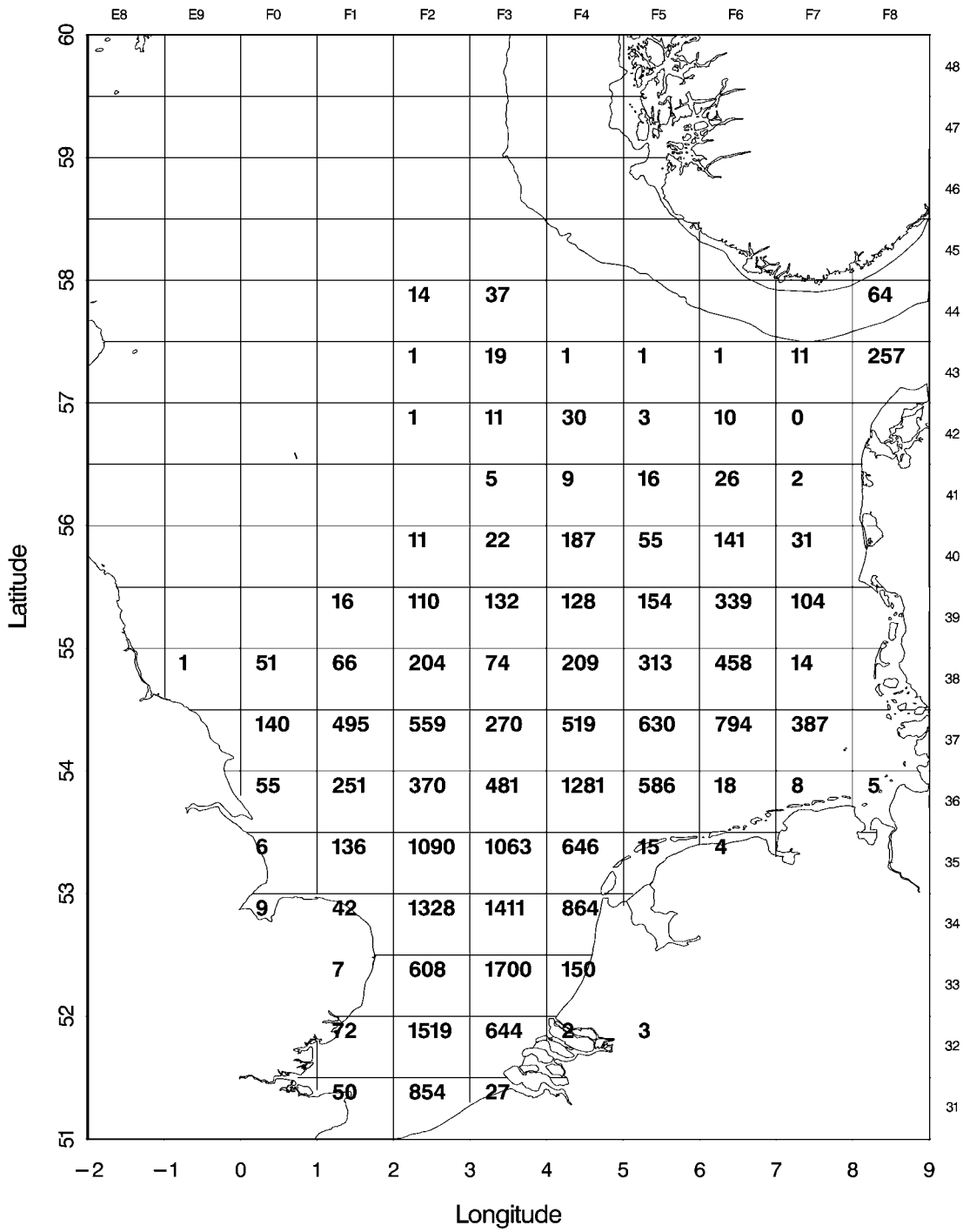


Figure 3.1.1a. Effort distribution of the Dutch beam trawl fleet in 2003, for vessels larger than 300 HP.

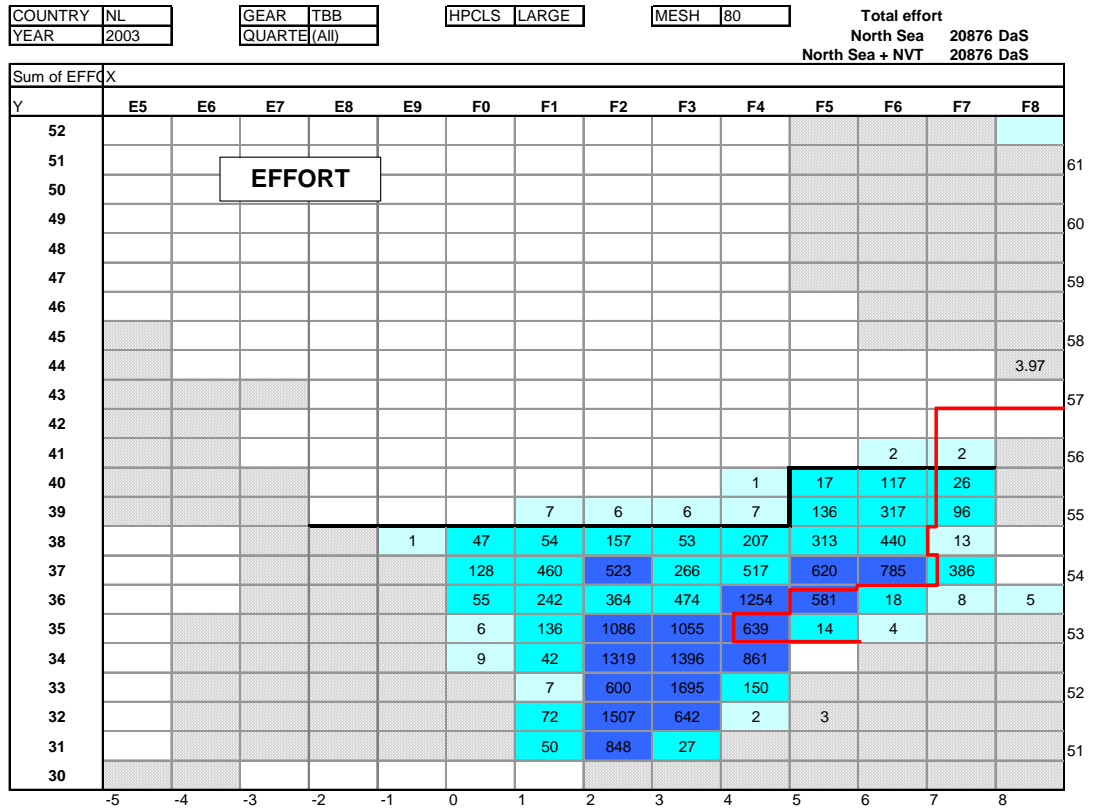


Figure 3.1.1b. Effort distribution of the Dutch beam trawl fleet in 2003, for vessels larger than 300 HP fishing with 80 mm mesh size.

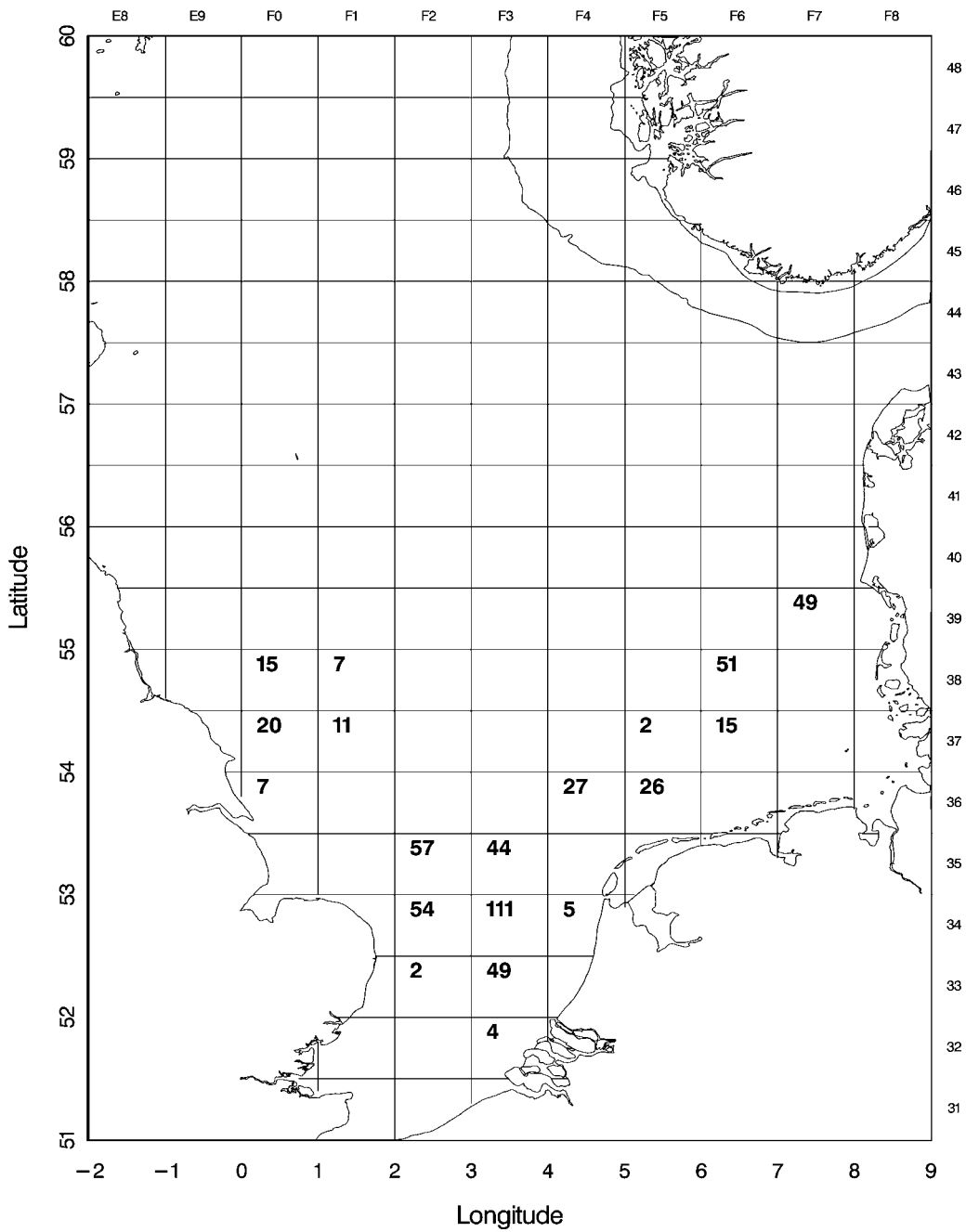


Figure 3.1.1c. Sampled effort in hours for beam trawl vessels with engine power larger than 300 HP.

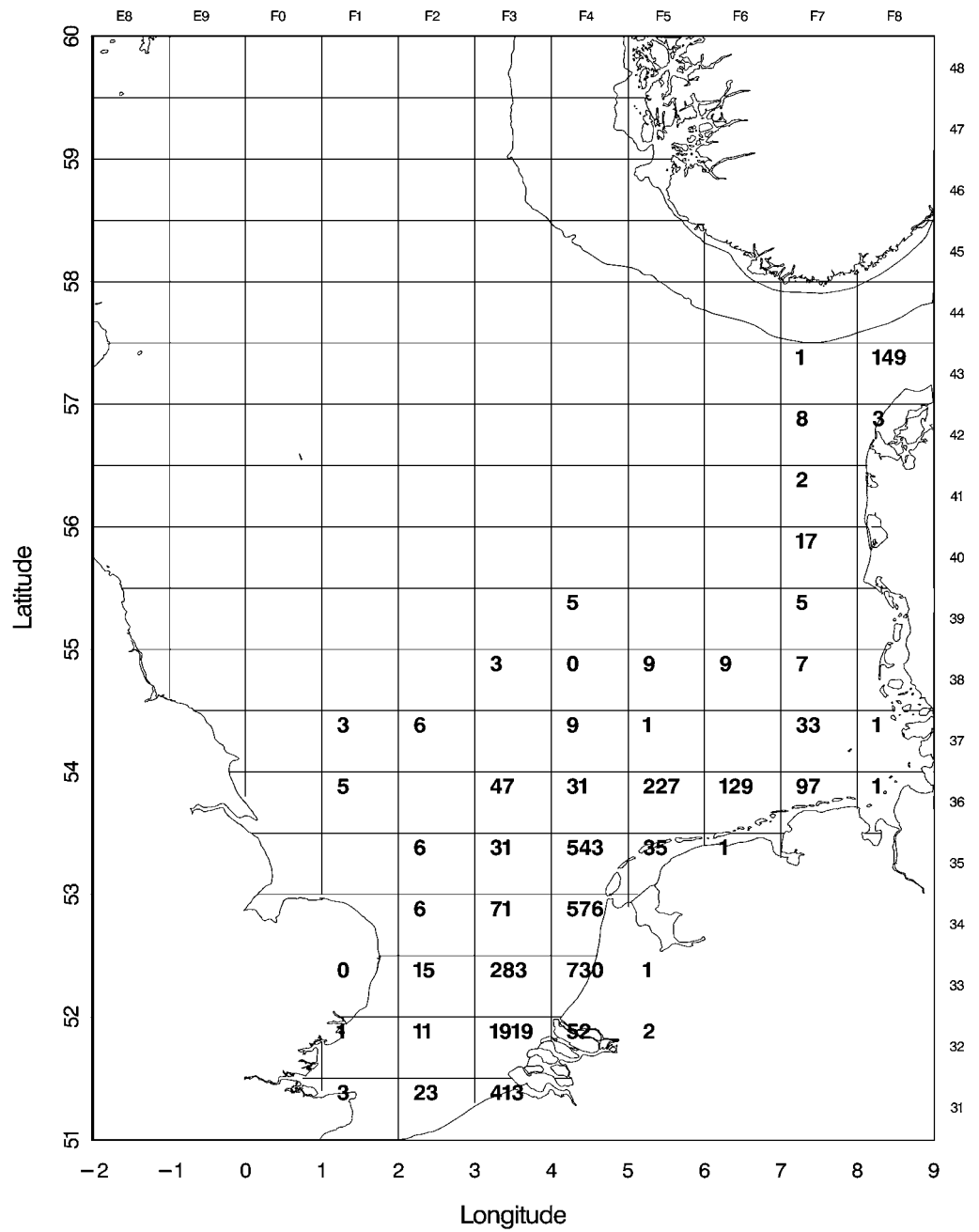


Figure 3.1.2a. Effort distribution of the Dutch beam trawl fleet in 2003, for vessels of 300 HP.

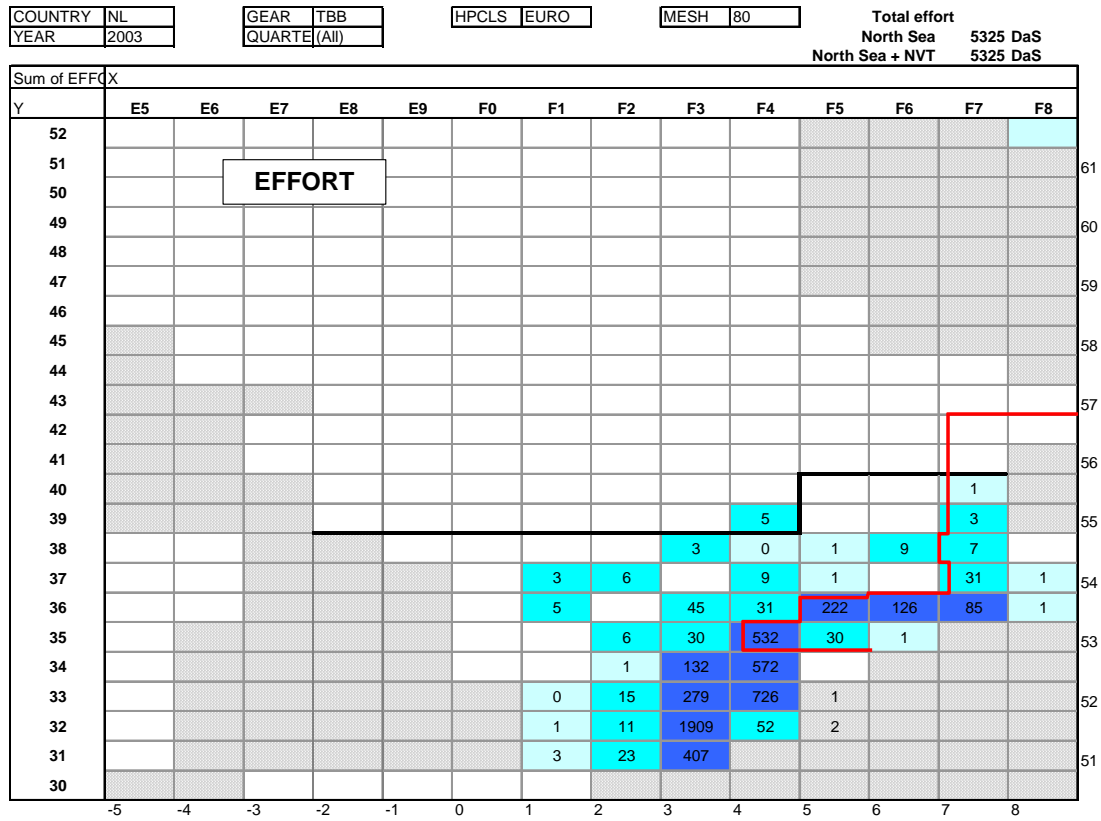


Figure 3.1.2b. Effort distribution of the Dutch beam trawl fleet in 2003, for vessels of 300 HP fishing with 80 mm mesh size.

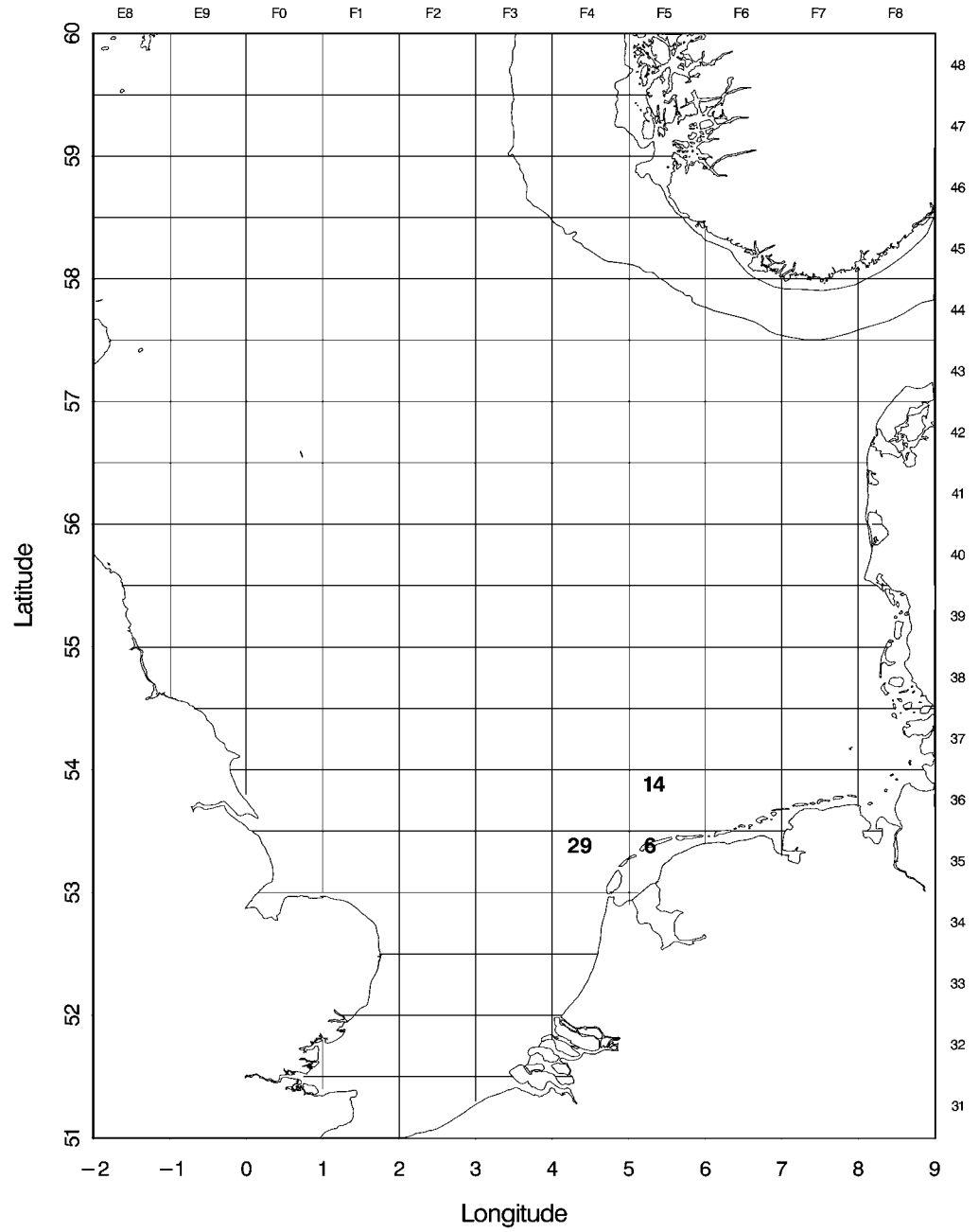


Figure 3.1.2c. Sampled effort in hours for beam trawl vessels with engine power of 300 HP.

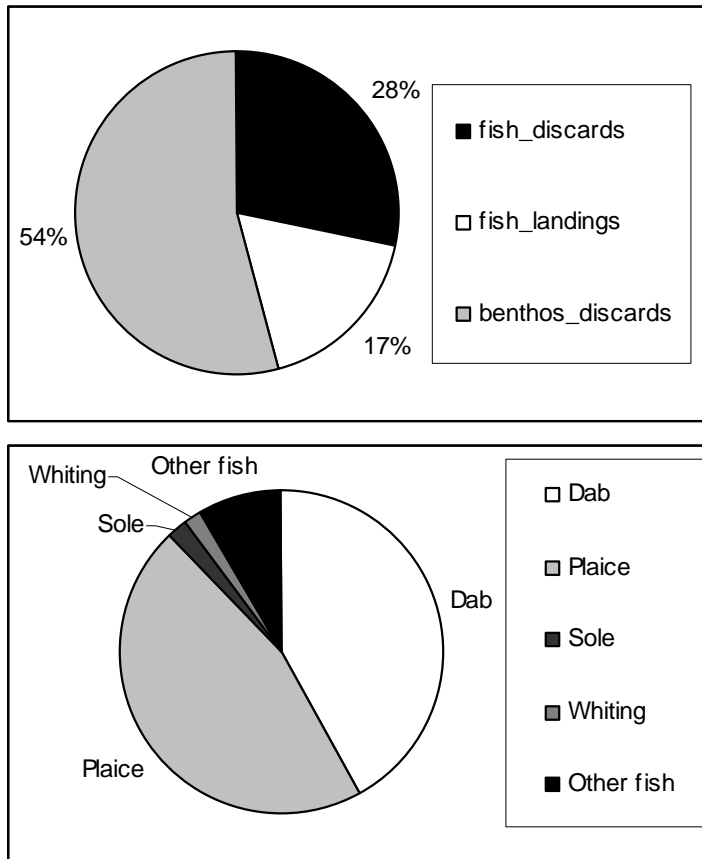


Figure 3.2. Composition of the catch (upper panel) and composition of the fish discards (lower panel).

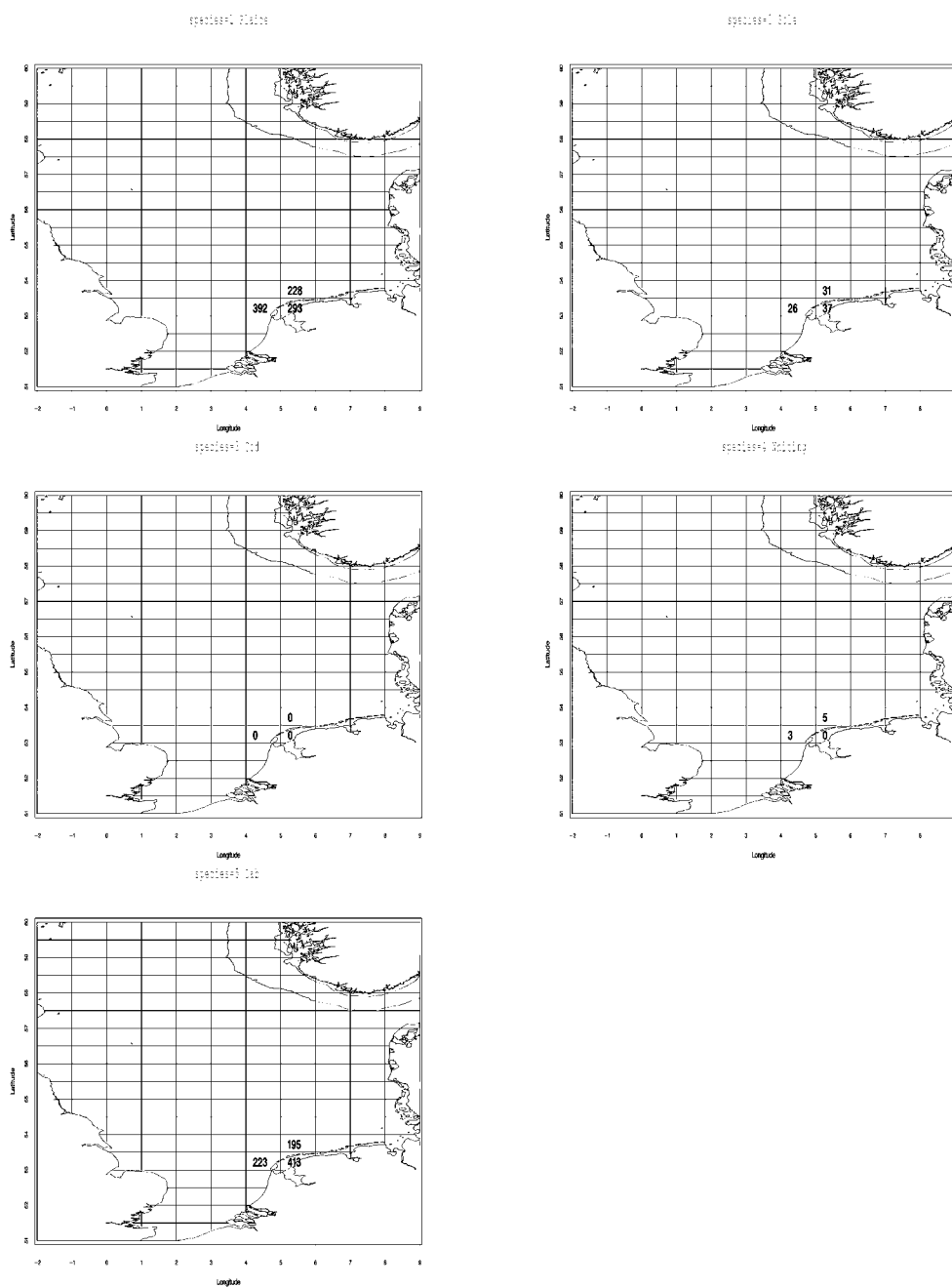


Figure 3.3.1b. Number of discards per hour per ICES area in 2003 for plaice (upper left), sole (upper right), cod (middle left), whiting (middle right) and dab (lower left) for a beam trawl vessel of 300 HP.

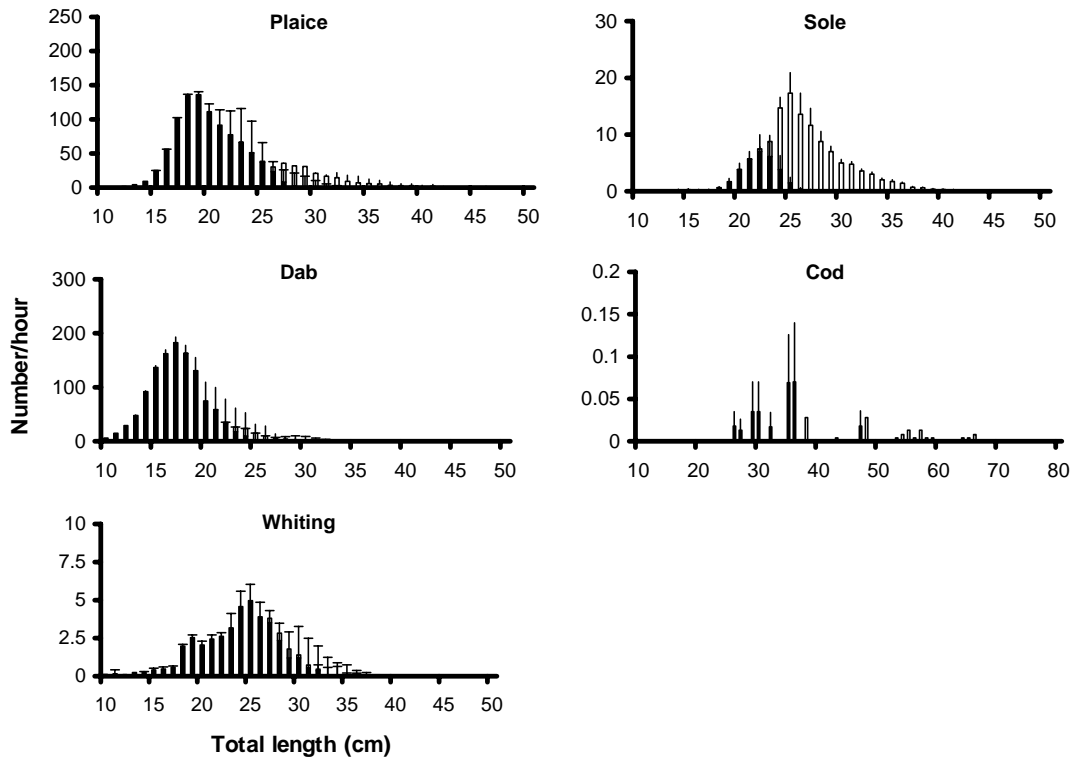


Figure 3.4.1. Length frequency distribution of plaice, sole, dab, whiting and cod in 2003, caught with beam trawl vessels larger than 300 HP. Black bars show discards, white landings.

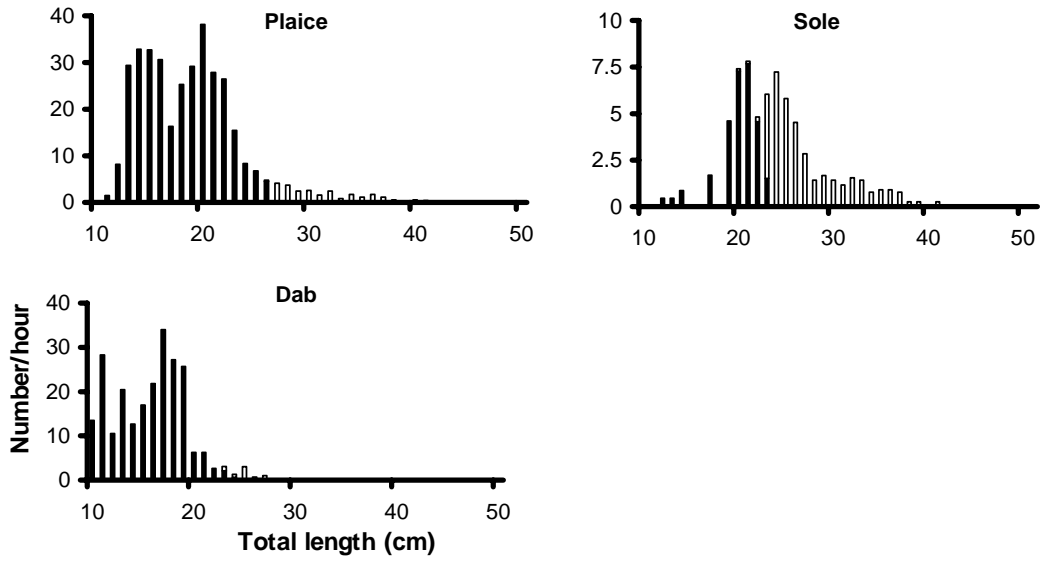


Figure 3.4.2. Length frequency distribution of plaice, sole and dab in 2003, caught with a beam trawl vessel of 300 HP. Black bars show discards, white landings.

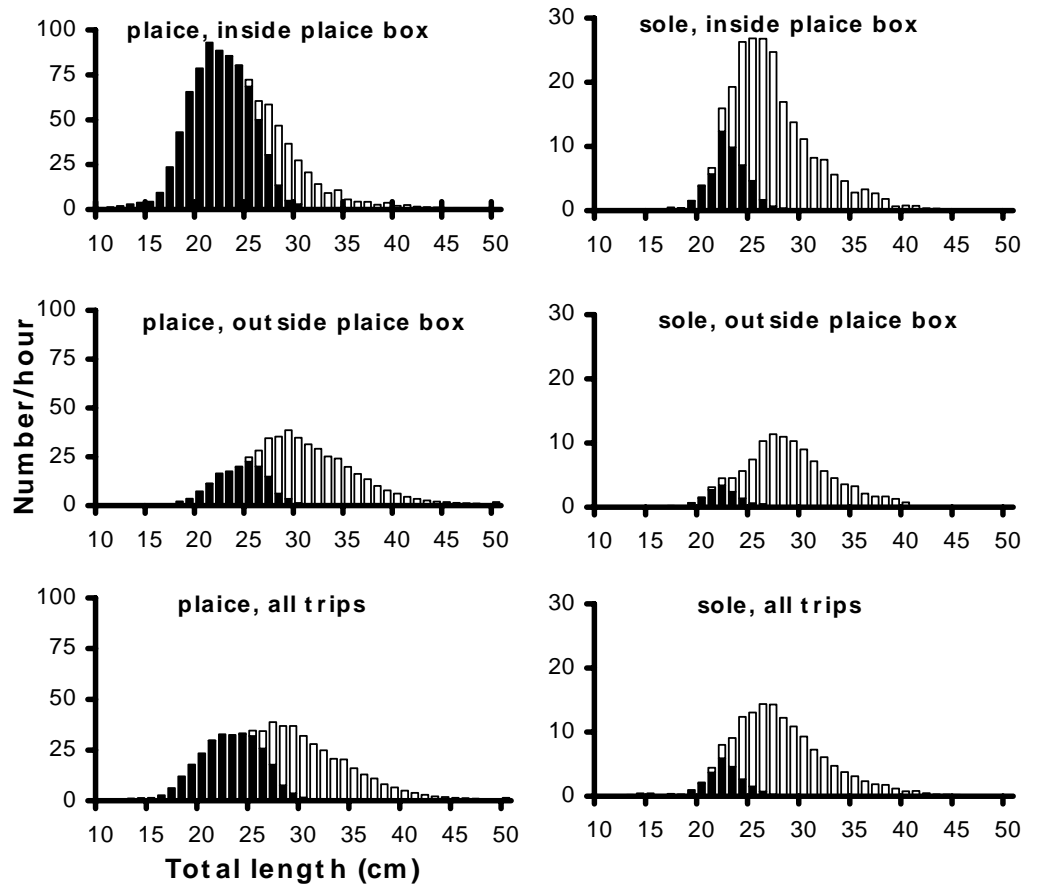


Figure 4.1. Length frequency distribution for plaice and sole inside and outside the plaice box and over all trips combined from 1976-1990 (Van Beek, 1998).

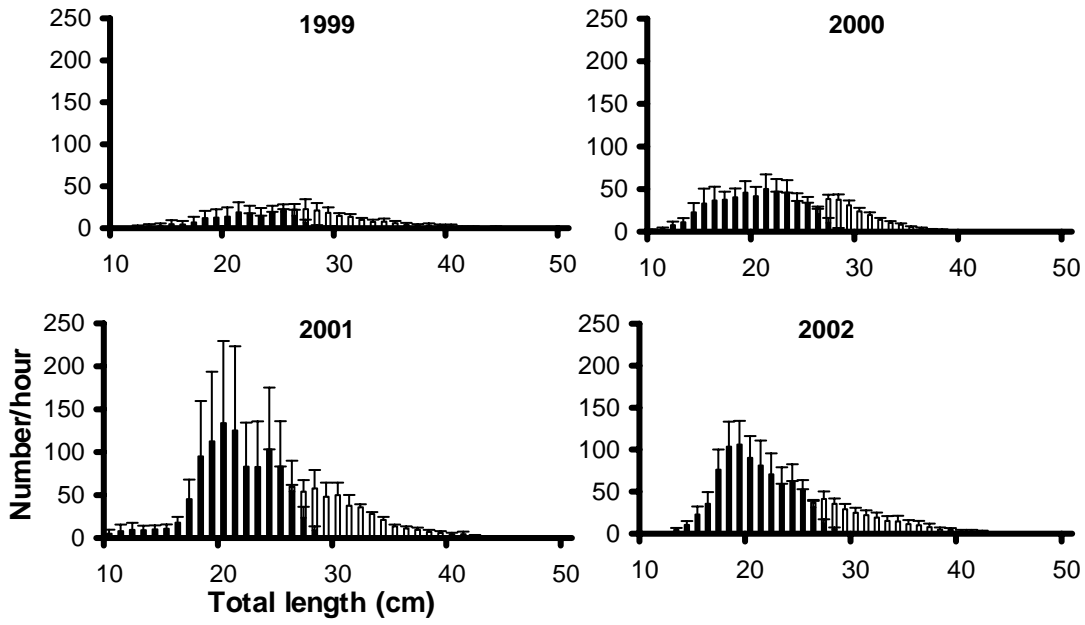


Figure 4.2. Plaice. Length frequency distribution from 1999 - 2002 (Netherlands Institute for Fisheries Research, unpublished data). Black bars show discards, white landings.

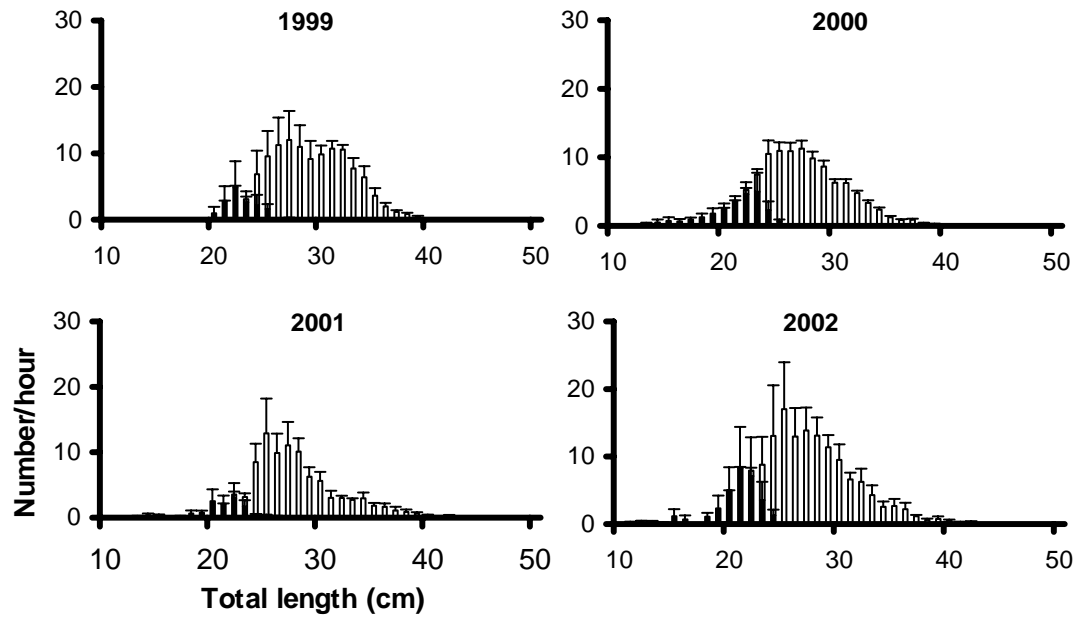


Figure 4.3. Sole. Length frequency distribution from 1999 - 2002 (Netherlands Institute for Fisheries Research, unpublished data). Black bars show discards, white landings.