Stichting DLO
Centre for Fishery Research (CVO)

P.O. Box 68
1970 AB IJMUIDEN
Phone: 0255564600
Fax: 0255 564765
Visitor address: Haringkade 1,
1976 CP IJmuiden

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Discard sampling of the Dutch beam trawl in 2006

Ir. A.T.M. van Helmond and drs. H.M.J van Overzee

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Postbus 20401
2500 EK Den Haag

Project number: 4391213001

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

Signature: _____

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Summary

This report describes the results of the discards sampling programme on the Dutch beam trawl fishery in the North Sea in 2006. The programme was instigated in 2002 as part of the EC regulations 1543/2000 and 1639/2001 on data collection in European fisheries. Beam trawlers with engine power larger than 300 HP fishing with 80 mm mesh size are the major part of the Dutch fleet and take most of the plaice and sole landings from the North Sea. Benthic animals, fish exceeding legal quota, or fish under minimum landing size are not retained on board and returned to the sea. This practice is called discarding. In 2006, ten trips were sampled. Nine trips were on board beam trawl vessels larger than 300 HP fishing with 80 mm cod-end mesh size. One trip was on board a German otter bottom trawl vessel larger than 300 HP fishing with 80 mm cod-end mesh size. The spatial distribution of fishing effort of the Dutch beam trawl fleet larger than 300 HP fishing with 80 mm mesh size was similar to the effort distribution in the discard sampling. Samples of the discards and landings were counted and measured, and raised to catches per hour, per trip, per quarter and per year.

The major fish species in the discards were dab (*Limanda limanda*) and plaice (*Pleuronectes platessa*). In 2006, the percentage plaice discards for the beam trawlers was on average 86% of the total catch in numbers and 54% in weight. For the otter bottom trawl vessel the percentage plaice discards was 74% in numbers and 46% in weight. The percentage discards for sole was on average 29% in numbers and 13% in weight for the beam trawl vessels. On board of the otter bottom trawl vessel less than 1 kg sole per hour was discarded.

The average percentage discarding of plaice in the sampled trips in 2006 appeared to be similar to the percentages that were obtained in 1999-2005 (on average 80% in number, 50% in weight). It was, however, higher in comparison with the period 1976-1990 (42%-53% in numbers, 18%-31% in weight). There was no apparent trend in discard percentage of sole in number and weight in 2006 compared to previous years.

Length frequency distributions showed that smaller plaice were being caught in recent periods compared to 1976-1990. This is thought to be caused by an observed shift in spatial distribution of small plaice to more offshore areas, whereby they become available to the beam trawl fleet.

Samenvatting

Dit rapport bevat de resultaten van het discardsbemonsteringsprogramma van de Nederlandse boomkorvisserij in de Noordzee in 2006. Het programma wordt sinds 2002 op deze wijze uitgevoerd als invulling van EC regelingen 1543/2000 en 1639/2001 voor gegevensverzameling in Europese visserijen. Nederlandse boomkorschepen met een motorvermogen groter dan 300 PK met 80 mm maaswijdte zijn verantwoordelijk voor de meeste schol en tong aanlandingen uit de Noordzee. Bodemdieren, vangst buiten het quota en ondermaatse vis worden teruggezet in de zee, hetgeen *discarding* genoemd wordt. In 2006 zijn tien reizen uitgevoerd. Hiervan werden 9 reizen uitgevoerd aan boord van boomkor schepen met een motorvermogen groter dan 300 PK vissend met 80 mm maaswijdte, en één aan boord van een otter bodemtrawler met een motorvermogen groter dan 300 PK vissend met 80 mm maaswijdte. De ruimtelijke verdeling van de visserijinspanning van de boomkorvisserij groter dan 300 PK vissend met 80 mm maaswijdte was vergelijkbaar met de verdeling van de visserij-inspanning in het bemonsteringsprogramma. De discards en de aanlandingen werden geteld en gemeten en vervolgens opgewerkt tot vangsten per visuur, per reis, per kwartaal en per jaar.

De discards in de boomkorvisserij bestaan voornamelijk uit schar (*Limanda limanda*) en schol (*Pleuronectes platessa*). Het percentage discards van schol was in 2006 voor de boomkorschepen gemiddeld 86% in aantallen en 54% in gewicht. Voor de otter trawler was het discardspercentage van schol 74% in aantallen en 46% in gewicht. Voor tong was het percentage discards gemiddeld 29% in aantal en 13% in gewicht voor de boomkorschepen. Aan boord van de otter trawler werd per uur minder dan 1 kg tong gediscard.

Het percentage discards van schol in de bemonsterde reizen in 2006 lijkt even hoog te zijn als in de afgelopen jaren 1999-2005 (gemiddeld ongeveer 80% in aantal, 50% in gewicht), wat hoger is in vergelijking met de periode 1976-1990 (42%-53% in aantal, 18%-31% in gewicht). Er was geen duidelijke trend in percentage discards van tong in aantallen en in gewicht in 2006 in vergelijking met de voorafgaande periode.

De lengteverdelingen van schol laten zien dat in recente periodes gemiddeld kleinere schol werd bijgevangen dan in de periode 1976-1990. Deze verandering hangt waarschijnlijk 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.

1 Introduction

Most demersal fisheries are mixed fisheries, targeting a limited number of species that live in or near the seabed. In general other catches will be thrown overboard, a practice called discarding (Van Beek, 1998). Worldwide the annual fish catch was within demersal fisheries was estimated at 84 million tonnes for 1992-2001 with a discard rate of 8 percent in weight, resulting in an estimated 7.3 million tonnes of discards worldwide (FAO, 2004). This estimate was considerable lower than the previous estimate for 1988-1990 (Alverson, et al., 1994), when worldwide discarding was estimated between 17.9 en 39.5 million tonnes annually. This reduction in discarding was due to the use of more selective fishing gears, introduction of bycatch and discard regulations and increased retention of bycatch for human or animal food (FAO, 2004).

Discarding can be highly variable in space and time caused by changing economic, biological, environmental or social factors (ICES, 2004b; Catchpole et al., 2005). There are many types 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 is an important issue in fisheries management, both from an economic, an ecosystem as well as a stock assessment point of view. Discarding leads to lower profits from fish stocks, because generally a large part of the discards will not survive the catching and sorting process (Van Beek et al., 1990; Jennings and Kaiser, 1998). Discards, however, also form an important food item for other organisms like birds (Camphuysen and Garthe, 2000) and benthic invertebrates (Lindeboom and De Groot, 1998) and affect their population dynamics. Discarding, and more important the 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, in the North Sea fisheries, discards are only incorporated into a few stock assessments such as haddock, cod, whiting and plaice (ICES, 2002, 2004c, a, 2005 and 2006 for North sea plaice) but the intention is to incorporate discards estimates for all stocks where relevant information becomes available. However, including discard data might also increase the noise in the assessment because the quality of the discard data is generally less than for landings (Dickey-Collas et al., 2007).

One of the main fisheries in the southern North Sea is the Dutch beam trawl fishery. This fishery is aimed at catching demersal fish, in particular sole (*Solea solea*) and plaice (*Pleuronectes platessa*). Within this fishery two nets, that are positioned at either side of the vessel, are dragged over the seabed. The mouth of the net is held open by a solid metal beam which is held into place by two solid plates that are positioned at both ends.
Tickler chains, that are also connected to these solid plates, are dragged along the seabed in order to chase the fish up into the water column whereupon they will be caught in the net. After the catch is hauled in, it is transported onto a conveyer belt. The crew sort out the marketable fish. All other catches are dropped back into sea.

Trips made with 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 suggested that the percentage of plaice discarded has increased to around 50% in weight (80% in numbers) (Van Keeken et al., 2003; Van Keeken and Pastoors, 2004; Van Keeken and Pastoors, 2005; Van Keeken, 2006). Since the end of the 1990's a change in the distribution of smaller plaice towards deeper water occurred (ICES, 1999; Grift et al., 2004; Van Keeken et al., 2004b) making small plaice more abundant on commercial fishing grounds and more susceptible to fishing (Pastoors et al., 2000; Grift et al., 2004). The discard percentage of plaice also increased due to declining biomass of marketable fish (Pastoors et al., 2000; ICES, 2002).

From 1999 to 2001 discarding practices of the Dutch beam trawl fleet in the North Sea were monitored within an EC funded international research project (Anon., 2002). From 2002 onwards discards data have been 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 results of the Dutch demersal discard sampling programme for 2006, which focuses mainly on beam trawl vessels larger than 300 HP fishing with 80 mm mesh size.

2 Methods

2.1 General information

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 2006 a total of nine trips were made on board of Dutch beam trawl vessels with an engine power between 1471-1765 KW (HP = 1.34*KW). In addition, one trip was made on board of an otter bottom trawl vessel with an engine power of 1103 KW. This vessel was fishing under the German flag. All vessels fished with a 80 mm cod-end mesh size (Table 2.1.1).

2.2 Sampling procedures

For each 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 taken from the conveyer belt. All fish in the sub-sample were counted and measured. Benthic invertebrates were only counted. Total and sampled volume of discards was recorded. Also sub-samples of the landed fish were measured, and total and sampled landings weight were 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 a central database.

Sampling protocol per haul:

1) Estimation total catch per haul. Registration of total catch in volume.
2) Take sample of discards.
    a. The sample consists of one basket (35 kg). To get a representative sample, discards are taken at different moments from the conveyer belt when processing the haul.
3) Measuring discard sample:
    a. Sort all fish species, take length measurements and register total number by species and length class.
    b. Sort all benthos and register total number by species.
4) Measuring landing sample:
    a. Sample landings from target species (sole and plaice), 10-15 kg. Register total number by species and length class.
    b. Sample landings from non-target species (e.g. dab, turbot, brill, whiting, cod) 10-15 kg. Register total number by species and length class.
5) Age estimations of discards:
    a. Sample otoliths from most discarded commercial species (plaice, sole and dab).
    b. The sample of age analysis consists of undersized fish. A sample consists of minimal 3 individuals per length class per area (ICES quadrant).
6) Registration of total landings:
    a. Information on total landings is collected at the end of the trip.

2.3 Raising procedures

This paragraph gives a short description of the raising procedures used to work up the raw data to annual estimates of discards in the beam trawl fleet. The raising procedures are the same as applied in previous years. A mathematical description of the raising procedure is given in Appendix I.

Sampled numbers of fish per haul were raised to numbers at length, and for some species at age, for both discards and landings. Different raising procedures were used for discards and landings because different sources of information were used for these catch components. For the landings the total landed weight per species by trip was available from the auction, 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. Numbers were converted to weight using standard 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. Landed weight per hour was calculated by dividing total landings weight by trip duration.

Average numbers landed and discarded at length per trip were then calculated per period (quarter or year) by summing the numbers at length per hour over the number observer trips in this period and dividing this by total number of trips in this period. Numbers at age were calculated from numbers at length using age-length keys, which calculate the proportion of fish at length (l) with age (a). Numbers at age landed and discarded are raised to fleet level by effort-ratio: multiplying total numbers at age in the sampled trips with the ratio of hpeffort (effort in days at sea multiplied by the engine power of the vessel in HP) of the fleet to hpeffort of the sampled trips.

3 Results

3.1 Sampling

During the ten sampled trips the total number of hauls in the trips varied between 30 and 48, with an average fishing duration of 80 hours per trip (Table 3.1.1). 70% of all hauls were sampled for discards and 57% for landings. Otoliths of plaice (179 otoliths), dab (140 otoliths) and sole (45 otoliths) were collected from the discards samples.

The sampling occurred during quarters 1, 2 and 4. Per quarter between 0.14% and 0.35% of the effort (in days at sea) of the Dutch beam trawl fleet with engine power larger than 300 HP fishing with 80 mm cod-end mesh size was sampled (Table 3.1.2). Fleet coverage by year was 0.24% in hpeffort for this fleet segment (Table 3.1.2). As the sampled otter bottom trawler was a German vessel, it was not possible to determine the fleet coverage.

The spatial distribution of fishing effort in the Dutch beam trawl fleet larger than 300 HP fishing with 80 mm cod-end mesh size was extracted from VIRIS and is shown in Figure 3.1.1a. The fleet is mainly distributed offshore from the Dutch coast. The distribution of all sampled vessels is presented in Figure 3.1.1b. This shows that the spatial distribution of sampling efforts covers the major areas for the whole fleet. In Figure 3.1.2 the distribution of the sampling effort of the otter bottom trawl vessel is depicted.

3.2 Numbers and weight

The total landings weight by trip for the observed vessels varied between 1275 and 9624 kg for plaice and between 187 and 1743 for sole (Table 3.2.1a). Sampled landings weight for all trips varied between 40 and 1050 kg for plaice and between 0 and 771 kg for sole (Table 3.2.1b).

The average weight of all discards on the observed beam trawl vessels (both fish and invertebrate discards) was estimated to be 38 tonnes per trip (CV 42%, Table 3.2.2). About 27% of the catch weight consisted of fish landings and 26% consisted of fish discards (Figure 3.2a). Dab and plaice were the most abundant fish species in the discards (Table 3.2.3a, Figure 3.2b). The swimming crab, comb-star, sea potato and common starfish were the most abundant benthos species (Table 3.2.3b).

The total weight of the discards on the observed otter bottom trawl vessel (both fish and invertebrate discards) was estimated to be 10 tonnes (Table 3.2.2). About 40% of the catch weight consisted of fish landings and 26% consisted of fish discards (Figure 3.2a). Dab and plaice were the most abundant fish species in the discards (Table 3.2.3a, Figure 3.2b). The common starfish and the comb-star were the most abundant benthos species (Table 3.2.3b).

3.3 Species

Plaice
On average 5418 kg of plaice was discarded per trip by the beam trawl vessels (CV 50%, Table 3.2.2). The average number per hour discarded was 997 compared to 166 individuals landed. This resulted in an average discard percentage of 86% in numbers and 54% in weight (Table 3.3.1). The average discard percentage per quarter varied between 68% and 89% in numbers and 39% and 55% in weight (Table 3.3.2). Between rectangles, the number discarded per hour varied between 16 and 1638 (Figure 3.3.1a).

On board of the otter bottom trawl vessel 2610 kg of plaice was discarded (Table 3.2.2). The average number per hour discarded was 332 compared to 116 individuals landed which resulted in a discard percentage of 74% in numbers and 46% in weight (Table 3.3.1).

Plaice were caught from 8 cm onwards during the beam trawl trips and from 15 cm onwards during the otter bottom trawl trip (Table 3.3.3). The peak of the discards length distribution was around 18 cm during the beam trawl trips (Table 3.3.3, Figure 3.4.1) and 25 cm during the otter bottom trawl trip (Table 3.3.3, Figure 3.4.2). Plaice were discarded up to 29 cm whereas the minimum landing size is 27 cm. Most discards during the beam trawl trips were between ages 1 and 3, with the highest number at the age of 1 (2005 year class). The strong 2001 year class, in 2006 at the age of 5, was the most apparent in the landings (Table 3.3.4).

Landings and discards in numbers at age were raised to fleet level for beam trawl vessels larger than 300 HP and are presented in Table 3.3.5. It must be noted that no trips were sampled during the third quarter of 2006.

Sole
On average 191 kg of sole was discarded per trip by the beam trawlers (CV 142%, Table 3.2.2). For all beam trawl trips, apart from R77, landings were higher than discards (Table 3.3.6). The average discard percentage was 29% in number and 13% in weight. The variation per quarter was between 11% and 39% in numbers and 4% and 25% in weight (Table 3.3.7).
On board of the otter bottom trawl vessel 31 kg of sole was discarded (Table 3.2.2). Per hour less than 1 kg sole was discarded (Table 3.3.6) which resulted in a discard percentage of 14% (in weight).

Sole was discarded up to 26 cm during the beam trawl trips. The peak of the discard length distribution was around 22 cm (Table 3.3.8, Figure 3.4.1). Most sole discards were between ages 1 and 2, with most discards being 1 (Table 3.3.9).

Landings and discards in numbers at age were raised to fleet level for beam trawl vessels larger than 300 HP (Table 3.3.10). No trips were sampled during the third quarter of 2006.

Dab
On average 6169 kg of dab was discarded per trip by the beam trawl vessels (CV 80%, Table 3.2.2). Per hour on average 79 kg was discarded compared to 9 kg landed (Table 3.3.11). The average discard percentage was 98% in numbers and 90% in weight. Per quarter the discard percentage varied in weight between 82% and 94% (Table 3.3.12).
On board of the otter bottom trawl vessel 3380 kg of dab was discarded (Table 3.2.2). Per hour 44 kg was discarded compared to 5 kg landed. This resulted in an average discard percentage of 89% per hour (Table 3.3.11).

Cod
On average 38 kg of cod was discarded per trip by the beam trawl vessels (CV 80%, Table 3.2.2). Per hour less than 1 kg cod was discarded (Table 3.3.13). The average discard percentage was 17% in weight. This estimate is however highly uncertain because of the low catches, expressed by the discard percentage in weight per quarter varying between 6% and 52% (Table 3.3.14).

Whiting
On average 195 kg of whiting was discarded per trip by the beam trawl vessels (CV 67%, Table 3.2.2). Discards in weight were higher than landings with less than 1 kg whiting landed to 3 kg discarded per hour (Table 3.3.15). The average discard percentage was 74% in weight. As the number of landings were not measured, the discard percentage could not be calculated. Per quarter the discard percentage in weight varied between 59% and 87% (Table 3.3.16).

4 Discussion

Although the discard sampling programme of beam trawl vessels larger than 300 HP covers the most important fleet fishing for the North Sea plaice and sole, it does not entirely cover the fishing ground of this fleet. However, the programme is assumed to give realistic indication on the level of discarding for the more abundant species. Unfortunately, due to the limited number of observations (coverage 0.24% in hpeffort), temporal and spatial distribution of fishing effort of this fleet cannot be fully covered. Estimates of total discards for less abundant species, especially those which show large seasonal and spatial differences in discarding, are considered very uncertain.

Plaice is, next to sole, the most important target species of the Dutch beam trawl fishery. The discard percentage of plaice in 2006 was on average 86% in numbers and 54% in weight, which is a similar percentage as in previous years (on average 80% in number, 50% in weight). In 2004 most landings were from the strong 2001 year class. During 2002-2003 the strong 2001 year class dominated the discards fraction. In 2004 and 2005 most landings were from this yearclass. This year (2006) The 2001 year class, at the age of 5, was still the most abundant year class in the landings.

Although the discard percentage of plaice observed in 2006 is similar to recent years, the percentages are higher than that observed during 1976-1990 (48% in numbers and 25% in weight, Table 4.1). Since the late 1990's a shift in the spatial distribution of juvenile plaice is apparent, through which relatively small and undersized plaice move outside the 12-miles zone and plaice box, towards deeper, more offshore water. As a consequence, they recruit earlier on the fishing grounds at smaller sizes (Pastoors et al., 2000; Grift et al., 2004; Van Keeken et al., 2004a; van Keeken et al., 2007). The smallest size of the plaice caught in recent discards trips corresponds to those lengths at which plaice in the 1970s and '80s were only caught inside the 12-mile zone and the plaice box, a coastal nursery area for plaice which is now closed to larger beamers (Rijnsdorp and Van Beek, 1991; ICES, 1999; Van Keeken and Pastoors, 2004). The more offshore distribution could be caused by changes in water temperature, predation risk, or intra- and inter-specific competitive interactions (Van Keeken et al., 2004b; Van Keeken et al., 2007). The high discard rates, observed in recent years are not only caused by larger catches of discards. Since the rate also depend on the amount of landings, the decrease in landings also contributed to the increase in plaice discard rates (Table 4.1).

The discard percentage of sole in 2006 was within the range of discard percentages observed in earlier years (29% in numbers and 13% in weight, Table 4.2). Most discards in 2006 were from the 2005 year class at the age 1 (Table 3.3.9).

Landings and discards in numbers at age for plaice and sole were raised to fleet level for beam trawl vessels larger than 300 HP per quarter and per year (Tables 3.3.5 and 3.3.10). In order to raise to quarter level, results from each trip within the specific quarter were used. As no sampling was conducted during the third quarter of 2006, the landings and discards for plaice and sole could not be raised for this quarter. However, effects on estimations of total discards in 2006 will be marginal, since aggregated annual effort data is used to raise the data.

As in previous years, the catches of cod were very low. It is very clear that the absolute numbers caught have decreased substantially compared to the 1970s and 1980s (Van Keeken and Pastoors, 2004). The main reason for the low cod catch is a depleted stock in the southern part of the North Sea where the beam trawlers operate. The discard rates calculated from these low catch numbers cannot be estimated with sufficient precision by the present programme and are not representative for the fleet.

In 2007 raised discard data from the UK, Denmark and the Netherlands were combined in the Northsea stock assessment for plaice. These countries contribute to approximately 85% of the landings. Up to 2003 discards have only been included into the stock assessments carried out

by ICES of haddock and whiting (ICES, 2002), but from 2004 a discards time series has also been used in the assessment of North Sea plaice. This time series was reconstructed using a modeling approach using historical discard observations for calibration and recent observations from discards trips during 1999-2005 (ICES, 2004c, 2005; Van Keeken et al., 2005; Van Keeken, 2006). In 2005 recent observations were derived only from the Dutch sampling programme while in 2006 also English observations were used.

In 2004 the Dutch fisheries sector through "Productschap Vis[1]" instigated a discards self-sampling programme (plaice only), whereby plaice discards were measured weekly onboard of a dozen commercial trawl vessels by fishermen themselves (detailed by week and area). Twice a week the volume of both discards and landings were measured from a single haul. The fisheries industry discards sampling programme covers the spatial and temporal variation, while research sampling yields the required level of detail and ensures the quality of the data.

The combination of both sampling programmes may achieve an adequate sampling programme. However, a substantial difference in the discard estimates was found between the two sampling methods (Aarts & Van Helmond, 2007). It is therefore essential to investigate the cause of this difference before these programmes are combined and continued. At present, it is thought that this difference may be explained by the different sampling methods that are used. Further research in uncovering these differences is planned in 2008.

[1] The Dutch Fish Product Board

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References

Aarts, G. M. and A.T.M. van Helmond. 2007. Discard sampling of Plaice (*Pleuronectes platessa*) and Cod (*Gadus morhua*) in the North Sea by the Dutch demersal fleet from 2004 to 2006. IJmuiden, Report number C120/07: 42 p.

Alverson, D. L., M. H. Freeberg, J. P. Pope and S. A. Murawski. 1994. A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper. NO. 339. Rome, FAO: 233 p.

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, Blackwell Science: 163-184.

Catchpole, T. L., C. L. J. Frid and T. S. Gray. 2005. Discards in North Sea fisheries: causes, consequences and solutions. Marine Policy 29: 421-430.

Dickey-Collas, M., M.A. Pastoors and O.A. van Keeken. 2007. Precisely wrong or vaguely right: simulations of noisy discard data and trends in fishing effort being included in the stock assessment of North Sea plaice. Journal of Marine Science 64: 1641-1649.

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. 2004. The state of world fisheries and aquaculture. Rome, FAO: 153 p.

Grift, R. E., I. Tulp, L. Clarke, U. Damm, A. McLay, S. Reeves, J. Vigneau and W. Weber. 2004. Assessment of the ecological effects of the Plaice Box. Report of the European Commission Expert Working Group to evaluate the Shetland and Plaice boxes. Brussels: 121 p.

ICES. 1999. Workshop on the evaluation of the plaice box, IJmuiden, 22-25 June 1999. ICES CM 1999/D:6.

ICES 2000. Report of the study group on discard and by-catch information, Copenhagen, Denmark. ICES CM 2000/ACFM:11.

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.

ICES. 2004a. Report of the ICES Advisory Committee on Fishery Management and Advisory Committee on Ecosystems, 2004, ICES Advice 1 (2): 1520 p.

ICES. 2004b. Report of the planning group on commercial catch, discards and biological sampling, 2-5 March, Mallorca, Spain. ICES CM 2004/ACFM:13.

ICES. 2004c. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, Bergen, Norway, 7-16 September 2004. ICES CM 2005/ACFM:07.

ICES. 2005. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 6-15 September 2005, ICES headquarters Copenhagen. ICES CM 2006/ACFM:09.

ICES. 2006. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 5-14 Septemer 2006, ICES headquarters Copenhagen. ICES ACFM:35. 1160pp.

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.

Pastoors, 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 Beek, F. A. 2001. Offerte voor het verzamelen en beheren van gegevens die essentieel zijn voor het gemeenschappelijk visserij beleid. RIVO offerte 01.063. IJmuiden, RIVO: 38 p.

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

Van Keeken, O. A. and M. A. Pastoors. 2004. Discard sampling of the Dutch beam trawl fleet in 2003. IJmuiden, CVO report nr 04.024: 55 p.

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

Van Keeken, O. A., M. Van Hoppe, R. E. Grift and A. D. Rijnsdorp. 2004b. The effect of changes in the spatial distribution of juvenile plaice (Pleuronectes platessa) in the North Sea on the management of its stocks. ICES C.M. 2004/K:25.

Van Keeken, O. A., M. A. Pastoors and A. D. Rijnsdorp. 2005. Discard reconstruction method used in the assessment of North Sea plaice in 2004. IJmuiden, RIVO report C032/05: 20 p.

Van Keeken, O. A. and M. A. Pastoors. 2005. Discards sampling of the Dutch beam trawl fleet in 2004. IJmuiden, CVO report 05.006: 56 p.

Van Keeken O.A. 2006. Discard sampling of the Dutch beam trawl fleet in 2005. IJmuiden, Report C061/06.

Van Keeken, O. A., M. Van Hoppe, R. E. Grift and A.D. Rijnsdorp. 2007. Changes in the spatial distribution of North Sea plaice (*Pleuronectes platessa*) and implications for fisheries management. Journal ofSea REsearch (57): 187-197.

Appendix I: Raising procedures

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		hour
		o	
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 in number of trips		
E	total fleet effort in number of trips		
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 (Σu_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:

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

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.

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 ($n_{l,t,s}$). 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 number landings or discards at length per hour per trip ($CN_{l,o,t,s}$) over all trips in that period (p) and then dividing this by the total number of trips (U_t) in this period:

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

Total numbers discards or landings ($CN_{o,p,s}$) were calculated by summing over length. Trips were 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 were 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 number of landings or discards at age per hour per trip ($CN_{a,o,t,s}$) over all trips in that period (p) and then dividing this by the total number of trips (U_t) in this period:

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

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 ($e_{p,f}$).

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

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

Appendix II: Tables and Figures

Table 2.1.1. Characteristics per trip sampled in 2006. For each vessel the gear (TBB=beam trawl, OTB=otter bottom trawl), the engine power in KW, the mesh size in mm and sampled ICES rectangles are represented.

Mesh	Gear	Vessel	KW	Quarter	Sampled ICES rectangles
80	TBB	R70	1471	1	36/F3, 36/F4, 37/F3, 37/F4
		R71	1471	1	36/F4, 36/F5, 37/F4, 37/F5, 38/F4, 38/F5
		R72	1467	1	33/F3, 33/F4, 34/F4, 35/F4, 36/F3, 36/F4, 36/F5, 37/F4, 37/F5, 38/F4, 38/F5
		R73	1471	1	36/F4, 37/F4
		R74	1471	2	32/F2, 32/F3, 33/F2, 33/F3, 33/F4, 34/F4
		R75	1467	2	32/F3, 33/F3, 33/F4
		R76	1471	2	36/F2, 36/F3
		R77	1471	4	34/F2, 34/F3, 35/F2, 35/F3
		R80	1765	4	31/F1, 31/F2, 32/F2, 33/F2
80	OTB	R79	1103	4	36/F4 37/F4 37/F5 38/F4

Table 3.1.1. Sampling effort per trip sampled in 2006. For each trip the duration and number of hauls sampled for landings and discards and total duration and number of hauls for the total trips are given, and the number of plaice, dab and sole otoliths taken from the discard fraction.

Mesh size	Gear	Vessel	Number of hauls			Duration (hours)			Plaice Otolith	Dab Otolith	Sole Otolith
			Land	Disc	Tot	Land	Disc	Tot			
80	TBB	R70	18	28	37	38	59	78	39	22	14
		R71	36	36	48	75	75	102			
		R72	34	34	44	67	67	87			
		R73	31	31	43	64	64	88			
		R74	29	34	46	51	60	82	36	25	
		R75	22	27	32	45	55	65	38	31	
		R76	27	36	43	46	61	73	29	26	
		R77	18	28	42	36	56	84	22	23	13
		R80	7	9	32	13	17	64	15	13	18
80	OTB	R79	4	15	30	11	39	77			
		Total	**226**	**278**	**397**	**446**	**553**	**800**	**179**	**140**	**45**
		%Total	**57%**	**70%**		**56%**	**69%**				

Table 3.1.2. Sampling effort in 2006 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 using 80 mm mesh size and using beam trawl (fleet data from VIRIS), and fleet coverage by the sampled trips.

Quarter	Vessel	Sampled effort		Fleet effort		Fleet coverage	
		D.A.S.	HPeff	D.A.S.	HPeff	D.A.S.	HPeff
1	R70	4	8096				
	R71	5	10120				
	R72	4	7980				
	R73	4	8096				
	Total	17	34292	4920	11158815	0.35%	0.31%
2	R74	4	8000				
	R75	4	7980				
	R76	4	8000				
	Total	12	23980	3893	8703607	0.31%	0.28%
4	R77	4	8000				
	R80	3	7200				
	Total	7	15200	4873	11034931	0.14%	0.14%
All	**Total**	**36**	**73472**	**13686**	**30897353**	**0.26%**	**0.24%**

Table 3.2.1a. Total landings weight per trip in 2006 for plaice, sole, cod, whiting, dab, turbot and brill for the beam trawl vessels (TBB) and for the otter bottom trawl vessel (OTB) larger than 300HP using 80 mm cod-end mesh size.

Mesh	Gear	Vessel	Quar	Plaice	Sole	Cod	Whiting	Dab	Turbot	Brill
80	TBB	R70	1	7812	1126	345	15	744	183	43
		R71	1	9624	1283	460	26	1465	297	68
		R72	1	2545	1037	278	7	721	193	78
		R73	1	2466	1368	231	20	1569	186	68
		R74	2	1275	1743	71	61	370	149	38
		R75	2	3857	882	21	40	745	178	19
		R76	2	6180	924	48	15	438	303	106
		R77	4	4098	1738	129	7	120	182	155
		R80	4	3507	1082	231	372	260	223	227
80	OTB	R79	4	3078	187	27	12	422	172	45
			All	**44442**	**11370**	**1841**	**575**	**6854**	**2066**	**847**

Table 3.2.1b. Sampled landings weight per trip in 2006 for plaice, sole, cod, whiting, dab, turbot and brill for the beam trawl vessels (TBB) and for the otter bottom trawl vessel (OTB) larger than 300 HP using 80 mm cod-end mesh size.

Mesh	Gear	Vessel	Quar	Plaice	Sole	Cod	Whiting	Dab	Turbot	Brill
80	TBB	R70	1	99	124	0	0	12	17	9
		R71	1	1050	636	467	0	0	0	0
		R72	1	440	771	125	0	0	0	0
		R73	1	675	752	39	0	0	0	0
		R74	2	122	182	25	0	31	9	4
		R75	2	122	107	0	0	74	21	3
		R76	2	104	104	0	0	17	43	22
		R77	4	79	94	0	0	0	8	6
		R80	4	85	51	0	0	0	0	0
80	OTB	R79	4	40	0	0	0	0	0	0
			All	**2816**	**2821**	**656**	**0**	**134**	**98**	**44**

Table 3.2.2. Total weight (kg) in 2006 of all discards per trip (fish and benthos) and of plaice, sole, dab, cod and whiting for the beam trawl vessels (TBB) and for the otter bottom trawl vessel (OTB) larger than 300 HP using 80 mm cod-end mesh size.

Mesh	Gear	Vessel	All discards	Plaice	Sole	Dab	Cod	Whiting
80	BT	R70	44376	7753	89	6121	27	143
		R71	56533	10098	214	11470	27	41
		R72	51113	2827	55	4065	7	36
		R73	57600	7074	202	6992	25	199
		R74	36951	5079	91	4240	91	380
		R75	32616	6827	32	16249	50	274
		R76	35965	4053	15	4493	9	86
		R77	16361	3454	890	1100	23	220
		R80	12843	1597	130	795	85	376
		Mean	**38262**	**5418**	**191**	**6169**	**38**	**195**
		CV	**42%**	**50%**	**142%**	**80%**	**80%**	**67%**
80	OUT	R79	10357	2610	31	3380	4	26
		Mean	**10357**	**2610**	**31**	**3380**	**4**	**26**

Table 3.2.3a. Numbers of fish discarded per hour in 2006 for the beam trawl vessels (TTB) and the otter bottom trawl vessel (OTB) larger than 300 HP using 80 mm cod-end mesh size.

Latin name	Dutch name	TBB	OTB
Ammodytes sp.	Ammodytes	6.1	
Anchovy	Ansjovis		0.3
Anglerfish	Zeeduivel	0.1	
Brill	Griet	0.3	
Bull-rout	Zeedonderpad	5.7	
Cod	Kabeljauw	4.6	0.2
Dab	Schar	1603.4	799.6
Dragonet	Pitvis	75.6	5.1
Five-bearded rockling	Vijfdradige meun	0.1	
Flounder	Bot	3.4	
Four-bearded rockling	Vierdradige meun	12.3	
Garfish	Geep	0.1	
Greater pipefish	Grote zeenaald	<0.1	
Greater sand-eel	Smelt	7.9	
Greater weever	Grote pieterman	0.1	
Grey gurnard	Grauwe poon	68.3	92
Hake	Heek	<0.1	
Herring	Haring	19.9	
Hooknose	Harnasmannetje	3.4	2.5
Horse mackerel	Horsmakreel	2.8	
John Dory	Zonnevis	<0.1	
Lemon sole	Tongschar	2.7	1.5
Lesser spotted dogfish	Hondshaai	0.2	
Lesser weever	Kleine pieterman	9.8	
Long rough dab	Lange schar	4.9	7.0
Lumpsucker	Snotolf	<0.1	
Mackerel	Makreel	0.1	
Nilsson's pipefish	Kleine zeenaald	0.2	
Plaice	Schol	997.1	331.5
Pomatoschistus sp.	Grondel	1.5	
Poor cod	Dwergbolk	0.5	
Red gurnard	Engelse poon	2.2	
Reticulated dragonet	Rasterpitvis	0.1	
Roker	Stekelrog	<0.1	
Sand sole	Franse tong	0.2	
Scaldfish	Schurftvis	185.1	19.2
Sea bass	Zeebaars	0.1	
Sea-snail	Slakdolf	0.1	
Smoothhound	Gladde haai	<0.1	
Snake pipefish	Adderzeenaald	0.6	
Sole	Tong	26.0	4.8
Solenette	Dwergtong	148.6	11.6
Spotted ray	Gevlekte rog	<0.1	
Sprat	Sprot	15.5	2.2
Striped red mullet	Mul	3.9	2.1
Tope	Ruwe haai	<0.1	
Topknot	Gevlekte griet	<0.1	
Tub gurnard	Rode poon	11.5	1.1
Twaite shad	Fint	0.1	
Whiting	Wijting	35.7	8.4
Bib	Steenbolk	3.2	

Table 3.2.3b. Numbers of benthic species discarded per hour in 2006 for beam trawl vessels (TBB) and for the otter bottom trawl vessel (OTB) larger than 300 HP using 80 mm cod-end mesh size.

Latin name	Dutch name	TBB	OTB
Acanthocardia echinata	Gedoornde Hartschelp	63.6	1.5
Aequipecten opercularis	Wijde mantel	3.3	
Alcyonium digitatum	Dodemansduim	1.2	6.9
Alloteuthis subulata	Dwergpijlinktvis		0.2
Anthozoa	Zeeanemonen	5.5	
Aphrodita aculeate	Fluwelen zeemuis	918.6	111.8
Arctica islandica	Noordkromp	6.7	0.3
Ascidiacea	Zakpijp	1.8	
Asterias rubens	Zeester	1586.0	2762.1
Astropecten irregularis	Kamster	3570.1	5328.6
Buccinum undatum	Wulk	13.8	
Cancer pagurus	Noordzeekrab	0.8	2.0
Carcinus maenas	Strandkrab	0.1	
Chamelea gallina	Venusschelp	0.1	
Corystes cassivelaunus	Helmkrab	300.2	98.9
Crangon crangon	Gewone garnaal	51.8	
Echinidae	Zeeegels	126.7	
Echinocardium cordatum	E. cordatum	3528.1	80.2
Ensis sp.	Ensis	12.5	
Flustra foliacea	Bladachtig hoornwier	1.5	
Goneplax rhomboides	G. rhomboides	19.2	0.5
Hyas sp.	Spinkrab	1.1	
Liocarcinus depurator	Blauwpootzwemkrab	31.2	132.9
Liocarcinus holsatus	Gewone zwemkrab	4158.4	940.1
Liocarcinus marmoreus	Gemarmerde zwemkrab	0.6	
Loligo sp.	Loligo	0.1	
Luidia sp.	Luidia	6.4	
Lunatia catena	Grote tepelhoorn	0.1	
Modiolus modiolus	Paardemossel	0.1	
Mytilus edulis	Mossel	0.2	
Necora puber	Fluwelen zwemkrab	4.7	0.2
Neptunea antique	Noordhoorn	0.1	
Nereis sp.	Zager	1.5	
Norway lobster	Noorse kreeft	27.9	26.4
Octopus vulgaris	Octopus	<0.1	
Ophiura ophiura	Slangster	531.9	304.8
Pagurus bernhardus	P. bernhardus	154.4	162.9
Pagurus sp.	Pagurus sp.	143.6	
Pecten maximus	St. Jacobsschelp	2.3	1.1
Psammechinus miliaris	Zeeappel	16.1	
Sepia officinalis	Zeekat	5.3	
Sepia sp.	Sepia	<0.1	
Spatangus purpureus	Purperen zeeklit	0.9	
Spisula sp.	Spisula	3.2	

Table 3.3.1. Plaice. Landings (L), discards (D) and percentage discards (%D) per hour in numbers (left) and weight (right) for beam trawl vessels (TBB) and the otter bottom trawl vessel (OTB) larger than 300 HP using 80 mm cod-end mesh size in 2006.

				Numbers			Weight		
Mesh	**Gear**	**Vessel**	**Quart**	**L**	**D**	**%D**	**L**	**D**	**%D**
80	TBB	R70	1	235	1710	88%	100	100	50%
		R71	1	296	1419	83%	95	99	51%
		R72	1	93	609	87%	29	33	53%
		R73	1	112	1385	93%	28	80	74%
		R74	2	52	1046	95%	16	62	80%
		R75	2	213	1493	88%	59	105	64%
		R76	2	217	716	77%	84	55	40%
		R77	4	91	385	81%	49	41	46%
		R80	4	188	211	53%	55	25	31%
			Mean	**166**	**997**	**86%**	**57**	**67**	**54%**
80	OTB	R79	4	116	332	74%	40	34	46%
			Mean	**116**	**332**	**74%**	**40**	**34**	**46%**

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 vessels larger than 300 HP using 80 mm cod-end mesh size in 2006.

	Numbers			Weight		
Quarter	**L**	**D**	**%D**	**L**	**D**	**%D**
1	184	1281	87%	63	78	55%
2	120	993	89%	61	69	53%
4	139	298	68%	52	33	39%

Table 3.3.3. Plaice. Number landed and discarded per hour per length class for beam trawl vessels (TBB) and the otter bottom trawl vessel (OTB) larger than 300 HP using 80 mm cod-end mesh in 2006.

Length	TBB >300 HP, 80 mm		OTB >300 HP, 80 mm	
(cm)	Discards	Landings	Discards	Landings
8	0.3			
9	0.5			
10	3.7			
11	9.5			
12	22.7			
13	37.9			
14	48.0			
15	59.2		0.2	
16	66.6		2.5	
17	89.9		7.8	
18	111.3		22.0	
19	107.4		32.2	
20	104.7		39.4	
21	81.4		34.4	
22	71.2		32.4	
23	65.9	0.1	26.9	
24	52.0	0.1	44.6	
25	39.3	0.6	46.6	
26	19.0	4.4	38.6	
27	4.4	20.5	4.0	19.0
28	1.2	21.4		20.0
29	1.0	17.2		18.0
30		16.6		18.0
31		14.4		10.0
32		13.8		6.0
33		10.9		6.0
34		9.8		5.0
35		8.0		4.0
36		6.7		2.0
37		5.8		2.0
38		4.7		2.0
39		3.8		2.0
40		2.2		2.0
41		1.6		
42		1.3		
43		0.9		
44		0.3		
45		0.6		
46		0.2		
47		0.1		
48		0.1		
49		0.1		
50		<0.1		

Table 3.3.4. Plaice. Numbers landed (L) and discarded (D) calculated at age per hour per quarter and per year for beam trawl vessels larger than 300 HP using 80 mm cod-end mesh size in 2006.

	Quarter 1		Quarter 2		Quarter 4		Year	
Age	**D**	**L**	**D**	**L**	**D**	**L**	**D**	**L**
0	3		1				2	
1	439		569	<0.1	120	4	411	3
2	541	8	425	74	86	27	401	34
3	293	27	82	35	73	41	174	33
4	3	27	8	15	15	16	7	21
5	4	57	0.9	16	4	23	3	36
6	0.1	18	0.6	5		8	0.3	12
7	0.3	20	0.2	5	0.2	8	0.2	12
8	0.2	12		2		5	0.2	7
9		8		2		2		5
10		7		1	0.2	5	0.2	5

Table 3.3.5. Plaice. Landings (L) and discards D) raised estimates of total fleet numbers (*1000) and mean length at age (cm), total weight (*1000) tonnes and mean weight at age (kg) per quarter and at age per year for beam trawl vessels larger than 300 HP using 80 mm cod-end mesh size in 2006.

		Numbers (*1000)		Mean length		Weight (*1000)		Mean weight	
Quarter	**Age**	**D**	**L**	**D**	**L**	**D**	**L**	**D**	**L**
1	0	214		8.4		1		0.00	
	1	49599		14.3		1336		0.03	
	2	62383	949	19.3	27.8	4080	183	0.06	0.19
	3	34171	3126	22.4	30.4	3470	806	0.10	0.26
	4	408	3181	26.2	32.0	66	971	0.16	0.30
	5	446	6707	26.3	32.8	73	2197	0.16	0.33
	6	9	2122	28.5	33.5	2	749	0.21	0.35
	7	16	2319	28.6	33.0	3	782	0.21	0.34
	8	5	1412	29.0	33.8	1	510	0.22	0.36
	9		953		34.9		381		0.40
	10		787		36.3		355		0.45
	All	**147251**	**21556**	**203.0**	**294.5**	**9032**	**6934**	**1.15**	**2.98**
2	0	77		8.4		0		0.00	
	1	44170	1	17.1	24.0	2047	0	0.05	0.12
	2	33758	5630	21.0	28.3	2877	1150	0.08	0.20
	3	6815	2747	23.3	29.9	783	680	0.11	0.25
	4	457	1226	26.2	32.2	74	384	0.16	0.31
	5	25	1331	28.8	32.9	5	449	0.21	0.34
	6	16	444	29.0	33.1	3	151	0.22	0.34
	7	4	469	28.0	33.1	1	162	0.20	0.34
	8		134		37.5		64		0.48
	9		224		36.3		99		0.44
	10		129		38.4		67		0.52
	All	**85322**	**12335**	**181.8**	**325.7**	**5790**	**3206**	**1.03**	**3.34**
4	0								
	1	13506	404	22.0	27.9	1323	80	0.10	0.20
	2	9739	2734	22.7	29.0	1050	608	0.11	0.22
	3	7719	4181	23.8	29.8	934	1024	0.12	0.24
	4	1740	1662	26.6	31.4	294	482	0.17	0.29
	5	354	2371	26.4	32.9	58	820	0.16	0.35
	6		866		34.5		348		0.40
	7	15	783	29.0	35.2	3	325	0.22	0.41
	8		460		36.2		205		0.44
	9	15	175	29.0	41.6	3	116	0.22	0.66
	10	**33088**	555	**179.5**	35.4	**3665**	237	**1.10**	0.43
	All		**14191**		**333.9**		**4245**		**3.64**
All		382		8.4		2		0.01	
	0	141073		15.9		6189		0.04	
	1	139238	533	20.0	27.9	10530	105	0.07	0.20
	2	64049	12247	22.6	28.3	6821	2553	0.10	0.21
	3	3425	13222	26.4	30.1	571	3301	0.16	0.25
	4	1085	7982	26.4	31.9	180	2416	0.17	0.30
	5	33	13689	28.8	32.8	7	4558	0.21	0.33
	6	46	4514	28.6	33.6	10	1641	0.21	0.36
	7	7	4696	29.0	33.2	1	1670	0.22	0.35
	8		2639		34.3		1025		0.38
	9	19	1778	29.0	35.6	4	783	0.22	0.42
	10	**349357**	1934	**235.1**	36.3	**24315**	866	**1.41**	0.45

Quarter	Age	Numbers (*1000) D	Numbers (*1000) L	Mean length D	Mean length L	Weight (*1000) D	Weight (*1000) L	Mean weight D	Mean weight L
	All		63234		324		18918		3.25

Table 3.3.6. Sole. Landings (L), discards (D) and percentage discards (%D) per hour in numbers (left) and weight (right) for beam trawl vessels (TBB) and for the otter bottom trawl vessel (OTB) larger than 300 HP fishing using 80 mm cod-end mesh size in 2006.

				Numbers			Weight		
Mesh	**Gear**	**Vessel**	**Quart**	**L**	**D**	**%D**	**L**	**D**	**%D**
80	TBB	R70	1	50	28	36%	14	1	7%
		R71	1	49	23	32%	13	2	14%
		R72	1	47	7	13%	12	<1	5%
		R73	1	60	24	29%	16	2	13%
		R74	2	72	13	15%	21	1	5%
		R75	2	56	6	9%	14	<1	3%
		R76	2	41	3	7%	13	<1	2%
		R77	4	81	108	57%	21	11	34%
		R80	4	120	23	16%	17	2	11%
			Mean	**64**	**26**	**29%**	**16**	**2**	**13%**
80	OTB	R79	4	*nm*	5		2	<1	14%
			Mean				**2**	**<1**	**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 beam trawl vessels larger than 300 HP using 80 mm cod-end mesh size in 2006.

	Numbers			Weight		
Quarter	**L**	**D**	**%D**	**L**	**D**	**%D**
1	52	21	28%	14	2	10%
2	56	7	11%	16	<1	4%
4	100	65	39%	19	6	25%

Table 3.3.8. Sole. Number landed and discarded per hour per length class for beam trawl vessels larger than 300 HP using 80 mm cod-end mesh size in 2006.

Length (cm)	TBB >300 HP, 80 mm	
	Disc	Land
8		
9	0.2	
10		
11	0.1	
12	0.4	
13	0.6	
14	1.2	
15	0.5	
16	0.1	
17	0.2	
18	0.2	<0.1
19	1.2	<0.1
20	3.0	<0.1
21	5.4	<0.1
22	6.2	0.1
23	4.6	2.4
24	1.5	7.8
25	0.4	8.0
26	0.1	7.3
27		6.1
28		5.4
29		4.7
30		4.0
31		3.7
32		3.2
33		2.8
34		2.5
35		1.9
36		1.2
37		0.9
38		0.7
39		0.4
40		0.3
41		0.2
42		0.1
43		0.1
44		0.1
45		<0.1
46		<0.1
47		<0.1
48		<0.1
49		<0.1
50		

Table 3.3.9. Sole. Numbers landed (L) and discarded (D) calculated at age per hour per quarter and per year for beam trawl vessels larger than 300 HP using 80 mm cod-end mesh size in 2006.

	Quarter 1		Quarter 2		Quarter 4		Year	
Age	**D**	**L**	**D**	**L**	**D**	**L**	**D**	**L**
0	0.1				2		0.9	
1	6		1		56	21	16	21
2	9	4	2	2	3	20	6	7
3	1	9	2	12	2	15	2	12
4	2	10	0.9	11	2	17	2	12
5	0.1	9	1	20	0.8	16	0.5	14
6	1	6	0.2	4		2	1	4
7	0.1	5		4	0.2	5	0.1	5
8	<0.1	4		1		1	<0.1	2
9	<0.1	2		2		0.8	<0.1	2
10	0.1	4		1	0.2	2	0.1	3

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 and at age per year for beam trawl vessels larger than 300 HP using 80 mm cod-end mesh size in 2006.

		Numbers (*1000)		Mean length		Weight (*1000)		Mean_weight	
Quarter	**Age**	**D**	**L**	**D**	**L**	**D**	**L**	**D**	**L**
1	0	2		7.5		0		0.00	
	1	645		13.6		14		0.02	
	2	1077	437	21.1	24.8	96	66	0.09	0.15
	3	181	1058	23.1	27.5	21	235	0.12	0.22
	4	250	1109	22.1	29.2	26	302	0.10	0.27
	5	11	1031	24.1	30.0	1	313	0.14	0.30
	6	172	646	23.0	28.6	20	172	0.12	0.27
	7	10	581	24.0	29.6	1	175	0.14	0.30
	8	0	411	29.0	32.0	0	153	0.25	0.37
	9	0	213	29.0	32.1	0	83	0.25	0.39
	10	14	471	24.0	29.3	2	142	0.13	0.30
	All	**2362**	**5957**	**240.5**	**263.1**	**181**	**1641**	**1.36**	**2.57**
2	0								
	1	119		15.8		4		0.04	
	2	201	164	20.2	24.8	16	25	0.08	0.15
	3	162	972	21.5	28.9	15	250	0.09	0.26
	4	53	894	23.1	28.8	6	231	0.12	0.26
	5	55	1584	23.2	30.3	7	493	0.12	0.31
	6	6	308	25.0	29.5	1	88	0.15	0.29
	7		336		30.1		103		0.31
	8		95		32.6		39		0.41
	9		96		32.1		36		0.37
	10		91		33.5		39		0.43
	All	**596**	**4540**	**128.8**	**270.6**	**49**	**1304**	**0.60**	**2.79**
4	0	77		9.0		0		0.00	
	1	6623	2178	21.6	24.8	634	334	0.10	0.15
	2	332	2059	22.5	26.4	37	395	0.11	0.19
	3	175	1608	23.8	27.9	23	377	0.13	0.23
	4	253	1762	22.8	27.3	29	391	0.12	0.22
	5	95	1641	24.3	28.0	13	401	0.14	0.24
	6		240		30.7		78		0.33
	7	12	499	26.0	28.5	2	131	0.18	0.6
	8		153		31.1		53		0.35
	9		80		29.7		22		0.28
	10	11	224	25.0	26.4	2	46	0.15	0.20
	All	**7578**	**10444**	**175.0**	**280.8**	**740**	**2228**	**0.93**	**2.45**
All	0	103		8.9		0		0.00	
	1	9714	2864	20.0	24.8	857	440	0.08	0.15
	2	2117	3497	21.1	25.8	196	639	0.09	0.18
	3	682	4785	22.7	28.1	79	1133	0.11	0.24
	4	731	4951	22.4	28.5	81	1216	0.11	0.25
	5	211	5597	23.7	29.7	28	1588	0.13	0.29
	6	235	1571	23.1	29.1	28	445	0.12	0.28
	7	28	1863	24.7	29.5	4	538	0.15	0.29
	8	0	867	29.0	32.0	0	322	0.25	0.37
	9	0	513	29.0	31.9	0	185	0.25	0.37
	10	33	1034	24.3	29.4	5	299	0.14	0.30
	All	**13854**	**27542**	**248.9**	**288.8**	**1278**	**6805**	**1.43**	**2.72**

Table 3.3.11. Dab. Landings (L), discards (D) and percentage discards (%D) per hour in numbers (left) and weight (right) for beam trawl vessels (TBB) and for the otter bottom trawl vessel (OTB) larger than 300 HP using 80 mm cod-end mesh size in 2006. *nm*=not measured.

				Numbers			Weight		
Mesh	**Gear**	**Vessel**	**Quart**	**L**	**D**	**%D**	**L**	**D**	**%D**
80	TBB	R70	1	56	1870	97%	10	79	89%
		R71	1	*nm*	2134		14	113	89%
		R72	1	*nm*	839		8	47	85%
		R73	1	*nm*	1704		18	79	82%
		R74	2	25	1173	98%	5	52	92%
		R75	2	62	5055	99%	11	250	96%
		R76	2	41	1244	97%	6	61	91%
		R77	4	*nm*	253		1	13	90%
		R80	4	*nm*	158		4	13	75%
			Mean	**46**	**2335**	**98%**	**9**	**79**	**90%**
80	OTB	R79	4	*nm*	800		5	44	89%
			Mean				**5**	**44**	**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 beam trawl vessel larger than 300 HP using 80 mm cod-end mesh size in 2006.

	Numbers			Weight		
Quarter	**L**	**D**	**%D**	**L**	**D**	**%D**
1	56	1637	97%	13	79	86%
2	43	2490	98%	7	121	94%
4		206		3	13	82%

Table 3.3.13. Cod. Landings (L), discards (D) and percentage discards (%D) per hour in numbers (left) and weight (right) for beam trawl vessels (TBB) and for the otter bottom trawl vessel (OTB) larger than 300 HP using 80 mm cod-end mesh size in 2006. *nm*=not measured.

				Numbers			Weight		
Mesh	**Gear**	**Vessel**	**Quart**	**L**	**D**	**%D**	**L**	**D**	**%D**
80	TBB	R70	1	*nm*	8		4	<1	7%
		R71	1	2	3	58%	5	<1	6%
		R72	1	1	<1	22%	3	<1	3%
		R73	1	1	3	68%	3	<1	10%
		R74	2	1	4	74%	<1	1	56%
		R75	2	*nm*	3		<1	<1	70%
		R76	2	*nm*	<1		<1	<1	16%
		R77	4	*nm*	4		2	<1	15%
		R80	4	*nm*	16		4	1	27%
			Mean	**2**	**3**	**63%**	**2**	**<1**	**17%**
80	OTB		4	*nm*	<1		<1	<1	13%
			Mean				**<1**	**<1**	**13%**

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 beam trawl vessel larger than 300 HP using 80 mm cod-end mesh size in 2006.

	Numbers			Weight		
Quarter	**L**	**D**	**%D**	**L**	**D**	**%D**
1	2	3	69%	4	<1	6%
2	1	3	64%	<1	<1	52%
4		10		3	<1	24%

Table 3.3.15. Whiting. Landings (L), discards (D) and percentage discards (%D) per hour in numbers (left) and weight (right) for beam trawl vessels (TBB) and for the otter bottom trawl vessel (OTB) larger than 300 HP using 80 mm cod-end mesh size in 2006. *nm*=not measured.

				Numbers			Weight		
Mesh	**Gear**	**Vessel**	**Quart**	**L**	**D**	**%D**	**L**	**D**	**%D**
80	TBB	R70	1	*nm*	33		<1	2	91%
		R71	1	*nm*	7		<1	<1	61%
		R72	1	*nm*	6		<1	<1	84%
		R73	1	*nm*	41		<1	2	91%
		R74	2	*nm*	55		<1	5	86%
		R75	2	*nm*	40		<1	4	87%
		R76	2	*nm*	23		<1	1	85%
		R77	4	*nm*	53		<1	3	97%
		R80	4	*nm*	63		6	6	50%
			Mean				**<1**	**3**	**74%**
80	OTB	R79	4		8		<1	<1	69%
			Mean				**<1**	**<1**	**69%**

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 beam trawl vessel larger than 300 HP using 80 mm cod-end mesh size in 2006.

	Numbers			Weight		
Quarter	**L**	**D**	**%D**	**L**	**D**	**%D**
1		22		<1	1	87%
2		39		<1	3	87%
4		58		3	4	59%

Table 4.1. Plaice. Landings (L), discards (D) and percentage discards (%D) per hour and year/period in numbers (left) and weight (right) for beam trawl vessels. Data raised by taking each trip as single observation. Results over 1976-1983 and 1989-1990 from Van Beek (1998), 1999-2001 from Netherlands Institute for Fisheries Research unpublished data.

Year/		Numbers			Weight		
Period	N trips	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	3	145	181	55%	42	18	29%
2000	12	194	601	76%	50	47	48%
2001	3	364	1184	76%	84	89	51%
2002	6	263	868	77%	69	71	51%
2003	9	196	945	83%	52	70	57%
2004	8	158	792	83%	42	57	57%
2005	8	143	710	83%	47	51	52%
2006	9	166	997	86%	57	67	54%

Table 4.2. Sole. Landings (L), discards (D) and percentage discards (%D) per hour and per period in numbers (left) and weight (right) for beam trawl vessels. Data raised by taking each trip as single observation. Results over 1976-1983 and 1989-1990 from Van Beek (1998), 1999-2001 from Netherlands Institute for Fisheries Research unpublished data.

Year/		Numbers			Weight		
Period	N trips	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	3	112	16	13%	32	2	5%
2000	12	90	25	22%	22	2	10%
2001	3	82	17	17%	17	1	6%
2002	6	126	38	23%	18	3	13%
2003	9	95	32	25%	20	3	14%
2004	8	175	69	28%	31	7	17%
2005	8	99	29	23%	20	2	11%
2006	9	64	26	29%	16	12	13%

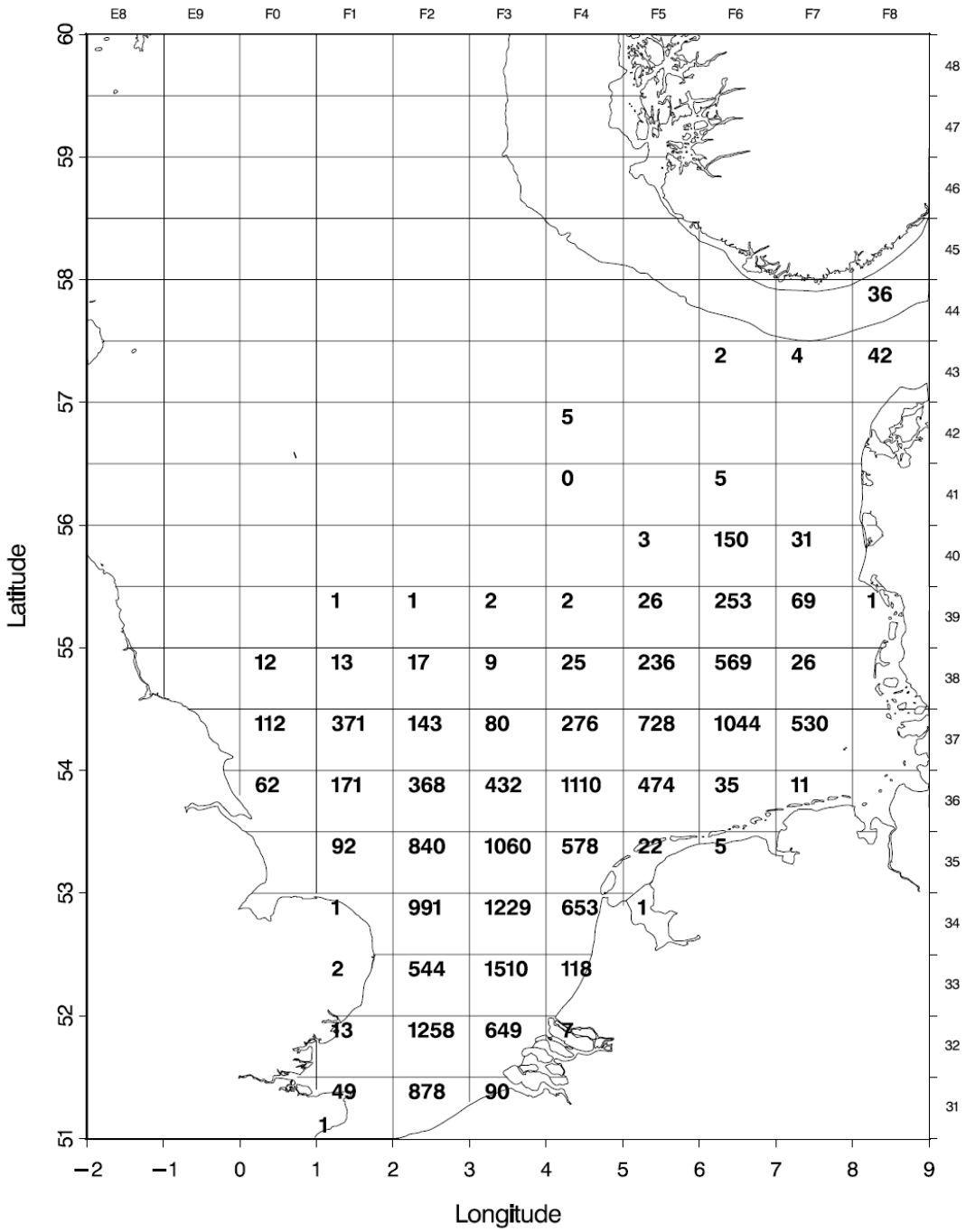

Figure 3.1.1a. Distribution of effort in days at sea by the Dutch beam trawl fleet in 2006, for vessels larger than 300 HP using 80 mm cod-end mesh size. Data from VIRIS database.

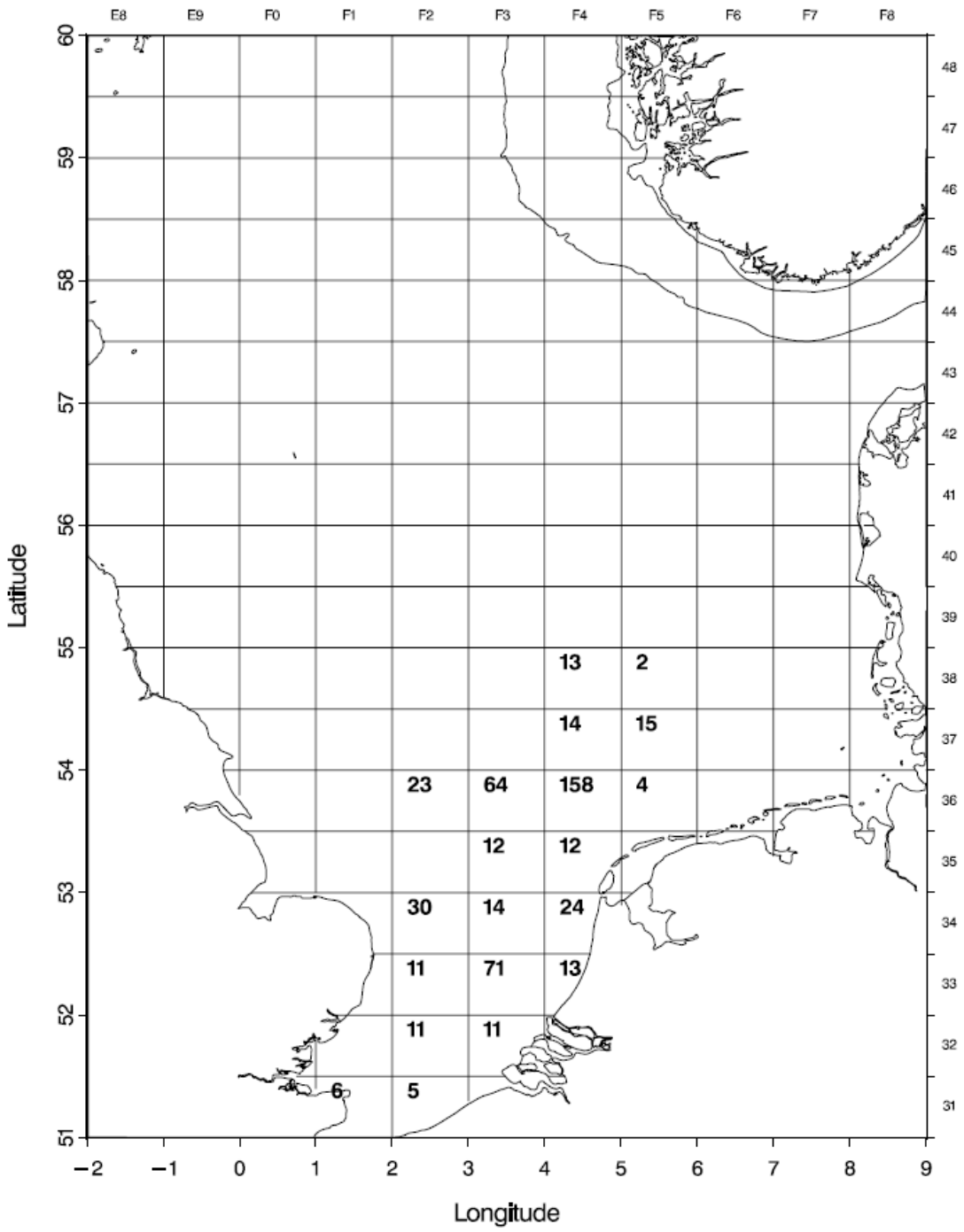

Figure 3.1.1b. Distribution of hours sampled for the sampled Dutch beam trawl fleet in 2006 for vessels larger than 300 HP fishing using 80 mm cod-end mesh size.

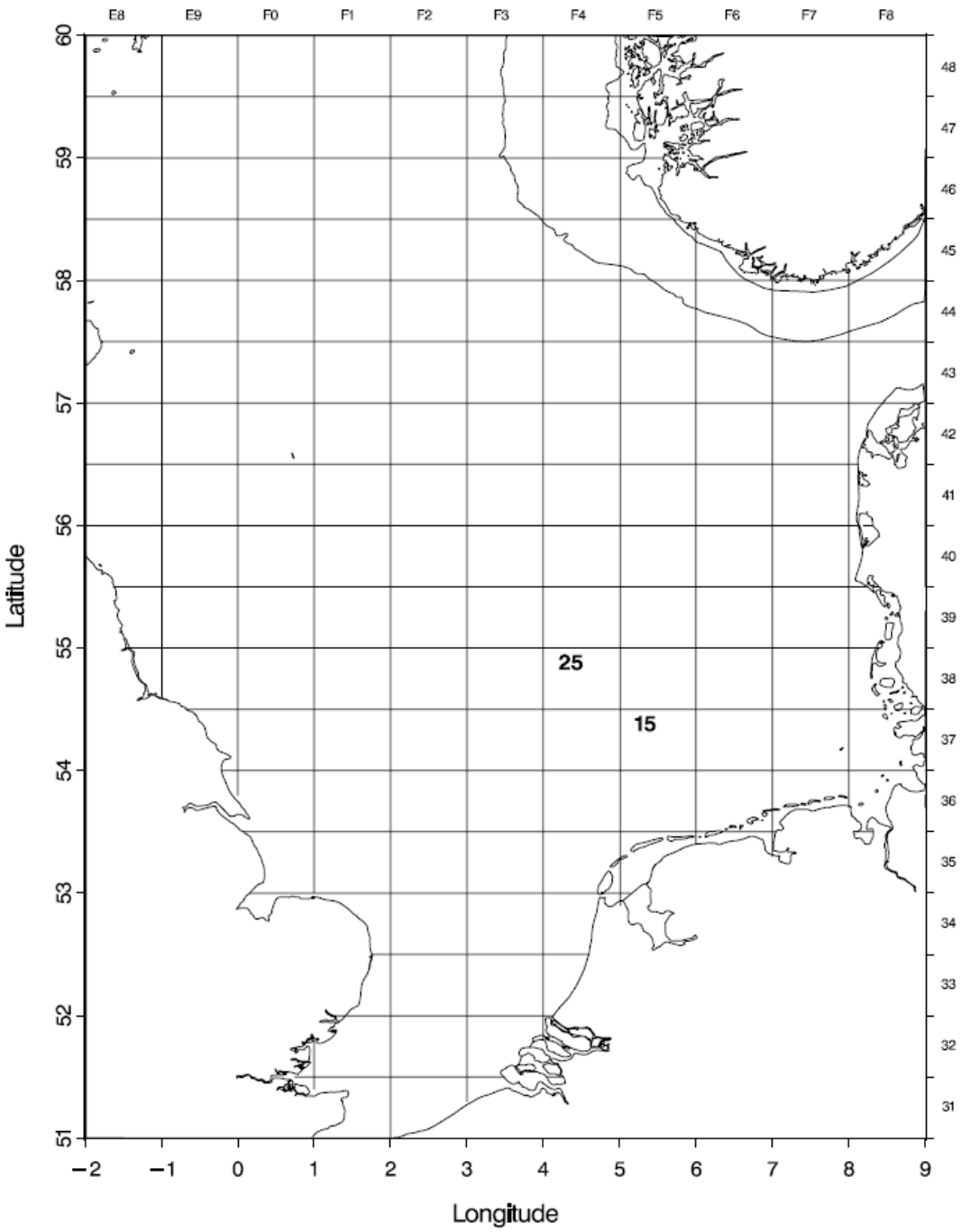

Figure 3.1.2. Distribution of hours sampled for the sampled otter beam trawl vessel in 2006 with an engine power larger than 300 HP fishing with 80 mm cod-end mesh size.

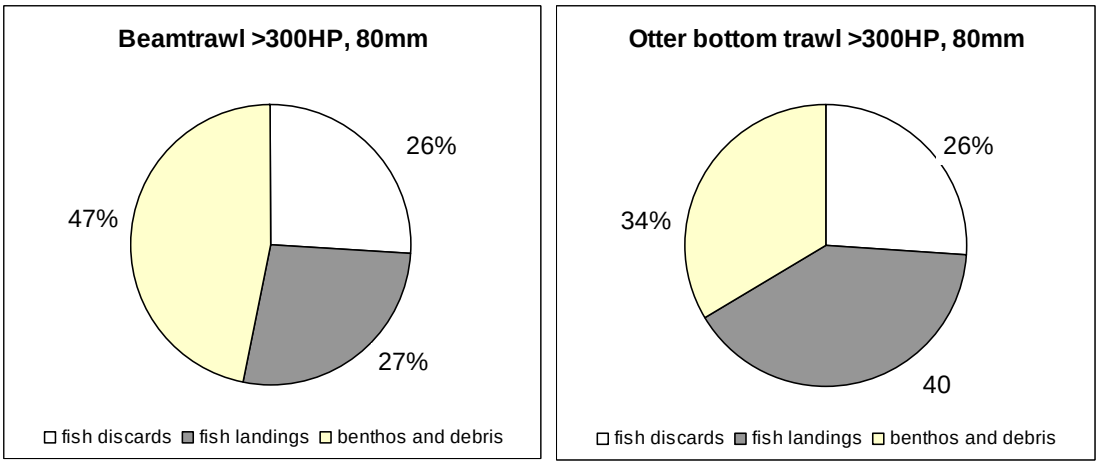

Figure 3.2a. Composition of the catch in weight for beam trawl vessels (left panel) and the otter bottom trawl vessel (right panel) larger than 300 HP using 80 mm cod-end mesh size.

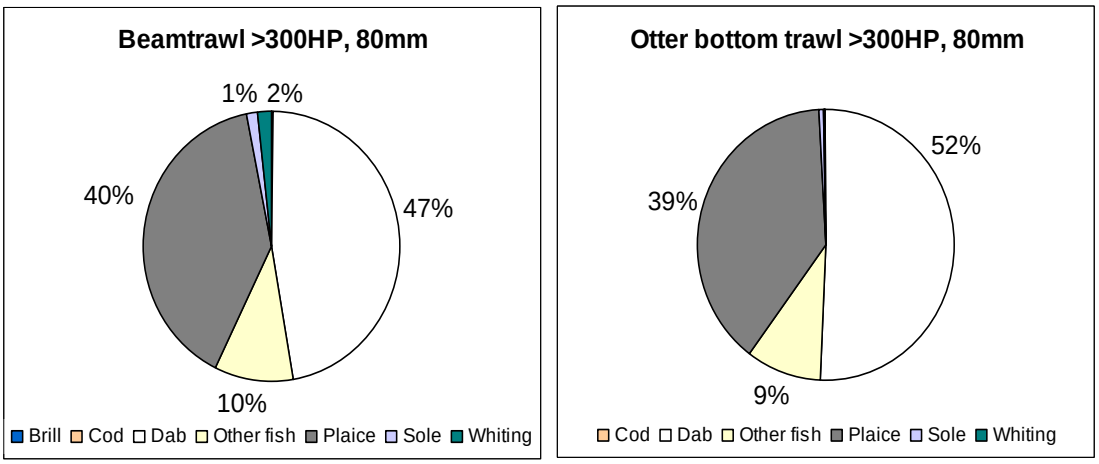

Figure 3.2b. Composition of fish discards in weight for beam trawl vessels (left panel) and the otter bottom trawl vessel (right panel) larger than 300 HP using 80 mm cod-end mesh size.

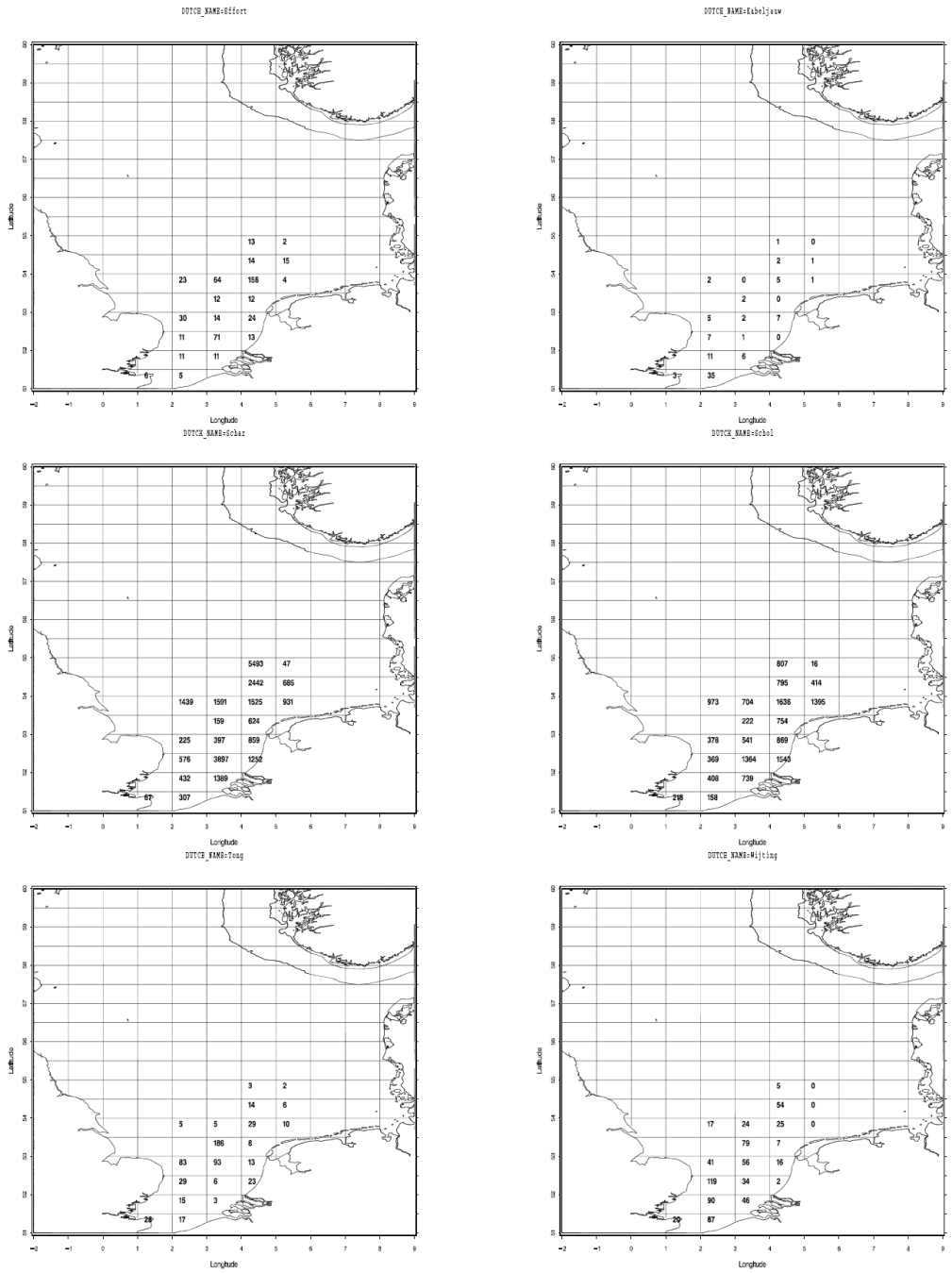

Figure 3.3.1a. Effort as sampled hours for discards (upper left) and number of discards per hour per ICES area in 2006 for cod (upper right), dab (middle left), plaice (middle right), sole (lower left) and whiting (lower right) for beam trawl vessels larger than 300 HP using 80 mm cod-end mesh size.

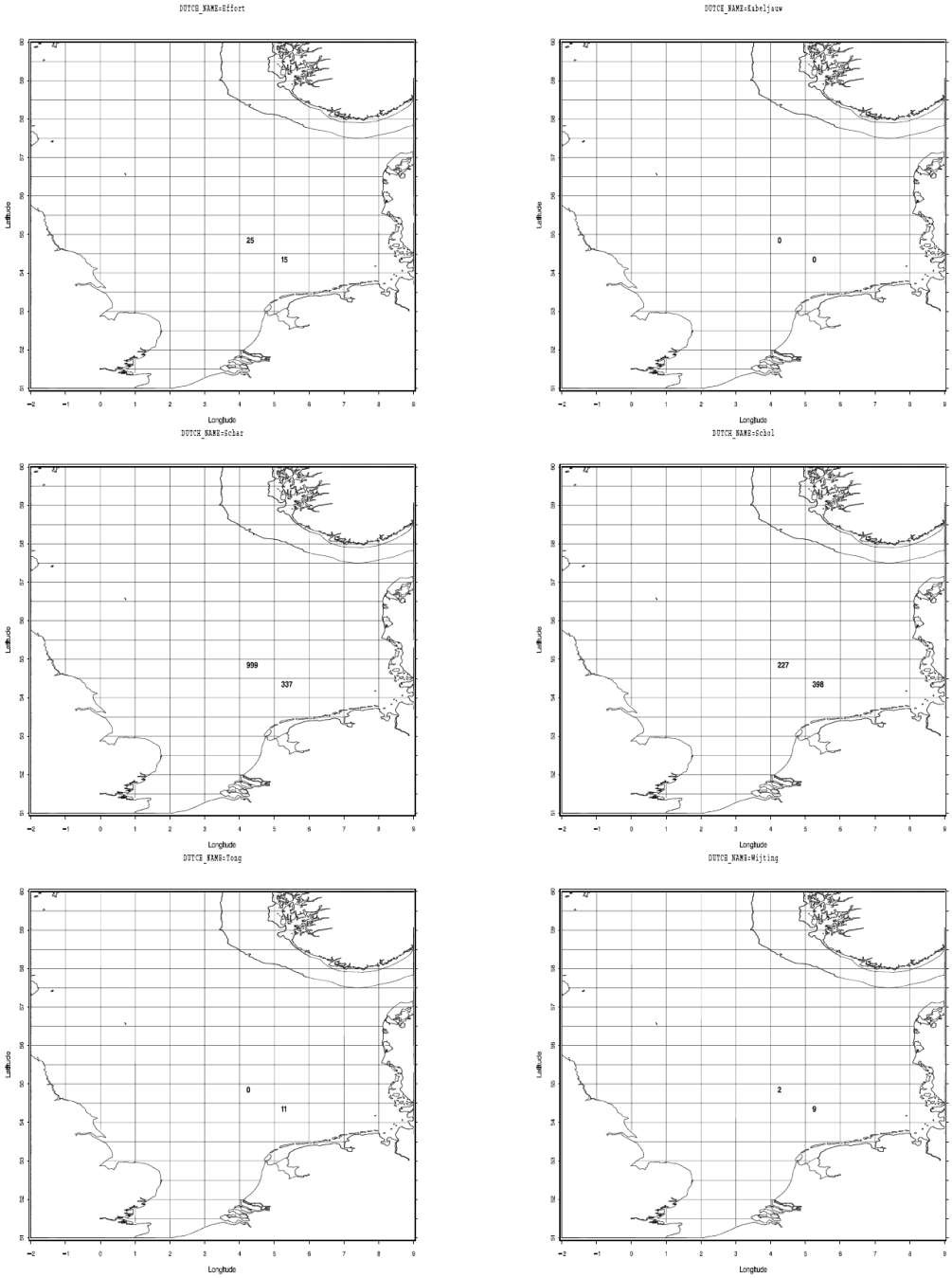

Figure 3.3.1b. Effort as sampled hours for discards (upper left) and number of discards per hour per ICES area in 2006 for cod (upper right), dab (middle left), plaice (middle right), sole (lower left) and whiting (lower right) for the otter bottom trawl vessel larger than 300 HP using 80 mm cod-end mesh size.

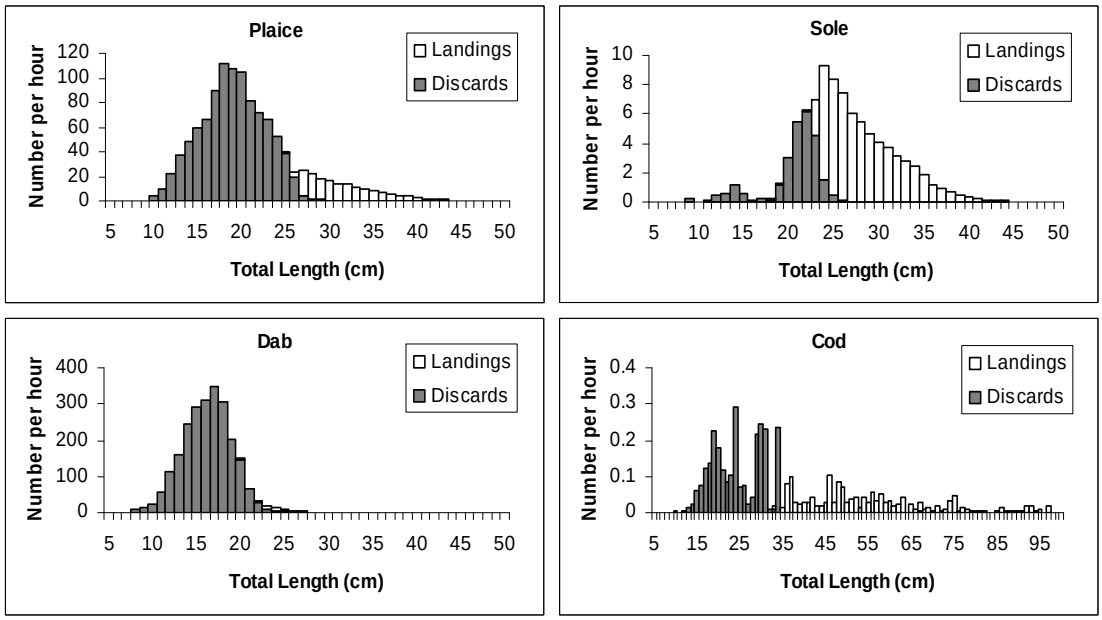

Figure 3.4.1. Length frequency distribution of plaice, sole, dab and cod in 2006, caught with beam trawl vessels larger than 300 HP fishing with 80 mm cod-end mesh size. Black bars show discards, white bars show landings.

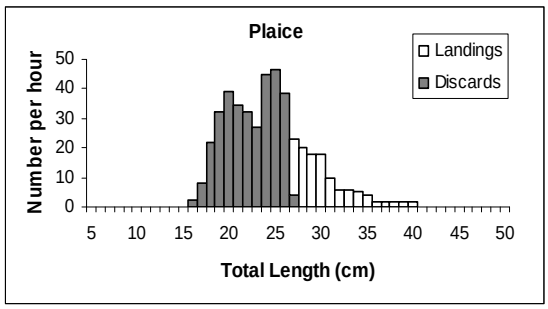

Figure 3.4.2. Length frequency distribution of plaice in 2006, caught with the otter bottom trawl vessel larger than 300 HP fishing with 80 mm cod-end mesh size. Black bars show discards, white bars show landings.