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# Discard sampling of the Dutch beam trawl fleet in 2002

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# 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 the results of the discards sampling program on the Dutch beam trawl fishery in the North Sea in 2002, which was instigated as part of the EC regulations 1543/2000 and 1639/2001 on data collection in European fisheries. The report gives an overview of the discard sampling onboard Dutch beam trawl vessels in 2002. A total of 8 trips were sampled, of which 6 trips could be used for data analysis. 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 (large beam trawlers fishing with 80 mm) is responsible for 91% of the plaice landings and 87% of the sole landings. This indicates that the most important fleet segment has been covered by the discards sampling. The spatial distribution of fishing effort of the Dutch beam trawl fleet over 300 Hp and fishing with 80 mm mesh size is similar to the effort distribution in the discards sampling. There is one potentially importing fishing area which has not been sampled: the area north of the Wadden islands.

The major fish species in the discards were dab and plaice. The percentage plaice discards in 2002 was around 77% in numbers and 51% in weight. The percentage discards for sole was around 13% in weight. The variation in the discard rates between trips was relatively low.

The percentage discarding of plaice in 2002 appeared to be higher than in earlier periods, e.g. 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 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 abundance of age 1 plaice from the second quarter of 2002 onwards, indicates that the relatively strong 2001 year class has become available to the fishery. The discards percentages of plaice may be inflated because of a reduction in landings due to quota restrictions.

# 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 boomkor visserij in de Noordzee in 2002, dat is opgezet als invulling van EC regelingen 1543/2000 en 1639/2001 voor gegevensverzameling in Europese visserijen. In totaal werden 8 reizen aan boord van boomkorschepen bemonsterd, waarvan 6 gebruikt konden worden voor analyse. 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 vloot segment (grote boomkor kotters met 80 mm maaswijdte) waren verantwoordelijk voor 91% van de schol aanvoer en 87% van de tong aanvoer. Dit geeft aan dat het belangrijkste Nederlandse vlootsegment is bemonsterd. De ruimtelijke verdeling van visserij-inspanning van het bemonsterde vlootsegement is vergelijkbaar met de verspreiding van de inspanning in de discards bemonstering. Het gebied boven de Nederlandse Waddeneilanden is echter ontbrekend in de bemonstering terwijl er wel een belangrijk deel van de inspanning van de vloot werd geregistreerd.

De discards in de boomkorvisserij bestaan voornamelijk uit schar en schol. Het percentage discards van schol was in 2002 rond de 77% in aantallen en 51% in gewicht. Voor tong was het percentage discards ongeveer 13% in gewicht. 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 1999-2001 (73% in aantal, 46% 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 1999-2001 (8%) 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. De hoge aantallen 1-jarige schol discards vanaf het tweede kwartaal van 2002 laten zien dat de relatief sterke 2001 jaarklas beschikbaar is gekomen voor de visserij. De discardpercentages van schol zijn mogelijk extra hoog door een beperking van de aanvoer door quota restricties.

# Acknowledgements

# 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. During 2002, observers of the Netherlands Institute for Fisheries Research participated on 8 trips on large beam trawl vessels (engine power larger than 300 HP or 221 kW). In the beginning of 2003 one skipper ended his co-operation with the project and withdrew his data. Therefore only 6 trips were available for analysis.

For a discard sampling trip, two observers went on 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. The total volume and the sampled volume of discards were recorded. A sub-sample of the fish taken from those to be landed was measured, and sampled and total 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

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 used for raising. The discards were raised by using the estimated haul volume.

*Raising discards*

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

$$N_{l,h,s} = \frac{V_h}{v_h} n_{l,h,s}$$

where $N_{l,h,s}$ is the total number 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 $n_{l,m}$ sampled number at length (l) in haul (h) for species (s).

The total number at length per haul and species was summed over the sampled hauls to obtain the total sampled number at length (l) for species (s) over all sampled hauls. The total number at length (l) per trip (t) and species (s) ($N_{l,t,s}$) was calculated by multiplying the total sampled number ($N_{l,h,s}$) over all sampled hauls with the ratio of total trip duration *(D_t)* and duration of all sampled hauls *(Σd_H)*:

$$N_{l,t,s} = \frac{D_t}{\sum d_h} \sum_H N_{l,h,s}$$

The number per hour per species ($N_{o,t,s}$) was calculated by dividing the total number at length per trip ($N_{l,t,s}$) by total trip duration *(D_t)*. The obtained number at length per hour ($N_{l,o,t,s}$) was summed over length to obtain the number per hour:

$$N_{o,t,s} = \sum_l \left( \frac{N_{l,t,s}}{D_t} \right)$$

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

$$W_{l,o,t,s} = \sum_l \left( \frac{N_{l,o,t,s} * A_s * l^{Bs}}{D_t} \right)$$

where $N_{l,o,t,s}$ is the number per length, per hour and per species, $A_s$ and $B_s$ species specific constants and $W_{l,o,t,s}$ is the weight per length, per hour and per species

*Raising landings*

Sampled number landings at length per haul and species ($n_{l,h,s}$) were summed over all sampled hauls (*h*) to calculate the sampled number at length for the entire trip ($n_{l,t,s}$) per species. The total number at length for the entire trip ($N_{l,t,s}$) per species was calculated by multiplying the sampled number at length for the entire trip ($n_{l,t,s}$) with the ratio total trip weight (obtained from auction or VIRIS data) ($W_{vir,t,s}$) to sampled landingsweight of the trip ($w_{t,s}$):

$$N_{l,t,s} = \frac{W_{vir,t,s}}{W_{t,s}} \left( \sum_h n_{l,h,s} \right)$$

Number per hour per species ($N_{o,t,s}$) was calculated by dividing total number at length per trip ($n_{l,t,s}$) by the trip duration ($D_t$). The obtained total number at length per hour ($N_{l,o,t,s}$) was summed to calculate number per hour per species:

$$N_{o,t,s} = \sum_l \left( \frac{N_{l,t,s}}{D_t} \right)$$

Total weight per hour ($_{Wo,t,s}$) was calculated per species by dividing total landings weight per species by total trip duration.

*Numbers per quarter and year*

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

$$N_{l,o,p} = \left( \sum_p N_{l,t} \right) / \sum_p D_t$$

Total numbers discards or landings 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.

*Numbers per fleet*

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

$$N_{p,f,s} = \frac{E_{p,f}}{E_{p,m}} N_{p,m,s}$$

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.

*Age-Length-Keys discards and landings*

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):

$$N_{l,a,t} = \sum_{l,a} f_{l,a} N_{l,t}$$

where $N_{l,a,t}$ is the number at age per hour and species, $f_{l,a}$ the proportion of fish at length (l) with age (a) and $N_{l,t}$ the number at length per hour 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.

*Variance and confidence limits*

Three different variance components were calculated (Anon., 2003):
- variance of all discards (in weight) per trip and per year
- variance per species (in weight) per trip and per year
- variance per species (in numbers) per trip and per year

The variance of the total weight of all discards combined per trip *VAR(DW$_y$)* was calculated per year as:

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

where *DW$_{yt}$* is the total weight of all discards in a trip.

The variance of the total weight per species per trip *VAR(DW$_{y,s}$)* was calculated per year (for the major species as:

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

where *DW$_{yst}$* is the total weight of a species discarded in a trip.

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.

Confidence limits around length-frequency distributions were calculated using weighted standard deviation (*STD$_l$*):

$$STD_l = \sqrt{\left[\left(T_t/(T_y-1)\right)*\frac{\sum_l\left[(N_{l,o,t}-N_{l,o,y})^2*(D_t)^2\right]}{D_y}\right]}$$

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, $D_t$ trip duration and $D_y$ total duration over all sampled trips in the concerning year (Sokal and Rohlf, 1981).

# 3. Results

## 3.1 Sampling

Six trips with large beamtrawlers were sampled and could be used for analysis in 2002. Two additional trips have been sampled but the skipper has withdrawn the information. All sampled trips were carried out on vessels with engine power larger than 300 Hp and mesh size 80 mm.

The landings of plaice and sole for the different Dutch fleet segments are shown in table 2.b for plaice and 2.c for sole. The sampled segment (large beam trawlers fishing with 80 mm) is responsible for 91% of the plaice landings and 87% of the sole landings. The Euro-cutter segment is responsible for respectively 4% (plaice) and 10% (sole) of the landings but has not been sampled. This indicates that the most important fleet segment has been covered by the discards sampling.

The total number of hauls in the trips varied between 29 and 47, with an average fishing duration of 72 hours per trip (Table 1). Of the hauls, 79% were sampled for discards and 72% for landings. Otoliths were collected from the discards samples for plaice (202 otoliths) and sole (28 otoliths). Between 0.05% and 0.12% of the Dutch beam trawl fleet was sampled per quarter (Table 2). The sampling effort varied between 2 and 63 hours per ICES rectangle (Figure 1.b).

The spatial distribution of fishing effort of the Dutch beam trawl fleet over 300 Hp and fishing with 80 mm mesh size is shown in figure 1.a. Effort is mainly distributed off-shore from the Dutch coast. The effort distribution of the fleet can be compared to the effort distribution in the discards sampling (figure 1.b). The comparison indicates that the overall pattern in effort distribution in the discards sampling is similar to the whole fleet segment, but with exception of the area north of the Wadden islands which has not been covered by the discards sampling.

The number of plaice discarded per sampled rectangle per hour varied between 196 and 2168 and for sole between 0 and 1128.

## 3.2 Numbers and weight

The average weight of all discards (both fish and invertebrate discards) during a trip was 23 tonnes (CV 17%,Table 3). Dab and plaice were the most abundant species in the discards (Table 4). Benthic invertebrates that were discarded heavily were *brittle stars, common starfish, swimming crab, hermit crab* and *masked crab*.

*Plaice*

On average 4800 kg of plaice were discarded per trip (CV 53%, Table 3). The average number of discards per hour was 825 to 240 individuals landed. This resulted in an average discard percentage of 77% in numbers and 51% in weight (Table 5). The highest discard rates were observed in the 1st and the 3rd quarter (Table 6). The average discard percentage per quarter varied between 69% and 85% in numbers and 41% and 68% in weight.

The peak of the discard length distribution of all trips combined was around 18 cm (Table 7). Selection of plaice was almost knife-edge: all plaice were discarded at 26 cm while at 27 cm around 70% was landed (Figure 3).

Plaice were discarded up to age 3, but age 4 plaice were discarded in quarter 1. Discards in quarter 1 were predominantly age 2. From quarter 2 onwards, discards were mainly age 1, indicating that the relatively strong 2001 year class became available to the fishery (Table 8). The effect of the strong 1996 year class, age 6 in 2002, was still apparent through high landings for this age. The variation in number per hour at age was larger than for all ages combined (Table 8). The variation was largest for fish entering the discard phase at young ages and fish at the end of the discard phase when almost all fish were landed. Landings and discards in numbers and weight at age were raised to fleet level (Table 9) by using an effort multiplier (Table 2). Due to the relatively low level of sampling, the raised estimates of landings and discards should be treated as indicative only.

*Sole*

On average 190 kg of sole were discarded per trip (CV 177%, Table 3). For all trips, landings were higher than discards both in numbers and in weight per hour (Table 10). The average discard percentage was 20% in number and 13% in weight. Per quarter the discard percentage in weight varied between 1% and 28% (Table 11).

The peak of the discard length distribution was around 22 cm (Table 12). At 23 cm, around 60% of sole were landed and at the minimum landing size (24 cm) around 90% were landed (Figure 3).

Almost all discards were of ages 1-3 (Table 13). The estimates of discards numbers at age were highly variable between trips (CV for ages 1 and 2 was around 200% (Table 13). Landings and discards in numbers at age were raised to fleet level (Table 14) by using an effort multiplier (Table 2). Due to the relatively low level of sampling, the raised estimates of landings and discards should be treated as indicative only.

*Dab*

On average 4100 kg of dab were discarded per trip (CV 69%, Table 3). Compared to plaice, more dab were discarded and less landed per hour (Table 15). The average discard percentage was 91% in numbers and 84% in weight. Per quarter the discard percentage varied in weight between 75% and 96% (Table 16).

*Cod*

On average 150 kg of cod were discarded per trip (CV 164%, Table 3) and per hour 3 kg were landed to 2 kg discarded (Table 17). The average discard percentage was 56% in number and 42% in weight. Per quarter the discard percentage in weight varied between 3% and 77% (Table 18).

*Whiting*

On average 500 kg of whiting were discarded (CV 92%, Table 3). Discards were higher than landings with 1 kg whiting landed to 7 kg discarded per hour (Table 19). The average discard percentage, taking discards from all trips into account, was 88% in number and 85% in weight. Per quarter the discard percentage in weight varied between 82% and 89% (Table 20).

# 4. Discussion

The discards sampling programme for the Dutch beam trawl fleet in 2002 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 2002 were presented. A total of 8 trips were sampled, of which 6 trips could be used for data analysis. The sampling was carried out as a pilot-survey (see annex of EC 1639/2001, chapter III, E1c).

The sampled fleet segment (large beam trawlers fishing with 80 mm) is responsible for 91% of the plaice landings and 87% of the sole landings. This indicates that the most important fleet segment has been covered by the discards sampling. The spatial distribution of fishing effort of the Dutch beam trawl fleet over 300 Hp and fishing with 80 mm mesh size is similar to the effort distribution in the discards sampling. There is one potentially importing fishing area which has not been sampled: the area north of the Wadden islands.

It is only possible to sample a limited number of vessels each year, because of the high costs of sampling. As a result the coverage of the entire fleet was relatively low (0.05%-0.12%). Other countries showed similar sampling coverage in their discard sampling programmes. The Scottish discard programme, sampling seines and demersal trawls, covered 0.1-0.2% of the fleet annually (Stratoudakis et al., 1998). Coverage of the French trawler fleet was 0.8% (Rochet et al., 2002), while the Irish discard sampling programme covered 0.3%, 4.1% and 3.5% of respectively the ottertrawl, beamtrawl and Scottish seine (Borges et al., 2003).

The results of the discards sampling could be sensitive to including or excluding trips due to the limited number of trips. Large variation could be caused by differences in spatial distribution of undersized fish, efficiency of vessels and actual mesh size and net geometry. However, the trips observed show relatively similar trends in numbers of discards, so that this phenomenon does not appear to distort the perception of fishing patterns in 2002.

High CVs could be due to low sampling levels and larger variability in discard rates (Stratoudakis et al., 1999), caused by different areas and species targeted. The best way to improve the precision of discard estimates is through increasing the amount of sampling activity (Stratoudakis et al., 1999; Allen et al., 2002), which however implies more efficient sampling strategies (Stratoudakis et al., 1999; Tamsett and Janacek, 1999; Rochet et al., 2002). Allen et al. (2002) and Borges et al. (2003) showed that sampling schemes with more trips and fewer hauls per trip lead to lower CVs than with few trips and more hauls per trip. Between 1999 to 2002 the CV on all discards combined varied between 17%-54% (Table 21), while at age the CVs varied between 40%-215% for plaice (Table 22) and 90%-250% for sole (Table 23). Stratoudakis et al. (1999) reported a CV of 20%-30% for 45-65 trips sampled annually in the North Sea and a CV of 50%-60% for 15-35 trips sampled annually in the Celtic Sea. Borges et al. (2003) reported a CV of 68% for beam trawls in the Irish Sea while Rochet et al. (2002) reported CVs between 19% to 96% for individual species caught with demersal trawls.

Plaice is one of the two important target species of the Dutch beam trawl fishery. The average discard percentage of plaice in 2002 was around 77% in numbers and 51% in weight. These discard rates are higher that the rates observed in the period 1999-2001 (73% in numbers and 46% in weight) and 1976-1990 (51% in numbers and 27% in weight) (Table 24, Figure 2) (Van Beek, 1998). The relatively strong 2001 yearclass has dominated the discard fraction in the sampled trips. Unfortunately, no direct comparisons can be made with discards rates from the previous strong year class (1996) because the discard sampling programme started only in 1999 when this yearclass was already 3 years old.

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. In recent discard trips that were carried out outside the plaice-box, the size of the smallest plaice caught corresponded to those lengths at which plaice were previously (1970s, 1980s) only caught inside the 12-mile zone and the plaice box (Figure 4) (Rijnsdorp and Van Beek, 1991; ICES, 1999). In recent years, plaice of around 10 cm were caught outside the plaice-box (Figure 5). In the period 1976-1990, plaice were caught at around 17 cm and larger by vessels fishing outside the plaice-box (Van Beek, 1998).

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 higher in 2002 (63 kg/hour) than in 1999-2001 (56 kg/hour), but substantially lower than in the 1970s and 1980s (around 110 kg/hour) (Table 24). 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) showed more landings of larger plaice compared to recent period (Figure 3 and Figure 5). The mean weight per fish landed was also higher (0.36 kg per fish in 1970 and 1980s, 0.26 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 2002 was within the range of discard percentages in earlier periods (Table 25). The length frequency distributions showed no apparent changes for 2002 (Figure 3) and 1999-2001 (Figure 5) compared to the 1970s and 1980s (Figure 4).

The discard percentage of cod in 2002 was 42% in weight. 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 (Figure 6).

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., 2003). 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).

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# Tables and Figures

**Table 1**. Discard 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 discards fraction.

| Vessel | Number of hauls | | | Duration (hour) | | | Plaice Otolith | Sole Otolith |
|---|---|---|---|---|---|---|---|---|
| | Landings | Discards | Total | Landings | Discards | Total | | |
| R29 | 27 | 27 | 29 | 59 | 59 | 63 | 29 | 13 |
| R30 | 30 | 39 | 47 | 55 | 72 | 87 | 39 | 0 |
| R31 | 24 | 24 | 33 | 43 | 43 | 59 | 31 | 0 |
| R32 | 27 | 29 | 37 | 62 | 66 | 84 | 40 | 15 |
| R35 | 21 | 23 | 34 | 37 | 41 | 61 | 36 | 0 |
| R36 | 27 | 30 | 38 | 54 | 61 | 75 | 27 | 0 |
| **Total** | **156** | **172** | **218** | **310** | **342** | **429** | **202** | **28** |
| **% Total** | **72%** | **79%** | | **72%** | **80%** | | | |

**Table 2.** Sampling effort in HP hours for the sampled trips and for the beam trawl fleet (>300 HP) and percentage coverage per quarter in 2002.

|  | Quarter 1 | Quarter 2 | Quarter 3 | Quarter 4 | All quarters |
|---|---|---|---|---|---|
| Sampling effort (HP hours) | 11881 | 17195 | 7200 | 8000 | 44276 |
| Fleet effort (HP hours) | 12261126 | 14870196 | 13512446 | 14220351 | 54864119 |
| Percentage coverage | 0.10% | 0.12% | 0.05% | 0.06% | 0.08% |

**Table 2.b.** Plaice. Dutch Beam trawl landings in 2002 by HP-class, mesh size (mm) and quarter. Note: ZZZ and 999 indicate missing or other categories.

| COUNTRY | NL | | GEAR | TBB |
|---|---|---|---|---|
| YEAR | 2002 | | SPECIES | PLE |

| Sum of CATCH | | QUARTER | | | | |
|---|---|---|---|---|---|---|
| HPCLS | MESH | 1 | 2 | 3 | 4 | Total |
| EURO | 80 | 158 | 472 | 232 | 168 | 1030 |
| | 90 | | | | 0 | 0 |
| | 100 | 0 | | | | 0 |
| | 120 | 0 | | 24 | 16 | 40 |
| | 999 | | 0 | 2 | 0 | 2 |
| EURO Total | | 158 | 473 | 257 | 185 | 1072 |
| LARGE | 80 | 8571 | 4822 | 4893 | 7130 | 25416 |
| | 90 | 11 | 6 | 2 | 3 | 21 |
| | 100 | 34 | 483 | 50 | 171 | 737 |
| | 110 | | 3 | | | 3 |
| | 120 | | 184 | 75 | 35 | 294 |
| | 999 | 21 | 62 | 21 | 65 | 169 |
| LARGE Total | | 8636 | 5560 | 5040 | 7404 | 26640 |
| ZZZ | 80 | 70 | 50 | 91 | 141 | 352 |
| | 100 | 0 | 10 | | | 10 |
| | 999 | 9 | | | 0 | 9 |
| ZZZ Total | | 79 | 60 | 91 | 141 | 371 |
| Total | | 8874 | 6092 | 5388 | 7729 | 28084 |

**Table 2.c.** Sole. Dutch Beam trawl landings in 2002 by HP-class, mesh size (mm) and quarter.
Note: ZZZ and 999 indicate missing or other categories.

| COUNTRY | NL | | GEAR | TBB |
|---|---|---|---|---|
| YEAR | 2002 | | SPECIES | SOL |

| Sum of CATCH | | QUARTER | | | | |
|---|---|---|---|---|---|---|
| HPCLS | MESH | 1 | 2 | 3 | 4 | Total |
| EURO | 80 | **231** | **488** | **303** | **163** | **1186** |
| | 90 | | | | 1 | 1 |
| | 120 | 1 | | 0 | 1 | 2 |
| | 999 | | 0 | 1 | 0 | 1 |
| EURO Total | | 232 | 489 | 304 | 164 | 1189 |
| LARGE | 80 | **2875** | **2190** | **2529** | **2921** | **10516** |
| | 90 | 4 | 3 | 2 | 4 | 13 |
| | 100 | **4** | **3** | **5** | **7** | **19** |
| | 110 | | 2 | | | 2 |
| | 120 | | 0 | | 3 | 3 |
| | 999 | 6 | 11 | 9 | 18 | 45 |
| LARGE Total | | 2889 | 2210 | 2546 | 2954 | 10598 |
| ZZZ | 80 | 32 | 39 | 73 | 92 | 237 |
| | 100 | | 0 | 0 | | 1 |
| | 999 | 2 | | 0 | 0 | 2 |
| ZZZ Total | | 34 | 40 | 73 | 92 | 239 |
| Total | | 3155 | 2738 | 2923 | 3211 | 12027 |

**Table 3**. Mean and variance of the total weight (kg) of all discards and of plaice, sole, dab, cod and whiting in 2002.

| | All discards | Plaice | Sole | Dab | Cod | Whiting |
|---|---|---|---|---|---|---|
| Mean weight over trips | 23438 | 4767 | 191 | 4063 | 148 | 489 |
| CV | 17% | 53% | 177% | 69% | 164% | 92% |

**Table 4.** Number discarded per hour per species over all trips in 2002 in descending order.

| Species | Number | Species | Number |
| --- | --- | --- | --- |
| Dab | 934 | *Ophiura ophiura* | 811 |
| Plaice | 825 | *Macropipus sp.* | 532 |
| Whiting | 104 | *Asterias rubens* | 452 |
| Grey gurnard | 44 | *Astropecten irregularis* | 409 |
| Sole | 31 | *Pagurus bernhardus* | 309 |
| Solenette | 29 | *Corystes cassivelaunus* | 205 |
| Scaldfish | 25 | *Echinocardium cordatum* | 129 |
| Dragonet | 18 | *Ensis sp.* | 95 |
| Lesser weever | 17 | *Buccinum undatum* | 58 |
| Cod | 11 | *Aphrodita aculeata* | 37 |
| Ammodytes sp. | 10 | *Psammechinus miliaris* | 22 |
| Red gurnard | 10 | *Echinidae* | 20 |
| Hooknose | 6 | *Echinocardium cordatum* | 10 |
| Bib | 5 | *Asteronyx loveni* | 5 |
| Starry ray | 5 | *Spisula sp.* | 5 |
| Corbin's sandeel | 4 | *Alcyonidium diaphanum* | 4 |
| Horse mackerel | 4 | *Ascidiacea* | 2 |
| Poor cod | 4 | *Cancer pagurus* | 2 |
| Lemon sole | 2 | *Flustra foliacea* | 2 |
| Long rough dab | 1 | *Alcyonium digitatum* | 1 |
| Flounder | <1 | *Lunatia* | 1 |
| Norway pout | <1 | *Mactra corallina* | <1 |
| Striped red mullet | <1 | *Natica catena* | <1 |
| Sea bass | <1 | *Anthozoa* | <1 |
| Roker | <1 | *Lunatia catena* | <1 |
| Smelt | <1 | *Aequipecten opercularis* | <1 |
| Brill | <1 | *Sepia officinalis* | <1 |
| Bull-rout | <1 | *Arctica islandica* | <1 |
| Reticulated dragonet | <1 | *Hyas sp.* | <1 |
| Herring | <1 | *Loligo sp.* | <1 |
| Mackerel | <1 | *Neptunea antiqua* | <1 |
| Sprat | <1 | *Lunatia alderi* | <1 |
| Pelser | <1 | *Luidia sp.* | <1 |
| John dory | <1 | *Donax vittatus* | <1 |

| Nilsson's pipefish | <1 | *Acanthocardia echinata* | <1 |

**Table 4.** Continued

| Species | Number | Species | Number |
| --- | --- | --- | --- |
| Twaite shad | <1 | *Nephrops norvegicus* | <1 |
| Lesser spotted dogfish | <1 | *Mytilus sp.* | <1 |
| Four-bearded rockling | <1 | *Syngnathus sp.* | <1 |
| Lumpsucker | <1 | *Ophiotrhix fragilis* | <1 |
| Starry smoothhound | <1 | *Demospongia sp.* | <1 |
| Anglerfish | <1 | | |

**Table 4.** Continued

| Species | Number | Species | Number |
| --- | --- | --- | --- |

**Table 5.** Plaice. Landings (L), discards (D) and percentage discards (%D) per hour and per trip in numbers (left) and weight (right).

| Vessel | Quarter | Numbers | | | Weight | | |
|--------|---------|-----|------|-----|-----|-----|-----|
| | | L | D | %D | L | D | %D |
| R29 | 1 | 386 | 291 | 43 | 126 | 36 | 22 |
| R31 | 1 | 543 | 1801 | 77 | 146 | 153 | 51 |
| R30 | 2 | 106 | 751 | 88 | 31 | 48 | 60 |
| R32 | 2 | 114 | 470 | 80 | 22 | 31 | 59 |
| R35 | 3 | 268 | 1196 | 82 | 65 | 106 | 62 |
| R36 | 4 | 161 | 688 | 81 | 26 | 55 | 68 |
| **Mean** | | **241** | **825** | **77** | **63** | **67** | **51** |

**Table 6**. Plaice. Landings (L), discards (D) and percentage discards (%D) per hour and per quarter in numbers (left) and weight (right).

| Quarter | Numbers | | | Weight | | |
|---------|-----|------|-----|-----|-----|-----|
| | L | D | %D | L | D | %D |
| 1 | 462 | 1024 | 69 | 135 | 92 | 41 |
| 2 | 110 | 612 | 85 | 27 | 40 | 60 |
| 3 | 268 | 1196 | 82 | 65 | 106 | 62 |
| 4 | 161 | 688 | 81 | 26 | 55 | 68 |

**Table 7.** Plaice. Number landed and discarded per hour per length class with weighted standard deviation.

| Length | Landings | STDEV Landings | Discards | STDEV Discards |
|--------|----------|----------------|----------|----------------|
| 5 | | | 0.08 | 0.08 |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | 0.06 | 0.06 |
| 11 | | | 0.3 | 0.2 |
| 12 | | | 1 | 0.7 |
| 13 | | | 5 | 2.3 |
| 14 | | | 10 | 4.6 |
| 15 | | | 23 | 9.8 |
| 16 | | | 36 | 13.8 |
| 17 | | | 76 | 24.1 |
| 18 | | | 104 | 29.6 |
| 19 | | | 106 | 28.3 |
| 20 | | | 90 | 26.2 |
| 21 | | | 81 | 29.6 |
| 22 | | | 71 | 25.0 |
| 23 | 0.2 | 0.2 | 59 | 20.4 |
| 24 | 0.2 | 0.2 | 62 | 20.4 |
| 25 | 1.6 | 0.8 | 51 | 13.2 |
| 26 | 6 | 2 | 31 | 8.9 |
| 27 | 29 | 9 | 12 | 4.9 |
| 28 | 31 | 6 | 5 | 2.8 |
| 29 | 28 | 6 | 0.8 | 0.6 |
| 30 | 24 | 6 | 0.9 | 0.7 |
| 31 | 22 | 6 | | |
| 32 | 19 | 6 | 0.02 | 0.02 |
| 33 | 15 | 6 | | |
| 34 | 15 | 7 | | |
| 35 | 12 | 5 | | |
| 36 | 10 | 5 | | |
| 37 | 8 | 4 | | |

| 38 | 5 | 3 |
|----|---|---|

**Table 7**. Continued.

| Length | Landings | STDEV Landings | Discards | STDEV Discards |
|--------|----------|----------------|----------|----------------|
| 39 | 4 | 2 | | |
| 40 | 3 | 2 | | |
| 41 | 3 | 2 | | |
| 42 | 2 | 1 | | |
| 43 | 0.6 | 0.3 | | |
| 44 | 0.9 | 0.6 | | |
| 45 | 0.3 | 0.3 | | |
| 46 | 0.2 | 0.1 | | |
| 47 | 0.3 | 0.2 | | |
| 48 | 0.2 | 0.2 | | |
| 49 | 0.2 | 0.2 | | |
| 50 | 0.05 | 0.05 | | |
| 51 | 0.4 | 0.3 | | |
| 52 | 0.05 | 0.05 | | |
| 53 | | | | |
| 54 | 0.2 | 0.2 | | |
| 55 | 0.05 | 0.05 | | |
| 56 | | | | |
| 57 | | | | |
| 58 | 0.05 | 0.05 | | |
| 59 | | | | |
| 60 | | | | |

**Table 8.** 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 L | Quarter 1 D | Quarter 2 L | Quarter 2 D | Quarter 3 L | Quarter 3 D | Quarter 4 L | Quarter 4 D | Year L | Year D | Year CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0.4 | 183% |
| 1 | 0 | 25 | 0 | 440 | 19 | 784 | 0 | 560 | 3 | 392 | 85% |
| 2 | 8 | 631 | 14 | 140 | 115 | 348 | 51 | 81 | 33 | 299 | 133% |
| 3 | 73 | 310 | 51 | 32 | 113 | 63 | 69 | 46 | 69 | 118 | 135% |
| 4 | 102 | 50 | 22 | 0.2 | 18 | 0.3 | 31 | 0 | 46 | 14 | 156% |
| 5 | 70 | 6 | 1 | 0.1 | 0.9 | 0.1 | 2 | 0 | 26 | 2 | 202% |
| 6 | 175 | 0.7 | 10 | 0.1 | 2 | 0.2 | 6 | 0 | 55 | 0.3 | 124% |
| 7 | 18 | 0 | 0.4 | 0 | 0.1 | 0 | 1 | 0 | 5 | 0 | - |
| 8 | 6 | 0 | 0.2 | 0 | 0 | 0 | 0.2 | 0 | 2 | 0 | - |
| 9 | 4 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 1 | 0 | - |
| 10 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | - |

**Table 9.** Plaice. Landings (L) and discards (D) raised estimate of total fleet numbers (*1000) and mean length (left), total fleet 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 | 125 | - | 3.0 | 0 | 0 | - | 0 |
| | 1 | 0 | 3152 | - | 14.1 | 0 | 78 | - | 0.025 |
| | 2 | 1036 | 79164 | 27.0 | 19.7 | 184 | 5545 | 0.178 | 0.070 |
| | 3 | 9175 | 38874 | 28.8 | 23.8 | 2006 | 4754 | 0.219 | 0.122 |
| | 4 | 12753 | 6273 | 30.5 | 26.5 | 3339 | 1055 | 0.262 | 0.168 |
| | 5 | 8842 | 774 | 32.2 | 27.6 | 2720 | 146 | 0.308 | 0.189 |
| | 6 | 21962 | 90 | 35.0 | 29.6 | 8692 | 21 | 0.396 | 0.233 |
| | 7 | 2254 | 0 | 35.7 | 32.0 | 959 | 0 | 0.425 | 0.294 |
| | 8 | 820 | 0 | 40.2 | - | 510 | 0 | 0.622 | - |
| | 9 | 448 | 0 | 44.5 | - | 367 | 0 | 0.821 | - |
| | 10 | 741 | 0 | 45.3 | - | 654 | 0 | 0.882 | - |
| | **All** | **58030** | **128453** | **32.8** | **21.2** | **19432** | **11599** | **0.372** | **0.102** |
| 2 | 0 | 0 | 50 | - | 7.1 | 0 | 0 | - | 0.004 |
| | 1 | 0 | 65150 | - | 17.5 | 0 | 3232 | - | 0.050 |
| | 2 | 2037 | 20754 | 27.9 | 21.8 | 399 | 2019 | 0.196 | 0.097 |
| | 3 | 7499 | 4736 | 29.4 | 24.2 | 1749 | 609 | 0.233 | 0.129 |
| | 4 | 3270 | 33 | 30.9 | 28.0 | 888 | 7 | 0.272 | 0.196 |
| | 5 | 1977 | 11 | 31.3 | 28.0 | 560 | 2 | 0.283 | 0.196 |
| | 6 | 1417 | 8 | 34.2 | 28.0 | 531 | 1 | 0.375 | 0.196 |
| | 7 | 57 | 2 | 41.0 | 28.0 | 37 | 0 | 0.654 | 0.196 |
| | 8 | 34 | 0 | 42.2 | - | 24 | 0 | 0.696 | - |
| | 9 | 3 | 0 | 49.0 | - | 3 | 0 | 1.067 | - |
| | 10 | 7 | 0 | 46.4 | - | 6 | 0 | 0.913 | - |
| | **All** | **16301** | **90743** | **30.2** | **18.8** | **4198** | **5871** | **0.270** | **0.075** |
| 3 | 0 | 0 | 0 | - | - | 0 | 0 | - | - |
| | 1 | 2132 | 89785 | 27.9 | 20.9 | 414 | 7565 | 0.194 | 0.084 |
| | 2 | 13208 | 39859 | 28.4 | 21.6 | 2731 | 3702 | 0.207 | 0.093 |
| | 3 | 12978 | 7241 | 30.2 | 22.9 | 3262 | 799 | 0.251 | 0.110 |
| | 4 | 2122 | 38 | 31.3 | 28.0 | 596 | 7 | 0.281 | 0.196 |
| | 5 | 97 | 10 | 36.7 | 28.0 | 44 | 2 | 0.456 | 0.196 |
| | 6 | 192 | 17 | 39.6 | 28.0 | 109 | 3 | 0.565 | 0.196 |
| | 7 | 6 | 3 | 40.0 | 28.0 | 3 | 1 | 0.578 | 0.196 |

| Quarter | Age | 8 | 0 | 3 | - | 28.0 | 0 | 1 | - | 0.196 |
|---------|-----|---|---|---|---|------|---|---|---|-------|
|         |     | 9 | 0 | 3 | - | 28.0 | 0 | 1 | - | 0.196 |

**Table 9.** Continued.

| Quarter | Age | Numbers (*1000) | | Mean length | | Weight (*1000) | | Mean weight | |
|---------|-----|------|------|------|------|------|------|------|------|
|         |     | L | D | L | D | L | D | L | D |
| 3 | 10 | 0 | 3 | - | 28.0 | 0 | 1 | - | 0.196 |
|   | **All** | **30736** | **136964** | **29.4** | **21.2** | **7159** | **12082** | **0.240** | **0.089** |
| 4 | 0 | 0 | 0 | - | - | 0 | 0 | - | - |
|   | 1 | 0 | 74640 | - | 19.9 | 0 | 5325 | - | 0.071 |
|   | 2 | 6815 | 10852 | 27.7 | 24.7 | 1302 | 1471 | 0.191 | 0.136 |
|   | 3 | 9220 | 6188 | 30.0 | 21.1 | 2290 | 552 | 0.248 | 0.089 |
|   | 4 | 4193 | 0 | 31.4 | - | 1198 | 0 | 0.286 | - |
|   | 5 | 266 | 0 | 35.0 | - | 105 | 0 | 0.393 | - |
|   | 6 | 745 | 0 | 38.6 | - | 395 | 0 | 0.530 | - |
|   | 7 | 179 | 0 | 42.4 | - | 124 | 0 | 0.693 | - |
|   | 8 | 20 | 0 | 48.0 | - | 20 | 0 | 1.035 | - |
|   | 9 | 9 | 0 | 43.9 | - | 7 | 0 | 0.772 | - |
|   | 10 | 5 | 0 | 45.0 | - | 4 | 0 | 0.836 | - |
|   | **All** | **21452** | **91679** | **30.0** | **20.5** | **5446** | **7348** | **0.280** | **0.085** |
| All | 0 | 0 | 176 | - | 4.2 | 0 | 0 | - | 0.004 |
|   | 1 | 2132 | 232727 | 27.9 | 19.5 | 414 | 16201 | 0.194 | 0.073 |
|   | 2 | 23096 | 150628 | 28.1 | 20.9 | 4616 | 12737 | 0.200 | 0.089 |
|   | 3 | 38872 | 57039 | 29.7 | 23.4 | 9307 | 6714 | 0.240 | 0.118 |
|   | 4 | 22338 | 6344 | 30.8 | 26.5 | 6022 | 1069 | 0.270 | 0.168 |
|   | 5 | 11182 | 795 | 32.1 | 27.6 | 3429 | 150 | 0.308 | 0.189 |
|   | 6 | 24317 | 115 | 35.1 | 29.3 | 9727 | 26 | 0.402 | 0.226 |
|   | 7 | 2496 | 5 | 36.3 | 28.1 | 1124 | 1 | 0.463 | 0.198 |
|   | 8 | 874 | 3 | 40.5 | 28.0 | 554 | 1 | 0.640 | 0.196 |
|   | 9 | 460 | 3 | 44.5 | 28.0 | 377 | 1 | 0.822 | 0.196 |
|   | 10 | 753 | 3 | 45.3 | 28.0 | 664 | 1 | 0.882 | 0.196 |
|   | **All** | **126519** | **447840** | **31.2** | **20.6** | **36234** | **36900** | **0.320** | **0.090** |

**Table 10.** Sole. Landings (L), discards (D) and percentage discards (%D) per hour and per trip in numbers (left) and weight (right).

| Vessel | Quarter | Numbers | | | Weight | | |
|---|---|---|---|---|---|---|---|
| | | **L** | **D** | **%D** | **L** | **D** | **%D** |
| R29 | 1 | | 0 | | 3 | 0 | 0 |
| R31 | 1 | 140 | 59 | 30 | 32 | 4 | 12 |
| R30 | 2 | 74 | 3 | 4 | 16 | <1 | 2 |
| R32 | 2 | 75 | 3 | 3 | 14 | <1 | 1 |
| R35 | 3 | 75 | 2 | 3 | 17 | <1 | 1 |
| R36 | 4 | 264 | 125 | 32 | 29 | 11 | 28 |
| **Mean** | | **124** | **31** | **20** | **18** | **3** | **13** |

**Table 11**. Sole. Landings (L), discards (D) and percentage discards (%D) per hour and per quarter in numbers (left) and weight (right).

| Quarter | Numbers | | | Weight | | |
|---|---|---|---|---|---|---|
| | **L** | **D** | **%D** | **L** | **D** | **%D** |
| 1 | 140 | 29 | 17 | 17 | 2 | 11 |
| 2 | 75 | 3 | 4 | 15 | <1 | 1 |
| 3 | 75 | 2 | 3 | 17 | <1 | 1 |
| 4 | 264 | 125 | 32 | 29 | 11 | 28 |

**Table 12.** Sole. Number landed and discarded per hour per length class with weighted standard deviation.

| Length | Landings | STDEV Landings | Discards | STDEV Discards |
|---|---|---|---|---|
| 10 | | | | |
| 11 | | | 0.2 | 0.2 |
| 12 | | | 0.3 | 0.3 |
| 13 | | | 0.2 | 0.2 |
| 14 | | | 0.2 | 0.1 |
| 15 | | | 1 | 1.0 |
| 16 | | | 0.7 | 0.6 |
| 17 | | | 0.05 | 0.05 |
| 18 | | | 1 | 0.5 |
| 19 | | | 2 | 1.9 |
| 20 | 0.01 | 0.01 | 5 | 3.4 |
| 21 | 0.1 | 0.1 | 8 | 6.1 |
| 22 | 0.8 | 0.4 | 7 | 5.8 |
| 23 | 5 | 4.1 | 4 | 2.7 |
| 24 | 12 | 7.5 | 1 | 0.8 |
| 25 | 17 | 6.9 | 0.03 | 0.03 |
| 26 | 13 | 4.2 | 0.07 | 0.07 |
| 27 | 14 | 3.4 | | |
| 28 | 13 | 2.7 | | |
| 29 | 11 | 1.8 | | |
| 30 | 9 | 2.3 | | |
| 31 | 7 | 1.0 | | |
| 32 | 6 | 1.9 | | |
| 33 | 4 | 1.4 | | |
| 34 | 3 | 0.8 | | |
| 35 | 3 | 1.0 | | |
| 36 | 2 | 1.0 | | |
| 37 | 1 | 0.2 | | |
| 38 | 0.6 | 0.2 | | |
| 39 | 0.8 | 0.3 | | |
| 40 | 0.5 | 0.1 | | |
| 41 | 0.2 | 0.2 | | |
| 42 | 0.3 | 0.1 | | |

| 43 |
|----|
|    |

**Table 12**. Continued.

| Length | Landings | STDEV Landings | Discards | STDEV Discards |
|--------|----------|----------------|----------|----------------|
| 44     |          |                |          |                |
| 45     |          |                |          |                |
| 46     |          |                |          |                |
| 47     | 0.036    | 0.035          |          |                |
| 48     |          |                |          |                |
| 49     | 0.085    | 0.085          |          |                |
| 50     |          |                |          |                |

**Table 13**. 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 L | Quarter 1 D | Quarter 2 L | Quarter 2 D | Quarter 3 L | Quarter 3 D | Quarter 4 L | Quarter 4 D | Year L | Year D | Year CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| 1 | 0 | 8 | 0 | 2 | 0 | 0.9 | 48 | 119 | 10 | 24 | 201% |
| 2 | 3 | 6 | 4 | 0.5 | 27 | 0.9 | 63 | 0.1 | 20 | 2 | 202% |
| 3 | 86 | 13 | 34 | 0.4 | 35 | 0.4 | 97 | 5 | 56 | 5 | 191% |
| 4 | 18 | 0 | 16 | 0.1 | 4 | 0 | 31 | 0 | 17 | 0.1 | 134% |
| 5 | 18 | 1 | 8 | 0.1 | 5 | 0 | 15 | 0 | 10 | 0.4 | 233% |
| 6 | 13 | 0 | 9 | 0 | 3 | 0 | 8 | 0 | 9 | 0 | - |
| 7 | 1 | 0 | 2 | 0 | 0.3 | 0 | 1 | 0 | 1 | 0 | - |
| 8 | 0.7 | 0 | 0.7 | 0 | 0 | 0 | 0.4 | 0 | 0.5 | 0 | - |
| 9 | 0 | 0 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | - |
| 10 | 0.4 | 0 | 0.7 | 0 | 0 | 0 | 0.6 | 0 | 0.5 | 0 | - |

**Table 14**. Sole. Landings (L) and discards (D) raised estimate of total fleet numbers (*1000) and mean length (left), total fleet weight (*1000) and mean weight (right) at age per quarter.

| Quarter | Age | Numbers (*1000) L | D | Mean length L | D | Weight (*1000) L | D | Mean weight L | D |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | - | - | 0 | 0 | - | - |
| | 1 | 0 | 1056 | - | 14.4 | 0 | 28 | - | 0.026 |
| | 2 | 348 | 745 | 24.7 | 20.6 | 52 | 61 | 0.150 | 0.081 |
| | 3 | 10388 | 1607 | 27.7 | 21.3 | 2309 | 148 | 0.222 | 0.092 |
| | 4 | 2123 | 0 | 29.3 | - | 570 | 0 | 0.269 | - |
| | 5 | 2150 | 177 | 29.5 | 23.0 | 612 | 21 | 0.285 | 0.117 |
| | 6 | 1615 | 0 | 30.7 | - | 525 | 0 | 0.325 | - |
| | 7 | 129 | 0 | 32.5 | - | 51 | 0 | 0.398 | - |
| | 8 | 78 | 0 | 32.8 | - | 31 | 0 | 0.399 | - |
| | 9 | 0 | 0 | - | - | 0 | 0 | - | - |
| | 10 | 52 | 0 | 30.7 | - | 17 | 0 | 0.324 | - |
| | **All** | **16883** | **3585** | **28.4** | **19.2** | **4168** | **257** | **0.254** | **0.084** |
| 2 | 0 | 0 | 0 | - | - | 0 | 0 | - | - |
| | 1 | 0 | 278 | - | 16.9 | 0 | 12 | - | 0.045 |
| | 2 | 591 | 80 | 25.0 | 20.8 | 92 | 7 | 0.155 | 0.088 |
| | 3 | 5067 | 56 | 27.7 | 23.1 | 1127 | 7 | 0.222 | 0.120 |
| | 4 | 2351 | 16 | 29.2 | 22.6 | 629 | 2 | 0.267 | 0.112 |
| | 5 | 1107 | 7 | 31.3 | 24.2 | 382 | 1 | 0.345 | 0.139 |
| | 6 | 1381 | 5 | 30.8 | 24.2 | 459 | 1 | 0.332 | 0.139 |
| | 7 | 309 | 1 | 33.3 | 24.1 | 130 | 0 | 0.421 | 0.137 |
| | 8 | 109 | 1 | 33.3 | 24.0 | 48 | 0 | 0.436 | 0.135 |
| | 9 | 25 | 0 | 36.9 | - | 14 | 0 | 0.575 | - |
| | 10 | 107 | 0 | 37.9 | - | 70 | 0 | 0.649 | - |
| | **All** | **11049** | **442** | **29.0** | **18.8** | **2949** | **30** | **0.287** | **0.082** |
| 3 | 0 | 0 | 0 | - | - | 0 | 0 | - | - |
| | 1 | 0 | 99 | - | 18.6 | 0 | 6 | - | 0.059 |
| | 2 | 3108 | 103 | 25.8 | 19.5 | 546 | 7 | 0.176 | 0.068 |
| | 3 | 4045 | 46 | 28.7 | 20.0 | 1021 | 3 | 0.252 | 0.074 |
| | 4 | 498 | 0 | 30.2 | - | 148 | 0 | 0.298 | - |
| | 5 | 567 | 0 | 29.6 | - | 165 | 0 | 0.291 | - |
| | 6 | 359 | 0 | 29.2 | - | 101 | 0 | 0.281 | - |
| | 7 | 35 | 0 | 38.5 | - | 22 | 0 | 0.651 | - |

| 8 | 4 | 0 | 42.0 | - | 4 | 0 | 0.860 | - |
| 9 | 0 | 0 | - | - | 0 | 0 | - | - |

**Table 14.** Continued.

| | | Numbers (*1000) | | Mean length | | Weight (*1000) | | Mean weight | |
|---|---|---|---|---|---|---|---|---|---|
| Quarter | Age | L | D | L | D | L | D | L | D |
| 3 | 10 | 4 | 0 | 42.0 | - | 4 | 0 | 0.860 | - |
| | All | 8622 | 248 | 27.9 | 19.2 | 2012 | 16 | 0.246 | 0.066 |
| 4 | 0 | 0 | 0 | - | - | 0 | 0 | - | - |
| | 1 | 6447 | 15936 | 24.0 | 21.1 | 876 | 1421 | 0.136 | 0.089 |
| | 2 | 8381 | 17 | 27.0 | 26.0 | 1707 | 3 | 0.204 | 0.176 |
| | 3 | 12915 | 713 | 28.4 | 24.1 | 3237 | 97 | 0.251 | 0.136 |
| | 4 | 4108 | 3 | 28.8 | 26.0 | 1126 | 1 | 0.274 | 0.176 |
| | 5 | 1975 | 4 | 29.2 | 26.0 | 565 | 1 | 0.286 | 0.176 |
| | 6 | 1118 | 3 | 32.4 | 26.0 | 453 | 1 | 0.405 | 0.176 |
| | 7 | 171 | 0 | 37.3 | - | 100 | 0 | 0.586 | - |
| | 8 | 54 | 0 | 39.9 | - | 40 | 0 | 0.729 | - |
| | 9 | 0 | 0 | - | - | 0 | 0 | - | - |
| | 10 | 83 | 0 | 46.5 | - | 102 | 0 | 1.231 | - |
| | All | 35252 | 16677 | 27.6 | 21.2 | 8206 | 1523 | 0.262 | 0.092 |
| All | 0 | 0 | 0 | - | - | 0 | 0 | - | - |
| | 1 | 6447 | 17368 | 24.0 | 20.6 | 876 | 1467 | 0.136 | 0.087 |
| | 2 | 12429 | 946 | 26.5 | 20.6 | 2397 | 78 | 0.195 | 0.084 |
| | 3 | 32414 | 2422 | 28.1 | 22.1 | 7693 | 255 | 0.238 | 0.109 |
| | 4 | 9080 | 19 | 29.1 | 23.2 | 2474 | 2 | 0.273 | 0.128 |
| | 5 | 5800 | 187 | 29.8 | 23.1 | 1724 | 22 | 0.299 | 0.120 |
| | 6 | 4474 | 8 | 31.0 | 25.0 | 1538 | 1 | 0.348 | 0.157 |
| | 7 | 644 | 1 | 34.5 | 24.1 | 304 | 0 | 0.489 | 0.137 |
| | 8 | 246 | 1 | 34.8 | 24.0 | 122 | 0 | 0.535 | 0.135 |
| | 9 | 25 | | 36.9 | | 14 | | 0.575 | |
| | 10 | 247 | | 39.3 | | 192 | | 0.934 | |
| | All | 71805 | 20952 | 28.0 | 20.8 | 17335 | 1826 | 0.262 | 0.091 |

**Table 15.** Dab. Landings (L), discards (D) and percentage discards (%D) per hour and per trip in numbers (left) and weight (right).

| Vessel | Quarter | Numbers | | | Weight | | |
|---|---|---|---|---|---|---|---|
| | | L | D | %D | L | D | %D |
| R29 | 1 | 75 | 462 | 86 | 15 | 39 | 72 |
| R31 | 1 | | 457 | | 5 | 23 | 81 |
| R30 | 2 | 68 | 1022 | 94 | 12 | 59 | 83 |
| R32 | 2 | 22 | 678 | 97 | 3 | 41 | 94 |
| R35 | 3 | 239 | 2474 | 91 | 33 | 150 | 82 |
| R36 | 4 | | 637 | | 2 | 38 | 96 |
| **Mean** | | **92** | **934** | **91** | **11** | **57** | **84** |

**Table 16**. Dab. Landings (L), discards (D) and percentage discards (%D) per hour and per quarter in numbers (left) and weight (right).

| Quarter | Numbers | | | Weight | | |
|---|---|---|---|---|---|---|
| | L | D | %D | L | D | %D |
| 1 | 74 | 460 | 86 | 11 | 31 | 75 |
| 2 | 45 | 853 | 95 | 7 | 50 | 87 |
| 3 | 239 | 2474 | 91 | 33 | 150 | 82 |
| 4 | | 637 | | 2 | 38 | 96 |

**Table 17.** Cod. Landings (L), discards (D) and percentage discards (%D) per hour and per trip in numbers (left) and weight (right).

| Vessel | Quarter | Numbers | | | Weight | | |
|---|---|---|---|---|---|---|---|
| | | L | D | %D | L | D | %D |
| R29 | 1 | | <1 | | 3 | <1 | 1 |
| R31 | 1 | | 2 | | 5 | <1 | 4 |
| R30 | 2 | | 2 | | <1 | <1 | 67 |
| R32 | 2 | 6 | 42 | 88 | 2 | 7 | 77 |
| R35 | 3 | 13 | 10 | 44 | 7 | 3 | 27 |
| R36 | 4 | | 2 | | 2 | <1 | 20 |
| **Mean** | | **9** | **11** | **56** | **3** | **2** | **42** |

**Table 18.** Cod. Landings (L), discards (D) and percentage discards (%D) per hour and per quarter in numbers (left) and weight (right).

| Quarter | Numbers | | | Weight | | |
|---|---|---|---|---|---|---|
| | L | D | %D | L | D | %D |
| 1 | | 1 | | 4 | <1 | 3 |
| 2 | 6 | 22 | 80 | 1 | 4 | 77 |
| 3 | 13 | 10 | 44 | 7 | 3 | 27 |
| 4 | | 2 | | 2 | <1 | 20 |

**Table 19.** Whiting. Landings (L), discards (D) and percentage discards (%D) per hour and per trip in numbers (left) and weight (right).

| Vessel | Quarter | Numbers | | | Weight | | |
|---|---|---|---|---|---|---|---|
| | | L | D | %D | L | D | %D |
| R29 | 1 | | 7 | | <1 | <1 | 90 |
| R31 | 1 | | 139 | | 1 | 6 | 82 |
| R30 | 2 | | 64 | | <1 | 4 | 86 |
| R32 | 2 | 11 | 121 | 92 | 2 | 9 | 80 |
| R35 | 3 | 18 | 289 | 94 | 3 | 20 | 87 |
| R36 | 4 | | 32 | | <1 | 2 | 89 |
| **Mean** | | **14** | **104** | **88** | **1** | **7** | **85** |

**Table 20**. Whiting. Landings (L), discards (D) and percentage discards (%D) per hour and per quarter in numbers (left) and weight (right).

| Quarter | Numbers | | | Weight | | |
|---|---|---|---|---|---|---|
| | L | D | %D | L | D | %D |
| 1 | | 71 | | <1 | 3 | 82 |
| 2 | 11 | 92 | 90 | 1 | 6 | 82 |
| 3 | 18 | 289 | 94 | 3 | 20 | 87 |
| 4 | | 32 | | <1 | 2 | 89 |

**Table 21.** Mean total weight (kg) and coefficient of variation (CV) of all discards and of plaice, sole, dab, cod and whiting discarded per year from 1999-2002.

| Species | 1999 | | 2000 | | 2001 | | 2002 | |
|---|---|---|---|---|---|---|---|---|
| | Discarded | CV | Discarded | CV | Discarded | CV | Discarded | CV |
| All discards | 39840 | 50% | 40889 | 54% | 35576 | 33% | 23438 | 17% |
| Plaice | 1287 | 81% | 3463 | 98% | 7079 | 133% | 4767 | 53% |
| Sole | 131 | 108% | 208 | 115% | 113 | 93% | 191 | 177% |
| Dab | 8090 | 109% | 4041 | 58% | 7258 | 38% | 4063 | 69% |
| Cod | 44 | 6% | 110 | 174% | 14 | 75% | 148 | 164% |
| Whiting | 353 | 137% | 640 | 154% | 291 | 105% | 489 | 92% |

**Table 22.** Plaice. Mean number caught and coefficient of variation (CV) per year for ages 0-5.

| Age | 1999 | | 2000 | | 2001 | | 2002 | |
|---|---|---|---|---|---|---|---|---|
| | Discarded | CV | Discarded | CV | Discarded | CV | Discarded | CV |
| 0 | 5 | 173% | 8 | 215% | 6 | 172% | 0 | 183% |
| 1 | 76 | 155% | 155 | 108% | 33 | 141% | 378 | 85% |
| 2 | 137 | 132% | 271 | 117% | 512 | 157% | 334 | 133% |
| 3 | 68 | 79% | 65 | 105% | 206 | 152% | 134 | 135% |
| 4 | 0 | 39% | 77 | 153% | 71 | 139% | 17 | 156% |
| 5 | 0 | 160% | 0 | 186% | 65 | 167% | 2 | 202% |

**Table 23.** Sole. Mean number caught and coefficient of variation (CV) per year for ages 0-5.

| Age | 1999 | | 2000 | | 2001 | | 2002 | |
|---|---|---|---|---|---|---|---|---|
| | Discarded | CV | Discarded | CV | Discarded | CV | Discarded | CV |
| 0 | 0 | - | 0 | - | 0 | 119% | 0 | - |
| 1 | 1 | 142% | 6 | 171% | 1 | 158% | 24 | 201% |
| 2 | 12 | 141% | 8 | 115% | 7 | 148% | 2 | 202% |
| 3 | 3 | 112% | 4 | 100% | 3 | 131% | 5 | 191% |
| 4 | 0 | 173% | 1 | 124% | 1 | 157% | 0 | 134% |
| 5 | 0 | 90% | 0 | 250% | 1 | 200% | 1 | 233% |

**Table 24**. 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% |

**Table 25**. 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% |

| COUNTRY | NL | | GEAR | TBB | | HPCLS | LARGE | | MESH | 80 | | Total effort | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | 2002 | | QUARTE | (All) | | | | | | | | North Sea | 23544 DaS |
| | | | | | | | | | | | | North Sea + NVT | 23544 DaS |

Sum of EFFOX

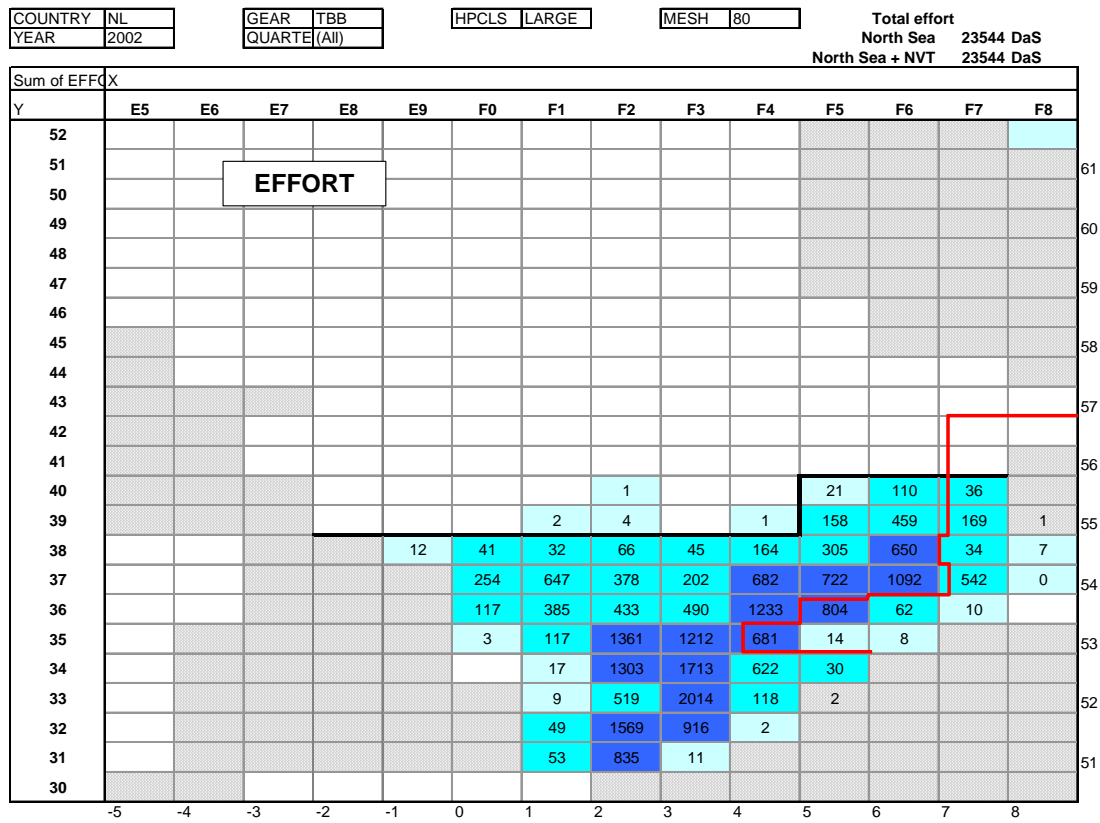| Y | E5 | E6 | E7 | E8 | E9 | F0 | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | | | | | | | | | | | | | | | |
| 51 | | | | | | | | | | | | | | | 61 |
| 50 | | | **EFFORT** | | | | | | | | | | | | |
| 49 | | | | | | | | | | | | | | | 60 |
| 48 | | | | | | | | | | | | | | | |
| 47 | | | | | | | | | | | | | | | 59 |
| 46 | | | | | | | | | | | | | | | |
| 45 | | | | | | | | | | | | | | | 58 |
| 44 | | | | | | | | | | | | | | | |
| 43 | | | | | | | | | | | | | | | 57 |
| 42 | | | | | | | | | | | | | | | |
| 41 | | | | | | | | | | | | | | | 56 |
| 40 | | | | | | | | 1 | | | 21 | 110 | 36 | | |
| 39 | | | | | | | 2 | 4 | | 1 | 158 | 459 | 169 | 1 | 55 |
| 38 | | | | | 12 | 41 | 32 | 66 | 45 | 164 | 305 | 650 | 34 | 7 | |
| 37 | | | | | | 254 | 647 | 378 | 202 | 682 | 722 | 1092 | 542 | 0 | 54 |
| 36 | | | | | | 117 | 385 | 433 | 490 | 1233 | 804 | 62 | 10 | | |
| 35 | | | | | | 3 | 117 | 1361 | 1212 | 681 | 14 | 8 | | | 53 |
| 34 | | | | | | | 17 | 1303 | 1713 | 622 | 30 | | | | |
| 33 | | | | | | | 9 | 519 | 2014 | 118 | 2 | | | | 52 |
| 32 | | | | | | | 49 | 1569 | 916 | 2 | | | | | |
| 31 | | | | | | | 53 | 835 | 11 | | | | | | 51 |
| 30 | | | | | | | | | | | | | | | |
| | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |

**Figure 1.a.** Effort distribution of the Dutch beamtrawl fleet in 2002, for vessels larger than 300 Hp and (declared) mesh size of 80 mm.
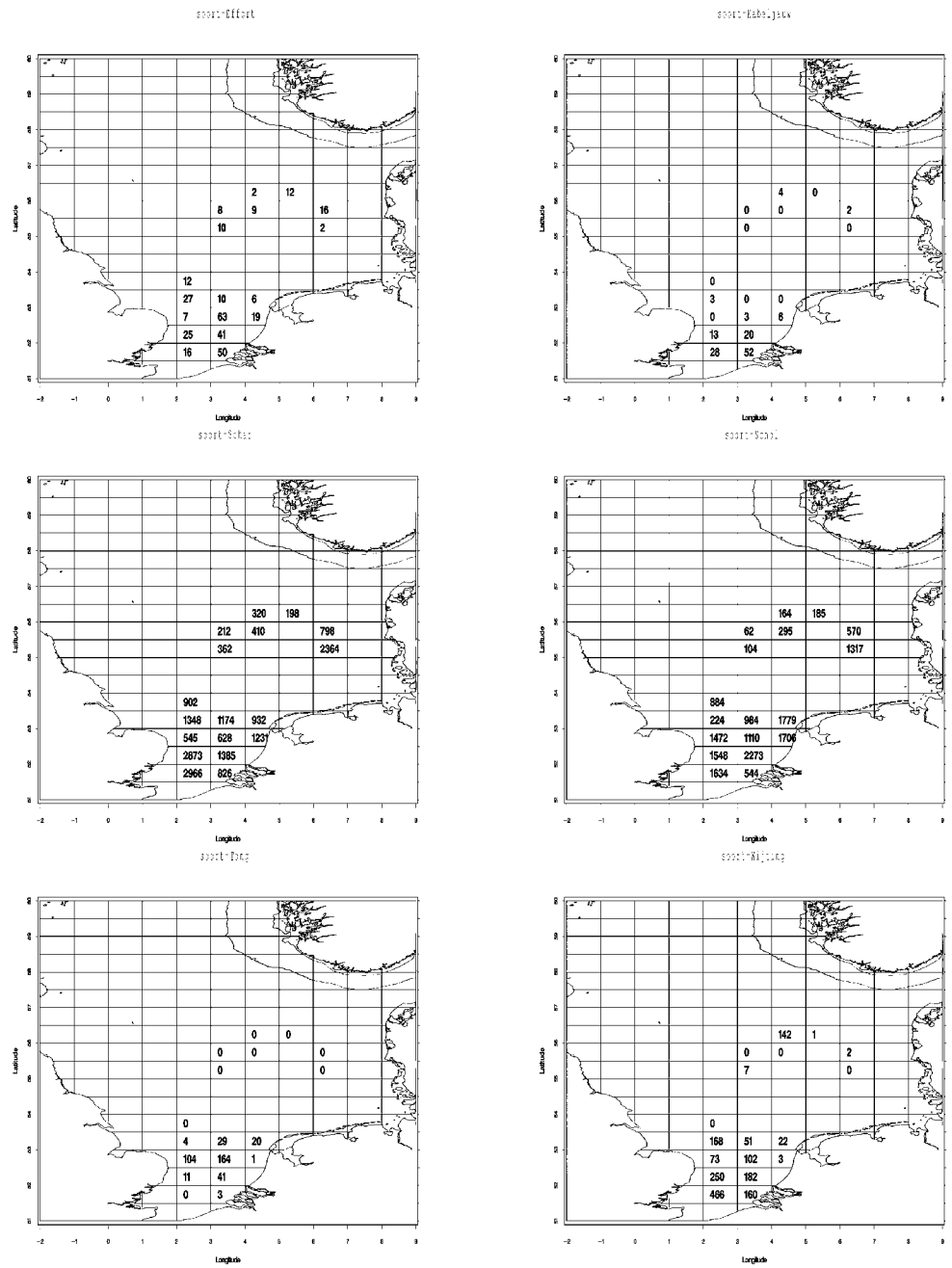
**Figure 1.b.** Sampling effort in hours (upper left) and number of discards per hour per ICES area for cod (upper right), dab (middle left), plaice (middle right), sole (lower left) and whiting (lower right) in 2002.
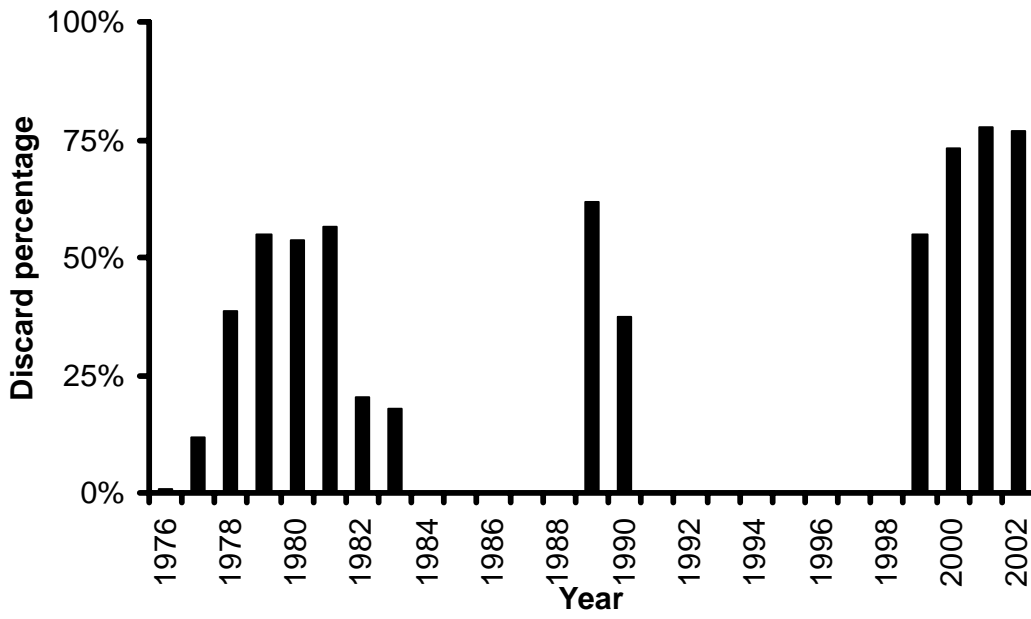
**Figure 2**. Plaice. Discard percentage per year from 1976-1983, 1989-1990 and 1999-2002 per year.
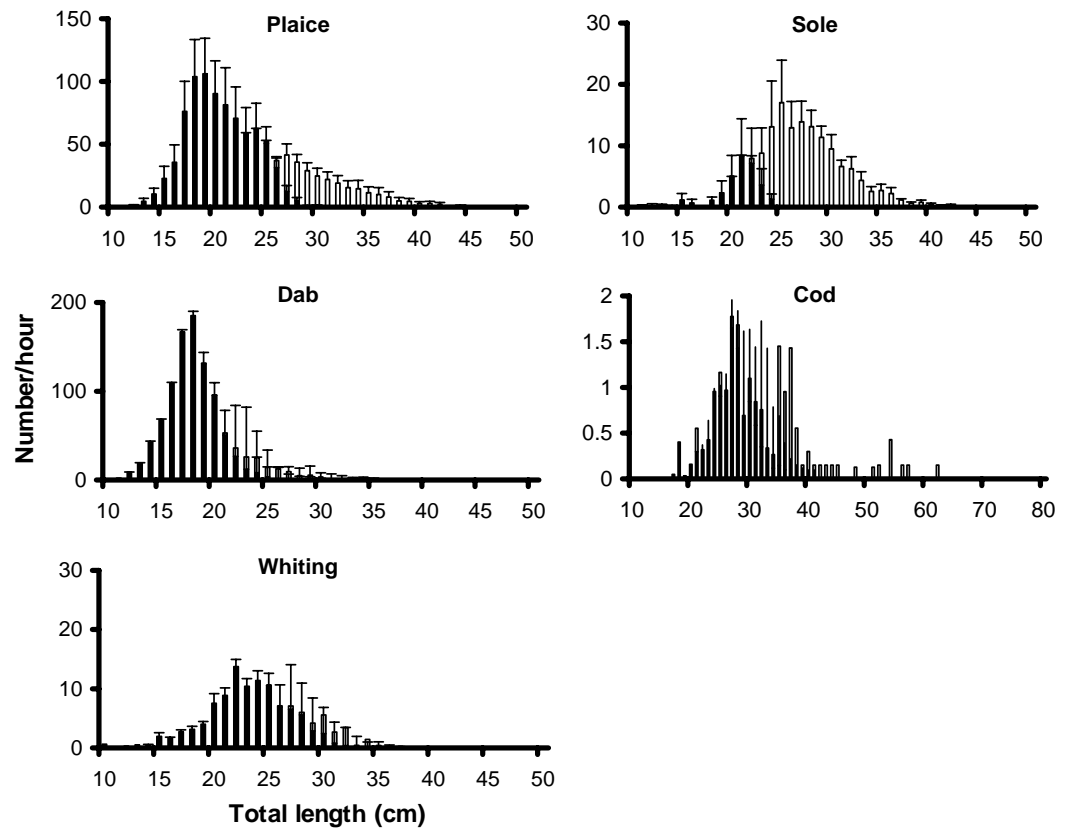
**Figure 3**. Length frequency distribution of plaice, sole, dab, whiting and cod in 2002. Black bars show discards, white landings.
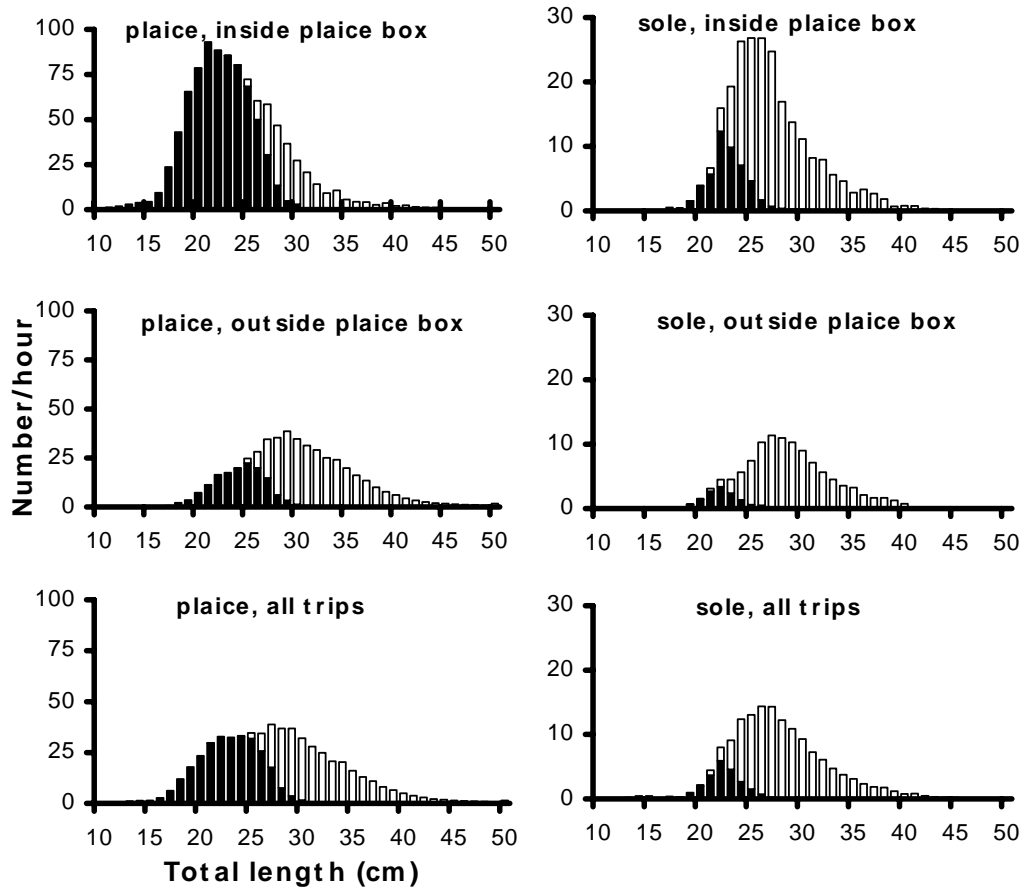
**Figure 4.** Length frequency distribution for plaice and sole from 1976-1990 inside and outside the plaice-box and all trips combined. Black bars show discards, white bars landings (Van Beek, 1998).
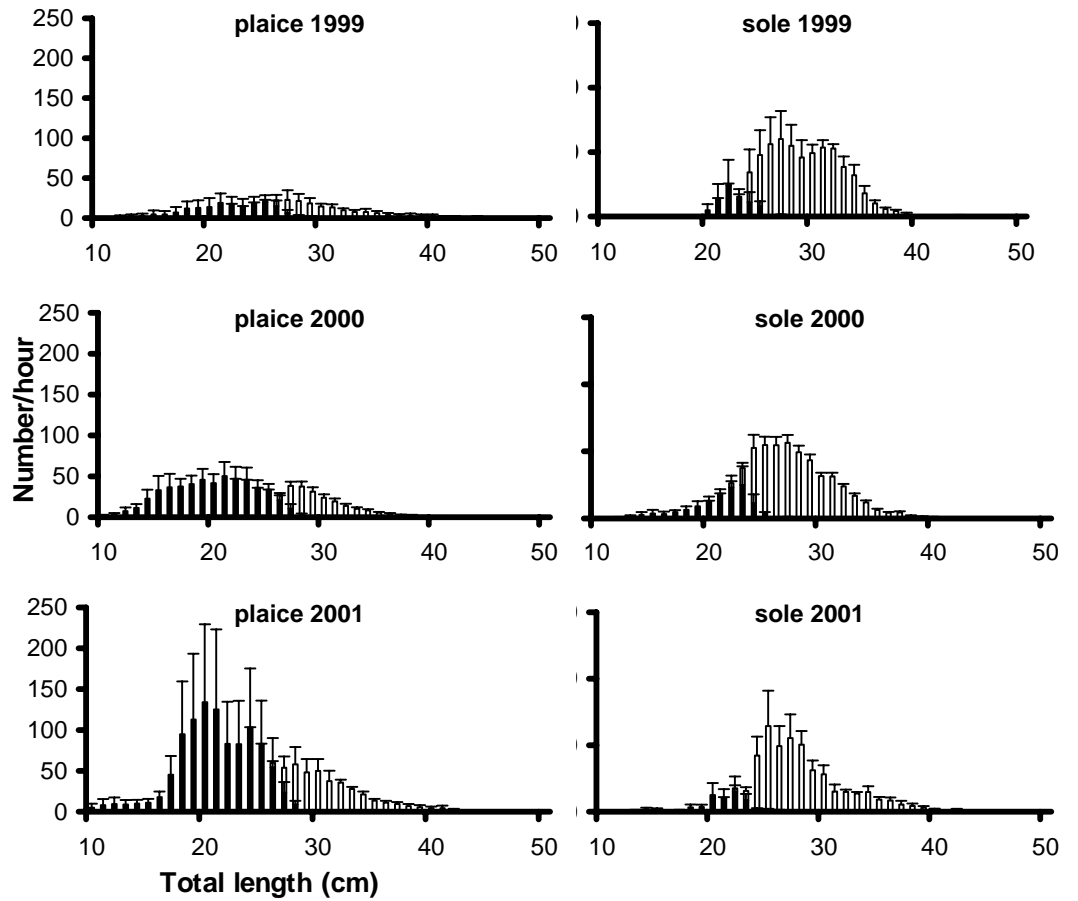
**Figure 5.** Length frequency distribution of plaice and sole from 1999-2001 (Netherlands Institute for Fisheries Research, unpublished data). Black bars show discards, white landings.
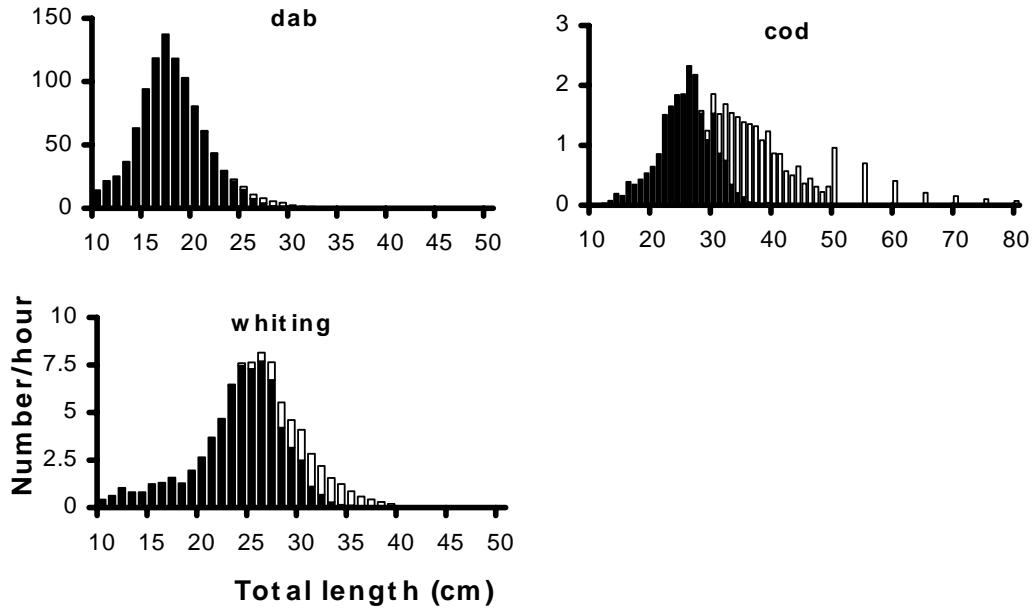
**Figure 6.** Length frequency distribution for dab, cod and whiting from 1976-1990 (Van Beek, 1998). Black bars show discards,