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Report

Number: C032/05

Discard reconstruction method used in the assessment of North Sea plaice in 2004

PRODUCT A3b VAN HET F-PROJECT

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Project number:	324-12470-02
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Date:	17 June 2005
Number of copies:	15
Number of pages:	20
Number of tables:	1
Number of figures:	15
Number of annexes:	-

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Samenvatting

In de bestandschatting van schol in 2004 is een tijdserie van discards gebruikt, die bestond uit gemodelleerde discardsschattingen voor de periode 1957-1998 en discardsgegevens uit recente reizen gemaakt aan boord van boomkorschepen gedurende 1999-2003.

De toestandsbeoordeling van Noordzee schol is gebaseerd op het aantal van iedere leeftijdsgroep die per jaar wordt aangeland. Omdat een aanzienlijk deel van de gevangen schol ondermaats is en weer in zee wordt teruggezet (discards) is de bestandsschatting onnauwkeurig. Waarnemingen van de bijvangst van ondermaatse schol zijn slechts beperkt beschikbaar. Sinds 1999 is een systematische bemonstering van discards aan boord van bedrijfsschepen gestart. Voor de periode waarvoor geen systematische discardschattingen beschikbaar zijn, is een methode ontwikkeld om de aantallen discards per leeftijdsgroep te reconstrueren. Voor de jaren vanaf 1999 zijn de aantallen discards bepaald aan de hand van de discardbemonstering aan boord van bedrijfsschepen.

Het aantal ondermaatse vis dat van een leeftijdsgroep wordt gevangen, wordt bepaald door de visserij-intensiteit (F). In principe staan de discardsleeftijdsgroepen aan dezelfde visserij-intensiteit bloot staan als de leeftijdsgroepen die volledig door de visserij kunnen worden gevangen (volledig gerecruteerd zijn). Omdat echter een deel van de discardsleeftijdsgroepen nog niet naar de visgronden zijn gegaan en nog deels door de mazen van het net kunnen ontsnappen, is de werkelijke visserijsterfte lager. De visserijsterfte van de gevangen fractie kan worden bepaald als bekend is hoeveel procent van een leeftijdsgroep op de visgronden beschikbaar is en in het net gevangen wordt. De visserijsterfte van de gevangen fractie kan vervolgens worden opgesplitst in een visserijsterfte van ondermaatse en van maatse vis op basis van de verhouding tussen het ondermaatse en maatse deel in de vangst. De visserijintensiteit van de leeftijdsgroepen die volledig door de visserij gevangen kunnen worden werd gebaseerd op de uitkomsten van de toestandsbeoordeling (VPA) van aanlandingsgegevens.

Aan de hand van groeigegevens en gegevens over de maaswijdte selectie werd vervolgens de verhouding bepaald tussen het aandeel ondermaatse vis die door de mazen ontsnapt, het aandeel ondermaatse vis die gevangen wordt (=discards), en het aandeel maatse vis (aanlandingen). De jaarlijkse variatie in groei werd geschat door de gemiddelde lengte in de BTS (Beam Trawl Survey) te voorspellen aan de hand van een wiskundig GLM model van de waargenomen gemiddelde lengte per leeftijdsgroep in de BTS en SNS (Sole Net Survey) en de terugberekende lengte op basis van gehoorsteentjes (otolieten) van volwassen schol uit de marktbemonstering. Grafieken van de maaswijdte selectie (vanaf welke lengte komt een vis in het net) en van het sorteergedrag aan boord (op welke lengte wordt een schol overboord gegooid of bewaard) werden geschat aan de hand van waarnemingen tijdens reizen bemonsterd op discards en werden voor de gehele tijdperiode 1958-2003 constant verondersteld. Het percentage schol dat op de visgronden beschikbaar is werd geschat uit de surveygegevens als het gedeelte van de populatie dat zich buiten de scholbox en 12 mijlszone bevindt en het gedeelte dat zich binnen de scholbox en 12 mijlszone bevindt.

Met de aldus berekende visserijsterfte voor de discard- en aangelande fractie van de niet volledig gerecruteerde leeftijdsgroepen en de aantallen overlevenden in de populatie werd vervolgens de aantallen vis in de vangst en de discards geschat. Aanlandingen werden berekend door de discards van de vangst af te trekken per leeftijdsgroep. De aantallen discards werden vervolgens gebruikt om een nieuwe bestandsschatting (VPA) uit te voeren.

De gemodelleerde groei die gebruikt wordt om proporties aangelande en gediscarde vissen te berekenen, was hoger eind jaren ‘70 en begin jaren ‘80 dan de periode ervoor en erna. De hieruit berekende proportie aangelande vissen in die periode was voor met name 2 jarigen hoger dan in de andere periode. Door de opname van discards wordt voornamelijk de invloed

van de sterke 1985 jaarklasse groter, omdat vangstaantallen voor de 1985 jaarklasse in verhouding tot andere jaren meer zijn toegenomen.
De opname van discardsschattingen in de toestandsbeoordeling (VPA) had geen grote invloed op de schatting van het paaibestand, maar had een grote invloed op de schatting van de jaarklassterkte en visserijsterfte, zowel qua niveau als qua variatie. Op het oog lijkt het patroon in recruitment tussen de verschillende jaren niet wezenlijk veranderd te zijn, maar schattingen voor de 1980 en de sterke 1985 jaarklasse zijn meer omhoog bijgesteld door de opname van discards. Opvallend is dat ook na de opname van discards in de populatieberekening er een patroon zichtbaar blijft van een periode van relatief lage jaarklassterkte in de jaren 1960 en 1970, van relatief hoge jaarklassterkte in de jaren 1980 en een periode van lage jaarklassterkte in de jaren 1990.

De opname van discards in de bestandsschatting heeft het probleem dat is ontstaan in de bestandschatting van 2003 niet opgelost. Gedacht werd dat de herziening van het scholbestand kwam door het discarden van de sterke 1996 jaarklasse, die uiteindelijk in lagere aantallen in de aanlandingsgegevens voorkwamen dan voorspeld in voorafgaande jaren. De opname van discards heeft dit probleem wel verminderd, maar niet verholpen.

Het gebruikte model is op een aantal punten nog onvolledig. Met name de mate waarin de ondermaatse leeftijdsgroepen op de visgronden voorkomen zal nog nauwkeuriger moeten worden onderzocht op basis van de verandering in de verspreiding van jonge schol en veranderingen in de verspreiding van de visserijvloot.

Summary

In the plaice assessment of 2004 a discard time series was used, which was based on reconstructed discard estimates for 1957-1998 and recent discard trip observations during 1999-2003. The numbers of reconstructed plaice discards at age were calculated from corrected fishing mortality estimates F, using a simulated population based on growth measurements and selection and distribution ogives.
The simulated population was calculated using a normal distribution derived from mean length at age measurements. These were predicted for the Beam Trawl Survey using a GLM model of the length at age (Li) estimated in surveys (Sole Net Survey and Beam Trawl Survey) and otolith back-calculations.
The mesh selection and sorting ogives were assumed to be constant throughout the time period and were estimated from observations. The distribution ogive was based on the proportion of plaice outside the plaice box and 12 miles zone compared to inside the plaice box and 12 miles zone, based on survey estimates.
From this the proportion of fish in the population available at the fishing ground, retained by the net and discarded was estimated per age group and year for 1957-1998. These values were used to correct landings data based fisheries mortality F for discards. Newly calculated F's were used to calculate new population numbers and new catch numbers at age. These newly calculated catch numbers at age were used to run a new assessment with discards included.
The overall SSB is not strongly affected by including discards, but the overall F and its pattern changes markedly with the inclusion of discards. Superficially the trends in recruitment appear to be similar, but a closer examination shows that recruitment estimates in the 1980s and especially the strong 1985 year class are adjusted more by including discard data.
The inclusion of discards into the assessment has not resolved the main problem that was identified in WGNSSK 2003: the revision of the stock size due to the revision of the estimated strength of the 1996 year-class. The retrospective patterns however did decrease.
The method will be further developed with a more in depth analyses of the distribution of plaice and the distribution of the fleet targeting it.

1. Introduction

Discarding occurs when part of the catch is thrown back in the sea and it is a major problem in many fisheries (Alverson et al., 1994). Stock assessments are generally based on landing data only and ignoring discards in the population analysis may lead to serious bias in the perceived dynamics of the population. In particular the estimates of year class strength will be underestimated (Casey, 1993; Dingsor, 2001). It is possible to estimate discarding by onboard sampling programmes but because discarding practices vary by season, year and area, such programmes are costly. In addition, in the case of plaice, it was felt necessary to estimate past discarding practices when at sea sampling was either not available or considered insufficient.

An alternative approach is to estimate discarding from knowledge on the selection characteristics of the gear and the growth rate of the species, in combination with information of the relative distribution of the fish and the fishery (ICES, 1987; Rijnsdorp & Van Beek, 1991, Casey 1993). Casey (1993) used this method to correct landings numbers at age for discards, which was also used by Van Keeken et al. (2004) in the first F-project discard report (A3) to estimate discards numbers at age. This method however cannot estimate numbers of discards for ages were no landings were reported, but discards were made.

Up to 2003, the status of the North Sea plaice stock was assessed using only landings at age data but in 2004 a discard time series was used in the assessment of North Sea plaice based on reconstructed discard estimates for 1957-1998 and recent discard trip observations during 1999-2003. A complete time series on discards (part of the catch that is thrown overboard) based on catch observations was not available because of gaps in this series. Discards in the Dutch beam trawl fleet were sampled during the end of the 1960's until the mid 1970's (De Veen and Rodenburg, 1971; De Veen et al., 1975), during 1976-1983 and 1989-1990 (Van Beek, 1998). In recent years discards have been sampled again from 1999 onwards (Van Keeken et al., 2003, 2004). The method to reconstruct discards is a further development of the approach of Casey (1993). In addition to the method used by Casey (1993), the new method can be used to estimate discards for ages with no reported landings.

The approach builds on the notion that during its life a cohort will grow through the discard size range. Dependent on the growth rate of plaice, mesh size, minimum landing size, and the availability of the fish to the fishery, the cohort size distribution may be broken up in different components: fish that are unavailable or escape through the meshes; undersized-fish that are retained in the cod-end; and marketable fish that are retained in the cod-end. The levels of F for fully recruited ages were corrected for these components to obtain discards numbers at age for juvenile age groups. This reports describes the method used to obtain the discard estimates used in the 2004 assessment presented in the report of the WGNSSK in 2004.

2. Methods

The discards numbers at age were calculated from corrected fishing mortality estimates F, using a simulated population and selection and distribution curves (Figure 2.1). From the proportion discards at age and F for fully recruited ages (age 5 and older), corrected F for discards age groups are calculated. Using these discard corrected F values, new population and catch numbers were calculated. These new catch numbers are used in the assessment.

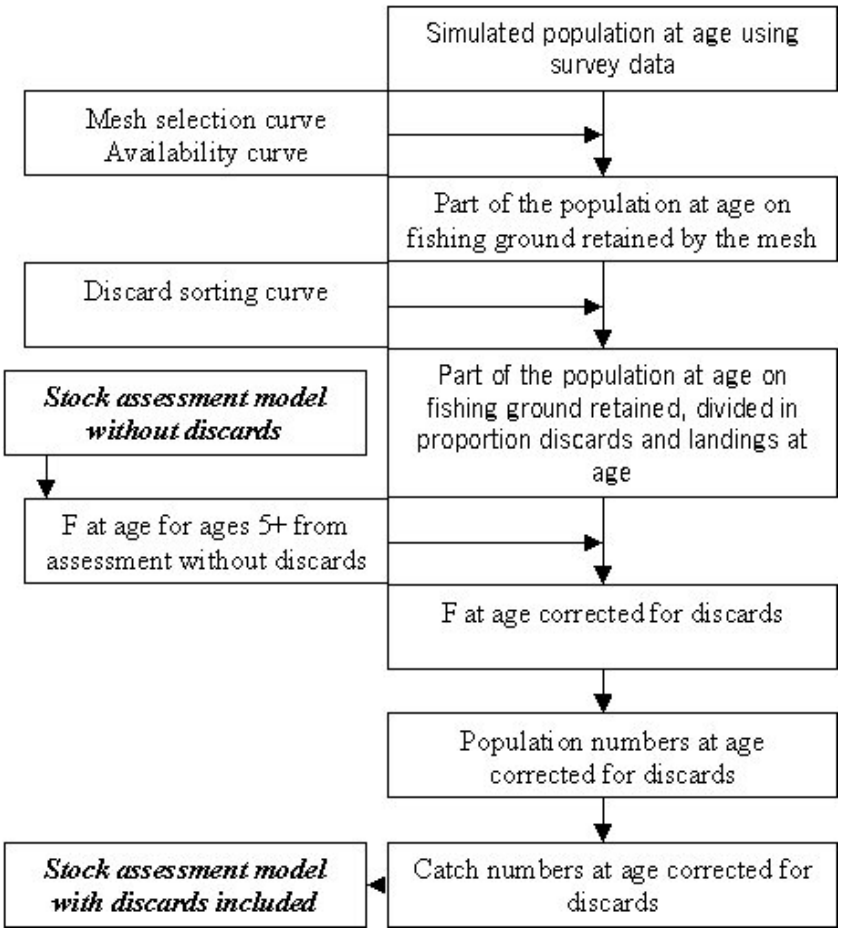

Figure 2.1. Flow diagram of the method used.

Following the analysis of Rijnsdorp et al. (2004), the mean length of age groups 1 – 6 were estimated using a GLM model of the length at age (Li) estimated in surveys (SNS and BTS survey) and otolith back-calculations. The model was estimated for each age separately.

$Li = Year + Survey + \varepsilon$

The class variable *Year* extracts the signal of inter-annual variations in length at age, whereas the class variable *Survey* estimates the differences in length observed between surveys. Differences in length estimates between the surveys do occur due to differences in timing (BTS: August-September; SNS: September-October) and differences in survey area. The otolith back-calculation time series includes female data only and will give higher length at age estimates for older age groups (2 plus) because of the sexual dimorphism in growth. The fitted model was used to predict the length at age for the BTS survey for each year during the whole time period, as the BTS length will most closely match the mean length of the population during the year. Length distributions were modeled as a normal distribution with the mean length at age from

the above analysis and the average coefficient of variation (9%) observed in the BTS survey (Figure 2.2).

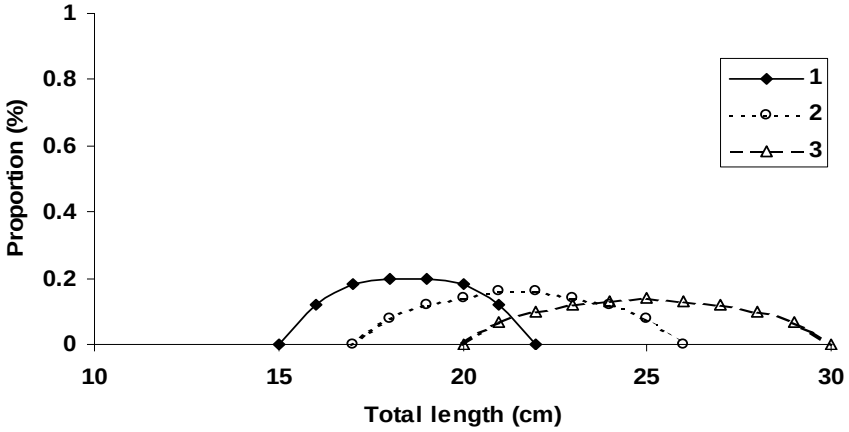

Figure 2.2. Fictive modelled population in a quarter and year. With the normal distribution the proportion of a length class within an age class is calculated.

The mesh selection and sorting curves (Figure 2.3, 2.4) were assumed to be constant throughout the time period and corresponds to a selection factor of 2.2, a selection range of 3 cm (Van Beek et al., 1981, 1983), a cod end mesh of 80 mm and a minimum landing size of 27 cm. Assuming that the selection curve is constant is probably close to reality. However, it is possible that the sorting curve has changed as a function of market demands and year class size.

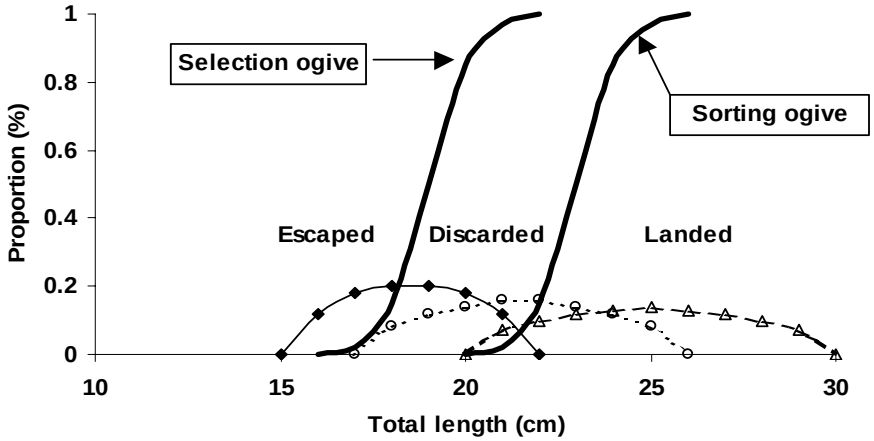

Figure 2.3. Selection and sorting ogive. The selection ogive divides the population in a part that escaped the nets and a part that is caught. The sorting ogive divides the caught part into a landed and a discarded part.

The distribution curves were estimated from survey data for individual years assuming that only those size classes that occur outside the coastal zone (12 nm zone and since 1989 the plaice box) are available to the fisheries. The distribution was estimated for each cm-class as the proportion of the population numbers outside the coastal zone of the area between 52°N-55°30'N and east of 3°E. The population numbers were estimated as the sum of the catch rates per stratum (ICES rectangle) times the surface area of the stratum. In the next step a logistic regression was calculated over the proportion of fish outside the coastal waters per cm-class. In order to smooth the relationships, the distribution curve was estimated from the pooled survey data of the year (i) and two neighboring years (i-1, i+1), analogous to a three-year running mean. Distribution curves were thus estimated for individual years since 1980. For

the period 1957 – 1979, a mean distribution curve was used based on the survey data from 1970-1979. With these regressions, the proportions of plaice availability at the fishing ground were estimated for the size range up to 30 cm, and rescaled to a proportion of 1 for 30 cm fish (Figure 2.4).

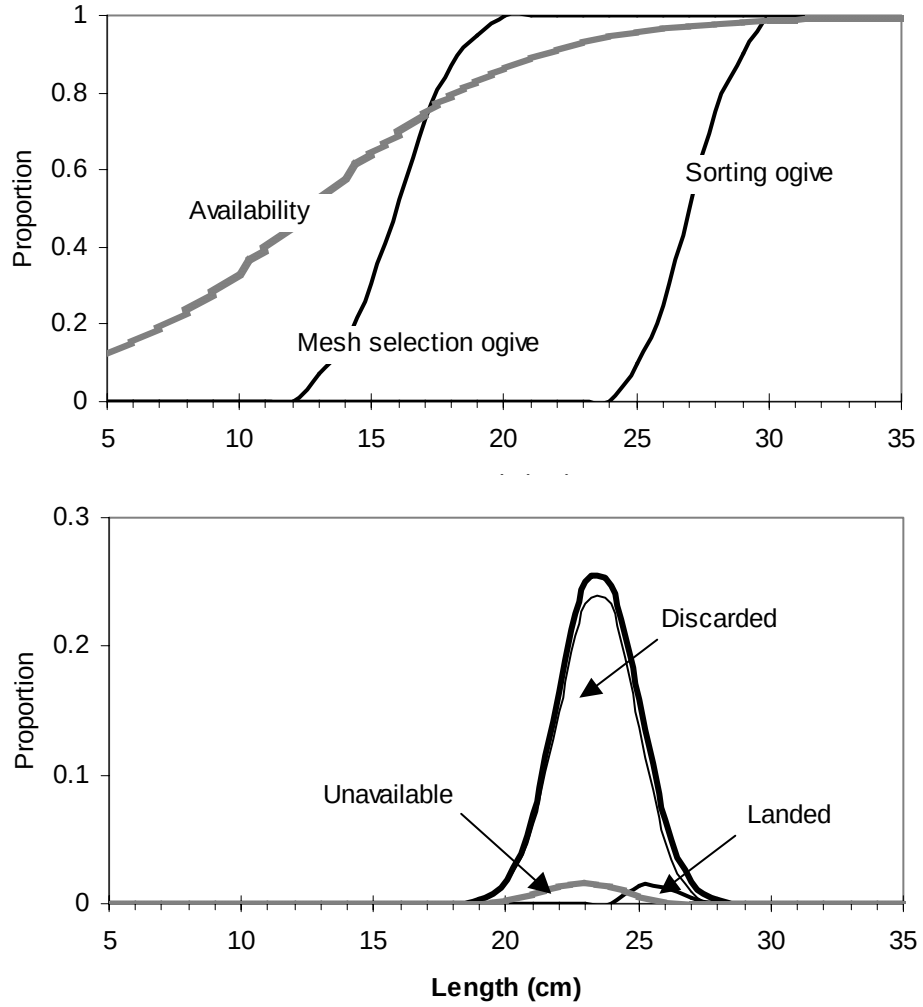

Figure 2.4. Factors determining the proportion of the population in a discards age group that will be retained in the cod-end and will be landed by the fishery (upper panel) and the resulting size distributions of the discarded and landed fraction. The heavy line in the bottom panel shows the length distribution of the cohort.

Fishing mortality on the discards age groups 1-4 was set relative to the mean F on the ages 5 and 6, since these age groups are almost completely recruited (vulnerable) to the fishery. For these age groups the F was available from the recent VPA of landings data and was corrected for the simulated proportion of discards estimated from the growth data and mesh selection, sorting and availability curves.

With the corrected fishing mortality for age groups 1-6, the population numbers at age for these age groups were calculated backwards from age 7 (first not corrected age) from the assessment without discards included:

$$N_{i-1} = N_i * e^{(M+F)}$$

With this formula population numbers at age are reconstructed backwards in time from population numbers at age one year later and one age older. Therefore population numbers at

age in the last year (final year population numbers at age) are necessary. These final population numbers at age were calculated for ages 1-4 using RCT3, projecting population numbers at age over the last 4 years using log transformed population numbers and survey indices from the current assessment. Catch numbers at age including discards were calculated using population numbers and corrected F:

$C_i = F/(F+M)*N_i - N_{i+1}$.

Discard numbers at age were eventually calculated from subtracting landings numbers at age from the newly calculated catch numbers at age.

The mean F for age 5-6 from which the F pattern on the younger ages was constructed with, was affected by the large 1996 yearclass in 1999 and 2000. This mean F 5-6 was perceived lower than the actual F on this 1996 yearclass, because of perceived high discard rates on this yearclass. In the final assessment, discards numbers at age were reconstructed for before 1999, while from 1999 discards numbers at age from the Dutch discard sampling program were used. A trial run was also explored using reconstructed discards numbers at age for the entire period 1957-2003. Discards numbers at age from the Dutch sampling program were raised to discards numbers at age of plaice in the North Sea by the ratio of the landings of the international fleet to the landings of the Dutch fleet.

Mean weight at age in the population, discards and landings were calculated from the size distribution used in the discard reconstruction, using a condition factor of 0.01, since the weight – length relationship in plaice is close to isometric with a mean condition factor of 0.01. Mean weight at age in the catch was calculated from discards weight and landings weights at age, weighted over the discards and landings numbers.

3. Results

3.1. Model

Modelled length at age used to estimate the proportion of a length class at age in a year from a normal distribution is shown in Figure 3.1. In the 1970s and beginning of the 1980s the mean length was on average higher than in the 1960s. After the 1980s the mean length at age decreased again. In the end of the 1990s the density related slow growth of the large 1996 year class is visible.

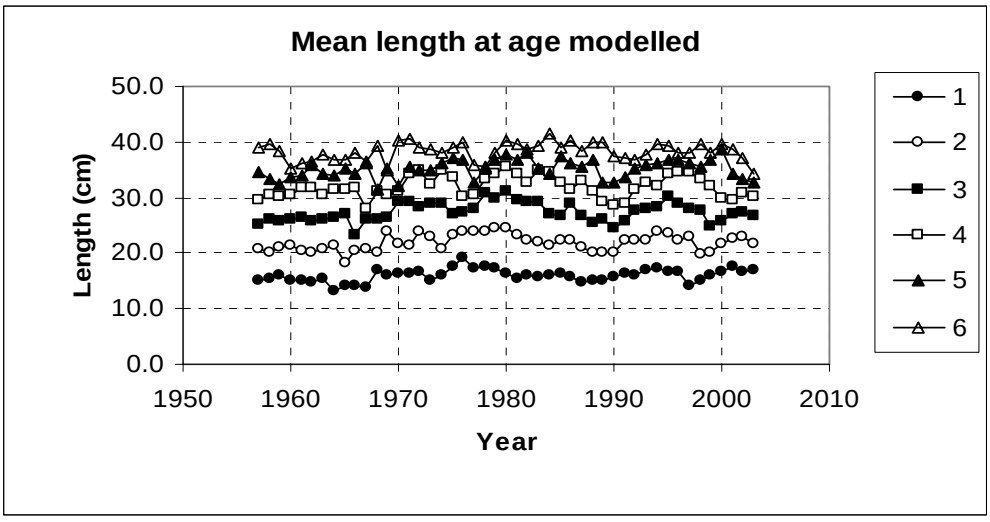

Figure 3.1. Variations in the mean length at age in summer as estimated from the BTS and SNS surveys and the time series of otolith back-calculations.

Before the closure of the plaice box a higher proportion of small plaice was estimated to have been available at the fishing ground than in the years after the closure (Figure 3.2). The selection curve for 1995 is more to the right side of the figure, because after the plaice box closure less small plaice were available to the fishery. However in recent years juvenile plaice moved offshore, resulting in a higher proportion of small plaice becoming available to the fishery.

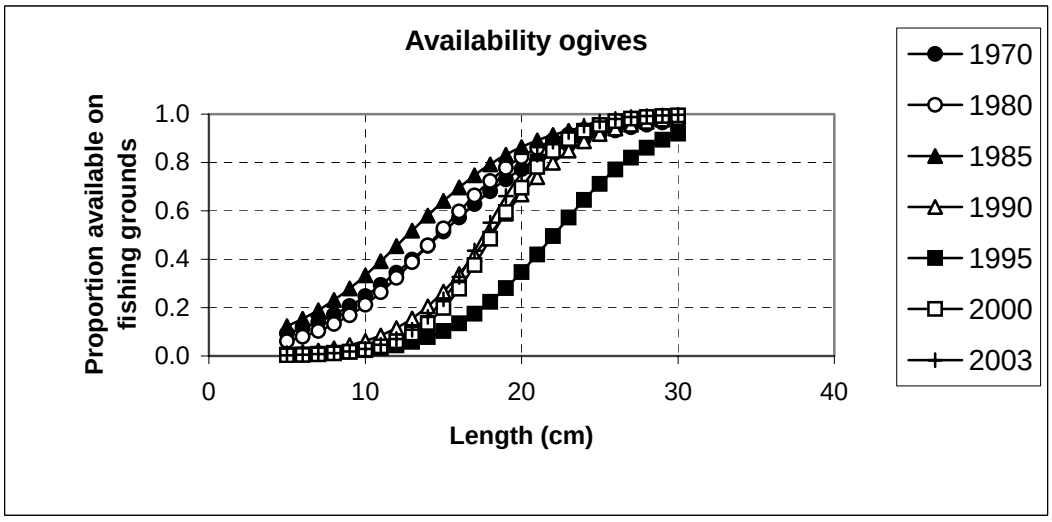

Figure 3.2. Variation in the availability curves for different years illustrating the effect of changes in distribution pattern of plaice and the establishment of the plaice box in 1989.

Of the age 3 and older plaice, most individuals were available at the fishing ground and retained in the net, while for age 1 and 2 only part of the population was available and retained (Figure 3.3). Because of the higher mean length at age during the 1970s and 1980s, more age 1 and 2 fish were retained than in the period before and after. During this period also more age 2 fish were landed from the catch (Figure 3.4).

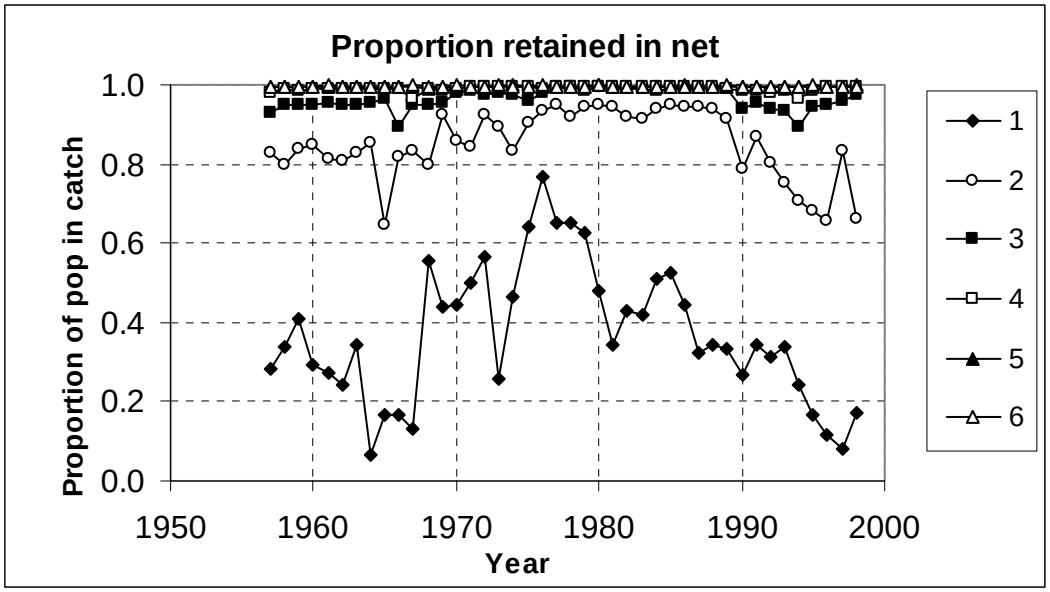

Figure 3.3. Proportion of the population retained by the cod-end and available at the fishing ground at age from 1957-1998.

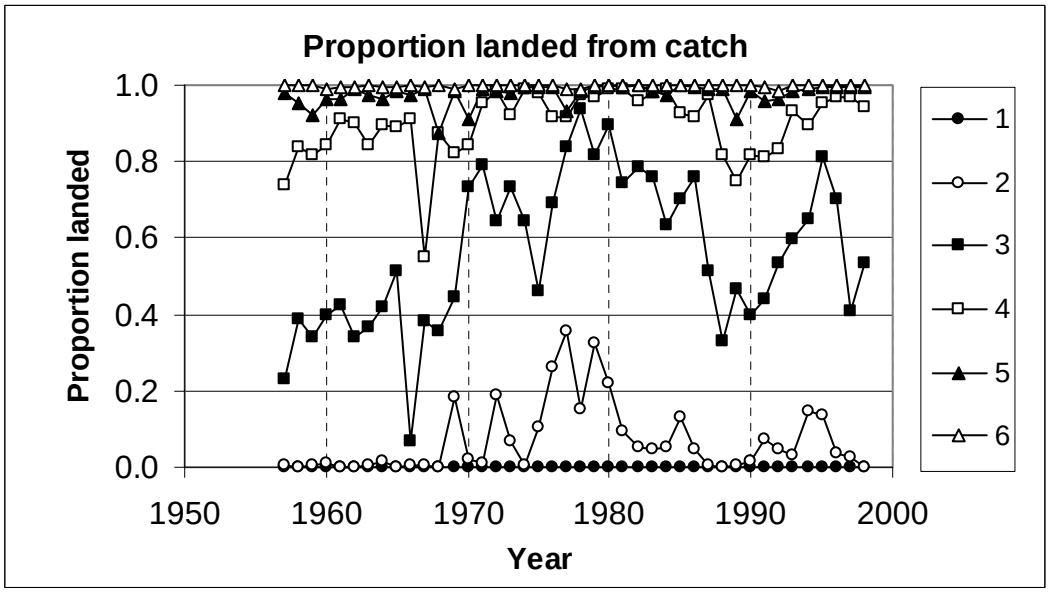

Figure 3.4. Proportion of the catch that is landed at age from 1957-1998.

In the newly calculated population numbers at age are high for 1986 and 1987, caused by the rescaling of the 1985 yearclass, in 1986 at the age of 1. This yearclass appears much bigger than the 1996 yearclass (Figure 3.5). As a result discard numbers at age are highest in the middle of the 1980s (Figure 3.6).

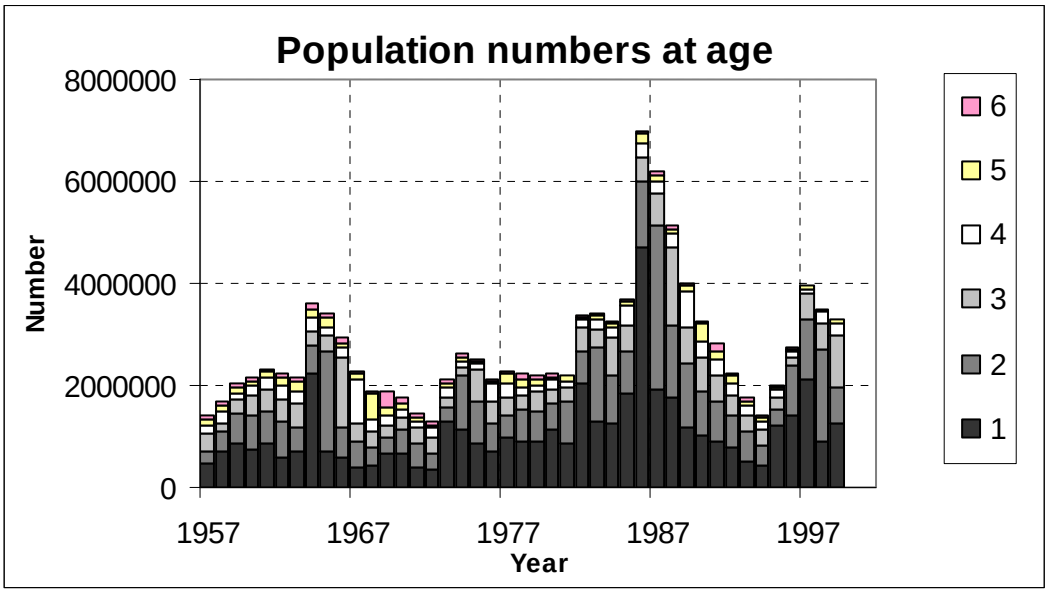

Figure 3.5. Population numbers at age corrected for discards for ages 1-6 from 1957-1999.

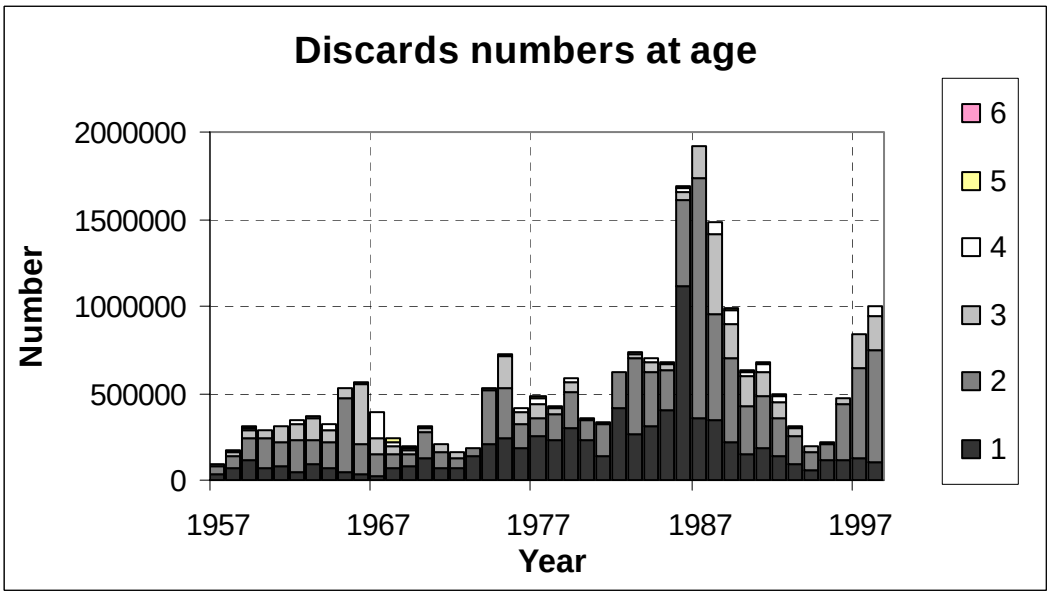

Figure 3.6. Discards numbers at age for ages 1-6 over 1957-1998.

The overall discard percentage estimated from the model was compared with the observations of discards from trip on commercial beam trawl vessels (Figure 3.7). In some years the discards percentage was in close agreement with the model, while in other years the observations were lower than the model. However during 1976-1977 and 1982-1983 only few observation trips were made each year.

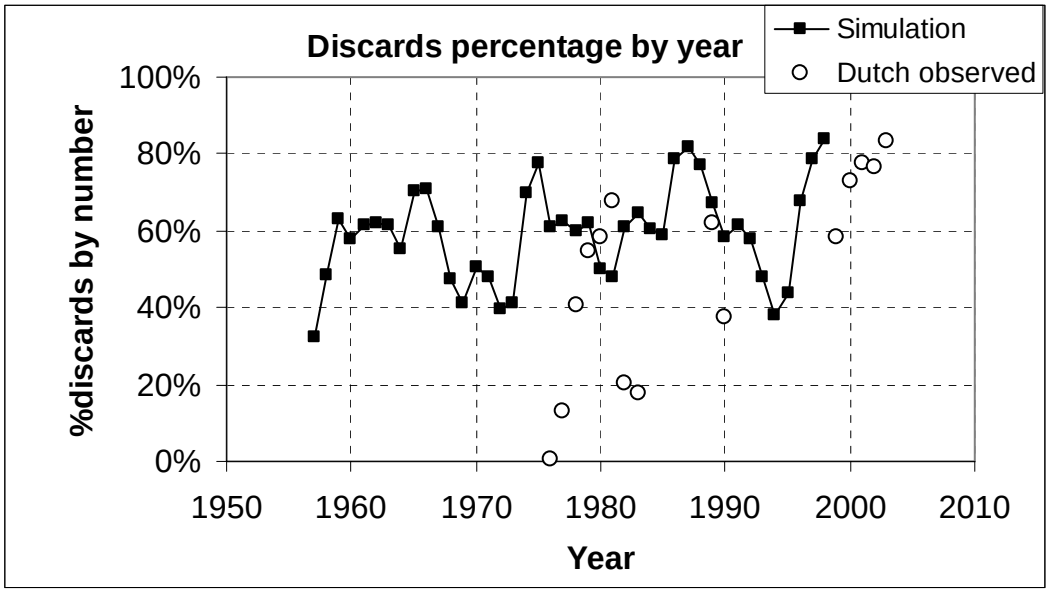

Figure 3.7. Discard percentage by year estimated from the discards numbers over all ages divided by the catch numbers over all ages (simulated), compared to observations from the Dutch discard sampling program (Van Beek, 1998; Van Keeken et al., 2004).

3.2 Stock assessment

This section shows how the inclusion of discard in the assessment affect the results. Sections are taken from the Working Group report of 2004. More detailed results are presented in this Working Group report.

The settings of the final XSA assessment are given in the text table below.

North Sea Plaice final assessment settings

year of assessment	2003					2004				
catch at age	landings only					landings and (reconstructed) discards				
		years	age	alpha	beta		years	age	alpha	beta
fleets	BTS	1985-2002	1-9	0.660	0.750	BTS	1985-2003	1-9	0.660	0.750
	SNS	1982-2002	1-3	0.660	0.750	SNS	1982-2002	1-3	0.660	0.750
	BTS-tri	1996-2002	1-9	0.660	0.750	BTS-tri	1996-2003	1-9	0.660	0.750
plus group	10					10				
first tuning year	1982					1982				
last data year	2002					2003				
time series weights	no taper					no taper				
Catchability dependent on stocksize for age<	1					1				
Catchability independent of age for ages >=	6					6				
Survivor estimates shrunk towards the mean F	5 years / 2 ages					5 years / 2 ages				
s.e. of the mean	0.5					0.5				
Minumum standard error for pop Estimates	0.3					0.3				
Prior weighting	not applied					not applied				
Number of iterations	49					34				
Convergence	Yes					Yes				

The discard estimates included in the catch are mostly for immature ages and it is therefore not surprising that the SSB is not strongly affected by including discards. Slightly higher SSB is estimated for the 1980s when discard data are included, and since 1995 in the case of observed discard data (Figure 3.8, upper panel). The overall F and its pattern change with the inclusion of discards, but the human consumption component of the fishery hardly changes (Figure 3.8, middle panel). The changes in F-patterns are caused by adjustments of year class

strengths of the different year classes. The overall recruitment increases if discards are included (Figure 3.8, lower panel). Superficially the trends in recruitment appear to be the same, but a closer examination shows that recruitment estimates in the 1980s and especially the strong 1985 year class are adjusted more by including discard data.

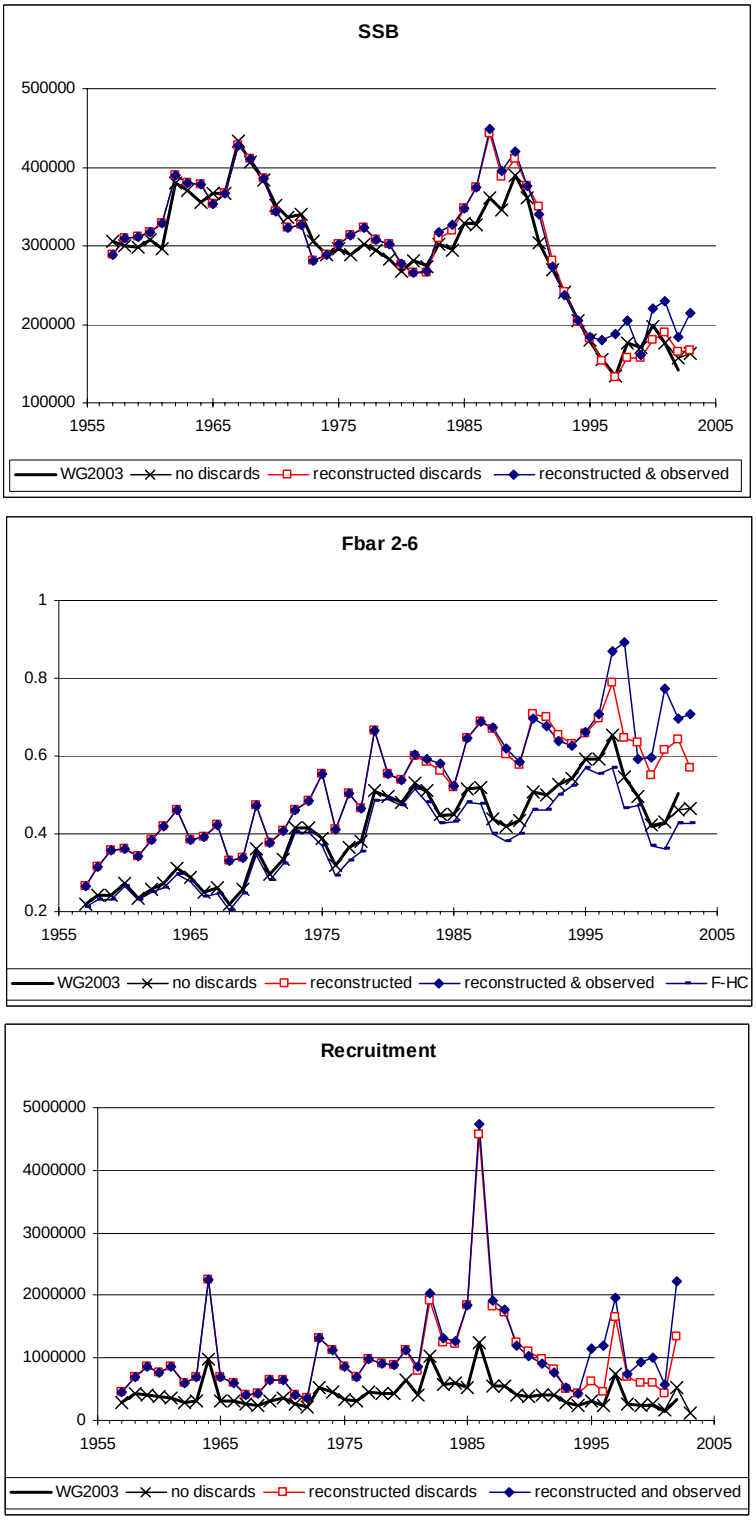

Figure 3.8. Comparison of XSA model results for catch at age data with no discards; reconstructed discards (reconstruction 1957-2003); and reconstructed + observed discards (reconstruction 1957-1998, observations 1999-2003).

Retrospective XSA analyses were carried out at high (0.5) and low (2.0) F-shrinkage using the catch at age data including observed and reconstructed discard estimates (Figure 3.9) and no discards included (Figure 3.10). All other settings were the same as those of the WG2003 final run (3 survey tuning fleets, no power model, no tuning window or time taper, 10+ group and the q-plateau at age 6). With a retrospective analysis, consistently lower or higher patterns in the times-series of SSB, F or recruitment between consecutive are investigated. The retrospective patterns improve if estimates of discards at age are included in the catch at age matrix. Although the tendency to over- or underestimate appears to decrease after including the discard data, the retrospective pattern is still considered to be too severe to allow low shrinkage.

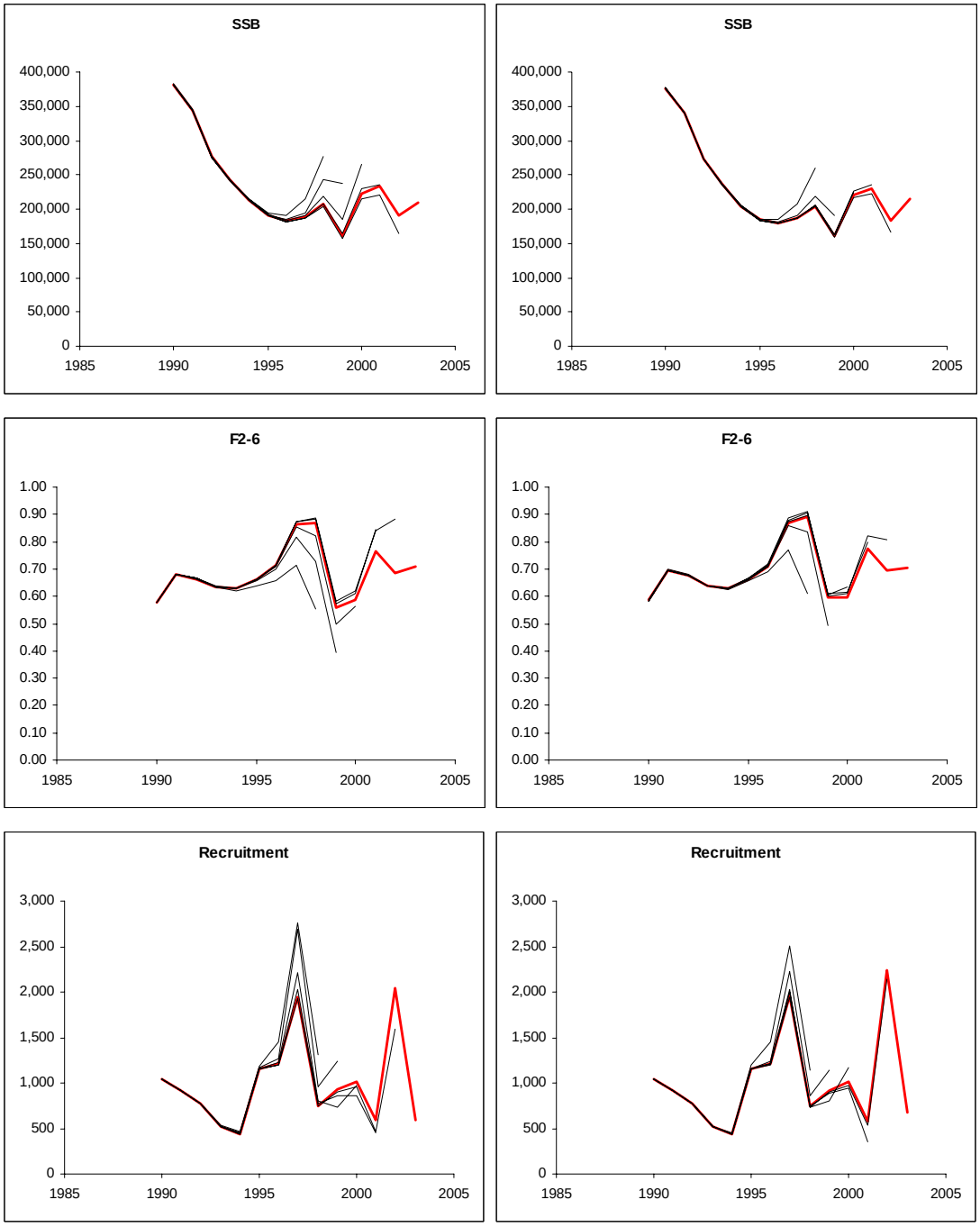

Figure 3.9. Retrospective patterns of low (2.0: left panels) and high (0.5: right panels) shrinkage XSA models including reconstructed and observed discards data.

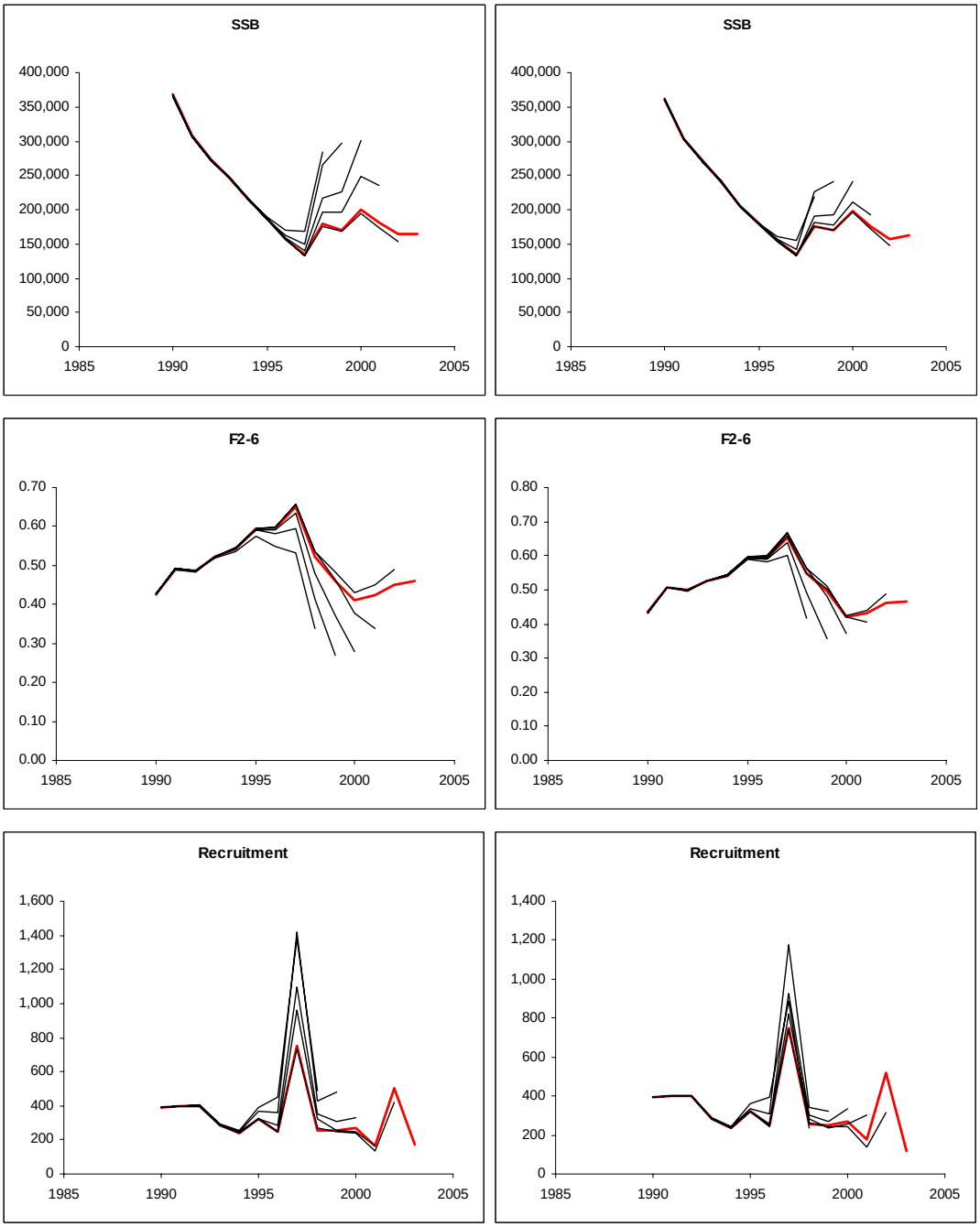

Figure 3.10. Retrospective patterns of low (2.0: left panels) and high (0.5: right panels) shrinkage XSA not including discards data.

4. Discussion

Including discards in the assessment of North Sea plaice has a large effect on the recruitment estimates and also substantial effects on trends in fishing mortality but less so on SSB. The trends in fishing mortality at the younger ages are heavily affected by the estimated fishing mortality on the discards component; the fishing mortality in the human consumption component is very comparable with the assessment without discards. The recruitment estimate of the strong 1985 year-class is much higher when including discards into the assessment. This re-evaluation of the strength of the 1985 year-class is beyond what has been observed in the surveys. According to the surveys, the 1985 and 1996 year-classes should have been in the same order of magnitude. The assessment including discards also indicates that the strength of the 2001 year-class is larger than previously assumed. Preliminary indications of the CPUE in the first half of 2004 appear to confirm this view.

If observed discard data are used for the most recent years, then both SSB and F since 1995 appear to be at a higher level and more variable than if reconstructed discard data are used for the whole time series. The reconstructed discard numbers at age in the most recent years are believed to be less reliable than the observed discard rates for 2 reasons. Firstly the overall discard rates which have been reconstructed for the most recent years do not correspond with the observed rates. Although the Dutch discard sampling programme only covers a small proportion of the beam trawl fleet (0.15% in effort), we don't expect that these observations overestimate the discards as strongly as is suggested by the reconstructed discards. Secondly the age compositions of the reconstructed and observed discards differ.

The reconstructed discards appear to underestimate the discarding of the 2001 year class and in general the discarding at age 2 (Figure 4.1). The underestimation of the discards of year class 2001 in the reconstructed series can be explained by the fact that the relatively low estimate of this year class was used in the projection (with RCT3) to estimate the stock numbers of this year class in later years. The raised age compositions of the discard sampling programme are considered to provide a more reliable estimate of the discarding of the relatively strong year-class 2001. The underestimation of age 2 in the model could be caused by either the distribution curves or by the mesh selection curve. The distribution curves were created based on the assumption that plaice within the 12 miles zone are not available for the large beam trawl fleet, and outside they are. The distribution curves however does not correct for changes in the distribution of the fleet over the area outside the plaice box. Fishing effort on plaice in areas less fished is lower than on plaice in areas fished heavily, which is not taken up in the model yet. On the other hand the underestimation could be a result of the use of the mesh selection characteristics of 80 mm mesh size. Due to changes in net material the selection parameters could have changed over time. Also liners are regularly used in the discard observation trips, resulting in a smaller effective mesh size than 80 mm. As a result smaller plaice will be retained in the net than assumed with the model. With this perspective in mind, the method will be further developed first with a more in depth analyses of the distribution of plaice and the distribution of the fleet targeting it.

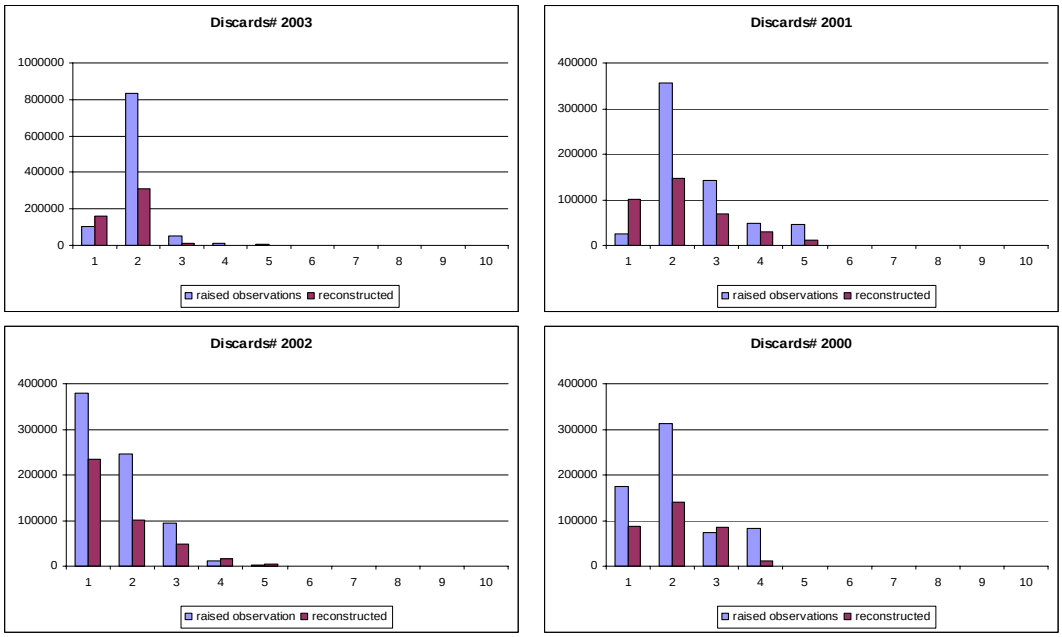

Figure 4.1. Observed and reconstructed discard numbers at age.

The inclusion of discards into the assessment has not resolved the main problem that was identified in WGNSSK 2003: the revision of the stock size due to the revision of the estimated strength of the 1996 year-class. Last year it was stated that the absence of discards in the assessment was the likely cause for that revision. The retrospective analysis that was carried out during this WG has shown that a retrospective pattern is still persistent for this assessment. With the inclusion of discards this can no longer be attributed to that factor, but it could still be due to the mismatch between the catch and discards data and the relative abundance indices. Further investigations are required to explore what the most likely causes are for this retrospective pattern.

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