Meeting on Cod Assessment and Technical Measures
28 April-7 May 2003, Brussels

Executive Summary of the Expert Meeting 29 April-6 May 2003
by Hans-Joachim Rätz (chairman)

Contents page

1. Data base on commercial landings

A data base including monthly fleet landings weight and effort for the North Sea and adjacent waters was collated from national data during the meeting. The database includes both cod landings and landings from other economically important species (haddock, whiting, saithe, plaice, sole and Nephrops). The data base comprises landings only as discard data were not obtainable from all countries. Data were available for all relevant nations except Sweden for the years 2000-2002 and Divisions IIIa (Skagerrak), IV (North Sea) and IIVd (Eastern Channel). It was not possible to standardise effort (to KW*hours) across national fleets for reasons of inconsistency and incompleteness. The data base made an important input for many analyses during the meeting. Maps with annual landings in 2000-2002 from the database are presented in Figures 1 and 2. For most species the total landings included in the data base were quite close to the nominal landings reported to ICES. Discrepancies between the two set of landings figures were mainly due to missing spatial information of catches for some fleets.

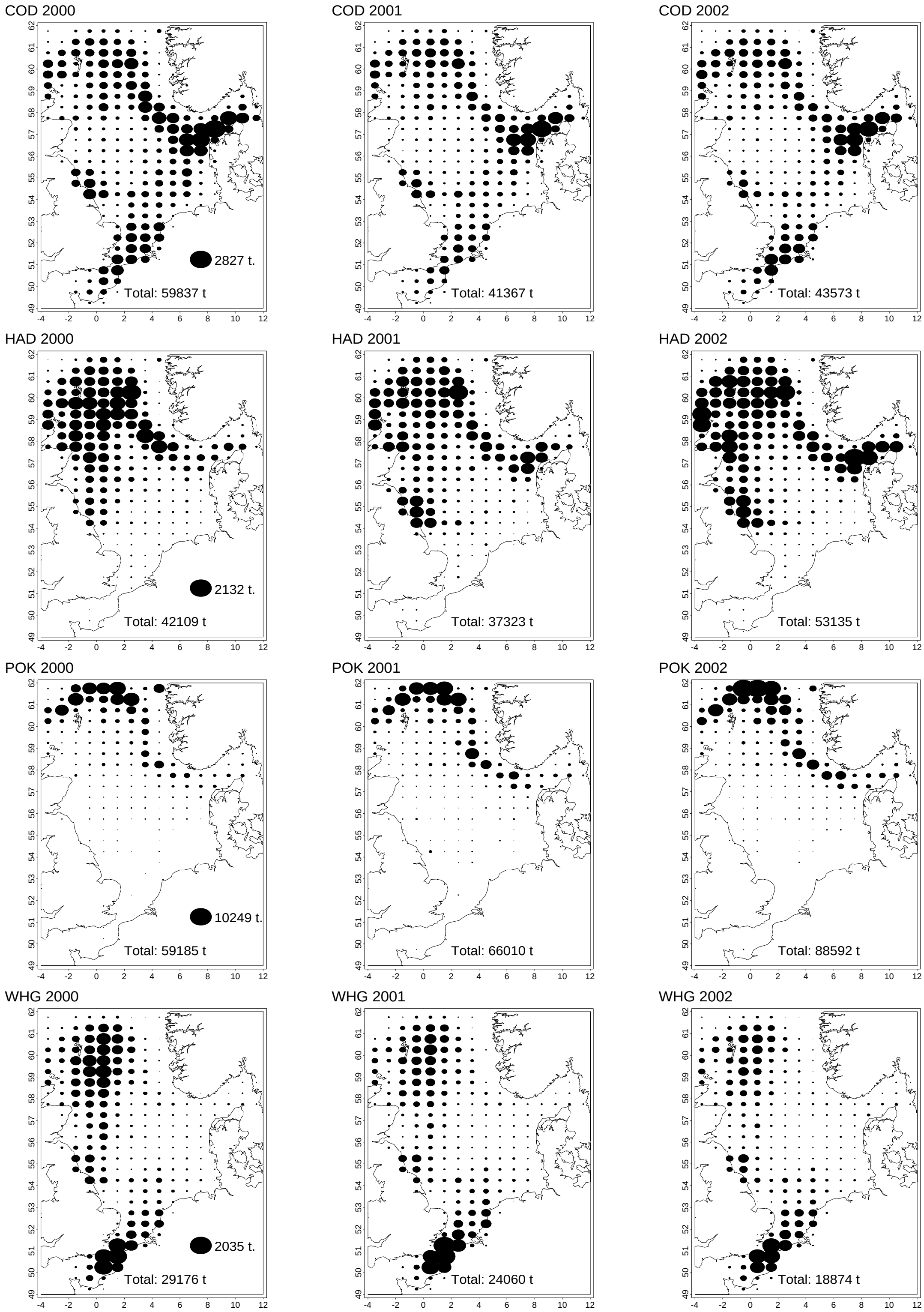

Figure 1. Spatial distribution of international landings (t) of cod (COD), haddock (HAD), saithe (POK), whiting (WHG) during 2000-2002.

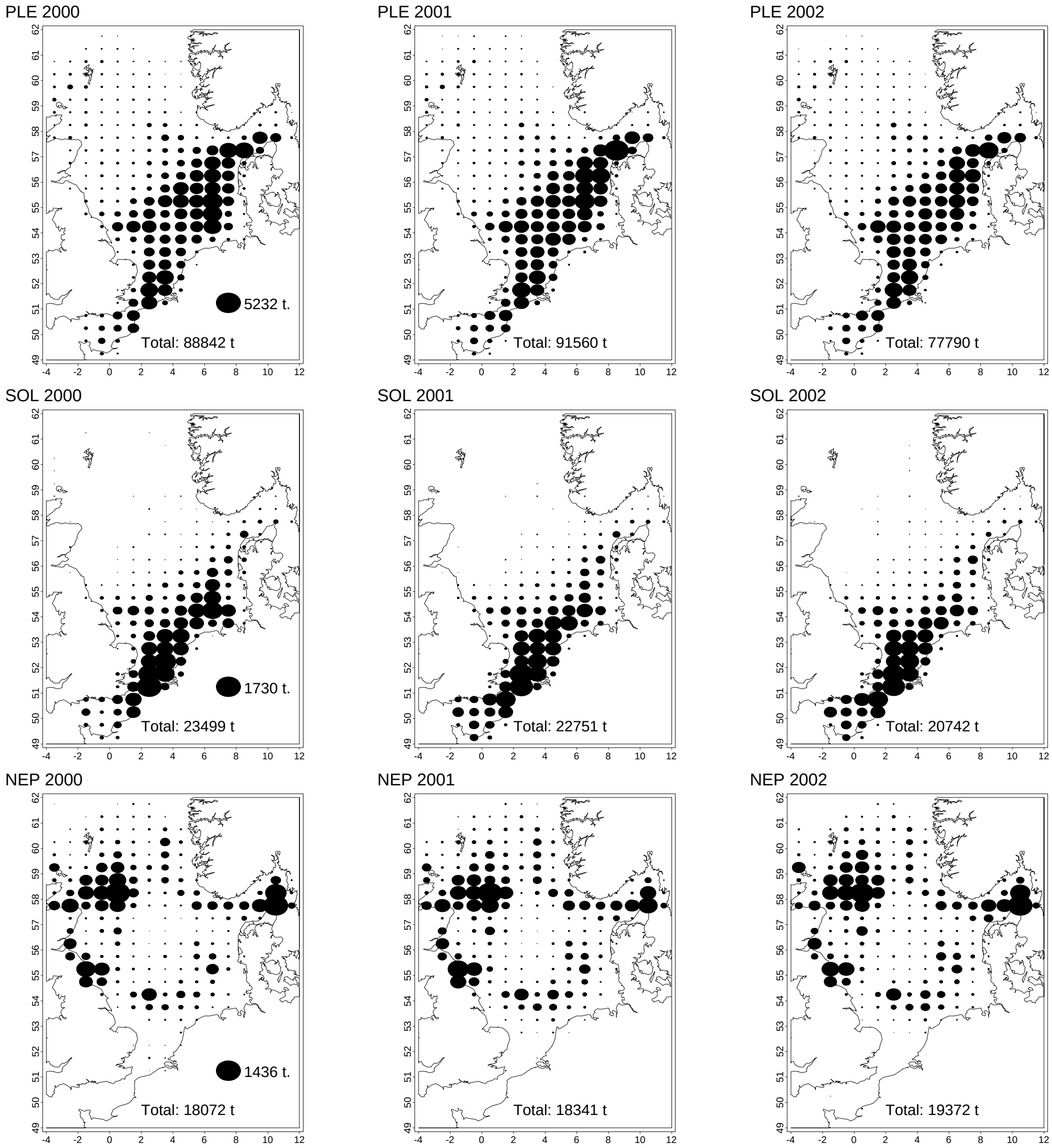

Figure 2. Spatial distribution of international landings (t) of plaice (PLE), sole (SOL), Nephrops (NEP) during 2000-2002.

2. Stock assessment updates

A full update of the assessments for cod in IIIa, IV and VIId, haddock in IIIa and IV, whiting in IV and VIId and plaice in IV could not be realised as there was insufficient new information to allow revised assessments, especially landings, discards and industrial by-catch in numbers for 2002 were not available. The expert group reviewed new survey information on the status of the stocks.

2.1 Cod in the North Sea, Skagerrak, and Eastern Channel

New international bottom trawl survey data first quarter (IBTS Q1) show that the stock index in quarter 1 of 2003 is the lowest in the time series (Fig. 3).
The previously presented indices for 2003 (on Monday, 28 April) were reviewed and corrected.

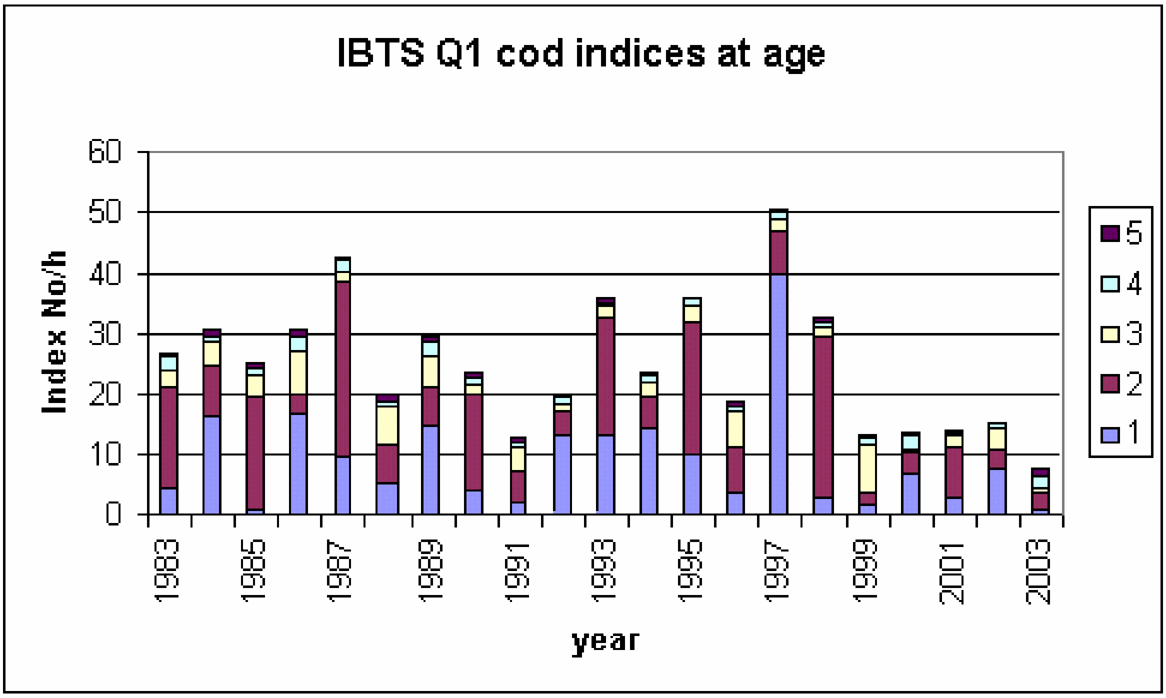

Figure 3. Survey indices for cod IBTS quarter 1, revised for 2003

Recruitment has been poor since 1997 and the 2003 estimate of 1-year-old cod (year class 2002) from the IBTS is the lowest in the series.

Stock status:

There is no evidence to alter the perception of the state of the stock and the following statement from ICES in October 2002 still holds true: *The stock is outside safe biological limits. The spawning stock is estimated to have been below Bpa since 1984 and in the region of Blim since 1990. SSB in 2001 is estimated at a new historic low at about 30 000 t and is now estimated 50% lower than last year. The SSB in 2002 is estimated around 38 000 t. Fishing mortality has remained at about the historic high and above Fpa since the early 1980s and F in 2001 is estimated to be above Flim. Except for the 1996 year class, recruitment has been below average in all years since 1987. The 1997 and 2000 year classes are estimated to be the poorest on record.*

Given the recent level of recruitment, the stock can be expected to decline further under the level of exploitation as estimated for 2001.

2.2 Haddock in the North Sea and Skaerrak

New survey information:
Trends in catch in numbers at age per unit of effort from research vessel surveys are presented in Figure 4.

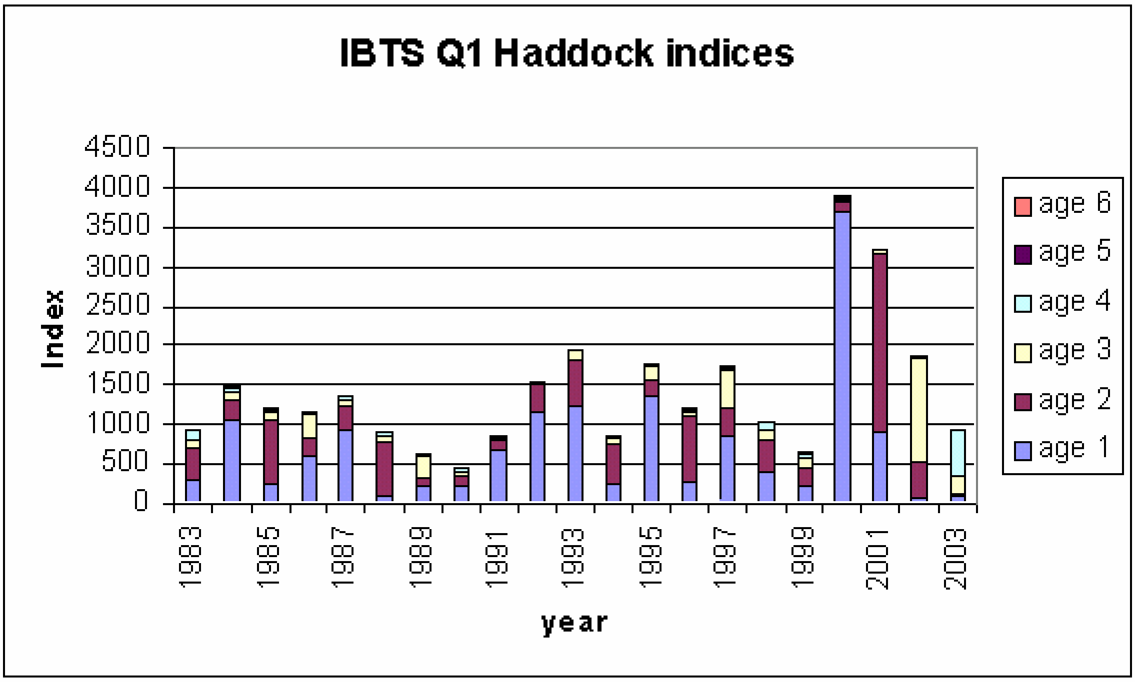

Figure 4. Survey indices for haddock IBTS quarter 1, reviewed for 2003

Recruitment:
The 2002 and 2003 recruitment indices at age 1 (year classes 2001 and 2002) are the first and second lowest in the series.

Stock status:
There is no evidence to alter the perception of the state of the stock and the following statement from ICES in October 2002 still holds true: *The stock is being harvested outside safe biological limits. SSB in 2002 is estimated to be above the Bpa, and fishing mortality in 2001 is estimated to be above the Fpa. The 1999 year class is estimated to be strong and has led to the current increase of SSB, but it is the only year class above average size for a number of years and dominates both the stock biomass and the catches. The 2001 year class is the lowest on record and the 2002 year class also appears to be well below average. The SSB is expected to decrease to below Bpa in the short term at the present fishing mortality rates.*

2.3 Whiting in the North Sea and Eastern Channel

New survey information:
Trends in catch in numbers at age per unit of effort from research vessel surveys are presented in Figure 5.

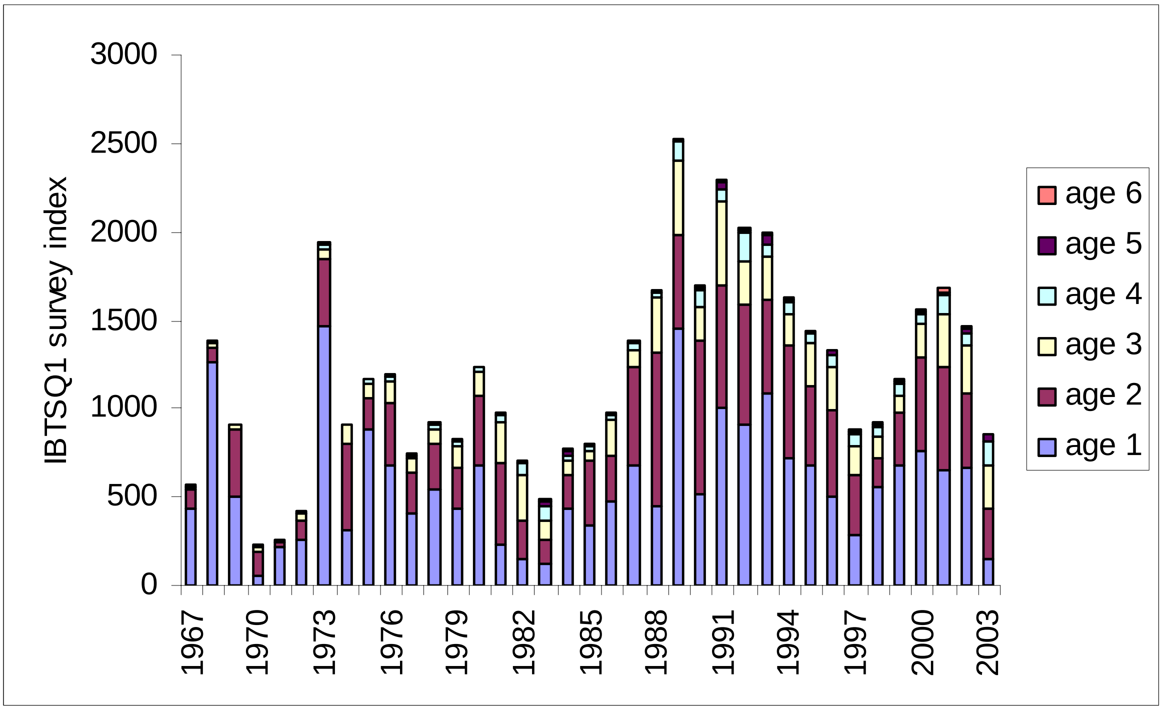

Figure 5. Survey indices for whiting IBTS quarter 1, reviewed for 2003

Recruitment:
The IBTS index for age group 1 in 2003 (2002 year class) is estimated to be very low, the third lowest in the time series since 1967 and about 25 % of the long term mean.

Stock status: There is no evidence to alter the perception of the state of the stock and the following statement from ICES in October 2002 still holds true: *The stock is outside safe biological limits. SSB has declined over the last 20 years, reaching a historic low in 1998. Fishing mortality has decreased and is below Fpa. Recruitment has fluctuated below the average (1980-2001) level since 1990, with the exception of the 1998 year class.*

2.4 Plaice in the North Sea

New survey information:
Trends in catch in numbers at age per unit of effort from research vessel surveys (beam trawl survey BTS, sole net survey SNS) are presented in Figures 6 and 7.

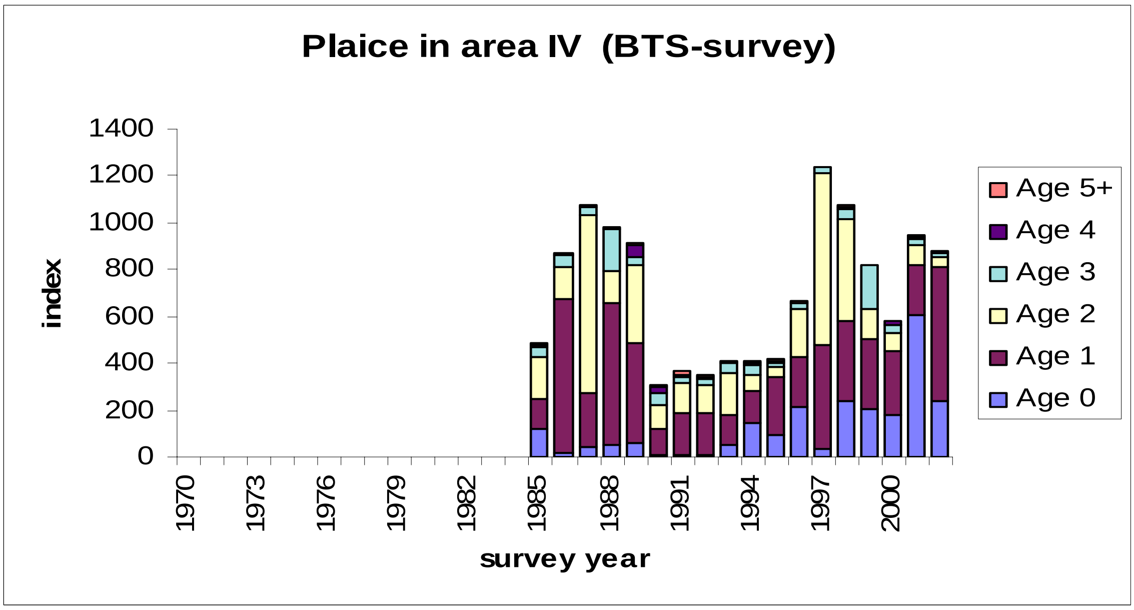

Figure 6. Survey indices for haddock BTS quarter 3.

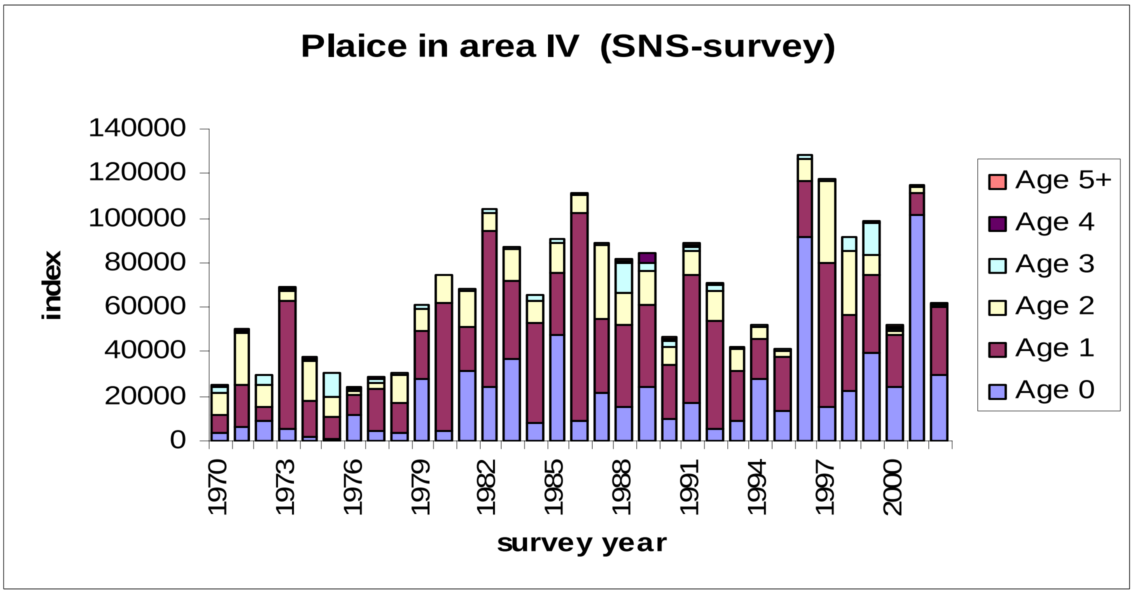

Figure 7. Survey indices for plaice SNS quarter 3.

Stock status: There is no evidence to alter the perception of the state of the stock and the following statement from ICES in October 2002 still holds true: *The stock is outside safe biological limits. SSB in 2002 is below Bpa and fishing mortality in 2001 was above Fpa. Spawning stock biomass has declined from 1989 to 1997, where it reached its historical minimum, but has increased in recent years due to the strong 1996 year class. Fishing mortality increased from the 1960s to the 1990s, reaching a record high in 1997 and has declined since then. Except for the 1996 year class, recruitment since 1993 has been below average. Surveys indicate that the 2001 year class is strong.*

3. Evaluation of past and further technical measures

3.1 Com regulation 259/2001 Emergency closure 14 Feb-30 Apr 2001 (ToR a and e5)

Survey and commercial landings data were examined to investigate whether any effect of the cod closure could be detected.

Survey indices of stock abundance indicated that a significant proportion and highest densities of the mature cod stock lay outside the specified area in 2001 (Figure 8).

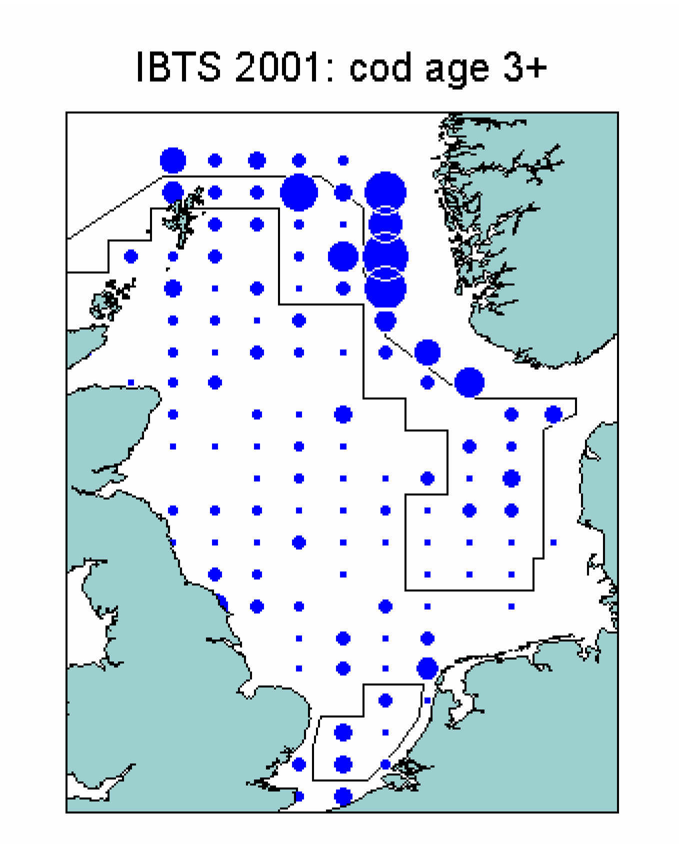

Figure 8. Quarter 1 IBTS indices of cod abundance (ages 3+) and the closed area of 2001.

The closed area was effective at minimising landings from the designated area during the closed period, the landings for this period coming mainly from the rectangles bordering the closed area (Figure 9). The fishery immediately re-entered the area at the end of the closure.

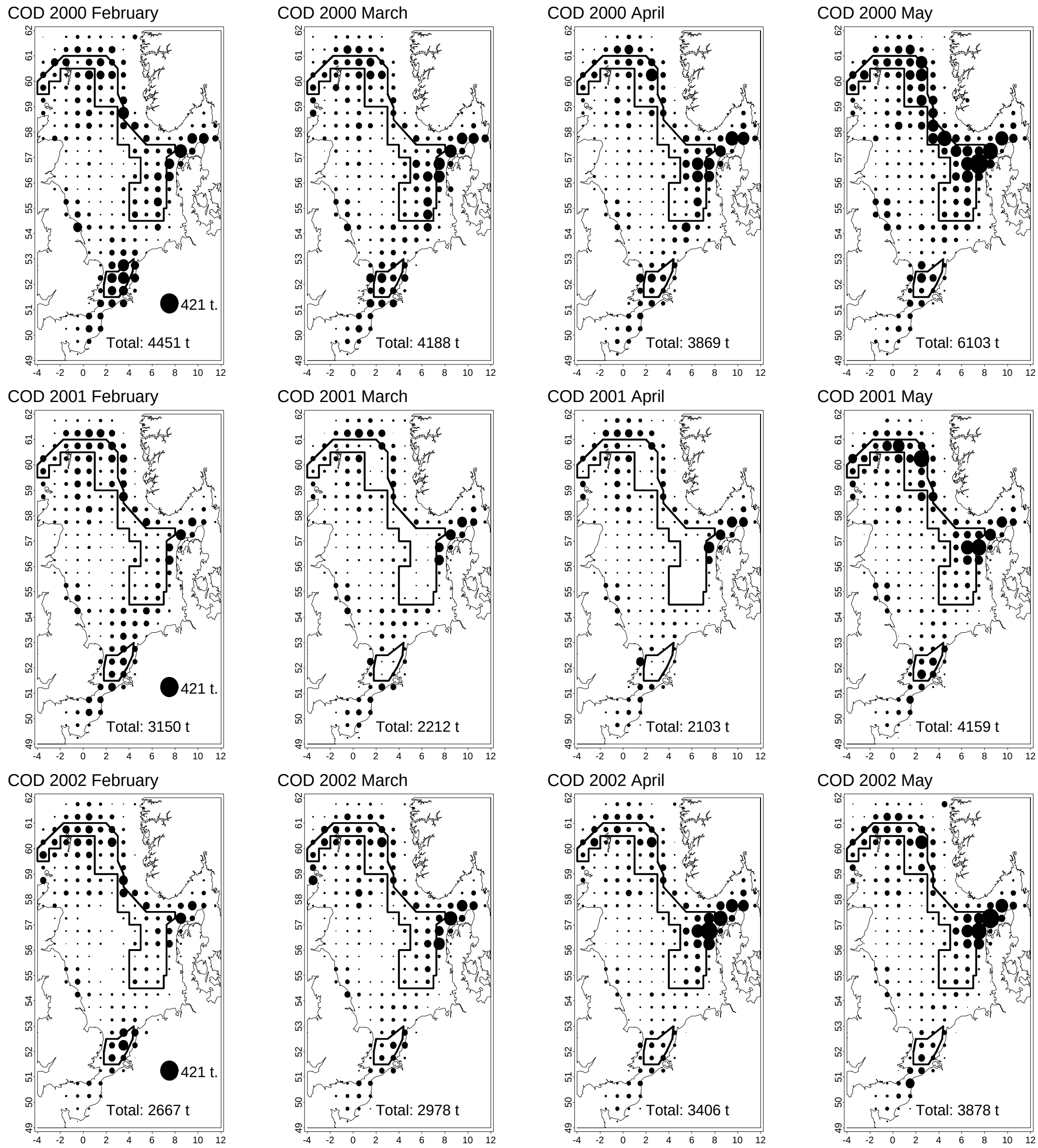

Figure 9. Monthly international landings of cod by statistical rectangle for the period 2000-2002 (February – May).

Monthly cod landings for 2000-2002 were analysed for a drop in uptake for the duration of the closure (Figure 10). There was a marginal increase in uptake in January and February 2001, followed by a marginal decrease during the closure. The net result of these small differences indicated that the closure resulted in a gain to the spawning potential of less than 1%.

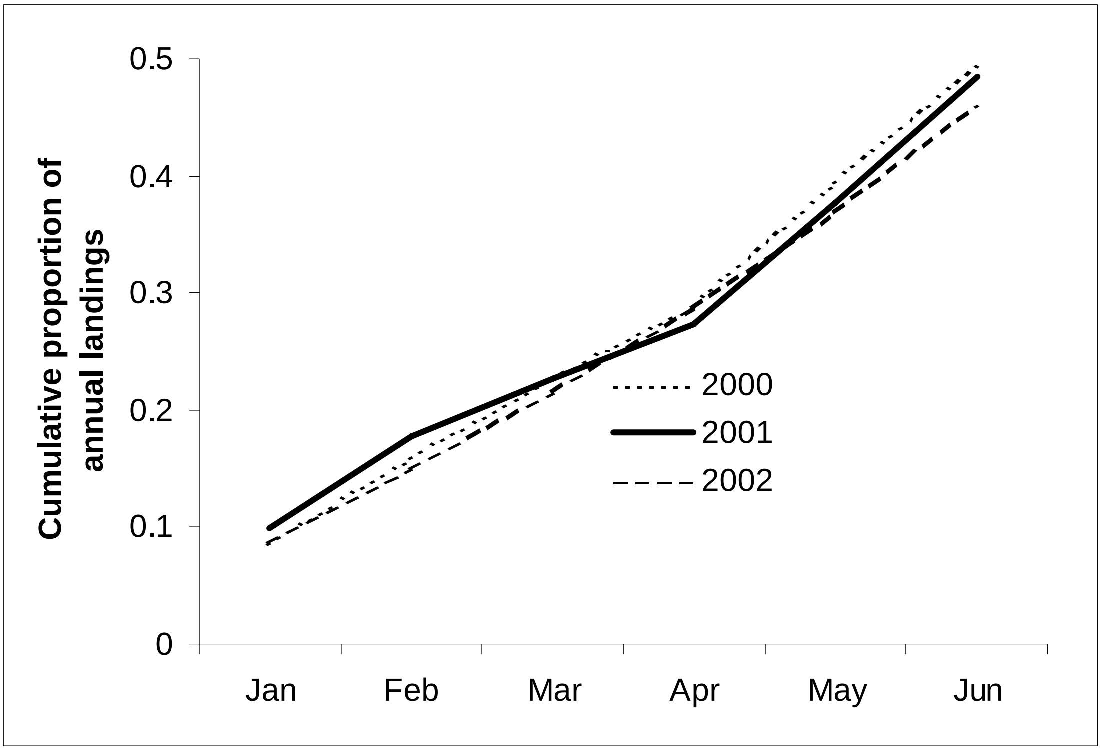

Figure 10. Monthly proportions of annual uptake of landings for cod in the North Sea, Skagerrak and Eastern Channel.

Conclusion:

The closure is considered to have been ineffective at protecting spawning cod since the area did not cover the major part of the spawning stock and was too late in that compensatory fishing may have already taken place earlier in the year.

3.2 Com regulation 2056/2001 and additional technical measures

Technical conservation measures relating to regulation of fishing gears

An analysis of the impact of recent UK national and EU international regulations on towed demersal roundfish gears was carried out. The model used was built upon the assessment of the changes in gears for the UK Scotland, UK England and other EU countries and the potential effects of these gear changes on the main roundfish stocks: cod, haddock and whiting. The selectivity properties of different gears were derived from selectivity trials. In the analysis, "applicability" and "compliance" were jointly considered as the "uptake percentage" of the measures, and results are presented for the entire range of uptake of 0% - 100% and are expressed relative to baseline cases in which no changes to fishing gear selectivity was applied. The main results of the analysis can be summarized as follows:

- For whiting, the effects of the gear regulations alone, result in immediate and short term (ca 2-3 years) losses in consumption landings that do not revert to gains in the medium term (ca 10 years). Discards are substantially reduced over both the short and medium terms.
- For haddock there are also immediate losses, but these revert to small gains within the short term, and to greater gains over the medium term. As with whiting, discards are substantially reduced over both the short and medium terms.
- For cod there is little noticeable effect on consumption landings or spawning biomass if discards are excluded from the analysis (as in assessments undertaken by ICES). Using a series of "derived" discard data produces a moderate benefit to the medium term consumption yield and spawning biomass.

An additional analysis was undertaken in which fishing mortality in the consumption fisheries was directly reduced by 40% in addition to the selectivity effects of the fishing gear changes. Results from this indicate that:

- The additional reduction in fishing mortality results in greater increases in spawning biomass in the medium term for all three species, and this is substantially so for cod. There are also substantially greater gains in the medium term consumption landings of cod.

The potential for these measures to offset the 40% reduction in fishing mortality for North Sea haddock and whiting, as would have been advised by ICES if not for its over-riding advice for North Sea cod, is substantial in the case of whiting and somewhat less, but still high for haddock.

All these results are dependent upon compliance with the regulations and applicability of the measures to the different fleet components. The relative gains and losses are generally very sensitive to the uptake percentage of the gear measures. For cod, the sensitivity of the model to the assumptions regarding discarding and the stock-recruitment data used, could not be tested due to time constraints in the meeting.

3.3 Evaluation of further developments of technical measures (mesh size or other selectivity measures, closed areas, closed seasons, gear efforts) in terms of recovery potential, protection of juvenile fish and species separation in demersal fisheries, explicit requests by the fishing industry

In response to specific questions from the industry on technical measures the group has the following comments:

- The use of 6mm double twine could be justified in the French saithe fishery if selectivity is maintained e.g. by a small increase in mesh size (approx. 5 mm).
- Dyneema is not used in gillnets as far as we know and so will not increase ghost fishing.
- Recent regulations on technical conservation measures relating to gear design have the potential to make significant improvement to selectivity, thus reducing discards in the juvenile year classes of the main commercial species.
- In principle the mesh sizes in square mesh panels in the cod end or extension should be harmonised over all fisheries since they are all intended to release juvenile roundfish. Additional measures requiring large mesh panels behind the headline may also help to release roundfish in these gears.

4 Identification of cod spawning areas in the North Sea, evaluation of permanent closures and mixed fisheries

4.1 Identification of cod spawning areas in the North Sea

The Group has focussed on the recent period (2001-2003) to try to identify spawning areas. In the absence of any other recent data, the distributions of cod aged 3 and older (3+) from the IBTS Q1 survey series have been used as a proxy for the distribution where mature fish are likely to spawn. However, the Group notes that the proportion of 3-year-old cod that are mature is assumed by ICES to be 23%, so the plots may give a biased impression of the distribution of mature fish.

The distribution of cod age 3+ from the IBTS Q1 survey series indicates that there are no discrete areas that can be identified as spawning areas, although their distribution is likely to be a reasonable representation of the potential extent of cod spawning.

Distribution plots of the density of cod aged 3+ from the IBTS Q1 survey are shown in Figures 11, 12 and 13. Figures 11 and 12 show the average catch rates by rectangle in terms of numbers per hour or biomass (kg) per hour in 5-year intervals from 1976-2000. Figure 13 shows the same data for 2001, 2002 and 2003.

Conclusion

Since 2000, the highest densities of 3+ cod were found in approximately the same areas as they have been observed in previous years of the survey time-series, but their overall density is lower, reflecting the decline in the stock over the last 10-15 years. There is an apparent greater reduction in the relative densities of 3+ cod in the southern and central North Sea and German Bight, and this may be an indication that as the stock has declined, their distribution has contracted into smaller areas. In the last three years, the highest densities of 3+ cod have been observed in the deeper waters of the northern North Sea and in the central North Sea.

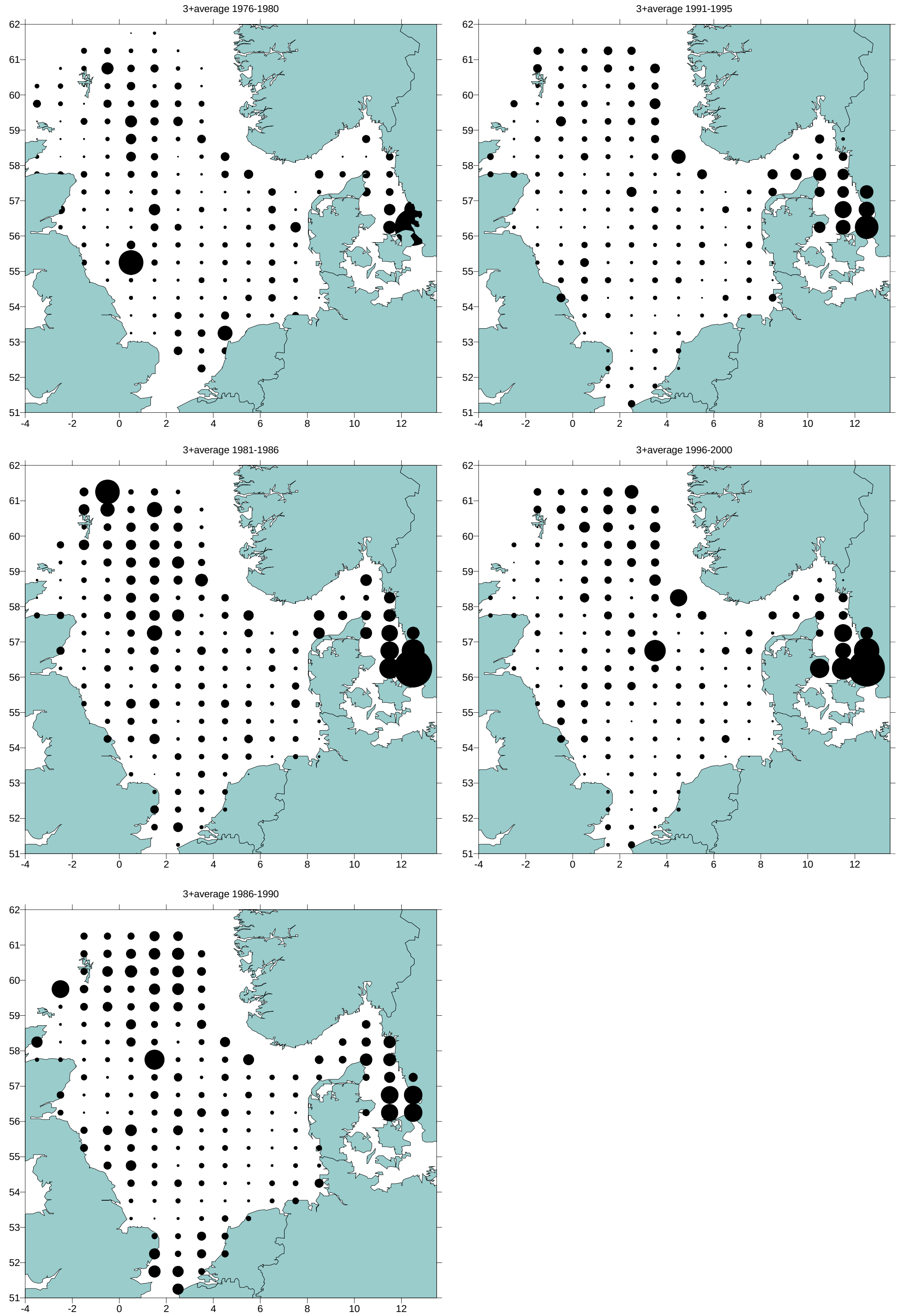

Figure 11 Relative density of cod aged 3 and older from the IBTS Q1 survey series from 1976-2000. Data are average catch per unit of effort (No/h) over 5-year periods.

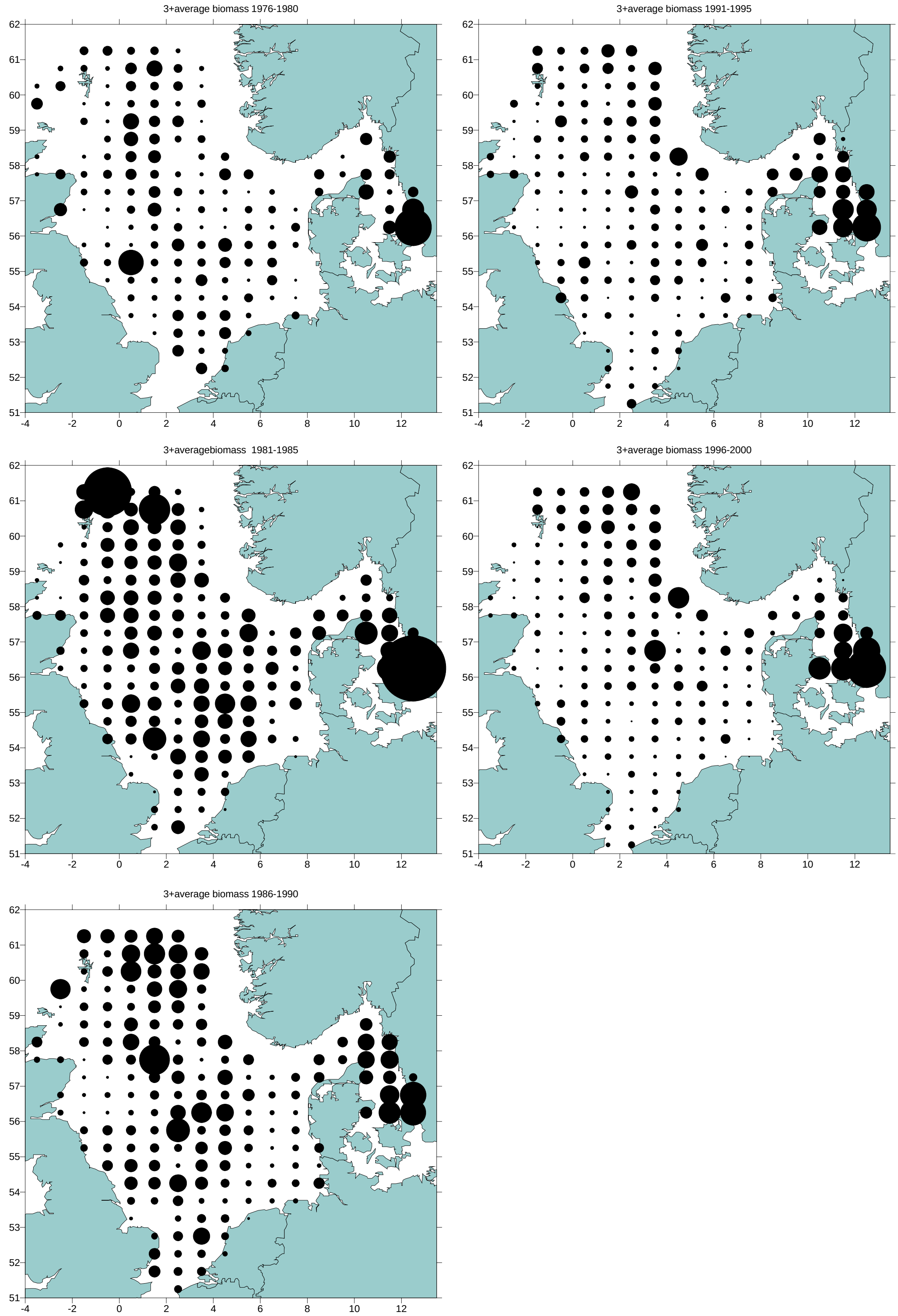

Figure 12. Relative biomass of cod aged 3 and older from the IBTS Q1 survey series from 1976-2000. Data are average catch per unit of effort (kg/h) over 5-year periods.

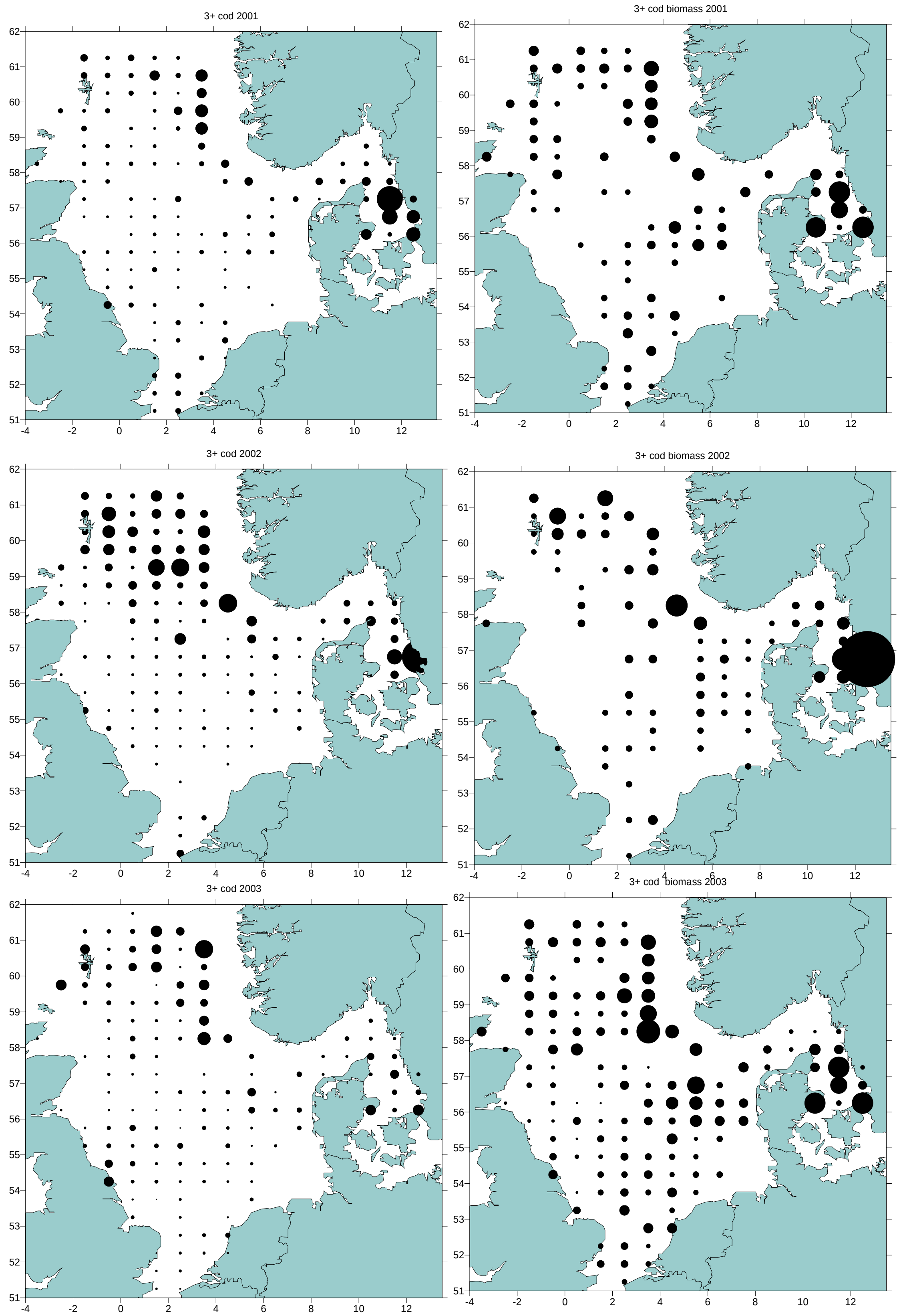

Figure 13. Relative density of cod aged 3 and older from the IBTS Q1 survey series for the years 2001, 2002 and 2003. Left hand plots = density in numbers per hour; right hand plots = density in biomass (kg) per hour.

4.2 Closed areas, seasons and real time closures in the North Sea and Skagerrak to reduce catching and discards of juveniles and spawning cod

The effect of closing areas of the North Sea was examined using spatially structured models developed at the meeting. The models calculate the effect of closing ICES statistical rectangles and either removing or re-distributing effort into the remainder of the North Sea.

The re-distribution of effort was evaluated as a uniform increase in all open areas or a spatially complex pattern that represented historic fishing patterns. The models were used to explore the sensitivity of model results to critical assumptions.

The group examined a series of hypothetical closed area scenarios, prior to any analysis for the EU Norway request for advice on closed areas:

1) Closure of the rectangles containing 80% of the IBTS survey adult catch per unit effort.
2) Closure of the rectangles containing 80% of the IBTS survey juvenile catch per unit effort.
3) Closure of the rectangles specified in the 2001 emergency measures described in EU259/2001.
4) Investigation of an area located to the east of Scotland an UK industry suggestion for an area in which haddock could be taken at low cod by-catch rates.

Option 4 is based on a request from the UK industry to examine the potential for a haddock fishing box to be located on the East Coast of Scotland. It was suggested that this is an area of low by-catch rates for cod.

The scenarios were examined in terms of the relative reduction in fishing mortality on adults and juveniles. It was assumed that total effort does not increase to compensate for reduced catch rates and that the displacement of a large amount of effort into an open area does not significantly reduce CPUE in that area during the year.

- In all case studies, removal of effort from the fishery has a larger effect on fishing mortality than that achieved when effort is redistributed.

- Boxes established for juvenile cod (scenario 2), which are distributed predominantly in the south, and adult cod, further north (scenario 1), result in different reductions in fishing mortality. This is due to the differences in the spatial pattern of catch rates for the two groups. In general juvenile box closures are usually considered to be more beneficial than those established for adults since they reduce the mortality in numbers to a greater extent, per unit weight of fish.

- The expected benefits of a closure are reduced by about 15 – 40% for scenarios 1 and 2 if effort is redirected.

- Redirection of effort essentially negates the potential benefits of the 2001 closure (scenario 3) for both adults and juveniles. Note that this result is based on the assumption that the closed area was for the whole of 2001, and not only for the period 14 February – 30 April. This result is consistent with the analysis presented in Section 3 of this report. A permanent closure of this area would be expected to marginally increase the risk to the stock by increasing the exploitation rate on juveniles, with a negligible reduction on adults.

- With the exception of increased mortality on juveniles with heterogeneous redistribution of effort, the relative effects of uniform or heterogenous redistribution of effort are largely the same.

- The models confirm that there may be a lower exploitation of cod in the rectangles which were identified by the UK industry as an area where the by catch of cod is considered to be lower than the surroundings. By inference this implies that if effort is moved into the box total cod mortality outside of it could be reduced. The effect for haddock is close to zero indicating that haddock CPUE inside and outside the box is similar for the fleets fishing in the area. Individual trip records of catch composition and observations of discard rates from this area should be investigated in order to establish the benefits of directed fishing in this area. This would be inline with ICES advice to encourage industry initiatives to reduce cod catches in the haddock fishery.

Conclusion

Closed areas can be used to beneficial effects in the management of fish stocks. However experience with the North Sea cod box and the 2001 Emergency Measures box illustrate that they may also be ineffective if additional management constraints are not imposed concurrently.

Redistributed effort can lead to no beneficial and sometimes significant negative effects on unprotected age groups and species. Discussions with fishers with regard to the potential changes in effort distribution would be beneficial before a full modelling evaluation of any box can be carried out.

4.3 Identification of areas, which would need to be closed in order to remove 80%, 60%, 40 % and 20 % of the fishing possibilities for cod in the North Sea, English Channel and Skagerrak

Using the landings data by rectangle for the years 2000-2002, plots were generated of the rectangles that contained the landings above a certain threshold and that accounted for a certain percentage of the total cod landings and associated species (haddock, whiting, saithe, plaice, sole and nephrops). Interaction maps were constructed that showed the selected areas for two species at a time and also the area of overlap (i.e. the rectangles where for both species high landings were taken). An example of the maps using an 80% landings threshold for 2002 is shown in Figure 14.

The overlap in the spatial landings distribution by species for the years 2000-2002 combined is shown in Figure 15. The horizontal axis in the figure represents the proportion of the cod landings by rectangle (i.e. the rectangles with the highest cod landings are on the left, the rectangles with the lowest catches on the right). The vertical axis shows the cumulative distribution for the other species. If we want to find the rectangles where 20% of the highest landings of cod are taken, we can read on the vertical axis, what the expected landings of the other species would have been given that no redeployment of effort would have taken place.

On the basis of the landings compositions in 2000-2002, a closure of the rectangles which account for 80% of the cod landings would result in 33% of the haddock landings to be still available, 25% for whiting and around 50% for the other stocks. These results are summarized in the text table below:

cod%	HAD	WHG	PLE	SOL	POK	NEP
19	88	99	87	99	98	96
40	79	78	70	74	89	87
61	60	55	61	59	74	85
80	33	25	50	47	47	47

The analysis only refers to officially reported landings by rectangle and do not include discards. The overlap between species does not take account of the actual by-catches that are realised in the individual trips. The areas of highest landings for cod from the method described above differed from the areas derived from the survey CPUE based method (section 4.2). This is likely to be caused by the effort distribution which causes cod to be caught where the abundance is lower than in other areas.

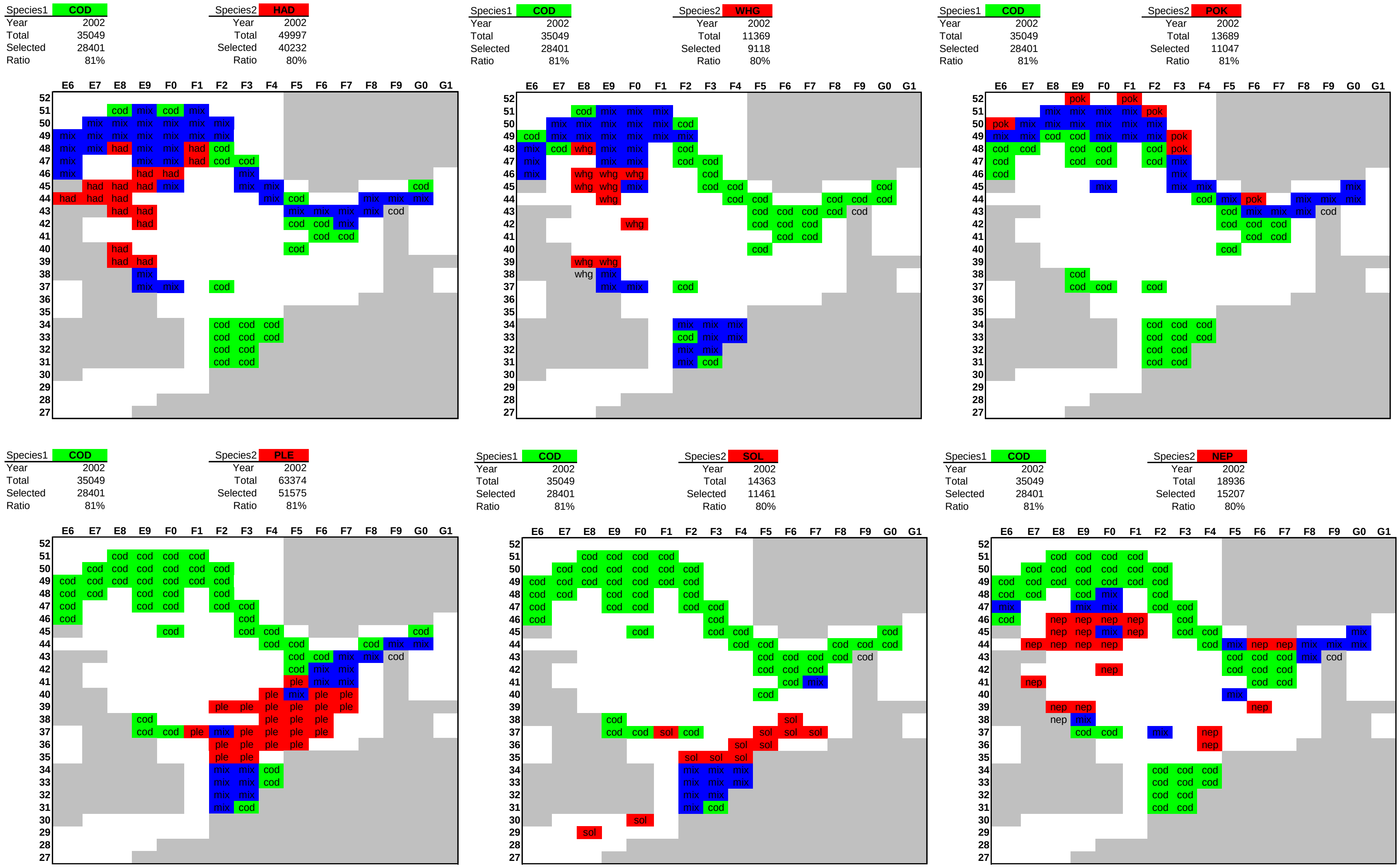

Figure 14. 80% of landings in 2002 (bottom) for cod and respectively haddock, whiting, saithe, plaice, sole and nephrops.

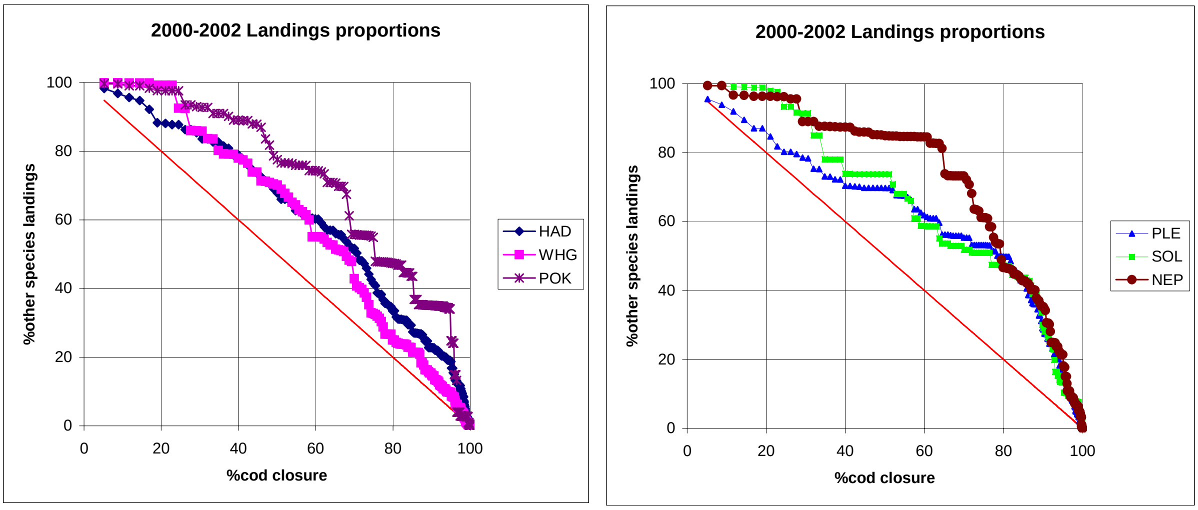

Figure 15. Overlap between cod and other species. The horizontal axis presents the proportion of the cod landings by rectangle (i.e. the rectangles with the highest cod landings are on the left, the rectangles with the lowest catches on the right). The vertical axis shows the cumulative distribution for the other species.

The figure can be interpreted as follows: if we want to find the rectangles where 20% of the highest landings of cod are taken, we can read on the vertical axis, what the expected landings of the other species would have been given that no redeployment of effort would have taken place.

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1 Introduction

1.1 Participants of the meeting day 28 April and 7 May 2003 (detailed information is given in Appendix 1)

Ken Patterson (chair)	Commission

Ship-owners/producers/industry representatives:

Luc Corbusier (AEOP)	Belgium
Manu Desutter (AEOP)	Belgium
Niels Wichmann	Denmark
Mike Andersen	Denmark
Mark Ghilgia	France
Lothar Fischer	Germany
Sean O'Donoghue (AEOP)	Ireland
Frank Doyle	Ireland
Lorcan Kennedy	Ireland
Fenneke Brocken	Netherlands
Ben Daalder	Netherlands
Victor Badiola	Spain
Reine J. Johannesson	Sweden
Douglas Beveridge (NFFO)	United Kingdom
Ron Gilland (NSFO-AEOP)	United Kingdom
Hamish Morrisson (SFF)	United Kingdom
Alex Smith (SFF)	United Kingdom
Mike Park (SFF)	United Kingdom

NGOs:

Christine Absil (Seas at Risk)	United Kingdom
Helen McLachlan (WWF)	Netherlands

The experts listed below attended the 2 days of consultations with the fishing industry and NGOs and (28 April and 7 May 2003) and also met during 29 April-6 May 2003 with the following participants:

Ronald Fonteyne	Belgium
Willy Vanhee	Belgium
Niels Madsen	Denmark
Morten Vinther	Denmark
Paul Marchal	France
François Theret	France
Hans-Joachim Rätz (chair)	Germany
Martin Pastoors	Netherlands
Are Salthaug	Norway
Ewen Bell	United Kingdom
John Casey	United Kingdom
Chris Darby	United Kingdom
Dick Ferro	United Kingdom
Phil Kunzlik	United Kingdom

1.2 Terms of references (ToRs)

During the December 2002 Fisheries Council the following ToRs were defined:

(a) To evaluate new information concerning the state of the cod stocks in the North Sea, the Skagerrak and the Eastern Channel, taking into account the most recent survey information and to take into account the management measures taken in 2001 and 2002. The group should evaluate the extent to which this information alters the perception of the state of the stock compared to that evaluated by ICES in 2002.

(b) To assess the extent to which further development of technical measures (such as increases in mesh size, other selectivity measures closed areas and the use of certain fishing methods) could contribute to the recovery of stocks of cod. The advantages and disadvantages of such measures shall be evaluated.
(c) Identify and delimit the cod spawning areas in the North Sea and West of Scotland, and evaluate the biological and economic impact of a permanent "no-fishing zone" in the areas so identified.
(d) To assess the contribution of technical measures in force in 2001 and 2002 to the recovery of the Northern stock of hake, and to assess the extent to which further development of technical measures (such as increases in mesh size, other selectivity measures closed areas and the use of certain fishing methods) could contribute to stock recovery. The advantages and disadvantages of such measures shall be evaluated.
(e) To address the terms of reference agreed between the Community and Norway (Annex IX of the Agreed Record of 20.12.2002 between Norway and the Community)

In addition, the following ToRs were defined in the Agreed Record between Norway and the Community of 20 Dec 2002 (Annex IX):

A Working Group of scientists and technical experts shall meet with the following Terms of Reference:
1. Collate available data for 2001 and 2002 on the geographical and seasonal distribution of effort and catch by gear type in the demersal fisheries in the North Sea and the Skagerrak. The catch data should include information on quantities both landed and discarded;
2. Collate and review the results of research on selectivity of fishing gears, in particular those studies, which are relevant to the protection of juvenile fish and to the separation of species in demersal fisheries;
3. Evaluate the use of closed areas and seasons as well as real-time closures of fishing grounds in the North Sea and the Skagerrak as measures for reducing catches and discards of juveniles;
4. Collate data on lost and abandoned gears in the North Sea and Skagerrak and review information on the mortality rates created by these gears. Advise on possible initiatives to be taken on this issue;
5. Evaluate the state of the stocks of North Sea cod, haddock, whiting and plaice as of 1 January 2003, using all relevant information concerning 2002 and in particular, evaluate the effects of technical measures, closures and changes in fishing effort made during 2002;
6. Advise on possible technical measures to improve the separation of species in demersal fisheries and to reduce the catch and discarding of juveniles;
7. Evaluate the areas, which would need to be closed in order to remove (a) 80%, (b) 60%, (c) 40% and (d) 20% of the fishing possibilities for cod in the North Sea; and
8. Identify areas of research of particular benefit for reducing cod catches, whilst maintaining other fishing opportunities.

The Working Group will begin its work in February 2003 and report to the Parties no later than 30 September 2003.

The expert group on cod assessment and technical measures is due to report to ACFM, STECF and ACFA.

1.3 Notes of the meeting and comments on 28 April and 7 May 2003

The working group on ‘Cod Assessment and Technical Measures’ met at Centre Albert Borschette, 36 rue Froissart, Brussels, 28 April-7 May 2003. It was agreed in advance of the meeting that ToR (d) should not be addressed during this meeting acknowledging the fact that the ICES WG on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim – WGHMM, 14-23 May 2003, is scheduled shortly after the end of this working group which prevented the appropriate expertise to participate. The ToR (d) was therefore forwarded to that ICES group WGHMM for consideration.

EU-COM represented by Ken Patterson opened the meeting by introducing the participants to the general scope, agenda and outline of the meeting being structured into consultations between the fishing industry, NGOs and an expert group on the 28 April and 7 May 2003, whilst the requested analyses had to be carried out by the expert group during 29 April-6 May 2003. It was regretted that no expertise on economy will be present as relevant experts denied their participation. Thus, the economic implications of the important ToRs could not be addressed but expected advice will be limited to biological and gear technical results. The fishing industry expressed serious concern about the expected non-compliance with the ToRs due to lack of expertise in economy.

The chairman of the expert group, Hans-Joachim Rätz, introduced the tasks to be accomplished in accordance with the ToRs as presented in section 1.2. A request from a representative of the fishing industry to attend the expert meetings as an observer was not allowed due to EC working procedures.

Dr. Rätz announced that stock assessment updates for cod 3a47d, haddock 3a4, whiting 47d and plaice 4 would be restricted to the review of new survey information as the necessary 2002 input data for age structured analytical assessment models were not yet available. Complete assessment updates will be available by end of October 2003 through ICES. It was noted that the ToR c) will be limited to the identification of the spawning area of cod in the North Sea, since the meeting dates of the ICES working group for the Assessment of Northern Shelf Demersal Stocks prevented the participation of appropriate expertise to identify the spawning area of cod west of Scotland.

The fishing industry criticised that selected data series of their catch per unit of effort have been withdrawn from some assessment formulations. The industry emphasized the importance of such data series. Dr. Rätz explained that these data have the potential problem of being biased due to technological improvements and quota limitations.

The fishing industry referred to major derogations resulting from recent managements measures which were generally criticised as too complicated and cost intensive. Furthermore, the fishing industry interpreted the existing management measures in combination with substantial TAC and effort reductions as sufficient to insure substantial cod recovery.

The industry emphasised that any technical measures should be elaborated in collaboration with the fishermen to enhance their basis, acceptance and effectiveness. Specific suggestions by the fishing industry pertained to gear changes in terms of avoidance of by-catch of juvenile cod, an increased species selection of nephrops trawls, effect and harmonisation of square mesh panels and the effect of the twine thickness in cod ends, especially between 5 and 6 mm. Those specific suggestions are dealt with under chapter 3.3 in this report. However, the requests regarding effects by industrial fisheries as well as further ecosystem effects were identified to fall outside the scope of this meeting but will be addressed by the ICES multi-species WG in August 2003.

During the considerations of the identification of cod spawning areas in the North Sea and west of Scotland, the fishing industry emphasised a general preference of real time closures as management tool. Permanent closures without the appropriate effort reductions are suggested to have unpredictable ecologic and economic consequences.

Given the long task list, less priority was envisaged for the effect of ghost fishing by lost or abandoned gears, with regard to the Dyneema net material. The working group was informed that there will be a review of the recent project FANTARED 2 dealing with ghost fishing will be made available through correspondence (chapter 5).

The group received written contributions by the Scottish Fishermen's Federation and Dutch fishing industry (see Appendix 2 and 3). The main items of the written contributions can be summarized under the following headings:

- Quality of stock assessment

The Scottish Federation asserts "*that the research vessels voyages adhere to the same route, and take no account of the evolving nature of fish stock dynamics, i.e. the vessels are surveying where they have always surveyed, not where the fish are.*" Although the group bears no specific responsibility to address this issue, the group commented that research vessel surveys are undertaken in a standardised way, using a fixed design in order to maintain comparability over time and to monitor areas irrespective of whether the fish are currently there or not. In this way it is possible to construct time series of spatial distributions. This issue is not pursued further in the report. In addition, the design of the surveys allows the collection of information on several different stocks that may have different spatial patterns.

- Evaluation of technological changes (mesh size, square mesh panels)

The evaluation of technological changes is addressed in sections 3.2, 3.3 and 3.4.

- Effectiveness of closed areas

The effectiveness of closed areas is addressed in section 4.2 and 4.3.

- Real time closures

The possibility of real time closures has been proposed by both the Dutch and Scottish fishing industry. The group welcomes this contribution. However, there is to date, no methodology available to evaluate quantitatively the potential or the realized contribution of real-time closed areas to the targets that have been set (e.g. reduction of catch of undersized fish).

- One net rule

The Dutch fishing industry has put forward the comment that the one-net rule that was introduced in 2003 is not practically feasible and may not bring the intended consequences. The group found itself not equipped to address this comment. There are no data available to address the biological consequences of a measure like the one-net rule. It would probably have an effect on the efficiency of the fishing vessels and is therefore likely to affect the economic performance of the vessels. Any measure that is introduced may have unintended consequences but the group could not oversee the consequences in this case.

- New effort reduction regulation (Council Regulation 2314/2002 Appendix XVII)

Several representatives of the fishing industry emphasized that they would like to see an evaluation of the new effort reduction regulation that was adopted in December 2002. The group endorsed the desirability of such an evaluation, but announced that the available effort data may not allow that analysis to be carried out at this stage. The group has been able to assemble some of the effort data but not all. During 29 April-6 May, the expert group compiled and analysed relevant data. However, the analyses regarding the effect of the new effort regulation could not be adequately addressed in the time available. In addition, the group noted that effort data required for such an analysis was not yet available for all countries. EU-COM has forwarded a request about scientific analyses of the effort regulation to ICES.

- Decommissioning

Several representatives of the fishing industry have emphasized that substantial capacity reductions have been achieved in certain fisheries and that these reductions should also result in reductions in fishing effort in these fisheries. The issue of capacity reduction is further addressed in section 1.5.2 of this report. However, it was noted that the reported data on fishing effort was inconsistent and incomplete to an extent which prevented detailed analyses. The need for harmonisation of log book entries was discussed and emphasised as the only practicable solution.

- Fishermen’s knowledge

The Scottish and Dutch fishing industry have emphasized the need to incorporate so-called traditional ecological knowledge from fishermen (FEK). The group endorses this recommendation but the methodology of involving that knowledge into the stock assessment process is still under development. This issue is not pursued further in this report.

1.4 Review of scientific working documents

WD 1 Simulation on discards and effects on cod assessment.

By Chris Darby

Discarding, as measured within the EU study is predominantly small juvenile North Sea cod and as such discards make up the first ages of the assessment age range. The dominant effect of the inclusion of discards in the cod assessment is an increase in the level of recruitment and in mortality at age 1. Management measures to reduce the level of discards will contribute to faster recovery rates but the consequences were not examined in this paper. Estimates of SSB and reference fishing mortality, based on older mature fish, are unchanged after the inclusion of discards and hence SSB reference points are unaffected. Due to the increase in the level of recruitment, estimates of fishing mortality limit reference points will increase marginally. However, the increased noise in recruitment at the oldest ages may leave the precautionary reference points unchanged.

The perception of the stock dynamics and the situation relative to management reference points will consequently be largely unaffected by the inclusion of the discarding levels measured in the EU study.

WD 2 Recent changes in fishing gear selectivity – exploration of potential impacts

By P Kunzlik, FRS Marine Laboratory, Aberdeen

This paper examines the potential short and medium term impacts of successive EU and UK national legislation on yields and spawning stock size for North Sea cod, haddock and whiting. From an initial stock in 2000, yields and stock size are projected forwards assuming a status quo fishing mortality. These simulations are then repeated to include the effects of gear selection changes. The difference in outcomes between the baseline run and the changed selection scenarios are used to indicate the likely proportionate impact of the measures. This is a single-species evaluation and does not account for any potential predatory interactions.

The implementation of the simulations assumes UK measures apply to UK fleets only, and that EU measures apply to both UK and non-UK fleets. However, it is not a fully fleet-disaggregated model, and some assumptions had to be made in relation to the proportion of the UK and non-UK fleets to which the measures apply. Nevertheless, the results are considered to be indicative of the overall impacts. For cod, an analyses excluding discards results in little benefit in yield or stock biomass when moving from 100mm to 120mm minimum codend mesh size. For haddock, there is an initial short term loss in yield but this rapidly changes to a small increase with more substantial increases in both yield and biomass over the medium term. Discards are reduced markedly. For whiting, there is a short term loss in yield that is not recovered in the medium term, although this is accompanied by a substantial reduction in discards and both short and medium term increases in biomass.

Additional scenarios including an overall reduction in fishing mortality of 40% are also evaluated. These tend to show greater medium term benefits to the yield and biomass than the gear selection measures alone. Further benefits accrue under the additional assumption that the industrial bycatch of these species is eliminated.

WD 3 (a) Potential impact of recent fishing gear regulations on ICES advice.
North Sea haddock and whiting, (b) Potential impact of recent fishing gear regulations on ICES advice – west of Scotland haddock and whiting, (c) Observations on changes in exploitation pattern as a result of increased minimum mesh sizes during 1987-1992

By P Kunzlik, FRS Marine Laboratory, Aberdeen

Using a similar simulation framework as outlined in WD 2, these papers explores the potential of the gear selection measures to offset the 2002 ICES supplementary comments for North Sea and west of Scotland haddock and whiting regarding their managagement (if the over-riding advice for cod was excluded). In these instances, ICES indicated that substantial decreases in fishing mortality were required to increase or maintain stocks above their biomass thresholds in the short term. Depending on the uptake rate of the gear measures, these papers indicate that the required reduction in fishing mortality could be approached or offset entirely, particularly in the case of whiting. The degree of uptake is not solely a compliance measure. It also includes a measure of the proportion of the aggregated fleets to which the gear measures are targeted, and whether there is any movement of vessels between regulatory bands. For example vessels fishing with 100mm minimum mesh for North Sea Nephrops at Fladen in 2002 and subsequent years, may move to the 80mm minimum mesh size band for Nephrops in that area if they are likely to be affected by the more stringent effort management regime aimed at whitefish vessels.

A brief evaluation of the effects of moving from an 80mm minimum mesh size for North Sea roundfish in 1987 to a 100mm minimum mesh size in 1992, indicates there to have been little, if any, detectable effect on fishing mortality. However, a number of the quite legitimate measures that were then available to offset the desired increase in gear selectivities, have since been addressed in more recent legislation on gear selection.

WD4 Calculation of potential reduction in fishing mortality of North Sea and west of Scotland cod, haddock and whiting due to decommissioning of UK vessels in 2002

By P Kunzlik, FRS Marine Laboratory, Aberdeen

In an internal working document to the UK Fisheries Conservation Group, Dr M Armstrong of the Department of Agriculture and Rural Development (Northern Ireland) has previously presented a calculation of the potential reduction in fishing mortality on Irish Sea cod, whiting and haddock that could be attributed to decommissioning of UK vessels in 2002. Using a similar approach, this paper indicates the potential reduction in fishing mortality on North Sea and west of Scotland cod, haddock and whiting based on the 2002 UK decommissioning scheme.

Results are summarised in the following table. The heading "Percentage reduction of UK landings" refers to the average proportion of the reported UK landings of each species, 1999 – 2001, that was taken by vessels decommissioned at the start of 2002. This is translated in the subsequent column into the proportionate reduction of the total international landings of each species attributable to UK decommissioning in 2002. To a first approximation, this latter quantity may be considered equivalent to the anticipated reduction in the total fishing mortality attributable to non-industrial fleets providing that quotas are not redistributed from decommissioned vessels to the active fleet. Where quota is redistributed, then it may still contribute to reduced fishing mortality if it prevents discarding or mis-reporting of catches that may have occurred otherwise.

	Percentage reduction of UK landings		Percentage reduction of total international landings	
	North Sea	VIa	North Sea	VIa
Cod	16	8	7	6
Haddock	21	13	18	12
Whiting	25	15	18	11

WD 5 Effort allocation of the Dutch beam trawl fleet in response to a temporarily closed area in the North Sea.

A presentation was made based on two earlier publications on the effort allocation of the Dutch beam trawl fleet :

- Rijnsdorp, A.D., Piet, G.J., Poos, J.J. (2001) Effort allocation of the Dutch beam trawl fleet in response to a temporarily closed area in the North Sea, ICES CM 2001/N:01
- Rijnsdorp, A.D., Piet, G.J., Poos, J.J. (2002) Evaluatie van het biologisch effect van het gesloten gebied in de Noordzee ter bescherming van kabeljauw in 2001. RIVO report C027/02

The papers attempt to analysis the effects of a large area in the North Sea which was closed between February 15 and April 30 2001 to all cod related fishing fleets in order to protect the spawning population. The closed area comprised important fishing grounds of the beam trawl fleet fishing for flatfish. In the papers, the response of the Dutch fleet (components 225-300hp and >300hp) is analysed using data from EU-logbooks and from position recordings from the Vessel Monitoring System. No change was observed in the fleet of small beam trawlers. The fleet of large vessels displaced its activity to fishing grounds in the North Sea outside the closed areas, and to fishing grounds outside the North Sea. In the North Sea, beam trawling concentrated along the borders of closed areas and the Plaice Box. In the first week after the closure the number of trips in the open area doubled. Coinciding with this increase, the catch rate, expressed as revenue per hp-day, decreased. After the area was re-opened, the catch rate was exceptionally high but decreased to the normal level in the 2nd - 3rd week. The change in catch rate in relation to the change in fishing effort indicated that competitive interactions (in particular interference interactions) occurred among vessels.

An analysis was carried out that indicated that the displacement of the beam trawl fishery as a consequence of the closed area may have increased the relative fishing pressure on cod on both juvenile and adult fish.

It is likely that negative consequences on the ecosystem occurred notably in the western North Sea where relative vulnerable species like rays and long-lived invertebrates occur. The by-catch of undersized plaice has likely been reduced in the closed period.

The main conclusion from the paper is that closed areas would need to be directly tied to effort reduction to prevent displacement of effort to sensitive areas.

WD 6 North Sea cod Spawning areas. Wright, P.J., Gibb, F.M. and Gibb, I.M.

A review of previous studies that attempted to document the historical distribution of cod spawning in the North Sea was carried out. Previous studies of cod spawning have relied on partial information on the distribution of eggs and larvae and on the distribution of mature cod from bottom trawl surveys. The information presented largely comes from periods when the cod spawning stock was higher than recent levels and there have been no recent studies specifically aimed at mapping the distribution of spawning cod. The paper concludes the following:

- Cod spawn throughout much of the North Sea but the adult and egg data do indicate a number of spawning aggregations.

- It is not possible to quantify long-term changes in the use of spawning grounds because of a lack of comprehensive survey data on eggs or spawning adults, and the lack of suitable sampling within ICES bottom trawl surveys.

- However, the limited data does suggest a contraction in significant spawning areas, beginning with the loss of sites at Great Fisher bank and Aberdeen bank by the 1980s, and more recently further coastal spawning sites around Scotland and the Forties area.

WD 7 Closed areas: the North Sea cod by Joe Horwood.

Closed areas have been a feature in the management of North Sea cod for a number of years. In particular, an area in the south-eastern North Sea was closed in the early 1980s to protect juvenile cod, while in 2001, an area in the north-eastern North Sea was closed for several weeks to protect spawning fish. This paper does not review all aspects of closed areas for fisheries. Rather it focuses on those aspects of closed areas as they reveal to conservation measures for North Sea cod. It looks wider at examples of attributed success of closed areas, as these colour the international public debate on the utility of closed areas, and draws some general principles for application of closed areas. It also indicates some of the practical fisheries and environmental problems even when areas could usefully be identified.

1.5 Review of available data bases

1.5.1 Brief description of scientific bottom trawl surveys (ToR a)

New information relevant to review the status of the four stocks mentioned in the ToR a and e5 was derived from the following scientific surveys:

International bottom trawl survey quarter 1 IBTSQ1: The International Quarter 1 Bottom Trawl Survey covers the whole of the North Sea using fixed stations of at least two tows per rectangle with the GOV trawl. Data are used since 1976 including new information from the first quarters in 2002 and 2003.

English groundfish survey quarter ENGGFSQ3: This survey covers the whole of the North Sea in August-September each year to about 200-m depth using a fixed station design of 75 standard tows with the GOV trawl. The data series commenced in 1977 and includes the new information from the third quarter in 2002.

Scottish groundfish survey quarter 3 SCOGFSQ3: The Scottish Groundfish survey (SCOGFS_Q3) is undertaken during August each year using a fixed station design with the GOV trawl. Coverage is restricted to the northern part of the North Sea. Data are used since 1982 including the new information from the third quarter in 2002.

Beam trawl survey quarter 3 BTSQ3: The survey was initiated in 1985 and was set up to obtain indices of the younger age groups of plaice and sole. However, due to its spatial distribution the BTS survey also catches considerable numbers of older plaice and sole. The survey is carried out with international cooperation and covers both inshore and offshore areas throughout the North Sea, Channel, and western waters of the UK. The Dutch survey is carried out using the RV ISIS. The fishing gear used is a pair of 8-

m beam trawls with 40 mm stretched mesh cod-ends. The Dutch participation in the survey is used as a tuning series for the plaice assessment and consists of average catches in numbers by fishing hour. The data series started in 1985 and the new 2002 indices were considered.

Sole net survey quarter 3 SNSQ3: The Sole Net Survey (SNS) was carried out with RV Tridens until 1995. Since 1996 the RV ISIS is used for this survey. The gear used is a pair of 6-m beam trawls with 40 mm stretched mesh cod-ends. The stations fished are on transects perpendicular to the coast. Data are used since 1982 and the new indices for 2002 are reviewed.

1.5.2 Data base of commercial landings and descriptions of fisheries (ToR e1)

This section includes a description of a data base of commercial landings created during the meeting and a fisheries description made on the basis of these data.

A database including monthly fleet landings weight and effort for the North Sea and adjacent waters was collated from national data during the meeting. The database includes both cod landings and landings from other economical important species (haddock, whiting, saithe, plaice, sole and *Nephrops*) that are caught alongside cod. Landings only were included, as discards data were not obtainable from all countries. Data were available for all relevant nations (Table 1), except Sweden for the years, 2000-2002 and area IV, IIIa (Skagerrak) and IIVd. Additional data for the period back to 1990 were available for some countries (Table 1.5.1).

Table 1.5.1 Data provision by country and year to the commercial landings and effort database for the North Sea and adjacent waters.

Country/year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Belgium											***x***	***x***	***x***
Denmark		***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***
France										***x***	***x***	***x***	***x***
Germany											***x***	***x***	***x***
Nederlands	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***
Norway				***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***
UK (E/W)		***x***		***x***	***x***		***x***	***x***	***x***	***x***	***x***	***x***	***x***
UK(Sco)						***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***

Effort was given by fleet, using various measures, and was not standardised (e.g. to KW*hours). Scottish effort data are based on the voluntary effort information from logbooks and might be biased. Other nations have derived effort from days absent from harbour and allocated to rectangles according to catch distributions from logbook data. The WG express concerns about the quality of the fishing effort data included in the data base.

A comparison of the landing included in the database and the official landings figures provided to ICES is presented in Table 1.5.2. For most species the database and ICES landings are quite close. However, for cod and saithe in the North Sea there are larger discrepancies between the two data sets. This is mainly due to missing Norwegian gillnet and long-line landings from the North Sea for which no spatial information was available. For area VIId, the database figures are in some cases bigger than those reported to ICES. This is believed to be because the figures reported to ICES are in some cases provisional estimates.

National fleets were defined from mesh sizes used and broad gear categories:

- OTB, Bottom otter trawl
- SDN, Seine nets (anchor and fly-dragging)
- TBB, Beam trawls
- GNS, Gill net, trammel net, tangle net
- OTH, Other gears

Ranges of mesh sizes were chosen to reflect the actual regulation with respect to by-catch species *etc.* and they do as such reflect the target species. Example, the “OTB, 70-90 mm” segment is probably targeting *Nephrops.* For other segments, the target species were not that clear. Mesh sizes from logbooks were not available for all nations and in such cases, mesh sizes were derived using informed estimates.

Table 1.5.2 Comparison of landings included in the data base and the official nominal landings provided by ICES, 2000-2002.

year 2000, Area IIIa

country	COD	HAD	WHG	POK	PLE	SOL	NEP
DEN	7,093	1,036	30	894	6,375	291	3,817
GER	9	0	0	0	5	8	2
NL	1	0	0	0	13	0	0
NOR	5	0	0	12	24	0	1
SCO	0	0	0	0	0	0	0
All	7,108	1,037	30	906	6,418	300	3,819
Total Nominal Landings	9,343				8,807		

year 2000, Area IV

country	COD	HAD	WHG	POK	PLE	SOL	NEP
BEL	3,198	384	529	119	7,049	1,920	320
DEN	12,322	1,496	100	2,478	12,601	917	3,398
ENG	6,543	1,876	1,783	1,227	11,370	600	2,209
FRA	1,187	716	3,224	21,711	521	835	0
GER	1,744	342	424	9,275	4,313	1,283	79
NL	5,831	116	1,869	8	34,808	15,205	546
NOR	466	272	1	19,531	688	175	48
SCO	19,600	35,938	16,450	5,193	7,515	319	7,679
All	50,212	41,083	23,992	59,422	78,241	21,138	14,252
Total Nominal Landings	60,824	46,629	34,453	88,483	82,151		

year 2000, Area VIId

country	COD	HAD	WHG	POK	PLE	SOL	NEP
ENG	385	0	118	0	755	622	0
FRA	2,700	0	5,623	1	4,002	2,111	0
NL	4	0	14	0	1	1	0
All	3,089	1	5,755	1	4,758	2,734	0
Total Nominal Landings	3,583		6,072		5,235		

year 2001, Area IIIa

country	COD	HAD	WHG	POK	PLE	SOL	NEP
DEN	5,389	1,646	28	1,092	8,889	257	2,646
GER	16	128	0	9	1	0	0
NL	0	0	0	0	3	0	0
NOR	13	4	0	166	121	1	0
SCO	1	7	0	0	7	0	0
All	5,418	1,786	29	1,267	9,021	258	2,647
Total Nominal Landings	7,086				11,559		

year 2001, Area IV

country	COD	HAD	WHG	POK	PLE	SOL	NEP
BEL	2,456	600	443	987	6,413	2,036	340
DEN	6,931	1,879	98	2,143	12,809	629	3,596
ENG	4,087	3,335	1,301	1,185	11,024	597	2,692
FRA	672	484	4,079	21,166	498	666	0
GER	1,819	684	403	9,473	4,742	963	139
NL	3,632	294	2,552	20	33,668	13,494	838
NOR	412	368	5	26,031	1,046	76	18
SCO	14,728	27,929	10,262	4,859	7,846	290	8,138
All	34,489	35,536	18,699	64,876	77,731	18,628	15,694
Total Nominal Landings	41,705	42,234	18,833	87,380	79,271		

year 2001, Area VIId

country	COD	HAD	WHG	POK	PLE	SOL	NEP
BEL	97	2	72	3	1,448	1,092	1
ENG	249	0	134	0	660	821	0
FRA	1,431	1	5,711	1	3,257	2,628	0
NL	11	0	63	0	3	0	0
All	1,786	4	5,908	1	5,379	4,538	0
Total Nominal Landings	2,009		6,585		4,971		

year 2002, Area IIIa

country	COD	HAD	WHG	POK	PLE	SOL	NEP
DEN	5,218	3,971	73	2,502	6,352	146	4,095
GER	81	240	0	45	26	0	0
NL	0	0	0	0	3	0	0
NOR	23	4	0	118	53	0	0
SCO	0	0	0	0	0	0	0
All	5,321	4,215	73	2,665	6,434	146	4,095

year 2002, Area IV

country	COD	HAD	WHG	POK	PLE	SOL	NEP
BEL	2,490	550	259	105	4,563	1,614	274
DEN	7,434	4,136	93	2,783	11,521	522	3,307
ENG	3,113	3,646	1,322	2,521	8,477	451	1,963
FRA	1,715	894	3,164	24,722	489	560	0
GER	2,030	778	323	10,959	3,937	763	126
NL	4,628	356	2,430	5	28,711	12,058	941
NOR	631	632	9	39,360	936	51	2
SCO	14,522	37,913	7,317	5,884	7,505	215	8,636
All	36,212	48,928	14,658	86,235	66,298	16,314	15,277
Total Nominal Landings	44,080	53,786	15,372	119,954	69,723		

year 2002, Area VIId

country	COD	HAD	WHG	POK	PLE	SOL	NEP
BEL	135	2	69	6	1,522	1,408	2
ENG	144	1	112	0	839	975	0
FRA	2,182	1	4,642	1	3,255	2,636	0
NL	7	0	23	0	0	0	0
SCO	0	0	0	0	1	1	0
All	2,464	3	4,777	1	5,665	5,054	0
Total Nominal Landings	1,625		5,581		5,479		

1.5.3 Description of the commercial fleets and fisheries

Spatial patterns in landings: There appears to have been only little changes in the relative spatial distributions of cod, haddock, whiting, plaice, saithe, sole and Nephrops over the period 2000-2002 (Fig. 1.5.1-2). The highest densities of cod landings are observed in the Skagerrak and close to the northern and southern geographical frontiers of the North Sea. Haddock landings are mostly concentrated in the northern and north-western parts of the North Sea, but landings in the Skagerrak have gradually increased over the investigated period. Saithe landings are distributed on the northern edge of the North Sea shelf. The highest concentrations of whiting landings are observed in the Eastern Channel and in the north-western part of the North Sea. Plaice and sole landings are distributed in the South-Eastern part of the North Sea, along the coasts of France, Belgium, Netherlands, Germany and Denmark. Finally, Nephrops landings appear to be scattered in the North Sea, with the most important fishing grounds being found off the northern coasts of England and Scotland and in the Skagerrak. There appears to be a spatial overlap between the haddock, whiting and Nephrops fishing grounds, particularly off the Eastern Scottish coast.

The spatial distribution of the 1989 and 1991 international landings of cod were available to the WG (Lewy et al., 1992) and these have been represented in fig. 1.5.3 for comparison purposes. The lack of landings in the Skagerrak is only due to that area not being included in the STECF database. Comparing Figures 1.5.1 and 1.5.3, the most noticeable change in the landings distribution is that the high concentrations of cod landings in the German Bight observed in 1989 and 1991 have almost disappeared in 2000-2002.

Spatial and monthly distributions of all stocks could also be derived over the period 2000-2002, and these have been presented in Appendix 4.

Development of the fisheries: The international landings by country and by gear groups are shown in Figures 1.5.4 and 1.5.5, respectively for the selected stocks. The landings of the stocks under consideration have followed contrasting trends over the period 2000-2002. Landings of cod, whiting, plaice and sole have overall decreased over time, while those of saithe, haddock and Nephrops have increased.

The bulk of the cod landings is taken by the Scottish and the Danish vessels fishing with otter-trawlers. Over a quarter of the total landings are also realized by Danish gill-netters and Scottish seiners. The Scottish otter-trawlers contribute to more than 75% of the haddock landings, and to over 50% of the Nephrops landings. The whiting landings are shared between Scottish and French otter-trawlers, while the saithe landings are shared between Norwegian, French and German otter-trawlers. The Dutch beam-trawlers contribute to over 75% of the total sole landings, and to over 50% of the plaice landings.

Long-term trends in landings were made available for the Danish, English, Dutch and Scottish vessels, and the cod landings have been presented in Figure 1.5.6 as an example. These graphs show that the cod landings by the four countries have overall increased before 1998 and then consistently decreased since 1998. These features are broadly in agreement with the trends in the North Sea cod TAC over the same period: increase from 100,000 to 140,000 tonnes over 1991-1997 and decrease from 140,000 to 50,000 tonnes over 1998-2002.

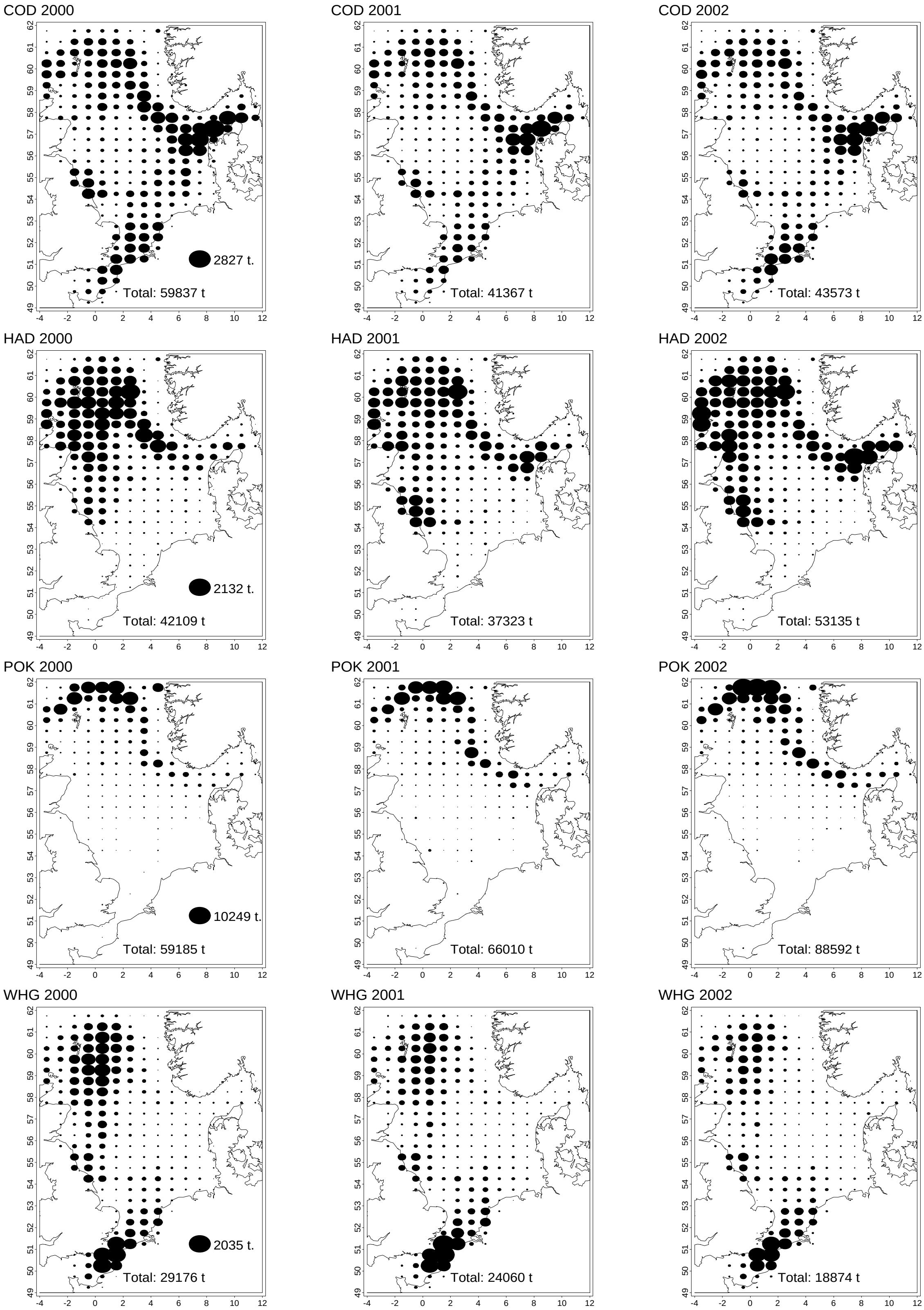


Fig. 1.5.1 Spatial distribution of international landings (t) of cod, haddock, saithe, whiting over 2000-2002.

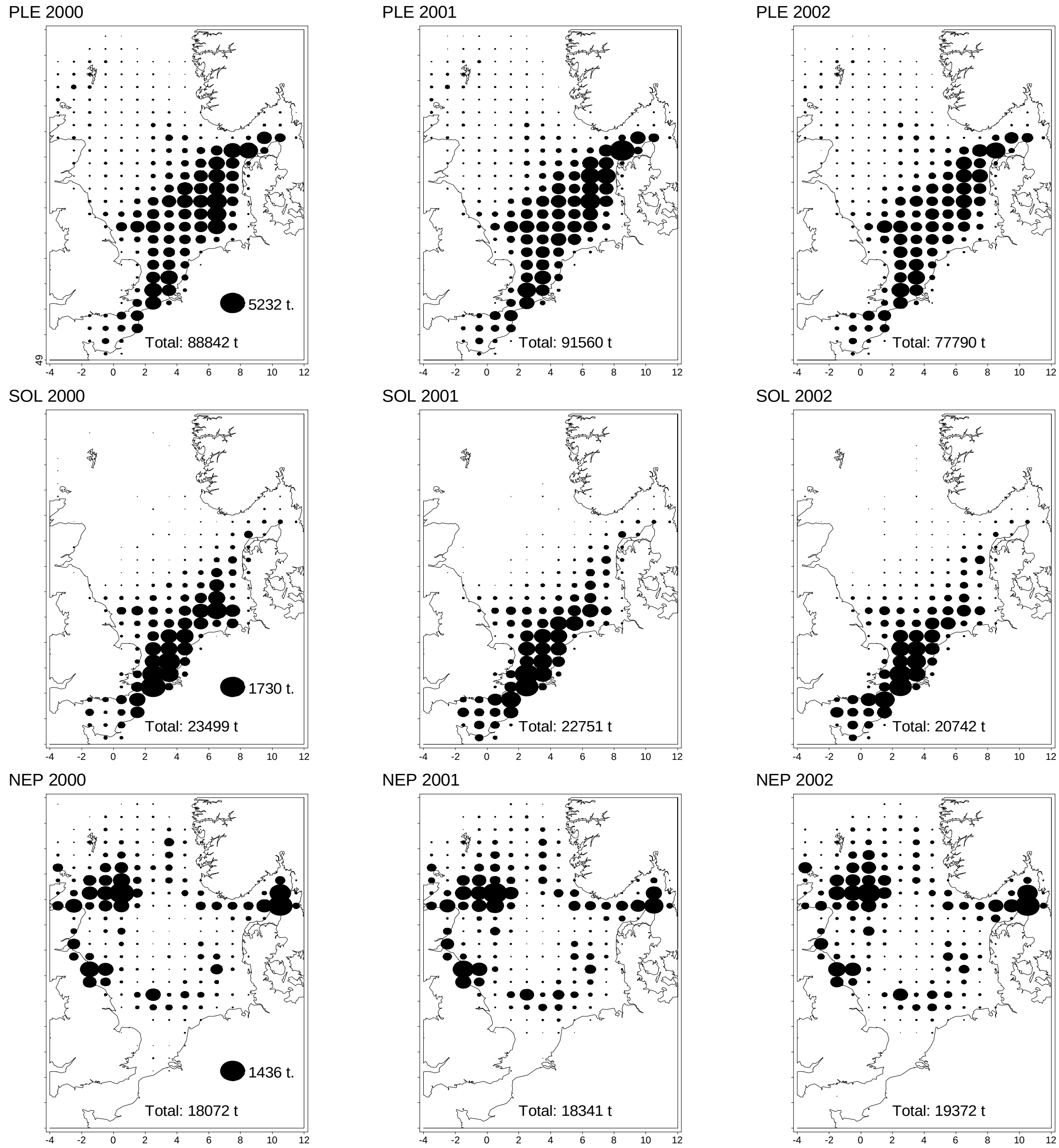


Fig. 1.5.2 Spatial distribution of international landings (t) of plaice, sole, Nephrops over 2000-2002.

1989 (Total landings: 94,000 t) *1991 (Total landings: 76,000 t)*

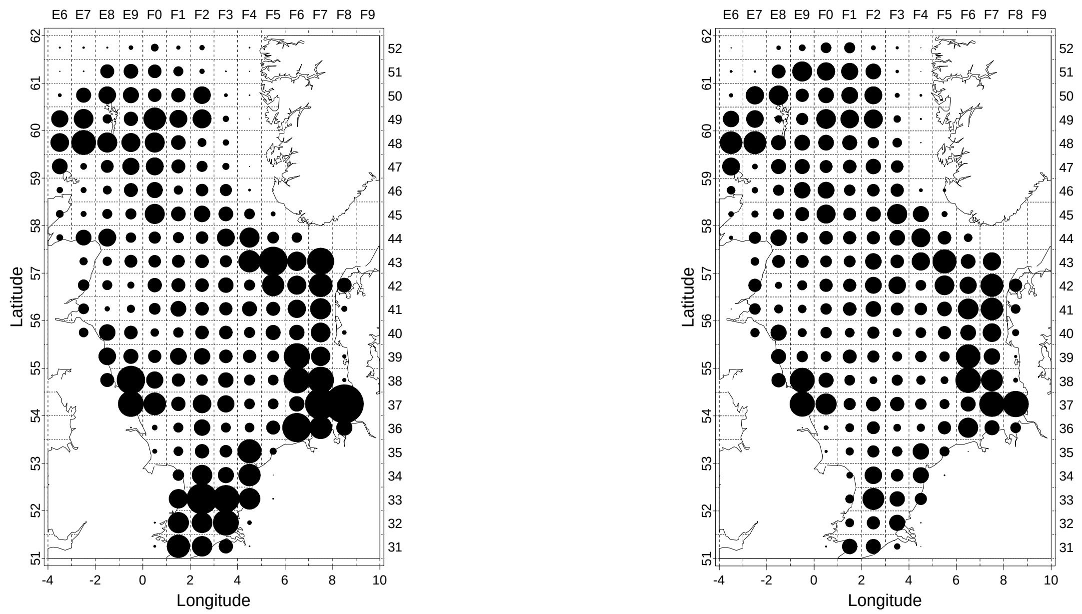


Fig. 1.5.3 International cod landings distribution as included in the STCEF data base 1989 and 1991. (Same scaling of symbols for both years)

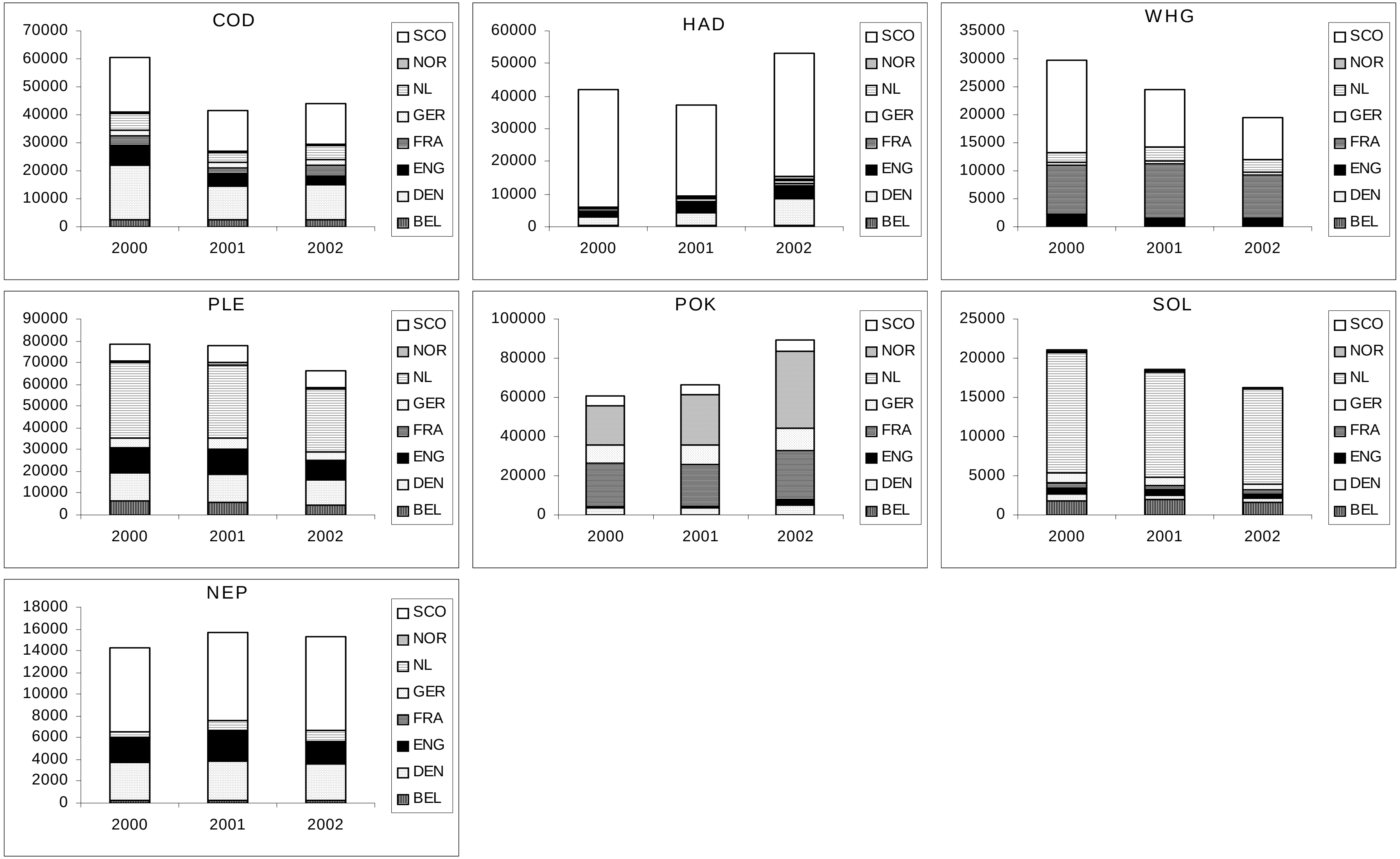


Fig. 1.5.4 International landings of cod (COD), haddock (HAD), whiting (WHG), plaice (PLE), saithe (POK), sole (SOL), Nephrops (NEP) by countries during the period 2000-2002.

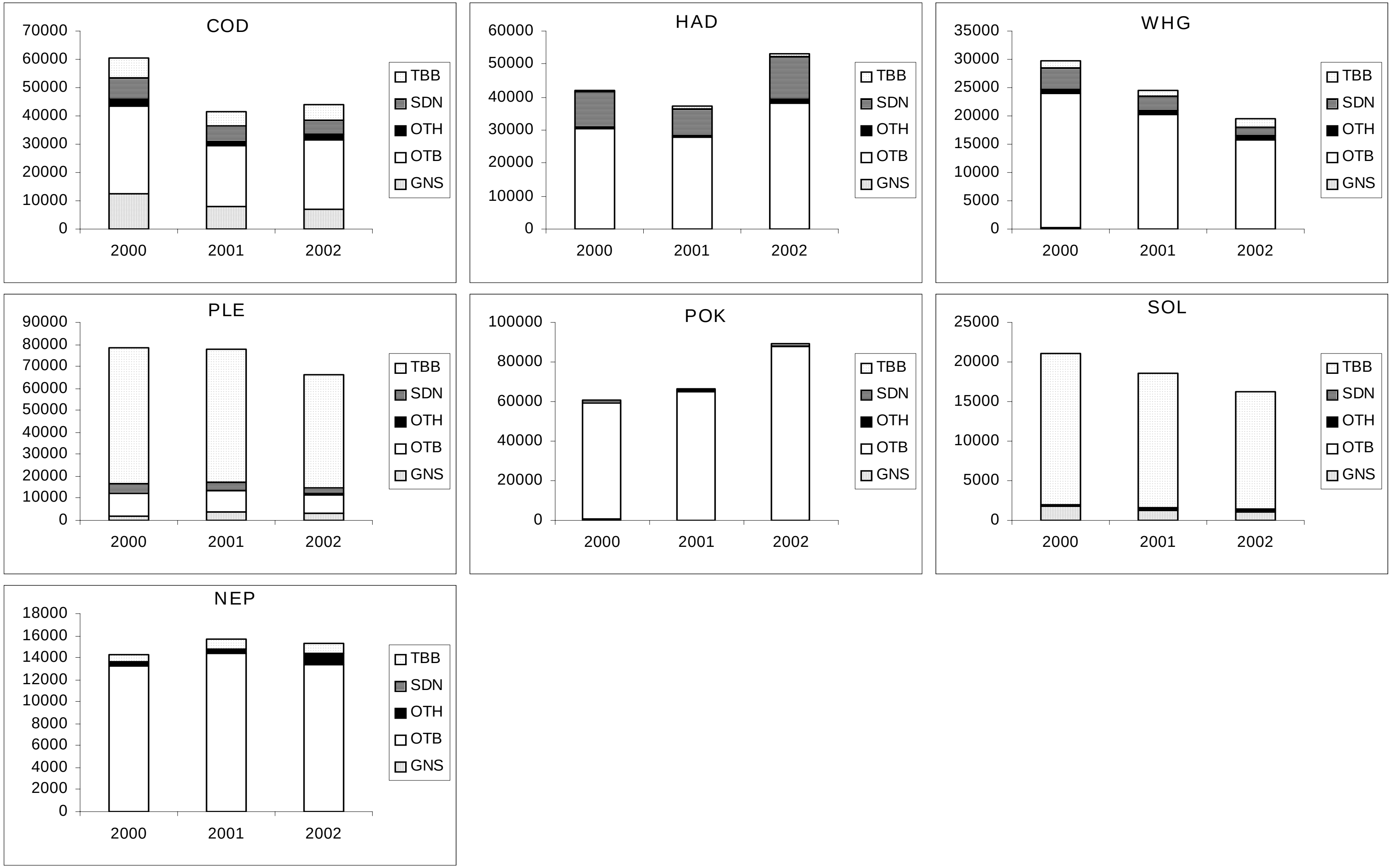


Fig. 1.5.5 International landings of cod (COD), haddock (HAD), whiting (WHG), plaice (PLE), saithe (POK), sole (SOL), Nephrops (NEP) by gear during the period 2000-2002.

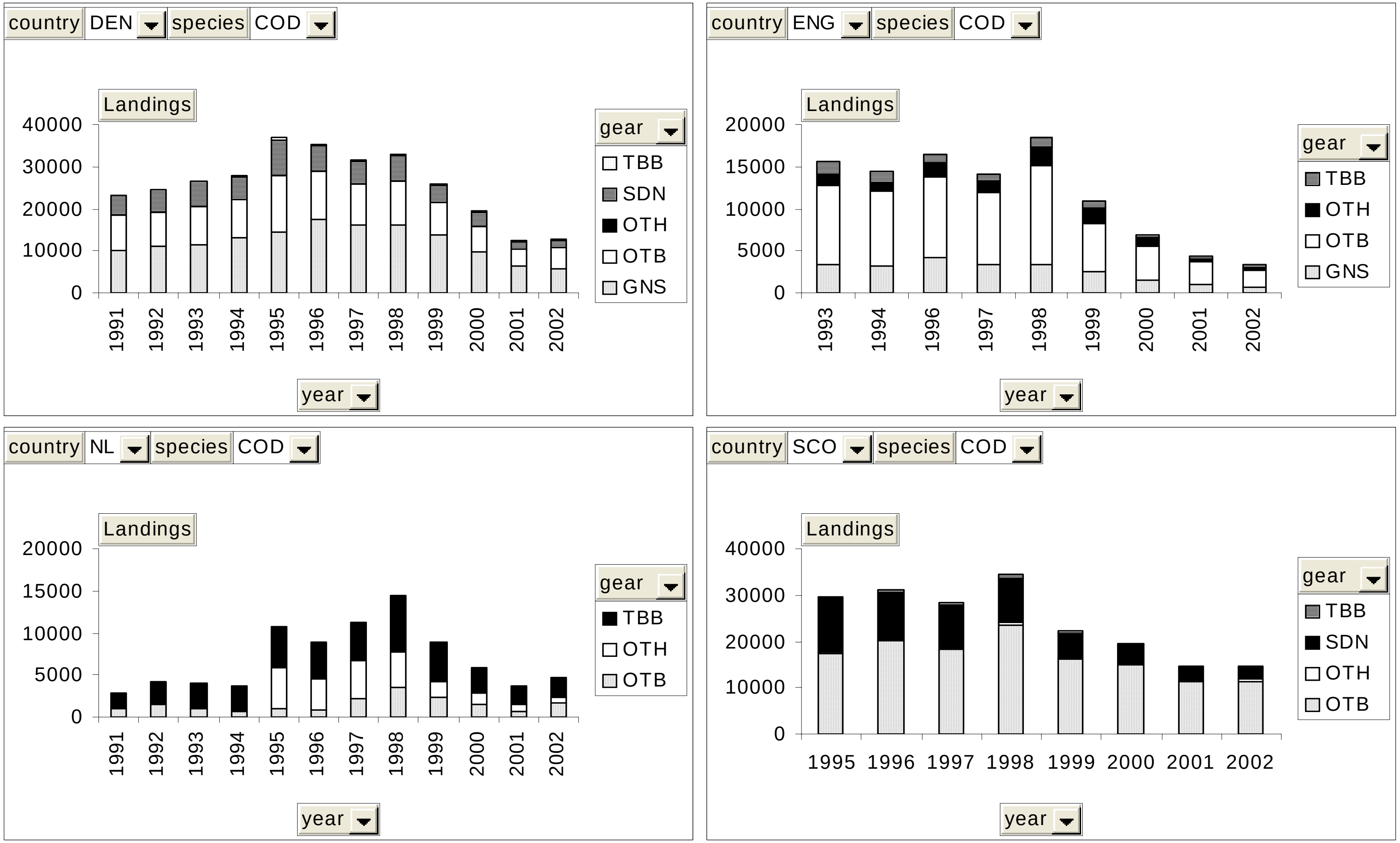


Fig. 1.5.6 National landings of cod (COD) by country and gear during the period 1991-2002.

Figures 1.5.7-8 present detailed information on the changes in the the landings of the Scottish and Danish fisheries. These fisheries were selected because they represent the main contributors in terms of cod landings. Detailed information for the other countries is available and may be provided on request. In the case of the Scottish vessels, mesh size information was not directly available, and some assumptions were made to allow deriving operational definitions of mesh size for those vessels. In particular, the WG estimated the mesh size range of Nephrops trawlers to be in the range 70-99 mm following the regulation applicable to this fishery. It was also assumed that the minimum mesh size applicable to otter-trawlers and seiners was of 100 mm in 2000 and 2001, before the EU regulation 2056/2001 came into force. In 2002, it was assumed that half of the vessels upgraded their minimum mesh size to 120 mm, while the remaining half could use the derogative 110 mm minimum mesh size. Given there was no quantitative evidence available to confirm or to infirm that assumption, it was only taken by the WG as a preliminary guess.

Figure 1.5.7 shows that the landings of cod and whiting by the Scottish otter-trawlers have decreased over time, while the landings of Nephrops and saithe have overall increased for the same vessels. These contrasting trends reflect the overall decreasing trend in the North Sea cod TAC over the period 2000-2002 and the increasing trend in the saithe TAC. The landing trends observed for whiting and Nephrops are less in accordance with the trends in the TAC. The Scottish landings of haddock and plaice followed no clear trends, while the sole landings were negligible.

Figure 1.5.8 shows that the majority of Danish cod landings have been realized by gill-netters fishing with a mesh size greater that 140 mm, that is the traditional mesh size of the Danish gill-netters targeting cod. The cod landings by the Danish fisheries have decreased over time. This decrease contrasts with the increase in the landings of haddock and saithe, particularly in 2002. The 2002 increase in haddock and saithe landings is consistent with the 2002 increase in these species' TAC. The Danish landings of Nephrops and plaice showed no clear trends, while the landings of whiting and sole were relatively small.

Figure 1.5.9 shows the seasonal patterns in the Scottish and Danish landings. The Scottish fishery for haddock is clearly seasonal and peaks in the third quarter of the year. The Danish gill-net fishery harvesting flatfish and the otter-trawl fishery harvesting plaice also show a clear seasonal pattern, with landings peaking in the first half of the year. There are no apparent seasonal patterns in the cod landings.

Figures 1.5.10-11 show the annual and monthly changes in the days at sea for the Danish fisheries. The changes in the fishing effort of the Scottish fisheries have not been presented here, as a result of the data concerns expressed in section 1.5.2. The days (or hours) at sea for the other countries is available and may be provided on request. Figure 1.5.10 suggests that the days at sea of both Danish gill-netters and seiners has declined, particularly in 2002. No clear annual trends in effort were observed for the Danish otter- and beam-trawlers. Figure 1.5.11 shows seasonal patterns for the fishing effort of flatfish gill-netters (GNS < 140), which take most of their activity in the first half of the year. Seasonal patterns were also observed for the effort of most otter-trawlers. The figure also shows that Danish seiners and beam-trawlers using a mesh size below 80 mm have a relatively low activity in the winter months.

In this section, a comprehensive database has been made out, which included the international annual and monthly landings of seven species and fishing effort by ICES rectangle, gear and mesh size. Using this data base, the most updated description of the main international fisheries of the North Sea has been made, which contributes to most of the first TOR of this WG. Future developments of this data base could include age-disaggregated landings and discard information, and also enhanced definitions of fishing effort. The reliability of fishing effort data should be further scrutinized. Moreover, additional information on fishing effort including measures of fishing capacity (horsepower, gross tonnage) and also of the fisheries technical development could be incorporated in the data base.

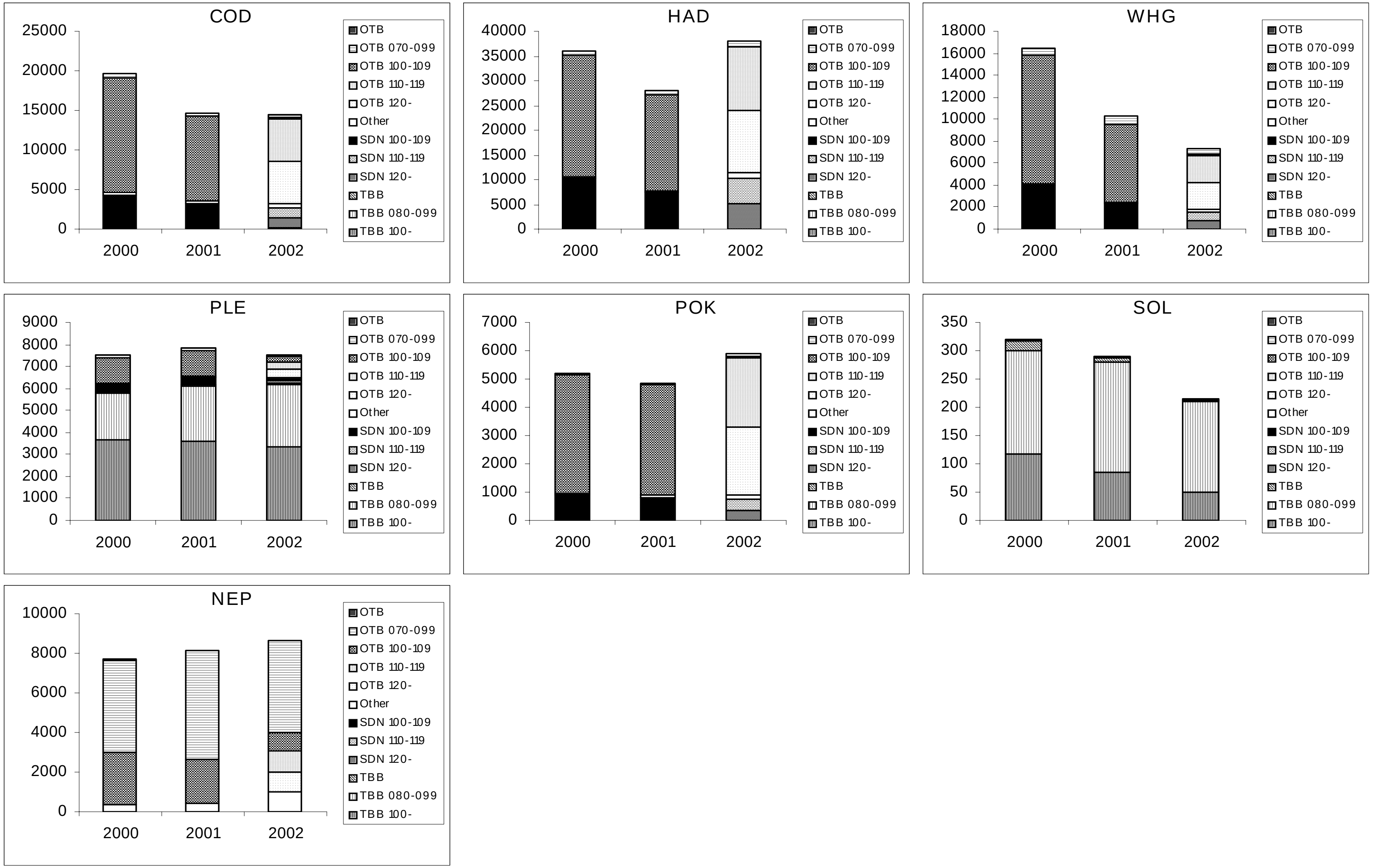


Fig. 1.5.7 Scottish landings (tonnes) of North Sea cod (COD), haddock (HAD), whiting (WHG), plaice (PLE), saithe (POK), sole (SOL) and Nephrops (NEP) by fishery over 2000-2002.

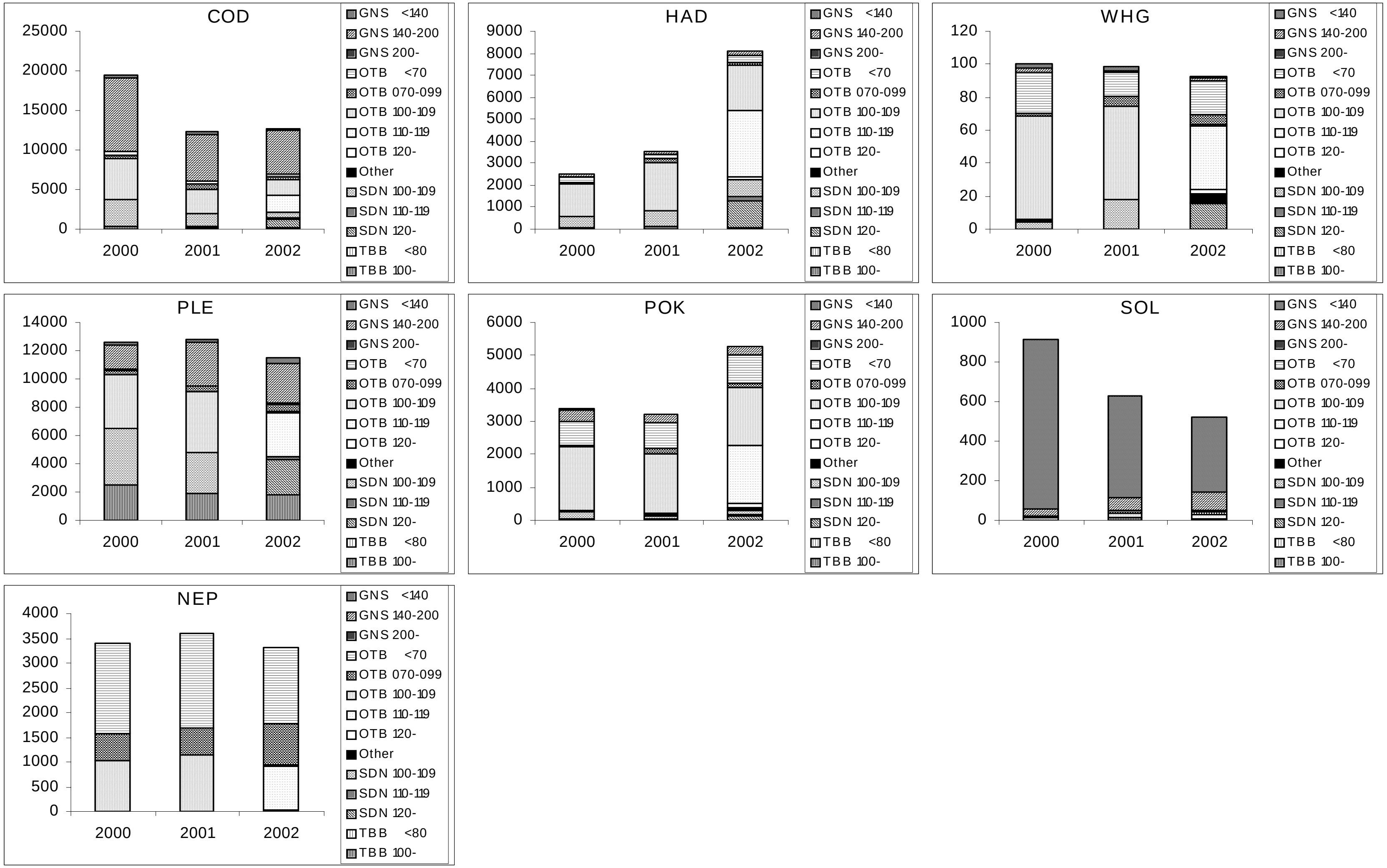


Fig. 1.5.8 Danish landings (tonnes) of North Sea cod (COD), haddock (HAD), whiting (WHG), plaice (PLE), saithe (POK), sole (SOL) and Nephrops (NEP) by fishery over 2000-2002.

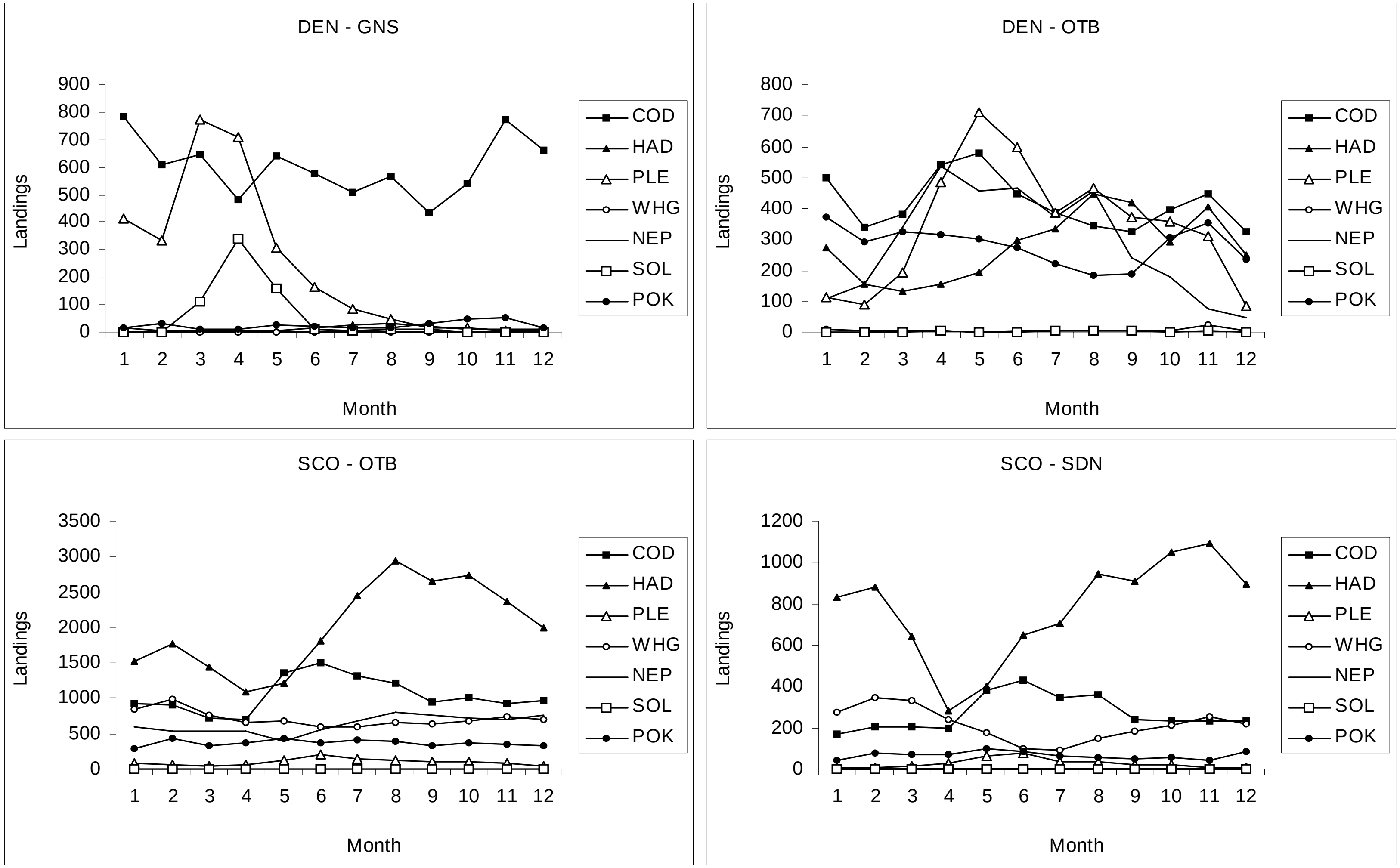


Fig. 1.5.9 Monthly distribution of Scottish and Danish landings (tonnes), averaged over 2000-2002 of North Sea cod, haddock, whiting, plaice, saithe, sole and Nephrops for selected fisheries over 2000-2002.

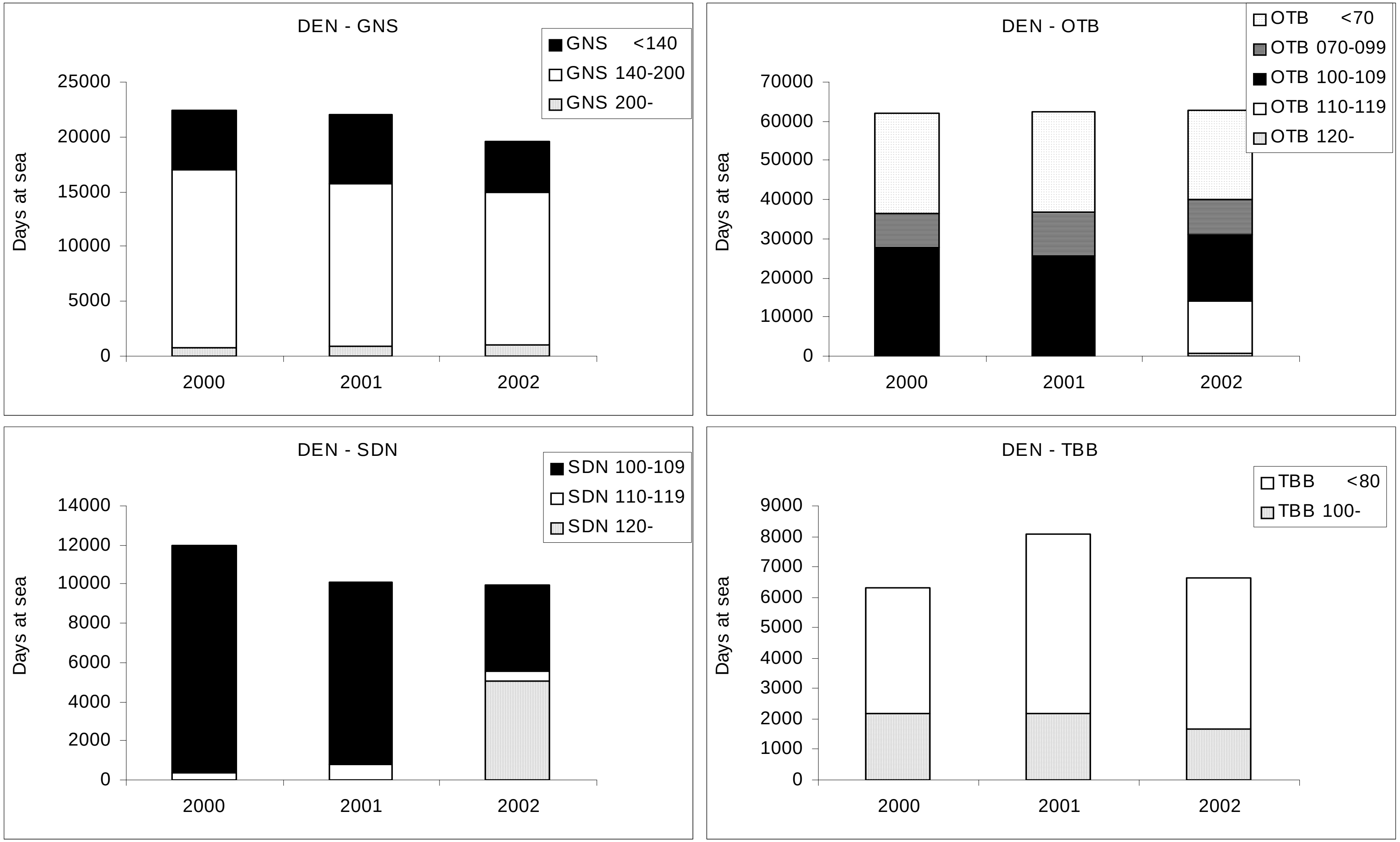


Fig. 1.5.10 Annual effort changes in days at sea by gear for the Danish fisheries fishing in the North Sea and Skagerrak during 2000-2002.

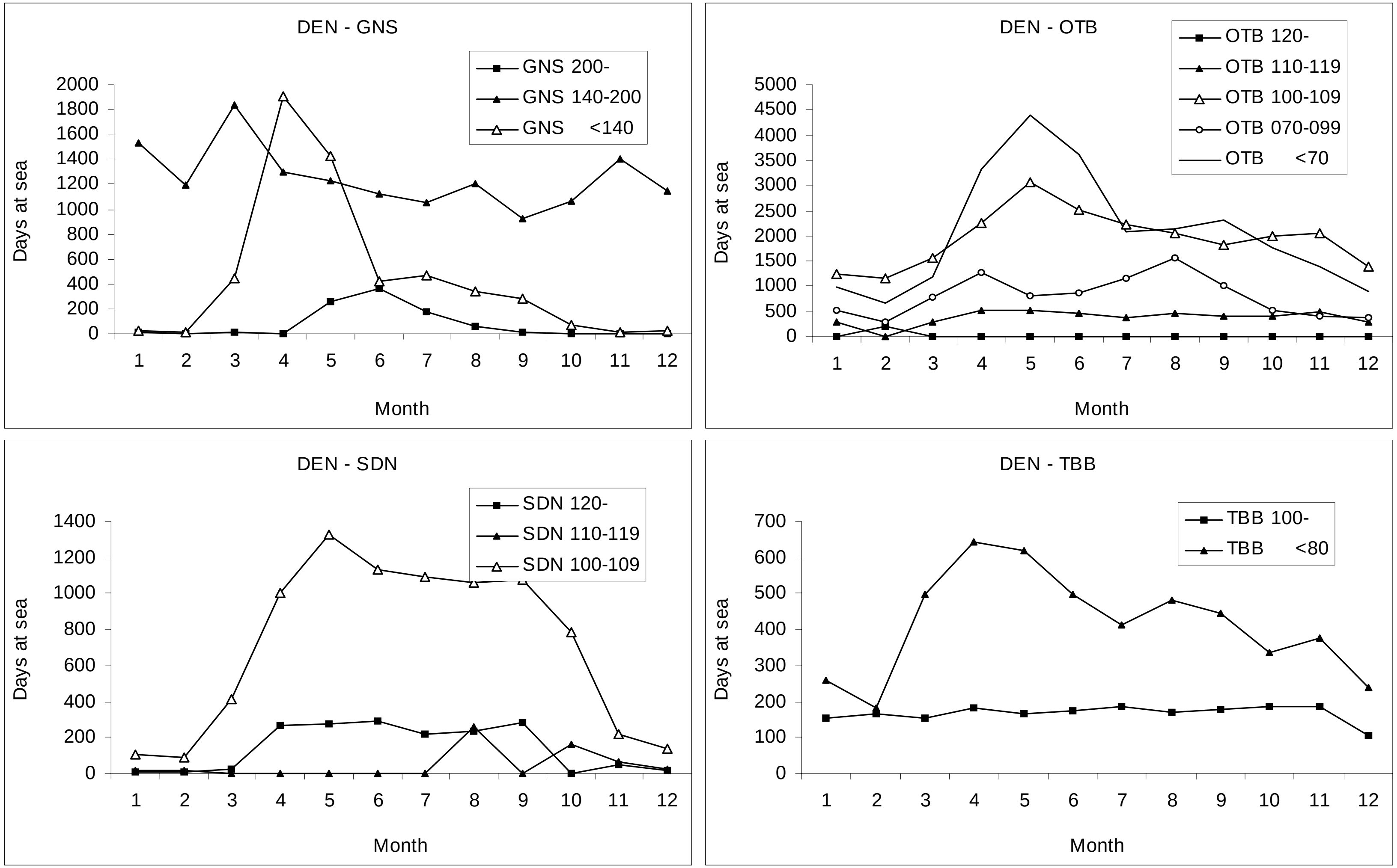


Fig. 1.5.11 Monthly effort changes in days at sea by gear for the Danish fisheries fishing in the North Sea and Skagerrak during 2000-2002..

2. Stock assessment updates

Comprehensive updates of the assessments for cod in IIIa, IV and VIId, haddock in IIIa and IV, whiting in IV and VIId and plaice in IV have not been attempted as there was insufficient new information to allow revised assessments.

For the gadoid stocks, the only available new information which was not used in the 2002 ICES assessments and subsequent advice are the results from the IBTS Q1 2003 survey, the ENGGFS Q3 and the SCOGFS Q3 in 2002, respectively. Although the 2002 data from EGFS Q3 and SCOGFS Q3 survey data were not used for the historic assessment, the data was used in the estimation of recruits to the fishery in 2002 and 2003. These estimates were then used in the forecasts of catch and SSB for 2002 and 2003.

For plaice, the newest information comes from the 2002 autumn Dutch beam trawl surveys BTS and SNS. Although the information from these surveys are not incorporated in the historic assessment, ICES has used the 2002 data points of the surveys for the recruitment estimates of year classes 2001 and 2002, and therefore used in subsequent advise.

2.1 Cod in Sub-area IV and Divisions IIIa and VIId stock assessment update (ToR a and e5)

2.1.1 Management applicable in 2001, 2002 and 2003.

Management of cod is by TAC and technical measures. The agreed TACs (kt) for Cod in Division IIIa (Skagerrak) and Sub-area IV were as follows:

	TAC 2001	TAC 2002	TAC 2003
IIIa (Skagerrak)	7.0	7.1	3.9
IIa + IV	48.6	49.3	27.3

There is no TAC for cod set for Division VIId alone. Landings from Division VIId count against the overall TAC agreed for ICES Divisions VII b-k. The agreed TACs for both 2001 and 2003 implied a reduction in status quo fishing mortality of about 50% and 65%, respectively.

In 1999, the EU and Norway agreed to implement a long-term management plan for the cod stock, which is consistent with the precautionary approach and is intended to constrain harvesting within safe biological limits and designed to provide for sustainable fisheries and greater potential yield. The plan consists of the following elements:

1. *Every effort shall be made to maintain a minimum level of SSB greater than 70 000 t (Blim).*
2. *For 2000 and subsequent years the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of 0.65 for appropriate age groups as defined by ICES.*
3. *Should the SSB fall below a reference point of 150 000 t (Bpa), the fishing mortality referred to under paragraph 2 shall be adapted in the light of scientific estimates of the conditions then prevailing. Such adaptation shall ensure a safe and rapid recovery of SSB to a level in excess of 150 000 t.*
4. *In order to reduce discarding and to enhance the spawning biomass of cod, the Parties agreed that the exploitation pattern shall, while recalling that other demersal species are harvested in these fisheries, be improved in the light of new scientific advice from, inter alia, ICES.*
5. *The Parties shall, as appropriate, review and revise these management measures and strategies on the basis of any new advice provided by ICES.*

Fishing for cod is governed by the technical conservation measures described in Section 3.

The EU minimum landing size (mls) for cod in Sub-area IV and Divisions IIIa and VIId is 35 cm, although the mls in Denmark is 40 cm.

2.1.2. Review of provisional landings for 2002.

Landings for 2002 as officially reported to ICES are as follows:

Table 2.1.1 Nominal landings (in tonnes) of cod in Division IIIa as officially reported to ICES, 1996-2002.

Country	1996	1997	1998	1999	2000	2001	2002*
Denmark	18,611	16,040	16,547	12,676	10,973	8,650	7,289
Germany	259	81	54	54	54	32	83
Norway	1,046	1,323	1,293	1,146	924	757	643
Sweden	4,279	4,637	4,269	4,497	2,734	2,333	1,628
Total	24,195	22,081	22,163	18,373	14,685	11,772	9,643

*Preliminary.

Table 2.1.2 Nominal landings (in tonnes) of cod in Subarea IV as officially reported to ICES, 1996-2002.

Country	1996	1997	1998	1999	2000	2001	2002*
Belgium	3,458	4,642	5,799	3,882	3,304	2,470	2,594
Denmark	23,573	21,870	23,002	19,697	14,000	8,358	9,018
Faroe Islands	44	40	102	96			
France	1,934	3,451	2,934*	1,750[1*]	1,222	704*	1,773
Germany	8,344	5,179	8,045	3,386	1,740	1,810	2,018
Netherlands	9,271	11,807	14,676	9,068	5,995	3,574[2]	4,712
Norway	5,869	5,814	5,823	7,432	6,353*	4,383*	4,994
Poland	18	31	25	19	18	18	39
Sweden	617	832	540	625	640	661	439
UK (E/W/NI)	15,930	13,413	17,745	10,344	6,543	4,087	…
UK (Scotland)	35,349	32,344	35,633	23,017	21,009	15,640	…
United Kingdom							18,493
Total	104,407	99,423	114,324	79,316			

*Preliminary. [1]Includes IIa(EC). [2]Note: Not included here 63t of cod reported in area unknown.

Table 2.1.3 Nominal landings (in tonnes) of cod in Division VIId as officially reported to ICES, 1996-2002.

Country	1996	1997	1998	1999	2000	2001	2002*
Belgium	321	310	239	172	110	93	50
France	2,808	6,387	7,788*		3,084	1,650*	1,425
Netherlands	+	-	19	3	4	17	6
UK (E/W/NI)	414	478	618	454	385	249	…
UK (Scotland)	4	3	1	-	-	-	…
United Kingdom							144
Total	3,547	7,178	8,665		3,583	2,009	1,625

*Preliminary.

It is presently not possible to comment on the TAC uptake for IIIa Skagerrak, since the landings officially reported to ICES for IIIa includes both the Skagerrak and Kattegat and only the Skagerrak component is allocated to the North sea stock. The TAC for IIa + IV was undershot by about 10% although this does not include any landings from IIa. There are no officially reported estimates of discards of cod and discard sampling is restricted to specific fleets. Furthermore the provisional landings do not include any industrial by-catch of cod.

2.1.3 Research vessel data

The most recent assessment of North Sea cod was undertaken in 2002 (ICES, 2002). Since then, only one further survey has been carried out; the International Bottom Trawl Survey of the North Sea in February 2003 (IBTS Q1 2003). In addition, 2002 data from the ENGGFS Q3 and SCOGFS Q3 were presented as they were yet only used in the prediction of stock size and not in the historic stock assessment.

2.1.4 Trends in survey indices of stock abundance

Trends in catch in numbers at age per unit of effort from research vessel surveys are presented in Figures 2.1.1-3. The survey data indicate that the stock has declined dramatically since 1997.

2.1.5 Trends in recruitment from survey data.

The trends in recruitment of cod at age 1 are given in Figure 2.1.4. Recruitment has been poor since 1997 and the 2003 estimate of 1-year-old cod from the IBTS is the lowest in the series.

2.1.6 Mortality estimates from survey data

Trends in annual relative total mortality for cod for age groups 1-4 from the quarter 1 IBTS are given in Figure 2.1.5. The trends in mortality indicate a relatively stable mortality rate (Z) over time although the annual estimates fluctuate about a mean level. There are no apparent reductions in overall mortality in recent years compared to earlier years.

2.1.7. Stock status

There is no evidence to alter the perception of the state of the stock and the following statement from ICES in October 2002 still holds true: *“The stock is outside safe biological limits. The spawning stock is estimated to have been below Bpa since 1984 and in the region of Blim since 1990. SSB in 2001 is estimated at a new historic low at about 30,000 t and is now estimated 50% lower than last year. The SSB in 2002 is estimated around 38,000 t. Fishing mortality has remained at about the historic high and above Fpa since the early 1980s and F in 2001 is estimated to be above Flim. Except for the 1996 year class, recruitment has been below average in all years since 1987. The 1997 and 2000 year classes are estimated to be the poorest on record”*.

Given the recent level of recruitment, the stock can be expected to decline further under the levels of exploitation as estimated for 2001.

2.1.8. The effect of including discard estimates in the assessment of North Sea cod.

The ICES assessment of North Sea cod is based on commercial landings data only. This results in unaccounted mortality on those sizes and age groups of cod that are subject to discarding. A working paper presented to the Group (Darby, 2003), examined the effect of including of discard estimates in the assessment. The estimates used were based on discard data collected under the EU project EC 98/07. The main findings are described in section 1.4, WD 1.

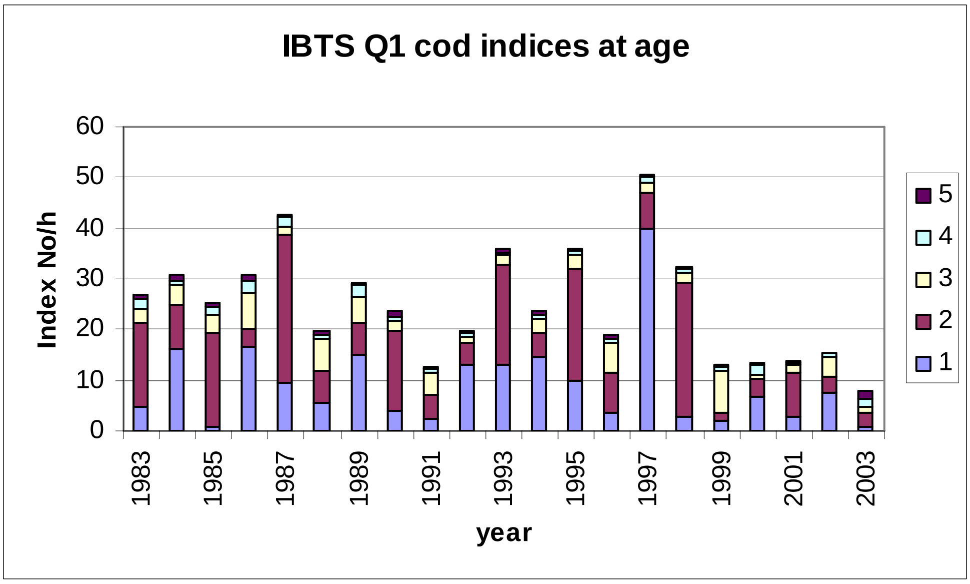


Fig. 2.1.1. Time series of stock size in numbers at age from IBTS Q1, 1983-2003.

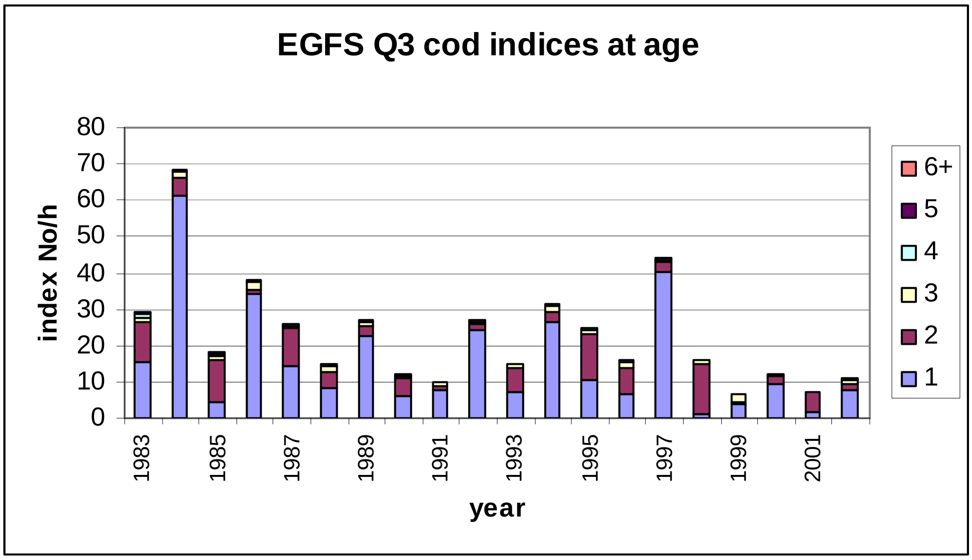


Fig. 2.1.2. Time series of stock size in numbers at age from ENGGFS Q3, 1977-2002.

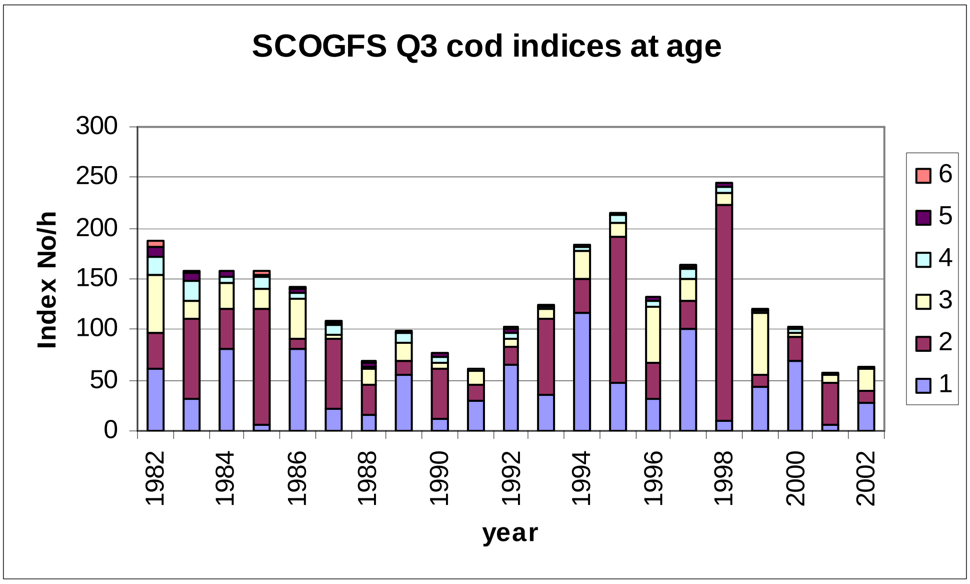


Fig. 2.1.3. Time series of stock size in numbers at age from SCOGFS Q3, 1982-2002.

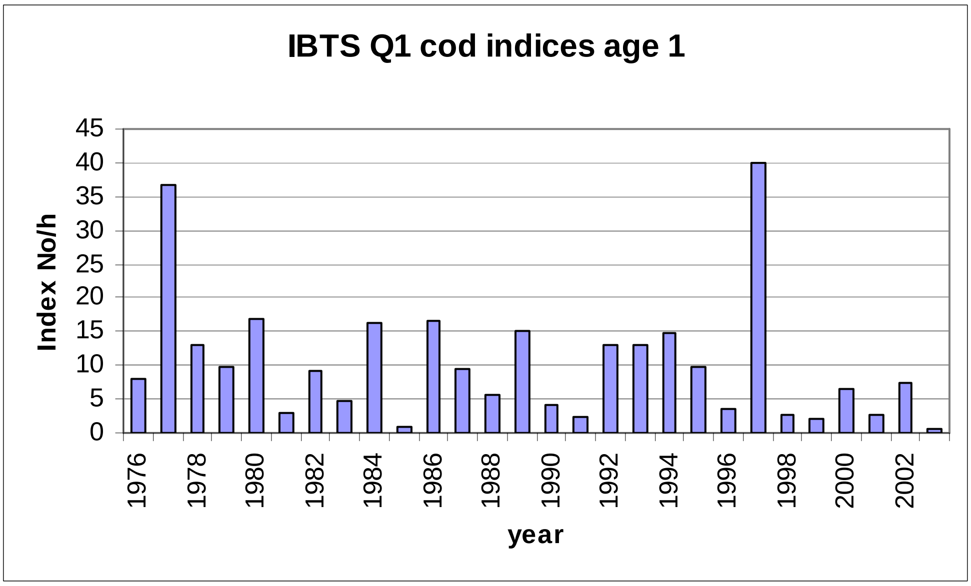


Figure 2.1.4 Recruitment indices for cod age 1 from IBTS Q1.

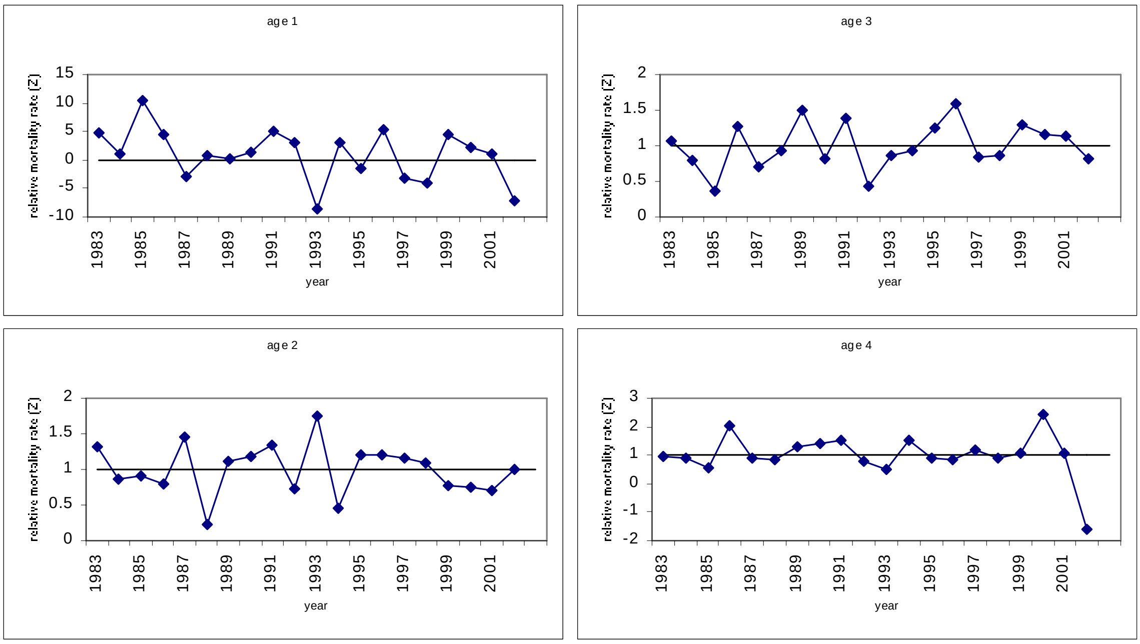


Figure 2.1.5 IBTS Q1: estimates of relative total mortality rate for cod ages 1-4

2.2 Haddock IIIa and IV stock assessment update (ToR e5)

2.2.1 Management applicable in 2001, 2002 and 2003.

Management of haddock is by TAC and technical measures. The agreed TACs (kt) for haddock in Division IIIa-d and Sub-area IV were as follows:

	TAC 2001	TAC 2002	TAC 2003
IIIa, IIIb-d (EC)	4.0	6.3	3.15
IIa (EC) + IV	61.0	104.0	51.7

In 1999 the EU and Norway have

"agreed to implement a long-term management plan for the haddock stock, which is consistent with the precautionary approach and is intended to constrain harvesting within safe biological limits and designed to provide for sustainable fisheries and greater potential yield. The plan shall consist of the following elements:

1. *Every effort shall be made to maintain a minimum level of SSB greater than 100 000 t (Blim).*
2. *For 2000 and subsequent years the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of 0.70 for appropriate age groups as defined by ICES.*
3. *Should the SSB fall below a reference point of 140 000 t (Bpa), the fishing mortality referred to under paragraph 2 shall be adapted in the light of scientific estimates of the conditions then prevailing. Such adaptation shall ensure a safe and rapid recovery of SSB to a level in excess of 140 000 t.*
4. *In order to reduce discarding and to enhance the spawning biomass of haddock, the Parties agreed that the exploitation pattern shall, while recalling that other demersal species are harvested in these fisheries, be improved in the light of new scientific advice from, inter alia, ICES.*
5. *The Parties shall, as appropriate, review and revise these management measures and strategies on the basis of any new advice provided by ICES."*

Fishing for haddock is governed by the technical conservation measures described in Section 3.

The EU minimum landing size (mls) for haddock is 30 cm, except in IIIa where it is 27 cm.

2.2.2 Review of provisional landings in 2002.

Landings for 2002 as officially reported to ICES are as follows:

Table 2.2.1 Nominal landings (in tonnes) of haddock in Division IIIa as officially reported to ICES, 1996-2002.

Country	1996	1997	1998	1999	2000	2001	2002*
Denmark	2,523	2,501	3,168	1,012	1,033	1,590	3,797
Germany	5	5	11	3	1	128	239
Norway	115	188	188	168	126*	148*	146
Sweden	536	835	529	206	367	283	395
UK (E/W/NI)	-	-	-	-	-	-	...
UK (Scotland)	-	-	-	-	-	7	…
United Kingdom							-
Total	3,179	3,529	3,896	1,389	1,527	2,156	4,577

*Preliminary.

Table 2.2.2 Nominal landings (in tonnes) of haddock in Sub-area IV as officially reported to ICES, 1996-2002.

Country	1996	1997	1998	1999	2000	2001	2002*
Belgium	215	436	724	462	399	606	566
Denmark	2,520	2,722	2,608	2,104	1,670	2,407	5,122
Faroe Islands	13	9	43	55			
France	369	548	427*	742[1*]	724	485*	860
Germany	1,769	1,462	1,314	565	342	681	852
Netherlands	110	480	275	110	119	274[2]	359
Norway	2,295	2,354	3,262	3,830	3,118*	1,901*	2,245
Poland	18	8	7	17	13	12	17
Sweden	689	655	472	686	596	804	559
UK (E/W/NI)	3,379	3,330	3,280	2,398	1,876	3,334	…
UK (Scotland)	63,542	61,098	60,324	53,628	37,772	29,263	…
United Kingdom							43,206
Total	74,919	73,102	72,736	64,597			

*Preliminary. [1]Includes IIa(EC). [2]Note: Not included here 21t of haddock reported in area unknown.

The officially reported landings of haddock for IIIa (Skagerrak) and IV+IIa combined, were below the TAC allocated to these areas.

There are no estimates of discards of haddock for 2002. Furthermore the provisional landings do not include any industrial by-catch of haddock.

2.2.3 Research vessel data

The most recent assessment of North Sea haddock was undertaken in 2002 (ICES, 2002). Since then, only one further survey has been carried out; the International Bottom Trawl Survey of the North sea in February 2003 (IBTS Q1 2003). The data from this survey represent the only new information currently available to provide an updated assessment of the state of the stock. In addition, the ENGGFS Q3 indices for 2002 were presented as they were not yet used in the historic assessment of the stock.

2.2.4 Trends in survey indices

Trends in catch in numbers at age per unit of effort from research vessel surveys are presented in Figures 2.2.1 to 2.2.2. The survey data indicate that the stock has been declining rapidly since 2000.

2.2.5 Trends in recruitment from survey data.

The trend in recruitment of haddock at age 1 is given in Figure 2.2.3. The 2000 recruitment (year class 1999) was the highest in the series. However the 2002 and 2003 recruitment estimates are the first and second lowest in the series.

2.2.6 Trends in total mortality

Trends in annual relative total mortality, scaled to the 1983-2003 average, for haddock age groups 1-4 from the quarter 1 IBTS are given in Figure 2.2.4. Z has fluctuated around a mean level with no trend at age 1, but it appears to have decreased in the last 10 years at ages 2-4.

2.2.7 Stock status

There is no evidence to alter the perception of the state of the stock and the following statement from ICES in October 2002 still holds true: *"The stock is being harvested outside safe biological limits. SSB in 2002 is estimated to be above the Bpa, and fishing mortality in 2001 is estimated to be above the Fpa. The 1999 year class is estimated to be strong and has led to the current increase of SSB, but it is the only year class above average size for a number of years and dominates both the stock biomass and the catches. The 2001 year class is the lowest on record and the 2002 year class also appears to be well below average. The SSB is expected to decrease to below Bpa in the short term at the present fishing mortality rates."*

Given the recent levels of recruitment, the stock can be expected to decline further under the level of exploitation as estimated for 2001.

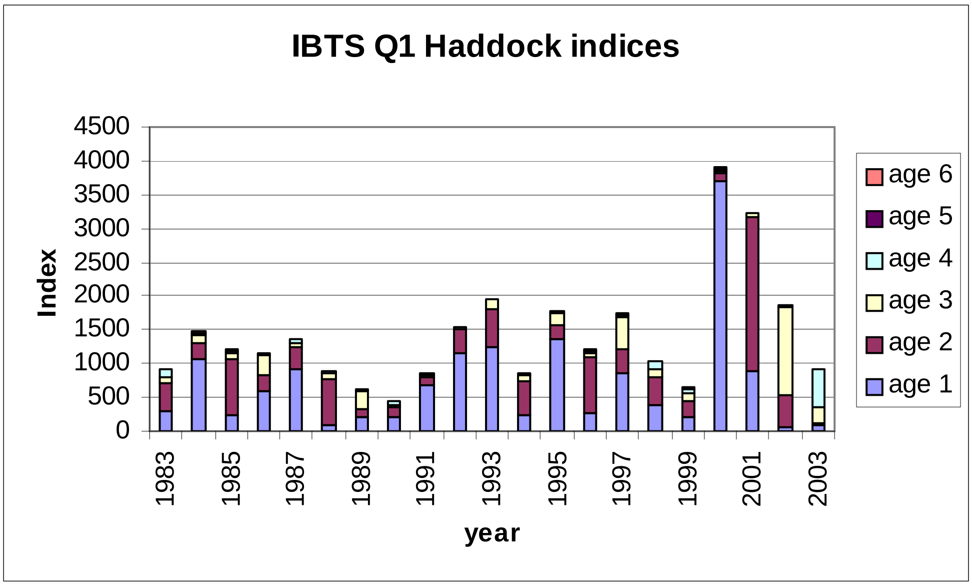


Fig. 2.2.1 IBTS Q1 haddock stock indices, 1983-2003.

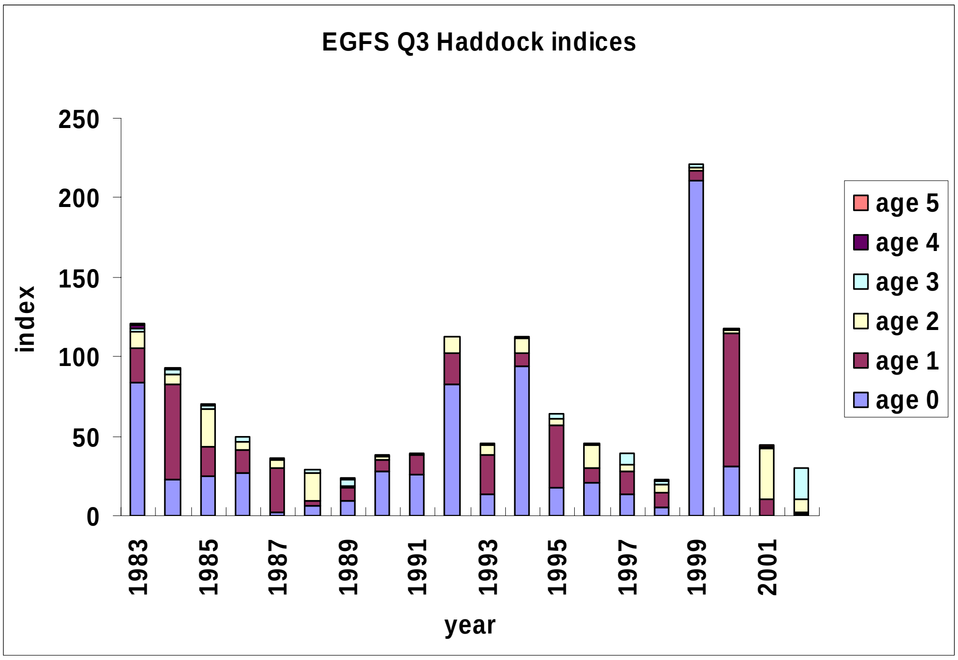


Fig. 2.2.2 ENGGFS Q3 haddock indices, 1983-2002

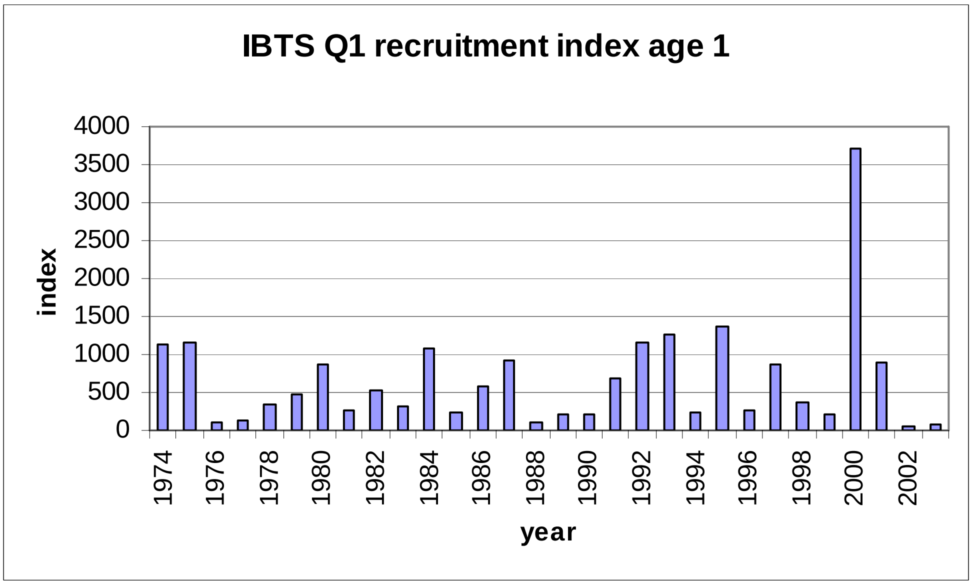


Figure 2.2.3 Recruitment indices for haddock age 1 from IBTS Q, 1974-2003.

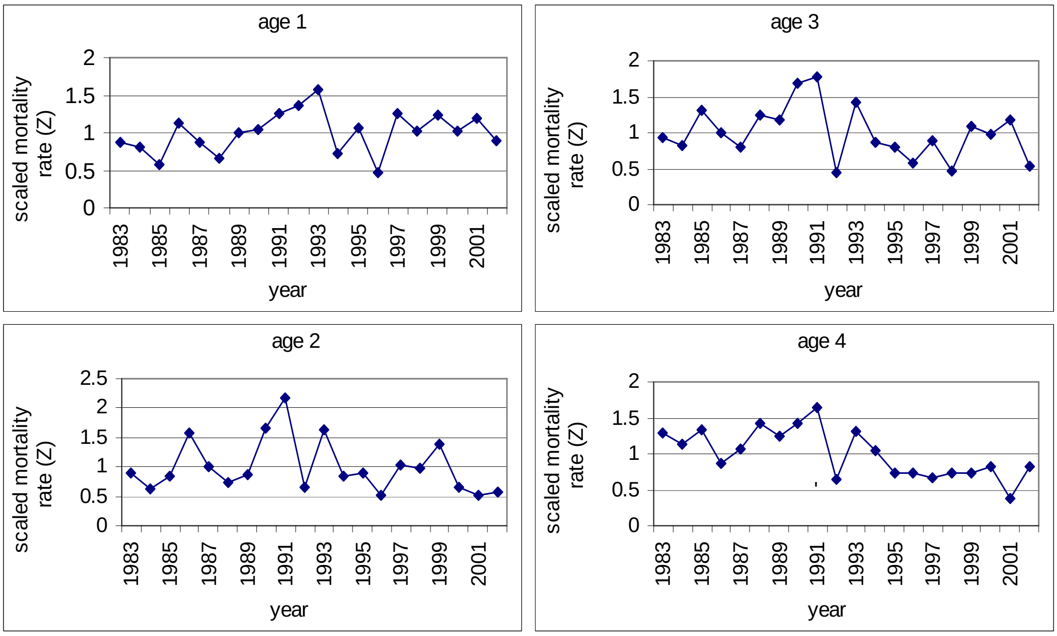


Figure 2.2.4. IBTS Q1:trends in annual relative total mortality rate, scaled to the 1983-2002 average, for haddock ages 1-4.

2.3 Whiting IV and VIID stock assessment update (ToR e5)

2.3.1 Management applicable in 2001, 2002 and 2003

The management of whiting is by TAC and technical measures. Agreed TACs (t) for area IV in 2001-2003 were

	TAC 2001	TAC 2002	TAC 2003
IV	29 700	32 358	16 000

There is no separate TAC for Division VIId, landings from this Division are counted against the TAC for Divisions VIIb-k combined (31 700 t in 2002 and 2003).

The agreed TACs for 2002 and 2003 implied a 30 % and 60 % reduction from the *status quo* fishing mortality in each year, respectively.

The minimum landing size of whiting in the human consumption fishery from this area is 27 cm.

Fishing for whiting is governed by technical conservation measures described in section 3.

2.3.2 Review of provisional landings for 2002

Officially reported landings have drastically declined since 1989. Provisional landings of whiting in 2002 as officially reported to ICES amounted to 20 953 t for human consumption landings, the lowest on record (Tab. 2.3.1 and 2.3.2). This figure represents only 65 % of the TAC in 2002.

Table 2.3.1 Nominal landings (in tonnes) of whiting in Subarea IV as officially reported to ICES, 1996-2002.

Country	1996	1997	1998	1999	2000	2001	2002[*]
Belgium	843	391	268	529	536	454	265
Denmark	189	103	46	58	105	105	97
Faroe Islands	-	6	1	1			
France	4,704	3,526	1,908[*]	4,292[1*]	2,527	3,454[*]	3,134
Germany	187	196	103	176	424	402	354
Netherlands	3,388	2,539	1,941	1,795	1,884	2,478[2]	2,427
Norway	66	75	65	68	33[*]	44[*]	41
Poland	-	-	1	-	-	-	-
Sweden	1	1	+	9	4	6	7
UK (E/W/NI)	2,329	2,638	2,909	2,268	1,782	1,301	…
UK (Scotland)	23,409	22,098	16,696	17,206	17,158	10,589	…
United Kingdom							9,047
Total	35,116	31,573	23,938	26,402			

[*]Preliminary. [1]Includes IIa(EC). [2]Note: Not included here 68t of whiting reported in area unknown

Table 2.3.2 Nominal landings (in tonnes) of whiting in Division VIId as officially reported to ICES, 1996-2002.

Country	1996	1997	1998	1999	2000	2001	2002[*]
Belgium	84	98	53	48	65	75	56
France	4,771	4,532	4,495[*]		5,875	6,309[*]	5,395
Netherlands	1	1	32	6	14	67	19
UK (E/W/NI)	199	147	185	135	118	134	…
UK (Scotland)	1	1	+	-	-	-	…
United Kingdom							111
Total	5,056	4,779	4,765		6,072	6,585	5,581

[*]Preliminary.

There are no estimates of discards of whiting for 2002. Furthermore the provisional landings do not include any industrial by-catch of whiting.

2.3.3 Research vessel data

The most recent assessment of whiting IV and VIID was undertaken in 2002 (ICES, 2003). 3 surveys were available but not used in that assessment, namely the IBTSQ1, ENGGFSQ3 and SCOGFS Q3. Their incorporation did not significantly affect the results of the age structured assessment model (time series analysis). Most recent indices and historic abundance trends derived from these surveys are shown in Figures 2.3.1-3 for IBTSQ1, ENGGFS and SCOGFS, respectively.

2.3.4 Trends in research vessel indices

The 3 survey indices reveal consistently high abundances for all ages 2-4 since 2000 except for the age group 0 and 1 in 2002 quarter 3 and 2003 quarter 1, respectively (year class 2002).

2.3.5 Trends in recruitment

The IBTS index for age group 1 in 2003 (2002 year class) is estimated to be very low, the third lowest in the time series since 1967 and about 25 % of the long term mean. The ENGGFS Q3 index for this year class at age 0 is also consistently poor as the lowest value on record and only 12 % of the long term-mean recruitment. The SCOGFS Q3 quantifies the year class 2002 at age 0 to be only 59 % of the long term mean.

2.3.6 Trends in total mortality

Trends in relative coefficients of total mortality scaled to the mean as derived from the IBTSQ1 survey for age grous 1-4 are shown in Figure 2.3.4. Despite some inter-annual variation, total mortality rates are indicated to be reduced for age groups 2-4 since 1998. Such reduction in total mortality could not be identified for fish at age 1.

2.3.7 Stock status based on survey results

The new survey information reviewed did not alter the perception of the stock status as formulated by ICES in October 2002: *The stock is outside safe biological limits. SSB has declined over the last 20 years, reaching a historic low in 1998. Fishing mortality has decreased and is below Fpa. Recruitment has fluctuated below the average (1980-2001) level since 1990, with the exception of the 1998 year class.*

The very low recruitment (year class 2002) will negatively affect stock productivity in short term.

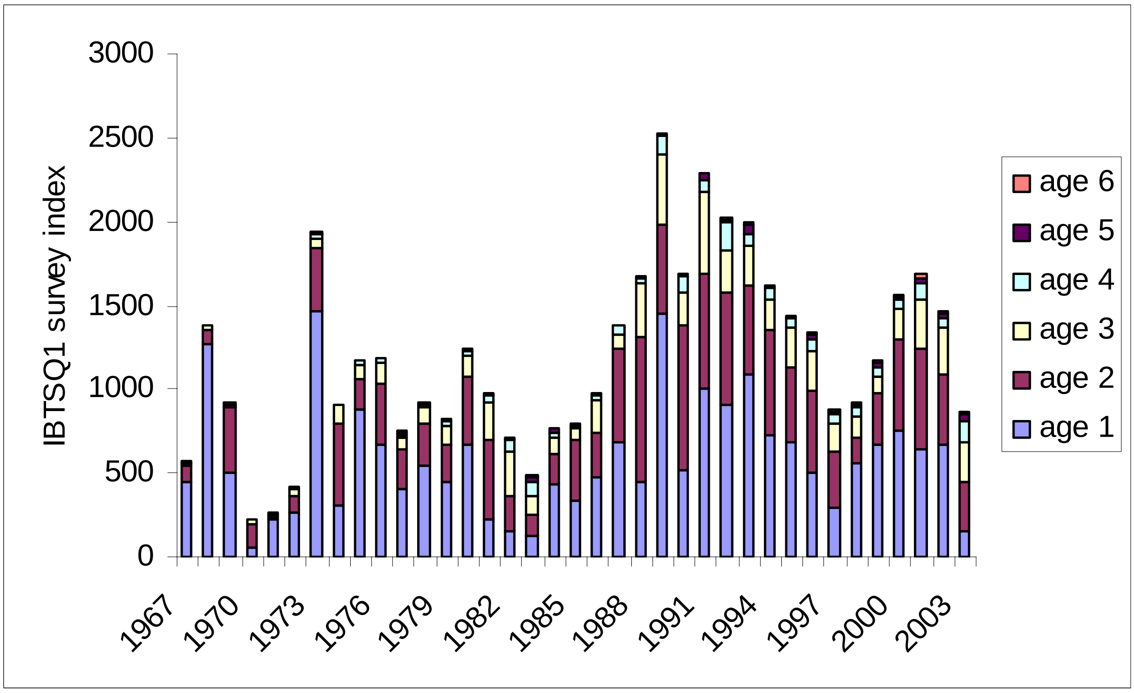


Fig. 2.3.1 Whiting 47d, IBTSQ1 survey indices by age groups 1-6+, 1967-2003.

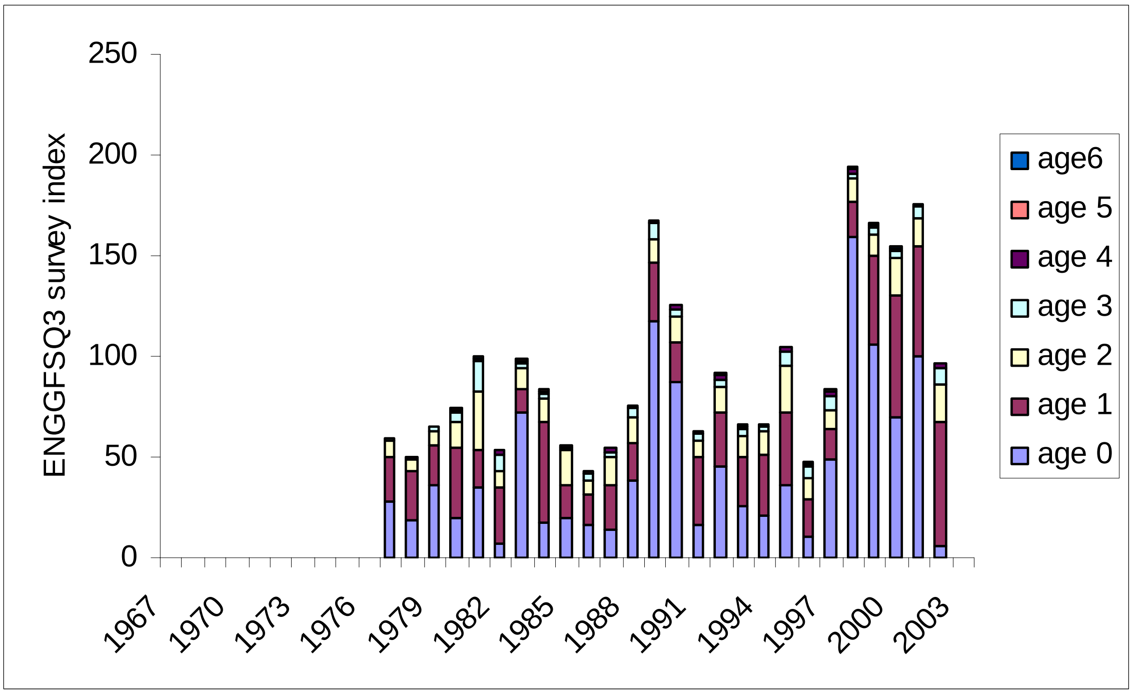


Fig. 2.3.2 Whiting 47d, ENGGFSQ3 survey indices by age groups 0-6, 1977-2002.

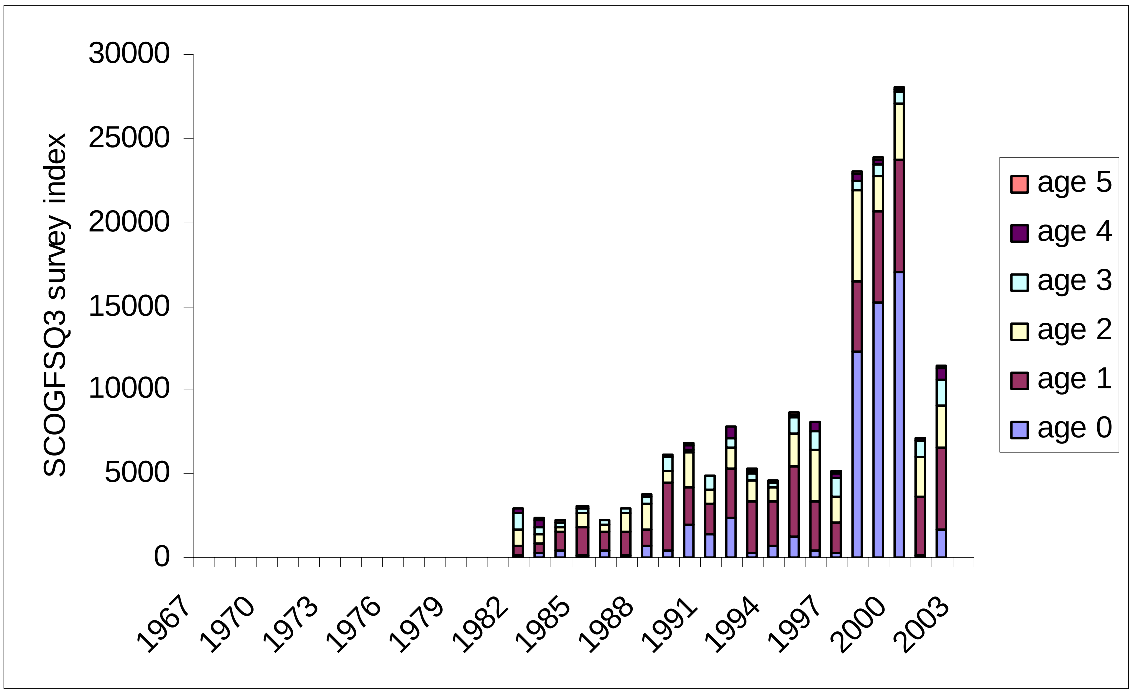


Fig. 2.3.3 Whiting 47d, SCOGFSQ3 survey indices by age groups 0-6, 1982-2002.

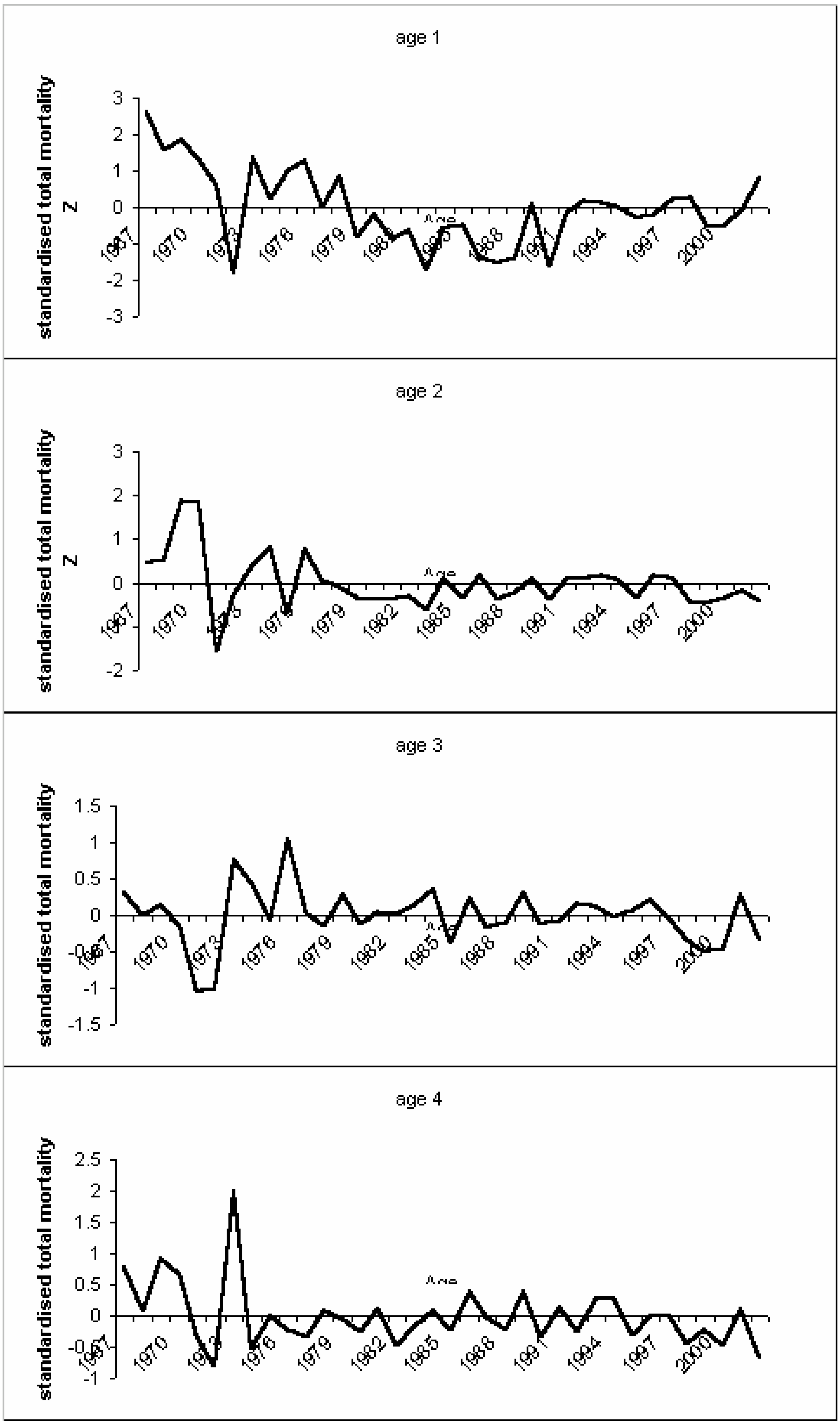


Fig. 2.3.4 Whiting 47d, coefficient of total mortality rates derived from the IBTSQ1 survey indices by age groups 1-4, 1967-2002.

2.4 Plaice IV stock assessment update (ToR e5)

2.4.1. Management applicable in 2001, 2002 and 2003.

Management of plaice is by TAC and technical measures. The agreed TACs for plaice in Sub-area IV are as follows:

	TAC 2001	TAC 2002	TAC 2003
IV	78,000	77,000	73,250

The advice provided by ICES in 2000 was based on the Agreed Record of the EC/Norway consultation. ICES considered that the agreed fishing mortality of F = 0.30 was consistent with the precautionary approach and advised a reduction in fishing mortality in 2001 to F = 0.3. The TAC for 2001 was set accordingly.

The agreed TACs for 2002 and 2003 implied a 30% and 25% reduction from the *status quo* fishing mortality in each year respectively.

In 1999, the EU and Norway have agreed to implement a long-term management plan for the plaice stock, which is consistent with the precautionary approach and is intended to constrain harvesting within safe biological limits and designed to provide for sustainable fisheries and greater potential yield. The plan shall consist of the following elements:

1. *Every effort shall be made to maintain a minimum level of SSB greater than 210,000 tonnes (**B**$_{lim}$)*
2. *For 2000 and subsequent years the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality of 0.3 for appropriate age groups as defined by ICES.*
3. *Should the SSB fall below a reference point of 300,000 tonnes (**B**$_{pa}$), the fishing mortality referred to under paragraph 2, shall be adapted in the light of scientific estimates of the conditions then prevailing. Such adaptation shall ensure a safe and rapid recovery of SSB to a level in excess of 300,000 tonnes.*
4. *In order to reduce discarding and to enhance the spawning biomass of plaice, the Parties agreed that the exploitation pattern shall, while recalling that other demersal species are harvested in these fisheries, be improved in the light of new scientific advice from, inter alia, ICES.*
5. *The Parties shall, as appropriate, review and revise these management measures and strategies on the basis of any new advice provided by ICES."*

The current Multi-annual guidance program (MAGP-IV) has defined national targets for EU fleet reductions in fleet capacity and/or days at sea.

Fishing for plaice is governed by the technical conservation measures described in Section 3. A closed area has been in operation since 1989 (the plaice box). Since 1995 this area was closed for all quarters. The closed area is only applicable for towed gears, but vessels smaller than 300 HP using towed gears have been exempted from the regulation. An additional technical measure concerning the fishing gear is the restriction of the aggregate beam length of beam trawlers to 24 m.

The minimum landing size of North Sea plaice is of 27 cm.

2.4.2. Review of provisional landings for 2002

Landings as officially reported to ICES are as follows:

Table 2.4.1 Nominal landings (in tonnes) of plaice as officially reported to ICES, 1996-2002.

Country	1996	1997	1998	1999	2000	2001	2002*
Belgium	5,765	5,223	5,592	6,160	7,260	6,369	4,816
Denmark	11,776	13,940	10,087	13,468	13,408	13,797	12,555
Faroe Islands	-	-	1	-			
France	379	254	489*	624*	547	429*	576
Germany	4,780	4,159	2,773	3,144	4,310	4,739	3,927
Netherlands	35,419	34,143	30,541	37,513	35,030	33,290	29,082
Norway	917	1,620	965	643	883*	1,926[1]*	1,996
Sweden	5	10	2	4	3	3	3
UK (E/W/NI)	13,541	13,789	11,473	9,743	13,131	11,025	…
UK (Scotland)	7,451	8,345	8,442	7,318	7,579	8,122	…
United Kingdom							16,768
Total	80,033	81,483	70,365	78,617	81,268	76,345	69,723

*Preliminary. [1]Note: Not included here 544t of plaice reported in area unknown

There are no officially reported estimates of discards for plaice.

Provisional total landings of North Sea plaice in 2002 were estimated by ICES at 69,723t, about 10,000t lower than the level of the last 3 years. Unlike in 2001, the total landings in 2002 did not exceed the TAC.

2.4.3. Research vessel data

At last years ICES North Sea Demersal Working Group, the 2002 survey information was not yet available, Nevertheless, ACFM was able to incorporate the 2002 data points of the surveys for the recruitment estimates of year classes 2001 and 2002. Figures 2.4.1 and 2.4.2 below show the updated survey series. The surveys indicate that the 2001 yearclass may be strong.

As there were problems with the correct age-readings in 1997 for the 1 and 2 year olds, these values have not been used in the assessment. They have been marked in the figures as hollow bars.

2.4.4. Trends in recruitment

The trends in recruitment of plaice at age 1 for the 2 surveys are given in Figures 2.4.3 and 2.4.4. Although there might be indications of a slight upward trend from the BTS-survey since 1990, the SNS-survey estimates stayed rather stable in that period. As in the section above, the recruitment values for age 1 in 1997 are taken out of the graphs.

2.4.5. Trends in total mortality

Trends in annual relative total mortality for plaice for age groups 1-3 from the BTS and SNS are given in Figures 2.4.5 and 2.4.6. Although for age 1 there is an increasing trend in both surveys for the total mortality (Z), ages 2 and 3 fluctuated without trend over the time series, with some extreme annual values. It should also be noted that the unused information from the age-readings in 1997 are left out in the plots.

2.4.6. Stock status

As the latest available information (survey indices for 2002) were used by ACFM in last years autumn meeting, the expert group had no reason to change the status of the plaice stock in the North Sea, expressed by ICES in October 2002: *The stock is outside safe biological limits. SSB in 2002 is below Bpa and fishing mortality in 2001 was above Fpa. Spawning stock biomass has declined from 1989 to 1997, where it reached its historical minimum, but has increased in recent years due to the strong 1996 year class. Fishing mortality increased from the 1960s to the 1990s, reaching a record high in 1997 and has declined since then. Except for the 1996 year class, recruitment since 1993 has been below average. Surveys indicate that the 2001 year class is strong.*

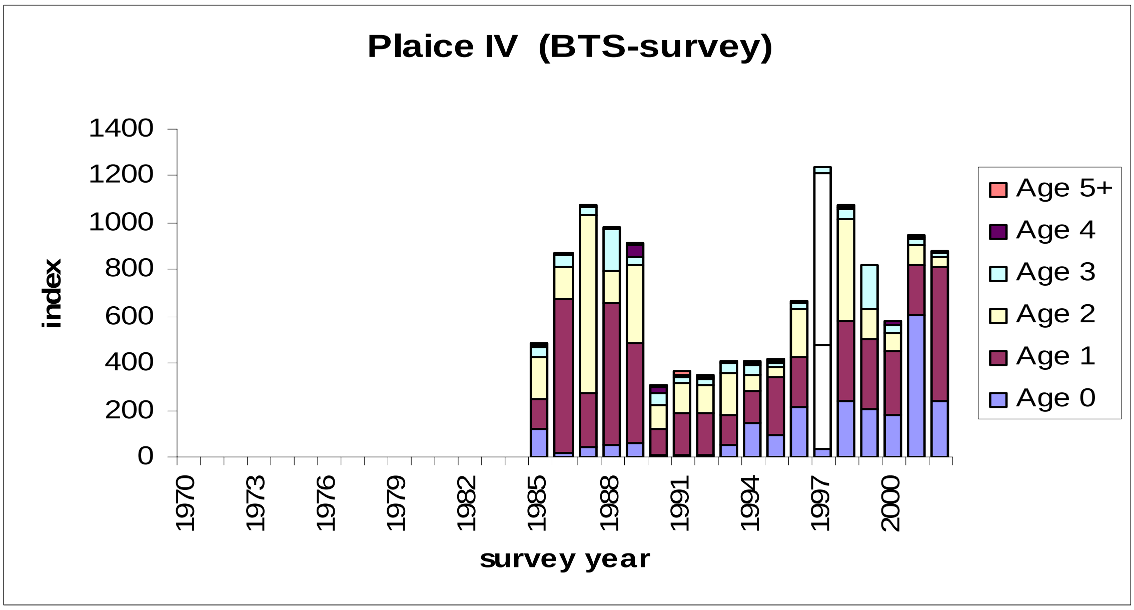


Figure 2.4.1 BTS-Survey index for place at age in ICES subarea IV. Hollow bar segments = not used

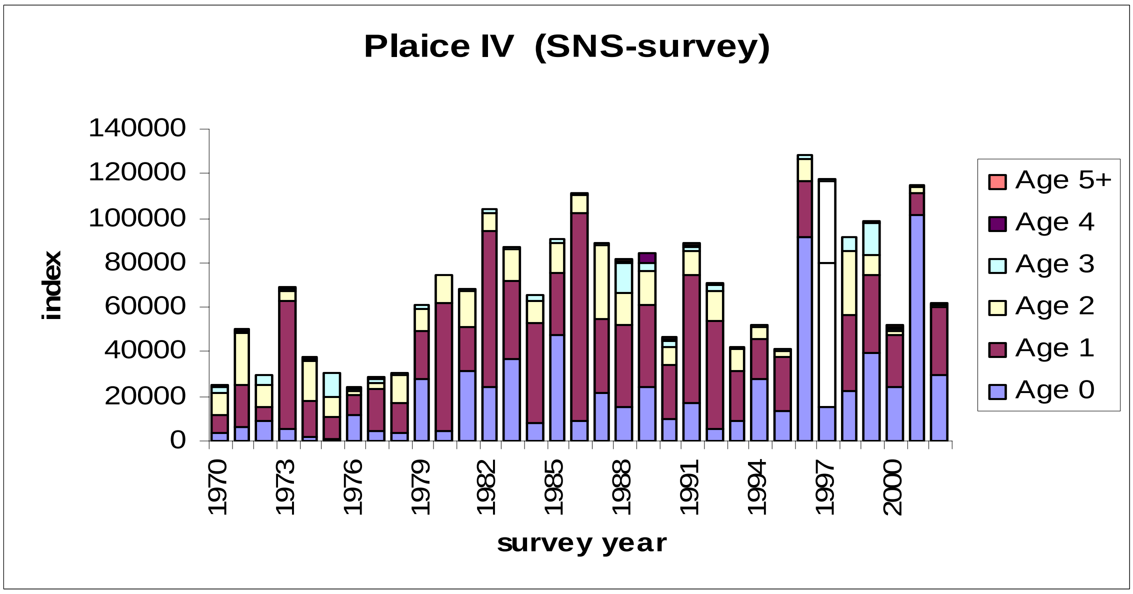


Figure 2.4.2 SNS-Survey index for place at age in ICES subarea IV.Hollow bar segments = not used

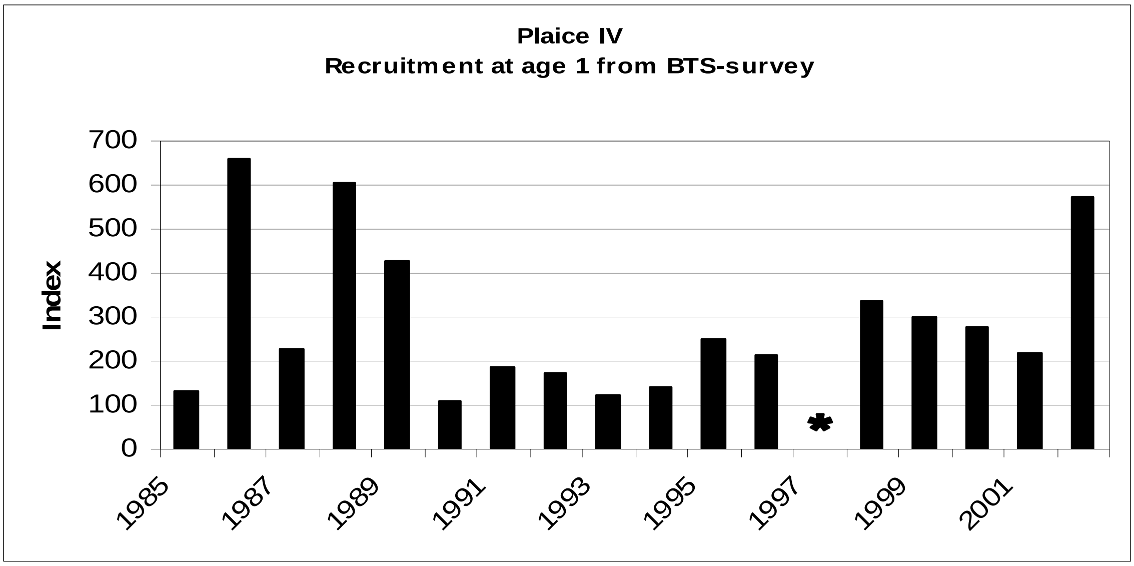


Figure 2.4.3 Recruitment for place at age 1 in ICES subarea IV from the BTS-Survey. * Not used in the assessment.

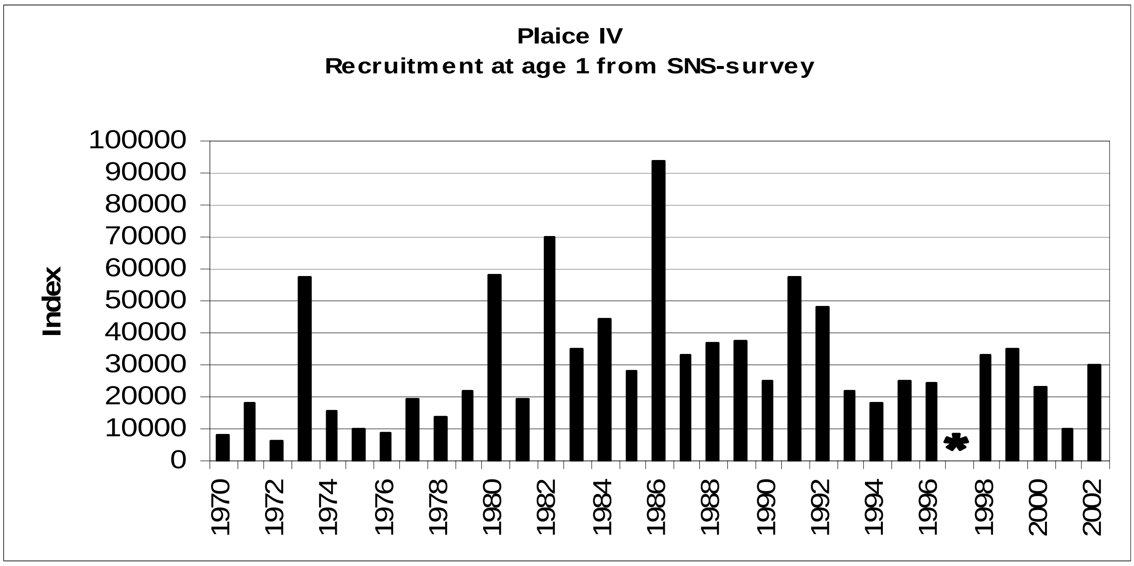


Figure 2.4.4 Recruitment for place at age 1 in ICES subarea IV from the SNS-Survey. * Not used in the assessment.

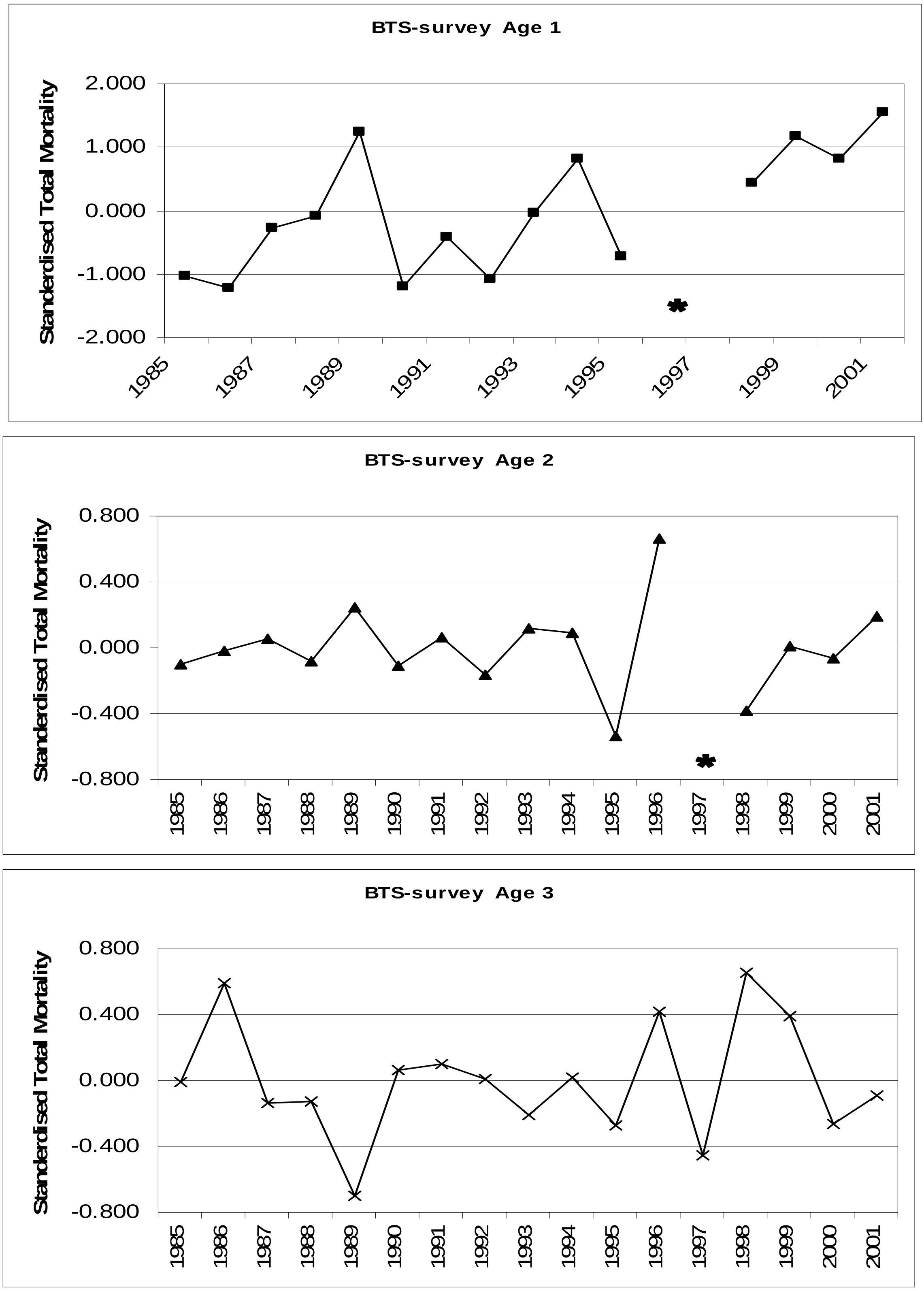


Figure 2.4.5 Relative total mortality rates from BTS-Survey for place in ICES subarea IV. * Not used in the assessment

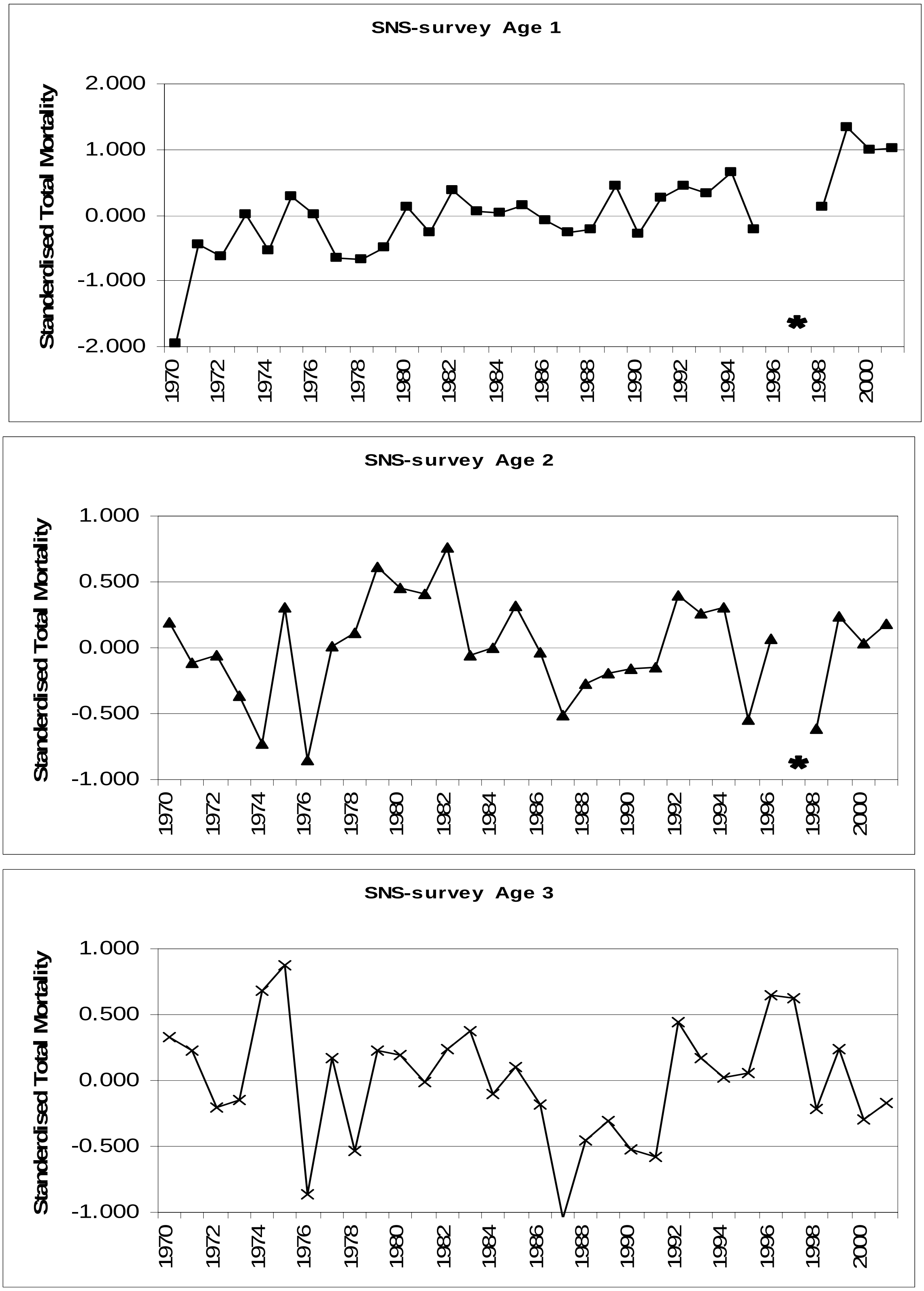


Figure 2.4.6 Total mortality from SNS-Survey for place in ICES subarea IV. * Not used in the assessment

3 Evaluation of past and further management and technical measures

New technical regulations for EU waters came into force on 1 January 2000 (Council Regulation (EC) 850/98 and its amendments). The regulation prescribes the minimum target species' composition for different mesh size ranges. Additional measures were introduced in Community waters from 1 January 2002 (Council regulation (EC) 2056/2001). The changes in technical measures relating to gear design implemented since Jan 1 2000, are summarised in Table 3.1.

In 2001, the European Commission implemented an emergency closure of a large area of the North Sea from 14 February to 30 April 2001. The details of the emergency regulation are given in Commission Regulation (EC) 259/2001 of 7 February 2001.

Effort restrictions in terms of data at sea were introduced in Annex XVII of Council Regulation 2341/2002 and amended by Council Regulation 671/2003 of 10 April 2003. The regulation prescribes the maximum number of days permitted for vessels using various gears.

Table 3.1 Changes in Technical Measures relating to gear design in force in 2001(Council Regulation (EC) No 850/98) (Council Regulation (EC) No 2056/2001) and 2002 (Council Regulation (EC) No 2056/2001) in the North Sea (ICES Sub-area IV and IIIa). Technical Measures for which no changes occurred are not enclosed. The present report also includes ICES Division VIId but no changes in gear related technical measures took place in the period considered.

	Year	Mesh size (mm)	Twine thickness (mm)	Cod-end: max number of meshes round	Square mesh panel	Large mesh panel	Others
Demersal towed gears - whitefish	2001	100	8 S / 2x6 D	100	No	No	
	2002	110 (2002 only) 120	8 S / 2x5 D 8 S / 2x5 D	100 100	YES – 90mm No	No No	
Demersal towed gears - saithe	2001	100	8 S / 2x6 D	100	No	No	
	2002	110	8 S / 2x5 D	100	No	No	
Demersal towed gears - Nephrops	2001	70	8 S / 2x6 D	No	Yes – 80mm	No	
	2002	70 (2002 only) 80 100	8 S / 2x5 D 8 S / 2x5 D 8 S / 2x5 D	120 120 100	Yes – 80mm Yes – 80mm Yes – 90mm	Yes – 140 mm Yes – 140 mm No	Square mesh cod-end
Beam trawl - Sth 56°N-5°E	2001	80	8 S / 2x6 D	N/A	No	No	
	2002	80	8 S / 2x5 D	N/A	No	Yes – 180 mm	
Beam trawl - Nth 56°N-5°E (sole)	2001	100	8 S / 2x6 D	N/A	No	No	
	2002	120	8 S / 2x5 D	N/A	No	Yes – 180 mm	
Fixed gears	2001	120	N/A				
	2002	140	N/A				

Apart from the technical measures set by the Commission additional unilateral measures are in force in the UK. In August and December 2000 Scottish Statutory Instruments (SI) 227 and 405 introduced additional measures on square mesh panels and multiple rigs (equivalent Westminster Statutory Instruments 649 and 650 followed in April 2001). These also implemented, in March 2001, a further restriction on twine size in both whitefish and Nephrops gears. In August 2001, Scottish SI 250 banned lifting bags and limited extension length for whitefish gear. A useful summary of the UK unilateral measures is given in Anon., 2002.

In 2001 vessels fishing in the Norwegian sector of the North Sea had to comply with Norwegian regulations setting the minimum mesh size at 105 mm and a ban on lifting bags.

3.1 Com Regulation 259/2001 emergency closure 14 Feb-30 Apr 2001 (ToR a and e5)

3.1.1 Effect of the closure on cod

Spatial effects.
The closed area in spring 2001 was defined on the basis of the ICES statistical rectangles which represented the top 80% landings of cod from the first 6 months of 1999 and was intended to protect mature fish while they spawned. Figure 3.1.1 shows the distribution of the adult ages of cod from the 2001 quarter 1 IBTS. There is a clear indication that the higher density areas for older cod lie along the border of the box. Figure 3.1.2 shows the total international landings (as dots) during the closed period against the IBTS data (as contours). It should be noted that the contour bins are on a logarithmic

scale. This type of scale appears to inflate the importance of lower density areas, but without such a scale the map would be reduced to a few small spots of high density on a white background and the finer detail would be invisible. From Figure 3.1.2 it can be seen that that catches of cod were kept to a minimum within the box, whilst the fishery concentrated along the edges of the box.

Figure 3.1.3 shows the IBTS indices of the younger ages (as contours) against the total international landings (as dots). A logarithmic scale is again used and the warnings concerning these types of scales described above for 3.1.2 still apply. Figure 3.1.3 shows that a significant proportion of the juvenile population was located within the box at the start of the year, hence the closure might be expected to offer some protection to these younger ages as well.

Figure 3.1.4 shows the monthly landings of cod by statistical rectangle for the period 2000-2002 (February-May). Again this demonstrates that the box was efficient at reducing catches of cod within that area although fishing concentrated along the border of the box. At the end of the closure in May the fishery moved into the box and resumed it's a similar fishing pattern observed in the other years.

These plots indicate that protection was offered to both juvenile and spawning cod within the box, although the consequences from the redistribution of effort require the further analyses presented below.

Analysis of quarterly landings by age.
Trends in quarterly landings by age for 2001 were compared to the period 1985-2000. Cumulative landings by age are heavily dependent upon year class strength and TAC constraints, hence to enable investigation into inter-annual patterns the cumulative proportion of annual landings at age were created. These data are shown in figure 3.1.5, the solid dark line being the pattern for 2001. For the closure to have been effective in terms of protecting mature cod while they spawned, we would expect to see a lower uptake of older ages in the first two quarters. Uptake of cod was in the lower range of historical observations for ages 4-7. This would indicate that there was some protection offered to these ages. Uptake of 8 year old fish do not appear to have been affected in a similar manner, but the numbers of fish in this category are to low for any significance to be attached to this result (a total of 3.8 tonnes of 8 year old cod for 2001).

The overall shape of the cumulative uptake curves will be governed by a combination of both biological and fishery actions. A constant fishing pattern throughout the year on a constantly distributed, infinite population of fish will produce a straight line. A constant fishing pattern on a small stock would result in a line which starts steeply and flattens out as the numbers at age are depleted although an identical line could be obtained from a fishery which targets different stocks through the year. A constant fishing pattern taking an age which grows into the fishery may be reflected by a steep rise in uptake towards the end of the year. Again, this pattern could also be obtained by a shift in fishery activity, either through changing gear or moving location. A significant difference in curve shape for a single age in a single year is likely to be a year class artefact, whereas a fishery driven effect is likely to affect several ages in a similar manner.

While the quarter 1 proportion of the annual landings for ages 4-7 were at low levels compared to the recent past (Fig. 3.1.5) this is in fact part of a long term trend in landings as shown in Figure 3.1.6. Over the past 15 years there has been a gradual reduction in quarter 1 landings compared to the other quarters for ages 5-7 whilst the annual proportion of 3 year olds caught in quarter 1 has increased. This contrasts to the situation for quarter 2 where the proportion of 6-7 year olds has decreased while the proportion of 3 year olds has increased (Fig. 3.1.7).

Analysis of monthly landings
Given that the closure operated for only part of quarters 1 and 2 it is possible that the fishery before and after the closure may have masked any effect. To investigate this possibility international monthly landings were analysed for signs of changes in uptake patterns. These data were not available in age disaggregated format and only covered the years 2000-2002. The short time series available significantly reduces the power of this analysis to produce reliable results and therefore any results must be treated with caution.

The data underwent the same transformation as the quarterly landings at age data to remove the effect of annual changes in TAC and the proportion of total annual landings taken in each month was produced. The results are shown in Figure 3.1.8. There is a small decrease in the uptake figures of cod for March and April in 2001, although these decreases are offset by increases in the proportion of landings taken in January and February. These changes to exploitation pattern are small and result in an increase of less than 1% in the spawning potential for cod in 2001. In terms of overall fishing mortality for 2001, the uptake pattern was back on track by May and the total quota uptake for 2001 was not significantly different to recent years hence the closed area would not offer any reduction in fishing mortality above that intended by the reduction in TAC.

Conclusion.
The conclusion from the quarterly catch at age analysis is that the apparent reduction in catch rates of mature fish in the first quarter 2001 is part of a general shift in exploitation pattern and can not be solely attributed to the closure.

From the information presented here it is appears that the closure had an insignificant effect upon the spawning potential for cod in 2001. There are several reasons for the lack of impact. The redistribution of the fishery, especially along the edges of the box coupled to the increases in proportional landings from January and February appear to have been able to negate the potential benefits of the box. The conclusion from this study is therefore that the box would have to be extended in both space and time to be more effective.

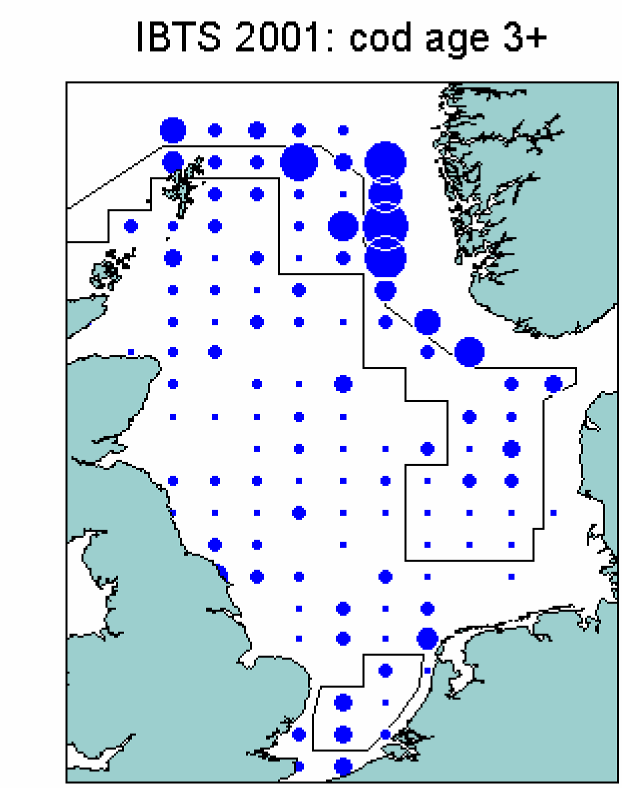


Figure 3.1.1 Quarter 1 IBTS indices of cod abundance (ages 3+) and the closed area of 2001.

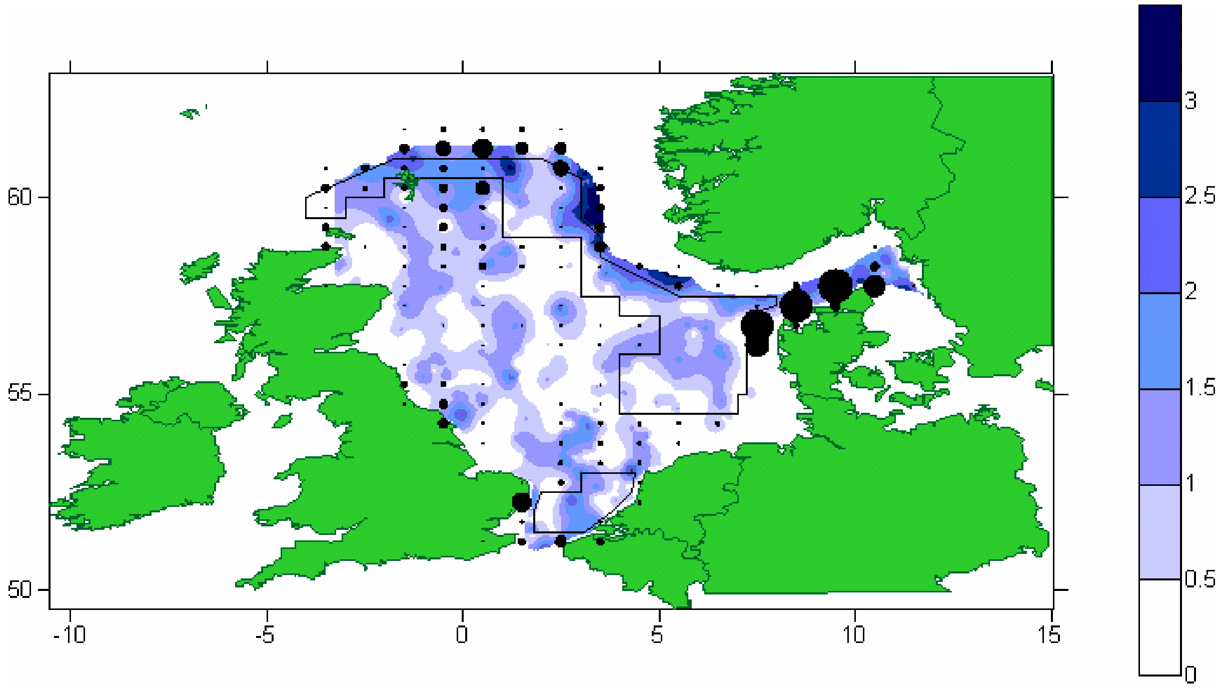


Fig 3.1.2 Distribution of mature cod in North Sea (density of 3+ cod (ln(n)/h) 2001 from the IBTS quarter 1, the closed area 14 Feb- 30 Apr 2001 and cod international landings Mar-Apr 2001.

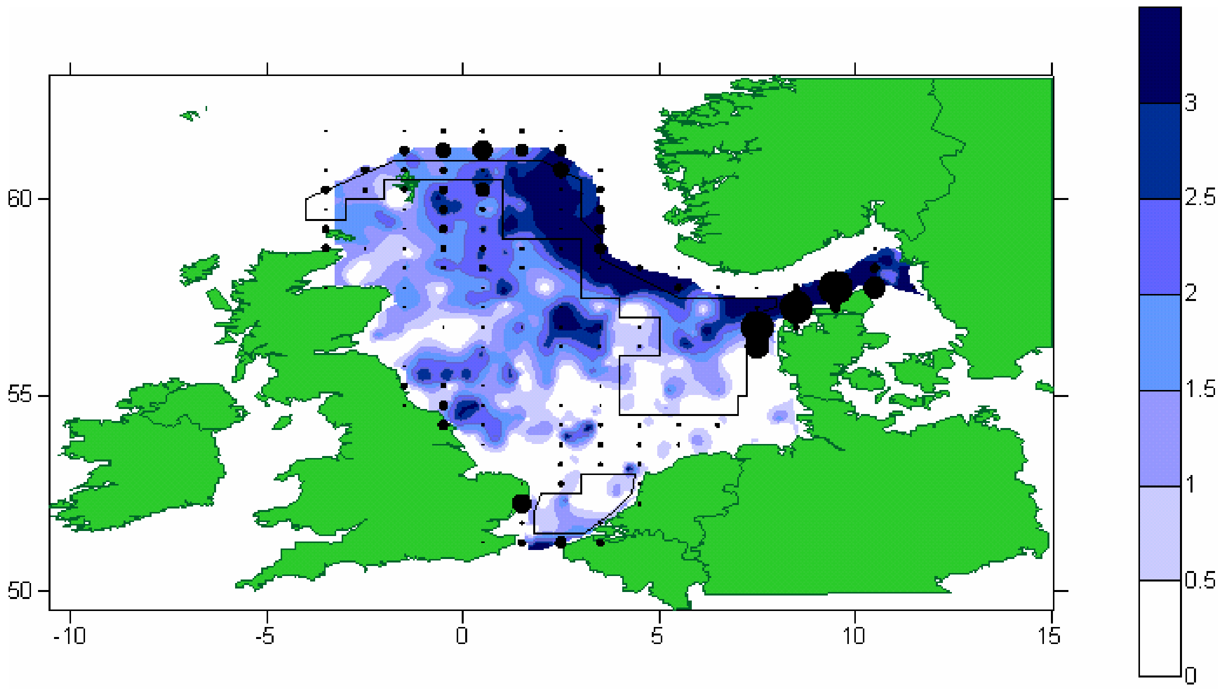


Fig 3.1.3 Distribution of juvenile cod in North Sea (density of 1-2 cod (ln(n)/h) 2001 quarter 1, the closed area 14 Feb- 30 Apr 2001 and cod international landings Mar-Apr 2001.

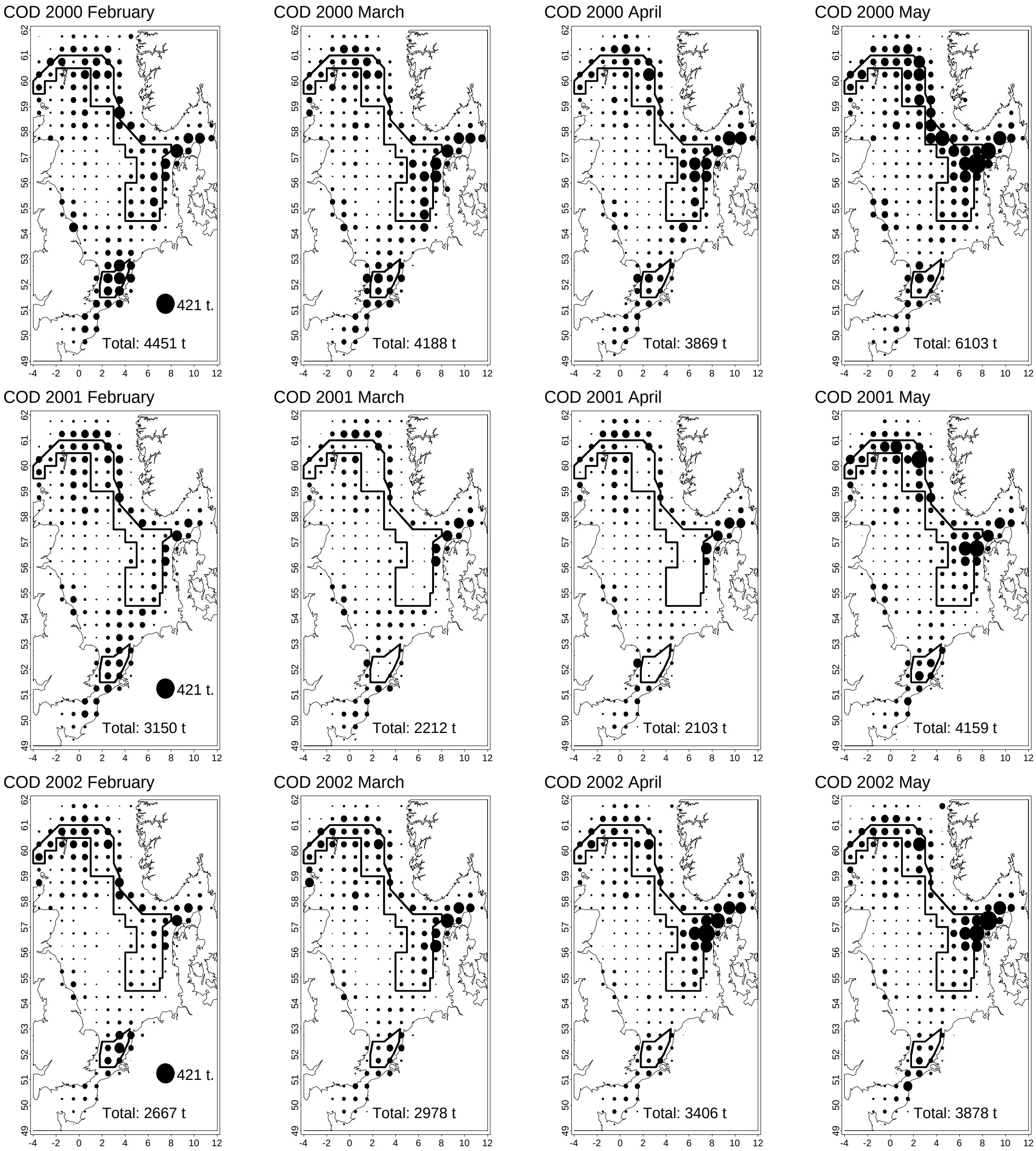


Figure 3.1.4 Monthly international landings of cod by statistical rectangle for the period 2000-2002 (February – May).

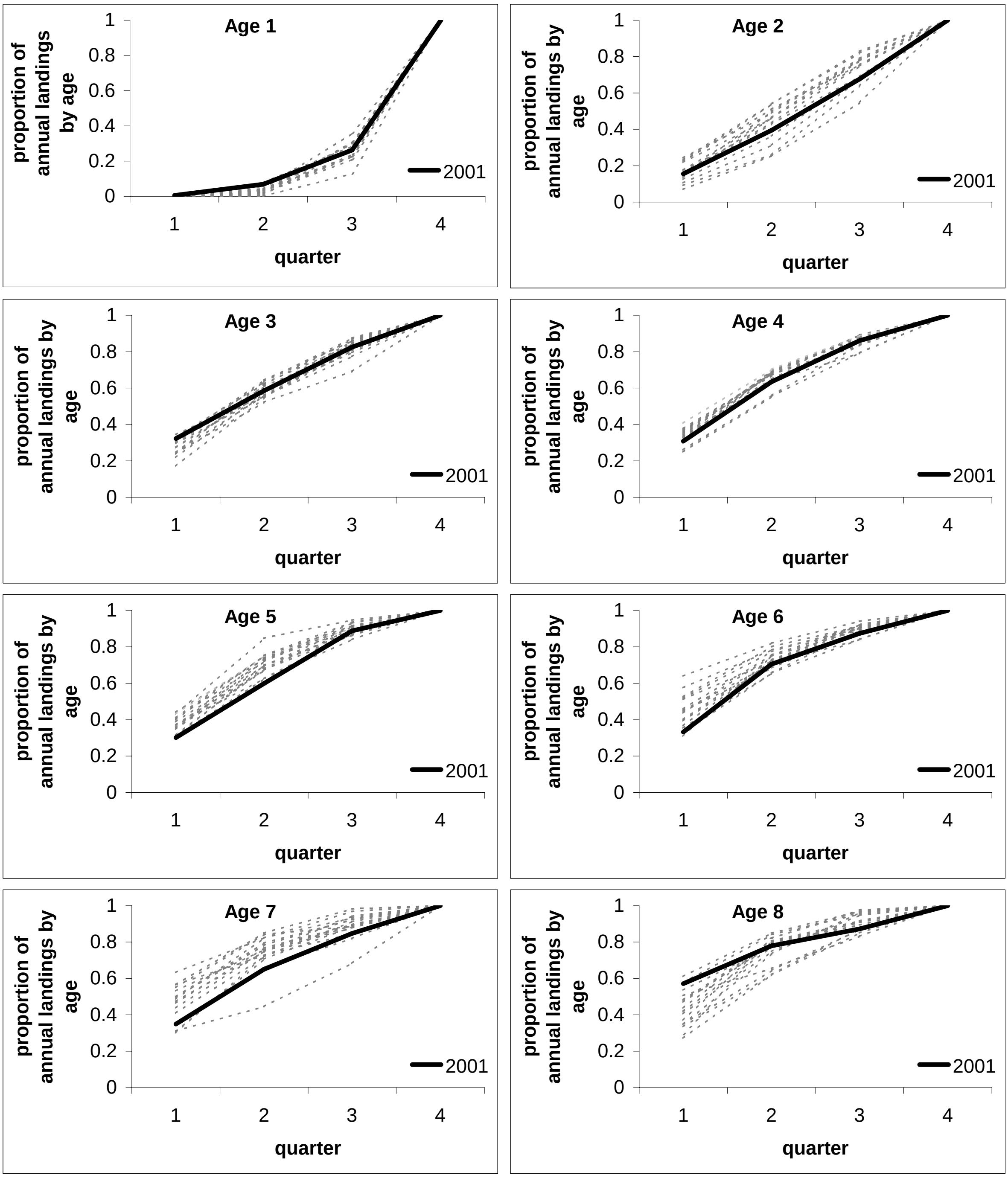


Figure 3.1.5 Annual patterns in uptake of landings for Cod, by age for the period 1985-2001.

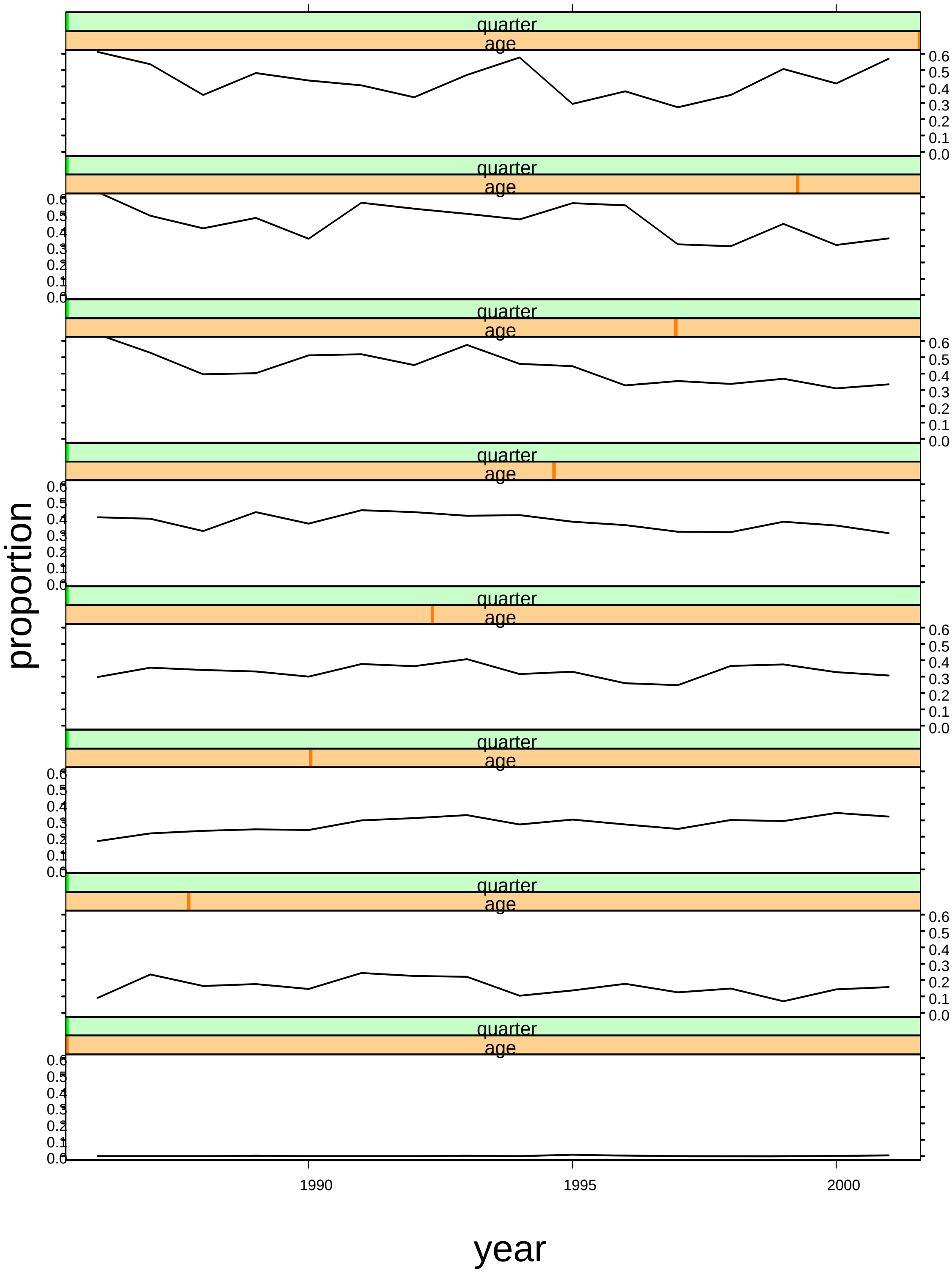


Fig 3.1.6 Trends in the quarter 1 proportion of annual landings by age for cod, 1985-2001. Ages read upwards from 1 to 8.

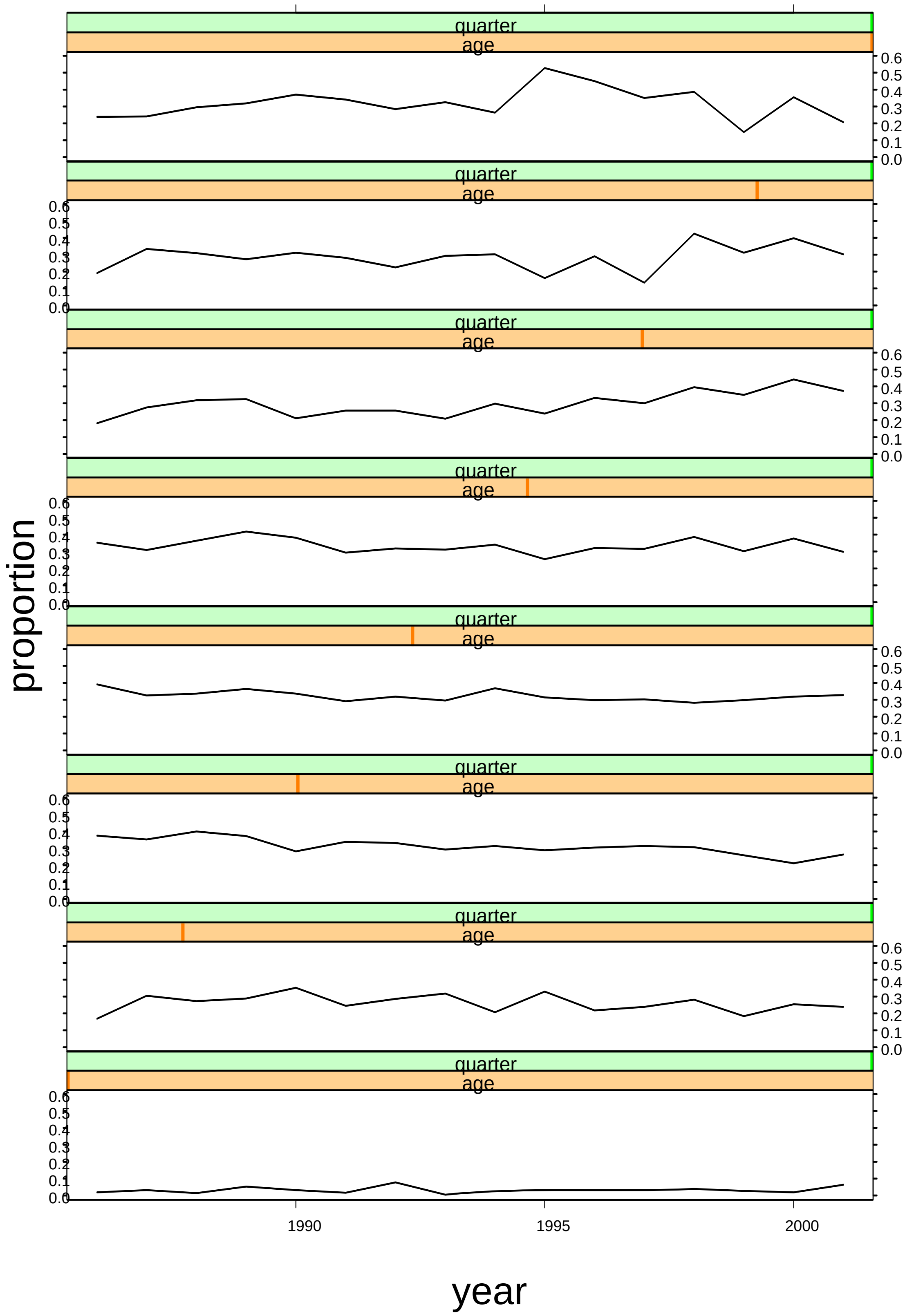


Fig 3.1.7 Trends in the quarter 2 proportion of annual landings by age for cod, 1985-2001. Ages read upwards from 1 to 8.

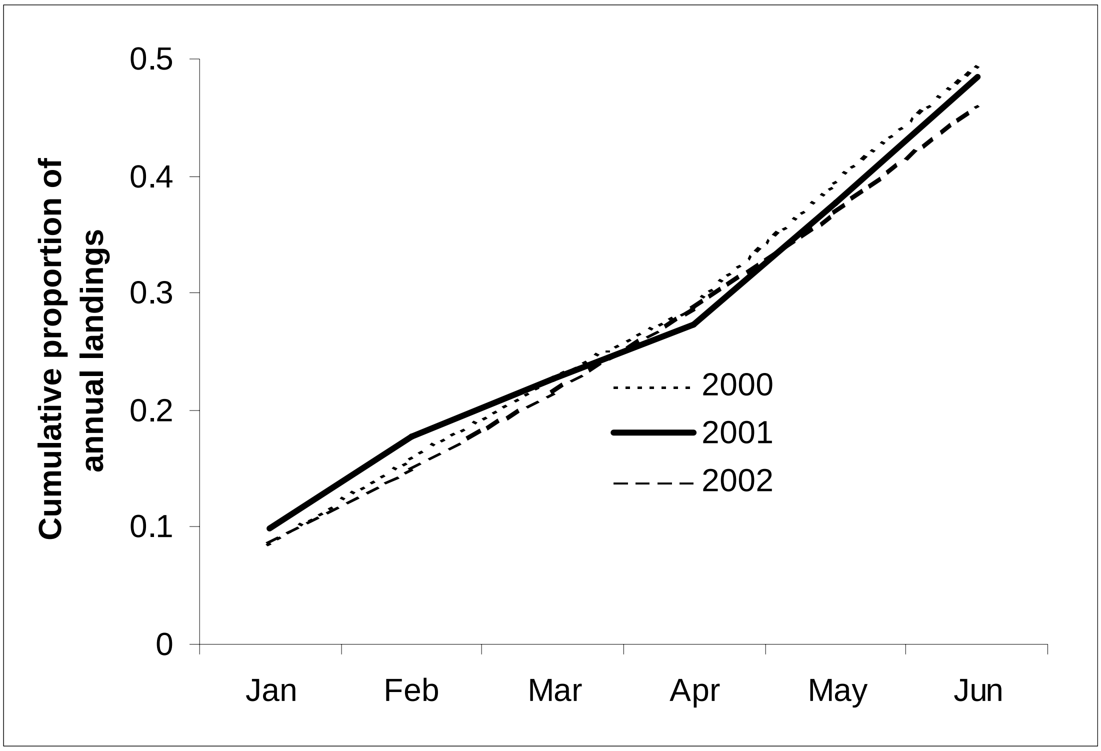


Figure 3.1.8 Monthly proportions of annual uptake of landings for cod.

3.1.2 Effect of the closure on haddock

The effect of the area closure on haddock landings was examined using the same protocol as the cod landings in section 3.1.1.

Figure 3.1.9 shows the annual pattern in cumulative quarterly uptake of landings by age. The pattern is similar to that observed by cod in that the older ages are taken up more slowly in the first 2 quarters for 2001 than in previous years. This is not part of a general trend in the 1st and 2nd quarter proportional landings (Fig. 3.1.10-11).

The monthly landings for 2000-2002 (Fig. 3.1.12) show that uptake patterns vary considerably from year to year. Haddock landings for January 2001 were already lower than the other two years even before the closure commenced. However, given the limited data there is not enough information to determine if the pattern for 2001 is significantly different from the other two years.

Conclusion.
A number of additional factors may have affected the haddock fishery in 2001. The UK imposed unilateral legislation for the inclusion of a 90mm square mesh panel during the year 2000, whilst a number of UK vessels remained in port for some of the closure period. The 1999 year class is also likely to have affected the actions of the fishery as this is a highly abundant year class which is exhibiting density dependent growth. It is therefore unclear as to whether the imposition of the closure had an effect upon the dynamics of the haddock stock.

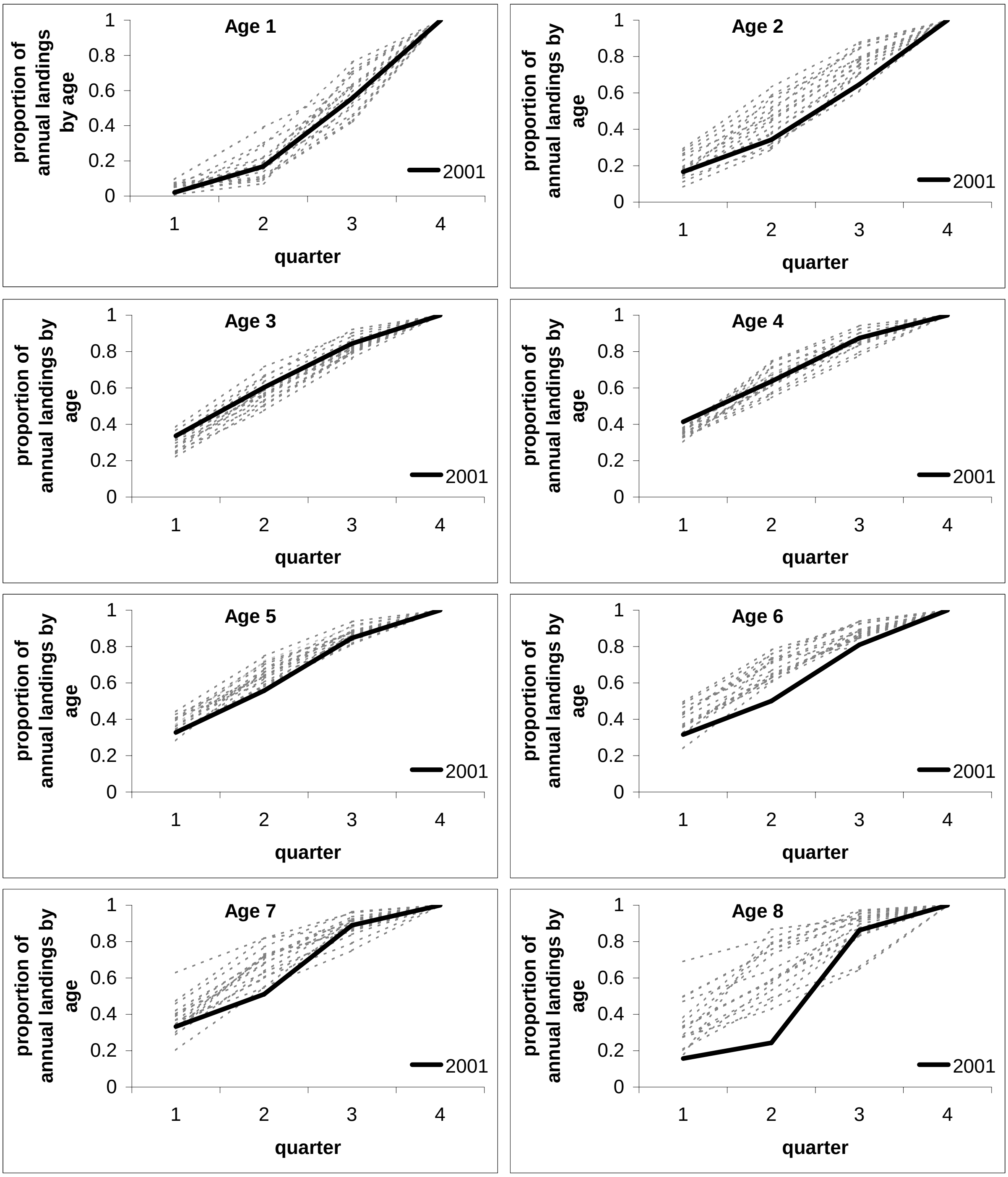


Figure 3.1.9 Annual patterns in quarterly uptake of landings for haddock, by age for the period 1985-2001.

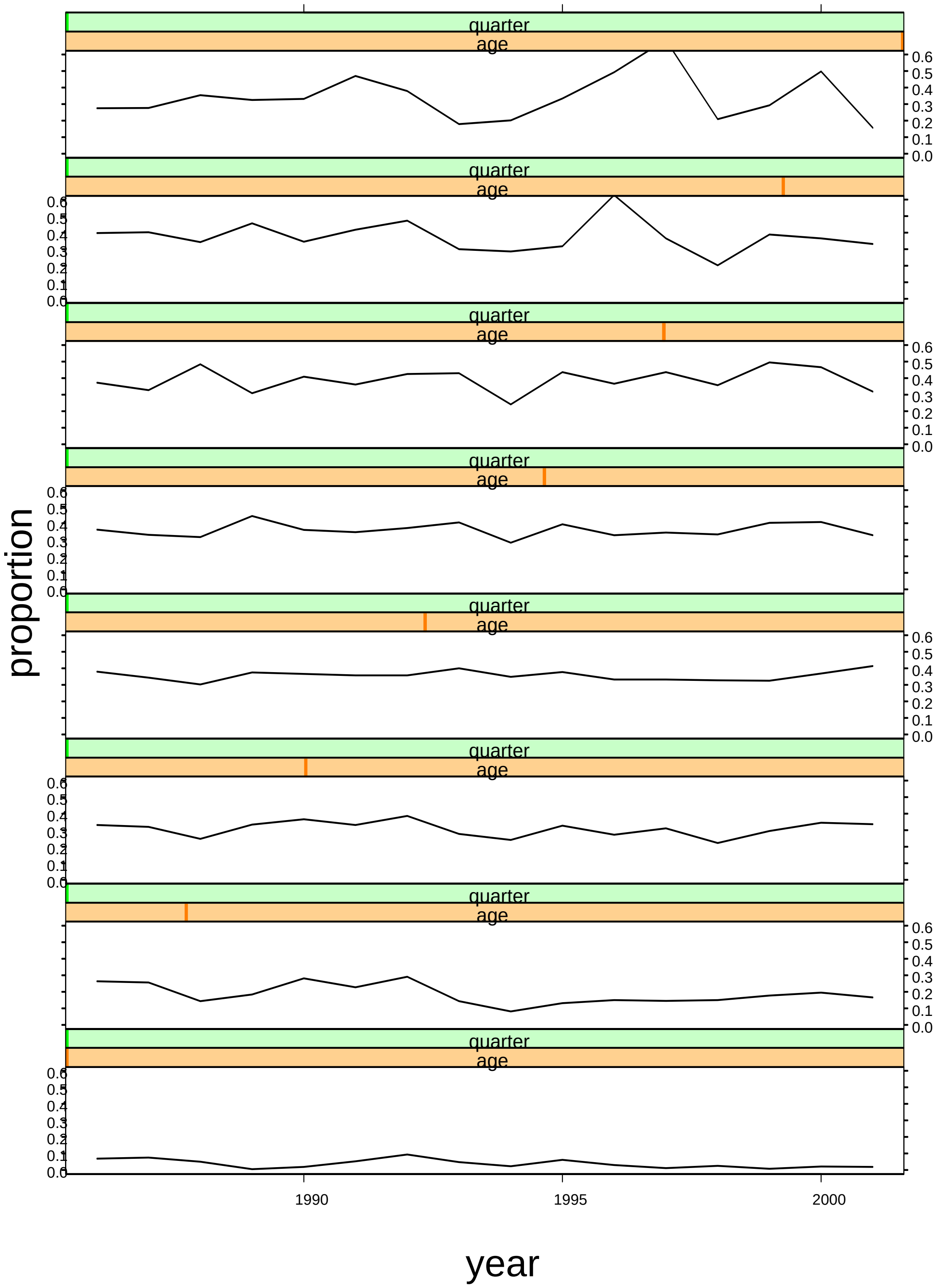


Figure 3.1.10 Trends in the quarter 1 proportion of annual landings by age for haddock, 1985-2001. Ages read upwards from 1 to 8.

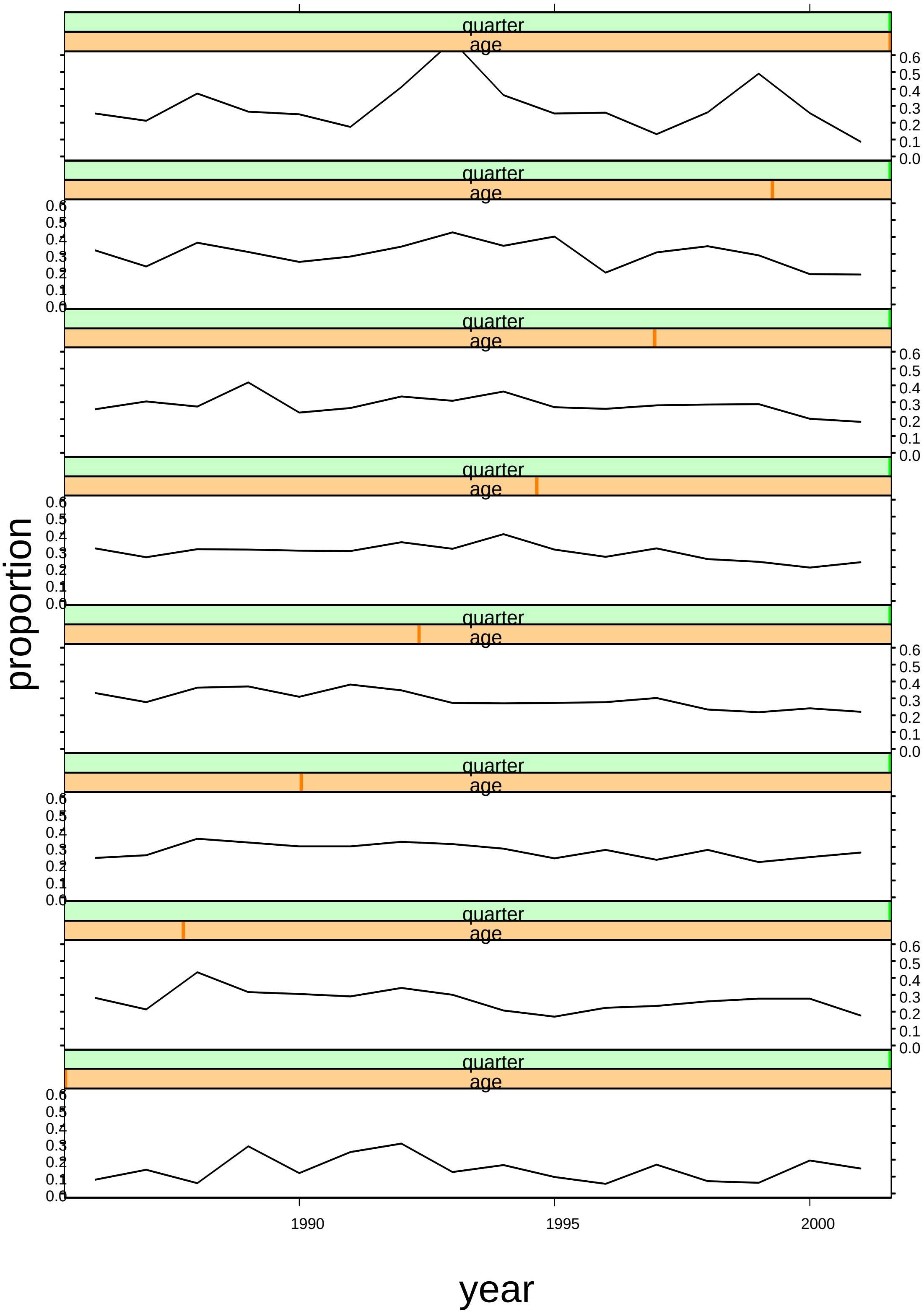


Figure 3.1.11 Trends in the quarter 2 proportion of annual landings by age for haddock, 1985-2001. Ages read upwards from 1 to 8.

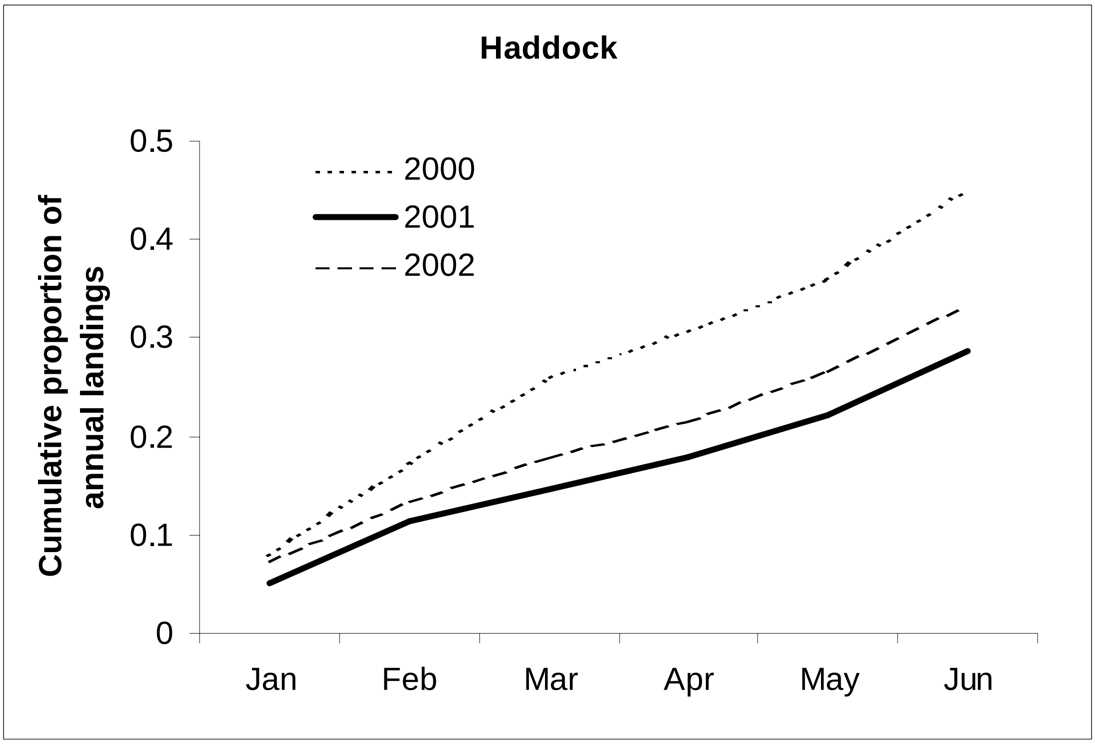


Figure 3.1.12 Monthly proportions of annual uptake of landings for haddock.

3.1.3 Effect of the closure on whiting

The effect of the area closure on whiting landings was examined using the same protocol as the cod landings in section 3.1.1.

Figure 3.1.13 shows the annual pattern in cumulative quarterly uptake of landings by age, whilst Figures 3.1.14-15 show the annual patterns in quarterly uptake. There is no consistent pattern within ages for the 2001 data indicating no effect of the closed area.

The monthly uptake proportions (Fig. 3.1.16) shows that uptake for whiting in January was slightly above the other two years and this continued through the year with no discernable difference between February and April.

Conclusion.
There is no evidence that the closure had any influence on the fishery for the North Sea whiting stock and hence the closure is unlikely to have affected the population dynamics.

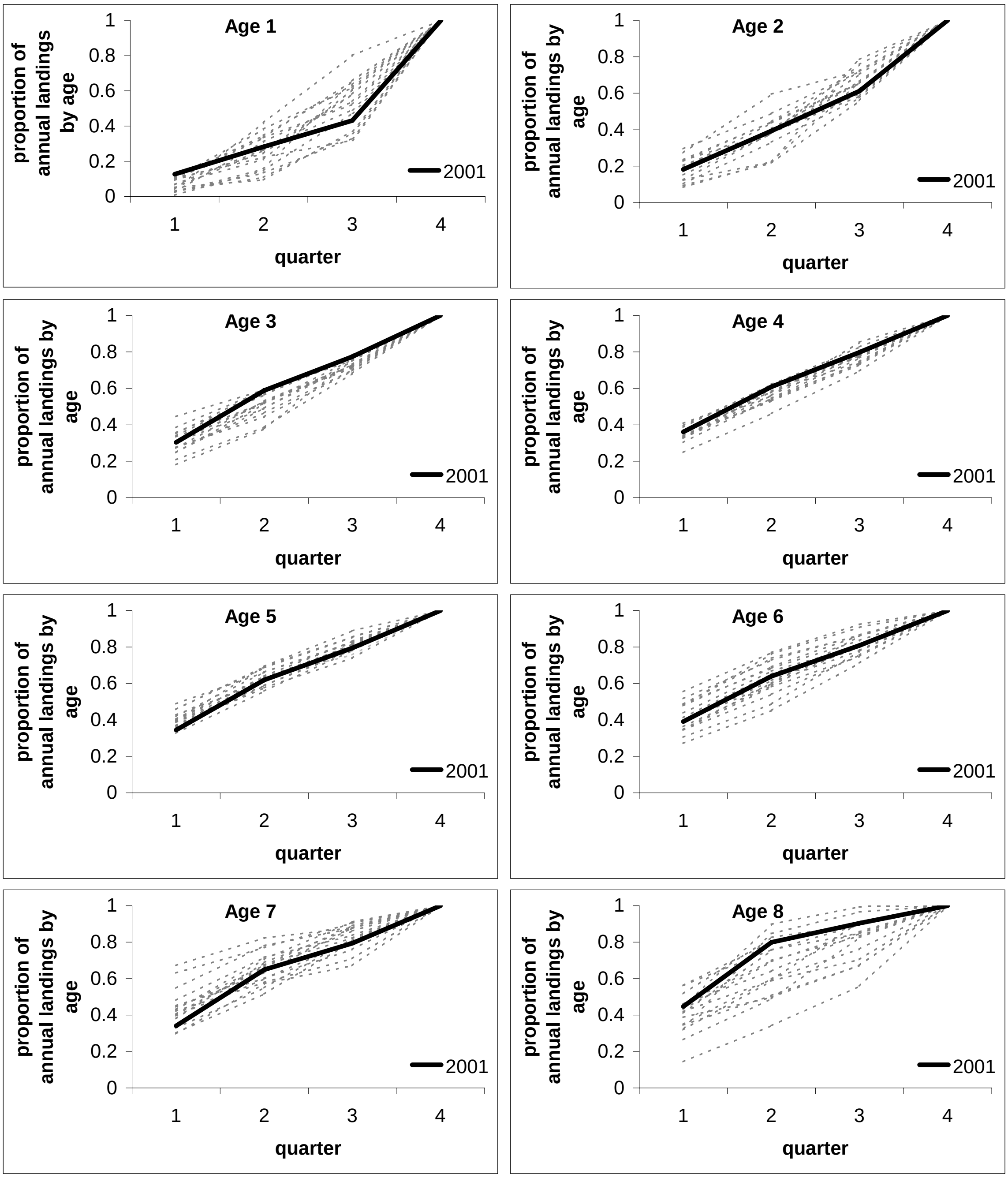


Figure 3.1.13 Annual patterns in uptake of landings for whiting, by age for the period 1985-2001.

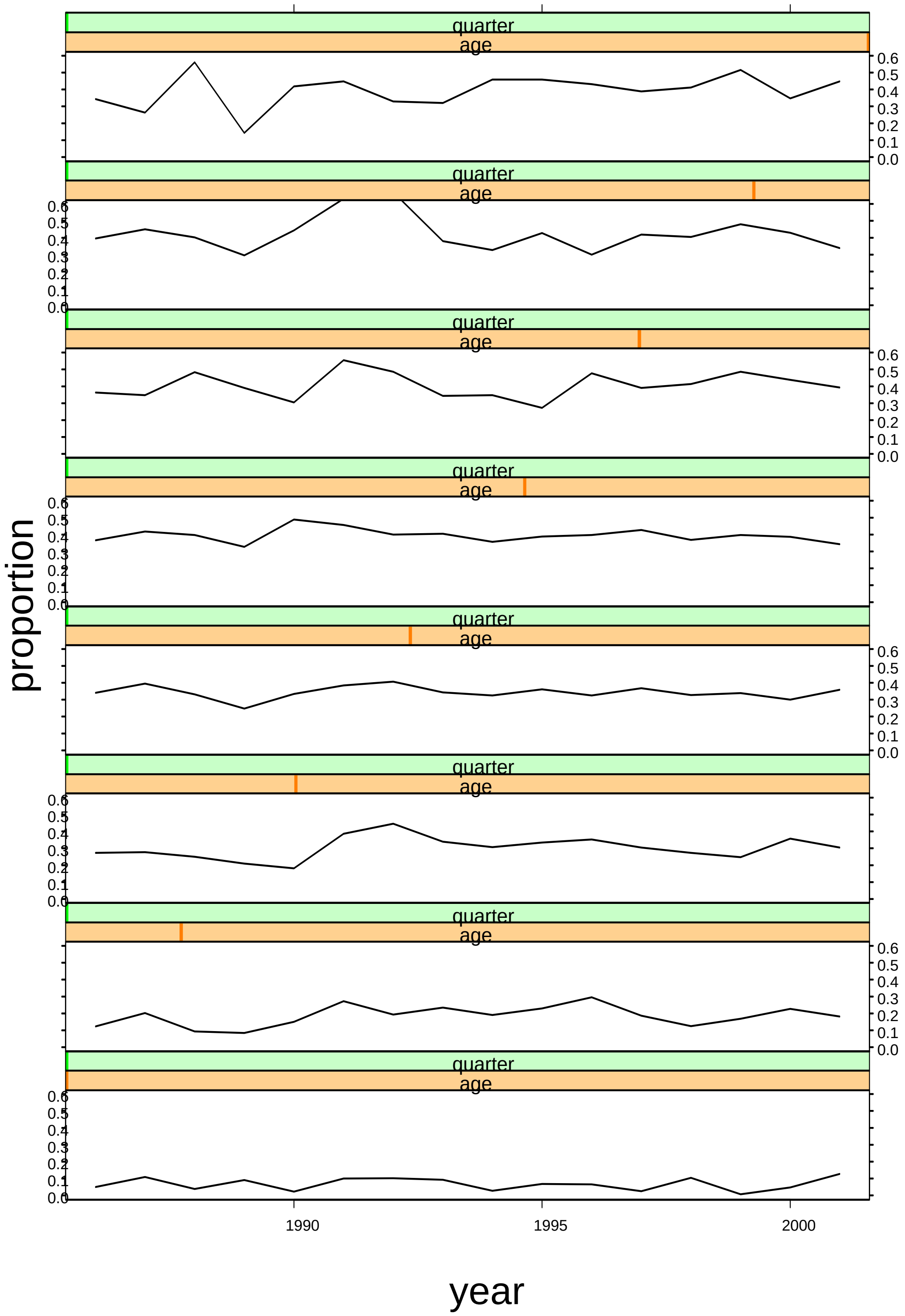


Fig 3.1.14 Trends in the quarter 1 proportion of annual landings by age for whiting, 1985-2001. Ages read upwards from 1 to 8.

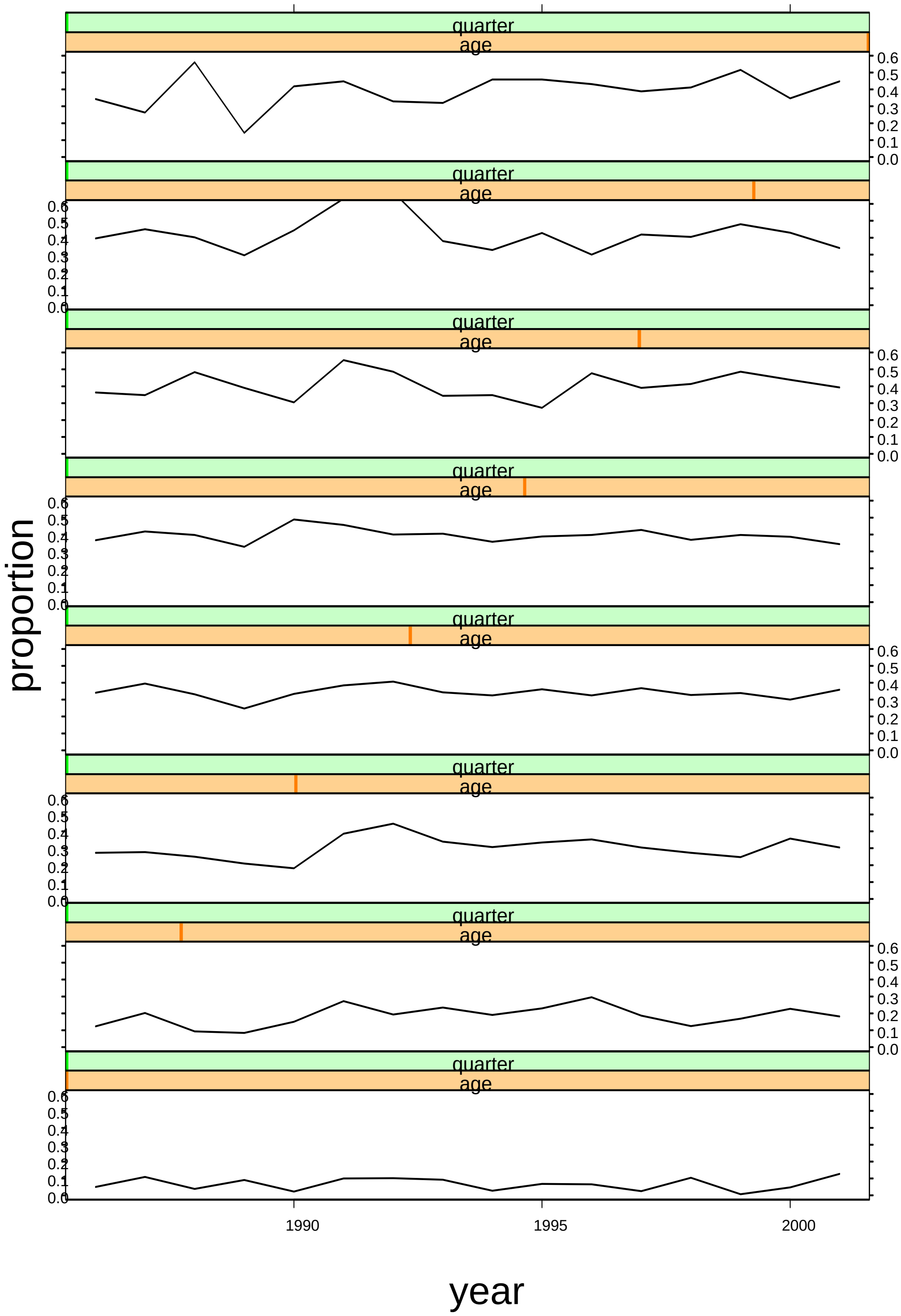


Fig 3.1.15 Trends in the quarter 2 proportion of annual landings by age for whiting, 1985-2001. Ages read upwards from 1 to 8.

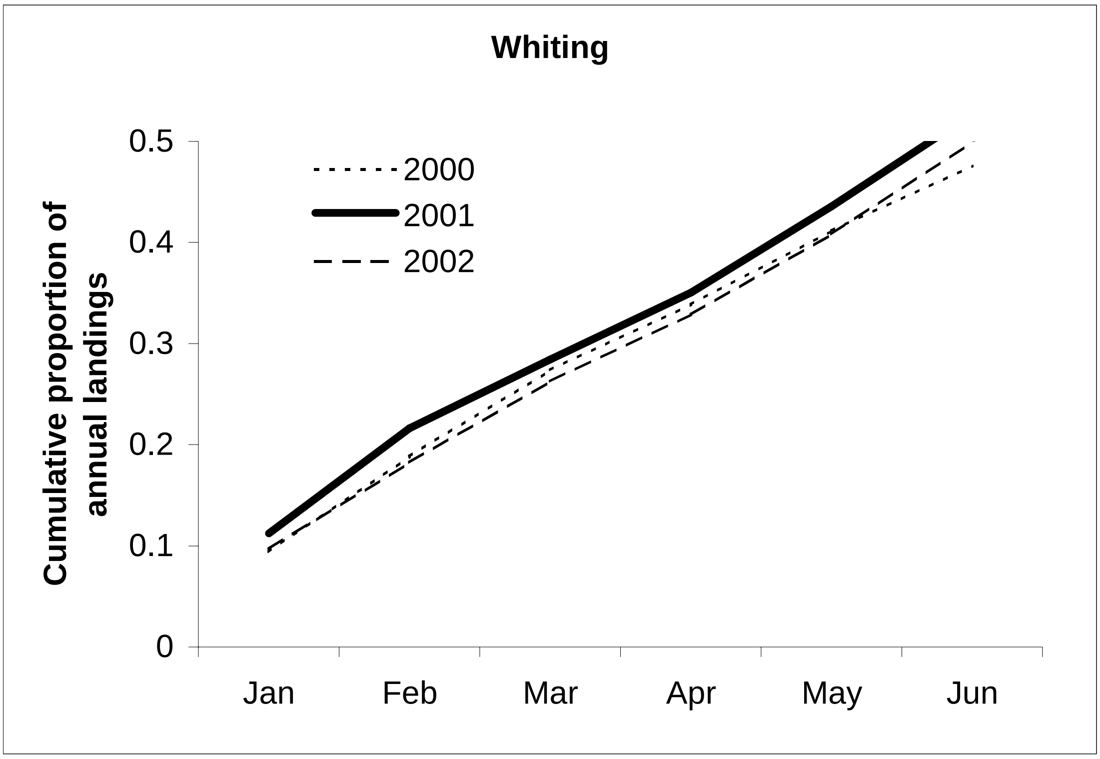


Figure 3.1.16 Monthly proportions of annual uptake of landings for whiting.

3.1.4 Effect of the closure on plaice

The effect of the area closure on plaice landings was examined using the same protocol as the cod landings in section 3.1.1.

Figure 3.1.17 shows the annual pattern in cumulative quarterly uptake of landings by age. Ages 3 and 4 showed decreased uptake in the first two quarters whilst the older ages showed an increased uptake. These changes are not part of overall trends (Fig. 3.1.18-19) and may represent an effect of the closure. (Note that quarterly catch at age data are not reliable before 1988 and have been set at a constant level).

The monthly uptake proportions (Fig. 3.1.20) shows that uptake for total landings of plaice in 2001 was not significantly different from the other years. Whilst there does seem to be a dip in uptake by the end of April, the other two years show wide divergence in the uptake patterns and it is impossible to attach any significance to the difference seen for 2001.

Conclusion.
These results indicate that the 2001 closure reduced the mortality on juvenile plaice during this period. Furthermore, Rinsdorp et al. (2001, WD 5) found that the closure also resulted in a substantial reduction in discarding of the younger ages of plaice.

A consequence of the move away from the younger ages is an increase in the fishery on the older ages. As plaice are also spawning during this period the closure may have had a negative effect on the spawning capacity of plaice in 2001.

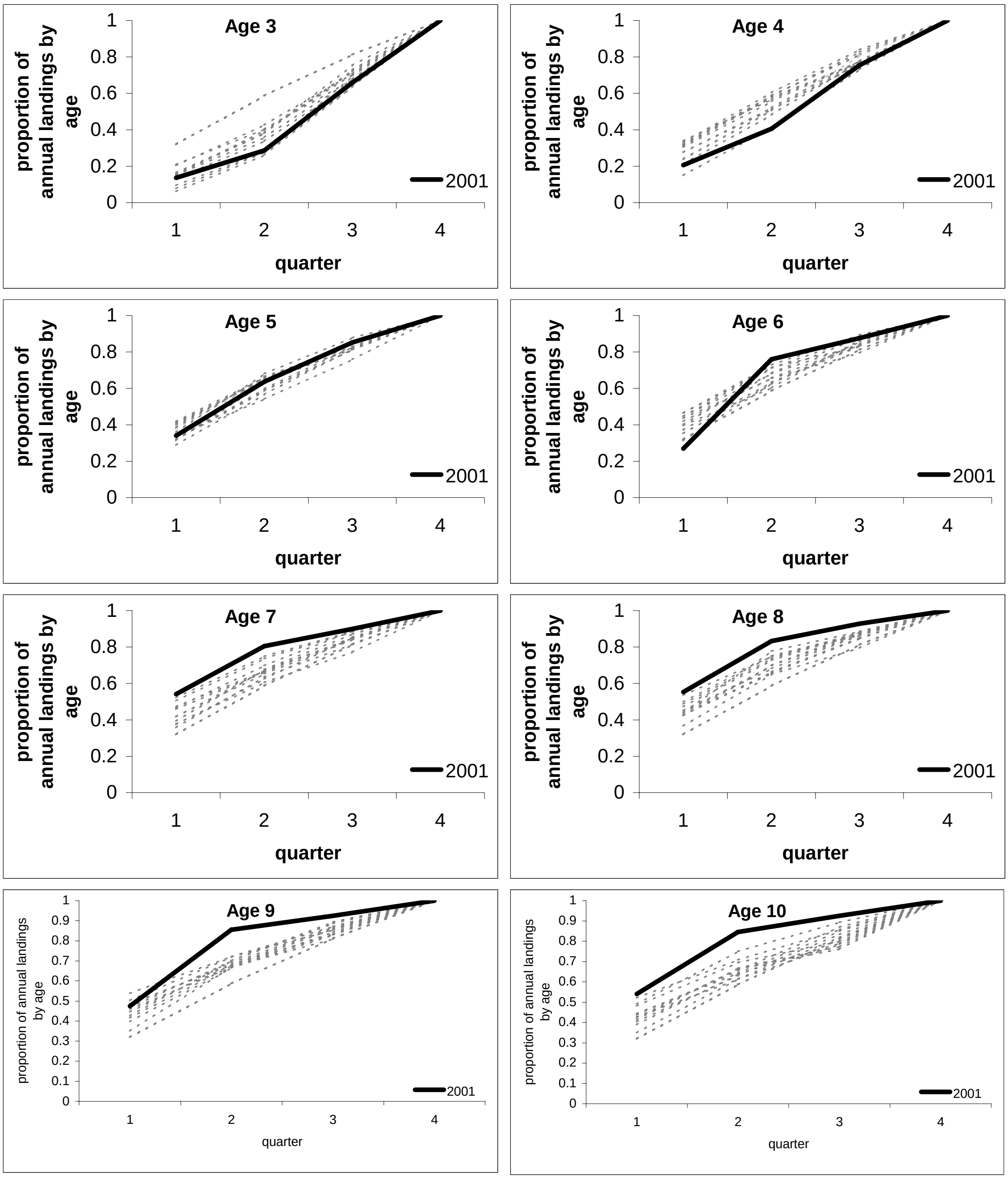


Figure 3.1.17 Annual patterns in uptake of landings for plaice, by age for the period 1985-2001.

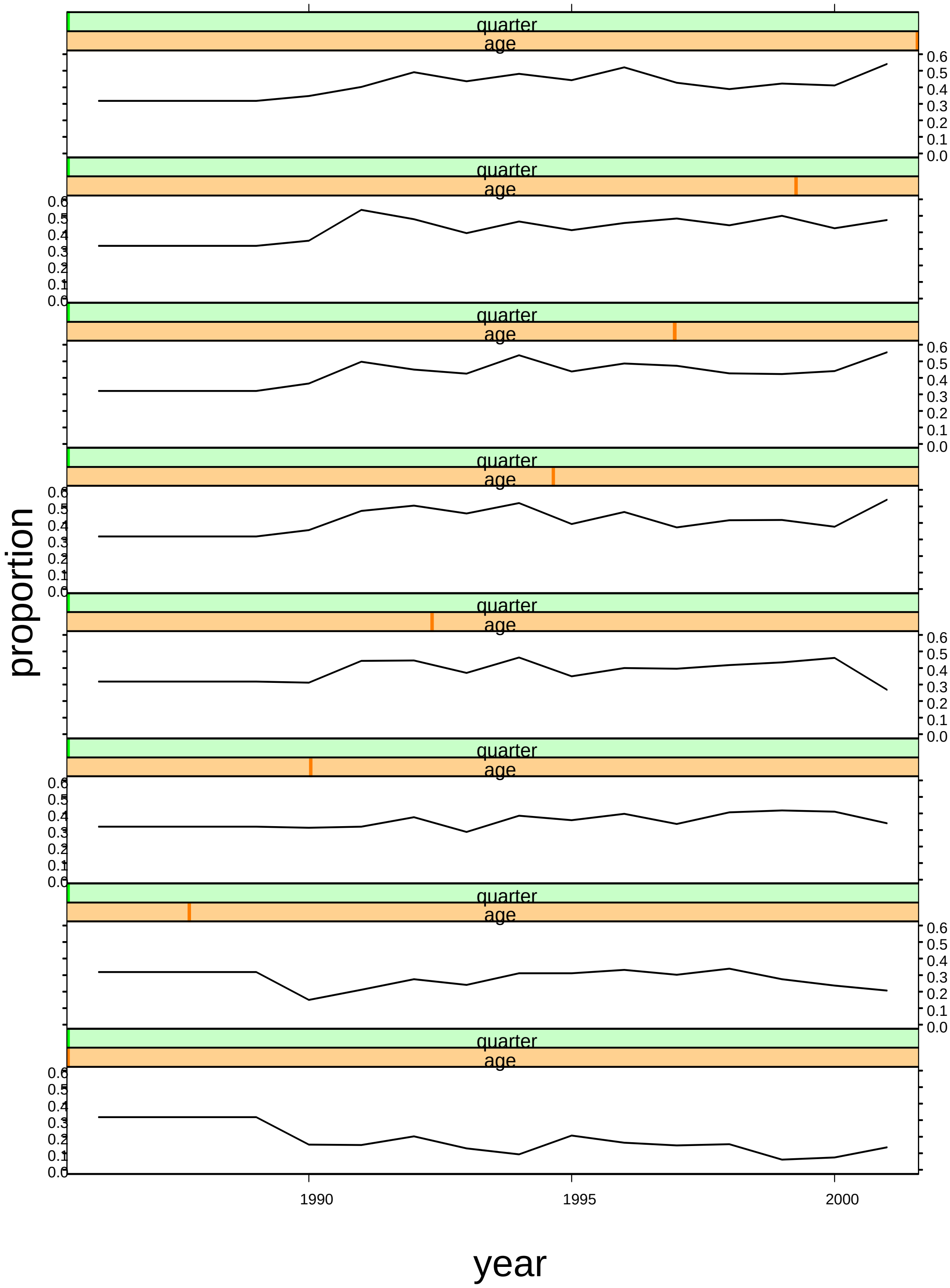


Figure 3.1.18 Trends in the quarter 1 proportion of annual landings by age for plaice, 1985-2001. Ages read upwards from 3 to 10.

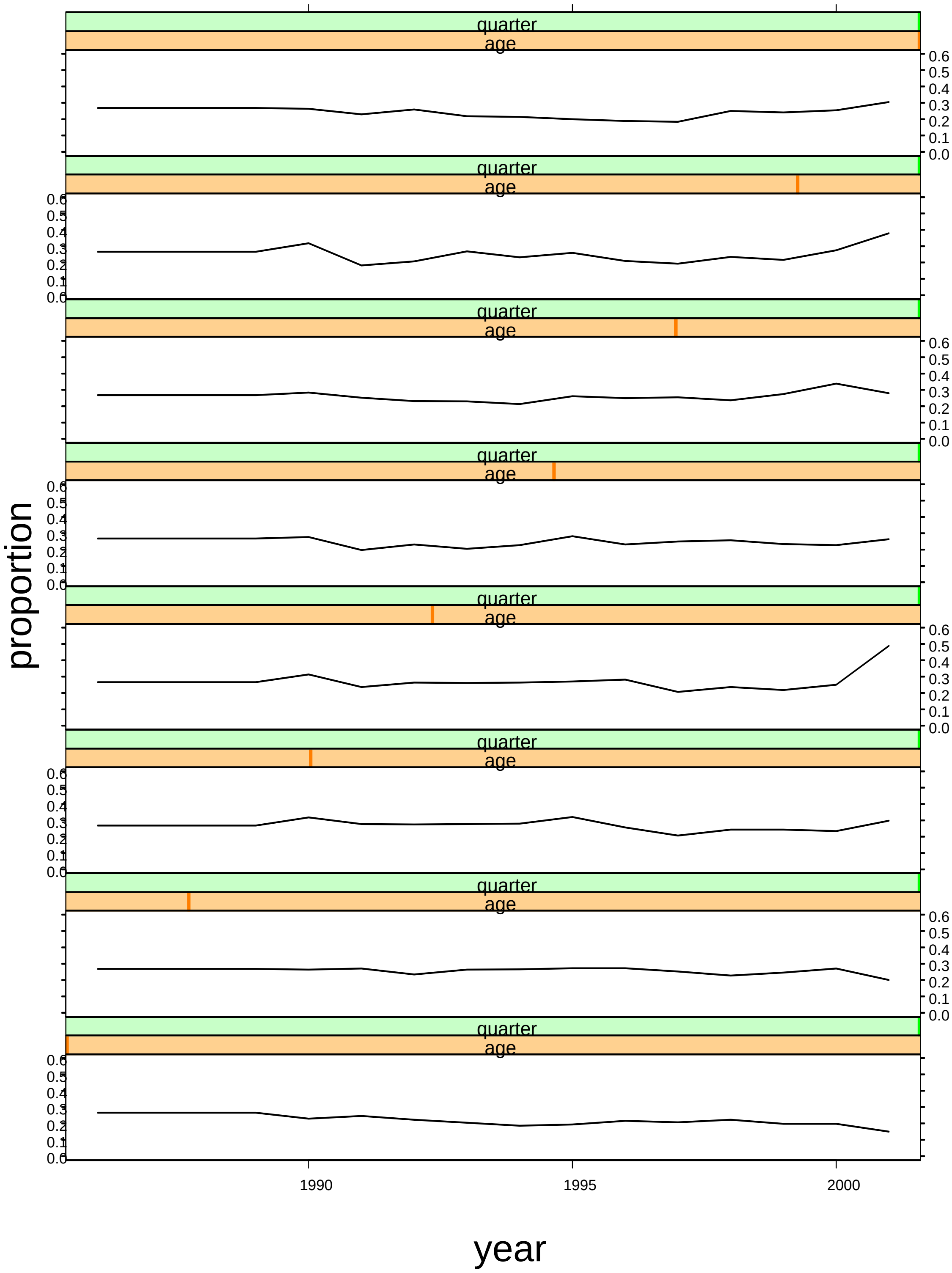


Fig 3.1.19 Trends in the quarter 2 proportion of annual landings by age for plaice, 1985-2001. Ages read upwards from 3 to 10.

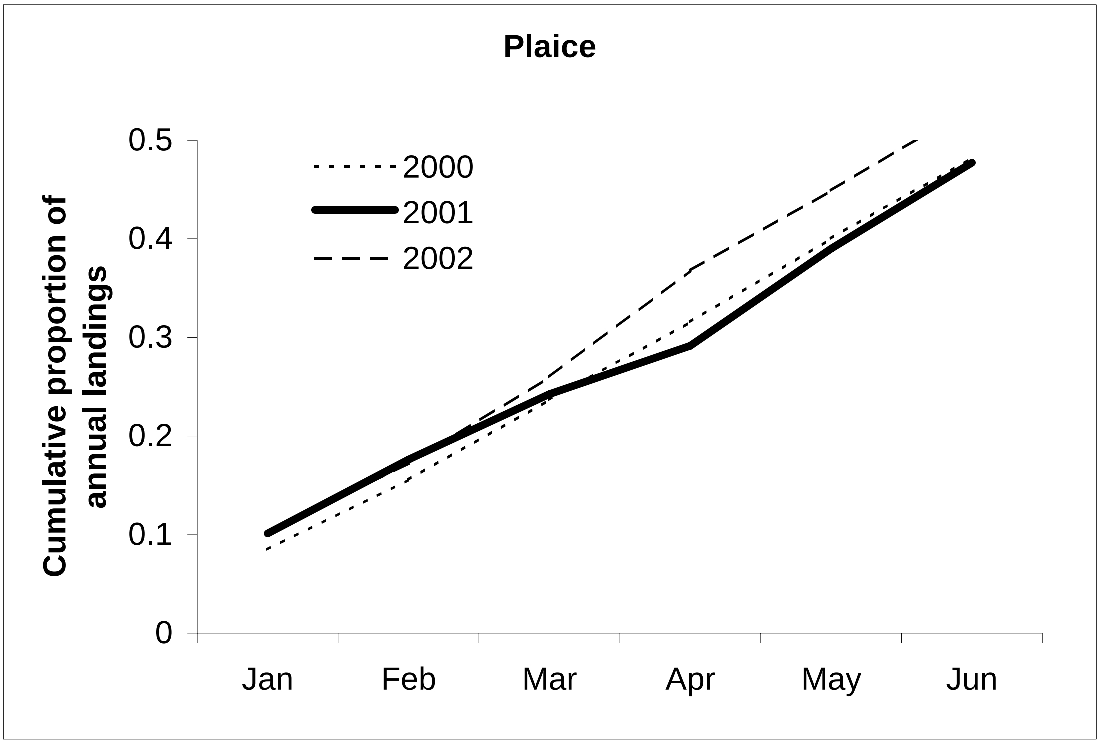


Figure 3.1.20 Monthly proportions of annual uptake of landings for plaice.

3.2 Com regulation 2056/2001 2001, additional technical measures 1 Jan 2002 (ToR a and e5)

3.2.1 Cod-end Selectivity for demersal towed gears due to technical conservation measures

Changes in technical measures since January 2000 aimed to reduce the mortality of juvenile cod by improving the selectivity of gears taking cod as a target or by-catch species. Information on cod-end selectivity is available. No data are available on the selectivity of the rest of the gear so that the effect of e.g. large mesh panels behind the headline is not included. The selectivity of a cod-end is characterised by the fish length at which 50% are retained by, and 50% escape from the cod-end (L50). The larger the length at which 50% are retained then the more selective the gear. A selectivity model (Appendix 5) has been used to estimate the selectivity parameters for haddock. Somewhat less reliable parameters are derived for cod and whiting from relationships between the L50s for the 3 species. Cod-end selectivities for three types of gear used in the North Sea are presented (Tables 3.2.1–3). These gears, for which the legislation differs, are for mixed whitefish, for saithe and for *Nephrops*. The selection range (SR) which describes the slope of the selection curve at L50 is also given.

Cod-end design features which determine its selective properties are:

- Mesh size in mm
- Twine size (double or single) in mm
- Open meshes round cod-end circumference
- Lifting or strengthening bag
- Square mesh panel (SMP) mesh size

The precise gear configurations used in commercial fishing will of course vary but values tend to be near the minimum legal specification. In two cases the UK unilateral measures have also been applied – the Scottish *Nephrops* and mixed whitefish fisheries where they form an important component of the North Sea fisheries. So the potential effect of technical measures is indicated by the increase in estimated L50 in the table for each gear type.

For the mixed whitefish and saithe gears the L50 after January 2002 is estimated to be slightly above the minimum landing size for haddock and cod and substantially above it for whiting.

For *Nephrops* gears L50 remains below or well below minimum landing size except in the case of the 100mm gear used by e.g. Scottish twin trawlers on the Fladen ground in 2001 and 2002. This mesh size is well above the legal minimum requirement for this fishery.

Table 3.2.1. COD SELECTIVITY (Minimum Landing Size = 35cm in North Sea)

Gear type	Cod-end design	2000-2001	2002		
Demersal towed gears - whitefish	Mesh size	100	110		120
	Twine size	5.5d	5d		5
	Open meshes	100	100		100
	Lifting bag	Yes	No		Yes
	SMP	No	90		No
	L50	28.1	36.7*		36.3
	SR	6.0	7.8		7.7
Demersal towed gears - saithe	Mesh size	100	110		
	Twine size	6d	5d		
	Open meshes	100	100		
	Lifting bag	No	No		
	SMP	No	No		
	L50	30.4	35.5		
	SR	6.5	7.5		
Demersal towed gears - Nephrops	Mesh size	70	80	80	100
	Twine size	4d	4d	4s	5d
	Open meshes	120	120	120	100
	Lifting bag	Yes	Yes	Yes	No
	SMP	No	90	90	90
	L50	16.9	23.0*	24.8*	34.1*
	SR	3.6	4.9	5.3	7.2

* This gear is mainly used by the Scottish fleet and is subject to UK unilateral measures requiring that a lifting bag is not used or thinner twine is used compared to EU Regulation 2056/2001.

Table 3.2.2. WHITING SELECTIVITY (Minimum Landing Size = 27cm in North Sea)

Gear type	Cod-end design	2000-2001	2002		
Demersal towed gears - whitefish	Mesh size Twine size Open meshes Lifting bag SMP	100 5.5d 100 Yes No	110 5d 100 No 90		120 5 100 Yes No
	L50 SR	29.5 8.4	38.6* 11.0		38.1 10.9
Demersal towed gears - saithe	Mesh size Twine size Open meshes Lifting bag SMP	100 6d 100 No No	110 5d 100 No No		
	L50 SR	31.9 9.1	37.3 10.7		
Demersal towed gears - Nephrops	Mesh size Twine size Open meshes Lifting bag SMP	70 4d 120 Yes No	80 4d 120 Yes 90	80 4s 120 Yes 90	100 5d 100 No 90
	L50 SR	17.8 5.1	24.2* 6.9	26.1* 7.5	35.9* 10.3

This gear is mainly used by the Scottish fleet and is subject to UK unilateral measures requiring that a lifting bag is not used or thinner twine is used compared to EU Regulation 2056/2001.

Table 3.2.3. HADDOCK SELECTIVITY (Minimum Landing Size = 30cm in North Sea). 95% confidence limits are indicated in brackets for selectivity parameters generated by the haddock model (Appendix 2) in those cases where there is no square mesh panel.

Gear type	Cod-end design	2000-2001	2002		
Demersal towed gears - whitefish	Mesh size	100	110		120
	Twine size	5.5d	5d		5
	Open meshes	100	100		100
	Lifting bag	Yes	No		Yes
	SMP	No	90		No
	L50	24.8 (22.7-26.9)	32.5*		32.1 (30.1-34.1)
	SR	4.4 (3.8-4.9)	5.4		6.1 (5.7-6.4)
Demersal towed gears - saithe	Mesh size	100	110		
	Twine size	6d	5d		
	Open meshes	100	100		
	Lifting bag	No	No		
	SMP	No	No		
	L50	26.9 (25.6-28.2)	31.4 (30.6-32.2)		
	SR	4.1 (3.4-4.8)	5.4 (5.0-5.7)		
Demersal towed gears - Nephrops	Mesh size	70	80	80	100
	Twine size	4d	4d	4s	5d
	Open meshes	120	120	120	100
	Lifting bag	Yes	Yes	Yes	No
	SMP	No	90	90	90
	L50	14.9 (12.6-17.3)	20.3*	21.9*	30.2*
	SR	3.0 (2.6-3.4)	3.7	4.3	4.6

* This gear with a square mesh panel is mainly used by the Scottish fleet and is subject to UK unilateral measures requiring that a lifting bag is not used or thinner twine is used compared to EU Regulation 2056/2001.

3.2.2 The potential impacts of recent fishing gear regulations

A number of regulations affecting the design and construction of cod-ends have been enacted in recent years (chapter 3). Based on information with regard to UK national legislation and EU legislation, an evaluation of their potential impacts is given below. This evaluation necessarily includes a number of simplifying assumptions due to the restricted availability of gear selection data and the appropriately disaggregated dataset of landings and discards.

For the purposes of this evaluation, selectivity based on the effects of EU 2000 was taken as the baseline case and considered to run from January 2000. For the evaluation of effects, Scotland 2000 selectivity was initiated at August 2000 and applied to Scottish catches only; UK 2001 selectivity was initiated at April 2001 and applied to UK catches only; Scotland 2001 selectivity was initiated at August 2001 and similarly applied to Scottish catches only. EU110 and EU120 measures were initiated at January 2002 subject to the partial uptake of a 110 mm derogation, and applied to non-UK fleets. Due to the additional national technical requirements for UK fishing gears to which the EU110 and EU120 measures apply, a UK110 and UK120 category was defined that reflects the enhanced selectivity attributable to the additional UK legislative requirements.

Table 3.2.4 A truncated overview of the regulations are given below in regard to their effects on the construction of towed demersal gears targeting gadoids in the North Sea:

Label	Regulation	Applicability	Constraint or additional constraint on gear design
EU 2000	EU 850/98	EU	100 mm minimum mesh size
Scotland 2000	SSI 227/2000	UK (Scotland)	90 mm square mesh panel with restrictions on its placement
UK 2001	SI 649/2001	UK	Maximum twine diameter in cod-end and 90 mm square mesh panel with restrictions on its placement
Scotland 2001	SSI 250/2001	UK (Scotland)	Ban on lifting bags and maximum number of meshes along the length of the extension piece
EU 110 or EU 120	EU 2056/2001	EU	120 mm minimum mesh size and a maximum length for the extension piece. Derogation for vessels targeting a mixed demersal gadoid fishery of 110 mm minimum mesh size in 2002, subject to rules on catch composition

The parameters of the gear selection curves are discussed in Section 3.3 and the selectivity curves corresponding to these measures are shown in Figure 3.2.1.

Underlying assumptions

Of those vessels directly affected by the requirement to move from a 100 mm minimum mesh size to the 120 mm minimum, 20% of UK and non-UK demersal vessels were assumed to adopt the 110 mm derogation in 2002. For 2003 and subsequent years, the 110 mm derogation was removed.

In the schedule of regulations under evaluation, the effect of EU vessels fishing in Norwegian waters is disregarded to the extent that they are assumed to meet EU but not Norwegian regulations. This is a technical adjustment because disaggregated data to allow for the calculation of partial fishing mortalities on cod, haddock and whiting by EU vessels in Norwegan waters was not available. Similarly, all fishing mortality on cod (IIIa, IV & VIId), haddock (IIa & IV) and whiting (IV & VIId) is assumed to stem from vessels with the selection characteristics defined above. In doing so, the differences in the selection characteristics of, for example, *Nephrops* trawlers and gill-netters is explicitly ignored. This is again due to the lack of available disaggregated data at the time of the analysis. However, this shortcoming is partly addressed by applying a factor for the applicability of the new gear regulations as and when they arise. An applicability of, say, 30%, implies that of the fishing mortality applied to a particular fish stock, then 30% of that fishing mortality is modified by the change in gear selection. It is not an explicit indicator of compliance with the measure, although compliance could be incorporated by modifying the applicability factor. In the results of this analysis, “applicability” and “compliance” are jointly considered as the “uptake percentage” of the measures, and results are presented for the entire range of uptake of 0% - 100%.

Within the analysis, three human consumption “fleets” were defined internally to the model, UK Scotland, UK England and Others, although the results are only presented for all the consumption fleets combined to simplify presentation. Where data for other catch categories are used in the ICES stock assessments, *ie*., discard data and industrial bycatch, they were also applied in this evaluation.

Gear selectivity changes to fishing mortality acted upon the mean length of fish at age by “fleet” and catch category.

Baseline forecasts were run using ICES’ most recent estimate (2002) of the stock size at age in 2000 and of weights-at-age and fishing mortality at that time. For the baseline, fishing mortality and mean weights at in subsequent years was taken as the *status quo* estimates relative to 2000. Recruitment in 2001 - 2004 was as used in the 2002 ICES short term forecasts. Subsequent recruitments were generated from deterministic stock and recruitment relationships defined under the EU MATES contract awarded to CEFAS, Lowestoft, and partners (EU Contract FISH/2001/02). (For the cod data set that was modified to include discards, the appropriate adjustments were made to all of these values). The inclusion of a stock and recruitment relationship to generate recruitment assumes that the past dynamics of the stock are predictive of the future.

The rationale behind 2000 as the baseline year, was to identify the potential effects of the successive EU and UK legislation since that year.

At the same time, a scenario forecast was run using the same input data as the baseline forecast, but with fishing mortality rates modified by the effects of the technical regulations as discussed above. Results are presented as the percentage deviation of the scenario from the baseline forecast.

<u>Results</u>

The results presented here are single-species, deterministic forecasts and a number of points are highlighted:

- Previous work has demonstrated that the medium and long term gains or losses that can be attributed to changes in fishing gear selectivity can be substantially reduced and even reversed under multi-species assumptions, due to the impact of increased predation mortality by enhanced stock sizes of pisciverous and/or cannibalistic fish;

- The outcomes of the scenario forecasts compared to the baseline results represent what may be considered a first approximation to the average outcome from the entire distribution of potential outcomes that can be generated if the uncertainties in the stock and selectivity inputs were considered. Consequently, they indicate the approximately average outcome of events, but that does not mean that the outcome is achieved with high probability;

Outcomes of the forecasts assume compliance with the relevant regulations.

Due to the inclusion of a stock recruitment relationship to generate subsequent recruitments that are conditional on spawning biomass, the baseline and scenario cases are not only affected by changes in fishing mortality attributable to the defined measures. They are, in addition, affected by the relative success of those measures to increase spawning biomass. Consequently, it is possible to see increases in discarding or industrial bycatch in the scenarios compared to the baseline despite lower fishing mortality rates in the former. This will occur where the reduced fishing mortality is sufficient to permit an appropriate increase in spawning biomass, and hence an increase in juvenile production.

In the subsequent text, the terms increases, gains, losses, reductions *etc*., refer to percentage changes for the various scenarios when compared to the baseline runs. It is a necessary caution to remember that a large percentage increase to a small value may result in a number that is still small in absolute value, and *vice versa*. The specific scenarios selected comprise:

Gear measures only. That is, the sequential application of the above gear measures alone;

a) Gear measures and a 40% reduction in F in the consumption fishery. This includes the application of the gear measures, but they are superimposed on an overall reduction of 40% in fishing mortality in the human consumption fisheries. This was done because ICES commented in 2002 that if its advice were to be given for haddock and whiting in the North Sea independently of its advice for cod, then in each case it would have advised a 40% reduction in fishing mortality;
b) Gear measures and a 40% reduction in F in the consumption fishery and industrial by catch. This corresponds to (b), but also includes an equivalent 40% reduction in the fishing mortality from the industrial fisheries.

The development of the spawning biomass for the baseline case for each set of forecasts is given in Figure 3.2.2.

<u>North Sea Whiting:</u> Figure 3.2.3a-c

The input data correspond to the standard ICES stock assessment for this stock in which consumption landings, discards and industrial bycatch are included as sources of fishing mortality.

(a) Gear measures only

In this scenario, there are immediate losses in consumption landings and discards due to the unilateral UK measures applied in 2000 and 2001. These reductions are increased by the subsequent move to the 110mm/120mm minimum mesh from 2002. The losses to the consumption fishery are accompanied by small increases in the industrial bycatch and spawning biomass. In the medium term, the consumption losses are maintained and the reduction in discards is continued. Both the industrial bycatch and spawning biomass show gains in the medium term, although the gains are never greater than 20% and 50% respectively.

(b) Gear measures and 40% reduction in F in the consumption fishery

In general, the pattern of development of yields and spawning biomass are as in case (a). Losses in the consumption landings and discards are higher, but the medium term gains of the industrial bycatch are little different. There is a greater increase in spawning biomass but not substantially so.

(c) Gear measures and 40% reduction in F in the consumption and industrial fisheries

Compared to case (b), the main effect of this scenario is to reduce the yield from the industrial bycatch by the order of 30% in the short and medium term. The additional inclusion of this level of reduction of fishing mortality in the industrial fisheries produces only marginal effects on the medium term losses to consumption landings compared to case (b). Similarly, there is only a marginal effect on the relative long term gains in spawning biomass compared with that case.

North Sea Haddock: Figure 3.2.4a-c

The input data correspond to the standard ICES stock assessment for this stock in which consumption landings, discards and industrial bycatch are included as sources of fishing mortality.

(a) Gear measures only

These measures imply small immediate losses in the consumption landings that are recovered to small gains in the short term. There is a substantially greater impact on discards that are reduced over this period, although not to the values seen in the corresponding whiting scenario. There are moderate increases in the short term for the industrial bycatch and the spawning biomass. In the medium term, the potentially greater gains in the consumption landings mirror those in the industrial bycatch. The reduction in discards is maintained and spawning biomass demonstrates an increase up to 150%.

(b) Gear measures and 40% reduction in F in the consumption fishery

As in case (a), immediate short term losses in consumption landings occur that revert to small gains in the short term. In this case, the immediate losses are greater, at approximately 30%. There is a greater short term increase in the industrial bycatch, but over the medium term the gains to the consumption landings and industrial bycatch are similar to each other. Although this represents a marginal increase in medium term yields compared to case (a), the medium term increase in spawning biomass is substantially greater, particularly if the relative applicability of the gear measures is low.

(c) Gear measures and 40% reduction in F in the consumption and industrial fisheries

The added reduction of 40% in industrial fishing mortality adds marginal increased benefit to consumption landings and spawning biomass compared with case (a). Short term reductions in the industrial bycatch do accrue compared to the baseline run, but these may be small by 2003 and revert to an increase in the medium term, presumably as the recruitment of haddock increases with increased spawning biomass.

<u>North Sea Cod</u>, *excluding* discards: Figure 3.2.5a-b

The input data correspond to the standard assessment for North Sea cod that is undertaken by ICES. Discard data are not currently used in the assessment, and due to the small values of industrial bycatch, this source of fishing mortality is also excluded from the ICES assessment (consequently scenario (c) is also excluded from evaluation here).

(a) Gear measures only

For this scenario, there are only trivial short and medium term changes to consumption landings and biomass. This is because the discard component of the catch is absent from the simulations. It is the discard mortality on young fish that would be impacted by the gear measures applied here.

(b) Gear measures and 40% reduction in F in the consumption fishery

There is little contrast in the results from this scenario relative to the uptake percentage of the gear measures. This is because the gear measures have only a small impact in the absence of discards. Although there is an immediate reduction in consumption landings, this is reversed in the short term, presumably through the rapid growth potential of individual cod. This individual growth potential is further reflected by the relative gains in the spawning biomass in the short term. Much more substantial percentage increases are seen in the medium term increases for both the consumption yield and spawning biomass, approximately by three-fold and six-fold respectively.

<u>North Sea Cod</u>, *including* discards: Figure 3.2.6a-b

These results correspond to a non-standard assessment of this stock, in which a derived series of discard-at-age data was used in addition to the landings-at-age data. The derivation of the discard estimates, and the effects of adding them to a catch-at-age analyses are discussed in Section 1.4 and Working Document 1. As in the case of cod excluding discards, scenario (c) is excluded from evaluation here.

(a) Gear measures only

The UK gear measures in 2000 and 2001 have little impact on cod, unsurprisingly, as they were not targeted at cod. However, the subsequent increases in minimum mesh size to 110mm/120mm in 2002 and thereafter present a more apparent effect. Discarding is reduced in the short term by up to 50%, but the greater effect is in the medium term where both consumption landings and spawning biomass increase, by broadly the same margin, to a maximum of 50% assuming high applicability of the gear measures.

(b) Gear measures and 40% reduction in F in the consumption fishery

If fishing mortality is reduced in addition by 40%, then the impacts on the stock are more marked. Immediate losses in the consumption yield of around 10% revert to small relative gains in the short term, but with a more rapid effect on gains to the spawning biomass of about 150%. These short term changes again reflect the potentially high individual productivity of cod. The medium term effects reflect this further as the individual growth of surviving fish enhances the spawning potential of the stock to the extent that even with a reduction in fishing mortality on discards, the relative amount of discards increase compared to the baseline scenario. This is because the increase in production of juveniles under this scenario outstrips the effect of a lower fishing mortality rate. These results imply between a four- and six-fold increase in consumption landings, and between a nine- and twelve-fold increase in spawning biomass. This is approximately double the increase in spawning biomass compared to the position where discards are excluded from the analysis.

An additional point of caution is required when interpreting these specific results. The stock and recruitment relationship used in these scenarios is directly analagous to that which was used in the scenarios that exclude discards, but uses the dataset that arose from the trial catch-at-age analysis that included the derived discard data (Section 1.4 and Working Document 1). As discussed there, the numbers of recruits estimated for years prior to *ca*. 1990 are highly uncertain. This introduces considerable uncertainty into the validity of the stock and recruitment relationship that underlies this analysis.

Nevertheless, although there is uncertainty on the magnitude of the changes discussed above, the directional effects of the changes are clear.

Concluding remarks

- For whiting, the effects of the gear regulations alone, result in immediate and short term (*ca* 2-3 years) losses in consumption landings that do not revert to gains in the medium term (*ca* 10 years). Discards are substantially reduced over both the short and medium terms;
- For haddock there are also immediate losses, but these revert to small gains within the short term, and to greater gains over the medium term. As with whiting, discards are substantially reduced over both the short and medium terms;
- For cod there is little noticeable effect on consumption landings or spawning biomass if discards are excluded from the analysis. Using a series of “derived” discard data produces a moderate benefit to the medium term consumption yield and spawning biomass;
- For cod, a substantially greater benefit accrues to the spawning biomass in the medium term if fishing mortality is reduced in addition to the effects of the gear measures. This also applies to a lesser extent for haddock and whiting. Similarly, there are substantially greater gains in the medium term consumption landings of cod in these circumstances, whilst those for haddock are little affected by the additional reduction in mortality. Losses to the consumption landings of whiting are greater in these circumstances.
- The gains or losses are expressed relative to the baseline (no change) values, and are not measures of the absolute changes in yield and spawning biomass.

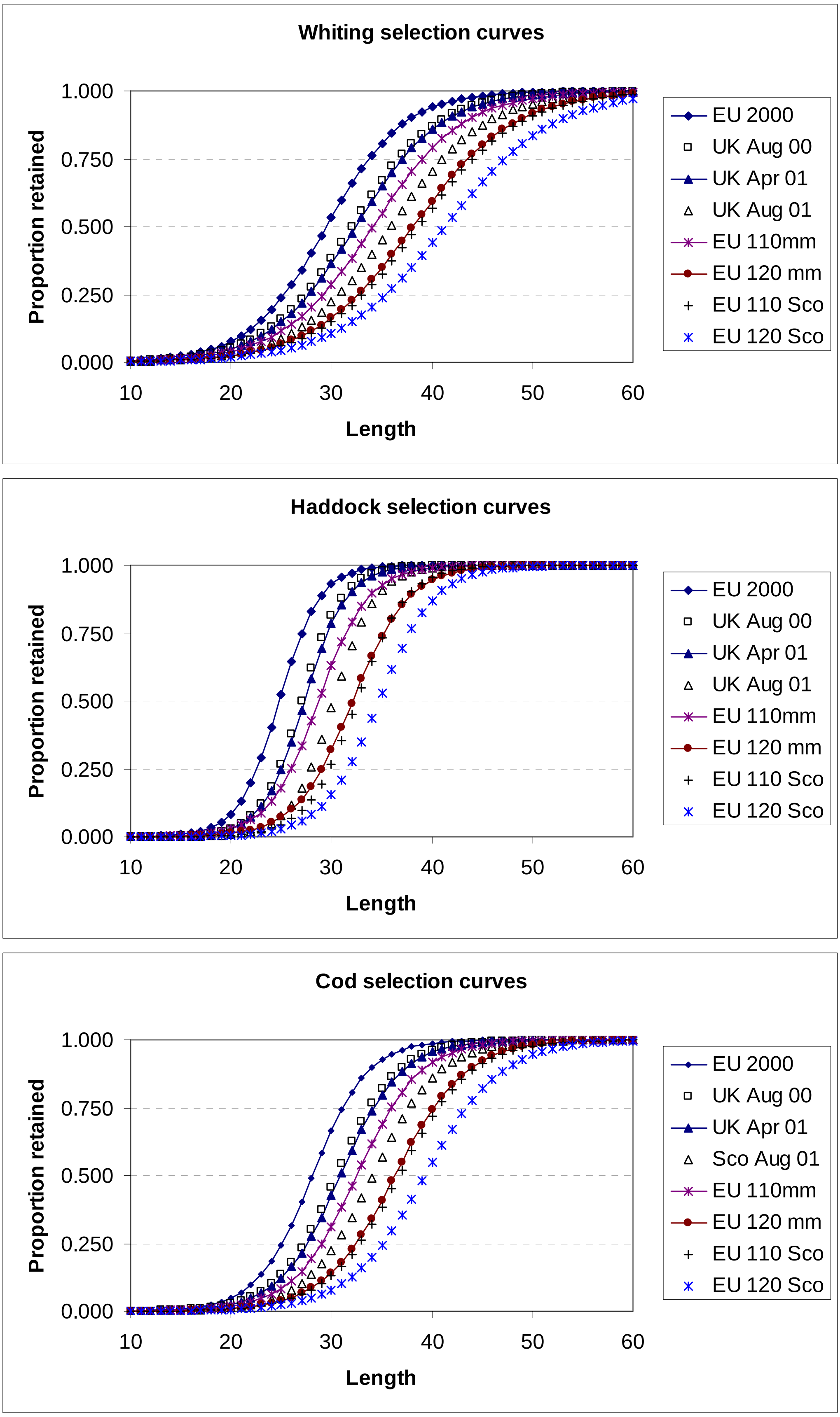


Figure 3.2.1 The selection ogives, by species, corresponding to the fishing gear regulations that have been evaluated in Section 3.3.

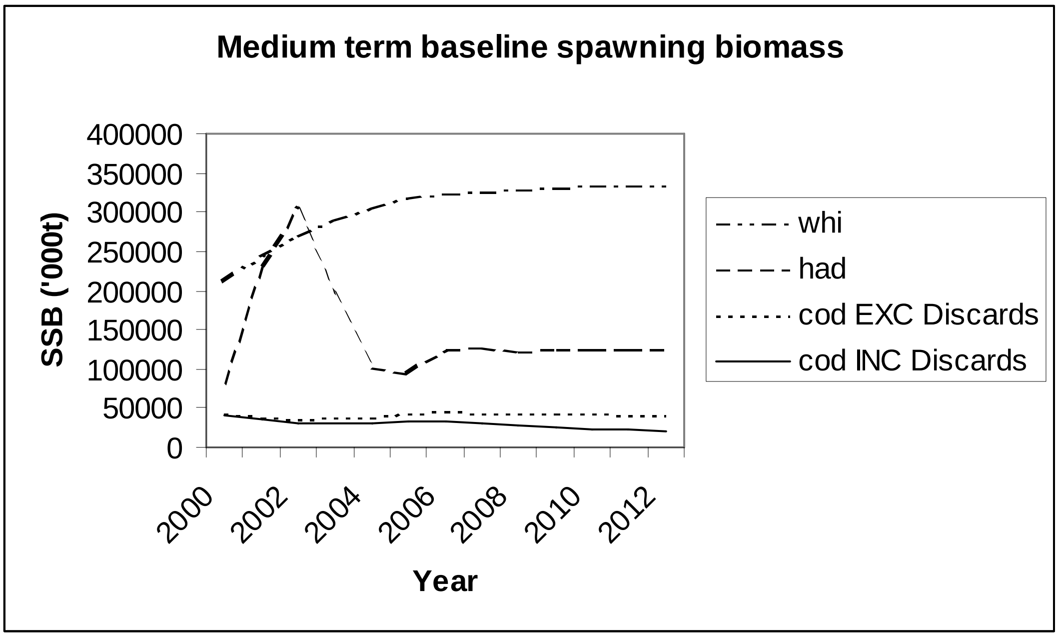


Figure 3.2.2 Baseline trajectories of spawning stock biomass against which scenario forecasts are compared: North Sea whiting, haddock and cod (the latter both including and excluding discard estimates).

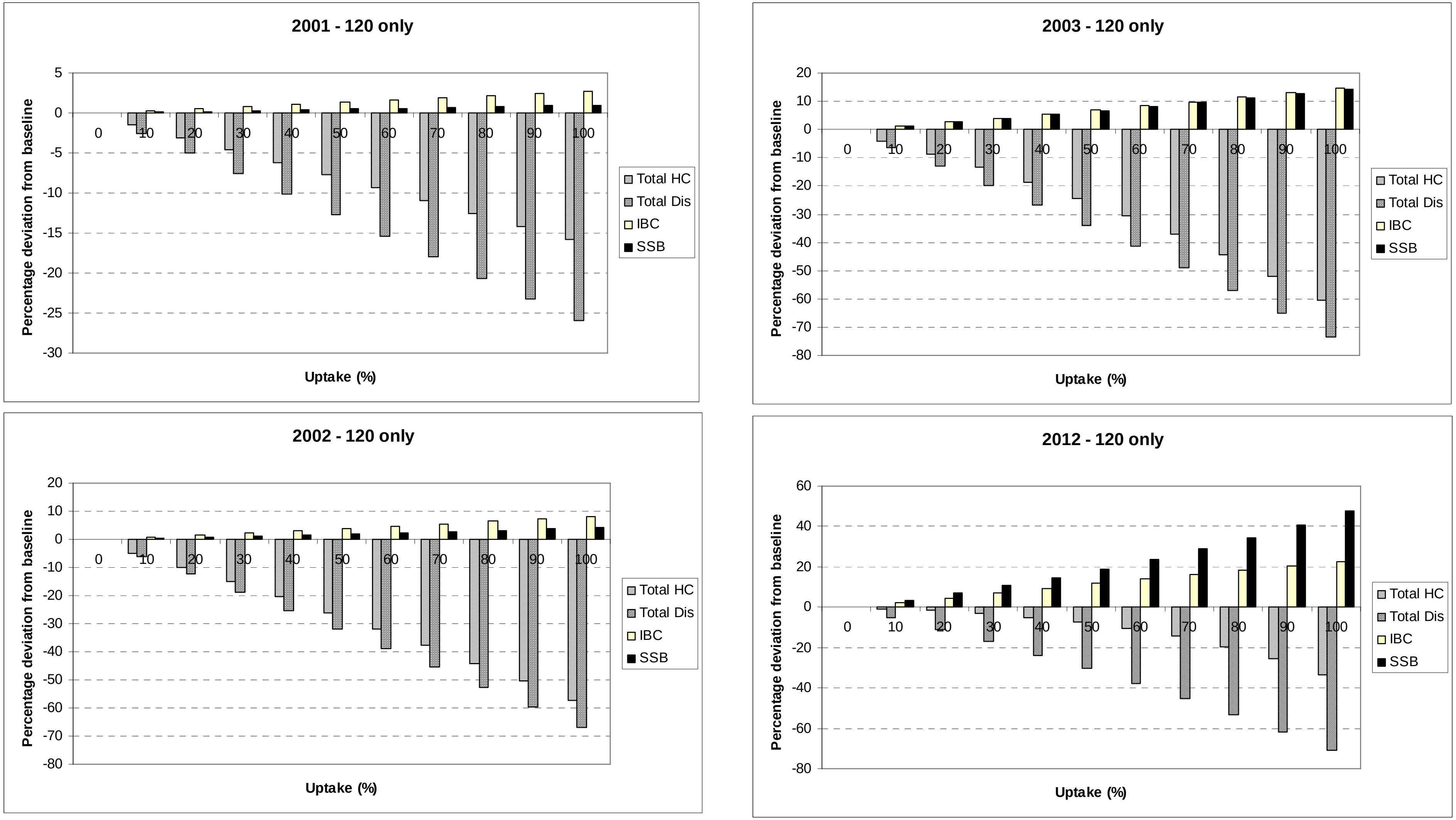


Fig. 3.2.3a North Sea WHITING. Results of gear selection simulations assuming gear effects only and no additional reductions in fishing mortality.

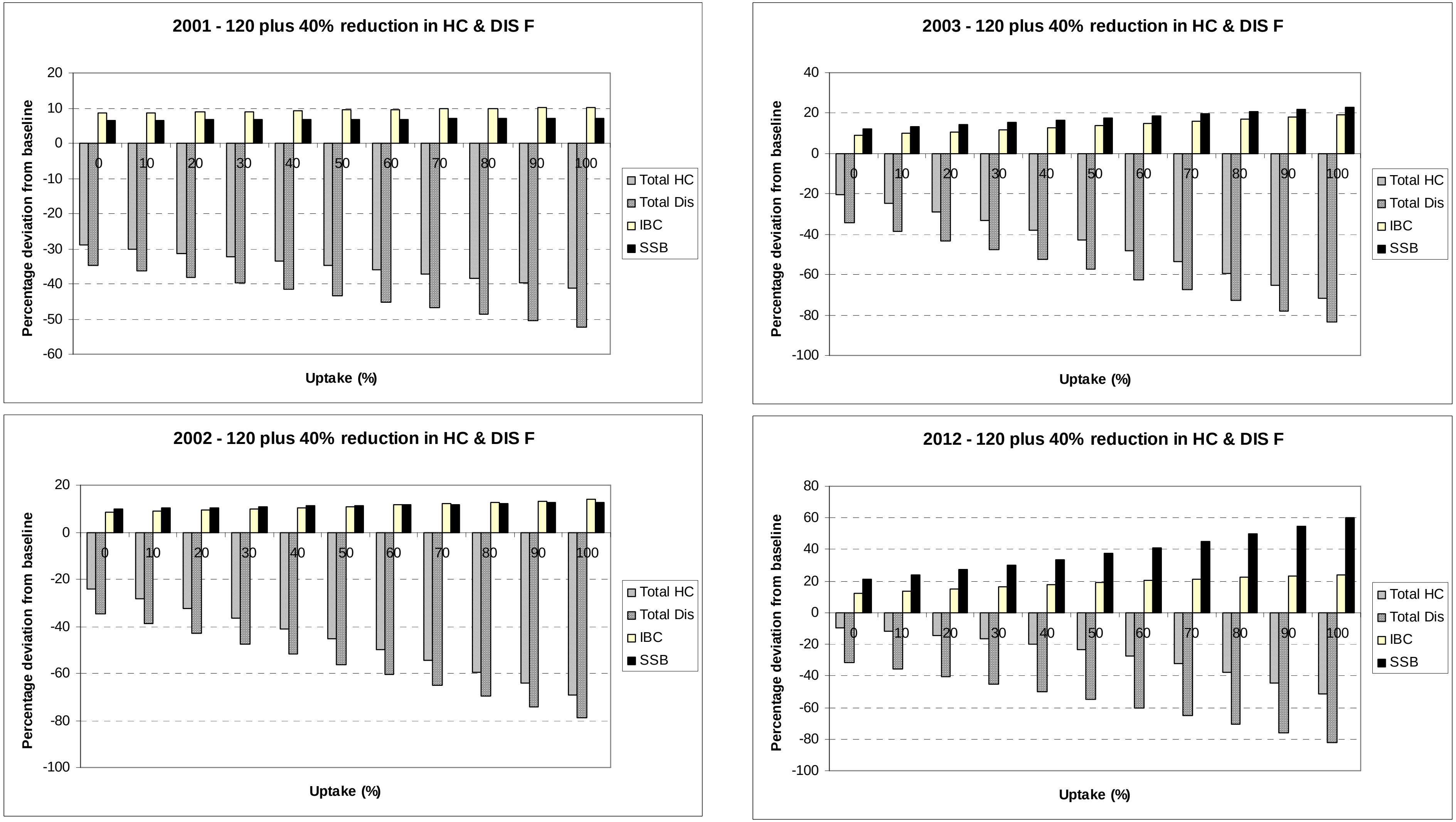


Fig. 3.2.3b North Sea WHITING. Results of gear selection simulations assuming gear effects and an additional direct reduction of 40% in fishing mortality attributable to the human consumption fishery.

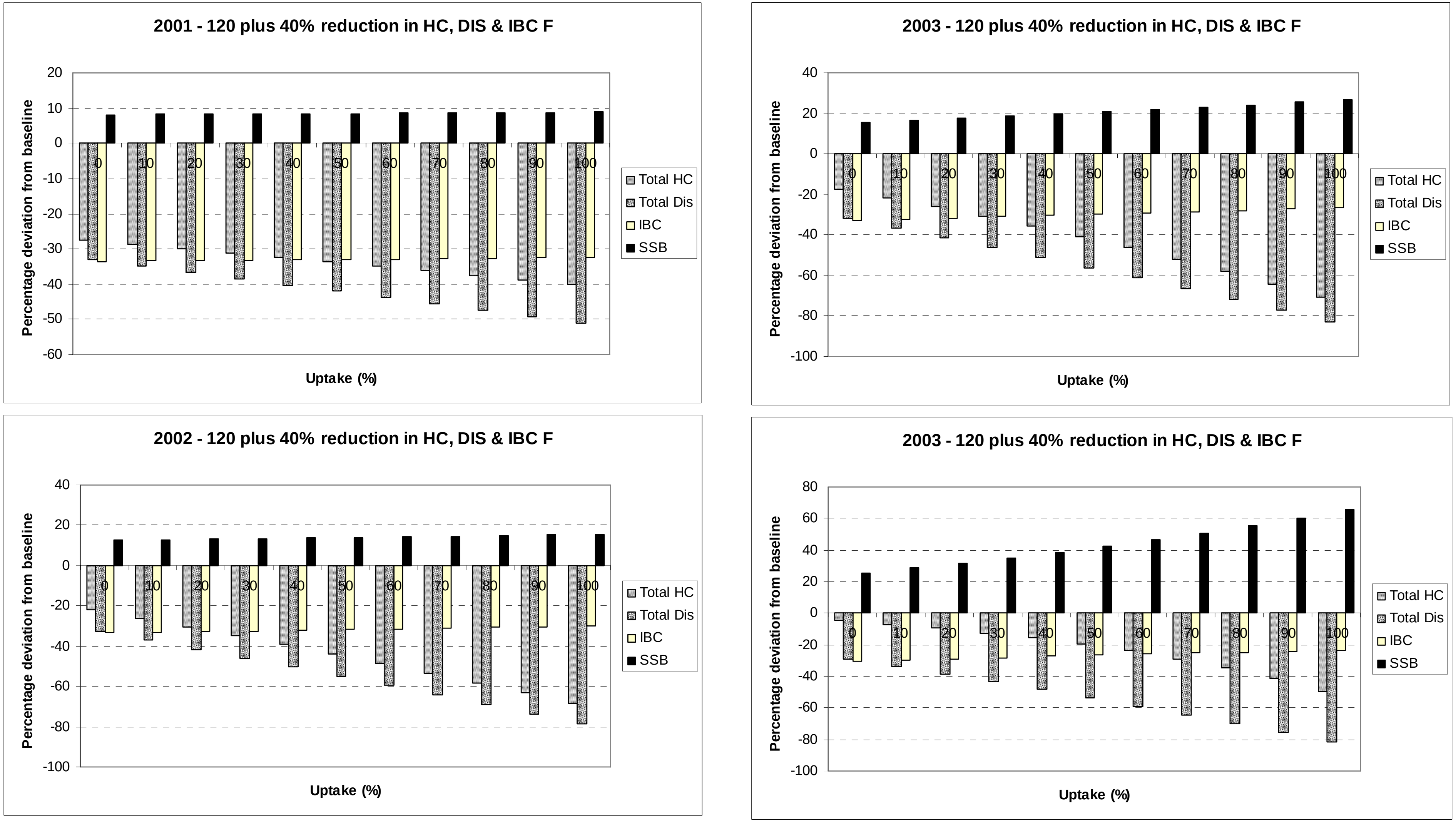


Fig. 3.2.3c North Sea WHITING. Results of gear selection simulations assuming gear effects and an additional direct reduction of 40% in fishing mortality attributable to both the human consumption and industrial fisheries..

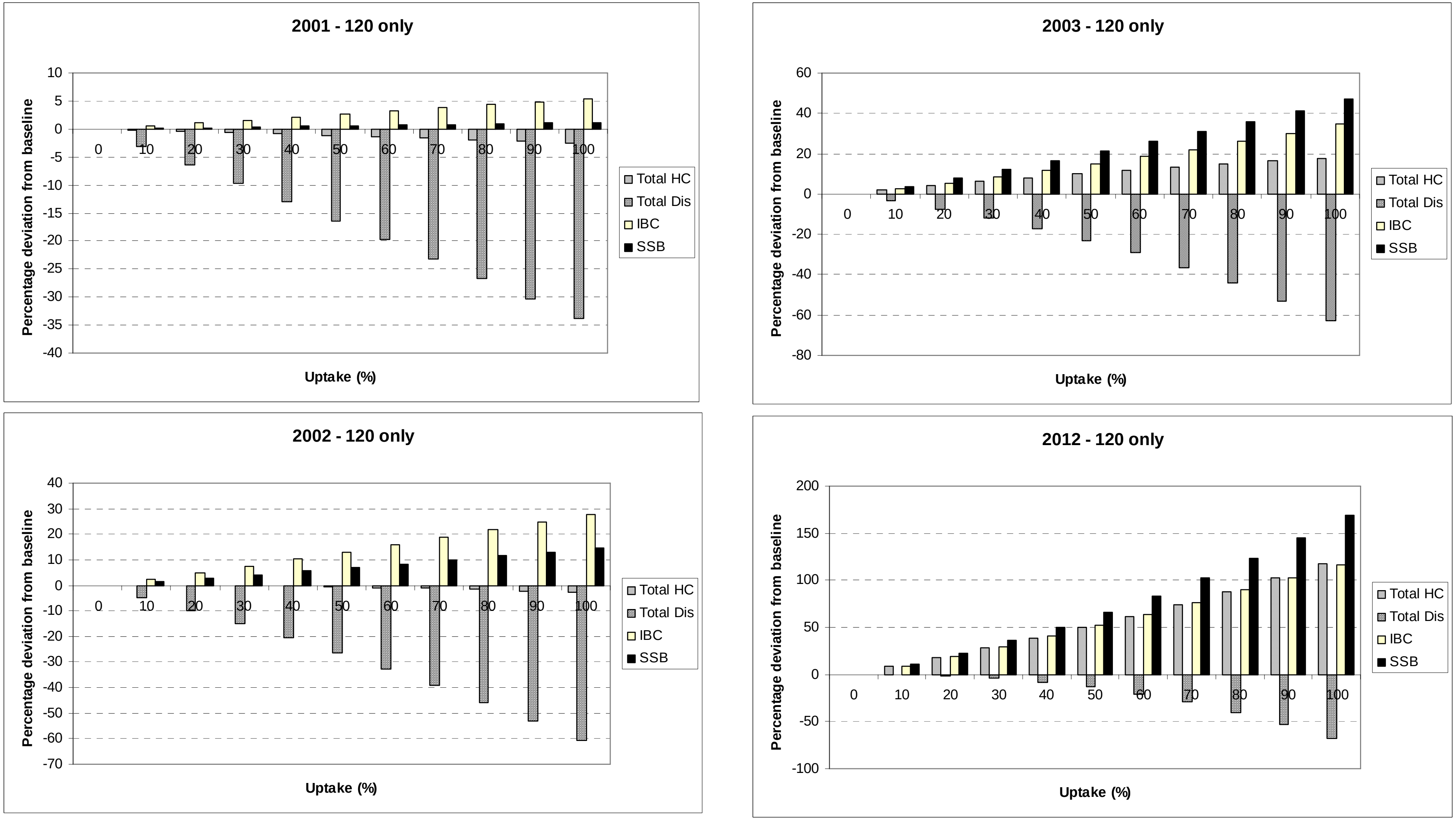


Fig. 3.2.4a North Sea HADDOCK. Results of gear selection simulations assuming gear effects only and no additional reductions in fishing mortality.

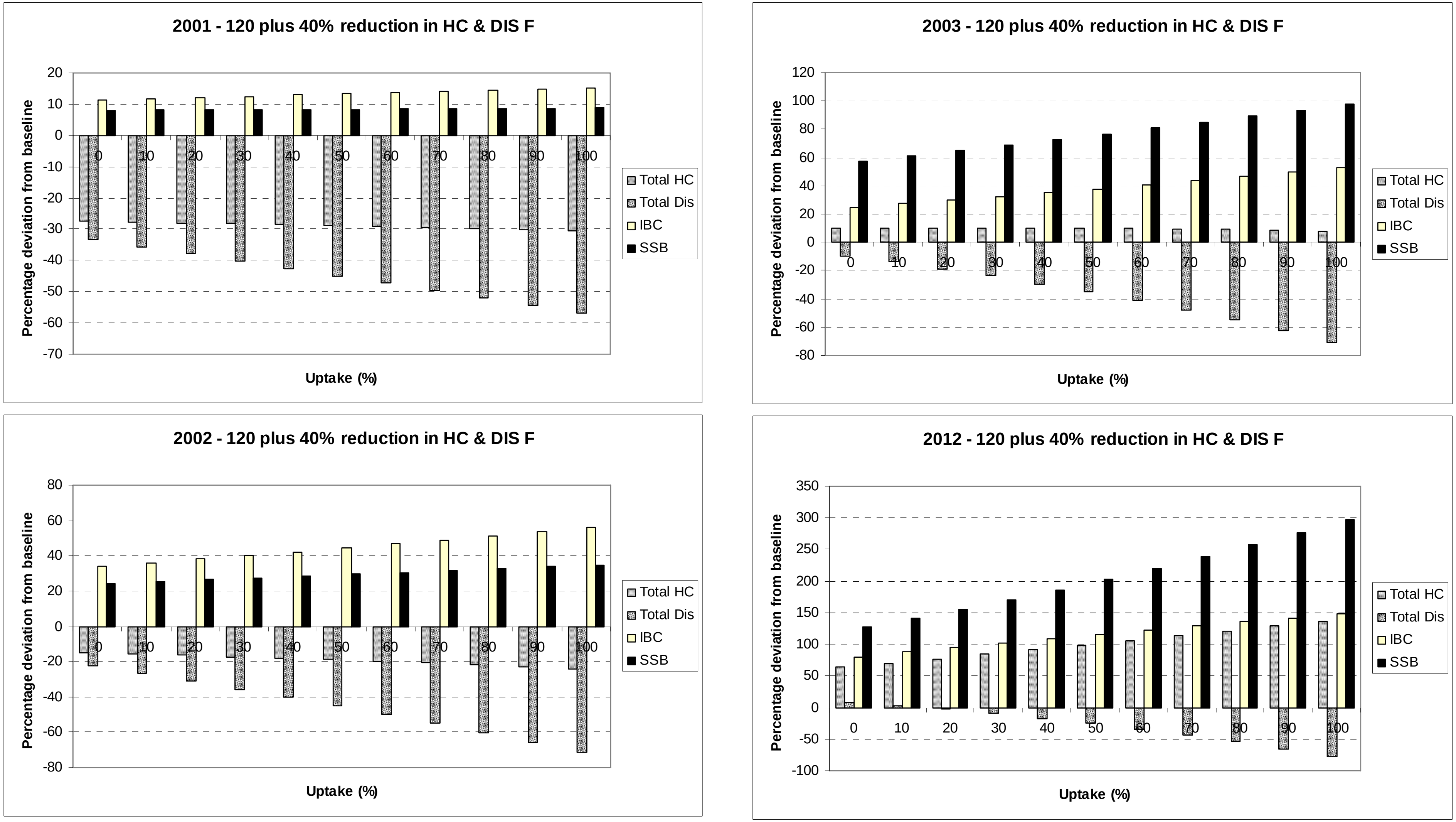


Fig. 3.2.4b North Sea HADDOCK. Results of gear selection simulations assuming gear effects and an additional direct reduction of 40% in fishing mortality attributable to the human consumption fishery.

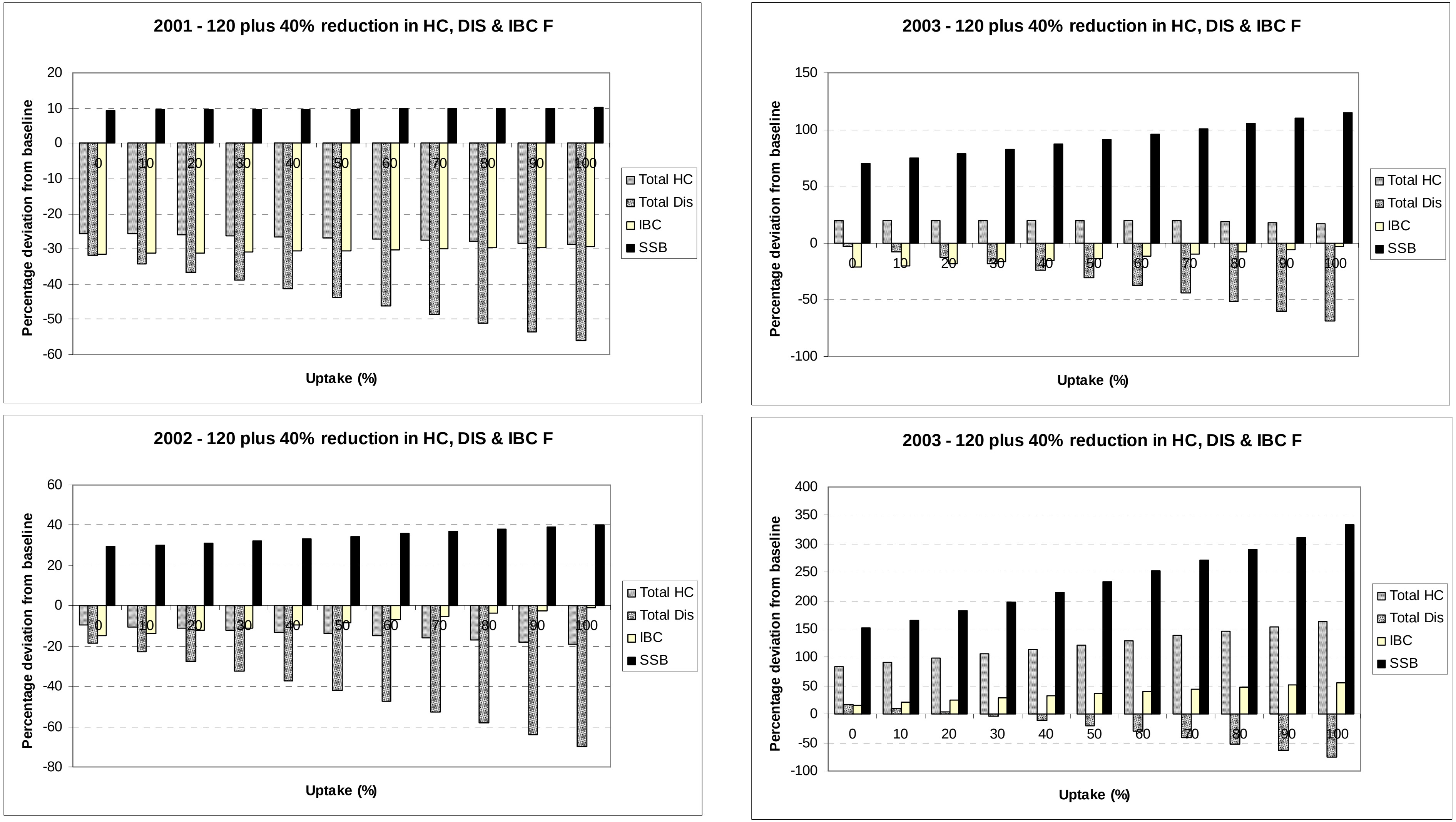


Fig. 3.2.4c North Sea HADDOCK. Results of gear selection simulations assuming gear effects and an additional direct reduction of 40% in fishing mortality attributable to both the human consumption and industrial fisheries.

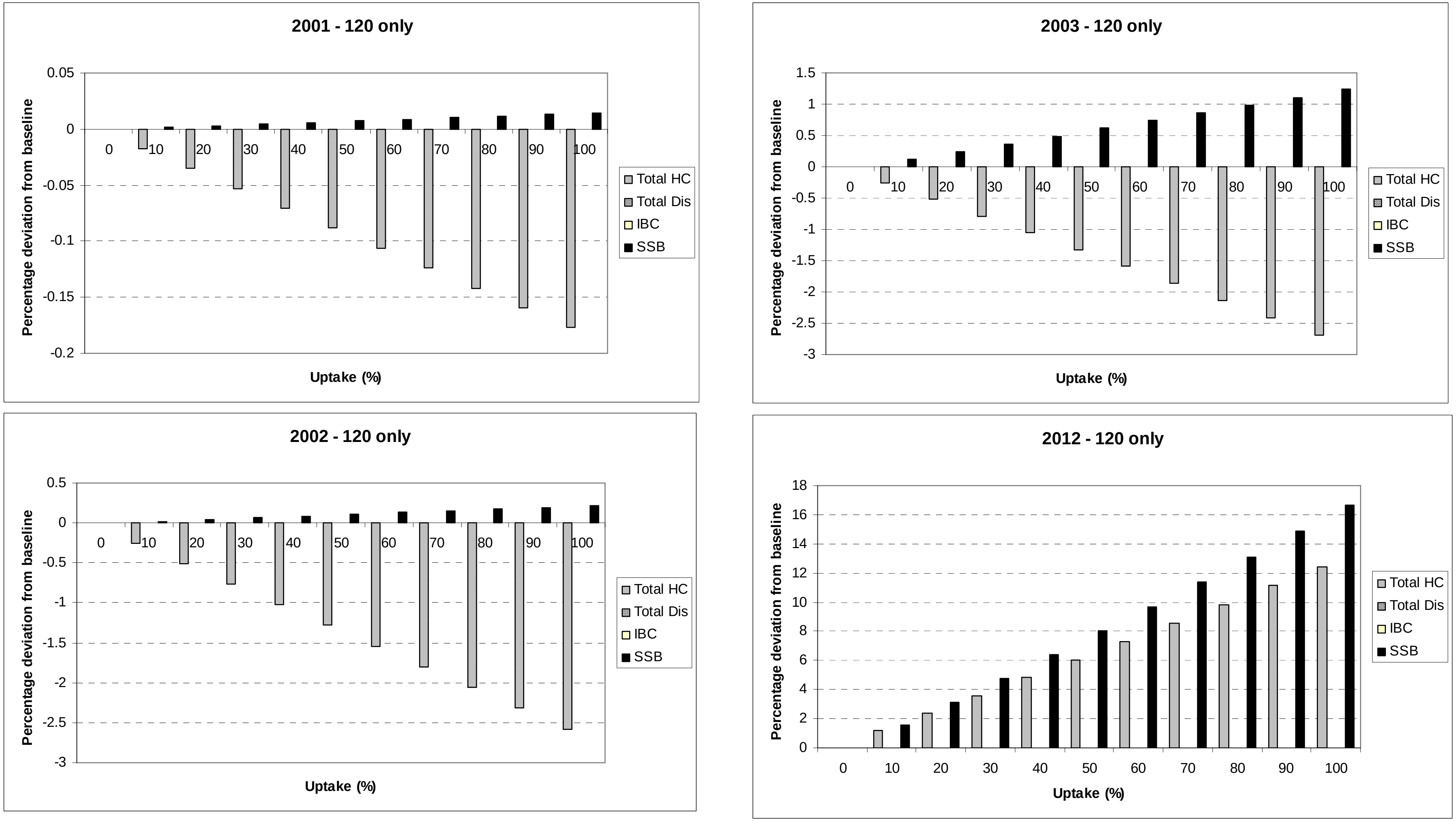


Fig. 3.2.5a North Sea COD (excluding discards). Results of gear selection simulations assuming gear effects only and no additional reductions in fishing mortality.

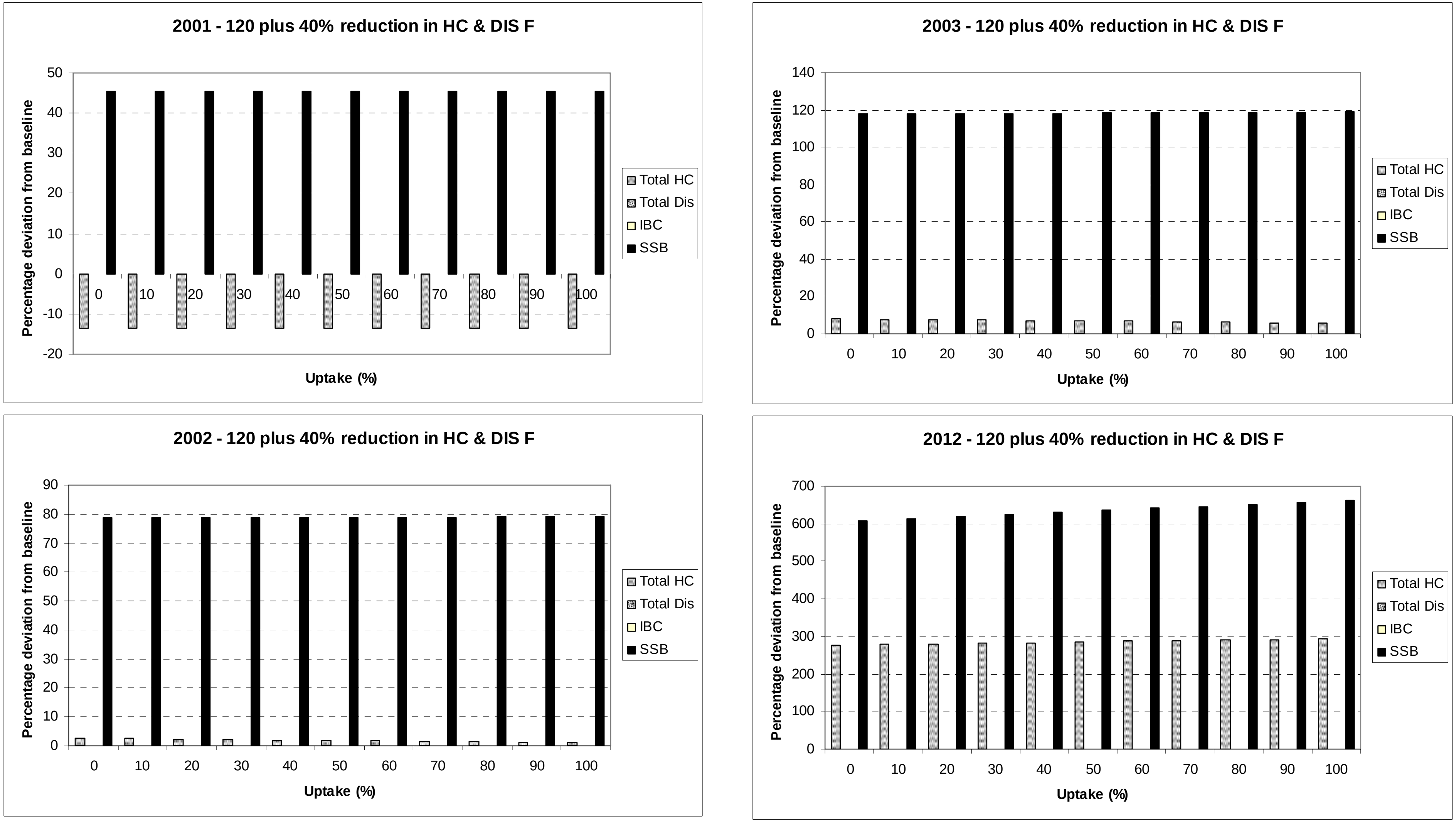


Fig. 3.2.5b North Sea COD (excluding discards). Results of gear selection simulations assuming gear effects and an additional direct reduction of 40% in fishing mortality attributable to the human consumption fishery.

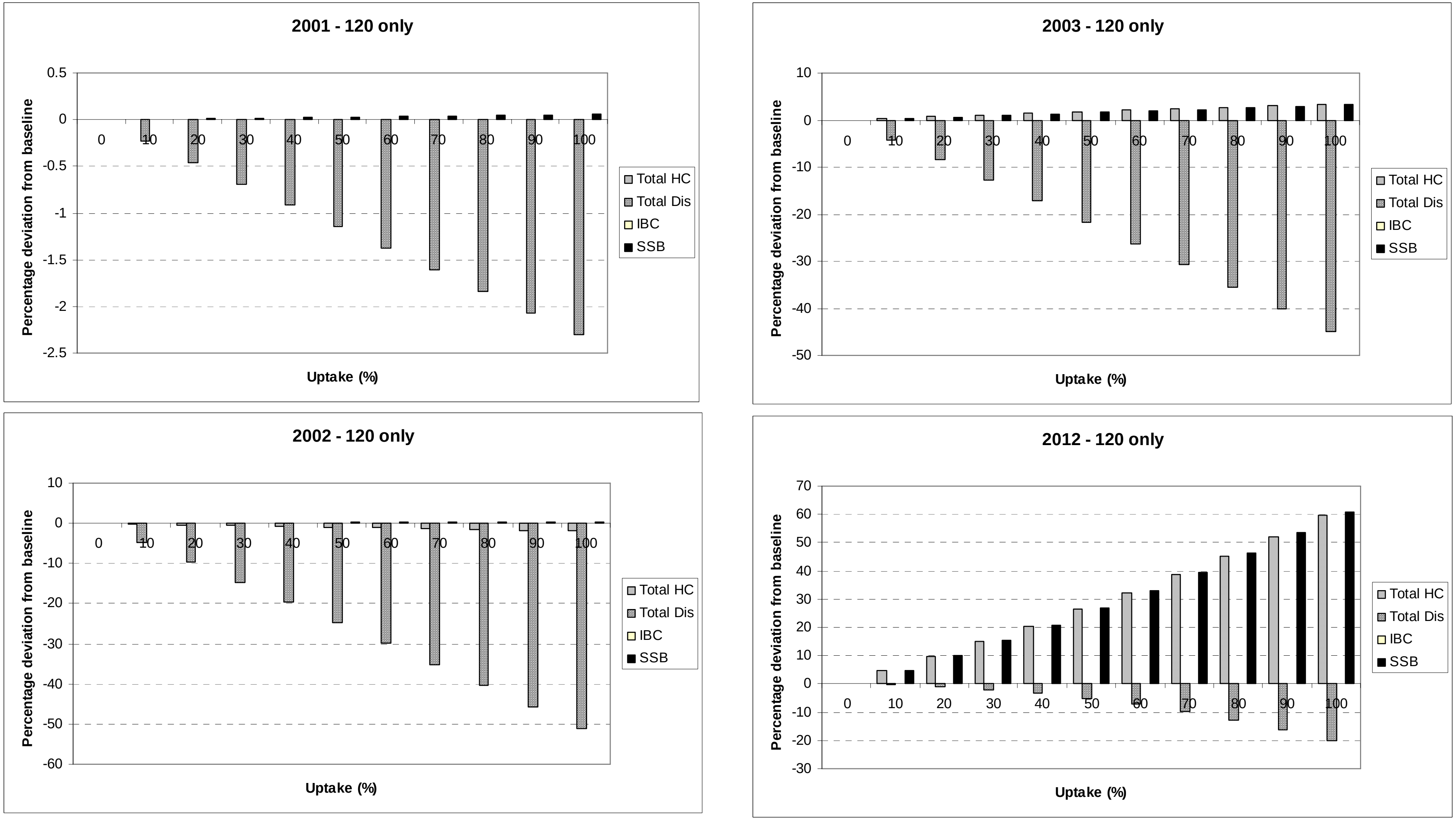
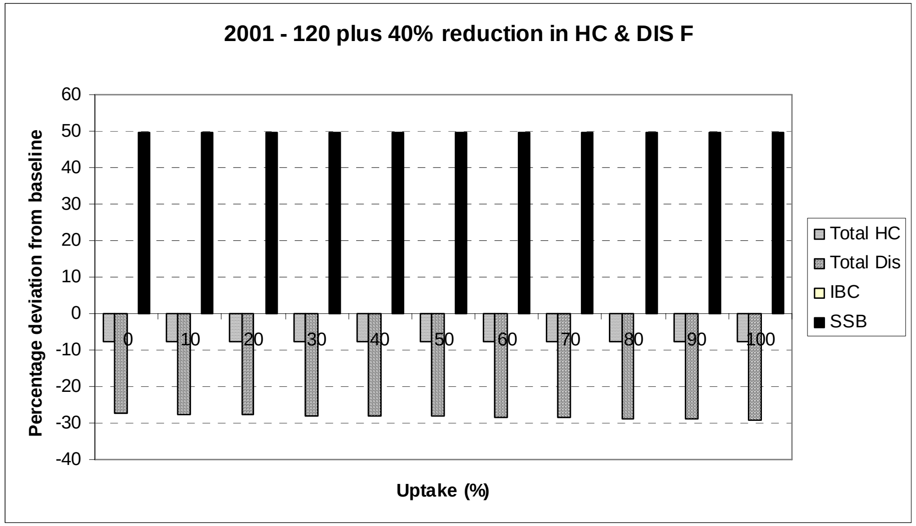
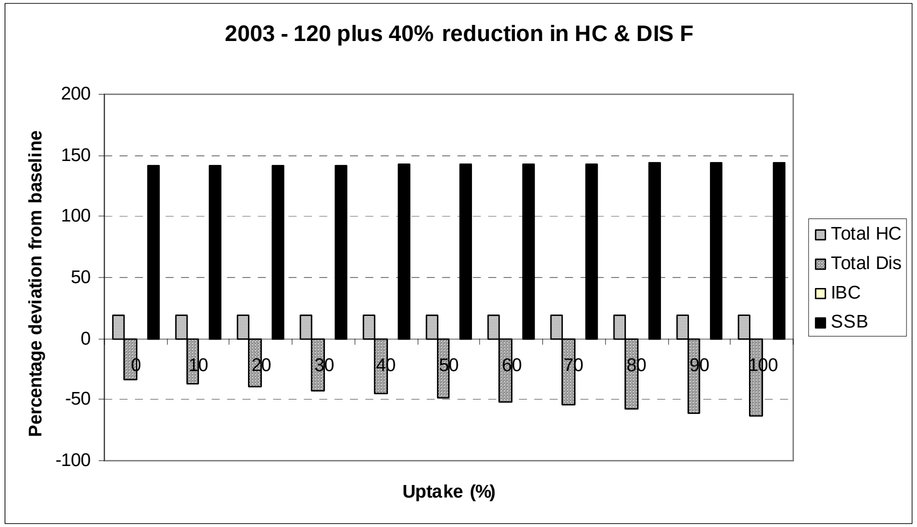
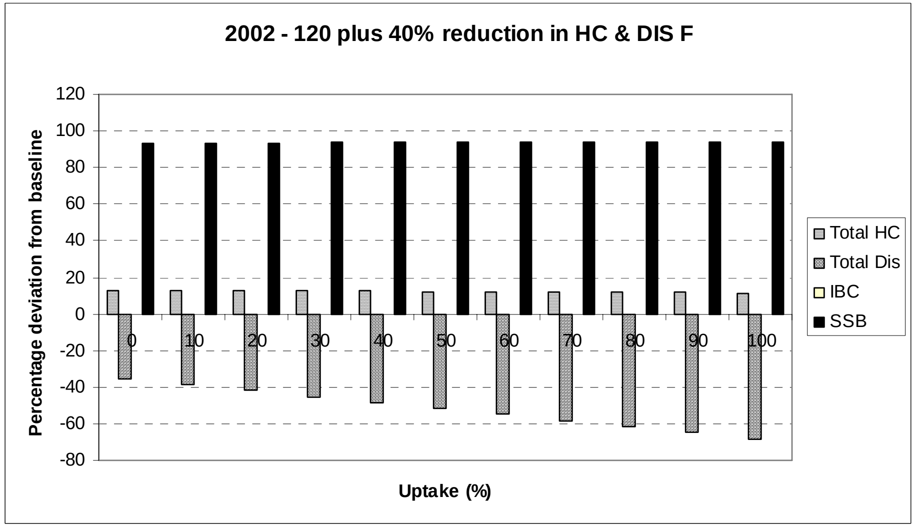


Fig. 3.2.6a North Sea COD (including discards). Results of gear selection simulations assuming gear effects only and no additional reductions in fishing mortality.







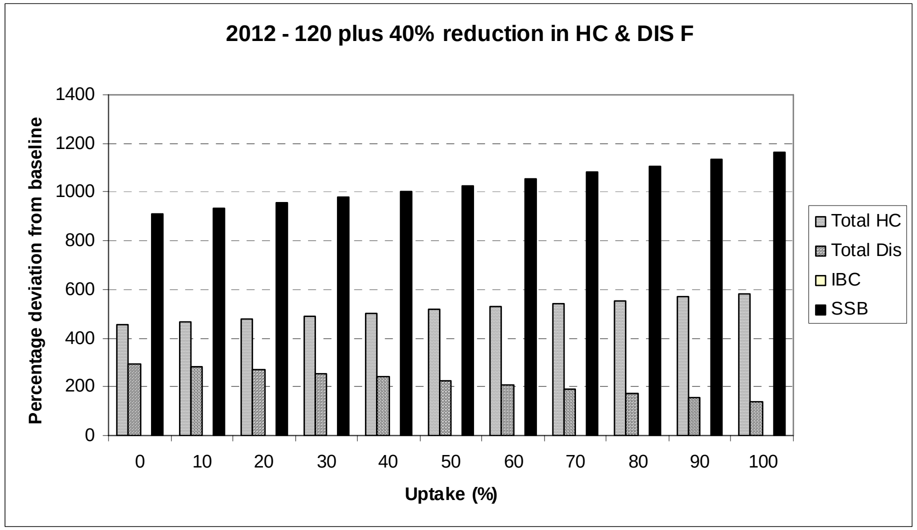


Fig. 3.2.6b North Sea COD (including discards). Results of gear selection simulations assuming gear effects and an additional direct reduction of 40% in fishing mortality attributable to the human consumption fishery.

3.2.3 The potential impact of 120mm minimum mesh sizes for ICES "Relevant Factors" for North Sea haddock and whiting

ICES' current (2002) advice for haddock and whiting in the North Sea is underwritten by its advice for cod in that area. Nevertheless, it has also indicated under "Relevant factors to be considered in management" what its advice for haddock and whiting would have been on the basis of the status of those stocks alone. For both species, advice would have been for a reduction in fishing mortality of 40%. In the case of haddock this would be to maintain SSB above B_{PA} in 2004 and 2005 and, for whiting, this would be expected to bring SSB up to B_{PA} in 2004. Simply on its own, this could be taken to indicate that ICES has disregarded the potential conservation impacts of the recent fishing gear regulations. However, subsequently in its relevant factors, ICES makes reference to these measures and, whilst reflecting that their effects have not yet been demonstrated in the available data, it does comment that the results of its evaluation of the potential impacts of measures are considered to be indicative of the likely impacts assuming full and effective implementation. This section explores in more detail the potential impacts of recent fishing gear regulations on the advised reduction in fishing mortality for these species, should their cases be considered in isolation from the cod advice.

The framework and data under which these exploratory forecasts have been made are broadly the same as those used in Section 3.2.1. The principal differences that were used in this analysis reflect the fact that ICES' advice is based on a specific stock status as of January 2002, and specific short term catch forecasts based on that. Consequently, this analysis replicates those stock projections, based on ICES' stock and mortality estimates for its inputs to projections (ICES CM 2003/ACFM:02 Appendix).

This work was undertaken prior to the current expert meeting. Consequently, there are some other differences in the formulation of the predictions compared with the work carried out in Section 3.2.1. There was no time available during the current meeting to eliminate such differences. The principal differences are:

- That EU110 and EU120 measures (see Section 3.2.!) were initiated at January 2002 subject to the uptake of the 110 mm derogation by 80% of applicable UK fishing mortality and 20% of non-UK fishing mortality;
- Separate UK110 and UK120 selection curves were not defined for this work.

Two scenarios were evaluated: (a) where the derogation for EU110 was removed from 2003 onwards, and (b) where the derogation continued.

Results are presented in graphical form and interpreted as explained below:

1. Upper graph - the projected spawning stock biomass of haddock in 2005 and of whiting in 2004 resulting from projections incorporating the potential effects of the fishing gear regulations alone. These are the quantities of concern regarding ICES' comments in isolation from its cod advice. In other words, do the gear regulations alone provide scope for the indicated fishing mortality reductions? If not, then what is the required level of reduction in addition to that provided by the gear regulations?
2. Middle graph - the mean fishing mortality rate on each stock according to the potential effects of the gear regulations alone;
3. Lower graph - the additional reduction in fishing mortality that is required in cases where the gear regulations themselves do not provide a sufficient reduction in fishing mortality to attain the relevant B_{PA} in accordance with the ICES relevant factors.

As with the forecasts in Section 3.2.1, the results are presented according to the percentage uptake of the measures. Furthermore, as in Section 3.2.1, this does not relate specifically to compliance levels, but to both the proportion of international fishing mortality that is modified by the gear measures and compliance.

For each species, forecasts have been made that assume (i) that the current 110mm derogation expires at the end of 2002, and (ii) that the 110mm derogation remains in place during 2003 and subsequent years.

Results are presented in Figures 3.2.7 (haddock) and 3.2.8 (whiting). Depending on the relevant uptake factor, the recent gear conservation measures if fully and effectively implemented, can be seen to contribute substantially to the fishing mortality reduction advised by ICES for haddock in isolation from the cod advice. If the 110mm derogation is continued after 2002, a greater additional reduction in fishing mortality is required than if the derogation expires at the end of that year. Ineffective implementation of the measures clearly negates their potential effect, requiring a greater reduction in fishing mortality through other measures.

The results are similar for whiting. For whiting, only if the uptake factor is less than 40% is there a projected requirement for any additional reduction in fishing mortality. The impact of the 110mm derogation continuing after 2002 is less severe for whiting than for haddock in terms of additional requirements for reduction in fishing mortality assuming full compliance.

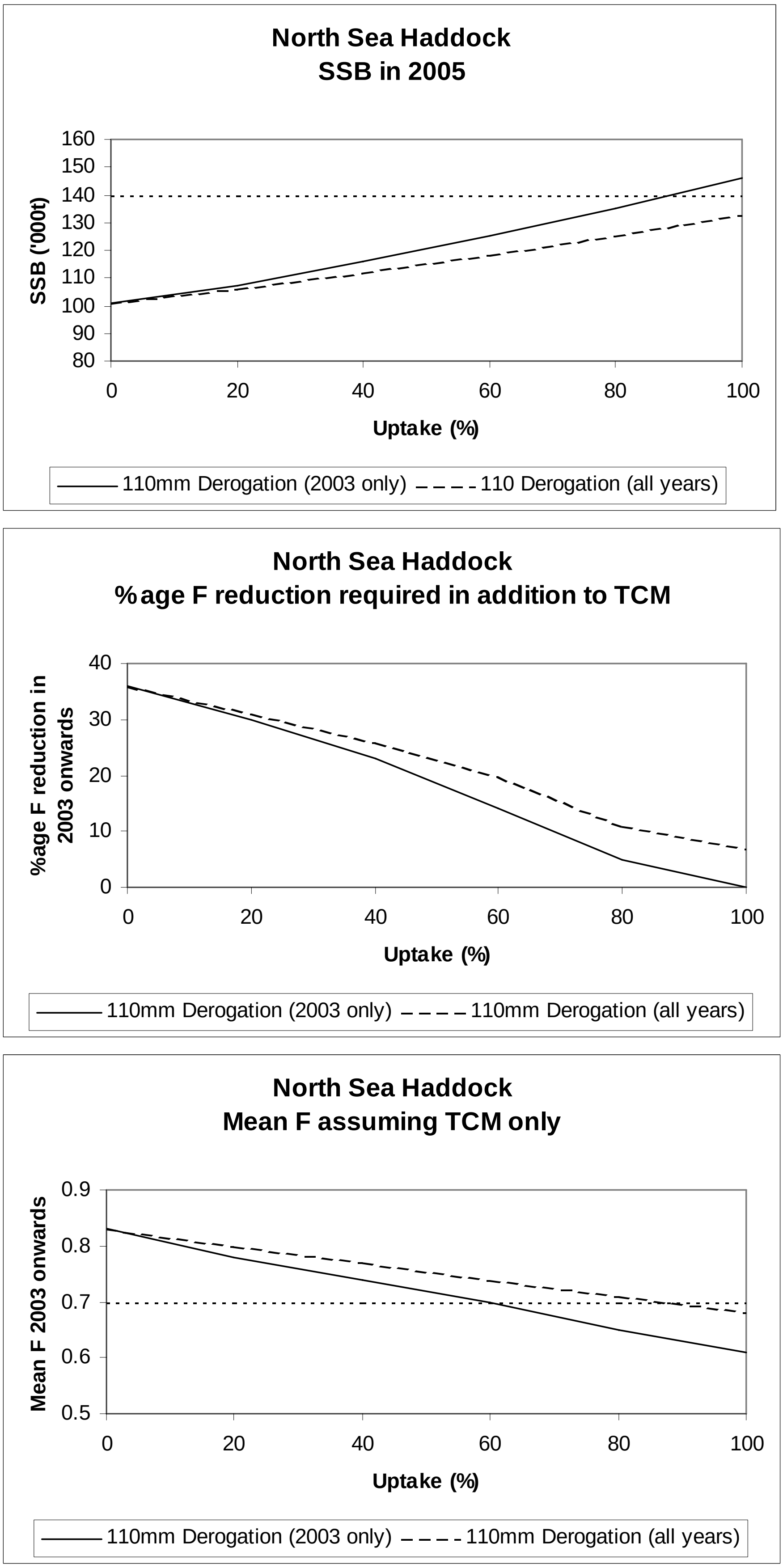


Figure 3.2.7 North Sea haddock, simulations considering technical measures – the dotted horizontal lines indicate BPA and FPA in the uppermost graphs.

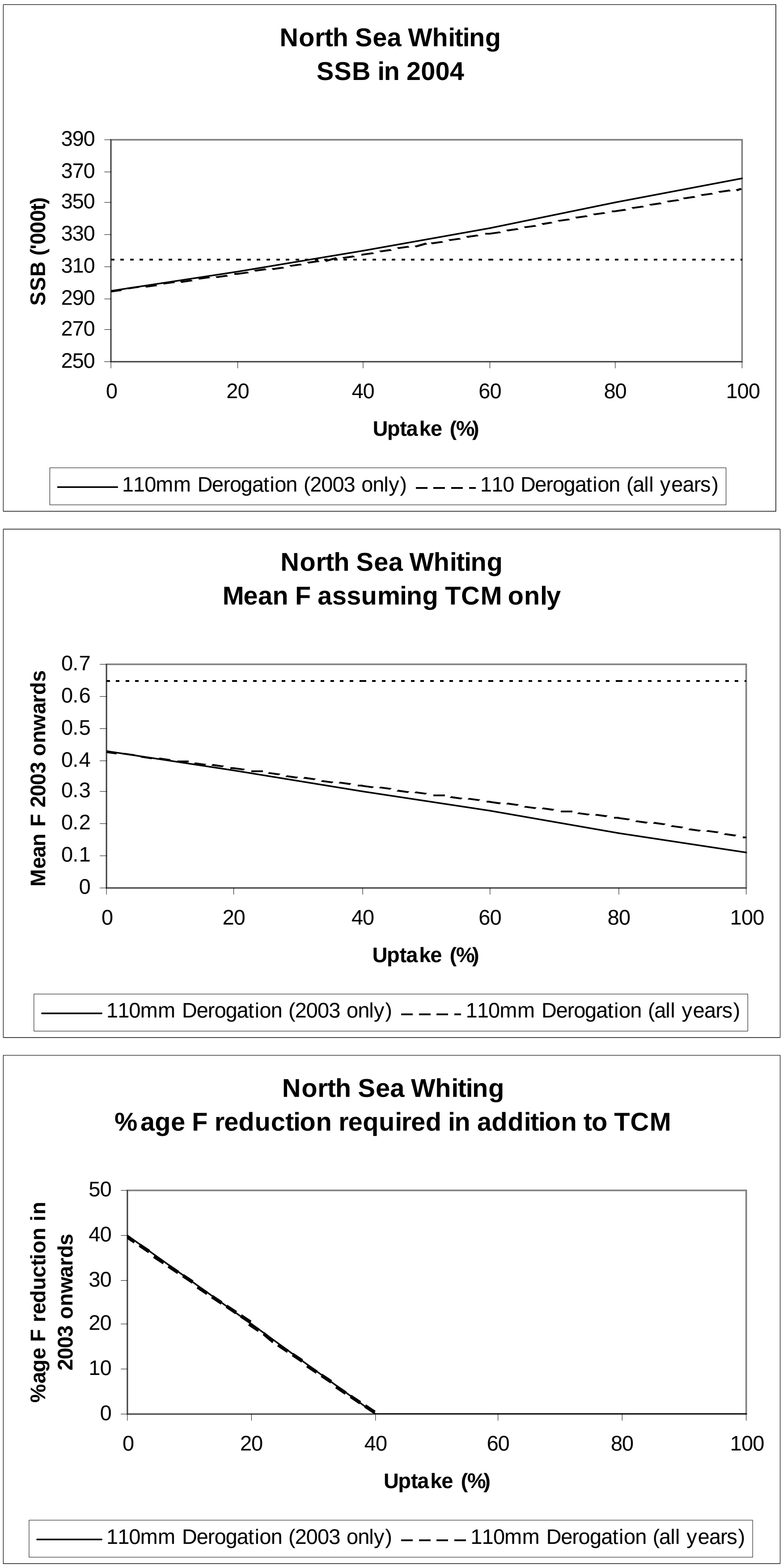


Figure 3.2.8 North Sea whiting, simulations considering technical measures – the dotted horizontal lines indicate BPA and FPA in the uppermost graphs.

3.3 Evaluation of further developments of technical measures (mesh size or other selectivity measures, closed areas, closed seasons, gear efforts) in terms of recovery potential, protection of juvenile fish and species separation in demersal fisheries (ToR b, e2, e3, e5, e6 and e8)

3.3.1 Proposals for technical conservation measures relating to gear design which may be applied in the short term

It has been shown (Section 3.2) that in principal improving the selectivity of fishing gears can substantially benefit the health of fish stocks by reducing mortality in juveniles and young adults. There is a body of evidence that indicates the key gear design features determining selectivity. An increasing number of these features are being regulated by legislation which however, is increasingly complex to frame and more difficult to enforce. Developments in gear design to achieve improved size or species selectivity are discussed in the following sections.

3.3.1.1 Protection of juvenile fish in demersal trawls

Current management strategy is to regulate fishing gear design such that the age at first capture of the main commercial species is delayed and significant numbers of fish survive long enough to spawn at least once. It may be an appropriate time to review for each species, the choice of minimum landing size (mls) based on assumptions regarding maturity at age (and hence length), the choice of target 50% retention length (L50) relative to mls and finally the choice of gear design that achieves this required L50.

a) Cod-end design
The analysis of selectivity data collected on commercial vessels since 1992 confirms that the significant design features affecting selectivity are mesh size, twine thickness, number of open meshes round the cod-end circumference and the presence of a lifting or strengthening bag. A new model of selectivity for cod, haddock and whiting has been developed (Appendix 5). The model provides estimates of the selectivity for cod, haddock and whiting in terms of these cod-end design features. Legislation has developed in recent years such that it is based on defined ranges of mesh sizes for specific gears and species. Mesh size is used as the main control of gear selectivity. It has been found necessary to set limits for other design characteristics such as twine thickness and number of open meshes in order to maintain a certain minimum selectivity. These limits are often determined from practical considerations relevant to each fishery. Once they are agreed with industry there should be no need for revision unless significant changes in technology take place (see comments on twine stiffness later). Thereafter any increase in selectivity can be achieved by altering mesh size. In some circumstances it may also be useful to use other devices such as square mesh panels e.g. to increase area of netting through which fish can escape.

Problems can arise however, when, for legitimate operational reasons, different sectors of the industry want to use alternative gear designs. Two examples illustrate the difficulty. First, in the French saithe fishery, stern trawlers take large catches and have made representations to this expert meeting that they need to use twine thicknesses larger than the maximum 5mm double twine currently allowed under Community law. By doing so the selectivity of their cod-ends will be reduced. Secondly, Scottish seiners and smaller trawlers in UK have traditionally used thinner twines and do not need to adopt cod-ends of heavy double 5mm twine with a lifting bag which are difficult to handle. However, they will be at a disadvantage relative to their competitors if they continue with thin twine as their gears will release more marketable fish. Individual derogations can be used to overcome each of these problems but they create complex legislation. An alternative is to allow a limited number of options for the key cod-end design characteristics, while maintaining the same selectivity over all these options. Using the selectivity model (Appendix 5), similar selectivity to the basic EU standard in these two cases is obtained by varying mesh size to account for required changes in twine thickness and the use of a lifting bag. The Table 3.3.1 below shows the change in mesh size needed to take account of the effect of twine thickness and a lifting bag to achieve similar 50% retention lengths (L50) and selection ranges (SR = L75-L25) for cod.

Table 3.3.1 Change in mesh size needed to take account of the effect of twine thickness and a lifting bag to achieve similar 50% retention lengths (L50) and selection ranges (SR = L75-L25) for cod.

Vessel	Mesh size mm	Twine size mm	Open meshes	Lifting bag	L50	SR
1. EU Standard	110	5	100	Allowed	32.5	6.9
French stern trawler	115	6	100	Allowed	33.0	7.0
2. EU Standard	120	5	100	Allowed	36.3	7.7
Small UK seiner/ trawler	110	4	100	Banned in UK	36.9	7.8

The mechanism by which the twine size has an effect on selectivity is not fully understood. The choice of twine thickness as a control variable was pragmatic in that this characteristic is relatively easy to measure. However, the stiffness of the twine is the actual property that limits the opening of the mesh and therefore reduces the selectivity. There has been a trend to use stiffer twines in some fisheries and further research is needed to assess the effect of these twines on selectivity.

Recommendations

- Review the relationships between minimum landing size, selectivity and gear design
- Consider urgently whether and how to ban the use of stiff netting twine materials (e.g. with wire core).

b) Square mesh panels

Whitefish trawls

The area of fish escape in a diamond mesh cod-end is relatively limited. Furthermore, the degree of mesh opening is influenced by the cod-end catch weight. Hence selectivity can be influenced by the cod-end catch weight (Anon, 1998, 2000; O'Neill and Kynoch, 1996; Madsen et al., 2002; Suuronen et al., 1991; Tschernij and Holst, 1999). A square mesh panel has the advantage that it provides a relatively large area with stable open meshes regardless of the catch weight. Square mesh panels extending to the end of the cod-end (BACOMA panel) have indicated very good selectivity properties for Baltic cod (Madsen et al., 2002) as well as for cod and haddock in the Skagerak (Madsen and Stæhr, 2003). Square mesh panels positioned up to 9m from the cod-line have been shown to increase the L50 for haddock and whiting significantly in the North Sea (Graham and Kynoch, 2001; Graham et al., 2002). A further consideration is that, unlike roundfish, the selectivity of plaice is lower for square than for diamond meshes of the same mesh size (Madsen et al., 1997). For sole, square and diamond mesh cod-ends are equally selective (Fonteyne and M'Rabet, 1992). In nets targeting flatfish, square meshes can consequently be a way to improve selectivity of roundfish without necessarily releasing more flatfish.

In general, the position of a square mesh panel should be as far back as is practically possible to improve fish escape. There might, however, be problems with the strength of square mesh netting if it is positioned in the aft part of the cod-end. The mesh size of the square mesh netting should be chosen relative to the mesh size of the diamond mesh netting in the cod-end to give about the same selectivity.

Recommendation

- Consider the application of square mesh panels in whitefish trawls in certain fisheries (e.g. where mesh size is lower than 120mm) as a means to increase areas available for fish escape.

Nephrops trawls

Square mesh panels can improve the selectivity of roundfish species in *Nephrops* trawls without influencing *Nephrops* selectivity (Madsen et al., 1999). In principle, the selectivity of roundfish in a *Nephrops* trawl should be similar to that of a demersal towed whitefish trawl. Therefore the mesh size of the square mesh panel should be harmonised to give about the same L50 as for whitefish trawls (with current minimum mesh size of 120mm). This would require a mesh size of the square mesh panel around 100mm compared to the current sizes of 80 and 90mm. The position of the panel should be precisely specified in the legislation and should be as far back as practically possible to improve escape of haddock, cod and whiting, although the optimum position for other species such as hake may be different. Positioning the panel too far aft could however, give an undesirable loss of the *Nephrops* target catch.

Recommendation

- Optimization, if possible, of panel size, panel mesh size and panel position in *Nephrops* trawls
- Consider the use of a single mesh size for square mesh panels designed to enhance the escape of roundfish in all *Nephrops* trawls

c) Grids

Whiting trawls

The SAUPLIMOR project (Mortreux et al., 2001) aimed at developing a selective device which allows plaice and cod juveniles to escape from 80mm whiting trawls used by the artisanal fleet from Boulogne/mer in area VIId. Four series of sea trials were conducted in 1999 and 2000 to test an aluminium grid with bar spacing of 25 mm.

A by-catch of cod is taken by this fleet during spring and autumn in an area close to Boulogne. The species concerned in that multispecies fishery are plaice, cod, whiting and sole. The size of the cod caught in spring is close to the minimum landing size and discarding has been reported. In autumn, the size of all the cod caught is greater than the minimum landing size and there are no discards of cod during that season.

During spring the grid (compared to the standard 80mm trawl) allows escapes of fish less than the minimum landing size, of 24% (2%) for cod, 68% (19%) for whiting and 26% (1%) for plaice. In autumn, there is no difference for cod (no cod smaller than MLS are caught) but the grid (compared to the standard 80mm trawl) allows escapes of 53 % (20%) for whiting and 35% (17%) for plaice. No significant difference appears for sole in spring and autumn.

The good selectivity for whiting is offset by losses of marketable fish of 34% for the grid compared to 6% for the standard trawl. The material used for the grid needs futher improvement before it can be used under commercial conditions.

Recommendation

- Investigate the application of grids in trawls with a mesh size under 120mm

Pandalus trawls

Experiments conducted with a grid system in the North Sea shrimp fishery showed a relatively large and significant reduction of cod, haddock and whiting (Madsen and Hansen, 2001). Grids are mandatory in shrimp fisheries in many areas in the North Atlantic. Several vessels use grids voluntarily in the North Sea and Skagerak Pandalus fishery.

Recommendation

- Consider a general use of grids in Pandalus fisheries

3.3.1.2 Improved species separation

Mixed fisheries often create high discarding because of the differences in species size and shape and hence in selection characteristics. Species separation allows either the creation of single species fisheries by retention of only the target species or the opportunity to ensure that each is subject to appropriate selection e.g. in separate cod-ends, each of appropriate mesh size.

Whitefish and *Nephrops* trawls

a) Horizontal panels

Species specific behaviour in the mouth or main body of a trawl has been used to separate species. An additional panel can be inserted inside the net to separate the species into two compartments. The particular objective of this gear is to improve selectivity for larger species while maintaining the marketable catch of all commercial species in a mixed fishery. The horizontal panel is placed inside the net with its leading edge level with the centre of the groundrope and extending to the end of the tapered section where two extensions and cod-ends are attached. Separating panels are appropriate for trawls with a minimum mouth vertical opening of 2m. Generally haddock, whiting and saithe enter the upper cod-end and flatfish, cod, *Nephrops* and monks enter the lower although the height of the panel has a major influence on the separation achieved.

Different mesh sizes can be used in each cod-end. Very good separation has been achieved in inshore waters (Main and Sangster, 1985; Arkley and Swarbrick, 1996) for cod, *Nephrops*, flatfish and haddock but whiting do not separate so well. In deeper offshore waters (Bailey et al., 1983; Anon, 1993) clear separation of haddock, whiting and Norway pout was not achieved. Developments of this technique to produce different separation results are discussed under section 3.3.2. The percentage of the catch of each species retained in the lower cod-end of the separator trawl with a horizontal panel is given below.

Table 3.3.2 Percentage of the catch of each species retained in the lower cod-end of the separator trawl with a horizontal panel.

Target species		By-catch species		Experiment
Nephrops	100	Cod Haddock Whiting	100 11 45	Report by Main & Sangster, 1985
Cod Lemon sole Plaice	71 - 85 89 - 97 87 - 99	Haddock Whiting	2 - 5 3 - 6	Report by Arkley and Swarbrick, 1996

There are a number of issues to be considered in relation to the implementation of technical measures on full-length horizontal separating panels:

1. Cost. A panel increases the cost by ~30%.
2. Rigging. Height and position of panel relative to the footrope is critical to achieve good separation. The design and rigging of the panel itself may need to be adapted for each net design.
3. Enforcement. Legislation may be difficult to frame and compliance difficult to assess.
4. Incentives. The uptake of this type of beneficial development might be enhanced by provision of incentives.

Recommendations

- Because of the possible difficulties of describing separating panels in legislation there is a need to consider circumstances under which horizontal separator panels could be adopted voluntarily by industry.
- Horizontal panels may be useful in separating cod, *Nephrops*, flatfish and monks from haddock and whiting. Further options are considered under research proposals (Section 3.3.2).

b) Inclined panels

This design has been permitted in certain closed areas of the Irish Sea (Cod recovery plan – Council Regulation (EC) N° 304/2000) since February 2000. A short inclined netting panel in the last tapered section of the net ahead of the cod-end. A gap around 30 cm is provided under the leading edge of this panel to allow *Nephrops*, monk and flatfish to pass through into the cod-end while cod and other whitefish are diverted upwards to an escape opening. A similar design can be produced with a dual cod-end which allows the roundfish to be retained in an upper cod-end of appropriate mesh size, but this gear has not yet been introduced into legislation.

The percentage of each species retained in the lower cod-end of the separator trawl with inclined panel is given in the table below. It is reported that the cod retained in the lower cod-end are mainly juveniles.

Table 3.3.3 Percentage of each species retained in the lower cod-end of the separator trawl with inclined panel.

Target species		By-catch species		Experiment
Nephrops	no data	Cod	15 - 35	Irish Sea 2000 Report by BIM, 2001
Nephrops	80	Cod Haddock Whiting	21 16 41	FRS, Firth of Clyde, Report by Anon 2001

Recommendation

- Investigate the use of inclined panels in specific mixed demersal fisheries

c) Low headline and/or cut back headline

A low headline in a *Nephrops* trawl will reduce the catch of haddock and whiting by about 30% and will retain *Nephrops* as well as catches of flatfish and monk. The effect on cod is less clear: mature cod may be released but most of the juveniles will be caught.

The percentages of each species retained in a low headline trawl compared to a trawl with standard headline height (100%) are:

Target species		By-catch species		Experiment
Nephrops	96	Cod	109	Seafish
		Haddock	29	Firth of Clyde,2002
		Whiting	28	Report by Anon, 2002

Cutting back the headline will result in a similar effect. The percentages of each species retained in a cut back headline trawl compared to a trawl with standard headline (100%) are:

Nephrops	120	Cod	89	Seafish 2003 (unpublished)
		Haddock	37	
		Whiting	35	

Recommendation

- The low and cut back headline designs are cheap and may help towards creating a single species (*Nephrops*) fishery. They may not have an effect on cod catches, however.

d) Square mesh panels
Square mesh panels can be used for separation of certain species such as *Nephrops* or flatfish from roundfish. This objective is considered along with the protection of juvenile roundfish under section 3.3.1.1.

e) Large diamond mesh top panels
These panels are mandatory in *Nephrops* trawls from January 2003. They are designed to improve the selectivity of roundfish that rise as they enter a net mouth. However, they could be made more effective by lengthening the panel, at least in larger trawls, beyond the 15 meshes length currently specified. A net with a cut back headline takes this design to the limit by effectively removing the panel completely.

Recommendation

- Optimization of the size of large diamond mesh panels in *Nephrops* trawls or the use of cut-back headline trawls.

Beam trawls

Species separation in beam trawls is based on differences in behaviour between different species. Solutions have been presented in the EU funded SOBETRA project (Fonteyne, 1997). A problem is that in the mouth of the net, cod, like flatfish, stay close to the bottom. Cod may be more effectively selected in the cod-end, e.g. by using square mesh panels. Another option is lowering the headline. These possible solutions will be investigated in the EU RECOVERY project (see 3.3.2).

a) Cut back headline

Cutting back the headline creates an escape area for roundfish, especially whiting and haddock. This modification is less efficient for cod. The degree of success depends on vessel and gear size. The reason is that on smaller vessels using smaller nets the escape area cannot be made sufficiently large to allow adequate escape of roundfish without incurring large losses of flatfish. Possible legislation should take into account the dimensions of the escape zone (extending from the headline to the joining round with the square).

The SOBETRA project (Fonteyne, 1997) yielded the following % difference between the numbers of fish caught with nets with an escape opening and the corresponding standard nets. Results of experiments with too low numbers of fish to draw firm conclusions are placed in brackets.

Table 3.3.4 Percentage difference between the numbers of fish caught with nets with an escape opening and the corresponding standard nets

Country/Vessel	Cod	Whiting	Haddock	Sole	Plaice
Chain matrix nets (R-nets)					
BE 300 hp	(-6)	-13	no data	+1	-6
BE 1200 hp	+5	-38	-24	+2	-1
UK 294 hp	-5	no data	-15	-1	+8
UK 945 hp	-18	no data	+18	+22	-17

Recommendations

- Cutting back the headline is a cheap solution to increase species selectivity.
- The effect on the flatfish target species is low but a lower by-catch of marketable roundfish, especially whiting, is likely.
- The effect on cod catches is small.

b) Large diamond mesh top panels

The use of a 180mm mesh selection panel has been made mandatory since 1 January 2002 (Commission Regulation (EC) No 2056/2001). Comparative fishing experiments with chain mat gears (R-nets) have been made to compare catches obtained by a 4m beam trawl equipped with a 180mm mesh panel with those of a standard trawl by the Belgian Sea Fisheries Department (Fonteyne, personal communication). For roundfish, data are only available for whiting, showing an overall decrease in numbers of 23%. The window had no effect on the target species sole.

It can be expected that the effect of the panel in larger beam trawls will be more pronounced as the size of the panel is dependent on the beam length. The larger the panel, the more opportunities fish have to escape. This is confirmed by experimental work on 4m beam trawls in which the whole top panel was made of 180mm meshes. The reduction in numbers of whiting caught rose up to 46 %.

No data are available for the release of cod by 180 mm panels. From the SOBETRA project it is known that very large mesh (mesh size 1000-2500mm) panels (size about 50% of top panel) may be efficient in reducing cod catches in tickler chain beam trawls, as indicated in the table.

Table 3.3.5 Reduced cod catches in tickler chain beam trawls.

Country/Vessel	Cod	Whiting	Haddock	Sole	Plaice
Tickler chain nets (V-nets)					
NL 300 hp	-38	(-36)	no data	-10	-14
NL 1500 hp	(-36)	No data	no data	no data	-1
NL 2000 hp	(-34)	-31	no data	-2	-6

Very large mesh panels are probably less efficient in beam trawls equipped with chain matrices as these nets are much shorter and may not allow for a sufficient large panel that would release roundfish efficiently without flatfish losses.

Recommendations

- The effect on cod of the present 180mm panels is doubtful, especially for smaller gears.
- The species selectivity of beam trawls could be improved by increasing the panel size of the 180mm mesh section or the mesh size or both. The penalty, however, is an increased loss of target flatfish species.

- Adaptation of existing gears is relatively cheap.

3.4 Identification of areas of research of particular benefit for reducing cod catches whilst maintaining other fishing opportunities (ToR e8).

Two major EU funded projects aim to develop techniques to separate species in many fisheries throughout EU waters from the Baltic to the Mediterranean. Project RECOVERY (Contract No Q5RS-2002-00935) includes studies of whitefish trawls with a raised footrope or a horizontal panel, of beam trawls with a low headline or square or large mesh panels and of *Nephrops* trawls with a low or cutback headline or large mesh panels. Proposal NECESSITY will concentrate on species separation in EU *Nephrops* fisheries.

Length selectivity

a) Netting twine characteristics (e.g. stiffness/resistance to opening)

There is a tendency towards use of stiffer netting materials in the cod-ends in several fisheries. The relative twine stiffness, rather than the twine thickness, might be the actual property that determines the resistance to opening of the mesh. Further research is needed to assess the effect of stiff twines on the selectivity properties of cod-ends.

b) Use and optimization of square mesh panels

The selectivity of cod in beam trawls may be improved by applying square mesh panels in the cod-end. The principle is described in section 3.3.1. This solution may be especially useful in R-nets (chain mat gears) where due to the short top panel, species separation is more difficult (see section 3.3.1.2 Beam trawls). Research on this topic will be performed in the RECOVERY project. Further research is needed on the optimum position of square mesh panels for releasing whitefish in trawls with mesh size less than 120mm, e.g. Nephrops trawls. In smaller trawls for low powered vessels, placing the square mesh panel in the tapered section should be considered.

c) Open diamond meshes

Knotted netting in square mesh panels may suffer from knot slippage after repeated loading. This effect depends on quality of the netting, weight of catches, way of handling the cod-end.

A solution could be the use of a panel with open diamond meshes, e.g. by using short selvedge ropes around the panel. Research is needed to determine the appropriate panel size, mesh size and rigging.

d) Standard cod-ends of large diamond mesh size

In recovery plans aiming to increase the selectivity of towed gears, increases in mesh size are regularly proposed. However, information on the selectivity of standard diamond mesh cod-ends with mesh size over 120 mm is scarce but urgently needed in order to provide input to stock prediction models.

Species selectivity

a) Improving of technical performance, handling and selective properties of grids

A sorting grid was tested in the industrial fishery for Norway Pout (Eigaard and Holst, 2003). Experimental fishing with a commercial trawl showed improved selectivity with reductions of haddock and whiting of 37 and 57%, respectively. The reduction of cod was more than 80% but few cod were caught. The loss of Norway pout was estimated to be less than 10%. The grid selectivity with 24mm bar distance was very constant with a L50 of approximately 22.6 cm for haddock, whiting and Norway pout. A reduction of the bar distance would lower the L50 of the grid and secure an even larger release of undersized cod, haddock and whiting, but it would also inflict an increase in the loss of Norway pout and hence the ability to maintain an economically sustainable fishery. The experiment indicated a potential management option. However, further research is needed to improve the grid design before it can be used under commercial conditions.

Grids have shown good performance to separate small from big fish or sometimes fish from crustaceans. Their use is still limited as fisherman complain about their endurance and the handling of heavy structures in a textile fishing gear. Some grids have already been developed in new light plastic materials solving problems due to the weight of the grid.

Research is needed on new flexible grids for solving handling problems caused by weight and rigidity. A more flexible grid was tested during the EUROGRID project (FAIR CT-98-3536), but it was not efficient enough in term of selectivity. The shape must be reconsidered and adapted to the shape of the cod-end. New highly flexible grids are now at the prototype stage and need to be tested.

b) Optimisation of square and large mesh panels

The use of square and large mesh panels in the body of the trawl requires further investigations to improve the release of roundfish especially in *Nephrops* trawl and beam trawls. Selectivity data should be obtained. Parameters such as mesh size and panel size and position should be included. These topics will also be dealt with in the RECOVERY project.

c) Rising ropes with set back horizontal panel
This device is a modification of the standard horizontal panel which is set back further behind the footrope. A series of rising parallel ropes are attached from the footrope to the leading edge of the horizontal panel. Preliminary results have shown that prawns and flatfish will drop between the rising ropes and enter the lower cod-end. Gadoids will tend to be guided upwards to enter the upper cod-end. The panel rigging should be less critical in this design. However, small roundfish may not be separated as well as larger individuals. No data on separation are available for this gear. Reseach is needed on this device which could provide an opportunity to adapt the horizontal panel for the cod recovery plan.
d) Raised footrope
Cod tends to keep low in the trawl opening. It is believed that it is possible to reduce the cod catch if the cod is allowed to go under the footrope gear. There is a need for research into the effect of a raised footrope in trawls. This topic will also be dealt with in the RECOVERY project.

e) Headline height of *Nephrops* trawls and beam trawls
A very limited headline height is required to retain *Nephrops* and flatfish. In such a design roundfish species can escape over the headline. There is a need for research into the effect on the roundfish catch in *Nephrops* trawls and beam trawls with very low headline heights. A low headline will be tested in the RECOVERY project.

Behaviour studies

For species selectivity the concept of each separating device should be based on the different behaviour of the species caught. There is a need for more information on species specific behaviour ahead of and in the mouth of the net at different light levels. New observation techniques need to be developed to achieve this. Also in size selectivity studies, it is important to know the differences in behaviour between juveniles and adults in the areas where selectivity occurs.
There is a lack of knowledge of species behaviour in relation to gill nets and trammel nets. The potential in developing species selective nets should be investigated.

Survival studies

Many studies have been carried out and the methodologies used in the experiments are constantly improving. There is a need of standardisation of the methods in order to obtain comparable data. A current EU funded contract (Q5RS-2001-01693) is studying this subject and aims to produce survival rates for gadoids escaping from diamond mesh at different seasons. Survival of flatfish escapees has not been studied to the same extent as roundfish and research is needed especially on the beam trawl escapees.

There is no knowledge about survival rates of fish which escaped from gill nets. This is an important research area since gill nets are relatively size selective and many smaller fish will get in contact with the nets and escape.

4 Identification of cod spawning areas in the North Sea, evaluation of permanent closures in terms of biological and economic impact. Identification of areas, which would need to be closed in order to remove 80%, 60%, 40 % and 20 % of the fishing possibilities for cod in the North Sea

4.1 Identification of cod spawning areas in the North Sea (ToR c)

4.1.1. Historical distributions of spawning cod

Historical information on cod spawning grounds is available from surveys of their pelagic eggs and ripe adults. The information available is patchy since there has never been a comprehensive survey of eggs or spawning cod throughout the North Sea and most survey data pre-dates the recent decline in the size of the spawning stock.

The timing of cod spawning is shown in Figure 4.1.1. Spawning takes place from the December through to April, with a tendency towards later timing with increasing latitude (Hislop, 1984; Brander, 1994). Only a few studies have sampled eggs or spawning fish throughout this protracted season. In the more northern areas spawning may be associated with subterranean banks on which the spawning fish may aggregate.

A number of compilations of various sources of historic data exist. Wright et al. (2003) provided a working document which summarised the majority of historical sources. Information on spawning areas during the early part of the last century was presented by Graham (1934), West (1970) and Anon (1971). The distribution of spawning cod after 1945 (Figure 4.1.2) was partially described in Daan (1978) and ICES (1994). Other studies include those reported by Graham and Carruthers (1925), Harding (1987), Saville (1959), Raitt (1967), Heath et al (1994), Heesen and Rijnsdorp (1989), Van der Land et al. (1990). A summary of the distributions of cod spawning since 1945 is given in Figure 4.1.2 (from Daan, 1978).

4.1.2. Recent distribution of spawning cod

More recent information is available from the ICES International Bottom Trawl Survey which has been conducted in a standardised way since the mid-1970s (IBTS Q1). The surveys were not specifically designed with the intention of mapping the distribution of spawning fish and the timing of the survey only covers part of the spawning season (February). Nevertheless, as a proxy for the distribution of adult cod, distributions of age groups three and older (3+) may be used to give an indication of where mature fish are likely to spawn. However, the Group notes that the proportion of 3-year-old cod that are mature is assumed by ICES to be 23%, so the plots may be give a biased impression of the distribution of mature fish.

The distributions of 3+ cod since 1976 expressed as number per hour per ICES rectangle is summarised in Figure 4.1.3. The plots show the average catch rate of 3+ fish per ICES rectangle in terms of numbers per hour. Plots showing the approximate biomass of 3+ cod for the same time periods are shown in Figure 4.1.4. The biomass estimates are derived from the sum of the average catch rate in Number per hour at age multiplied by the annual mean weight at age from the 2002 ICES WG on the assessment of demersal stocks in the North sea and Skagerrak. In terms of numbers (Figure 4.1.3), cod age 3+ are distributed over the whole of the North Sea and Skagerrak but there are clearly defined areas of highest density, notably the central part of the northern North Sea and along the western and northern edge of the Norwegian trench. In some periods densities were also higher than average off the eastern coast of England and in the Southern Bight.

Comparing Figures 4.1.3 and 4.1.4 there are some obvious differences. The most obvious differences occur for the years prior to 1991, where there appears to be relatively higher biomass of 3+ cod in the central North Sea than in the periods 1991-1995 and 1996-2000. This is a reflection of the fact that the 3+ biomass at that time comprised relatively greater number of older fish than in the period after 1990.

Figure 4.1.5, shows the distribution of 3+ cod as both numbers and biomass for the years 2001, 2002 and 2003.

The distribution of cod age 3+ form the IBTS Q1 survey series indicates that there are no discrete areas that can be identified as spawning areas, although their distribution is likely to be a reasonable representation of the potential extent of cod spawning.

Since 2000, the highest densities of 3+ cod were found in approximately the same areas as they have been observed in previous years of the survey time-series, but their overall density is lower, reflecting the decline in the stock over the last 10-15 years. There is an apparent greater reduction in the relative densities of 3+ cod in the southern and central North Sea and German Bight, and this may be an indication that as the stock has declined, their distribution has contracting into smaller areas. In the last three years, the highest densities of 3+ cod have been observed in the deeper waters of the northern North Sea and in the central North Sea.

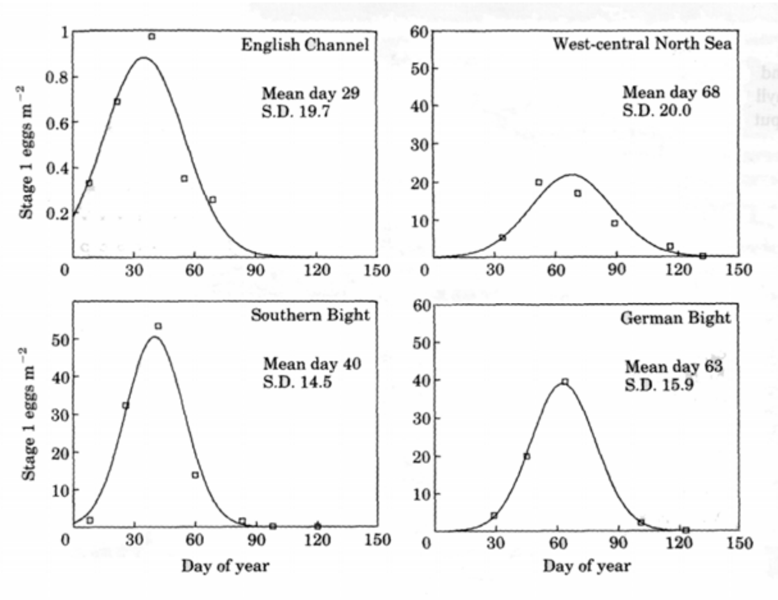


Figure 4.1.1. Timing of spawning of North Sea cod. The figure depicts the abundance of stage I cod eggs and fitted normal distributions with mean dates of spawning and standard deviations. For the English Channel cod eggs of all stages are amalgamated because abundance of stage I eggs was too low to give an estimate (from Brander, 1994).

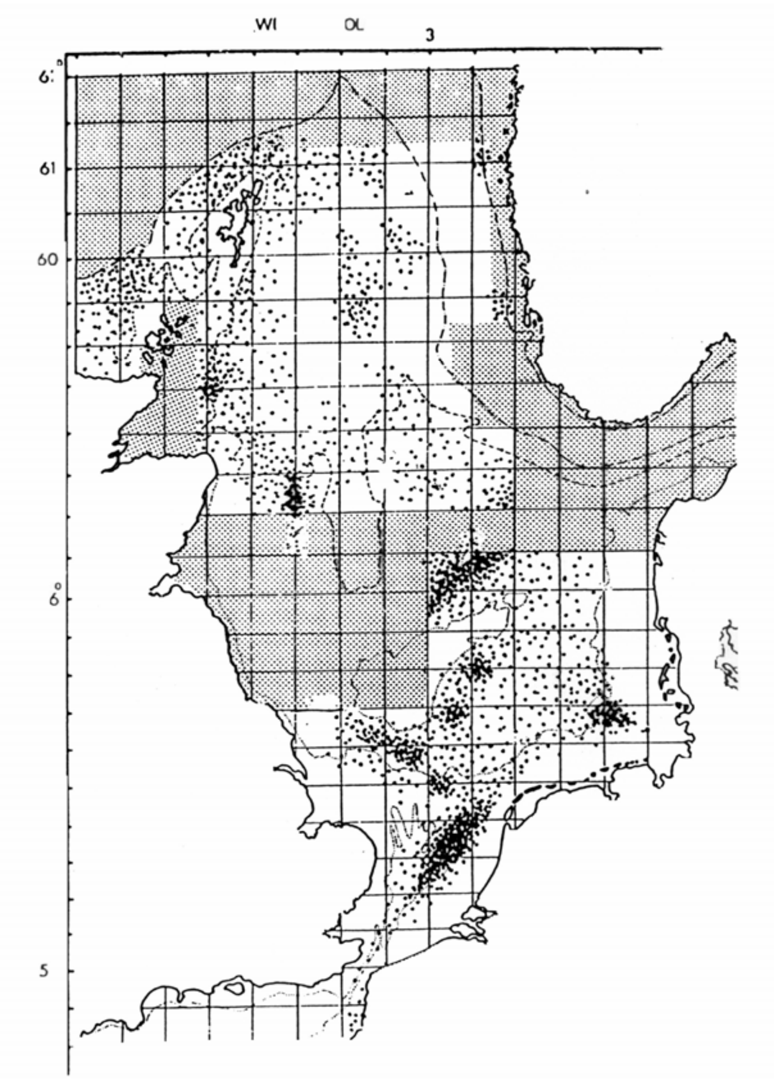


Figure 4.1.2. Spawning areas of cod in the North Sea according to information after 1945. Note that the shaded areas have NOT been surveyed ([Daan, 1978 #2618])

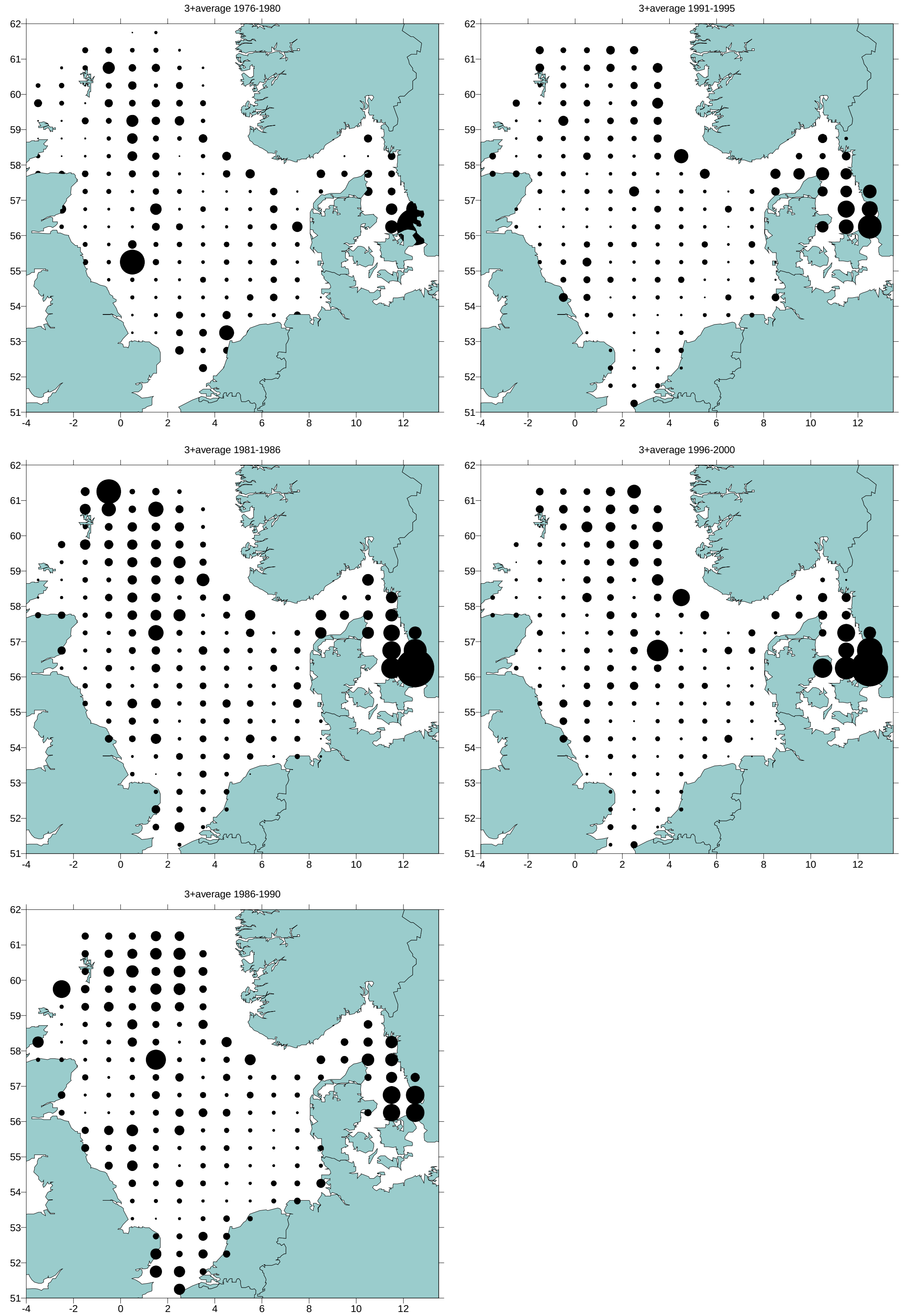


Figure 4.1.3. Relative density of cod aged 3 and older from the IBTS Q1 survey series from 1976-2000. Data are average catch per unit of effort (No/h) over 5-year periods.

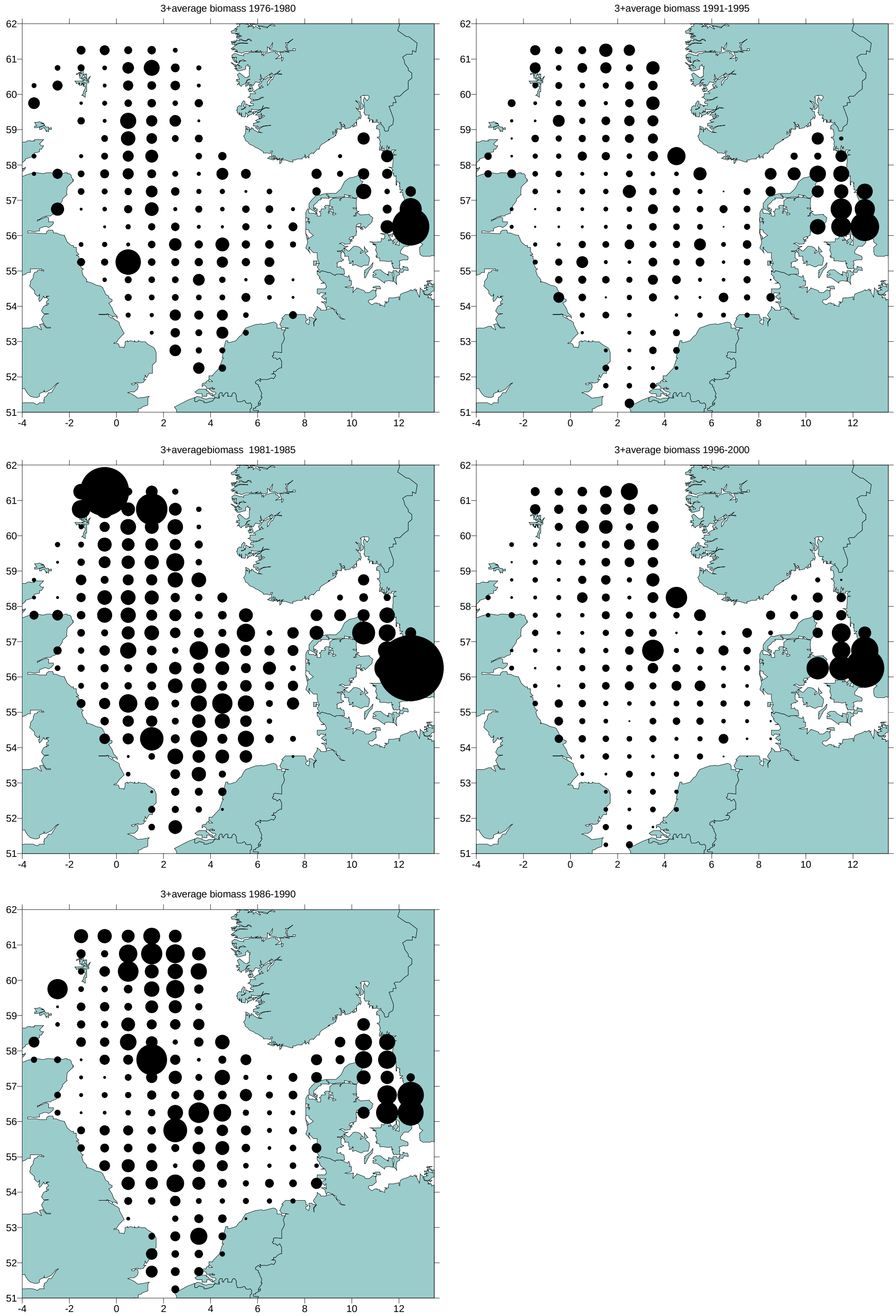


Figure 4.1.4. Relative biomass of cod aged 3 and older from the IBTS Q1 survey series from 1976-2000. Data are average catch per unit of effort (kg/h) over 5-year periods.

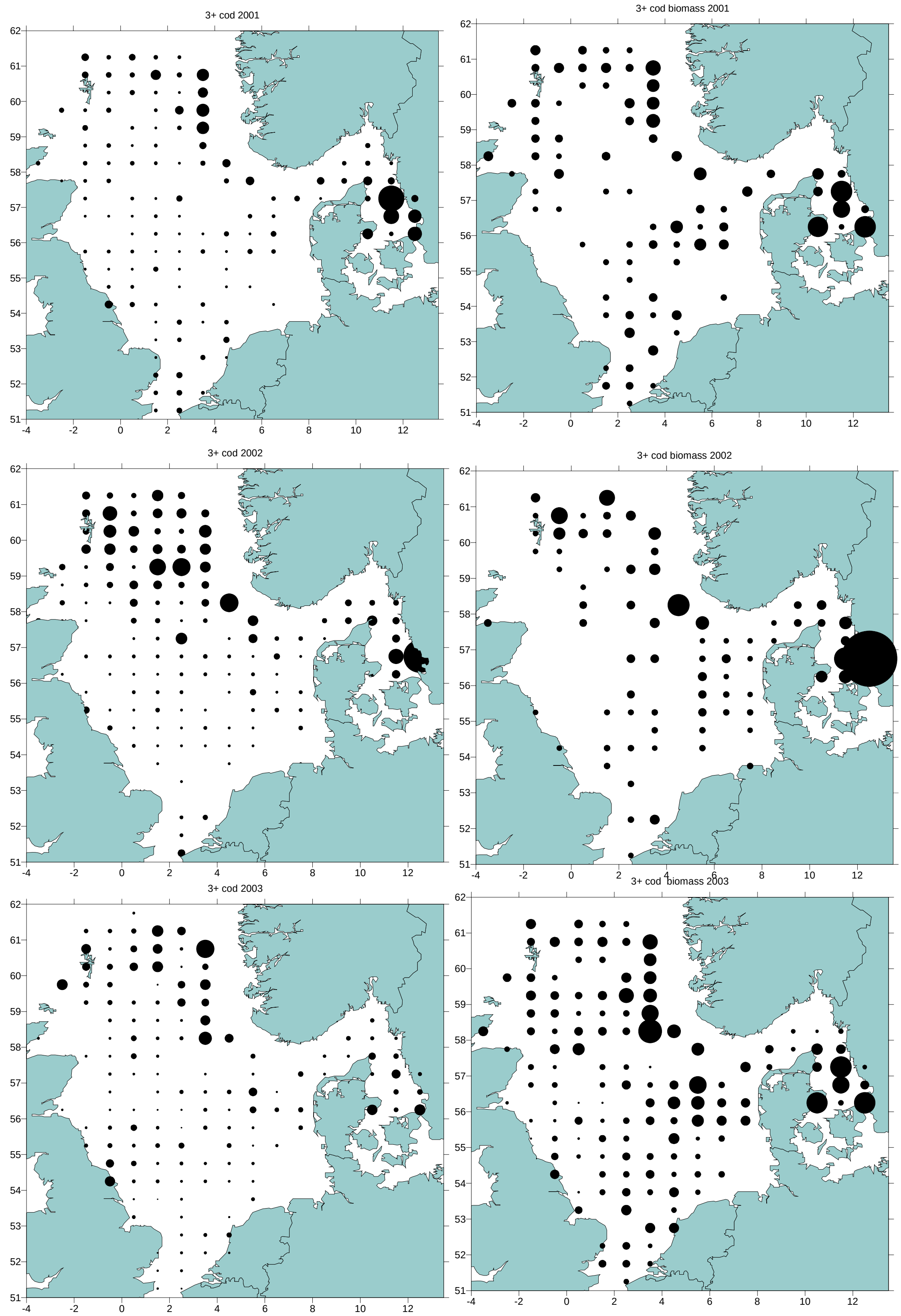


Figure 4.1.5. Relative density of cod aged 3 and older from the IBTS Q1 survey series for the years 2001, 2002 and 2003. Left hand plots = density in numbers per hour; right hand plots = density in biomass (kg) per hour.

4.2 Closed areas, seasons and real time closures in the North Sea and Skagerrak to reduce catching and discards of juveniles (ToR c and e3)

4.2.1 Management of the North Sea cod by closed area

Closed area management is reviewed in Horwood et al (WD 7). In the North Sea, closed areas are used to protect young sole and plaice (the Plaice Box), herring spawning grounds, and young roundfish (the Pout Box). The management measures and studies examining the impact of closed areas on the North Sea cod stock and fishery dynamics are listed below.

North Sea cod Box
The North Sea cod Box was introduced in 1987 (EC4034/86) with the intention of protecting the large 1985 cod year-class. It was located in the coastal areas of the Southern and German Bights defined by {the Danish coast at 55N; 55N7E; 54.30N7E; 54.30N6E; 53.30N6E; 53.30N4E; the Dutch coast at 4E}. The Box prohibited trawling and similar gears with meshes less than 100 mm, over the first and fourth quarters of the year. The implementation of the box was considered to be too late to have the maximum conservation effect.

North Sea cod Task Force
In 1993 a North Sea Task Force was established by the European Commission to advise on management measures for cod, including closed areas. They considered four large areas, which were based on roundfish reporting areas. They evaluated a closure of each box for the whole year, assuming that the effort displaced from the box was redeployed in the remaining open areas. The analysis was based on two data sets, one containing catch by rectangle data for 1989 and the other for 1991. Using the 1989 data, closure of one area (NE North Sea), for the full year, resulted in a long-term increase in SSB of 25%. Closure of other areas showed no such result. However, repeating the analysis using data for 1991 did not show any benefit with the same closed area. This suggested that the distribution of cod was not sufficiently stable over time to make useful predictions about the value for specific boxes.

2001 Closed area
Two boxes were closed in the North Sea in 2001 during the period 14 February 2001 to 30 April 2001. The boxes were introduced, in response to ICES advice to reduce fishing mortality. They were not part of the ICES advice but were introduced as part of emergency measures in the absence of an agreement to reduce fishing effort directly (EU259/2001). The rationale for the box was that cod aggregated at spawning time and as many as possible should be allowed to breed in that year, increasing the probability of better recruitment. They were also thought to be a supportive measure for the reduction in fishing effort associated with a lower TAC. The box was identified largely on the basis of where about 80% of the cod were caught in 1999 quarters 1 and 2. No attempt was made to renew the box by the Commission in for 2002 or 2003. The spawning area closure was essentially a short-term measure, aimed at increasing spawning potential in that one year.

4.2.2 A single species closed area model for the North Sea cod

The effect of closing areas of the North Sea was examined using a simplified spatially structured model developed at the meeting. The model takes a similar form to that of the Report of the North Sea Task Force (SEC93/2119) and Horwood et al (1998), in that it calculates the effect of closing statistical rectangles and either removing or re-distributing effort into the remainder of the North Sea. The re-distribution of effort was modelled either as a uniform increase in all open areas or a spatially complex pattern that represented historic fishing patterns. The model was used to explore the sensitivity of analysis results to critical assumptions.

The model input data

In order to simulate the effects of closing areas of the North Sea, data are required representing the spatial distribution of catch rates per unit of effort (cpue) and effort. Reliable measures of effort could not be obtained from all major fleets fishing for the North Sea cod. Therefore, the spatial information was calculated using the following assumptions:

Catch per unit effort

It was assumed that, during the years 2000 – 2002, the spatial pattern of the cpue recorded by the ICES International Bottom trawl Survey (IBTS 1st and 3rd quarter) is representative of the spatial distribution of cpue resulting from commercial fishing.

Figures 4.2.1a-b and 4.2.2a-b compare the spatial trends in the standardised commercial and the IBTS survey catch rates for cod averaged over the years 1999 - 2002. Figure 4.2.1a presents the biomass data from the IBTS survey at ages 2 and older and the Scottish and English commercial fishery data from the statistical rectangles extending north from 36F2 to 52F2. Similarly Figure 4.2.1b shows the biomass data from the IBTS survey and the English, Danish and Dutch commercial fisheries from statistical rectangles extending west from 42E7 to 42F8. Figures 4.21a and b present the IBTS and commercial catch rates for English and Scottish fleet data for the north western and central North Sea, for the year 2001, with fitted regression models. The IBTS survey shows good spatial correlation with the available commercial information and was therefore used as a relative index of the spatial distribution of commercial catch per unit effort. It is interesting to note the truncation of the distribution of commercial catch rates at high values.

The IBTS survey does not extend into deep water to the north of Scotland and south into the Channel, therefore the CPUE model does not cover the complete stock distribution. Information derived from other surveys will be used in the development of a more comprehensive model.

Effort

Data was collated at the meeting on the distribution of commercial cod landings (without discards) by statistical rectangle. Under the assumption that the spatial distribution of the IBTS survey cod cpue can be used as a proxy for the spatial distribution of commercial cpue, the spatial distribution of commercial effort was derived using landings / IBTS cpue. Several rectangles at the extremes of the distribution have landings data but no survey cpue information, they represent a low proportion of the rectangles and were excluded from the model sensitivity analysis.

The distribution of effort showed concentrations along the Dutch and Danish coasts and also on the East Coasts of Scotland and England. Lower levels of effort were estimated for the central North Sea (Figure 4.2.3). Preliminary comparisons with the spatial distribution of commercial effort show similar aggregations.

Simulation of effort reallocation

The closed area model was specified such that statistical rectangles were open or closed in total. Two scenarios were examined for the control of effort displaced from each closed area; removal of the effort from the fishery and redistribution to the open areas.

Effort was redistributed in the open areas with one of two spatial formats, uniform and heterogeneous. Within the uniform format, effort removed from the closed area was redistributed equally in each rectangle in the open area. For the heterogeneous format, effort removed from the closed area was redistributed according to the spatial distribution of the effort in the open area prior to the closure. Both assumptions are open to criticism, since the specific behaviour of the fleets excluded from the closed area is largely unpredictable. However, these assumptions regarding redistribution of effort do permit an exploration of the sensitivity of the model to the impact of ignoring spatial pattern.

Closed area simulations

The group examined four closed area scenarios:

1) Closure of the rectangles containing 80% of the IBTS survey adult catch per unit effort (Figure 4.2.4).
2) Closure of the rectangles containing 80% of the IBTS survey juvenile catch per unit effort (Figure 4.2.5).
3) Closure of the rectangles specified in the 2001 emergency measures described in EU259/2001 (Figure 4.2.6).
4) Investigation of an area located to the east of Scotland. A UK industry suggestion for an area in which haddock could be taken at low cod by-catch rates (Figure 4.2.7).

Option 4 is based on a request from the UK industry to examine the potential for a haddock fishing box to be located on the East Coast of Scotland. It was suggested that this is an area of low by-catch rates for cod. The approach taken here was to simulate the closure of the area and to evaluate whether there is a negative effect on cod mortality by moving effort out from the area. By inference if a negative effect were to be estimated there should be lower partial mortality of cod inside the area and this would indicate potential for further investigation as an area for a more intense haddock fishery.

The scenarios were examined in terms of relative reduction in fishing mortality on adults and juveniles separately. It is assumed that total effort does not increase to compensate for reduced catch rates and that the displacement of a large amount of effort into an open area does not significantly reduce cpue in that area during the year.

Results

Table 4.2.1 presents the results of the four simulation studies in terms of the relative reduction in fishing mortality by age group. These reductions are not strictly changes in F, but represent the proportional change in landings which are used as a proxy for change in F.

Boxes established for juvenile cod, which are distributed predominantly in the south, and adult cod, further north, result in different reductions in fishing mortality. This is due to the differences in the spatial pattern of catch rates for the two age groups. In general juvenile box closures are usually considered to be more beneficial than those established for adults since they reduce the mortality in numbers to a greater extent, per unit weight of fish (Horwood et al, 1998).

In all case studies, it is not surprising that removal of effort from the fishery has a larger effect on fishing mortality than that achieved when effort is redistributed. The expected benefits of a closure are reduced by about 15 – 40% for scenarios 1 and 2 if effort is redirected. Similarly, redirection of effort essentially negates the potential benefits of the 2001 closure (scenario 3) for both adults and juveniles. Note that this result is based on the assumption that the closed area was for the whole of 2001, and not only for the period 14 February – 30 April.. This result is consistent with the analysis presented in Section 3 of this report. A permanent closure of this area would be expected to marginally increase the risk to the stock by increasing the exploitation rate on juveniles, with a negligible reduction on adults.

With the exception of increased mortality on juveniles with heterogeneous redistribution of effort, the relative effects of uniform or heterogenous redistribution of effort are largely the same.

Closure of the rectangles which were identified by the UK industry as an area where the by catch of cod is considered to be lower than the surroundings, results in a marginal increase in fishing mortality on cod if effort is redistributed.. This implies that cod catch rates and mortality are lower inside the area. Further investigations into the potential for fishing for haddock with, relatively, lower by-catches of cod are suggested.

The model developed here will be investigated further and the potential for extensions of the survey based modeling of effort examined in order to cover the whole of the North Sea area. Investigation of restrictions imposed by, for example, economics on the redistribution of effort may mean that the reallocation regime imposed here is too simplistic. In addition the model assumes a single fleet, species dynamic and as such may be limited in its application. Mixed fishery, fleet interactions in response to closed areas are considered below.

4.2.3. A model for box closures using commercial landings and effort data

The method used is similar to the one developed during the North Sea cod task force meeting in 1993 (Commission paper SEC 93) 2119). However, due to missing catch at age in numbers, the method applied here operates on landings weight. Roughly outlined the method is:

1. Calculate sum of all landings for status quo situation (L_{stq})
2. Define an open and a closed box for fisheries from ICES rectangles
3. Sum effort by fleet in the closed (E_{closed}) and in the open box (E_{open})
4. Sum landings in the open box (L_{open})
5. Reallocate effort from the closed box into the open box and assume a CPUE by fleet as previously obtained in the open box (alternatively take the effort out)
6. Calculate the new landing from the open box as: $L_{new} = L_{open} + L_{open} / E_{open} * E_{closed}$

7. Calculate the relative change in landings (as L_{new} / L_{stq}), which is approximately equivalent to the change in fishing mortality.

These calculations were categorised by individual fleet and quarter of the year using the 2002 data from the database of commercial landings and effort. In case of no historical E_{open} (e.g. closure of area IVb and IVc will force sole beam trawlers to fish in IVa where fishery has not taken place before), the effort was removed. As no age information is included in the model, it is not possible evaluate possible gains or losses for specific size classes, e.g. juveniles and spawners.

The assumption made in point 5 of the method is that vessels reallocated in the open area can maintain a CPUE as high as the vessels fishing there previously. This assumption is critical and probably not valid for larger changes in effort distribution. The assumption also implies that fish redistribute instantaneously according to the historical spatial distribution after each fishing operation. Again unlikely, especially for species like Nephrops, where distinct sub-populations exist in the North Sea.

To illustrate how the model works, a hypothetical example of closing ICES area IVb was simulated. The results (Table 4.2.2) show an 11% increase in fishing mortality for cod if effort from IVb was reallocated into the open areas. The change in F was -32% (or 32% reduction) if effort was removed. The higher F on cod, assuming effort reallocation, is due to a generally higher cod CPUE in the area outside area IVb. A closure of IVb increases F on Cod, Nephrops, saithe, sole and whiting. A simulation keeping area IVb open and closing the rest of the North Sea and Skagerrak (Table 4.2.4), gives the opposite results with respect to increase/decrease in fishing mortality.

Taking into consideration that the assumption of instantaneous redistribution of the stock is unrealistic the model underestimates the beneficial effect of the decrease in F of the box closure. For larger closed areas, the density of fish will probably be relatively higher within the box than outside such that fixed CPUE (or more precise, fixed partial F) in the open area cannot be maintained.

Scenarios examined using the mixed fishery model

The 2001 emergency box closure

If the area for the emergency box closure in 2001 was closed the whole year, the model estimate a -18% change (decrease) in F for cod (Table 4.2.4) when effort was reallocated, or a reduction by 51% when effort was taken out. Such a closure would give higher F on Nephrops and saithe, and lower F for haddock, plaice, sole and whiting.

The East of Scotland haddock box

The box East of Scotland (Figure 4.2.7), as proposed by the UK industry was analyzed in the same way as in section 4.2.2. The results show that the F on cod and whiting will increase in case of a box closure if effort is reallocated (Table 4.2.5). This is due to a higher CPUE of cod and whiting outside the box. The effect for haddock is close to zero indicating that haddock CPUE inside and outside the box is similar for the fleets fishing in the area. This means that the fishing mortality on cod and whiting could decrease if the haddock fisheries are moved into the box. The F change for the other species considered in the model will be negligible.

Discussion

The models developed here show that modeling of the effects of closed areas is tractable but complex and highly dependent on the underlying assumptions. The effectiveness of closed areas is dependent upon features that must be considered when the management measures are imposed (Horwood et al, 1998; Horwood et al., WD 7).

Closed areas will fail to be effective in the management of fishing mortality if the fish protected by a box are caught after migrating elsewhere, or if at the end of a seasonal closure fish remain in the box where they are then caught. This has been demonstrated to be the case for the 2001 cod box (Section 3.1.1). Adult fish were caught elsewhere during the spawning closure and in the box area after reopening. Closed areas protecting juveniles, such as the Plaice and Mackerel Boxes, which reduce fishing mortality on the younger ages until they migrate after maturing to join the adult stock are exceptions to this.

In recent years, protection of juvenile cod has been addressed only through gear measures rather than area closures. As with adults, juvenile concentrations exist, generally across the central North Sea, along the frontal area from the Humber (UK) to northern Denmark and in the German Bight. The simple closed area model (Section 4.2.2) uses catch rate averages from the IBTS survey for the years 2000 – 2002 in order to define the area of a juvenile box. However the distribution of juvenile cod has changed through time. Designing a box with a fixed location could have a reduced effect unless its area is increased to allow for inter-annual spatial variation. An alternative is to consider updating or supplementing the closed area by adding areas with high juvenile catch rates.

There is also the question of the existence of "sub-populations" of cod. It has been hypothesized that the assessment area for North Sea cod may encompasses several discrete spawning populations. It is quite possible that if one or more of these sub-stocks collapses, the remaining units may not have the same capability to bring about stock recovery. Closure of the NE North Sea, for example, may not be beneficial to the spawning components in the southern North Sea.

The fishery

Derogations can be exploited as loopholes in the regulations, allowing continued fishing for the protected stock. This can happen for smaller vessels that have limited scope to move elsewhere and may be considered to have a minor impact on the protected stock. Unfortunately these vessels can often increase their power and effort which negates the effect of the closure (Pastoors et al., 2000).

The simulation studies have established that removal and/or the spatial reallocation of effort displaced from the box is critical to its effectiveness. Displaced effort will cause problems for other fisheries. Fishing patterns are regional, and the displacement model used to predict impacts can only be effective if fleet interactions are considered.

Interactions between ages in a population distribution were examined using the single species cod model; species interactions were addressed within the second model. The results of the sensitivity runs established that the impact of a box closure for one species or age group could have negative effects for a second.

Disrupted regional fishing patterns can also cause environmental concerns. The 2001 closed area caused a change in fishing pattern which impacted upon some environmentally sensitive areas (Rijnsdorp et al, 2001).

4.2.4 Conclusions

Closed areas can be used to beneficial effects in the management of fish stocks. However experience with the North Sea cod box and the 2001 Emergency Measures box illustrate that they may also be ineffective if additional management constraints are not imposed concurrently.

The studies carried out at the meeting have enabled the group to examine the sensitivity of models for closed area management of the North Sea stocks to key assumptions.

In general the group concludes that

1) The term of reference for the EU Norway meeting,

   "The group is requested to Evaluate the areas, which would need to be closed in order to remove (a) 80%, (b) 60%, (c) 40%, (d) 20% of the fishing possibilities for cod in the North Sea "

   is not only ambiguous but also a complex modeling exercise with large data requirements and potential solutions that are highly conditional on the model structure. The group has collated a data set that could be used to explore scenarios but time for testing and evaluation was not available at the meeting.

2) If effort is removed from the fishery at the time of closure (and not reallocated) the effects on the reduction in fishing mortality are generally of significantly greater magnitude.

3) Redistributed effort can lead to no beneficial and sometimes significant negative effects on unprotected age groups and species. Discussions with fishers with regard to the potential changes in effort distribution would be required before a full modeling evaluation of any box can be carried out.

4) The area suggested by the UK industry for a haddock fishery with limited cod by-catch has been examined with the available data and models indicating a beneficial effect for cod and whiting if effort is moved into to area to target haddock. Individual trip records of catch composition and observations of discard rates from this area should however be investigated in order to establish the benefits of directed fishing in this area. This would be inline with ICES advice to encourage industry initiatives to reduce cod catches in the haddock fishery.

Table 4.2.1 The changes in fishing mortality resulting from the single species closed area model for North Sea cod with effort removal, and redistribution using uniform and spatially heterogeneous distribution patterns. Scenario 1 is a closure of rectangles containing 80% of the adult (3+) cpue in numbers from the IBTS survey. Scenario 2 is a closure of rectangles containing 80% of the Juvenile (ages 1&2) cpue in numbers from the IBTS survey. Scenario 3 is an annual closure of the rectangles closed in 2001. Scenario 4 represents the closure of an area to the east of Scotland. Increases in fishing mortality are indicated in bold type.

		Effort		
Closure		Removed	Uniform redistribution	Heterogeneous redistribution
Scenario 1	Juveniles	-71%	-53%	-52%
	Adults	-75%	-58%	-58%
Scenario 2	Juveniles	-83%	-67%	-67%
	Adults	-65%	-25%	-30%
scenario 3	Juveniles	-39%	-4%	**+8%**
	Adults	-44%	0%	-1%
scenario 4	Juveniles	-1%	**+4%**	**+5%**
	Adults	-3%	**+3%**	**+3%**

Table 4.2.2 Close area 4b, (open 4a, 4c, IIIa) mixed fishery model.

	Status quo landings (t)	Landings effort reallocated (t)	% change	Landings no effort reallocated (t)	% change
species					
COD	37,051	41,056	11	25,157	-32
HAD	43,152	38,972	-10	29,803	-31
NEP	18,144	21,966	21	12,683	-30
PLE	66,049	46,114	-30	25,025	-62
POK	87,339	126,980	45	85,613	-2
SOL	16,246	18,578	14	11,003	-32
WHG	12,945	15,322	18	10,561	-18

Table 4.2.3 Open area 4b (close 4a, 4c, IIIa) mixed fishery model.

species	Status quo landings (t)	Landings effort reallocated (t)	% change	Landings no effort reallocated (t)	% change
COD	37,051	28,679	-23	11,894	-68
HAD	43,152	67,495	56	13,349	-69
NEP	18,144	13,833	-24	5,462	-70
PLE	66,049	84,372	28	41,024	-28
POK	87,339	14,306	-84	1,726	-98
SOL	16,246	12,485	-23	5,243	-68
WHG	12,945	11,322	-13	2,383	-82

Table 4.2.4 Permanent (annual) closure of 2001 emergency cod box mixed fishery model

species	Status quo landings (t)	Landings effort reallocated (t)	% change	Landings no effort reallocated (t)	% change
COD	37,051	30,550	-18	18,041	-51
HAD	43,152	41,273	-4	28,339	-34
NEP	18,144	21,102	16	16,346	-10
PLE	66,049	59,866	-9	32,517	-51
POK	87,339	89,420	2	58,349	-33
SOL	16,246	15,912	-2	9,076	-44
WHG	12,945	12,358	-5	8,870	-31

Table 4.2.5 East of Scotland box closure mixed fishery effects

species	Status quo landings (t)	Landings effort reallocated (t)	% Change	Landings no effort reallocated (t)	% Change
COD	37,051	37,989	3	36,858	-1
HAD	43,152	43,187	0	39,907	-8
NEP	18,144	18,768	3	16,740	-8
PLE	66,049	66,039	0	65,933	0
POK	87,339	87,735	0	87,311	0
SOL	16,246	16,246	0	16,246	0
WHG	12,945	13,495	4	12,705	-2

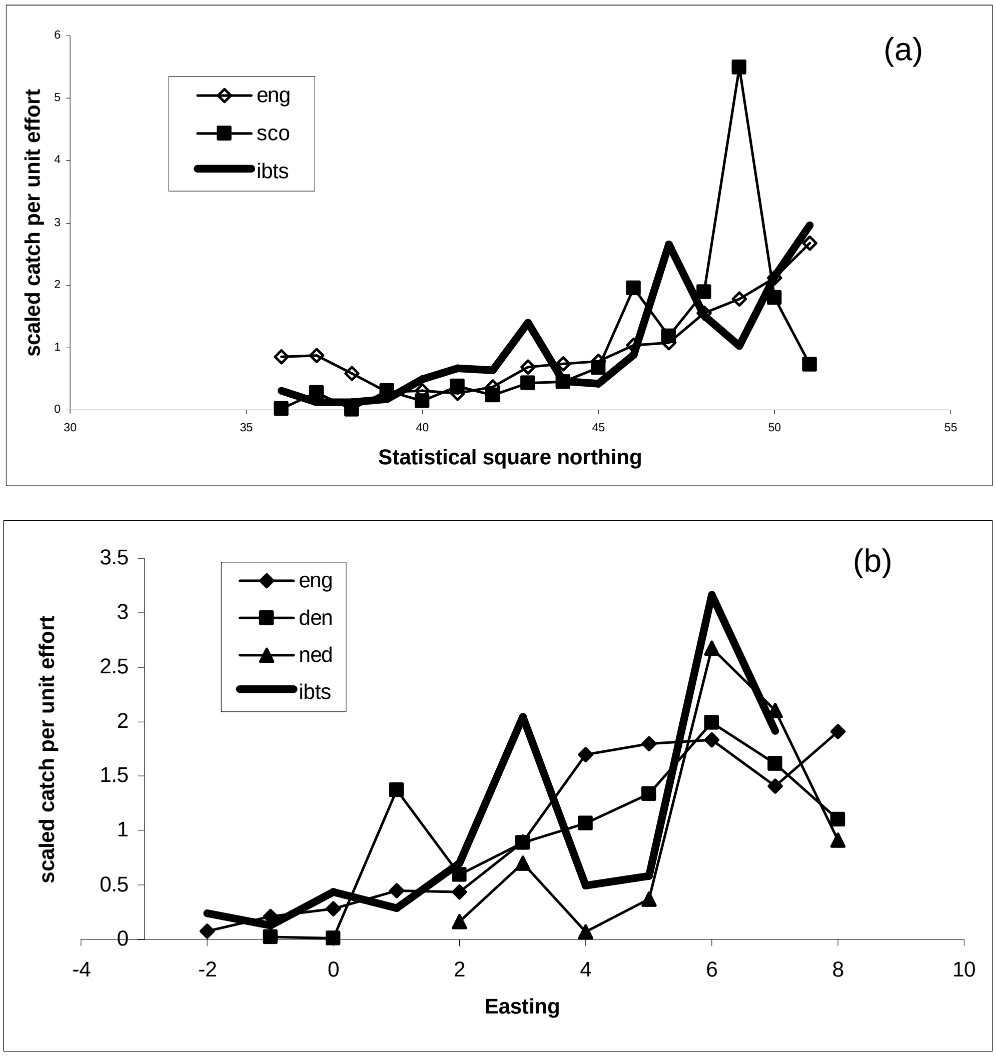


Figure 4.2.1a and b. The standardised distribution of IBTS catch per unit effort of 2+ biomass of cod plotted with commercial catch per unit effort derived from the English, Scottish, Danish and Dutch commercial log book information. Data taken from the years 2000 - 2002. 1(a) illustrates a transect north from 36F2 to 52F2, 1(b) west from 42E7 to 42F8.

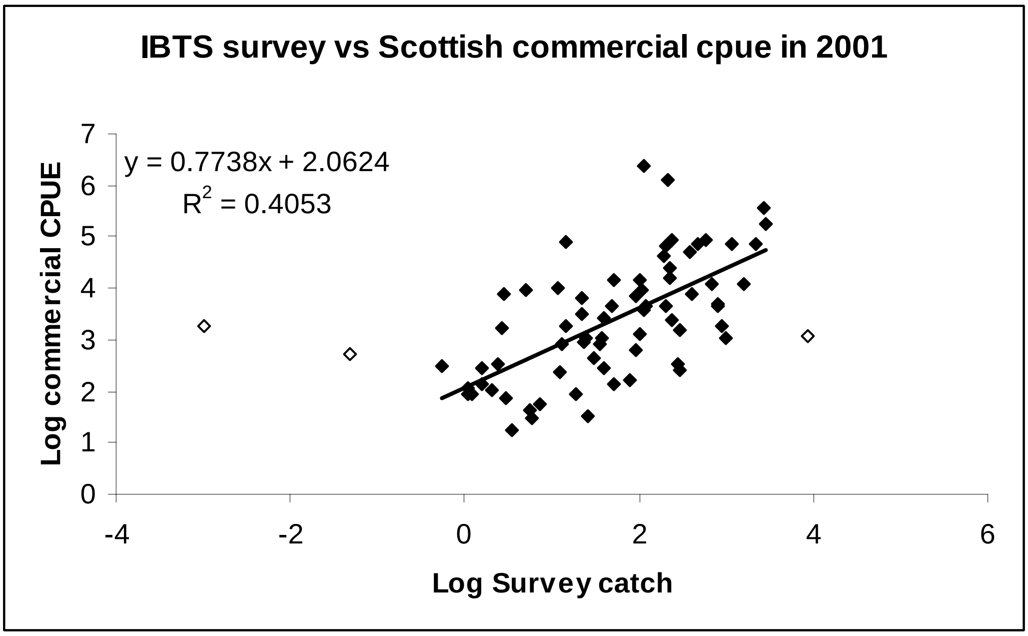


Figure 4.2.2a The correlation between catch per unit effort for each of the rectangles in the north western area of the North Sea and catch per unit effort from Scottish commercial landings and recorded effort. Hollow points indicate outliers excluded from the regression model. Note the truncation of commercial cpue at high catch rates.

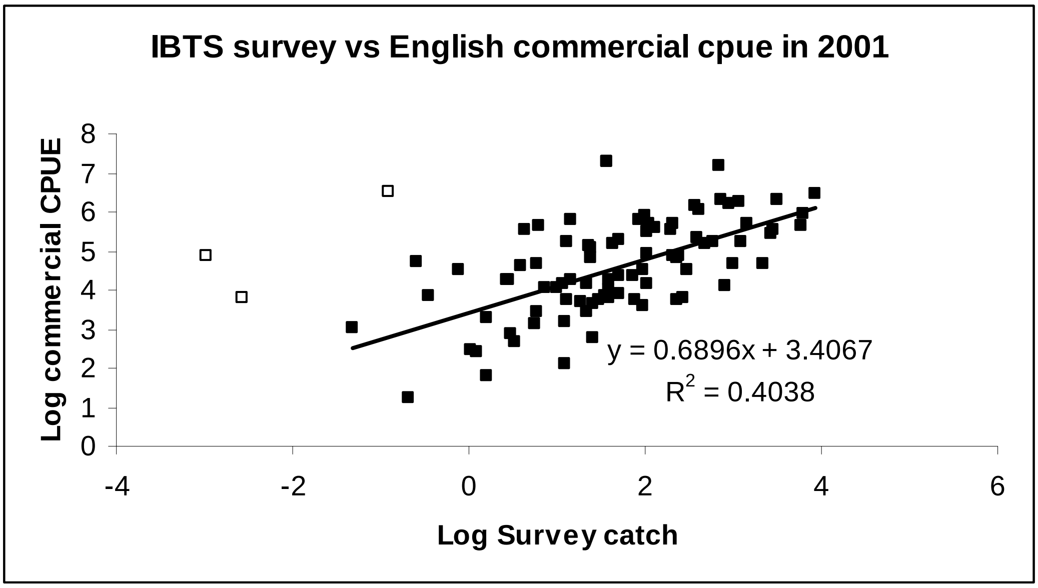


Figure 4.2.2b The correlation between catch per unit effort for each of the rectangles in the central area of the North Sea and catch per unit effort from English commercial landings and recorded effort. Hollow points indicate outliers excluded from the regression model. Note the truncation of commercial cpue at high catch rates.

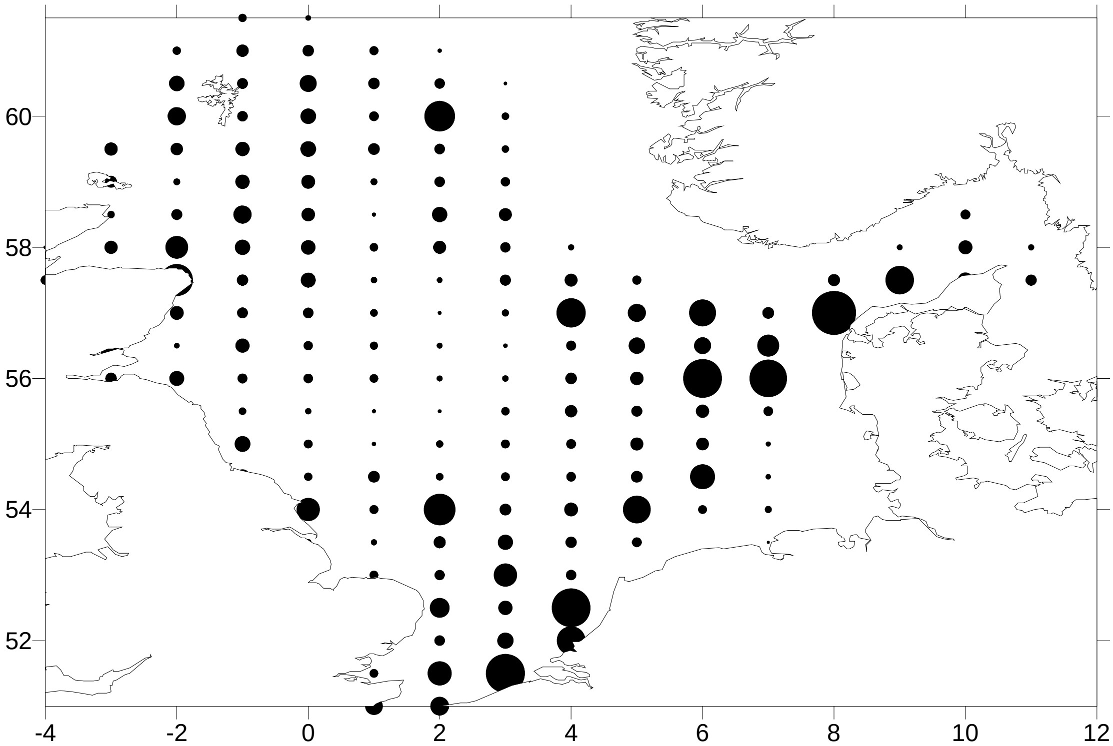


Figure 4.2.3 The spatial distribution of effort estimated from commercial landings and survey catch per unit effort used in the single species closed area model.

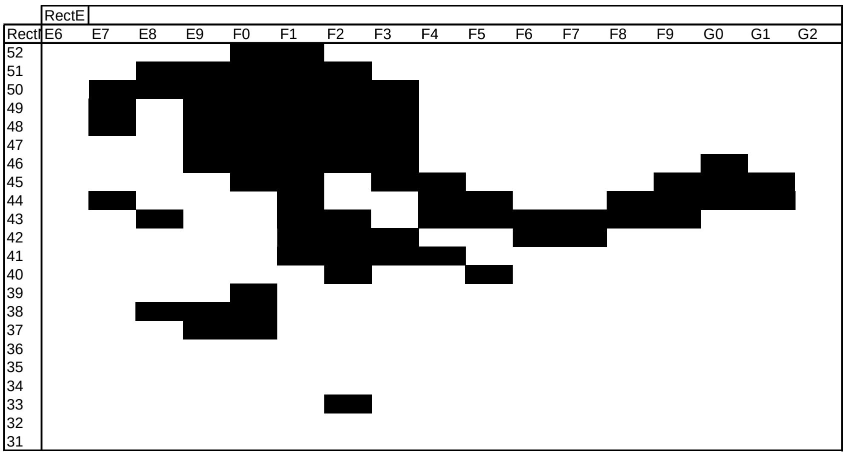


Figure 4.2.4 Adult rectangles closed for the removal of 80% of the adult IBTS cpue by numbers

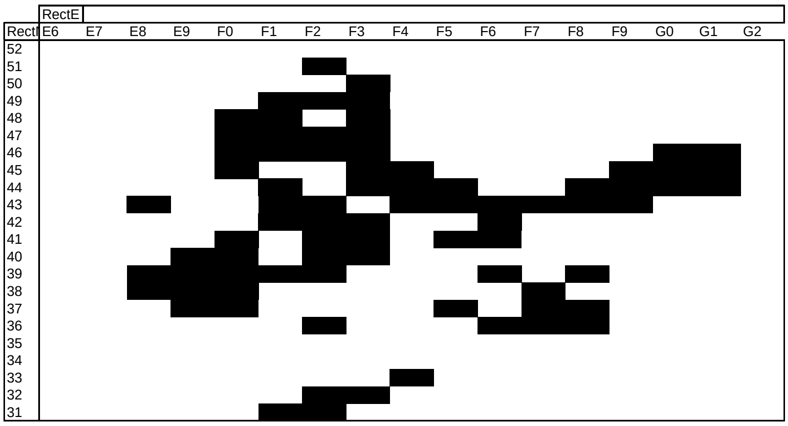


Figure 4.2.5 Adult rectangles closed for the removal of 80% of the juvenile IBTS cpue by numbers

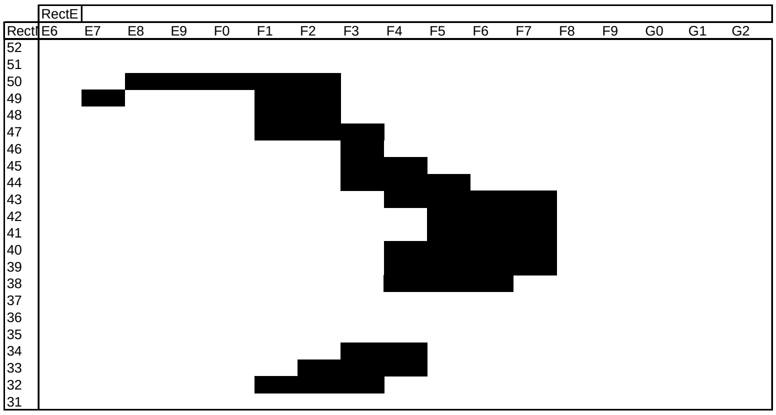


Figure 4.2.6 The rectangles closed in the 2001 emergency measures.

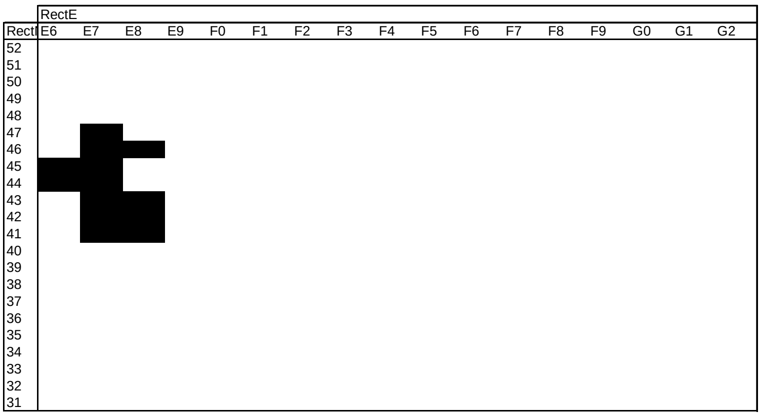


Figure 4.2.7 The rectangles suggested by the UK industry as having relatively low cod by-catch rates during targeted haddock fishing.

4.3 Identification of areas, which would need to be closed in order to remove 80%, 60%, 40 % and 20 % of the fishing possibilities for cod in the North Sea (ToR e7)

The group is requested to “Evaluate the areas, which would need to be closed in order to remove (a) 80%, (b) 60%, (c) 40%, (d) 20% of the fishing possibilities for cod in the North Sea “ (ToR e7). The term “fishing opportunities” used in this ToR is not well defined. The group decided to explore two alternative approaches to address the ToR of which the interpretation of “fishing landings” is reported in this section and the interpretation of “catch rates” is presented in section 4.2.

The landings and effort database, described in section 1.5.2 was used to generate patterns of landings for all fleets combined by statistical rectangle and by year. From this extraction of the database, maps were made which highlighted the rectangles that had the highest landings for the different species (cod, haddock, whiting, saithe, plaice, sole and nephrops). Different tresholds were used to delimited the rectangles which had the highest landings and which accounted for respectively 80%, 60%, 40% and 20% of the landings for each species.

Interaction maps were constructed that showed the selected areas for two species at a time and also the area of overlap (i.e. the rectangles where for both species high landings were taken). The maps are shown in figures 4.3.1a-d using tresholds of respectively 20%, 40%, 60% and 80%. When using an 80% treshold (i.e. the top 80% of rectangles contribution to the overall landings) a major part of the North Sea is covered. From this graph is is clear that the cod landings in the central North Sea have dimished substantially.

Figure 4.3.2 is an attempt to summarize the overlap in the spatial landings data by species for the years 2000-2002 combined. The horizontal axis in the figure represents the proportion of the cod landings by rectangle (i.e. the rectangles with the highest cod landings are on the left, the rectangles with the lowest catches on the right). The vertical axis shows the cumulative distribution for the other species. If we want to find the rectangles where 20% of the highest landings of cod are taken, we can read on the vertical axis, what the expected landings of the other species would have been given that no redeployment of effort would have taken place. Results of the analysis for 2000-2002 are also summarized in the table below.

Table 4.3.1 Increased closed areas (rectangles) accounting for the specified percentage of cod landings in 2000-2002 and corresponding percentage reductions in landings of haddock (HAD), whiting (WHG), plaice (PLE), sole (SOL), saithe (POK) and nephrops (NEP).

cod%	HAD	WHG	PLE	SOL	POK	NEP
19	88	99	87	99	98	96
40	79	78	70	74	89	87
61	60	55	61	59	74	85
80	33	25	50	47	47	47

On the basis of the landings compositions in 2000-2002, a closure of the rectangles which account for 80% of the cod landings would result in 33% of the haddock landings to be still available, 25% for whiting and around 50% for the other stocks. A 20% closure would only affect haddock and plaice but to a much lesser extend.

It should be noted that the results only refer to the officially reported landings by rectangle and do not include discards. Furthermore, the overlap between species does not take account of the actual by-catches that are realised in the individual trips. Observer trips could also be used for this purpose.

It was found that the areas of highest landings for cod from the method described above differ substantially from the areas derived from the survey CPUE based method (section 4.2). This is likely to be caused by the effort distribution which causes cod to be caught where the abundance is lower than in other areas.

Conclusions

The areas, which would need to be closed in order to remove (a) 80%, (b) 60%, (c) 40%, (d) 20% of the landings of cod in the North Sea, have been investigated in relation to the landings of other species. The overlap between each set of two species was presented.

It is noted that the results only refer to the officially reported landings by rectangle and do not include discards. Furthermore, the overlap between species does not take account of the actual by-catches that are realised in the individual trips. Observer trips could also be used for this purpose.

It was found that the areas of highest landings for cod from the method described above differ substantially from the areas derived from the survey CPUE based method (section 4.2). This is likely to be caused by the effort distribution which causes cod to be caught where the abundance is lower than in other areas.

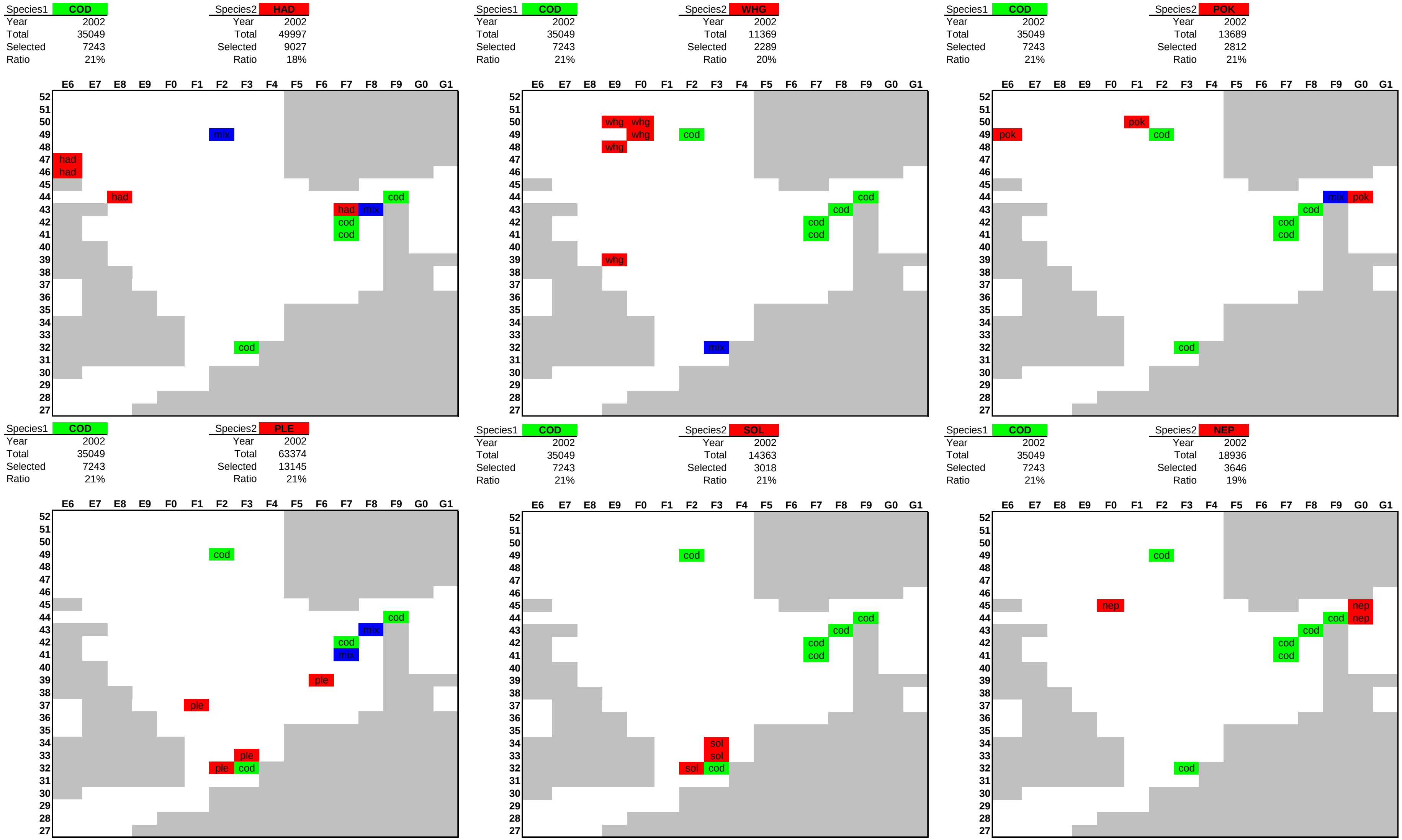


Figure 4.3.1.a. 20% of landings in 2002 for cod and respectively haddock, whiting, saithe, plaice, sole and nephrops.

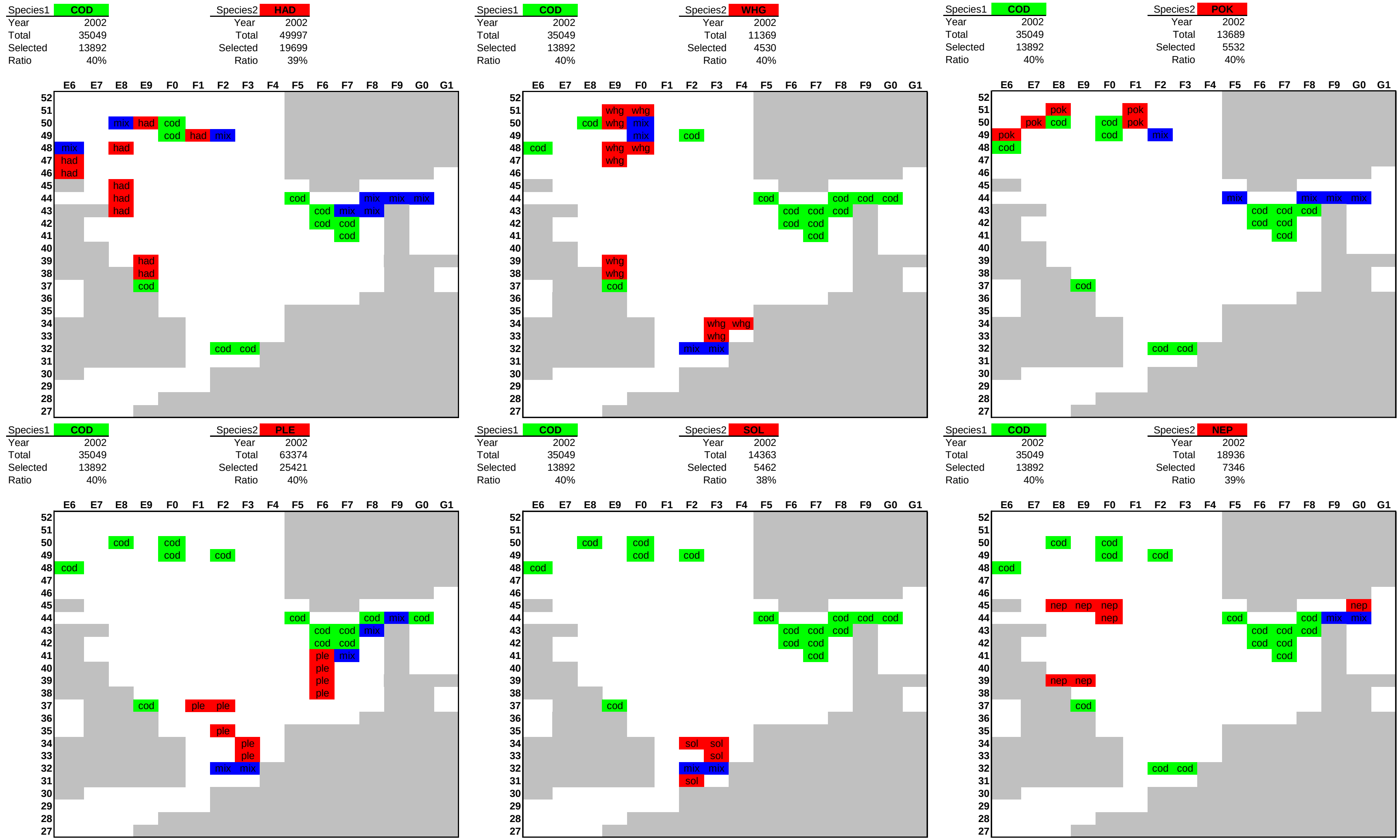


Figure 4.3.1.b. 40% of landings in 2002 (bottom) for cod and respectively haddock, whiting, saithe, plaice, sole and nephrops.

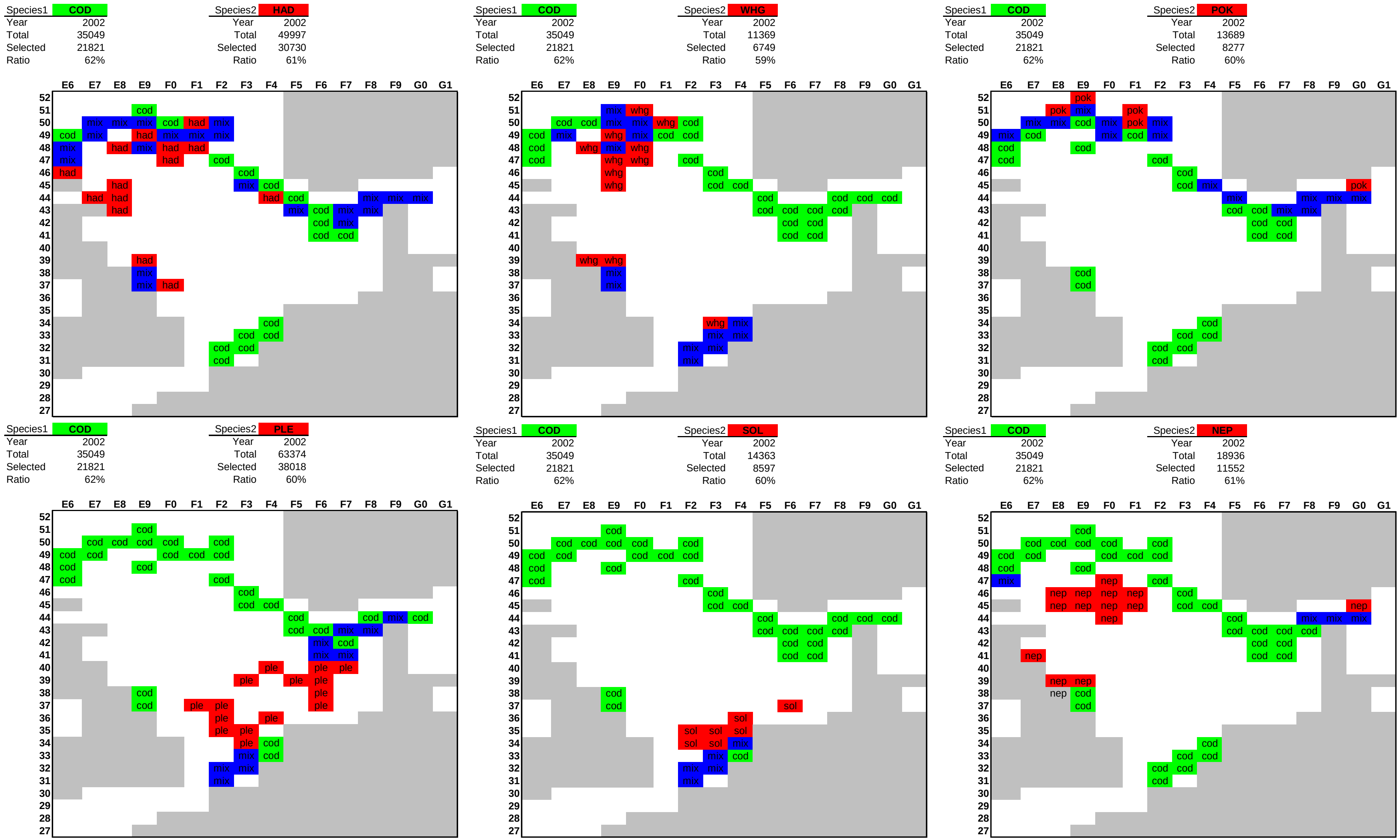


Figure 4.3.1.c. 60% of landings in 2002 for cod and respectively haddock, whiting, saithe, plaice, sole and nephrops.

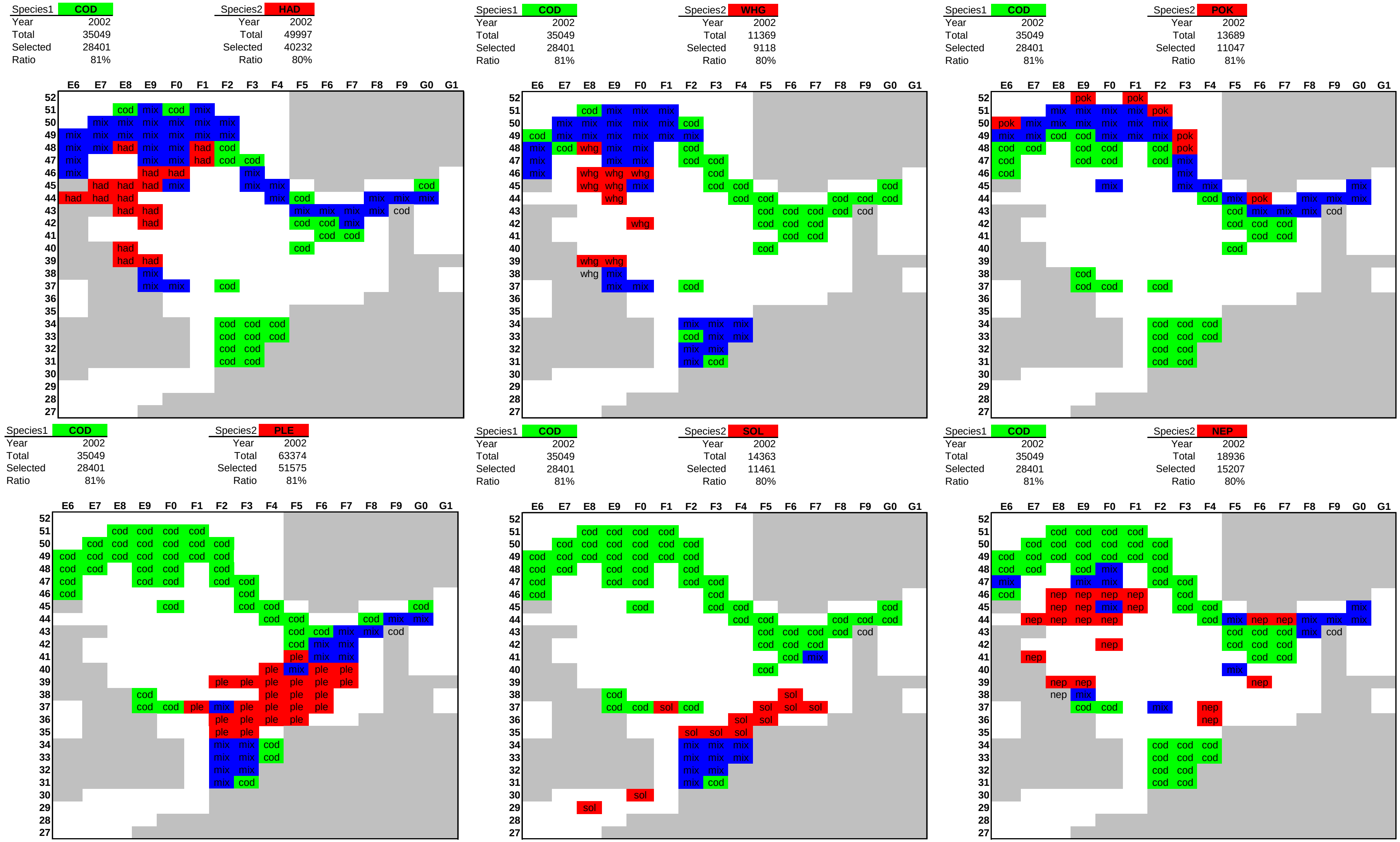


Figure 4.3.1.d. 80% of landings in 2002 (bottom) for cod and respectively haddock, whiting, saithe, plaice, sole and nephrops.

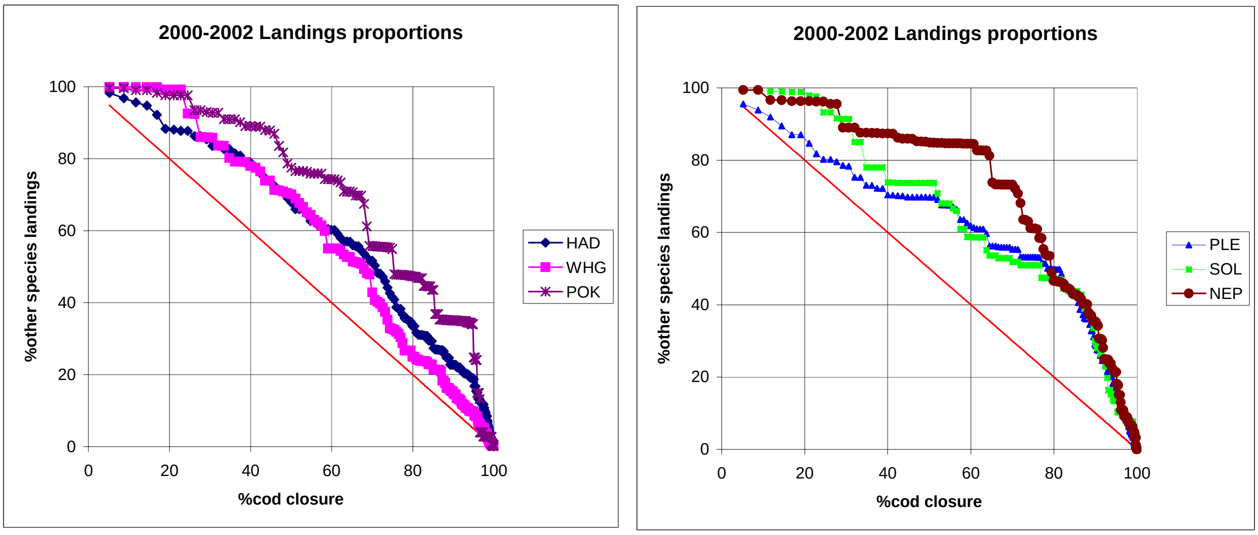


Figure 4.3.2. Overlap between cod and other species. The horizontal axis presents the proportion of the cod landings by rectangle (i.e. the rectangles with the highest cod landings are on the left, the rectangles with the lowest catches on the right). The vertical axis shows the cumulative distribution for the other species.

The figure can be interpreted as follows: if we want to find the rectangles where 20% of the highest landings of cod are taken, we can read on the vertical axis, what the expected landings of the other species would have been given that no redeployment of effort would have taken place.

5. Collate data on lost and abandoned gears in the North Sea and Skagerrak, and review mortality effects and advise on measures (by correspondence)

The following information was obtained through correspondence with Phillip M. McMullen, the co-ordinator of the FANTARED II project, a study to identify, quantify and ameliorate the impacts of static gear lost at sea (EC contract FAIR-PL98-4338). Partners of the project were IMR Norway, IMR Sweden, Seafish UK, AZTI from the Basque region of Spain, IPIMAR and CCMAR Portugal, and IFREMER France.

5.1 Data available on lost and abandoned gears (ToR e4)

The FANTARED II project devised a methodology which enabled the teams to use national catch information and interviews with fishermen to determine which fishing métiers were sustaining the highest levels of loss. The levels of gear losses in representative European metiers were established along with principal causes of loss. Descriptors were developed which can now be used to assess the likelihood of any static gear fishery being vulnerable to gear loss and subsequent sustained fishing by lost gears.

The extent of gear loss was established in those fisheries where it was significant. The terrestrial surveys proved to generate very reliable data on gear loss but it was not found possible to undertake satisfactory seabed surveys because of the technical limitations of the equipment used. Typically levels of permanent loss were well below 1% of gear deployed annually. In most shelf fisheries the level of recovery of nets that have been subject to minor damage is now very high. This is because of the almost universal adoption of GPS by fishing vessels.

5.2 Review of mortality (ToR e4)

The FANTARED II project established the physical evolution of gears lost under a range of conditions by loss simulations. This work was guided by industry advisory groups who were content that the methodology reflected commercial realities as far as possible. Observations by divers, ROVs and via retrievals generated good quality data which described the range of evolutionary pathways for gears deployed in representative conditions. In nearly all simulations the fishing gears showed a rapid decline in fishing performance which reflected physical changes. This often occurred over a period of only a few weeks. The effective life of nets could be substantially longer in low energy environments – typically in sheltered conditions or in water depths >200m.

The FANTARED II project assessed the ecosystem impacts of lost gears, particularly with respect to stocks of commercially important marine species. Impacts were identified and quantified where the level of net loss was significant and the lost gears were observed to maintain fishing capacity for a sensible period. For most fisheries the estimated impacts were very low compared to fishing mortality from targeted commercial activities, generally well under 1%. This compares very favourably with other sources of unaccounted mortality such as discarding.

A range of mitigating measures were reviewed which had the potential to reduce the extent and/or impact of lost gears. A global review was undertaken which included a field visit to North America. The key strategic options were identified and assessed for their relevance to the fisheries in this study. Clear recommendations were agreed as to the most effective means of mitigating the impacts of lost gears where these are a cause for concern. For most shelf fisheries these involve fishermen's associations adopting codes of good practice, improving communications between the towed and static gear sectors and zoning of effort from these sectors to reduce conflicts. More urgent recommendations are made for fisheries in the Southern Baltic and the deep water fisheries to the north and west of Europe.

5.3 Advice on possible initiatives (ToR e4)

The FANTARED II project formulated the following recommendations:

- The value of strong industry liaison has been recognised by all parties to this study. Researchers, technologists and, most importantly, fishing professionals urge all similar work to include this aspect of cooperation.
- A consensus was reached that codes of good practice were the most appropriate vehicle to reduce gear losses in coastal fisheries. A generic European code for gill netters was drafted at the workshop which should form the basis for further, fishery-specific codes. It was agreed that all relevant reports to the Commission should emphasise the need to facilitate adoption of such a code as a broad framework which would enable local variations to be introduced.
- The towed gear sector should also consider developing a matching code in order to improve its own performance. There was also a case to be made for 'decriminalising' the landing of gill nets by trawlers – current provisions often encouraged the illegal dumping of gear at sea.
- Recent initiatives by the International Baltic Sea Fisheries Commission to reduce gill net losses were supported with the proviso that more comprehensive action needs to be taken within a shorter time scale that currently seems likely.
- It is believed that the situation on deep water grounds demands that urgent action be taken to reduce the levels of gear conflict and loss in these fisheries. Specific recommendations from the workshop outline a means by which could be achieved.
- A major element of any strategy to reduce conflict between competing sectors is effort management by zoning. Very successful models are available which should be drawn upon in order to achieve significant improvements in the performance of the competing sectors.
- Further research on the consequences of gear conflicts should be undertaken. These would comprise a number of simulations of interactions between static and towed gears.

In addition to the FANTARED II project, the expert group recognised two more initiatives related to minimise ghost fishing which are described below.

"Fishing for Litter" Pilot Project of the Dutch North Sea Directorate

In March 2000, the North Sea Directorate in co-operation with the fisheries association started the "Fishing for Litter" pilot project. The aim of the project is to clear the North Sea from litter, by bringing ashore the litter that is gathered in nets during fishing. Subsequently the litter is being properly destroyed. Alongside with the policy to diminish the waste loads from shipping by means of prevention, the project aims at reducing the presently existing loads of litter in the sea. The principal idea is that by bringing ashore and destroying the litter that is caught in the nets, the litter will gradually disappear. Less rubbish will be washed ashore, and less will be found in the fishing nets.

The litter consists mainly of parts of shiploads, wood, packing material, decaying fishing gear and rope. The results show that the project is practically possible, that the process of collecting and landing the litter is not importantly hindering the fishing process, and that fishermen and the general public are enthusiastic. A gradual extension of the project to all of the fishing harbours in the Netherlands that have a Port Reception Facility and a maximum number of fishing vessels is, therefore, being considered by the ministry of Transport, Public Works and Water Management in co-operation with other ministries.

The project “Save the North Sea” has the main objective to improve knowledge and exchange information about maritime litter in the North Sea, aiming to change attitudes and behaviour of key groups using the North Sea and its coasts. Activities include networking, promotion, education and research. The project is co-financed by EU-Interreg IIIB North Sea Programme, the leading partner being The Keep Sweden Tidy Foundation, Sweden. Other participating countries are Denmark, Norway, Netherlands and United Kingdom.

One specific objective is to conduct a pilot study on recycling of mixed-material fishing nets/equipment and investigate relevant waste management systems for these. On April 8th, Skagen Education Center launched the Save the North Sea project in Skagen, Denmark. At a well-visited seminar, the problems of marine litter were discussed and a recycling machine for fishnets and other plastic materials from the fishing industry shown. This initiative should contribute to landings of old nets and thus contribute to reduce lost and abandoned gears.

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