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Report of the Inter Benchmark Protocol on Norway Pout in the North Sea and Skagerrak (IBP Pout 2012)

March–April 2012

By correspondence

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Executive Summary

The ICES IBPNorwayPout inter-benchmark exercise evaluated alternative biological inputs in the stock assessment for natural mortality, sexual maturity and growth (mean weight-at-age in the stock) for the Norway pout stock in the North Sea and Skagerrak. The natural mortality, maturity, and mean weight used in the scenarios evaluated in the benchmarking process originate from results published in Nielsen *et al*. (2012); Lambert *et al*. (2009); Sparholt *et al*. (2002a,b); as well as from the multispecies assessment working group ICES WGSAM 2011. In particular, natural mortality estimates for Norway pout originating from the new key run of the multispecies SMS model were applied here. Five scenarios were considered, a Baseline Scenario following the current assessment approach and four additional scenarios which explored alternative biological inputs.

Baseline

The May 2011 assessment is selected as the Baseline assessment. The settings of the Baseline are constant natural mortality by quarter and age fixed at 0.4, 10% maturity for the 1-group and 100 % mature for the 2+ group, and constant MWA assumed for the stock. The following alternative scenarios were tested in the benchmark exercise:

Scenario1

Natural mortality (M) change: Average Z at-age used as a proxy for M, computed for ages 1–3 in the years 2004, 2005, 2007 and 2008 (years with low fishing mortality) based on Q1 IBTS ICES NP indices from the standard ICES NP index area (calculated from Q1 in one year to Q1 in the next year for cohorts as averages for these four years based on the approach in Nielsen *et al*. (2012, Figure 1). Yearly Ms are divided by 4 to obtain quarterly Ms, and M at age 0 is set equal to that for age 1. In Scenario 1 the same maturity ogive and mean weight-at-age is used as in the Baseline assessment.

Scenario 2

Natural mortality (M) change*:* Same M inputs as Scenario 1. Maturity ogive change: Maturity-at-age 1 is set to 0.2 from Lambert *et al*., 2009, Figure 4. Maturity-at-age 2 is set to 100%. Mean weight-at-age in stock (MWA) change: The settings are based on results from commercial fishery during the period 1983 to 2006 as presented in Lambert *et al*. (2009, Figure 8.). The long-term trends in MWA have been calculated for the period 1983 to 2011 by quarter and area for the Danish commercial fishery and compared with Lambert *et al*. (2009), Figure 8 values and were found to be consistent. The revised Mean Weight-at-Age (MWA) in the stock used in the benchmark assessment are for the 1-, 2- and 3- age groups taken as the long-term averages from the commercial data. Data for MWA by quarter for age 0 are kept constant as used in the Baseline. MWA is recorded from commercial fishery catch data and not from the IBTS, for which only length data are available.

Scenario 3

Natural mortality (M) change*:* Average Z at age (being a proxy for M) for ages 1–3 for the full year range 1983–2005 from Q1-Q1 IBTS revised indices from Nielsen *et al*. (2012) Figure 1 (as presented in Table 2 below). Yearly Ms divided by 4 to obtain average quarterly M's. M at age 0 set equal to that for age 1. Maturity ogive change and mean weight-at-age (MWA) change: Same as in Scenario 2.

Scenario 4

Natural mortality (M) change*:* M1+M2 from the multispecies SMS model from the new key run presented in the ICES WGSAM 2011 Report (ICES 2011b). Averages of the SMS key run estimates of quarterly M1+M2 were used for the full year range. Maturity ogive change and mean weight-at-age (MWA) change: Same as in Scenario 2.

The change in natural mortality in Scenario 1, where survey based average Zs in the four years with very low or no fishing mortality has been used as a proxy for M, results in applying M-values of similar magnitude by age and quarter (around 0.3 for age 0 and 1 and 0.4 for age 2 and 3) as the age and quarter invariant values used in the Baseline assessment (0.4 by age and quarter). The total mortality on the cohort (and the age specific variation herein) determines the recruitment, the number of survivors and the biomass. The slightly lower natural mortality for the 0-group fish, for which the fishing mortality is very low, and the slightly higher natural mortality for the oldest fish (age 3 at 0.44) results in a slightly lower total-stock biomass (TSB) and R and nearly the same SSB and F_{BAR}(1–2) as the Baseline. This is expected given these modest age specific changes in M between Baseline and Scenario 1. The maturity ogive in Scenario 1 is the same as the Baseline with only 10% of age 1 mature, resulting in SSB similar to the Baseline. Because the catch-at-age data used in the Baseline and in all tested scenarios is the same, and because natural mortality on the main fished part of the population, i.e. age 1–3, is slightly lower for age 1 at 0.29 and slightly higher for age 3 at 0.44 in Scenario 1 (and 2), this results in the recruitment being a little bit lower while fishing mortality is similar comparing Scenario 1 (and Scenario 2) with the Baseline. The same perception of the stock dynamics (fluctuations) over time is observed for Scenario 1 and the Baseline.

Scenario 2 has the same natural mortality change used as in Scenario 1 but the maturity ogive and MWA vector are different. The maturity ogive has been changed to 20% mature of the 1-group, and the revised MWA in the stock is applied, obtained from long-term averages measured from the commercial fishery catch. The changes in MWA are minor compared with the Baseline and do not have much impact. The change in the maturity ogive, where 20% are mature compared with value of 10% in the Baseline results in a higher SSB in Scenario 2 compared with the Baseline (and Scenario 1) as would be expected. The same trends in R and TSB as well as F are observed in Scenario 2 as in Scenario 1 and the reason for this is the same as described above under Scenario 1. Also recruitment is somewhat lower under Scenario 2. In combination, higher SSB and lower R under Scenario 2 imply a lower overall recruitment rate (R/SSB). Overall, the same perception of the stock dynamics (fluctuations) over time is observed for Scenario 2 and the Baseline. In line with this the retrospective patterns for scenario 2 is consistent and stable.

Scenario 3 operates with bigger changes in mortality by age compared with the baseline. In this scenario the M-value for the 0- and 1-groups is around 0.25 and the M for the older age groups are substantially higher (around 0.55 for age 2 and 0.7 for age 3). The same maturity ogive and MWA vector is in Scenario 3 as was used in Scenario 2. Much greater mortality on the old, large fish together with fishing mortality results in a high total mortality on the older fish, and consequently, there needs to be more recruits to sustain this mortality (as the same number of fish is caught in all scenarios). This results in higher R, and a much higher TSB and SSB, and a perceived lower fishing mortality. Because of the significant change in M in this scenario the stock dynamics and perception of the stock and recruitment for Scenario 3 are different over time compared with the Baseline.

Scenario 4 uses the multispecies model estimates of M where the quarterly mortality is higher on the young fish and lower on the older fish, i.e. around 0.65 for age 0, 0.4 for age 1, 0.35 for age 3 and 0.3 for age 3. This results in similar TSB and SSB as the Baseline but a perception of slightly higher recruitment and fishing mortality.

The independent reviewers considered that the new values for biological inputs constituted an improvement to the assessment of Norway pout and they support the use of Scenario 2 as the new Baseline for the stock assessment. They expressed some concern regarding the estimation of mortality rates from survey data without accounting for the survey catchability-at-age. Ideally natural mortality should be estimated within the stock assessment model simultaneously with estimates of survey catchability, but in most cases the data are inadequate to do this. Evidence of density-dependence in Norway Pout mortality, growth and maturation rates suggests that using fixed estimates in stock assessments could lead to biases and this is worthy of further investigation. The reviewers note that the stock–recruit scatter was relatively uninformative but considered that the values being used for biological reference point should still apply. Consideration could also be given to a higher target escapement level given the importance of Norway Pout as a forage species in the ecosystem.

The Benchmark group concluded that revisions to natural mortality, maturity and mean weight-at-age should be included in the final benchmark assessment based on the approach in Lambert *et al*. (2009) and Nielsen *et al*. (2012). It is not recommended that Z values be used as proxies for M values for the full year range since 1983 (Scenario 3) as this average includes fishing mortality which, especially in the early part of the period, has been relatively high, i.e. this gives a biased overestimation of M. Both Scenarios 2 and 4 were found worthy of further consideration in the Benchmark. The results of Scenarios 2 and 4 are not significantly different from the baseline scenario, and both scenarios give the same perception of the stock dynamics (fluctuations) over time as is observed for the baseline.

The population dynamic parameters and approach used in Scenario 2 have been documented in Nielsen *et al*. (2012) and in Lambert *et al*. (2009). SMS estimates of mortality on age 1 are higher than those based on Z estimates from the IBTS index. This difference in perception could occur if the catchability on age 1 was low. The above cited papers investigate and argue that the catchability of the 1-group Norway pout is not lower than for the older age groups (although this is somewhat contrary to the catchability estimates at age for IBTS coming out of both the Baseline and the Scenario 2 SXSA assessment model estimates), and that there is no age specific migration out of the assessment area (being the whole North Sea and Skagerrak–Kattegat).

Scenario 4 uses results of M from the SMS model assessment which has a number of characteristics and assumptions as well. The SMS assumes constant residual mortality-at-age (M1), i.e. natural mortality due to other reasons than predation. This is in contradiction to potential spawning mortality as discussed in Nielsen *et al*. (2012) which would result in M increasing with age. Also, the SMS smoothes mortality out between ages 1–3, i.e. does not fully consider potential differences in natural mortality between these ages, because the model uses rather wide size intervals in its prey–predator preference model (ICES 2011b; Pers. Comm. Morten Vinther and Anna Rindorf, DTU Aqua, March 2011). This means that the mortalities between age 1, age 2 and age 3 tend to be equalized in the model. In the SMS a main predator on Norway pout age 1 to age 3 is saithe, and the SMS assessment results are sensitive to biomass estimates of saithe in the North Sea. The SMS uses the saithe (predator) biomass estimates from the ICES WGNSSK single-stock assessment (ICES 2011a), and this assessment is very uncertain. Consequently, the SMS natural mortality estimates on Norway pout depend on uncertain assessment estimates of saithe in the North Sea which also influences age specific mortalities on Norway pout.

Compared with the analysis of IBTS survey data, SMS estimates of total yearly M (and also Z) are higher for age 0 and 1 and lower for age 2 and 3 Norway pout (ICES 2011b; Nielsen *et al*., 2012). Even if the catchability in the surveys was lower for age group 1, it is difficult to explain the lower mortalities estimated by the SMS for age 2 and age 3 compared with the comparable observed survey based mortality estimates. In Nielsen *et al*. (2012) it is argued that migration in or out of the area is very unlikely, so the lower estimates of Z from SMS at age 2 and especially age 3 compared with estimates from the IBTS data (Nielsen *et al*., 2012) is difficult to explain.

In conclusion the benchmark group agreed that Scenario 2 is preferred based on the available information, and recommends Scenario 2 be used as the new baseline assessment for the Norway pout stock.

Due to the short-lived nature of this species a preliminary TAC is set every year, which is updated on the basis of advice in the first half of the year using the escapement management strategy approach. Reference points are estimated from the SXSA model fit and based on the previous assessment, MSY $B_{escapement}$ = B_{pa} = 150 kt where B_{pa} = B_{lim} $^{e0.3*1.65}$ and B_{lim} = B_{loss} = 90 kt (lowest observed SSB in the 1980s). A segmented regression was fit to Scenario 2 estimates as part of the Benchmarking process. Norway pout data do not provide strong evidence of a well-defined breakpoint (inflection) in the SSB-R relationship indicating the onset of recruitment overfishing. This is somewhat typical for short-lived species. The statistics from the segmented regression in Table 18 confirms that the inflection point is rather poorly estimated by the maximum likelihood approach. The Benchmark group recommends that B_{loss} be retained as the B_{lim} reference point = 90 kt and B_{PA} as MSY $B_{escapement}$ reference point = 150 kt. Higher escapement targets could be considered in future based on the importance of Norway pout as a forage species in the ecosystem.

1 Introduction

In 2011 ICES ACOM established the Inter Benchmark Protocol (Terms of Reference) for Norway pout North Sea stock (IBPNorwayPout; 2011/2/ACOM46), to be chaired by Peter Shelton (Canada), with ICES Convener J. Rasmus Nielsen (Denmark; also NP Stock coordinator) and invited external reviewer Jake Schweigert (Canada), to convene by correspondence.

The Terms of Reference are:

a) Review the proposed updates in data analysis and assessment methodology as described in the stock issue list.

b) Prioritize the issues and provide guidance to stock experts on methods with which to solve issues.

c) Describe the choice of preferred method for data analysis and assessment in a concise report. Include recommendations on progress to be made in cases where work is not yet finalized.

d) Describe the resulting data analysis procedure and assessment methodology in the stock annex.

e) Review and agree on the resulting stock annex.

The request was made that IBPNorwayPout report by 1st September for the attention of ACOM. In practice the aim is to have the IBPNorwayPout report ready for WGNSSK which will meet starting 27 April 2012.

The work of IBPNorwayPout was ably coordinated by Barbara Schoute from ICES Secretariat with excellent secretarial support from Helle Gjeding Jørgensen.

The primary aim of the benchmark (see Issue List and Table in Appendix) is to consider and change (where necessary) the values of a number of biological parameters that are treated as inputs to the assessment (maturity, growth, natural mortality) based on new biological information from research carried out since 2007, summarized in two scientific primary publications. This could have implications for the overall perception of the stock, as well as reference points and management targets.

In addition it was considered that updated natural mortality information on Norway Pout from a recent MSVPA model/SMS model run would be required. This is provided in the Report of the Working Group on Multispecies Assessment Methods (WGSAM) from the 10–14 October 2011 meeting in Woods Hole (ICES CM 2011/SSGSUE:10).

The issue Table compiled by WGNSSK is given in the Appendix to this report.

2 Description of the Benchmark Process

IBPNorwayPout met by WebEx on three occasions to plan and review the work of the Inter-Benchmark.

On February 9, 2012 the Benchmark team was introduced, an overview of the ICES Inter Benchmark protocol was given (ACOM 28-4-2009), the ToR and expected products from IBPNorwayPout were discussed, and time tables and deadlines were considered. Consideration was given to the proposal of assessment scenarios based on biological parameters provided as input (growth, maturation and natural mortality) in the light of two recent papers published in the primary literature (Lambert *et al*., 2009; Nielsen *et al*., 2012). The decision was made to apply five assessment scenarios in addition to the baseline (2011) assessment that explored stepwise departures from the baseline assessment by introducing new parameters for mortality rate, proportion mature, proportion mature and mortality together, weights, and finally all three changes in concert. Natural mortality rate estimates were based on average total mortality rates at age across years from Table 1 in Nielsen *et al*. (2012). These analyses are based on an area that is wider than the combined index area covered for the standard calculation of the ICES IBTS abundance indices to assure the coverage of the full NP stock distribution area needed for the area disaggregated analyses of geographical variability (Nielsen *et al*., 2012).

On March 8 IBPNorwayPout met by WebEx to address outstanding issues related to the inputs, to review the results and diagnostics from five assessment scenarios that had been completed and to discuss the revision of reference points. The decision was made to carry out an additional set of assessment scenarios in which natural mortality from Average Z at-age (being a proxy for M) for ages 1–3 came only from years in which landings of Norway pout were very low (2004, 2005, 2007 and 2008) from Q1 IBTS ICES Northern Pout indices from the standard ICES Norway pout index area (rather than the wider area used in Nielsen *et al*., 2012).

On March 27 IBPNorwayPout met by WebEx to review the new scenarios in which natural mortality was based on average Z for only years of low catch. The decision was made to present four assessment scenarios as candidates for the preferred assessment approach compared with the baseline (i) the Baseline assessment, (ii) an assessment based on the new estimates of average Z at-age as a proxy for M from only for those years in which landings were very low ((2004, 2005, 2007 and 2008) and with baseline maturation and weight parameters (Scenario 1), (iii) an assessment based on the estimates of average Z at-age as a proxy for M from only those years in which landings were very low ((2004, 2005, 2007 and 2008) and with new maturation and weight parameters (Scenario 2), (iv) an assessment based on estimates of long-term average Z at-age as a proxy for M from Table 1 in Nielsen *et al*. (2012) and with new maturation and weight parameter (Scenario 3), and (v) an assessment based on the new maturation and weight parameters, along with average quarterly values of M1+M2 from MSM for the years 1983–2010.

Between March 27 and April 20, 2012, IBPNorwayPout met periodically by correspondence through e-mails to agree on a preferred scenario, to evaluate the detailed diagnostics for this scenario relative to the Baseline scenario, and to finalize the Inter-Benchmark report including reviewers comments.

3 Norway pout in the North Sea

3.1 Stock ID and substock structure

This is not under consideration in the benchmarking.

3.2 Issue list in the benchmarking

The issues addressed in the benchmarking process (see Appendix for issues table) relate to the evaluation of the impacts of using different population dynamics parameters in the assessment for natural mortality, sexual maturity and growth (mean weight-at-age in the stock) for the Norway pout stock in the North Sea and Skagerrak. A series of exploratory assessment runs and scenario testing with different population dynamics parameters were completed as listed below. The parameters in the scenarios and the approach used originates partly from results published in Nielsen *et al*. (2012); Lambert *et al*. (2009); Sparholt *et al*. (2002a,b) as well as from the multispecies assessment working group ICES WGSAM 2011 using natural mortality estimated for Norway pout in the North Sea and Skagerrak from the key new run of the multispecies SMS model.

A series of scenarios under the benchmarking were tested as well as the baseline with the settings of population dynamic parameters used in the assessment up to 2011 (including May and September 2011). The May 2011 assessment is selected as the baseline assessment.

Baseline Baseline parameters May 2011 assessment:

Natural mortality: Constant by quarter and age set to 0.4 by the WG back to the 1990s (benchmarked in 2004; see stock annex).

Maturity ogive: Only 10% mature of the 1-group set by the WG back in the 1990s. (origin: unknown)

Mean weight-at-age in stock (MWA): Constant, assumed MWA in stock as set back in the 1990s (origin: settled by the WG in the 1990s).

Scenario 1 Natural mortality (M) change:

Natural mortality (M) change: Average Z at-age is used as a proxy for M for ages 1–3 in the years 2004, 2005, 2007 and 2008 based on Q1 IBTS ICES NP indices from the standard ICES NP index area (calculated from Q1–Q1 cohorts as averages for these four years having very low fishing mortality where the calculations are based on Nielsen *et al*., 2012, Figure 1 and the yearly Ms are divided by 4 to obtain quarterly M's, and M at-age 0 is set equal to that for age 1).

Maturity ogive and mean weight-at-age in stock (MWA): The maturity ogive and mean weight-at-age as in the baseline assessment.

Scenario 2 Natural mortality (M) and proportion mature and mean weight-at-age (MWA) in stock change:

Natural mortality (M) change: As in Scenario 1.

Maturity ogive change: Maturity-at-age 1 is set to 0.2 from Lambert *et al*. (2009, Figure 4). Maturity-at-age 2 is set to 100% similar to the baseline.

Mean weight-at-age in stock (MWA) change: Values are based on results from commercial fishery during the period 1983 to 2006 as presented in Lambert *et al*. (2009, Figure 8). On this basis long-term trends in MWA have been calculated for the period 1983 to 2011 by quarter and area for the Danish commercial fishery as a validation of the Lambert *et al*. (2009) Figure 8 values. They are consistent. The revised Mean Weight-at-Age (MWA) in the stock used in the benchmark assessment are for the 1-, 2- and 3- age groups as determined from the long-term averages. Data for MWA by quarter for age 0 are fixed at values in the Baseline. MWA is determined from commercial fishery catch data and not from the IBTS, from which only length data are available.

Scenario 3 Natural mortality (M) and proportion mature and mean weight-at-age (MWA) in stock change:

Natural mortality (M) change: Average Z at-age (being a proxy for M) for ages 1–3 for the full year range 1983–2005 from Q1–Q1 IBTS indices from Nielsen *et al*. (2012) Figure 1 (as presented in Table 2 below). Yearly Ms divided by 4 to obtain average quarterly M's. M at age 0 set equal to that for age 1.

Maturity ogive change: As in Scenario 2.

Mean weight-at-age in stock (MWA) change: As in Scenario 2.

Scenario 4 Natural mortality (M) and proportion mature and mean weight-at-age (MWA) in stock change using multispecies SMS assessment model output for M:

Natural mortality (M) change: M1+M2 from the multispecies SMS model from key new run presented in the ICES WGSAM 2011 Report (ICES 2011b). Averages of the SMS estimates of quarterly M1+M2 have been used for the full year range used in the SMS key run.

Maturity ogive change: As in Scenario 2

Mean weight-at-age in stock (MWA) change: As in Scenario 2.

Table 1. Norway pout IV and IIIaN (Skagerrak). Mean weight-at-age in the stock, proportion mature and natural mortality used in the assessment. Baseline settings and Scenario 1-4 settings for population dynamics parameters. New parameter settings are in red.

Baseline

Age	Weight (g)				Proportion mature	M Quarterly	M values evaluated (Exploratory run)
	Q1	Q2	Q3	Q4			
0	-	-	4	6	0	0.4	0.25
1	7	15	25	23	0.1	0.4	0.25
2	22	34	43	42	1	0.4	0.55
3	40	50	60	58	1	0.4	0.75

Scenario 1

Age	Weight (g)				Proportion mature	M Quarterly
	Q1	Q2	Q3	Q4		
0	-	-	4	6	0	0.29
1	7	15	25	23	0.1	0.29
2	22	34	43	42	1	0.39
3	40	50	60	58	1	0.44

Scenario 2

Age	Weight (g)				Proportion mature	M Quarterly
	Q1	Q2	Q3	Q4		
0	-	-	4	6	0	0.29
1	9	14	28	28	0.2	0.29
2	26	25	38	40	1	0.39
3	43	38	51	58	1	0.44

Scenario 3

Age	Weight (g)				Proportion mature	M Quarterly
	Q1	Q2	Q3	Q4		
0	-	-	4	6	0	0.26
1	9	14	28	28	0.2	0.26
2	26	25	38	40	1	0.54
3	43	38	51	58	1	0.71

Scenario 4

Age	Weight (g)				Proportion mature	M Quarterly
	Q1	Q2	Q3	Q4		
0	-	-	4	6	0	0.65
1	9	14	28	28	0.2	0.41
2	26	25	38	40	1	0.35
3	43	38	51	58	1	0.29

3.3 Scorecard on data quality (WKACCU)

No new information.

3.4 Multispecies and mixed fisheries issues

Multispecies considerations were evaluated in relation to the natural mortality population dynamics parameters in the benchmarking for Norway pout stock in the North Sea and Skagerrak including predation mortality. A series of assessment scenarios were run with different parameter settings of natural mortality. Natural mortality has been derived from analysis of total mortality rates estimated from IBTS survey catch rates (cpue from IBTS Q1 and Q3) using the approach described in Nielsen *et al*. (2012); Lambert *et al*. (2009) and Sparholt *et al*. (2002a,b). Furthermore, natural mortalities derived from the multispecies SMS model were used in one of the exploratory scenarios (Scenario 4) in the benchmarking. This is described under natural mortality in Section 3.6.4.

Mixed fisheries are not dealt with in the benchmarking.

3.5 Ecosystem drivers

Ecosystem drivers have not been considered in the benchmark assessment.

3.6 Stock assessment

3.6.1 Catch-quality, misreporting, discards

This issue is not considered or addressed in the benchmark assessment.

3.6.2 Surveys

Total and natural mortality as well as sexual maturity and growth estimates of Norway pout are derived directly from the IBTS survey indices both from the ICES DATRAS database and from Nielsen *et al*. (2012); Lambert *et al*. (2009) and Sparholt *et al*. (2002a,b) using IBTS Q1 and Q3 data (mainly Q1). The population dynamic parameters derived from the IBTS surveys are used as input in the different exploratory scenarios in the benchmarking process and are described under Sections 3.6.3 and 3.6.4.

3.6.3 Natural mortality

The natural mortality used in the previous and the current baseline assessments was fixed by quarter and age at 0.4 by the ICES WGNSSK back in the 1990s (benchmarked in 2004; see ICES 2011a and associated stock annex). In this Inter-Benchmark, revised natural mortalities are considered in Scenarios 1–4. In Scenario 3 M by quarter for age 1 to 3 originates from the analyses of mortality from revised IBTS Q1 surveys for 1983–2005 as given in Nielsen *et al*. (2012) Figure 1 (Table 2 below). In Scenarios 1 and 2, Z as a proxy for M is estimated only from low fishing mortality years (2004, 2005, 2007 and 2008) using the standard IBTS Q1 survey data. In Scenario 4 estimates of M1+M2 for Norway pout from ICES WGSAM 2011 (ICES 2011b) are applied.

Table 2. Norway pout IV and IIIaN (Skagerrak). Total mortality (Z), at age by year during the period 1983–2005 from the estimates in Nielsen *et al.* (2012, Figure 1). Long-term average Z at-age by year and resulting quarterly averages. Estimates based on cohort analyses from IBTS Q1 data from the extended survey area used in Nielsen *et al.* (2012).

Year	Age 1	2	3
1983	0.84	2.52	
1984	1.23	2.56	3.38
1985	1.74	4.08	4.08
1986	1.37	1.91	1.56
1987	1.38	3.56	3.28
1988		1.58	1.79
1989	1.03	1.89	4.22
1990	0.52	1.35	1.30
1991	0.96	3.14	3.69
1992	0.67	1.26	0.90
1993	1.89	3.60	5.35
1994	0.85	1.53	2.01
1995	0.84	1.31	2.89
1996	0.26	1.44	4.12
1997	0.66	1.75	1.78
1998	0.60	2.08	4.23
1999	0.71	2.14	2.51
2000	1.02	1.91	2.91
2001	0.64	1.18	1.80
2002	1.00	2.10	2.22
2003	0.96	2.81	3.36
2004	1.79	2.47	
2005	1.59	1.81	2.11
Average	1.02	2.17	2.83
Average / 4	0.26	0.54	0.71

Commercial fishery catches were reduced in 2004, 2005, 2007, and 2008. Fishing mortality was estimated at 0.000 in 2005 and low in 2004, 2007 and 2008 at, respectively, 0.159, 0.023, and 0.137 (ICES 2011a; see Baseline summary in Table 5 below) from the previous single-stock assessments with natural mortality fixed at 0.4 by age and quarter of year (ICES 2011a). The time-series of Z estimates from Nielsen *et al.* (2012) based on the extended (full) Norway pout survey area covers the period 1983 to 2005. The average quarterly Z for 2004 and 2005 is 0.42 for age 1, 0.54 for age 2, and 0.53 for age 3. In these four years the total mortality, Z at-age, has been similar to total mortality in years with higher fishing mortality (Nielsen *et al.*, 2012).

Table 3. Z at age 1, 2 and 3 for the years 2004, 2005, 2007 and 2008 based on ICES NP indices from the IBTS Q1 survey (ICES DATRAS Database). The Z estimates are calculated based on eq. 1 in Nielsen *et al*. (2012).

Year	Age 1 Q1	Age 2 Q1	Z(age1)
Cohort 1, 2004-05	894.965	132.591	1.91
Cohort 2, 2005-06	689.849	161.532	1.45
Cohort 3, 2007-08	1283.764	506.069	0.93
Cohort 4, 2008-09	2344.512	1619.893	0.37
Average Z (age 1)			1.17
Quarterly average			0.29
Year	Age 2 Q1	Age 3 Q1	Z(age2)
Cohort 5, 2004-05	376.305	37.084	2.32
Cohort 6, 2005-06	132.591	35.107	1.33
Cohort 7, 2007-08	788.262	185.873	1.44
Cohort 8, 2008-09	506.069	150.22	1.21
Average Z (age 2)			1.58
Quarterly average			0.39
Year	Age 3 Q1	Age 4 Q1	Z(age3)
Cohort 9, 2004-05	34.023	0.704	3.88
Cohort 10, 2005-06	37.084	6.267	1.78
Cohort 11, 2007-08	12.707	9.69	0.27
Cohort 12, 2008-09	185.873	63.831	1.07
Average Z (age 3)			1.75
Quarterly average			0.44

The quarterly average Z at age is 0.29 for age 1, 0.39 for age 1, and 0.44 for age 3, based on the ICES standard area indices from 2004, 2005, 2007 and 2008. The average total mortalities-at-age by year and quarter is in the same range as Nielsen *et al*. (2012) based on the two years 2004 and 2005 (Table 2) and averages from the standard ICES Norway pout index area for 2004, 2005, 2007 and 2008 (Table 3).

Catches and fishing mortalities for the recent years 2004, 2005, 2007, and 2008 have been very low (ICES WGNSSK 2011 Report, ICES 2011a). Accordingly, the average Z at-age by year and quarter for these years can be used as proxies for the natural mortality M at-age. Although the variability of Z at-age is high between years and the averages are based on only a few years of observations, these values are considered representative for the natural mortality in the new benchmark assessment. Therefore, M is fixed at 0.29 for age 1, 0.39 for age 2, and 0.44 for age 3 using the four years averages from the standard IBTS area in Scenarios 1 and 2. M at age 0 is set equal to the value for age 1. The average Zs are lower for age 2 and 3 than the two year averages (2004, 2005) estimated from Nielsen *et al*. (2012).

Natural mortalities (predation mortality M2) of Norway pout has also been estimated in the ICES WGSAM Report from 2011 (ICES, 2011b) using the multispecies SMS model in a 2011 key run. The output from this multispecies assessment is shown below (Table 4 and Figure 1). It appears that the SMS estimates of total mortality for age 1, 2 and 3 are very similar to a tendency of higher age 1 (blue line, Figure1) mortality compared with age 2 and 3 natural mortality and a very high 0-group mortality.

The SMS estimates of natural mortality vary significantly by quarter for the different ages. The SMS model makes a number of assumptions such as constant residual mortality (M1) across ages, i.e. natural mortality due to reasons other than predation. This is inconsistent with the potential spawning mortality hypothesis discussed in Nielsen *et al*. (2012) where non-predation mortality increases with age as proportion mature at-age increases. SMS smooths mortality estimates between ages 1–3 and therefore does not fully consider potential differences in natural mortality between these ages. This is because the model uses rather wide size intervals in its prey–predator preference (ICES 2011b; Pers. Comm. Morten Vinther and Anna Rindorf, DTU Aqua, March 2011). Therefore, the estimates of mortalities between ages 1, 2 and 3 tend to be equalized in the model. In the SMS a main predator on Norway pout age 1 to age 3 is saithe. SMS assessment results are very sensitive to biomass estimates of saithe in the North Sea. The SMS uses the saithe (predator) biomass estimates from the ICES WGNSSK single-stock assessment (ICES 2011a), and this assessment is very uncertain. Consequently, the SMS natural mortality estimate for Norway pout depends on uncertain assessment estimates of saithe in the North Sea. This could also influence estimates of age specific mortalities on Norway pout in the SMS assessment.

The SMS estimates of total annual M (and also Z) are higher for ages 0 and 1 and lower for ages 2 and 3 Norway pout compared with the estimates from the IBTS surveys (Nielsen *et al*., 2012). Even if the catchability in the surveys was lower for age group 1 (as indicated in the Baseline SXSA model fit) it is difficult to explain the lower mortalities estimated by the SMS for age 2 and age 3 compared with the survey based mortality estimates. Nielsen *et al*. (2012) also argue that migration in or out of the area is very unlikely, so the lower estimates in Z at age 2 and especially at age 3 than from the IBTS data are difficult to explain.

Table 4. Average quarterly M (= M1 + M2) from the SMS Model key run presented in ICES WGSA 2011 (ICES 2011b). Quarterly averages calculated for the year range 1983–2010.

	Age 0	Age 1	Age 2	Age 3
Quarter 1	na	0.481	0.304	0.285
Quarter 2	na	0.528	0.491	0.414
Quarter 3	0.505	0.273	0.262	0.188
Quarter 4	0.769	0.345	0.328	0.284
Yearly	2.598	1.625	1.383	1.169
Average quarterly	0.65	0.41	0.35	0.29

The SMS estimates of natural mortality vary significantly by quarter for the different ages. Because the SXSA assessment model does not converge (as shown in a test run) when using the variable quarterly values of natural mortality obtained from the SMS key run, the average quarterly M values are used in the scenario 4 assessment. When using the variable values for M by quarter from the SMS the SXSA model gives warnings that "there is no data to fix the survivors (s) in a given cohort" and the model is not able to converge.

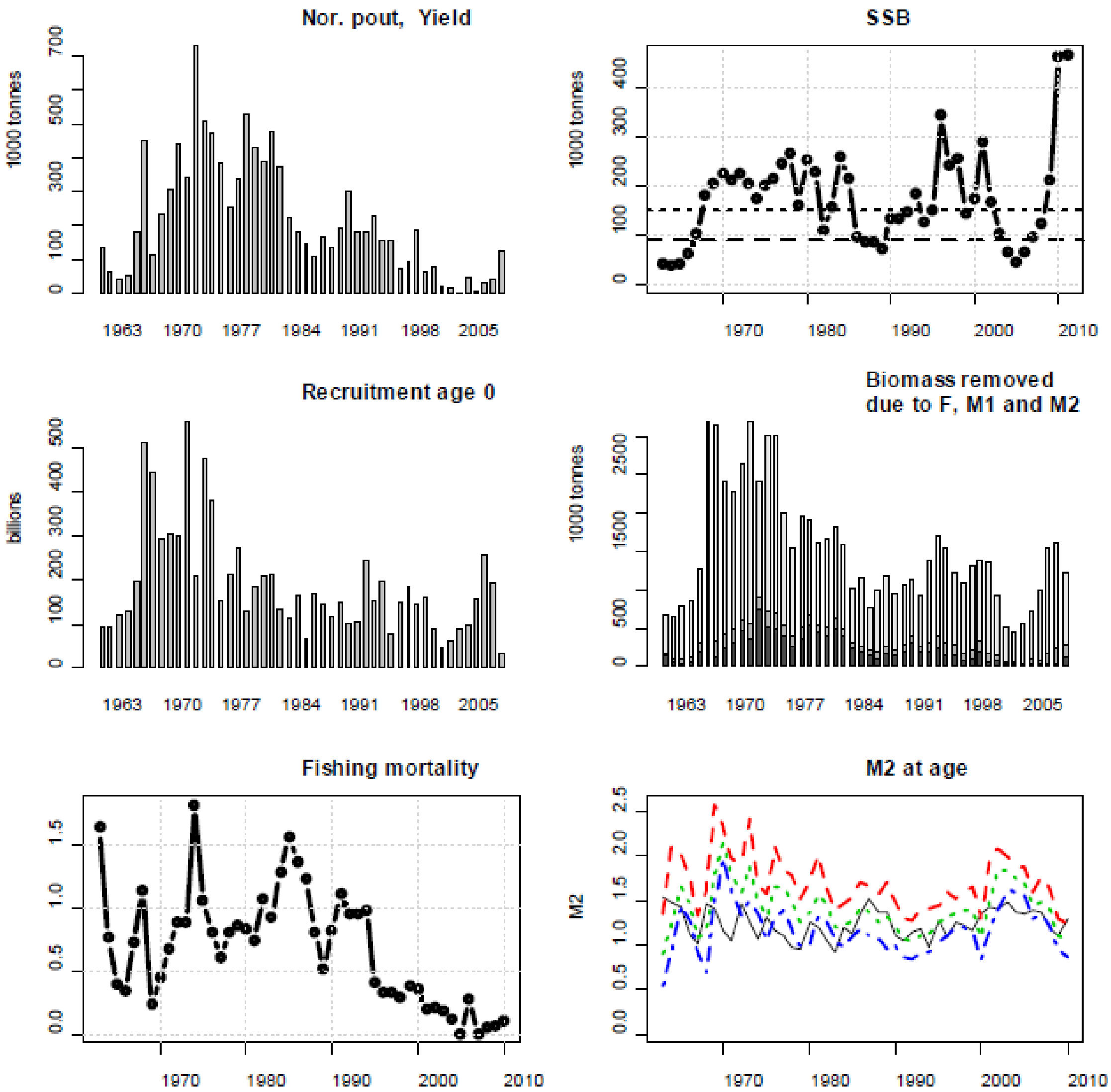


Figure 1. Output from SMS Multispecies assessment on Norway pout in key run from 2011 (from Figure 4.1.2 in ICES 2011b). SMS output for Norway pout. SOP (catch numbers * catch weight), Recruitment, F, SSB, Biomass removed due to the fishery (F), predation by SMS species (M2) and residual natural mortality (M1). The predation mortality (M2) presented by the 0-group (black solid line) is for the second half of the year. The M2 for the rest of the ages are annual values. (See also Appendix).

3.6.4 Weights, maturities, growth

Maturity ogive

The Benchmark exercise used the revised maturity ogive for Norway pout from Figure 4 in Lambert *et al.* (2009) as shown in Figure 2 and Table 5 of this report. Although there is a trend over time, the average maturity from the period 1983–2006 for age is used. As the most recent data (2007–2011) are not available, the mean values are used. Although Lambert *et al.* (2009) document factors influencing the maturity-at-ages 1 and 2 (and trends herein), the precise functional relationships in this are not known. Consequently, the functional relationship of the trend is not used but rather the long-term average in the period 1983–2004. On this basis maturity is changed for age 1 from 0.1 to 0.2. Proportion mature-at-age 2 and 3 is set at 1.

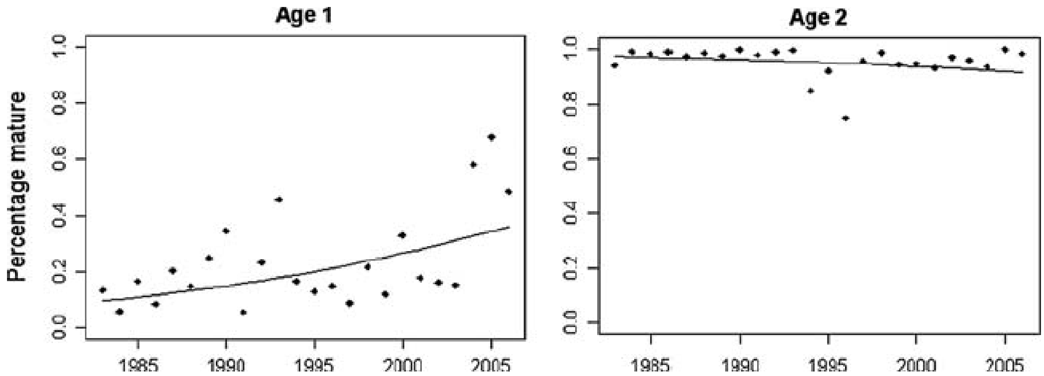


Figure 2. Temporal variability of the maturity ratio of Norway pout during Q1 at ages 1 (left) and 2 (right) from 1983 to 2006. (From Lambert *et al.*, 2009, Figure 4).

Table 5. Maturity-at-age from the maturity ogive in Figure 4 in Lambert *et al.* (2009). Maturity-at-age 1 and 2 in first quarter of the year (Q1) as estimated for the period 1983–2006.

Age	Year	Ratio Mature	Fitted model value
1	1983	0.1317	0.0939
1	1984	0.0553	0.1003
1	1985	0.1649	0.1071
1	1986	0.0824	0.1143
1	1987	0.2019	0.1220
1	1988	0.1456	0.1300
1	1989	0.2481	0.1385
1	1990	0.3445	0.1475
1	1991	0.0550	0.1570
1	1992	0.2319	0.1669
1	1993	0.4580	0.1773
1	1994	0.1655	0.1883
1	1995	0.1284	0.1997
1	1996	0.1475	0.2117
1	1997	0.0858	0.2242
1	1998	0.2157	0.2372
1	1999	0.1169	0.2507
1	2000	0.3279	0.2647
1	2001	0.1770	0.2792
1	2002	0.1599	0.2942
1	2003	0.1493	0.3096
1	2004	0.5831	0.3255
1	2005	0.6809	0.3417
1	2006	0.4842	0.3584
2	1983	0.9404	0.9745
2	1984	0.9909	0.9731
2	1985	0.9833	0.9716
2	1986	0.9916	0.9700
2	1987	0.9748	0.9684
2	1988	0.9869	0.9667
2	1989	0.9766	0.9649
2	1990	1.0000	0.9629
2	1991	0.9805	0.9609
2	1992	0.9918	0.9588
2	1993	0.9968	0.9566
2	1994	0.8475	0.9542
2	1995	0.9205	0.9518
2	1996	0.7486	0.9492
2	1997	0.9577	0.9464
2	1998	0.9871	0.9436
2	1999	0.9446	0.9406
2	2000	0.9461	0.9374
2	2001	0.9319	0.9341
2	2002	0.9707	0.9307
2	2003	0.9586	0.9270
2	2004	0.9352	0.9232
2	2005	1.0000	0.9192
2	2006	0.9840	0.9150

Weight and growth

The MWA inputs for the Benchmark exercise were values from the commercial fishery published in Lambert *et al*. (2009; Figure 8, two top panels for age 1 and 2 for all areas (4aw, 4ae, SK) as shown in Appendix Figure A.1 and Table A.6). A significant difference in MWA by quarter and area is presented in the Annex to the present report. Lambert *et al*. (2009, Figure 8 top panels) show the trend in quarterly MWA at ages 1 and 2 in areas 4ae (eastern North Sea), 4aw (western North Sea), and SK (Skagerrak–Kattegat), for the period 1983–2004. The mean weights are for the commercial fishery, and are available by quarter and subarea.

Long-term trends from 1983 to 2011 in MWA are shown below in Figures 3–6. Averages from the Danish commercial fishery have been calculated for the period 1983 to 2011 by quarter and area as a check of Lambert *et al*. (2009, Figure 8). The revised Mean Weight-at-Age (MWA) in the Stock used in the benchmark assessments Scenarios 2–4 for 1-, 2- and 3- groups are based on taking long-term averages.

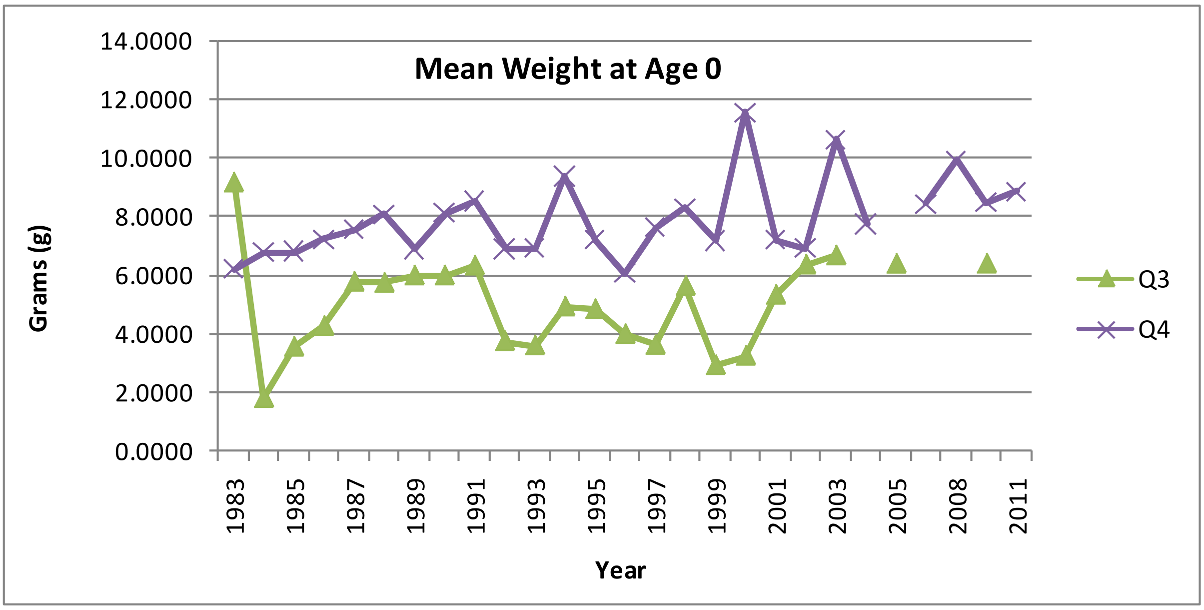


Figure 3. Norway pout in the North Sea and Skagerrak. Variability of average mean weight-at-age 0 by year and quarter for all areas in the North Sea and Skagerrak from Danish commercial catches. (Not weighted with numbers-at-age caught).

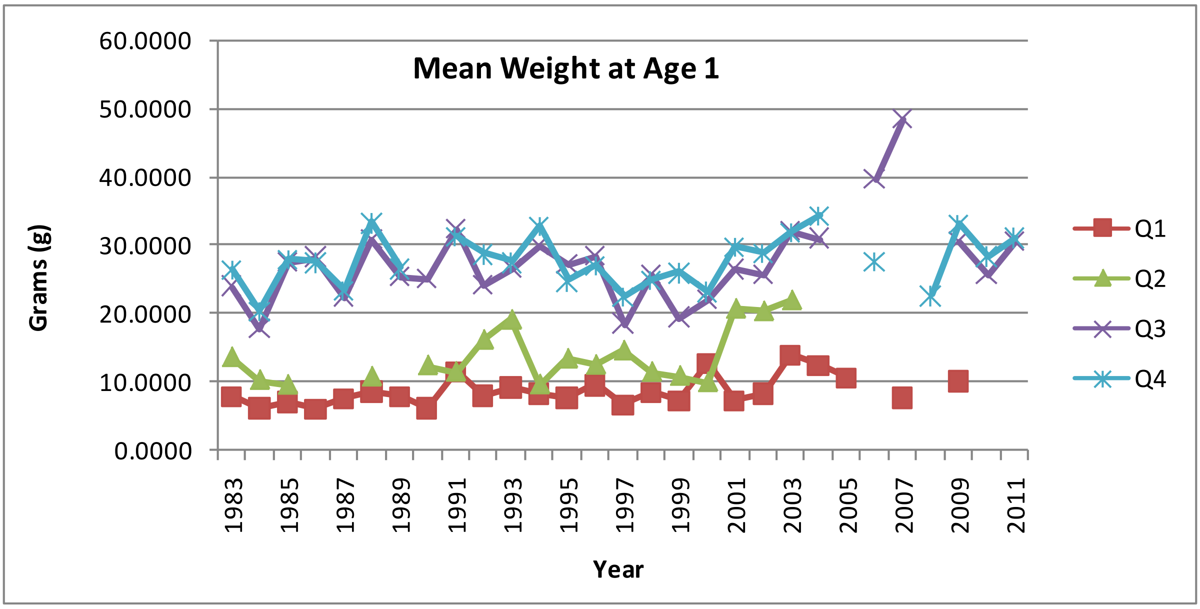


Figure 4. Norway pout in the North Sea and Skagerrak. Variability of average mean weight-at-age 1 by year and quarter of year for all areas in the North Sea and Skagerrak from Danish commercial catches. (Not weighted with numbers-at-age caught).

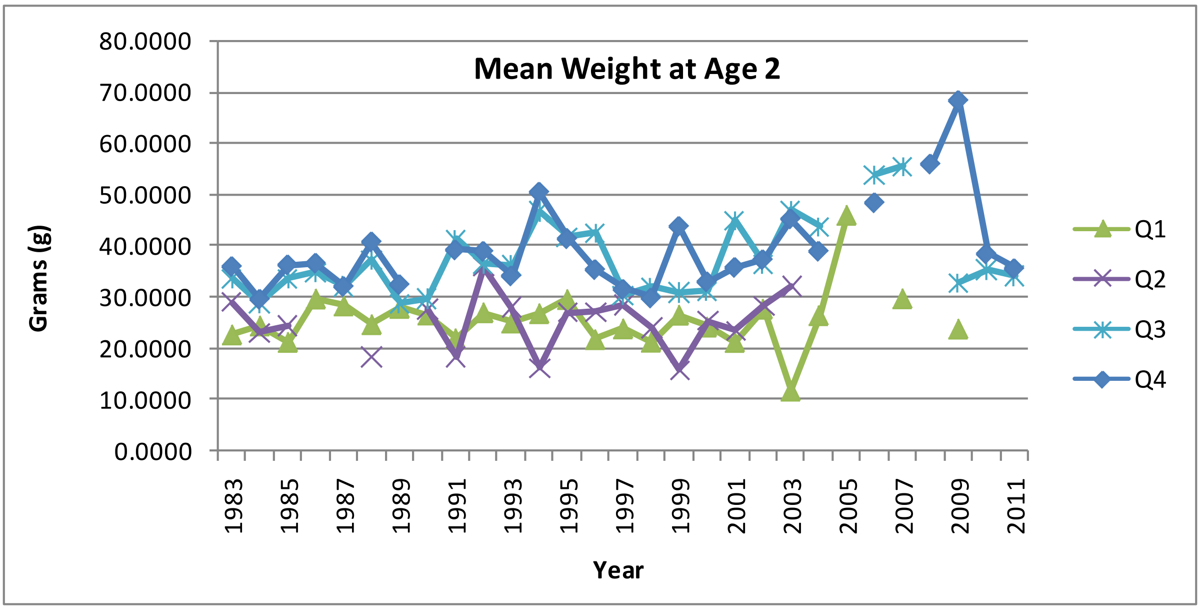


Figure 5. Norway pout in the North Sea and Skagerrak. Variability of average mean weight-at-age 2 by year and quarter of year for all areas in the North Sea and Skagerrak from Danish commercial catches. (Not weighted with numbers-at-age caught).

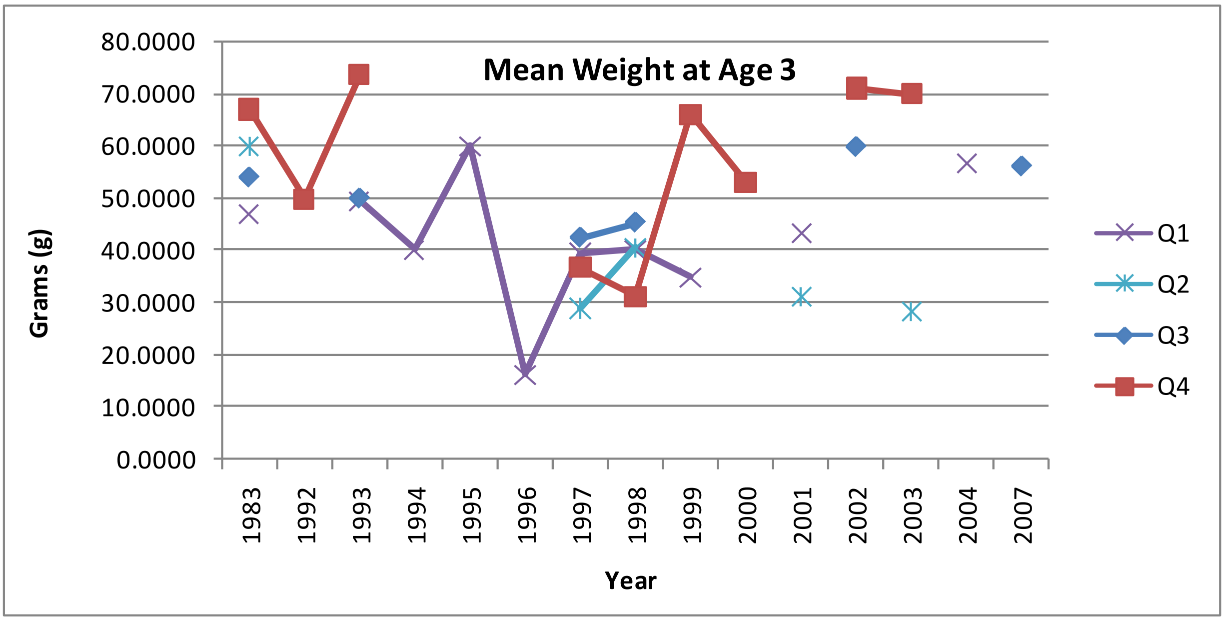


Figure 6. Norway pout in the North Sea and Skagerrak. Variability of average mean weight-at-age 3 by year and quarter of year for all areas in the North Sea and Skagerrak from Danish commercial catches. (Not weighted with numbers-at-age caught).

There is evidence of a trend over time in quarterly MWA but it is not consistent across ages and somewhat variable (Figures 3–6.

In Lambert *et al*. (2009) mean weight-at-age (MWA) is determined from commercial fishery catch data (1983–2004, and the second half of 2006). The IBTS collected only length data. The GLM ANOVA (Table 5) on logtransformed MWA data showed that the variability is explained by quarter, age, and area factors, and the interactions of quarter–area and quarter–age. Age 2 growth was slower than for age 1, and the MWA did not differ in the two northern areas but was higher in the Skagerrak–

Kattegat (Lambert *et al*. (2009), Figure 8). However, the spatial difference did not explain much of the variability, even if it was significant. Quarterly growth was faster from Q2 to Q3, and there was no evidence of an increase from Q1 to Q2 at age 2. Moreover, growth apparently decreased in area 4aw (northwestern North Sea; Lambert *et al*., 2009, Figure 8), which can be due to either a loss of spawning products or spawning mortality.

The trajectories of MWA and MLA exhibited similar seasonal and spatial patterns. Both were higher from Q2 to Q3, and thereafter the values were either stable, with a very small increase, or even decreasing from Q3 to Q2 the following year (Lambert *et al*. (2009), Figure 8). With respect to intraspecific density-dependence in MWA, there was a general trend towards a decrease. However, the relationship between MWA of age 2 and the number-at-age 1 in Q4 of the previous year was the only statistically significant result (Lambert *et al*. (2009), Figure 10). The results of the analyses of interspecific density-dependence using MWA data from the MSVPA show that whiting SSB is positively correlated with MWA at ages 0 and 1, in Q3 and Q4, and that, for cod, SSB is negatively correlated with MWA at age 0 in Q4 and with MWA at age 1 in Q2 (Lambert *et al*. (2009), Figure 12, Table 7). MLA is correlated with whiting and haddock SSB (data from ICES, 2007b; Figure 12). These results demonstrate that the MLA and MWA values depend on sex and maturity stage as much as on geographical area. The relationships between growth and population density and predator biomass are evident but causative factors analysed by Lambert *et al*. (2009) suggest that the processes are not well understood.

3.6.5 Assessment model

The assessment model used in the benchmarking is the same as in the Baseline, i.e. the Seasonal XSA model (SXSA). Natural mortality from the multispecies SMS model was used in one benchmarking scenario (Scenario 4) of the SXSA model.

3.6.6 Results of scenarios and exploratory runs with changed population dynamic parameters

Baseline

Table 6. Norway pout IV and IIIaN (Skagerrak). Stock summary table. (SXSA Baseline May 2011). (Recruits in millions. SSB and TSB in t, and Yield in '000 t).

Year	Recruits (age 0 3rd qrt)	SSB (Q1)	TSB (Q3)	Landings ('000 t)	Fbar(1-2)
1983	147976	369522	1901011	457.6	0.873
1984	80005	371015	1145011	393.01	1.242
1985	57167	166377	640501	205.1	1.296
1986	106282	87714	724626	174.3	1.093
1987	31003	96154	594509	149.3	0.878
1988	85557	126856	572328	109.3	0.659
1989	91121	85488	767853	166.4	0.813
1990	85639	125452	743228	163.3	0.736
1991	162754	145172	1091838	186.6	0.876
1992	69508	174922	1050844	296.8	0.920
1993	48709	218802	622932	183.1	0.816
1994	206484	118979	1085095	182.0	1.051
1995	65163	117389	1194644	236.8	0.573
1996	158806	295459	1137528	163.8	0.436
1997	45016	193585	1038222	169.7	0.590
1998	62962	263826	648244	57.7	0.291
1999	154416	151706	1006321	94.5	0.655
2000	53309	163257	1042099	184.4	0.585
2001	47347	234024	599942	65.6	0.269
2002	32439	159675	461955	80.0	0.509
2003	14484	108764	283023	27.1	0.250
2004	18798	84146	208517	13.5	0.159
2005	73565	54405	423210	1.9	0.000
2006	35734	75927	547661	46.6	0.262
2007	58558	148575	524305	5.7	0.023
2008	112529	135132	833393	36.1	0.137
2009	151852	175524	1268935	54.5	0.259
2010	15671	289223	979481	126	0.420
2011		319002			
Arit mean	**81,173**	**174,347**	**826,331**		**0.595**
Geomean	**65,465**				

Scenario 1

Table 7. Norway pout IV and IIIaN (Skagerrak). Stock summary table. (SXSA Scenario 1 May 2011). (Recruits in millions. SSB and TSB in t, and Yield in '000 t).

Year	Recruits (age 0 3rd qrt)	SSB (Q1)	TSB (Q3)	Landings ('000 t)	Fbar(1-2)
1983	85114	342204	1452591	457.6	0.901
1984	46288	354207	911959	393.01	1.283
1985	31310	158626	483262	205.1	1.330
1986	62397	82120	503228	174.3	1.106
1987	16623	86400	465668	149.3	0.906
1988	49533	124366	402712	109.3	0.652
1989	53139	78935	556751	166.4	0.831
1990	47452	117768	527327	163.3	0.759
1991	92427	136722	743547	186.6	0.894
1992	39684	160455	813526	296.8	0.931
1993	28523	212742	493825	183.1	0.836
1994	116927	116410	696854	182.0	1.071
1995	36775	99265	930394	236.8	0.584
1996	88038	294113	813194	163.8	0.442
1997	24283	183722	835242	169.7	0.584
1998	34348	265073	503275	57.7	0.296
1999	84314	150167	676817	94.5	0.648
2000	28380	148837	821293	184.4	0.576
2001	26016	234085	473866	65.6	0.262
2002	17554	159954	367353	80.0	0.509
2003	7801	107180	230505	27.1	0.245
2004	9983	84285	163049	13.5	0.157
2005	39201	53951	270056	1.9	0.000
2006	19279	69099	419032	46.6	0.257
2007	31138	148209	389021	5.7	0.023
2008	59931	133542	573947	36.1	0.134
2009	81567	166429	889950	54.5	0.249
2010	8438	277019	828064	126	0.409
2011		326506			
Arit mean	**45,231**	**168,013**	**615,582**		**0.603**
Geomean	**36,187**				

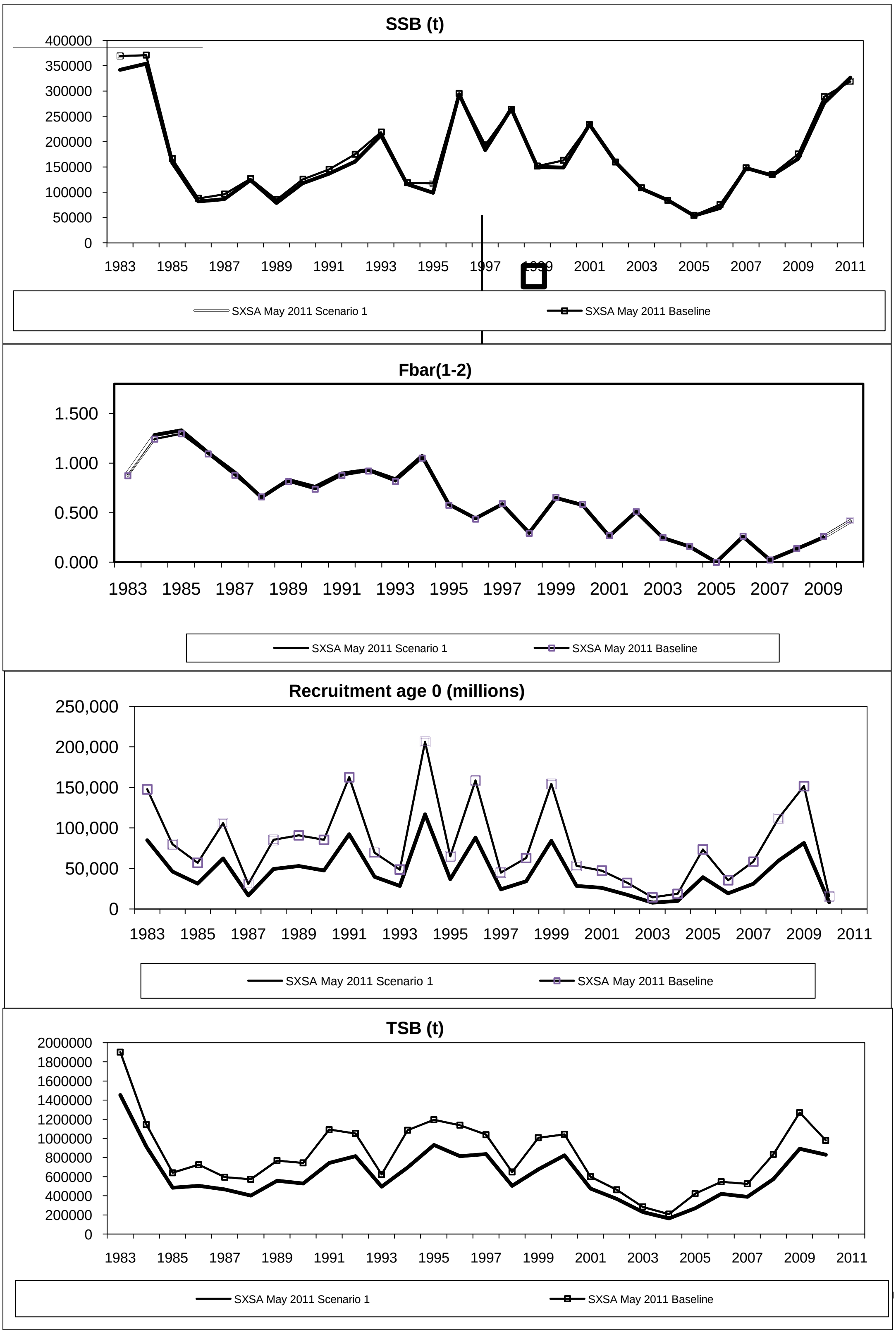


Figure 7. Norway pout IV and IIIaN (Skagerrak). Comparison of May 2011 SXSA baseline assessment with SXSA May 2011 Scenario 1 assessment.

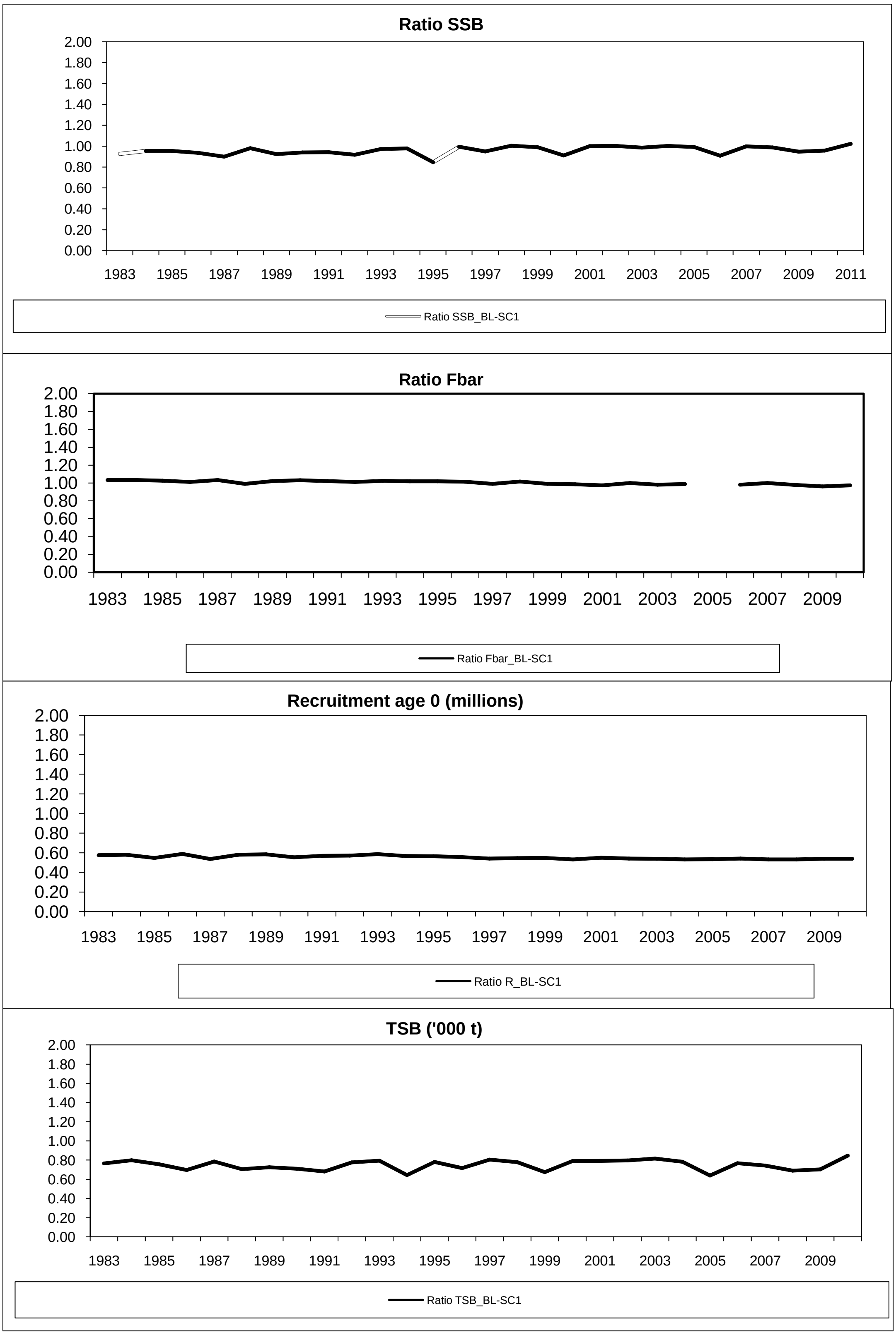


Figure 8. Norway pout IV and IIIaN (Skagerrak). Comparison of May 2011 SXSA Baseline assessment with SXSA May 2011 Scenario 1 assessment. Ratios.

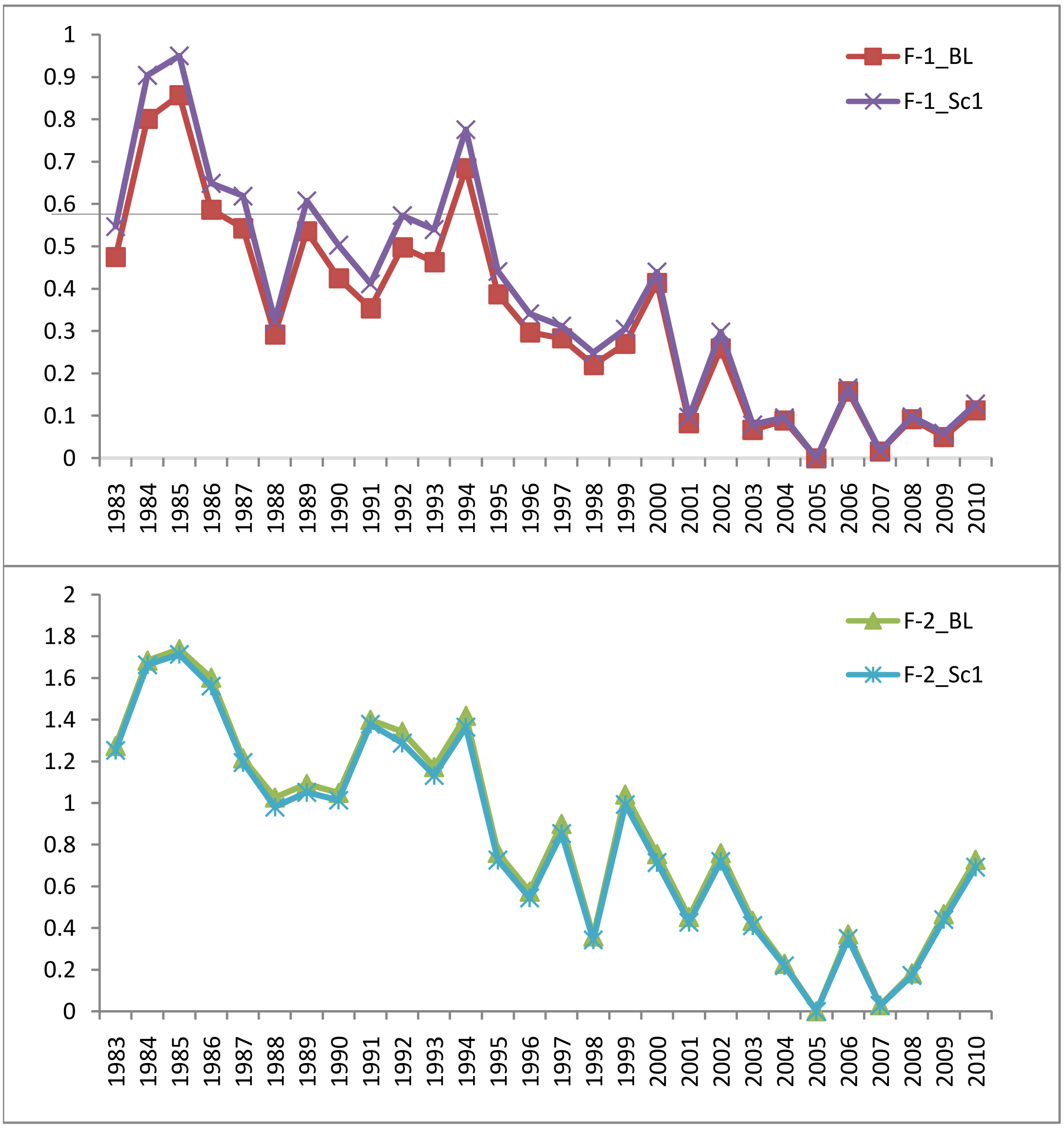


Figure 9. Comparison of trends in fishing mortality for age 1 and age 2 between Baseline assessment and Scenario 1 assessment (changed M).

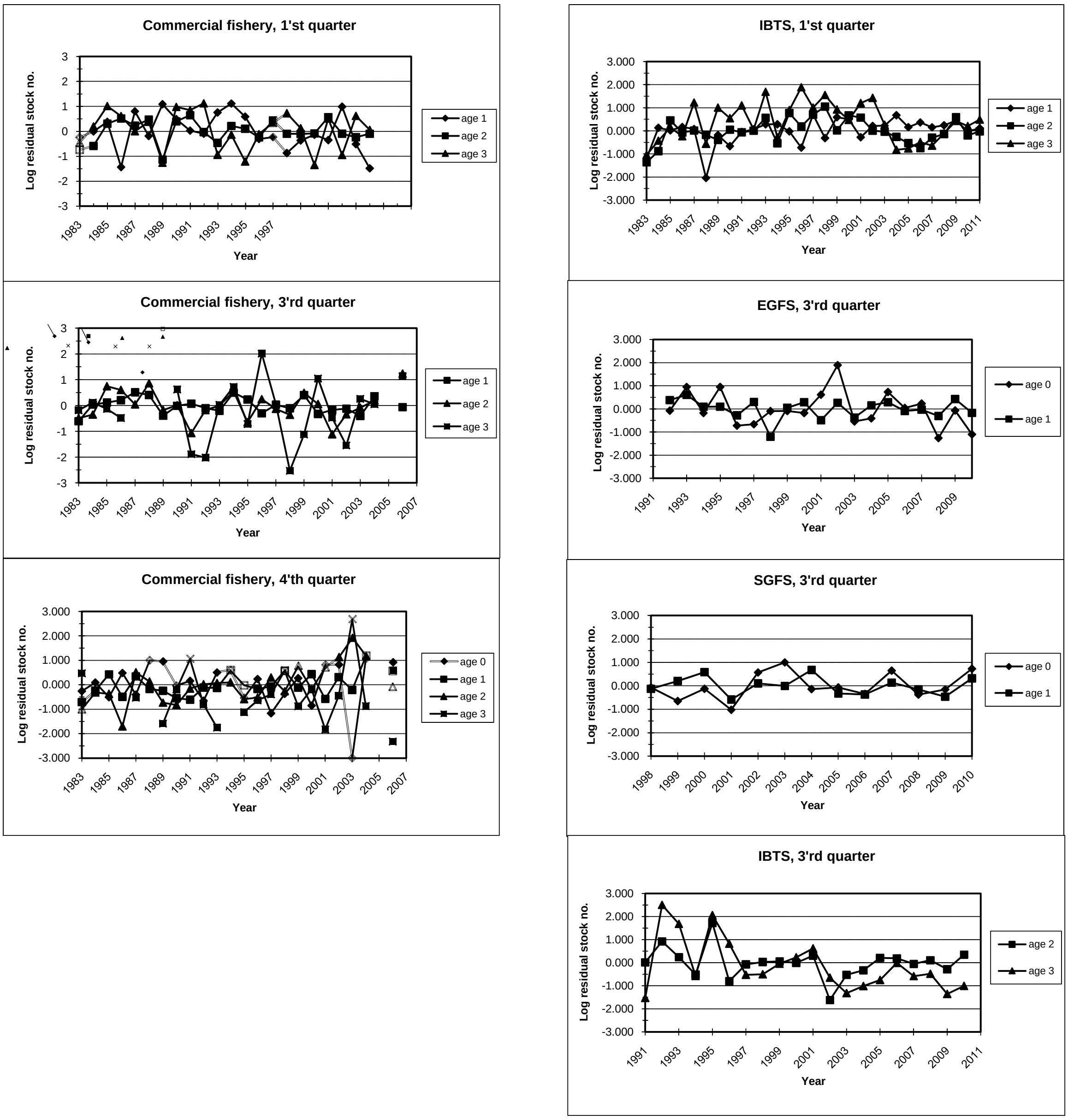


Figure 10a. Norway pout IV and IIIaN (Skagerrak). Logresidual stock numbers (log (Nhat/N)) per age group SXSA divided by fleet and season. SXSA Baseline May 2011.

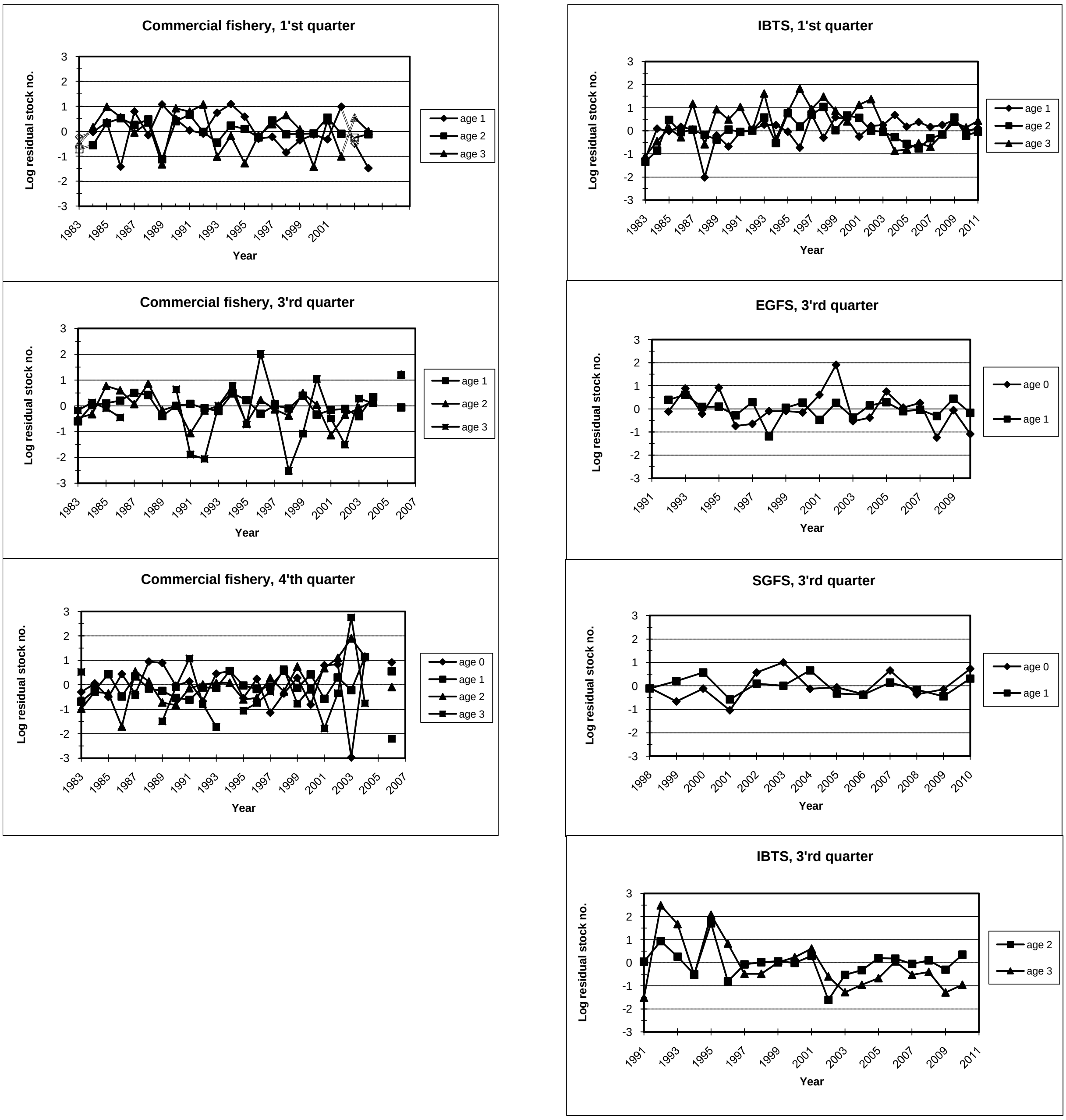


Figure 10b. Norway pout IV and IIIaN (Skagerrak). Logresidual stock numbers (log (Nhat/N)) per age group SXSA divided by fleet and season. SXSA Scenario 1 May 2011.

Table 8. Norway pout IV and IIIaN (Skagerrak). SXSA (Seasonal extended survivor analysis). Diagnostics of the SXSA. Comparison, May 2011 SXSA Baseline and Scenario 1.

Log inverse catchabilities, fleet no: 1 (commercial q134)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	11.536
1	10.719	*	9.872	9.178
2	9.250	*	8.755	8.426
3	9.250	*	8.755	8.426

Scenario 1:

Season	1	2	3	4
AGE				
0	*	*	*	11.102
1	10.380	*	9.728	9.129
2	9.258	*	8.790	8.486
3	9.258	*	8.790	8.486

Log inverse catchabilities, fleet no: 2 (ibtsq1)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	2.468	*	*	*
2	1.492	*	*	*
3	1.492	*	*	*

Scenario 1:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	2.125	*	*	*
2	1.505	*	*	*
3	1.505	*	*	*

Table 8. (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Log inverse catchabilities, fleet no: 3 (egfsq3)

Year 1992-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	2.904	*
1	*	*	1.638	*
2	*	*	*	*
3	*	*	*	*

Scenario 1:

Season	1	2	3	4
AGE				
0	*	*	2.350	*
1	*	*	1.495	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 4 (sgfsq3)

Year 1998-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	2.914	*
1	*	*	1.874	*
2	*	*	*	*
3	*	*	*	*

Scenario 1:

Season	1	2	3	4
AGE				
0	*	*	2.346	*
1	*	*	1.731	*
2	*	*	*	*
3	*	*	*	*

Table 8. (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Log inverse catchabilities, fleet no: 5 (ibtsq3)

Year 1991-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.481	*
3	*	*	1.481	*

Scenario 1:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.526	*
3	*	*	1.526	*

Table 8. (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 1 (commercial q134)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	1.071
1	1.341	*	3.184	2.066
2	2.157	*	1.694	1.240
3	1.255	*	0.831	0.764

Scenario 1:

Season	1	2	3	4
AGE				
0	*	*	*	1.080
1	1.361	*	3.213	2.102
2	2.166	*	1.694	1.242
3	1.247	*	0.830	0.779

Weighting factors for computing survivors:
Fleet no: 2 (ibtsq1)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	1.725	*	*	*
2	1.833	*	*	*
3	1.074	*	*	*

Scenario 1:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	1.730	*	*	*
2	1.845	*	*	*
3	1.111	*	*	*

Table 8. (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 3 (egfsq3)

Year 1992-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	1.263	*
1	*	*	2.342	*
2	*	*	*	*
3	*	*	*	*

Scenario 1:

Season	1	2	3	4
AGE				
0	*	*	1.275	*
1	*	*	2.356	*
2	*	*	*	*
3	*	*	*	*

Weighting factors for computing survivors:
Fleet no: 4 (sgfsq3)

Year 1998-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	1.651	*
1	*	*	2.479	*
2	*	*	*	*
3	*	*	*	*

Scenario 1:

Season	1	2	3	4
AGE				
0	*	*	1.638	*
1	*	*	2.520	*
2	*	*	*	*
3	*	*	*	*

Table 8. (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 5 (ibtsq3)

Year 1991-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.487	*
3	*	*	0.854	*

Scenario 1:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.491	*
3	*	*	0.872	*

Scenario 2

Table 9. Norway pout IV and IIIaN (Skagerrak). Stock summary table. (SXSA Scenario 2 May 2011). (Recruits in millions. SSB and TSB in t, and Yield in '000 t).

Year	Recruits (age 0 3rd qrt)	SSB (Q1)	TSB (Q3)	Landings ('000 t)	Fbar(1-2)
1983	85114	462550	1439995	457.6	0.901
1984	46288	443752	898802	393.01	1.283
1985	31310	201777	478213	205.1	1.330
1986	62397	109124	501393	174.3	1.106
1987	16623	127701	462741	149.3	0.906
1988	49533	149481	397142	109.3	0.652
1989	53139	112081	554336	166.4	0.831
1990	47452	158200	524015	163.3	0.759
1991	92427	179387	740175	186.6	0.894
1992	39684	229481	808757	296.8	0.931
1993	28523	261020	484530	183.1	0.836
1994	116927	144129	693348	182.0	1.071
1995	36775	173125	928522	236.8	0.584
1996	88038	351643	798024	163.8	0.442
1997	24283	247486	830400	169.7	0.584
1998	34348	311633	490521	57.7	0.296
1999	84314	180607	673138	94.5	0.648
2000	28380	212718	816130	184.4	0.576
2001	26016	278926	463186	65.6	0.262
2002	17554	188898	361567	80.0	0.509
2003	7801	127383	226210	27.1	0.245
2004	9983	97214	159453	13.5	0.157
2005	39201	63761	268349	1.9	0.000
2006	19279	98443	416846	46.6	0.257
2007	31138	177183	381153	5.7	0.023
2008	59931	162394	569631	36.1	0.134
2009	81567	217071	883258	54.5	0.249
2010	8438	356051	817075	126	0.409
2011		369413			
Arit mean	**45,231**	**213,539**	**609,533**		**0.603**
Geomean	**36,187**				

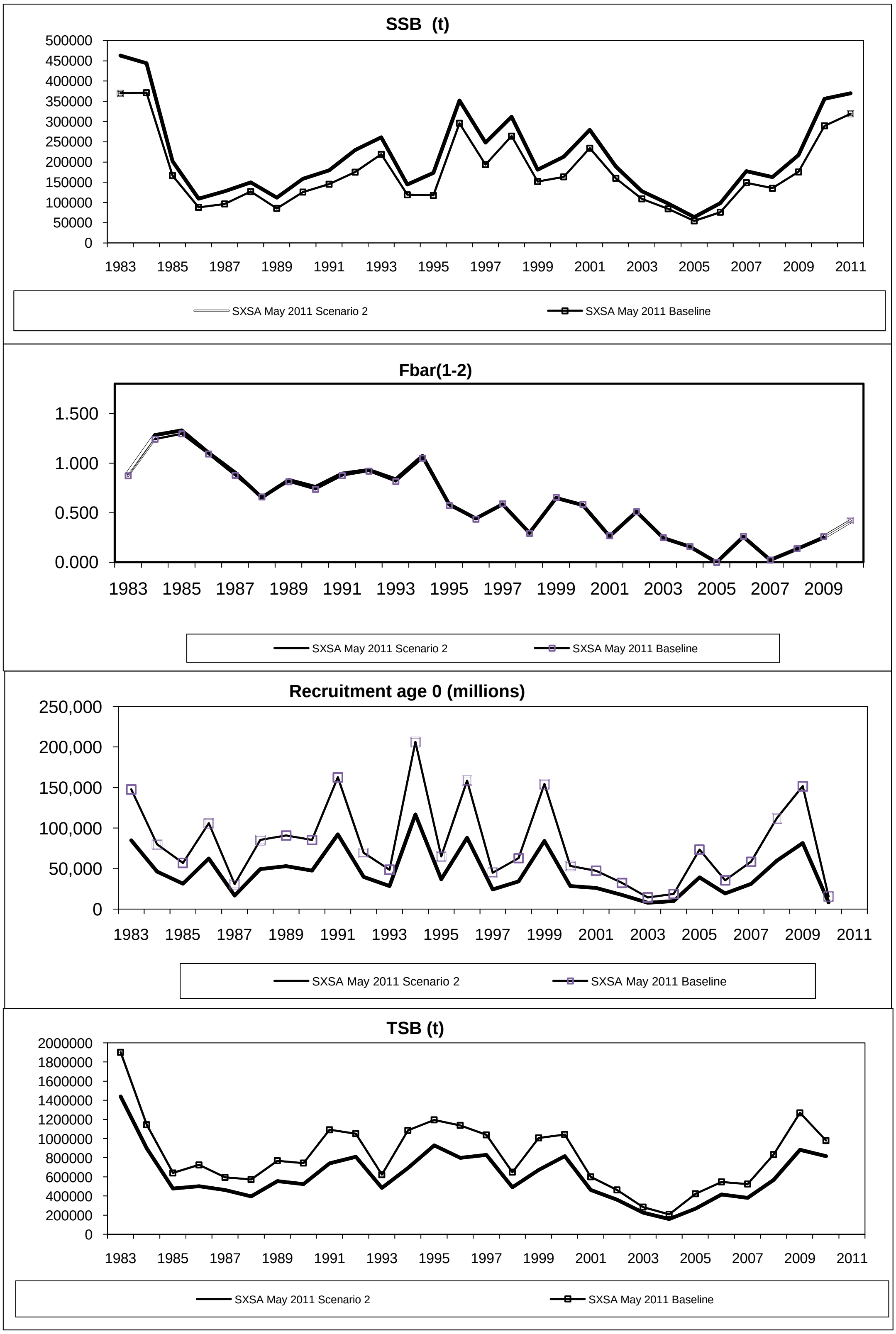


Figure 11. Norway pout IV and IIIaN (Skagerrak). Comparison of May 2011 SXSA baseline assessment with SXSA May 2011 Scenario 2 assessment.

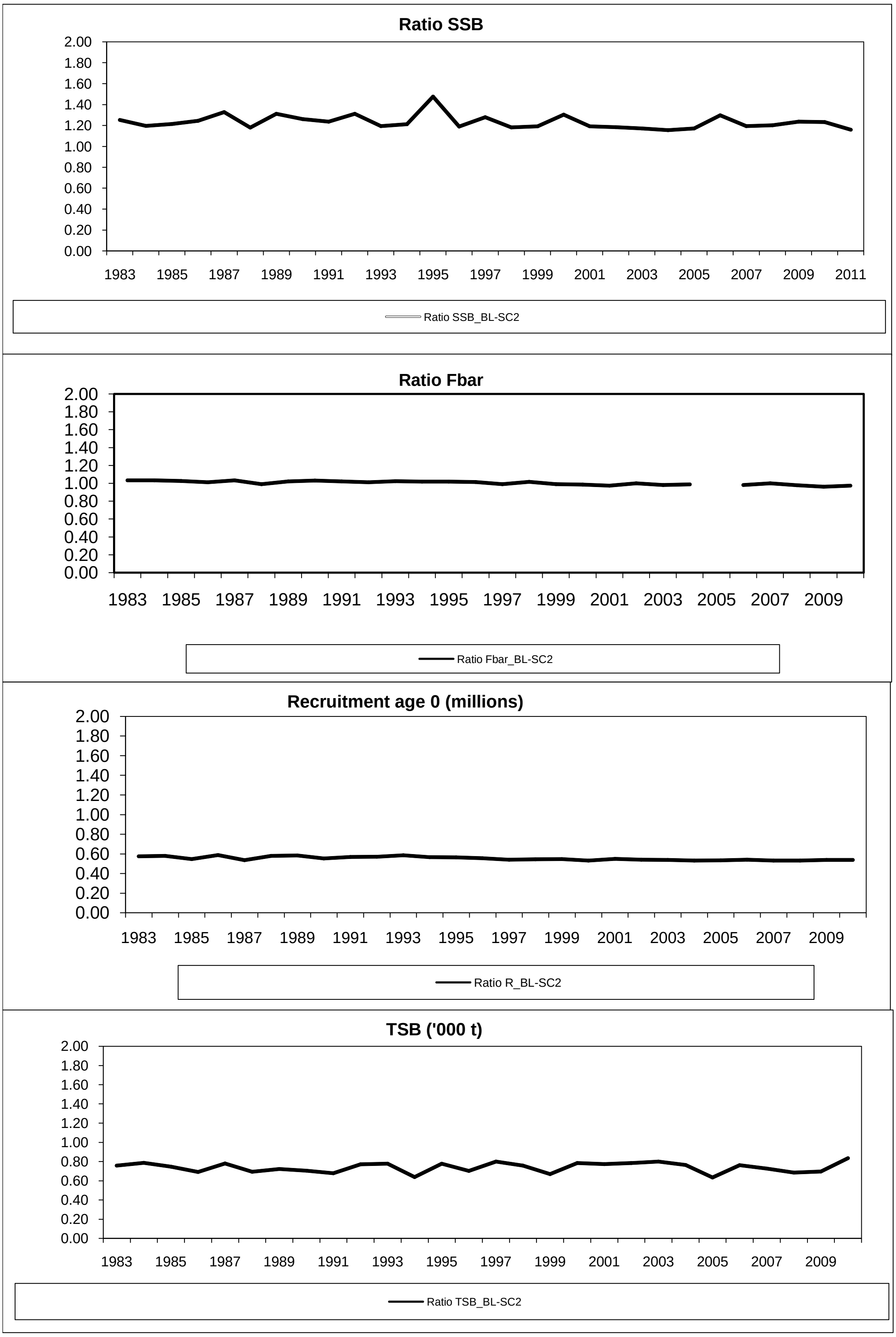


Figure 12. Norway pout IV and IIIaN (Skagerrak). Comparison of May 2011 SXSA baseline assessment with SXSA May 2011 Scenario 2 assessment. Ratios.

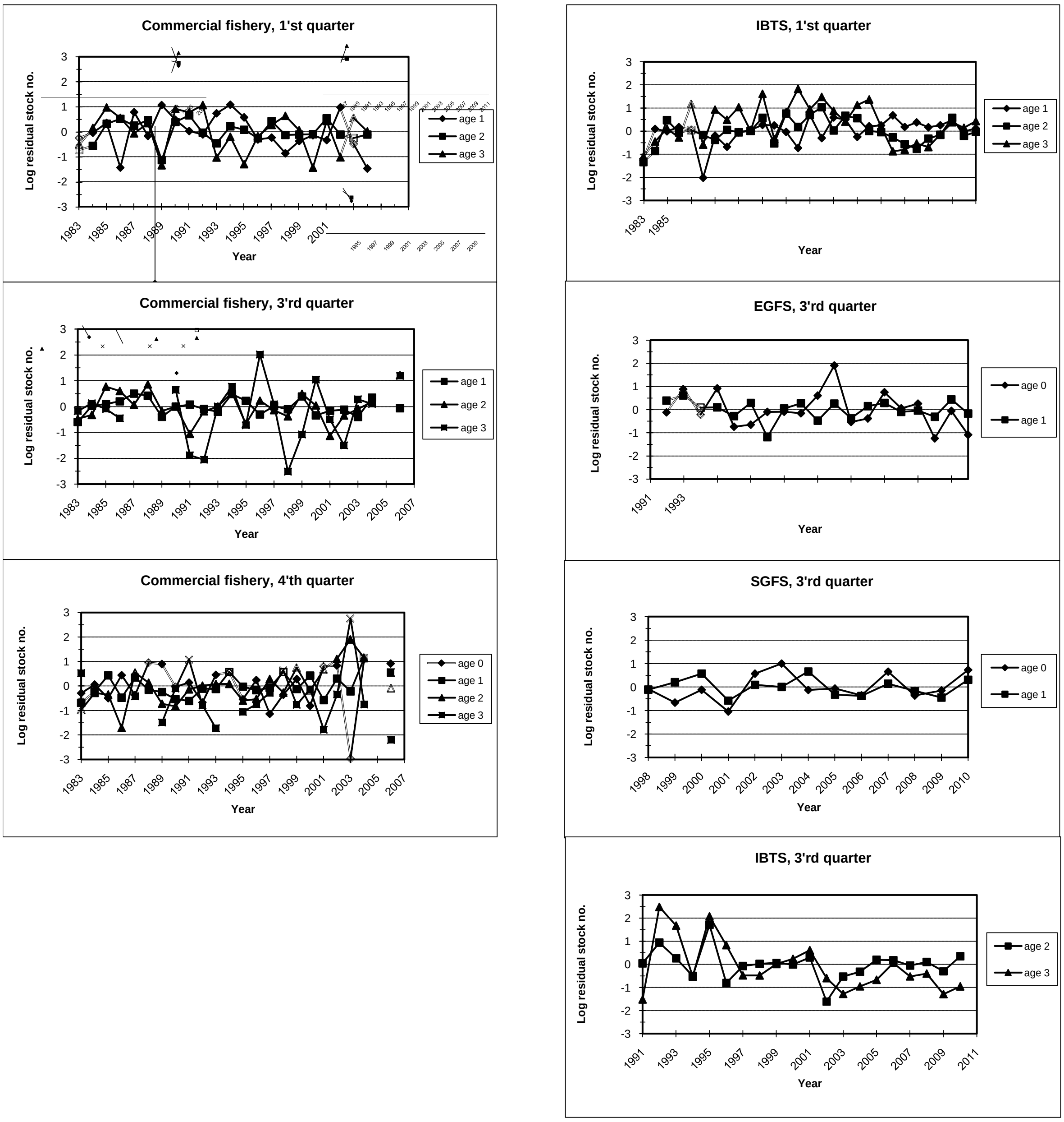


Figure 13. Norway pout IV and IIIaN (Skagerrak). Logresidual stock numbers (log (Nhat/N)) per age group SXSA divided by fleet and season. SXSA Scenario 2 May 2011.

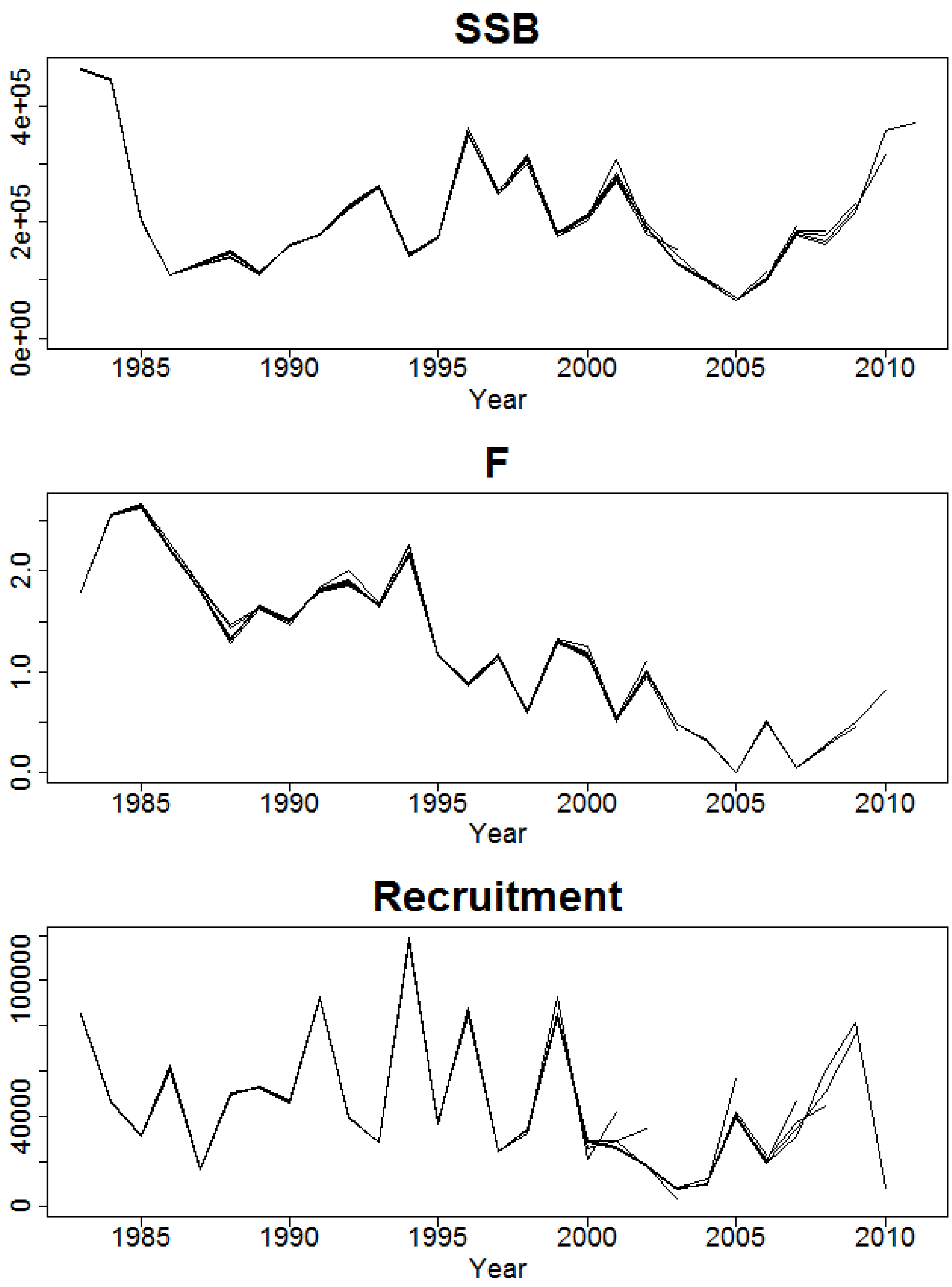


Figure 14. Norway pout IV and IIIaN (Skagerrak). Retrospective plot of SXSA Scenario 2 May 2011 assessment with assessment years ranging from 2003–2011. Retrospective trends for SSB (spawning–stock biomass), F (fishing mortality), and R (recruitment). Recruitment is in millions.

Table 10. Norway pout IV and IIIaN (Skagerrak). SXSA (Seasonal extended survivor analysis). Diagnostics of the SXSA. Comparison, May 2011 SXSA Baseline and Scenario 2.

Log inverse catchabilities, fleet no: 1 (commercial q134)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	11.536
1	10.719	*	9.872	9.178
2	9.250	*	8.755	8.426
3	9.250	*	8.755	8.426

Scenario 2:

Season	1	2	3	4
AGE				
0	*	*	*	11.102
1	10.380	*	9.728	9.129
2	9.258	*	8.790	8.486
3	9.258	*	8.790	8.486

Log inverse catchabilities, fleet no: 2 (ibtsq1)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	2.468	*	*	*
2	1.492	*	*	*
3	1.492	*	*	*

Scenario 2:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	2.125	*	*	*
2	1.505	*	*	*
3	1.505	*	*	*

Table 10. (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Log inverse catchabilities, fleet no: 3 (egfsq3)

Year 1992-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	2.904	*
1	*	*	1.638	*
2	*	*	*	*
3	*	*	*	*

Scenario 2:

Season	1	2	3	4
AGE				
0	*	*	2.350	*
1	*	*	1.495	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 4 (sgfsq3)

Year 1998-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	2.914	*
1	*	*	1.874	*
2	*	*	*	*
3	*	*	*	*

Scenario 2:

Season	1	2	3	4
AGE				
0	*	*	2.346	*
1	*	*	1.731	*
2	*	*	*	*
3	*	*	*	*

Table 10. (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Log inverse catchabilities, fleet no: 5 (ibtsq3)

Year 1991-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.481	*
3	*	*	1.481	*

Scenario 2:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.526	*
3	*	*	1.526	*

Table 10. (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 1 (commercial q134)

Year 1983-2011 (all quarters of year); (The same for all years; esti-mated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	1.071
1	1.341	*	3.184	2.066
2	2.157	*	1.694	1.240
3	1.255	*	0.831	0.764

Scenario 2:

Season	1	2	3	4
AGE				
0	*	*	*	1.080
1	1.361	*	3.213	2.102
2	2.166	*	1.694	1.242
3	1.247	*	0.830	0.779

Weighting factors for computing survivors:
Fleet no: 2 (ibtsq1)

Year 1983-2011 (all quarters of year); (The same for all years; esti-mated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	1.725	*	*	*
2	1.833	*	*	*
3	1.074	*	*	*

Scenario 2:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	1.730	*	*	*
2	1.845	*	*	*
3	1.111	*	*	*

Table 10. (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 3 (egfsq3)

Year 1992-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	1.263	*
1	*	*	2.342	*
2	*	*	*	*
3	*	*	*	*

Scenario 2:

Season	1	2	3	4
AGE				
0	*	*	1.275	*
1	*	*	2.356	*
2	*	*	*	*
3	*	*	*	*

Weighting factors for computing survivors:
Fleet no: 4 (sgfsq3)

Year 1998-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	1.651	*
1	*	*	2.479	*
2	*	*	*	*
3	*	*	*	*

Scenario 2:

Season	1	2	3	4
AGE				
0	*	*	1.638	*
1	*	*	2.520	*
2	*	*	*	*
3	*	*	*	*

Table 10. (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 5 (ibtsq3)

Year 1991-2010 (all quarters of year); (The same for all years; esti-mated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.487	*
3	*	*	0.854	*

Scenario 2:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.491	*
3	*	*	0.872	*

Scenario 3

Table 11. Norway pout IV and IIIaN (Skagerrak). Stock summary table. (SXSA Scenario 3 May 2011). (Recruits in millions, SSB and TSB in t, and Yield in '000 t).

Year	Recruits (age 0 3rd qrt)	SSB (Q1)	TSB (Q3)	Landings ('000 t)	Fbar(1-2)
1983	156265	673342	2718066	457.6	0.472
1984	89631	882134	2050561	393.01	0.459
1985	70341	629200	1318495	205.1	0.315
1986	175212	401989	1496870	174.3	0.217
1987	38341	385405	1741046	149.3	0.205
1988	102105	731558	1181501	109.3	0.137
1989	101980	319872	1359230	166.4	0.261
1990	123171	437329	1478356	163.3	0.209
1991	224391	476222	2154996	186.6	0.226
1992	95668	647635	2536291	296.8	0.215
1993	92555	978013	1708718	183.1	0.200
1994	356718	551096	2458430	182.0	0.209
1995	107264	574428	3655840	236.8	0.098
1996	321336	1573860	3151426	163.8	0.102
1997	67588	848725	3430078	169.7	0.127
1998	121553	1495979	1983580	57.7	0.071
1999	303914	613120	2547612	94.5	0.161
2000	86607	715012	3351324	184.4	0.119
2001	91775	1412434	1974727	65.6	0.055
2002	64331	678748	1389657	80.0	0.146
2003	33758	504725	974802	27.1	0.059
2004	40159	381721	675132	13.5	0.040
2005	152054	232632	1084405	1.9	0.000
2006	77014	285562	1780815	46.6	0.064
2007	126975	748776	1644202	5.7	0.006
2008	209680	549382	2242897	36.1	0.033
2009	286517	744034	3387521	54.5	0.058
2010	29005	1181778	3267501	126	0.103
2011		1471467			
Arit mean	**133,782**	**728,489**	**2,098,003**		**0.156**
Geomean	**108,290**				

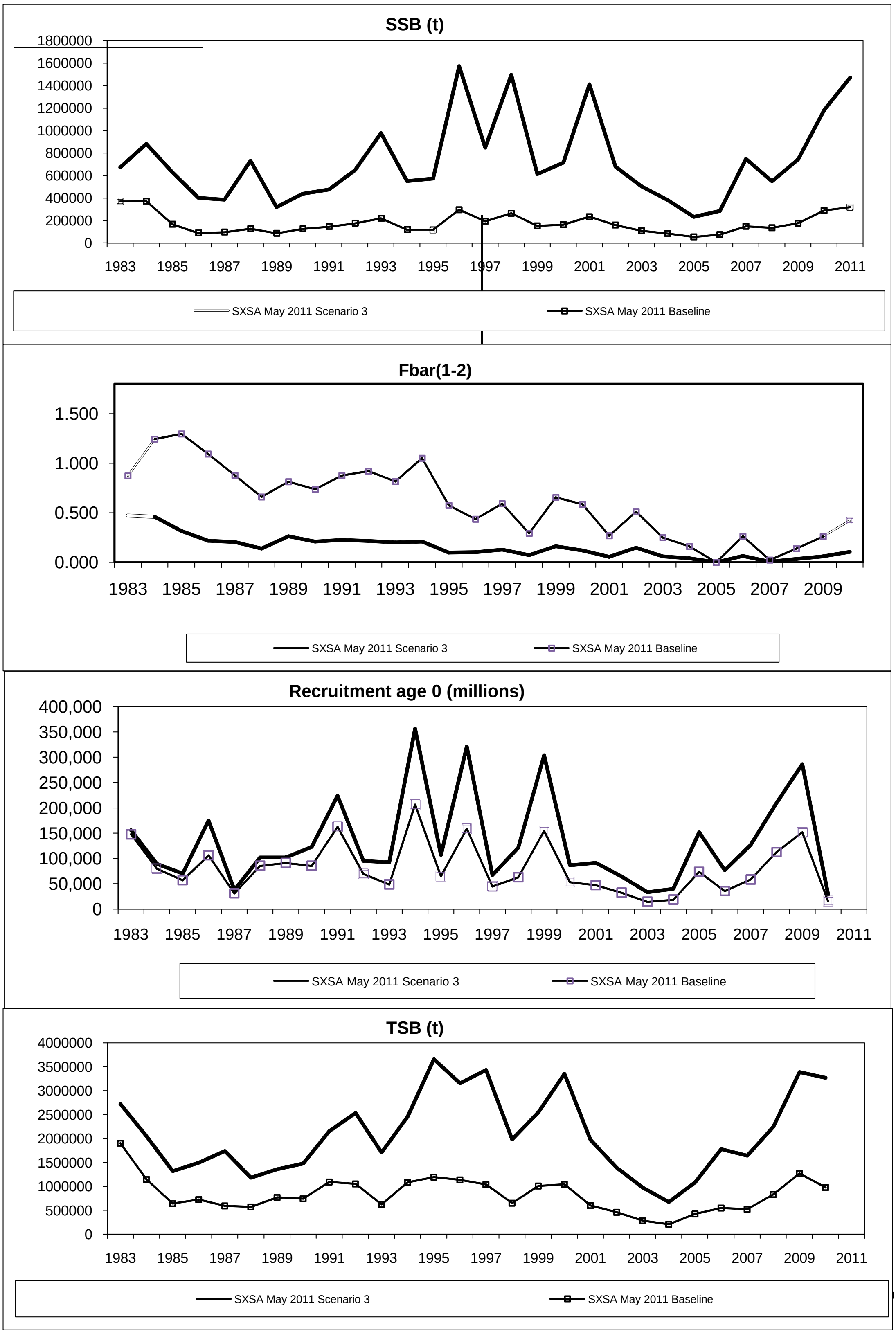


Figure 15. Norway pout IV and IIIaN (Skagerrak). Comparison of May 2011 SXSA baseline assessment with SXSA May 2011 Scenario 3 assessment.

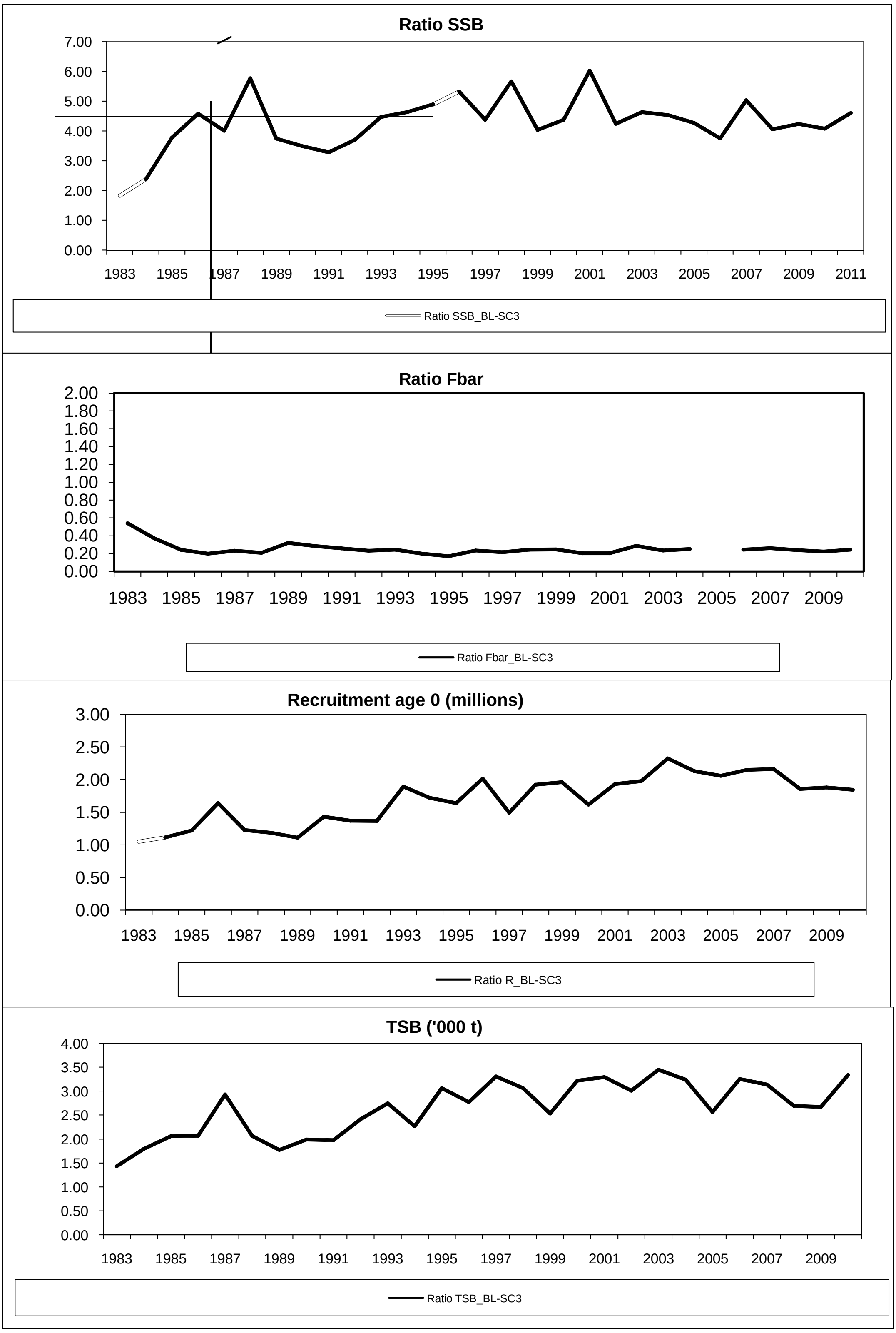


Figure 16. Norway pout IV and IIIaN (Skagerrak). Comparison of May 2011 SXSA baseline assessment with SXSA May 2011 Scenario 3 assessment. Ratios.

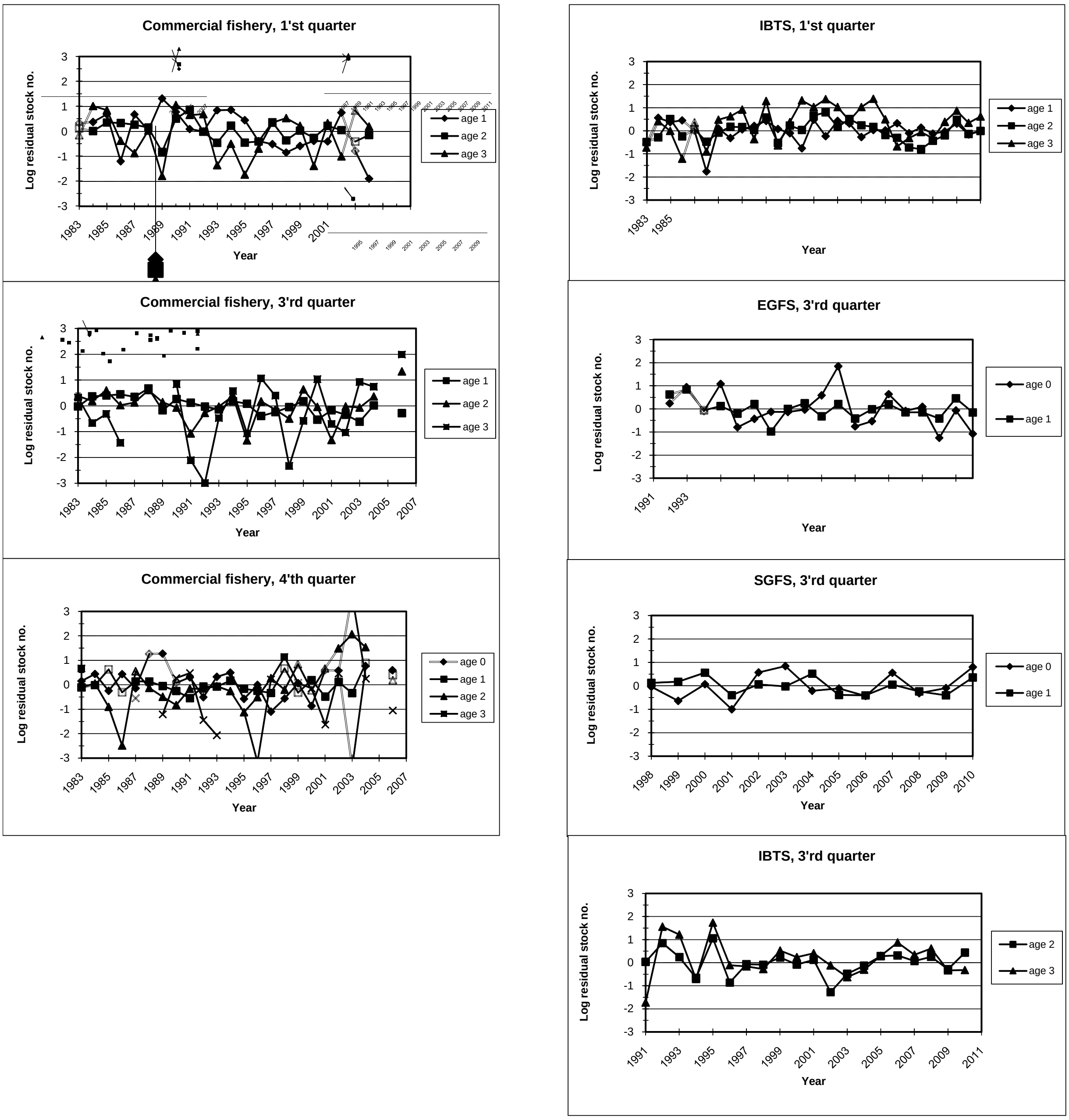


Figure 17. Norway pout IV and IIIaN (Skagerrak). Logresidual stock numbers (log (Nhat/N)) per age group SXSA divided by fleet and season. SXSA Scenario 3 May 2011.

Table 12. Norway pout IV and IIIaN (Skagerrak). SXSA (Seasonal extended survivor analysis). Diagnostics of the SXSA. Comparison, May 2011 SXSA Baseline and Scenario 3.

Log inverse catchabilities, fleet no: 1 (commercial q134)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	11.536
1	10.719	*	9.872	9.178
2	9.250	*	8.755	8.426
3	9.250	*	8.755	8.426

Scenario 3:

Season	1	2	3	4
AGE				
0	*	*	*	12.215
1	11.501	*	11.006	10.558
2	10.735	*	10.219	10.030
3	10.735	*	10.219	10.030

Log inverse catchabilities, fleet no: 2 (ibtsq1)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	2.468	*	*	*
2	1.492	*	*	*
3	1.492	*	*	*

Scenario 3:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	3.315	*	*	*
2	2.998	*	*	*
3	2.998	*	*	*

Table 12. (Cont´d.). Norway pout IV and IIIaN (Skagerrak).

Log inverse catchabilities, fleet no: 3 (egfsq3)

Year 1992-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	2.904	*
1	*	*	1.638	*
2	*	*	*	*
3	*	*	*	*

Scenario 3:

Season	1	2	3	4
AGE				
0	*	*	3.604	*
1	*	*	2.940	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 4 (sgfsq3)

Year 1998-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	2.914	*
1	*	*	1.874	*
2	*	*	*	*
3	*	*	*	*

Scenario 3:

Season	1	2	3	4
AGE				
0	*	*	3.667	*
1	*	*	3.201	*
2	*	*	*	*
3	*	*	*	*

Table 12. (Cont´d.). Norway pout IV and IIIaN (Skagerrak).

Log inverse catchabilities, fleet no: 5 (ibtsq3)

Year 1991-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.481	*
3	*	*	1.481	*

Scenario 3:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	2.968	*
3	*	*	2.968	*

Table 12. (Cont´d.). Norway pout IV and IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 1 (commercial q134)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	1.071
1	1.341	*	3.184	2.066
2	2.157	*	1.694	1.240
3	1.255	*	0.831	0.764

Scenario 3:

Season	1	2	3	4
AGE				
0	*	*	*	1.027
1	1.236	*	2.967	2.632
2	2.493	*	1.575	1.024
3	1.061	*	0.734	0.646

Weighting factors for computing survivors:
Fleet no: 2 (ibtsq1)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	1.725	*	*	*
2	1.833	*	*	*
3	1.074	*	*	*

Scenario 3:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	2.134	*	*	*
2	2.382	*	*	*
3	1.221	*	*	*

Table 12. (Cont´d.). Norway pout IV and IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 3 (egfsq3)

Year 1992-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	1.263	*
1	*	*	2.342	*
2	*	*	*	*
3	*	*	*	*

Scenario 3:

Season	1	2	3	4
AGE				
0	*	*	1.260	*
1	*	*	2.377	*
2	*	*	*	*
3	*	*	*	*

Weighting factors for computing survivors:
Fleet no: 4 (sgfsq3)

Year 1998-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	1.651	*
1	*	*	2.479	*
2	*	*	*	*
3	*	*	*	*

Scenario 3:

Season	1	2	3	4
AGE				
0	*	*	1.722	*
1	*	*	2.758	*
2	*	*	*	*
3	*	*	*	*

Table 12. (Cont´d.). Norway pout IV and IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 5 (ibtsq3)

Year 1991-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.487	*
3	*	*	0.854	*

Scenario 3:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.808	*
3	*	*	1.176	*

Scenario 4

Table 13. Norway pout IV and IIIaN (Skagerrak). Stock summary table. (SXSA Scenario 4 May 2011). (Recruits in millions. SSB and TSB in t, and Yield in '000 t).

Year	Recruits (age 0 3rd qrt)	SSB (Q1)	TSB (Q3)	Landings ('000 t)	Fbar(1-2)
1983	236202	467475	2133362	457.6	0.985
1984	128154	426920	1275229	393.01	1.379
1985	87554	197475	733541	205.1	1.469
1986	153900	109496	883710	174.3	1.334
1987	45276	128169	575324	149.3	1.060
1988	130857	119942	709630	109.3	0.897
1989	141036	110373	924446	166.4	0.957
1990	128158	155789	872529	163.3	0.864
1991	243860	177019	1360285	186.6	1.015
1992	104931	231816	1093790	296.8	1.127
1993	74177	227756	663155	183.1	0.985
1994	286773	128081	1372686	182.0	1.288
1995	91649	182839	1118571	236.8	0.725
1996	210582	269421	1234395	163.8	0.569
1997	64115	217710	928184	169.7	0.773
1998	86478	229564	650403	57.7	0.381
1999	210422	152310	1157907	94.5	0.813
2000	71597	201621	948926	184.4	0.767
2001	62971	205909	556315	65.6	0.373
2002	43064	148990	432570	80.0	0.632
2003	18127	103188	246840	27.1	0.324
2004	24276	78450	199762	13.5	0.196
2005	97291	55056	491064	1.9	0.000
2006	46418	96735	504044	46.6	0.328
2007	75507	139591	524703	5.7	0.027
2008	151998	140562	911780	36.1	0.170
2009	205852	198749	1352562	54.5	0.331
2010	21187	317448	816529	126	0.518
2011		285885			
Arit mean	**115,800**	**189,805**	**881,152**		**0.725**
Geomean	**92,215**				

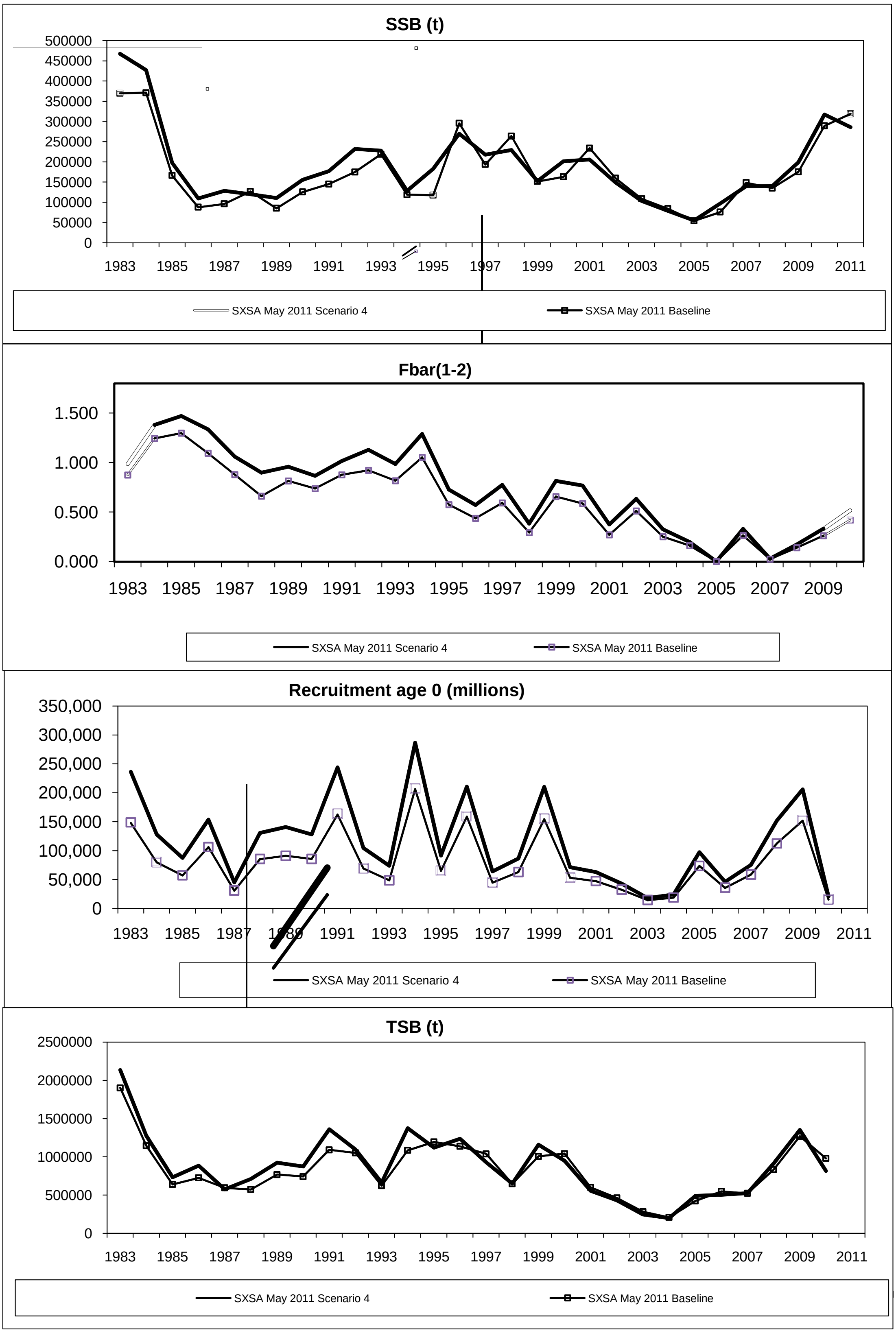


Figure 18. Norway pout IV and IIIaN (Skagerrak). Comparison of May 2011 SXSA baseline assessment with SXSA May 2011 Scenario 4 assessment.

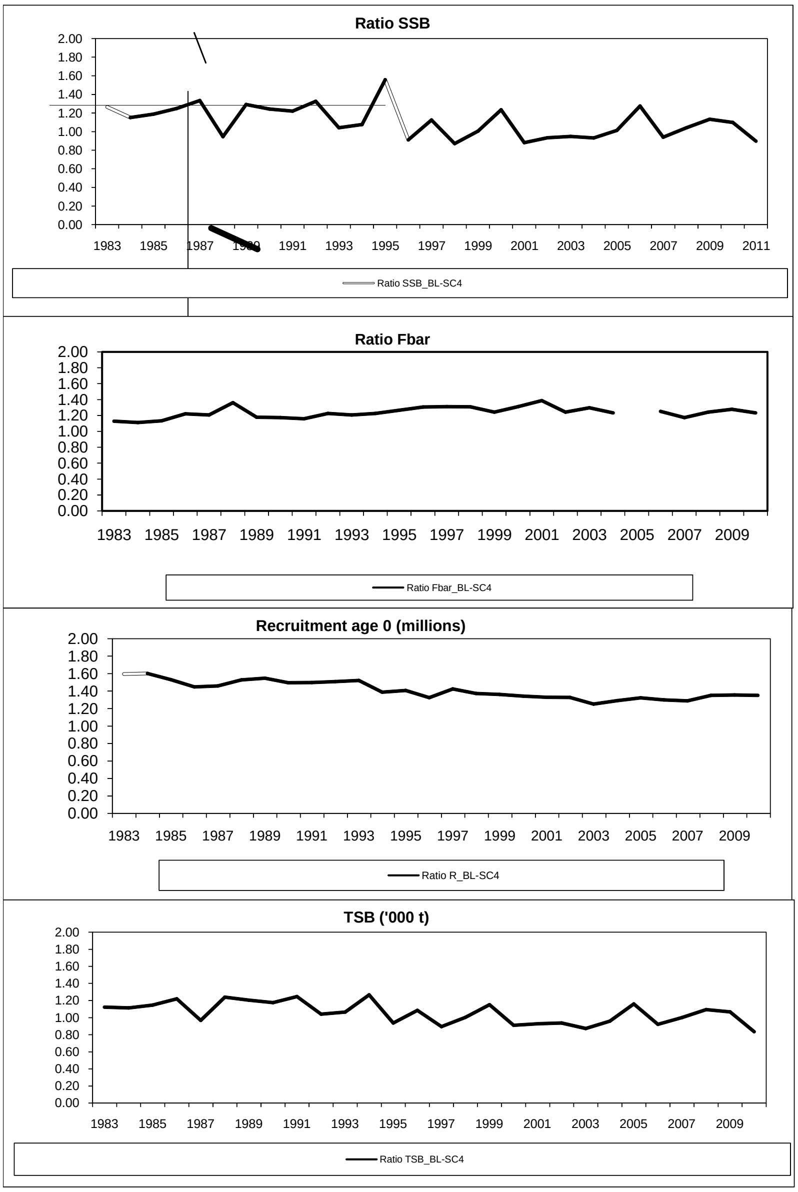


Figure 19. Norway pout IV and IIIaN (Skagerrak). Comparison of May 2011 SXSA baseline assessment with SXSA May 2011 Scenario 4 assessment. Ratios.

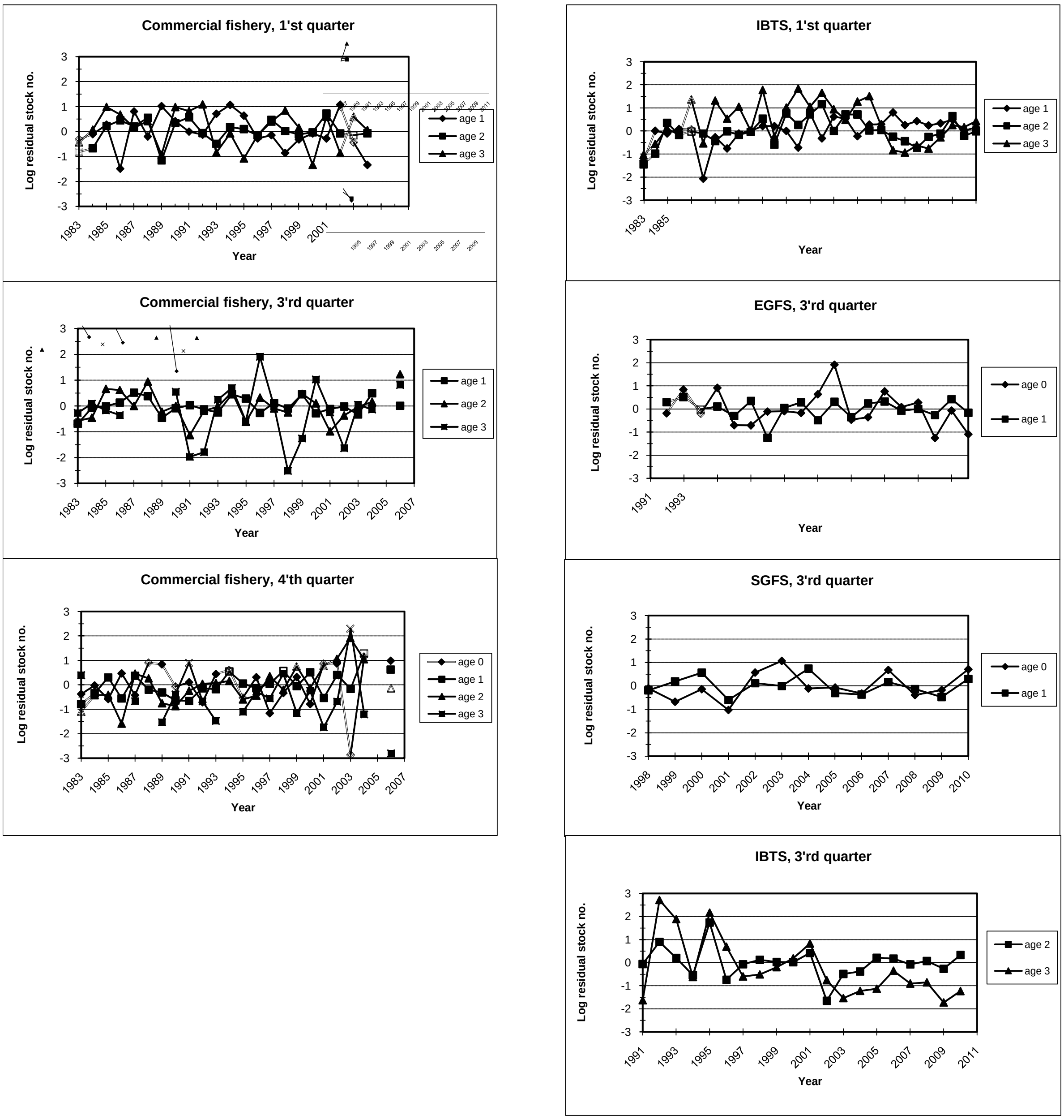


Figure 20. Norway pout IV and IIIaN (Skagerrak). Logresidual stock numbers (log (Nhat/N)) per age group SXSA divided by fleet and season. SXSA Scenario 3 May 2011.

Table 14. Norway pout IV and IIIaN (Skagerrak). SXSA (Seasonal extended survivor analysis). Diagnostics of the SXSA. Comparison, May 2011 SXSA Baseline and Scenario 4.

Log inverse catchabilities, fleet no: 1 (commercial q134)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	11.536
1	10.719	*	9.872	9.178
2	9.250	*	8.755	8.426
3	9.250	*	8.755	8.426

Scenario 4:

Season	1	2	3	4
AGE				
0	*	*	*	11.528
1	10.581	*	9.696	8.963
2	9.020	*	8.552	8.189
3	9.020	*	8.552	8.189

Log inverse catchabilities, fleet no: 2 (ibtsq1)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	2.468	*	*	*
2	1.492	*	*	*
3	1.492	*	*	*

Scenario 4:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	2.309	*	*	*
2	1.251	*	*	*
3	1.251	*	*	*

Table 14. (Cont´d.). Norway pout IV and IIIaN (Skagerrak).

Log inverse catchabilities, fleet no: 3 (egfsq3)

Year 1992-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	2.904	*
1	*	*	1.638	*
2	*	*	*	*
3	*	*	*	*

Scenario 4:

Season	1	2	3	4
AGE				
0	*	*	3.096	*
1	*	*	1.411	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 4 (sgfsq3)

Year 1998-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	2.914	*
1	*	*	1.874	*
2	*	*	*	*
3	*	*	*	*

Scenario 4:

Season	1	2	3	4
AGE				
0	*	*	3.083	*
1	*	*	1.627	*
2	*	*	*	*
3	*	*	*	*

Table 14. (Cont´d.). Norway pout IV and IIIaN (Skagerrak).

Log inverse catchabilities, fleet no: 5 (ibtsq3)

Year 1991-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.481	*
3	*	*	1.481	*

Scenario 4:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.263	*
3	*	*	1.263	*

Table 14. (Cont´d.). Norway pout IV and IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 1 (commercial q134)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	1.071
1	1.341	*	3.184	2.066
2	2.157	*	1.694	1.240
3	1.255	*	0.831	0.764

Scenario 4:

Season	1	2	3	4
AGE				
0	*	*	*	1.081
1	1.381	*	3.063	1.918
2	2.096	*	1.694	1.244
3	1.320	*	0.857	0.761

Weighting factors for computing survivors:
Fleet no: 2 (ibtsq1)

Year 1983-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	1.725	*	*	*
2	1.833	*	*	*
3	1.074	*	*	*

Scenario 4:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	1.632	*	*	*
2	1.742	*	*	*
3	1.017	*	*	*

Table 14. (Cont´d.). Norway pout IV and IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 3 (egfsq3)

Year 1992-2010 (all quarters of year); (The same for all years; esti-mated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	1.263	*
1	*	*	2.342	*
2	*	*	*	*
3	*	*	*	*

Scenario 4:

Season	1	2	3	4
AGE				
0	*	*	1.273	*
1	*	*	2.344	*
2	*	*	*	*
3	*	*	*	*

Weighting factors for computing survivors:
Fleet no: 4 (sgfsq3)

Year 1998-2010 (all quarters of year); (The same for all years; esti-mated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	1.651	*
1	*	*	2.479	*
2	*	*	*	*
3	*	*	*	*

Scenario 4:

Season	1	2	3	4
AGE				
0	*	*	1.616	*
1	*	*	2.427	*
2	*	*	*	*
3	*	*	*	*

Table 14. (Cont´d.). Norway pout IV and IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 5 (ibtsq3)

Year 1991-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Baseline:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.487	*
3	*	*	0.854	*

Scenario 4:

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.475	*
3	*	*	0.747	*

3.7 Short-term projections

The change of M, MWA and maturity ogive in the accepted scenario 2 influences the short-term projections for the stock. Accordingly, a comparison has been made between the short-term forecast based on the May 2011 Baseline assessment and the May 2011 Scenario 2 assessment, i.e. the forecast has been updated with the revised mortalities, mean weight-at-ages and proportion mature rations adopted in Scenario 2.

Tables 15–16 present inputs for the two forecasts for the baseline and scenario 2, and Table 17 presents the outputs from the two forecasts.

Table 15. Baseline May 2011 Forecast. Basis: HCR with assessment year 2010 quarter 1 to 4 and forecast year 2011 quarter 1 observed exploitation pattern and 2011 quarter 2 to quarter 4 fishing pattern scaled to the average 2008–2010 seasonal exploitation pattern (standardized with the 2008–2010 F_{BAR} to (F(1,2)=1). Recruitment in forecast year is assumed to the 25% percentile = 46 764 million (of the long-term geometric mean 65 465 million) in the 3rd quarter of the year.

Year	Season	Age	N	F	WEST	WECA	M	PROPMAT
2010	1	0	0	0.000	0.000	0.000	0.4	0
2010	1	1	68190	0.000	0.007	0.001	0.4	0.1
2010	1	2	9509	0.000	0.022	0.037	0.4	1
2010	1	3	602	0.000	0.040	0.039	0.4	1
2010	2	0	0	0.000	0.000	0.000	0.4	0
2010	2	1	45705	0.021	0.015	0.016	0.4	0
2010	2	2	6373	0.187	0.034	0.030	0.4	0
2010	2	3	403	0.053	0.050	0.047	0.4	0
2010	3	0	15671	0.000	0.004	0.009	0.4	0
2010	3	1	29983	0.046	0.025	0.026	0.4	0
2010	3	2	3531	0.286	0.043	0.039	0.4	0
2010	3	3	256	0.073	0.060	0.046	0.4	0
2010	4	0	10505	0	0.006	0.009	0.4	0
2010	4	1	19183	0.046	0.023	0.028	0.4	0
2010	4	2	1763	0.254	0.042	0.040	0.4	0
2010	4	3	160	0.002	0.058	0.062	0.4	0

Year	Season	Age	N	F	WEST	WECA	M	PROPMAT
2011	1	0	0	0.000	0.000	0.000	0.4	0
2011	1	1	7041	0.000	0.007	0.011	0.4	0.1
2011	1	2	12272	0.000	0.022	0.028	0.4	1
2011	1	3	911	0.000	0.040	0.039	0.4	1
2011	2	0	0	0.000	0.000	0.000	0.4	0
2011	2	1	0	0.028	0.015	0.015	0.4	0
2011	2	2	0	0.230	0.034	0.026	0.4	0
2011	2	3	0	0.068	0.050	0.037	0.4	0
2011	3	0	46764	0.001	0.004	0.009	0.4	0
2011	3	1	0	0.122	0.025	0.029	0.4	0
2011	3	2	0	1.019	0.043	0.036	0.4	0
2011	3	3	0	0.120	0.060	0.049	0.4	0
2011	4	0	0	0.046	0.006	0.009	0.4	0
2011	4	1	0	0.227	0.023	0.027	0.4	0
2011	4	2	0	0.361	0.042	0.038	0.4	0
2011	4	3	0	0.005	0.058	0.050	0.4	0

Table 16. Scenario 2 May 2011 Forecast. Basis: HCR with assessment year 2010 quarter 1 to 4 and forecast year 2011 quarter 1 observed exploitation pattern and 2011 quarter 2 to quarter 4 fishing pattern scaled to the average 2008–2010 seasonal exploitation pattern (standardized with the 2008–2010 FBAR to (F(1,2)=1). Recruitment in forecast year is assumed to the 25% percentile = 25 583 million (of the long-term geometric mean 36 187 million) in the 3rd quarter of the year.

Year	Season	Age	N	F	WEST	WECA	M	PROPMAT
2010	1	0	0	0.000	0.000	0.000	0.29	0
2010	1	1	45622	0.000	0.009	0.001	0.29	0.2
2010	1	2	9616	0.000	0.026	0.037	0.39	1
2010	1	3	659	0.000	0.043	0.039	0.44	1
2010	2	0	0	0.000	0.000	0.000	0.29	0
2010	2	1	34132	0.027	0.014	0.016	0.29	0
2010	2	2	6509	0.182	0.025	0.030	0.39	0
2010	2	3	425	0.051	0.038	0.047	0.44	0
2010	3	0	8438	0.000	0.004	0.009	0.29	0
2010	3	1	24849	0.053	0.028	0.026	0.29	0
2010	3	2	3663	0.274	0.038	0.039	0.39	0
2010	3	3	260	0.073	0.051	0.046	0.44	0
2010	4	0	6314	0	0.006	0.009	0.29	0
2010	4	1	17627	0.048	0.028	0.028	0.29	0
2010	4	2	1873	0.236	0.040	0.040	0.39	0
2010	4	3	155	0.002	0.058	0.062	0.44	0

Year	Season	Age	N	F	WEST	WECA	M	PROPMAT
2011	1	0	0	0.000	0.000	0.000	0.29	0
2011	1	1	4724	0.000	0.009	0.011	0.29	0.2
2011	1	2	12570	0.000	0.026	0.028	0.39	1
2011	1	3	996	0.000	0.043	0.039	0.44	1
2011	2	0	0	0.000	0.000	0.000	0.29	0
2011	2	1	0	0.037	0.014	0.015	0.29	0
2011	2	2	0	0.228	0.025	0.026	0.39	0
2011	2	3	0	0.068	0.038	0.037	0.44	0
2011	3	0	25583	0.001	0.004	0.009	0.29	0
2011	3	1	0	0.146	0.028	0.029	0.29	0
2011	3	2	0	0.998	0.038	0.036	0.39	0
2011	3	3	0	0.125	0.051	0.049	0.44	0
2011	4	0	0	0.077	0.006	0.009	0.29	0
2011	4	1	0	0.241	0.028	0.027	0.29	0
2011	4	2	0	0.345	0.040	0.038	0.39	0
2011	4	3	0	0.006	0.058	0.050	0.44	0

Table 17. Norway pout in IV and IIIaN (Skagerrak), May 2011 Benchmark Baseline compared with May 2011 Benchmark Scenario 2. Results of the short-term forecast for Norway pout May 2011. Basis: HCR with assessment year 2010 (quarter 1–4) observed fishing mortality (F), and 2011 (forecast year) quarter 1 observed fishing mortality (F), as well as forecast year 2011 quarter 2–4 fishing pattern scaled to the average 2008–2010 seasonal exploitation pattern (standardized with the 2008–2010 F_{BAR} to F(1,2)=1).

Benchmark Baseline Basis: F (2010)=F(1,2)=0.420 corresponding to 132 kt in landings in 2010; R(2011) = 25% percentile of long-term recruitment (1983–2010) = ~ 47 billion; SSB (2011) = 317 kt;

Rationale	Landings 2011	Basis	F 2011	SSB 2012	%SSB change[1)]
MSY approach	6	MSY $B_{escapement}$	0.02	150	- 53
Precautionary approach	6	B_{PA}	0.02	150	- 53
Zero Catch	0	No fishery	0	154	- 51
Status quo	50	Fixed TAC Strat.	0.21	124	-61
	82	Fixed F Strat.	0.35	106	- 67
	101	B_{lim}	0.40	90	- 72

Weights in '000 tonnes.

[1)] SSB 2012 relative to SSB 2011.

Benchmark Scenario 2 Basis: F (2010)=F(1,2)=0.409; corresponding to 132 kt catch in 2010; R(2011) = 25% percentile of long-term recruitment (1983–2010) = ~ 26 billion; SSB (2011) = 383 kt;

Rationale	Landings 2011	Basis	F 2011	SSB 2012	%SSB change[1)]
MSY approach	54	MSY $B_{escapement}$	0.209	150	- 61
Precautionary approach	54	B_{PA}	0.209	150	- 61
Zero Catch	0	No fishery	0	186	- 51
Status quo	50	Fixed TAC Strat.	0.19	153	-60
	83	Fixed F Strat.	0.35	132	- 66
	151	B_{lim}	0.808	90	- 77

Weights in '000 tonnes.

[1)] SSB 2012 relative to SSB 2011.

The changes in the natural mortality and the maturity ogive results in a higher level of SSB in scenario 2 compared with the baseline. When keeping the stock reference points at the same level as previously (see Section 3.8 below) then the scenario 2 forecast will result in advice on a higher fishing mortality and TAC in 2011 compared with the one from the baseline when following the escapement management strategy which is currently in force. This is further discussed below in relation to appropriate reference points (see Section 3.8). For both scenarios no fishery will result in a 51% reduction in SSB. The difference in SSB change given the different fishing options in the two scenarios is because the fishing mortality (exploitation pattern) is different from the natural morality pattern. Consequently, the higher fishing mortality and catch in 2011 will result in harvest of a larger proportion of the SSB than if it is only natural mortality influencing the stock, or a lower fishing mortality when the catch is only very small.

3.8 Appropriate reference points (MSY)

The proposed revised Benchmark assessment (Scenario 2) is similar to the previous baseline assessment, and the understanding of the stocks dynamics is therefore also similar.

Reference points are estimated from the SXSA model fit and based on the previous assessment, MSY $B_{escapement}$ = B_{PA} = 150 kt where B_{PA} = B_{lim} e0.3*1.65 and B_{lim} = B_{loss} = 90 kt (lowest observed SSB in the 1980s) (ICES, 2003). A segmented regression was fit to Scenario 2 estimates (Figure 20) as part of the Benchmarking process.

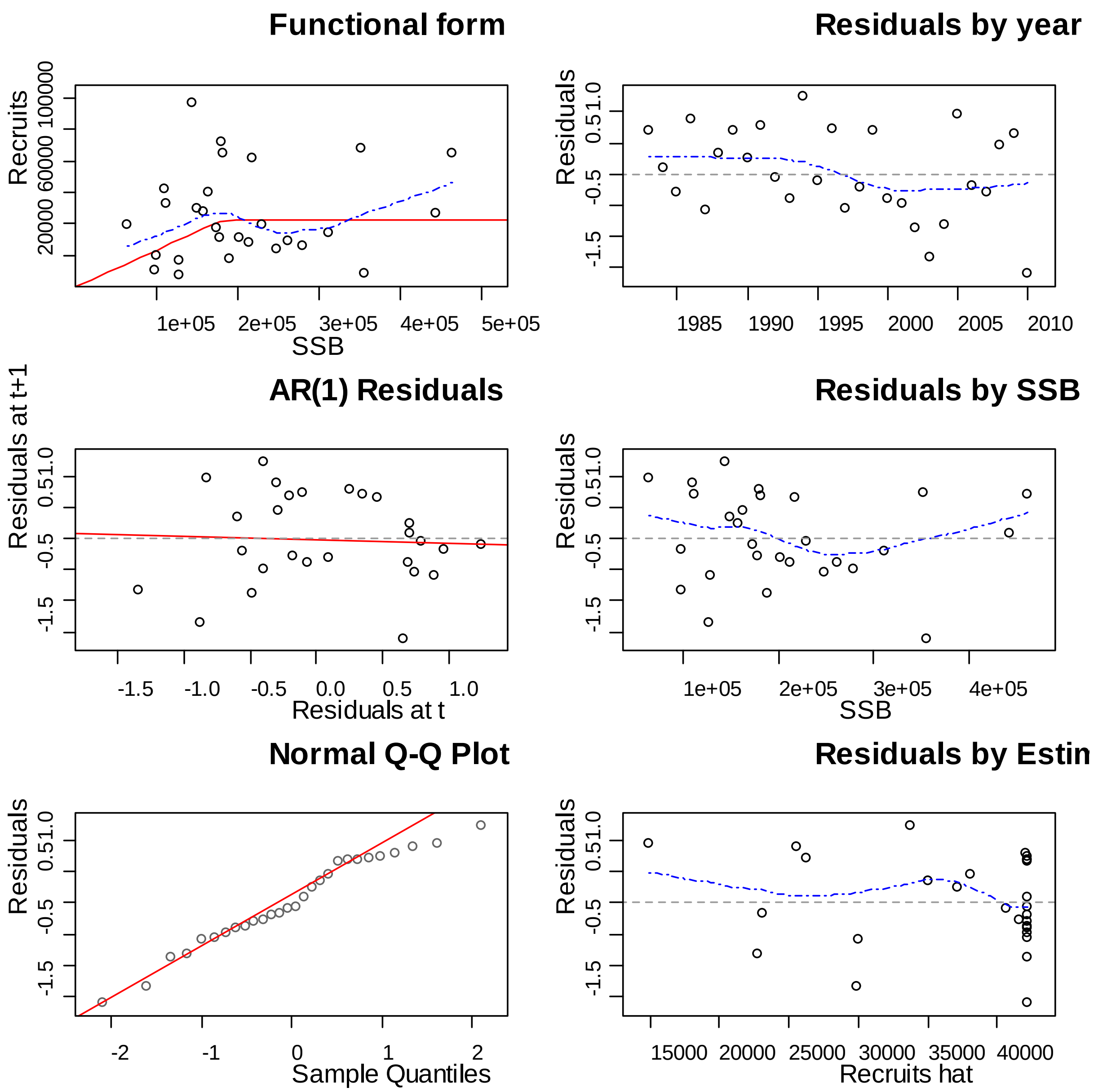


Figure 21. Norway pout IV and IIIaN (Skagerrak). Results of the Stock–recruitment segmented regression in FLR including data from 1983 to 2011.

Table 18. SSB-R segmented regression statistics from FLR using the object of class "FLSR".

```
An object of class "FLSR"

Name: NOP segreg
Description:
Range:  min     minyear max     maxyear
NA      1983    NA              2010
Quant: quant

rec:            [ 1 28 1 1 1 1 ], units =  1
ssb:            [ 1 28 1 1 1 1 ], units =  1
residuals:      [ 1 28 1 1 1 1 ], units =  1 1
fitted:         [ 1 28 1 1 1 1 ], units =  1

Model:  rec ~ FLQuant(ifelse(ssb <= b, a * ssb, a * b))
Parameters:
        params
iter    a    b
        1 0.2346 179997

Loglikelihood:  2.0034(0)
Variance-covariance:
        a             b
        a 6.527354e-20  1.483392e+03
        b 1.483392e+03 -2.275224e+09
```

Lambert *et al*. (2009) evaluated the SSB/R relationships for the stock. The resulting SSB/R relationship fits the Beverton–Holt equation best, followed by the segmented regression equation (Lambert *et al*., 2009, Table 4, Figure 7). Both the segmented and Beverton–Holt SSB/R relationships show clearly negative trends in the residuals during the last ten years of the dataseries (Lambert *et al*., 2009).

A segmented regression with current data was fit in relation to the benchmarking process as shown in Figure 20 and in Table 15. It is obvious that the Norway pout, being a short-lived species, has no well-defined breakpoint (inflection) in the SSB-R relationship and therefore there is no clear point at which impaired recruitment can be considered to commence (i.e. SSB does not impact R negatively, and that there is a relatively high recruitment observed at B_{loss} as well as more observations above than below the inflection point). The statistics from the segmented regression in Table 18 shows that the inflection point is rather badly estimated (high value of b), has poor convergence, and the maximum likelihood method cannot estimate the inflection point (and the slope before inflection) well. Results therefore suggest that B_{loss} be retained as the B_{lim} reference point = 90 kt and B_{PA} as MSY $B_{escapement}$ reference point = 150 kt.

Higher escapement targets could be considered in future based on the importance of Norway Pout as a forage species in the ecosystem.

3.9 Future research and data requirements

Survey based natural mortality for the Norway pout stock in the North Sea and Skagerrak–Kattegat should also be explored in the coming years where the stock is exposed to no or only very limited fishery in order to obtain more observations on natural mortality from here.

Given the importance of Norway pout as a forage species in the ecosystem, consideration could be given to setting higher MSY $B_{escapement}$ than B_{PA} as a management option for this stock.

3.10 External reviewers comments

The Norway pout stock in Subarea IV (North Sea) and Division IIIa (Skagerrak–Kattegat) is important both in terms of supporting a significant commercial fishery and as a forage species in the ecosystem. The fishery is variable, responding to abundance changes, bycatch limits and economic incentives. Norway pout is important in the diet of commercially valuable saithe, haddock, cod and mackerel. ICES provides scientific advice in the context of an escapement management strategy, generally considered best practice in the management of important forage species. Due to the short-lived nature of this species a preliminary TAC is set every year, which is updated on the basis of advice in the first half of the year using the escapement management strategy approach. MSY $B_{escapement}$ = B_{PA} = 150 kt where $B_{PA} = B_{lim}\, e^{0.3*1.65}$ and B_{lim} = B_{loss} = 90 kt (lowest observed SSB in the 1980s). Estimates of these reference points and current SSB in relation to these reference points are obtained from biannual (spring and fall) assessments in which an age-based seasonal XSA is applied taking into account landings data and tuned with four survey indices. Advice, including zero TAC in some years, is based on short-term projections relative to MSY $B_{escapement}$. Actual TACs set may be less than the ICES advice and catches have been less than the TACs in a number of recent years for a variety of reasons.

Inputs to the SXSA estimates of SSB include values for natural mortality (M) mean weights-at-age (MWA) and proportion mature-at-age. Changing these inputs from the current values used in the stock assessment could potentially have an important impact on the reference points, the perceived status of the stock relative to the reference points and scientific advice under the escapement strategy. Important new research published in the primary literature has brought into question the biological support for the values currently being used and provided the motivation for this Inter-benchmark evaluation.

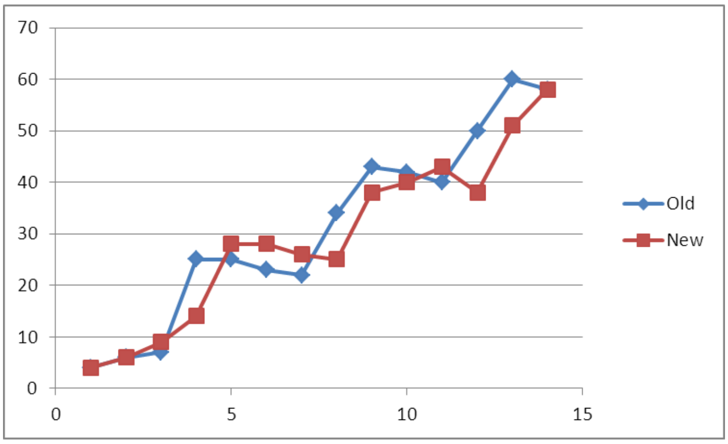
Lambert *et al*. (2009) analysed data on maturity- and weight-at-age. They found that the juvenile growth rate is higher when the stock density is low and this results in a reduced age-at-50%-maturity. The authors suggested that a value of 20% mature for the 1-group may be more appropriate than the value of 10% being used in the stock assessment. Nielsen *et al*. (2012) found evidence that Norway pout undergo heavy spawning mortality and that M is consequently significantly correlated with maturation and growth rates. There is also evidence in both studies of the impact of intraspecific factors on mortality, growth and maturation rates.

Stock assessments vary in the way in which they account for M, MWA and maturation rates. In some assessments fixed values (year invariant and/or age invariant) are applied. In some cases overall sample mean values-at-age or annual sample mean values-at-age may be used for weights and proportion mature-at-age. M cannot be estimated directly from sample data independent of the assessment model because of confounding effects with fishing mortality and catchability. In some cases model estimates, typically cohort based growth and maturation models, will be fit to the sample data and these estimates applied in the assessment model instead of averaging. Seldom are the functional relationships between population density, growth, maturation and mortality estimated as part of the parameter fitting process within the actual assessment model, although this would be the preferred approach where such functional relationships are thought to exist (as is the case with respect to Norway pout) and where there are sufficient data to carry out the estimation.

Nielsen *et al*. (2012) estimated total mortality (Z) for cohorts arising between 1982 and 2005 using revised area-disaggregated IBTS cpue values for age groups 1–4+ and compared these estimates with mortality estimates from abundance indices from the ICES standard index as used in the assessment and got similar results. Both indicated that Z increased with age, assumed to be attributable to spawning stress. Based on the assumption that fishing mortality has not had a big impact on the stock over the period examined, it could be argued that most of the Z constitutes M rather than F. Computing average Z at-age as a proxy for M for ages 1–3 for the 1983–2005 cohorts from Q1–Q1 IBTS indices, Nielsen *et al*. (2012) estimated quarterly Z values of the order of 0.26 for age 1, 0.54 for age 2 and 0.71 for age 3. These values were applied in one of the scenarios considered in the Benchmark but, because some of these cohorts experience significant fishing mortality it was considered more appropriate to apply the approach only to data from low fishing mortality years (2004, 2005, 2007 and 2008). Because the revised index was not available for the more recent years, the estimates were based on Q1 IBTS ICES indices from the standard ICES NP index area. This gave estimates of quarterly average Z as a proxy for M of 0.29 for age 1, 0.39 for age 1, and 0.44 for age 3. M on age 0 was assumed to be equal to M on age 1. Although these estimates of M are not considered to be contaminated by significant contributions from F, there is still concern that the survey catchability is assumed to be constant across age. Ideally catchability and M would be estimated simultaneously with population size in the assessment model, but this may not be feasible given the available data. It should be noted that the SXSA assessments give catchability estimates for age 1 that are lower than those on age 2 for the IBTS Q1 tuning index, while catchability is constrained to be equal on ages 2 and 3. This would imply that not accounting for catchability in the estimation of M from age 1 to age 2 could lead to an underestimate. Another concern is that the M estimates come from only a few years/cohorts and thus the estimates must be considered to have high uncertainty. Lastly, Lambert *et al*. (2009) and Nielsen *et al*. (2012) found evidence of density-dependence and intraspecific effects in mortality rates which are not captured by using fixed values over time. Nevertheless, the new estimates of M based on Z estimates in low fishing mortality years are considered to be preferable to the previously applied values.

An alternative to using the M estimates from survey data would be to use the M1+M2 estimates for Norway pout from the 2011 key run of the Stochastic Multispecies Model (SMS). While SMS estimates of M are considered in one of the scenarios included in the Benchmark, the estimates of M are not consistent with the estimates from the IBTS (without catchability correction) and the difference are such that they are not easily explained by feasible values of age specific catchability in the survey according to the stock coordinator. Reconciling the causes for this difference between the SMS estimates and the direct survey-based estimates should be the focus of further investigation. Incorporating time-varying M resulting from predation effects as well as density-dependent effects would provide more realistic modelling of the Norway pout population in future and should be seen as a long-term objective for improving the assessment and management of the stock.

The impact of proposed new values for proportion mature and weight-at-age have relatively less impact on the assessment of the stock than changes to M. The analysis in Lambert *et al*. (2009) supports an overall average value of around 20% mature for A1-Q1 although evidence of an underlying trend from values of around 10% in the early part of the series to values >40% towards the end of the series (2006) brings into question the advisability of using year-invariant values and this could be subject to further investigation in future. The proposed change to the MWA is illustrated in the text figure below, starting from A0-Q3 in quarterly steps. The main difference is that the seasonality in the new values is lagged slightly relative to the old values and the weights reached at A1 are slightly higher. Because the new values are based on a more comprehensive evaluation of the available data they are to be preferred. Again, however, there is the concern that evidence of density-dependent and intraspecific effects on growth are not captured by using year-invariant values which could lead to biased estimates of SSB.



Having concluded that use of the Z estimates from low fishing mortality years as a proxy for M and the use of the new estimates of proportion mature and weights-at-age are preferred in regard to future assessments of Norway pout (Scenario 2), it is important to note how this changes the perspective regarding the goodness of the model fit (with respect to the new values of M) and the revised status of the stock relative to possibly new estimates of biological reference points from the revised biological inputs (with respect to revised values of M, MWA and proportion mature).

Model fit residuals under the preferred scenario (Scenario 2) do not appear to be any worse than in the Baseline assessment. SSB estimates have the same trend as the Baseline assessment but the estimates for Scenario 2 are slightly higher while the recruitment estimates are somewhat lower for Scenario 2. In combination this results in lower R/SSB rates. It may be useful in future assessments to examine the impact of the Scenario 2 biological inputs on yield-per-recruit (YPR) and spawner per recruit

(SPR) because together, R/SSB and SPR and YPR determine the productivity of the stock and the sustainable yield that can be harvested. The S–R scatter under Scenario 2 looks similar to the Baseline assessment and there is no clear indication of the point at which recruitment overfishing commences, confirmed by the poor fit of the segmented regression model. Nevertheless, both the segmented regression model fit and the LOWESS smoother (the broken line in Figure 20) do provide some indication of lower recruitment at low SSB. Based on Scenario 2 there does not appear to be a good reason for setting B_{PA} lower than the current value of 150 kt. However, given that B_{MSY} is expected to be higher than B_{PA} and given the importance of Norway pout as a forage species in the ecosystem, consideration could be given to setting higher MSY $B_{escapement}$ than B_{PA} as a management option for this stock.

4 Conclusions

The Inter-Benchmark on Norway pout in the North Sea and Skagerrak evaluated five alternative scenarios with regard to input population dynamic parameters in the assessment for natural mortality, sexual maturity and growth (mean weight-at-age in the stock). The parameters of natural mortality, maturity, and mean weight used in the scenarios evaluated in the benchmarking process originates from results published in Nielsen *et al*. (2012); Lambert *et al*. (2009); Sparholt *et al*. (2002a,b); as well as from the multispecies assessment working group ICES WGSAM 2011 with respect to natural mortality estimates for Norway pout originating from the new key run of the multispecies SMS model here. The scenarios tested are presented in Section 3.2.

The change in natural mortality in Scenario 1, where survey based average Zs in the four years with very low or no fishing mortality has been used as a proxy for M, results in applying M-values in the same order of magnitude by age and quarter (around 0.3 for age 0 and 1 and 0.4 for age 2 and 3) as the constant values used in the Baseline assessment (constant 0.4 by age and quarter). The total mortality on the cohort (and the age specific variation herein) determines the recruitment, the number of survivors and the biomass. The slightly lower natural mortality for the 0-group fish, for which the fishing mortality is very low, and the slightly higher natural mortality for the oldest fish (age 3 at 0.44) results in a slightly lower total-stock biomass (TSB) and R and in nearly the same SSB and F_{BAR}(1–2) as the Baseline. This is expected given these modest age specific changes in M between Baseline and Scenario 1. The maturity ogive in Scenario 1 is the same as the Baseline with only 10% of age 1 mature, with the resulting in SSB similar to the Baseline. Because the catch-at-age data used in the Baseline and in all tested scenarios are the same, and because the natural mortality on the main fished part of the population, i.e. age 1–3, is slightly lower for age 1 at 0.29 and slightly higher for age 3 at 0.44 in scenario 1 (and 2), this results in the recruitment being a little bit lower while fishing mortality is similar comparing Scenario 1 (and Scenario 2) with the Baseline. The same perception of the stock dynamics (fluctuations) over time is observed for Scenario 1 and the Baseline.

Scenario 2 has the same natural mortality change used as in Scenario 1, but the maturity ogive and MWA vector are different. The maturity ogive has been changed to 20% mature of the 1-group, and the revised MWA in the stock is applied, obtained from long-term averages measured from the commercial fishery catch. The changes in MWA are minor compared with the Baseline and do not have much impact. The change in the maturity ogive, where 20% are mature compared with the value of 10% in the Baseline results in a higher SSB in Scenario 2 compared with the Baseline (and Scenario 1) as would be expected. R is a little lower in Scenario 2 compared with the Baseline. In combination, a higher SSB and a lower R imply a lower productivity of the stock in terms of the recruitment rate. The same trends in R and TSB as well as F are observed in Scenario 2 as in Scenario 1. Also, the same perception of the stock dynamics (fluctuations) over time is observed for Scenario 2 and the Baseline. In line with this the retrospective patterns for scenario 2 is consistent and stable.

Scenario 3 operates with bigger changes in mortality by age compared with the Baseline. In this scenario the M-value for the 0- and 1-groups is around 0.25 and the M for the older age groups are significantly higher (around 0.55 for age 2 and 0.7 for age 3). The same maturity ogive and MWA is applied in Scenario 3 as in Scenario 2. The greater mortality on the old, large fish together with fishing mortality in Scenario 3 results in a high total mortality on the older fish, and consequently, there needs to be more recruits to sustain this mortality (as the same number of fish are caught). This results in higher estimates of R, and a much higher TSB and SSB, and a perceived lower fishing mortality. Because of the significant change in M in this scenario the stock dynamics and perception of the stock and recruitment in Scenario 3 are different compared with the Baseline.

Scenario 4 uses the multispecies model estimates of M where the quarterly mortality is higher on the young fish and lower on the older fish, i.e. around 0.65 for age 0, 0.4 for age 1, 0.35 for age 3 and 0.3 for age 3. This results in similar TSB and SSB as the baseline but a perception of slightly higher recruitment and fishing mortality.

The Norway pout Inter-Benchmark recommends that revisions to natural mortality, maturity and mean weight-at-age should be included in the final new Benchmark assessment for this stock, based on the recent new knowledge published in Lambert *et al*. (2009); Nielsen *et al*. (2012) and in the ICES WGSAM 2011 report presenting a new SMS key run. It is not recommended that Z values be used as proxies for M from the full year range (1983–2005) as in Scenario 3 as this average includes fishing mortality which, especially in the early part of the period, has been relatively high, i.e. this gives a biased overestimation of M. On this basis the Baseline, the Scenario 1, and the Scenario 3 are considered less preferable than Scenario 2. With respect to Scenario 2 and 4 there are several aspects to be considered. The results of Scenarios 2 and 4 are not significantly different from the Baseline scenario, and both scenarios have the same perception of the stock dynamics (fluctuations) over time as observed for the Baseline.

The population dynamic parameters used in the Scenario 2 have been documented in Nielsen *et al*. (2012) and in Lambert *et al*. (2009). SMS estimates of mortality on age 1 are higher than those based on Z estimates from the IBTS index (ICES 2011b). This difference in perception could occur if the catchability on age 1 was low. The above cited papers investigate and argue that the catchability of the 1-group Norway pout is not substantially lower than for the older age groups (although this is somewhat contrary to the catchability estimates at-age coming out of both the Baseline and Scenario 2 SXSA assessment model estimates), and that there is no age specific migration out of the assessment area (being the whole North Sea and Skagerrak–Kattegat area).

Scenario 4 uses results of M from the SMS model assessment which has a number of characteristics and assumptions as well. The SMS assumes constant residual mortality (M1), i.e. natural mortality due to other reasons than predation. This contradicts the hypothesis of spawning mortality as discussed in Nielsen *et al*. (2012) which result in M increasing with age. Also, the SMS smoothes mortality out between ages 1–3, i.e. does not fully consider potential differences in natural mortality between these ages, because the model uses rather wide size intervals in its prey–predator preference model (ICES 2011b; Pers. Comm. Morten Vinther and Anna Rindorf, DTU Aqua, March 2011). This means that the mortalities between age 1, age 2 and age 3 tend to be equalized in the model. In the SMS a main predator on Norway pout age 1 to age 3 is saithe, and the SMS assessment results are sensitive to biomass estimates of saithe in the North Sea. The SMS uses the saithe (predator) biomass estimates from the ICES WGNSSK single stock assessment (ICES 2011a), and this assessment is very uncertain. Consequently, the SMS natural mortality estimates on Norway pout depends on uncertain assessment estimates of saithe in the North Sea which also influences age specific mortalities on Norway pout in Scenario 4.

Compared with the analysis of IBTS survey data, SMS estimates of total yearly M (and also Z) are higher for age 0 and 1 and lower for age 2 and 3 Norway pout (ICES

2011b; Nielsen *et al.*, 2012). Even if the catchability in the surveys was lower for age group 1 (as indicated in the Baseline SXSA assessment model fit) it is difficult to explain the lower mortalities estimated by the SMS for age 2 and age 3 compared with the observed age 2 and age 3 survey based mortality estimates. In Nielsen *et al.* (2012) it is argued that migration in or out of the area is very unlikely, so the lower estimates in Z from SMS at age 2 and especially age 3 compared with estimates of Z from the IBTS data (Nielsen *et al.*, 2012) is difficult to explain.

In conclusion the Benchmark group agrees on Scenario 2 to be the best way forwards, and recommends Scenario 2 to be used as the new Baseline assessment for this stock.

Due to the short-lived nature of this species a preliminary TAC is set every year, which is updated on the basis of advice in the first half of the year using the escapement management strategy approach. Reference points are estimated from the SXSA model fit and based on the previous assessment, MSY $B_{escapement}$ = B_{PA} = 150 kt where B_{PA} = B_{lim} $e^{0.3*1.65}$ and B_{lim} = B_{loss} = 90 kt (lowest observed SSB in the 1980s). A segmented regression was fit to Scenario 2 estimates as part of the Benchmarking process. Norway pout data do not provide strong evidence of a well-defined breakpoint (inflection) in the SSB-R relationship indicating the onset of recruitment overfishing. This is somewhat typical for short-lived species. The statistics from the segmented regression in Table 15 confirms that the inflection point is rather poorly estimated by the maximum likelihood approach. The Benchmark group recommends that B_{loss} be retained as the B_{lim} reference point = 90 kt and B_{PA} as MSY $B_{escapement}$ reference point = 150 kt. Higher escapement targets could be considered in future based on the importance of Norway pout as a forage species in the ecosystem.

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Appendix

Table A.1. Norway pout in the North Sea and Skagerrak. Long-term average mean weight-at-age 0 by year and quarter of year for all areas in the North Sea and Skagerrak from Danish commercial catches. (Not weighted with numbers-at-age caught).

Year	Q3	Q4
1983	9.1670	6.2212
1984	1.8250	6.8094
1985	3.5714	6.8173
1986	4.2794	7.2451
1987	5.7857	7.5571
1988	5.7500	8.0968
1989	6.0000	6.8969
1990	6.0000	8.1429
1991	6.3354	8.5406
1992	3.7583	6.8955
1993	3.6171	6.9183
1994	4.9412	9.4044
1995	4.8551	7.2100
1996	4.0051	6.0828
1997	3.6360	7.6339
1998	5.6465	8.3069
1999	2.9432	7.1882
2000	3.2638	11.5745
2001	5.3438	7.2314
2002	6.3711	6.9163
2003	6.6829	10.6429
2004		7.7500
2005	6.4000	
2006		8.4583
2008		9.9211
2009	6.4030	8.5000
2011		8.8846
Average	5.1	7.9

Table A.2. Norway pout in the North Sea and Skagerrak. Long-term average mean weight-at-age 1 by year and quarter of year for all areas in the North Sea and Skagerrak from Danish commercial catches. (Not weighted with numbers-at-age caught).

Year	Q1	Q2	Q3	Q4
1983	7.9557	13.6993	23.9769	26.4579
1984	6.2473	10.3634	17.8378	20.3526
1985	7.1512	9.6619	27.5656	28.0134
1986	6.1349		28.2480	27.5228
1987	7.7060		22.4525	23.3367
1988	8.6567	10.8571	30.9020	33.3198
1989	7.9309		25.3309	26.6239
1990	6.2745	12.5034	25.0134	
1991	11.6816	11.5634	32.3283	31.3842
1992	8.0899	16.2280	24.2268	28.7341
1993	9.2800	19.1505	26.6929	27.5152
1994	8.3822	9.7164	29.8977	32.9074
1995	7.7567	13.4747	27.2525	24.7717
1996	9.6322	12.5727	28.5026	27.1189
1997	6.6033	14.6648	18.5540	22.4945
1998	8.6122	11.5421	25.6089	24.9862
1999	7.3227	10.9644	19.4127	25.9942
2000	12.7533	10.0345	22.0038	23.2135
2001	7.3476	20.7687	26.4847	29.7564
2002	8.3537	20.4013	25.6071	28.8398
2003	14.0000	22.0000	32.1181	31.9145
2004	12.5636		31.0000	34.3500
2005	10.7143			
2006			39.6316	27.6545
2007	7.7778		48.4286	
2008				22.6452
2009	10.2340		30.5587	33.2546
2010			25.7372	28.3939
2011			30.4865	31.1531
Average	8.8	13.9	27.6	27.8

Table A.3. Norway pout in the North Sea and Skagerrak. Long-term average mean weight-at-age 2 by year and quarter of year for all areas in the North Sea and Skagerrak from Danish commercial catches. (Not weighted with numbers-at-age caught).

Year	Q1	Q2	Q3	Q4
1983	22.8713	29.0982	33.6027	36.0972
1984	24.6047	23.0868	28.9848	29.7465
1985	21.4303	24.4151	33.7291	36.4286
1986	29.8126		34.8872	36.7529
1987	28.4806		32.1961	32.2110
1988	24.8567	18.3333	37.3085	40.8922
1989	28.0000		28.8333	32.5909
1990	26.7273	27.7184	29.7620	
1991	22.1364	18.3714	41.1763	39.3242
1992	27.1580	35.8352	36.6119	39.0506
1993	25.1754	28.0667	36.2894	34.2838
1994	26.9791	16.2941	46.7778	50.5500
1995	29.7143	27.0000	41.7778	41.5000
1996	21.9565	27.1269	42.6073	35.5000
1997	24.0398	28.4103	30.5055	31.6691
1998	21.4667	24.0930	31.8930	29.9874
1999	26.6869	15.8482	31.0000	43.8889
2000	24.3854	25.3158	31.2734	33.1534
2001	21.4164	23.4069	45.0000	35.9256
2002	27.8462	28.3333	36.4223	37.4234
2003	12.0000	32.1014	47.1420	45.3529
2004	26.5946		43.6667	39.0667
2005	46.0000			
2006			53.8889	48.4853
2007	29.8605		55.5000	
2008				56.0000
2009	24.0000		32.7273	68.3333
2010			35.4659	38.5707
2011			34.2828	35.6808
Average	25.8	25.2	37.5	39.6

Table A.4. Norway pout in the North Sea and Skagerrak. Long-term average mean weight-at-age 3 by year and quarter of year for all areas in the North Sea and Skagerrak from Danish commercial catches. (Not weighted with numbers-at-age caught).

Year	Q1	Q2	Q3	Q4
1983	47.0642	60.0000	54.0808	66.8571
1992				49.7500
1993	49.5313		50.0000	73.5000
1994	40.0800			
1995	60.0000			
1996	16.2000			
1997	39.5085	29.0000	42.4063	36.7059
1998	40.0000	40.5000	45.3333	31.2400
1999	34.8356			66.0000
2000				53.0000
2001	43.2632	31.2308		
2002			60.0000	71.0000
2003		28.5000		70.0000
2004	56.6667			
2007			56.2222	
Average	42.7	37.8	51.3	57.6

Table A.5. Norway pout in the North Sea and Skagerrak. Long-term average mean weight-at-age by year, quarter of year and by area in the North Sea and Skagerrak from Danish commercial catches. (Not weighted with numbers-at-age caught).

Area 4aw, Age 0

Year	Q3	Q4
1983	20.6789	6.4860
1984		5.6157
1985		10.0526
1986		6.3850
1987	5.2500	
1988		7.7468
1989		5.8086
1991	9.2500	9.2420
1992	8.0000	7.4583
1993	2.7500	8.2897
1994		7.8542
1995		6.1210
1996		6.2857
1997		20.0263
1998		22.0000
1999		7.3333
2001		7.8228
2009	5.0000	
Average	8.5	9.0

Area 4aw, Age 0

Year	Q3	Q4
1983	4.7569	6.1353
1984	1.0000	6.9246
1985	3.6667	6.5993
1986	4.2794	7.5736
1987	6.0000	7.3745
1988	5.7000	8.1261
1989	5.0000	6.8646
1990	6.0000	
1991		6.4403
1992	3.0000	8.1696
1993	5.0000	7.9515
1994	5.4605	9.6590
1995		6.8571
1996	3.8537	6.5743
1997	4.0000	6.5556
1998		6.3882
1999		7.3881
2000		17.2022
2001		8.1845
2002	6.2247	6.9163
2003		10.6429
2004		7.7500
2006		8.2568
2008		9.9211
2009	6.6207	8.5000
2011		8.8846
Average	4.7	8.1

Area IIIa, Age 0

Year	Q3	Q4
1983	5.8246	6.2743
1984	1.8462	6.9821
1986		5.1631
1987		9.1333
1988	5.8333	8.2727
1989	6.1000	7.4352
1990		8.1429
1991	6.3244	8.7237
1992	3.7542	6.5213
1993	3.6103	6.1181
1994	3.4000	8.4127
1995	4.8100	7.2985
1996	4.0150	5.1730
1997	3.6345	7.0552
1998	6.1212	8.6460
1999	2.9432	6.2706
2000	3.2638	6.5152
2001	5.3438	6.6734
2002	4.0000	
2003	6.6829	
2005	6.4000	
Average	4.7	7.2

Table A.5. (continued).

Area 4ae, Age 1

Year	Q1	Q2	Q3	Q4
1983	6.8417	12.9057	20.7627	23.4720
1984	6.2732	8.7326	16.5909	24.1891
1985	6.8428	10.6800	22.8495	29.4125
1986	5.9508		33.0988	28.4110
1987	7.5560		23.6255	
1988	8.0500		28.4410	33.1856
1989	7.8993		22.7054	27.0353
1990	6.1697	18.5507	25.0134	
1991	12.1350		29.2449	32.1932
1992	7.7551		24.2339	24.8088
1993	8.6903	20.1462	24.2108	26.0580
1994	8.4183			28.0000
1995	7.6693	10.3627		25.1136
1996	10.4869	15.0227		26.7981
1997	6.7445			26.8636
1998	7.4194		23.5862	60.0000
1999	7.0286		21.3248	29.0000
2000	7.7231	9.7273		
2001	7.2681			27.8095
2002	8.1476		23.4713	
2003		13.9048		
2007	7.7778			
2009			29.5909	
Average	7.8	13.3	24.6	29.5

Area 4aw, Age 1

Year	Q1	Q2	Q3	Q4
1983	8.2455	15.1911	23.6776	26.7235
1984	6.2194	6.8665	15.1359	19.8179
1985	6.8359	6.4279	28.3934	26.3962
1986	6.3077		27.2826	25.1218
1987	8.3939		20.7006	23.0321
1988	8.1594		35.6220	33.4500
1989			29.8061	25.4638
1991	6.7576	11.9899	35.5670	31.3494
1992	7.1471		27.1614	28.9015
1993	12.4298		29.2152	28.1189
1994	8.5526		32.7913	33.1961
1995			25.0000	24.0912
1996			35.4444	27.6750
1997			21.2465	21.8571
1998	7.4286		19.4783	24.0369
1999	6.3228			26.3684
2000	21.3786			23.0742
2001	7.7692			24.4156
2002			37.8305	28.8398
2003				31.9145
2004				34.3500
2005	10.7143			
2006				26.8153
2008				22.6452
2009	10.2032		30.9339	33.2546
2010			25.7372	28.3939
2011			30.4865	31.1531
Average	8.9	10.1	28.0	27.3

Area IIIa, Age 1

Year	Q1	Q2	Q3	Q4
1983	7.6445	13.7249	26.8986	24.8394
1984	7.0769	14.5922	19.9017	19.0000
1985	8.5044	9.4037	24.1087	
1986				30.8364
1987			29.0584	37.9231
1988	10.0127	10.8571	35.5000	
1989	10.1000		23.3725	27.3281
1990	12.7000	12.2051		
1991		11.1894	32.2462	27.2041
1992	10.3885	16.2280	23.0816	28.5704
1993	7.7549	18.5753	27.2403	26.0317
1994	8.2092	9.7164		
1995	10.8125	13.7793	28.2839	26.7475
1996	9.0304	12.4824	28.0955	
1997	6.4409	14.6648	17.9264	22.0962
1998	9.3667	11.5421	26.4097	29.4107
1999	8.8601	10.9644	19.0861	25.7200
2000	9.2537		22.0038	25.9074
2001		20.7687	26.4847	31.2738
2002	10.7826	20.4013	25.0351	
2003		24.7419	32.1181	
2004	12.5636		31.0000	
2006			39.6316	38.7931
2007			48.4286	
2009	16.0000			
Average	9.8	14.5	27.9	28.1

Table A.5. (continued).

Area 4ae, Age 2

Year	Q1	Q2	Q3	Q4
1983	20.8113	25.6310	28.2530	33.3333
1984	25.1342	24.1195	29.7778	28.8070
1985	23.5542	26.9236	33.3061	38.6842
1986	30.2941		49.4091	36.7800
1987	28.3580		39.4000	
1988	26.7867		34.6000	41.7912
1989	28.0000		25.6761	34.5000
1990	26.7786	32.4286	31.4923	
1991	22.6807		49.0000	41.0625
1992	27.6672		33.6400	38.0000
1993	24.7138	27.8035	33.5931	35.7826
1994	26.3366			
1995	29.0385	27.0000		
1996	21.9115	23.2289		31.0116
1997	24.1579			44.9000
1998	22.0370	20.0659	29.7429	
1999	25.6483		38.0000	
2000	23.9756	20.0000	31.0000	
2001	21.7190			
2002	28.0000		28.0866	
2003		17.7222		
2007	29.8605			
2009			35.6667	
Average	25.6	24.5	34.4	36.8

Area 4aw, Age 2

Year	Q1	Q2	Q3	Q4
1983	23.0263	37.0000	32.6117	36.0718
1984	24.2804	20.5630	27.8791	30.0854
1985	19.5256	14.9512	33.1134	35.7203
1986	24.5833		33.0405	31.0714
1987	28.9318		29.0438	31.6463
1988	21.9542		40.8607	40.1681
1989			37.4082	31.8750
1990			23.5824	
1991	19.3875	17.0400	50.1667	37.4896
1992	26.3425		36.3274	38.5603
1993	25.9749		35.6491	33.6747
1994	30.2958		46.3529	50.5500
1995			50.0000	41.0000
1996			41.2484	37.9744
1997			30.7436	29.7069
1998	20.9167		28.7568	29.5641
1999	27.6776			43.8889
2000	23.0000			32.2685
2001	21.3355		30.0000	35.2663
2002			49.5294	37.4234
2003				45.3529
2004	27.0000			39.0667
2005	46.0000			
2006				46.4231
2008				56.0000
2009	24.0000		31.3556	68.3333
2010			35.4659	38.5707
2011			34.2828	35.6808
Average	25.5	22.4	36.1	39.0

Area IIIa, Age 2

Year	Q1	Q2	Q3	Q4
1983	21.2500	36.6867	43.5583	44.0000
1984	30.8000	33.4706	31.8544	
1985	23.9767	24.0000	49.2917	
1986				44.3000
1987			45.2414	47.1111
1988	29.9600	18.3333		
1989			25.8636	33.1875
1990	20.0000	26.2197		
1991		21.7000	41.1059	48.0000
1992	32.5385	35.8352	41.9032	41.3871
1993	26.9744	41.1250	42.9221	46.6000
1994	22.4444	16.2941	35.0000	
1995	38.5000		40.7500	
1996	23.0000	28.8757	44.4153	
1997	23.9416	28.4103	30.4401	41.2000
1998		27.0484	35.7508	52.0000
1999		15.8482	30.0667	
2000	24.8980	25.6901	31.2778	42.5714
2001		23.4069	50.0000	44.1250
2002	18.0000	28.3333	38.5057	
2003	12.0000	37.1765	47.1420	
2004	26.2857		43.6667	
2006			53.8889	49.6216
2007			55.5000	
Average	25.0	27.6	40.9	44.5

Table A.5. (continued).

Area 4ae, Age 3

Year	Q1	Q2	Q3	Q4
1983	30.0000		42.0000	
1993	52.6111		43.6000	85.0000
1994	40.0800			
1995	60.0000			
1996	16.2000			
1997	39.3158			
1998		38.0000		
1999	36.5000			
2001	41.1111			
2002			45.6000	
2003		28.5000		
Average	39.5	33.3	43.7	85.0

Area 4aw, Age 3

Year	Q1	Q3	Q4
1983	46.9282	54.0000	66.8571
1992			49.5000
1993	45.1111	65.0000	62.0000
1997		42.4063	36.7059
1998	40.0000		31.2400
1999	34.4750		66.0000
2000			53.0000
2001	45.2000		
2002		69.0000	71.0000
2003			70.0000
2004	58.0000		
Average	45.0	57.6	56.3

Area IIIa, Age 3

Year	Q1	Q2	Q3
1983	57.5000	60.0000	55.2970
1993	46.4000		
1997	45.0000	29.0000	
1998		48.0000	45.3333
2001		31.2308	
2004	56.0000		
2007			56.2222
Average	51.2	42.1	52.3

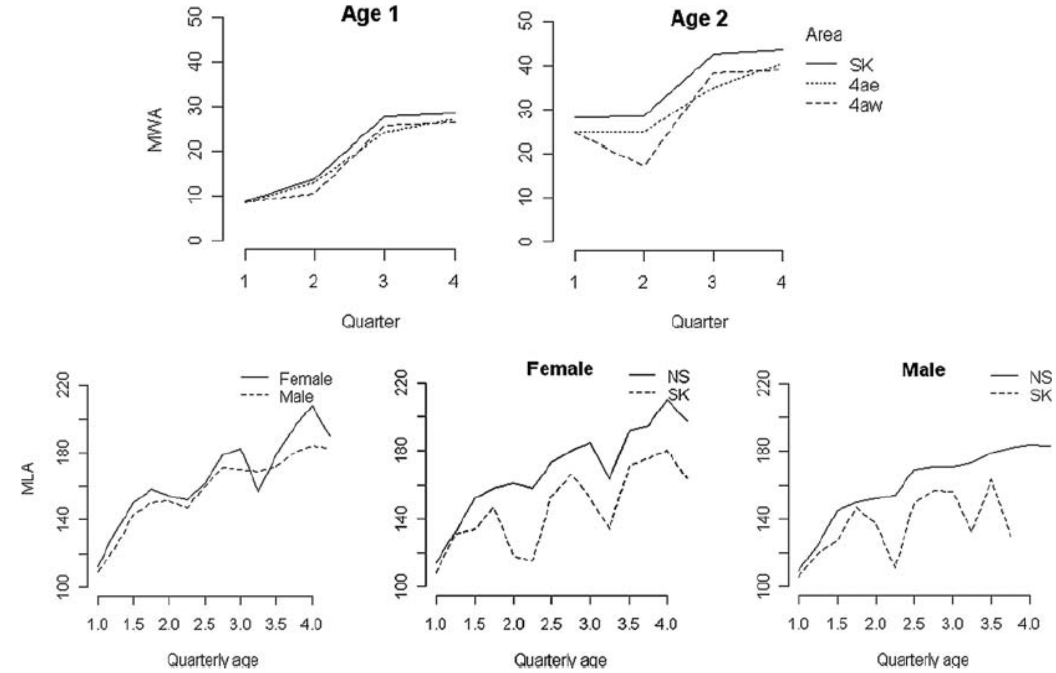


Figure A.1. MWA from Figure 8 in Lambert *et al.*, 2009. Top panels: quarterly evolution of MWA at ages 1 and 2 in Areas 4ae (eastern North Sea), 4aw (western North Sea), and SK (Skagerrak-Kattegat), based on data for the period 1983–2004. Bottom panels: evolution of mean length-at-quarterly age (MLA by quarter where age 1 in Q1 = 1.00, and age 1 in Q2 = 1.25, etc.) for males and females in the North Sea and Skagerrak and Kattegat, based on data for the period 1991–1996.

Table A.6. Tabulated mean weight-at-age corresponding to Figure 8 in Lambert *et al*. (2009).

Quarter	Area	Age	Year	Mean_Weight	MWA over years (model)
1	4ae	1	1983	6.82	7.88
1	4aw	1	1983	8.25	7.97
1	SK	1	1983	7.61	9.03
2	4ae	1	1983	12.66	12.34
2	4aw	1	1983	15.19	9.21
2	SK	1	1983	14.92	13.56
2	SK	1	1983	10.35	13.56
3	4ae	1	1983	20.14	23.21
3	4aw	1	1983	23.35	25.07
3	SK	1	1983	26.46	27.10
4	4ae	1	1983	23.45	27.00
4	4aw	1	1983	26.41	26.04
4	SK	1	1983	24.91	28.35
1	4ae	1	1984	6.27	7.88
1	4aw	1	1984	6.23	7.97
1	SK	1	1984	7.28	9.03
2	4ae	1	1984	8.65	12.34
2	4aw	1	1984	6.88	9.21
2	SK	1	1984	14.59	13.56
3	4ae	1	1984	16.45	23.21
3	4aw	1	1984	14.64	25.07
3	SK	1	1984	19.84	27.10
4	4ae	1	1984	23.66	27.00
4	4aw	1	1984	19.70	26.04
1	4ae	1	1985	6.84	7.88
1	4aw	1	1985	6.84	7.97
1	SK	1	1985	8.48	9.03
2	4ae	1	1985	10.50	12.34
2	4aw	1	1985	6.41	9.21
2	SK	1	1985	9.40	13.56
3	4ae	1	1985	21.15	23.21
3	4aw	1	1985	26.77	25.07
3	SK	1	1985	23.96	27.10
4	4ae	1	1985	29.21	27.00
4	4aw	1	1985	25.96	26.04
1	4ae	1	1986	5.95	7.88
1	4aw	1	1986	6.31	7.97
3	4ae	1	1986	32.66	23.21
3	4aw	1	1986	26.87	25.07
4	4ae	1	1986	28.23	27.00
4	4aw	1	1986	25.12	26.04
4	SK	1	1986	30.60	28.35
1	4ae	1	1987	7.56	7.88
1	4aw	1	1987	8.40	7.97
3	4ae	1	1987	23.21	23.21
3	4aw	1	1987	20.34	25.07

Quarter	Area	Age	Year	Mean_Weight	MWA over years (model)
3	SK	1	1987	29.20	27.10
3	SK	1	1987	28.83	27.10
4	4aw	1	1987	22.71	26.04
4	SK	1	1987	37.02	28.35
1	4ae	1	1988	8.11	7.88
1	4aw	1	1988	8.17	7.97
1	SK	1	1988	9.99	9.03
2	SK	1	1988	11.07	13.56
3	4ae	1	1988	25.97	23.21
3	4aw	1	1988	32.00	25.07
4	4ae	1	1988	31.08	27.00
4	4aw	1	1988	31.94	26.04
1	4ae	1	1989	7.90	7.88
1	SK	1	1989	10.10	9.03
3	4ae	1	1989	21.95	23.21
3	4aw	1	1989	29.23	25.07
3	SK	1	1989	21.86	27.10
4	4ae	1	1989	26.93	27.00
4	4aw	1	1989	25.50	26.04
4	SK	1	1989	26.96	28.35
1	4ae	1	1990	6.17	7.88
1	SK	1	1990	13.11	9.03
2	4ae	1	1990	18.15	12.34
2	SK	1	1990	11.84	13.56
3	4ae	1	1990	21.83	23.21
1	4ae	1	1991	10.56	7.88
1	4aw	1	1991	6.83	7.97
2	4aw	1	1991	12.31	9.21
2	SK	1	1991	10.55	13.56
2	SK	1	1991	12.70	13.56
3	4ae	1	1991	29.24	23.21
3	4aw	1	1991	35.54	25.07
3	SK	1	1991	29.97	27.10
3	SK	1	1991	33.05	27.10
4	4ae	1	1991	30.74	27.00
4	4aw	1	1991	34.26	26.04
4	SK	1	1991	30.61	28.35
4	SK	1	1991	19.49	28.35
1	4ae	1	1992	7.77	7.88
1	4aw	1	1992	7.15	7.97
1	SK	1	1992	10.38	9.03
1	SK	1	1992	10.17	9.03
2	SK	1	1992	16.91	13.56
2	SK	1	1992	11.88	13.56
3	4ae	1	1992	25.04	23.21
3	4aw	1	1992	26.00	25.07
3	SK	1	1992	23.00	27.10
4	4ae	1	1992	24.82	27.00

Quarter	Area	Age	Year	Mean_Weight	MWA over years (model)
4	4aw	1	1992	28.17	26.04
4	SK	1	1992	28.40	28.35
1	4ae	1	1993	8.56	7.88
1	4aw	1	1993	11.08	7.97
1	SK	1	1993	8.10	9.03
1	SK	1	1993	6.17	9.03
2	4ae	1	1993	19.45	12.34
2	SK	1	1993	20.11	13.56
2	SK	1	1993	13.42	13.56
3	4ae	1	1993	23.29	23.21
3	4aw	1	1993	27.94	25.07
3	SK	1	1993	26.91	27.10
3	SK	1	1993	22.84	27.10
4	4ae	1	1993	25.46	27.00
4	4aw	1	1993	27.05	26.04
4	SK	1	1993	26.20	28.35
1	4ae	1	1994	8.29	7.88
1	4aw	1	1994	8.40	7.97
1	SK	1	1994	8.63	9.03
1	SK	1	1994	7.74	9.03
2	SK	1	1994	9.48	13.56
3	4aw	1	1994	32.63	25.07
4	4ae	1	1994	28.00	27.00
4	4aw	1	1994	33.04	26.04
1	4ae	1	1995	7.66	7.88
1	SK	1	1995	10.97	9.03
2	4ae	1	1995	10.36	12.34
2	SK	1	1995	14.20	13.56
3	4aw	1	1995	25.00	25.07
3	SK	1	1995	28.30	27.10
4	4ae	1	1995	25.11	27.00
4	4aw	1	1995	24.09	26.04
4	SK	1	1995	27.01	28.35
1	4ae	1	1996	9.26	7.88
1	SK	1	1996	8.44	9.03
1	SK	1	1996	9.04	9.03
2	4ae	1	1996	12.04	12.34
2	SK	1	1996	12.02	13.56
3	4aw	1	1996	30.84	25.07
3	SK	1	1996	27.92	27.10
4	4ae	1	1996	27.38	27.00
4	4aw	1	1996	27.05	26.04
1	4ae	1	1997	6.74	7.88
1	SK	1	1997	6.42	9.03
2	SK	1	1997	14.38	13.56
3	4aw	1	1997	21.07	25.07
3	SK	1	1997	17.31	27.10
3	SK	1	1997	15.10	27.10

Quarter	Area	Age	Year	Mean_Weight	MWA over years (model)
4	4ae	1	1997	27.15	27.00
4	4aw	1	1997	21.54	26.04
4	SK	1	1997	21.32	28.35
1	4ae	1	1998	7.53	7.88
1	4aw	1	1998	7.43	7.97
1	SK	1	1998	9.48	9.03
2	SK	1	1998	10.36	13.56
3	4ae	1	1998	22.24	23.21
3	4aw	1	1998	19.24	25.07
3	SK	1	1998	25.75	27.10
4	4aw	1	1998	23.26	26.04
4	SK	1	1998	30.81	28.35
1	4ae	1	1999	7.03	7.88
1	4aw	1	1999	6.32	7.97
1	SK	1	1999	8.86	9.03
2	SK	1	1999	10.64	13.56
3	4ae	1	1999	21.32	23.21
3	SK	1	1999	19.05	27.10
4	4ae	1	1999	29.00	27.00
4	4aw	1	1999	25.94	26.04
4	SK	1	1999	25.82	28.35
1	4ae	1	2000	7.74	7.88
1	4aw	1	2000	21.42	7.97
1	SK	1	2000	8.80	9.03
2	4ae	1	2000	9.77	12.34
3	SK	1	2000	21.77	27.10
4	4aw	1	2000	22.88	26.04
4	SK	1	2000	25.87	28.35
1	4ae	1	2001	7.27	7.88
1	4aw	1	2001	7.79	7.97
2	SK	1	2001	20.29	13.56
3	SK	1	2001	24.75	27.10
4	4aw	1	2001	21.92	26.04
4	SK	1	2001	30.90	28.35
1	4ae	1	2002	8.28	7.88
1	SK	1	2002	10.78	9.03
2	SK	1	2002	19.79	13.56
3	4ae	1	2002	24.34	23.21
3	4aw	1	2002	35.94	25.07
3	SK	1	2002	23.94	27.10
4	4aw	1	2002	28.86	26.04
2	4ae	1	2003	14.38	12.34
2	SK	1	2003	23.54	13.56
3	SK	1	2003	30.62	27.10
3	SK	1	2003	33.54	27.10
4	4aw	1	2003	31.38	26.04
1	4aw	1	2004	8.44	7.97
1	SK	1	2004	12.01	9.03

Quarter	Area	Age	Year	Mean_Weight	MWA over years (model)
1	SK	1	2004	16.19	9.03
3	SK	1	2004	42.77	27.10
3	SK	1	2004	52.00	27.10
4	4aw	1	2004	32.07	26.04
3	SK	1	2006	38.34	27.10
4	4aw	1	2006	26.65	26.04
4	SK	1	2006	37.52	28.35
1	4ae	2	1983	21.13	24.45
2	4ae	2	1983	26.78	24.55
3	4ae	2	1983	31.35	35.12
1	4aw	2	1983	23.05	24.74
3	4aw	2	1983	35.93	37.94
4	4aw	2	1983	39.23	38.88
1	SK	2	1983	22.67	28.03
2	SK	2	1983	39.68	26.98
3	SK	2	1983	45.88	41.01
1	4ae	2	1984	25.32	24.45
2	4ae	2	1984	25.61	24.55
3	4ae	2	1984	32.88	35.12
4	4ae	2	1984	35.02	40.31
1	4aw	2	1984	24.87	24.74
2	4aw	2	1984	20.58	18.31
3	4aw	2	1984	29.08	37.94
4	4aw	2	1984	32.60	38.88
1	SK	2	1984	30.80	28.03
2	SK	2	1984	33.50	26.98
3	SK	2	1984	35.09	41.01
1	4ae	2	1985	25.03	24.45
2	4ae	2	1985	28.05	24.55
3	4ae	2	1985	36.49	35.12
4	4ae	2	1985	41.20	40.31
1	4aw	2	1985	20.29	24.74
2	4aw	2	1985	15.37	18.31
3	4aw	2	1985	36.78	37.94
4	4aw	2	1985	40.38	38.88
1	SK	2	1985	24.49	28.03
2	SK	2	1985	24.00	26.98
3	SK	2	1985	49.96	41.01
1	4ae	2	1986	30.65	24.45
3	4ae	2	1986	55.79	35.12
4	4ae	2	1986	43.78	40.31
1	4aw	2	1986	24.95	24.74
3	4aw	2	1986	40.25	37.94
1	4ae	2	1987	28.97	24.45
3	4ae	2	1987	41.47	35.12
1	4aw	2	1987	28.90	24.74
3	4aw	2	1987	33.23	37.94
4	4aw	2	1987	33.80	38.88

Quarter	Area	Age	Year	Mean_Weight	MWA over years (model)
3	SK	2	1987	50.04	41.01
3	SK	2	1987	50.76	41.01
4	SK	2	1987	48.62	42.33
1	4ae	2	1988	26.94	24.45
3	4ae	2	1988	37.38	35.12
4	4ae	2	1988	43.59	40.31
1	4aw	2	1988	22.64	24.74
3	4aw	2	1988	43.30	37.94
4	4aw	2	1988	42.34	38.88
1	SK	2	1988	31.11	28.03
1	4ae	2	1989	28.00	24.45
3	4ae	2	1989	28.03	35.12
3	4aw	2	1989	40.55	37.94
4	4aw	2	1989	35.14	38.88
3	SK	2	1989	26.63	41.01
4	SK	2	1989	34.72	42.33
1	4ae	2	1990	27.64	24.45
2	4ae	2	1990	33.80	24.55
3	4ae	2	1990	33.59	35.12
3	4aw	2	1990	23.91	37.94
2	SK	2	1990	28.68	26.98
1	4ae	2	1991	23.41	24.45
4	4ae	2	1991	46.12	40.31
1	4aw	2	1991	19.36	24.74
2	4aw	2	1991	16.88	18.31
4	4aw	2	1991	38.88	38.88
2	SK	2	1991	18.68	26.98
3	SK	2	1991	44.22	41.01
3	SK	2	1991	42.91	41.01
4	SK	2	1991	37.79	42.33
1	4ae	2	1992	28.20	24.45
3	4ae	2	1992	39.36	35.12
4	4ae	2	1992	39.96	40.31
1	4aw	2	1992	27.76	24.74
3	4aw	2	1992	38.70	37.94
4	4aw	2	1992	41.60	38.88
1	SK	2	1992	32.58	28.03
2	SK	2	1992	37.05	26.98
2	SK	2	1992	20.27	26.98
3	SK	2	1992	46.86	41.01
4	SK	2	1992	46.95	42.33
1	4ae	2	1993	24.83	24.45
2	4ae	2	1993	30.47	24.55
3	4ae	2	1993	34.90	35.12
4	4ae	2	1993	37.33	40.31
1	4aw	2	1993	26.07	24.74
3	4aw	2	1993	36.74	37.94
4	4aw	2	1993	35.89	38.88

Quarter	Area	Age	Year	Mean_Weight	MWA over years (model)
1	SK	2	1993	27.03	28.03
2	SK	2	1993	43.33	26.98
3	SK	2	1993	46.22	41.01
3	SK	2	1993	45.30	41.01
4	SK	2	1993	46.48	42.33
1	4ae	2	1994	26.73	24.45
1	4aw	2	1994	30.51	24.74
3	4aw	2	1994	47.97	37.94
4	4aw	2	1994	51.20	38.88
1	SK	2	1994	22.10	28.03
2	SK	2	1994	16.89	26.98
1	4ae	2	1995	29.08	24.45
4	4aw	2	1995	41.54	38.88
3	SK	2	1995	38.53	41.01
1	4ae	2	1996	22.32	24.45
2	4ae	2	1996	23.51	24.55
4	4ae	2	1996	31.90	40.31
3	4aw	2	1996	41.46	37.94
4	4aw	2	1996	38.08	38.88
2	SK	2	1996	30.35	26.98
3	SK	2	1996	48.05	41.01
1	4ae	2	1997	23.86	24.45
4	4ae	2	1997	44.99	40.31
3	4aw	2	1997	29.79	37.94
4	4aw	2	1997	30.83	38.88
1	SK	2	1997	24.19	28.03
2	SK	2	1997	29.00	26.98
3	SK	2	1997	31.90	41.01
4	SK	2	1997	39.04	42.33
1	4ae	2	1998	22.00	24.45
2	4ae	2	1998	19.88	24.55
3	4ae	2	1998	31.23	35.12
1	4aw	2	1998	20.92	24.74
3	4aw	2	1998	29.05	37.94
4	4aw	2	1998	29.65	38.88
2	SK	2	1998	29.11	26.98
3	SK	2	1998	37.21	41.01
1	4ae	2	1999	25.60	24.45
1	4aw	2	1999	26.07	24.74
4	4aw	2	1999	43.87	38.88
2	SK	2	1999	16.01	26.98
3	SK	2	1999	30.64	41.01
1	4ae	2	2000	23.93	24.45
2	4ae	2	2000	19.00	24.55
1	4aw	2	2000	22.29	24.74
4	4aw	2	2000	34.28	38.88
1	SK	2	2000	25.04	28.03
2	SK	2	2000	25.69	26.98

Quarter	Area	Age	Year	Mean_Weight	MWA over years (model)
3	SK	2	2000	33.19	41.01
4	SK	2	2000	43.25	42.33
1	4ae	2	2001	21.69	24.45
1	4aw	2	2001	21.35	24.74
4	4aw	2	2001	35.03	38.88
2	SK	2	2001	24.05	26.98
3	SK	2	2001	46.31	41.01
4	SK	2	2001	46.68	42.33
1	4ae	2	2002	28.06	24.45
3	4ae	2	2002	27.10	35.12
3	4aw	2	2002	50.51	37.94
4	4aw	2	2002	37.60	38.88
2	SK	2	2002	28.98	26.98
3	SK	2	2002	36.86	41.01
2	4ae	2	2003	17.17	24.55
4	4aw	2	2003	45.69	38.88
2	SK	2	2003	37.97	26.98
3	SK	2	2003	50.86	41.01
3	SK	2	2003	47.35	41.01
1	4aw	2	2004	27.47	24.74
4	4aw	2	2004	39.91	38.88
1	SK	2	2004	27.74	28.03
3	SK	2	2004	42.44	41.01
4	4aw	2	2006	46.95	38.88
3	SK	2	2006	56.73	41.01
4	SK	2	2006	52.47	42.33

Brief examination of survey and SMS estimates of Z by reviewers

Z from survey cpue data

Modified IBT first quarter survey estimates (preliminary data, see below) approximately corresponding to the Z estimates in Figure 1 in Nielsen *et al*. (2012) were examined, and mortality estimates from here were compared with mortality estimates from the multispecies SMS model.

Table A.7. Preliminary (see below) modified IBTS first quarter survey estimates corresponding to the Z estimates in Figure 1 and Table 1 in Nielsen *et al.* (2012); see final data in Table A.8.

Year	A1	A2	A3	A4
1983	1263.071	436.379	5.160	2.603
1984	2132.605	434.996	28.594	0.421
1985	848.422	590.059	31.767	1.391
1986	850.706	178.190	9.698	0.482
1987	1390.189	209.135	24.822	1.185
1988	66.752	436.470	8.599	1.485
1989	937.365	99.532	59.845	0.944
1990	643.042	350.385	19.470	1.451
1991	1303.922	435.351	100.224	0.689
1992	2455.829	454.029	17.283	1.933
1993	1250.588	1499.955	139.725	3.385
1994	957.675	203.168	33.733	1.275
1995	3225.812	442.526	43.391	4.476
1996	1418.520	1481.702	124.231	2.286
1997	5246.529	813.499	338.824	1.540
1998	529.321	2539.477	128.775	41.230
1999	1731.757	237.025	248.031	1.453
2000	4177.286	821.289	34.682	25.961
2001	533.457	1248.072	102.818	1.671
2002	859.463	383.229	396.544	17.809
2003	597.116	325.800	49.537	45.824
2004	446.864	215.420	18.607	1.163
2005	355.887	73.808	18.728	0.344
2006	1707.909	74.856	14.089	2.249

These values were logtransformed and plotted by age, means at-age were calculated and the slopes examined in Figure A.2.

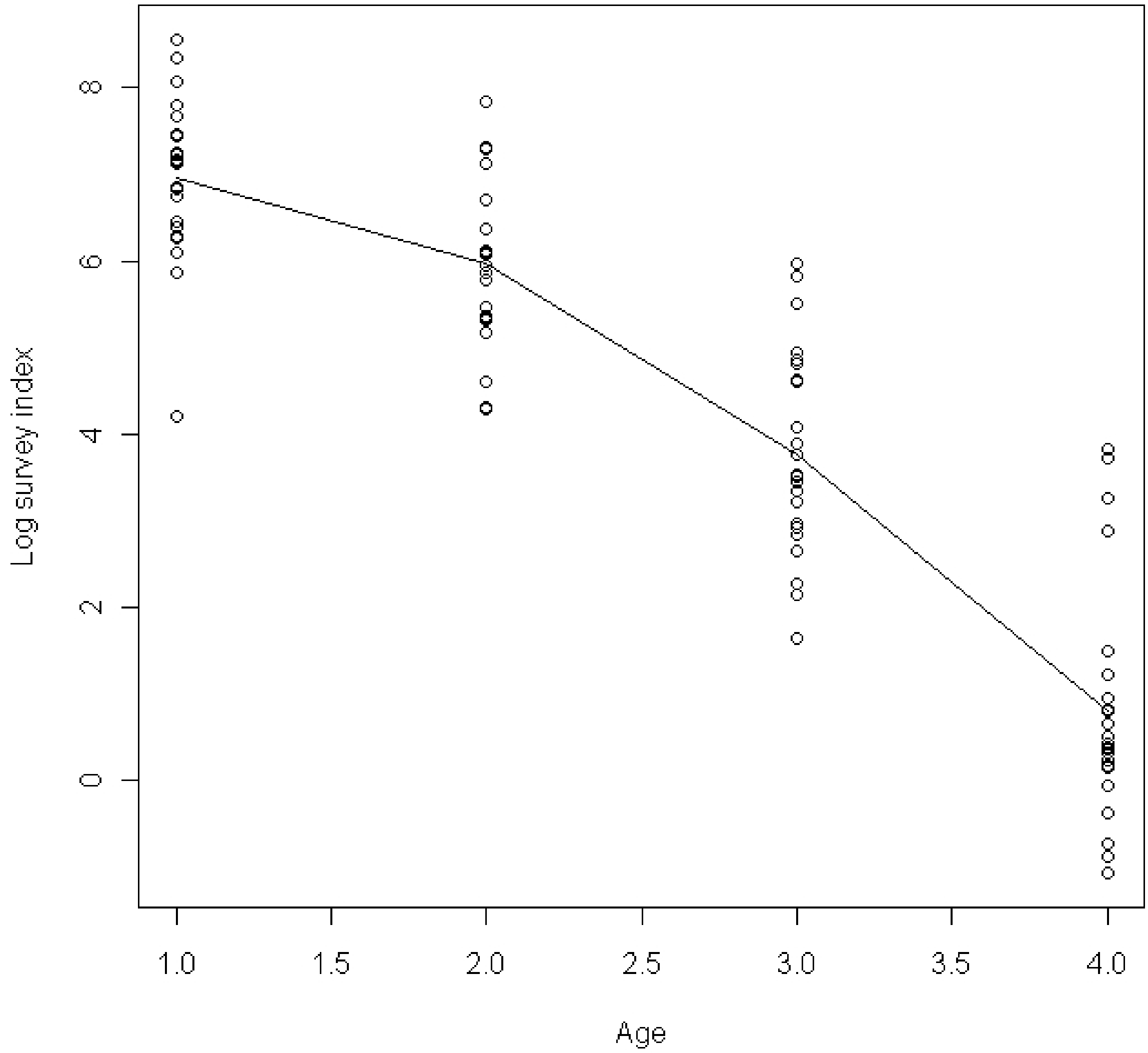


Figure A.2. Datascatter, means and slopes for the modified IBT first quarter cpue estimates approximately corresponding to Figure 1 in Nielsen *et al.* (2012). The slopes corresponding to mean Z are, respectively 0.9769, 2.2071 and 2.9533.

As is known, the Z increases with age. There are only very few observations of age 4. According to Nielsen *et al*. (2012) age 1 is fully selected by the gear although this may not be entirely consistent with catchability estimates from the SXSA model fits.

Separate slopes can be fit to each cohort (catch curves) to see if the overall slope(Z) from age 1 to 4 has changed over time (Figure A.3).

Figure A.3. Catch curves giving cohort Z's.

Cohort Z has varied between 1.5 and 2.8 over the time period. Note that fitting a single slope to each cohort results in a residual pattern (Figure A.4) because there is less age 1 and age 4 than are predicted by the model.

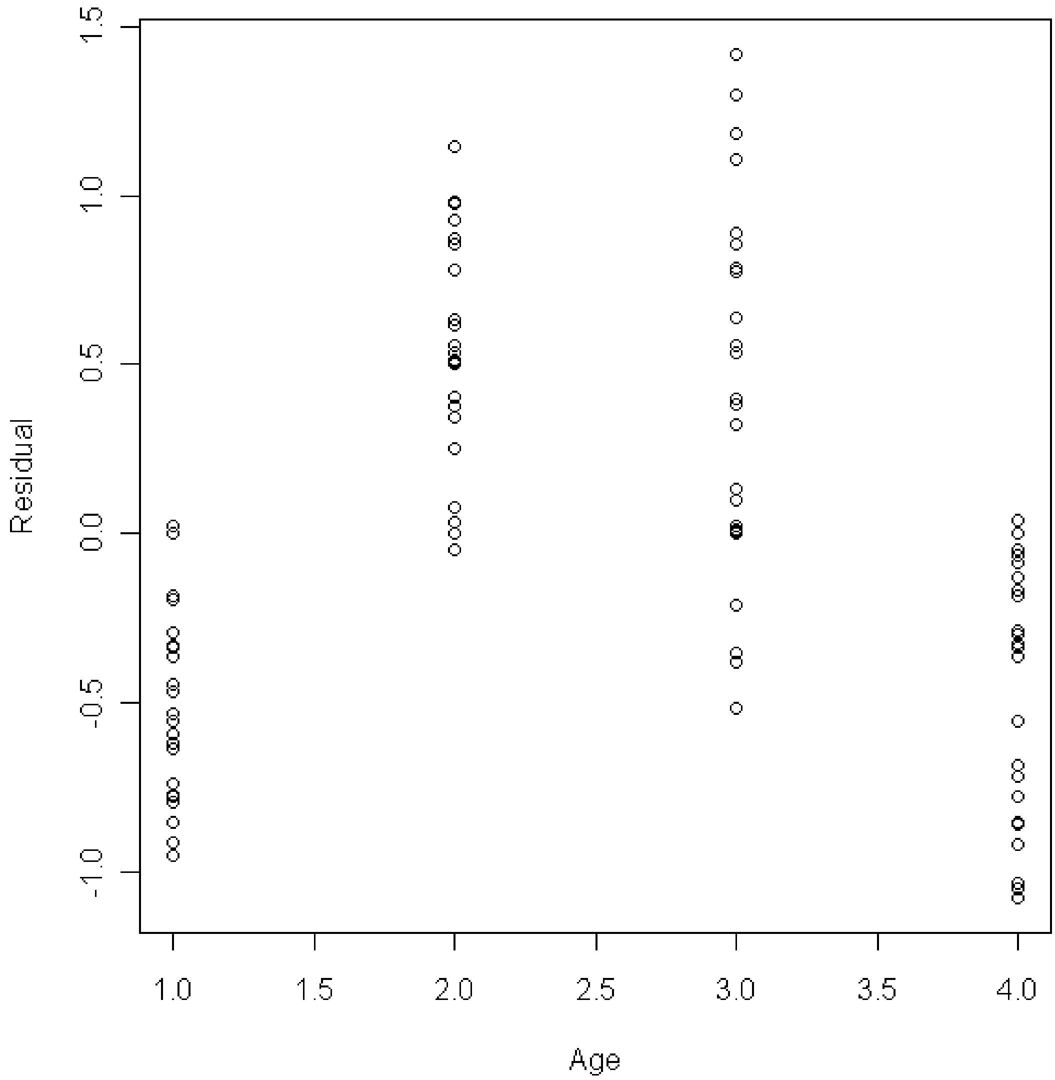


Figure A.4. Residuals from catch curve analysis (fitting a slope to each cohort corresponding to Z).

The below comparison is a preliminary benchmarking process comparison between the modified IBTS first quarter survey estimates corresponding to the Z estimates in Figure 1 and Table 1 in Nielsen *et al*. (2012) and the standard survey estimates from DATRAS. This comparison was based on preliminary values extracted from Figure 1 and Table 1 in Nielsen *et al*. (2012), i.e. not the final ones coming from this figure and table which is shown in Table A.8 below. This is because updated values (extracted from the figure and table) were not available until late in the benchmarking process. The results of this comparison have not been directly used in the benchmark or referred to in the benchmark report, but have only been used as an informative preliminary analysis.

Table A.8. Final modified IBTS first quarter survey estimates corresponding to the Z estimates in Figure 1 and Table 1 in Nielsen *et al*. (2012).

Year	Age 1 (revised)	*Age1 ICES*	Age 2 (revised)	*Age2 ICES*	Age 3 (revised)	*Áge3 ICES*	Age 4 (revised)
1983	1758	*2,258*	732	*592*	10	*7*	4
1984	3811	*4,994*	760	*982*	59	*75*	1
1985	2030	*2,342*	1119	*1,429*	59	*73*	2
1986	1652	*2,070*	357	*383*	19	*20*	1
1987	2604	*3,171*	420	*481*	53	*61*	4
1988	126	*124*	658	*722*	12	*15*	2
1989	1733	*2,013*	218	*255*	136	*172*	2
1990	1053	*1,295*	619	*748*	33	*39*	2
1991	1942	*2,450*	624	*712*	160	*130*	9
1992	4290	*5,071*	742	*885*	27	*32*	4
1993	2207	*2,682*	2197	*2,644*	210	*258*	11
1994	1588	*1,839*	332	*374*	60	*66*	1
1995	4959	*5,940*	682	*785*	72	*77*	8
1996	1542	*923*	2150	*2,631*	184	*228*	4
1997	7964	*9,752*	1189	*1,474*	510	*670*	3
1998	855	*1,010*	4132	*5,336*	207	*265*	86
1999	2667	*3,527*	469	*597*	516	*667*	3
2000	6495	*8,095*	1310	*1,535*	55	*65*	42
2001	1341	*1,305*	2349	*2,861*	194	*235*	3
2002	1580	*1,795*	705	*809*	721	*880*	32
2003	1021	*1,239*	582	*575*	86	*94*	78
2004	799	*895*	391	*376*	35	*34*	3
2005	606	*691*	134	*131*	33	*37*	0
2006	2649	*3,340*	123	*146*	22	*27*	4

Z from SMS and comparison with Survey Z (based on preliminary data)

The 2011 SMS estimates of Z for Norway pout can be compared with the survey Z values (Table A.9).

Table A.9. Survey Z (preliminary data)vs.SMS Z.

Year	Age	Cohort	Surv_Z	MS_Z	MS/Sur
1983	1	1982	1.065965	2.066747	1.938852
1983	2	1981	2.725314	2.786895	1.022596
1983	3	1980	2.506059	2.644518	1.05525
1984	1	1983	1.284877	2.31205	1.799433
1984	2	1982	2.616909	3.338349	1.275684
1984	3	1981	3.023174	3.07695	1.017788
1985	1	1984	1.560528	2.529594	1.620986
1985	2	1983	4.108303	3.78287	0.920787
1985	3	1982	4.188239	3.613608	0.862799
1986	1	1985	1.403087	2.598405	1.851921
1986	2	1984	1.97112	3.659883	1.856753
1986	3	1983	2.102177	3.410648	1.622436
1987	1	1986	1.158475	2.485096	2.145144
1987	2	1985	3.191334	3.390253	1.062331
1987	3	1984	2.816316	3.141398	1.115428
1988	1	1987	-0.39949	2.189718	
1988	2	1986	1.986962	2.664146	1.340814
1988	3	1985	2.209275	2.477619	1.121462
1989	1	1988	0.98404	2.16574	2.200865
1989	2	1987	1.631604	2.291438	1.404408
1989	3	1986	3.719505	1.92777	0.518287
1990	1	1989	0.390057	2.093082	5.366087
1990	2	1988	1.251625	2.62108	2.094142
1990	3	1987	3.341389	2.403383	0.719277
1991	1	1990	1.054971	2.066639	1.958954
1991	2	1989	3.226429	2.916677	0.903995
1991	3	1988	3.948335	2.721736	0.689338
1992	1	1991	0.493029	1.960098	3.975622
1992	2	1990	1.178485	2.651929	2.250287
1992	3	1989	1.63037	2.457771	1.507493
1993	1	1992	1.817336	2.068542	1.138228
1993	2	1991	3.794714	2.740945	0.722306
1993	3	1990	4.69673	2.528064	0.53826
1994	1	1993	0.772009	2.109527	2.732515
1994	2	1992	1.543781	2.803308	1.815871
1994	3	1991	2.019747	2.582629	1.278689
1995	1	1994	0.777993	1.84846	2.375933
1995	2	1993	1.270357	2.053854	1.616754
1995	3	1992	2.943449	1.840717	0.625361
1996	1	1995	0.556025	1.96798	3.539375

Year	Age	Cohort	Surv_Z	MS_Z	MS/Sur
1996	2	1994	1.475466	2.009758	1.362118
1996	3	1993	4.39036	1.802403	0.410536
1997	1	1996	0.725609	1.894445	2.610836
1997	2	1995	1.843278	2.068974	1.122443
1997	3	1994	2.106315	1.891981	0.898242
1998	1	1997	0.803429	1.938555	2.41285
1998	2	1996	2.32616	2.033241	0.874076
1998	3	1995	4.484436	1.833569	0.408874
1999	1	1998	0.746017	2.031642	2.72332
1999	2	1997	1.921945	2.157679	1.122654
1999	3	1996	2.256958	1.912586	0.847418
2000	1	1999	1.208062	1.669085	1.381622
2000	2	1998	2.077915	1.807638	0.869929
2000	3	1997	3.032799	1.574785	0.519251
2001	1	2000	0.330746	2.235623	6.759341
2001	2	1999	1.146568	1.930289	1.683536
2001	3	1998	1.753257	1.628815	0.929023
2002	1	2001	0.970024	2.386219	2.459958
2002	2	2000	2.045913	2.352455	1.149831
2002	3	1999	2.157979	1.910673	0.885399
2003	1	2002	1.019522	2.273347	2.229817
2003	2	2001	2.862746	2.315234	0.808746
2003	3	2000	3.751717	2.092017	0.557616
2004	1	2003	1.800787	2.156451	1.197505
2004	2	2002	2.44257	2.114308	0.865608
2004	3	2001	3.990652	1.961105	0.491425
2005	1	2004	1.559047	2.065207	1.32466
2005	2	2003	1.656073	1.888873	1.140574
2005	3	2002	2.119534	1.761844	0.831241

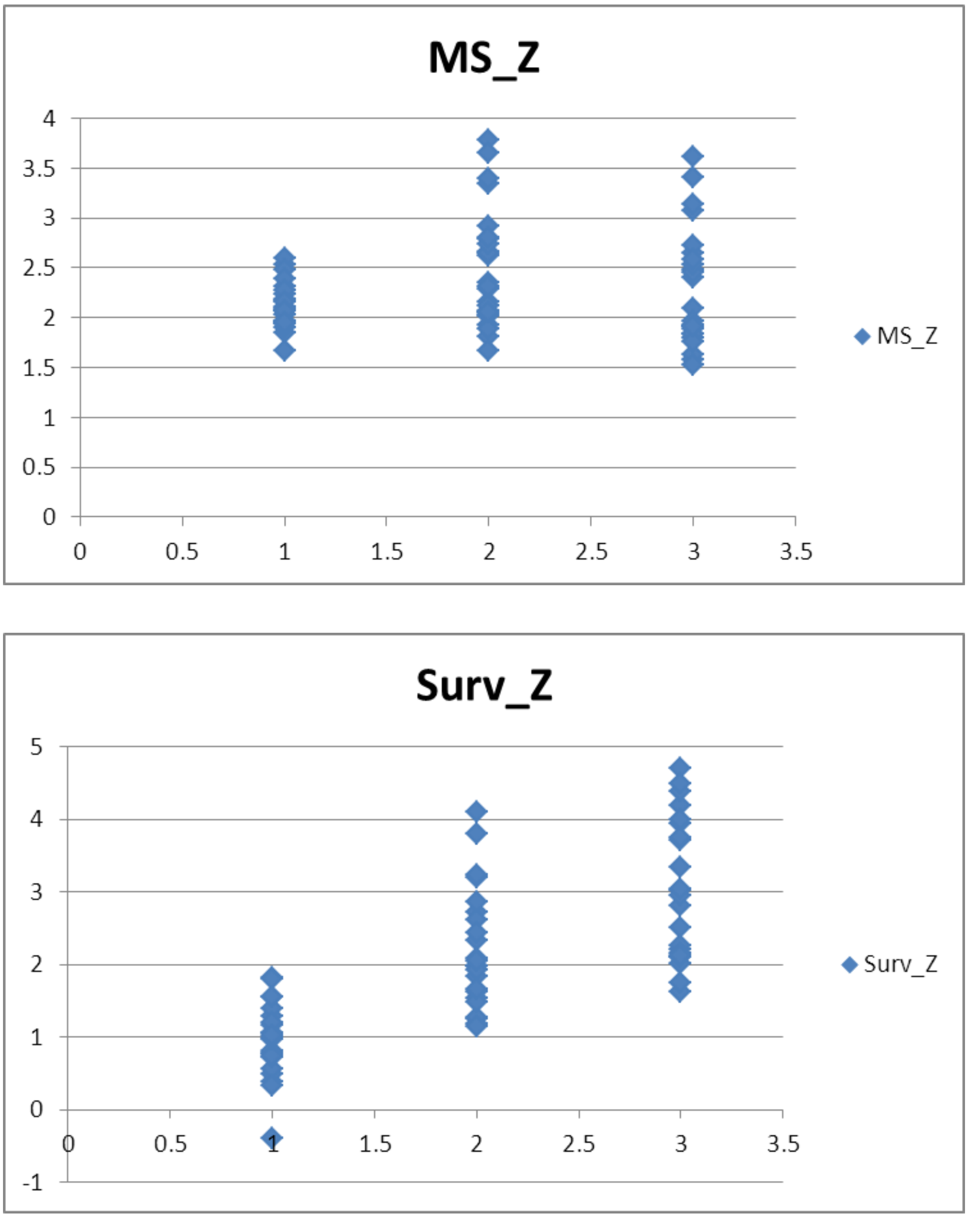


Figure A.5. Plots of survey Z and SMS Z by age.

From Figure A.5 it can be seen that SMS estimates of Z are more constant with age whereas survey Z increases with age.

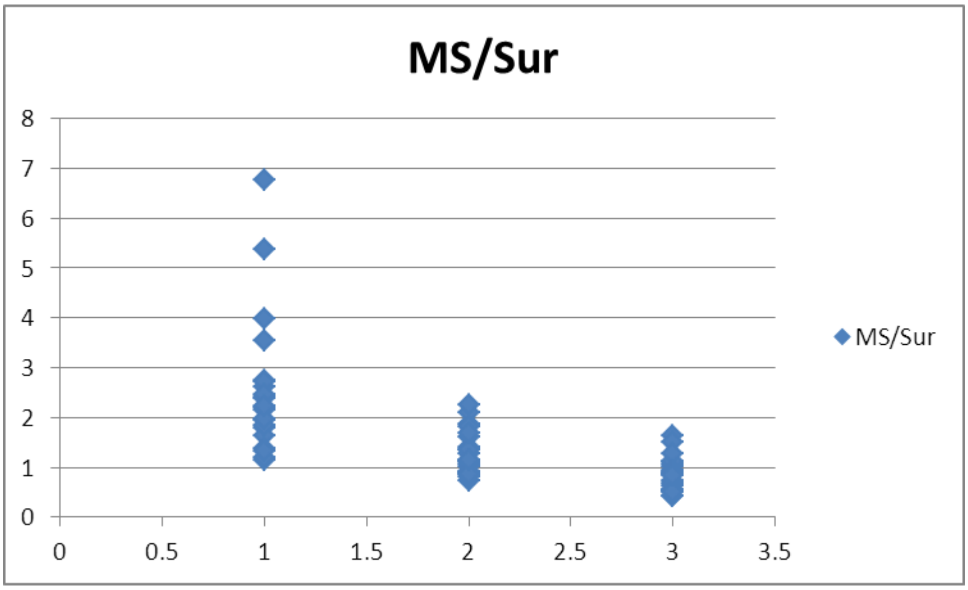


Figure A.6. The ratio of SMS estimates of Z to the survey estimates of Z.

It can be seen from Figure A.6 that the SMS estimates of Z are about two times higher for age 1 compared with the survey Zs. For age 2 the SMS values are slightly higher than survey values while for age 3 they are similar to survey values.

Issues table for Norway pout

Stock	NOP34			
Stock coordinator	Name: J. Rasmus Nielsen, DTU Aqua, DK	E-mail: rn@aqua.dtu.dk		
Stock assessor	Name: Internal: Ewen Bell, Cefas, UK Coby Needle, MARLAB, UK-Scotland External: Beatrix Morales, IEO Mallorca, Spain Jacques Massé, Ifremer, France	E-mail:		
Data contact	Name: J. Rasmus Nielsen, DTU Aqua, DK	E-mail: rn@aqua.dtu.dk		
Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available/ where should these come from?	External expertise needed at benchmark type of expertise/ proposed names
Tuning series	Not to be evaluated in coming benchmark			
Discards	Not relevant			

Stock	**NOP34**			
Stock coordinator	Name: J. Rasmus Nielsen, DTU Aqua, DK	E-mail: rn@aqua.dtu.dk		
Stock assessor	Name: Internal: Ewen Bell, Cefas, UK Coby Needle, MARLAB, UK-Scotland External: Beatrix Morales, IEO Mallorca, Spain Jacques Massé, Ifremer, France	E-mail:		
Data contact	Name: J. Rasmus Nielsen, DTU Aqua, DK	E-mail: rn@aqua.dtu.dk		
Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available/ where should these come from?	External expertise needed at benchmark type of expertise/ proposed names
Biological Parameters	The primary aim of the benchmark will be to consider and change the values of a number of biological parameters (maturity, growth, natural mortality) based on new biological information from some work mainly in 2007–2008 and summarized in two scientific publications (one already published, one on its way). This would have implications for the overall perception of the stock, as well as reference points and management targets. But there will likely not be inclusion of any new data or new methods.	The work needed is to include results from evaluation of new biological parameters performed in 2007–2008 and summarized in two scientific publications (one already published, one on its way) and then include those in the assessment and perform exploratory and comparative assessment runs as well as discuss the output of the assessments and finally to revise management reference points.	The needed data are available and analysed in peer reviewed publications and manuscripts. There are no major data deficiencies identified for this stock, whose assessment is usually of high quality. It will for the benchmarking be relevant to have updated natural mortality information from a updated MSVPA model/SMS model run.	Expertise on population dynamics for short-lived fish species and stock assessment expertise
Assessment method	Not to be evaluated in coming benchmark			

Stock	NOP34			
Stock coordinator	Name: J. Rasmus Nielsen, DTU Aqua, DK	E-mail: rn@aqua.dtu.dk		
Stock assessor	Name: Internal: Ewen Bell, Cefas, UK Coby Needle, MARLAB, UK-Scotland External: Beatrix Morales, IEO Mallorca, Spain Jacques Massé, Ifremer, France	E-mail:		
Data contact	Name: J. Rasmus Nielsen, DTU Aqua, DK	E-mail: rn@aqua.dtu.dk		
Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available/ where should these come from?	External expertise needed at benchmark type of expertise/ proposed names
Biological Reference Points	Will need to be re-evaluated given change of the biological parameters in the assessment	Evaluate and estimate revised reference points based on the new biological input parameters in the assessment (B-$MSY_{Escapement}$ and B_{lim})	Output data from revised assessment	Assessment expertise and expertise on population dynamics on short-lived fish species.

Annex 1: Stock Annex WGNSSK; Norway pout

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Norway pout in the North Sea and Skagerrak (ICES Area IV and IIIa); nop34

Working Group: WG on the Assessment of Demersal Stocks in the North Sea and Skagerrak

Date: 10.5.11

A. General

A.1. Stock definition

Norway pout is a small, short-lived gadoid species, which rarely gets older than five years (Lambert, Nielsen, Larsen and Sparholt, 2009).

It is distributed from the west of Ireland to Kattegat; and from the North Sea to the Barents Sea. The distribution for this stock is in the northern North Sea (>57°N) and in Skagerrak at depths between 50 and 250 m (Raitt, 1968; Sparholt, Larsen and Nielsen, 2002b; (Lambert, Nielsen, Larsen and Sparholt, 2009). Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway (Lambert, Nielsen, Larsen and Sparholt, 2009). Figures 1 and 2 show geographical distribution of the stock obtained from the ICES IBTS surveys. The IBTS Surveys only cover areas within the 200 m depth zone. However, very few Norway pout are caught at depths greater than 200 m in the North Sea and Skagerrak on shrimp trawl survey (Sparholt *et al.*, 2002b). For the Norwegian Trench, Albert (1994) found Norway pout at depths greater than 200 m, but very few deeper than 300 m.

At present, there is no evidence for separating the North Sea component into smaller stock units (Lambert, Nielsen, Larsen and Sparholt (2009)). Norway pout in the eastern Skagerrak is only to a very small degree a self-contained stock. The main bulk drifts as larvae from more western areas to which they return mainly during the latter part of their second year of life before becoming mature (Poulsen, 1968). ICES ACFM (October 2001) asked the ICES WGNSSK to verify the justification of treating ICES Division VIa as a management area for Norway pout (and sandeel) separately from ICES Areas IV and IIIa. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in a Working Document to the 2000 meeting of the ICES WGNSSK Working Group (Larsen, Lassen, Nielsen and Sparholt, 2001 in ICES C.M.2001/ACFM:07), gave no evidence for a stock separation in the whole northern area. This conclusion is supported by the results in Lambert, Nielsen, Larsen and Sparholt (2009).

Spawning distribution: So far it has been evaluated that around 10% of the Norway pout reach maturity already at age 1, and that most individuals reach maturity-at-age 2 on which the maturity ogive in the assessment has been based. Results in a recent paper (Lambert, Nielsen, Larsen and Sparholt (2009)) indicate that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was only around 90% and 95%, respectively, as compared with 100% used in the assessment. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in Larsen, Lassen, Sparholt and Nielsen (2001), gave no evidence for a stock separation in the whole northern area. Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway in coastal waters (along the 120 m isocline) (Lambert, Nielsen, Larsen and Sparholt (2009)).

Larvae and juvenile distribution: The species is not generally considered to have specific nursery grounds, but pelagic 0-group fish remain widely dispersed in the northern North Sea close to spawning grounds (Lambert, Nielsen, Larsen and Sparholt (2009)). The main bulk drifts as larvae from more western areas to which they return mainly during the latter part of their second year of life before becoming mature (Poulsen, 1968). The IBTS cpue map (Figure 2) shows, however, a relative high cpue in the Skagerrak area in the third quarter, where the 0-group dominates the catches.

Adult migration: There is an adult spawning migration out of Skagerrak and Kattegat as no spawning occurs in this area. Otherwise there is no indication of adult migration. Based on IBTS data, the main aggregations of settled fish are distributed around the 150 m contour, with a slight preference for deeper water for the older fish.

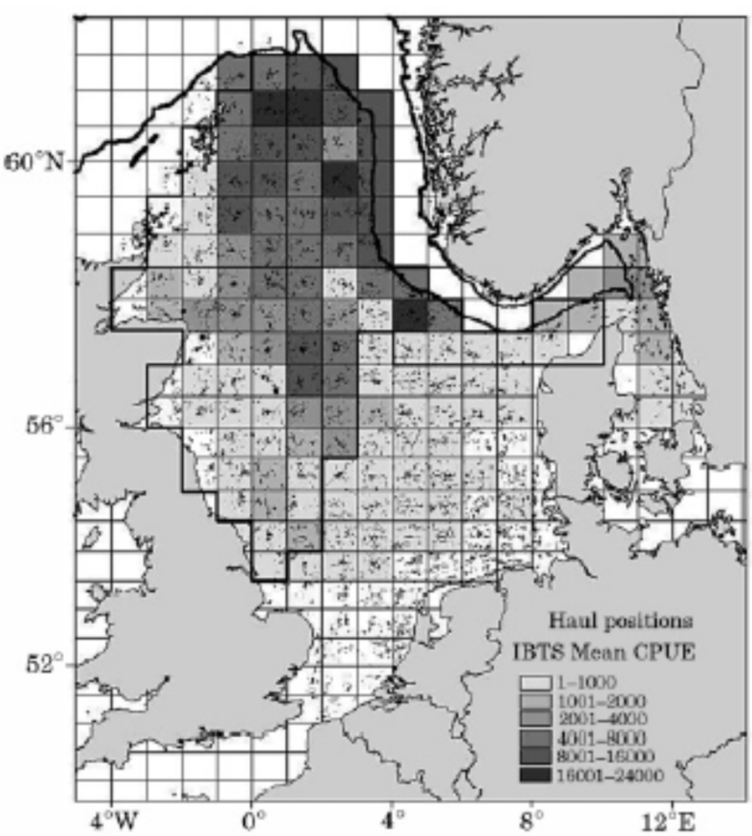


Figure 1. Positions fished at the International Bottom Trawl Survey (IBTS) first quarter and mean cpue (numbers) of Norway pout by rectangle, 1981–1999. The standard area used to calculate abundance indices and the 200 m depth contour is also shown [from Sparholt *et al.*, 2002b].

A.2. Fishery

The fishery is mainly carried out by Danish and Norwegian (large) vessels using small-mesh trawls in the northwestern North Sea especially at the Fladen Ground and along the edge of the Norwegian Trench in the northeastern part of the North Sea. Main fishing seasons are 3rd and 4th quarters of the year with also high catches in 1st quarter of the year especially previous to 1999. Norway pout is caught in small-meshed trawls (16–31 mm) in a mixed fishery with blue whiting, i.e. in addition to the directed Norway pout fishery; the species is also taken as bycatch in the blue whiting fishery. The fishery in more recent times is mainly carried out by Denmark (~70–80%) and Norway (~20–30%) at fishing grounds in the northern North Sea especially at Fladen Ground and along the edge of the Norwegian Trench. Norway pout is landed for reduction purposes (fishmeal and fishoil). In recent years Denmark has performed the main Norway pout landings compared with Norway, while the long-term average show more equal catches between the countries. There is a tendency towards the more recent Danish landings mainly originates from the Fladen Ground area compared with the Norwegian Trench area.

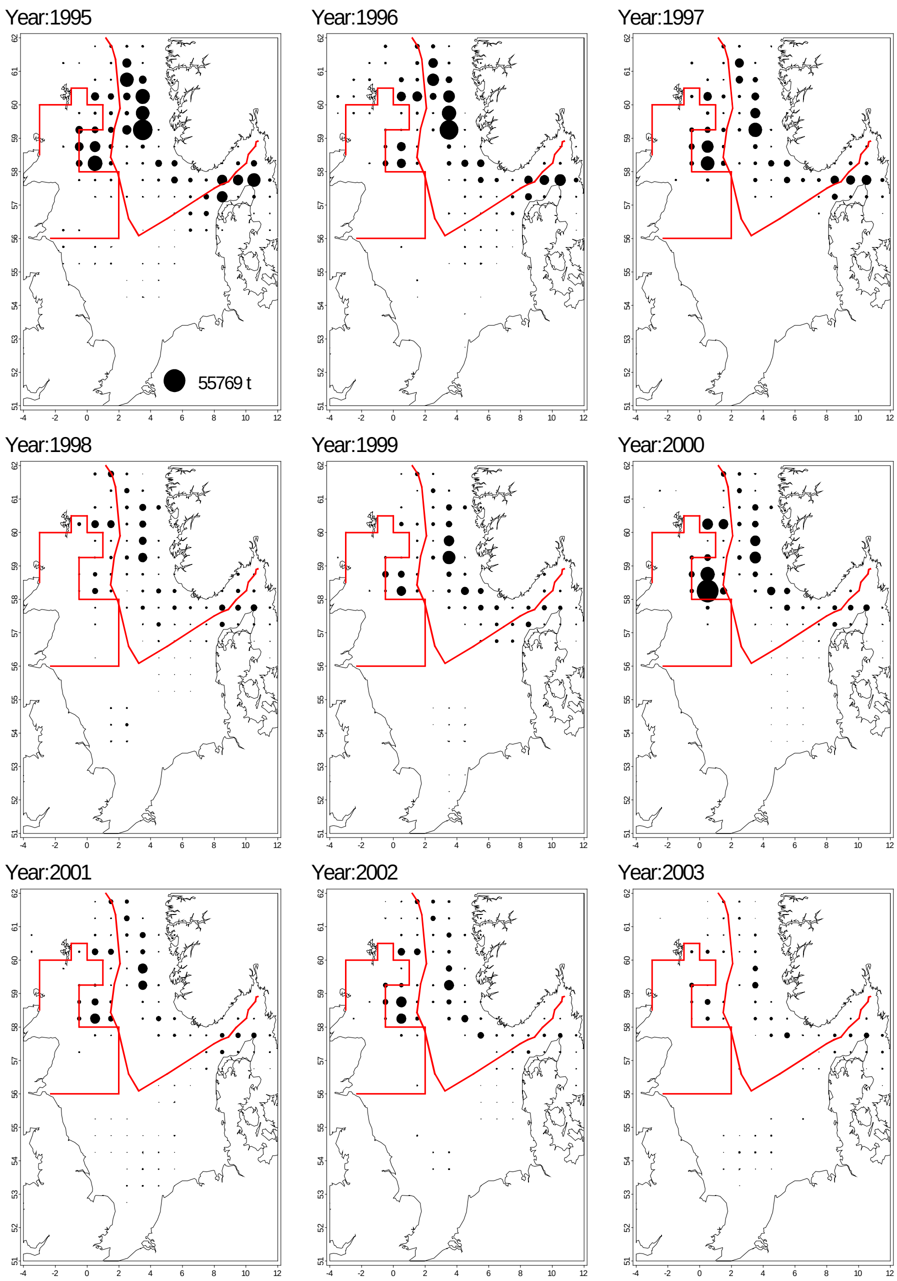


Figure 2. Landings of Norway pout by year and ICES rectangles for the period 1995–2003. Landings include Danish and Norwegian landing for the whole period. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the 1995 map. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map.

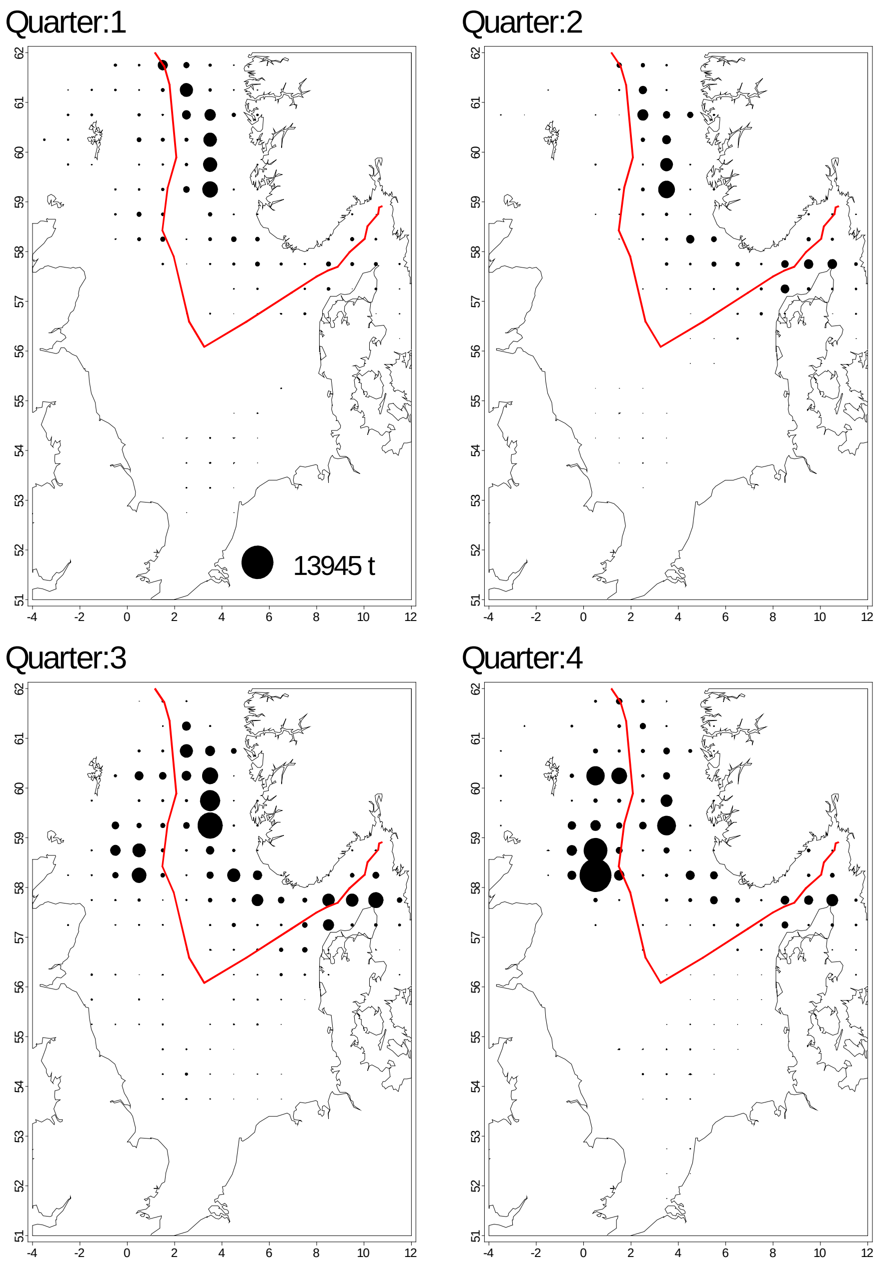


Figure 3. Average Danish and Norwegian landings of Norway pout by quarter of the year and ICES rectangles for the period 1994–2003. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the quarter 1 map.

Landings have been low since 2001, and the 2003–2004 landings were the lowest on record. Effort in 2003 and 2004 has been historically low and well below the average of the five previous years. The effort in the Norway pout fishery was in 2002 at the same level as in the previous eight years before 2001. The targeted Norway pout fishery was closed for 2005, in the first half year of 2006, as well as in all of 2007, but Norway pout were in the periods of closure taken as a bycatch in the Norwegian mixed blue whiting and Norway pout fishery, as well as in a small experimental fishery in 2007. The fishery was open for the second half year of 2006 and in all of 2008 based on the 2005 and 2007 year classes, respectively, both being on the long-term average level. However, the Norwegian part of the Norway pout fishery was only open from May to August in 2008. Despite opening of the fishery by 1st January 2008 (with a preliminary EU quota of 36 500 t and a Norwegian quota of 4750 t as well as a final EU quota of 110 000 t set late in 2008) only 30.4 kt was taken by Denmark, and the Norwegian catches were 5.7 kt, i.e. 36.1 kt in total. The fishery has been open full year in the period 2008 to 2010 based on recent strong year classes being on or above the long-term average level, especially the 2009 year class has been strong. The ICES advice according to the escapement management strategy was in 2008, 2009 and 2010 148 kt, 157 kt and 434 kt, respectively, while the TAC in 2008 was 115 kt and 162 kt in 2010, and the respective landings were 36 kt, 55kt and 126kt in 2008, 2009 and 2010. Consequently, the TAC has not been taken in recent years (2008, 2009 and 2010). This is due to high fishing (fuel) costs in all years as well as bycatch regulations in 2009 and 2010 (mainly in relation to whiting bycatch), which is a recent problem. Also, there might be an effect of late setting of the final yearly quota affecting the trade of individual Danish vessel quotas and accordingly the fishing opportunities. The 2010 landings was 126 kt based on the strong 2009 year class, but based on a very low 2010 year class being at the same level as the low 2003–2004 year classes the fishery has so far been closed in 2011.

Bycatch of herring, saithe, cod, haddock, whiting, and monkfish at various levels in the small-meshed fishery in the North Sea and Skagerrak directed towards Norway pout has been documented (Degel *et al*., 2006, ICES CM 2007/ACFM:35, (WD 22 and Section 16.5.2.2)), and recent bycatch numbers are given in Section 2 of the WGNSSK report. Bycatches of these species have been low in the recent decade, and in general, the bycatch levels of these gadoids have decreased in the Norway pout fishery over the years. Review of scientific documentation reveals that bycatch reduction gear selective devices can be used in the Norway pout fishery, significantly reducing bycatches of juvenile gadoids, larger gadoids, and other non-target species (Nielsen and Madsen, 2006, ICES CM 2007/ACFM:35, WD 23 and section 16.5.2.2; Eigaard and Nielsen, ICES CM2009/M:22). ICES advises that such species selective devices are used in the Norway pout fishery. Bycatches of other species should also be taken into account in management of the fishery. Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and bycatch regulations to protect other species have been maintained. A detailed description of the regulations and their background can be found further below in this Stock Quality Handbook (Q5).

With present fishing mortality levels the status of the stock is more determined by natural processes and less by the fishery. The Norway pout fishery is regulated by technical measures such as minimum mesh size in the trawls, fishing area closure in the Norway pout box in the northwestern part of the North Sea, and bycatch regulations to protect other species. An overview of relevant technical regulations for the Norway pout fishery and stock is given below in Section f. Bycatch in the fishery is described in detail in Annex 1.

A.3. Ecosystem aspects

In relation to an ecosystem based approach to fisheries management (CFP), spatial planning and EU Directives such as the Marine Strategy Framework Directive there will for this quality handbook be produced plots using coupled VMS and Logbook data for the Norway pout fishery by métier with recent distributions in effort, landings, and fishery capacity in the Norway pout fishery together with GIS Plots of recent stock distributions based on research survey data. This is also relevant to the fishery section below with inclusion of description of recent developments in the Danish and Norwegian Norway pout fishery.

The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by high recruitment variation and variation in predation mortality (or other natural mortality causes) due to the short lifespan of the species (Sparholt, Larsen and Nielsen, 2002a,b; Lambert, Nielsen, Larsen and Sparholt (2009)). With present fishing mortality levels in recent years the status of the stock is more determined by natural processes and less by the fishery, and in general the fishing mortality on 0-group Norway pout is low (ICES WGNSSK Reports). However, there is a need to ensure that the stock remains high enough to provide food for a variety of predator species. This stock is among other important as food source for other species (e.g. saithe, haddock, cod and mackerel) (ICES-SGMSNS 2006). Natural mortality levels by age and season used in the stock assessment do include the predation mortality levels estimated for this stock from the most recent multispecies stock assessment performed by ICES (ICES-SGMSNS 2006). Growth and mean weight-at-age for the above mentioned predators seems independent of the stock size of Norway pout.

Natural mortality varies between age groups, and natural mortality-at-age varies over different time periods. Although different sources of information (surveys, MSVPA) give slightly different perception of natural mortality-at-age (see below), the natural mortalities obtained from the most recent run with the North Sea MSVPA model (presented and used in the ICES SGMSNS (2006)) indicate high predation mortality on Norway pout. Especially the more recent high abundance of saithe predators and the more constant high stock level of western mackerel as likely predators on smaller Norway pout are likely to significantly affect the Norway pout population dynamics. However, interspecific density-dependent patterns in Norway pout growth and maturity were not found in relation to stock abundance of those predators but rather in relation to North Sea cod and whiting stock abundance (Lambert, Nielsen, Larsen and Sparholt, 2009).

The Review Group (2007) asked the WG to provide guidance on how to deal with the objective of keeping a certain amount of biomass for predators. If a minimum biomass is found to be required, then natural mortality could not be kept constant in the prediction (if it does during the assessment period). It was suggested that variable M be examined to determine the amount of biomass removed via predation, to serve as a baseline biomass requirement for predators.

In order to protect other species (cod, haddock, saithe, whiting, and herring as well as mackerel, monkfish, squids, flatfish, gurnards, *Nephrops*) there is a row of technical management measures in force for the small-meshed fishery in the North Sea such as the closed Norway pout box, bycatch regulations, minimum mesh size, and minimum landing size (Stock Quality Handbook (Q5). Bycatch of saithe, cod, haddock, whiting, and other species at various levels in the small-meshed fishery in the North Sea and Skagerrak directed towards Norway pout has been documented (Degel *et al.*, 2006, ICES CM 2007/ACFM:35, (WD 22 and Section 16.5.2.2). Bycatches of these species have been low in the recent decade, and in general, the bycatch levels of these gadoids have decreased in the Norway pout fishery over the years.

B. Data

B.1. Commercial catch and effort data

The assessment uses the combined catch and effort data from the commercial Danish and Norwegian small-meshed trawler fleets fishing mainly in the northern North Sea. Standardized effort data for both the Norwegian and Danish commercial fishery vessels are included in the assessment commercial fishery tuning fleet up until 2006.

For the Danish and Norwegian commercial landings sampling procedures of the commercial landings, which vary between the countries, were described in detail in the report of the WGNSSK meeting in September 2004 (ICES WGNSSK (2005) ICES C.M. 2005/ACFM:07).

From 2002 onwards, an EU regulation (1639/2001) was endorsed which affects the market sampling procedures. First, each country is obliged to sample all fleet segments, including foreign vessels landing in their country. Second, a minimum number of market samples per tonnes of landing are required. The national market sampling programmes have been adjusted accordingly. In general there is set a level of minimum 1 sample per 1000 tonnes landed for Norway pout in the North Sea and Skagerrak.

Sampling and reporting from Norwegian vessels fishing Norway pout and blue whiting has been slightly changed in 2009 and onwards. Previously, all catch reported as Norway pout included bycatch of other species which was used as input in the assessment. These data were also the basis for the Norwegian official catch statistics reported to among other ICES. The procedure up until 2009 was that if a catch (landing) from a fishing trip consisted of more than 50% of Norway pout in weight then the full catch consisting of all species was reported as Norway pout for this landing, i.e. bycatch was included in the reported Norway pout catch. In 2009 and onwards, each catch (landing) per trip is evaluated (sorted) according to species, and the actual catch per species for each landing is reported. This makes the actual catch numbers of Norway pout from Norway more precise. Norway pout caught both in the Norway pout fishery as well as in the blue whiting fishery are from 2009 included in the assessment, and bycatch of other species are excluded. There has not been made an analysis and thorough evaluation of the effect of this change in Norwegian sampling procedure with respect to relative change in the reported catch-at-age and weight-at-age. However, the Norwegian assessment experts evaluate that this will have only minor effect on the catch-at-age in number and the weight-at-age used in the assessment as the bycatch and the actual catch has balanced each other out previously. With respect to effort data (see below), only effort is reported for Norwegian trips with landings consisting of more than 50% Norway pout in weight for 2009 and onwards. Consequently, the procedure in estimating and reporting (average) effort data from Norway has remained unchanged according to previous years' standard procedure for estimating effort data.

Method of effort standardization of the commercial fishery tuning fleet

Results and parameter estimates by period from the yearly regression analysis on cpue vs. GRT for the different Danish vessel size categories are used in the effort standardization of both the Norwegian and Danish commercial fishery vessels included in the assessment tuning fleet with data up until 2006.

Background descriptions of the commercial fishery tuning-series used (including data up to 2006) and methods of effort standardization of the commercial fishery between different vessel size categories and national commercial fleets are given in the 2004 working group report (ICES WGNSSK (2005) ICES CM 2005/ACFM: 07) and the 1996 working group report (ICES CM 1997/Assess:6). Previous to the 2001 assessment the effort has been standardized by vessel category (to a standard 175 GRT vessel) only using the catch rate proportions between vessel size categories within the actual year. In 2002, a new regression standardization method was introduced (see methodological description below), and the assessment was run both with and without the new standardization method (regression). The differences in results of output SSB, TSB and F between the two assessment runs were small.

With respect to further exploration of the effect of using effort standardization and using a combined Danish and Norwegian commercial fishery tuning fleet in the Norway pout assessment (including data up to 2006) different analyses have been made in relation to this in the benchmark assessment in 2004. This was done to investigate alternative standardization methods and alternative division of the commercial fishery assessment tuning fleet used in the assessment. The results of these analyses were presented to and discussed by the working group in 2004 and presented in the 2004 working group report in Section 12 (ICES CM 2005/ACFM:07).

Since 2002, the assessments have used output of the regression analyses using time-series from 1987(1994)–most recent assessment year, where the regressions have been applied to the Danish and Norwegian commercial fishery. Effort standardization of both the Danish and the Norwegian part of the commercial fishery tuning-series is performed by applying standardization factors to reported catch and effort data for the different vessel size categories. The standardization factors are obtained from regression of cpue indices by vessel size category over years of the Danish commercial fishery tuning fleet. The number of small vessels in the Danish Norway pout fishing fleet has decreased significantly and the relative number of large vessels has increased in the more recent years. Furthermore, there were found no trends in cpue between vessel categories over time. For these reasons the cpue indices used in the regression has been obtained from pooled catch and effort data over the years 1994–present assessment year by vessel category in order to obtain and include estimates for all vessel categories also for the latest years where no observations exists for the smallest vessels groups.

The conclusion of the discussion in the working group of these analysis results was that further analysis and exploration of data are necessary before suggesting an alternative standardization method and alternative division of commercial fishery tuning fleets (potentially) to be used in the assessment. This should be done in a coming benchmark assessment of the stock. Among other it should be further investigated whether or not it is possible to split the Danish and Norwegian commercial tuning fleet, and also effects of excluding the commercial tuning fleets from the assessment should be further exploited.

Parameter estimates from regressions of ln(cpue) vs. ln(average GRT) by period together with estimates of standardized cpue to the group of Danish 175 GRT industrial fishery trawlers is shown for the period 1994–2006 in this quality control handbook below.

The regression model used in effort standardization is the following:

Regression models: $cpue=b*GRT^{a}$ => $\ln(cpue)=\ln(b)+a*\ln((GRT-50))$

Parameter estimates from regressions of ln(cpue) vs. ln(average GRT) by period together with estimates of standardized Cpue to the group of Danish 175 GRT industrial fishery trawlers is used to standardize effort in the commercial fishery tuning fleet used in the Norway pout assessment. Parameter estimates for the period 1994–2004 is the following:

Year	Slope	Intercept	R-Square	Cpue(175 tonnes)
1994–2006	0.18	14.05	0.77	32.76

Norwegian effort data

In 1997, Norwegian effort data were revised as described in Sections 13.1.3.1 and 1.3.2 of the 1997 working group report (ICES CM 1998/Assess:7). Furthermore, in the 2000 assessment Norwegian average GRT and Effort data for 1998–1999 were corrected because data from ICES Area IIa were included for these years in the 1998–1999 assessments. Observed average GRT and effort for the Norwegian commercial fleets are given in the input data to the yearly performed assessment. This information has been put together in the report of the ICES WGNSSK meeting in 2004 (ICES WGNSSK (2005), ICES CM 2005/ACFM:07). No Norwegian effort data exist for the commercial fishery tuning fleet in 2005, the first part of 2006, and in 2007 due to closure of the fishery. Norwegian effort data for the directed Norway pout fishery in 2008 has not been prepared because the fishery has been on low level, and data for 2010 has not been prepared because of introduction of selective grids in the Norwegian fishery in 2010.

Danish effort data

In each yearly assessment the input data as cpue data by vessel size category and year for the Danish commercial fishery in Area IVa is given. This is based on fishing trips where total catch included at least 70% Norway pout and blue whiting per trip, and where Norway pout was reported as main species in catch in the logbook per fishing day and fishing trip. There has been a relative reduction in the number and effort of small vessels and an increase for the larger vessels in the fleet in the latest years. Furthermore, it appears clearly that there is big difference in cpue (as an indicator of fishing power) between different vessel size categories (BRT). Accordingly, standardization of effort is necessary when using a combined commercial fishery tuning fleet in the assessment including several vessel categories. Minor revisions (updating) of the Danish effort and catch data used in the effort standardization and as input to the tuning fleets have been made for the 2001 assessment. No Danish effort data exist for the commercial fishery tuning fleet in 2005, the first part of 2006, and in 2007 due to closure of the fishery.

Exploration of methods for effort standardization

With respect to further exploration of the effect of using effort standardization and using a combined Danish and Norwegian commercial fishery tuning fleet in the Norway pout assessment (including data up until 2006) different analyses have been made in relation to the benchmark assessment in 2004. This was done to investigate alternative standardization methods and alternative division of the commercial fishery assessment tuning fleet used in the assessment. The results of these analyses were presented to the working group and were discussed here in 2004 (ICES CM 2005/ACFM:07).

Analysis of variance (GLM-analyses) of catch, effort and log transformed cpue data on trip basis for the Danish commercial fishery for Norway pout during the period 1986 to 2004 showed statistical significant differences in catch rates between different GT-groups, years, quarters of years (seasons), and fishing areas, as well as statistical significant first order interaction effects between all of these variables. The detailed patterns in this variation are not clear and straightforward to conclude on.

It has so far not been possible to obtain disaggregated effort and catch data by area and vessel size (GT-group) from the Norwegian Norway pout fishery to perform similar analyses for the Norwegian fishery.

Also it is not possible to regenerate the historical time-series (before 1996) of catch numbers-at-age in the commercial fishery tuning fleet by nation which is only available for the combined Danish and Norwegian commercial tuning fleet. The reason for this is partly that there is no documentation of historical allocation of biological samples (mean weight-at-age data) to catch data (catch in weight) in the tuning fleet in order to calculate catch number-at-age for the period previous to 1996 for both nations, and partly because it seems impossible to obtain historical biological data for Norway pout (previous to 1996) from Norway. Alternative division of the commercial fishery tuning fleet would, thus, need new allocation of biological data to catch data for both the Danish and Norwegian fleet, and result in a significantly shorter Norwegian commercial fishery tuning fleet time-series, and a historically revised Danish commercial fishery tuning fleet with new allocation of biological data to catch data. Revision of the tuning fleet would, furthermore, need analyses of possible variation in biological mean weight-at-age data to be applied to different fleets, as well as of the background for and effect of this possible variation.

Standardized effort data

The resulting combined and standardized Danish and Norwegian effort for the commercial fishery used in the assessment is presented in the input data to the yearly performed assessment, as well as the combined cpue indices by age and quarter for the commercial fishery tuning fleet.

The seasonal variation in effort data is one reason for performing a seasonal VPA.

B.2. Biological data

Age reading

There are no reports of age reading problems of Norway pout otoliths, and no indications of low quality of the age–length keys used in the assessment of this stock.

Weight-at-age

Mean weight-at-age in the catch is estimated as a weighted average of Danish and Norwegian data. Historical levels and variation in mean weight-at-age in catch by quarter of year is shown in Figure 12.2.1 in the 2004 benchmark assessment in the 2004 ICES WGNSSK Report (ICES WGNSSK (2005), ICES CM 2005/ACFM:07) and has been yearly/half yearly updated since then. In general, the mean weights-at-age in the catches are variable between seasons of year. The same mean weight-at-age in the stock is used for all years. The reason for mean weight-at-age in catch is not used as estimator of weight in the stock is mainly because of the smallest 0-group fish are not fully recruited to the fishery in 3rd quarter of the year because of likely strong effects of selectivity in the fishery. As no age composition data for Norwegian landings have been provided for 2007 and 2008 because of small catches the catch-at-age numbers from Norwegian fishery are calculated from Norwegian total catch weight divided by mean weight-at-age from the Danish fishery. Mean landings weight-at-age from Danish and Norwegian fishery from 2005–2008 are uncertain because of the few observations. Missing values have been filled in using a combination of sources (values from 2004, from adjacent quarters and areas, and from other countries within the same year, for the period 2005–2008, and in first half year 2010 there has also been used information from other quarters. No age composition data for the Danish landings in first half year 2010 have been sampled because of very small catches. Mean weight-at-age data are available from both Danish and Norwegian fishery in 2009 and second half year 2010.There is, furthermore, referred to Section B.1 concerning modifications in Norwegian sampling procedures of catch-at-age data from 2009 and onwards also (potentially) affecting Norwegian mean weight-at-age data slightly.

Maturity and natural mortality

Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway. Around 10% (varying between years and sex; see below) of the Norway pout reach maturity already at age 1, however, most individuals reach maturity-at-age 2. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in Larsen *et al.* (2001), indicated variation in maturity between years and sexes, especially for the 1-group. Results in a recent paper (Lambert, Nielsen, Larsen and Sparholt (2009)) indicate that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was only around 90% and 95%, respectively, as compared with 100% used in the assessment.

The same proportion mature and natural mortality are used for all years in the assessment. The proportion mature used is 0% for the 0-group, 10% of the 1-group and 100% of the 2+-group independent of sex. The natural mortality is set to 0.4 for all age groups in all seasons that result in an annual natural mortality of 1.6 for all age groups.

In the 2001 and 2002 assessment exploratory runs were made with revised input data for natural mortality based on the results from two papers presented to the working group in 2001, (both papers published in ICES J. Mar. Sci. in 2002, Sparholt, Larsen and Nielsen, 2002a,b). This was not explored further in the 2003 update assessment but the 2004 benchmark assessment of the stock includes an exploratory run with revised natural mortalities. These revised natural mortalities are given in Table 12.2.3 in the 2004 ICES WGNSSK Report (ICES WGNSSK (2005); ICES CM2005/ACFM:07).

The resulting SSB, TSB (3rd quarter of year), TSB (1st quarter of year) and F for the final exploratory run was compared with those for the accepted run with standard settings. It appears that the implications of these revised input data are very significant. The working group in 2002 suggested that an assessment with partly the traditional settings (constant M) and a new assessment with the revised values for M were made for at least a three year period in order to compare the output and the performance of the assessments before the working group decided on final adoption of the revised values for M to be used in the assessment. This attitude was adopted by the Working Group again in the 2004 benchmark assessment where an exploratory run with revised values for M was performed as well. The results of the exploratory runs have been consistent throughout the three years of exploratory runs.

Research results on population dynamics parameters (e.g. natural mortality and maturity)

Investigations on population dynamics (natural mortality, distribution, and spawning and maturity as well as growth patterns) of Norway pout in the North Sea are ongoing. Results in a recent paper (Lambert, Nielsen, Larsen and Sparholt (2009)) indicate that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was only around 90% and 95%, respectively, as compared with 100% used in the assessment.

Studies presented to the working group in 2001 and published in 2002 indicate that natural mortality may be significantly different between age groups compared to constant as currently assumed in the assessment model Sparholt, Larsen and Nielsen (2002a,b). This result is further supported by the results of the population dynamics analyses performed in Lambert, Nielsen, Larsen and Sparholt (2009).

Exploratory runs of the SXSA model was presented in the 2001 and 2002 assessment reports as well as in the 2004 and 2006 assessments (Norway pout benchmark assessments) with revised input data for natural mortality by age based on the results from two papers presented to the working group in 2001, (later published in Sparholt, Larsen and Nielsen, 2002a,b) as well as natural mortality estimates from the North Sea MSVPA model in the 2006 assessment (ICES CM 2006/ACFM:35).

The resulting SSB, TSB (3rd quarter of year), TSB (1st quarter of year) and F for the final exploratory run was compared with those for the accepted run with standard settings. It appeared that the implications of these revised input data are very significant. The working group in 2002 suggested that an assessment with partly the traditional settings (constant M) and a new assessment with the revised values for M were made for at least a three year period in order to compare the output and the performance of the assessments before the working group decided on final adoption of the revised values for M to be used in the assessment. This attitude was adopted by the working group again in the 2004 benchmark assessment where an exploratory run with revised values for M was performed as well. The results of the exploratory runs have been consistent throughout all years of exploratory runs.

The working group recommended in 2005 that there was made a limited benchmark assessment for Norway pout in the 2006 assessment (ICES CM 2006/ACFM:35) with specific reference to evaluation of effects of using revised natural mortalities, and that the WG on this basis decides on which natural mortalities to use in the assessment. Here three data time-series for natural mortality were considered and compared through exploratory assessment runs:

1) Constant natural mortalities by age, quarter and year as used in previous years standard (baseline) assessment;
2) Revised natural mortalities obtained from and based on the results from Sparholt *et al*. (2002a,b);
3) Revised natural mortalities obtained from the most recent run with the North Sea MSVPA model (presented and used in the ICES SGMSNS (2006).

The estimates of natural mortality by Sparholt *et al*. (2002a,b) indicate age and periodical tendencies and differences in natural mortality with higher M for age 2 and 3 compared with age 1 (and 0). The proportion of the natural mortality due to predation was found highest at age 1. Non-predation mortality on Norway pout increases with age and is very high for age 2 and older fish resulting in relatively higher overall M values for age 2 and 3 compared with age 1. The estimates are based on analysis of IBTS quarter 1 survey time-series in two periods from 1977–1981 and 1987–1991. The results also revealed high variation in total mortality (Z) by age and period using different survey time-series (IBTS Q1 1977–1981, 1987–1991, 1979–1999, SGFS Q3 1987–1991, 1980–1997, and EGFS Q3 1982–1992) as well as other source time-series (commercial catch data time-series 1977–1981, 1987–1991, and numbers consumed by year class 1977–1981, 1987–1991). Although the results using different sources and surveys confirmed overall age specific tendencies in Z there were high variability and some in-consistency in the estimates from different sources in different periods.

The estimated M and Z values by age based on the 1987-1991 IBTS Q1 data from this study are shown in ICES CM 2006/ACFM:35, Figures 5.2.3–5.2.4 as well as in Table 5.2.6. The M values from 1987–1991 were extrapolated and used as constant values by age and quarter for all years for the period 1983–2006 in exploratory SMS assessment runs comparing use of baseline M and M from Sparholt *et al*. (2002a,b) (Figures 5.2.3–5.2.4). The results showed different levels of SSB, F, recruitment and TSB but the same perception of stock dynamics in accordance with previous years' results (Figure 5.3.10).

Estimates of total mortality based on the SURBA assessment model estimates (2005 SURBA run for Norway pout, ICES C.M. 2006/ACFM:35) using all survey time-series included in the baseline assessment (as given in Table 5.3.2 of ICES CM 2007/ACFM:18 and 30) covering the period 1983–2005 was also presented in Figure 5.2.3**.** It appeared that for the period up to 1990–1995 Z estimated from SURBA and Sparholt, Larsen and Nielsen (2002a,b) is on the same level for both the 1–2 group and 2–3 group, and there also seems to be age specific differences in Z. In the period from 1995 and onwards the Z-estimates from SURBA are lower compared with the constant M values obtained from Sparholt, Larsen and Nielsen (2002a,b). In recent years from 2002–2003 SURBA estimates of Z increases again compared with the period 1995–2001.

In conclusion, the survey based mortality estimates indicate age-specific differences in Z and M. However, different survey time-series indicate high variability of the mortality with somewhat contradicting tendencies between periods. Sparholt, Larsen and Nielsen (2002a,b) discussed their results in context of changed catchability in the surveys, migration out of the area, or age-specific distribution patterns of Norway pout and concluded that the mortality patterns were not caused by this.

The MSVPA estimates of Z in the period 1983–2003 also shown in Figure 5.2.3-4 of ICES CM 2007/ACFM: 18 and 30 and obtained from ICES SGMSNS (2006) are higher than the survey based estimates from Sparholt, Larsen and Nielsen (2002a,b) and from SURBA for the 1–2 age groups, but on the same level for the 2–3 age groups indicating relatively high difference for the 1-group. Higher natural mortality (M) values for the 1-group from MSVPA compared with those from Sparholt, Larsen and Nielsen (2002a,b) are evident from Figure 5.2.4. The MSVPA indicate that M by quarter of year is on the same level for all three age groups (1–3) by year during the whole assessment period.

MSVPA M increase in 2002 and 2003 for both age 1, 2 and 3 (as was also observed in SURBA estimated Z). Whether or not this tendency of change in level of MSVPA M for in recent years has continued is unknown because MSVPA M estimates in 2004 and 2005 are not available (ICES-SGMSNS 2006). The SURBA estimates for 2003–2005 might indicate that the increasing tendency in Z (and accordingly M as F is 0) is not continuing from 2003 to 2004–2005 (Figure 5.2.3). Accordingly, when using the MSVPA natural mortalities it is necessary to make assumptions about natural mortality for the years 2004 and 2005. The rather constant level of natural mortality for all age groups in the MSVPA in previous years might be changing (increasing) in recent years from 2002 and onwards as indicated on Figures 5.2.3–5.2.4, but this cannot be finally documented. When update estimates of MSVPA M-values are available it should again be considered whether or not to use MSVPA estimates of M in the assessment. In the exploratory runs with SMS using MSVPA values, the M for 2004 and 2005 was assumed to be equal to the 2003 values. The results of this exploratory run revealed that there was no difference in perception of the stock compared with the baseline assessment with constant M (Figure 5.3.11). This should be seen in context of the constant M by age and quarter chosen in the baseline assessment at 0.4 by quarter and age is based on the rather constant level of M estimates from MSVPA in the period 1983–2001.

Consequently, the MSVPA estimates indicate rather constant M between age groups (and years), and do not provide the most recent estimates of M.

Overall, the independent sources of information on mortality are contradicting between age groups and inconclusive between periods (variable). Consequently, it has been chosen to continue using the baseline assessment constant values for M-at-age and quarter as in previous years' assessment.

Executive summary and conclusions of the explorative comparison runs using recent research results

In response to the wish from ACFM RG 2006 on a separate description of natural mortality aspects for Norway pout in the North Sea a summary of the September 2006 benchmark assessment on this issue is given here (see also ICES CM 2006/ACFM:35):

Investigations on population dynamics (natural mortality, distribution, and spawning and maturity as well as growth patterns) of Norway pout in the North Sea are ongoing.

Studies presented to the working group in 2001 and published in 2002 as well as results published in 2009 indicate that natural mortality may be significantly different between age groups compared with constant as currently assumed in the assessment model (Sparholt, Larsen and Nielsen, 2002a,b; Lambert, Nielsen, Larsen and Sparholt, 2009).

Exploratory runs of the SXSA model was presented in the 2001 and 2002 assessment reports as well as in the 2004 and 2006 Norway pout benchmark assessments with revised input data for natural mortality by age based on the results from two papers presented to the working group in 2001, (later published in Sparholt, Larsen and Nielsen, 2002a,b) as well as natural mortality estimates from the North Sea MSVPA model in the 2006 assessment.

The resulting SSB, TSB (3rd quarter of year), TSB (1st quarter of year) and F for the final exploratory run was compared with those for the accepted run with standard settings. It appeared that the implications of these revised input data are very significant. The results of the exploratory runs have been consistent throughout all years of exploratory runs. The working group recommended in 2005 that there was made a limited benchmark assessment for Norway pout in the 2006 assessment with specific reference to evaluation of effects of using revised natural mortalities, and that the WG on this basis decides on which natural mortalities to use in the assessment.

The benchmarking evaluated three independent sources and data time-series for natural mortality and made exploratory SMS assessment model runs for those:

1) Constant natural mortalities by age, quarter and year as used in previous years standard assessment;
2) Revised natural mortalities obtained from and based on the results from Sparholt *et al.* (2002a,b);
3) Revised natural mortalities obtained from most recent run with the North Sea MSVPA model (presented and used in the ICES-SGMSNS 2006).

The survey based mortality estimates all indicate age specific differences in Z and M. These mortality estimates show high within survey variability and, periodically, contradictory patterns between the surveys. Sparholt, Larsen and Nielsen (2002a,b) discussed their results in context of changed catchability in the surveys, migration out of the area, or age-specific distribution patterns of Norway pout and concluded that the mortality patterns were not caused by this.

In contrast, the MSVPA estimates indicate rather constant M between age groups and years, and do not provide the most recent estimates of M.

In conclusion, the exploratory runs gave very much similar results and showed no differences in the perception of the stock status and dynamics. However, with respect to the exploratory runs using different natural mortalities no conclusions could be reached as the mortality between age groups was contradictive and inconclusive between periods (variable) from the different sources showing different trends with no obvious biological explanation. On that basis it was in the 2006 benchmark assessment decided that the final assessment continues using the baseline assessment constant values for natural mortality-at-age and quarter by year as in previous years' assessment. This has been adopted in this year's update assessment.

Evaluation of total mortality Z in recent years, where fishing mortality has been very low and where total mortality accordingly approximately equals natural mortality, has been performed and is shown in the September 2007 report (ICES CM 2007/ACFM:18 and 30, Table 5.2.12). This evaluation has been based on catch curve analysis on the most recent (IBTS Q1 and Q3) survey estimates for Norway pout. The results indicate somewhat different levels of Z between different survey time-series mirroring the results from the 2006 benchmark assessment. The overall Z estimates for the period 2003–2007 indicates present levels of Z-at-age between 1.2–1.9. Also, these results confirm the results from the 2006 benchmark assessment on different natural mortality-at-age. The assessment uses constant values of M-at-age of 0.4 per quarter (totally 1.6 per year). A comprehensive study on Norway pout natural mortality is in the process of being published on this work which should also be addressed in the coming benchmark assessment.

Maturity

Preliminary results from an analysis of regionalized survey data on Norway pout maturity is presented in a Working Document to the 2000 meeting of the Working Group (Larsen, Lassen, Nielsen and Sparholt, 2001 in ICES C.M.2001/ACFM:07). Results in a recent paper (Lambert, Nielsen, Larsen and Sparholt (2009)) indicate that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was only around 90% and 95%, respectively, as compared with 100% used in the assessment.

B.3. Assessment tuning fleet data and indices (general)

Revision of assessment tuning fleets (survey cpue data and commercial fishery cpue data) in the 2004 benchmark assessment (see also section B.1 and B.5 concerning the commercial fishery tuning fleet)

Revision of the Norway pout assessment tuning fleets was performed during the 2004 benchmark assessment. The background for this, the results, and the conclusions from the analyses in relation to this are described here in the stock quality handbook as well as in the benchmark assessment in the working group report from 2004.

Revision of the Norway pout assessment tuning fleets during benchmark assessment have been based partly on cohort analyses and analyses of correlations within and between the different tuning fleet indices by age group, as well as on the results from a row of exploratory assessment runs described under Section 12.3 of the 2004 benchmark assessment (ICES WGNSSK (2005)) which analyses the performance of the different tuning fleets in the assessment. The exploratory assessment runs also give indications of possible catchability patterns and trends in the fishery over time within the assessment period. The analyses of the tuning fleet indices are presented in the benchmark assessment 2004 (ICES WGNSSK (2005)) Figures 12.2.3–12.2.8 and Tables 12.2.9–12.2.12.

An overview over the resulting tuning data and fleets used in the assessment during different time periods are shown in the table over tuning data in Section C below.

B.4. Survey data

Survey index-series of abundance of Norway pout by age and quarter are for the assessment period available from the IBTS (Q1 and Q3) and the EGFS (Q3) and the SGFS (Q3). The SGFS data from 1998 onwards should be used with caution due to new survey design (new vessel from 1998 and new gear and extended survey area from 1999). The 0-group indices from this survey have accordingly not been used in the assessment tuning fleet for this survey previous to the 2004 benchmark assessment. The index for the 0-group from SGFS changed with an order of magnitude in the years after the change in survey design compared with previous years (Table 12.2.8, ICES WGNSSK (2005)). The EGFS data from previous to 1992 should be used with caution as the survey design shifted in 1992. This change in survey design has until 2004 been accounted for by simply multiplying all indices with a factor 3.5 for all age groups in the years previous to 1992 in order to standardize it to the later indices. The EGFS survey indices for Norway pout has been revised in the 2004 assessment compared with the previous years' assessment for the 1996, 2001, 2002, and 2003 indices. In previous years assessments (before 2004) the full EGFS survey time-series for all age groups have been included as an assessment tuning fleet. Time-series for IBTS Q3 are only available from 1991 and onwards. The 3rd quarter IBTS and the EFGS and SGFS are not independent of each other as the two latter is a part of the first. Accordingly, the following changes have been made for the survey tuning index-series in the 2004 benchmark assessment (also shown in the tuning-series overview table in Section C):

1) The IBTS Q3 for the period 1991 onwards has been included in the assessment. This survey has a broader coverage of the Norway pout distribution area compared with the EGFS and SGFS isolated. However, as this survey index is not available for the most recent year to be used in the seasonal assessment it has been chosen to exclude the 0- and 1-group indices from the IBTS Q3 in order to allow inclusion of the 0- and 1-group indices from the SGFS and EGFS which are available for the most recent year in the assessment. (Not relevant in relation to spring assessments). Accordingly, the IBTS Q3 tuning fleet for age 2 and age 3 has been included in the assessment as a new tuning fleet. The SXSA demands at least two age groups in order to run which is the reason for including both age 0 and age 1 under the EGFS and SGFS tuning fleets and not including age 1 in the IBTS Q3 tuning fleet.
2) The SGFS for age group 0 and 1 for the period 1998 and onwards has been used as tuning fleet in the assessment. The short time-series is due to the

change in survey design for SGFS as explained above. The quarter 3 0-group survey index for SGFS is back-shifted to the final season of the assessment in the terminal year, i.e. to quarter 2 of the assessment year in order to include the most recent 0-group estimate in the assessment.

3) The EGFS for age group 0 and 1 for the period 1992 and onwards has been used as tuning fleet in the assessment. The shorter time-series is due to the change in survey design for EGFS as explained above. Furthermore, there is a good argument for excluding the age 2–3 of the EGFS as the within survey correlation between the age groups 1–2 and 2–3 is very poor while the within correlation between age groups 0–1 is good. The quarter 3 0-group survey index for EGFS is back-shifted to the final season of the assessment in the terminal year, i.e. to quarter 2 of the assessment year in order to include the most recent 0-group estimate in the assessment.

4) The IBTS Q1 tuning fleet has remained unchanged compared with previous years' assessment.

From 2009 and onwards the SGFS changed it survey area slightly with a few more hauls in the northern North Sea and a few less hauls in the German Bight. This is not evaluated to influence the indices significantly as the indices are based on weighted subarea averages.

For an overview of the time-series included and used by year and age in the assessment see Table 5.3.1 in Section 5 of the assessment report. The table is also given in updated form here under Section C.

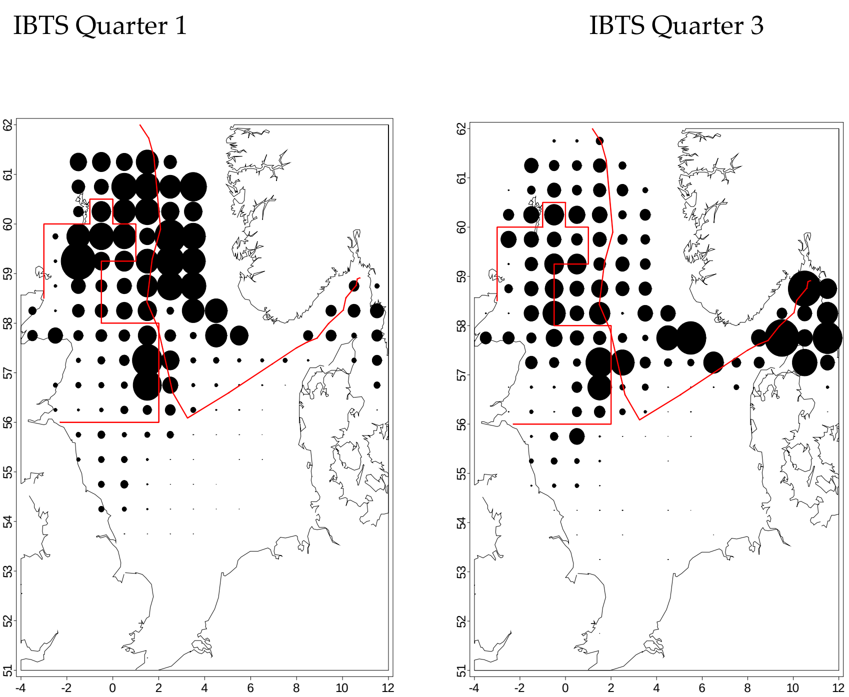


Figure 4. IBTS mean cpue (numbers per hour) by quarter during the period 1991–2004. The area of the circles is proportional to cpue. The IBTS surveys do only cover areas within the 200 m depth zone. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map. The maps are scaled individually.

B.5. Commercial cpue data

Combined cpue indices by age and quarter for the Danish and Norwegian commercial fishery tuning fleet (including data up to 2006) is calculated from effort data obtained from the method of effort standardization of the commercial fishery tuning fleet described under Section B.1 (and B.3) and vessel category specific catches by area. Cpue is estimated on a quarterly basis for the Danish and Norwegian commercial fleets.

The resulting combined, commercial fishery cpue data by age and quarter is presented in the input data to the yearly performed assessment. The commercial fleet data (up to 2006) are used in tuning of the assessment based on the combined and standardized Danish and Norwegian effort data and on the catch data for the commercial fishery.

See also Section B.1 and B3 concerning the commercial fishery tuning fleet.

Commercial fishery tuning fleets

In addition to the analyses of the commercial fishery assessment tuning fleet (including data up to 2006) as described above (effort standardization) the quarterly cpue indices of the commercial fishery tuning fleet were analysed during the 2004 benchmark assessment:

1) The indices for the 0-group in 3rd quarter of the year have been excluded from the commercial fishery tuning fleet. The main argumentation for doing that is that this age group indicate clear patterns in trends in catchability over the assessment period as shown in the single fleet/quarter assessment runs in Section 12.3 (Figure 12.3.7), ICES WGNSSK (2005). Secondly, there is no correlation between the commercial fishery 3rd quarter 0-group index and the commercial fishery 4th quarter 0-group index, and no correlation between the 3rd quarter commercial fishery 0-group index in a given year with the 1-group index of the 3rd quarter commercial fishery the following year.

2) The 2nd quarter indices for all age groups have been excluded from the commercial fishery tuning fleet. This is mainly because of indications of strong trends in catchability over time in the assessment period for this part of the tuning fleet for all age groups as indicated by single fleet tuning runs in the Section 12.3 (Figure 12.3.7), ICES WGNSSK (2005). Also, the within quarter and between quarter correlation indices are in general relatively poor. The cohort analyses of the 2nd quarter commercial fishery indices indicate as well relative changes over time.

C. Historical stock development

The SXSA (Seasonal Extended Survivors Analysis: Skagen (1993)) has been used to estimate quarterly stock numbers and fishing mortalities for Norway pout in the North Sea and Skagerrak as the standard assessment method. The catch-at-age analysis was carried out according to the specifications given in the present stock quality handbook. The assessment is analytical using catch-at-age analysis based on quarterly catch and cpue data. The assessment is considered appropriate to indicate trends in the stock and immediate changes in the stock because of the seasonal assessment taking into account the seasonality in fishery, use seasonal based fishery-independent information, and using most recent information about recruitment. The seasonal variation in effort data is one reason for performing a seasonal VPA. The assessment provides stock status and year-class strengths of all year classes in the stock up to the first quarter of the assessment year (spring assessment) and second quarter of the assessment year (autumn assessment). The real-time assessment method with update every half year also gives a good indication of the stock status the 1st January the following year based on projection of existing recruitment information in 3rd quarter of the assessment year.

In the options chosen in the SXSA for the Norway pout assessment the catchability, r, per age and quarter and fleet is assumed to be constant within the period 1983–2005 where the estimated catchability, that, is a geometric mean over years by age, quarter and tuning fleet. In the 2004 benchmark assessment exploration of trends in tuning fleet catchabilities was investigated by single fleet runs with the SXSA. The accepted assessment with revised tuning fleets in the 2004 benchmark assessment assumes constant catchability.

Tuning is performed over the period 1983 to present producing logresidual (log(Nhat/N)) stock numbers and survivor estimates by year, quarter, age and tuning fleet. The contributions from the various age groups to the survivor estimates by year and quarter and fleet are in the SXSA combined to an overall survivors estimate, shat, estimated as the geometric mean over years of log(shat) weighted by the exponential of the inverse cumulated fishing mortality as described in Skagen (1993).

In exploratory and comparison runs between the SXSA model and other models, especially the SMS model has been used during the period 2005–2007

SMS (**S**tochastic **M**ulti**S**pecies model; Lewy and Vinther, 2004) is an age-structured multispecies assessment model which includes biological interactions. However, the model can be used with one species only. In "single-species mode" the model can be fitted to observations of catch-at-age and survey cpue. SMS uses maximum likelihood to weight the various data sources assuming a lognormal error distribution for both data sources. The likelihood for the catch observation is then as defined below:

$$L_C = \prod_{a,y,q} \frac{1}{\sigma_{catch}(aa)\sqrt{2\pi}} \exp(-(\ln(C(a,y,q)) - \ln(\hat{C}(a,y,q)))^2 / (2\sigma^2_{catch}(aa)))$$

where C is the observed catch-at-age number, $\hat{C}$ is expected catch-at-age number, y is year, q is quarter, a is age group, and aa is one or more age groups.

SMS is a "traditional" forward running assessment model where the expected catch is calculated from the catch equation and F-at-age, which is assumed to be separable into an age selection, a year effect and a season (year, half-year, quarter) effect.

As an example, the F model configuration is shown below for a species where the assessment includes ages 0–3+ and quarterly catch data and quarterly time-step are used:

$$F = F(a_a) \times F(y_y) \times F(q_q),$$

with F-components defined as follows:

$F(a)$:

Age 0	Fa_0
Age 1	Fa_1
Age 2	Fa_2
Age 3	Fa_3

$F(q)$:

	Q1	q2	q3	q4
Age 0	0.0	0.0	Fq	0.25
Age 1	$Fq_{1,1}$	$Fq_{1,2}$	$Fq_{1,3}$	0.25
Age 2	$Fq_{2,1}$	$Fq_{2,2}$	$Fq_{1,3}$	0.25
Age 3	$Fq_{3,1}$	$Fq_{3,2}$	$Fq_{3,3}$	0.25

$F(y)$:

Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	...
1	Fy_2	Fy_3	Fy_4	Fy_5	Fy_6	Fy_7	Fy_8	Fy_9	….

The parameters $F(a_a)$, $F(y_y)$ and $F(q_q)$ are estimated in the model. $F(q_q)$ in the last quarter and $F(y_y)$ Fy in the first year are set to constants to obtain a unique solution. For annual data, the $F(q_q)$ is set to a constant 1and the model uses annual time-steps.

One *F*(*a*) vector can be estimated for the whole assessment period, or alternatively, individual *F*(*a*) vectors can be estimated for subsets of the assessment periods. A separate *F*(*q*) matrix is estimated for each *F*(*a*) vector.

For the cpue time-series the expected cpue numbers are calculated as the product of an assumed age (or age group) dependent catchability and the mean stock number in the survey period.

The likelihood for cpue observations, L_S, is similar to L_C, as both are assumed log-normal distributed. The total likelihood is the product of the likelihood of the catch and the likelihood for cpue ($L = L_C * L_{cpue}$,). Parameters are estimated from a minimization of -log(*L*).

The estimated model parameters include stock numbers the first year, recruitment in the remaining years, age selection pattern, and the year and season effect for the separable *F* model, and catchability-at-age for cpue time-series.

SMS is implemented using ADmodel builder (Otter Research Ltd.), which is a software package to develop nonlinear statistical models. The SMS model is still under development, but has extensively been tested in the last year on both simulated and real data.

SMS can estimate the variance of parameters and derived values like average *F* or SSB from the Hessian matrix. Alternatively, variance can be estimated by using the built-in functionality of the AD-Model builder package to carry out Markov Chain Monte Carlo simulations (Gilks *et al*., 1996), MCMC, to estimate the posterior distributions of the parameters. For the historical assessment, period uniform priors are used. For prediction, an additional stock/recruitment relation including CV can be used.

Comparison of SXSA and SMS model output and assessment model evaluation

The September 2006 limited benchmarking considered the most appropriate assessment model to be used and considered in order to describe the dynamics of the stock.

Previously, the SXSA (Seasonal Extended Survivors Analysis) model has been used in the assessment of Norway pout. The method is described in the quality control handbook.

The SMS is like the SXSA a seasonal based model being able to deal with assessment of a short-lived species (where there are only few age groups in the VPA) and seasonality in fishing patterns.

The SMS (Stochastic MultiSpecies model; see Section 1.3.3 and the stock quality handbook) objective functions (in "single-species mode") for catch-at-age numbers and survey indices at-age time-series are minimized assuming a lognormal error distribution for both data sources. The expected catch is calculated from the catch equation and F-at-age, which is assumed to be separable into a year effect, an age selection, and an age-season selection. The SMS assumes constant seasonal and age-dependent F-pattern. SMS uses maximum likelihood to weight the various data sources. For years with no fishery (here 2005 and 2006 in this assessment) SMS simply set F to zero and exclude catch observations from the objective function. In such case only the survey indices are used in the model. The SXSA needs catch input for all quarters, all years, and in years with no catch infinitive small catch values have to be put into the model as an approximation. SXSA handles catch-at-age observation as exact, i.e. the SXSA does not rely on the assumption of constant exploitation pattern in catch-at-age data as for example the SMS does. As a stochastic model, SMS uses catch observations as observed with noise, but assumes a separable F. Both assumptions are violated to a certain degree.

SMS being a stochastic model can estimate the variance of parameters and derived values like average F and SSB. The SXSA is a deterministic model.

The Norway pout assessment includes normally catches from the first and second quarter of the assessment year. SMS uses survey indices from the third quarter of the assessment year under the assumption that the survey is conducted the very beginning of the third quarter. SXSA model has not that option and data from the third quarter of the assessment year can only be used by “back-shifting” the survey one quarter back in time.

The SMS model has so far assumed recruitment in 3rd quarter of the year and not in the start of the 2nd quarter of the year which the SXSA use. Actual recruitment is in the 2nd quarter of the year. Consequently, the assumed natural mortality of 0.4 for the 0-group in first and second quarter of the year is not included in the SMS compared with use of this in 2nd quarter of the year for the SXSA for the 0-group.

The diagnostics and results of the exploratory runs for comparison between SXSA and SMS assessment are shown in the WGNSSK September 2006 report (ICES WGNSSK, 2007). The models give comparable results and the same perception of the Norway pout stock dynamics, which have been documented in the 2004 benchmark assessment, the September 2005 and April 2006 update assessments (see above), as well as in the September 2006 exploratory runs. However, as SMS is a stochastic model it also provides uncertainties of the results. Accordingly, SMS was in September 2006 chosen as the new standard assessment model for Norway pout. However, it was decided that near future assessments should also include a comparative, exploratory SXSA assessment.

Comparison of output from a seasonal based assessment model (the SXSA model) and an annual based model (the XSA model)

In the 2004 benchmark assessment of the Norway pout stock a comparison of the output, performance and weighting of tuning fleets of the seasonal based SXSA model and the annual based XSA model was performed. The results are in detail presented in the 2004 ICES WGNSSK Report (ICES WGNSSK (2005)). The differences in results of output SSB, TSB and F between the two assessment runs were small. Both model runs gave in general similar weighting to the different tuning fleets used. This was based on comparison of runs of the accepted assessment (by the WG and ACFM) in 2003.

Summary of conclusions from the exploratory catch-at-age analyses in the 2004 benchmark assessments

A number of exploratory runs were carried out as part of the benchmark assessment in 2004 in order to evaluate performance of stock indices as tuning fleets and also to compare performance of the seasonal XSA (SXSA) with the 'conventional' XSA. The exploratory runs are described in the 2004 working group report. The conclusions of the explorative runs in the 2004 benchmark assessment were the following:

1) Catch and cpue data for the assessment of Norway pout are very noisy, but internally consistent. The assessment, using SMS, gave very similar results irrespective of the cpue time-series used. Four of the seven cpue series are data from the commercial fishery and these data are already included in the catch data. Therefore, these commercial fleets will not give a signal very different from the catch data. None of the scientific surveys had a clear signal different form the signal in the catch data.

2) A comparison of the revised 2004 assessment with new tuning fleets compared with the previous 2003 assessment showed that the estimates of the SSB, recruitment and the average fishing mortality of the 1- and 2-group for the revised, accepted assessment were in general consistent with the estimates of previous years' assessment. Only historical F seemed to slightly deviate from the previous years' assessment.

3) The overall performance and output for the XSA model was similar to the SXSA model, so the working group in 2004 decided to continue using SXSA. Both methods did overall not show insensible to the tuning fleet indices used in the assessment.

In the update assessment in 2005 output of the SXSA model was compared with output from the SMS and SURBA model to evaluate the use of the SXSA model in a situation with having zero catches in the terminal year of the assessment. The results showed similar output of the different models and the same perception of the stock. The results are in detail presented in the 2005 ICES WGNSSK Report (ICES WGNSSK (2006)).

Analysis of output from SXSA and SMS and to evaluate the effect on the assessment of no catches in 2005 and 2006

Due to closure of the Norway pout fishery and no catches in 2005 and in the first part of 2006 there has been made exploratory and comparative assessment runs using different assessment models (SXSA, SMS) to evaluate the effect on the assessment of this situation during the April 2006 assessment. This has been considered necessary to evaluate the effect of the absolute value of the artificial catch numbers on the SXSA output and to use a modified version of SMS that allows for no fishing in the end of the assessment period, where the SMS assessment uses identical input data as the SXSA assessment. Also the aim has been to evaluate how the SMS reacts to a situation with several years of no catches.

In the April 2006 assessments exploratory runs of SXSA was made where the artificial catch numbers in 2005 and 2006 was four-doubled (but still low, from 400 t per quarter of year to 1600 t per quarter) compared with the very low catch levels used in the accepted assessment. The results of these comparative runs are not shown, however, the resulting output of the assessments were identical giving the same perception of the stock status and dynamics. Furthermore, in the September 2005 update assessment a SXSA assessment was performed with the change of using catch numbers in the first and second quarter of 2005 corresponding to 50% of the 2004 quarter 1 and 2 catch numbers (instead of 10% of the catches in the accepted assessment). The results of these comparative runs are shown in Figure 5.3.8 of the September 2005 report (ICES-WGNSSK 2006). The resulting outputs of these assessments were identical giving the same perception of the stock status and dynamics. From these SXSA runs it can be concluded that the absolute values of the artificial (small) catches does not practically affect the assessment output.

In April 2006 a SMS run was made with an assumption of no catches in 2005–2006. SMS was modified to exclude the likelihood of catch observation for 2005–2006 (and 2007) from the objective function. Cpue observations for 2005 and 2006 were, however, used in the model and objective function. By letting the model include 2007 as terminal year it is possible to forecast stock status under the assumption of no fishery in 2006–2007, and recruitments that follows the SMS recruitment function (geometric mean).

It appeared that the diagnostics of the SMS looked very similar to the one produced for the 2005 assessment As it was also shown in the 2004 benchmark assessment, the SMS model results in a rather similar weighting of the catch-at-age data as well as the tuning fleets as the SXSA model does. As seen in the previous years' assessments, the SMS model tends to estimate lower SSB and higher F compared with results of the SXSA model, however, the perception of the stock status and dynamics are very much similar from the results of both model runs. Recruitment estimates of the two models cannot be directly compared as the SMS gives recruitment in third quarter of the year while the SXSA gives recruitment in the second quarter of the year.

Software used

SXSA program available from ICES. Used for the final assessment as standard software.

SMS program available from Morten Vinther, DIFRES, Copenhagen (Exploratory run, 2004 and 2005, April 2006 and September 2006). Used in exploratory runs.

XSA program from ICES. Used in exploratory runs.

SURBA program available from Coby Needle, MARLAB, Aberdeen; Used in an exploratory run, 2005.

The XSA and SURBA models and software cannot perform quarterly based assessment.

Model options chosen

The parameter settings and options of the SXSA and SMS have been the same in all recent years of the assessment, except that recruitment season to the fishery has been backshifted from 3rd quarter of the year to 2nd quarter of the year when running SXSA in the autumn in order to gain benefit from the most recent 0-group indices from the 3rd quarter surveys (SGFS and EGFS as explained above) in the assessment. This procedure is still followed. This was not necessary in the SMS assessment. In the May 2007 assessment with SXSA this backshifting has not been performed.

No time-taper or shrinkage is used in the catch-at-age analysis in general. The four surveys and the seasonally (by quarter) divided commercial fleets (the latter only including data up to year 2006) in are all used in the tuning.

The following parameters were used:

```
Year range:
       1983–2007
Seasons per year:                                                         4
The last season in the last year is season:                3
Youngest age:                                                             0
Oldest true age:
       3
Plus group:                                                               No
plus group in SMS (4+-group in SXSA)
Recruitment in season:                                                    3
Spawning in season:                                                       1
Single species mode:                                                      Yes,
number of species = 1
```

The following tuning fleets were included:

```
Fleet  1: (Q1: Age 1-3; Q2: None; Q3: Age 1-3; Q4: Age 0-2) commercial
q134
Fleet  2:                                                   ibtsq1
       (Age 1-3)
Fleet  3:                                                   egfsq2
       (Age 0-1)
Fleet  4:                                                   sgfsq2
       (Age 0-1)
Fleet  5:                                                   ibtsq3
       (Age 2-3)
```

Data were input from the following files:

```
Catch in numbers:                                          canum.qrt
Weight in catch:                                           weca.qrt
Weight in stock:                                           west.qrt
Natural mortalities:                                       natmor.qrt
Maturity ogive:                                            propmat.qrt
Tuning data (cpue):                                        tun2007.xsa
Weighting for rhats:                                       rweigh.xsa
```

SXSA: In the SXSA the following options were used:

```
The following options were used:
1: Inv. catchability:                                  2
  (1: Linear; 2: Log; 3: Cos. filter)
2: Indiv. shats:                                       2
  (1: Direct; 2: Using z)
3: Comb. shats:                                        2
  (1: Linear; 2: Log.)
4: Fit catches:                                        0
  (0: No fit; 1: No SOP corr; 2: SOP corr.)
5: Est. unknown catches:                               0
  (0: No; 1: No SOP corr; 2: SOP corr; 3: Sep. F)
6: Weighting of rhats:                                 0
  (0: Manual)
```

```
7: Weighting of shats:                                            2
  (0: Manual; 1: Linear; 2: Log.)
8: Handling of the plus group:                                    1
  (1: Dynamic; 2: Extra age group)
Factor (between 0 and 1) for weighting the inverse catchabilities
at the oldest age vs. the second oldest age (factor 1 means that
the catchabilities for the oldest age are used as they are):
0

Specification of minimum value for the survivor number (this is
Used instead of the estimate if the estimate becomes very low):
0

Iteration until convergence (setting 0):
0
```

SMS-Model: The following tuning fleet options were used in the SMS model (summary from fleet_info.dat):

```
Minimum CV of cpue observations:           0.2

Fleet specific options:
1-2, First year last year,
3-4. Alpha and beta - the start and end of the fishing period for the fleet
given as fractions of the season (or year if annual data are used)
5-6  First and last age,
7.   last age with age dependent catchability,
8.   last age for stock size dependent catchability (power model), -1 indicated
no
     ages uses power model
9.   season for survey,
10.  number of variance groups for estimated catchability
     by species and fleet
1 commercial q1:                                    1983 2004 0 1 1 3 3 -1 1 3
1 commercial q3:                                    1983 2004 0 1 1 3 3 -1 3 3
1 commercial q4:                                    1983 2004 0 1 0 2 2 -1 4 3
2 IBTS q1:                                          1983 2006 0 1 1 3 3 -1 1 3
3 EGFS q 3:                                         1992 2005 0 1 0 1 1 -1 3 2
4 SGFS q3:                                          1998 2006 0 0 0 1 1 -1 3 2
5 ibts_q3:                                          1991 2005 0 1 2 3 3 -1 3 2
Variance groups:
Fleet: 1 season 1:                                  1 2 3
Fleet: 1 season 3:                                  1 2 3
Fleet: 1 season 4:                                  0 1 2
Fleet: 2:                                                  1 2 3
Fleet: 3:                                                  0 1
Fleet: 4:                                                  0 1
Fleet: 5:                                                  2 3
```

SMS-Model: The following SMS model settings were used in the SMS model (summary from SMS.dat):

```
SSB/R relationship:                                        Geometric mean

Object function weighting:
First=catch observations                                                  1.0
Second=cpue observations                                                  1.0
Third=SSB/R relations                                                     1.0
Minimum CV of commercial catch at-age
observations option min.catch.CV):                                        0.20
Minimum CV of S/R relation (option min.SR.CV):             0.20
No. of separate catch sigma groups by species:             4 (one variance
group by age)
Exploitation pattern by age and season:                    Age 0 (3rd-4th quar-
ter)
                                                     Age 1 (1st, 3rd, 4th quar-
                                                 ter)
                                                     Ages 2-3 (1st, 3rd, 4th quar
                                                    ter)
If tuning survey index has the value 0 then 5% of the
average of the rest of the observations are used
because the logarithm to zero cannot be taken:
Minimum "observed" catch, negative value gives
```

```
percentage (-10 ~ 10%) of average catch in age group
if option>0 and catch=0 then catch=option
if option<0 then catch=average(catch at-age)*(-option)/100 -5

Assuming fixed exploitation pattern by age and season

Number of years with zero catch:                            2 (2005, 2006)
```

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1983–present	0–3+	Yes
Canum	Catch-at-age in numbers	1983–present	0–3+	Yes
Weca	Weight-at-age in the commercial catch	1983–present	0–3+	Yes
West	Weight-at-age of the spawning stock at spawning time.	1983–present	0–3+	No
Mprop	Proportion of natural mortality before spawning	Not relevant in SXSA		
Fprop	Proportion of fishing mortality before spawning	1983–present	0–1	Yes
Matprop	Proportion mature at-age	1983–present	1–3+	No, 10%age 1, 100% 2+
Natmor	Natural mortality	1983–present	0–3+	No, 0.4 per quarter per age group

Tuning data used in the present and historical assessments:

Table 5.3.1 **Norway pout IV & IIIaN (Skagerrak). Stock indices and tuning fleets used in final 2004 benchmark assessment as well as in the 2005-2011 assessments compared to the 2003 assessment.**

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-11 ASSESSMENTS
Recruiting season		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA)	3rd quarter (SXSA)
Last season in last year		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA)	1st quarter (SXSA)
Plus-group		4+	4+ (SXSA)	None (SMS); 4+ (SXSA)	4+ (SXSA)
FLT01: comm Q1					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT01: comm Q2			NOT USED	NOT USED	NOT USED
	Year range	1982-2003			
	Quarter	2			
	Ages	1-3			
FLT01: comm Q3					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	3	3	3	3
	Ages	0-3	1-3	1-3	1-3
FLT01: comm Q4					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	4	4	4	4
	Ages	0-3	0-3	0-2 (SMS); 0-3 (SXSA)	0-3 (SXSA)
FLT02: ibtsq1					
	Year range	1982-2003	1982-2006	1982-2006	1982-2011
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT03: egfs					
	Year range	1982-2003	1992-2005	1992-2005	1992-2010
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3
	Ages	0-3	0-1	0-1	0-1
FLT04: sgfs					
	Year range	1982-2003	1998-2006	1998-2006	1998-2010
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3
	Ages	0-3	0-1	0-1	0-1
FLT05: ibtsq3		NOT USED			
	Year range		1991-2005	1991-2005	1991-2010
	Quarter		3	3	Q3
	Ages		2-3	2-3	2-3

D. Short-term projection

A deterministic short-term forecast is given for the stock. This was done for the Norway pout stock for the first time in 2004. From April 2006 deterministic short-term prognoses were performed for the Norway pout stock. From 2006 and onwards there have been given seasonal (real-time) short-term forecast.

The forecast is based on an escapement management strategy but also providing output for the long-term fixed E or F management strategy and a long-term fixed TAC strategy for Norway pout (see ICES WGNSSK Report ICES CM 2007/ACFM:30 Section 5.3, and ICES AGNOP Report ICES CM 2007/ACFM:39, and the ICES AGSANNOP Report ICES CM 2007/ACFM:40 as well as Section 5.11 of the ICES WGNSSK Reports).

The forecast was calculated as a stock projection up to 1st of January of the forecast year using full assessment information for the assessment year.

The projection up to 1st of January of the forecast year is based on the SXSA assessment estimate of stock numbers-at-age at the start of the assessment year. The forecast is using the geometric mean recruitment for the stock–recruitment relationship.

The forecast uses relevant recent exploitation pattern according to temporal changes in this according to changes in exploitation between seasons and between ages.

Ten percent of age 1 is considered mature and is included in SSB. Therefore, the recruitment in the year after the assessment year does influence the SSB in the following year.

Usually the recruitment in the year after the assessment year is assumed to be at 25% level (25 percentile) of the long-term geometric mean. This level has been chosen to take into account that the frequency of strong year classes seems to have decreased in the recent 10–15 year period compared with previously.

Mean weight-at-age in the catch in the forecast year (as well as in the assessment year where direct observations are not available from the assessment and sampling) there has been estimated quarterly and age-based average means of mean weight-at-age in catch from recent running five year averages (for the five latest years with covering observations).

A management table is presented from the forecast. The objective set in relation to this is to set the fishing mortality and catch on a level that maintain spawning–stock biomass above B_{MSY} = $B_{trigger\ MSY}$ = B_{PA} by 1st of January one–two years after the assessment year with a high probability (95% level).

Catch predictions for 0- and 1-groups are important as the fishery to some extent (traditionally) target the 0-group already in 3rd and (more in) 4th quarter of the year as well as the 1-group in the 1st quarter of the following year. In the 2004 benchmark assessment, it was shown that survey indices in the 3rd quarter seems to predict strong 0-group year classes relatively well when comparing with 0-group indices from commercial fishery (4th quarter) and to 1-group survey indices in surveys and fishery the following spring (year).

The deterministic forecast is naturally affected by that: (a) the potential catches are largely dependent on the size of a few year classes, (b) the large dependence on the strength of the recruiting 0-group year classes, and (c) added uncertainty (in assessment and potential forecast) arising from variations in natural mortality. However, the forecast is not dependent on any assumption about the strength of the new year class.

The forecast has previously assumed a forecast year fishing pattern scaled to long-term seasonal exploitation pattern for 1991–2004 (standardized with yearly F_{BAR} to F(1,2)=1) which has been used in e.g. the 2007 and 2008 ICES WGNSSK Reports (ICES CM 2007/ACFM:30; ICES CM 2008/ACOM:09) and in the ICES AGNOP Report as well (ICES CM 2007/ACFM:39). The 2011 forecast assumes a 2011 (the forecast year) fishing pattern scaled to the average standardized exploitation pattern (F) for 2008, 2009 and 2010 (all years included and standardized with yearly F_{BAR} to F(1,2)=1). The background for selecting these three recent years exploitation pattern is that the exploitation pattern between seasons (and ages) has changed since 2004 which was the last year where the directed Norway pout fishery was open in all seasons of the year in the EU Zone up to 2007. The recent exploitation pattern is very different from the average previous long-term (1991–2004) exploitation pattern. The targeting in the small-meshed trawl fishery has changed recently where targeting of Norway pout has decreased (see also the Stock Annex (Q5)).

E. Biological reference points

From 2010 and onwards

	Type	Value	Technical basis
MSY	MSY $B_{escapement}$	150 000 t	= B_{PA}
Approach	F_{MSY}	Undefined	None advised
	B_{lim}	90 000 t	B_{lim} = B_{loss}, the lowest observed biomass in the 1980s
Precautionary	B_{PA}	150 000 t	= B_{lim} e0.3*1.65
Approach	F_{lim}	Undefined	None advised
	F_{PA}	Undefined	None advised

(unchanged since: 2010).

Biomass based reference points have been unchanged since 1997 given MSY $B_{escapement}$ = B_{PA}.

Norway pout is a short-lived species and most likely a onetime spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and TSB rapidly due to the short lifespan of the species. (Basis: Sparholt, Larsen and Nielsen, 2002a,b; Lambert, Nielsen, Larsen and Sparholt, 2009). Furthermore, 10% of age 1 is considered mature and is included in SSB. Therefore, the recruitment in the year after the assessment year does influence the SSB in the following year. Also, Norway pout is to limited extent exploited already from age 0. All in all, the stock is very dependent of yearly dynamics and should be managed as a short-lived species.

On this basis B_{PA} is considered a good proxy for a SSB reference level for B_{MSY}. B_{lim} is defined as B_{loss} and is based on the observations of stock developments in SSB (especially in 1989 and 2005) been set to 90 000 t. B_{MSY} = B_{PA} has been calculated from

$B_{pa} = B_{lim}\, e^{0.3\text{-}0.4*1.65}$ (SD).

A SD estimate around 0.3–0.4 is considered to reflect the real uncertainty in the assessment. This SD-level also corresponds to the level for SD around 0.2–0.3 recommended to use in the manual for the Lowestoft PA Software (Cefas, 1999). The relationship between the B_{lim} and B_{MSY} = B_{PA} (90 000 and 150 000 t) is 0.6. B_{lim} is 90 000 t, the lowest observed biomass.

There are not established any F-reference points.

Previous to 2010

Precautionary approach reference points

ICES considers that:	ICES proposes that:
B_{lim} is 90 000 t	B_{PA} be established at 150 000 t. Below this value the probability of below average recruitment increases.
Note:	

Technical basis

B_{lim} = B_{loss} = 90 000 t	B_{PA} = B_{lim} e0.3–0.4*1.65 (SD).
F_{lim} None advised.	F_{PA} None advised.

Biomass based reference points have been unchanged since 1997.

B_{lim} is defined as B_{loss} and is based on the observations of stock developments in SSB (specially in 1989 and 2005) been set to 90 000 t. B_{PA} has been calculated from

$B_{PA} = B_{lim}\, e^{0.3\text{-}0.4*1.65}$ (SD).

A SD estimate around 0.3–0.4 is considered to reflect the real uncertainty in the assessment. This SD-level also corresponds to the level for SD around 0.2–0.3 recommended to use in the manual for the Lowestoft PA Software (Cefas, 1999). The relationship between the B_{lim} and B_{PA} (90 000 and 150 000 t) is 0.6.

B_{lim} is 90 000 t, the lowest observed biomass.

F_{lim} None advised.

F_{PA} None advised.

Management

There is no specific management objective set for this stock. With present fishing mortality levels the status of the stock is more determined by natural processes and less by the fishery. The European Community has decided to apply the precautionary approach in taking measures to protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimize the impact of fishing on marine ecosystems.

Long-term management strategies have been evaluated for this stock by ICES (see below), and an overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found below in the Stock Annex (Q5).

There is consistent biannual information available to perform real-time monitoring and management of the stock. This can be carried out both with fishery-independent and fishery-dependent information as well as a combination of those. Real-time advice (forecast) and management has been carried out every half year since 2006. In recent years the escapement strategy has been practiced in reality in management although there is no decision on management strategy on the stock.

Norway pout is a short-lived species and most likely a onetime spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and TSB rapidly due to the short lifespan of the species. (Basis: Sparholt, Larsen and Nielsen, 2002a,b; Lambert, Nielsen, Larsen and Sparholt, 2009). On this basis B_{PA} is considered a good proxy for a SSB reference level for MSY $B_{escapement}$.

There is a need to ensure that the stock remains high enough to provide food for a variety of predator species. Natural mortality levels by age and season used in the stock assessment reflects the predation mortality levels estimated for this stock from the most recent multispecies stock assessment performed by ICES (ICES-SGMSNS 2006).

The fishery is targeting Norway pout and blue whiting. Historically, the fishery includes bycatches especially of haddock, whiting, saithe, and herring. In managing this fishery, bycatches of cod, haddock, whiting, saithe, herring, and blue whiting should be taken into account, and existing technical measures to protect these bycatch species should be maintained or improved. Bycatches of these species have been low in the recent decade. Sorting grids in combination with square mesh panels have been shown to reduce bycatches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen, 2006 (ICES CM 2006/ACFM:35); Eigaard and Nielsen, 2009). ICES suggests that these devices (or modified forms of those) should be brought into use in the fishery. In 2010 grids have been used in the Norwegian fishery. The introduction of these technical measures should be followed up by adequate control measures of landings or catches at sea to ensure effective implementation of the existing bycatch measures. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in this Stock Annex (Q5).

From the results of the recent May 2011 forecast presented it can be seen that if the objective is to maintain the spawning–stock biomass above a reference level of MSY $B_{trigger} = B_{PA}$ by 1st of January 2012 then a catch around 6000 t can be taken in 2011 according to the escapement strategy. Under a fixed F-management-strategy with F around 0.35 a catch around 82 000 t can be taken in 2011. Under a fixed TAC strategy a TAC of 50 000 t can be taken in 2011 (corresponding to a F around 0.21) according to the long-term management strategies. In recent years the escapement strategy has been practiced in reality in management. Under a fixed F-management-strategy with F around 0.35 in 2011 as well as under a fixed TAC strategy with a TAC of 50 000 t 2011 the stock will decrease to be under B_{PA} by 1st of January 2012 according to the long-term management strategies.

Long–term management strategies (this part last updated May 2009)

In autumn 2006 the management plans and harvest control rules for Norway pout were evaluated by ICES based on an EU request with respect to bycatches in the fishery and evaluation of recent initiatives to introduce more selective fishing methods in the Norway pout fishery. See addendum below to this Stock Quality Handbook (Stock Annex).

Summary of management plan evaluations

ICES has evaluated and commented on three management strategies, following requests from managers; fixed fishing mortality (F=0.35), Fixed TAC (50 000 t), and a variable TAC escapement strategy. The evaluation shows that all three management strategies are capable of generating stock trends that stay at or above $B_{PA} = B_{MSY\text{-}trigger} = B_{MSY}$, i.e. away from B_{lim} with a high probability in the long term and are, therefore, considered to be precautionary. ICES does not recommend any particular one of the strategies.

The choice between different strategies depends on the requirements that fisheries managers and stakeholders have regarding stability in catches or the overall level of the catches. The escapement strategy has higher long-term yield compared with the fixed fishing mortality strategy, but at the cost of a substantially higher probability of having closures in the fishery. If the continuity of the fishery is an important property, the fixed F (equivalent to fixed effort) strategy will perform better. Recent years TACs indicate choice of a management strategy close to the fixed F strategy.

A detailed description of the long-term management strategies and management plan evaluations can be found in the Stock Quality Handbook (Q5) and in the ICES AGNOP 2007 (ICES CM 2007/ACFM:39), ICES WGNSSK 2007 (ICES CM 2007/ACFM:30) and the ICES AGSANNOP (ICES CM 2007/ACFM:40) reports.

Background

On basis of an joint EU and Norwegian Requests in autumn 2006 with respect to Norway pout management strategies and bycatches in the Norway pout fishery as well as on basis of the work by ICES WGNSSK in autumn 2006 and spring 2007 during the ICES AGNOP 2007 (ICES CM 2007/ACFM:39) ACFM has already by May 2007 evaluated detailed output from management plans and harvest control rules evaluations considering two different management strategies for Norway pout, i.e. the real-time escapement management strategy and the long-term fixed F or E management strategy. This has been based on use of advanced stochastic simulation models and results from here supplied by DTU-Aqua. The fixed TAC long-term management strategy was not evaluated in depth by the ICES AGNOP as it was not considered realistic at that time because of substantial loss in yield, but have later in autumn 2007 associated to the ICES WGNSSK in autumn 2007 (ICES CM 2007/ACFM:30) been evaluated and presented with the two other management strategies. Furthermore, in addition to the ICES response on the EC and Norway joint request on management measures for Norway pout, Denmark has, in autumn 2007, requested ICES to provide a full evaluation of the fixed TAC strategy for Norway pout including an estimation of the long-term TAC which would be sustainable with a low probability (5%) of the stock falling below B_{lim}. An ICES ACFM subgroup considered the documentation during the autumn 2007 ACFM meeting and found that some further studies would be required in order to provide a well documented answer. All this was provided through the ICES AGSANNOP Report (ICES CM 2007/ACFM:40).

Long-term harvest control rules for Norway pout in the North Sea and Skagerrak

ICES and DTU-Aqua have now provided comprehensive evaluation for three types of long-term management strategies for the stock which all have been accepted by ICES:

- Escapement strategy;
- Long-term fixed fishing mortality or fishing effort strategy; and
- Long-term fixed TAC strategy.

The conclusions from the evaluation methods used for the three strategies are the following:

Escapement strategy

ICES evaluated an escapement strategy defined as follows: 1) an initial TAC that would be set for the first half of the TAC year, based on a recruitment index, and 2) a TAC for the second half of the year which would be based on a survey assessment conducted in the first half of the TAC year and the setting TAC for the second half of the year based on an SSB escapement rule. This escapement strategy shall generally assure an SSB above B_{pa}, i.e. with a target of obtaining an SSB that is truly above B_{lim} with a high probability (95%). In practice this Harvest Control Rule (HCR) is an escapement strategy with an additional maximum effort. The conclusion is that the equilibrium median yield is around 110 kt, and there is a 50% risk for a closure of the fishery in the first half year and a 20–25% risk of a closure in the second half year. The distribution of F shows that the fishery will mostly alternate between a low and a high effort situation. When the fishery has been closed in the second half year, there is around 20% probability for another closure in the following year.

The robustness of the HCR to uncertainties in stock size indicates that annual assessment might not be necessary for this stock; an annual survey index could be sufficient.

Caveats to the evaluation of the escapement strategy:

- The sensitivity of the parameters in the HCR used for TAC in the first half year has not been fully evaluated;
- Non-random distribution of residuals in the surveys may give biased perceptions and need to be included in the evaluation.

Effort control strategy

The effort control scenario with a fixed F indicates that an F of around 0.35 is expected to give a low (5%) probability of the stock going below B_{lim}. The scenario appears robust to implementation uncertainties; and a target F below 0.35 and an implementation noise CV around 25% is expected to give a long-term yield around 90 kt and no closures of the fishery would be needed. This management strategy is not dependent on a yearly assessment because it assumes a direct link between fishing effort and fishing mortality which is also apparent from the historical assessment of this stock.

Caveats to the evaluation of the effort control strategy:

- A regime shift towards a lower recruitment level will not be detected by this approach and there is a risk of overfishing in such a situation with a fixed effort approach;
- Implementation of a fixed standardized effort (which is not measurable) can be difficult;
- Effort management in bycatch fisheries (e.g. bycatch of Norway pout in blue whiting fishery) is difficult to regulate;
- Effort; F relationships are known to suffer from technological creep and this aspect needs to be tested in the evaluation.

Fixed TAC strategy

The scenario with fixed TAC indicates that a long-term TAC on around 50 kt will be sustainable with a low (5%) probability of the stock going below B_{lim}. ICES concludes that a fixed TAC rule for Norway pout would be in accordance with the precautionary approach provided the fixed TAC is not greater than 50 kt and F does not exceed the value of 0.5, and provided measures are in place to reduce TAC in the exceptional case of a low recruitment in a number of consecutive years. The evaluations indicate that if a target TAC below 50 kt is implemented no closures of the fishery would be needed.

Caveats to the evaluation of the fixed TAC strategy:

- A regime shift towards a lower recruitment level will not be detected by this approach and there is a risk of overfishing in such a situation with a fixed TAC approach;
- For a short-lived species with highly variable recruitment such as Norway pout, a catch-stabilizing strategy (fixed TAC) is likely to imply a substantial loss in long-term yield compared with other strategies if the risk of SSB falling below B_{lim} is to remain reasonably low. This strategy is also sensible in relation to potential risks of regime shifts in the stock–recruitment relationship.

Conclusions from management strategy evaluations

Not any particular of the management strategies presented above is recommended. All strategies that have a low risk of depleting the stock below B_{lim} are considered to be in accordance with the precautionary approach and being sustainable. The choice between different strategies depends on the requirements that fisheries managers and stakeholders have regarding stability in catches or the overall level of the catches. It should be noted that this is a long-term management strategy evaluation and it is accordingly not possible to switch between strategies from year to year. Often switching between different long-term strategies will be in conflict with the basic assumptions behind the evaluations of them.

The evaluation shows that all three types of management strategies (escapement, fixed effort, fixed TAC) are capable of generating stock trends that stay away from B_{lim} with a high probability.

The escapement strategy has a higher long-term yield (110 kt) compared with the fixed effort strategy (90 kt) and the fixed TAC strategy (50 kt) but at the cost of having closures in the fishery with a substantially higher probability. If the continuity of the fishery is an important property, then the fixed effort strategy performs better.

The simulations deal with observation error and implementation error of the management strategies but do not take into account process error in relation to natural mortality, maturity-at-age, or mean weight-at-age in the stock, which could have a significant impact.

The fixed effort strategy does not rely critically on the results of stock assessment models in any particular year. On the other hand, that strategy is very dependent on the possibility of actually implementing an effort scheme, including an account of the bycatch fisheries (e.g. for blue whiting) and ways to deal with effort creep.

The fixed effort strategy and the fixed TAC strategy are likely to imply a substantial loss in long-term yield compared with the escapement strategy if the risk of SSB falling below B_{lim} is to remain reasonably low. These strategies are also sensible in relation to potential risks of regime shifts in the stock–recruitment relationship.

F. Other issues

Suggestions for future Benchmark assessments

A benchmark-assessment is planned and organized for the stock in 2012.

The primary aim of the benchmark will be to consider and change the values of a number of biological parameters (maturity, growth, natural mortality) based on new biological information from some work mainly in 2007–2008 and summarized in two scientific publications (one already published, one on its way). This would have implications for the overall perception of the stock, as well as reference points and management targets. But there will likely not be inclusion of any new data or new methods.

There are no major data deficiencies identified for this stock, whose assessment is usually of high quality. It will for the benchmarking be relevant to have updated natural mortality information from a updated MSVPA model/SMS model run.

However, some detailed information on distribution of different life stages will be very welcome. For example precise indications on spawning sites and spawning periods (i.e. observations of fish with running roe or just post-spawned fish); information/data on detailed distribution changes in different size groups e.g. on the Fladen Ground (outer bank, inner bank according to age; schools of size groups or mixing; vertical distribution patterns) over the fishing seasons and changes herein will be welcome (especially 1st, 3rd and 4th quarter). Potential distribution patterns regarding when and where it is possible to obtain the cleanest Norway pout fishery, i.e. with minimum bycatch would be important, as well as information on potential diurnal changes in distribution, density, and availability. Potential changes in the southern borders of its distribution range in the North Sea would also be relevant to obtain according to a potential temperature effect of climate driven sea warming.

New research findings on developments in bycatch reducing gear devices should be reported and evaluated under ecosystem aspects and fisheries aspects in relation to future benchmark assessment.

Other issues to be considered at a later stage

Consideration of revision of the tuning fleets with special focus on the commercial tuning fleets should be done at a certain point (see also the May 2007 assessment ICES CM 2007/ACFM:18 and 30, as well as this Stock Quality Handbook (Q5)). This includes evaluation of the quality of the assessment with respect to inclusion of historical time-series for fisheries data. The fluctuations in the fisheries effort over times and between seasons should be evaluated.

Recent developments in relation to implementation of seasonal stochastic assessment models not dependent on constant exploitation patterns (F-patterns between years and ages) should be considered for the assessment of the stock, e.g. the SAM model or further developments of the SMS model.

Evaluation of survey based assessment and/or more simple assessment methods: Assessment of stock status based exclusively on survey indices should be considered, and robustness of survey indices should be further evaluated and considered.

New research findings on developments in bycatch reducing gear devices should be reported and evaluated under ecosystem aspects and fisheries aspects in relation to future benchmark assessment.

Trends and dynamics in landings and other available relevant information of Norway pout in VIa should be evaluated and brought forward to ACOM.

F.1 Overview of some recent management measures and regulations relevant for the Norway pout fishery and stock (from STCEF, 2005)

Existing bycatch regulations:

In the agreed EU Council and EU-Norway Bilateral Regulation of Fisheries bycatch regulations in the Norway pout fishery have been established (e.g. EU Regulation No 850/98 (EU, 1998)). The bycatch regulations in force at present for small-meshed fishery (16–31 mm in mesh size) in the North Sea is that catch retained on board must consist of i) at least 90% of any mixture of two or more target species, or ii) at least 60% of any one of the target species, and no more than 5% of any mixture of cod, haddock, saithe, and no more than 15% of any mixture of certain other bycatch species. Provisions regarding limitations on catches of herring which may be retained on board when taken with nets of 16 to 31 mm mesh size are stipulated in EU Community legislation fixing, for certain fish stocks and groups of fish stocks, total allowable catches and certain conditions under which they may be fished. (EU, 1998) At current 40% herring is allowed in the Norway pout fishery.

Technical measures by EU

Mesh size regulations in the North Sea and adjacent areas

Use of towed nets of any size mesh is permitted, however according to the mesh size in use there is an obligation to retain only particular species of fish. These tables are a simplified synopsis of measures in Council Regulation 850/98 and Commission Regulation 2056/2001.

Conditions for use of towed gear (North Sea and West Scotland)		
Mesh size	Main target species in North Sea	Synopsis of required catch percentages
b.) 16 to 31 mm	Norway pout, sprat	Minimum 60% of one species of Norway pout, sardine, sandeel, anchovy, eels, smelt and some non-human consumption species (with no more than 5% of cod, haddock or saithe, and some upper limits on the percentages of other species such as mackerel, squids, flatfish, gurnards, *Nephrops*), or at least 90% of any two or more of those species.

Areas closed to some fishing activities

During the 1960s a significant small-meshed fishery developed for Norway pout in the northern North Sea. This fishery was characterized by relatively large bycatches, especially of haddock and whiting. In order to reduce bycatches of juvenile roundfish, the "Norway pout box" was introduced where fisheries with small-meshed trawls were banned. The "Norway pout box" has been closed for industrial fishery for Norway pout since 1977 onwards (EC Regulation No 3094/86). The box includes roughly the area north of 56°N and west of 1°W (see Figure 6.2).

(It is not possible to fully quantify the effect of the closure of the fishery inside the Norway pout box. Before closure, the Danish and Faroes fisheries mainly took place in the northwestern North Sea and the Norwegian fishery in the Norwegian Trench (ICES 1977). Based on IBTS samples for the period 1991–2004 (Figure 6.2), 30.0% and 27.5% of Norway pout numbers were estimated to be inside the Norway pout box for the first and third quarter, respectively. It should be noted that the IBTS survey does not cover depths >200 m along the Norwegian Trench, and that no fishery inside the Norway pout box may contribute to overestimation of the abundance relative to area outside).

Area	Characteristics, Location and Seasonality	Purpose	Defined in Regulation (EC):
Northwest of Scotland	Annual, closed to all fishing except static gear and pelagic fishing	Reduction in fishing mortality on VIa cod	Annex III 27/2004 (annual measure in place since 2004).
Norway pout box	Prohibited to retain more than 5% of the catch as Norway pout if they are caught within an area boounded by 56°N and the UK coast, 58°N 2°E, 58°N 0°30' W, 59°15' N 0°30'W, 59°15' N 1° E, 60° N 1° E, 60°N 0°, 60°30'N 0°, 60°30'N and the coast of the Shetland Islands, 60°N and the coast of the Shetland Islands, 60°N 3°W, 58°30'N 3°W 58°30'N and the coast of the mainland UK.	Protection of juvenile gadoids (cod, haddock) caught in mixtures with Norway pout)	Article 26 of Regulation 850/98

Minimum landing sizes

These sizes are defined in Annex XII to Regulation 850/1998, though some changes are in effect for 2005 by means of the TAC and quota regulation (Regulation 27/2005). Here sizes for some of the main commercial species only are stated.

Species	Minimum Landing Size in 2005, as North Sea/IIIa	Regulation
Norway pout	None	850/1998

Quotas relevant to the European Community

Quotas have been established by the Community as follows for the relevant species. These figures refer to Total Allowable Catches in Community waters and to quotas for the Community in Norwegian waters.

Year	Sandeel, IIa+IIIa+IV EC zone	Sandeel, IVa, Norway zone	Norway Pout IIa+IIIa+IV, EC zone	Norway pout, Norway zone	Anglerfish, IIa+IVa, EC zone	Anglerfish, IVa Norway Zone
2000	1 020 000	150 000	220 000	50 000[1]	17 660	in 'others'
2001	1 020 000	150 000	211 200	50 000[1]	14 130	in 'others'
2002	918 000	150 000	198 000	50 000[1]	10 500	in 'others'
2003	918 000	131 000	198 000	50 000[1]	7000	in 'others'
2004	826 200	131 000	198 000	50 000[1]	7000	in 'others'
2005	660 960	10 000	0	5000[2]	10 314	1800

[1] Including mixed horse mackerel.

[2] Including mixed horse mackerel, and only as bycatches.

Year	Anglerfish Vb, VI, XII, XIV (EC)	Horse mackerel, IIa (EC), IV(EC)	Horse mackerel, Vb (EC waters), VI, VII, VIIIa,b,d,e, XII, XIV	Industrial fish, IV (Norwegian waters)	Other species, IIa, IV, VIa N of 56°30, allocation to NO, FAR, no restriction for EC.	Other species, Norwegian waters of IV
2000	8000	51 000	240 000	800[1]	5400	11 000
2001	6400	51 000	240 000	800[1]	5400	11 000
2002	4770	58 000	150 000	800[1]	5400	11 000
2003	3180	50 267	130 000	800[1]	5400	11 000
2004	3180	50 267	137 000	800[1]	5400	11 000
2005	4686	42 727	137 000	800[1]	5120	7000

[1] Of which maximum 400 tonnes of horse mackerel.

Effort limits

Days-at-sea

Since 2003, the Community has limited the number of days that a fishing vessel can be out of port and fishing in the North Sea and adjacent areas. This is implemented through annexes to the TAC and Quota Regulations (2341/2002, 2287/2003, 27/2005). Days at sea may be transferred between vessels with an adjustment for differences in engine power between the vessels. Additional days have been allocated to some member states in respect of decommissioning taking place since 2001.

The baseline days-at-sea allocations (i.e. before additions to take account of decommissioning) were as follows:

Gear type	Otter trawl, 100 mm (90 mm in IIIa) or over	Beam trawls, 80 mm or over	Static demersal nets	Demersal longlines	Otter trawls 70–99 mm (70–89 mm in Skagerrak)	Trawl fishery 16–31 mm
Typical target species	Cod, haddock, whiting	Plaice and sole	Cod, turbot	Cod	*Nephrops*	Norway pout, sandeel
2003	9	15	16	19	25	23
2004	10	14	14	17	22	20
2005	10 *	13	13	16	21	19

(*) - including one additional day allowable where administrative sanctions are in place.

Technical measures by Norway

TACs and effort limits

Norway has no national quotas on anglerfish, sandeel, Norway pout or horse mackerel, for Norwegian vessels in the Norwegian economic zone. These fisheries are regulated by technical measures and effort regulations.

Technical measures

The Norwegian technical regulations are generally designed to avoid catches of non-targeted species and/or fish below the minimum size. The discard ban on commercially important species is considered a cornerstone of this policy. Other important elements are the surveillance, monitoring and inspections at sea by the Coastguard, the obligation to change fishing grounds, prohibition against fishing for particular species during specific periods or in specific areas, and the development of, and the requirement to use selective fishing gear. The philosophy behind the Norwegian technical regulations is to enable the fishermen to meet their obligation to avoid illegal catches.

The technical regulations are summarized in "Regulations relating to seawater fisheries" of 22 December 2004.This stipulates the discard ban, the percentage composition of the catch that may be legally caught according to area and type of fishing gear being used, the characteristics of fishing gear that may be used in the fishery on certain species or in different areas, the minimum catching sizes and specific measures to limit catches of fish under the minimum catching size, regulations of mesh design, mesh sizes, selectivity devices, etc.

When fishing demersal species for human consumption in the North Sea with trawl or Danish seine, it is prohibited to use gear where the mesh size of any part of the gear is less than 120 mm. In the Norwegian saithe fishery in the EU zone 110 mm may be used in accordance to the EU regulation in the EU zone.

In the North Sea gillnet fisheries for cod, haddock, saithe, plaice, ling, pollock and hake it is prohibited to use gillnets where the full mesh size is less than 148 mm. In the fishery for anglerfish the minimum mesh size is 360 mm and in the halibut fishery the minimum mesh size is 470 mm.

Only the most relevant regulations with regard to anglerfish, sandeel, Norway pout and horse mackerel will be highlighted below.

Norway has since 2010 implemented a regulation with demand of use of selection grids with larger bar widths (40 mm?) in trawls used for fishing Norway pout and blue whiting in order to reduce bycatches of other species, especially saithe.

Sandeel and Norway pout

Summary of the Norwegian regulations for sandeel and Norway pout:

- The sandeel fishery is closed from 25 June to 31 March;
- Norway pout may only be fished as bycatch in the mixed industrial fishery in all areas under Norwegian fisheries jurisdiction;
- Two areas (the Patch bank and the Egersund bank) in the Norwegian economic zone are closed to fishing for Norway pout, sandeel, and blue whiting;
- Licensing scheme for vessels fishing with small-mesh trawl;
- Reduction capacity scheme for vessels fishing with small-mesh trawl.

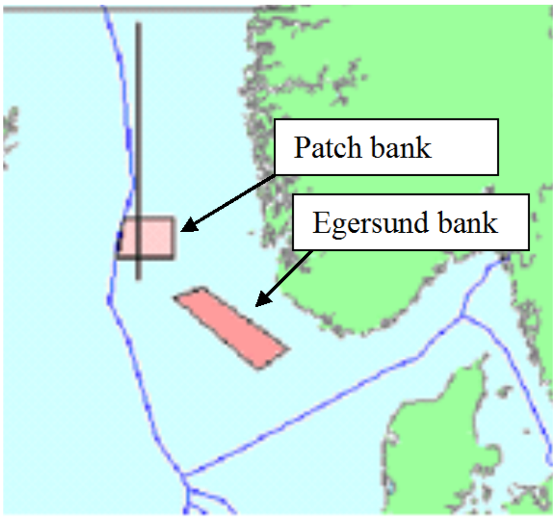
ACFM recommended that effort in 2005 should not exceed 40% of the effort in 2004. Based upon this advice, the sandeel season in the Norwegian economic zone was further shortened in 2005. The sandeel season, defined as the period when smaller mesh size than 16 mm can be used, was eight months (March–October) in 2003 and earlier. This season was reduced to April–September in 2003 and to the period 1 April to 23 June in 2005.

Furthermore, as a consequence of the advice on effort reduction Norway and the EU agreed to reduce the exchange of sandeel quotas dramatically compared with previous years. Due to the same reason, Norway did not allocate a traditional quota of sandeel to the Faroes in 2005.

As a result of the recommendation from ACFM, Norway and the EU have agreed that Norway pout only may be fished as bycatch in 2005. Consequently, Norway pout was excluded from the exchange of quotas between Norway and the Faroes in 2005.

Areas closed to fishing for Norway pout, sandeel and blue whiting

Two areas in the Norwegian economic zone have been closed for fishing on Norway pout, sandeel and blue whiting. The approach has been to close areas were the probability of illegal bycatches of juveniles and not-targeted species, such as cod, saithe, haddock, are considered unacceptable high. This measure could therefore also be mentioned as a measure to protect juveniles of other species than Norway pout and sandeel. As of 1 January 2002 the Patch bank was permanently closed. Before the closure of the Patch bank an annual average of approximately 2000 tonnes of Norway pout were fished in this area by Norwegian vessels. As from 1 May 2005 a seasonal closure of the Egersund bank in the period 1 December to 31 May was determined (map below). Other areas are under evaluation for permanent or seasonal closure.



Capacity reduction scheme for vessels fishing for sandeel and Norway pout

A small mesh trawl licence is required to use a smaller mesh size than 16 mm in the directed fishery for sandeel in the season 15 April–23 June. The same licence is required in order to participate in the mixed industrial fishery for blue whiting and Norway pout.

The number of vessels holding such a licence has been reduced substantially the latter years as a result of the capacity reduction scheme put in place in 2002. The potential number of participating vessel was about 75 vessels in 2001. By May 2005 the number of potential participants has been reduced to about 50. In 2004 38 vessels participated in the sandeel fishery. The number of participating vessels so far in 2005 was 22 as of 24 May 2005.

Additional Danish regulations of the industrial fisheries can be found in Section 5, sandeel, STCEF Report 2005.

There is a recommendation from ICES and ongoing Danish initiatives and sea trials aiming at implementing selective grids in the trawls used for Danish Norway pout fishery in the North Sea and in Skagerrak–Kattegat (IIIa). It is expected that a regulation introducing such selective devices will be implemented soon. The difficulty here is to develop a robust selective grid with smaller grid bar widths which have to be used in the Danish trawls in order to reduce bycatch of especially other smaller gadoids (in the areas where the Danish fishery operate) compared with the Norwegian trawls where the main aim is to reduce the bycatch of especially larger saithe in the areas where the Norwegian fishery operate.

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Appendix 1 Bycatch in Norway pout fisheries and possible reduction in bycatch

The fishery is targeting Norway pout and blue whiting. Historically, the fishery includes bycatches especially of haddock, whiting, saithe, and herring. In managing this fishery, bycatches of cod, haddock, whiting, saithe, herring, and blue whiting should be taken into account, and existing technical measures to protect these bycatch species should be maintained or improved. Bycatches of these species have been low in the recent decade. Sorting grids in combination with square mesh panels have been shown to reduce bycatches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen, 2006 (ICES CM 2006/ACFM:35); Eigaard and Nielsen, 2009). ICES suggests that these devices (or modified forms of those) should be brought into use in the fishery. In 2010 grids have been used in the Norwegian fishery. The introduction of these technical measures should be followed up by adequate control measures of landings or catches at sea to ensure effective implementation of the existing bycatch measures. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in this Stock Annex (Q5).

Bycatches in Norway pout fisheries (2006 evaluations)

Demersal fisheries in the North Sea are mixed fisheries, with many stocks exploited together in various combinations in different fisheries. Small-mesh industrial fisheries for Norway pout takes place in the northern and northeastern North Sea and has bycatches of haddock, whiting, herring and blue whiting. Some cod is also taken as a bycatch, predominantly at ages 0 and 1 (ICES, 2006). With respect to unintended bycatch in the commercial, small-meshed Norway pout trawl fishery in the North Sea and Skagerrak conducted by Denmark and Norway for reduction purposes ICES ACFM writes that management advice must consider both the state of individual stocks and their simultaneous exploitation. Stocks at reduced reproductive capacity should be the overriding concern for the management of mixed fisheries where these stocks are exploited either as a targeted species or as a bycatch (e.g. ICES, 2006).

Existing bycatch regulations

In the agreed EU Council and EU-Norway Bilateral Regulation of Fisheries bycatch regulations in the Norway pout fishery have been established (e.g. EU Regulation No 850/98 (EU, 1998)). The bycatch regulations in force at present for small-meshed fishery (16–31 mm in mesh size) in the North Sea is that catch retained on board must consist of i) at least 90% of any mixture of two or more target species, or ii) at least 60% of any one of the target species, and no more than 5% of any mixture of cod, haddock, saithe, and no more than 15% of any mixture of certain other bycatch species. Provisions regarding limitations on catches of herring which may be retained on board when taken with nets of 16 to 31 mm mesh size are stipulated in EU Community legislation fixing, for certain fish stocks and groups of fish stocks, total allowable catches and certain conditions under which they may be fished (EU, 1998). At current 40% herring is allowed in the Norway pout fishery.

Important bycatch species

Bycatch of the following species in the commercial, small-meshed Norway pout fishery has been unwanted and a concern for fisheries management: Cod, Haddock, Saithe, Whiting, Monkfish, Herring, and Blue Whiting, where especially bycatch of juvenile haddock and cod as well as larger saithe has been in focus.

Bycatch levels from landings statistics

In Tables A1 and A2 below are presented recent (2002–2005) bycatch levels by species in Danish and Norwegian small-meshed industrial trawl fishery in the North Sea and Skagerrak areas targeting Norway pout. For Norway the landings used for consumption purposes in the small-meshed fishery can only be allocated to industrial fishery for the last two years. IMR does not have access to logbooks from industrial vessels. The Norwegian data are evaluated rather uncertainly.

Bycatch levels and factors affecting them from commercial fishing trials 2005

Danish–Norwegian fishing trials and pilot investigations were performed in autumn 2005 in order to explore bycatch levels in the small-meshed industrial trawl fishery in the North Sea targeting Norway pout. The results are given in Working Document No. 22 to the WGNSSK (2006) by Degel, Nedreaas and Nielsen (2006). The trial fishery was performed by two Norwegian commercial trawlers and a Danish commercial trawler traditionally involved in the small-meshed industrial trawl fishery in the North Sea and Skagerrak targeting Norway pout. The investigation was in cooperation between the fisheries research institutes DIFRES and IMR. The South Norwegian Trawl Association (SNTA) and the Danish Fishermen's Association provided the contact to the fishing vessels used.

The fishery was carried out in autumn 2005 within periods and areas of conducting traditional fishery for Norway pout. The Norwegian vessels conducted each a survey to the area vest of Egersund on the edge of the Norwegian Trench. The Danish vessel conducted two surveys at Fladen Ground in and around the closed box for Norway pout fishery in the North Sea. Comparison fishery between one of the Norwegian vessels and the Danish vessel was performed on a spatio-temporally overlapping scale at the Patch Bank, a closed box for Norway pout fishery in an area between the Egersund Bank and Fladen Ground. The Norwegian vessels conducted both day and night fishery while the Danish vessels only fished during daytime.

The results (except for the figure and table showing the diurnal variation in the fishery) comprise only hauls from daytime fishery conducted with standard trawl gears used in the commercial small-meshed industrial fishery targeting Norway pout. The skipper at the Danish vessel decided the positions and fishing design on a smaller fraction of the conducted hauls based on his evaluation of optimizing the fishery economically, while the rest of the hauls were allocated and predistributed in two selected ICES statistical squares.

In general the ratio between the Norway pout target species and the sum of bycatch of certain selected species indicate that the bycatch ratio is high in the commercial Norway pout fishery. However, statistical analyses reveal that the fishermen can significantly minimize the bycatch ratio by targeting in the fishery (spatio-temporal targeting, way of fishing, etc.), i.e. when they determine the fishing stations and the fishery performed. The pilot investigations show no general significant spatio-temporal patterns in the bycatch ratio. However, there are from the results obvious geographical and diurnal differences in the species composition of the bycatch between areas and between day and night fishery. The length distributions of the catch rates by species indicate spatial patterns between some of the species caught. These fishing trials and pilot investigations are based on only very few observations, and data are obviously rather uncertain, variable and noisy. In general, it can be concluded that relatively high bycatches can be reduced by specific targeting in the fishery, both with respect to allocation of the fishery in time and space but also in relation to fishermen knowledge of the fishery and resource availability. This demands though that the skippers/fishermen act accordingly when fishing, and a proper at-sea control. The conclusions above relate to using the Turbotrawl and the Expo1300. The few experiments with Jordfraeser and Kolmuletrål 1100 indicate a different species composition, with unchanged or higher bycatch rates of most species and general significant lower catch rates of Norway pout.

With regard to diurnal differences in the catch rates of Norway pout and bycatches of other species, the few results at present indicate significant lower bycatch of Blue whiting during night hauls. The rest of the bycatch species show no diurnal differences.

With regard to possible depth differences in the catch rates of Norway pout and bycatches of other species, this matter relates primarily to the areas close to the Norwegian Deep, and more investigations are about to be carried out to document this better.

Technical measures to reduce bycatches

Regulation of spatio-temporal effort allocation (closed seasons and areas)

The above investigations indicate spatio-temporal differences in catch levels by species in the commercial small-meshed fishery for Norway pout as well as an effect of targeting and use of fishing method on the bycatches. However, these patterns are only based on results from pilot investigations. Knowledge of spatio-temporal patterns in catch rates of target species and bycatch species in the fishery are at present not adequate to implement management measures with respect to regulations on spatio-temporal allocation of fishing effort to reduce bycatches.

During the 1960s a significant small-meshed fishery developed for Norway pout in the northern North Sea. This fishery was characterized by relatively large bycatches, especially of haddock and whiting. In order to reduce bycatches of juvenile roundfish, the "Norway pout box" was introduced where fisheries with small-meshed trawls were banned. The "Norway pout box" has been closed for industrial fishery for Norway pout since 1977 onwards (EC Regulation No 3094/86). The box includes roughly the area north of 56°N and west of 1°W. In the Norwegian economic zone, the Patch bank has been closed since 2002. It is not possible to fully quantify the effect of the closure of the fishery inside the Norway pout box both with respect to catch rates of target and bycatch species as well as effects on the stocks (EU, 1985; 1987a; 1987b; ICES, 1979). There has not been performed fully covering evaluation of the effect of closed areas in relation to interacting effects of technological development in the fishery including changed selectivity and fishing behaviour over time in relation to bycatch rates. These effects can not readily be distinguished.

Gear technological bycatch reduction devices

Investigations of gear specific selective devices and gear modifications to reduce unwanted bycatch in the small-meshed Norway pout fishery in the North Sea and Skagerrak have been performed in a number of studies. It was recently investigated based on sea trials in year 2000 and reported through an EU Financed Project (EU, 2002), and the results from here have been followed up upon in a scientific paper from DIFRES and CONSTAT, DK (Eigaard and Holst, 2004). Previous investigations of size selective gear devices in the Norway pout trawl fishery in the North Sea was performed by IMR Norway during sea trials in 1997–1999 also published in a scientific paper (Kvalsvik *et al*., 2006), as well as in a number of other earlier studies on the issue. Main results of previous investigations have been reviewed and summarized in Working Document No. 23 to the WGNSSK (2006) by Nielsen and Madsen (2006).

Early Scottish and Danish attempts to divide haddock, whiting and herring from Norway pout by using separator panels, square mesh windows, and grids were all relatively unsuccessful. More recent Faroese experiments with grid devices have been more successful. A 74% reduction of haddock was estimated (Zachariassen and Hjalti, 1997) and 80% overall reduction in the bycatch (Anon., 1998).

Eigaard and Holst (2004) and EU (2002) found that when testing a trawl gears with a sorting grid with a 24 mm bar distance in combination with a 108 mm (nominal) square mesh window through experimental, commercial fishery the results showed improved selectivity of the commercial trawl with catch weight reductions of haddock and whiting of 37 and 57%, but also a 7% loss of Norway pout. The study showed that application of these reduction percents to the historical level of industrial bycatch in the North Sea lowered on average the yearly haddock bycatch from

4.3 to 2.7% of the equivalent spawning-stock biomass. For whiting the theoretical reduction was from 4.8 to 2.1%. The purpose of the sorting grid was to remedy the bycatch of juvenile gadoids in the industrial fishery for Norway pout, while the purpose of square mesh window was to retain larger marketable consume fish species otherwise sorted out by the grid. Bycatches in this study was mainly evaluated for haddock, whiting and cod, i.e. not for all above mentioned bycatch species of concern in the Norway pout fishery. However, the experiments have shown that the bycatch of important human consumption species in the industrial fishery for Norway pout can be reduced substantially by inserting a grid system in front of the codend. The study also demonstrated that it is possible to retain a major part of the larger marketable fish species like whiting and haddock and at the same time maintain substantial reductions of juvenile fish of the same species. The study also gave clear indications that further improvement of the selectivity is possible. This can be obtained by adjusting the bar distance in the grid and the mesh size in the selective window, but further research would be necessary in order to establish the optimal selective design.

The results reported in Kvalsvik *et al*. (2006) include results for more species of concern in the Norway pout fishery. They carried out experimental fishing with commercial vessels first testing a prototype of a grid system with different mountings of guiding panel in front of the grid and with different spacing (25, 22 and 19 mm) between bars, and then, secondly, testing if the mesh size in the grid section and the thickness of the bars influenced the selectivity of the grid system. Two different mesh sizes and three different thicknesses of bars were tested. Based on the first experiments, only a bar space of 22 mm were used in the later experiments. These showed respectively that a total of 94.6% (weight) of the bycatch species was sorted out with a 32.8% loss of the industrial target species, where the loss of Norway pout was around 10%, and respectively that 62.4% of the bycatch species were sorted out and the loss of target species was 22%, where the loss of Norway pout was around 6%. When testing selectivity parameters for haddock, the main bycatch species, the parameters indicated a sharp size selection in the grid system.

In conclusion, the older experiments indicate that there is no potential in using separator devices and square mesh panels. Recent and comprehensive experiments with grid devices indicate a loss of Norway pout at around 10% or less when using a grid with a 22–24 mm bar distance. It is also indicated that there is a considerable loss of other industrial species being blue whiting, Argentine and horse mackerel. A substantial bycatch reduction of saithe, whiting, cod, ling, hake, mackerel, herring, haddock and tusk have been observed. The reduction in haddock bycatch is, however, lowered by the presence of smaller individuals. The Danish experiment indicates that it is possible to retain larger valuable consume fish species by using a square mesh panel in combination with the grid. Selectivity parameters have been estimated for haddock, whiting and Norway pout. These can be used for simulation scenarios including estimates of the effect of changing the bar distance in the grid. Selectivity parameters for more bycatch species would be relevant. However, the grid devices have shown to work for main bycatch species.

A general problem by implementing sorting grids in industrial fisheries is the very large catches handled. Durability and strength of the grid devices used under fully commercial conditions are consequently very important and needs further attention. Furthermore, handling of heavy grid devices can be problematic from some vessels. Grid devices are, nevertheless, used in most shrimp fisheries, where catches often are large.

Conclusions from the above section

In conclusion, the commercial, exploratory fishery and provision of recent bycatch information has shown bycatch-ratios to be significant in the fishery, however, spatio-temporal differences in catch levels by species has been observed and bycatches can be reduced through targeting and fishing method. Recent scientific research based on at sea trials in the commercial fishery has shown that use of gear technological bycatch devices can reduce bycatches of among other juvenile gadoids significantly. Accordingly, it is recommended that these gear technological bycatch reduction devices (or modified forms of those) are brought into use in the fishery. Introduction of those should be followed up upon by adequate landings or at sea catch control measures to assure effective implementation of the existing bycatch measures.

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Table A1. Landings (tons) per species in the Danish small-meshed Norway pout fishery in the North Sea by year and quarter. Landings are divided into the part used for reduction purposes and the part used for human consumption purposes. The latter landings are included in catch in numbers of human consumption landings

Year	Species	Purpose	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Blank	Total	% of total catch
2005	Norway pout	Reduction						0	0
2004		Reduction	504		1474	5877		7855	87.5
2003		Reduction		45	1556	6322		7923	87.8
2002		Reduction	2,546		5,603	25,567	9,508	43224	78.6
2005	Blue whiting	Reduction						0	0
2004		Reduction	66					66	0.73
2003		Reduction		19	23	8		50	0.55
2002		Reduction	1966		589	950	1171	4676	8.50
2005	Herring							0	0
2004			11		422	304		737	8.21
2003				1	113	222		336	3.73
2002					217	2337	639	3193	5.81
2005	Cod	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction				1		1.3	0.01
		Hum. Con.	0.3		0.2	0.3		0.8	0.01
2003		Reduction				3		3	0.03
		Hum. Con.			0.5	0.8		1.3	0.01
2002		Reduction				3		3	0.01
		Hum. Con.	2		15.4	22.7		40.1	0.07
2005	Haddock	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction	5		49	3		57	0.63
		Hum. Con.	0.2		0.2	0.5		0.9	0.01
2003		Reduction				16		16	0.18
		Hum. Con.			0.1	1.8		1.9	0.02
2002		Reduction			408	1137		1545	2.81
		Hum. Con.	0.7		4.3	9.8		14.8	0.03
2005	Whiting	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction	32		59	141		232	2.58
		Hum. Con.	0.4		0.3	0.2		0.9	0.01
2003		Reduction			51	214		265	2.94
		Hum. Con.			0.3	2		2.3	0.03
2002		Reduction			239	1436		1675	3.05
		Hum. Con.			5.4	5.5		10.9	0.02
2005	Saithe	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction						0	0
		Hum. Con.	0.7		5.8	4.2		10.7	0.12
2003		Reduction		0.4	4	22.8		27.2	0.30
		Hum. Con.						0	0
2002		Reduction			45	201		246	0.45
		Hum. Con.	30		84.3	66.3		180.6	0.33
2005	Other human	Hum. Con.						0	0
2004	Cons. Species	Hum. Con.	0.9		2.7	2.5		6.1	0.07
2003		Hum. Con.		0.6	2.2	6.2		9	0.10
2002		Hum. Con.						0	0
2005	All species	All						0	0
2004		All	626		2023	6331		8980	100
2003		All		66	2025	6929		9020	100
2002		All	4511		6815	31887	11767	54980	100

Annex 2: Participants list

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