6.4.10 Sole in Subarea IV (North Sea)

State of the stock

Spawning biomass in relation to precautionary limits	Fishing mortality in relation to precautionary limits	Fishing mortality in relation to high long-term yield	Fishing mortality in relation to agreed target	Comment
Full reproductive capacity	Harvested sustainably	Appropriate	Above target	

Based on the most recent estimate of SSB (in 2009) and fishing mortality (in 2008), ICES classifies the stock as having full reproductive capacity and is being harvested sustainably. SSB has fluctuated around the precautionary reference points for the last decade, but has increased since 2008 owing to a large incoming 2005 year class and reduced fishing mortality. Fishing mortality has shown a declining trend since 1995 and is currently estimated to be below F_{pa}. The assessment suggests that the 2006 year class was below average, and 2007 average.

Management objectives

The EC has adopted a management plan for flatfish in the North Sea in June 2007 (Council Regulation (EC) No. 676/2007, see 6.4.10 Annex). This plan has two stages. The first stage aims at an annual 10% reduction of fishing mortality in relation to the fishing mortality estimated for the preceding year until an F of 0.2 is reached, with a maximum change in TAC of 15% until the precautionary reference points are reached for both sole and plaice for two successive years. ICES interprets the F for the preceding year as the estimate of F for the year in which the assessment is carried out. The basis for this F estimate in the preceding year will be a constant application of the procedure used by ICES in 2007. In the second stage, the management plan aims for exploitation at F = 0.2.

ICES has evaluated the long-term management plan and concluded that it leads on average to a low risk of $B < B_{lim}$ within the next 10 years. ICES concludes that for sole the management plan can be provisionally accepted as precautionary. According to the evaluation the agreed management plan can be provisionally accepted as precautionary for sole and could be used as a basis for the management of the stock in the short term. Additional evaluations of the management plan are necessary to take into account retrospective bias of the assessment and the sporadic nature of recruitment.

Reference points

	Type	**Value**	**Technical basis**
Precautionary approach	B_{lim}	25,000 t	B_{loss}
	B_{pa}	35,000 t	$B_{pa}1.4 * B_{lim}$
	F_{lim}	Not defined	
	F_{pa}	0.40	$F_{pa} = 0.4$ implies $B_{eq} > B_{pa}$ and $P(SSB_{MT} < B_{pa}) < 10\%$.
Targets	F_{mgt}	0.2	EU management plan

(unchanged since 1998, target added in 2008)

Yield and spawning biomass per Recruit F-reference points (2009):

	Fish Mort Ages 2–6	Yield/R	SSB/R
Average last 3 years	0.39	0.17	0.36
F_{max} *	0.59	0.17	0.24
$F_{0.1}$	0.11	0.14	1.02
F_{med}	0.32	0.17	0.43

*Poorly defined

Candidates for reference points consistent with high long-term yields and a low risk of depleting the productive potential of the stock are in the range of $F_{0.1}$–F_{pa}.

Single-stock exploitation boundaries

Considering the options below, ICES advises on the basis of exploitation boundaries in relation to the agreed management plan that landings should be less that 14 100 t in 2010.

Exploitation boundaries in relation to the agreed management plan

According to the management plan adopted by the EC in 2007, fishing mortality in 2010 should be reduced by 10% compared to the fishing mortality estimated for the preceding year (F2008=F2009=0.34) with the constraints that the TAC should not be changed by more than 15%. A 10% reduction in fishing mortality corresponds to an F of 0.304 and landings of 14 100t in 2010 which is within the 15% change (TAC 2009=14 000t).

Exploitation boundaries in relation to high long-term yield, low risk of depletion of production potential and considering ecosystem effects

The current fishing mortality is within the range that is expected to lead to high long-term yields and low risk to stock depletion.

Exploitation boundaries in relation to precautionary limits

The fishing mortality in 2010 should be no more than Fpa, corresponding to landings of less than 17 800 t..

Short-term implications

Outlook for 2010

Basis: F(2009) = F_{sq} = mean F(2006–2008) scaled to 2008 = 0.34 ; R(2009) = GM (1957–2006) =93.800 mln; SSB(2010) = 37.660 ; landings (2009) = 15.140

Rationale	Landings (2010)	Basis	F (2010)	SSB (2011)	%SSB change[1)]	%TAC change[2)]
Zero catch	0	F=0	0	53	+41%	-100%
High long-term yield	5.6	F0.1	0.11	48	+27%	-60%
Management plan	14.1	Fsq*0.9	0.3	40	+5%	+1%
Status quo	4.4	Fsq*0.25	0.08	49	+30%	-69%
	8.4	Fsq*0.5	0.17	45	+20%	-40%
	9.8	Fsq*0.59	0.2	44	+16%	-30%
	11.9	Fsq*0.74	0.25	42	+11%	-15%
	15.5	Fsq*1	0.34	38	+2%	+10%
	16.1	Fsq*1.05	0.36	38	0	+15%
	17.8	Fsq*1.18 = Fpa	0.4	36	-4%	+27%
	18.6	Fsq*1.25	0.42	35	-6%	+33%
	21.4	Fsq*1.5	0.51	33	-13%	+53%
	24	Fsq*1.75	0.59	30	-20%	+72%
	26.5	Fsq*2	0.68	28	-26%	+89%

Weights in '000 t.
Shaded scenarios are not considered consistent with the precautionary approach.
[1)] SSB(2011) relative to SSB(2010).
[2)] Calculated landings (2010) relative to TAC 2009 (14 000 t).

Management considerations

Sole are mainly caught in a mixed beam trawl fishery with plaice and other flatfish using 80 mm mesh in the southern North Sea. The minimum mesh size in the mixed beam trawl fishery in the southern North Sea means that large numbers of undersized plaice and cod are discarded. There are indications that in recent years sole discarding has taken place. Measures to reduce discarding in the mixed beam trawl fishery would greatly benefit these stocks. An increase in the minimum landing size of sole could provide an incentive to fish with larger mesh sizes and would therefore mean a reduction in the discarding of plaice. The minimum landing size of North Sea sole is 24 cm. An increased mesh size in the fishery would reduce the catch of undersized plaice and cod, but would also result in a short-term loss of marketable sole.

For two succesive years, the stock has been classified within safe precautionary bounderies and thus fullfilled the 1st phase of the management plan. The increase in SSB is mainly achieved by the strong 2005 year class. The main explanation for the reduction of fishing mortality seems to be a proper implementation of the current management plan complemented with a reduction of capacity in the beam trawl fleet and a limitation of fishing effort. Also high fuel prices have contributed to the decrease in fishing mortality.

The peaks in the historical time-series of SSB of North Sea sole correspond with the occasional occurrence of strong year classes. Due to a high fishing mortality the SSB has declined during the nineties. The fishery opportunities and SSB are now dependent on incoming year classes and can therefore fluctuate considerably between years. The SSB and landings in recent years have been dominated by the 2001 and 2005 year classes. The predicted SSB in 2011 is still largely dependent on the above-average recruitment of the 2005 year class.

ICES has developed a generic approach to evaluate whether new survey information that becomes available in September forms a basis to update the advice. If this is the case, ICES will publish new advice in November 2009.

Management plan evaluation

According to evaluation of the agreed management plan it can be provisionally accepted as precautionary for sole. Estimations of sole stock status appear to have a retrospective under-estimation of fishing mortality and over-estimation of SSB, which have resulted in forecast bias. The probability of successfully attaining the objectives of the first stage of the management plan is dependent on the assumption of a stock–recruitment relationship, which is not well founded. The dynamics of the stock is driven by the sporadic strong year classes that lead to wide fluctuations in the SSB. Additional evaluations of the management plan are necessary to take into account retrospective bias of the assessment and the nature of recruitment to conclude on the precautionary nature of the plan in the long term.

Impacts of fisheries on the ecosystem

Currently the mixed plaice and sole fishery is dominated by bottom trawls, with bycatch of both commercial and non-commercial species and with physical impact on the seabed. Bottom trawling reduces biomass, production, and species richness. For the North Sea, an ecosystem model showed that the bottom trawl fleet reduced benthic biomass and production by 56% and 21%, respectively, compared with an un-fished situation (Hiddink *et al.*, 2006; Hinz *et al.*, 2008). Chronic fishing has caused a shift from communities dominated by relatively sessile, emergent, high biomass species to communities dominated by infaunal, smaller-bodied fauna (Kaiser *et al.*, 2000).

Within species, the size selectivity may lead to a shift in the age and size at maturation. For example, plaice and sole become mature at younger ages and at smaller sizes in recent years than in the past. There is a risk that this shift is a genetic fisheries-induced change (Grift *et al.*, 2004; Mollet *et al.*, 2007)

Factors affecting the fisheries and the stock

The effects of regulations

Due to a range of factors such as TAC constraints on plaice, effort limitations, and increases in fuel prices, the fishing effort of the major fleets targeting sole has decreased since the mid-1990s and concentrated in the southern part of the North Sea. This is the area where a large part of the juvenile plaice in the North Sea is found. The combination of a change in fishing pattern and the spatial distribution of juvenile plaice has led to an apparent increase in discarding of plaice.

The plaice box was established in 1989, and the area has been closed in all quarters since 1995. The closed area applies to vessels using towed gears, but vessels smaller than 300 HP are exempted from the regulation. The effectiveness of the plaice box has been evaluated by a STECF expert group which concluded that the proportion of undersized sole inside the plaice box did not change after the closure and remained stable at 60–70% (Grift *et al.*, 2004).

Changes in fishing technology and fishing patterns

Due to a range of factors such as effort limitations, increases in fuel prices, and disproportionate changes in the TACs for the two main target species sole and plaice, the fishing effort of the major fleets has concentrated in the southern part of the North Sea. This is the area where many juvenile plaice are found. In addition, juvenile plaice has shown a more offshore distribution in recent years. The combination of a change in fishing pattern and the spatial distribution of juvenile plaice has lead to an increase in discarding of plaice.

The technical efficiency has increased by about 2.8% per year in the sole fishery since 1990, which could have counteracted part of the decrease in effort (Rijnsdorp *et al.*, 2006).

Impacts of the environment on the fish stocks

There has been an overall increase in growth of North Sea sole, followed by a decline correlated with the temporal patterns in eutrophication, in particular the discharge of dissolved phosphates by the Rhine. The spatial distribution of juvenile and adult sole remains constant within the Plaice Box (Grift *et al.*, 2004), following the removal of a large amount of effort. The proportion of undersized sole (<24 cm) did not change after closure and remained stable at a level of 60–70% (Grift *et al.*, 2004). Different length groups showed different patterns in abundance. Sole of around 5 cm showed a decrease in abundance from 2000 onwards, while the groups of 10 and 15 cm seemed rather stable. The largest groups showed a declining trend in abundance, which had already set in years before the closure.

Scientific basis

Data and methods

The stock assessment is based on an XSA assessment, calibrated with two survey indices and one commercial lpue index.

Discards are not included in the assessment. Routine discard sampling since 2003 under the EU Data Collection Regulations indicates overall discarding of sole in the order of 10% in weight and discards are considered to be a minor bias to the assessment results.

Uncertainties in assessment and forecast

There are indications of recurring underestimation of fishing mortality and overestimation of abundance. A discrepancy between the trends in surveys and the commercial cpue is apparent in the the results of comparisons between survey and commercial time-series of information. The survey information indicates higer mortality rates and lower stock abundance, consistent with the more recent values to which the assessment estimates are revised each year.

There are indications that discarding may have an impact on the assessment results

Information from the fishing industry

The North Sea Fisher's survey took place in 2008. A total of 195 responses were collected for sole. As in the 2007 survey, the beam trawl and gill net fishing groups indicated that sole were "more" abundant and the fishers felt that discarding had reduced slightly with respect to 2007. Of those that expressed an opinion on recruitment the majority considered it to be "moderate" or "high". These observations are consistent with the assessment results.

Comparison with previous assessment and advice

The estimate of F for 2007 from the 2008 assessment was revised down by 5% in the 2009 assessment. The SSB estimate for 2007 increased 3% in the 2009 assessment. The revisions are different from retrospective bias in the assessment results previously.

Fishing mortality in the intermediate year used in the 2009 forecast was the average F (2006-2008) scaled to F (2008). The basis for this forecast is different from the previous forecasts, where the average F over the final 3 years was used to counteract the retrospective change from year to year.

The advice this year is based on the EU management plan, similar to last year.

Sources of information

Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 6-12 May 2009 (ICES CM 2009/ACOM:10).

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

Hiddink, J. G., Jennings, S., Kaiser, M. J., Queirós, A. M., Duplisea, D. E, and Piet, G. J. 2006. Cumulative impacts of seabed trawl disturbance on benthic biomass, production, and species richness in different habitats. Canadian Journal of Fisheries and Aquatic Sciences, 63: 721–736.

Hinz, H., Hiddink, J. G., Forde, J., and Kaiser, M. J. 2008. Large-scale responses of nematode communities to chronic otter-trawl disturbance. Canadian Journal of Fisheries and Aquatic Sciences, 65: 723–732.

Kaiser, M. J., Ramsay, K., Richardson, C. A., Spence, F. E., and Brand, A. R. 2000. Chronic fishing disturbance has changed shelf sea benthic community structure. Journal of Animal Ecology, 69: 494–503.

Rijnsdorp, A. D., Daan, N., and Dekker, W. 2006. Partial fishing mortality per fishing trip: a useful indicator of effective fishing effort in mixed demersal fisheries. ICES Journal of Marine Science, 63: 556–566.

Table 6.4.10.1 Sole in Subarea IV (North Sea). Single stock exploitation boundaries (advice), management and landings.

Year	ICES Advice	Single-stock exploitation boundaries	Predicted catch corresponding to advice	Predicted catch corresponding to single-stock	Agreed TAC	Official landings	ICES landings
1987	Rebuild SSB to 40 000 t; TAC		11.0		14.0	13.8	17.4
1988	Increase SSB towards 50 000 t; TAC		11.0		14.0	13.4	21.6
1989	Increase SSB towards 50 000 t; TAC		14.0		14.0	14.5	21.8
1990	80% of F(88); TAC		25.0		25.0	26.5	35.1
1991	SSB>50 000 t ; TAC		27.0		27.0	27.6	33.5
1992	TAC		21.0		25.0	26	29.3
1993	no long-term gains in increased F		29.0[1]		32.0	29.8	31.5
1994	no long-term gains in increased F		31.0[1]		32.0	31.3	33
1995	no long-term gains in increased F		28.0[1]		28.0	28.8	30.5
1996	Mixed fishery, link plaice advice		23.0[1]		23.0	20.4	22.7
1997	<80% of F(95)		14.6		18.0	13.7	15
1998	75% of F(96)		18.1		19.1	19.7	20.9
1999	$F<F_{pa}$ (80% of F(97))		20.3		22.0	22	23.5
2000	$F< F_{pa}$		<19.8		22.0	20.7	22.5
2001	$F< F_{pa}$		<17.7		19.0	16.4	19.9
2002	F<0.37		<14.3		16.0	16	16.9
2003	$F< F_{pa}$		<14.6		15.85	17.1	17.9
2004	[2]	$F< F_{pa}$	[2]	<17.9	17.0	17.8	17.1
2005		$F< F_{pa}$		<17.3	18.6	15.6	16.4
2006		Keep SSB above B_{pa}		<11.9	17.67	11,9	12.6
2007		SSB above B_{pa}		<10.8	15.0	13.8	14.6
2008		SSB above B_{pa}		<9.8	12.8	13.4	14.1
2009		Apply management plan		<14.0	14.0		
2010		Apply management plan		<14.1			

Weights in '000 t.

[1] Catch *status quo* F.

[2] Single-stock boundary and the exploitation of this stock should be conducted in the context of mixed fisheries protecting stocks outside safe biological limits.

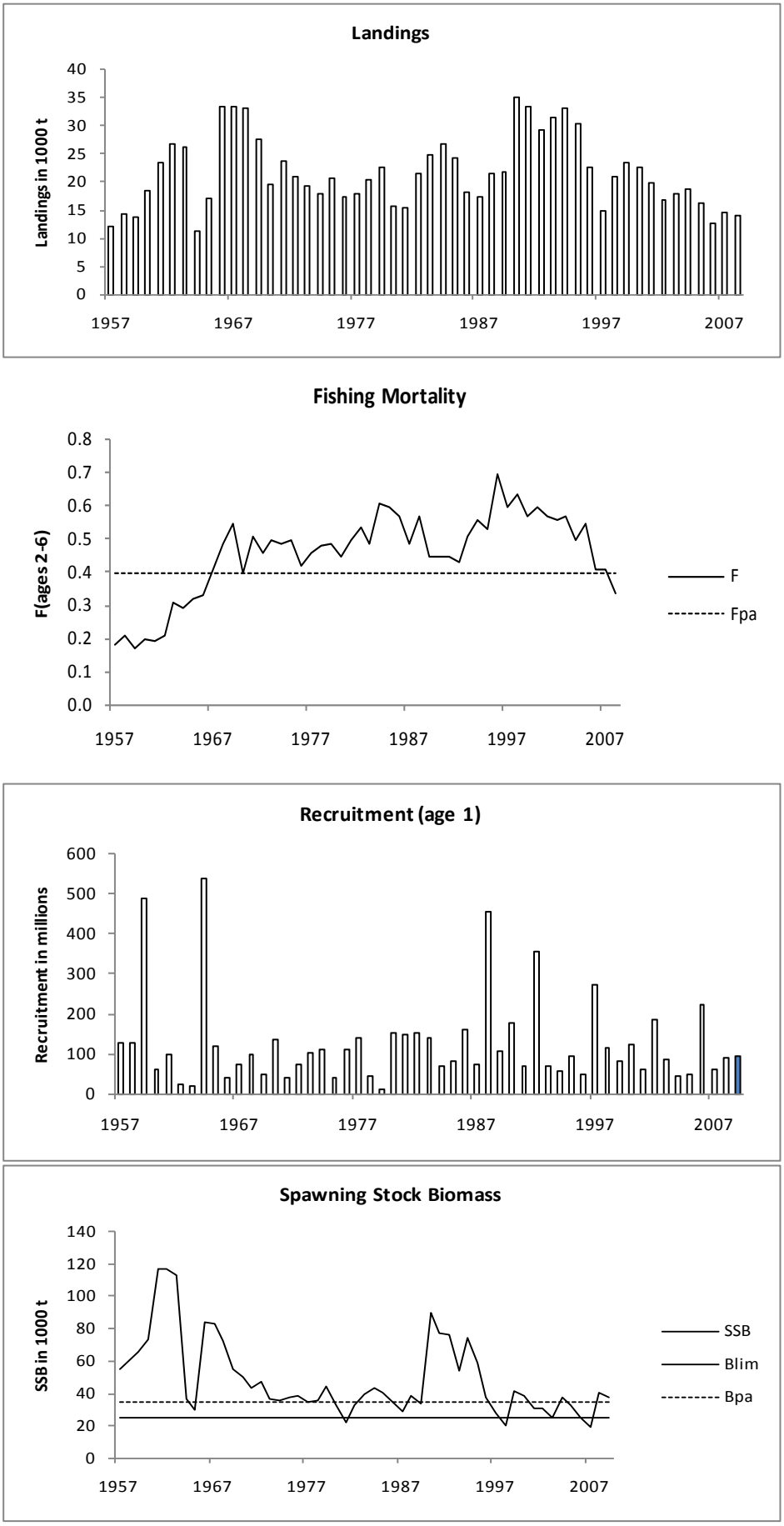
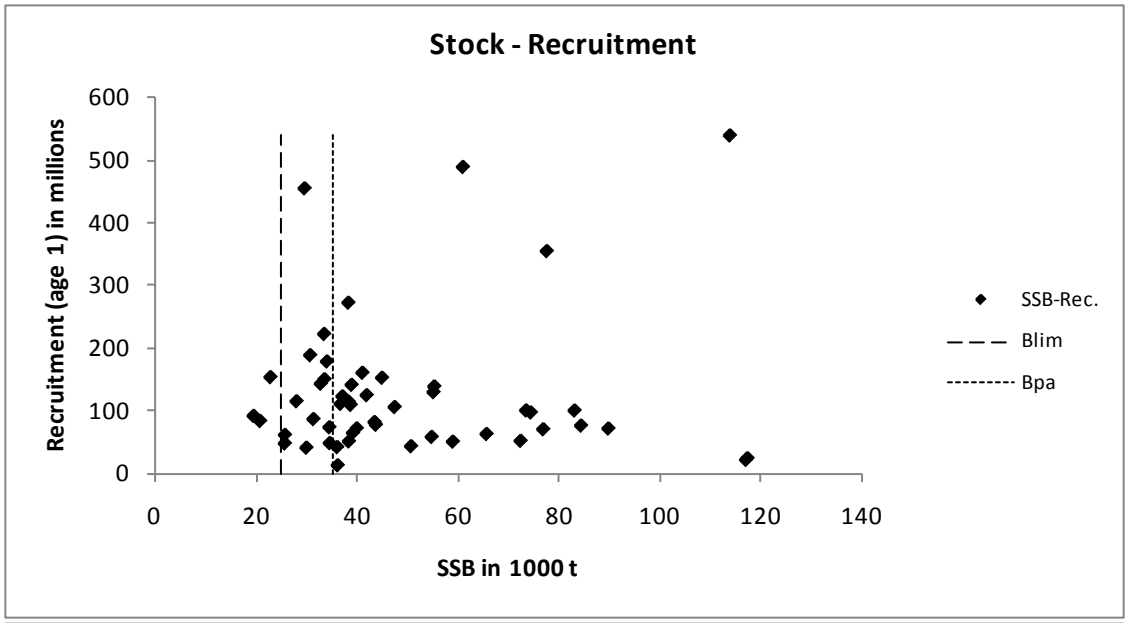
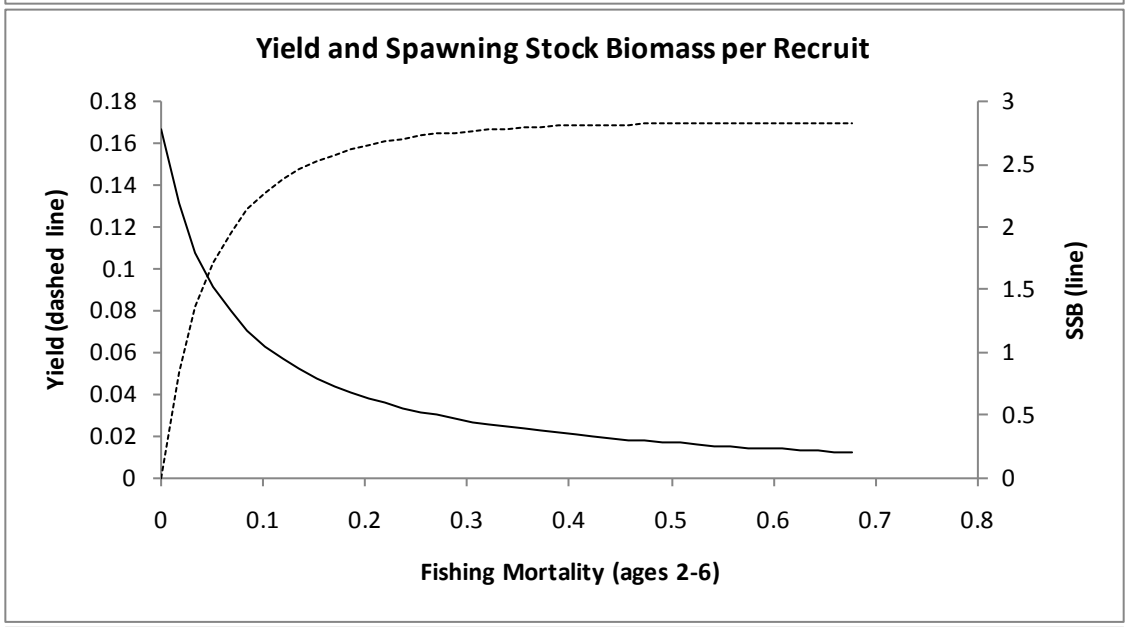


Figure 6.4.10.1 Sole in Subarea IV (North Sea). Landings, fishing mortality, recruitment, and biomass (SSB). Predicted values are shaded.





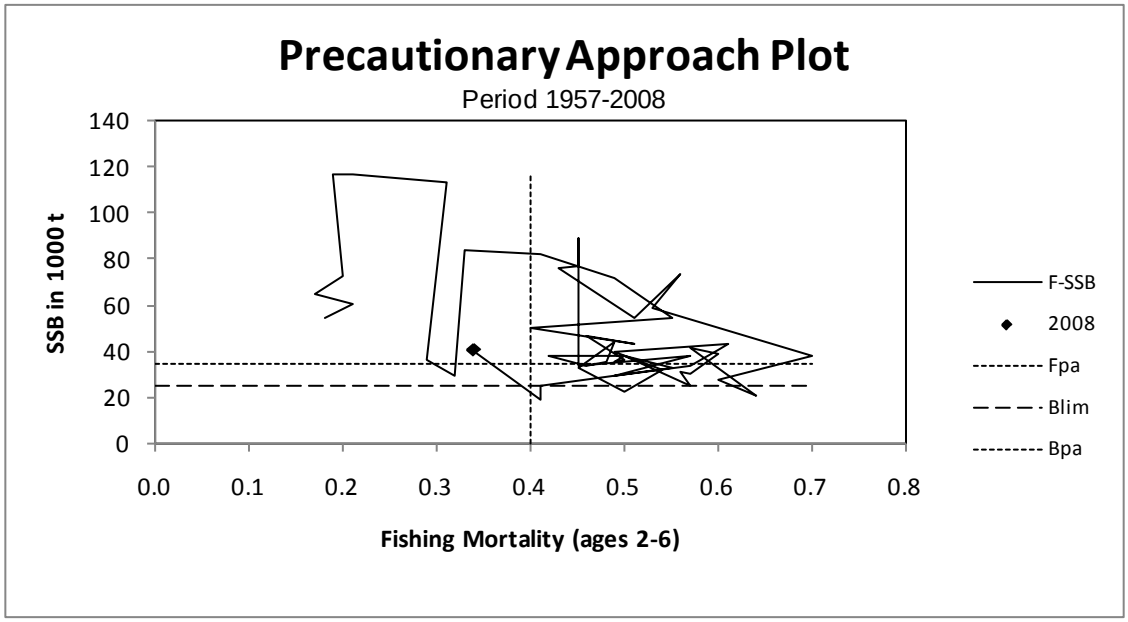


Figure 6.4.10.2 Sole in Subarea IV (North Sea). Stock recruitment, yield, and precautionary approach.

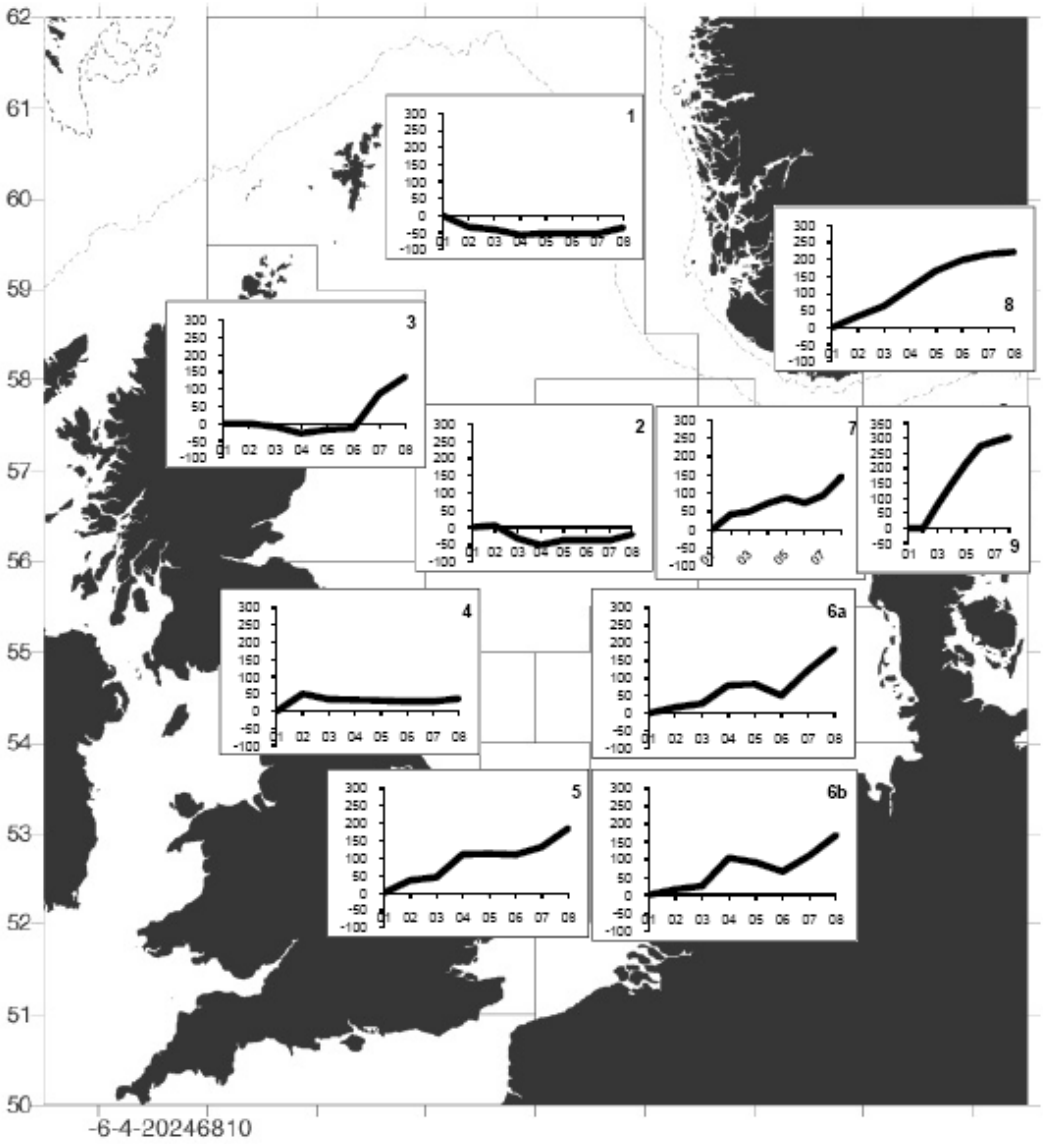


Figure 6.4.10.3 Sole in Subarea IV (North Sea). Results of the North Sea Commission fishers' survey 2008.

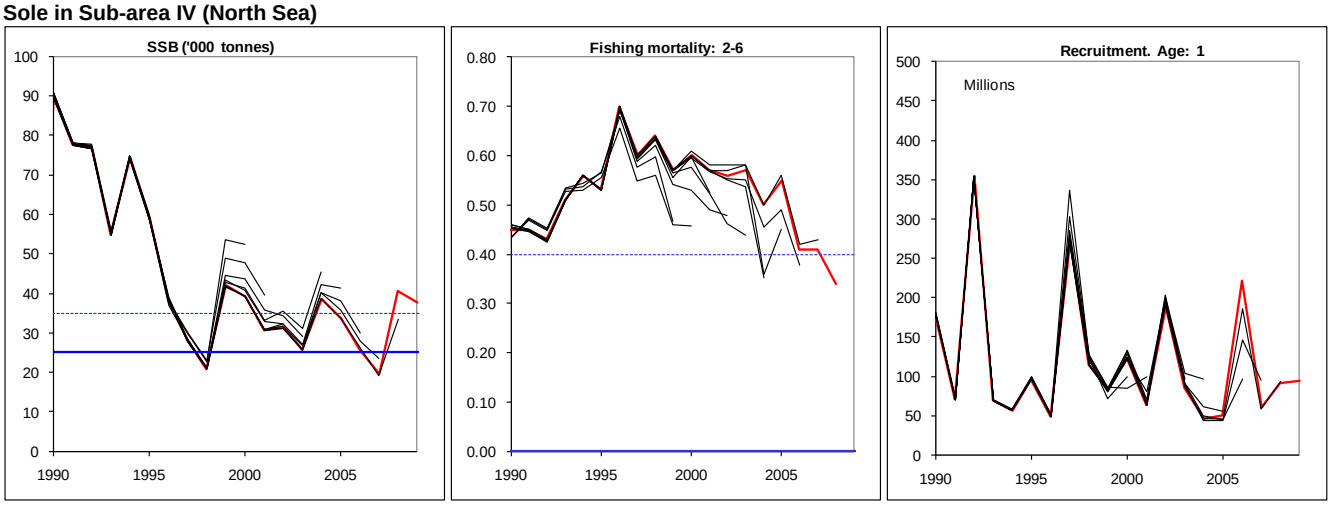


Figure 6.4.10.4 Sole in Subarea IV (North Sea). Historical performance of the assessments.

Table 6.4.10.2 Sole in Subarea IV (North Sea). Nominal landings and landings as estimated by the Working Group (tonnes).

Year	Belgium	Denmark	France	Germany	Netherlands	UK (E/W/NI)	Other countries	Total reported	Unallocated landings	WG Total	TAC
1982	1900	524	686	266	17686	403	2	21467	112	21579	21000
1983	1740	730	332	619	16101	435		19957	4970	24927	20000
1984	1771	818	400	1034	14330	586	1	18940	7899	26839	20000
1985	2390	692	875	303	14897	774	3	19934	4314	24248	22000
1986	1833	443	296	155	9558	647	2	12934	5266	18200	20000
1987	1644	342	318	210	10635	676	4	13829	3539	17368	14000
1988	1199	616	487	452	9841	740	28	13363	8227	21590	14000
1989	1596	1020	312	864	9620	1033	50	14495	7311	21806	14000
1990	2389	1427	352	2296	18202	1614	263	26543	8577	35120	25000
1991	2977	1307	465	2107	18758	1723	271	27608	5905	33513	27000
1992	2058	1359	548	1880	18601	1281	277	26004	3337	29341	25000
1993	2783	1661	490	1379	22015	1149	298	29775	1716	31491	32000
1994	2935	1804	499	1744	22874	1137	298	31291	1711	33002	32000
1995	2624	1673	640	1564	20927	1040	312	28780	1687	30467	28000
1996	2555	1018	535	670	15344	848	229	21199	1452	22651	23000
1997	1519	689	99	510	10241	479	204	13741	1160	14901	18000
1998	1844	520	510	782	15198	549	339	19742	1126	20868	19100
1999	1919	828		1458	16283	645	501	21634	1841	23475	22000
2000	1806	1069	362	1280	15273	600	539	20929	1603	22532	22000
2001	1874	772	411	958	13345	597	394	18351	1593	19944	19000
2002	1437	644	266	759	12120	451	292	15969	976	16945	16000
2003	1605	703	728	749	12469	521	363	17138	782	17920	15850
2004	1477	808	655	949	12860	535	544	17828	-681	17147	17000
2005	1374	831	676	756	10917	667	357	15579	776	16355	18600
2006	980	585	648	475	8299	910		11933	667	12600	17670
2007	955	413	401	458	10365	1203	5	13800	835	14635	15000
2008	1379	507	714	513	9456	851	15	13435	710	14145	12800

Table 6.4.10.3 Sole in Subarea IV (North Sea). Summary of stock assessment.

Year	Recruitment Age 1 thousands	SSB tonnes	Landings tonnes	Mean F Ages 2-6
1957	128909	55107	12067	0.18
1958	128643	60919	14287	0.21
1959	488757	65580	13832	0.17
1960	61714	73398	18620	0.20
1961	99488	117099	23566	0.19
1962	22895	116830	26877	0.21
1963	20420	113628	26164	0.31
1964	539075	37127	11342	0.29
1965	121959	30029	17043	0.32
1966	39901	84243	33340	0.33
1967	75135	82958	33439	0.41
1968	99262	72306	33179	0.49
1969	50787	55267	27559	0.55
1970	137795	50680	19685	0.40
1971	42148	43742	23652	0.51
1972	76525	47437	21086	0.46
1973	104859	36775	19309	0.50
1974	109939	36110	17989	0.49
1975	40816	38365	20773	0.50
1976	113311	38944	17326	0.42
1977	140375	34623	18003	0.46
1978	47256	36195	20280	0.48
1979	11723	44954	22598	0.49
1980	151694	33584	15807	0.45
1981	149346	22921	15403	0.50
1982	152751	32855	21579	0.54
1983	142179	39956	24927	0.49
1984	70791	43464	26839	0.61
1985	80833	41082	24248	0.60
1986	159654	34554	18201	0.57
1987	72553	29658	17368	0.49
1988	454627	38765	21590	0.57
1989	108296	34075	21805	0.45
1990	177757	89643	35120	0.45
1991	70476	77479	33513	0.45
1992	354171	76772	29341	0.43
1993	69289	54752	31491	0.51
1994	57057	74337	33002	0.56
1995	96104	58934	30467	0.53
1996	49508	38310	22651	0.70
1997	271749	28071	14901	0.60
1998	114161	20882	20868	0.64
1999	82581	41918	23475	0.57
2000	123824	39217	22641	0.60
2001	63480	30762	19944	0.57
2002	187821	31412	16945	0.56
2003	85663	25758	17920	0.57
2004	46679	38402	18757	0.50
2005	49955	33520	16355	0.55
2006	221770	25778	12594	0.41
2007	60383	19585	14635	0.41
2008	90949	40676	14144	0.34
2009	93786*	37670		
Average	124747	49191	21703	0.46

* GM (1957–2006)

6.4.10 Annex

Extract from *Council Regulation (EC) No 676/2007 of 11 June 2007 establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea*

Article 8 Procedure for setting the TAC for sole:

1) *The Council shall adopt a TAC for sole at that level of catches which, according to a scientific evaluation carried out by STECF is the higher of:*
   a) *that TAC the application of which will result in the level of fishing mortality rate of 0,2 on ages two to six years in its year of application;*
   b) *that TAC the application of which will result in a 10 % reduction in the fishing mortality rate in its year of application compared to the fishing mortality rate estimated for the preceding year.*
2) *Where the application of paragraph 1 would result in a TAC which exceeds the TAC of the preceding year by more than 15 %, the Council shall adopt a TAC which is 15 % greater than the TAC of that year.*
3) *Where the application of paragraph 1 would result in a TAC which is more than 15 % less than the TAC of the preceding year, the Council shall adopt a TAC which is 15 % less than the TAC of that year.*

Under the consideration nr 3 in the "Council Regulation (EC) No 676/2007 of 11 June 2007 establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea" it is stated:

The Scientific, Technical and Economic Committee for Fisheries (STECF) has advised … that the precautionary biomass for the stock of sole in the North Sea should be 35 000 tonnes.