Sole (*Solea solea*) in Subarea 4 (North Sea)

ICES advice on fishing opportunities

ICES advises that when the MSY approach is applied, catches in 2024 should be no more than 3 588 tonnes.

ICES notes the existence of a precautionary management plan, developed and adopted by one of the relevant management authorities for this stock.

ICES advice on conservation aspects

ICES has not identified any conservation aspects.

Stock development over time

Fishing pressure on the stock is below F_{MSY}, and spawning-stock size is below MSY $B_{trigger}$ and between B_{pa} and B_{lim}.

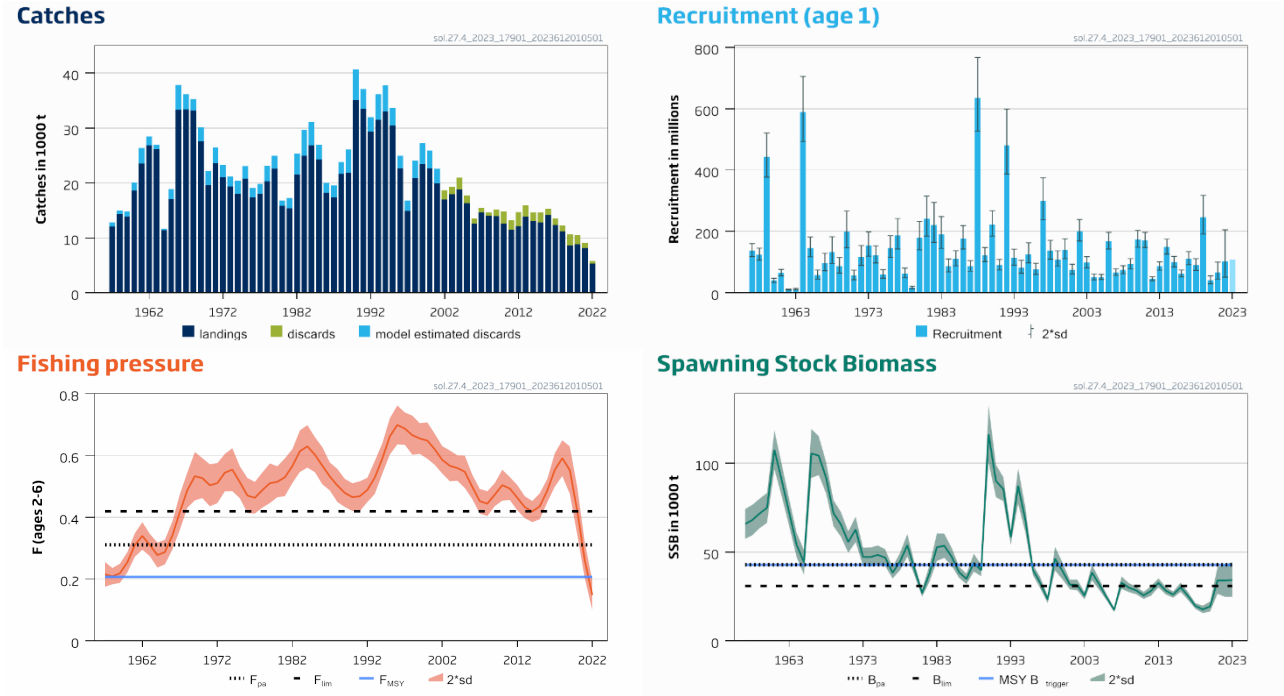

Figure 1 Sole in Subarea 4. Summary of the stock assessment. Discard data are only available since 2002 and include below minimum size (BMS) landings; values prior to that are model estimates. The assumed recruitment value in 2023 is shaded in a lighter colour.

Conservation status

ICES is not aware of any information on stock/species-specific conservation status.

Catch scenarios

Table 1 Sole in Subarea 4. Values in the forecast and for the interim year.

Variable	Value	Notes
$F_{ages\ 2–6}$ (2023)	0.179	Based on the assumed total catch (2023) and exploitation pattern in 2022
SSB (2023)	22339	Estimated SSB from corrected numbers at age to account for retrospective pattern*; in tonnes
SSB (2024)	25138	Short-term forecast (STF); in tonnes

Variable	Value	Notes
$R_{age\ 1}$ (2023, 2024)	109511	Geometric mean of recruitment (GM; 1957–2017); in thousands
Total catch (2023)**	4289	Expected catch, calculated as TAC (2023) multiplied by the average TAC uptake over the period 2020-2022 (0.469)
Projected landings (2023)	3878	STF, assuming average estimated landing ratio by age 2020–2022; in tonnes
Projected discards (2023)	412	STF, assuming average estimated discard ratio by age 2020–2022; in tonnes

* Calculated from the five-year SSB Mohn's rho, 0.556; correction factor = 1 / (1 + 0.556) = 0.643.

** Differences between the total catch and the sum of projected landings and discards result from rounding.

Table 2 Sole in Subarea 4. Annual catch scenarios. Weights are in tonnes.

Basis	Total catch* (2024)	Projected landings (2024)	Projected discards** (2024)	F_{total}# (ages 2–6) (2024)	$F_{projected\ landings}$ (ages 2–6) (2024)	$F_{projected\ discards}$ (ages 1–3) (2024)	SSB (2025)	% SSB change ^	% TAC change^^	% advice change ^^
ICES advice basis										
MSY approach: F_{MSY} × SSB (2024) /MSY $B_{trigger}$	3588	3164	424	0.122	0.089	0.022	33979	35	−61	−61
Other scenarios										
F_{MSY}	5861	5158	703	0.207	0.151	0.038	31484	25	−36	−36
$F_{MSY\ lower}$	3630	3201	429	0.123	0.090	0.022	33933	35	−60	−60
$F_{MSY\ lower}$ × SSB (2024) /MSY $B_{trigger}$	2186	1930	256	0.072	0.053	0.0131	35518	41	−76	−76
F = 0	0	0	0	0.00	0.00	0.00	37914	51	−100	−100
F_{pa}	8365	7342	1022	0.311	0.23	0.057	28734	14.3	−8.6	−8.6
F_{lim}	10722	9387	1335	0.420	0.31	0.076	26143	4.0	17.2	17.2
SSB (2025) = B_{pa} = MSY $B_{trigger}$##										
SSB (2025) = B_{lim}	6458	5680	778	0.23	0.169	0.042	30828	23	−29	−29
F = F_{2023}	5143	4529	614	0.179	0.131	0.033	32273	28	−44	−44
Rollover advice	9152	8027	1125	0.35	0.25	0.063	27868	10.9	0.00	0.00

* Differences between the total catch and the sum of projected landings and discards result from rounding.

** Including BMS landings. Assuming average estimated discard rate by age 2020–2022.

^ SSB 2025 relative to SSB 2024.

^^ Total catch in 2024 relative to the advice value 2023 and TAC (both 9152 tonnes).

$F_{projected\ landings}$ and $F_{projected\ discards}$ do not add up to F_{total} as they are calculated using different ages.

B_{pa} and MSY $B_{trigger}$ cannot be achieved in 2025, even with zero catches.

The change in advice (−61%) is mainly due the downward revision of the SSB and to the correction applied to the estimated numbers at age in 2023 (correction factor = 0.643) following ICES (2020a). Additionally, the target F for advice in 2024 is lower than the target F used in 2023 advice because the SSB in the beginning of 2024 is now much lower than MSY $B_{trigger}$ when compared to last year's assessment results.

Basis of the advice

Table 3 Sole in Subarea 4. The basis of the advice.

Advice basis	MSY approach.
Management plan	ICES is aware of the multiannual management plan (MAP) which has been adopted by the EU for this stock (EU, 2018) and which ICES considers to be precautionary. There is no agreed shared management plan with UK for this stock, and ICES provides advice according to ICES MSY approach. Catch scenarios consistent with the MAP F_{MSY} ranges are provided.

Quality of the assessment

The assessment model currently presents a large retrospective pattern in estimated SSB and fishing mortality, which has led to a correction being applied to the estimated numbers at age in 2023 when generating advice for 2024 (ICES, 2020a). The correction factor (0.643) applied was calculated from the five-year SSB Mohn's rho, which is a measure of the rescaling of stock size as each new year of data is added.

Between 2014 and 2018, the pulse trawl fleet was the main fishery targeting sole in the North Sea (ICES, 2018). Following the EU decision in February 2019 to revise the technical measures regulations, pulse gear was prohibited from 30 June 2021 (EU, 2019). This has caused some rapid changes in the selection pattern, which might be contributing to the retrospective pattern of the assessment. The assumed constant natural mortality also does not appear consistent with the observed changes over time in weight- and length-at-age, which seems to contribute to the observed retrospective pattern. Possible explanations for this pattern need further investigation. A benchmark is scheduled for this stock in 2024.

Recruitment estimates from 2018 to 2022 were excluded from the estimation of the geometric mean used for the short-term forecast because of the large retrospective pattern.

A number of stations were not sampled in 2022 in either the Q3 BTS and SNS surveys. For the BTS, an evaluation of the potential impact of the reduced number of hauls was carried out and the difference was found to be negligible. On the other hand, the model encountered difficulties in fitting to the SNS survey 2022 data points. The estimated survey selectivity for SNS were considered unrealistic; therefore, the 2022 data from the SNS was not included in the assessment.

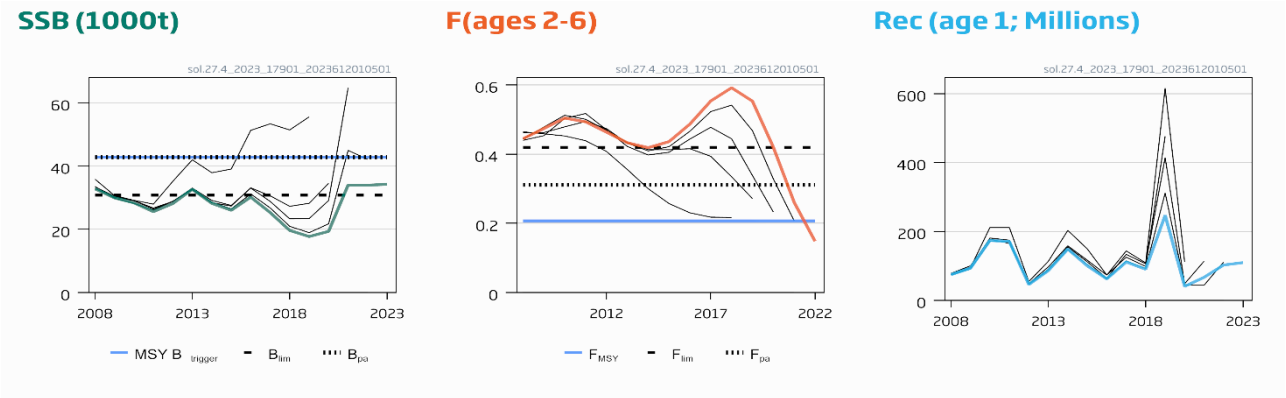

Figure 2 Sole in Subarea 4. Historical assessment results (final-year recruitment included for each line, corresponding to the forecast recruitment in the interim year). The reference points were revised in 2020 following a benchmark, and only assessment results from the last four years should be compared to the reference points indicated.

Issues relevant for the advice

Sole in the North Sea is under EU landing obligation as well as Norway and UK national legislation regulating discards. Catch monitoring programs estimate that discarding in 2022 amounted to 9.5% of the total catch. Below minimum size (BMS) landings of sole reported to ICES are currently much lower than the estimates of discards, representing < 0.5% of the total catch in 2022.

Reference points

Table 4 Sole in Subarea 4. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	42838	B_{pa}; in tonnes	ICES (2020b)
	F_{MSY}	0.207	EqSim analysis, assuming a hockey stick stock–recruit relationship, based on the recruitment period 1958–2018	ICES (2020b)
Precautionary approach	B_{lim}	30828	Breakpoint of the hockey stick stock–recruit relationship, based on the recruitment period 1958–2018; in tonnes	ICES (2020b)
	B_{pa}	42838	$B_{lim} \times \exp(1.645 \times \sigma)$, $\sigma = 0.20$; in tonnes	ICES (2020b)
	F_{lim}	0.420	EqSim analysis, based on the recruitment period 1958–2018	ICES (2020b)
	F_{pa}	0.311	The F that provides a 95% probability for SSB to be above B_{lim} ($F_{P.05}$ with advice rule [AR])	ICES (2020b, 2022)
EU management plan (MAP)*	MAP MSY $B_{trigger}$	42838	MSY $B_{trigger}$; in tonnes	ICES (2020b)
	MAP B_{lim}	30828	B_{lim}; in tonnes	ICES (2020b)
	MAP F_{MSY}	0.207	F_{MSY}	ICES (2020b)
	MAP range F_{lower}	0.123–0.207	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2020b)
	MAP range F_{upper}	0.207–0.311	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with MSY	ICES (2020b)

*EU multiannual plan (MAP) for the North Sea (EU, 2018).

Basis of the assessment

Table 5 Sole in Subarea 4. Basis of the assessment and advice.

ICES stock data category	1 (ICES, 2023a)
Assessment type	Age-based analytical assessment (Aarts and Poos, 2009; ICES, 2023b) that uses catches and surveys in the model and in the forecast
Input data	Commercial catches (age frequencies from catch sampling), two survey indices (BTS combined [NL, DE, BE] Q3 [B2453] and SNS Q3 [B3499]). Natural mortality is assumed constant at 0.1 (except for 1963, when it is set at 0.9). Maturity-at-age is assumed to be knife-edged (at age 3) and constant over time.
Discards, BMS landings, and bycatch	Discard data from 2002 are included in the assessment; discards before 2002 are estimated by the model. In 2022, 88% of the landings had associated discarding information and 89% of the discards were sampled. BMS landings, where reported, are included with discards in the assessment from 2016.
Indicators	None
Other information	The stock was last benchmarked in 2020 (ICES, 2020b). The main change was the inclusion of a single index combining various BTS Q3 surveys (NL, DE, and BE; ICES, 2020b).
Working group	Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)

History of the advice, catch, and management

Table 6 Sole in Subarea 4. ICES advice, and ICES estimates of landings and discards reported to ICES. Weights are in tonnes.

Year	ICES advice	Landings corresponding to advice	Catch corresponding to advice	Agreed TAC	ICES landings	ICES discards^	ICES catch^
1987	Rebuild SSB to 40 000 t; TAC	11000		14000	17368		
1988	Increase SSB towards 50 000 t; TAC	11000		14000	21590		
1989	Increase SSB towards 50 000 t; TAC	14000		14000	21804		
1990	80% of F (88); TAC	25000		25000	35121		
1991	SSB > 50 000 t; TAC	27000		27000	33514		
1992	TAC	21000		25000	29341		
1993	No long-term gains in increased F	29000		32000	31491		
1994	No long-term gains in increased F	31000		32000	33002		

Year	ICES advice	Landings corresponding to advice	Catch corresponding to advice	Agreed TAC	ICES landings	ICES discards^	ICES catch^
1995	No long-term gains in increased F	28000		28000	30468		
1996	Mixed fishery, link plaice advice	23000		23000	22650		
1997	< 80% of F (95)	14600		18000	14902		
1998	75% of F (96)	18100		19100	20867		
1999	$F < F_{pa}$ (80% of F (97))	20300		22000	23475		
2000	$F < F_{pa}$	< 19800		22000	22641		
2001	$F < F_{pa}$	< 17700		19000	19944		
2002	F < 0.37	< 14300		16000	16946	1712	18 658
2003	$F < F_{pa}$	< 14600		15900	17921	1364	19 285
2004	$F < F_{pa}$	< 17900		17000	18757	2181	20 938
2005	$F < F_{pa}$	< 17300		18600	16355	1341	17 696
2006	Keep SSB above B_{pa}	< 11900		17700	12594	994	13 588
2007	SSB above B_{pa}	< 10800		15000	14635	871	15 506
2008	SSB above B_{pa}	< 9800		12800	14071	545	14 616
2009	Apply management plan	< 14000		14000	13952	1261	15 213
2010	Apply management plan	< 14100		14100	12603	2246	14 849
2011	See scenarios	-		14100	11485	1703	13 188
2012	Apply first stage of the management plan	< 15700		16200	12168	2528	14 696
2013	Apply first stage of the management plan	< 14000		14000	13839	2119	15 958
2014	Apply first stage of the management plan	< 11900		11900	13072	1568	14 640
2015	Apply second stage of the management plan	< 11400		11900	12827	1763	14 590
2016	Apply second stage of the management plan		≤ 12800	13262	14118	1205	15 323
2017	Apply second stage of the management plan		≤ 15300	16123	12327	1246	13 573
2018	Apply second stage of the management plan		≤ 15726	15694	11209	1056	12 265
2019	MAP* F ranges: F_{lower} to F_{upper} (F = 0.113–0.367), but F_{higher} than F_{MSY} = 0.202 only under conditions specified in the MAP		7451–21644, but catches greater than 12801 only under conditions specified in the MAP	12555	8658	1949	10607
2020	Management plan		17545 (range 10192–29767)	17545	8841	1649	10490
2021	Management plan		21361 (range 13237–32920)	21361	8185	959	9144
2022	MSY approach		≤ 15330	15330	5282	545	5827
2023	MSY approach		≤ 9152	9152			
2024	MSY approach		≤ 3588				

^ Since 2016, discards include BMS landings.

* EU multiannual plan (MAP) for the North Sea (EU, 2018).

History of the catch and landings

Table 7 Sole in Subarea 4. Catch distribution by fleet in 2022 as estimated by and reported to ICES.

Catch	Landings				Discards*
5827 tonnes	Beam trawl 93%	Gillnets & trammel nets 3%	Bottom trawls 3%	Other 1%	545 tonnes
	5282 tonnes				

* Discards include BMS landings from EU and UK fleets.

Table 8 Sole in Subarea 4. History of landings; the official reported landings are presented by country and total. Official reported BMS landings, ICES estimated landings, and the TAC are presented. Weights are in tonnes.

Year	Belgium	Denmark	France	Germany	Netherlands	UK	Other	Total landings	Official BMS landings	ICES total landings	TAC
1982	1900	524	686	266	17686	403	2	21467		21578	21000
1983	1740	730	332	619	16101	435	0	19957		24927	20000
1984	1771	818	400	1034	14330	586	1	18940		26839	20000
1985	2390	692	875	303	14897	774	3	19934		24248	22000
1986	1833	443	296	155	9558	647	2	12934		18201	20000
1987	1644	342	318	210	10635	676	4	13829		17368	14000
1988	1199	616	487	452	9841	740	28	13363		21590	14000
1989	1596	1020	312	864	9620	1033033	50	14495		21804	14000
1990	2389	1427	352	2296	18202	1614	263	26543		35121	25000
1991	2977	1307	465	2107	18758	1723	271	27608		33514	27000
1992	2058	1359	548	1880	18601	1281	277	26004		29341	25000
1993	2783	1661	490	1379	22015	1149	298	29775		31491	32000
1994	2935	1804	499	1744	22874	1137	298	31291		33002	32000
1995	2624	1673	640	1564	20927	1040	312	28780		30468	28000
1996	2555	1018	535	670	15344	848	229	21199		22650	23000
1997	1519	689	99	510	10241	479	204	13741		14902	18000
1998	1844	520	510	782	15198	549	339	19742		20867	19100
1999	1919	828	n/a	1458	16283	645	501	21634*		23475	22000
2000	1806	1069	362	1280	15273	600	539	20929		22641	22000
2001	1874	772	411	958	13345	597	394	18351		19944	19000
2002	1437	644	266	759	12120	451	292	15969		16946	16000
2003	1605	703	728	749	12469	521	363	17138		17921	15900
2004	1477	808	655	949	12860	535	544	17828		18757	17000
2005	1374	831	676	756	10917	667	357	15579		16355	18600
2006	987	582	714	475	8299	912	36	12004		12594	17700
2007	973	413	591	458	10364	1208	5	14011		14635	15000
2008	1379	501	574	514	9456	851	16	13290		14071	12800
2009	1368	476	910	555	9606	952	1	13867		13952	14000
2010	1268	406	630	537	8770	943	2	12556		12603	14100
2011	864	347	566	327	8137	820	2	11063		11485	14100
2012	607	418	634	440	9085	610	3	11797		12168	16200
2013	706	497	687	561	9967	870	1	13290		13839	14000
2014	966	314	675	642	9018	843	0	12458		13072	11900
2015	935	271	542	765	9273	813	0	12598		12827	11900
2016	768	355	362	861	9600	706	0	12652		14118	13262
2017	557	433	393	761	9482	514	0	12139^	30	12327	16123
2018	404	368	432	721	8581	432	3	10939^	57	11209	15694
2019	253^	110	108	619^	6914^	333^	1	8339^	47	8658	12555
2020	240^	123	37	920^	6707^	542^	0	8569^	5	8841	17545
2021**	266^	172	166	643^	6167^	476^	0	7926^	36	8185	21361
2022**	160^	78	26	144^	4281^	347	1	5059^	22	5282	15330

* These totals do not include reported official landings of all countries.
** Preliminary reported official landings.
^ Including BMS landings.
n/a = not available.

Summary of the assessment

Table 9 Sole in Subarea 4. Assessment summary. Recruitment is in thousands, weights in tonnes. High and Low correspond to 2 standard deviations.

Year	Recruitment (Age 1)			Spawning stock biomass			Landings	Discards*	Fishing pressure (ages 2–6)		
	Low	R	High	Low	SSB	High			Low	F	High
1957	118196	137714	160476	57320	65753	74186	12067	757	0.175	0.22	0.26

Year	Recruitment (Age 1)			Spawning stock biomass			Landings	Discards*	Fishing pressure (ages 2–6)		
	Low	R	High	Low	SSB	High			Low	F	High
1958	106622	124691	145940	59425	68032	76639	14287	738	0.183	0.21	0.24
1959	377079	443230	521148	63437	71774	80111	13832	958	0.188	0.22	0.25
1960	34120	40430	47876	66490	74949	83408	18620	1492	0.22	0.25	0.29
1961	55289	65149	76702	96549	107620	118691	23566	2829	0.27	0.31	0.35
1962	8966	10556	12426	81107	90249	99391	26877	1590	0.30	0.34	0.38
1963	10496	12374	14589	64473	72183	79893	26164	753	0.27	0.31	0.35
1964	493656	589814	705319	47203	54157	61111	11342	294	0.24	0.28	0.32
1965	117571	146425	182262	37223	44188	51153	17043	1859	0.25	0.29	0.33
1966	44877	57743	74334	91718	105540	119362	33340	4477	0.30	0.34	0.39
1967	71741	96117	128692	93409	104380	115351	33439	2685	0.36	0.42	0.48
1968	95546	132130	182890	82896	91849	100802	33179	2115	0.43	0.49	0.55
1969	64463	86231	115400	64508	71896	79284	27559	2578	0.45	0.53	0.61
1970	147208	198109	266839	58644	65644	72644	19684	2524	0.46	0.53	0.59
1971	42784	56211	73871	49614	55659	61704	23652	2807	0.44	0.50	0.57
1972	89306	117356	154227	55540	62757	69974	21087	2126	0.45	0.51	0.58
1973	119360	154007	198809	42131	47314	52497	19308	1861	0.48	0.54	0.61
1974	97392	122279	153507	41770	47202	52634	17990	2444	0.48	0.55	0.62
1975	47854	60145	75667	43085	48418	53751	20773	2315	0.46	0.51	0.57
1976	115416	146628	186409	42081	46870	51659	17326	1716	0.41	0.47	0.53
1977	142869	186133	242394	35081	38415	41749	18003	1851	0.41	0.46	0.52
1978	49124	63085	80975	39722	44618	49514	20280	2843	0.43	0.49	0.55
1979	13482	17072	21618	47468	53883	60298	22598	2356	0.45	0.51	0.57
1980	140398	180708	232759	36401	39842	43283	15806	1007	0.47	0.52	0.57
1981	185005	241524	315483	24777	26963	29149	15403	1893	0.47	0.53	0.59
1982	164440	220094	294696	33278	38044	42810	21578	3786	0.51	0.57	0.62
1983	144747	189684	248515	44926	52718	60510	24927	4735	0.55	0.61	0.68
1984	68276	86918	110711	46750	53585	60420	26839	4250	0.56	0.63	0.70
1985	88258	110076	137308	42241	47369	52497	24248	2678	0.55	0.60	0.66
1986	142726	176820	219108	35445	38687	41929	18201	1860	0.51	0.57	0.63
1987	70430	86035	105200	31925	34919	37913	17368	2186	0.49	0.53	0.58
1988	527082	636146	767496	38956	44018	49080	21590	2225	0.45	0.50	0.56
1989	102109	122846	147887	36416	39715	43014	21804	4307	0.43	0.48	0.52
1990	185058	222523	267688	100207	116400	132593	35121	5531	0.42	0.47	0.51
1991	74420	90058	108936	80883	90053	99223	33514	3549	0.42	0.47	0.52
1992	387488	481581	598726	78654	85460	92266	29341	2594	0.45	0.49	0.53
1993	90016	113158	142381	54060	58402	62744	31491	4697	0.48	0.53	0.58
1994	63704	82237	106085	77252	87316	97380	33002	4770	0.54	0.59	0.64
1995	97675	126246	163179	60494	67751	75008	30468	3247	0.60	0.66	0.72
1996	60179	76274	96657	37011	40060	43109	22650	2340	0.64	0.70	0.76
1997	237823	298508	375015	29411	32631	35851	14902	1897	0.64	0.69	0.74
1998	109882	137173	171243	21209	23327	25445	20867	3191	0.60	0.67	0.73

Year	Recruitment (Age 1)			Spawning stock biomass			Landings	Discards*	Fishing pressure (ages 2–6)		
	Low	R	High	Low	SSB	High			Low	F	High
1999	86974	109169	137124	39577	46315	53053	23475	3786	0.61	0.66	0.71
2000	111380	140132	176187	34660	39446	44232	22641	3282	0.59	0.65	0.71
2001	60847	75472	93702	28988	31714	34440	19944	2660	0.57	0.62	0.67
2002	168635	200781	239070	28413	31493	34573	16946	1712	0.54	0.59	0.63
2003	81834	98256	117896	23353	25447	27541	17921	1364	0.52	0.57	0.62
2004	42293	50793	61061	34059	38523	42987	18757	2181	0.52	0.56	0.60
2005	43445	51111	60160	28575	31691	34807	16355	1341	0.50	0.55	0.60
2006	142879	167809	197254	22678	24396	26114	12594	994	0.46	0.50	0.54
2007	57087	66910	78406	16206	17471	18736	14635	871	0.41	0.45	0.49
2008	62575	74484	88600	29285	32820	36355	14071	545	0.40	0.44	0.48
2009	78045	93361	111632	27390	29972	32554	13952	1261	0.44	0.47	0.51
2010	148552	173790	203477	26229	28401	30573	12603	2246	0.45	0.50	0.55
2011	147750	170837	197348	23593	25598	27603	11485	1703	0.46	0.49	0.53
2012	39602	45805	52964	25451	28172	30893	12168	2528	0.42	0.46	0.51
2013	73895	86258	100670	30055	32652	35249	13839	2119	0.40	0.43	0.47
2014	126212	148810	175305	26105	28237	30369	13072	1568	0.38	0.42	0.45
2015	84232	100189	119213	24276	26038	27800	12827	1763	0.39	0.44	0.48
2016	52170	62225	74291	27527	30198	32869	14118	1205	0.45	0.49	0.53
2017	91867	111236	134579	23049	25312	27575	12327	1246	0.50	0.55	0.61
2018	73119	90323	111542	18044	19669	21294	11209	1056	0.53	0.59	0.65
2019	191511	246789	317839	15613	17726	19839	8658	1949	0.48	0.55	0.63
2020	29615	40466	55270	16530	19371	22212	8841	1649	0.34	0.42	0.50
2021	44522	66853	100334	26507	34006	41505	8185	959	0.20	0.26	0.32
2022	51153	102517	205545	24781	33962	43143	5282	545	0.100	0.148	0.197
2023		109511***		24830**	34270**	44276**					

* Since 2002, discard estimates are raised from the observer programme. Discards prior to 2002 are reconstructed by the model. Since 2016, discards include BMS landings from EU and UK fleets.

** The values are not used in the forecast due to the retrospective bias and replaced using a correction factor of 0.643 applied to the abundances at age in 2023.

*** Geometric mean (1957–2017).

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