

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

ICES stock advice

ICES advises that when the second stage of the EU management plan (Council Regulation No. 676/2007) is applied, catches in 2017 should be no more than 15 251 tonnes.

Stock development over time

The spawning-stock biomass (SSB) has increased since 2007 and has been estimated at above $MSY B_{trigger}$ since 2012. Fishing mortality (F) has declined since 1997 and is estimated to be at F_{MSY} in 2015. Recruitment (R) has fluctuated without trend since the early 1990s.

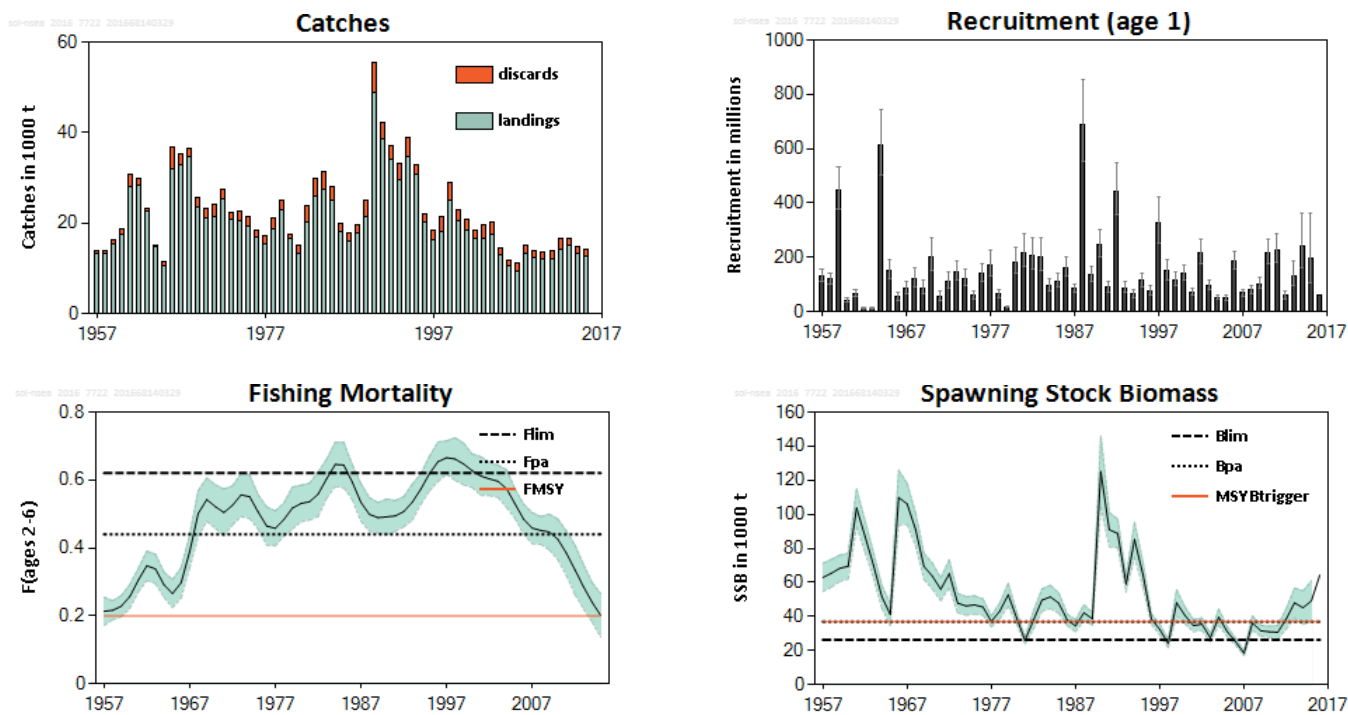


Figure 6.3.49.1 Sole in Subarea 4. Summary of stock assessment.

Stock and exploitation status

Table 6.3.49.1 Sole in Subarea 4. State of the stock and fishery relative to reference points.

		Fishing pressure			Stock size				
		2013	2014	2015	2014	2015	2016		
Maximum sustainable yield	F_{MSY}	✗	✗	✓	MSY	✓	✓	✓	Above trigger
Precautionary approach	F_{pa} , F_{lim}	✓	✓	✓	B_{pa} , B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	✗	✗	✓	SSB_{MGT}	✓	✓	✓	Above

Catch forecast and outlook

Table 6.3.49.2 Sole in Subarea 4 (North Sea). The basis for the forecast.

Variable	Value	Source	Notes
F ages 2–6 (2016)	0.16	ICES (2016a)	Catch constraint (13268 tonnes)
SSB (2017)	77202 t	ICES (2016a)	Short-term forecast (STF), tonnes
R _{age1} (2016)	59248	ICES (2016a)	RCT3, thousands
R _{age1} (2017)	111851	ICES (2016a)	Geometric mean (GM, 1957–2012), thousands
Total catch (2016)	13268 t	ICES (2016a)	Tonnes
Commercial landings (2016)	12021 t	ICES (2016a)	Tonnes
Unwanted catch (2016)	1247 t	ICES (2016a)	Average discard rate by age 2013–2015 in tonnes

Table 6.3.49.3 Sole in Subarea 4 (North Sea). The forecast and catch options. All weights are in thousand tonnes.

Rationale	Total catch (2017)	Wanted catch (2017)*	Unwanted catch (2017)*	Basis	F _{total} ages 2–6 (2017)	F _{wanted} ages 2–6 (2017)	F _{unwanted} ages 1–3 (2017)	SSB (2018)	% SSB change **	% TAC change total catch ***
Management plan (MP)	15251	14187	1065	15% TAC constraint in (MP)	0.17	0.14	0.04	76196	-1	15
MSY approach	18064	16800	1264	F _{MSY}	0.2	0.17	0.05	73429	-5	36
Zero catch	0	0	0	F = 0	0	0	0	91259	18	-100
Other options	11273	10488	785	TAC -15% (F ₂₀₁₆ × 0.75)	0.12	0.1	0.03	80116	4	-15
	13262	12337	925	Stable TAC (F ₂₀₁₆ × 0.89)	0.14	0.12	0.04	78155	1	0
	15251	14187	1065	TAC + 15% (F ₂₀₁₆ × 1.03)	0.17	0.14	0.04	76196	-1	15
	14757	13727	1030	F ₂₀₁₆	0.16	0.14	0.04	76682	-1	11
	35177	32680	2496	F _{pa}	0.44	0.37	0.11	56683	-27	165
	55589	51550	4040	SSB > B _{pa}	0.84	0.71	0.22	37000	-52	319
	45422	42164	3258	F _{lim}	0.62	0.53	0.16	46753	-39	242
	66927	61971	4955	SSB > B _{lim}	1.166	0.99	0.3	26300	-66	405
55589	51550	4040	SSB > MSY B _{trigger}	0.84	0.71	0.22	37000	-52	319	
<i>Mixed fisheries options – differences with calculations above can occur because of the different methodology used (ICES, 2016b.)</i> †										
Maximum	21551			A	0.26			66045	-14	
Minimum	10620			B	0.12			76786	-1	
Cod	14786			C	0.17			72686	-6	
SQ effort	18020			D	0.21			69508	-10	
Value	16321			E	0.19			71177	-8	

* “Wanted” and “unwanted” catch are used to described fish that would be landed and discarded in the absence of the EU landing obligation, based on the average discard rates (at age) estimates for 2013–2015.

** SSB 2018 relative to SSB 2017.

*** Total catch 2017 relative to TAC 2016.

Mixed-fisheries assumptions

(note: “fleet’s stock share” is used to describe the share of the fishing opportunities for each particular fleet, which has been calculated based on the single-stock advice for 2017 and the historical proportion of the stock landings taken by the fleet):

- Maximum scenario: Each fleet stops fishing when its last stock share is exhausted.
- Minimum scenario: Each fleet stops fishing when its first stock share is exhausted.
- Cod scenario: Each fleet stops fishing when its cod stock share is exhausted.
- SQ (status quo) effort scenario: The effort of each fleet in 2016 and 2017 is as in 2015.
- Value scenario: The effort of each fleet is equal to the weighted average of the efforts required to catch the fleet’s quota share of each of the stocks, where the weights are the relative catch values of each stock in the fleet’s portfolio.

† Version 2: Mixed-fisheries considerations as part of this advice added

Basis of the advice

Table 6.3.49.4 Sole in Subarea 4 (North Sea). The basis of the assessment and advice.

Advice basis	EU management plan (Council Regulation No. 676/2007; EU, 2007)
Management plan	An evaluation of the management plan (ICES, 2010) concluded that the management plan is precautionary. The stocks are in stage two of the EU multiannual plan (EU, 2007). Application of stage two of the plan is based on transitional arrangements until an evaluation of the plan has been conducted. ICES assumes that harvesting the stock with the newest estimate of F_{MSY} is in accordance with stage two of the current plan.

Quality of the assessment

The North Sea sole assessment was recently benchmarked (ICES, 2015a). The new assessment is very similar in terms of SSB and recruitment, but has a smoothed pattern of F over time.

Age compositions of the landings and discards are well sampled and the quality of the surveys is adequate. However, current survey indices do not cover the southwestern part of the stock distribution.

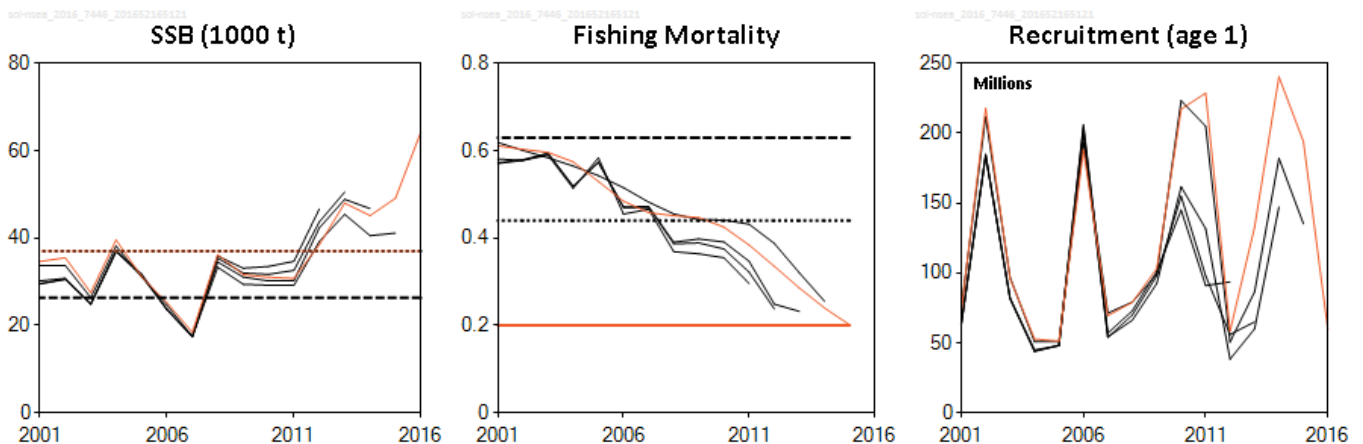


Figure 6.3.49.2 Sole in Subarea 4 (North Sea). Historical assessment results (final-year recruitment estimates included).

Issues relevant for the advice

Technical measures applicable to the mixed flatfish beam-trawl fishery in the southern North Sea affect both sole and plaice. The minimum mesh size of 80 mm generates high discards of plaice which have a larger minimum landing size than sole. The use of larger mesh sizes would reduce the catch of undersized plaice and sole, but would also result in loss of marketable sole in the short term (Cardinale and Hjelm, 2012).

Since 2011, the use of pulse trawls in the Dutch fishery has increased sharply to 74 vessels (of which 65 > 221 kW) and only few vessels operating with traditional beam trawls are now left. The increased use of pulse trawls and other adaptations like fuel-saving wings may affect catchability and selectivity of North Sea sole.

There is a long-term management plan for North Sea plaice and sole, which was evaluated by ICES to be in accordance with the precautionary approach. However, in 2016 ICES does not use this plan as the basis for the advice for plaice. The European Commission has informed ICES that agreement has not been reached between the EU and Norway on a method to split the joint advice between the North Sea and Skagerrak. ICES continues to use the management plan as the basis of advice for sole.

Results from a North Sea mixed-fisheries analysis are presented in ICES (2016b). For 2017, assuming a strictly implemented discard ban (corresponding to the “Minimum” scenario), haddock would be the most limiting stock (assuming that the full advised catch is taken), constraining 36 out of 41 fleet segments (corresponding to 91% of the 2015 kW days of effort). Cod and eastern Channel sole would be limiting for fleets, corresponding to 5% and 4% of the 2015 effort, respectively. Conversely, in the “Maximum” scenario with *Nephrops* managed by separate TACs for the individual functional units (FUs), *Nephrops* would be considered the least limiting stocks in many FUs. *Nephrops* in FU 33, FU 5, FU 32, FU 7, and FU Others would be the least limiting stocks for fleets in these FUs, representing 32%, 16%, 10%, 4%, and 17% of the 2015 effort, respectively. Eastern Channel plaice and saithe would be least limiting for other fleet segments, representing 12% and 9% of the 2015 effort, respectively.

Results for the North Sea sole stock are also included as additional rows in the catch options table of this advice sheet.

Reference points

Table 6.3.49.5 Sole in Subarea 4 (North Sea). Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	37000 t	Default to value of B_{pa} .	ICES (2015b)
	F_{MSY}	0.2	Median of stochastic MSY analysis, assuming a hockey-stick stock–recruit relationship.	ICES (2014)
Precautionary approach	B_{lim}	26300 t	Breakpoint of segmented regression	ICES (2015b)
	B_{pa}	37000 t	$B_{pa} = B_{lim} \times \exp(1.645 \sigma_B)$, with $\sigma_B = 0.20$	ICES (2015b)
	F_{lim}	0.62	The F that in equilibrium will maintain the stock above B_{lim} with a 50% probability	ICES(2016a)
	F_{pa}	0.44	$F_{pa} = F_{lim} \times \exp(-1.645 \sigma_F)$, with $\sigma_F = 0.20$	ICES(2016a)
Management plan	SSB_{MGT}	35000 t	Stage two	EU management plan (Council Regulation No. 676/2007)
	F_{MGT}	0.2	Stage two: Article 4.3 – F_{MSY}	EU management plan (Council Regulation No. 676/2007)

Basis of the assessment

Table 6.3.49.6 Sole in Subarea 4 (North Sea). The basis of the assessment and advice.

ICES stock data category	1 (ICES, 2016c)
Assessment type	Statistical catch-at-age model with flexible selectivity functions to reconstruct historical discard records (Aarts and Poos, 2009, ICES, 2015a)
Input data	Commercial catches (age frequencies from catch sampling), three survey indices (BTS-ISIS Q3, SNS Q3, DFS Q3). Natural mortality is assumed constant. Maturity-at-age is assumed to be knife-edged (at age 3) and constant over time.
Discards and bycatch	Discards are included in the assessment. Discard records (1957–2002) are reconstructed. In 2015, 90% of the landings had associated discarding information, and 78% of the discards were sampled.
Indicators	None
Other information	The stock has been benchmarked (ICES, 2015a). The main changes were the inclusion of discards and the removal of the Dutch beam trawl fleet commercial index (ICES, 2015b).
Working groups	Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) and Working Group on Mixed-Fisheries Advice (WGMIXFISH-ADVICE)

Information from stakeholders

The cumulative index of perceptions of the abundance of common sole (Figure 6.3.49.3) increased in about half of the areas (mainly in the south and east), but declined or remained the same in the others. The stock is primarily distributed in the southern areas (areas 5 and 6) and trends in these areas generally match the assessed stock biomass trends in recent years (Napier, 2014). No new information has been provided for 2015.

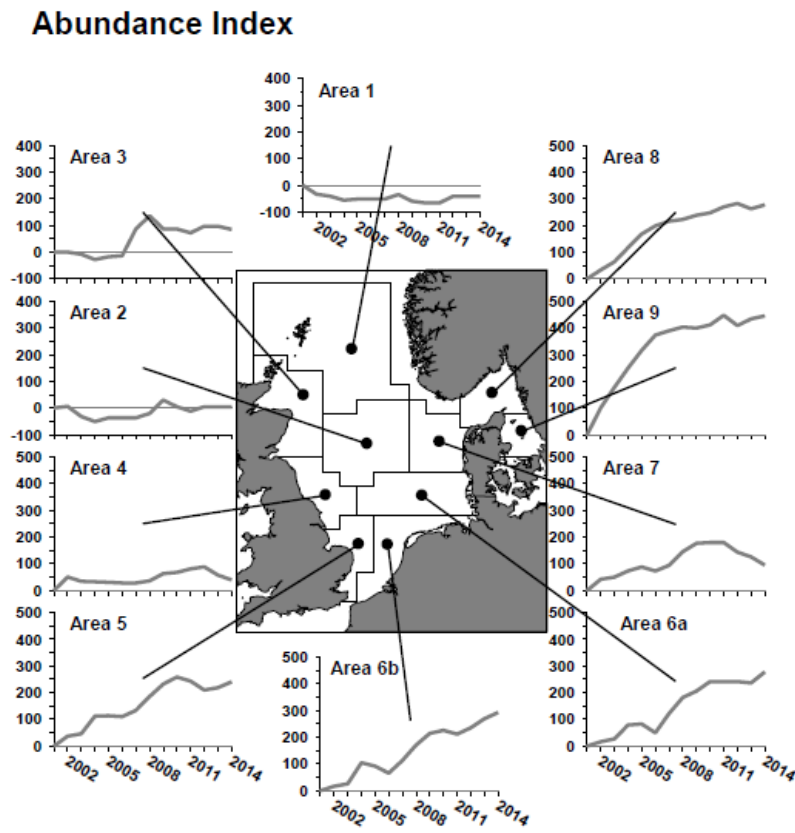


Figure 6.3.49.3 Cumulative time-series of index of perceptions of abundance of common sole by roundfish sampling area from the Fishers' North Sea Stock Survey (Napier, 2014; see page 14 for an explanation of the index).

History of the advice, catch, and management

Table 6.3.49.7 Sole in Subarea 4 (North Sea). History of ICES advice, the agreed TAC, and the official as well as ICES estimates of landings. All weights are in thousand tonnes.

Year	ICES advice	Predicted landings corresp. to advice	Predicted catch corresp. to advice	Agreed TAC	ICES landings	ICES discards
1987	Rebuild SSB to 40 000 t; TAC	11.0		14.0	17.4	
1988	Increase SSB towards 50 000 t; TAC	11.0		14.0	21.6	
1989	Increase SSB towards 50 000 t; TAC	14.0		14.0	21.8	
1990	80% of F(88); TAC	25.0		25.0	35.1	
1991	SSB >50 000 t ; TAC	27.0		27.0	33.5	
1992	TAC	21.0		25.0	29.3	
1993	no long-term gains in increased F	29.0*		32.0	31.5	
1994	no long-term gains in increased F	31.0*		32.0	33.0	
1995	no long-term gains in increased F	28.0*		28.0	30.5	
1996	Mixed fishery, link plaice advice	23.0*		23.0	22.7	
1997	< 80% of F(95)	14.6		18.0	14.9	
1998	75% of F(96)	18.1		19.1	20.9	
1999	F< F _{pa} (80% of F(97))	20.3		22.0	23.5	
2000	F< F _{pa}	< 19.8		22.0	22.6	
2001	F< F _{pa}	< 17.7		19.0	19.9	
2002	F< 0.37	< 14.3		16.0	16.9	1.7
2003	F< F _{pa}	< 14.6		15.9	17.9	1.4
2004	F< F _{pa}	< 17.9		17.0	18.8	2.4
2005	F< F _{pa}	< 17.3		18.6	16.4	1.3
2006	Keep SSB above B _{pa}	< 11.9		17.7	12.6	1.0
2007	SSB above B _{pa}	< 10.8		15.0	14.6	0.9
2008	SSB above B _{pa}	< 9.8		12.8	14.1	0.5
2009	Apply management plan	< 14.0		14.0	14.0	1.3
2010	Apply management plan	< 14.1		14.1	12.6	2.2
2011	See scenarios	-		14.1	11.5	1.7
2012	Apply first stage of the management plan	< 15.7		16.2	11.6	2.5
2013	Apply first stage of the management plan	< 14		14.0	13.1	2.1
2014	Apply first stage of the management plan	< 11.9		11.9	13.1	1.6
2015	November update: Apply second stage of the management plan	< 11.4		11.9	12.9	1.7
2016	Apply second stage of the management plan		≤ 12.8	13.3		
2017	Apply second stage of the management plan		≤ 15.3			

* Catch status quo F.

History of catch and landings

Table 6.3.49.8 Sole in Subarea 4 (North Sea). Catch distribution by fleet in 2015 as estimated by ICES.

Catch (2015)	Wanted catch				Unwanted catch
14.6 kt	87.8% beam trawls	8.8% gill-/ trammel nets	3.3% otter trawls	0.1% other gears	1.7 kt
	12.9 kt				

Table 6.3.49.9 Sole in Subarea 4 (North Sea). History of the official and ICES landings. All weights are in tonnes.

Year	Belgium	Denmark	France	Germany	Netherlands	UK	Other	Total reported landings	ICES total landings	TAC
1982	1900	524	686	266	17686	403	2	21467	21579	21000
1983	1740	730	332	619	16101	435		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	1033	50	14495	21805	14000
1990	2389	1427	352	2296	18202	1614	263	26543	35120	25000
1991	2977	1307	465	2107	18758	1723	271	27608	33513	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	30467	28000
1996	2555	1018	535	670	15344	848	229	21199	22651	23000
1997	1519	689	99	510	10241	479	204	13741	14901	18000
1998	1844	520	510	782	15198	549	339	19742	20868	19100
1999	1919	828	NA	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	16945	16000
2003	1605	703	728	749	12469	521	363	17138	17920	15850
2004	1477	808	655	949	12860	535	544	17828	18757	17000
2005	1374	831	676	756	10917	667	357	15579	16355	18600
2006	980	585	648	475	8299	910		11933	12594	17670
2007	955	413	401	458	10365	1203	5	13800	14635	15000
2008	1379	507	714	513	9456	851	15	13435	14071	12800
2009	1353	NA	NA	555	12038	951	1	NA	13952	14000
2010	1268	406	621	537	8770	526	1.38	12129	12603	14100
2011	857	346	539	327	8133	786	2	10990	11485	14100
2012	593	418	633	416	9089	599	3	11752	11602	16200
2013	697	497	680	561	9987	867	0	13291	13137	14000
2014	920	314	675	642	9569	840	0	12547	13060	11900
2015	933	271	532	765	8899	804	0	12203	12867	11900

NA = not available.

Summary of the assessment

Table 6.3.49.10 Sole in Subarea 4 (North Sea). Assessment summary. Weights are in tonnes.

Year	Recruitment Age 1 (thousands)	High	Low	Spawning-stock biomass	High	Low	Landings	Discards	Fishing mortality Ages 2–6	High	Low
1957	133173	156990	112878	62928	71209	54647	13181	739	0.213	0.255	0.172
1958	120070	142852	100956	65375	73525	57225	13235	701	0.216	0.244	0.188
1959	446825	531193	375916	68284	75999	60569	15479	937	0.228	0.259	0.197
1960	41799	50147	34867	69492	77012	61972	17466	1260	0.257	0.291	0.222
1961	68261	81701	57021	103720	114838	92602	27981	2777	0.305	0.339	0.271
1962	11057	13165	9286	87064	96252	77876	28290	1481	0.347	0.391	0.304
1963	12754	15349	10598	70159	77627	62691	22572	778	0.338	0.382	0.295
1964	611539	745278	502067	51556	58197	44915	14772	280	0.291	0.328	0.254
1965	151219	189075	120825	41217	47732	34702	10450	895	0.265	0.307	0.224
1966	55092	72335	41980	109817	125893	93747	32060	4723	0.297	0.342	0.253
1967	85651	113260	64768	106122	118156	94084	32749	2668	0.389	0.438	0.341
1968	120554	159318	91248	91237	100788	81686	34733	1819	0.501	0.569	0.434
1969	86543	117011	63958	69397	77025	61769	23590	2116	0.542	0.606	0.478
1970	203014	272262	151370	63714	71310	56118	21091	2200	0.522	0.585	0.458
1971	57000	75243	43197	56001	62722	49280	21295	2700	0.504	0.574	0.435
1972	110647	145129	84341	65080	73200	56960	25195	2221	0.525	0.582	0.468
1973	146093	185305	115179	47830	53508	42152	20773	1631	0.556	0.62	0.492
1974	122131	154094	96827	46208	51644	40772	20616	2120	0.551	0.615	0.487
1975	59092	75151	46478	46806	52080	41532	19338	2178	0.505	0.556	0.455
1976	138917	176374	109496	45552	50308	40796	16824	1631	0.464	0.52	0.408
1977	172911	224889	133071	37143	40406	33880	15510	1658	0.458	0.509	0.406
1978	63381	81207	49476	43159	47817	38501	18781	2233	0.483	0.532	0.435
1979	17880	22600	14144	52765	59454	46076	23045	2133	0.517	0.579	0.456
1980	181294	234784	140026	39168	42662	35674	16474	1040	0.531	0.585	0.477
1981	218640	287093	166448	25990	28171	23809	13339	1740	0.536	0.59	0.482
1982	204054	270103	154113	37887	43202	32572	20355	3565	0.558	0.624	0.493
1983	203846	272813	152278	49563	56093	43033	25889	4071	0.604	0.661	0.546
1984	95271	121937	74365	51530	58364	44696	27521	3874	0.646	0.711	0.581
1985	111974	140984	88930	47927	53897	41957	25123	2846	0.644	0.711	0.577
1986	163489	203524	131460	38037	41458	34616	18051	1841	0.593	0.644	0.542
1987	84106	103456	68398	34507	38027	30987	15870	1950	0.534	0.589	0.479
1988	686583	852339	552528	42206	46916	37496	17661	1996	0.499	0.548	0.449
1989	135009	165516	110104	38607	42273	34941	21383	3764	0.489	0.533	0.445
1990	247976	302317	203368	125120	145880	104360	48929	6398	0.491	0.544	0.439
1991	88638	109200	71902	91008	101096	80920	38715	3537	0.494	0.539	0.449
1992	442592	547315	357618	88799	97193	80405	34069	2956	0.506	0.551	0.462
1993	88109	109581	70798	59020	63707	54333	29598	3671	0.534	0.587	0.481
1994	64572	81497	51209	85156	95328	74984	34753	4031	0.573	0.618	0.528
1995	113851	143585	90339	64557	71797	57317	30630	2296	0.618	0.669	0.568
1996	76031	96976	59622	38480	41597	35363	20241	1749	0.654	0.712	0.596
1997	326152	423276	251254	32375	35546	29204	16388	2045	0.666	0.715	0.616
1998	150896	192136	118426	24075	26478	21672	18008	3556	0.662	0.725	0.599
1999	116975	146418	93506	48060	55757	40363	24942	3937	0.647	0.708	0.586
2000	140444	173255	113946	40595	45519	35671	20461	2610	0.627	0.676	0.578
2001	72200	87683	59427	34640	38191	31089	18453	2247	0.612	0.668	0.555
2002	217842	266540	178210	35489	39122	31856	16617	1817	0.603	0.653	0.554
2003	96079	117241	78748	27520	30093	24947	16691	3007	0.596	0.643	0.549

Year	Recruitment Age 1 (thousands)	High	Low	Spawning-stock biomass	High	Low	Landings	Discards	Fishing mortality Ages 2–6	High	Low
2004	52786	63207	44083	39574	44315	34833	17420	2800	0.575	0.63	0.519
2005	51243	61249	42843	31191	34147	28235	12936	1535	0.53	0.573	0.487
2006	188203	223267	158558	25213	27280	23146	10577	1078	0.485	0.529	0.44
2007	69450	82705	58277	18415	19861	16969	9460	1576	0.458	0.504	0.413
2008	79121	95199	65794	36219	40422	32016	13352	1836	0.451	0.492	0.411
2009	103169	124499	85472	31630	34919	28341	12399	1480	0.447	0.499	0.394
2010	217368	265891	177577	31029	34272	27786	11971	1596	0.425	0.485	0.366
2011	228790	288445	181632	30767	34695	26839	11997	2015	0.384	0.45	0.319
2012	58439	77375	44160	38452	44462	32442	14339	2147	0.335	0.408	0.263
2013	132788	185639	95077	48012	56644	39380	15059	1602	0.286	0.351	0.221
2014	240457	360022	160505	45163	55058	35268	13302	1398	0.24	0.298	0.182
2015	194127	361899	104076	49142	60909	37375	12630	1663	0.201	0.266	0.137
2016	59248			64312							

Sources and references

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[‡] Version 2: Reference added