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

## ICES stock advice

Please note: This advice was updated in November 2017 (ICES, 2017c).

ICES advises that when the second stage of the EU management plan (Council Regulation No. 676/2007) is applied, catches in 2018 should be no more than 14 900 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 slightly above F_{MSY} in 2016. Recruitment (R) has fluctuated below average without trend since the early 1990s.
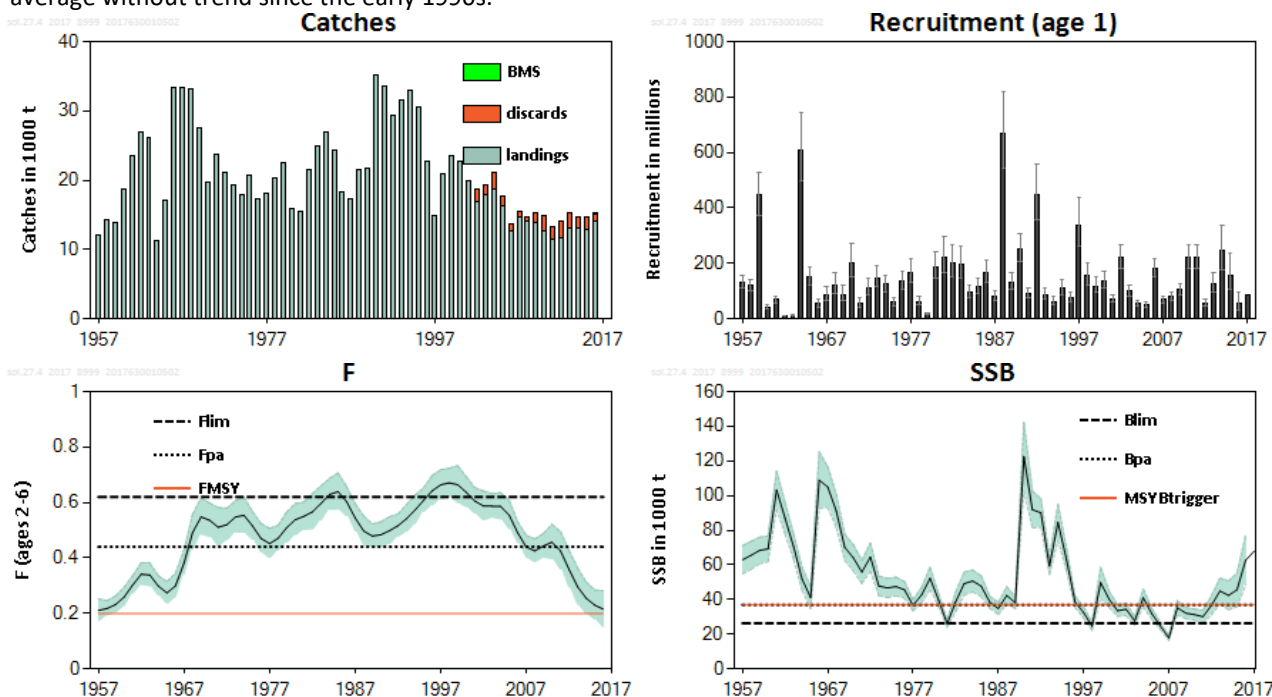
Figure 1   Sole in Subarea 4. Summary of the stock assessment. Shaded areas (F, SSB) and error bars (R) indicate ± 2×standard error (approximately 95% confidence intervals).

Stock and exploitation status

Table 1   Sole in Subarea 4. State of the stock and fishery relative to reference points.

		Fishing pressure				Stock size		
		2014	2015	2016		2015	2016	2017
Maximum Sustainable Yield	F_{MSY}	❌	❌	❌ Above	MSY $B_{Trigger}$	✅	✅	✅ Above trigger
Precautionary Approach	$F_{pa'}$ F_{lim}	✅	✅	✅ Harvested sustainably	$B_{pa'}$ B_{lim}	✅	✅	✅ Full reproductive capacity
Management plan	F_{MGT}	❌	❌	❌ Above	B_{MGT}	✅	✅	✅ Above

Catch options

Table 2   Sole in Subarea 4. The basis for the catch options.

Variable	Value	Source	Notes
F ages 2–6 (2017)	0.21	ICES (2017a)	TAC constraint for total catch based on TAC for 2017 (16123 tonnes)
SSB (2018)	62818	ICES (2017a)	Tonnes
R_{age1} (2017)	86425	ICES (2017a)	RCT3, thousands
R_{age1} (2018)	112078	ICES (2017a)	Geometric mean (1957–2013), thousands
Total catch (2017)	16123	ICES (2017a)	TAC 2017, tonnes
Wanted catch (2017)	15029	ICES (2017a)	Average landings rate by age 2014–2016, tonnes
Unwanted catch (2017)	1094	ICES (2017a)	Average discard rate by age 2014–2016, tonnes

Table 3   Sole in Subarea 4. Annual catch options. All weights are in tonnes.

Basis	Total catch (2018) ^	Wanted catch* (2018)	Unwanted catch* (2018)	F_{total} (ages 2–6) (2018)	F_{wanted} (ages 2–6) (2018)	$F_{unwanted}$ (ages 1–3) (2018)	SSB (2019)	% SSB change **	% TAC change ***
ICES advice basis									
F_{mp}	14900	14017	882	0.20	0.171	0.048	61164	−3.5	−7.6
Other options									
MSY approach: F_{MSY}	14900	14017	882	0.20	0.171	0.048	61164	−3.5	−7.6
F = 0	0	0	0	0	0	0	74895	18.2	−100
F_{pa}	29165	27390	1775	0.44	0.38	0.105	48120	−24	81
F_{lim}	37801	35454	2346	0.62	0.53	0.147	40293	−36	134
SSB (2019) = B_{lim}	53464	49992	3472	1.06	0.91	0.25	26300	−58	232
SSB (2019) = B_{pa}	41456	38859	2597	0.71	0.60	0.168	37000	−42	157
SSB (2019) =	41456	38859	2597	0.71	0.60	0.168	37000	−42	157
F = F_{2017}	15365	14454	910	0.21	0.177	0.049	60737	−4.1	−4.7
Mixed-fisheries options									
A: Max.	24210			0.34			56174	−11	
B: Min.	11924			0.15			67469	6	
C: Stock	14363			0.18			66631	5	
D: SQ effort	18659			0.28			54211	−14	
E: SQ effort	16679			0.23			60859	−4	
F: Value	15114			0.20			64530	2	
G: Range	13545			0.18			62409	−1	

* "Wanted" and "unwanted" catch are used to describe fish that would be landed and discarded in the absence of the EU landing obligation, based on average discard rate estimates for 2014–2016.

** SSB 2019 relative to SSB 2018 (63 353 t).

*** Total catch in 2018 relative to TAC in 2017 (16 123 t).

^ Differences between the total catch and the sum of wanted and unwanted catches result from rounding.

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 2018 and the historical proportion of the stock landings taken by the fleet):

A. Maximum scenario: Each fleet stops fishing when its last stock share is exhausted.

B. Minimum scenario: Each fleet stops fishing when its first stock share is exhausted.

C. HAD: Each fleet stops fishing when its individual haddock share is exhausted.

D. POK: Each fleet stops fishing when its individual saithe share is exhausted.

E. SQ (*status quo*) effort scenario: The effort of each fleet in 2017 and 2018 is as in 2016.

F. 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.

G. Range scenario: where the potential for TAC mismatches in 2018 are minimized within the F_{MSY} range, for the demersal fish stocks for which such a range is available (cod.27.47d20; had.27.46a20; pok.27.3a46; ple.27.420; ple.27.7d; sol.27.4; sol.27.7d).

Basis of the advice

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

Advice basis	EU management plan (Council Regulation No. 676/2007; EU, 2007).
Management plan	An evaluation of the management plan for North Sea plaice and sole (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 sole stock with the newest estimate of F_{MSY} is in accordance with stage two of the current plan.

Quality of the assessment

There are currently no major issues in relation to this assessment.

Figure 2   Sole in Subarea 4. Historical assessment results (final-year recruitment estimates included).

Issues relevant for the advice

Between 2014 and 2017 the use of pulse trawls in the Dutch fishery operating in the North Sea has increased to 76 vessels (of which 65 > 221 kW) and a handful of vessels operating with traditional beam trawls are now left.

The EU long-term management plan for North Sea plaice and sole was evaluated by ICES to be in accordance with the precautionary approach (ICES, 2010). ICES continues to use the management plan as the basis of advice for North Sea sole.

It is expected that under the EU landing obligation, below minimum size fish that would formerly have been discarded would now be reported as below minimum size (BMS) landings in logbooks. However, BMS landings reported to ICES may be lower than expected for several reasons: fish caught below minimum size could either not have been landed and not recorded in logbooks, or landed but not recorded as BMS; additionally, BMS landings recorded in logbooks may not be reported to ICES.

In the case of sole, there is no indication that fish that would formerly have been discarded are being reported as BMS, based on the observation that BMS landings reported to ICES are currently much lower than the estimates of discards from observer programmes, which estimate discards at 8% of the total catch.

Results from a North Sea mixed-fisheries analysis are presented in ICES (2017b). For 2018, assuming a strictly implemented discard ban (corresponding to the "Minimum" scenario), whiting would be the most limiting stock, being estimated to constrain 24 out of 42 fleet segments. Haddock is the second most limiting stock, constraining eight fleet segments. Additionally, if Norway lobster was managed by separate TACs for the individual functional units (FUs), Norway lobster in FU 6 would be considered the most limiting stock for ten fleet segments. Conversely, in the "Maximum" scenario, saithe and Eastern Channel plaice would be least limiting for 20 and 11 fleet segments, respectively. Finally, if Norway lobster was managed by separate TACs, Norway lobster in FUs 7, 5, 33, and 4.non-FU would be the least limiting for nine, two, one, and two fleet segments, respectively. For those demersal fish stocks for which the F_{MSY} range is available, a "range" scenario is presented that minimizes the potential for TAC mismatches in 2018 within the F_{MSY} range. This scenario returns

a fishing mortality by stock which, if used for setting single-stock fishing opportunities for 2018, may reduce the gap between the most and the least restrictive TACs, thus reducing the potential for quota over- and undershoot. This "range" scenario suggests that the potential for mixed-fisheries mismatch would be lowered with a 2018 TAC in the lower part of the F_{MSY} range for Eastern English Channel plaice and saithe, and in the upper part of the range for cod and North Sea plaice.

Reference points

Table 5   Sole in Subarea 4. 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 (2015a)
	F_{MSY}	0.20	EQsim analysis, assuming a hockey-stick stock–recruit relationship based on the recruitment period 1958–2010.	ICES (2015a)
Precautionary approach	B_{lim}	26300 t	Break-point of hockey-stick stock–recruit relationship, based on the recruitment period 1958–2010.	ICES (2015a)
	B_{pa}	37000 t	$B_{lim} \times \exp(1.645 \times 0.2) \approx 1.4 \times B_{lim}$	ICES (2015a)
	F_{lim}	0.62	EQsim analysis based on the recruitment period 1958–2010.	ICES (2016a)
	F_{pa}	0.44	$F_{lim} \times \exp(-1.645 \times 0.2) \approx F_{lim} / 1.4$	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   Sole in Subarea 4. Basis of assessment and advice.

ICES stock data category	1 (ICES, 2016b).
Assessment type	Statistical catch-at-age model with flexible selectivity functions to reconstruct historical discard records (Aarts and Poos, 2009; ICES, 2017a)
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, BMS landings, and bycatch	Discards are included in the assessment. Discard records (1957–2002) are reconstructed. In 2016, 89.96% of the landings had associated discarding information, and 89.07% of the discards were sampled. BMS landings, where reported, are included with discards as unwanted catch in the assessment from 2016.
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 group	Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)

Information from stakeholders

No additional information was provided.

History of the advice, catch, and management

Table 7   Sole in Subarea 4. ICES advice and official landings. All weights are in tonnes.

Year	ICES advice	Predicted landings corresp. to advice	Predicted catch corresp. to advice	Agreed TAC	ICES landings	ICES discards	BMS reported to ICES
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	21805		
1990	80% of F(88); TAC	25000		25000	35120		
1991	SSB >50 000 t; TAC	27000		27000	33513		
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		
1995	no long-term gains in increased F	28000*		28000	30467		
1996	Mixed fishery, link plaice advice	23000*		23000	22651		
1997	< 80% of F(95)	14.600		18000	14901		
1998	75% of F(96)	18100		19100	20868		
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	16945	1700	
2003	F< F_{pa}	< 14600		15900	17920	1400	
2004	F< F_{pa}	< 17900		17000	18757	2400	
2005	F< F_{pa}	< 17300		18600	16355	1300	
2006	Keep SSB above B_{pa}	< 11900		17700	12594	1000	
2007	SSB above B_{pa}	< 10800		15000	14635	900	
2008	SSB above B_{pa}	< 9800		12800	14071	500	
2009	Apply management plan	< 14000		14000	13952	1300	
2010	Apply management plan	< 14100		14100	12603	2200	
2011	See scenarios	-		14100	11485	1700	
2012	Apply first stage of the management plan	< 15700		16200	11602	2500	
2013	Apply first stage of the management plan	< 14000		14000	13137	2100	
2014	Apply first stage of the management plan	< 11900		11900	13060	1600	
2015	*Apply second stage of the management	< 11400		11900	12867	1700	
2016	Apply second stage of the management plan		≤ 12800	13262	14127	1208	15
2017	Apply second stage of the management plan		≤ 15300	16123			
2018	Apply second stage of the management plan		≤ 14900				

* November update.

History of the catch and landings

Table 8   Sole in Subarea 4. Catch distribution by fleet in 2016 as estimated by and reported to ICES.

Catch	Wanted catch				Unwanted catch	
	Beam trawl	Gillnets 3.83%	Trammelnets	other	Discards	BMS landings
15350 tonnes	14127 tonnes				1208 tonnes	15 tonnes

Table 9 Sole in Subarea 4. History of commercial catch and landings; both the official reported and ICES estimated values are presented by area for each country. All weights are in tonnes.

Year	Belgium (reported)	Denmark (reported)	France (reported)	Germany (reported)	Netherlands (reported)	UK (reported)	Other (reported)	Total reported landings	ICES total landing	TAC
1982	1900	524	686	266	17686	403	2	21467	21579	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	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	0	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	476	NA	555	12038	951	1	*14898	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
2016	**767	**355	**362	**861	**9600	**705	**0	**12651	14127	13262

* These totals do not include reported official landings of all countries.
** Preliminary reported landings.
NA = not available.

Summary of the assessment

Table 10 Sole in Subarea 4. Assessment summary. Weights are in tonnes. 'High' and 'Low' are ±2 standard error (approximately 95% confidence intervals).

Year	Recruitment Age 1 thousands	High	Low	SSB tonnes	High	Low	Wanted catch tonnes	Unwanted catch* tonnes	F Ages 2–6	High	Low
1957	133277	157330	112859	62951	71130	54772	12067		0.21	0.25	0.170
1958	119237	142089	100087	65521	73570	57472	14287		0.22	0.25	0.190
1959	445212	528931	374515	68339	75969	60709	13832		0.23	0.26	0.20
1960	41864	50175	34917	69232	76648	61816	18620		0.26	0.29	0.22
1961	68533	82118	57187	103212	114205	92215	23566		0.30	0.34	0.27
1962	11002	13109	9233	86875	95959	77791	26877		0.34	0.38	0.30
1963	12732	15346	10564	70529	77938	63120	26164		0.34	0.38	0.30
1964	606577	742576	495895	51794	58345	45243	11342		0.30	0.34	0.26
1965	149746	186924	120035	41119	47516	34722	17043		0.27	0.32	0.23
1966	55012	71824	42109	108951	125152	92748	33340		0.30	0.35	0.25
1967	86645	115522	65041	104919	116658	93182	33439		0.38	0.43	0.33
1968	123437	164049	92789	91218	100712	81724	33179		0.49	0.56	0.43
1969	88165	119475	65065	70097	77685	62509	27559		0.55	0.62	0.48
1970	202370	272998	150058	64109	71649	56569	19685		0.54	0.60	0.47
1971	56296	73765	42931	55916	62603	49229	23652		0.51	0.58	0.44
1972	110810	145318	84569	64570	72612	56530	21086		0.52	0.58	0.46
1973	148539	189624	116448	47820	53446	42194	19309		0.55	0.61	0.49
1974	124012	156198	98432	46689	52231	41147	17989		0.55	0.62	0.49
1975	59216	75430	46492	47513	52848	42178	20773		0.52	0.57	0.46
1976	136518	173265	107519	45657	50424	40890	17326		0.47	0.52	0.42
1977	168197	215647	131216	36705	39942	33468	18003		0.45	0.51	0.40
1978	63044	81336	48906	42569	46975	38163	20280		0.47	0.52	0.43
1979	18291	23135	14462	52281	58659	45901	22598		0.51	0.57	0.45
1980	187369	242191	145004	39679	43325	36033	15807		0.54	0.60	0.48
1981	221990	294779	167045	26090	28240	23940	15403		0.55	0.60	0.50
1982	200654	265338	151636	38600	44239	32961	21579		0.57	0.63	0.50
1983	197456	262073	148690	49211	55814	42608	24927		0.60	0.66	0.53
1984	94911	122514	73572	50710	56982	44438	26839		0.63	0.69	0.57
1985	115068	144128	91816	47706	53694	41718	24248		0.64	0.71	0.57
1986	167104	209831	132978	38487	41934	35040	18201		0.60	0.66	0.55
1987	82858	101873	67408	34879	38436	31322	17368		0.55	0.60	0.49
1988	667131	820279	542856	42374	47412	37336	21590		0.50	0.55	0.44
1989	133529	164266	108528	38162	41582	34742	21805		0.48	0.52	0.44
1990	253242	308603	207771	122584	142153	103007	35120		0.48	0.53	0.44
1991	91031	111886	74070	91883	102544	81222	33513		0.50	0.55	0.45
1992	448133	559881	358800	90099	98379	81819	29341		0.52	0.56	0.47
1993	87272	108989	69913	59420	64350	54490	31491		0.54	0.59	0.49
1994	63189	79110	50483	84580	94924	74236	33002		0.57	0.63	0.52
1995	110762	139291	88052	62927	69484	56370	30467		0.61	0.65	0.56
1996	75318	94750	59814	38775	42087	35463	22651		0.64	0.70	0.59
1997	336195	435435	259341	32537	35715	29359	14901		0.66	0.72	0.61
1998	156889	203756	120731	24627	27055	22199	20868		0.67	0.72	0.62
1999	118445	148961	94142	49838	58603	41073	23475		0.66	0.73	0.60
2000	138196	170399	111983	40152	44795	35509	22641		0.64	0.69	0.58
2001	71605	87062	58902	33565	36894	30236	19944		0.61	0.65	0.56
2002	220969	267923	182325	34391	37962	30820	16945	1712	0.59	0.64	0.53
2003	99003	121431	80733	27656	30096	25216	17920	1364	0.59	0.63	0.54
2004	53342	64132	44325	41024	46122	35926	18757	2353	0.59	0.64	0.54
2005	49858	59091	42073	31855	35038	28672	16355	1341	0.55	0.61	0.50
2006	181664	215585	153106	24799	26734	22864	12594	994	0.49	0.53	0.45
2007	68707	81323	58094	17880	19315	16445	14635	871	0.44	0.48	0.40
2008	78724	94532	65599	35279	39309	31249	14071	545	0.43	0.47	0.38

Year	Recruitment Age 1 thousands	High	Low	SSB tonnes	High	Low	Wanted catch tonnes	Unwanted catch* tonnes	F Ages 2–6	High	Low
2009	103983	126263	85637	32163	35379	28947	13952	1261	0.44	0.49	0.40
2010	221683	267768	183528	31358	34548	28168	12603	2246	0.46	0.52	0.39
2011	219556	267830	179852	30070	33758	26382	11485	1703	0.43	0.50	0.36
2012	56463	70921	44922	36744	42240	31248	11602	2528	0.36	0.43	0.29
2013	127683	168299	96809	44948	52373	37523	13137	2119	0.30	0.36	0.23
2014	245184	338284	177790	42397	50759	34035	13060	1568	0.26	0.31	0.20
2015	158732	235226	107119	45650	55408	35892	12867	1763	0.23	0.29	0.176
2016	53947	97229	29947	62636	76805	48467	14127	1223	0.22	0.28	0.148
2017	86425**			67961							

* Unwanted catch values include discards and BMS landings from 2016.

** RCT3 estimates.

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