Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East (Skagerrak and Kattegat and northern North Sea in the Norwegian Deep)

ICES advice on fishing opportunities

ICES advises that when the MSY approach is applied, catches should be no more than 7712 tonnes in 2022, and catches for the first six months of 2023 should be no more than 5882 tonnes.

Stock development over time

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

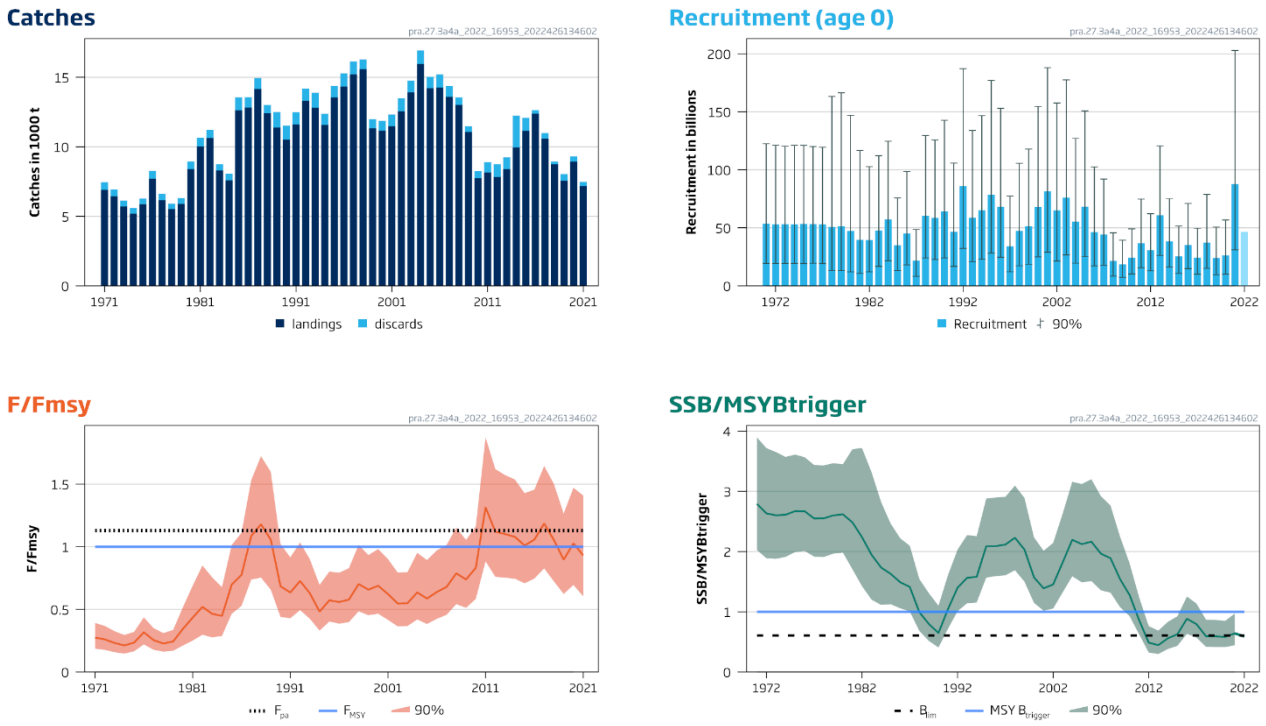

Figure 1 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. Summary of the stock assessment. The assumed recruitment value for 2022 is shown in a lighter shade of blue. [Note: B_{pa} = MSY $B_{trigger}$]. Spawning-stock biomass (SSB) is the biomass of mature females.

Update for the catch scenarios 2022

Table 1 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. Assumptions made in the forecast.

Variable	Value	Notes
F_{2021*}/F_{MSY}	0.921	From the assessment; relative value
SSB_{2022}/MSY $B_{trigger}$	0.60	From the assessment; relative value
R_{2022}	46.61	Estimated from the model; in billions

* $F_{2021}=F_{MSY} \times (SSB_{2021}/\text{MSY } B_{trigger})$

Table 2 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2022)	F_{total} (2022)/F_{MSY}	Stock size (2023)/$B_{trigger}$	% probability^ of SSB (2023) <B_{lim}	% probability^ of SSB (2023) >$B_{trigger}$	% SSB change*	% TAC change **	% advice change***
MSY approach: $F = F_{MSY} \times (SSB_{2022}/MSY\ B_{trigger})$	7712	0.60	0.79	14.1	14.5	32	7.6	7.6
Other scenarios								
F = 0	0	0	1.04	0.3	58.6	73.3	−100	−100
F_{pa}	13475	1.13	0.61	53.2	3.0	1.67	88	88
F_{2021}	11454	0.93	0.67	38.8	4.8	11.7	60	60
$SSB_{2023} = B_{lim}$	13177	1.10	0.63	49.3	3.2	5.0	84	84
$SSB_{2023} = B_{pa} = B_{trigger}$	1120	0.08	1.00	0.7	50.4	66.7	−84.37	−84

* $SSB_{2023}/MSY\ B_{trigger}$ relative to predicted $SSB_{2022}/MSY\ B_{trigger}$.
** Advised catch in 2022 relative to TACs in 2021 (7166 tonnes).
*** Advised catch in 2022 relative to advised catch in 2021 (7166 tonnes).
^ Note this probability relates to the short-term probability of SSB< B_{lim} and is not comparable to the long-term probability of SSB<B_{lim} tested in simulations when estimating fishing mortality reference points.

The stock was benchmarked in 2022 (ICES, 2022a), which resulted in a new assessment model, new reference points, and a changed perception of the stock. The stock estimates are therefore not directly comparable to the assessment in 2021.

Catch scenarios for the first six months of 2023

In order to provide catch advice for 2023, an additional assessment was conducted that assumes catches in 2022 are consistent with the present advice (7712 tonnes).

Table 3 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
F_{2022*}/F_{MSY}	0.73	Average exploitation pattern (2020–2022); scaled to the catch advice for 2022
$SSB_{2023}/MSY\ B_{trigger}$	0.68	Short-term forecast
R_{2023}	39.67	Estimated from the model; in billions
Catches 2022	7712	Catch advice for 2022; in tonnes.

* $F_{2022} = F_{MSY} \times (SSB_{2022}/MSY\ B_{trigger})$

Table 4 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	Q1 and Q2 catch (2023)^	F_{total} (2023)/ F_{MSY}	Stock size (2024)/ $B_{trigger}$	% probability^^ of SSB (2024) < B_{lim}	% probability^^ of SSB (2024)>$B_{trigger}$	% SSB change*	% TAC change **	% advice change***
MSY approach: $F=F_{MSY}\times(SSB_{2023}/MSY\ B_{trigger})$	11646	5882	0.6764	1.33	0.6		96	51	51
F = 0	0	0	0	1.80	0		165	−100	−100
F_{pa}	17814	8997	1.13	1.05	6.8		54	131	131
F_{2022}	12186	6155	0.71	1.31	0.8		93	58	58
$SSB_{2024} = B_{lim}$	27765	14023	2.08	0.67	44.6		−1.47	260	260
$SSB_{2024} = B_{pa} = B_{trigger}$	19280	9738	1.25	0.99	16.5		46	150	150

* $SSB_{2024}/MSY\ B_{trigger}$ relative to predicted $SSB_{2023}/MSY\ B_{trigger}$.
** Advised catch in 2023 relative to advised catch in 2022 (7712 t).
^ Total catch 2023 × average proportion of catch taken in the first six months of each of the years 2017–2021 (0.505).
^^ Note this probability relates to the short-term probability of SSB< B_{lim} and is not comparable to the long-term probability of SSB<B_{lim} tested in simulations when estimating fishing mortality reference points.

The initial catch advice for 2023 is 51% greater than the advised catch for 2022 mainly because the estimated 2021 and the projected 2022 year classes are larger than the 2020 year class.

Basis of the advice

Table 5 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. The basis of the advice.

Advice basis	MSY approach
Management plan	In April 2018, a long-term management strategy (LTMS) was agreed by the EU and Norway (Anon., 2018). ICES has evaluated this strategy and found it to be precautionary (ICES, 2017a). The LTMS has been applied since 2019. However, the adoption of a new assessment model with new reference points requires the LTMS to be evaluated.

Quality of the assessment

The stock was benchmarked in 2022, during which it was agreed that in order to account for uncertainty in natural mortality an ensemble of three models would be used to estimate stock status and forecast. The use of an ensemble model and forecast is considered to result in a significant improvement in the quality of the assessment and advice. The perception of the status of the stock is similar to the previous assessment.

Issues relevant for the advice

The stock was benchmarked in 2022 and this resulted in a new model and new reference points. The adoption of a new assessment model with new reference points requires the LTMS to be evaluated.

The catch forecast for 2023 depends on the 2022 uptake, which is assumed to be equal to the advised catch (7712 tonnes).

The initial catch advice for 2023 depends to great extent on the large estimated 2021 and projected 2022 year classes. However, the estimation of the 2021 year-class is based on a single source (the Norwegian survey in 2022) and is associated with large uncertainty. The projection of the 2022 year class is based on the stock—recruitment relationship and is associated with even greater uncertainty.

With the potentially large incoming 2021 year class there is an increased risk of discarding of small shrimp in 2022.

National quota management should take account of the loss in landed weight compared to live weight due to on-board boiling.

Reference points

Table 6 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. Reference points, values, and their technical basis.

Framework	Reference	Value*	Technical basis	Source
MSY approach	MSY $B_{trigger}$	$0.8 \times B_{30\%}$	Relative value; set at 80% of $B_0 \times 30\%$ (B_{MSY}); determined through management strategy evaluation with the objective to achieve high sustainable yields without exceeding a 5% probability of SSB falling below B_{lim} in any single year	ICES (2022a)
	F_{MSY}	$F_{B30\%}$	Relative value; set as the F which will achieve $B_0 \times 30\%$ (B_{MSY}); determined through management strategy evaluation with the objective to achieve high sustainable yields without exceeding a 5% probability of SSB falling below B_{lim} in any single year	ICES (2022a)
Precautionary approach	B_{lim}	$0.15 \times B_0$	Relative value; set at 15% of B_0, which is approximately the average B_{loss} for the three models in the ensemble	ICES (2022a)
	B_{pa} MSY $B_{trigger}$	$0.8 \times B_{30\%}$	Relative value; set at 80% of $B_0 \times 30\%$ (B_{MSY}); determined through management strategy evaluation with the objective to achieve high sustainable yields without exceeding a 5% probability of SSB falling below B_{lim} in any single year.	ICES (2022a)
	F_{pa}	$1.13 \times F_{MSY}$	F_{P05}. The F that leads to SSB ≥ B_{lim} with 95% probability	ICES (2022a)
Management plan	B_{mgt}			
	F_{mgt}			

*Fishing mortality is presented only in relation to F_{MSY} and total stock biomass is presented only in relation to B_{MSY}. These values are directly estimated from the stock assessment and change when the assessment is updated.

Basis of the assessment

Table 7 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. Basis of the assessment and advice.

ICES stock data category	1 (ICES, 2021)
Assessment type	Quarterly, two-area length-based analytical assessment (Stock Synthesis 3) that uses catches in the model and in the forecast. An ensemble of three models is used where each model differs based on the assumed level of M.
Input data	Length–frequency distributions from commercial landings, discards, catches and survey. Commercial landings and discards (since 2008), commercial catches (since 1970) and a survey index derived from Norwegian shrimp surveys (based on three survey time series: 1984–2002; 2004–2005, and 2006–onwards [G7438, G7635, and G1758]). The model estimates discards for the entire time-series, but bases the estimates on observed values since 2008. Boiled landings have been corrected for loss in weight by a factor of 1.13.
Discards and bycatch	Discards are included in the assessment (Swedish observed values since 2008, Norwegian values since 2009 and Danish values since 2013). Norwegian discards were estimated using the Danish discard ratio until 2016 and using data from the Norwegian Coastal Reference fleet since 2017.
Indicators	Swedish, Danish, and Norwegian standardized landings per unit of effort (LPUE)
Other information	This stock was benchmarked in January 2022 (ICES, 2022a)
Working group	Joint NAFO/ICES *Pandalus* Assessment Working Group (NIPAG)

History of the advice, catch, and management

Table 8 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. ICES advice and official landings. All weights are in tonnes. ICES discard estimates were revised during the 2022 benchmark.

Year	ICES advice	Landings corresponding to advice	Catch corresponding to initial advice	Catch corresponding to final advice	TAC Division 3.a	TAC Norwegian zone Subarea 4	ICES discard estimates	ICES landings	ICES catch (discards and landings)
1987	Not assessed							14162	
1988	Catches significantlybelow 1985–1986 catch							12409	
1989	No advice				3100 *			11384	
1990	3.a: F as F (pre-1985); 4.a East: no increase in F	10000			2750 *			10526	
1991	No increase in F; TAC	12000			8550			11600	
1992	Within safe biological limits	15000**			10500	4500		13322	
1993	Within safe biological limits	13000**			10500	4500		12814	
1994	Within safe biological limits	19000**			12600	5400		11578	
1995	Within safe biological limits	13000**			11200	4800		13548	
1996	No advice	11000**			10500	4500		14338	
1997	No advice	13000**			10500	4500		15208	
1998	No increase in F; TAC	19000**			13160	5640		15584	
1999	Maintain F	19000**			13160	5640		11322	
2000	Maintain F	< 11500**			9100	3900		11160	
2001	Maintain F	13400			10150	4350		11478	
2002	Long-term average landings	12600			10150	4350		12560	
2003	Maintain F	14700			10150	4425		13908	
2004	No increase in F	15300^			10710	4590		15960	
2005	No increase in catch above recent level	~13000^			10710	4590		14218	
2006	No increase in catch above recent level	~13500^			11200	4800		14268	
2007	No increase in landings above recent level	~14000^			11620	4980		13600	
2008	No increase in landings above recent level	~15000^			11620	4980	540	13016	13556
2009	Same advice as last year	~15000^			11620	4980	415	11069	11484
2010	No increase in landings above 2008 level	~13000^			9800	4200	496	7754	8250
2011	At least 30% decrease in landings of 2007–2009, reduce discards, mandatory sorting grids	< 8800			8300	3570	731	8161	8892
2012	Reduce catches and reduce discards	-			7100	3035	919	7829	8748
2013	Reduce landings by 36% and reduce discards	≤ 5800			6650	2850	855	8396	9251
2014	MSY considerations, reduce discards	≤ 5426		≤ 6000	6650	2850	2289	9951	12240

Year	ICES advice	Landings corresponding to advice	Catch corresponding to initial advice	Catch corresponding to final advice	TAC Division 3.a	TAC Norwegian zone Subarea 4	ICES discard estimates	ICES landings	ICES catch (discards and landings)
2015	MSY considerations; no increase in F; reduce discards	≤ 9777		≤ 10900	7630	3270	945	11145	12090
2016	MSY approach	≤ 11869^^		≤ 13721	10987	4709	248	12387	12635
2017	MSY approach			≤ 10316	7221	3095	423	10571	10994
2018	MSY approach		≤ 10475	≤ 8571	6230	2670	212	8734	8946
2019	Long-term management strategy		≤ 9036	≤ 6163	4314	1849	472	7569	8041
2020	Long-term management strategy		≤ 12439	≤ 8736	6116	2620	383	8937	9320
2021	Long-term management strategy		≤ 8753	≤ 7166	5016	2150	311	7173	7484
2022	Long-term management strategy/MSY approach (final advice)		≤ 5554[#]	≤ 7712					
2023	MSY approach		≤ 5882[##]						

* EU zone only.
** Catch at *status quo* F.
^ Single-stock boundaries and the exploitation of this stock should be conducted in the context of mixed fisheries, protecting stocks outside safe biological limits.
^^ Wanted catch.
[#] For quarters 1 and 2 only, based on an annual total of 10 890 tonnes.
[##] For quarters 1 and 2 only, based on an annual total of 11 646 tonnes.

History of the catch and landings

Table 9 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. Catch distribution by fleet in 2021 as estimated by ICES.

Catch	Landings	Discards
7484 tonnes	Trawls 96%	Trawls 4%
	7173 tonnes	311 tonnes

Table 10 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. History of commercial catch and landings; ICES estimated values are presented by country. All weights are in tonnes.

Year	Denmark*^	Norway*	Sweden*	Total landings	Estimated Danish discards	Estimated Norwegian discards*	Estimated Swedish discards	Estimated catch
1970	1101	1986	2741	5828				5828
1971	1190	2810	2906	6906				6906
1972	1016	2904	2525	6445				6445
1973	756	2823	2130	5709				5709
1974	529	2668	2004	5201				5201
1975	817	3040	2001	5858				5858
1976	1204	3977	2530	7711				7711
1977	1120	3015	2019	6154				6154
1978	1459	2453	1609	5521				5521
1979	1062	3040	1788	5890				5890
1980	1678	4562	2159	8399				8399
1981	2593	5186	2242	10021				10021
1982	3765	5427	1450	10642				10642
1983	1803	5371	1134	8308				8308
1984	1799	4769	1023	7591				7591
1985	4498	6553	1571	12622				12622
1986	4866	6493	1462	12821				12821
1987	4488	8351	1323	14162				14162

Year	Denmark*^	Norway*	Sweden*	Total landings	Estimated Danish discards	Estimated Norwegian discards*	Estimated Swedish discards	Estimated catch
1988	3473	7659	1277	12409				12409
1989	3376	6575	1433	11384				11384
1990	2767	6152	1607	10526				10526
1991	3586	6105	1909	11600				11600
1992	3967	7202	2153	13322				13322
1993	2976	7538	2300	12814				12814
1994	2163	6815	2600	11578				11578
1995	2644	8021	2883	13548				13548
1996	4056	7911	2371	14338				14338
1997	4044	8569	2595	15208				15208
1998	3412	9705	2467	15584				15584
1999	2143	6735	2444	11322				11322
2000	2495	6441	2224	11160				11160
2001	2100	7270	2108	11478				11478
2002	2558	7702	2300	12560				12560
2003	3333	8186	2389	13908				13908
2004	3947	9548	2465	15960				15960
2005	3002	8960	2256	14218				14218
2006	3112	8668	2488	14268				14268
2007	2468	8686	2446	13600				13600
2008	2276	8262	2478	13016			540	13556
2009	2224	6362	2483	11069		78	337	11484
2010	1300	4674	1780	7754		110	386	8250
2011	1593	4800	1768	8161		227	504	8892
2012	1456	4853	1520	7829		248	671	8748
2013	2027	5179	1190	8396	185	405	265	9251
2014	2431	6122	1398	9951	526	1191	572	12240
2015	2690	6810	1645	11145	202	418	325	12090
2016	1995	8305	2087	12387	35	105	108	12635
2017	2158	6778	1635	10571	206	114	104	10994
2018	1867	5492	1375	8734	12	115	86	8946
2019	2048	4414	1107	7569	83	178	211	8041
2020	2300	5348	1289	8937	60	82	242	9320
2021	1687	4561	925	7173	57	99	156	7484

* Swedish (all years), Norwegian (since 2000), and Danish (since Q4 in 2002) landings have been corrected for loss in weight due to boiling.
** Norwegian discard estimates until 2016 are obtained by applying the Danish discard ratio to Norwegian data and since 2017 by using data from the Norwegian reference fleet.
^ Danish estimates include smaller catches from the most north-eastern parts of Division 4.b. *Pandalus* from this area are considered to belong to the *Pandalus* stock in divisions 3.a and 4.a East.

Summary of the assessment

Table 11 Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East. Assessment summary. All weights are in tonnes and recruitment in thousands. High and Low refers to 95% confidence intervals.

Year	Recruitment age 0			SSB relative to MSY $B_{trigger}$*			Landings	Discards**	Fishing pressure relative F_{MSY}		
	Low	Median	High	Low	Median	High			Low	Median	High
1971	19300000	53480000	122510000	2.03	2.79	3.9	6906	551	0.186	0.27	0.39
1972	19290000	53030000	121210000	1.89	2.63	3.72	6445	491	0.177	0.26	0.37
1973	19390000	53220000	120380000	1.88	2.6	3.65	5709	421	0.158	0.23	0.33
1974	19390000	53060000	121140000	1.91	2.61	3.57	5201	392	0.147	0.21	0.30
1975	19280000	53410000	121120000	1.99	2.67	3.61	5858	424	0.165	0.23	0.32
1976	19400000	53330000	120000000	2.01	2.67	3.57	7711	554	0.22	0.32	0.44
1977	19220000	53070000	119500000	1.92	2.55	3.44	6154	457	0.177	0.25	0.35
1978	13060000	50840000	163280000	1.91	2.55	3.43	5521	394	0.163	0.23	0.31

Year	Recruitment age 0			SSB relative to MSY $B_{trigger}$*			Landings	Discards**	Fishing pressure relative F_{MSY}		
	Low	Median	High	Low	Median	High			Low	Median	High
1979	13100000	51280000	166350000	1.97	2.6	3.47	5890	418	0.170	0.24	0.34
1980	12060000	47400000	146980000	1.98	2.62	3.45	8399	556	0.21	0.34	0.52
1981	10660000	39650000	116730000	1.71	2.48	3.7	10021	630	0.25	0.43	0.69
1982	12040000	39480000	102710000	1.43	2.24	3.72	10642	567	0.30	0.52	0.85
1983	16750000	47770000	112150000	1.2	1.95	3.32	8308	436	0.28	0.46	0.76
1984	21600000	57190000	124640000	1.11	1.73	2.82	7591	473	0.29	0.45	0.68
1985	13190000	35020000	75810000	1.13	1.63	2.46	12622	943	0.46	0.70	1.01
1986	18050000	45230000	98540000	1.06	1.49	2.22	12821	750	0.53	0.78	1.11
1987	8180000	21650000	48570000	1.01	1.41	2.1	14162	789	0.74	1.09	1.53
1988	24020000	60260000	129580000	0.68	0.99	1.54	12409	602	0.75	1.18	1.72
1989	22680000	58710000	125740000	0.52	0.8	1.31	11384	1120	0.66	1.06	1.60
1990	24090000	64290000	142710000	0.41	0.65	1.1	10526	1000	0.44	0.68	1.02
1991	16730000	46670000	105760000	0.72	1.05	1.61	11600	892	0.43	0.63	0.92
1992	32220000	85920000	187160000	1.01	1.4	2.03	13322	854	0.49	0.73	1.03
1993	20840000	58810000	133910000	1.14	1.56	2.27	12814	1073	0.43	0.63	0.90
1994	22970000	65150000	146690000	1.15	1.58	2.26	11578	801	0.33	0.48	0.70
1995	28180000	78700000	177100000	1.57	2.09	2.88	13548	830	0.40	0.57	0.80
1996	24630000	68140000	153030000	1.59	2.09	2.9	14338	944	0.39	0.56	0.79
1997	12100000	34120000	77370000	1.61	2.12	2.91	15208	926	0.40	0.58	0.83
1998	17270000	47420000	105610000	1.69	2.23	3.1	15584	699	0.48	0.70	1.01
1999	18500000	51320000	117890000	1.5	2.03	2.89	11322	663	0.45	0.66	0.93
2000	24930000	68030000	154620000	1.15	1.57	2.24	11160	708	0.47	0.69	0.98
2001	28940000	81310000	188040000	1.02	1.39	2.01	11478	846	0.42	0.62	0.90
2002	21350000	65040000	157590000	1.05	1.45	2.14	12560	936	0.36	0.55	0.79
2003	26690000	75930000	177480000	1.32	1.82	2.63	13908	854	0.37	0.55	0.80
2004	19520000	55490000	127160000	1.59	2.2	3.16	15960	969	0.42	0.64	0.95
2005	25130000	68230000	150780000	1.49	2.12	3.12	14218	811	0.38	0.59	0.89
2006	17200000	46380000	102560000	1.51	2.16	3.2	14268	941	0.42	0.64	0.97
2007	17570000	44320000	92090000	1.36	1.96	2.92	13600	770	0.46	0.68	1.01
2008	8350000	21510000	45730000	1.32	1.89	2.77	13016	540	0.54	0.79	1.15
2009	7330000	18540000	39280000	1.08	1.54	2.25	11069	415	0.51	0.74	1.05
2010	10270000	24290000	49120000	0.93	1.28	1.8	7754	496	0.58	0.83	1.16
2011	15560000	36760000	74740000	0.62	0.86	1.24	8161	731	0.88	1.31	1.87
2012	12950000	30870000	62130000	0.32	0.49	0.76	7829	919	0.76	1.12	1.62
2013	26180000	60900000	120650000	0.3	0.45	0.69	8396	855	0.75	1.10	1.57
2014	16220000	38270000	75070000	0.38	0.56	0.83	9951	2289	0.75	1.08	1.54
2015	10700000	25620000	51540000	0.43	0.63	0.93	11145	945	0.71	1.01	1.43
2016	14870000	35200000	71030000	0.63	0.89	1.25	12387	248	0.75	1.06	1.46
2017	10000000	24330000	49600000	0.57	0.79	1.14	10571	423	0.83	1.19	1.64
2018	15080000	37280000	78780000	0.42	0.59	0.87	8734	212	0.72	1.05	1.50
2019	9600000	23980000	50650000	0.41	0.59	0.86	7569	472	0.62	0.90	1.27
2020	10090000	26270000	56720000	0.41	0.58	0.85	8937	383	0.69	1.03	1.47
2021	31040000	87770000	202880000	0.44	0.64	0.97	7173	311	0.60	0.93	1.41
2022		46540000			0.60						

* The spawning–stock biomass (mature females) constitutes a fraction of the total exploitable biomass. The value represents SSB relative to $MSYB_{trigger}$.
** Estimated by the assessment model up until 2007 and observed values from 2008

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Download the stock assessment data and figures.

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