UPDATE OF THE PROJECTIONS FOR ATLANTIC MACKEREL (SUBAREAS 3 AND 4)

Context

The assessment of Atlantic mackerel (*Scomber scombrus)* of subareas 3 and 4 is undertaken every two year, with the TAC usually rolled over during interim years. From the last stock assessment (DFO 2017), scientific advice was provided, in part, in the form of standard projections of spawning stock biomass (SSB) over a 3-year period (2016-2019). Both the probabilities of growth out of the Critical Zone and of any stock growth under various levels of total catch (declared and undeclared) were provided, and were used to support the 2017 advice on catch levels. The TAC in 2017 was set at 10,000 t, assuming that total removals (reported and unreported catch) in the commercial, bait and recreational fisheries would equal 16,000 t.

Fisheries Management has engaged the DFO Science Branch to provide an update of assessment model projections for Atlantic Mackerel (Subareas 3 and 4) to support the ongoing development of a Rebuilding Plan and a Management Strategy Evaluation. Both processes are occurring via the Atlantic Mackerel Rebuilding Plan Working Group. Specifically, Science was requested to provide projections of total catch rates or F values that would 1) increase the Atlantic Mackerel spawning stock biomass (SSB) out of the Critical Zone in a) 5, b) 10 and c) 15 years, with 75% probability, and 2) double the spawning stock biomass of Atlantic Mackerel in 10 years. A probability of 75% was chosen to reflect the desire for a “high probability” (DFO 2009).

This Science Response Report results from the Science Response Process of March 2, 2018 on the update of the projections for Atlantic Mackerel (Subareas 3 and 4).

Background

Fisheries and Oceans Canada published a Sustainable Fisheries Framework in 2009 (DFO 2018), which outlines the fundamental policy and methodology for applying the Precautionary Approach (PA) (DFO 2009). A key component of the PA policy requires that “when a stock has reached the Critical Zone, a rebuilding plan must be in place with the aim of having a high probability of the stock growing out of the Critical Zone within a reasonable timeframe”. Subsequently, Fisheries and Oceans Canada also released guidance for the development of rebuilding plans under the PA framework (DFO 2013).

In compliance with these policies, based on the last assessment (DFO 2017) and to inform ideas for objective-setting put forward by the newly established Mackerel Rebuilding Working Group in December 2017, the aim of this Science Response is to predict the probability of the SSB (a) growing out of the Critical Zone and (b) growing and (c) doubling with respect to its 2016 biomass within 3 time references, i.e. 2022 (5 years), 2027 (10 years) and 2032 (15 years) under a range of catch regimes.

Analysis and Response

The probability of growth outside of the Critical Zone was defined as the probability of the SSB being above the Limit Reference Point (LRP) which delimits the Critical Zone (DFO 2017) and which was defined to be 103,000 t (DFO 2017). The probability of any stock growth and stock doubling were calculated relative to the 2016 SSB (the last year in the assessment), estimated to be approximately 40,000 t or 39% of the LRP. We performed projections under various scenarios of constant catches, ranging from 0 to 30,000 t, as well as under $F_{40\%}$ using the same data and methodology as in the last assessment (DFO 2017). The $F_{40\%}$ reference point (fishing mortality associated with a reduction in spawners-per-recruit to 40% of the unfished stock and a proxy for F_{MSY}) was derived from a yield-per recruit analysis and was used in the last assessment to define the LRP (as $0.40*SSB_{F40\%}$). The probability of stock growth outside the Critical Zone, any growth of SSB or doubling of SSB relative to 2016 levels was considered ‘high probability’ if it reached or exceeded 75% (DFO 2009). Projections were provided for 5, 10 and 15 years.

It is important to note that the following results are based on total catch, including both declared and undeclared catch. Previous analyses have estimated that undeclared catches in recent years have been around 6,000 t (DFO 2017). Total allowable catches (TAC), which represent declared catches, should therefore be calculated by subtracting 6,000 t from the total catch values used in the projections.

The probabilities of the mackerel stock being above the LRP, any growth in stock biomass and doubling of biomass under the various catch scenarios are shown in Figure 1 and Table 1. A high probability (>75%) of the stock growing out of the Critical Zone in 5 years can only be attained if total annual catch does not exceed 10,000 t (i.e., 4,000 t TAC under current undeclared catch levels). However, the LRP is 75% likely to be exceeded in 10 years if total catches are held constant at 18,000 t (i.e., 12,000 t TAC). Within 15 years, the LRP is 85% likely to be exceeded if catches were held at 20,000 t (i.e., 14,000 t TAC). The probability of stock doubling shows a similar annual pattern, although probabilities are somewhat higher because a doubling of the stock biomass would not project the stock out of the Critical Zone. To reach a high probability of stock biomass doubling in 5 years, total catches should not exceed 14,000 t annually (8,000 t TAC), or 18,000 t (12,000 t TAC) for doubling in 10 years. However, under most considered catch levels, stock biomass is likely to increase relative to 2016, if only by a small amount. Under the current total catches of 16,000 t, the stock would have at least a 75% probability of growing out of the Critical Zone by 2024 (7 years) and of doubling by 2022 (5 years).

Projections under $F_{40\%}$ (F=0.32) show that the stock would grow out of the Critical Zone in 6 years (2024) (Table 2; Figure 2). However, to do so, total catches would need to be reduced by around 60% during the first year (an approximately 90% reduction in TAC), after which a steady increase might be possible. This would quickly result in a high probability in growth (>75%).

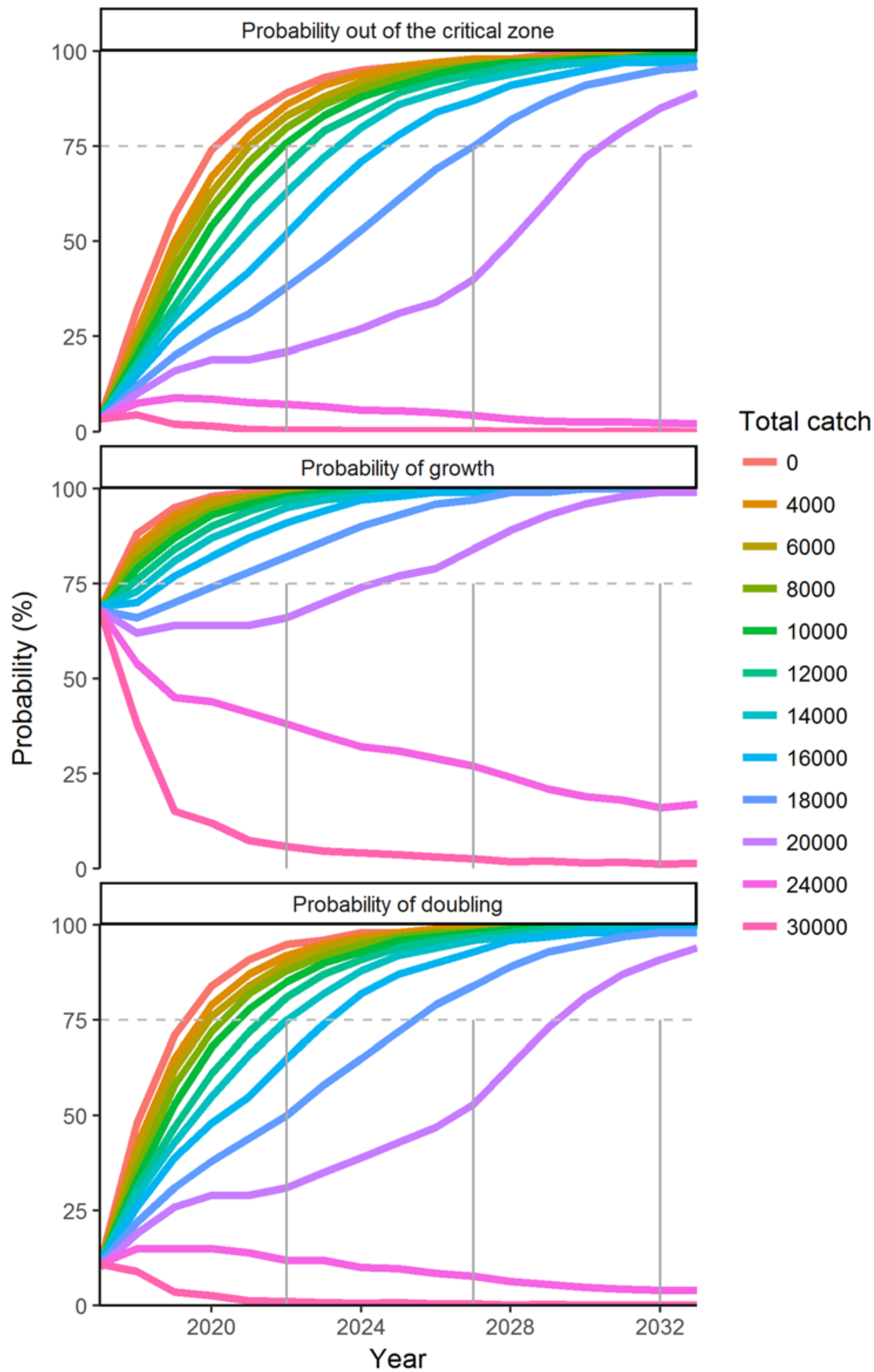


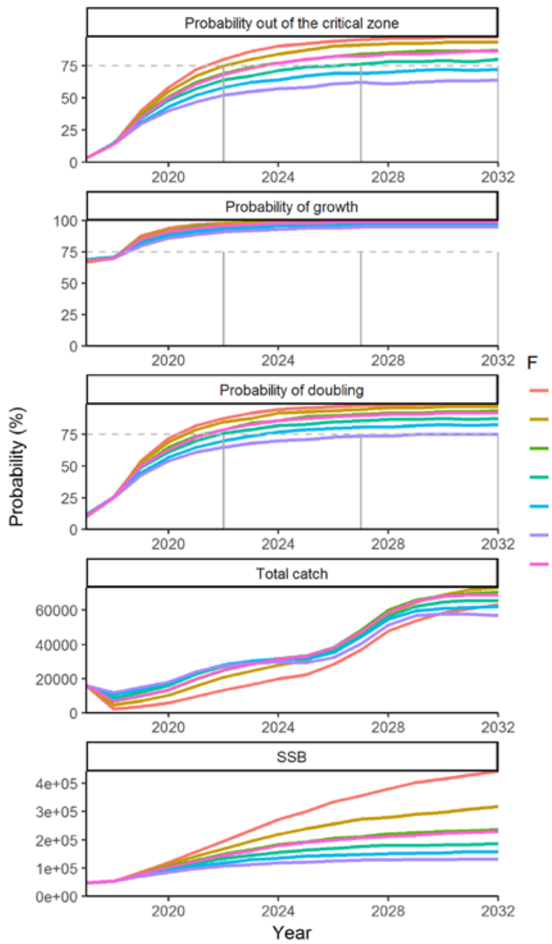
Figure 1. Estimated future probabilities of stock growth out of the Critical Zone, any stock growth and doubling (relative to 2016) under various total catch scenarios. The grey dashed horizontal line indicates the 75% probability level, considered the demarcation for high probability (DFO 2009). Gray solid vertical lines indicate the considered time steps (5 years, 10 years and 15 years).

Table 1. Estimated future spawning stock biomass (SSB) and probabilities of stock growth out of the Critical zone, defined by the Limit Reference Point (LRP), any growth of SSB and doubling of SSB (relative to 2016) under various catch scenarios. TAC = total allowable catch, or declared catch, given estimates of undeclared catches of 6,000 t per year (DFO 2017).

		2022				**2027**				**2032**			
Total catch	TAC	SSB	Probability SSB>LRP	Probability $SSB>SSB_{2016}$	Probability $SSB>2*SSB_{2016}$	SSB	Probability SSB>LRP	Probability $SSB>SSB_{2016}$	Probability $SSB>2*SSB_{2016}$	SSB	Probability SSB>LRP	Probability $SSB>SSB_{2016}$	Probability $SSB>2*SSB_{2016}$
0	0	257 914	0.89	0.99	0.95	508 107	0.98	1	0.99	715 254	0.99	1	1
4 000	0	224 141	0.86	0.99	0.92	459 279	0.98	1	0.99	660 456	0.99	1	1
6 000	0	209 637	0.83	0.99	0.9	434 803	0.97	1	0.99	642 254	0.99	1	1
8 000	2 000	192 594	0.8	0.98	0.88	409 997	0.96	1	0.98	609 388	0.99	1	0.99
10 000	4 000	171 453	0.76	0.98	0.85	372 752	0.96	1	0.98	574 547	0.99	1	0.99
12 000	6 000	151 714	0.7	0.97	0.81	344 464	0.94	1	0.97	538 262	0.98	1	0.99
14 000	8 000	132 904	0.63	0.95	0.75	303 346	0.92	1	0.96	509 563	0.98	1	0.99
16 000	10 000	106 285	0.52	0.91	0.65	259 676	0.87	0.99	0.93	451 914	0.97	1	0.99
18 000	12 000	79 417	0.38	0.82	0.5	170 918	0.75	0.97	0.84	361 352	0.95	1	0.98
20 000	14 000	54 495	0.21	0.66	0.31	84 155	0.4	0.84	0.53	230 244	0.85	0.99	0.91
24 000	18 000	31 805	0.07	0.38	0.12	23 807	0.04	0.27	0.08	16 893	0.02	0.16	0.04
30 000	24 000	9 314	0.00	0.06	0.01	5 299	0.00	0.03	0.00	3 579	0.00	0.01	0.00

Table 2 and Figure 2. Probabilities of stock growth out of the Critical Zone, any growth of SSB and doubling of SSB (relative to 2016) under fishing at $F_{40\%}$ (F=0.32) from 2018 onward. TAC = total allowable catch or declared catch, given estimates of undeclared catches of 6,000 t per year (DFO 2017).

year	Total catch	TAC	Probability SSB>LRP	Probability $SSB>SSB_{2016}$	Probability $SSB>2*SSB_{2016}$
2017	16 000	10 000	0.03	0.67	0.11
2018	7 006	1 006	0.15	0.69	0.25
2019	9 996	3 996	0.35	0.84	0.49
2020	13 665	7 665	0.49	0.91	0.63
2021	20 291	14 291	0.6	0.94	0.73
2022	25 602	19 602	0.68	0.96	0.8
2023	28 953	22 953	0.74	0.97	0.83
2024	31 902	25 902	0.78	0.98	0.86
2025	32 928	26 928	0.8	0.98	0.88
2026	37 753	31 753	0.82	0.99	0.89
2027	47 469	41 469	0.83	0.99	0.91
2028	58 913	52 913	0.84	0.99	0.92
2029	65 053	59 053	0.85	0.99	0.92
2030	67 621	61 621	0.86	0.99	0.92
2031	69 316	63 316	0.86	0.99	0.93
2032	68 640	62 640	0.87	0.99	0.93



Note that the 2017 stock assessment model included censored catch, assuming that declared landings represented the minimum level for true catch (DFO 2017, Van Beveren et al. 2017b). Total catches estimated by the model thus should reflect both declared and undeclared catch and the projections employed for the current advice explicitly assume an undeclared catch level. Undeclared catches can include mackerel caught in an unrecorded bait fishery, the recreational fishery, discarded mackerel and subareas 3 and 4 fish caught by the US fleet in winter. It is not possible to disentangle the relative importance of each of these components, which are also likely to have varied over the time series and may continue to contribute in varying proportions to undeclared catch in the future.

Once the total catch is determined according to fishery objectives, a declared catch quota can be determined by subtracting a recent level for undeclared catches from the allowable catch. As the undeclared catch is not well known, it was set during the last stock assessment as the average undeclared landings estimated by the model over the last six years (2011-2016), calculated as the difference between estimated total catch and declared catch. This value (6,000 t) was in accordance with polling survey data on the fishing industry (Van Beveren et al. 2017a) and was also accepted by fishers present at the peer-reviewed stock assessment meeting as well as at the Atlantic Mackerel Advisory Committee meeting that both took place in March 2017 (DFO 2017).

Sources of uncertainty

Projections are always highly dependent on the assumptions and suitability of the model. The projections presented here, extending those provided in March 2017 (DFO 2017), are considered optimistic, as they assume a large likelihood of a positive combination of natural mortality, immigration, emigration and recruitment to occur in the future. For instance, only under these favourable conditions can a probability of stock growth outside the Critical Zone of 56% be attained in only 3 years under the no fishing scenario (DFO 2017), as the 2016 stock biomass would need to increase by 250%.

Conclusions

The rebuilding plan agreed upon by the mackerel working group is to get the stock out of the Critical Zone, although no recovery goal has yet been proposed. In order to reach this goal with 75% probability, projections indicated that a constant total catch should not exceed 10,000 t (i.e., TAC of 4,000 t considering current undeclared catches) for the stock to grow out of the Critical Zone by 2022, a total catch of 18,000 t (i.e., TAC of 12,000 t) by 2027 or a total catch of 20,000 t (i.e., TAC of 14,000 t) by 2032. Fishing at $F_{40\%}$ would require total catches to be reduced to 7,000 t (i.e., a TAC of 1,000 t) in the first year, after which fishing can gradually increase to reach the 75% threshold for SSB in 2024. Under the current total catches of 16,000 t, the stock would have a 75% probability of growing out of the Critical Zone by 2025 (8 years) and of doubling by 2024 (7 years).

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Date : March 7, 2018

Sources of Information

This Science Response results from the Science Response process of March 2, 2018 on the Update of the projections for Atlantic mackerel (Subareas 3 and 4).

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This Report is Available from the :

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ISSN 1919-3769

Correct Citation for this Publication:

DFO. 2018. Update of the projections for Atlantic Mackerel (Subareas 3 and 4). DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/024.

Aussi disponible en français :

MPO. 2018. Mise à jour des projections relatives au maquereau (sous-régions 3 et 4). Secr. can. de consult. sci. du MPO, Rép. des Sci. 2018/024.