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Ecosystems and Oceans Science
Sciences des écosystèmes et des océans

Quebec Region

Canadian Science Advisory Secretariat
Science Advisory Report 2021/029

ASSESSMENT OF THE NORTHERN CONTINGENT OF ATLANTIC MACKEREL (*SCOMBER SCOMBRUS*) IN 2020

Figure 1: Atlantic mackerel (Scomber scombrus L.). Photo credit: Claude Nozères, DFO.

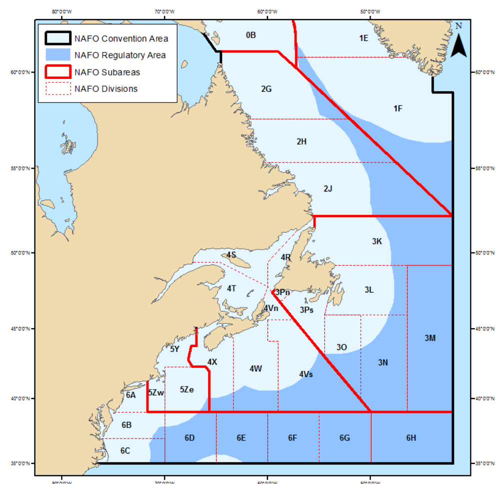

Figure 2. NAFO subareas and divisions

Context:

Atlantic mackerel (Scomber scombrus L.; Figure 1) can be found in the coastal waters of the Northwest Atlantic from North Carolina to Labrador (Figure 2). They overwinter in deeper warmer waters at the edge of the continental shelf and migrate inshore during the spring to spawn and then disperse to feed during the summer. There are two spawning contingents in the Northwest Atlantic. The Northern contingent spawns in Canadian waters primarily in the Southern Gulf of St. Lawrence during June and July. The southern contingent spawns between March and April in U.S. waters off the coasts of southern New England and in the western Gulf of Maine.

The commercial fishery for mackerel in Canadian waters takes place off the shores of all of the Maritime provinces and Quebec (primarily in NAFO subareas 3-4). It is an inshore, open competitive fishery that employs a variety of fixed and mobile gear types (e.g. traps, gillnets, various hand and mechanized hook and lines, as well as purse and tuck seines) the predominance of which varies by region and season. Mackerel are also caught through a bait fishery and recreation fishery.

The Spawning Stock Biomass (SSB) has been in the Critical Zone since 2011. The fishing mortality rate is above the reference point. Recruitment has been near all time lows in recent years and the age structure of the population is severely truncated as it has been eroded by overexploitation.

The last assessment of the northern contingent of mackerel was undertaken in the winter of 2021 following a request by The Fisheries and Aquaculture Management Branch for scientific advice on Total Allowable Catch (TAC) of mackerel for the 2021-2022 fishing seasons. Short-term projections of Spawning Stock Biomass trajectories under a variety of TACs and two recruitment scenarios were provided to inform these decisions.

SUMMARY

- Nominal landings were updated for the years 2017-2020 and were 9786 t, 10 964 t, 8623 t, and 7772 t respectively. The TACs were 10 000 t from 2017-2018 and 8000 t from 2019-2020. Landings during these years occurred primarily in the Gulf of Saint Lawrence (NAFO 4RST) and off the northeast coast of Newfoundland (NAFO 3K).
- Recent genetic analyses confirmed previous studies that the Northwest Atlantic mackerel stock is distinct from the Northeast Atlantic stock. These analyses also supported the previously established distinction between the northern and southern spawning contingents of the Northwest Atlantic stock. Genetic results showed some mixing of southern contingent mackerel in Canadian waters as well as northern contingent mackerel in U.S. waters.
- A fine-scale analysis of recruitment variability showed that a spatio-temporal match between mackerel larvae and their preferred food as well as optimal population structure and dynamics (maternal condition, SSB, age-structure) benefits recruitment.
- The annual egg survey did not occur in 2020 due to restrictions incurred by the global Covid pandemic. The absence of this survey index for one year did not prevent the use of the stock assessment model to estimate stock status.
- The Spawning Stock Biomass (SSB) of the northern contingent of Atlantic mackerel is was at the lowest value estimated and was at 58% of the Limit Reference Point (LRP) in 2020. The stock has been near or below the LRP for the past decade according to the Precautionary Approach.
- The last notable recruitment event was in 2015, while the stock was in the Critical Zone, but fish belonging to this cohort represented about 7% of the SSB in 2020. There was no sign of any notable recruitment event in recent years.
- The estimated fully selected exploitation rate (fish aged 5-10+) in 2020 was 74%, above the reference level of 51% (F40%). The fishery was concentrated on fish aged 2-5 (exploitation rate of 56%). There are currently very few fish older than 5 years old (<1%).
- Depending on the TAC (0-10 000 t) and recruitment projection, the probability of the SSB exiting the Critical Zone by 2023 varies from 29% (TAC = 10 000 t) to 58% (TAC = 0 t). These projections also indicate that the probability SSB in 2023 being greater than SSB in 2021 varies from 39% (TAC = 10 000 t) to 92% (TAC = 0 t).
- The SSB in 2020 was the lowest ever estimated and has been in or near the Critical Zone for over 10 years. According to the Precautionary Approach, removals from all sources should be as low as possible to allow rebuilding. Rebuilding the stock will also require rebuilding the age structure of the stock which has been eroded by overexploitation.

INTRODUCTION

Ecology and population structure

Atlantic Mackerel (henceforth mackerel) are a highly migratory, pelagic, temperate water, forage fish, in the *Scombridae* family. They play a key role in the ecosystem through the transfer of energy from lower trophic levels to higher order predators including a large range of fish, marine mammals, and sea birds (Studholme et al. 1999). They have a broad distribution and occur on both sides of the North Atlantic.

In the Northwest Atlantic (NWA), mackerel distribution can range from Cape Lookout, North Carolina to Hopedale, Labrador. The northern (i.e. Canadian) contingent of the NWA mackerel stock spawns primarily in the southern Gulf of Saint Lawrence (GSL) in June and July. The southern (i.e. U.S.) contingent spawns between March and April in the waters off the coasts of southern New England and in the western Gulf of Maine. Year to year variation in mackerel distribution as well as their seasonal movements can be largely attributed to their biology, changes in water temperature, and the availability of food (Mackay 1979). Mackerel generally only tolerate temperatures between 7-16 °C (Galbraith and Grégoire 2014). In the spring, the northern contingent of mackerel migrates northwards and inshore from their overwintering grounds on the edge of the continental shelf. The bulk of the stock continues its migration into the southern GSL where sexually mature adults spawn in June and July. Following this, both adults and juveniles disperse among the coastal waters of the Atlantic provinces and Quebec to opportunistically feed on zooplankton (e.g. copepods, krill, etc.) and small fish (Mackay 1979; Studholme et al. 1999). Optimal water temperatures as well as food availability have been shown to explain much of their summer and fall distributions as well as differences in catch among different regions (Smith et al. 2020; DFO 2019). Juveniles can, however, be found year round on the Scotian shelf (Kulka 1977; Mackay 1979; Grégoire and Showell 1994). In the fall, large aggregations of mackerel migrate South to overwinter in the deeper warmer waters on the edge of the continental shelf where they mix with the southern contingent. The mixing and extent of the overlap between the two contingents is unknown but likely large (Redding et al. 2020; Arai et al. 2021).

Recent genetic analyses undertaken by DFO as well as evidence from a number of different sources have validated our current understanding of mackerel population structure. These results confirmed that the stock in the NWA is genetically distinct from the one in the Northeast Atlantic (Gíslason et al. 2020) and the distinction between the northern and southern contingents in the NWA previously shown with otolith isotopes composition (Redding et al. 2020; Arai et al. 2021). Evidence for additional, genetically distinct, spawning populations in the NWA was, however, not found. In addition to the genetic evidence, the lack of meaningful differences in the age-structure of catches across regions as well as the migration patterns evidenced through multiple tagging studies or inferred from the seasonality of catches across regions support this assertion (Smith et al. 2020; DFO 2019). In addition a review of multiple ichthyoplankton surveys undertaken in Canadian waters since 1914 has similarly shown that there are no large, temporally stable spawning areas outside of the southern GSL. Taken together, the evidence suggests that it is unlikely that additional substantial spawning populations exist in the NWA.

Most northern contingent mackerel reach sexual maturity around 2-3 years old (L_{50} = 266 mm +/- 1.50 mm for the 2014-2018 cohorts). Recruitment to the spawning stock is dependent on the biomass of the spawning stock and the presence of larger older females which are much more fecund than smaller individuals. Recruitment has also been linked to the spatio-temporal overlap in the distributions of mackerel larvae with that of their preferred food. Optimal feeding conditions for adults lead to better individual condition (i.e. increased energy reserves) and have likewise been associated with relatively better recruitment (Brosset et al. 2020; Smith et al. 2020).

ASSESSMENT

Landings

Mackerel in Canadian waters are exploited by commercial, bait, and recreational fisheries. Landings from the commercial fishery are recorded through logbooks, purchase slips, and dockside monitoring companies, the coverages of which have varied over time and among regions. Records of landings from the bait fishery have been inconsistent or non-existent for much of the fisheries' history and have only begun to be recorded more thoroughly in recent years. Few estimates are available for landings made by the recreational fishery despite its widespread popularity (Van Beveren et al. 2017b, 2019). Mackerel are also caught as bycatch in a number of different fisheries. Discarding, particularly of smaller mackerel, is also known to occur. An unknown but likely large proportion of northern contingent mackerel are also caught by the winter U.S. fishery when the two contingents mix (Redding et al. 2020).

Nominal landings in Canadian waters were relatively low prior to 1960 (Figure 3). Landings increased during the 1960s through the late 1970s due to the presence of the foreign distant water fleet fishing on the Scotian Shelf. Following the establishment of the 200 nautical mile rule and Canada's Exclusive Economic Zone in 1977 (EEZ), landings on the Scotian Shelf (NAFO 4VWX5YZ) decreased whereas landings increased in the southern GSL (NAFO 4T) and off the northeast coast of Newfoundland (mostly NAFO 3K). Landings from 1980 to 1999 were relatively stable and averaged around 22 534 t per year. Over this time period, landings off the northeast coast of Newfoundland began to decrease in the 1990s while remaining stable or increasing in other regions. Annual landings increased substantially from 2000 to 2010, averaging 40 593 t. This period of greater landings reached a record high of 54 809 t in 2005 due to the marked increase in fishing effort by small and large seiners in the northern GSL, off the west coast of Newfoundland (NAFO 4R), and coincided with the arrival of the large 1999 year class. This period was followed by a severe drop in landings that reached a recent low of 4272 t in 2015 (the fourth lowest value on record since 1876). At the time of the current assessment, landings in Canada's EEZ for 2016-2020 were 8057 t (TAC 8000 t), 9786 t (TAC 10 000 t), 10 964 t (TAC 10 000 t), 8623 t (TAC 8000 t), and 7772 t (TAC 8000 t), respectively.

The commercial and bait fisheries use a number of different gear types to capture mackerel which vary by region and season (Tables 2-5). During the spring migration of mackerel, various traps, nets, weirs, and gillnets are used in the inshore waters of Nova Scotia, New Brunswick, Prince Edward Island, and Quebec. This gives way to various types of hand lines and mechanized jiggers as the season progresses through the summer and fall. The mackerel fishery in Newfoundland and Labrador is largely dominated by small and large purse seines as well as tuck seines which target aggregations in the late summer through the fall.

Catch-at-age

Length frequency and biological samples are acquired from the commercial fishery through DFO's port sampling program as well as opportunistically through various research programs and collaborations with harvesters. This information is used to decompose total landings by age, estimates of which were updated for the years 2015 to 2020 (Figure 4).

Observations of mackerel caught by the fishery that are 10 years and older were more common prior to the late 1990s. Since then, the age structure of the population has become truncated. By the early 2010s, fish older than 6 were uncommon. The last notable cohort that could be tracked in the catch was that of 2015. Catches from this cohort were largest in 2018 (86% of the catch) when they were 3 years old. The contribution of this cohort to the fishery dropped to 19% of the catch in 2020, when the fish were 5 years old.

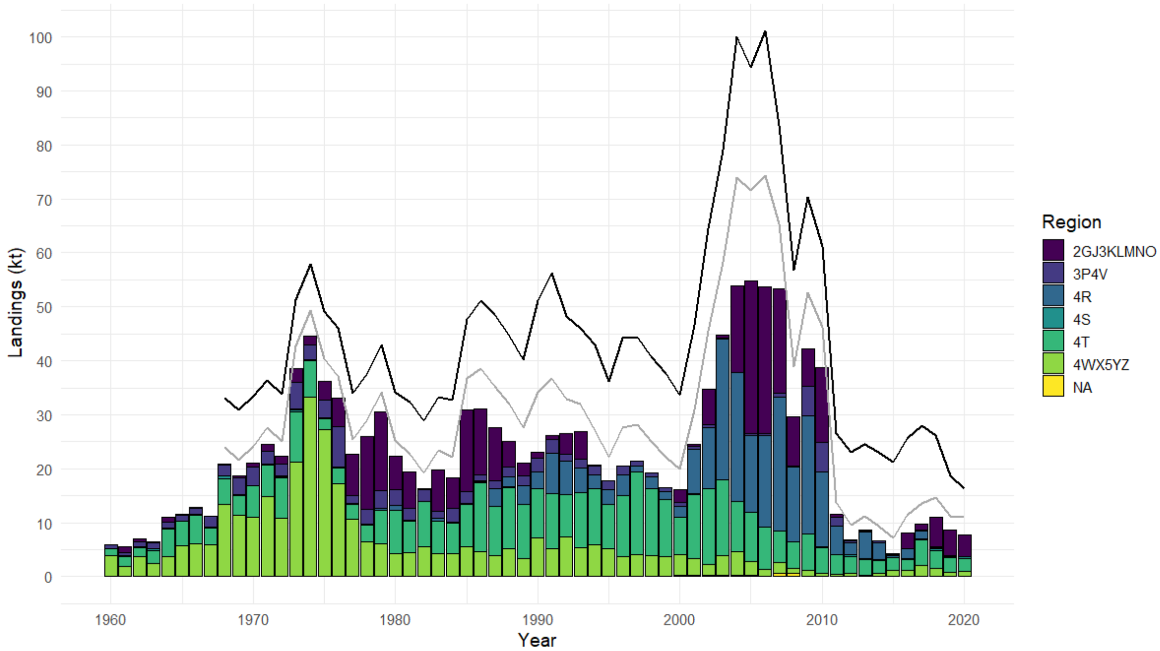

Figure 3. Landings (kt) within Canada's Exclusive Economic Zone by aggregated NAFO divisions. The grey and black lines represent the upper (black) and lower (grey) bounds in which total removals are estimated in the stock assessment model (1968-2020). These bounds are defined by total recorded landings as well as estimates of maximum unaccounted-for removals from all sources (e.g. recreational catch, unaccounted-for bait, discards, and 25% of U.S. landings for the lower bound and 50% of U.S. landings for the upper bound).

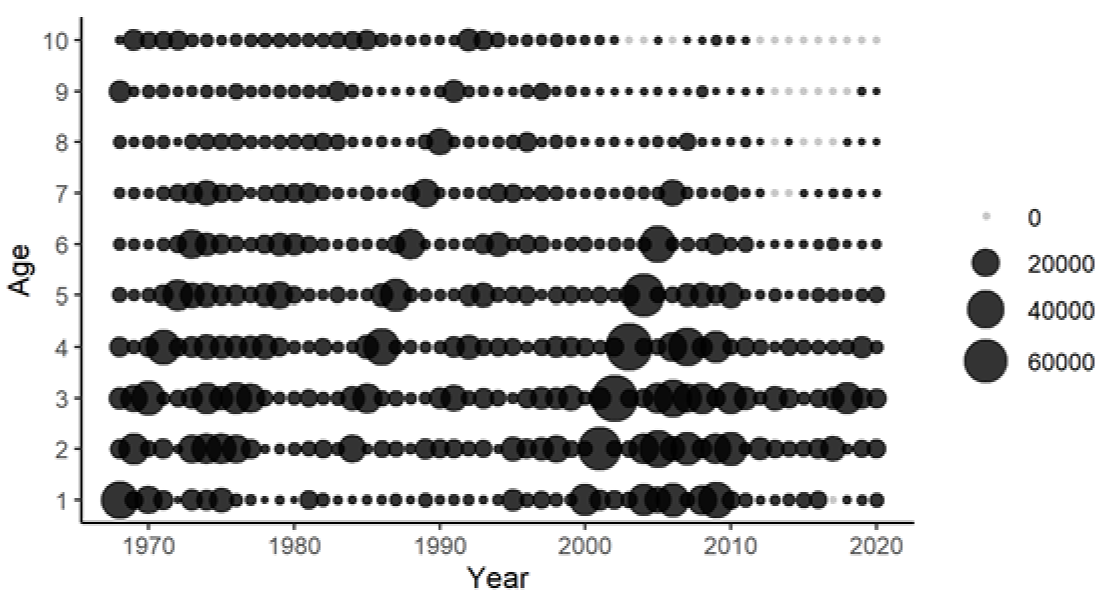

Figure 4. Bubble plot of mackerel catch-at-age data (ages 1-10+) from 1968-2020. Bubble size reflects the estimated number of fish caught in a given year and age class. Grey bubbles represent zeros.

Total egg production

The total egg production index (TEP) calculated from the annual egg survey and from biological data from commercial samples in the southern GSL shows a variable yet clearly declining trend, reaching historic lows in the past decade (Figure 5). Mean TEP from 1979 to 1994 was 513 billion eggs. Between 1994 and 1999, TEP dropped to 63 billion eggs, approximately 12% of the values observed from 1979-1994. TEP began to rise again in 2000 reaching a peak of 233 billion eggs in 2003 but started to decline the following year and subsequently reached a time series low value in 2012 at 8.67 billion eggs (approximately 2% of the values observed from 1979-1994) and has continued to stay low since then. In 2018 and 2019, TEP was 38.76 and 56.82 billion eggs respectively. TEP could not be calculated for 2020 as no survey took place due to restrictions related to the global Covid pandemic.

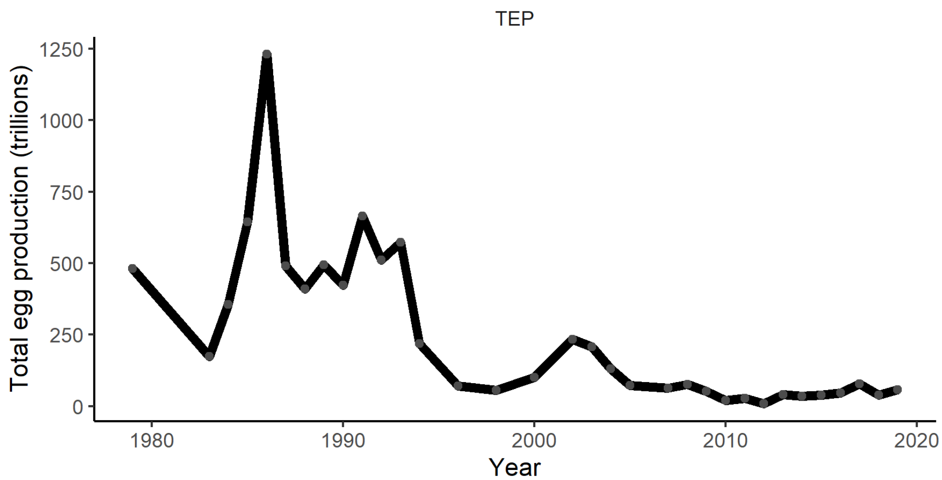

Figure 5. Relative total egg production index derived from the egg survey.

Analytical assessment

An analytical assessment was performed with a censored statistical catch-at-age model (Van Beveren et al. 2017a, Doniol-Valcroze et al. 2019), which was updated from the last stock assessment and Management Strategy Evaluation (for details, see DFO 2019, Smith et al. 2020, Van Beveren et al. 2020). Population dynamics were estimated from catch-at-age proportions, TEP, and the upper and lower limit of total removals (Figures 3-5). Note that the removals are explicitly assumed to be within certain limits, rather than around the reported landings, to reflect the uncertainty and bias created by the sources of unaccounted-for catch.

Stock status

The SSB dropped below the LRP in 2011 (Figure 6A). SSB approached the LRP in 2017 and 2018 with the arrival of the 2015 cohort but recently reverted to values similar to those observed from 2011-2015. In 2019 and 2020, SSB was estimated to be at 72% and 63% of the LRP respectively. The SSB in 2020 was the lowest observed value in the time series.

The estimated recruitment of age 1 fish into the population has fluctuated over time and has been punctuated by periodic occurrences of strong year classes (e.g. 1973, 1974, 1982, 1988, and 1999) (Figure 6C-D). The last notable recruitment event occurred in 2015 (age 1 in 2016). In 2020, fish belonging to this cohort represented about 7% of the population in terms of numbers and 13% in terms of biomass. Recruitment, estimated to be in relation to the low stock biomass (Beverton-Holt stock recruitment curve; Figure 6D), has subsequently remained near all-time low values. The combination of low SSB and fewer older more fecund mackerel in the population is likely hindering recruitment as there is a reduction in the reproductive potential of the stock.

Estimates of numbers-at-age highlight the periodic occurrence of dominant year classes as well as the truncation of the age structure of the population which began in the late 1990s (Figure 6B). This erosion of the age-structure of the population has increased over time to the point that there were very few fish over the age of 5 years old in 2020 (i.e. less than 1% of the total numbers-at-age). The age structure of the population in 2020 was relatively evenly spread among individuals between 1 and 5 years, old with no single dominant cohort.

The mean fishing mortality rate ($F_{\overline{5-10}}$; Figure 6E) of fully exploited mackerel (ages 5 to 10) has been above the reference level of F40% since 1998. This high fishing mortality rate coincided with the increase in total removals (Figure 6F) in the 2000s. $F_{\overline{5-10}}$ has continued to remain above the reference level despite a decrease in total catch. In 2020, the fishing mortality rate on fully exploited mackerel was 1.30, corresponding to an exploitation rate of 73%. Although exploitation rate is usually given for fish that are fully recruited to the fishery, these mackerel do not compose a large fraction of the population anymore. The exploitation rate over all ages in 2020 was F = 0.97 (exploitation rate of 62%). This exploitation rate is considered as relatively high given that most fish in the population were 1 to 5 years old and some were not fully selected by the fishery yet.

Projections

Projections were made over a three-year period to estimate the impact of different TACs (0-10 000 t) and recruitment scenarios on the projected SSB. Recruitment scenarios included SSB projected forward under the assumptions of the Beverton-Holt stock-recruitment relationship as estimated for the whole time series (Figure 6D) or using the mean recruitment over the past ten years (Figure 6C). These projections included stochastically projected unaccounted-for catches of both Canada and the US separately (i.e., implementation error; Figure 7, Table 1). The TAC was added to these estimated catches to calculate total removals and the resulting next years' stock biomass. During the last assessment there was agreement that the Canadian unaccounted-for catches would likely steadily decrease due to recent management measures aiming to improve catch monitoring. The fraction of northern contingent mackerel in U.S. catches was presumed to remain at 25-50%. Total landings in the U.S. in 2020 were not available for the stock assessment so the 5-year mean was used for 2020. Modelling details are provided in Van Beveren et al. (2020).

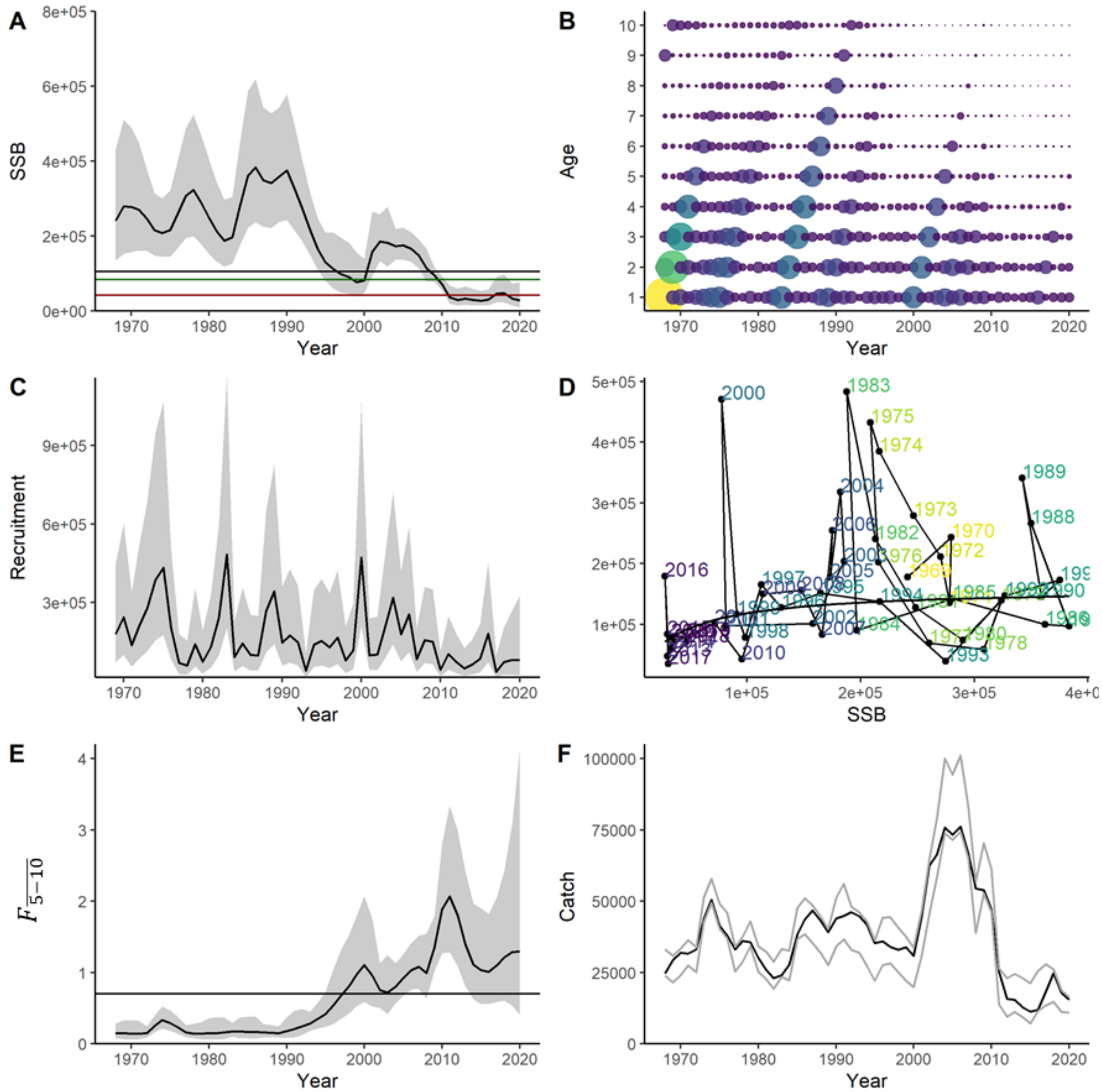

Figure 6. Model output: (A) Spawning Stock Biomass (t) with horizontal lines indicating the reference point ($SSB_{F40\%}$; black), proposed USR (80%$SSB_{F40\%}$; green) and LRP (40%$SSB_{F40\%}$; red), (B) numbers-at-age, (C) recruitment (numbers), (D) stock-recruitment, (E) fishing mortality $F_{\overline{5-10}}$ (averaged over the fully selected age classes 5-10), (F) estimated catch (black) between the pre-determined bounds (grey).

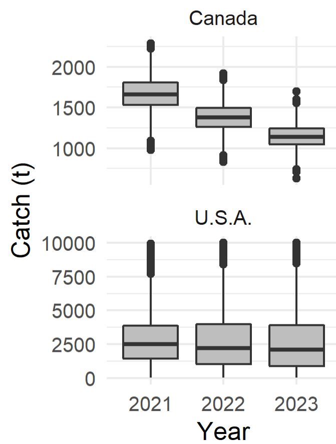

Figure 7. Boxplots of the assumed unaccounted-for catch over the next 3 years (2021-2023), for Canada (upper panel) and the U.S. (lower panel).

Projected short-term trends in SSB with respect to the LRP under different TACs and two recruitment scenarios were provided in a decision table (Table 1). Considering both recruitment scenarios, projections showed that the probability of reaching the LRP by 2023 is 33% or 41% at the current TAC of 8000 t. Under the same scenario, the probability of SSB in 2023 being greater than SSB in 2021 is 46% or 66%. Finally, with respect to the LRP, SSB in 2023 is projected to be at 0.46 or 0.60 of that value for a TAC of 8000 t. Depending on the TAC (0-10 000 t) and recruitment projection, the probability of the SSB exiting the Critical Zone by 2023 varies from 29% (TAC = 10 000 t) to 58% (TAC = 0 t). These projections also indicate that the probability SSB in 2023 being greater than SSB in 2021 varies from 39% (TAC = 10 000 t) to 92% (TAC = 0 t).

Table 1. Three-year projections under different Total Allowable Catch (TAC) and recruitment scenarios. Recruitment was projected assuming a Beverton-Holt stock-recruit relationship (BH: 1968-2020) and the average recruitment of the last 10 years (mean; 2011-2020) . For each TAC scenario, the probabilities of spawning stock biomass (SSB) being greater than the Limit Reference Point (LRP) in 2022 and 2023 are provided. The probabilities of SSB growth from 2021 to 2023 are also provided. The ratios between SSB with respect to the LRP (SSB/LRP) for each scenario are likewise given for 2022 and 2023. Projections were performed under the assumption that mackerel will also be caught outside of the TAC, by both the Canadian and U.S.A. fleets (shaded columns; uncertainties represented by the 5th and 95th quantiles taken over the three years; details in Figure 5).

TAC			SSB > LRP				SSB_{2023} > SSB_{2021}		SSB/LRP				Unaccounted-for landings			
2021	2022	2023	2022		2023		2021→2023		2022		2023		Canada		U.S.A.	
													5%	95%	5%	95%
			BH	mean	BH	mean	BH	mean	BH	mean	BH	mean				
0			42%	46%	51%	58%	85%	92%	0.73	0.78	0.85	0.97	982	1883	410	7735
2000			39%	44%	46%	54%	75%	86%	0.67	0.72	0.76	0.88	982	1883	410	7735
4000			37%	40%	41%	49%	64%	79%	0.61	0.66	0.65	0.79	982	1883	410	7735
6000			34%	38%	36%	45%	55%	72%	0.55	0.61	0.55	0.69	982	1883	410	7735
8000			32%	36%	33%	41%	46%	66%	0.50	0.55	0.46	0.60	982	1883	410	7735
10000			30%	34%	29%	37%	39%	59%	0.44	0.50	0.39	0.52	982	1883	410	7735

Sources of Uncertainty

Many of the key uncertainties within the data highlighted in previous assessments, as well as our knowledge of stock dynamics, have in large part been accounted for through the use of the current stock assessment model. Although uncertainties remain, stock status trends across different indices were consistent and large enough to lend confidence as to stock status. The trends and derived conclusions were also consistent when different stock assessment models and sensitivity analyses were performed. However, the proportion of northern population mackerel caught in the U.S. mackerel fishery is not known but is likely to be high (Redding et al. 2020). Improved monitoring of commercial landings, discards, and recreational catches will improve certainty of future assessments.

CONCLUSIONS AND ADVICE

The northern contingent of the Northwest Atlantic mackerel population has been in the Critical Zone since 2011 as described by the Precautionary Approach (DFO 2013). In 2020, fishing mortality was higher than reference levels. SSB and recruitment were either close to or at all-time historic lows and there was a severe truncation in the population’s age structure. Low recruitment was associated with the low SSB. Short-term projections over three years indicated that there is an increasing probability of stock growth with a corresponding decrease in exploitation. According to the Precautionary Approach, removals from all sources should be kept as low as possible to allow rebuilding.

LIST OF MEETING PARTICIPANTS

Name	Affiliation	Feb. 25th	Feb. 26th	March 3rd
Barry, David	Barry group	x	x	x
Barry, Joe	Barry group	x	-	-
Benoit, Hugues	DFO Science	x	x	-
Bonnet, Claudie	DFO Science	x	-	-
Boudreau, Ginny	Guysborough County Inshore Fishermen’s Assoc.	x	-	x
Boudreau, Mathieu	DFO Science	x	x	-
Boudreau, Mélanie	DFO Science	x	x	-
Bourbonnière, Jean-Patrick	DFO Science	x	-	-
Bourdages, Hugo	DFO Science	x	-	x
Bourret, Audrey	DFO Science	x	x	-
Brushett, Rebecca	WWF	x	x	x
Carruthers, Erin	FFAW	x	-	-
Castonguay, Martin	DFO Science	x	x	x
Cawthray, Jenness	DFO Fisheries management – Ottawa	x	x	x
Chamberland, Jean-Martin	DFO Science	x	x	-
Chandler, Alan	Fisheries and Aquaculture, Nova Scotia	x	x	x
Claytor, Ross	COSEWIC	x	x	-
Cogliati, Karen	DFO Science Ottawa	x	x	x
Couture, John	UINR	x	x	-
Curti, Kierten	NOAA	x	x	x
Cyr, Charley	DFO Science	x	x	x
d’Eon, Sherman	Cape Breeze Seafoods Ltd.	x	x	x
Deraspe, Mario	APPIM	x	-	-
Desgagnés, Mathieu	DFO Science	x	-	-
Dubé, Sonia	DFO Science	x	x	x
Duguay, Gilles	RPPSG	-	x	x
Duplisea, Daniel	DFO Science	x	-	-
Dunne, Erin	DFO Fisheries management – NL	x	x	x
Emond, Kim	DFO Science	x	x	-
Ferguson, Louis	UPM-MFU	x	x	x
Gauthier, Johanne	DFO Science	x	-	-

Name	Affiliation	Feb. 25th	Feb. 26th	March 3rd
Giffin, Melanie	PEIFA	x	x	x
Girard, Linda	DFO Science	x	x	-
Huard, David	RPPSG	x	x	-
Hubert, Nicholas	Membertou First Nations	x	-	x
Kelly, Brianne	WWF - Canada	x	x	x
Langelier, Serge	AMIK	x	x	-
MacMillan, Robert	PEI Fisheries	x	x	x
Marancik, Katey	NOAA	x	x	-
McQuinn, Ian	DFO Science	x	x	-
Mitchell, Vanessa	MAPC-MAARS	x	x	x
Munden, Jenna	Herring Science Council	x	x	x
McQuinn, Ian	DFO Science	x	x	x
Nilo, Pedro	DFO Science	x	x	-
Paquet, Frédéric	DFO Science	x	x	x
Pardo, Sebastian	Ecology Action Centre	x	x	x
Parent, Geneviève	DFO Science	x	x	-
Plourde, Stéphane	DFO Science	x	x	x
Rees, Bobbi	Government of NL	x	x	x
Richardson, David	NOAA	x	-	-
Rivierre, Antoine	DFO Fisheries management – Quebec	x	-	-
Sandt-Duguay, Emmanuel	AGHAMM	x	-	-
Scarratt, Michael	DFO Science	x	x	-
Schleit, Katie	Oceans North	x	x	x
Senay, Caroline	DFO Science	x	x	x
Smith, Andrew	DFO Science	x	x	x
Spingle, Jason	FFAW	x	x	x
Van Beveren, Elisabeth	DFO Science	x	x	x
Vautier, Jeffrey	Southern Gaspesia Processor	x	x	-
Wainwright, Hillary	DFO Fisheries management – Maritimes	-	x	x
Waters, Christa	DFO Fisheries management – Maritimes	x	x	x

SOURCES OF INFORMATION

This Science Advisory Report is from the February 25-26 and March 3, 2021 regional advisory meeting on the Assessment of the northern contingent of Atlantic Mackerel (*Scomber scombrus*). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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APPENDIX

Table 2. Nominal landings of mackerel in NAFO divisions 2-6 grouped by fishery and Exclusive Economic Zone. All landings in Canada's EEZ prior to 1995 as well as landings made by foreign vessels after 1994 were extracted from NAFO's Statlant 21a database. Landings within the EEZ of the United States were provided by NOAA

Year*	Canada EEZ**			U.S.A. EEZ***				
	Commercial	Foreign landings	Total Canada EEZ	Commercial	Recreational	Discards	Foreign Landings	Total USA EEZ
1968	11118	9720	20838	3929	-	-	56043	59972
1969	13257	5379	18636	4364	-	-	108811	113175
1970	15710	5296	21006	4049	-	-	205568	209617
1971	14942	9554	24496	2406	-	-	346338	348744
1972	16253	6107	22360	2006	-	-	385358	387364
1973	21566	16984	38550	1336	-	-	379828	381164
1974	16701	27954	44655	1042	-	-	293883	294925
1975	13540	22718	36258	1974	-	-	249005	250979
1976	15746	17319	33065	2712	-	-	205956	208668
1977	19852	2913	22765	1377	-	-	53664	55041
1978	25429	470	25899	1605	-	-	371	1976
1979	30244	368	30612	1990	-	-	72	2062
1980	22135	161	22296	2683	-	-	406	3089
1981	19294	61	19355	2941	2628	-	5300	10869
1982	16380	3	16383	3330	1877	-	6471	11678
1983	19797	9	19806	3805	2793	-	5882	12480
1984	17320	913	18233	5954	2726	-	14957	23637
1985	29855	1051	30906	6632	4088	-	17639	28359
1986	30325	772	31097	9637	7662	-	25735	43034
1987	27488	71	27559	12310	7555	-	34951	54816
1988	24060	956	25016	12309	5421	-	51463	69193
1989	20795	347	21142	14556	2829	160	37209	54755
1990	19190	3796	22986	31261	3254	827	9232	44575
1991	24914	1281	26195	26961	3540	1098	5989	37588
1992	24307	2255	26562	11761	921	2072	-	14754
1993	26158	690	26848	4662	1231	3902	-	9796
1994	20564	49	20613	8917	2654	5409	-	16980
1995	17740	62	17802	8468	1697	54	-	10219
1996	20406	76	20482	15728	2466	2053	-	20246
1997	21309	116	21425	15403	2857	229	-	18489
1998	19176	10	19186	14525	1553	98	-	16176
1999	16561	12	16573	12031	2832	771	-	15634
2000	16080	26	16106	5649	3055	153	-	8857
2001	24429	11	24440	12340	3301	718	-	16359
2002	34662	7	34669	26530	2679	155	-	29364

Year*	Canada EEZ**			U.S.A. EEZ***				
	Commercial	Foreign landings	Total Canada EEZ	Commercial	Recreational	Discards	Foreign Landings	Total USA EEZ
2003	44736	12	44748	34298	1874	264	-	36436
2004	53951	15	53966	54990	1169	2141	-	58300
2005	54809	-	54809	42209	1694	1083	-	44986
2006	53741	3	53744	56640	3911	135	-	60687
2007	53394	-	53394	25546	763	159	-	26468
2008	29671	4	29675	21734	2731	747	-	25212
2009	42231	42	42273	22634	1769	126	-	24529
2010	38700	1	38701	9877	4288	97	-	14261
2011	11508	-	11508	533	4040	38	-	4610
2012	6847	2	6849	5333	2671	33	-	8037
2013	8674	1	8675	4372	2406	20	-	6799
2014	6680	-	6680	5905	2296	51	-	8252
2015	4280	1	4281	5616	4275	13	245	10150
2016	8055	2	8057	5687	4572	18	1	10278
2017	9783	3	9786	6975	4173	83	132	11362
2018	10926	1	10927	-	-	-	-	10784
2019*	8704	-	8704	-	-	-	52	6857
2020*	7838	-	7838	8025	-	-	-	8025

* 2019 and 2020 values are preliminary

** For convenience, exclusive economic zones of the U.S.A. and Canada were applied even for years when the boundaries did not exist. In addition, the exclusive economic zone of France (St. Pierre and Miquelon) was included within the Canadian EEZ for convenience since 1995.

*** Total landings in the U.S. EEZ for 2018, and 2019 were acquired from NOAA's website and estimates of discards and recreational catches were not available for 2020. So called foreign landings from 2015-2020 are from Canadian vessels fishing in NAFO subarea 5 and presumably did not inscribe the NAFO subdivision correctly in their logbook.

Table 3. Nominal landings of mackerel by Canadian vessels from 1995-2020 rounded to the nearest tonne and grouped by NAFO division. Blank cells indicate there were no recorded landings for that year and division while a zero indicates that less than one tonne was landed. Landings where NAFO division was not recorded are indicated in the 'NA' column.

Year	2G	2J	3K	3L	3O	3P	4R	4S	4T	4V	4W	4X	5Y	5Z	NA
1995	-	-	11	11	-	124	2807	30	8184	1475	622	4477	-	0	-
1996	-	-	3	0	-	72	3794	9	11358	1591	1182	2398	-	-	-
1997	-	-	-	-	-	8	1181	1	15358	838	716	3208	-	0	-
1998	-	-	7	-	-	92	2232	0	12412	554	138	3662	78	-	-
1999	-	-	-	-	-	7	1438	2	10562	762	126	3663	-	-	-
2000	-	13	2317	55	-	20	2001	0	7005	576	120	3663	1	-	311
2001	-	-	322	10	-	273	8375	16	12008	125	248	2743	-	-	308
2002	-	-	6566	3	-	162	11251	2	14158	308	115	1771	-	-	326
2003	-	-	588	0	-	149	25938	-	14107	60	9	3669	-	-	217
2004	-	-	15993	58	-	79	23873	0	9346	13	59	4169	-	-	362
2005	-	-	24201	4105	-	238	14116	35	9238	126	36	2529	-	-	186
2006	-	-	19176	7960	-	266	16874	76	7785	224	75	1304	-	-	-
2007	-	-	8768	10673	27	354	24782	19	5763	370	59	1928	-	-	651
2008	-	-	9125	4	-	166	13741	23	4889	111	63	1000	-	-	549
2009	-	-	6898	39	-	5387	21913	64	6658	55	65	980	-	16	157
2010	-	-	12916	830	-	5541	13871	123	4706	7	129	418	-	-	158
2011	-	-	426	61	-	1544	5306	107	3544	2	18	390	-	-	112
2012	-	78	129	3	-	149	2261	304	3131	150	177	365	-	-	101
2013	40	4	191	-	-	26	4909	245	2759	146	17	241	-	-	97
2014	-	-	6	25	-	246	3155	20	2389	143	220	340	-	-	135
2015	-	-	208	54	-	-	438	29	2242	58	186	682	245	-	137
2016	-	-	2797	-	-	-	1836	62	1988	124	149	942	1	-	158
2017	-	-	1144	0	-	46	1463	139	4795	167	302	1453	133	-	141
2018	-	74	5295	0	0	-	247	467	3189	137	165	1226	0	2	160
2019	-	38	4652	-	-	0	124	223	2685	83	253	516	52	-	-
2020	-	207	3698	62	-	-	46	259	2344	80	200	848	-	0	27

Table 4. Nominal landings of mackerel by Canadian vessels from 1995-2020 rounded to the nearest tonne and grouped by gear type. Blank cells indicate there were no recorded landings for that year and division while a zero indicates that less than one tonne was landed. Landings by foreign vessels are not included. Gear types are aggregated from multiple subtypes of a given class of gear.

Year	Gillnets	Lines	Traps nets and weirs	Purse seine	Tuck seine	Other seines	Trawls	Miscellaneous
1995	4506	4732	4904	2727	-	0	59	812
1996	6429	5941	3823	3634	-	0	68	510
1997	6657	9232	3890	1116	-	9	92	313
1998	7656	5652	4146	1712	-	0	9	0
1999	5129	6008	4065	1348	-		12	-
2000	5297	2324	4215	3922	-	5	1	316
2001	6610	5897	3283	8097	-	231	3	308
2002	4958	9987	2136	16907	-	344	5	326
2003	4542	9882	3725	26331	-	22	0	234
2004	4716	5128	4657	36987	-	2088	2	373
2005	3903	6497	3440	33518	832	6423	1	195
2006	4509	4099	2333	35118	2788	4837	21	36
2007	3619	3097	2903	35592	4038	3465	7	673
2008	2475	2707	1155	20836	1718	186	0	592
2009	3469	3591	1660	29566	3019	681	1	245
2010	2730	2415	1129	27712	3428	1097	1	188
2011	1708	2058	646	5693	1066	130	1	206
2012	949	2245	705	2375	240	44	3	288
2013	621	2101	470	5000	266	-	5	211
2014	506	1819	596	3022	321	-	6	409
2015	644	1787	440	659	355	16	2	379
2016	930	1555	582	3895	290	345	4	455
2017	3959	1500	968	2337	452	40	6	521
2018	271	915	1042	5160	376	93	6	3100
2019	260	373	566	3949	713	80	6	2680
2020	168	268	952	3322	704	14	8	2336

Table 5. Nominal landings of mackerel by Canadian vessels from 1995-2020 rounded to the nearest tonne and grouped by DFO region. Landings by foreign vessels are not included.

Year	Gulf	Newfoundland	Quebec	Maritimes
1995	4831	2953	3382	6574
1996	7049	3869	4317	5170
1997	9590	1188	5769	4762
1998	8676	2331	3738	4431
1999	5462	1445	5104	4550
2000	5294	4406	2022	4359
2001	9123	8981	3212	3113
2002	10069	17982	4421	2190
2003	9727	26675	4597	3737
2004	7728	40003	1979	4241
2005	8238	42660	1221	2691
2006	6043	44277	1818	1603
2007	4685	44602	1750	2357
2008	3599	23036	1863	1173
2009	4562	34237	2316	1116
2010	3278	33159	1709	554
2011	2417	7337	1345	409
2012	2258	2619	1278	692
2013	1648	5169	1453	403
2014	1042	3432	1502	703
2015	1226	701	1182	1172
2016	1241	4633	966	1215
2017	3726	2653	1347	2057
2018	2390	5625	1426	1522
2019	2151	4814	754	908
2020	1951	4014	679	1128

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