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Quebec Region | **Canadian Science Advisory Secretariat**
Science Advisory Report 2019/035

ASSESSMENT OF THE ATLANTIC MACKEREL STOCK FOR THE NORTHWEST ATLANTIC (SUBAREAS 3 AND 4) IN 2018

Atlantic mackerel (Scomber sombrus L.). Photo credit: Claude Nozères.

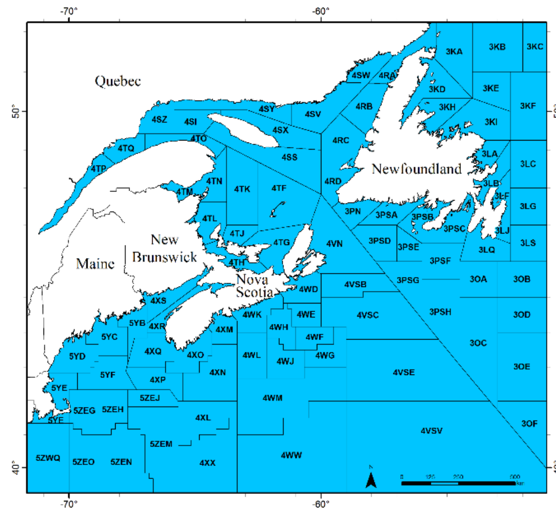

Figure 1. NAFO subareas and divisions.

Context:

Atlantic mackerel (Scomber scombrus L.) are found in the coastal waters of the Northwest Atlantic from North Carolina to Labrador (Figure 1). 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. 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. An unknown but possibly large proportion of the Northern contingent overwinters in American waters. The Southern contingent spawns in American waters between March and April primarily in the southern Gulf of Maine.

The commercial fishery for Atlantic mackerel in Canadian waters takes place in the Maritimes, Newfoundland and Labrador, and Quebec (NAFO subareas 3-4). It is primarily an inshore fishery that employs gillnets, jiggers, hand lines, seines, and traps, depending on the region and the time of year. Landings by Canadian harvesters increased substantially in the early 2000s with the entry of the Newfoundland large seiner fleet into the fishery and also coincided with a relatively strong 1999 year class. Landings subsequently fell substantially to reach a historic low of 4272 t in 2015 vs. a record high of 54 726 t in 2005.

The stock is currently in the Critical Zone of the Precautionary Approach and a management strategy evaluation is being developed.

The last assessment of the Northern Atlantic mackerel contingent was completed in March 2017. The Fisheries and Aquaculture Management Branch has requested scientific advice on the Canadian Atlantic mackerel quota and other issues for the 2019-2020 fishing seasons.

SUMMARY

- Reported commercial landings in Canadian waters have decreased significantly in recent years. Between 2005 and 2013, they decreased from 54,726 t to 8,674 t before reaching a record low of 4,272 t in 2015. Preliminary landings in 2017 and 2018 were 9,430 t and 10,499 t.
- The TAC was reached for the first time in 2016. The TAC increased from 8,000 t to 10,000 t in 2017 and was surpassed in 2018.
- Total landings in US waters (commercial and estimated recreational and discards) also decreased significantly in recent years. In 2016 and 2017 landings were 10,277 t and 11,230 t. Based on the 2017 American assessment of the NW Atlantic stock, mackerel were determined overfished and overfishing is occurring.
- Preliminary analyses on otolith stable isotopes as well as a synthesis of tagging data suggest that a large proportion of Northern contingent (Canadian) Atlantic mackerel are caught in US fisheries. As such, estimates of removals of Northern contingent mackerel in US waters are now explicitly accounted for in this stock assessment.
- Preliminary genetic analyses of mackerel caught in Northeast Newfoundland, the Gulf of St. Lawrence, and Europe suggest that nearly all genotyped adult mackerel caught in Northeast Newfoundland have a Northwest Atlantic genetic signature. This concords with information from previous tagging studies.
- Preliminary analyses suggest that mackerel recruitment and condition are negatively influenced by warming temperatures and the reduced availability of their preferred prey.
- Since 2005, the spawning stock biomass index has declined and is now approximately one twentieth of the levels observed in the 1980s.
- The current age structure is truncated compared to the pre-2000 period and is now dominated by one year class. The 2015 year class represented 75% of declared landings by weight in 2018.
- A revised catch-censored statistical catch-at-age model was developed to include unaccounted for Canadian catch as well as US catch of Northern contingent mackerel.
- According to the consensus model, the current estimate of the 2016 spawning stock biomass is 59% of the LRP compared to 77% in 2018. The estimated 2018 fishing mortality was 1.13 (exploitation rate of 68%). Recruitment levels in 2017 and 2018 are at all-time lows.
- Short-term projections under different harvest control rules indicated that, with increasing TACs from 0 to 10,000 t, the probability of exceeding the LRP by 2021 decreased from 68 to 48%, and the probability of stock growth by 2021 decreased from 78 to 49%.
- A draft Management Strategy Evaluation (MSE) was peer-reviewed. Scientific review resulted in suggestions to add trade-offs to management objectives, to improve operating models, and to develop quantitative metrics for strategy evaluation. These steps would provide an improved basis to select Management Procedures to attain specific objectives (including rebuilding) for the stock under key uncertainties.

BACKGROUND

Ecology

Atlantic Mackerel are a highly migratory temperate water fish in the *Scombridae* family. They have a broad distribution and occur on both sides of the North Atlantic in water temperatures between 7-16˚C. In the Northwest Atlantic (NWA), they can range from Cape Lookout, North Carolina to Black Island, Labrador. The Northern contingent of the NWA mackerel stock spawns primarily in the Southern Gulf of Saint Lawrence (GSL) in June and July and subsequently disperses to feed opportunistically on zooplankton and small fish. In the fall, they migrate South to overwinter in deeper warmer waters along the continental shelf as far South as the coastal waters of New Jersey and Northwards along the Scotian Shelf. Mackerel play a key role in the ecosystem through the transfer of energy from lower trophic levels (e.g. zooplankton) to higher order predators including a large range of fish, marine mammals, and sea birds. Mackerel recruitment is dependent on favourable water temperatures, the availability of prey, and the presence of older individuals in the population which contribute a disproportionally greater amount of higher quality eggs compared to smaller younger individuals.

Recent history of the fishery

During the 1980s and 1990s, Canadian landings were relatively stable and averaged around 22,000 t per year. Landings increased by nearly 400% between 2000 and 2006, reaching a record high of 55,726 t in 2005. This was due to the marked increase in fishing effort by small and large seiners on the Northeast and West coasts of Newfoundland (NAFO Divisions 3KL and 4R) and the presence of a large 1999 year class. From 2000 to 2010, Canadian landings averaged 40,498 t with the fleets in Newfoundland consistently taking the majority of the catch. This was followed by a severe drop in total landings across all regions, reaching a low of 4,272 t in 2015 (Figure 2). From 2014-2016, the TAC was lowered to 8,000 t and was reached for the first time in 2016. The TAC was subsequently increased in 2017-2018 to 10,000 t. The TAC was surpassed by nearly 500 t in 2018 resulting in the closure of the commercial fishery. A rebuilding plan working group (RPWG) is currently developing a management strategy evaluation (MSE) framework and has met several times a year since 2017.The RPWG includes stakeholders from the industry, fisheries management, First Nations, non-governmental environmental organisations, and provincial governments from each of the five Provinces in Eastern Canada.

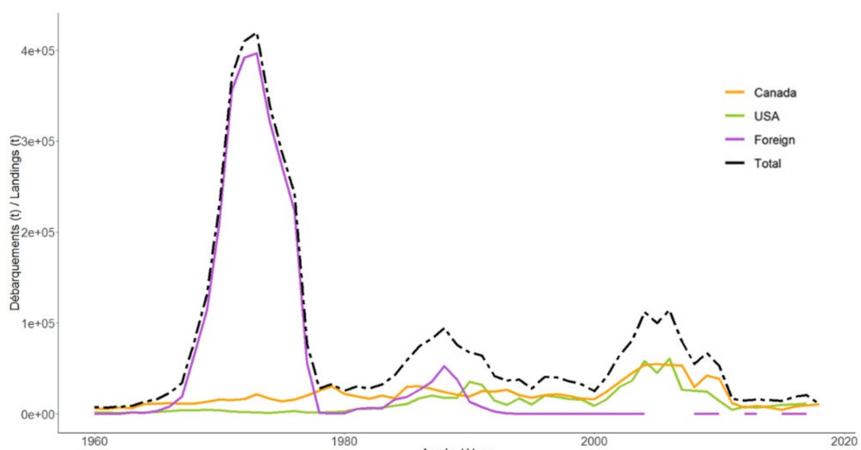

Figure 2. Annual Atlantic mackerel landings (t) in the Northwest Atlantic (NAFO subareas 2-6) since 1960.

ASSESSMENT

Landings: 2015-2018

In NAFO subareas 3-4, landings totalled 4,272 t, 8,050 t, 9,430 t, and 10,499 t from 2015 to 2018 respectively. Landings in 2015 were the lowest on record since 1960 and they have remained far below the catch levels from 2001-2010. Mackerel landings continue to be underestimated due to undeclared catches in the bait, and recreational fisheries. The magnitude of discards (in which mortalities are likely high) is also unknown. Landings in the United States dropped sharply in 2010 and have subsequently remained low compared to historic catches (Table 1).

Table 1. Annual Atlantic mackerel landings (t) in NAFO subareas 2-6 from 2000 to 2018. Canadian landings are underestimated due to undeclared catches in the bait and recreational fisheries.

	NAFO 3-4			NAFO 5-6			
Year	Canadian TAC	Canadian	Foreign	USA Commercial	USA Recreational	USA Discards	Total
2000	100,000	16,080	26	5,649	3,055	153	24,964
2001	75,000	24,336	11	12,340	3,301	718	40,706
2002	75,000	34,755	7	26,530	2,679	155	64,126
2003	75,000	44,736	12	34,298	1,874	264	81,184
2004	75,000	53,650	15	54,990	1,169	2,141	111,966
2005	75,000	54,726		42,209	1,694	1,083	99,712
2006	75,000	53,554	3	56,640	3,911	135	114,244
2007	75,000	53,275		25,546	763	159	79,743
2008	75,000	29,511	4	21,734	2,731	747	54,726
2009	75,000	42,206	42	22,634	1,769	126	66,777
2010	60,000	38,650	1	9,877	4,288	97	52,913
2011	60,000	11,485		533	4,040	38	16,096
2012	60,000	6,844	2	5,333	2,671	33	14,883
2013	36,000	8,674	1	4,372	2,406	20	15,474
2014	8,000	6,679		5,905	2,296	51	14,931
2015	8,000	4,272	1	5,616	4,275	13	14,178
2016	8,000	8,050	2	5,687	4,572	18	18,329
2017*	10,000	9,430	3	6,975	4,173	83	20,664
2018*	10,000	10,499	NA	NA	NA	NA	NA

**2017 and 2018 values are preliminary*

Before 1999, most landings occurred in the Gulf and Maritimes Regions. Following the arrival of the 1999 year class and an increase in fishing effort, the Newfoundland region has caught 58% of total catches on average (Table 2, Table 3).

Table 2. Landings (t) by DFO Region from 2015-2018. Values in parentheses represent the proportion of total catches caught by region. Mean proportional landings by DFO Region are also shown.

Year	Gulf Region	Newfoundland Region	Quebec Region	Maritimes Region	Total
2015	1,218 (29%)	701 (16%)	1,182 (28%)	1,171 (27%)	4,272
2016	1,241 (15%)	4,631 (58%)	966 (12%)	1,213 (15%)	8,050
2017*	3,560 (38%)	2,648 (28%)	1,211 (13%)	2,012 (13%)	9,430
2018*	2,260 (22%)	5,625 (54%)	1,239 (12%)	1,375 (13%)	10,499

Time period	Mean Gulf	Mean Newfoundland	Mean Quebec	Mean Maritimes
Pre-1999	8,446 (39%)	3,950 (17%)	3,446 (16%)	1,846 (28%)
Post-1999	4,759 (21%)	18,491 (58%)	1,952 (11%)	1,846 (10%)

**2017 and 2018 values are preliminary*

Table 3. Annual landings (t) by Canadian vessels by NAFO Division.

Year	2GJ	3K	3L	3PO	4R	4S	4T	4V	4W	4X	5YZ	NA	Grand Total
2000	13	2,317	55	20	2,001	0	7,005	576	120	3,663	1	311	16,080
2001	0	322	10	273	8,375	16	11,915	125	248	2,743	0	308	24,336
2002	0	6,566	3	162	11,251	2	14,251	308	115	1,771	0	326	34,755
2003	0	588	0	149	25,938	0	14,107	60	9	3,669	0	217	44,736
2004	0	15,964	58	78	23,631	0	9,342	13	59	4,143	0	362	53,650
2005	0	24,170	4,105	238	14,077	35	9,234	126	36	2,521	0	186	54,726
2006	0	19,050	7,932	266	16,872	76	7,755	224	75	1,304	0	0	53,554
2007	0	8,672	10,659	381	24,777	19	5,759	370	59	1,928	0	651	53,275
2008	0	8,974	4	166	13,741	23	4,884	111	63	997	0	549	29,511
2009	0	6,883	39	5,387	21,909	64	6,652	55	65	980	16	157	42,206
2010	0	12,874	830	5,541	13,869	123	4,702	7	129	418	0	158	38,650
2011	0	426	61	1,544	5,286	107	3,542	2	18	390	0	112	11,485
2012	78	128	3	149	2,261	304	3,129	150	177	365	0	101	6,844
2013	44	191	0	26	4,909	245	2,759	146	17	241	0	97	8,674
2014	0	6	25	246	3,155	20	2,389	143	220	339	0	135	6,679
2015	0	208	54	0	438	29	2,234	58	186	682	245	137	4,272
2016	0	2,795	0	0	1,836	62	1,987	124	149	939	1	158	8,050
2017*	1	1,160	0	45	1,443	139	4,629	156	288	1,435	133	3	9,430
2018*	74	5,336	3	0	211	467	3,015	118	112	1,143	2	14	10,499

**2017 and 2018 values are preliminary*

Population Structure

For decades, harvesters and other stakeholders in Newfoundland have questioned whether the mackerel caught in their coastal waters originated from the same spawning stock as those caught in other areas of Eastern Canada. To address this question, multiple tagging studies as well as comparative analyses of the age structure of mackerel caught across these areas have been employed since the 1970s. In addition, multiple egg and larvae surveys have been conducted on the Western (2004-2008), Southwestern (2009), and Northeastern (2015-2016) coasts of Newfoundland to attempt to identify additional spawning areas. These studies concluded there is little to no spawning on the coasts of Newfoundland, that mackerel migrate between Newfoundland and the other regions and that the age structure of mackerel caught in Newfoundland corresponded to that elsewhere in Canada. Hence, there is evidence that mackerel caught off the coasts of Newfoundland originate from the same population as the rest of mackerel caught in Canadian waters.

A request for further analyses into the origin of mackerel in Newfoundland was made in 2018. DNA from mackerel of Northeastern Newfoundland (3KL), the Gulf of Saint Lawrence (4RST), the Scotian Shelf (4WX), and the Bay of Biscay (Europe) were obtained from the commercial fishery as well as fisheries independent surveys in 2018. The genomes of the samples were sequenced and analysed to determine whether samples obtained from 3KL were from Northeast Atlantic (NEA) population or the Northwest Atlantic (NWA) population. The results confirmed the existence of only two populations of Atlantic mackerel (NWA and NEA), as over 99% of the samples from Canada had a NWA mackerel genetic signature. These results therefore confirm that mackerel caught in Newfoundland do not originate from the European population.

Ecosystem considerations

Surface and bottom water temperatures have increased steadily across the Northern contingent's entire habitat since the late 1990s. Zooplankton biomass, particularly that of *Calanus finmarchicus*, one of mackerel's preferred prey, has also decreased throughout the

NWA in recent years. Mackerel recruitment, and gain in condition (reflecting health) and the availability of food have also been below average over the same time period.

Changes in mackerel distribution, recruitment, survival, and growth are known to vary with changes in temperature and the availability of prey in the NWA and NEA populations. During the current stock assessment, new exploratory analyses testing whether variation in mackerel migration, recruitment, and seasonal growth could be explained by variation in environmental variables linked to prey availability and water temperature were presented and discussed. The hypothesis that mackerel recruitment and condition are mainly driven by trophic conditions (food quantity and quality) was tested by analyzing the relationship between these biological indices and both physical and biological environmental factors. These analyses suggested that mackerel recruitment and condition are negatively influenced by warming temperatures and the reduced availability of their preferred prey, *Calanus* copepods. The hypothesis that mackerel migration is also constrained by both physical and biological factors was also tested. These results showed that the variation in relative landings from a given region depend on the relative availability of prey from one region to another as well as the presence of favourable water temperatures. As these analyses lent support to the current understanding of mackerel's interaction with its environment, this line of research will be continued in future assessments within an ecosystem approach framework.

Biological indicators

The length at which 50% of individuals are sexually mature (L_{50}) is calculated using samples obtained from the Southern GSL in June and July. This measure has been used in the past as a management measure to set a minimum commercial size to ensure that at least half of all fish caught have the chance to spawn at least once. In 2018, the time series mean L_{50} was 267 mm while the mean L_{50} of the last five years (2013-2018) was 268 mm (Figure 3).

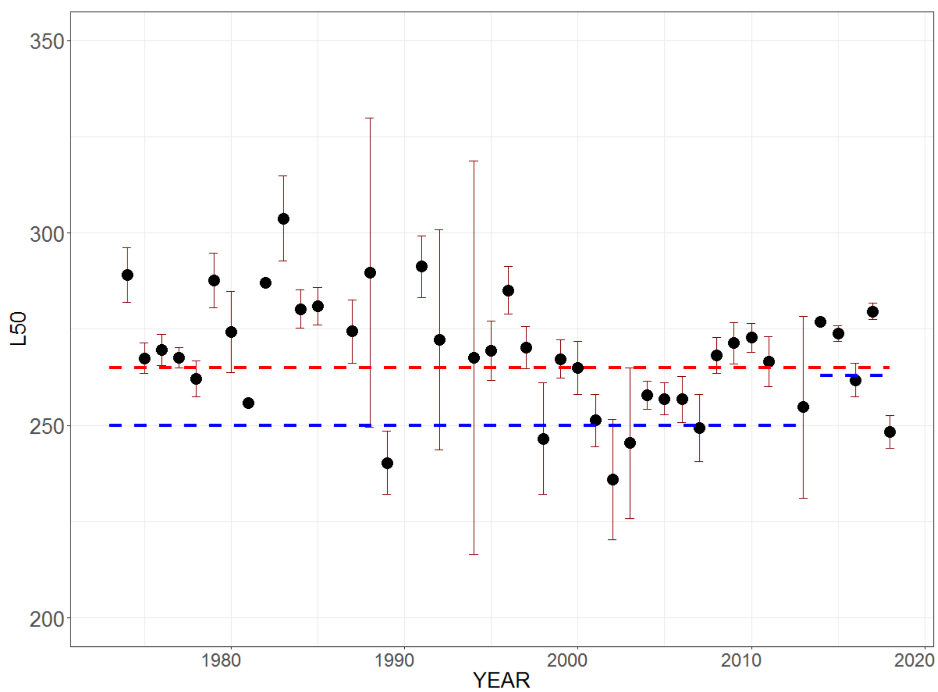

Figure 3. L_{50} of mackerel calculated from commercial samples in June and July. The red dotted line represents the time series mean while the blue dotted line represents the minimum legal size.

Catch-at-age structure

Mackerel age structure in the landings is influenced by the periodic arrival of dominant year classes (e.g. 1967, 1974, 1982, 1988, and 1999), which could often be tracked until age 10^+. However, in the last few decades, older individuals gradually disappeared from the catches as especially new dominant year classes did not persist as long over time (Figure 4). The truncation of the age structure in the catches culminated in the observations of only 7 mackerel over age 6 in the commercial samples since 2015 (n = 7,593 fish aged). Age-length keys applied to unaged individuals confirm this age truncation (n = 47,625 fish measured). The last individual confirmed to be at least ten years old was caught in 2011.

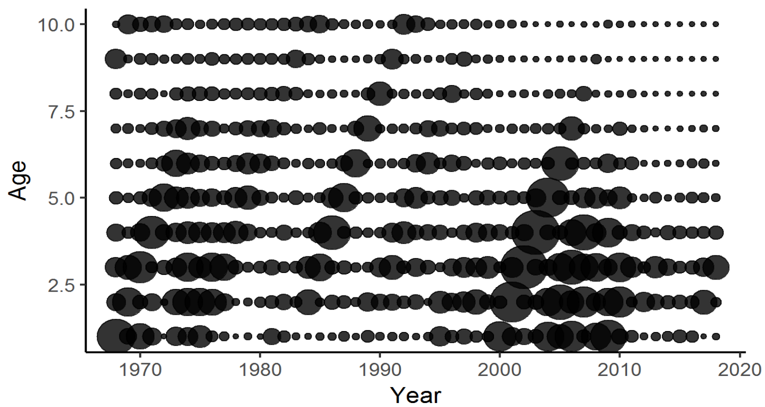

Figure 4. Catch-at-age data calculated from samples from the commercial fishery (1968-2018).

During the last stock assessment, the arrival of a potentially large 2015 year class was anticipated (DFO 2017). In 2017, the 2015 year class began indeed to dominate landings and by 2018 it composed around 75% of mackerel landed in Canada. No new strong year-classes have been observed in the catch-at-age data since 2015, despite increased sampling across all DFO regions and increased proportions of commercial samples under the legal size of 263 mm being analysed (Figure 5).

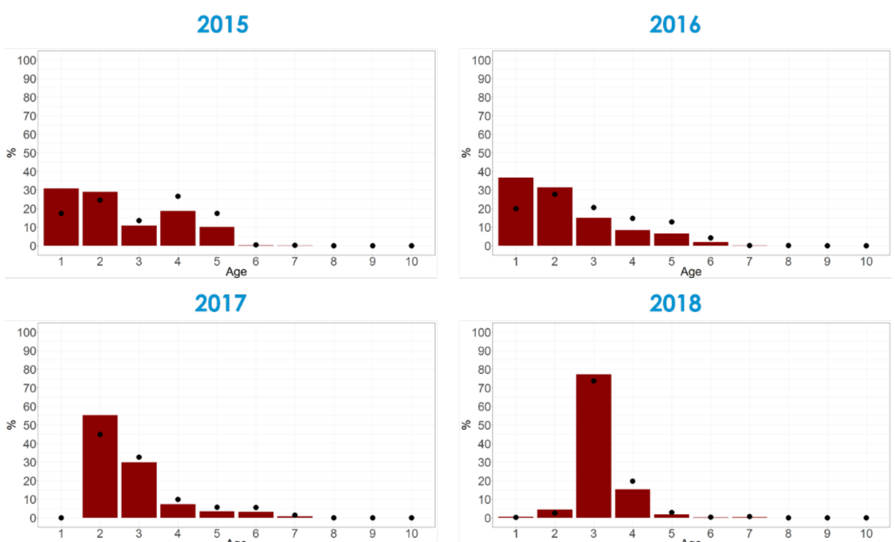

Figure 5. Catch-at-age data calculated from samples obtained from the commercial fishery (2015-2018). Red bars represent proportion of catch-at-age by number and black dots represent proportion of catch-at-age by weight (t).

Egg Survey Index

Regular standardised ichthyoplancton surveys targeting mackerel eggs have taken place in the Southern GSL since 1979. A relative abundance index of the Spawning Stock Biomass (SSB) is calculated from data collected on this mission and was used to calibrate the censured-catch-at-age model (Van Beveren et al. 2017a). The Southern GSL is the main spawning area, as exploratory surveys elsewhere found little to no mackerel eggs (Scotian Shelf in 1922, 1999, and 2009; Southwest coast of Newfoundland in 2004, 2005, 2007, 2008; Northeast coast of Newfoundland in White Bay, Notre Dame Bay, and Trinity Bay in 2015 and 2016). Habitat suitability analyses confirmed that areas where exploratory surveys were conducted would not represent significant spawning areas relative to the main one, the Southern GSL.

Spawning in the Southern GSL begins on average on June 5th, peaks on June 21st, and ends on July 22nd (Figure 6). While the duration of spawning time has contracted progressively in recent years, the peak spawning date has remained fairly constant over time. The area over which mackerel eggs are found has also contracted considerably since 1979. Whereas mackerel eggs and larvae used to be found across the entire sampling area they are in recent years mostly found in the Western portion of the Southern GSL (Figure 7).

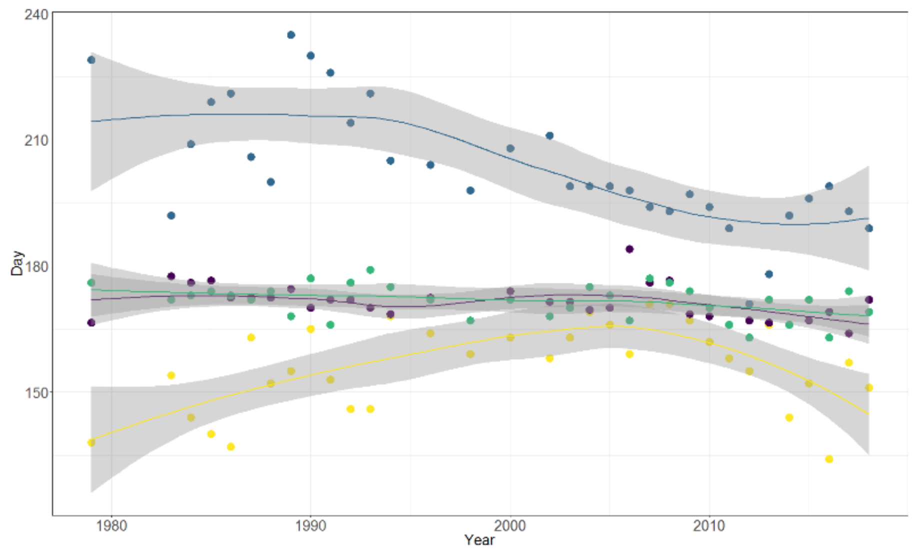

Figure 6. Atlantic mackerel spawning dates (Julian day) as calculated from biological samples from the commercial fishery. Colours indicate start date (yellow), peak spawning date (green), median mission date (violet), and spawning end date (blue).

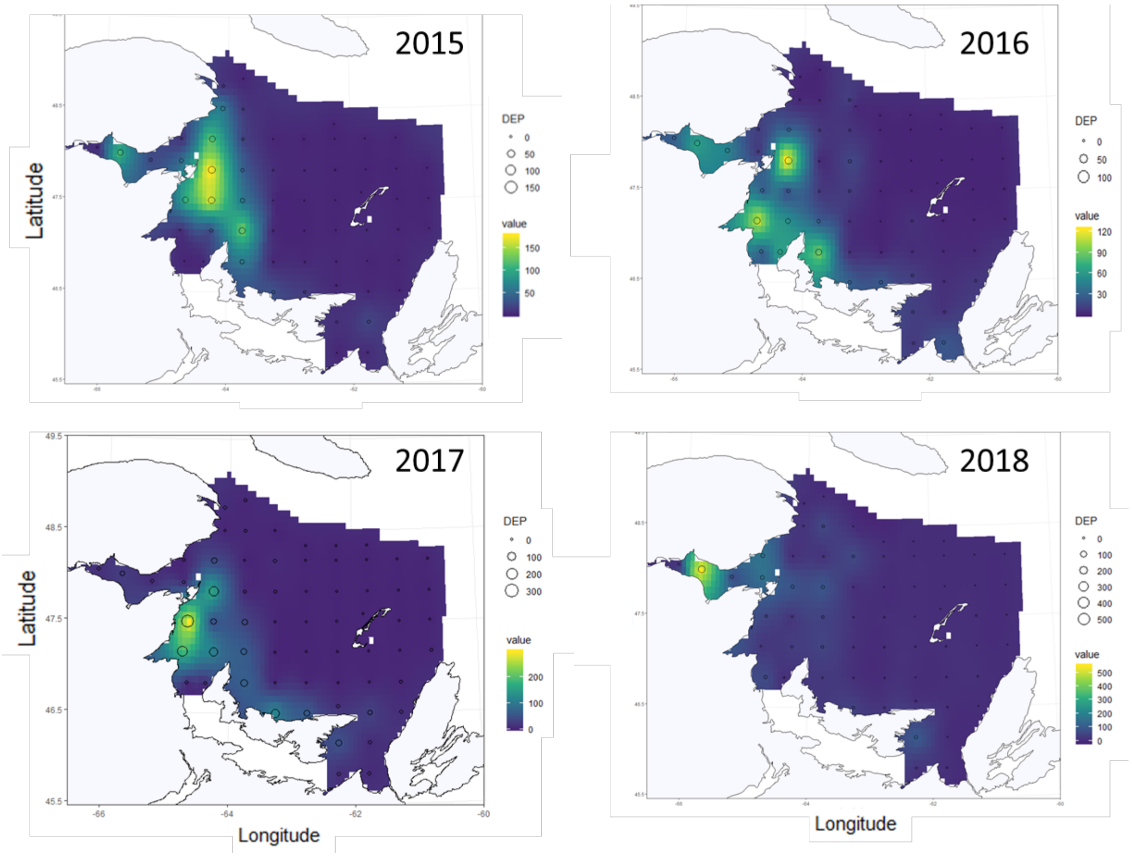

Figure 7. Daily egg production (DEP) of mackerel eggs (n/m²) from 2015-2018. Sampling stations are indicated by circles, the size of which represents the calculated daily egg production for each station. The interpolated DEP values for the entire survey area are also shown.

The index calculated from the egg survey has decreased sharply since 1994, but increased slightly with the arrival of the 1999 year class. The index then dropped again to reach an all time low in 2012. The index has continued to remain low ever since with the mean value of the last 10 years representing approximately 6% of the mean values calculated prior to 2000 (Figure 8).

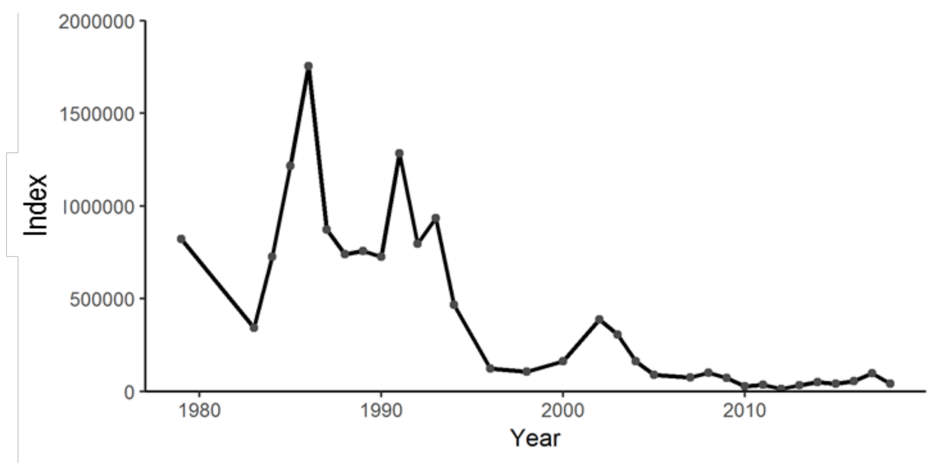

Figure 8. Mackerel egg index calculated using the daily egg production method.

Analytical assessment

An analytical assessment was performed with a censored-catch statistical catch-at-age model, which was updated from the 2017 stock evaluation (DFO 2017, Van Beveren *et al.* 2017a). Population dynamics were estimated from catch-at-age proportions, egg index values (SSB) and total catch data. The DFO statistics of total mackerel landings were explicitly considered to be biased. That is, catch was estimated between lower and upper catch limits, which reflected the uncertainty in fisheries removals of Northern contingent fish in both Canadian and US waters (Figure 9).

The model estimated that SSB has been below the Lower Reference Point (LRP) since 2011, reaching historical lows in 2015 and 2016 (both years at 59% of the LRP; Figure 10). According to the model, SSB subsequently increased in 2017 (73% of the LRP) and 2018 (77% of the LRP) because the 2015 year-class reached average recruitment levels (Figure 10). That is, the number of age-1 recruits from the 2015 year-class is 38% of that of the 1999 year-class. With the exception of this year-class, recruitment has however been below average since 2010 and was estimated to be at an all-time low in 2017. Therefore, the 2015 cohort is currently dominating the population. Fishing mortality of fully selected fish (ages 5-10) in both 2017 and 2018 was estimated at 1.13, equal to an annual exploitation rate of 68%.

Projections were made over a three-year period to estimate the impact of different Harvest Control Rules (HCRs) on the SSB. Because the stock is currently considered to be within the Critical Zone, HCRs usually result in the application of a constant floor TAC over the next three years, with the exception of HCR 3, which allows the TAC to change up to 25% from one year to the next, depending on the relative change in the egg survey index. With increasing TACs from 0 to 10,000 t, the probability of exceeding the LRP by 2021 decreased from 68% to 48%, and the probability of stock growth from 2019 to 2021 decreased from 78% to 49%. Note that under the current quota (10,000 t), the stock is more likely to decline than grow (49%). The projections accounted for the uncertainty surrounding unaccounted-for catch from both Canada and the US (see Figure 11 and Table 4).

Table 4. Three-year projections under different TACs (as determined by the Harvest Control Rules or HCRs, described in the corresponding research document). Some HCRs (e.g. HCR 2, 4, 5 and 6) would result in (quasi-)identical TACs (median values) over the next three years and were therefore removed. The projections indicate the probability of reaching the Limit Reference Point (LRP) in 2020 and 2021 (Prob(SSB > LRP) and the probability of growth occurring between 2019 and 2021 (Prob(SSB2021 > SSB2019)). The beginning of year SSB is given relative to the LRP (median value) for 2020 and 2021. Projections were performed under the assumption that mackerel will also be caught outside of the TAC, by both the Canadian and US fleets (uncertainties represented by the 5th and 95th quantile taken over the three years). Figure 9 shows the assumed annual unaccounted-for catch distributions in detail.

HCR	**TAC**			**Prob(SSB >LRP)**		**Prob(SSB_{2021}>SSB_{2019})**	**SSB/LRP**		**Unaccounted-for catch**			
									Canada		US	
	2019	2020	2021	2020	2021	2019→2021	2020	2021	5%	95%	5%	95%
3	9640	9334	8614	0.49	0.49	0.51	0.69	0.71	2425	4986	420	7282
4	0	0	0	0.60	0.68	0.78	0.98	1.16	2425	4986	420	7282
7	2000	2000	2000	0.58	0.65	0.72	0.92	1.06	2425	4986	420	7282
8	4000	4000	4000	0.55	0.60	0.65	0.86	0.96	2425	4986	420	7282
9	6000	6000	6000	0.53	0.56	0.59	0.79	0.86	2425	4986	420	7282
10	8000	8000	8000	0.51	0.52	0.53	0.74	0.76	2425	4986	420	7282
11	10000	10000	10000	0.49	0.48	0.49	0.67	0.68	2425	4986	420	7282

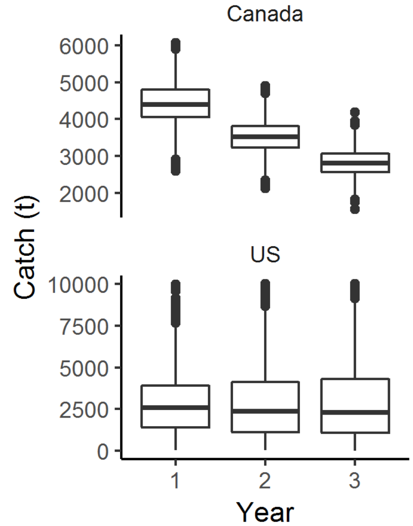

Figure 9. Boxplots of the assumed unaccounted-for catch over the next 3 years (2019-2021), for Canada (upper panel) and the US (lower panel). Boxes include 50% of all observations as they are delimited by the 1st and 3rd quantile, with the median value represented by the central horizontal line.

A Management Strategy Evaluation (MSE) was also peer reviewed and results will, after further development, be published in an associated research document. Projections performed under the MSE framework will incorporate key uncertainties and be presented in function of management objectives, as defined by members of the RPWG.

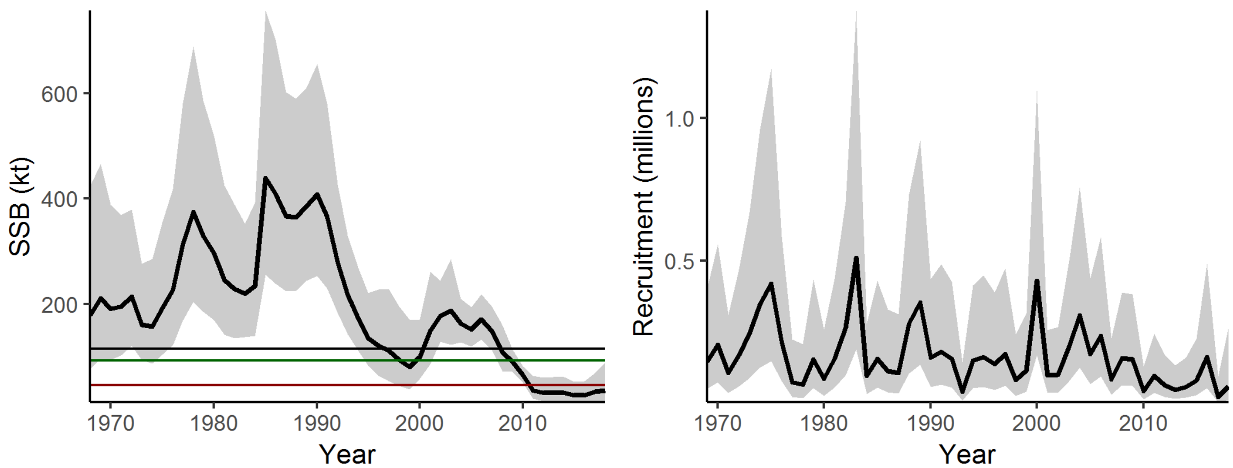

Figure 10.Spawning Stock Biomass (SSB; left) and age-1 recruitment (number of fish in millions; right) time-series estimated by the model. The SSB at $F_{40\%}$ (black line) was used as a proxy for F_{MSY} and the Limit Reference Point (LRP; red line) and Upper Stock Reference point (USR; green line) were calculated as 40% and 80% of this value, respectively. The shaded area indicates the 95% confidence interval.

Sources of Uncertainty

Canadian landing statistics are known to underestimate total fisheries mackerel removals and traditionally this has been considered to be the largest source of uncertainty in the assessment (Van Beveren *et al.* 2017b). Since 2017, this uncertainty has been explicitly incorporated within the assessment. However, the magnitude and temporal pattern of this uncertainty is inherently inexact. Any level of uncertainty and its boundaries will affect estimates and projections. Effort should be made to improve catch monitoring in Canadian waters and gain a better understanding of US catches of northern contingent fish.

CONCLUSIONS

The Northern contingent of the Northwest Atlantic mackerel population remains in the Critical Zone of the Precautionary Approach. Fishing mortality is much higher than reference levels. SSB and recruitment are either close to or at all-time historic lows and there is a severe truncation in the population's age structure. Low recruitment is largely driven by the low SSB but also by unfavourable environmental conditions. The absence of older larger mackerel, which produce a greater quantity and quality of eggs, likely also contributes to low productivity. While there was a slight increase in SSB from 2016 to 2018 due to the arrival of the 2015 year class into the fishery, the actual total number of fish in the water has decreased. Short term projections over three years indicate that there is little chance of leaving the Critical Zone by 2021, even under the most restrictive exploitation scenarios.

LIST OF MEETING PARTICIPANTS

Name	Affiliation	March 5	March 6	March 7
Boudreau, Brian	Acadian Marine Inc.	x	x	x
Boudreau, Mélanie	DFO Science	x	x	-
Bourdages, Hugo	DFO Science	x	x	-
Brassard, Claude	DFO Science	x	x	-
Brosset, Pablo	DFO Science	x	x	x
Carruthers, Erin	FFAW	x	x	x
Castonguay, Martin	DFO Science	x	x	x
Cawthray, Jenness	DFO Fisheries Management – Ottawa	x	x	x
Collin, Ghislain	RPPSG	-	x	-
Comtois, Sophie	DFO Science	x	-	-
Cook, Jim	PEIFA	x	x	x
Cox, Sean	Simon Fraser University	x	x	x
Curti, Kiersten (tel)	NOAA	x	-	-
Cyr, Charley	DFO Science	x	x	x
Deroba, Jonathan (tel)	NOAA	-	x	-
Desgagnés, Mathieu	DFO Science	x	x	x
Dubé, Sonia	DFO Science	x	x	x
Duguay, Gilles	RPPSG	-	-	x
Duplisea, Daniel*	DFO Science	x	-	-
Dunne, Erin	DFO Fisheries Management – NL	x	x	x
Ellefsen, Hans F.	DFO Science	-	x	-
Émond, Kim	DFO Science	x	x	-
Giffin, Melanie	PEIFA	x	x	x
Girard, Linda	DFO Science	x	x	x
Huard, Christian	RPPSG	-	-	x
Hurtubise, Sylvain	DFO Science	x	x	x
Kelly, Brianne	WWF - Canada	x	x	x
Khamassi, Safouane	ISMER – UQAR	x	x	x
Krondlund, Allen Rob	DFO Science – Ottawa	x	x	x
Lelièvre, Lauréat	Fisherman	x	x	x
Lester, Brian	DFO Fisheries Management – Ottawa	x	x	x
Mallet, Pierre	DFO Fisheries Management – Golfe	x	x	x
Marentette, Julie	DFO Science – Ottawa	x	x	x
Mitchell, Vanessa	MAPC-MAARS	x	x	x
Munden, Jenna	Herring Science Council	x	x	x
MacEwen, David	PEI Dept Fisheries	x	x	x
McQuinn, Ian	DFO Science	x	-	-
Nozères, Claude	DFO Science	x	-	-
Perrin, Geneviève	DFO Science	x	-	-
Richardson, David (tel)	NOAA	x	x	-
Rivierre, Antoine	DFO Fisheries Management – Québec	x	x	x
Robert, Dominique	UQAR-ISMER	x	x	-
Roy, Virginie	DFO Science	x	-	-
Schleit, Katie	Oceans North	x	x	x
Senay, Caroline	DFO Science	x	x	x
Smith, Andrew	DFO Science	x	x	x
Van Beveren, Elisabeth	DFO Science	x	x	x
Veillet, Guillaume	UQAR-ISMER	x	x	x
Waters, Christa	DFO Fisheries Management – Maritimes	x	x	x
Zhang, Fan	MI-MUN	x	x	x

SOURCES OF INFORMATION

This Science Advisory Report is from the March 5-7, 2019 on Assessment of Atlantic Mackerel in Subareas 3-4. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Doniol-Valcroze, T., Van Beveren, E., Légaré, B., Girard, L., and Castonguay, M. 2019. Atlantic mackerel (Scomber scombrus L.) in NAFO Subareas 3 and 4 in 2016. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/062. v + 51 p.

DFO. 2017. Assessment of the Atlantic Mackerel Stock for the Northwest Atlantic (Subareas 3 and 4) in 2016. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/034.

Van Beveren, E., Duplisea, D., Castonguay, M., Doniol-Valcroze, T., Plourde, S., and Cadigan, N. 2017a. How catch underreporting can bias stock assessment of and advice for northwest Atlantic mackerel and a possible resolution using censored catch. Fisheries Research. 194. 146-154. 10.1016/j.fishres.2017.05.015.

Van Beveren, E., Castonguay, M., Doniol-Valcroze, T., and Duplisea, D. 2017b. Results of an informal survey of Canadian Atlantic mackerel commercial, recreational and bait fishers. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/029. v + 26 p

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MPO. 2019. Évaluation du stock de maquereau bleu du Nord-Ouest de l'Atlantique (sous-régions 3 et 4) en 2018. Secr. can. de consult. sci. du MPO, Avis sci. 2019/035.