Atlantic salmon from North America

Summary of the advice for 2021 to 2024

ICES advises that, in line with the management objectives agreed by the North Atlantic Salmon Organization (NASCO) and consistent with the MSY approach, the catch of one-sea-winter (1SW) non-maturing salmon and two-sea-winter (2SW) salmon in mixed-stock fisheries in North America should be zero in the period 2021 to 2023. ICES advises that when the MSY approach is applied, fishing should only take place on salmon from rivers where stocks are at full reproductive capacity. Mixed-stock fisheries present particular threats and should be managed based on the individual status of all stocks exploited in the fishery.

In the absence of any fishing on 1SW non-maturing salmon and 2SW salmon in North America, there is a less than 75% probability in the period 2021 to 2023 that the numbers of 2SW salmon returning to the six regions of North America will be above the defined management objectives (conservation limits [CLs] for the four northern areas; rebuilding objectives for the two southern areas) simultaneously for the six regions.

The Framework of Indicators (FWI) was updated in support of the multiyear catch advice and the potential approval of multiyear regulatory measures. The FWI can be applied at the beginning of 2022, using the returns or return rate data for 2021 to evaluate the appropriateness of the advice for 2022, and again at the beginning of 2023, using the returns or return rate data for 2022 to evaluate the appropriateness of the advice for 2023.

NASCO 3.1 Describe the key events of the 2020 fisheries (including the fishery at Saint Pierre and Miquelon)

The provisional reported (i.e. nominal) catch of Atlantic salmon in eastern North America in 2020 was estimated at 105.6 t, of which 103.9 t was reported from Canada, 1.7 t from France (Islands of Saint Pierre and Miquelon [SPM], located off the southern coast of Newfoundland), and 0 t from USA (tables 1 and 2; Figure 1). There were no commercial or recreational fisheries for Atlantic salmon in USA in 2020. The dramatic decline in catches since 1980 is in large part the result of the reductions in commercial fisheries effort, with the closure of the Newfoundland commercial fishery in 1992, the Labrador commercial fishery in 1998, and the Quebec commercial fishery in 2000. All commercial fisheries for Atlantic salmon remained closed in Canada in 2020.

Unreported catch for Canada in 2020 was 27.1 t and for USA 0 t. France (Saint Pierre and Miquelon) did not provide an unreported catch value.

The assessment regions for North America are shown in Figure 2.

Three groups exploited salmon in Canada in 2020: indigenous people, residents fishing for food in Labrador, and recreational fishers. No rivers in the Gulf and Scotia–Fundy regions of Canada were opened for retention recreational fisheries. Mandatory catch-and-release measures were in effect during the period 2015–2020 in the recreational fisheries for the Gulf region. Recreational fisheries regulations in Quebec limited the retention of small (< 63 cm, fork length) and large salmon to 20 of 114 rivers and the retention of small salmon only to 52 rivers. Eight rivers were opened to catch-and-release only, and 34 rivers were closed to salmon fishing. Retention of small salmon was only allowed in rivers which were open for recreational fisheries in Newfoundland and Labrador.

For Canada in 2020, 7% of the catches were taken in coastal areas, and these were entirely from Labrador. The catches from France (Saint Pierre and Miquelon) were entirely from coastal areas. Overall for eastern North America in 2020, 50% of the catches were in-river, 42% from estuaries, and 8% from coastal areas.

Exploitation rates of both large salmon (≥ 63 cm – MSW and repeat spawners) and small salmon (mostly 1SW) remained relatively stable until 1984 and 1992, respectively, then declined sharply with the introduction of restrictive management measures (Figure 3). Declines continued in the 1990s. In the last few years, exploitation rates have remained among the lowest in the time-series.

In the 2020 recreational fisheries of Canada, 59 627 salmon (38 012 small and 21 615 large) were estimated to have been caught and released, representing about 72% of the total catch by number.

Table 1 Salmon catches and catch locations in the North American Commission (NAC) area in 2020. Catches of NAC-origin salmon at Greenland are reported in the West Greenland Commission area. Differences in sums and percentages are due to rounded values.

	Canada					St Pierre & Miquelon	USA	North America
	Commercial	Indigenous	Labrador resident	Recreational	Total			
2020 reported catches (t)	0	59	2	44	104	2	0	106
% of NAC total	0	56	2	42	98	2	0	100
Unreported catch (t)					27	na	0	27
Location of catches								
% in-river					51	0	-	50
% in estuaries					42	0	-	42
% coastal					7	100	-	8

Table 2 Total reported catches (in tonnes, round fresh weight) of salmon in home waters in North America for Canada (small salmon, large salmon, and total), USA, and France (Saint Pierre and Miquelon) from 1980 to 2020. The 2020 figures include provisional data.

Year	Canada			USA	St Pierre & Miquelon
	Small salmon	Large salmon	Total		
1980	917	1763	2680	6	-
1981	818	1619	2437	6	-
1982	716	1082	1798	6	-
1983	513	911	1424	1	3
1984	467	645	1112	2	3
1985	593	540	1133	2	3
1986	780	779	1559	2	3
1987	833	951	1784	1	2
1988	677	633	1310	1	2
1989	549	590	1139	2	2
1990	425	486	911	2	2
1991	341	370	711	1	1
1992	199	323	522	1	2
1993	159	214	373	1	3
1994	139	216	355	0	3
1995	107	153	260	0	1
1996	138	154	292	0	2
1997	103	126	229	0	2
1998	87	70	157	0	2
1999	88	64	152	0	2
2000	95	58	153	0	2
2001	86	61	148	0	2
2002	99	49	148	0	2
2003	81	60	141	0	3
2004	94	68	161	0	3
2005	83	56	139	0	3
2006	82	55	137	0	3
2007	63	49	112	0	2
2008	100	57	158	0	4
2009	74	52	126	0	3
2010	100	53	153	0	3
2011	110	69	179	0	4
2012	74	52	126	0	3
2013	72	66	137	0	5
2014	77	41	118	0	4

Year	Canada			USA	St Pierre & Miquelon
	Small salmon	Large salmon	Total		
2015	86	54	140	0	4
2016	79	56	135	0	5
2017	55	55	110	0	3
2018	39	39	79	0	1
2019	53	47	100	0	1
2020	55	49	104	0	2

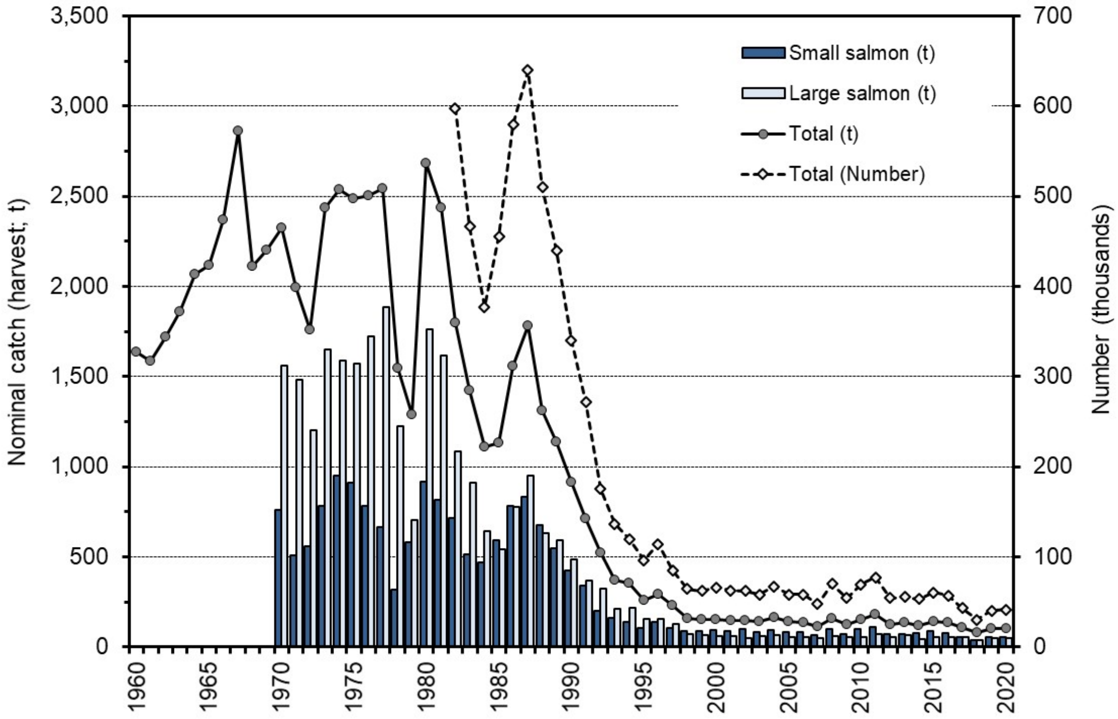

Figure 1 Reported catch (harvest; t and number in thousands) of small (< 63 cm) and large (≥ 63 cm) salmon in Canada (combined catches in USA and Saint Pierre and Miquelon are ≤ 6 t in any year) from 1960 to 2020.

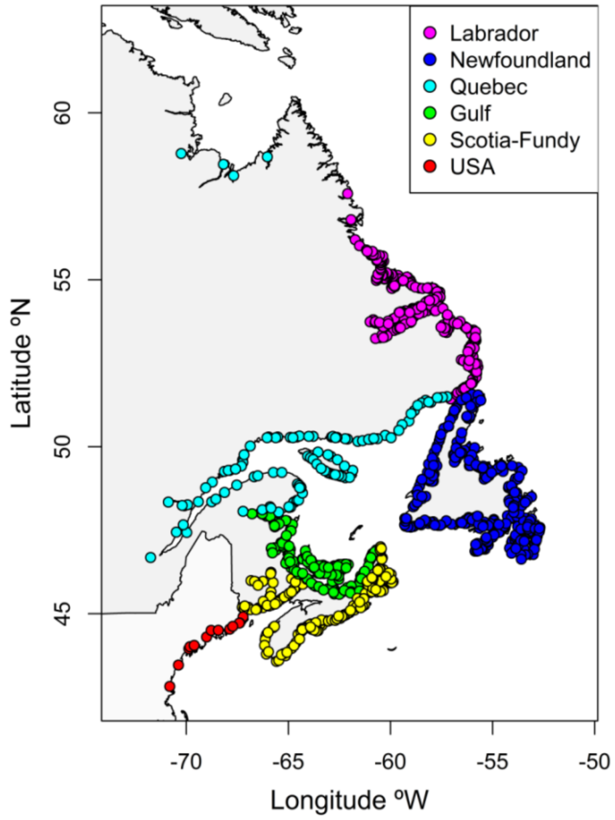

Figure 2 Assessment regions for salmon in the NAC area. Dots indicate locations of salmon rivers.

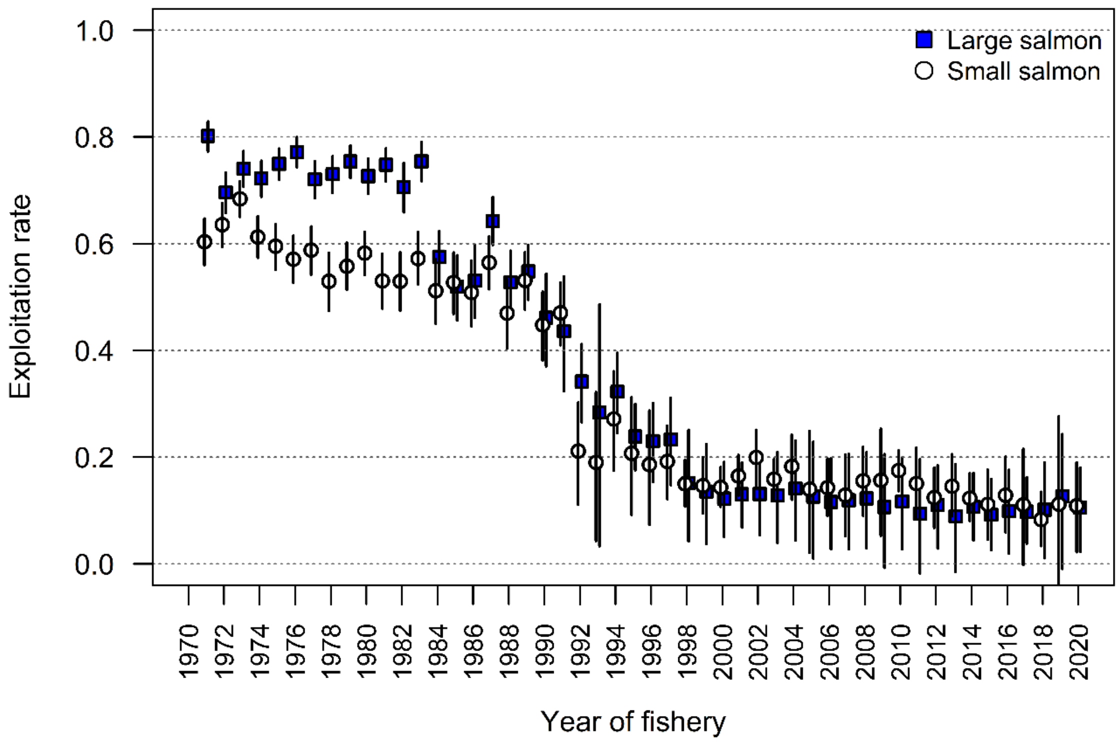

Figure 3 Exploitation rates in North America on small (1SW) and large (MSW and repeat spawners) salmon from 1971 to 2020.

Origin and composition of catches

In the past, salmon from both Canada and USA were taken in the commercial fisheries of eastern Canada. Sampling programmes of current marine fisheries (Labrador subsistence and Saint Pierre and Miquelon) are used to monitor the stock composition of these mixed-stock fisheries.

The stock composition was previously determined using a North American genetic baseline for Atlantic salmon, which allowed assignment to twelve regional groups in North America based on 15 microsatellite loci (Bradbury *et al.*, 2014; Moore *et al.*, 2014). A single nucleotide polymorphism (SNP) panel range-wide baseline has been developed and has been used since 2018 to provide assignment of individual salmon to one of 21 North American or ten European reporting groups (Jeffery *et al.*, 2018; Figure 4). The accuracy of assignment in the SNP analyses was 90%. The origin of salmon in the mixed-stock fisheries has been previously reported for the Labrador subsistence fishery (Bradbury *et al.,* 2015; ICES, 2015, 2020) and for the SPM fishery (ICES, 2015, 2020; Bradbury *et al.,* 2016). The accuracy of assignment in these analyses was very high (94.5%). Assignment accuracy was tested using a leave-one-out cross validation method described in Anderson *et al.* (2008) which can yield essentially unbiased estimates of genetic stock identification accuracy, providing all populations in the mixture are accurately represented in the baseline.

The reporting groups from the genetic assignments do not correspond directly to the regions used by ICES to characterize stock status and to provide catch advice. Assessment of stock status and provision of catch advice is not possible at the scale of the genetic groups because historical catch reporting is available at a jurisdictional scale that is broader than the these groups. However, these genetic reporting groups can be aligned to the assessment regions (Figure 4).

Assessment region	Genetic Reporting group	Group acronym
Quebec (North)	Ungava	UNG
Labrador	Labrador Central	LAC
	Lake Melville	MEL
	Labrador South	LAS
Quebec	St Lawrence North	QLS
	Anticosti	ANT
	Gaspe Peninsula	GAS
	Quebec City Region	QUE
Gulf	Gulf of St Lawrence	GUL
Scotia–Fundy	Inner Bay of Fundy	IBF
	Eastern Nova Scotia	ENS
	Western Nova Scotia	WNS
	Saint John River &	SJR
Newfoundland	Northern	NNF
	Western	WNF
	Newfoundland 1	NF1
	Newfoundland 2	NF2
	Fortune Bay	FTB
	Burin Peninsula	BPN
	Avalon Peninsula	AVA
USA	Maine, United States	USA

Assessment region	Genetic Reporting group	Group acronym
Europe	Spain	SPN
	France	FRN
	European Broodstock	EUB
	United	BRI
	Barents-White Seas	BAR
	Baltic Sea	BAL
	Southern Norway	SNO
	Northern Norway	NNO
	Iceland	ICE
	Greenland	GL

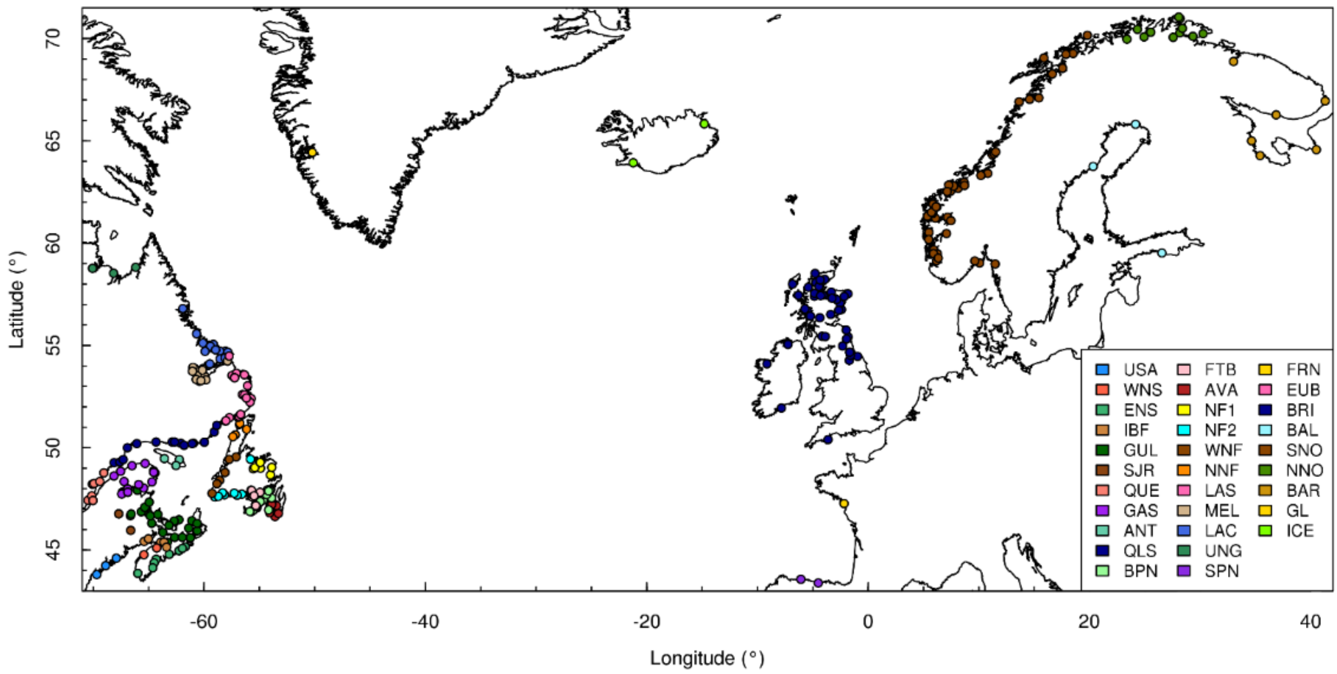

Figure 4 Map of sample locations used in the range-wide genetic baseline (single nucleotide polymorphisms [SNPs]) for Atlantic salmon. The SNP provided assignment of individual salmon to 21 North America and ten European genetic reporting groups (labelled and identified by colour) and correspondence between genetic reporting groups and assessment regions for eastern North America (upper table). The EUB (European Broodstock) reporting group is not represented on the map.

Labrador fishery origin and composition of the catches

In 2020, 741 tissue samples from the Labrador subsistence salmon fisheries were analysed using the SNP panel (9.2% of the catch by number for the coastal area fisheries). Emphasis was placed on genotyping samples from the coastal areas (Northern Labrador Salmon Fishing Area [SFA] 1A, and Southern Labrador SFA 2). In these areas, interception of non-local stocks has been more prevalent in the past at the exclusion of samples from the estuarine portion of Labrador located in Lake Melville (SFA 1B) for which the catches were almost exclusively assigned to that area. As in previous years, the estimated origin of the samples was dominated (> 98%) by the Labrador reporting groups. The dominance of these groups is consistent with previous analyses conducted for the period 2006–2019, which estimated > 95.0% of the catch was attributable to Labrador stocks (ICES, 2019, 2020). Furthermore, assignment of catches within the two coastal Labrador genetic reporting groups (Labrador Central and Labrador South) suggests a largely local catch within salmon fishing areas (Figure 5).

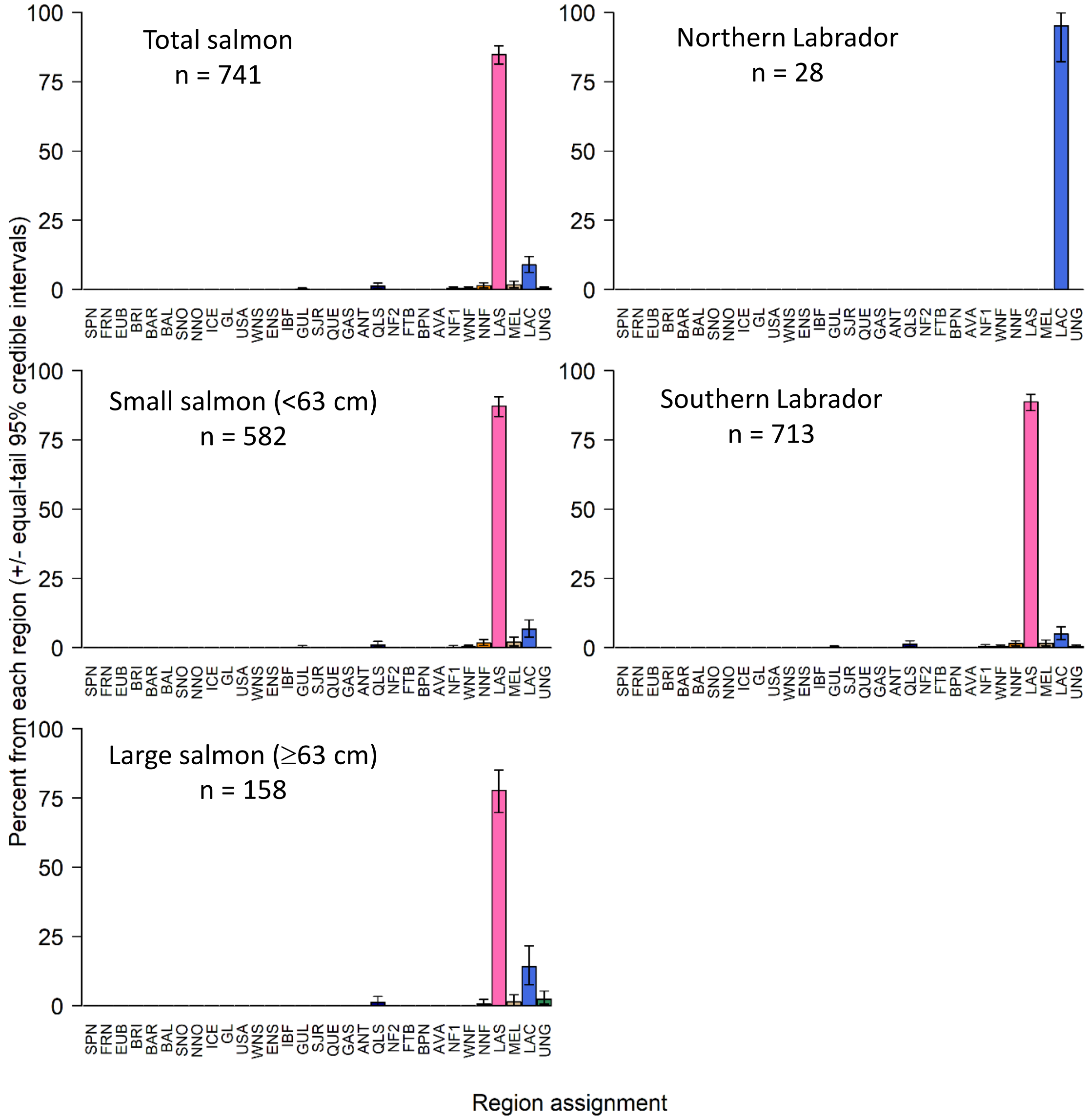

Figure 5 Percentages of Labrador subsistence fishery samples by size group and by Labrador SFA (Northern Labrador = SFA 1A; Southern Labrador = SFA 2), assigned using SNPs to regional reporting groups of the North Atlantic for the 2020 fishery year. The colours used for the bars and match those used in Figure 4.

Saint Pierre and Miquelon (SPM) fishery origin and composition of the catches

Regional analysis using the SNP panel applied to tissue samples from the fishery at SPM showed the consistent dominance (83–89%) of three genetic reporting groups – southern Gulf of St Lawrence, Gaspe Peninsula, and Newfoundland – consistent with previous studies (Bradbury *et al.,* 2016; ICES, 2018, 2020). A total of 116 samples were collected from the SPM salmon fishery in 2020. The samples were representative of the reported catch by size class (60.7% small salmon and 39.3% large salmon, by weight). Due to the extraordinary circumstance in 2020 associated with COVID-19, the samples were not received in time for genetic analyses. These samples will be analysed and reported with the 2021 samples.

NASCO 3.2 Update age-specific stock conservation limits based on new information as available, including updating the time-series of the number of river stocks with established CLs by jurisdiction

Limit reference points in terms of 2SW CLs have been defined for all six areas in North America (MFFP, 2016; DFO, 2018; ICES, 2020). No changes to the 2SW CLs or the management objectives were made from those identified previously (ICES, 2020).

Rebuilding management objectives have been defined for Scotia–Fundy and USA. For Scotia–Fundy, the management objective is based on an increase of 25% in returns of 2SW salmon from the mean return in the base years 1992 to 1996. For USA, the management objective is to achieve 2SW adult returns of 4549 or greater (Table 3).

Table 3 2SW CLs and management objectives for the regional groups in North America in 2020.

Country and Commission area	Assessment regional group	2SW conservation limit (number of fish)	2SW management objective (number of fish)
Canada	Labrador	34746	
	Newfoundland	4022	
	Quebec	32085	
	Southern Gulf of St Lawrence	18737	
	Scotia–Fundy	24705	10976
	Total	114295	
USA		29199	4549
North American Commission		143494	

In Canada, CLs were first established in 1991 for 74 rivers. Since then the number of rivers with defined CLs increased to 266 in 1997 and to 498 in 2018 (Figure 6). CLs have been established for 33 river stocks in USA since 1995 (Figure 6).

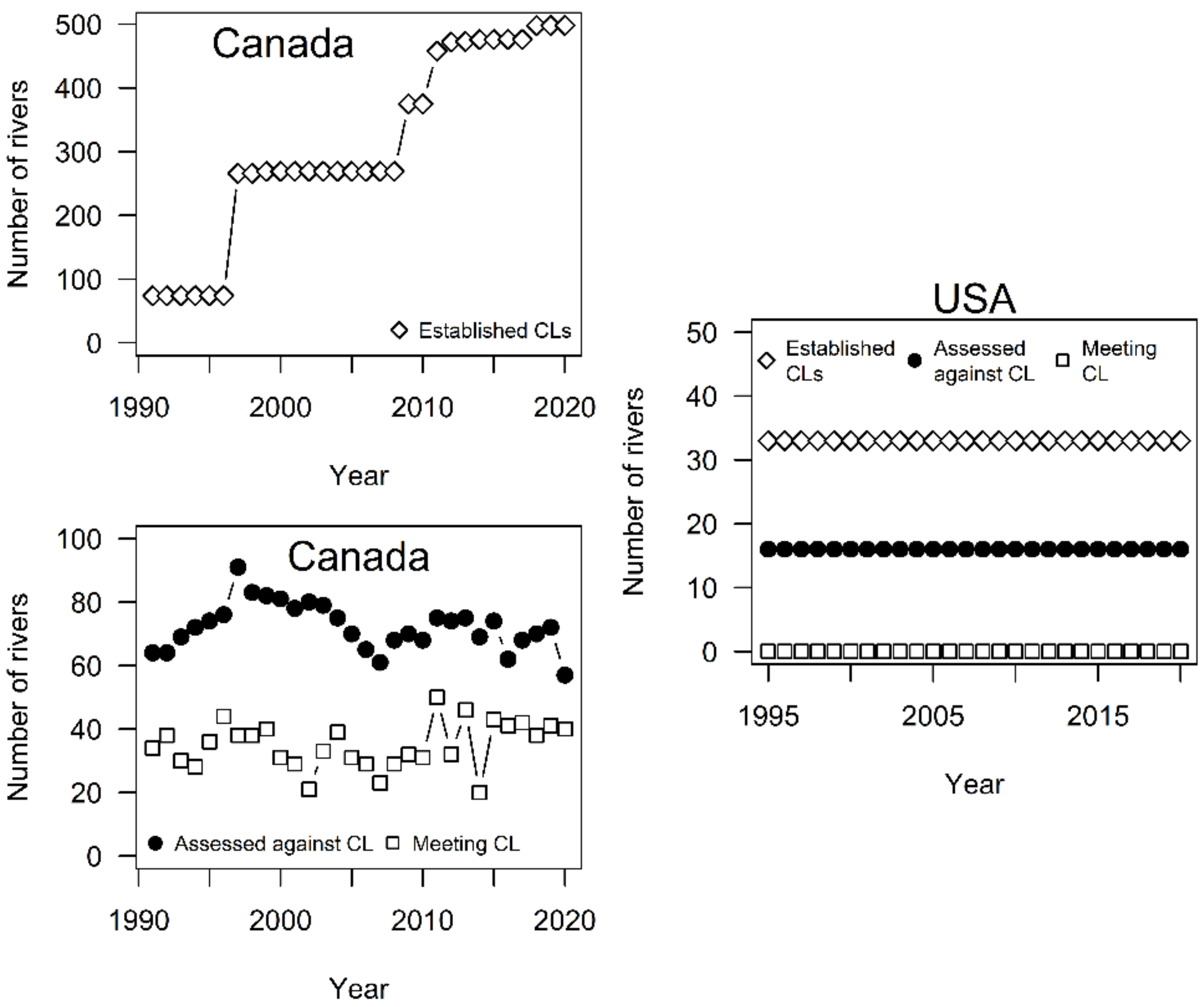

Figure 6 Time-series for Canada and USA showing the number of rivers with established CLs, the number of rivers assessed, and the number of assessed rivers meeting CLs for the period 1991 to 2020. Further details can be found in ICES (2021a).

NASCO 3.3 Describe the status of the stocks, including updating the time-series of trends in the number of river stocks meeting CLs by jurisdiction

Stock status is presented for six assessment regions (Figure 2) and overall for North America.

Returns of small (1SW), large (MSW and repeat spawners), and 2SW salmon (a subset of large) to each region are estimated by the methods reported in ICES (1993). The 2SW component of the returns of large salmon was determined using the sea-age composition of one or more indicator stocks. Returns are the number of salmon that returned to each geographic region, including fish caught by home water commercial fisheries. Two exceptions are the Newfoundland and Labrador regions, where returns do not include landings in commercial and subsistence fisheries.

The non-maturing component of 1SW salmon, destined to be 2SW returns (excluding three-sea-winter [3SW] and repeat spawners), is the estimated number of salmon in the North Atlantic on 1 August of the second summer at sea. Estimates of pre-fishery abundance (PFA) account for returns to rivers, fisheries at sea in North America, and fisheries at West Greenland and are corrected for natural mortality. Catches of North American-origin salmon in the fishery at the Faroes are not included. As the PFA estimate for potential 2SW salmon requires an estimate of returns to rivers, the most recent year for which an estimate of PFA is available is 2019. Maturing 1SW salmon are in some areas (particularly Newfoundland) a major component of salmon stocks, and their abundance when combined with that of the 2SW age group provides an index of the majority of a cohort.

The total estimated returns of small salmon to North America in 2020 was 456 100 (Figure 7). For the previous five years 2015 to 2019, small salmon returns to Labrador (197 900) and Newfoundland (202 400) combined represented 88% of the total small salmon returns to North America

The total estimate of returns of large salmon to North America in 2020 was 155 600 (Figure 7). Large salmon returns in 2020 increased from the previous year in the assessed regions of Labrador (69%), Quebec (27%), and USA (30%).

The total estimate of 2SW salmon returns (subset of returns of large salmon) to North America in 2020 was 94 700. Returns of 2SW salmon in 2020 increased from the previous year in the assessed regions of Labrador (69%), Quebec (27%), and USA (28%). For the previous five years, 2015 to 2019, 2SW salmon returns to Labrador (29 700), Quebec (28 300), and Gulf (31 200) combined represented 94% of the total estimated 2SW salmon returns to North America. There are few 2SW salmon returns to Newfoundland as the majority of the large salmon returns to that region are composed of previously spawned 1SW salmon.

In 2020, the estimates (median) of 2SW salmon returns to rivers and spawners were below CLs (suffering reduced reproductive capacity) all the assessment regions except the Gulf; for spawners ranging from 10% in Scotia-Fundy to 161% in Gulf (Figure 10). Particularly large deficits relative to CLs and rebuilding management objectives are noted in the Scotia–Fundy and USA regions. The status of the Gulf region was assessed using the previous 5 year-mean as a proxy for the unavailable 2020 input data. It is not expected that this has caused the substantial increase in the returns and spawners to this region in 2020 compared to the previous year. The increase appears to be a true reflection of the increased escapement in the region, which was also mirrored to a degree in the adjacent areas Quebec, Labrador, and Newfoundland in 2020 relative to 2019.

River-specific assessments are provided for 73 rivers in 2020 for NAC. Egg depositions by all sea ages combined in 2020 exceeded or equalled the river-specific CLs in 40 of the 73 assessed rivers (55%) and were less than half of CLs in 23 rivers (32% [Figure 11]). The number of rivers in Canada assessed annually has ranged from 57 to 91, and the annual percentages of these rivers achieving CLs has ranged from 26% to 67% (70% in 2020) with no temporal trend (Figure 6). Sixteen rivers in USA are assessed against CL attainment annually, with none meeting CLs to date (Figure 6).

Estimates of PFA (defined as the number of maturing and non-maturing 1SW salmon) suggest continued low abundance of North American salmon (Figure 9). The PFA in the Northwest Atlantic has oscillated around a generally declining trend since the 1970s, with a period of persistent low abundance since the early 1990s. During the period 1992 to 2019, the average PFA was 615 500 fish, less than half of the average abundance (1 252 600 fish) during the period 1971 to 1991. PFA of maturing and non-maturing 1SW salmon in 2019, the most recent available value, was estimated at 562 400 fish. Abundance declined by 66% over the time-series, from a peak of 1 704 000 fish in 1975 (Figure 12).

Despite major changes in fisheries management two to three decades ago and increasingly more restrictive fisheries measures since then, returns of salmon have remained near historical lows, with the exception of those in Labrador and Newfoundland. All salmon populations within USA and the Scotia–Fundy regions have either been listed or are being considered for listing under country-specific species at risk legislation. The continued low and declining abundance of salmon stocks across North America, despite significant fishery reductions, strengthens the conclusions that factors acting on survival in the first and second years at sea at both local and broad ocean scales are constraining abundance of Atlantic salmon. Declines in smolt production in some rivers of eastern North America are now being observed and are also contributing to lower adult abundance.

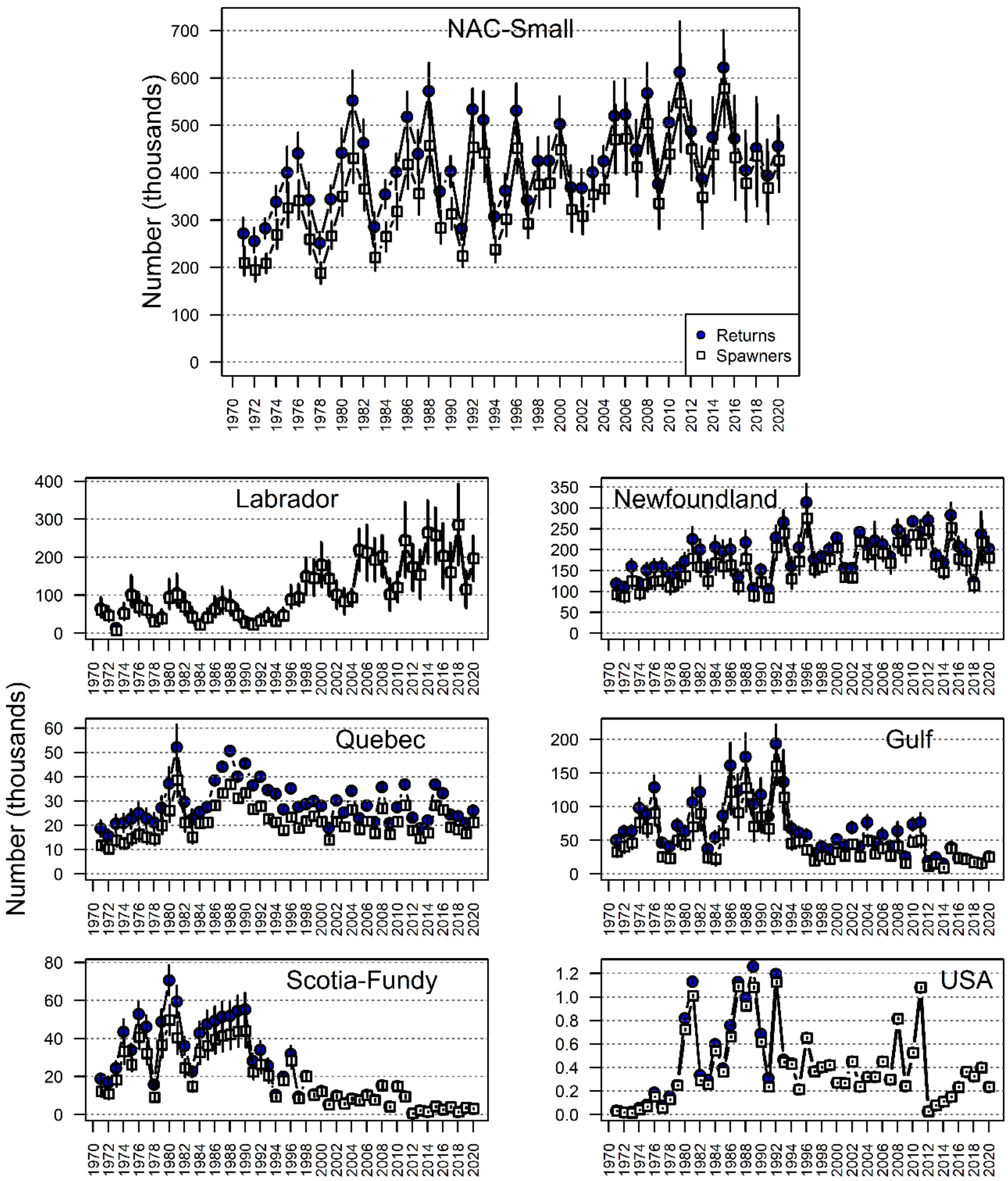

Figure 7 Estimated (median, 5th to 95th percentile range) returns (shaded circles), and spawners (open squares) of small salmon (primarily 1SW) for eastern North America overall (top panel) and for each of the six regions in 1971 to 2020.

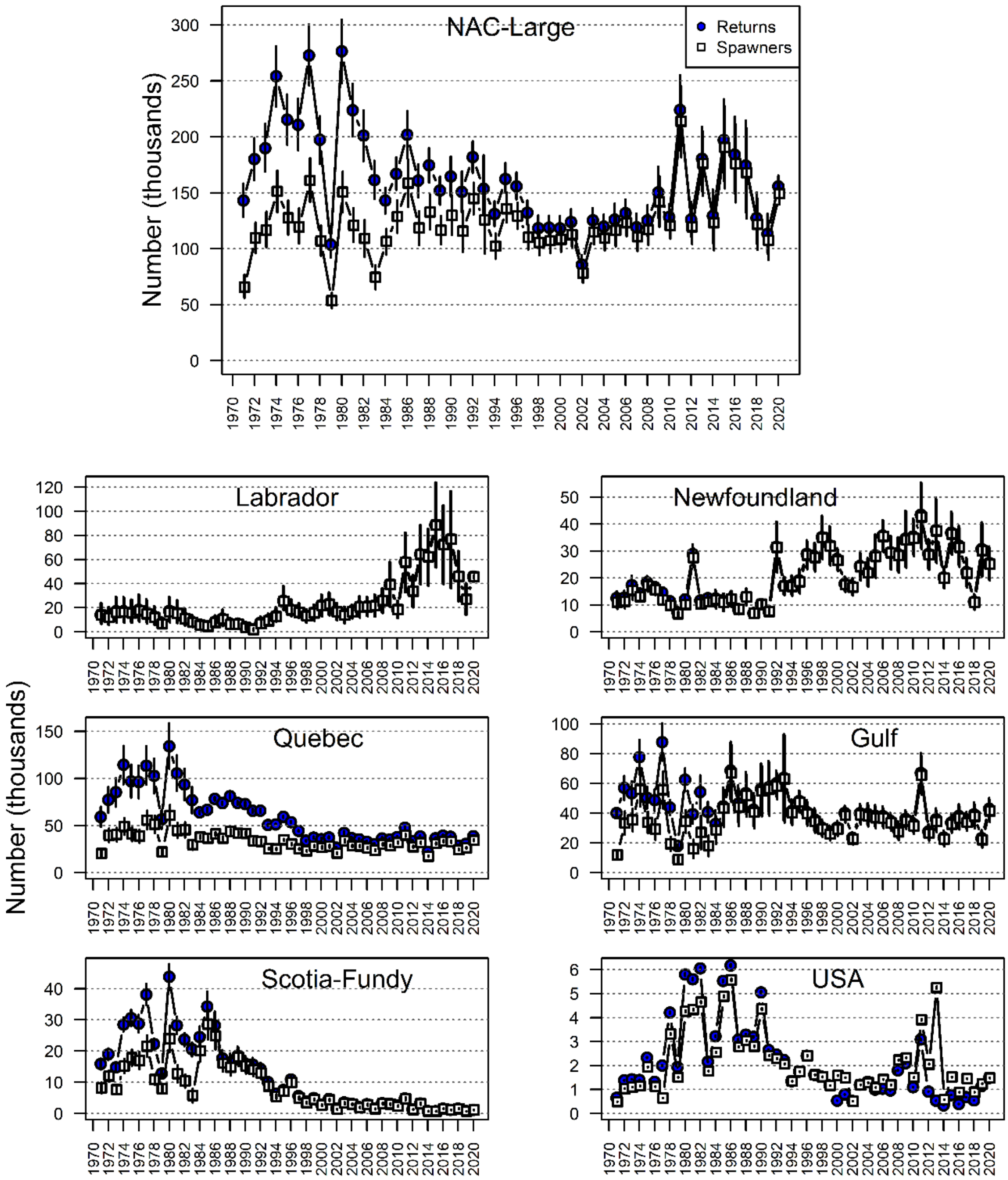

Figure 8 Estimated (median, 5th to 95th percentile range) returns (shaded circles), and spawners (open squares) of large salmon (primarily MSW and repeat spawners) for eastern North America overall (top panel) and for each of the six regions in 1971 to 2020.

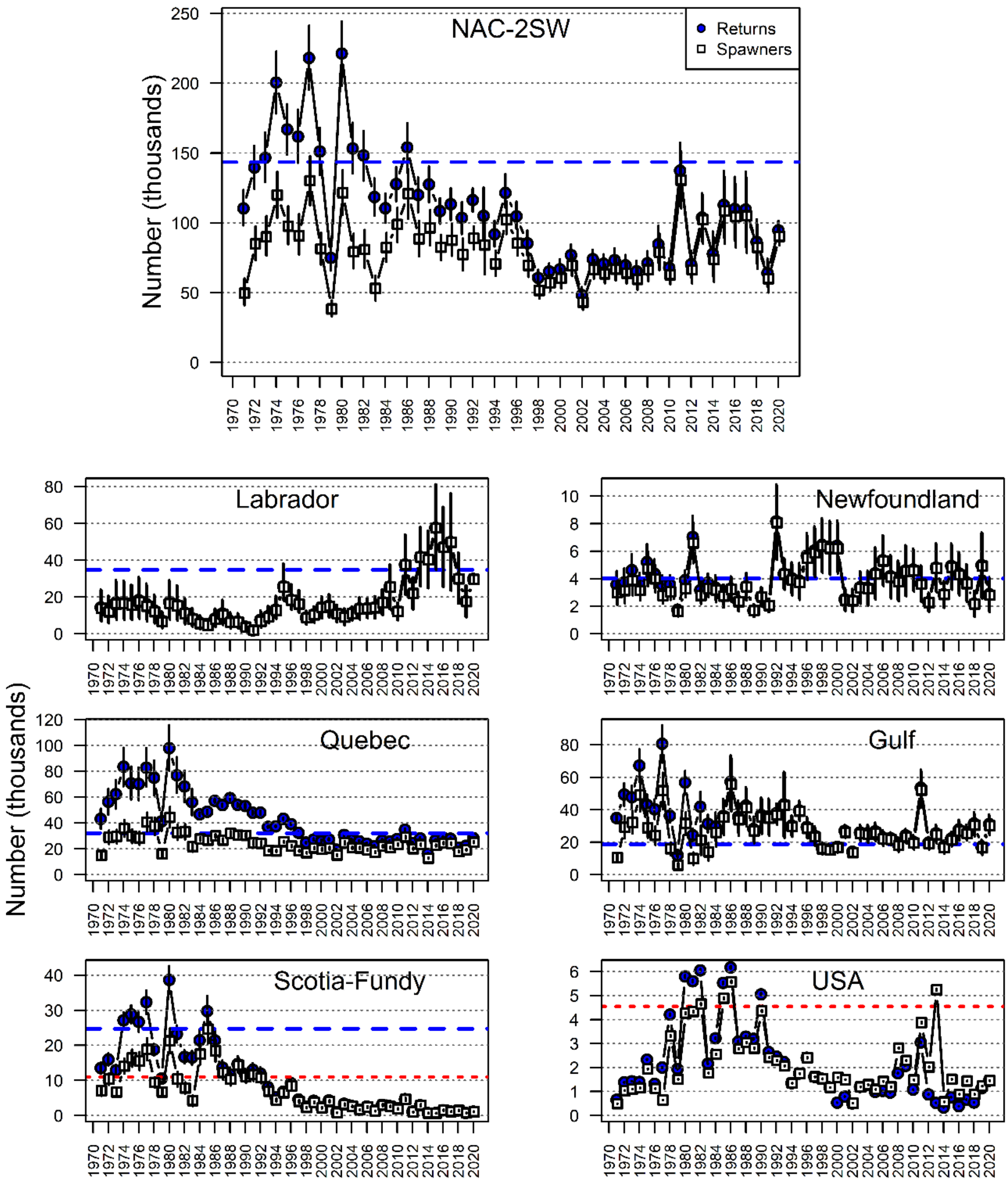

Figure 9 Estimated (median, 5th to 95th percentile range) returns (shaded circles), and spawners (open squares) of 2SW salmon for eastern North America overall (top panel) and for each of the six regions in 1971 to 2020. The blue dashed lines are the corresponding 2SW CLs; the 2SW CL (29 199 fish) is off scale in the plot for USA. The red dotted lines in the Scotia–Fundy and USA panels are the region-specific management objectives. For USA, estimated spawners exceed the estimated returns in some years as a result of adult stocking restoration efforts.

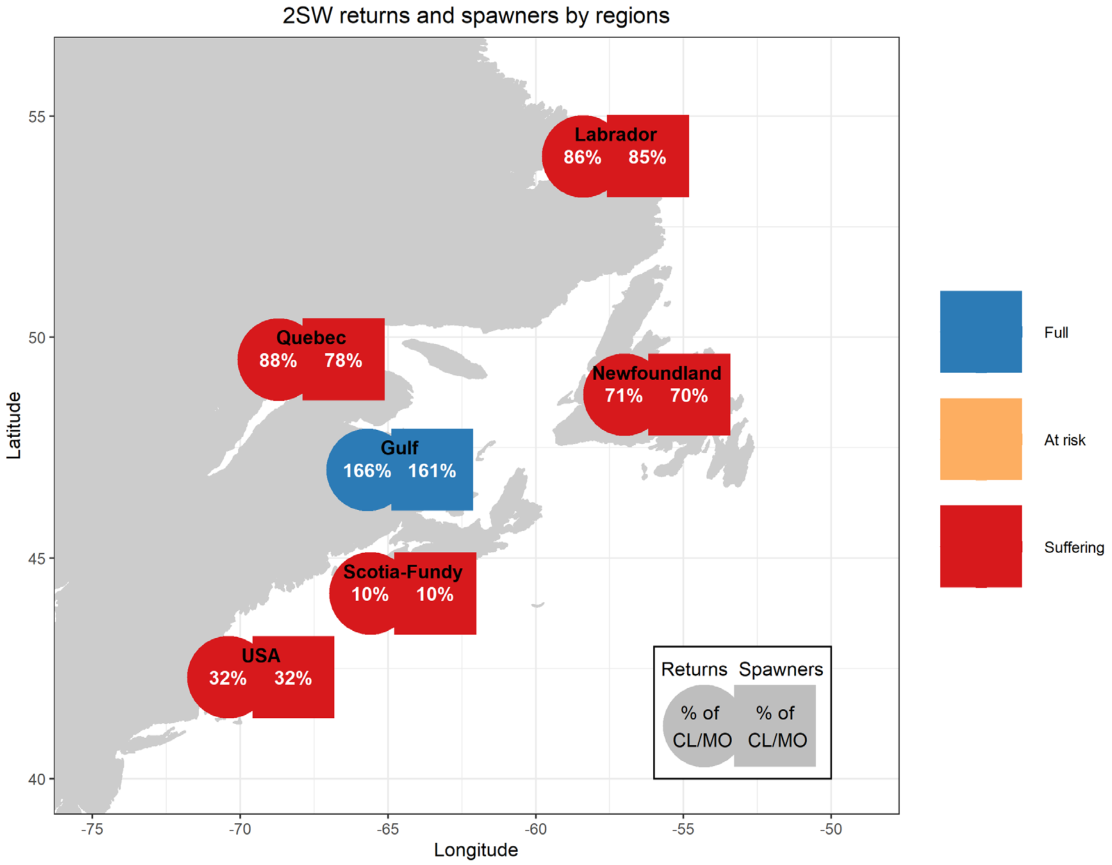

Figure 10 Estimated returns (circle symbol) and spawners (square symbol) of 2SW salmon in 2020 to six regions of North America relative to the stock status categories. The percentage of the 2SW CLs for the four northern regions and to the rebuilding management objectives (MO) for the two southern areas are shown based on the median of the Monte Carlo distribution. The blue shading refers to the stock being at full reproductive capacity (the median and 5th percentile of the Monte Carlo distributions are above the CL), the orange shading refers to the stock being at risk of suffering reduced reproductive capacity (the median is above but 5th percentile below the CL), and the red shading refers to the stock suffering reduced reproductive capacity (the median is below the CL).

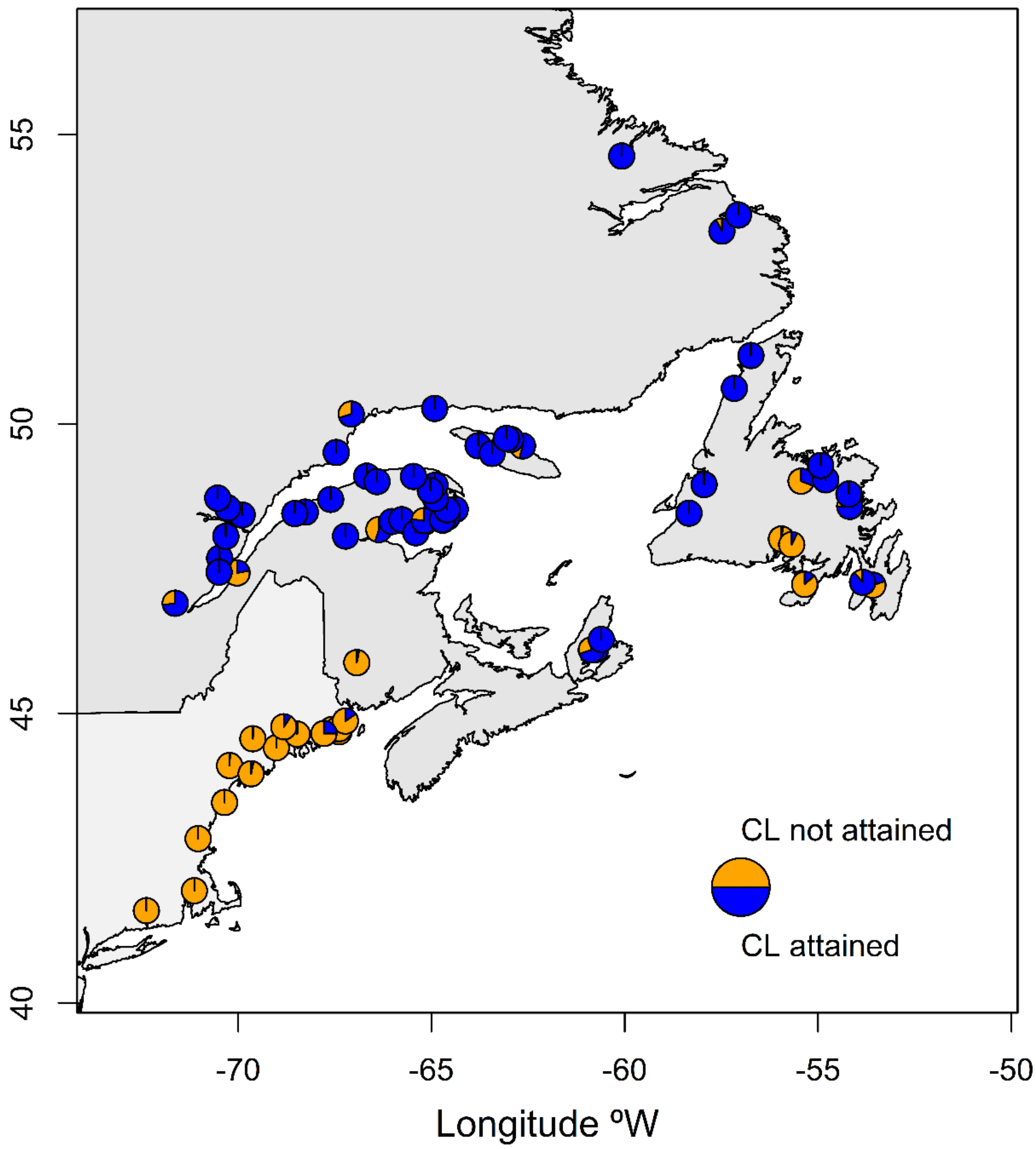

Figure 11 Degree of attainment for the river-specific conservation limit (CL) egg requirement in the 73 rivers of the North American Commission area assessed in 2020. One river in the USA is not shown because it was partially assessed, but it is considered not to have attained CL in 2020.

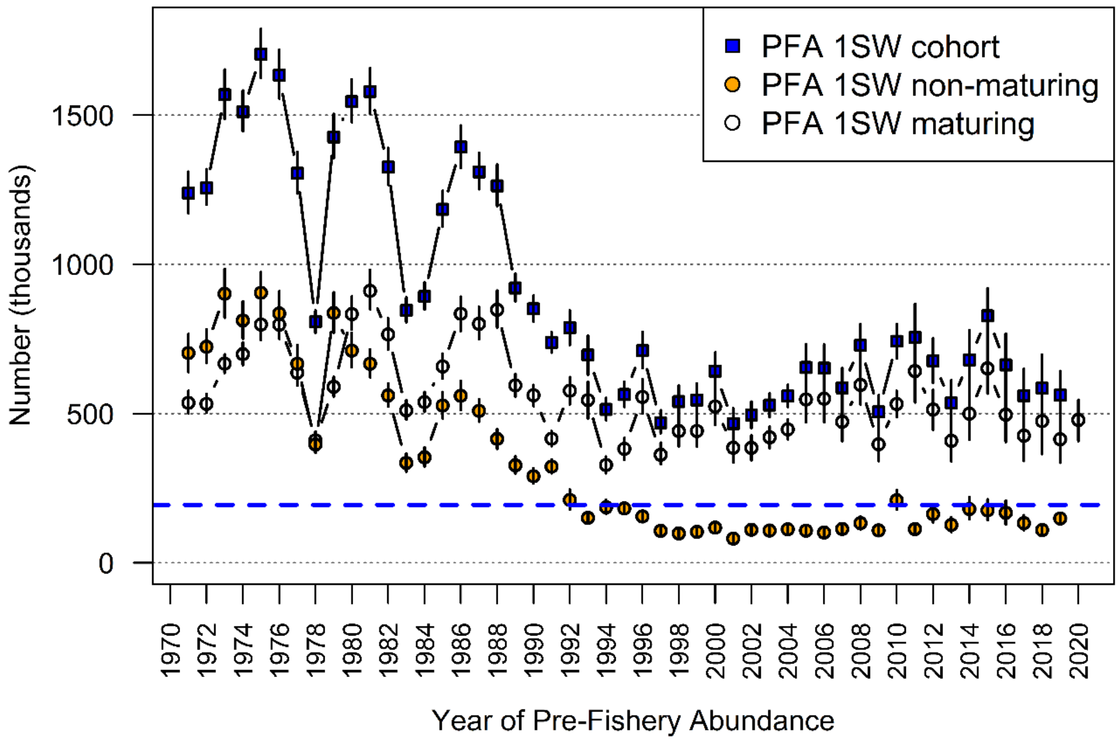

Figure 12 Estimated (median, 5th to 95th percentile range) pre-fishery abundance (PFA) for 1SW maturing, 1SW non-maturing, and total cohort of 1SW salmon for North America for the 1971 to 2020 PFA years. The horizontal dashed blue line is the corresponding sum of the 2SW CLs for North America, corrected for 11 months of natural mortality and against which 1SW non-maturing abundance is assessed.

NASCO 3.4 Provide catch options or alternative management advice for 2021–2024* with an assessment of risks relative to the objective of exceeding stock conservation limits, or pre-defined NASCO Management Objectives, and advise on the implications of these options for stock rebuilding

Catch options for mixed-stock fisheries are only provided for the non-maturing 1SW and maturing 2SW components as the maturing 1SW component is not fished outside home waters.

As the predicted numbers of 2SW salmon returning to the six regions in North America in the period 2021 to 2024 are below the region-specific 2SW CLs of the four northern areas and of the 2SW management objectives of the two southern areas, there are no catch options for the 2SW mixed-stock fisheries in North America (Table 4).

Wild salmon populations are critically low in the southern regions (Scotia–Fundy, USA) of North America and the remaining populations require alternative conservation actions including habitat restoration, captive rearing strategies, and very restrictive fisheries regulations. This is also the case for other species in certain areas.

Relevant factors to be considered in management

Management for all fisheries should be based upon assessments of the status of individual stocks. Fisheries on mixed-stocks, particularly in coastal waters or on the high seas, pose particular difficulties for management as they may catch stocks that are not meeting their CLs. Conservation would be best achieved if fisheries target stocks that have been shown to be meeting CLs. Fisheries in estuaries and especially rivers are more likely to meet this requirement.

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* Version 2: Year corrected.

The salmon caught in the Labrador subsistence fisheries are predominantly (> 95%) from rivers in Labrador, although there is occasional attribution of very low proportions of salmon in the sampled catches from other areas, including USA. The salmon caught in the SPM mixed-stock fisheries originate in all areas of North America; all sea age groups, including previous spawners, contribute to the fisheries in varying proportions.

Updated forecast and catch options for the 2021 to 2024 fisheries on 2SW maturing fish

It is possible to provide catch options for the North American Commission area for four years.

ICES (2015, 2018) developed estimates of the PFA for the non-maturing 1SW salmon using a Bayesian framework that incorporates the estimates of 2SW lagged spawners and works through the fisheries at sea to determine the corresponding returns of 2SW salmon, conditioned by fisheries removals and natural mortality at sea. This model considered lagged spawners (Figure 12) and returns of 2SW salmon for each of the six regions of North America (Figure 8). Dataseries were finalized for 2020 and updated for past years in some regions. North American region-specific PFA and productivity value inferences are provided by the model (Figures 15 and 16).

The model forecasts productivity using a random walk with the forecast value set at the value of the most recent assessment year (2019), and it applies this value to the assessment abundance of lagged spawners to forecast PFA. The overall productivity estimate (on the log scale) for the NAC in the most recent PFA year (2019) is positive but remains below the higher levels of the late 1970s and 1980s (Figure 14). By region, the most recent year values of productivity are positive for all regions. Positive values indicate that the PFA is greater than the lagged spawner abundance that produced it, and the salmon abundances in these regions are expected to increase from current levels if the positive productivity and lagged spawner abundances are maintained (Figure 14). Negative productivity parameters (log scale) in the past indicate that the PFA was less than the lagged spawner abundance that produced it, and the salmon abundances in these regions declined to very low levels in the southern regions (Scotia–Fundy, USA) in particular. Annual productivity estimates are highly variable among years, and large changes in values have been observed over a short time period, as in 2011 to 2017 (Figure 14).

For 2021 to 2023 PFA years, the 5th percentiles of the posterior distributions of the regional PFAs are less than the management objective reserves for all six regions (Figure 15). There are, therefore, no mixed-stock fishery options on 1SW non-maturing salmon in the period 2021 to 2023 or on 2SW salmon in the period 2021 to 2024 which would provide a greater than 95% chance of meeting the individual management objectives; the probability of simultaneous attainment in any year is near zero (Table 4). The forecasts have very high uncertainty, and the uncertainties increase as the forecasts move further forward in time.

Table 4 Probabilities that returns of 2SW salmon to the six regions of the NAC area will meet or exceed the 2SW objectives both for the six regions and simultaneously for all regions in the absence of fishing on the 1SW non-maturing and 2SW age groups for the 2SW salmon return years 2021 to 2024. For the 2021 return year, catches of 1SW non-maturing salmon in 2020 in Labrador and at Greenland have already occurred and are accounted for in the estimation of the probabilities of meeting the 2SW objectives for the 2021 return year.

Region	Region specific 2SW objective	Probability of meeting the 2SW objectives in the absence of fisheries for the 2SW return year			
		2021	2022	2023	2024
Labrador	34746	0.645	0.632	0.573	0.671
Newfoundland	4022	0.465	0.401	0.268	0.300
Quebec	32085	0.534	0.413	0.419	0.464
Gulf	18737	0.890	0.870	0.799	0.831
Scotia–Fundy	10976	0.013	0.030	0.026	0.029
USA	4549	0.094	0.144	0.213	0.226
Simultaneously for all regions		0.004	0.006	0.006	0.007

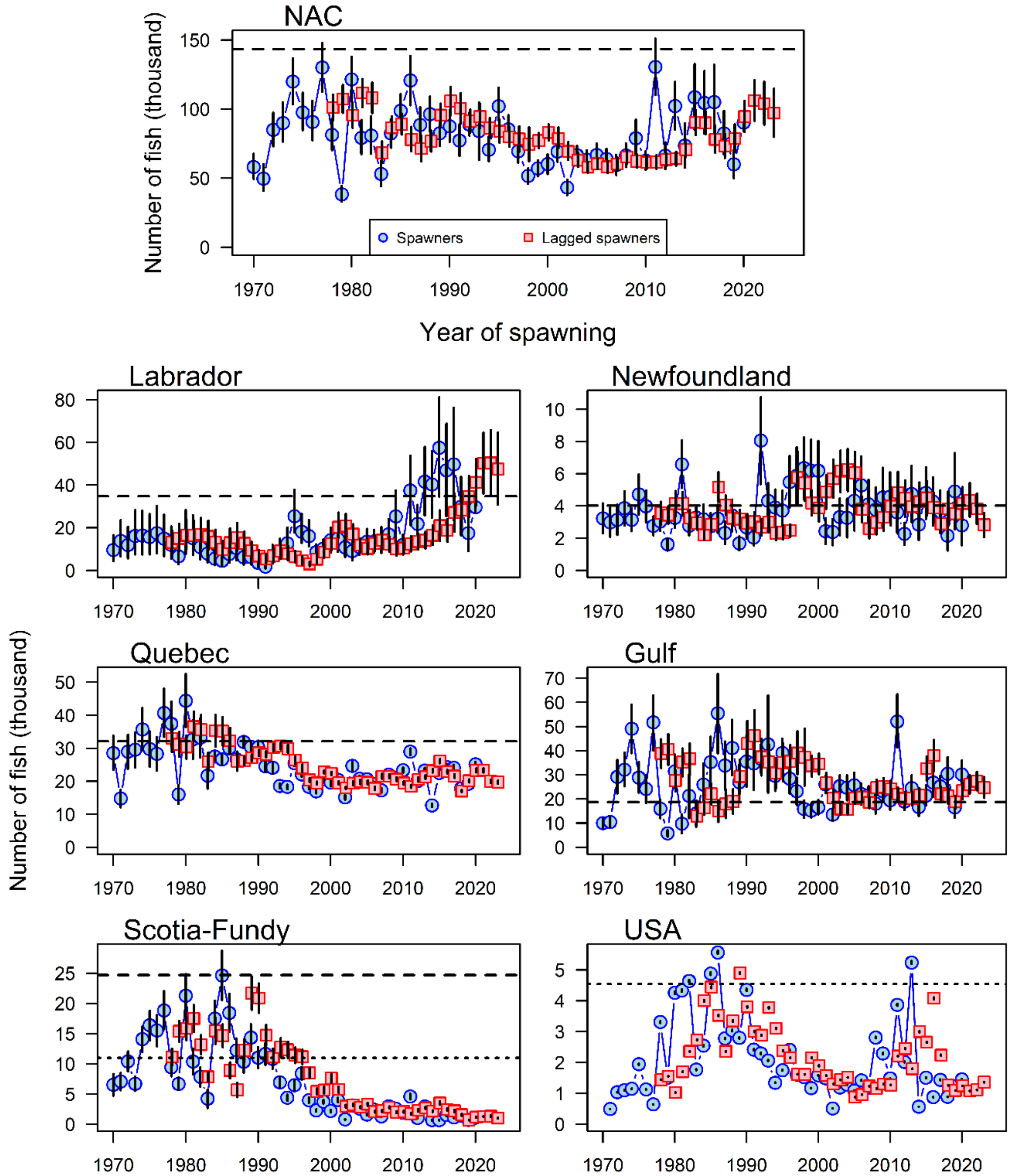

Figure 13 Median (fifth to 95th percentile range) of spawners (circles) and lagged spawners (squares) of 2SW salmon to the NAC area overall (top panel) and for each of the six assessment regions. For spawners, year corresponds to the year of spawning. For lagged spawners, year corresponds to the year of PFA. The horizontal dashed line is the corresponding 2SW CLs for the NAC area overall and for each region; the 2SW CL for USA (29 990 fish) is off scale in the plot. The dotted horizontal line in the Scotia–Fundy and USA panels are the region specific 2SW management objectives.

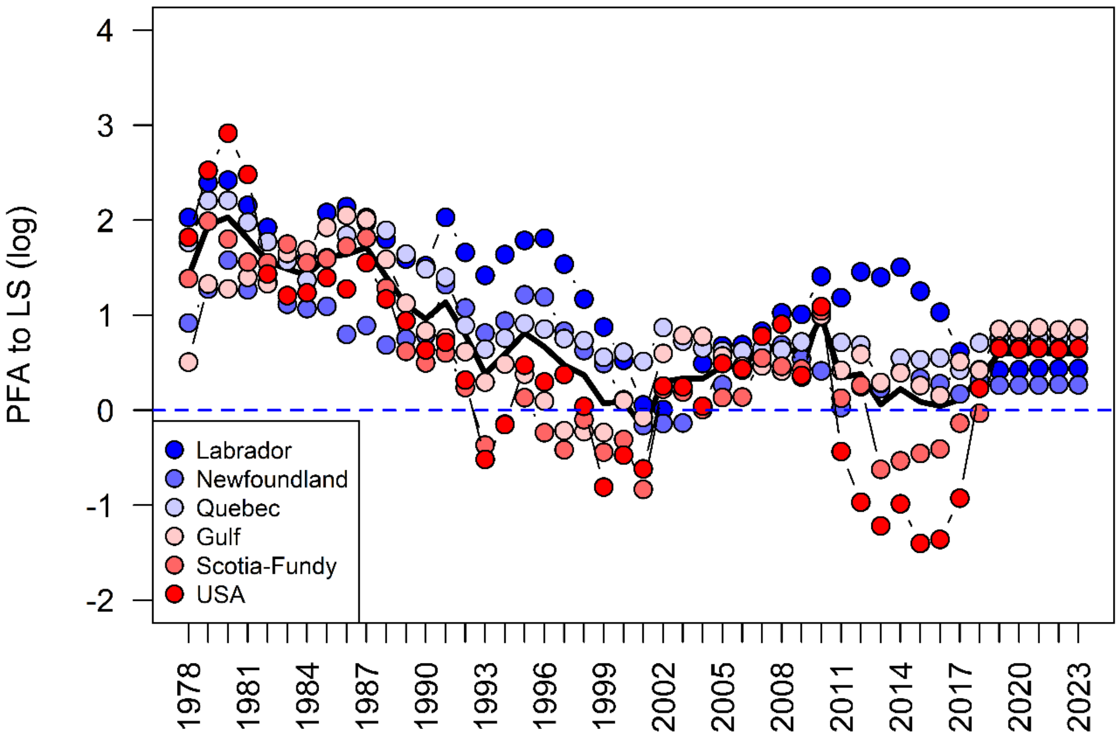

Figure 14 Region specific (median) PFA to LS ratio (log scale; productivity) and mean over all regions (solid black line) for NAC for PFA years 1978 to 2023. The horizontal dashed blue line is the PFA to LS ratio on the log scale of zero, which equates to a PFA to LS ratio of one. The values for 2020 to 2023 are forecast values.

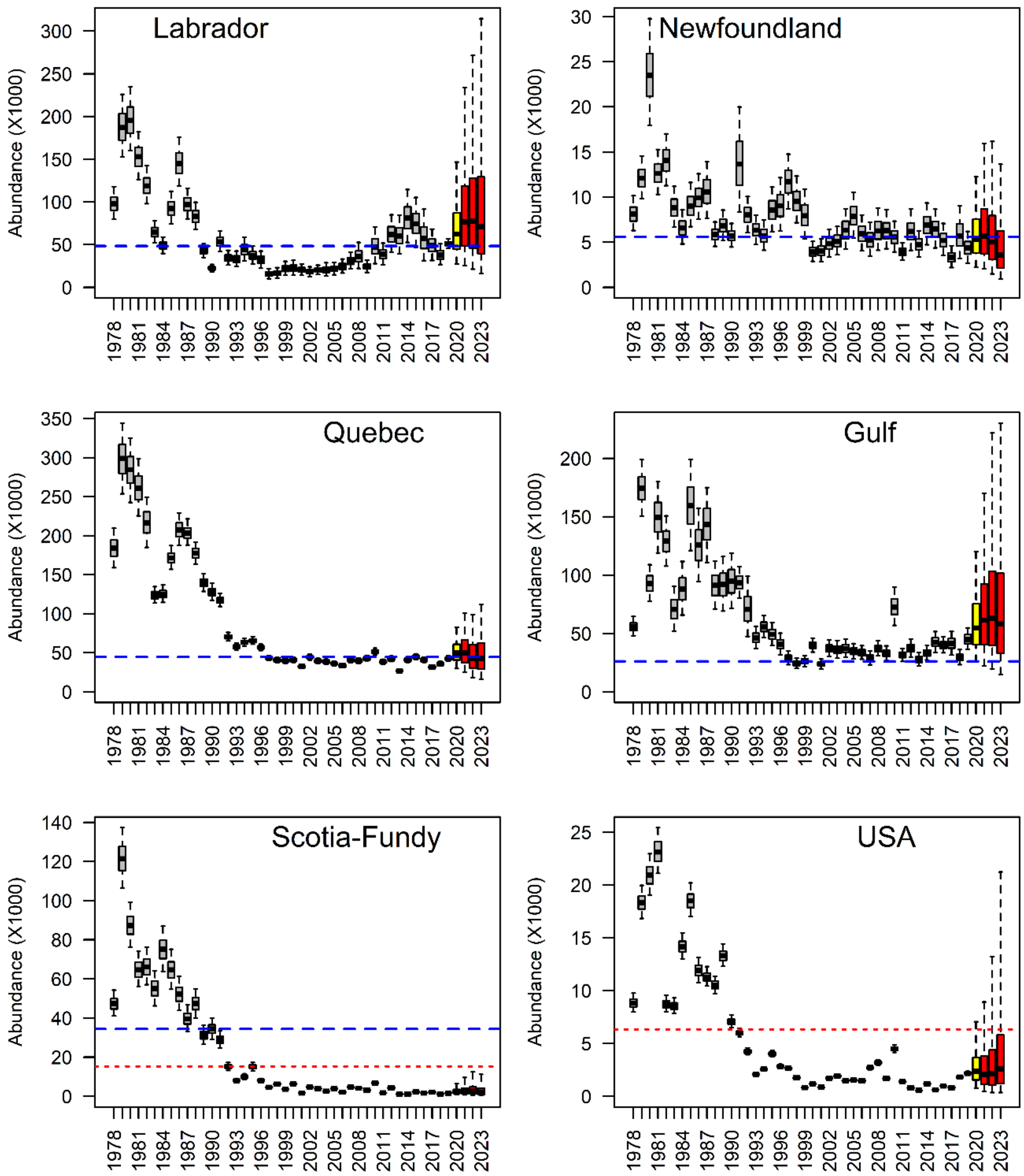

Figure 15 Region-specific PFA values for PFA years 1978 to 2023. The values for 2020 (yellow shading) and for the period 2021 to 2023 (red shading) are predicted based on lagged spawners and forecasts of the PFA to LS ratio. The dashed blue line is the corresponding 2SW CL reserve for each region. For Scotia–Fundy and USA the dotted red line corresponds to the 2SW management objectives (adjusted for eleven months of natural mortality). Boxplots are interpreted as follows: the dashed line is the median, the shaded rectangle is the inter-quartile range, and the dashed vertical line is the fifth to 95th percentile range.

NASCO 3.5 Update the Framework of Indicators used to identify any significant change in the previously provided multi-annual management advice

An updated Framework of Indicators (FWI) that can be used to identify any significant change in the previously provided multiannual management advice has been provided. The same FWI is used for the North American Commission (NAC) and West Greenland Commission areas of NASCO with the exception that for the NAC area, only indicators from regions in North America apply.

The update consisted of:

- Adding the values of the indicator variables for the most recent years;
- Running the objective function spreadsheet for both each indicator variable and the variable of interest relative to the management objectives;
- Quantifying the threshold value for the indicator variables and the probabilities of a true high state and a true low state for those variables retained for the framework;
- Revising/adding the indicator variables and the functions for evaluating the indicator score to the framework spreadsheet; and
- Providing the spreadsheet for carrying out the FWI assessment.

The updated FWI contains 19 indicator variables, represented by 13 different rivers (Figure 16). Of these variables, two were survival rate indicators, while of the remainder 13 were indicators of 2SW and large salmon and four were indicators of wild 1SW and small salmon returns to rivers. No indicator variables were retained for the Labrador or Newfoundland.

The FWI can be applied at the beginning of 2022, using the returns or return rate data for 2021 to evaluate the appropriateness of the advice for 2022, and again at the beginning of 2023, using the returns or return rate data for 2022 to evaluate the appropriateness of the advice for 2023.

Catch Advice	Catch option > 0 (Yes = 1, No = 0)	0

Overall Recommendation
No Significant Change Identified by Indicators

Geographic Area	River/ Indicator	**2020 Value***	Ratio Value to Threshold	Threshold	True Low	True High	Indicator State	Probability of Correct Assignment	Indicator Score	Management Objective Met?
USA	Penobscot 2SW Returns	998	46%	2,167	100%	100%	-1	1.00	-1.00	
	Penobscot 2SW Survival (%)	0.002	18%	0.011	100%	60%	-1	1.00	-1.00	
	possible range				*-1.00*	*0.80*				
	Average		32%						**-1.00**	**No**
Scotia-Fundy	Saint John Return Large	115	3%	3,329	97%	100%	-1	0.97	-0.97	
	Lahave Return Large	22	8%	285	82%	85%	-1	0.82	-0.82	
	North Return Large	226	36%	626	96%	75%	-1	0.96	-0.96	
	Saint John Return Small	241	11%	2,276	90%	80%	-1	0.90	-0.90	
	LaHave Return Small	278	17%	1,679	96%	67%	-1	0.96	-0.96	
	possible range				*-0.92*	*0.81*				
	Average		15%						**-0.92**	**No**
Gulf	Miramichi Return 2SW	4746	57%	8,366	100%	98%	-1	1.00	-1.00	
	Miramichi Return 1SW	8792	36%	24,287	58%	92%	-1	0.58	-0.58	
	possible range				*-0.79*	*0.95*				
	Average		46%						**-0.79**	**No**
Quebec	Bonaventure Return Large	1531	68%	2,243	73%	100%	-1	0.73	-0.73	
	Grande Rivière Return Large	426	96%	442	100%	83%	-1	1.00	-1.00	
	Saint-Jean Return Large	814	80%	1013	79%	100%	-1	0.79	-0.79	
	Dartmouth Return Large	889	118%	756	86%	75%	1	0.75	0.75	
	Madeleine Return Large	922	137%	672	94%	74%	1	0.74	0.74	
	Sainte-Anne Return Large	780	134%	584	82%	60%	1	0.60	0.60	
	Mitis Return Large	873	237%	369	89%	50%	1	0.50	0.50	
	De la Trinité Return Large	113	29%	385	88%	100%	-1	0.88	-0.88	
	De la Trinité Return Small	150	26%	578	90%	85%	-1	0.90	-0.90	
	De la Trinité 2SW Survival	0.28	57%	0.49	100%	68%	-1	1.00	-1.00	
	possible range				*-0.88*	*0.80*				
	Average		98%						**-0.27**	**No**
Newfoundland										
	possible range									
	Average								**NA**	**Unknown**
Labrador										
	possible range									
	Average								**NA**	**Unknown**
Southern NEAC										
	possible range									
	Average								**NA**	**Unknown**

* 2020 value: or if not available, the latest value of the time-series.

Figure 16 FWI spreadsheet for the NAC. For illustrative purposes, the 2020 value of returns or survival rates for the 19 retained indicators is entered in the cells corresponding to the annual indicator variable values.

Relevant data deficiencies, monitoring needs, and research requirements

The following data deficiencies, monitoring needs, and research requirements were identified as being relevant to the NAC area:

- Complete and timely reporting of catch statistics from all fisheries for all areas of eastern Canada is recommended.
- Improved catch statistics and sampling of the Labrador and SPM fisheries is recommended. Improved catch statistics and sampling of all aspects of the fishery across the fishing season will improve the information on biological characteristics and stock origin of salmon caught in these mixed-stock fisheries. A sampling rate of at least 10% of catches in Labrador would be required to achieve a relatively unbiased estimate.
- Additional monitoring in Labrador should be considered to estimate stock status for that region. Additionally, efforts should be undertaken to evaluate the utility of other available data sources (e.g. indigenous and recreational catches and effort) to describe stock status in Labrador.
- A database is needed that lists individual PIT tag numbers or codes identifying the origin, source, or programme of the tags on a North Atlantic basin-wide scale. This is needed to facilitate identification of individual tagged fish taken in marine fisheries or surveys. Data on individual PIT tags used in Norway have now been compiled, although an ICES-coordinated database where the data could be stored is needed and is being considered by ICES. Tag users should be encouraged to include these tags or tagging programmes as this greatly facilitates identification of the origin of tags recovered in fisheries or tag scanning programmes in other jurisdictions.

The full list of data deficiencies, monitoring needs, and research requirements for North Atlantic salmon is presented in Section 1.4 of the sal.oth.nasco advice (ICES, 2021b).

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Annex 1 Glossary of acronyms and abbreviations

1SW *one-sea-winter.* Maiden adult salmon that have spent one winter at sea.

2SW *two-sea-winter.* Maiden adult salmon that have spent two winters at sea.

3SW *three-sea-winter.* Maiden adult salmon that have spent three winters at sea.

CL(s) *conservation limit(s)*, **i.e.** $\mathbf{S_{lim}}$. Demarcation of undesirable stock levels or levels of fishing activity; the ultimate objective when managing stocks and regulating fisheries will be to ensure that there is a high probability that undesirable levels are avoided.

FWI *Framework of Indicators.* The FWI is a tool used to indicate if any significant change in the status of stocks used to inform the previously provided multiannual management advice has occurred.

ICES *International Council for the Exploration of the Sea*

NAC *North American Commission*. A commission under NASCO.

NASCO *North Atlantic Salmon Conservation Organization*

PFA *pre-fishery abundance.* The numbers of salmon estimated to be alive in the ocean from a particular stock at a specified time.

SFA *Salmon Fishing Area*. The 23 areas for which Fisheries and Oceans Canada (DFO) manages the salmon fisheries.

SPM *the islands of Saint Pierre and Miquelon (France)*

Annex 2 General considerations

Management plans

The North Atlantic Salmon Conservation Organization (NASCO) has adopted an Action Plan for Application of the Precautionary Approach, which stipulates that management measures should be aimed at maintaining all stocks above their CLs through the use of management targets. CLs for North Atlantic salmon stock complexes have been defined by ICES as the level of a stock (number of spawners) that will achieve long-term average maximum sustainable yield (MSY). NASCO has adopted the region-specific CLs as limit reference points (S_{lim}); having populations fall below these limits should be avoided with high probability. Within the management plan for the NAC, the following has been agreed for the provision of catch advice on 2SW salmon exploited in North America (as non-maturing 1SW and 2SW salmon): a risk level (probability) of 75% for simultaneous attainment of the 2SW CLs for the four northern regions (Labrador, Newfoundland, Quebec, Gulf); management objectives defined as achieving a 25% increase in 2SW returns relative to a baseline period (average returns in the period 1992–1996) for the Scotia–Fundy region; and the achievement of 2SW adult returns of 4549 fish or greater for the USA region of NAC. An FWI has been developed to identify any significant change in the multiannual management advice in the intervening years of the three-year assessment cycle.

Biology

Atlantic salmon (*Salmo salar*) is an anadromous species found in rivers of countries bordering the North Atlantic. In the Northwest Atlantic it ranges from the Connecticut River (USA, 41.6°N) northwards to the Ungava Bay rivers (58.8°N; Quebec, Canada). Juveniles emigrate to the ocean at ages of between one and eight years (dependent on latitude) and generally return after one or two years at sea. Long-distance migrations to ocean feeding grounds are known to take place, with adult salmon from both the North American and Northeast Atlantic stocks migrating to West Greenland to feed in their second summer and autumn at sea. Recent genetic information has demonstrated that fish from North America were also exploited in the historical Faroes fishery in the North East Atlantic Commission (NEAC) area.

Environmental and other influences on the stock†

Environmental conditions in both freshwater and marine environments have a marked effect on the status of salmon stocks. Across the North Atlantic, a range of problems in the freshwater environment play a significant role in explaining the poor status of stocks. In many cases, river damming and habitat deterioration have had a devastating effect on freshwater environmental conditions. In the marine environment, return rates of adult salmon have declined through the 1980s and are now at the lowest levels in the time-series for some stocks, even after closure of marine fisheries. Climatic factors modifying ecosystem conditions and the impact of predators of salmon at sea are considered to be the main contributory factors to lower productivity, which is expressed almost entirely in terms of lower marine survival.

Effects of the fisheries on the ecosystem

The current salmon fisheries probably have no influence, or only a minor influence, on the marine ecosystem. However, the exploitation rate on salmon may affect the riverine ecosystem through changes in species composition. Knowledge on the magnitude of these effects is limited.

Quality considerations

Uncertainties in input variables to the stock status and stock forecast models are incorporated in the assessment. The reliability of catch statistics could be improved in all areas of eastern North America. Estimates of abundance of adult salmon in some areas, in particular Labrador, are based on a small number of counting facilities raised to a large production area. In 2020, some regions were affected by the COVID-19 global pandemic and had to either modify the way return and spawner estimates were produced (e.g. SFA 15 [Gulf] using spawners snorkel counts instead of angling data) or could not

† Version 2: Section header corrected

provide return and spawner estimates (SFAs 16, 17, 18 [Gulf], and 21 and 23 [Scotia–Fundy]. When no data were available, the previous five-year average values were used, except for Newfoundland for which previous six-year averages were used.

The forecasts for PFA, based on availability of lagged spawners for three years and forecast values of productivity, have very high uncertainty, and the uncertainties increase as the forecasts move further forward in time. Annual productivity estimates are highly variable among years, and large changes in values have been observed over a short time period, as in 2011 to 2017. In the 2018 assessment, the productivity parameter used for the 2018 to 2020 PFA years was negative for three regions, positive and at low values for two regions, and high for Labrador (ICES, 2018). When assessed in 2021, the returns of 2SW salmon in 2018 to 2020 were slightly higher than expected in all regions except Labrador, and the realized productivity for the 2017 to 2019 PFA years was higher than forecast for those years. As a result, the estimated regional PFA values were lower in Labrador for the 2017 to 2019 PFA years and slightly higher in all the other regions; however, the larger overestimate for Labrador relative to the other regions resulted in a lower PFA value for the NAC area for those years than forecast in the 2018 assessment. Due to the large uncertainty associated with the forecast values, the estimated PFA values for 2017 to 2019 were within the 95% confidence intervals of the forecast values.

Basis of the assessment

Table A1 Atlantic Salmon from North America. The basis of the assessment.

ICES stock data category	1 (ICES, 2021c)
Assessment type	Run-reconstruction models and Bayesian forecasts, taking into account uncertainties in the data
Input data	Catches (by sea-age class) for commercial, indigenous, and recreational fisheries Estimates of unreported/illegal catches Estimates of exploitation rates Natural mortalities (from earlier assessments)
Discards and bycatch	It is illegal to retain salmon that are incidentally captured in fisheries not directed at salmon (no bycatch). In the directed recreational fishery, mortality from catch and release is accounted for in the regional assessments to estimate spawners. There is no accounting of discarding mortality in non-salmon directed fisheries.
Indicators	The FWI is used to indicate whether a significant change has occurred in the status of stocks in intermediate years where multiannual management advice applies
Other information	Advice subject to annual review. A stock annex was developed in 2014 and updated in 2021 (ICES, 2021b).
Working group	Working Group on North Atlantic Salmon (WGNAS) (ICES, 2021a)