

Atlantic salmon at West Greenland

Summary of the advice for 2021–2023*

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 at West Greenland in 2021, 2022, and 2023 should be zero.

Mixed-stock fisheries present particular threats and should be managed based on the individual status of all stocks exploited in the fishery.

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 with the returns or return rate data for 2022 to evaluate the appropriateness of the advice for 2023.

NASCO 4.1 Describe the key events of the 2020 fishery

Fishing for salmon using hooks and fixed gillnets is currently allowed along the entire west coast of Greenland (Figure 1). Commercial fishers are allowed to fish using single gillnets fixed to the shore, with no limit on the number of gillnets that can be used. Driftnetting has not been allowed since 2020. Private licensed fishers can only use one gillnet fixed to the shore. Gillnets are the preferred gear in Greenland, but rod and reel catches and bycatch in poundnets are also noted in small amounts within the catch reports.

The commercial fishery for export closed in 1998; the fishery for internal use, however, continues to date. Since 2002, licensed commercial fishers have only been allowed to sell salmon to hotels, institutions, local markets, and factories when factory landings were allowed. People fishing for private consumption only were not required to have a licence until 2018 and are prohibited from selling salmon.

In 2018, the Government of Greenland set a total quota for all components of the 2018–2020 fisheries to 30 t annually. Within the regulatory measure (NASCO, 2018), the government agreed to continue its ban on the export of wild Atlantic salmon or its products from Greenland and to prohibit landings and sales to fish processing factories. The government also agreed to restrict the fishery from 15 August to no later than 31 October each year, and any overharvest in a particular year would result in an equal reduction in the total allowable catch (TAC) the following year. The regulatory measure also set out a number of provisions aimed at improving the monitoring, management control, and surveillance of the fishery. These included a new requirement for all fishers (private and commercial) to obtain a licence to fish for Atlantic salmon, an agreement to collect catch and fishing activity data from all licensed fishers, and mandatory reporting requirements of all fishers. The measure also stated that as a condition of the licence, all fishers will be required to allow international samplers to take samples of their catches upon request. The measure was applied to the 2018–2020 fisheries as the FWI indicated no significant change in the catch advice provided prior to the 2019 and 2020 fisheries. Given the 2018 fishery overharvest, the 2019 quota was set to 19.5 t. Given the 2019 fishery overharvest, the 2020 fishery quota was set to 20.7 t.

Reported (i.e. nominal) catches of Atlantic salmon at West Greenland (Figure 2; Table 1) increased through the 1960s, reached a peak of approximately 2700 t in 1971, and then decreased until the closure of the commercial fishery for export in 1998. Catches are reported from all six NAFO divisions, and proportions vary annually (Table 2). A total salmon catch of 31.7 t was reported for the 2020 fishery, an increase from the 2019 catch (29.8 t) but a harvest of 11 t over the 20.7 t quota (Table 2). In 2020, commercial landings represented the majority of the harvest at 22.0 t (79.5%) and the remaining 9.7 t (30.5%) was for private use, compared to 21.8 t and 7.6 t, respectively, in 2019 (Table 3). The mean percentage of

* This advice was originally published in May 2021, and ICES has evaluated this advice and ICES confirms that it conforms to the ICES standard of providing advice based on the best available science to decision makers. ICES considers it suitable to inform management actions and it remains valid.

commercial landings registered for private use was 41 from 1997 to 2017 (excluding 2000 and 2001) and 0.2 from 2018 to 2020. Reported commercial and private landings by NAFO/ICES areas in 2020 are presented in Table 4. The number of licences issued, the number of fishers that reported, and the number of reports received have all increased greatly since 2017, a result of the new regulatory measure requirements both for all fishers to obtain a licence and for mandatory reporting (Figure 3).

The 2020 fishery opened on 1 September. On 17 September, more than 15 t of landings had been registered and, given landings projections, the Government of Greenland announced the fishing season would end on 20 September. However, an approximate one-week delay from landings to registration of landings resulted in the quota being exceeded by 11 t. Unreported catch is assumed to have been at the same level (10 t) as historically reported by the Greenlandic authorities.

An adjustment for some of the unreported catch has been carried out since 2002 using two approaches: 1) comparisons of the sampling programme statistics and reported landings (adjusted landings [survey]) and 2) utilizing results from the previously implemented phone surveys (adjusted landings [sampling]). Adjusted landings (sampling) are estimated by comparing the weight of salmon observed by the sampling teams and the corresponding community-specific reported landings for the entire fishing season. Sampling is not random and only occurs during part of the fishing season; it is therefore not representative of the total unreported catch. An evaluation of non-reporting of harvest was not possible in 2020 due to international samplers not being in Greenland given travel restrictions associated with the COVID-19 pandemic. Adjusted landings (survey) are estimated from results of phone surveys, conducted after each of the fishing seasons 2014–2016 in order to gain further information on inconsistencies in the reported catch data. Adjusted landings (survey) are added to the adjusted landings (sampling) and reported landings to estimate the landings for assessment (Table 5). Landings for assessment do not replace the official reported statistics.

The sampling programme for 2020 was modified from past efforts, because travel restrictions associated with the COVID-19 pandemic meant that international samplers were not able to travel to Greenland to sample harvested Atlantic salmon. Instead, individual sampling kits were provided to three groups of potential samplers located within Greenland: wildlife officers from the Greenland Fisheries License Control Authority (GFLK), staff from the Greenland Institute of Nature Resources (GINR), and individual fishers as part of a citizen science initiative. The sampling programme was marginally successful because of the short fishing season and challenges associated with the COVID-19 pandemic. A total of 114 Atlantic salmon were sampled, but shipping delays prevented these samples from being processed. The samples will be processed in 2021 and made available to support future assessment efforts.

A summary of the biological characteristics and continent and region of contributions to the harvest is therefore not available for the 2020 catch, although the time-series of salmon sampled that were determined to be of North American and European origin is presented in Figure 4. To mitigate for the lack of biological characteristics data and continent of origin estimates for the 2020 fishery, five-year mean values were used in the North American Commission (NAC) and North-East Atlantic Commission (NEAC) pre-fishery abundance run-reconstruction models, which generated estimates of the number of North American (9600) and European (3200) fish harvested in 2020 (Figure 5). The total number of fish harvested in 2020 (12 800) is an increase from the estimated number harvested in 2019 (9400) and approximate to the previous ten-year mean (2010–2019; 11 900).

Table 1 Reported catches of salmon at West Greenland since 1960 (tonnes, round fresh weight) by participating nations. For Greenlandic vessels specifically, all catches up to 1968 were taken with set gillnets only; catches 1968–2019 were taken with both set gillnets and driftnets; and catches from 2020 to the present were taken with set gillnets only. All non-Greenlandic vessel catches 1969–1975 were taken with driftnets. The quota figures applied to Greenlandic vessels only, and entries in parentheses identify when quotas did not apply to all sectors of the fishery.

Year	Norway	Faroes	Sweden	Denmark	Greenland	Total	Quota	Comments
1960	-	-	-	-	60	60		
1961	-	-	-	-	127	127		
1962	-	-	-	-	244	244		
1963	-	-	-	-	466	466		
1964	-	-	-	-	1539	1539		
1965	-	36	-	-	825	858		Norwegian harvest figures not available, but known to be less than Faroese catch
1966	32	87	-	-	1251	1370		
1967	78	155	-	85	1283	1601		
1968	138	134	4	272	579	1127		
1969	250	215	30	355	1360	2210		
1970	270	259	8	358	1244	2139		Greenlandic catch includes 7 t caught by longlines in the Labrador Sea
1971	340	255	-	645	1449	2689	-	
1972	158	144	-	401	1410	2113	1100	
1973	200	171	-	385	1585	2341	1100	
1974	140	110	-	505	1162	1917	1191	
1975	217	260	-	382	1171	2030	1191	
1976	-	-	-	-	1175	1175	1191	
1977	-	-	-	-	1420	1420	1191	
1978	-	-	-	-	984	984	1191	
1979	-	-	-	-	1395	1395	1191	
1980	-	-	-	-	1194	1194	1191	
1981	-	-	-	-	1264	1264	1265	Quota set to a specific opening date for the fishery
1982	-	-	-	-	1077	1077	1253	Quota set to a specific opening date for the fishery
1983	-	-	-	-	310	310	1191	
1984	-	-	-	-	297	297	870	
1985	-	-	-	-	864	864	852	
1986	-	-	-	-	960	960	909	
1987	-	-	-	-	966	966	935	
1988	-	-	-	-	893	893	840	Quota for 1988–1990 was 2520 t with an opening date of 1 August. Annual catches were not to exceed an annual average (840 t) by more than 10%.
1989	-	-	-	-	337	337	900	Quota adjusted to 900 t for later opening date
1990	-	-	-	-	274	274	924	Quota adjusted to 924 t for later opening date
1991	-	-	-	-	472	472	840	
1992	-	-	-	-	237	237	258	
1993	-	-	-	-			89	The fishery was suspended. NASCO adopt a new quota allocation model
1994	-	-	-	-			137	The fishery was suspended and the quota was bought out
1995	-	-	-	-	83	83	77	
1996	-	-	-	-	92	92	174	
1997	-	-	-	-	58	58	57	Private (non-commercial) catches to be reported after 1997
1998	-	-	-	-	11	11	20	Fishery restricted to catches used for internal consumption in Greenland
1999	-	-	-	-	19	19	20	Same as previous year
2000	-	-	-	-	21	21	20	Same as previous year

Year	Norway	Faroes	Sweden	Denmark	Greenland	Total	Quota	Comments
2001	-	-	-	-	43	43	114	Final quota calculated according to the <i>ad hoc</i> management system
2002	-	-	-	-	9	9	55	Quota bought out; quota represented the maximum allowable catch (no factory landing allowed).
2003	-	-	-	-	9	9		Quota set to nil (no factory landing allowed); fishery restricted to catches used for internal consumption in Greenland
2004	-	-	-	-	15	15		Same as previous year
2005	-	-	-	-	15	15		Same as previous year
2006	-	-	-	-	22	22		Same as previous year
2007	-	-	-	-	25	25		Same as previous year
2008	-	-	-	-	26	26		Same as previous year
2009	-	-	-	-	26	26		Same as previous year
2010	-	-	-	-	40	40		Same as previous year
2011	-	-	-	-	28	28		Same as previous year
2012	-	-	-	-	33	33	(35)	35 t quota for factory landings only
2013	-	-	-	-	47	47	(35)	Same as previous year
2014	-	-	-	-	58	58	(30)	Quota for factory landings only
2015	-	-	-	-	57	57	45	Quota for all sectors (private and commercial) of the fishery
2016	-	-	-	-	27	27	32	Same as previous year
2017	-	-	-	-	28	28	45	Same as previous year
2018	-	-	-	-	40	40	30	Same as previous year
2019	-	-	-	-	30	30	19.5	Same as previous year
2020	-	-	-	-	32	32	21	Same as previous year

Table 2 Annual distribution of reported catches (in tonnes) at Greenland by NAFO division (when known). NAFO divisions are shown in Figure 1. Since 2005, gutted weights have been reported and converted to total weight by a factor of 1.11. Rounding issues are evident for some totals.

Year	NAFO Division						Unknown	West Greenland	East Greenland	Total
	1A	1B	1C	1D	1E	1F				
1960							60	60		60
1961							127	127		127
1962							244	244		244
1963	1	172	180	68	45			466		466
1964	21	326	564	182	339	107		1539		1539
1965	19	234	274	86	202	10	36	861		861
1966	17	223	321	207	353	130	87	1338		1338
1967	2	205	382	228	336	125	236	1514		1514
1968	1	90	241	125	70	34	272	833		833
1969	41	396	245	234	370		867	2153		2153
1970	58	239	122	123	496	207	862	2107		2107
1971	144	355	724	302	410	159	560	2654		2654
1972	117	136	190	374	385	118	703	2023		2023
1973	220	271	262	440	619	329	200	2341		2341
1974	44	175	272	298	395	88	645	1917		1917
1975	147	468	212	224	352	185	442	2030		2030
1976	166	302	262	225	182	38		1175		1175
1977	201	393	336	207	237	46	-	1420	6	1426
1978	81	349	245	186	113	10	-	984	8	992
1979	120	343	524	213	164	31	-	1395	+	1395
1980	52	275	404	231	158	74	-	1194	+	1194
1981	105	403	348	203	153	32	20	1264	+	1264
1982	111	330	239	136	167	76	18	1077	+	1077
1983	14	77	93	41	55	30	-	310	+	310
1984	33	116	64	4	43	32	5	297	+	297
1985	85	124	198	207	147	103	-	864	7	871
1986	46	73	128	203	233	277	-	960	19	979
1987	48	114	229	205	261	109	-	966	+	966
1988	24	100	213	191	198	167	-	893	4	897
1989	9	28	81	73	75	71	-	337	-	337
1990	4	20	132	54	16	48	-	274	-	274
1991	12	36	120	38	108	158	-	472	4	476
1992	-	4	23	5	75	130	-	237	5	242
1993*	-	-	-	-	-	-	-	-	-	-
1994*	-	-	-	-	-	-	-	-	-	-
1995	+	10	28	17	22	5	-	83	2	85
1996	+	+	50	8	23	10	-	92	+	92
1997	1	5	15	4	16	17	-	58	1	59
1998	1	2	2	4	1	2	-	11	-	11
1999	+	2	3	9	2	2	-	19	+	19
2000	+	+	1	7	+	13	-	21	-	21
2001	+	1	4	5	3	28	-	43	-	43
2002	+	+	2	4	1	2	-	9	-	9
2003	1	+	2	1	1	5	-	9	-	9
2004	3	1	4	2	3	2	-	15	-	15
2005	1	3	2	1	3	5	-	15	-	15
2006	6	2	3	4	2	4	-	22	-	22
2007	2	5	6	4	5	2	-	25	-	25
2008	4.9	2.2	10.0	1.6	2.5	5.0	0	26.2	0	26.2
2009	0.2	6.2	7.1	3.0	4.3	4.8	0	25.6	0.8	26.3
2010	17.3	4.6	2.4	2.7	6.8	4.3	0	38.1	1.7	39.6
2011	1.8	3.7	5.3	8.0	4.0	4.6	0	27.4	0.1	27.5
2012	5.4	0.8	15.0	4.6	4.0	3.0	0	32.6	0.5	33.1
2013	3.1	2.4	17.9	13.4	6.4	3.8	0	47.0	0.0	47.0

Year	NAFO Division						Unknown	West Greenland	East Greenland	Total
	1A	1B	1C	1D	1E	1F				
2014	3.6	2.8	13.8	19.1	15.0	3.4	0	57.8	0.1	57.9
2015	0.8	8.8	10.0	18.0	4.2	14.1	0	55.9	1.0	56.8
2016	0.8	1.2	7.3	4.6	4.5	7.3	0	25.7	1.5	27.1
2017	1.1	1.7	9.3	6.9	3.2	5.6	0	27.8	0.3	28.0
2018	2.4	5.7	13.7	8.2	4.2	4.8	0	39.0	0.8	39.9
2019	0.8	3.0	4.4	8.0	4.8	7.3	0	28.3	1.4	29.8
2020	0.9	3.6	6.6	9.7	3.0	7.1	0	30.9	0.8	31.7

* The fishery was suspended.

+ Small catches, < 0.5 t.

- No catch.

Table 3 Reported 2019 and 2020 catches (in tonnes) by license type and landings category. Licences for private fishers were introduced in 2018. Entries of 0.0 represent reported values of < 0.1. Note: Due to rounding, numbers presented may not add up precisely to the totals indicated.

Licence status	Landings type	Reported 2019 catch	Reported 2020 catch
Licensed	Commercial (from commercial fishers)	21.8	22.0
	Private use (from commercial fishers)	0.1	0
	Commercial use (from private fishers)	0.2	0
	Private use (from private fishers)	7.6	9.7
Total commercial catch		22.0	22.0
Total private use catch		7.7	9.7
Total catch		29.8	31.7

Table 4 Reported 2020 landings in NAFO/ICES areas (in tonnes) by licence type, landing category, the number of fishers reporting, and the total number of landing reports received. Empty cells identify categories with no reported landings and 0.0 entries represent reported values of < 0.1. Note: due to rounding, numbers presented may not add up precisely to the totals indicated.

NAFO/ICES	Licence type	No. of fishers	No. of reports	Commercial	Private	Total
NAFO 1A	Private	41	58		0.2	0.2
	Commercial	59	120	0.7		0.7
	Total	100	178	0.7	0.2	0.9
NAFO 1B	Private	42	92		0.5	0.5
	Commercial	47	147	3.1		3.1
	Total	89	239	3.1	0.5	3.6
NAFO 1C	Private	28	47		0.8	0.8
	Commercial	75	181	5.8		5.8
	Total	103	228	5.8	0.8	6.6
NAFO 1D	Private	116	171		2.8	2.8
	Commercial	35	102	7.0		7.0
	Total	151	273	7.0	2.8	9.7
NAFO 1E	Private	27	47		1.1	1.1
	Commercial	20	44	1.9		1.9
	Total	47	91	1.9	1.1	3.0
NAFO 1F	Private	79	191		3.9	3.9
	Commercial	39	93	3.2		3.2
	Total	118	284	3.2	3.9	7.1
ICES Subarea 14	Private	8	23		0.5	0.5
	Commercial	2	5	0.3		0.3
	Total	10	28	0.3	0.5	0.8
ALL	Private	341	629		9.7	9.7
	Commercial	277	692	22.0		22.0
	Total	618	1321	22.0	9.7	31.7

Table 5 Reported landings and adjusted landings (in tonnes) for the assessment of Atlantic salmon at West Greenland 2002–2020. The total adjusted landings do not include the unreported catch (ten tonnes per year since 2000).

Year	Reported landings (West Greenland)	Adjustment to landings (sampling)	Adjustment to landings (survey)	Total adjusted landings
2002	9.0	0.7	-	9.8
2003	8.7	3.6	-	12.3
2004	14.7	2.5	-	17.2
2005	15.3	2.0	-	17.3
2006	23.0	0.0	-	23.0
2007	24.6	0.2	-	24.8
2008	26.1	2.5	-	28.6
2009	25.5	2.5	-	28.0
2010	37.9	5.1	-	43.1
2011	27.4	0.0	-	27.4
2012	32.6	2.0	-	34.6
2013	46.9	0.7	-	47.7
2014	57.7	0.6	12.2	70.5
2015	55.9	0.0	5.0	60.9
2016	25.7	0.3	4.2	30.2
2017	27.8	0.3	-	28.0
2018	39.0	0.0	-	39.0
2019	28.3	0.0	-	28.3
2020	30.9	-	-	-

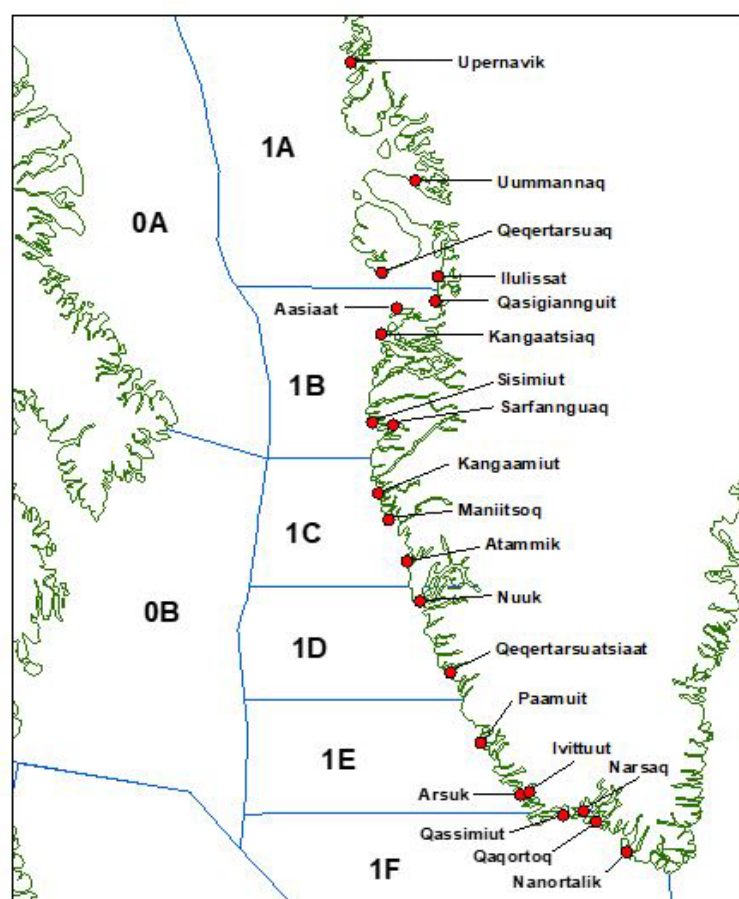


Figure 1 Map of communities in West Greenland where Atlantic salmon have historically been landed and the corresponding NAFO divisions (1A–1F).

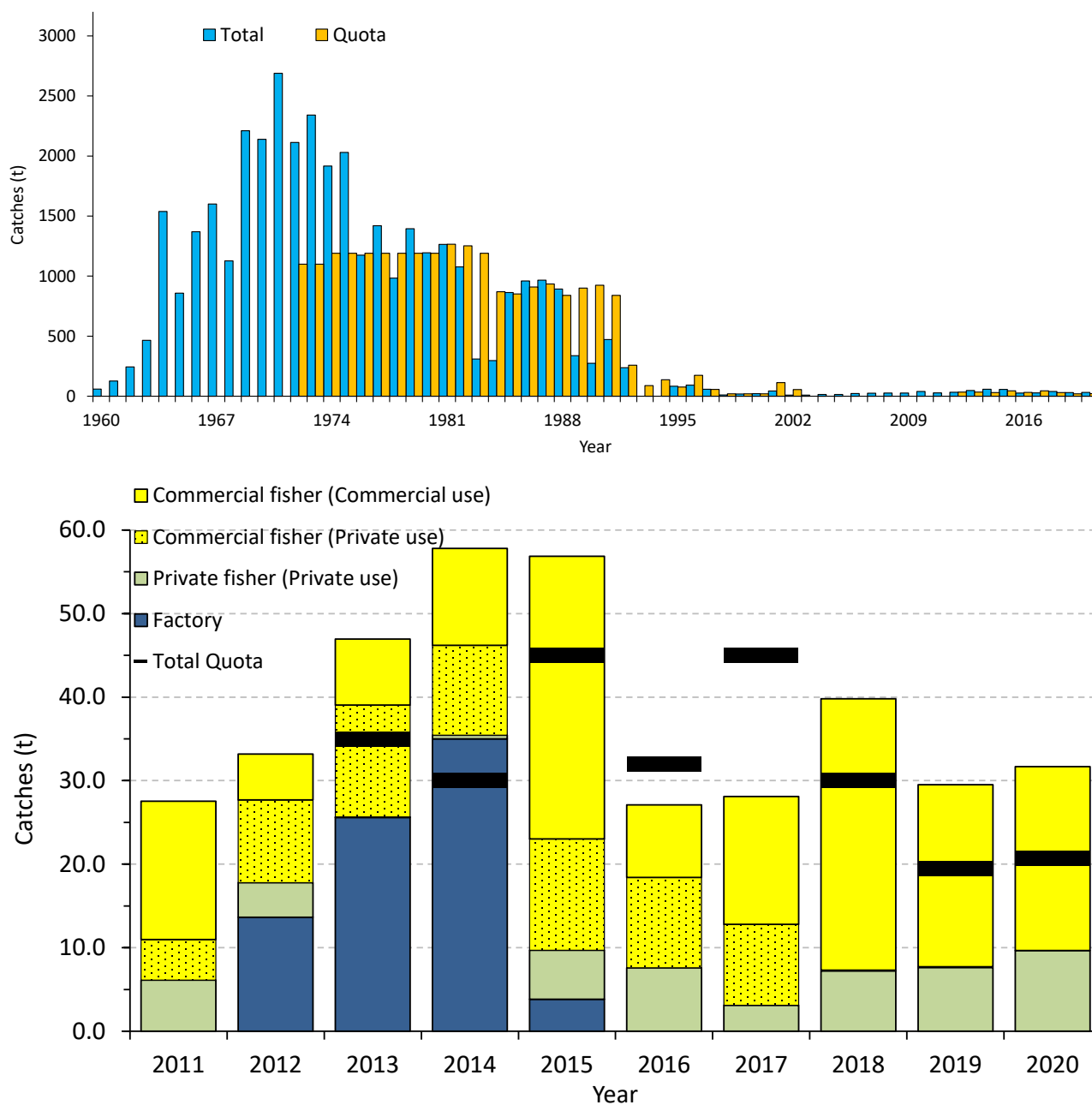


Figure 2 Reported landings and commercial quotas (tonnes, round fresh weight) of salmon at West Greenland from 1960 to 2020 (upper panel). Landings from 2011 to 2020 are also displayed by landing type (lower panel). No quotas were set for 2002–2011, and the quotas for 2012–2014 were for factory landings only.

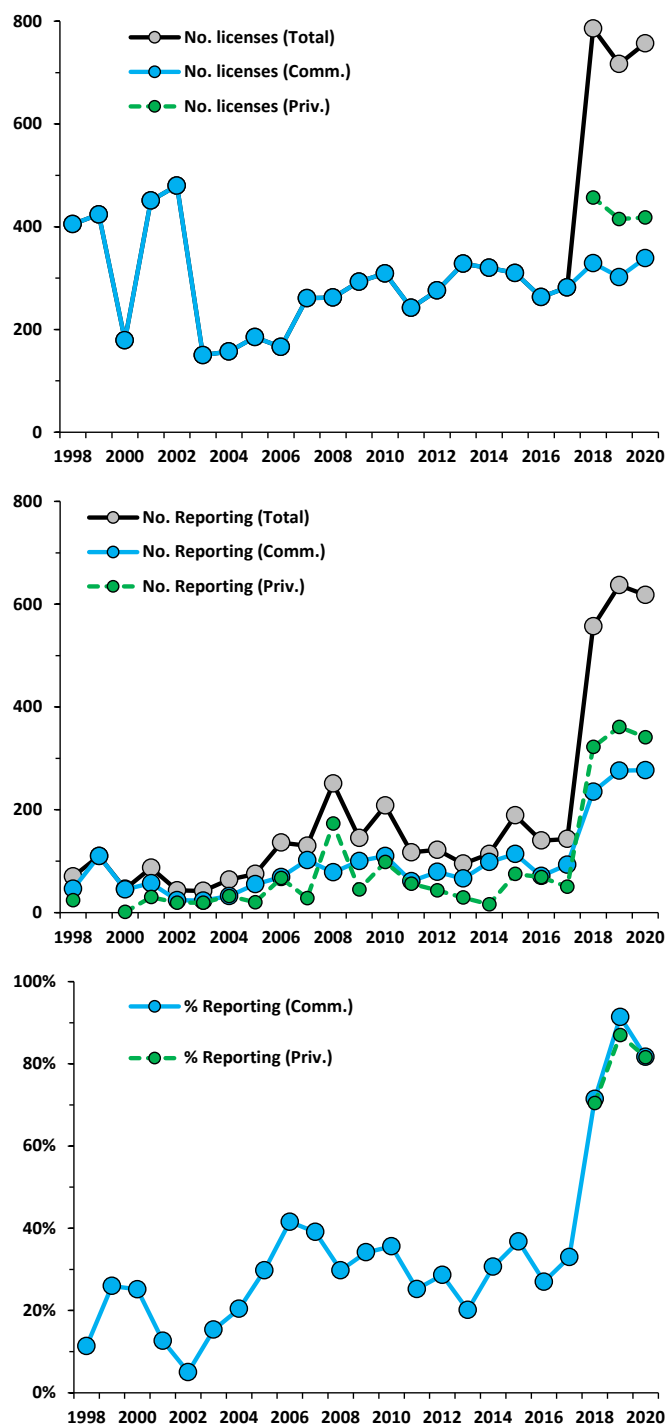


Figure 3 Number of licences issued by licence type (upper panel), number of fishers reporting by licence type (middle panel), and percent of licensed fishers reporting by licence type (lower panel). Starting in 2018 all fishers were required to have a licence.

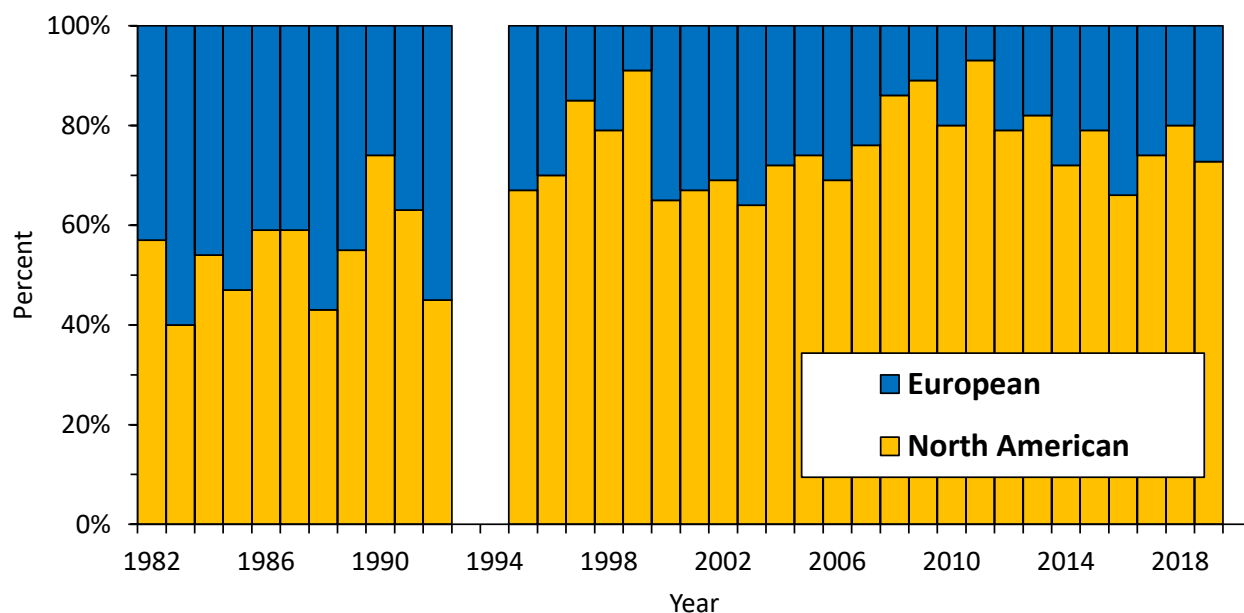


Figure 4 Estimated percent of continental origin of Atlantic salmon harvested at West Greenland from 1982 to 2019. No estimate is available for 2020 because of restrictions associated with the COVID-19 pandemic.

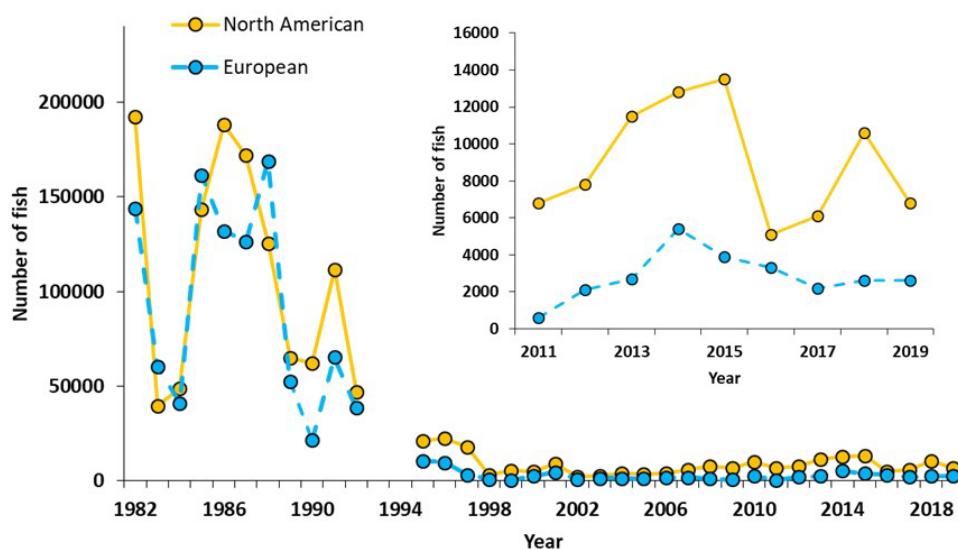


Figure 5 Number of North American and European Atlantic salmon caught at West Greenland in 1982–2019 and 2011–2019 (inset). Estimates are based on continent of origin by NAFO division, weighted by catch (weight) in each division. Unreported catch is not included. No estimate is available for 2020 because of restrictions associated with the COVID-19 pandemic.

NASCO 4.2 Describe the status of the stocks

Recruitment (pre-fishery abundance [PFA]) estimates of non-maturing 1SW salmon at Greenland show continued low abundance compared to historical levels. PFA estimates are currently below the spawner escapement reserves (SER) for the NAC stock complex (Figure 6) but above for the Southern NEAC stock complex (Figure 7). The CLs and SERs for the Southern NEAC complexes have been revised downwards substantially compared to last year due to changes in UK (Northern Ireland) and particularly UK (Scotland) estimates.

In 2020, the estimates (median) of 2SW salmon returns to rivers and spawners were below CLs (suffering reduced reproductive capacity) in the NAC assessment regions except for the Gulf region; for spawners, the percentage of the CL ranged from 10% in Scotia–Fundy to 161% in Gulf (Figure 8). Particularly large deficits relative to CLs and rebuilding management objectives are noted in the Scotia–Fundy and USA regions. The Gulf status was assessed using the previous five-year mean as a proxy for the unavailable 2020 input data. This is not expected to have caused the substantial increase in 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.

The exploitation rate (catch in Greenland divided by PFA) in 2019 was 6.0% for NAC fish and 0.7% for Southern NEAC fish (Figure 9). Despite major changes in fisheries management in the past few decades and increasingly more restrictive fisheries measures, returns have remained low compared to historical levels. It is likely, therefore, that other factors besides fisheries are constraining production.

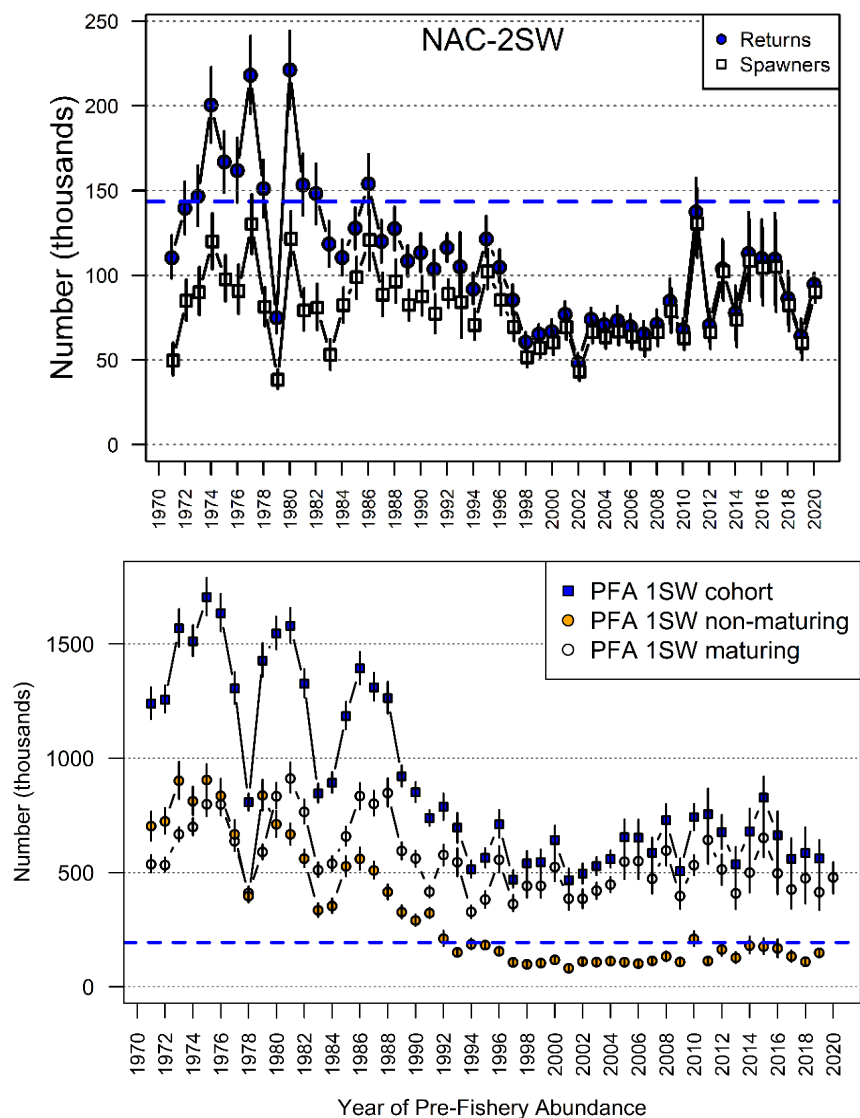


Figure 6

Upper panel: estimated (median, 5th to 95th percentile range; in thousands) returns (blue circles) and spawners (white squares) of 2SW salmon for the NAC area in 1971–2020. The dashed blue line is the corresponding 2SW CL for NAC. Bottom panel: estimated (median, 5th to 95th percentile range; in thousands) PFA for 1SW maturing, 1SW non-maturing, and the total cohort of 1SW salmon for the NAC area in PFA years 1971–2019. The dashed horizontal blue line is the corresponding sum of the 2SW CLs for NAC, corrected for 11 months of natural mortality against which 1SW non-maturing salmon are assessed.

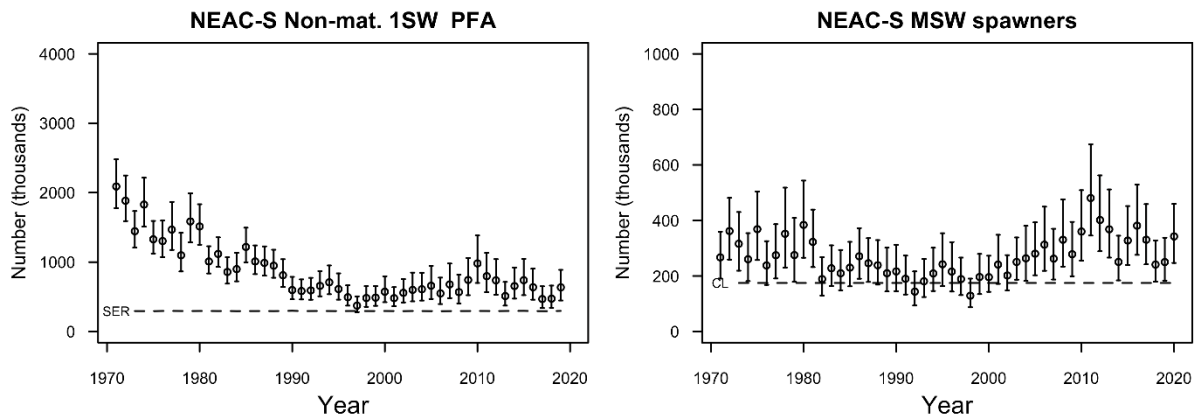


Figure 7 Estimated spawners with 90% confidence limits for MSW salmon for Southern NEAC (right panel). The dashed line is the corresponding MSW conservation limit for Southern NEAC. Estimated PFA with 90% confidence limits for non-maturing 1SW salmon for Southern NEAC (left panel). The dashed line is the corresponding SER for Southern NEAC.



Figure 8 Summary of 2SW (NAC regions) and MSW (Southern NEAC) 2020 median (from the Monte Carlo posterior distributions) spawner estimates in relation to CLs or management objectives (only for USA and Scotia-Fundy). The colours used as shading represent the three ICES stock status designations: blue – Full (at full reproductive capacity: the 5th percentile of the spawner estimate is above the CL); orange – At risk (at risk of suffering reduced reproductive capacity: the median spawner estimate is above but the 5th percentile below the CL); and red – Suffering (suffering reduced reproductive capacity: the median spawner estimate is below the CL).

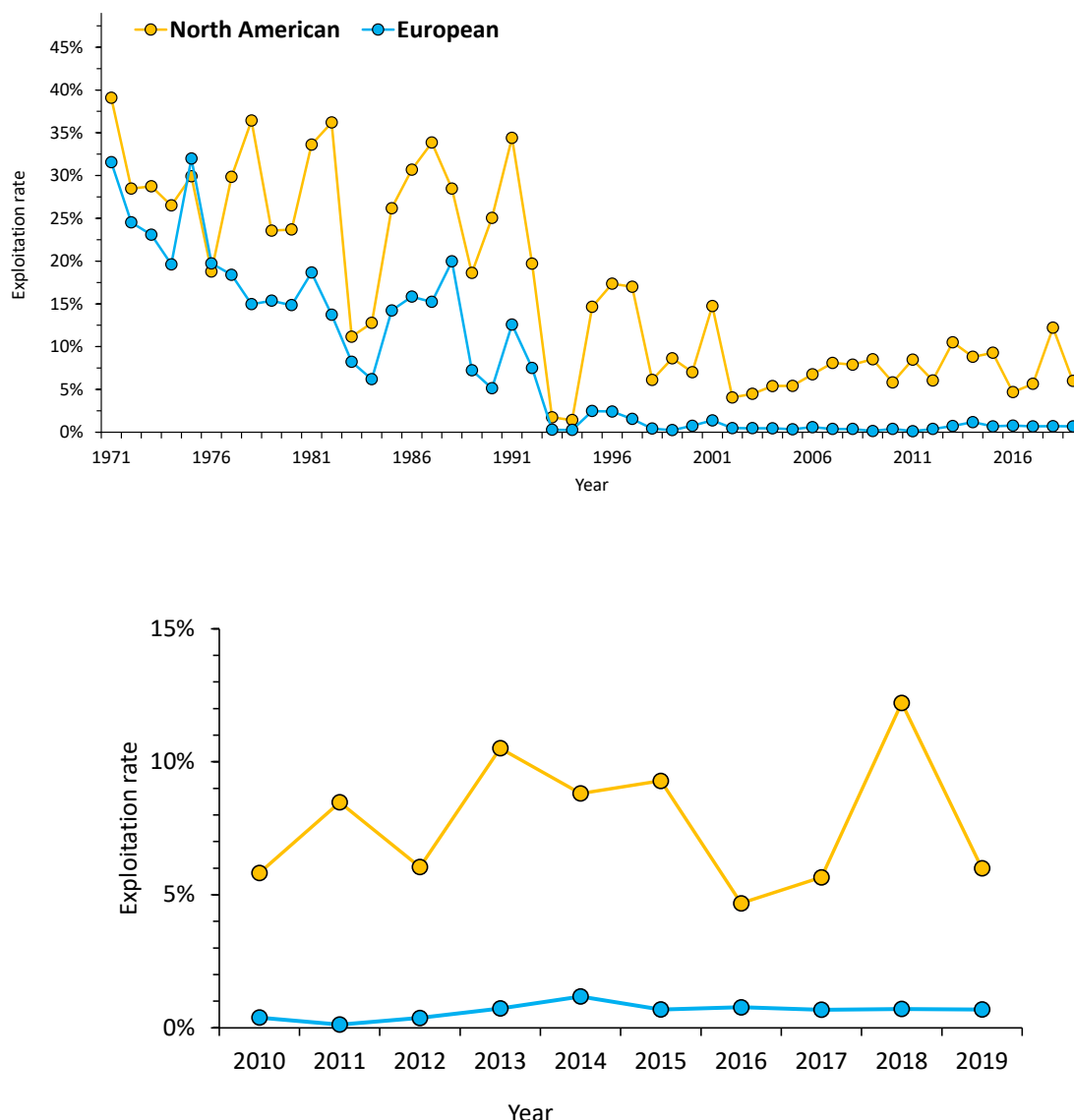


Figure 9 Exploitation rate (%) for NAC 1SW non-maturing and Southern NEAC non-maturing Atlantic salmon at West Greenland in 1971–2019 (upper panel) and 2010–2019 (lower panel). Exploitation rate estimates are only available up to 2019, as 2020 exploitation rates are dependent on 2021 returns.

NASCO 4.3 Provide catch options or alternative management advice for 2021–2023 with an assessment of risk 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

The management advice for the West Greenland fishery for 2021 to 2023 is based on the models used by ICES since 2003 and was most recently revised in 2018 (ICES, 2018). ICES followed the processes developed in previous years for providing management advice and catch options for West Greenland using the PFA and CLs or alternate management objectives for the NAC and NEAC areas (Table 6). The risks of the Greenland fishery to NAC and NEAC stock complexes are developed in parallel and combined into a single catch options table (Table 7). In summary, none of the stated management objectives would allow a mixed-stock fishery at West Greenland to take place in 2021, 2022, or 2023. Specifically:

- Newfoundland has the lowest probabilities of any of the four northern regions of reaching the CLs; these were estimated to be 0.51, 0.44, and 0.30 for the years 2021, 2022, and 2023, respectively (Table 7).
- In the absence of any marine fishing mortality at Greenland and North America, there is a low probability (from 0.01 to 0.03) that the returns in the southern region of Scotia–Fundy will be sufficient to meet the stock

rebuilding objective during the period 2021–2023 (Table 7). The probability of meeting or exceeding the stock rebuilding objective of the USA region is estimated at 0.11–0.23 over the three years.

- In the absence of any marine fishing mortality at Greenland and in NEAC, the probabilities of meeting or exceeding the SER for the Southern NEAC MSW complex are 0.93, 0.83, and 0.75 in 2021–2023, respectively (Table 7).
- In the absence of any fishing mortality on these stocks, there is a near zero probability (0.004–0.006) of meeting or exceeding the seven management objectives simultaneously in 2021–2023 (Table 7).

Relevant factors to be considered in management

The management of 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 target all stocks present, whether or not they are meeting their individual 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.

The salmon caught in the West Greenland fishery are mostly (> 90%) non-maturing 1SW salmon, most of which are destined to return to home waters in Europe or North America as 2SW fish. European stocks contributing to the fishery in West Greenland mainly originate in the southern MSW stock complex, although small numbers may also originate in northern Europe. Most MSW stocks in North America contribute to the fishery at West Greenland. Previous spawners, including salmon that spawned first as 1SW and 2SW salmon, also contribute to the fishery although in low (< 5%) proportions.

Table 6 Management objectives and equivalent number of fish relevant to the development of catch options at West Greenland for the six geographic areas in the NAC area and the Southern NEAC non-maturing complex.

Area	Objective	Number of fish
USA	2SW proportion of recovery criteria	4549
Scotia–Fundy	25% increase from 2SW returns during 1992 to 1997	10976
Gulf	2SW conservation limit	18737
Québec	2SW conservation limit	32085
Newfoundland	2SW conservation limit	4022
Labrador	2SW conservation limit	34746
Southern NEAC non-maturing complex	MSW conservation limit	174735
	(Spawner escapement reserve to Jan. 1 of first winter at sea)	295582

Table 7 Catch options tables for the mixed-stock fishery at West Greenland by PFA year 2021 to 2023.

Probability of meeting or exceeding region-specific management objectives								
	LABRADOR	NEWFOUNDLAND	QUÉBEC	GULF	SCOTIA– FUNDY	USA	SOUTHERN NEAC	SIMULTANEOUS
2021 Catch options (tonnes)								
0	0.75	0.51	0.60	0.92	0.01	0.11	0.93	0.004
10	0.73	0.49	0.58	0.91	0.01	0.10	0.93	0.004
20	0.72	0.47	0.55	0.90	0.01	0.10	0.93	0.004
30	0.70	0.45	0.52	0.88	0.01	0.09	0.92	0.004
40	0.68	0.44	0.50	0.87	0.01	0.09	0.92	0.004
50	0.67	0.42	0.47	0.86	0.01	0.08	0.92	0.003
60	0.65	0.40	0.45	0.84	0.01	0.08	0.92	0.003
70	0.63	0.38	0.42	0.83	0.01	0.08	0.92	0.003
80	0.61	0.36	0.40	0.81	0.01	0.07	0.91	0.003
90	0.59	0.34	0.37	0.79	0.01	0.07	0.91	0.003
100	0.57	0.32	0.35	0.77	0.01	0.07	0.91	0.003
2022								
0	0.73	0.44	0.47	0.90	0.03	0.15	0.83	0.006
10	0.72	0.42	0.44	0.88	0.03	0.15	0.82	0.006
20	0.70	0.40	0.42	0.87	0.03	0.15	0.82	0.005
30	0.68	0.39	0.40	0.86	0.03	0.14	0.81	0.004
40	0.67	0.37	0.38	0.85	0.03	0.14	0.81	0.004
50	0.65	0.35	0.37	0.83	0.03	0.13	0.81	0.004
60	0.63	0.34	0.35	0.82	0.03	0.13	0.80	0.004
70	0.62	0.32	0.33	0.80	0.02	0.12	0.80	0.004
80	0.60	0.31	0.31	0.78	0.02	0.12	0.79	0.004
90	0.58	0.29	0.30	0.76	0.02	0.12	0.79	0.004
100	0.57	0.28	0.28	0.74	0.02	0.11	0.78	0.004
2023								
0	0.67	0.30	0.46	0.83	0.03	0.23	0.75	0.005
10	0.66	0.28	0.44	0.82	0.03	0.22	0.74	0.005
20	0.64	0.27	0.43	0.80	0.03	0.22	0.74	0.005
30	0.63	0.26	0.41	0.79	0.03	0.21	0.74	0.005
40	0.61	0.25	0.39	0.77	0.03	0.21	0.73	0.005
50	0.60	0.24	0.37	0.76	0.02	0.20	0.73	0.004
60	0.58	0.23	0.35	0.73	0.02	0.19	0.72	0.004
70	0.56	0.22	0.34	0.72	0.02	0.19	0.72	0.004
80	0.55	0.20	0.32	0.70	0.02	0.18	0.71	0.004
90	0.53	0.19	0.30	0.69	0.02	0.18	0.71	0.004
100	0.51	0.18	0.29	0.67	0.02	0.17	0.70	0.003

NASCO 4.4 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 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;

- Providing the spreadsheet for carrying out the FWI assessment.

The updated FWI contains 19 indicator variables, represented by 13 different rivers (Figure 10). 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, Newfoundland or Southern NEAC. Although informative for the mixed fisheries in the NEAC, the Faroe FWI is uninformative for the West Greenland fishery.

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
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										

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

Figure 10 FWI spreadsheet for the West Greenland fishery. 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.

Identify relevant data deficiencies, monitoring needs, and research requirements

No data deficiencies, monitoring needs, or research requirements of relevance to the West Greenland Commission were identified. The full list of data deficiencies, monitoring needs, and research requirements for North Atlantic salmon is presented in Section 1.45 of the [sal.oth.nasco.advice](#) (ICES, 2021c).

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Recommended citation: ICES. 2022. Atlantic salmon at West Greenland. *In* Report of the ICES Advisory Committee, 2022. ICES Advice 2022, sal.wgc.all. <https://doi.org/10.17895/ices.pub.19706242>

Annex 1 Glossary of acronyms and abbreviations

1SW	<i>one-sea-winter</i> . Maiden adult salmon that has spent one winter at sea.
2SW	<i>two-sea-winter</i> . Maiden adult salmon that has spent two winters at sea.
CL(s)	<i>conservation limits(s), i.e. S_{lim}</i> . Demarcation of undesirable stock levels or levels of fishing activity; the ultimate objective when managing stocks and regulating fisheries is to ensure that there is a high probability that undesirable levels are avoided.
ICES	<i>International Council for the Exploration of the Sea</i>
NAC	<i>North American Commission</i> . A commission under NASCO.
NAFO	<i>Northwest Atlantic Fisheries Organization</i> . An intergovernmental fisheries science and management organization that ensures the long-term conservation and sustainable use of fishery resources in the Northwest Atlantic.
NASCO	<i>North Atlantic Salmon Conservation Organization</i>
NEAC	<i>North-East Atlantic Commission</i> . A commission under NASCO.
PFA	<i>pre-fishery abundance</i> . The numbers of salmon estimated to be alive in the ocean from a particular stock at a specific time.

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 by 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, a simultaneous risk level (probability) of 75% has been agreed for the provision of catch advice on the stock complexes exploited at West Greenland (non-maturing 1SW fish from North America and Southern NEAC). The management objectives are to meet (a) the Southern NEAC MSW CL, (b) the 2SW CLs for the four northern areas of the NAC (Labrador, Newfoundland, Quebec, and Gulf) to achieve a 25% increase in returns of 2SW salmon from the average returns in the period 1992–1996 for the Scotia–Fundy region of NAC, and (c) to achieve 2SW adult returns of 4549 fish or greater for USA region of NAC. An FWI of indicators has been developed in support of the multiannual catch options.

Biology

Atlantic salmon (*Salmo salar*) is an anadromous species found in rivers of countries bordering the North Atlantic. In the Northeast Atlantic area its current distribution extends from the Lima River (41°69') in northern Portugal to the Pechora River (68°20') in Northwest Russia and Iceland (66°44'). In the Northwest Atlantic distribution ranges from the Connecticut River (USA, 41°6'N) northwards to 60°29' N in the Ungava Bay (Quebec, Canada). Juveniles migrate 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 Greenland to feed during their second summer and autumn at sea.

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 factors contributing to lower productivity, which is expressed almost entirely in terms of lower marine survival.

Effects of the fisheries on the ecosystem

The current salmon fishery uses nearshore surface gillnets. There is no information on bycatch of other species with this gear. The fisheries probably have no influence, or only a minor influence, on the marine ecosystem.

Quality considerations

Uncertainties in input variables to the stock status and stock forecast models are incorporated in the assessment. Catch reporting at Greenland is considered to be incomplete.

The COVID-19 pandemic prevented the international sampling programme from taking place, which resulted in no data on biological characteristics, continent/region of origin, and non-reporting of harvest being available for 2020. Previous five-year mean values were used for the 2020 biological characteristics of salmon in the fishery at West Greenland. For the 2020 assessment year, previous five-year mean values were used in some regions of NAC because of the impact of the COVID-19 pandemic on field programmes.

Scientific basis

Table A1 Atlantic Salmon at West Greenland. The basis of the assessment.

ICES stock data category	1 (ICES, 2021a)
Assessment type	Run–reconstruction models and Bayesian forecasts, taking into account uncertainties in the data
Input data	Reported (i.e. nominal) catches (by sea-age class and continent of origin) for internal use fisheries Estimates of unreported/illegal catches Estimates of exploitation rates Natural mortalities (from earlier assessments)
Discards and bycatch	No salmon discards in the directed salmon fishery
Indicators	An FWI is used to indicate whether a significant change has occurred in the status of stocks in intermediate years where multi-annual management advice applies
Other information	Advice subject to annual review. Stock annex completed in 2014 and updated in 2021 (ICES, 2021b)
Working group	Working Group on North Atlantic Salmon (WGNAS) (ICES, 2021c; 2022)