

Atlantic salmon at West Greenland

Summary of the advice for 2019–2020

ICES advises that when the Framework of Indicators (FWI) was applied in 2019 there was no indication of underestimated abundance forecasts. Therefore, a full reassessment was not required in 2019 and the 2018 ICES advice remains valid (ICES, 2018a). Consequently, in line with the management objectives agreed by the North Atlantic Salmon Conservation Organization (NASCO) and consistent with the MSY approach, there are no mixed-stock fishery options at West Greenland for the fishing years 2019 to 2020. The FWI can be applied again at the beginning of 2020, with the returns or return-rate data for 2019, in order to evaluate the appropriateness of the advice for 2020.

NASCO 4.1 Describe the key events of the 2018 fishery, including details of catch, gear, effort, composition and origin of the catch, rates of exploitation, and location of the catch as in-river, estuarine, and coastal

Fishing for salmon at Greenland is currently allowed using hook, fixed gillnets, and driftnets along the entire coast (Figure 1). The commercial fishery for export closed in 1998; the fishery for internal use, however, continues. Since 2002, licensed commercial fishers have only been allowed to sell salmon to hotels, institutions, and local markets. People fishing for private consumption only, were not required to have a licence until 2018, and are prohibited from selling salmon. The Government of Greenland has unilaterally set the quota for the fishery since 2012, as there was no agreement on the quota by all parties of the West Greenland Commission of NASCO (Table 1). Licensed fishers were also permitted to sell to factories from 2012 to 2015, although the export ban persisted. Specific factory quotas were set at 35 tonnes (t) for 2012 and 2013, and 30 t in 2014. The Government of Greenland set a quota in 2015 for all components of the fishery (private, commercial, and factory landings) at 45 t, but stated that any overharvest in a particular year would result in an equal reduction in the quota the following year. As a result of an overharvest in 2015, the 2016 quota was set by Greenland at 32 t. The quota for 2017 remained at 45 t. Factory landings were not permitted in 2016 and 2017.

In 2018, the Government of Greenland set an annual quota for the 2018–2020 fisheries to 30 t; as agreed by all parties of the West Greenland Commission of NASCO. A 10 t quota was allocated for the private fishery, with the balance (20 t) for the commercial fishery. Within the regulatory measure, the Government of Greenland agreed to continue its ban on the export of both wild Atlantic salmon and its products from Greenland and to prohibit landings and sales to fish processing factories. They also agreed the fishery should be restricted to run from 15 August to no later than 31 October each year, and that any overharvest in a particular year would result in an equal reduction in the total allowable catch in 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 include 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 fishers, and mandatory reporting requirements. The measure also stated that as a condition of the licence, all fishers would be required to allow samplers from the NASCO sampling programme to take samples of their catches upon request.

Catches of Atlantic salmon at West Greenland (Figure 2 and Table 1) increased through the 1960s, reaching a peak reported harvest 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 39.9 t was reported for the 2018 fishery, an increase over the 2017 catch (28 t; Table 2). In 2018, commercial landings represented the majority of the harvest at 32.6 t (81.8%) and the remaining 7.3 t was for private use, compared to 15.3 t and 12.7 t respectively in 2017 (Table 3). Only 0.4% (0.1 t) of commercial fishery landings were identified as being for private use in 2018, compared to 39% (9.7 t) in 2017. Given the new licence requirements in 2018, the number of private fishers reporting their landings increased, from 50 fishers in 2017 to 322 fishers in 2018. Reports of commercial landings also increased from 93 fishers in 2017 to 255 fishers in 2018 (Table 3).

When the fishery closed on 31 October 2018, 18.4 t of landings had been registered; this number was later corrected to 39.9 t in March 2019, resulting in an overharvest of approximately 10 t. The Greenlandic authorities indicated a further 10 t of unreported harvest.

The variations in the number of people reporting catches, variation in reported landings in each of the NAFO divisions, and documentation of underreporting of landings suggest that there are inconsistencies in the reported catch data in both the commercial and private fisheries. A phone survey to gain further information on catch and effort was conducted after the

fishing season from 2014 to 2016. Unreported catches of 12.2 t (2014), 5 t (2015), and 4.2 t (2016) were identified from these surveys (referred to as adjusted landings (survey) for assessment). With just nine fishers taking part, the phone survey conducted in 2017 was not considered adequate to adjust the reported landings. A phone survey was not conducted in 2018.

An adjustment for some unreported catch, primarily for commercial landings, has been done since 2002. This was done by comparing the weight of salmon observed by the sampling teams and the corresponding community-specific reported landings for the entire fishing season (commercial and private landings combined; referred to as adjusted landings (sampling) for assessment). Sampling only occurs during a portion of the fishing season, and therefore these adjustments are considered to be minimum adjustments for unreported catch (Table 6).

The international sampling programme continued in 2018 (Figure 1). A summary of the biological characteristics of the 2018 catch is presented in Table 7. The 2018 total number of fish harvested (13 200) was an increase over the 2016 and 2017 estimates, and is only 3.9% of the maximum estimate of 336 000 fish harvested since 1982 (Figure 4). Estimates prior to 1982 may be biased due to non-random sampling of catch, but approach approximately 900 000 individuals harvested in the early 1970s.

In 2018, 83.1% of the salmon sampled were determined to be of North American origin and 16.9% of European origin (Figure 3), approximately 10 600 (32.4 t) North American and 2600 (6.6 t) fish of European origin were harvested in 2018 (Figure 4). The origin of salmon harvested at West Greenland (2017 and 2018) has been further refined, based on an updated genetic range-wide baseline (using Single Nucleotide Polymorphisms [SNPs]). This uses samples from 189 rivers, and can discriminate salmon from 21 North American and 10 European genetic reporting groups with an average accuracy of 90% (Jeffery *et al.*, 2018) (Figure 5). The North American contributions to the West Greenland fishery are dominated by (74%) the Gaspé Peninsula, Gulf of St Lawrence, and Labrador (Central and South) genetic reporting groups (Tables 8). The Northeast Atlantic contributions were dominated by the United Kingdom/Ireland genetic reporting group (84%). There are smaller, but consistent contributions to the harvest for a number of other genetic reporting groups. Results are similar to those reported for the 2017 fishery (ICES, 2018a). A single sample, based on the individual assignment method, was identified as having originated from the Greenland genetic reporting group (Kapisillit River).

Table 1 Nominal catches of salmon at West Greenland since 1960 (tonnes [t], round fresh weight) by participating nations. For Greenlandic vessels specifically, all catches up to 1968 were taken with set gillnets only and catches after 1968 were taken with set gillnets and driftnets. All non-Greenlandic vessel catches from 1969 to 1975 were taken with driftnets. The quota figures applied to Greenlandic vessels only, and parenthetical entries 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 total 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	

Year	Norway	Faroes	Sweden	Denmark	Greenland	Total	Quota	Comments
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	1988–1990 quota was 2520 t with a 1 August opening date. Annual catches were not to exceed an annual average (840 t) by more than 10%. Quota adjusted to 900 t in 1989 and 924 t in 1990 for later opening dates.
1989	-	-	-	-	337	337	900	
1990	-	-	-	-	274	274	924	
1991	-	-	-	-	472	472	840	
1992	-	-	-	-	237	237	258	Quota set by Greenlandic authorities.
1993	-	-	-	-			89	The fishery was suspended. NASCO adopted a new quota allocation model.
1994	-	-	-	-			137	Fishery suspended and quotas were bought out.
1995	-	-	-	-	83	83	77	Quota advised by NASCO.
1996	-	-	-	-	92	92	174	Quota set by Greenlandic authorities.
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	
2000	-	-	-	-	21	21	20	
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), and higher catch figures based on sampling programme information are used for the assessments.
2003	-	-	-	-	9	9		Quota set to nil (no factory landing allowed), fishery restricted to catches used for internal consumption in Greenland, and higher catch figures based on sampling programme information are used for the assessments.
2004	-	-	-	-	15	15		Same as previous year.
2005	-	-	-	-	15	15		Same as previous year.
2006	-	-	-	-	22	22		Quota set to nil (no factory landing allowed) and fishery restricted to catches used for internal consumption in Greenland.
2007	-	-	-	-	25	25		Quota set to nil (no factory landing allowed), fishery restricted to catches used for internal consumption in Greenland, and higher catch figures based on sampling programme information are used for the assessments.
2008	-	-	-	-	26	26		Same as previous year.
2009	-	-	-	-	26	26		Same as previous year.
2010	-	-	-	-	40	40		No factory landing allowed and fishery restricted to catches used for internal consumption in Greenland.
2011	-	-	-	-	28	28		Same as previous year.

Year	Norway	Faroes	Sweden	Denmark	Greenland	Total	Quota	Comments
2012	-	-	-	-	33	33	(35)	Unilateral decision made by Greenland for a 35 t quota for factory landings only, fishery restricted to catches used for internal consumption in Greenland, and higher catch figures based on sampling programme information are used for the assessments.
2013	-	-	-	-	47	47	(35)	Same as previous year.
2014	-	-	-	-	58	58	(30)	Unilateral decision made by Greenland to allow factory landing with a 30 t quota for factory landings only, fishery restricted to catches used for internal consumption in Greenland, and higher catch figures based on sampling programme information and phone surveys are used for the assessments.
2015	-	-	-	-	57	57	45	Unilateral decision made by Greenland to set a 45 t quota for all sectors of the fishery, fishery restricted to catches used for internal consumption in Greenland, and higher catch figures based on sampling programme information and phone surveys are used for the assessments.
2016	-	-	-	-	27	27	32	Unilateral decision made by Greenland to reduce the previously set 45 t quota for all sectors of the fishery to 32 t based on overage of 2015 fishery, fishery restricted to catches used for internal consumption in Greenland, and higher catch figures based on sampling programme information and phone surveys are used for the assessments.
2017	-	-	-	-	28	28	45	Unilateral decision made by Greenland to set a 45 t quota for all sectors of the fishery, fishery restricted to catches used for internal consumption in Greenland, and higher catch figures based on sampling programme information are used for the assessments.
2018	-	-	-	-	40	40	30	No factory landing allowed and fishery restricted to catches used for internal consumption in Greenland.

Table 2 Annual distribution of nominal catches (t) at Greenland by NAFO division when known. NAFO divisions are shown in Figure 2. 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		1 539		1 539
1965	19	234	274	86	202	10	36	861		861
1966	17	223	321	207	353	130	87	1 338		1 338
1967	2	205	382	228	336	125	236	1 514		1 514
1968	1	90	241	125	70	34	272	833		833
1969	41	396	245	234	370		867	2 153		2 153
1970	58	239	122	123	496	207	862	2 107		2 107
1971	144	355	724	302	410	159	560	2 654		2 654
1972	117	136	190	374	385	118	703	2 023		2 023
1973	220	271	262	440	619	329	200	2 341		2 341
1974	44	175	272	298	395	88	645	1 917		1 917
1975	147	468	212	224	352	185	442	2 030		2 030
1976	166	302	262	225	182	38		1 175		1 175
1977	201	393	336	207	237	46	-	1 420	6	1 426
1978	81	349	245	186	113	10	-	984	8	992
1979	120	343	524	213	164	31	-	1 395	+	1 395
1980	52	275	404	231	158	74	-	1 194	+	1 194
1981	105	403	348	203	153	32	20	1 264	+	1 264
1982	111	330	239	136	167	76	18	1 077	+	1 077
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

* The fishery was suspended.

+ Small catches < 5 t.

- No catch.

Table 3 Reported 2017 and 2018 catches by fisher. Licences for private fishers were introduced in 2018.

Licence status	Landings type	Reported 2017 catch (t)	Reported 2018 catch (t)
Licensed	Commercial (from commercial fishers)	15.3	32.5
	Private use (from commercial fishers)	9.7	0.1
	Private use (from private fishers)	-	7.2
Unlicensed	Commercial	0.0	-
	Private use	3.1	-
	Total Commercial catch	15.3	32.6
	Total Private use catch	12.8	7.3
	Total catch	28.0	39.9

Table 4 Reported landings (t) by licence type, landing category, the number of fishers reporting, and the total number of landing reports received in 2018. Empty cells identify categories with no reported landings and 0.0 entries represent reported values of < 0.1. Rounding issues are evident for some totals.

NAFO/ICES	Licence type	No. of fishers	No. of reports	Commercial	Private	Factory	Total
NAFO 1A	Private	35	58	0.0	0.2		0.2
	Commercial	63	177	2.2	0.0		2.2
	TOTAL	98	235	2.2	0.2		2.4
NAFO 1B	Private	47	105		1.0		1.0
	Commercial	31	125	4.6			4.6
	TOTAL	78	230	4.6	1.0		5.7
NAFO 1C	Private	25	51		0.8		0.8
	Commercial	56	200	12.9			12.9
	TOTAL	81	251	12.9	0.8		13.7
NAFO 1D	Private	125	163	0.0	1.4		1.4
	Commercial	18	120	6.8			6.8
	TOTAL	143	283	6.8	1.4		8.2
NAFO 1E	Private	20	86		1.5		1.5
	Commercial	24	98	2.7	0.1		2.8
	TOTAL	44	184	2.7	1.6		4.2
NAFO 1F	Private	65	169	0.0	2.0		2.0
	Commercial	40	130	2.8			2.8
	TOTAL	105	299	2.8	2.0		4.8
ICES Subarea 14	Private	5	42		0.4		0.4
	Commercial	3	12	0.4			0.4
	TOTAL	8	54	0.4	0.4		0.8
ALL	Private	322	674	0.0	7.2		7.3
	Commercial	235	862	32.5	0.1		32.6
	TOTAL	557	1536	32.5	7.4		39.9

Table 5 Reported landings (t) by landing category, the number of fishers reporting, and the total number of landing reports received for licensed and unlicensed fishers in 2017. Empty cells identify categories with no reported landings and 0.0 entries represents reported values of < 0.1. Rounding issues are evident for some totals.

NAFO/ICES	Licensed	No. of fishers	No. of reports	Commercial	Private	Factory	Total
NAFO 1A	NO	2	12	0	0		0
	YES	15	66	0.3	0.8		1.1
	TOTAL	17	78	0.3	0.9		1.1
NAFO 1B	NO						0
	YES	9	40	1.4	0.2		1.7
	TOTAL	9	40	1.4	0.2		1.7
NAFO 1C	NO	7	23	0	0.4		0.4
	YES	33	135	5.9	3		8.9
	TOTAL	40	158	5.9	3.4		9.3
NAFO 1D	NO	17	44	0	0.9		0.9
	YES	7	23	5.1	0.9		5.9
	TOTAL	24	67	5.1	1.8		6.9
NAFO 1E	NO	8	24	0	0.6		0.6
	YES	15	114	0.7	1.9		2.6
	TOTAL	23	138	0.7	2.5		3.2
NAFO 1F	NO	16	51	0	1.2		1.2
	YES	12	78	1.8	2.6		4.4
	TOTAL	28	129	1.8	3.8		5.6
ICES Subarea 14	NO						0
	YES	2	21	0.1	0.2		0.3
	TOTAL	2	21	0.1	0.2		0.3
ALL	NO	50	154	0	3.1		3.1
	YES	93	477	15.3	9.7		24.9
	TOTAL	143	631	15.3	12.7		28

Table 6 Reported landings and adjusted landings (t) for assessment of Atlantic salmon at West Greenland 2002–2018. The total adjusted landings number does not include the unreported catch (10 t per year since 2000).

Year	Reported landings (West Greenland)	Adjusted landings (Sampling)	Adjusted 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	-	-	39.0

Table 7 Summary of biological characteristics of catches of Atlantic salmon at West Greenland in 2018 (NA = North America, E = Europe).

River-age distribution (%) by origin								
Continent of origin	1	2	3	4	5	6	7	8
NA	0.5	29.8	38.4	24.1	6.5	0.7	0	0
E	13.7	62.1	19.0	5.2	0	0	0	0
Length and weight by origin and sea age								
Continent of origin	1 SW		2 SW		Previous spawners		All sea ages	
	Fork length	Whole	Fork length	Whole	Fork length	Whole	Fork	Whole
NA	63.8	2.91	87.5	9.27	77.1	4.53	64.2	2.97
E	63.9	2.93	76.3	5.59	-	-	64.2	3.00
Continent of origin (%)								
North America				Europe				
83.1				16.9				
Sea-age composition (%) by continent of origin								
Continent of origin	1SW		2SW		Previous spawners			
NA	97.4		0.4		2.2			
E	97.4		2.6		0			

Table 8 Bayesian estimates of mixture composition for the West Greenland Atlantic salmon fishery, by region and overall for 2018. Baseline locations refer to regional reporting groups identified in Figure 5. Sample locations are identified by NAFO divisions. Mean estimates provided with 95% credible interval in parentheses. Credible intervals with a lower bound of zero, or close to zero, indicate little support for the mean assignment value; reporting groups with such low credible intervals are indicated with grey font.

Regional group	COO	NAFO 1B	NAFO 1C	NAFO 1E	NAFO 1F	Overall
Baltic Sea	EUR	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.2)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)
Barents–White Seas	EUR	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)	0.1 (0.0, 0.7)	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)
European Broodstock	EUR	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)
France	EUR	0.6 (0.1, 1.7)	0.8 (0.2, 1.9)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.5 (0.2, 1.1)
Greenland	EUR	0.0 (0.0, 0.0)	0.2 (0.0, 0.9)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.1 (0.0, 0.4)
Iceland	EUR	0.0 (0.0, 0.0)	0.5 (0.1, 1.3)	0.0 (0.0, 0.0)	0.9 (0.1, 2.6)	0.4 (0.1, 0.9)
Northern Norway	EUR	0.1 (0.0, 0.6)	0.0 (0.0, 0.1)	0.2 (0.0, 1.8)	0.0 (0.0, 0.2)	0.0 (0.0, 0.1)
Southern Norway	EUR	0.6 (0.0, 1.7)	1.0 (0.2, 2.1)	0.6 (0.0, 5.5)	0.6 (0.0, 2.3)	0.6 (0.2, 1.2)
Spain	EUR	2.5 (1.0, 4.5)	0.6 (0.1, 1.7)	0.0 (0.0, 0.1)	0.7 (0.0, 2.3)	1.2 (0.6, 2.0)
United Kingdom/Ireland	EUR	10.9 (7.7, 14.6)	15.8 (12.5, 19.4)	41.1 (23.5, 60.0)	11.3 (7.4, 15.9)	14.5 (12.3, 16.8)
Anticosti	NA	0.2 (0.0, 1.2)	0.3 (0.0, 1.0)	0.1 (0.0, 1.6)	0.9 (0.1, 2.6)	0.4 (0.1, 0.9)
Avalon Peninsula	NA	0.0 (0.0, 0.2)	0.0 (0.0, 0.1)	0.2 (0.0, 1.9)	0.0 (0.0, 0.2)	0.0 (0.0, 0.1)
Burin Peninsula	NA	0.0 (0.0, 0.6)	0.0 (0.0, 0.2)	0.5 (0.0, 5.6)	0.5 (0.0, 2.8)	0.0 (0.0, 0.1)
Eastern Nova Scotia	NA	0.0 (0.0, 0.1)	0.1 (0.0, 0.9)	0.1 (0.0, 0.9)	1.0 (0.1, 2.7)	0.2 (0.0, 0.8)
Fortune Bay	NA	0.1 (0.0, 0.7)	0.0 (0.0, 0.1)	0.1 (0.0, 1.0)	1.2 (0.0, 3.5)	0.1 (0.0, 0.5)
Gaspe Peninsula	NA	34.2 (28.7, 39.9)	29.2 (24.6, 34.1)	15.7 (2.9, 35.5)	21.8 (16.0, 27.8)	29.1 (26.1, 32.3)
Gulf of St Lawrence	NA	16.4 (12.1, 21.1)	12.6 (9.2, 16.4)	3.8 (0.0, 19.0)	13.4 (8.8, 18.7)	13.8 (11.5, 16.2)
Inner Bay of Fundy	NA	0.0 (0.0, 0.0)	0.0 (0.0, 0.1)	0.1 (0.0, 0.5)	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)
Labrador Central	NA	1.4 (0.2, 3.5)	4.1 (1.9, 6.7)	3.9 (0.1, 13.6)	5.9 (2.1, 10.5)	3.3 (1.8, 5.2)
Labrador South	NA	15.6 (11.7, 19.9)	12.4 (9.1, 16.0)	11.4 (2.5, 25.4)	18.4 (12.6, 24.7)	14.8 (12.4, 17.3)
Lake Melville	NA	4.8 (2.7, 7.5)	5.2 (3.2, 7.7)	3.8 (0.1, 13.6)	4.3 (1.6, 8.0)	4.9 (3.5, 6.4)
Maine, United States	NA	1.9 (0.7, 3.6)	2.7 (1.3, 4.4)	0.0 (0.0, 0.2)	1.8 (0.4, 4.0)	2.2 (1.4, 3.3)
Newfoundland 1	NA	1.6 (0.5, 3.3)	0.7 (0.1, 1.7)	1.8 (0.0, 11.1)	0.7 (0.0, 3.5)	1.2 (0.6, 2.1)
Newfoundland 2	NA	0.6 (0.0, 2.0)	0.1 (0.0, 0.7)	0.6 (0.0, 6.7)	1.1 (0.0, 3.8)	0.5 (0.0, 1.3)
Northern Newfoundland	NA	0.9 (0.2, 2.3)	0.6 (0.1, 1.6)	1.2 (0.0, 8.9)	1.0 (0.1, 2.9)	0.9 (0.4, 1.6)
Quebec City Region	NA	1.0 (0.0, 3.1)	1.0 (0.0, 2.9)	4.1 (0.0, 19.1)	3.6 (1.3, 6.8)	1.5 (0.5, 2.7)
St John River & Aquaculture	NA	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)	2.7 (0.0, 12.6)	0.0 (0.0, 0.3)	0.0 (0.0, 0.2)
St Lawrence N. Shore Lower	NA	2.8 (1.2, 5.0)	6.3 (4.1, 9.0)	3.9 (0.1, 13.7)	3.7 (1.4, 6.9)	4.5 (3.3, 6.0)
Ungava	NA	2.8 (1.3, 4.8)	3.4 (1.9, 5.3)	3.7 (0.1, 13.1)	6.4 (3.6, 10.0)	3.9 (2.8, 5.2)
Western Newfoundland	NA	1.0 (0.0, 2.5)	2.4 (1.0, 4.2)	0.1 (0.0, 0.7)	0.6 (0.0, 2.3)	1.3 (0.6, 2.2)
Western Nova Scotia	NA	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.1)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)

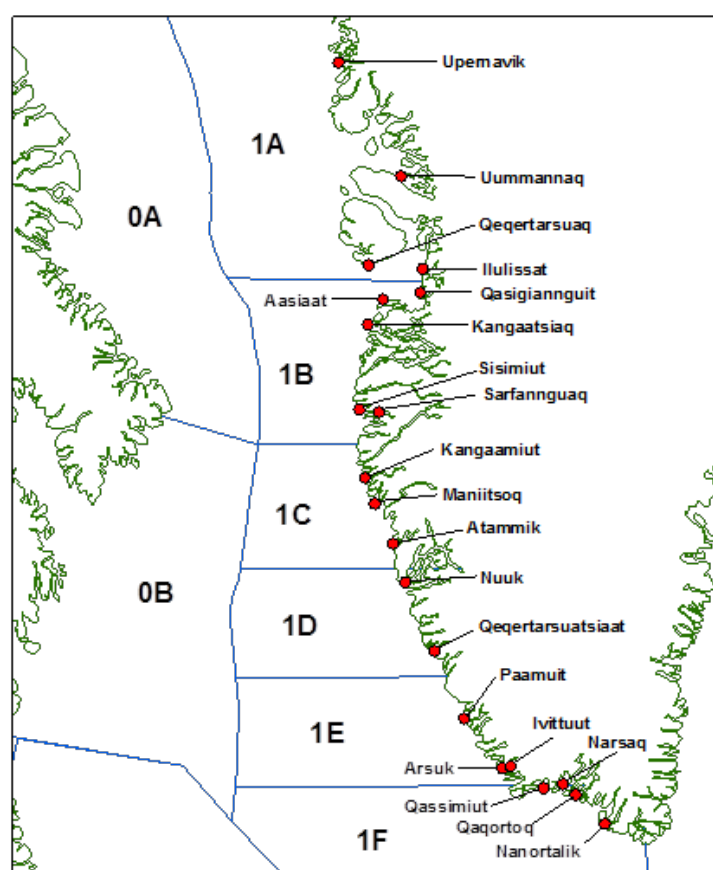


Figure 1 Map of communities in West Greenland where Atlantic salmon have historically been landed and the corresponding NAFO divisions (1A–1F). In 2018, samples were obtained from Sisimiut (1B), Maniitsoq (1C), Paamut (1E), and Qaqortoq (1F).

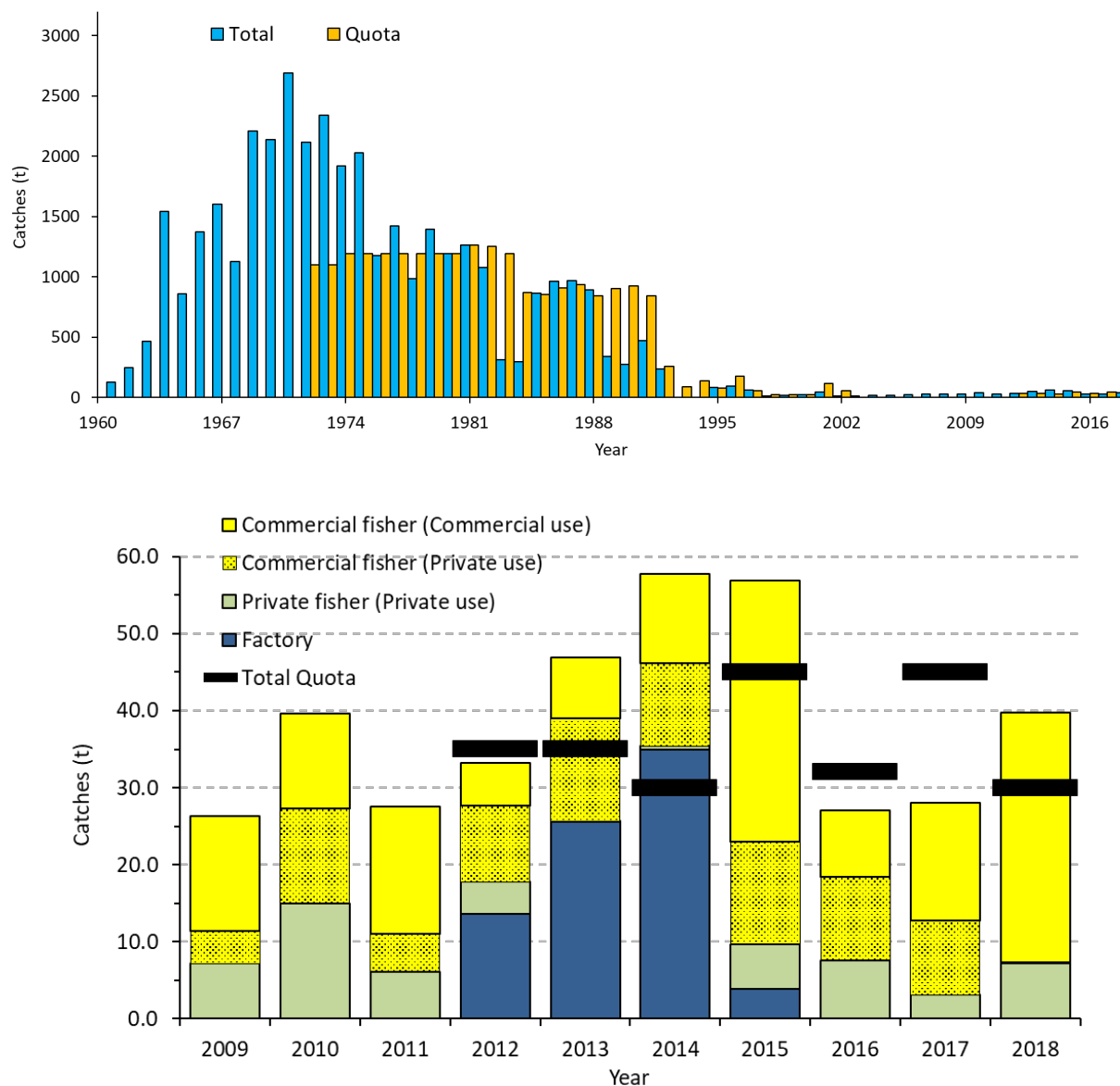


Figure 2 Nominal landings and commercial quotas (t, round fresh weight) of salmon at West Greenland from 1960 to 2018 (top panel). Landings from 2009 to 2018 are also displayed by landing type (lower panel). No quotas were set for 2002–2011 and the quotas for 2012–2014 were for factory landings only.

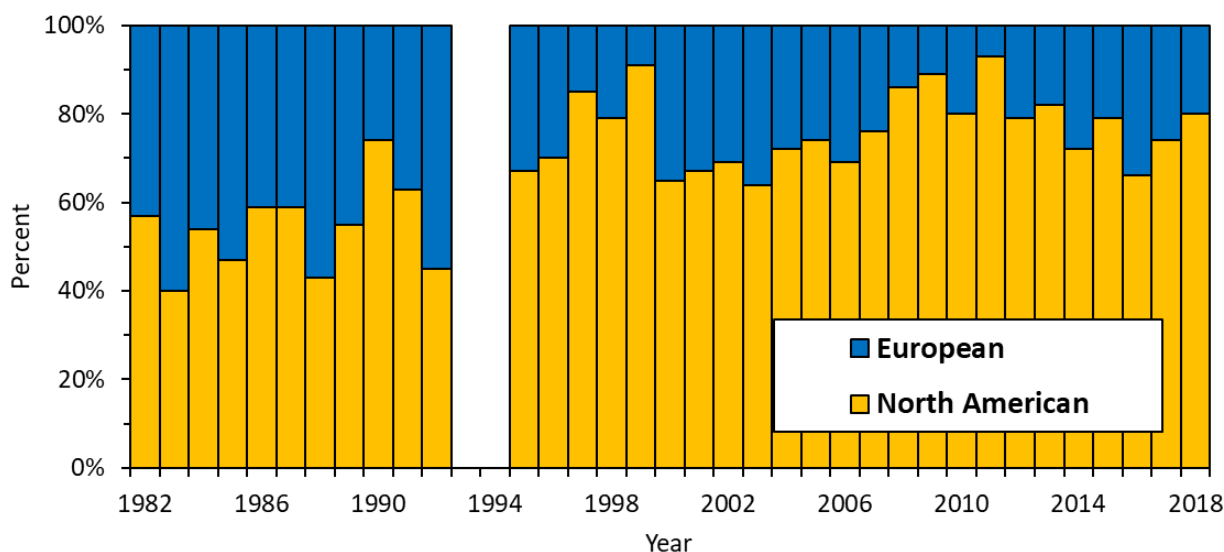


Figure 3 Estimated percent continent of origin of Atlantic salmon harvested at West Greenland from 1982 to 2018.

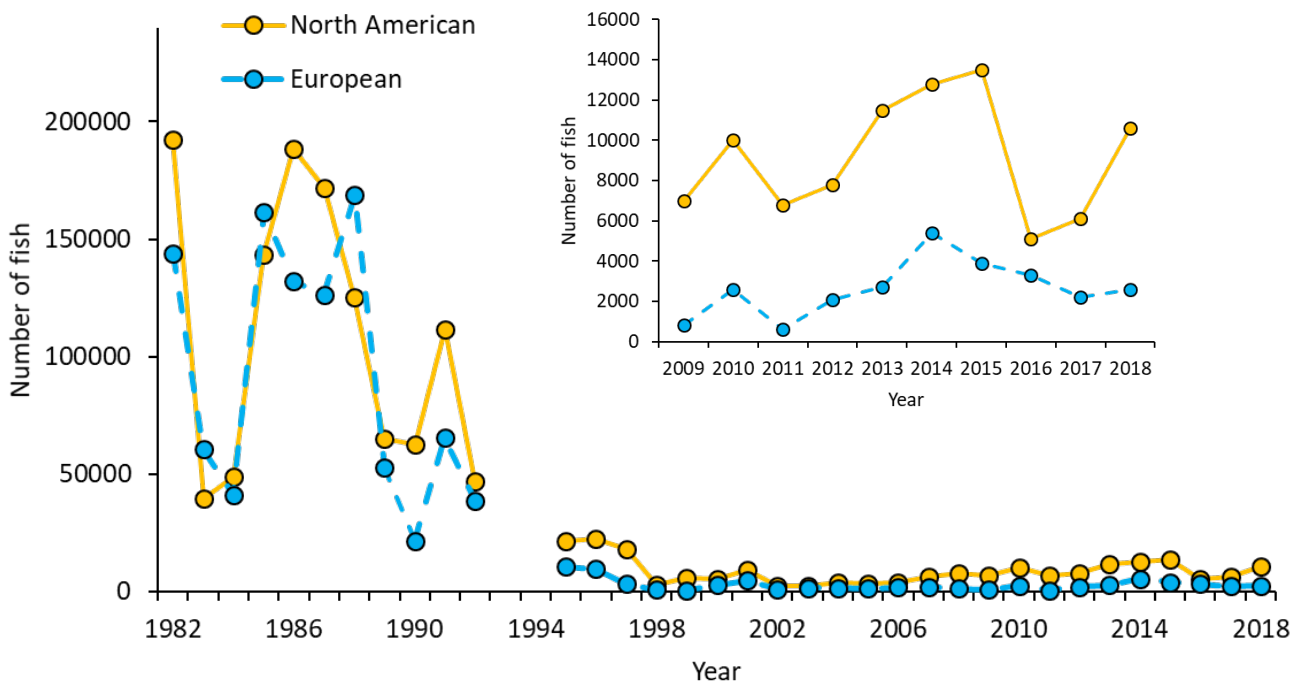


Figure 4 Number of North American and European Atlantic salmon caught at West Greenland in 1982–2018 and 2009–2018 (inset). Estimates are based on continent of origin by NAFO division, weighted by catch (weight) in each division. Numbers are rounded to the nearest hundred fish. Unreported catch not included.

ICES REGION	REGIONAL GROUP	GROUP ACRONYM	ICES REGION	REGIONAL GROUP	GROUP ACRONYM
Quebec (North)	Ungava	UNG	Europe	Spain	SPN
Labrador	Labrador Central	LAC		France	FRN
	Lake Melville	MEL		European Broodstock	EUB
	Labrador South	LAS		United Kingdom/Ireland	BRI
Quebec	St Lawrence North Shore Lower	QLS		Barents-White Seas	BAR
	Anticosti	ANT		Baltic Sea	BAL
	Gaspé Peninsula	GAS		Southern Norway	SNO
	Quebec City Region	QUE		Northern Norway	NNO
Gulf	Gulf of St Lawrence	GUL		Iceland	ICE
Scotia-Fundy	Inner Bay of Fundy	IBF		Greenland	GL
	Eastern Nova Scotia	ENS			
	Western Nova Scotia	WNS			
	Saint John River & Aquaculture	SJR			
Newfoundland	Northern Newfoundland	NNF			
	Western Newfoundland	WNF			
	Newfoundland 1	NF1			
	Newfoundland 2	NF2			
	Fortune Bay	FTB			
	Burin Peninsula	BPN			
	Avalon Peninsula	AVA			
USA	Maine, United States	USA			

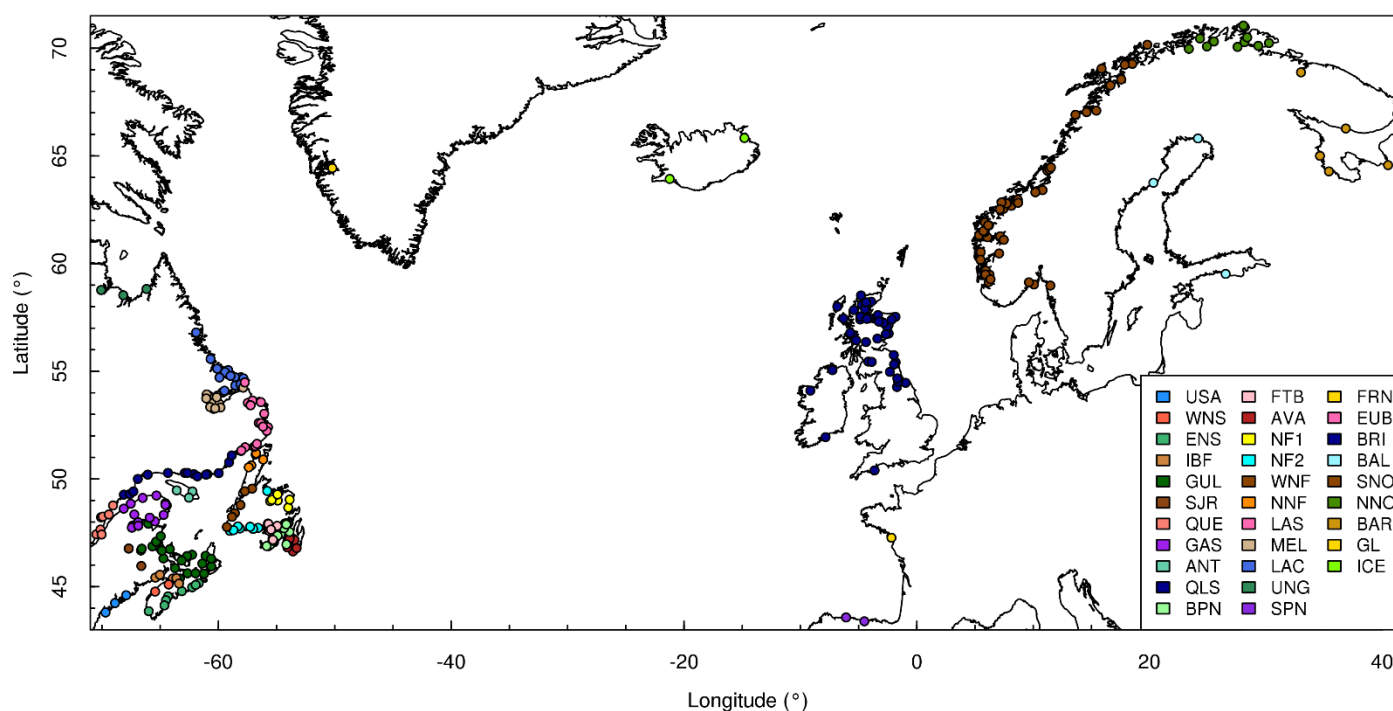


Figure 5 Regional groupings and codes from the SNP-based genetic baseline (upper table) and location map. The EUB (European Broodstock) regional grouping does not have a geographic location and therefore is not represented on the map.

NASCO 4.2 Describe the status of the stocks

Recruitment (pre-fishery abundance) estimates of non-maturing 1SW salmon at Greenland show continued low abundance compared to historical levels and are currently below the spawner escapement reserves (SER) for North American (Figure 6) and Southern NEAC (Figure 7).

In 2018, the median estimates of spawners were below the conservation limits (CLs) (suffering reduced reproductive capacity) for 2SW salmon in five of the six regions of NAC, and for MSW salmon in Southern NEAC (Figure 8). Particularly large deficits relative to CLs and rebuilding management objectives are noted in the NAC Scotia–Fundy and USA regions.

The exploitation rate (catch in Greenland divided by pre-fishery abundance [PFA]) in 2017 was 6.7% for NAC fish and 0.8% 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 near historical lows. It is likely, therefore, that other factors besides fisheries are constraining production.

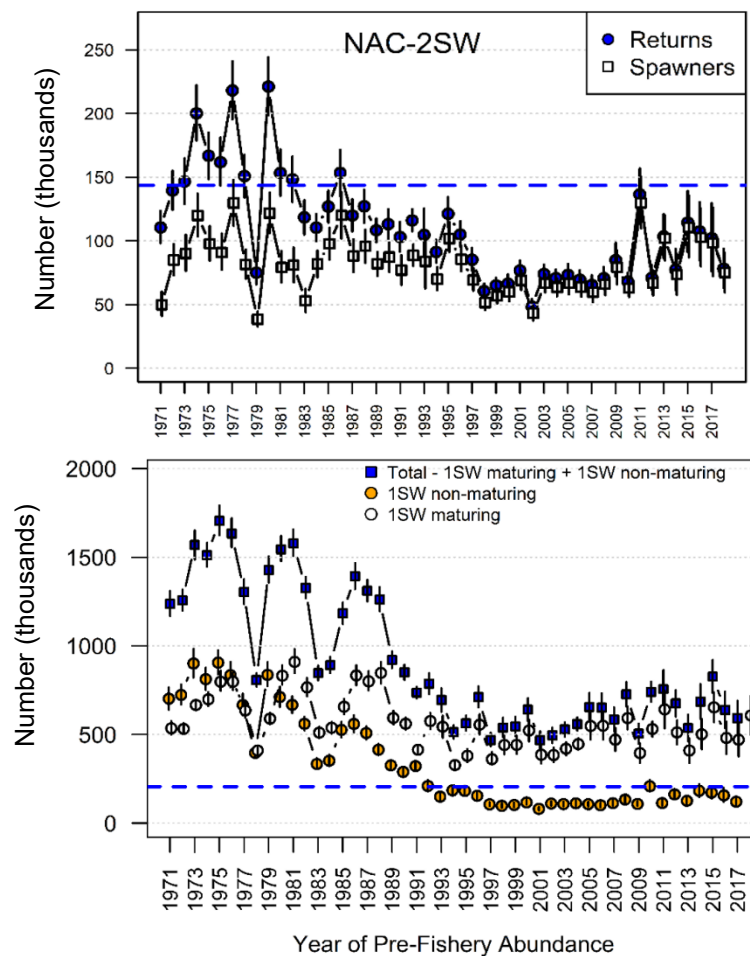


Figure 6 Top panel: Estimated (median, 5th to 95th percentile range, in thousands) returns (blue circles) and spawners (white square) of 2SW salmon for NAC 1971 to 2018. The dashed line is the corresponding 2SW conservation limit for NAC. Bottom panel: Estimated (median, 5th to 95th percentile range, in thousands) pre-fishery abundance (PFA) for 1SW maturing, 1SW non-maturing, and the total cohort of 1SW salmon for NAC, PFA years 1971 to 2017. The dashed blue horizontal line is the corresponding sum of the 2SW conservation limits for NAC (143 494) corrected for 11 months of natural mortality (193 697) against which 1SW non-maturing salmon are assessed.

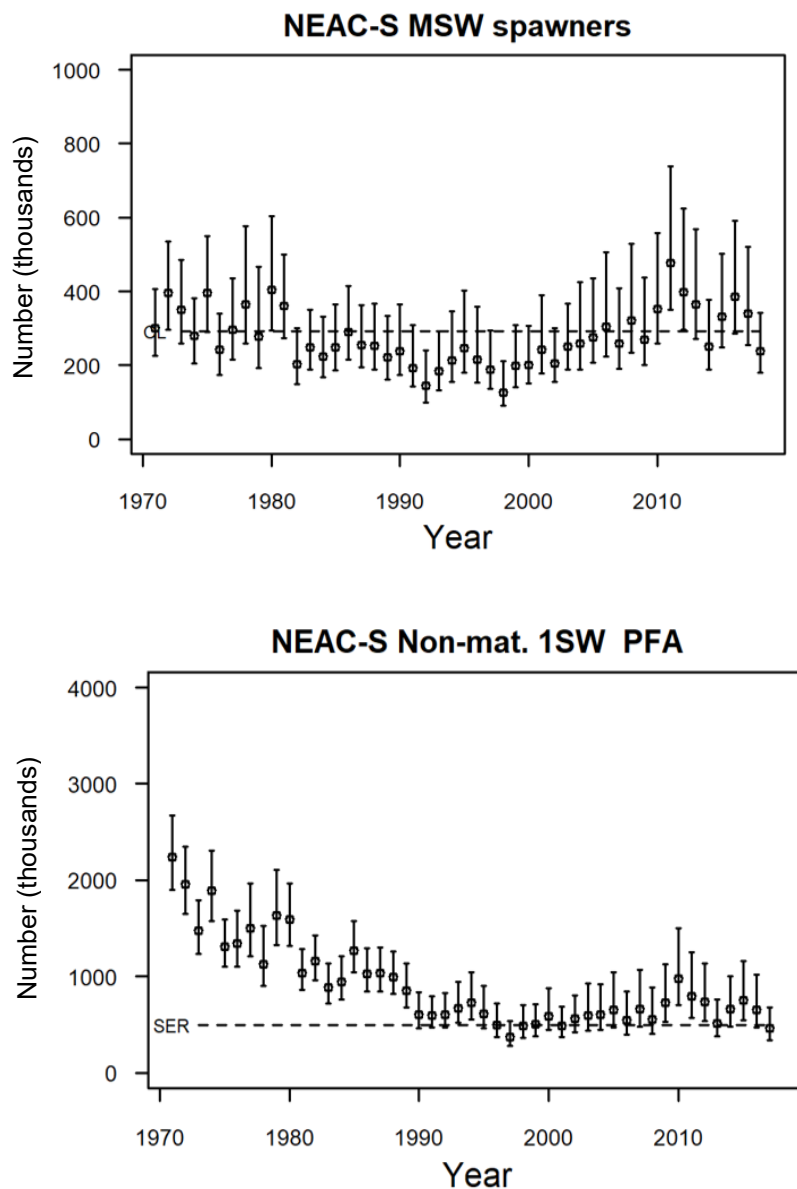


Figure 7 Estimated spawning escapement (upper panel) and PFA (lower panel) and spawning escapement with 90% confidence limits, for non-maturing 1SW (MSW spawners) salmon in the Southern NEAC (NEAC-S) stock complex.



Figure 8 Summary 2SW (NAC regions) and MSW (Southern NEAC) 2018 median (from the Monte Carlo posterior distributions) spawner estimates in relation to conservation limits/management objectives (CL/MO). The colour shading represents the three ICES stock status designations: Full (at full reproductive capacity: the 5th percentile of the spawner estimate is above the CL), At Risk (at risk of suffering reduced reproductive capacity: the median spawner estimate is above the CL, but the 5th percentile is below), and Suffering (suffering reduced reproductive capacity: the median spawner estimate is below the CL).

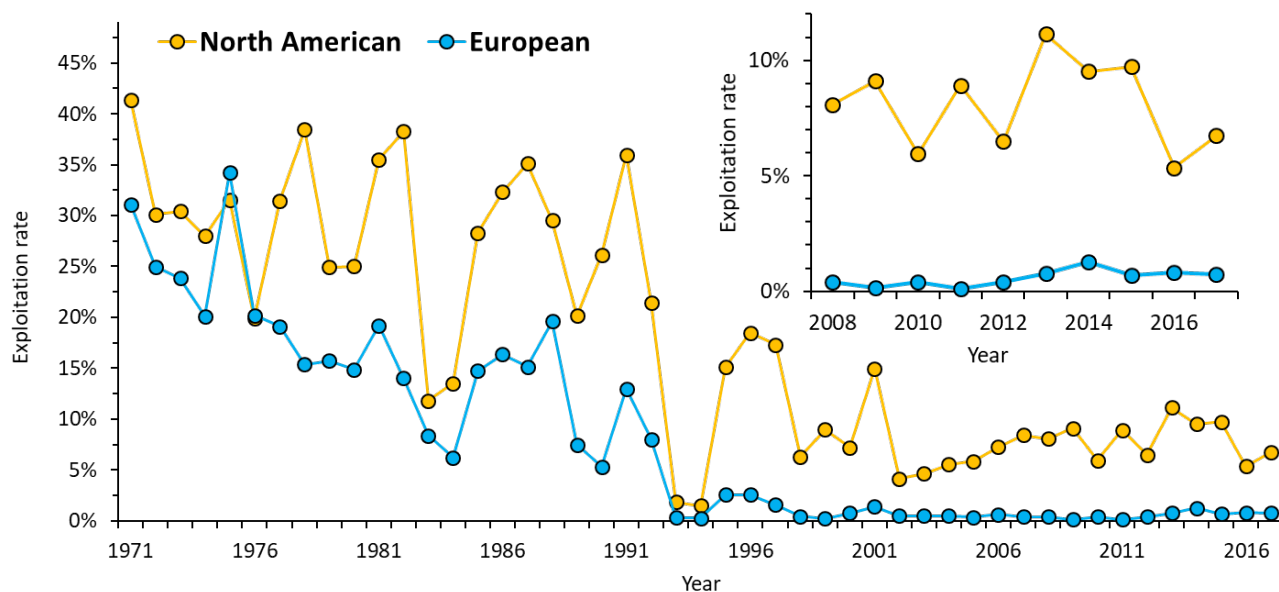


Figure 9 Exploitation rate (%) for NAC 1SW non-maturing and southern NEAC non-maturing Atlantic salmon at West Greenland, 1971–2017 and 2008–2017 (inset). Exploitation rate estimates are only available to 2017, as 2018 exploitation rates are dependent on 2019 returns.

Relevant data deficiencies, monitoring needs, and research requirements

The following data deficiencies, monitoring needs, and research requirements were identified as being of relevance to the West Greenland Commission:

- 1) Efforts to improve the reporting system of catch in the Greenland fishery should continue, while spatially and temporally explicit catch and effort data from all fishers should be made available for analyses.
- 2) The broad geographic sampling programme including in Nuuk (multiple NAFO divisions including factory landings when permitted) should be expanded across the fishing season to ensure that samples are representative of the entire catch. This will allow more accurate estimates of region of origin and biological characteristics of the mixed-stock fishery.

The full list of data deficiencies, monitoring needs, and research requirements for North Atlantic salmon is presented in Section 1.5 of the sal.oth.nasco advice (ICES, 2019a).

References

- ICES. 2018a. North Atlantic Salmon Stocks. *In* Report of the ICES Advisory Committee, 2018. ICES Advice 2018, Book 14, sal.oth.nasco, <https://doi.org/10.17895/ices.pub.4335>.
- ICES. 2018b. Advice basis. *In* Report of the ICES Advisory Committee, 2018. ICES Advice 2018, Book 1, Section 1.2. <https://doi.org/10.17895/ices.pub.4503>.
- ICES. 2019a. North Atlantic Salmon Stocks. *In* Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sal.oth.nasco, <https://doi.org/10.17895/ices.advice.5230>
- ICES. 2019b. Report of the Working Group on North Atlantic Salmon (WGNAS), 25 March–4 April 2019, Bergen, Norway. ICES Scientific Reports, 1:16. 368 pp. <http://doi.org/10.17895/ices.pub.4978>.
- ICES. 2019c. Stock Annex: Atlantic salmon (*Salmo salar*). Created 28 March 2014 by the Working Group on North Atlantic Salmon (WGNAS). Updated: April 2019. 140 pp.
- Jeffery, N. W., Wringer, B. F., McBride, M., Hamilton, L. C., Stanley, R. R. E., Bernatchez, L., Bentzen, P., *et al.* 2018. Range-wide regional assignment of Atlantic salmon (*Salmo salar*) using genome wide single-nucleotide polymorphisms. *Fisheries Research*, 206: 163–175. <https://doi.org/10.1016/j.fishres.2018.05.017>

Recommended citation: ICES. 2019. Atlantic salmon at West Greenland. *In* Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sal.wgc.all, <https://doi.org/10.17895/ices.advice.5227>

Annex 1 Glossary of acronyms and abbreviations

1SW (*one-sea-winter*). Maiden adult salmon that has spent one winter at sea.

2SW (*two-sea-winter*). Maiden adult salmon that has spent two winters at sea.

CL, i.e. S_{lim} (*conservation limit*). 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.

ICES (*International Council for the Exploration of the Sea*).

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

NAFO (*Northwest Atlantic Fisheries Organization*). NAFO is an intergovernmental fisheries science and management organization that ensures the long-term conservation and sustainable use of the fishery resources in the Northwest Atlantic.

NASCO (*North Atlantic Salmon Conservation Organization*).

NEAC (*North East Atlantic Commission*). A commission under NASCO.

PFA (*pre-fishery abundance*). The numbers of salmon estimated to be alive in the ocean from a particular stock at a specified 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 conservation limits (CLs) by the use of management targets. 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 agreed 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 NAC (Labrador, Newfoundland, Québec, 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 the USA region of NAC. A framework of indicators has been developed in support of the multi-annual 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 their current distribution extends from northern Portugal to the Pechora River in northwestern Russia and Iceland. In the Northwest Atlantic distribution ranges from the Connecticut River in USA (41.6°N) to the Leaf River in Ungava Bay (Quebec, Canada; 58.8°N). Juveniles migrate to the ocean at ages one to 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 during their second summer and autumn at sea.

Environmental influence 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.

Scientific basis

ICES stock data category	1 (ICES, 2018b).
Assessment type	Run–reconstruction models and Bayesian forecasts, taking into account uncertainties in the data.
Input data	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	A framework of indicators (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 2019 (ICES, 2019c).
Working group	Working Group on North Atlantic Salmon (WGNAS) (ICES, 2019b).