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by Timothy F. Sheehan¹, Denise Deschamps², Helen Downie³,
James Hawkes⁴, Michael McAuliffe⁵, Michael Millane⁶, Kerry Sims⁷,
Rasmus Nygaard⁸, Barbara Lubinski⁹,
Martha J. Robertson¹⁰, Niall Ó Maoiléidigh¹¹

¹Integrated Statistics, 16 Sumner Street, Woods Hole, MA 02543

¹ NOAA Fisheries Service, Northeast Fisheries Science Center, 166 Water Street, Woods Hole, Massachusetts 02543, USA

² Ministère des Forêts, de la Faune et des Parcs, Direction de la faune aquatique, 880, chemin Sainte-Foy, Québec, Québec G1S 4X4, Canada

³ Marine Scotland, Scottish Government, Freshwater Laboratory Field Station, Inchbraoch House, South Quay, Ferryden, Montrose, DD10 9SL, UK (Scotland)

⁴ NOAA Fisheries Service, Northeast Fisheries Science Center, Maine Field Station, 17 Godfrey Drive - Suite 1, Orono, ME 04473, USA

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ABSTRACT

An Atlantic salmon (*Salmo salar*) mixed-stock fishery operating from August through October exists off the western coast of Greenland and primarily harvests 1 sea-winter (1SW) North American and European origin salmon destined to return to natal waters as 2 sea-winter (2SW) spawning adults. To collect data on the biological characteristics and origin of the harvest necessary for international stock assessment efforts, parties to the North Atlantic Salmon Conservation Organization's (NASCO) West Greenland Commission agreed to participate in an international sampling program for the 2016 fishery. The sampling program was coordinated by the United States (NOAA Fisheries Service) and involved 6 samplers from 6 countries, deployed among 4 communities (Sisimiut, Maniitsoq, Paamiut, and Qaqortoq) located on the west coast of Greenland. Reported landings in 2016 were 27.1 metric tons (t). Data on length, weight, freshwater and marine age from scale samples, and continent of origin from genetic analysis of tissue samples were collected. Since 2002 (with the exception of 2006, 2011, and 2015), unreported landings were identified by comparing the reported landings to the weight of the sampled harvest for each community. Unreported landings were detected in 2016. In total, 1,624 salmon were observed by the sampling teams, and 1,314 of these were sampled for biological characteristics. Approximately 19% by weight of the reported landings were observed by the sampling teams. No samples were collected from factory-landed fish because landings were not allowed in 2016. As seen since the mid-1990s, a high proportion of the harvested stock was of North American origin (64%) with the balance European origin (36%). North American origin fish were primarily freshwater age 2 or 3 years (21.3% and 43.4% respectively) and 1SW (93.5%). European origin fish were primarily freshwater age 2 (63.3%) and 1SW (95.5%). The mean length of North American 1SW salmon was 65.2 cm, and the mean whole weight was 3.18 kg; the mean length of European 1SW salmon was 62.6 cm, and the mean whole weight was 2.79 kg. Approximately 5,100 North American (17.2 t) and 3,300 European salmon (8.7 t) were harvested, not taking into account any unreported catch. The sampling program was successful in adequately sampling the Greenland catch, both temporally and spatially, and provided essential input data to international stock assessment efforts that provide stock status and catch options for subsequent fishery management.

INTRODUCTION

An important mixed-stock Atlantic salmon (*Salmo salar*) fishery exists off the western coast of Greenland. This fishery takes primarily 1 sea-winter (1SW, fish that have spent 1 winter at sea) North American and European origin salmon that would potentially return to natal waters as mature 2 sea-winter (2SW) spawning adults or older. Effective management of the resource on both continents requires annual collection of accurate landings data, continent of origin assignments, and biological characteristics data to assess the impact of the fishery on the contributing stock complexes. Data collected from the fishery are also required for use in assessment models which predict prefishery abundance of North American and European stocks to provide fishery managers with catch options required for setting harvest regulations. Atlantic salmon were first documented off the coast of Greenland in 1780 and were targeted by a small local inshore gillnet fishery (Jensen 1990). During the early 1960s, the fishery developed an international presence; in 1965, vessels from Norway, Denmark, Sweden, and the Faroe

Islands arrived and introduced an offshore drift-gillnet fishery (ibid.). Reported catches increased to a high of 2,689 t in 1971 (Figure 1). Mark-recapture studies conducted during this period indicated that the Atlantic salmon caught in this fishery were of North American and European origin and were not uniformly distributed along the coast (Reddin et al. 2012). Because of the concerns that this fishery would have deleterious impacts on the contributing stock complexes, a quota system was agreed upon and implemented in 1976 (Colligan et al. 2008), and since 1984, catch regulations have been established by NASCO.

Since 1969, a coordinated international sampling program has been conducted to obtain biological samples from the Greenland salmon fishery. From 1969-1981, research vessels were used to obtain samples. Since 1982, international teams of samplers have been deployed throughout West Greenland to obtain samples from fish processing plants (when a commercial fishery is allowed), local markets, and other vendors from individual communities landing salmon. The focus of this sampling program is to collect biological data and samples. Historically, length, weight, and scale samples were collected, and individual salmon were scanned for fin clips or external/internal tags. Beginning in 2002, tissue samples have been collected from fish for genetic stock identification.

The purpose of this paper is to:

- Describe the international sampling program;
- Present the results from the continent of origin analysis; and
- Summarize the biological characteristics of the catch from West Greenland during the internal-use-only fishery of 2016.

INTERNATIONAL SAMPLING PROGRAM

The West Greenland Commission (WGC) of NASCO has agreed to regulatory measures for the West Greenland fishery for all years from 1984 onward (except 1985, 1991, 1992, and 1996). Since 2006, these regulations have been applied as multiyear measures. The latest measure was established for the period 2015 to 2017 (WGC(15)21), and these regulations would also apply in 2016 and 2017 if the Framework of Indicators (FWI) developed and updated by the International Council for the Exploration of the Sea (ICES 2007, 2015) indicate no significant change, implying that a reassessment of the catch advice would not be required.

From 2002 to 2011 the quota for commercial landings of Atlantic salmon for export was set to 0 tons by the Government of Greenland, but the internal-use-only fishery for personal and local consumption was unaffected. Selling of salmon to hotels, institutions, and local markets by licensed fishermen and an unlicensed fishery for private consumption were allowed. The internal-use-only fishery was without a quota limit but previously had been estimated at 20 t annually. The fishery generally operates during the months of August, September, and October, and from 2005-2014 the fishery opened on 1 August and closed on 31 October. The fishery is regulated according to the Government of Greenland Executive Order No. 12 of 1 August 2012, an update to the previous order (Government of Greenland Executive Order No. 21 of 10 August 2002). Starting in 2015, the Government of Greenland delayed the opening of the fishery until 15 August with a closing date of 31 October.

From 2012-2014, the Government of Greenland set the national quota for commercial landings of Atlantic salmon for export to 0 tons. No export of salmon from Greenland was allowed. However, in 2012 the Government of Greenland set a 35 t national quota for landing at fishing processing factories to provide a year-round supply of locally harvested Atlantic salmon

within Greenland. The internal-use-only fishery for personal and local consumption remained unaffected and unrestricted by the quota for factory landings. A factory landings-only quota was again set to 35 t in 2013, but was then reduced to 30 t in 2014. In 2015 the Government of Greenland unilaterally set a quota of 45 t for all components of its fishery, as a quota could not be agreed to by all parties of the WGC of NASCO (NASCO 2015). The regulatory measure stated that any harvest exceeding the quota within a year would be subtracted from the quota in the following year. Given overage of the 2015 harvest, the 2016 quota was set to 32 t by the Government of Greenland.

Under NASCO's West Greenland Fishery Sampling Agreement (NASCO 2016), parties to NASCO's WGC agreed to provide staff to sample Atlantic salmon catches from the West Greenland internal-use-only fishery during the 2016 season.

The objectives of the sampling program were to:

- Continue the time series of data (1969-2015) on continent of origin and biological characteristics of the Atlantic salmon in the West Greenland fishery;
- Provide data on mean weight, length, age, and continent of origin for use in the North American and European Atlantic salmon run-reconstruction models; and
- Collect information on the recovery of internal and external tags.

As outlined in the sampling agreement, the European Union agreed to provide staff to sample the fishery for a minimum of 8 person-weeks (which would amount to 8 weeks of sampling); the United States agreed for a minimum of 2 person-weeks; and Canada for a minimum of 2 person-weeks. Samplers from various countries involved in the program are outlined in Table 1.

The coordination of this effort was handled by the United States (NOAA Fisheries Service) with assistance from the Greenland Institute of Natural Resources (GINR). Individual samplers were deployed during the course of the fishing season to provide the best possible spatial and temporal coverage of the fishery. Samplers were stationed in 4 communities that are located within 4 Northwest Atlantic Fisheries Organization (NAFO) divisions (Figure 2): Sisimiut (1B), Maniitsoq (1C), Paamiut (1E), and Qaqortoq (1F). Samplers were not deployed to Nuuk (1D) because of the continued uncertainty of access to landed Atlantic salmon in this community (ICES 2012). Factory landings were not allowed by the Government of Greenland in 2016, and therefore no factory landings samples were collected.

Reported landings in 2016 were 27.1 t (25.7 t for West Greenland and 1.5 t for East Greenland ICES Statistical Area XIV). In the past, nonreporting of harvest was identified by comparing the reported landings to the sample data. From 2002-2015 (with the exception of 2006, 2011, and 2015), the sampling team documented more fish than reported in at least 1 division (ICES 2016). A documented salmon could be one that was either sampled, checked for an adipose clip only, or not sampled but seen. When this type of discrepancy occurs, the reported landings are adjusted to include the total weight of the fish documented as being landed during the sampling period, and the adjusted landings are included in all subsequent assessments. Considering that samplers are not stationed within a community throughout the entire fishing season and that there are numerous communities without samplers present, these adjusted landings should be considered minimum estimates.

In 2016 a discrepancy was detected in a single community (Table 2). The reported landings for Sisimiut (1B) were 1,234 kg, and the total weight of fish identified by the sampling teams was 1,499 kg. As such the landings for Sisimiut were adjusted for this discrepancy, and

the adjusted landings were set to 1,499 kg. The time series of reported landings and adjusted landings for 2002-2016 are presented in Table 3. To provide the most reliable estimate of catch, which is necessary for estimating the potential fishery impacts on contributing stocks, it is important to continually improve the catch reporting procedures and the quality of the catch statistics. Factory landings and samples are not considered within this process since these landings are strictly regulated by the Government of Greenland (e.g., only licensed commercial fishers can land at designated factories) and are accounted for and reported by the factory managers to the Greenland Fisheries License Control Authority on a daily to weekly basis.

Landed fish were sampled at random, and when possible, the total catch was sampled. Individual fish were measured (fork length, mm) and weighed (gutted weight [GW] or whole weight [WW], 0.01 kg). Scales were taken for age determination, and adipose fins were taken for DNA analysis for stock identification. Fish were also examined for fin clips, external marks, external tags, and internal tags. Adipose-clipped fish were sampled for microtags (coded wire tags).

Sampling teams observed 1,624 salmon. Of this total, 1,314 were sampled for biological characteristics representing 19% of the reported landings. Factory landings were not allowed by the Government of Greenland, and therefore no samples were obtained from factory landed fish. A total of 277 fish were only checked for an adipose clip, and 33 were documented as being landed but were not sampled or examined further. Biological characteristics data were collected as follows:

- 1,312 fork lengths;
- 1,296 gutted weights;
- 0 whole weights;
- 1,252 scale samples; and
- 1,302 genetic samples.

A total of 19 adipose-clipped fish was documented. Of all the fish examined by the samplers, 2 internal tags (coded wire tags) were detected; both fish also had an adipose clip. In addition, 12 additional tags were provided directly by a fisher or consumer to a sampler or the GINR; many of the tags were from historic releases across the North Atlantic. The tag breakdown was as follows (Table 4):

- 2 coded wire tags
- 11 Carlin tags
- 1 data storage tag

Nonfactory sampling often occurs at a local market which is a centralized location where harvested salmon are present and available. Prior to any sampling, the sampler always obtains permission from the market manager. This arrangement has generally been successful for all samplers, although there have been issues in some years in Nuuk (Sheehan et al. 2013). Because of concerns that proper arrangements had not been made to allow sampling of fish in Nuuk in 2016, no sampling occurred in that community. In 2014 some minor problems were encountered when samplers were not allowed access to fish. Further communication from the Program Coordinator and GINR helped rectify the situation. These issues were restricted to Maniitsoq and Qaqortoq. No such issues were identified in 2015 or 2016.

The limitation of the fishery to internal-use-only caused some practical problems for the sampling teams; however, the sampling program provided adequate representation of the

Greenland catch, both temporally and spatially. There continued to be no sampling in Nuuk, which results in a potential for bias when describing the biological characteristics of the harvest, stock assessment results, and catch advice. However, this potential bias is expected to be minimized given that sampling occurred both to the north and south of Nuuk.

CONTINENT OF ORIGIN

Fin tissue samples were collected and preserved in RNAlater™, an aqueous, nontoxic tissue and cell storage reagent that stabilizes and protects cellular RNA. A total of 1,302 usable samples were collected from 4 communities in 4 NAFO divisions: Sisimiut in 1B (n = 318), Maniitsoq in 1C (n = 542), Paamiut in 1E (n = 125), and Qaqortoq in 1F (n = 317). In previous years, a small number of tissue samples were collected but not processed because of poor sample quality. However, all samples collected in 2016 were of good quality and were processed.

DNA isolation and the subsequent microsatellite analyses were performed according to standardized protocols (King et al. 2001; Sheehan et al. 2010). A database of approximately 5,000 Atlantic salmon genotypes of known origin was used as a baseline to assign the samples to continent of origin. In total, 66.4% of the salmon sampled were of North American origin, and 33.6% were of European origin. The NAFO division-specific continent of origin assignments are presented in Table 5.

These findings show that high proportions of fish from the North American stock complex continue to contribute to the fishery (Figure 3), although this recent estimate is the lowest estimate for the North American contribution since 1992 (54%). The variability in the recent stock complex contributions between divisions and the deviation from past trends (Figure 4) underscore the need to annually sample multiple NAFO divisions to achieve accurate estimates of continental contributions to the harvest.

Variations in the estimated weighted proportions and number of North American and European salmon harvested in the fishery during 1987-2016 are shown in Table 6 and Figures 3 and 5. The 2016 North American weighted contribution (64%) is lower than the long-term mean (1982-2015, 69%) and lower than the recent 10-year mean (2006-2015, 80%). It is among the lowest values within the last decade when the North American weighted contribution peaked at 93% in 2011. The European weighted contribution (36%) to the 2016 fishery was above the long-term mean (1982-2015, 31%) and the 10-year mean (2006-2015, 20%). In terms of numbers of fish, the 2016 fishery caught approximately 5,100 North American salmon (~17.2 t) and 3,300 European fish (~8.7 t). The 2016 total number of fish harvested (8,400) is well below the 2015 estimate (17,400). It is the lowest estimate since 2011 (8,100), the 22nd highest total in the 33 year time series (1982-2016 with no harvest estimates in 1993 and 1994), and only 2.5% of the maximum estimate of 336,000 fish harvested in 1982.

BIOLOGICAL CHARACTERISTICS OF THE CATCHES

Biological characteristics (length, weight, and age) were recorded for all sampled fish. Overall across all sea ages, the mean sampled fork length was 64.9 cm, and the mean gutted weight was 2.85 kg.

An overall decrease in mean whole weight of both European and North American 1SW salmon occurred between 1969 and 1995 (Table 7 and Figure 6). This trend was reversed in 1996

when mean weights began to increase, although evidence suggests that these trends may be partially explained by annual variation in the timing of the sampling program (ICES 2011, 2015). In 2016, the mean length of North American 1SW salmon was 65.2 cm, and the mean whole weight was 3.18 kg; the mean length of European 1SW salmon was 62.6 cm, and the mean whole weight was 2.79 kg. The North American 1SW fork length estimate was approximately equal to the 2015 value (65.6 cm) and the previous 10-year average (65.4 cm, 2006-2015). The European 1SW mean fork length was below the 2015 value (64.4 cm) and the previous 10-year average (64.5 cm, 2006-2015). The North American 1SW whole weight was slightly lower than the 2015 value (3.36 kg) and previous 10-year average (3.23 kg, 2006-2015). The European 1SW whole weight (2.79 kg) was lower than both the 2015 value (3.13 kg) and previous 10-year average (3.17 kg, 2006-2015). A summary of the mean fork lengths and whole weights in the 2016 fishery by sea age, continent of origin, and NAFO division is presented in Table 8. Note that the weight data have not been adjusted for date of capture, and hence may not represent an actual change in mean weight over the time series because fish sampled later in the fishing season have had additional time to grow compared to fish sampled early in the season (ICES 2011).

The smolt age distribution of the sampled catch by continent of origin and NAFO division is presented in Table 9. The river age (i.e. smolt age) distributions by origin for all North American and European origin salmon caught (1968-2016) are provided in Table 10.

The mean smolt age of the 2016 North American origin samples was 3.2 years. Although age-1 smolts historically represent a small proportion of the catch (previous 10-year mean of 0.9%, 2006-2015), the 2016 value (0.1%) is one of the lowest. There has been a consistent trend over the past 2 decades of decreasing contributions of age-1 smolts. This trend is indicative of the relatively minor contributions of the more southerly North American populations as age-1 smolt natural and hatchery production is restricted to the southern end of the range (ICES 2004). The percentage of smolt age 2 salmon of North American origin in the 2016 fishery (21.3%) is lower than in 2015 (31.6%) and the previous 10-year mean (27.5%, 2006-2015). Age 3 and older smolts accounted for 78.5% of the 2016 harvest of North American fish, which is slightly higher than the previous 10-year mean (71.6%, 2006-2015) and the overall mean for the 42-year time series (66.3%, 1968-2015 excluding data gaps in 1977 and 1993-1994).

The mean smolt age of the European salmon in 2016 was 2.4 years. The percentage of smolt age 1 (2.5%) is lower than the 2015 value below the previous 10-year mean of 10.4% (2006-2015), and one of the lowest in the time series. The percentage of smolt age 2 (63.3%) in the 2016 fishery is higher than in 2015 (54.9%) and the previous 10-year mean (59.0%, 2006-2015). The contribution of age 3 and older European origin smolts (34.2%) is slightly greater than the previous 10-year mean (30.6%, 2006-2015).

The sea age distribution of the sampled catch by continent of origin and NAFO division is presented in Table 11. As expected, the 1SW age group was dominant (94.2%) in the 2016 fishery. This value is lower than the 2015 value (97.3%) but still within the range of historical values (Table 12). Concerns have been raised over recent difficulty with discerning winter annuli from apparent “checks” in the marine zone of Atlantic salmon multi-sea winter scales. Care should be taken to properly discern true marine annuli from growth checks, and we note that further study of this phenomenon is warranted.

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REFERENCES CITED

- Colligan M, Sheehan T, Pruden J, Kocik J. 2008. The challenges posed by international management of Atlantic salmon: balancing commercial, recreational and societal interests - The North Atlantic Salmon Conservation Organization (NASCO). In Schechter MG, Leonard NJ, Taylor WW (eds.), *International Governance of Fisheries Ecosystems: learning from the past, finding solutions for the future*. American Fisheries Society; p. 458.
- King TL, Kalinowski ST, Schill WB, Spidle AP, Lubinski BA. 2001. Population structure of Atlantic salmon (*Salmo salar* L.): a range-wide perspective from microsatellite DNA variation. *Molec Ecol.* 10: 807-821.
- ICES. 2004. Report of the Working Group on North Atlantic Salmon (WGNAS), 29 March – 8 April 2004, Halifax, Canada. ICES CM 2004/ACFM:20. 293 p.
- ICES. 2007. Study Group on Establishing a Framework of Indicators of Salmon Stock Abundance (SGEFISSA), 27–30 November 2006, Halifax, Canada. ICES CM 2007/DFC:01. 71 p.
- ICES. 2011. Report of the Working Group on North Atlantic Salmon (WGNAS), 22–31 March 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:09. 286 p.
- ICES. 2012. Report of the Working Group on North Atlantic Salmon (WGNAS), 26 March–4 April 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:09. 322 p.
- ICES. 2015. Report of the Working Group on North Atlantic Salmon (WGNAS), 17–26 March, Moncton, Canada. ICES CM 2015/ACOM:09. 332 pp.
- ICES. 2016. Report of the Working Group on North Atlantic Salmon (WGNAS), 30 March–8 April 2016, Copenhagen, Denmark. ICES CM 2016/ACOM:10. 323 pp.
- Jensen JM. 1990. Atlantic salmon at Greenland. *Fish Res.* 10: 29-52.
- NASCO (North Atlantic Salmon Conservation Organization). 2015. Report of the Thirty-Second Annual Meetings of the Commissions. Happy Valley-Goose Bay, Canada, 2–5 June 2015.
- NASCO (North Atlantic Salmon Conservation Organization). 2016. Report of the Thirty-Third Annual Meetings of the Commissions. Bad Neuenahr-Ahrweiler, Germany, 7-10 June 2016.
- Reddin DG, Hansen LP, Bakkestuen V, Russell I, White J, Potter ECE. , Sheehan TF, Ó Maoiléidigh N, Dempson JB, Smith GW, Isaksson A, Fowler M, Jacobsen JA, Mork KA, Amiro P. 2012. Distribution of Atlantic salmon (*Salmo salar* L.) at Greenland, 1960s to present. *ICES J Mar Sci.* 69(9): 1589–1597.
- Sheehan TF, Legault CM, King TL, Spidle AP. 2010. Probabilistic-based genetic assignment model: assignments to subcontinent of origin of the West Greenland Atlantic salmon harvest. *ICES J Mar Sci.* 67: 537–550.
- Sheehan TF, Assunção MGL, Deschamps D, Laughton B, Ó Cuaig M, Nygaard R, King TL, Robertson MJ, Ó Maoiléidigh N. 2013. The International Sampling Program: Continent of origin and biological characteristics of Atlantic salmon collected at West Greenland in 2012. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 13-20; 25 p.

Table 1. Samplers participating in the 2016 sampling program by country, home institution, sampling period, and community/Northwest Atlantic Fisheries Organization (NAFO) division sampled.

Sampler	Country	Home Institution	Sampling Period	Community (NAFO Division)
James Hawkes	USA	NOAA Fisheries Service	16 Aug - 1 Sep	Qaqortoq (1F)
Helen Downie	UK (Scotland)	Marine Scotland	1 Sep – 15 Sep	Maniitsoq (1C)
Michael Millane	Ireland	Inland Fisheries Ireland	05 Sep – 20 Sep	Sisimiut (1B)
Denise Deschamps	Canada	Ministère des Forêts, de la Faune et des Parcs du Québec	6 Sep – 26 Sep	Paamiut (1E)
Michael McAuliffe	Ireland	Marine Institute	06 Sep – 22 Sep	Qaqortoq (1F)
Kerry Sims	UK (England & Wales)	Environment Agency	13 Sep – 29 Sep	Maniitsoq (1C)

Table 2. Evaluation of underreporting in sampled communities during the 2016 Greenland Atlantic salmon (*Salmo salar*) fishery by community/Northwest Atlantic Fisheries Organization (NAFO) division. The total number of salmon documented by the sampling teams (salmon that have been sampled, seen but not sampled, and seen and checked for an adipose fin clip only) is converted to a total whole weight (WW) based on a conversion factor of 1.11 and compared to the reported landings for each community. Gutted weight is denoted as GW.

Community (NAFO Division)	# sampled	Additional # seen	Ave. sampled GW (kg)	Ave. converted WW (kg)		
Sisimiut (1B)	326	116	3.06	3.39		
Maniitsoq (1C)	545	54	2.86	3.18		
Paamiut (1E)	126	95	2.58	2.86		
Qaqortoq (1F)	317	45	2.74	3.04		
Total	1,314	310	2.85	3.17		
	Est. WW sampled/seen (kg)	Reported landings (kg)	Adjusted landings (kg)	Difference (kg)	Difference as % of reported landings	
Sisimiut (1B)	1,499	1,234	1,499	265	21%	
Maniitsoq (1C)	1,904	5,881	5,881	0	0%	
Paamiut (1E)	633	2,683	2,683	0	0%	
Qaqortoq (1F)	1,099	3,602	3,602	0	0%	
Total	5,136	13,400	13,665	265	2%	

Table 3. Reported landings (kg) for the Greenland Atlantic salmon (*Salmo salar*) fishery (2002–2016) by Northwest Atlantic Fisheries Organization (NAFO) division as reported by the home rule government and the division-specific adjusted landings where the sampling teams observed more fish landed than were reported. Landings from International Council for the Exploration of the Sea Statistical Area XIV (East Greenland) are not included in the assessment but amounted to 1.5 t in 2016. Shaded cells indicate that sampling took place in that year and division.

Year		NAFO Division						Total
		1A	1B	1C	1D	1E	1F	
2002	Reported	14	78	2,100	3,752	1,417	1,661	9,022
	Adjusted						2,408	9,769
2003	Reported	619	17	1,621	648	1,274	4,516	8,694
	Adjusted			1,782	2,709		5,912	12,312
2004	Reported	3,476	611	3,516	2,433	2,609	2,068	14,712
	Adjusted				4,929			17,209
2005	Reported	1,294	3,120	2,240	756	2,937	4,956	15,303
	Adjusted				2,730			17,276
2006	Reported	5,427	2,611	3,424	4,731	2,636	4,192	23,021
	Adjusted							
2007	Reported	2,019	5,089	6,148	4,470	4,828	2,093	24,647
	Adjusted						2,252	24,806
2008	Reported	4,882	2,210	10,024	1,595	2,457	4,979	26,147
	Adjusted				3,577		5,478	28,627
2009	Reported	195	6,151	7,090	2,988	4,296	4,777	25,496
	Adjusted				5,466			27,975
2010	Reported	17,263	4,558	2,363	2,747	6,766	4,252	37,949
	Adjusted		4,824		6,566		5,274	43,056
2011	Reported	1,858	3,662	5,274	7,977	4,021	4,613	27,407
	Adjusted							
2012	Reported	5,353	784	14,991	4,564	3,993	2,951	32,636
	Adjusted		2,001				3,694	34,596

Table 3, continued. Reported landings (kg) for the Greenland Atlantic salmon (*Salmo salar*) fishery (2002–2016) by Northwest Atlantic Fisheries Organization (NAFO) division as reported by the home rule government and the division-specific adjusted landings where the sampling teams observed more fish landed than were reported. Landings from International Council for the Exploration of the Sea Statistical Area XIV (East Greenland) are not included in the assessment but amounted to 1.5 t in 2016. Shaded cells indicate that sampling took place in that year and division.

Year		NAFO Division						Total
		1A	1B	1C	1D	1E	1F	
2013	Reported	3,052	2,359	17,950	13,356	6,442	3,774	46,933
	Adjusted		2,461				4,408	47,669
2014	Reported	3,626	2,756	13,762	19,123	14,979	3,416	57,662
	Adjusted						4,036	58,282
2015	Reported	751	8,801	10,055	17,966	4,170	14,134	55,877
	Adjusted							
2016	Reported	763	1,234	7,271	4,630	4,492	7,265	25,655
	Adjusted		1,499					25,920

Table 4. Reported tag recaptures (n = 14) from the 2016 Greenland Atlantic salmon (*Salmo salar*) fishery. NAFO division refers to Northwest Atlantic Fisheries Organization statistical areas. Two tags were recovered from sampled fish by the sampling team, and the remaining 12 tags were provided directly by a fisher or consumer to a sampler or to the Greenland Institute of Natural Resources. Many of the tags provided directly by a fisher or consumer are from historical recoveries. Empty cells identify incomplete recapture or released information, cwt refers to coded wire tags, and DST refers to data storage tags.

Tag type	Tag code (Seq. code)	Release country	River released	Place released	Release year	Recapture Community (NAFO Division)	Recapture year
cwt	42 01 87 18 (incomplete seq code)	UK (E&W)	Dee	Worthenbury	2015	Paamuit (1E)	2016
cwt	47 07 14	IRE	Corrib	Galway City	2015	Qaqortoq (1F)	2016
carlin	Blue (A59055)	Canada				Arsuk Area (1E)	1975-1980
carlin	Blue (G48113)	Canada				Arsuk Area (1E)	1975-1980
carlin	Blue (RHD M97851)	Canada				Arsuk Area (1E)	1975-1980
carlin	Green (DD20701)	Canada				Arsuk Area (1E)	1975-1980
carlin	Green (BB62280)	Canada				Arsuk Area (1E)	1975-1980
carlin	Brown (B334255)	Norway				Arsuk Area (1E)	1975-1980
carlin	Green (W1346)	Scotland				Arsuk Area (1E)	1975-1980
carlin	Green (40825)	Scotland				Arsuk Area (1E)	1975-1980
carlin	Green (USA15812)	USA				Arsuk Area (1E)	1975-1980
carlin	Green (USA61 466)	USA				Arsuk Area (1E)	1975-1980
carlin	Light blue (YY00,898)	Canada				Narsaq area (1F)	2004
DST	White (360 027)	unkn				Kangaamiut (1C)	2016

Table 5. The continental proportions of North American (NA) and European (E) Atlantic salmon (*Salmo salar*) caught in West Greenland 2016 by Northwest Atlantic Fisheries Organization (NAFO) division.

NAFO Div.	Fishing dates	Number		Totals	Percentages	
		NA	E		NA	E
1B	Sep 06 - Oct 19	249	69	318	78.3	21.7
1C	Sep 08 - 28	384	158	542	70.8	29.2
1E	Sep 12 - Sep 23	49	76	125	39.2	60.8
1F	Aug 17 - Sep 20	182	135	317	57.4	42.6
TOTAL		864	438	1302	66.4	33.6

Table 6. The catch weighted numbers of North American (NA) and European (E) Atlantic salmon (*Salmo salar*) caught in West Greenland from 1982-2016 and the proportion of the catch by weight. Numbers are rounded to the nearest hundred fish. Continent of origin assignments were based on scale characteristics until 1995, scale characteristics and DNA based assignments until 2001, and DNA based assignments only from 2002 onwards. No samples were collected in 1993 and 1994.

	Proportion weighted by catch		Numbers of salmon caught	
	NA	E	NA	E
1982	57	43	192,200	143,800
1983	40	60	39,500	60,500
1984	54	46	48,800	41,200
1985	47	53	143,500	161,500
1986	59	41	188,300	131,900
1987	59	41	171,900	126,400
1988	43	57	125,500	168,800
1989	55	45	65,000	52,700
1990	74	26	62,400	21,700
1991	63	37	111,700	65,400
1992	45	55	46,900	38,500
1993	-	-	-	-
1994	-	-	-	-
1995	67	33	21,400	10,700
1996	70	30	22,400	9,700
1997	85	15	18,000	3,300
1998	79	21	3,100	900
1999	91	9	5,700	600
2000	65	35	5,100	2,700
2001	67	33	9,400	4,700
2002	69	31	2,300	1,000

Table 6, continued. The catch weighted numbers of North American (NA) and European (E) Atlantic salmon (*Salmo salar*) caught in West Greenland from 1982-2016 and the proportion of the catch by weight. Numbers are rounded to the nearest hundred fish. Continent of origin assignments were based on scale characteristics until 1995, scale characteristics and DNA based assignments until 2001, and DNA based assignments only from 2002 onwards.

	Proportion weighted by catch		Numbers of salmon caught	
	NA	E	NA	E
2003	64	36	2,600	1,400
2004	72	28	3,900	1,500
2005	74	26	3,500	1,200
2006	69	31	4,000	1,800
2007	76	24	6,100	1,900
2008	86	14	8,000	1,300
2009	89	11	7,000	800
2010	80	20	10,000	2,600
2011	93	7	7,500	600
2012	79	21	7,800	2,100
2013	82	18	11,500	2,700
2014	72	28	12,800	5,400
2015	79	21	13,500	3,900
2016	64	36	5,100	3,300

Table 7. Annual mean fork lengths and whole weights by continent of origin (NA = North American and E = European) and sea age (1SW = 1 sea-winter, 2SW =2 sea-winter and PS = previous spawner) of Atlantic salmon (*Salmo salar*) caught at West Greenland, 1969-2016. No samples were collected in 1993 and 1994.

	Whole weight (kg)									Fork length (cm)					
	Sea age & origin									Sea age & origin					
	1SW	2SW		PS		All sea ages		TOTAL	1SW	2SW		PS		E	
NA	E	NA	E	NA	E	NA	E		NA	E	NA	E	NA	E	
1969	3.12	3.76	5.48	5.80	-	5.13	3.25	3.86	3.58	65.0	68.7	77.0	80.3	-	75.3
1970	2.85	3.46	5.65	5.50	4.85	3.80	3.06	3.53	3.28	64.7	68.6	81.5	82.0	78.0	75.0
1971	2.65	3.38	4.30	-	-	-	2.68	3.38	3.14	62.8	67.7	72.0	-	-	-
1972	2.96	3.46	5.85	6.13	2.65	4.00	3.25	3.55	3.44	64.2	67.9	80.7	82.4	61.5	69.0
1973	3.28	4.54	9.47	10.00	-	-	3.83	4.66	4.18	64.5	70.4	88.0	96.0	61.5	-
1974	3.12	3.81	7.06	8.06	3.42	-	3.22	3.86	3.58	64.1	68.1	82.8	87.4	66.0	-
1975	2.58	3.42	6.12	6.23	2.60	4.80	2.65	3.48	3.12	61.7	67.5	80.6	82.2	66.0	75.0
1976	2.55	3.21	6.16	7.20	3.55	3.57	2.75	3.24	3.04	61.3	65.9	80.7	87.5	72.0	70.7
1977	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	2.96	3.50	7.00	7.90	2.45	6.60	3.04	3.53	3.35	63.7	67.3	83.6	-	60.8	85.0
1979	2.98	3.50	7.06	7.60	3.92	6.33	3.12	3.56	3.34	63.4	66.7	81.6	85.3	61.9	82.0
1980	2.98	3.33	6.82	6.73	3.55	3.90	3.07	3.38	3.22	64.0	66.3	82.9	83.0	67.0	70.9
1981	2.77	3.48	6.93	7.42	4.12	3.65	2.89	3.58	3.17	62.3	66.7	82.8	84.5	72.5	-
1982	2.79	3.21	5.59	5.59	3.96	5.66	2.92	3.43	3.11	62.7	66.2	78.4	77.8	71.4	80.9
1983	2.54	3.01	5.79	5.86	3.37	3.55	3.02	3.14	3.10	61.5	65.4	81.1	81.5	68.2	70.5
1984	2.64	2.84	5.84	5.77	3.62	5.78	3.20	3.03	3.11	62.3	63.9	80.7	80.0	69.8	79.5
1985	2.50	2.89	5.42	5.45	5.20	4.97	2.72	3.01	2.87	61.2	64.3	78.9	78.6	79.1	77.0
1986	2.75	3.13	6.44	6.08	3.32	4.37	2.89	3.19	3.03	62.8	65.1	80.7	79.8	66.5	73.4
1987	3.00	3.20	6.36	5.96	4.69	4.70	3.10	3.26	3.16	64.2	65.6	81.2	79.6	74.8	74.8
1988	2.83	3.36	6.77	6.78	4.75	4.64	2.93	3.41	3.18	63.0	66.6	82.1	82.4	74.7	73.8
1989	2.56	2.86	5.87	5.77	4.23	5.83	2.77	2.99	2.87	62.3	64.5	80.8	81.0	73.8	82.2
1990	2.53	2.61	6.47	5.78	3.90	5.09	2.67	2.72	2.69	62.3	62.7	83.4	81.1	72.6	78.6
1991	2.42	2.54	5.82	6.23	5.15	5.09	2.57	2.79	2.65	61.6	62.7	80.6	82.2	81.7	80.0
1992	2.54	2.66	6.49	6.01	4.09	5.28	2.86	2.74	2.81	62.3	63.2	83.4	81.1	77.4	82.7
1995	2.37	2.67	6.09	5.88	3.71	4.98	2.45	2.75	2.56	61.0	63.2	81.3	81.0	70.9	81.3
1996	2.63	2.86	6.50	6.30	4.98	5.44	2.83	2.90	2.88	62.8	64.0	81.4	81.1	77.1	79.4
1997	2.57	2.82	7.95	6.11	4.82	6.9	2.63	2.84	2.71	62.3	63.6	85.7	84.0	79.4	87.0
1998	2.72	2.83	6.44	-	3.28	4.77	2.76	2.84	2.78	62.0	62.7	84.0	-	66.3	76.0
1999	3.02	3.03	7.59	-	4.20	-	3.09	3.03	3.08	63.8	63.5	86.6	-	70.9	-
2000	2.47	2.81	-	-	2.58	-	2.47	2.81	2.57	60.7	63.2	-	-	64.7	-
2001	2.89	3.03	6.76	5.96	4.41	4.06	2.95	3.09	3.00	63.1	63.7	81.7	79.1	75.3	72.1
2002	2.84	2.92	7.12	-	5.00	-	2.89	2.92	2.90	62.6	62.1	83.0	-	75.8	-
2003	2.94	3.08	8.82	5.58	4.04	-	3.02	3.10	3.04	63	64.4	86.1	78.3	71.4	-
2004	3.11	2.95	7.33	5.22	4.71	6.48	3.17	3.22	3.18	64.7	65.0	86.2	76.4	77.6	88.0
2005	3.19	3.33	7.05	4.19	4.31	2.89	3.31	3.33	3.31	65.9	66.4	83.3	75.5	73.7	62.3
2006	3.10	3.25	9.72	-	5.05	3.67	3.25	3.26	3.24	65.3	65.3	90.0	-	76.8	69.5
2007	2.89	2.87	6.19	6.47	4.94	3.57	2.98	2.99	2.98	63.5	63.3	80.9	80.6	76.7	71.3
2008	3.04	3.03	6.35	7.47	3.82	3.39	3.08	3.07	3.08	64.6	63.9	80.1	85.5	71.1	73.0
2009	3.28	3.40	7.59	6.54	5.25	4.28	3.48	3.67	3.50	64.9	65.5	84.6	81.7	75.9	73.5
2010	3.44	3.24	6.40	5.45	4.17	3.92	3.47	3.28	3.42	66.7	65.2	80.0	75.0	72.4	70.0
2011	3.30	3.18	5.69	4.94	4.46	5.11	3.39	3.49	3.40	65.8	64.7	78.6	75.0	73.7	76.3
2012	3.34	3.38	6.00	4.51	4.65	3.65	3.44	3.40	3.44	65.4	64.9	75.9	70.4	72.8	68.9
2013	3.33	3.16	6.43	4.51	3.64	5.38	3.39	3.20	3.35	66.2	64.6	81.0	72.8	69.9	73.6
2014	3.25	3.02	7.60	6.00	4.47	5.42	3.39	3.13	3.32	65.6	63.6	86.0	78.7	73.6	83.5
2015	3.36	3.13	7.52	7.10	4.53	3.81	3.42	3.18	3.37	65.6	64.4	84.1	82.5	74.2	67.2
2016	3.18	2.79	7.77	5.18	4.03	4.12	3.32	2.89	3.18	65.2	62.6	85.1	76.0	72.2	70.9

Table 8. Mean fork lengths (cm) and whole weight (kg) by sea age (1SW = 1 sea-winter and 2SW = 2 sea-winter), continent of origin and Northwest Atlantic Fisheries Organization (NAFO) division for Atlantic salmon (*Salmo salar*) caught in West Greenland in 2016 with corresponding standard deviation (S.D.). Table does not include salmon of unknown age, origin, fork length, or weight.

NAFO Div.	1 SW		2 SW		Previous spawners		Fork length (cm) (S.D.)	All sea ages		No.
	Fork length (cm) (S.D.)	Whole weight (kg) (S.D.)	Fork length (cm) (S.D.)	Whole weight (kg) (S.D.)	Fork length (cm) (S.D.)	Whole weight (kg) (S.D.)		No.	Whole weight (kg) (S.D.)	
North American and European										
1B	64.9 (3.1)	3.17 (0.53)	84.6 (6.5)	7.40 (1.70)	72.8 (7.5)	3.94 (1.00)	66 (5.5)	306	3.38 (1.08)	300
1C	64.6 (3.1)	3.09 (0.48)	81.4 (7.0)	6.77 (1.86)	71.2 (7.1)	3.64 (0.73)	65.0 (4.2)	528	3.18 (0.78)	527
1E	63.5 (2.7)	2.81 (0.37)	79.9 (11.2)	5.75 (2.89)	59.9 -	2.42 -	63.7 (3.5)	124	2.86 (0.59)	124
1F	63.3 (3.6)	2.91 (0.56)	75.6 (9.7)	5.54 (2.90)	72.6 (9.4)	4.32 (1.76)	64.4 (5.4)	246	3.09 (1.02)	246
All Areas	64.3 (3.2)	3.05 (0.52)	81.4 (8.0)	6.70 (2.13)	72.1 (8.4)	4.04 (1.43)	65.0 (4.8)	1204	3.18 (0.91)	1197
North American										
1B	65.4 (2.8)	3.25 (0.52)	87.2 (1.8)	8.14 (0.67)	72.8 (7.5)	3.94 (1.00)	66.7 (5.5)	239	3.49 (1.14)	234
1C	65.3 (2.9)	3.19 (0.49)	81.1 (7.3)	6.74 (1.99)	72.2 (8.8)	3.60 (0.94)	65.6 (3.9)	374	3.26 (0.73)	373
1E	65.0 (2.3)	2.93 (0.36)	87.8 -	7.79 -	59.9 -	2.42 -	65.4 (4.0)	49	3.02 (0.78)	49
1F	64.5 (3.4)	3.11 (0.60)	87.2 (4.7)	9.44 (0.31)	72.6 (9.7)	4.30 (1.80)	65.8 (5.8)	141	3.34 (1.16)	141
All Areas	65.2 (2.9)	3.18 (0.51)	85.1 (5.3)	7.77 (1.49)	72.2 (8.7)	4.03 (1.47)	66.0 (4.8)	803	3.32 (0.96)	797
European										
1B	63.2 (3.6)	2.92 (0.51)	76.0 (9.7)	4.93 (1.86)	- -	- -	63.8 (4.7)	67	3.01 (0.73)	66
1C	62.9 (2.7)	2.85 (0.38)	81.9 (7.5)	6.82 (1.88)	69.0 (2.3)	3.72 (0.05)	63.6 (4.5)	154	2.99 (0.86)	154
1E	62.5 (2.5)	2.73 (0.36)	72.0 -	3.71 -	- -	- -	62.7 (2.7)	75	2.75 (0.37)	75
1F	61.8 (3.3)	2.66 (0.46)	71.0 (6.5)	3.99 (1.41)	72.9 (9.7)	4.51 (2.02)	62.4 (4.3)	105	2.76 (0.67)	105
All Areas	62.6 (3.0)	2.79 (0.43)	76.0 (8.3)	5.18 (2.00)	70.9 (6.2)	4.12 (1.25)	63.1 (4.2)	401	2.89 (0.73)	400

Table 9. The river age (smolt age) composition (%) of Atlantic salmon (*Salmo salar*) by continent of origin (NA = North American and E = European) and Northwest Atlantic Fisheries Organization (NAFO) division caught in 2016 in West Greenland. Table does not include salmon of unknown age or origin (n = 50).

NAFO Division	Origin	River age (%)						Total No.
		1	2	3	4	5	6	
1B	NA	0.0	24.3	46.0	23.0	5.9	0.8	239
	E	1.5	76.1	19.4	3.0	0.0	0.0	67
		0.3	35.6	40.2	18.6	4.6	0.7	306
1C	NA	0.3	23.1	44.1	24.5	7.4	0.6	363
	E	3.3	72.2	21.2	3.3	0.0	0.0	151
		1.2	37.5	37.4	18.3	5.3	0.4	514
1E	NA	0.0	14.3	59.2	24.5	2.0	0.0	49
	E	1.3	50.7	44.0	4.0	0.0	0.0	75
		0.8	36.3	50.0	12.1	0.8	0.0	124
1F	NA	0.0	14.2	31.2	39.7	11.3	3.5	141
	E	2.9	51.4	38.1	6.7	1.0	0.0	105
		1.2	30.1	34.1	25.6	6.9	2.0	246
All Areas	NA	0.1	21.3	43.3	26.8	7.3	1.1	792
	E	2.5	63.3	29.6	4.3	0.3	0.0	398
		0.9	35.4	38.7	19.2	5.0	0.8	1190

Table 10. River age distribution (%) for North American and European origin Atlantic salmon (*Salmo salar*) caught in West Greenland, 1968-2016. Table does not include salmon of unknown age or origin. Not all rows add to 1.0 because of rounding errors. No samples were collected in 1993 and 1994.

YEAR	1	2	3	4	5	6	7	8
North American								
1968	0.3	19.6	40.4	21.3	16.2	2.2	0	0
1969	0	27.1	45.8	19.6	6.5	0.9	0	0
1970	0	58.1	25.6	11.6	2.3	2.3	0	0
1971	1.2	32.9	36.5	16.5	9.4	3.5	0	0
1972	0.8	31.9	51.4	10.6	3.9	1.2	0.4	0
1973	2	40.8	34.7	18.4	2	2	0	0
1974	0.9	36	36.6	12	11.7	2.6	0.3	0
1975	0.4	17.3	47.6	24.4	6.2	4	0	0
1976	0.7	42.6	30.6	14.6	10.9	0.4	0.4	0
1978	2.7	31.9	43	13.6	6	2	0.9	0
1979	4.2	39.9	40.6	11.3	2.8	1.1	0.1	0
1980	5.9	36.3	32.9	16.3	7.9	0.7	0.1	0
1981	3.5	31.6	37.5	19	6.6	1.6	0.2	0
1982	1.4	37.7	38.3	15.9	5.8	0.7	0	0.2
1983	3.1	47	32.6	12.7	3.7	0.8	0.1	0
1984	4.8	51.7	28.9	9	4.6	0.9	0.2	0
1985	5.1	41	35.7	12.1	4.9	1.1	0.1	0
1986	2	39.9	33.4	20	4	0.7	0	0
1987	3.9	41.4	31.8	16.7	5.8	0.4	0	0
1988	5.2	31.3	30.8	20.9	10.7	1	0.1	0
1989	7.9	39	30.1	15.9	5.9	1.3	0	0
1990	8.8	45.3	30.7	12.1	2.4	0.5	0.1	0
1991	5.2	33.6	43.5	12.8	3.9	0.8	0.3	0
1992	6.7	36.7	34.1	19.1	3.2	0.3	0	0
1995	2.4	19	45.4	22.6	8.8	1.8	0.1	0
1996	1.7	18.7	46	23.8	8.8	0.8	0.1	0
1997	1.3	16.4	48.4	17.6	15.1	1.3	0	0
1998	4	35.1	37	16.5	6.1	1.1	0.1	0
1999	2.7	23.5	50.6	20.3	2.9	0.0	0.0	0
2000	3.2	26.6	38.6	23.4	7.6	0.6	0	0
2001	1.9	15.2	39.4	32	10.8	0.7	0	0
2002	1.5	27.4	46.5	14.2	9.5	0.9	0	0
2003	2.6	28.8	38.9	21	7.6	1.1	0	0
2004	1.9	19.1	51.9	22.9	3.7	0.5	0	0
2005	2.7	21.4	36.3	30.5	8.5	0.5	0	0
2006	0.6	13.9	44.6	27.6	12.3	1	0	0
2007	1.6	27.7	34.5	26.2	9.2	0.9	0	0
2008	0.9	25.1	51.9	16.8	4.7	0.6	0	0
2009	2.6	30.7	47.3	15.4	3.7	0.4	0	0
2010	1.6	21.7	47.9	21.7	6.3	0.8	0	0
2011	1.0	35.9	45.9	14.4	2.8	0.0	0	0
2012	0.3	29.8	39.4	23.3	6.5	0.7	0	0
2013	0.1	32.6	37.3	20.8	8.6	0.6	0	0
2014	0.4	26.0	44.5	21.9	6.9	0.4	0	0
2015	0.1	31.6	40.6	21.6	6.0	0.2	0	0
2016	0.1	21.3	43.3	26.8	7.3	1.1	0	0
10 yr mean (2007-2016)	0.9	28.2	43.3	20.9	6.2	0.6	0.0	0.0
Overall Mean	2.4	31.3	39.8	18.6	6.8	1.1	0.1	0.0

Table 10, continued. River age distribution (%) for North American and European origin Atlantic salmon (*Salmo salar*) caught in West Greenland, 1968-2016. Table does not include salmon of unknown age or origin. Not all rows add to 1.0 because of rounding errors. No samples were collected in 1993 and 1994.

YEAR	1	2	3	4	5	6	7	8
	European							
1968	21.6	60.3	15.2	2.7	0.3	0	0	0
1969	0	83.8	16.2	0	0	0	0	0
1970	0	90.4	9.6	0	0	0	0	0
1971	9.3	66.5	19.9	3.1	1.2	0	0	0
1972	11	71.2	16.7	1	0.1	0	0	0
1973	26	58	14	2	0	0	0	0
1974	22.9	68.2	8.5	0.4	0	0	0	0
1975	26	53.4	18.2	2.5	0	0	0	0
1976	23.5	67.2	8.4	0.6	0.3	0	0	0
1978	26.2	65.4	8.2	0.2	0	0	0	0
1979	23.6	64.8	11	0.6	0	0	0	0
1980	25.8	56.9	14.7	2.5	0.2	0	0	0
1981	15.4	67.3	15.7	1.6	0	0	0	0
1982	15.6	56.1	23.5	4.2	0.7	0	0	0
1983	34.7	50.2	12.3	2.4	0.3	0.1	0.1	0
1984	22.7	56.9	15.2	4.2	0.9	0.2	0	0
1985	20.2	61.6	14.9	2.7	0.6	0	0	0
1986	19.5	62.5	15.1	2.7	0.2	0	0	0
1987	19.2	62.5	14.8	3.3	0.3	0	0	0
1988	18.4	61.6	17.3	2.3	0.5	0	0	0
1989	18.0	61.7	17.4	2.7	0.3	0	0	0
1990	15.9	56.3	23	4.4	0.2	0.2	0	0
1991	20.9	47.4	26.3	4.2	1.2	0	0	0
1992	11.8	38.2	42.8	6.5	0.6	0	0	0
1995	14.8	67.3	17.2	0.6	0	0	0	0
1996	15.8	71.1	12.2	0.9	0	0	0	0
1997	4.1	58.1	37.8	0	0	0	0	0
1998	28.6	60.0	7.6	2.9	0.0	1.0	0	0
1999	27.7	65.1	7.2	0	0	0	0	0
2000	36.5	46.7	13.1	2.9	0.7	0	0	0
2001	16.0	51.2	27.3	4.9	0.7	0	0	0
2002	9.4	62.9	20.1	7.6	0	0	0	0
2003	16.2	58.0	22.1	3.0	0.8	0	0	0
2004	18.3	57.7	20.5	3.2	0.2	0	0	0
2005	19.2	60.5	15	5.4	0	0	0	0
2006	17.7	54.0	23.6	3.7	0.9	0	0	0
2007	7.0	48.5	33.0	10.5	1	0	0	0
2008	7.0	72.8	19.3	0.8	0	0	0	0
2009	14.3	59.5	23.8	2.4	0	0	0	0
2010	11.3	57.1	27.3	3.4	0.8	0	0	0
2011	19.0	51.7	27.6	1.7	0	0	0	0
2012	9.3	63.0	24.0	3.7	0	0	0	0
2013	4.5	68.2	24.4	2.5	0.5	0	0	0
2014	4.5	60.7	30.8	4.0	0	0	0	0
2015	9.2	54.9	28.8	5.8	1.2	0	0	0
2016	2.5	63.3	29.6	4.3	0.3	0	0	0
10 yr mean (2007-2016)	8.9	60.0	26.9	3.9	0.4	0.0	0.0	0.0
Overall Mean	16.5	60.9	19.4	2.8	0.3	0.0	0.0	0.0

Table 11. The sea-age (1SW = 1 sea-winter, 2SW = 2 sea-winter, and Previous Spawners) composition of Atlantic salmon (*Salmo salar*) by continent of origin (NA = North American and E = European) and Northwest Atlantic Fisheries Organization (NAFO) division caught in West Greenland in 2016. Table does not include salmon with unknown age or origin (n = 96). Not all rows add to 100 because of rounding errors.

NAFO	Origin	Sea-age composition (%)			Total No.
		1SW	2SW	Previous Spawners	
1B	NA	91.2	4.2	4.6	239
	E	95.5	4.5	0.0	67
		92.2	4.2	3.6	306
1C	NA	97.1	1.9	1.1	374
	E	95.5	3.2	1.3	154
		96.6	2.3	1.1	528
1E	NA	95.9	2.0	2.0	49
	E	98.7	1.3	0.0	75
		97.6	1.6	0.8	124
1F	NA	87.4	1.4	11.2	143
	E	93.3	4.8	1.9	105
		89.9	2.8	7.3	248
All areas	NA	93.5	2.5	4.0	805
	E	95.5	3.5	1.0	401
		94.2	2.8	3.0	1206

Table 12. Sea age (1SW = 1 sea-winter, 2SW = 2 sea-winter, and PS = Previous Spawners) distribution (%) for North American and European origin Atlantic salmon (*Salmo salar*) caught in West Greenland, 1985-2016. Table does not include salmon of unknown age or origin. Not all rows add to 100 because of rounding errors. No samples were collected in 1993 and 1994.

	North American			European		
	1SW	2SW	PS	1SW	2SW	PS
1985	92.5	7.2	0.3	95.0	4.7	0.4
1986	95.1	3.9	1.0	97.5	1.9	0.6
1987	96.3	2.3	1.4	98.0	1.7	0.3
1988	96.7	2.0	1.2	98.1	1.3	0.5
1989	92.3	5.2	2.4	95.5	3.8	0.6
1990	95.7	3.4	0.9	96.3	3.0	0.7
1991	95.6	4.1	0.4	93.4	6.5	0.2
1992	91.9	8.0	0.1	97.5	2.1	0.4
1993	-	-	-	-	-	-
1994	-	-	-	-	-	-
1995	96.8	1.5	1.7	97.3	2.2	0.5
1996	94.1	3.8	2.1	96.1	2.7	1.2
1997	98.2	0.6	1.2	99.3	0.4	0.4
1998	96.8	0.5	2.7	99.4	0.0	0.6
1999	96.8	1.2	2.0	100.0	0.0	0.0
2000	97.4	0.0	2.6	100.0	0.0	0.0
2001	98.2	2.6	0.5	97.8	2.0	0.3
2002	97.3	0.9	1.8	100.0	0.0	0.0
2003	96.7	1.0	2.3	98.9	1.1	0.0
2004	97.0	0.5	2.5	97.0	2.8	0.2
2005	92.4	1.2	6.4	96.7	1.1	2.2
2006	93.0	0.8	5.6	98.8	0.0	1.2
2007	96.5	1.0	2.5	95.6	2.5	1.5
2008	97.4	0.5	2.2	98.8	0.8	0.4
2009	93.4	2.8	3.8	89.4	7.6	3.0
2010	98.2	0.4	1.4	97.5	1.7	0.8
2011	93.8	1.5	4.7	82.8	12.1	5.2
2012	93.2	0.7	6.0	98.0	1.6	0.4
2013	94.9	1.4	3.7	96.6	2.4	1.0
2014	91.3	1.1	7.6	96.1	2.4	1.5
2015	97.0	0.7	2.3	98.2	1.2	0.6
2016	93.5	2.5	4.0	95.5	3.5	1.0

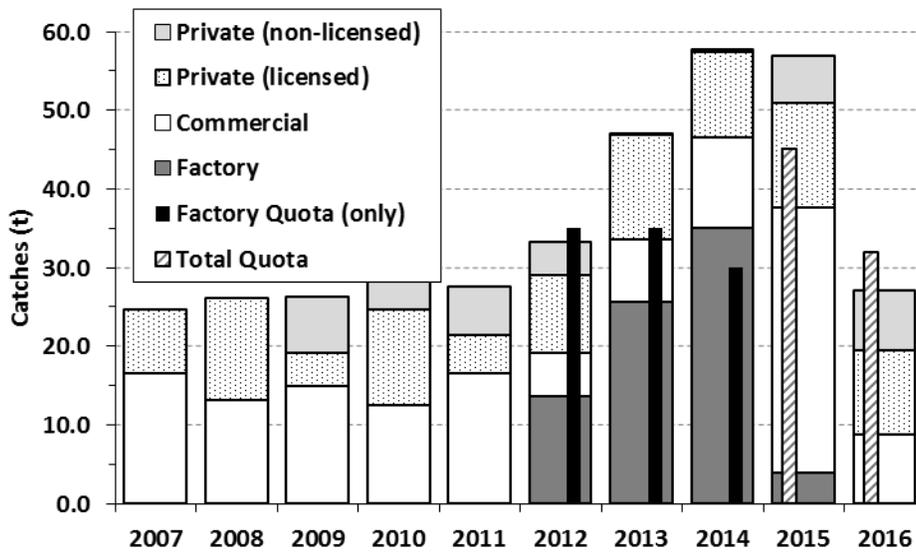
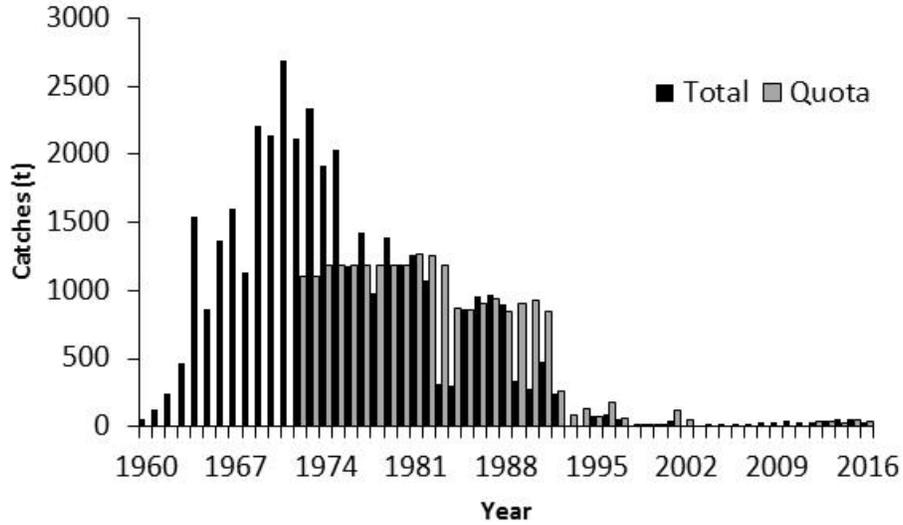


Figure 1. Nominal catches and commercial quotas (metric tons, round fresh weight) of Atlantic salmon (*Salmon salar*) in West Greenland for 1960–2016 (top panel) and 2007–2016 (bottom panel). Total reported landings from 2007–2016 are displayed by landings type. From 2009 to the present, private landings are reported as coming from licensed or nonlicensed fishers. No quotas were set from 2003–2011, but from 2012–2014 an annual quota was set and applied to factory landings only. Starting in 2015, a single quota was set for all components of the fishery.

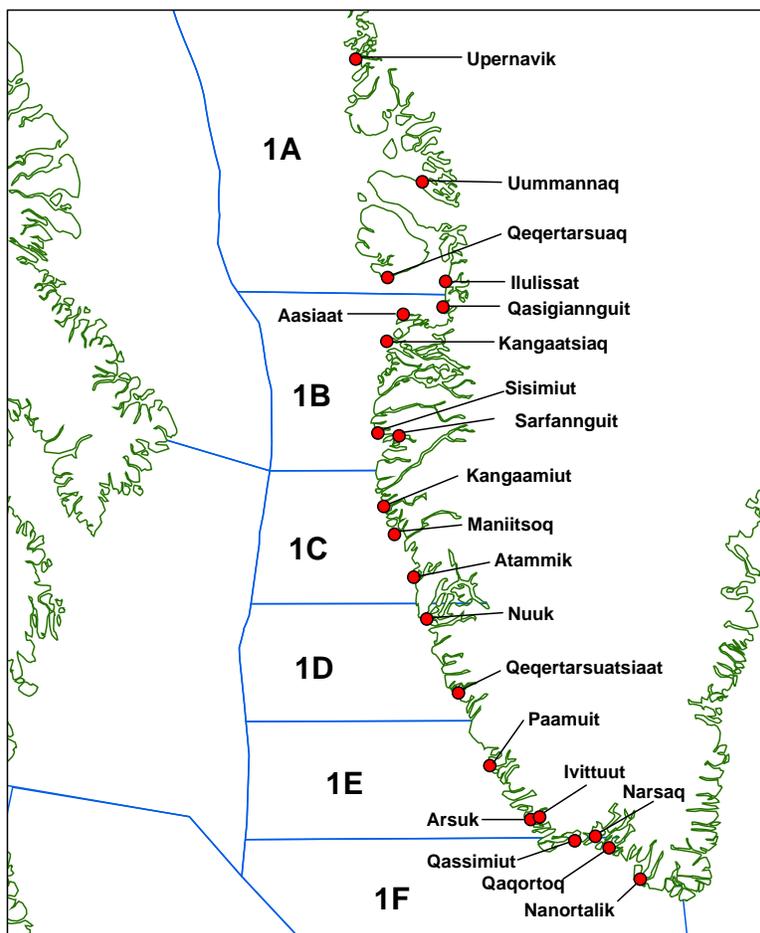


Figure 2. Map of southwest Greenland showing communities to which Atlantic salmon (*Salmo salar*) have historically been landed. Northwest Atlantic Fisheries Organization Division (NAFO) divisions (1A-1F) are also shown. In 2016 samples were obtained from Sisimiut (NAFO Division 1B), Maniitsoq (1C), Paamiut (1E), and Qaqortoq (1F).

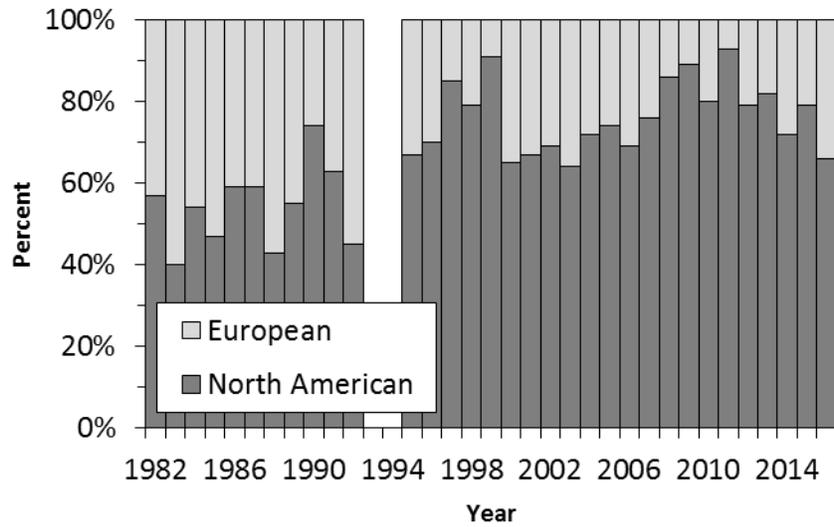


Figure 3. The weighted proportions of North American and European Atlantic salmon (*Salmo salar*) caught in West Greenland from 1982-2016. Proportions were weighted by the estimated numbers of salmon, by origin, for each division according to the adjusted landings.

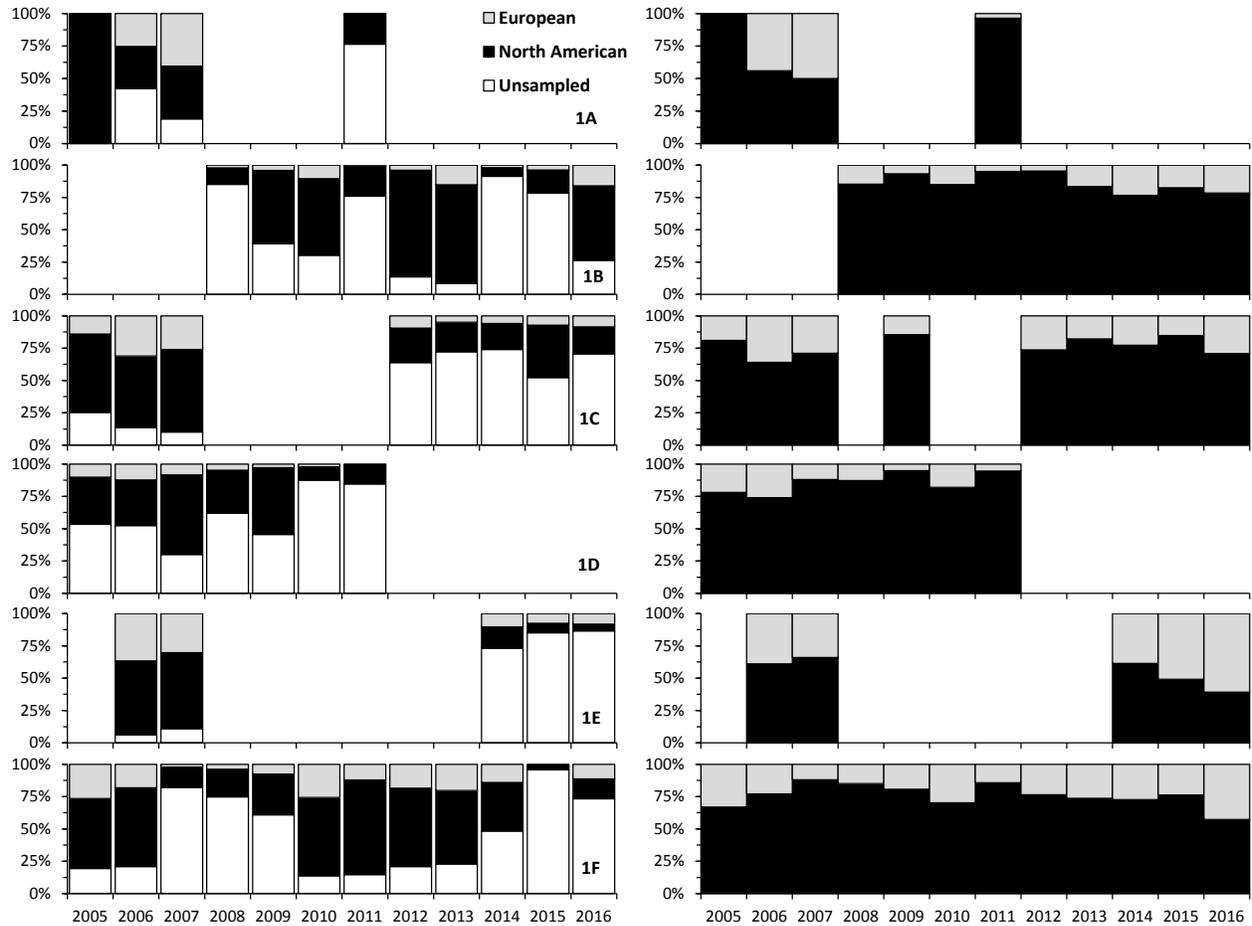


Figure 4. Proportions of unsampled adjusted landings, North American origin and European origin Atlantic salmon (*Salmo salar*, left panels) and of sampled adjusted landings, North American origin and European origin Atlantic salmon (right panels) by North Atlantic Fisheries Organization division (NAFO, top row represents division 1A and bottom row represents division 1F) sampled in West Greenland from 2005–2016. Year-division combinations with data identify when and where sampling occurred. Division 1A 2005 value is from 1 sample.

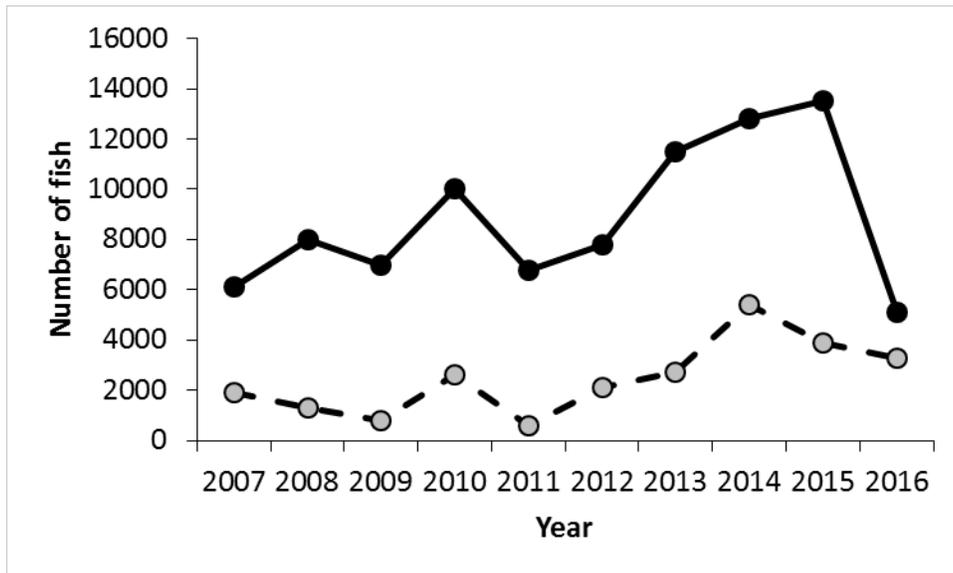
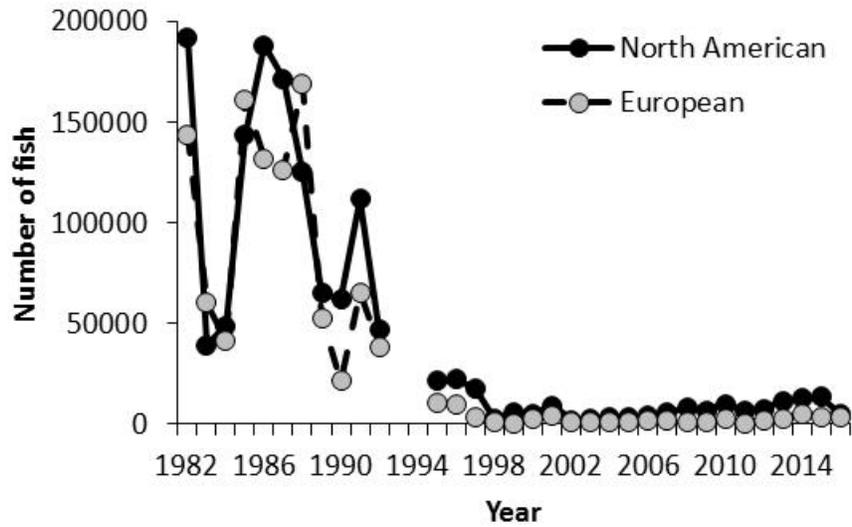


Figure 5. The weighted numbers of North American and European Atlantic salmon (*Salmo salar*) caught in West Greenland from 1982–2016 (top) and 2007–2016 (bottom). Numbers are rounded to the nearest hundred fish. In 2016, it is estimated that approximately 5,100 and 3,300 North American and European origin fish were harvested, respectively.

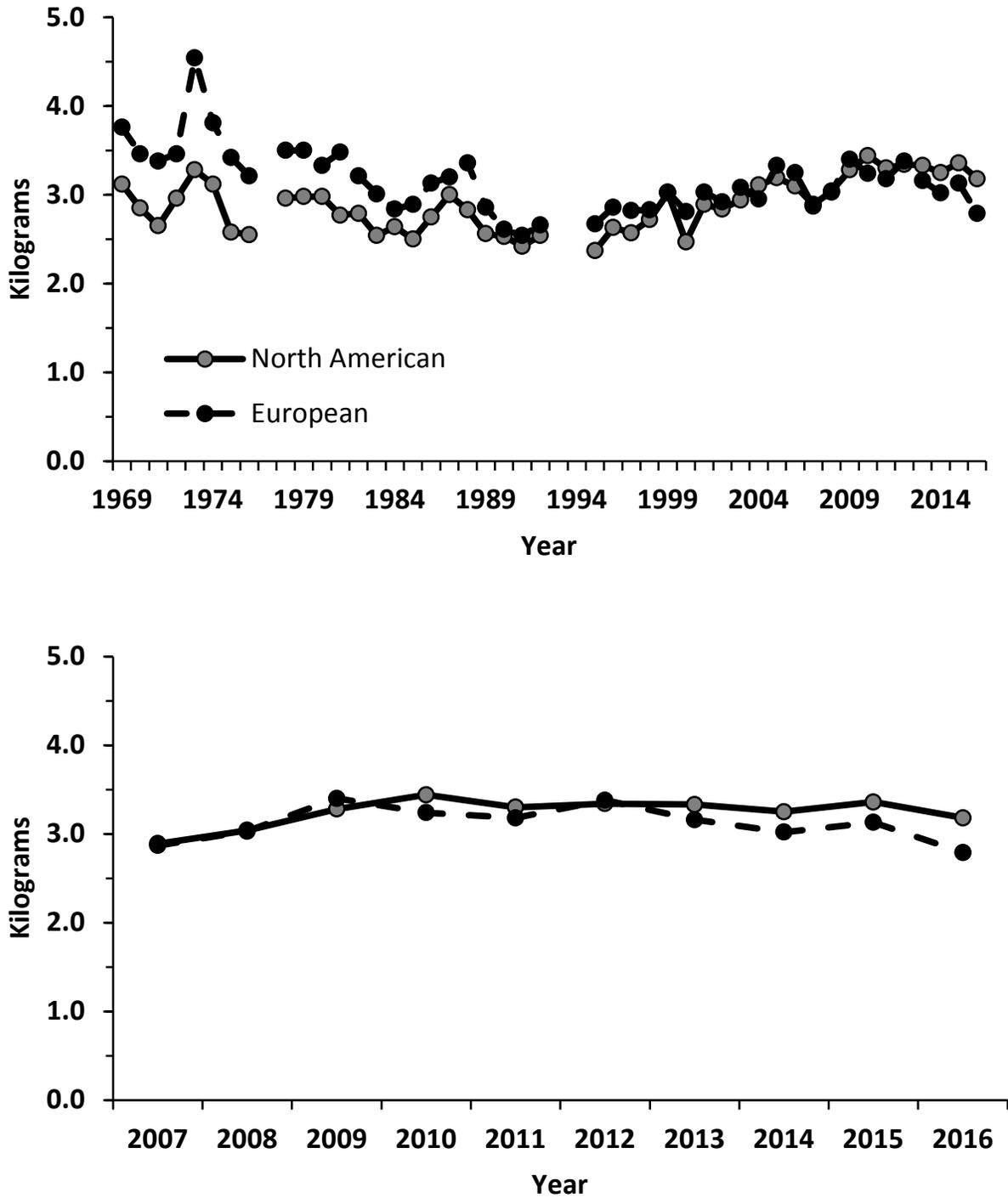


Figure 6. Mean uncorrected whole weight (kg) of European and North American 1 sea winter (fish that have spent 1 winter at sea) Atlantic salmon (*Salmo salar*) sampled in West Greenland from 1969-2015 (top panel) and 2007-2016 (bottom panel).

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