Agenda Item 4.4
For Information

Council

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Report of the ICES Advisory Committee

10 NORTH ATLANTIC SALMON STOCKS Advice May 2013

10.1 Introduction

10.1.1 Main tasks

At its 2012 Statutory Meeting, ICES resolved (C. Res. 2012/2/ACOM09) that the **Working Group on North Atlantic Salmon** [WGNAS] (chaired by: Ian Russell, UK) will meet at ICES HQ, 3 April–12 April 2013 to consider questions posed to ICES by the North Atlantic Salmon Conservation Organization (NASCO).

The sections of the report which provide the responses to the terms of reference are identified below.

a)	With respect to Atlantic salmon in the North Atlantic area:	Section 10.1
i)	provide an overview of salmon catches and landings, including unreported catches by country, catch and release, and production of farmed and ranched Atlantic salmon in 2012[1];	10.1.5
ii)	report on significant new or emerging threats to, or opportunities for, salmon conservation and management[2];	10.1.6
iii)	provide a review of examples of successes and failures in wild salmon restoration and rehabilitation and develop a classification of activities which could be recommended under various conditions or threats to the persistence of populations;	10.1.7
iv)	advise on the potential threats to Atlantic salmon from exotic salmonids, including brown trout and rainbow trout where appropriate;	10.1.8
v)	provide a compilation of tag releases by country in 2012;	10.1.10
vi)	identify relevant data deficiencies, monitoring needs, and research requirements. Where relevant suggest improvement for the revision of the DCF, to be taken into account by WKESDCF.	10.1.13

b)	With respect to Atlantic salmon in the Northeast Atlantic Commission area:	Section 10.2
i)	describe the key events of the 2012 fisheries[3];	10.2.1
ii)	review and report on the development of age-specific stock conservation limits;	10.2.1
iii)	describe the status of the stocks;	10.2.1
iv)	further develop a risk-based framework for the provision of catch advice for the Faroese salmon fishery, reporting on the implications of selecting different numbers of management units[4];	10.1.11
*In the event that NASCO informs ICES that the Framework of Indicators (FWI) indicates that re-assessment is required: **		
v)	provide catch options or alternative management advice for 2013–2016, with an assessment of risks relative to the objective of exceeding stock conservation limits and advise on the implications of these options for stock rebuilding[5];	10.2.1
vi)	update the Framework of Indicators used to identify any significant change in the previously provided multi-annual management advice.	10.1.12

c) With respect to Atlantic salmon in the North American Commission area:	Section 10.3
i) describe the key events of the 2012 fisheries (including the fishery at St Pierre and Miquelon)[3];	10.3.1
ii) update age-specific stock conservation limits based on new information as available;	10.3.1
iii) describe the status of the stocks;	10.3.1
*In the event that NASCO informs ICES that the Framework of Indicators (FWI) indicates that re-assessment is required: **	
iv) provide catch options or alternative management advice for 2013–2016 with an assessment of risks relative to the objective of exceeding stock conservation limits and advise on the implications of these options for stock rebuilding[5];	
v) update the Framework of Indicators used to identify any significant change in the previously provided multi-annual management advice.	

d) With respect to Atlantic salmon in the West Greenland Commission area:	Section 10.4
i) describe the key events of the 2012 fisheries[3];	10.4.1
ii) Describe the status of the stocks[6];	10.4.1
*In the event that NASCO informs ICES that the Framework of Indicators (FWI) indicates that re-assessment is required: **	
iii) provide catch options or alternative management advice for 2013–2015 with an assessment of risk relative to the objective of exceeding stock conservation limits and advise on the implications of these options for stock rebuilding[5];	
iv) update the Framework of Indicators used to identify any significant change in the previously provided multi-annual management advice.	

Notes:

1. With regard to question a) i, for the estimates of unreported catch the information provided should, where possible, indicate the location of the unreported catch in the following categories: in-river, estuarine, and coastal. Numbers of salmon caught and released in recreational fisheries should be provided.
2. With regard to question a) ii, ICES is requested to include reports on any significant advances in understanding of the biology of Atlantic salmon that is pertinent to NASCO, including information on any new research into the migration and distribution of salmon at sea and the potential implications of climate change for salmon management.
3. In the responses to questions b) i, c) i and d) i, ICES is asked to provide details of catch, gear, effort, composition, and origin of the catch and rates of exploitation. For homewater fisheries, the information provided should indicate the location of the catch in the following categories: in-river, estuarine, and coastal. Any new information on non-catch fishing mortality of the salmon gear used, on the bycatch of other species in salmon gear, and on the bycatch of salmon in any existing and new fisheries for other species is also requested.
4. In response to question b) iv, ICES is asked to advise on the limitations for defining management units smaller than the current NEAC stock complexes, the implications of applying probabilities of achieving CLs to separate management units versus the use of simultaneous probabilities and the choice of risk levels for achieving management objectives.
5. In response to questions b) v, c) iv and d) iii, provide a detailed explanation and critical examination of any changes to the models used to provide catch advice and report on any developments in relation to incorporating environmental variables in these models.
6. In response to question d) ii, ICES is requested to provide a brief summary of the status of North American and Northeast Atlantic salmon stocks. The detailed information on the status of these stocks should be provided in response to questions b) iii and c) iii.

*** The aim should be for NASCO to inform ICES by 31 January of the outcome of utilizing the FWI.**

In response to the terms of reference, the Working Group considered 38 Working Documents. A complete list of acronyms and abbreviations used in this report is provided in Annex 1. References cited are given in Annex 2.

10.1.2 Management framework for salmon in the North Atlantic

The advice generated by ICES is in response to terms of reference posed by the North Atlantic Salmon Conservation Organization (NASCO), pursuant to its role in international management of salmon. NASCO was set up in 1984 by international convention (the Convention for the Conservation of Salmon in the North Atlantic Ocean), with a responsibility for the conservation, restoration, enhancement, and rational management of wild salmon in the North Atlantic. Although sovereign states retain their role in the regulation of salmon fisheries for salmon originating in their own rivers, distant-water salmon fisheries, such as those at Greenland and Faroes, which take salmon originating in rivers of another Party, are regulated by NASCO under the terms of the Convention. NASCO now has six Parties that are signatories to the Convention, including the EU which represents its Member States.

NASCO discharges these responsibilities via the three Commission areas shown below:

10.1.3 Management objectives

NASCO has identified the primary management objective of that organization as:

"To contribute through consultation and cooperation to the conservation, restoration, enhancement and rational management of salmon stocks taking into account the best scientific advice available".

NASCO further stated that "the Agreement on the Adoption of a Precautionary Approach states that an objective for the management of salmon fisheries is to provide the diversity and abundance of salmon stocks", and NASCO's Standing Committee on the Precautionary Approach interpreted this as being "to maintain both the productive capacity and diversity of salmon stocks" (NASCO, 1998).

NASCO's Action Plan for Application of the Precautionary Approach (NASCO, 1998) provides an interpretation of how this is to be achieved:

"Management measures should be aimed at maintaining all stocks above their conservation limits by the use of management targets".

"Socio-economic factors could be taken into account in applying the precautionary approach to fisheries management issues".

"The precautionary approach is an integrated approach that requires, *inter alia*, that stock rebuilding programmes (including as appropriate, habitat improvements, stock enhancement, and fishery management actions) be developed for stocks that are below conservation limits".

10.1.4 Reference points and application of precaution

Atlantic salmon has characteristics of short-lived fish stocks; mature abundance is sensitive to annual recruitment because there are only few age groups in the adult spawning stock. Incoming recruitment is often the main component of the fishable stock. For such fish stocks, the ICES maximum sustainable yield (MSY) approach is aimed at achieving a target escapement (MSY $B_{escapement}$, the amount of biomass left to spawn). No catch should be allowed unless this escapement can be achieved. The escapement level should be set so there is a low risk of future recruitment being impaired, similar to the basis for estimating B_{pa} in the precautionary approach. In short-lived stocks, where most of the annual surplus production is from recruitment (not growth), MSY $B_{escapement}$ and B_{pa} might be expected to be similar and B_{pa} is a reasonable initial estimate of MSY $B_{escapement}$.

ICES considers that to be consistent with the MSY and the precautionary approach, fisheries should only take place on salmon from rivers where stocks have been shown to be at full reproductive capacity. Furthermore, due to differences in status of individual stocks within stock complexes, mixed-stock fisheries present particular threats.

Conservation limits (CLs) for North Atlantic salmon stock complexes have been defined by ICES as the level of stock (number of spawners) that will achieve long-term average maximum sustainable yield. In many regions of North America, the CLs are calculated as the number of spawners required to fully seed the wetted area of the rivers. In some regions of Europe, pseudo stock–recruitment observations are used to calculate a hockey-stick relationship, with the inflection point defining the national CLs. In the remaining regions, the CLs are calculated as the number of spawners that will achieve long-term average MSY, as derived from the adult-to-adult stock and recruitment relationship (Ricker, 1975; ICES, 1993). NASCO has adopted the region-specific CLs (NASCO, 1998). These CLs are limit reference points (S_{lim}); having populations fall below these limits should be avoided with high probability.

Management targets have not yet been defined for all North Atlantic salmon stocks. When these have been defined they will play an important role in ICES advice.

Where there are no specific management objectives for the assessment of the status of stocks and advice on management of national components and geographical groupings of the stock complexes in the NEAC area, the following shall apply:

ICES considers that if the lower bound of the 90% confidence interval of the current estimate of spawners is above the CL, then the stock is at full reproductive capacity (equivalent to a probability of at least 95% of meeting the CL).

When the lower bound of the confidence interval is below the CL, but the midpoint is above, then ICES considers the stock to be at risk of suffering reduced reproductive capacity.

Finally, when the midpoint is below the CL, ICES considers the stock to suffer reduced reproductive capacity.

Therefore, stocks are regarded by ICES as being at full reproductive capacity only if they are above the MSY $B_{escapement}$ (or CLs).

For catch advice on the mixed-stock fishery at West Greenland (catching non-maturing 1SW fish from North America and non-maturing 1SW fish from Southern NEAC), NASCO has adopted a risk level (probability) of 75% of simultaneous attainment of management objectives in seven geographic regions (ICES, 2003) as part of an agreed management plan. NASCO uses the same approach for catch advice for the mixed-stock fishery affecting six geographic regions for the North American stock complex. ICES notes that the choice of a 75% risk (probability) for simultaneous attainment of six or seven stock units is approximately equivalent to a 95% probability of attainment for each individual unit.

10.1.5 Catches of North Atlantic salmon

10.1.5.1 Nominal catches of salmon

Figure 10.1.5.1 displays reported total nominal catch of salmon in four North Atlantic regions during 1960–2012. Nominal catches of salmon reported for countries in the North Atlantic for 1960–2012 are given in Table 10.1.5.1. Catch statistics in the North Atlantic include fish farm escapees, and in some Northeast Atlantic countries also ranched fish.

Icelandic catches have traditionally been split into two separate categories, wild and ranched, reflecting the fact that Iceland has been the only North Atlantic country where large-scale ranching has been undertaken with the specific intention of harvesting all returns at the release site. The release of smolts for commercial ranching purposes ceased in Iceland in 1998, but ranching for rod fisheries in two Icelandic rivers continued into 2012 (Table 10.1.5.1). While ranching does occur in some other countries, this is on a much smaller scale. Some of these operations are experimental and at others harvesting does not occur solely at the release site. The ranched component in these countries has therefore been included in the nominal catch.

Reported catches in tonnes for the three NASCO Commission Areas for 2003–2012 are provided below.

AREA	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
NEAC	2304	1978	1998	1867	1409	1533	1163	1415	1419	1240
NAC	144	164	142	140	114	162	129	156	182	136
WGC	9	15	15	22	25	26	26	40	28	33
Total	2457	2157	2156	2029	1548	1721	1318	1610	1629	1409

The provisional total nominal catch for 2012 was 1409 t, 220 t below the updated catch for 2011 (1629 t). The 2012 catch was below the average of the previous five years (1565 t), and >500 t below the average of the last ten years (1928 t).

ICES recognises that mixed-stock fisheries present particular threats to stock status. These fisheries predominantly operate in coastal areas and NASCO specifically requests that the nominal catches in homewater fisheries be partitioned according to whether the catch is taken in coastal, estuarine, or riverine areas. The 2012 nominal catch (in tonnes) was partitioned accordingly and is shown below for the NEAC and NAC Commission Areas. Figure 10.1.5.2 presents these data on a country-by-country basis. There is considerable variability in the distribution of the catch among individual countries. In most countries the majority of the catch is now taken in freshwater; the coastal catch has declined markedly.

AREA	COAST		ESTUARY		RIVER		TOTAL
	Weight	%	Weight	%	Weight	%	Weight
NEAC	369	30	49	4	823	66	1240
NAC	9	6	47	34	81	59	136

Coastal, estuarine, and riverine catch data aggregated by region are presented in Figure 10.1.5.3. In northern Europe, about half the catch has typically been taken in rivers and half in coastal waters (although there are no coastal fisheries in Iceland and Finland), with estuarine catches representing a negligible component of the catch in this area. There has been a reduction in the proportion of the catch taken in coastal waters over the last five years. In southern Europe, catches in all fishery areas have declined dramatically over the period. While coastal fisheries have historically made up the largest component of the catch, these fisheries have declined the most, reflecting widespread measures to reduce exploitation in a number of countries. In the last four years, the majority of the catch in this area has been taken in freshwater.

In North America, the total catch over the period 2000–2012 has been relatively constant. The majority of the catch in this area has been taken in riverine fisheries; the catch in coastal fisheries has been relatively small in any year (15 t or less), but has increased as a proportion of the total catch over the period.

10.1.5.2 Unreported catches

The total unreported catch in NASCO areas in 2012 was estimated to be 403 t; however, there was no estimate for Russia. The unreported catch in the North East Atlantic Commission Area in 2012 was estimated at 363 t, and that for the West Greenland and North American commission areas at 10 t and 31 t, respectively. The following table shows unreported catch by NASCO commission areas in the last ten years:

AREA	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
NEAC	719	575	605	604	465	433	317	357	382	363
NAC	118	101	85	56	-	-	16	26	29	31
WGC	10	10	10	10	10	10	10	10	10	10

The 2012 unreported catch by country is provided in Table 10.1.5.2. It has not been possible to separate the unreported catch into that taken in coastal, estuarine, and riverine areas. Over recent years efforts have been made to reduce the level of unreported catch in a number of countries (e.g. through improved reporting procedures and the introduction of carcass tagging and logbook schemes).

10.1.5.3 Catch-and-release

The practice of catch-and-release (C&R) in rod fisheries has become increasingly common as a salmon management/conservation measure in light of the widespread decline in salmon abundance in the North Atlantic. In some areas of Canada and USA, C&R has been practiced since 1984, and in more recent years it has also been widely used in many European countries, both as a result of statutory regulation and through voluntary practice.

The nominal catches do not include salmon that have been caught and released. Table 10.1.5.3 presents C&R information from 1991 to 2012 for countries that have records; C&R may also be practised in other countries while not being formally recorded. There are large differences in the percentage of the total rod catch that is released: in 2012 this ranged from 14% in Norway (this is a minimum figure, as statistics were collected on a voluntary basis) to 74% in UK (Scotland), reflecting varying management practices and angler attitudes among countries. C&R rates have typically been highest in Russia (average of 84% in the five years 2004 to 2008) and are believed to have remained at this level. However, there were no obligations to report C&R fish in Russia in 2009 and records since 2010 are incomplete. Within countries, the percentage of fish released has tended to increase over time. There is also evidence from some countries that larger MSW fish are released in higher proportions than smaller fish. Overall, more than 173 000 salmon were reported to have been caught-and-released around the North Atlantic in 2012.

10.1.5.4 Farming and sea ranching of Atlantic salmon

The provisional estimate of farmed Atlantic salmon production in the North Atlantic area for 2012 is 1450 kt. The production of farmed salmon in this area has been over one million tonnes since 2009. The 2012 total represents an 8% increase from 2011 and a 30% increase on the previous five-year mean. Norway and UK (Scotland) continue to produce the majority of the farmed salmon in the North Atlantic (79% and 11%, respectively). Farmed salmon production in 2012 was above the previous five-year average in all countries.

World-wide production of farmed Atlantic salmon has been in excess of one million tonnes since 2002. It is difficult to source reliable production figures for all countries outside the North Atlantic area and it has been necessary to use 2011 estimates for some countries in deriving a world-wide estimate for 2012. Noting this caveat, total production in 2012 is provisionally estimated at around 1961 kt (Figure 10.1.5.4), a 6% increase on 2011. Production outside the North Atlantic is estimated to have accounted for 26% of the total in 2012 (up from 20% in 2011). Production outside the North Atlantic is still dominated by Chile.

The world-wide production of farmed Atlantic salmon in 2012 was over 1300 times the reported nominal catch of Atlantic salmon in the North Atlantic.

The total harvest of ranched Atlantic salmon in countries bordering the North Atlantic in 2012 was 12 t, all of which was taken by the Icelandic ranched rod fisheries (Figure 10.1.5.5). Small catches of ranched fish from experimental projects were also known for Ireland, but no data were available for 2012.

10.1.6 NASCO has asked ICES to report on significant, new, or emerging threats to, or oppor tunities for, salmon conservation and management.

10.1.6.1 Dam Impact Analysis model for Atlantic salmon in the Penobscot River, Maine

The Dam Impact Analysis (DIA) model is a population viability analysis that was developed to help better understand the impacts of dams on the production potential of Atlantic salmon (Nieland *et al.*, 2013). Dams have been identified as a major contributor to the historical decline and current low abundance of salmon in the Gulf of Maine Distinct Population Segment, which was first listed as endangered in 2000 and then expanded in 2009. The DIA model specifically simulates the interactions of Atlantic salmon and 15 hydroelectric dams in the Penobscot River watershed in Maine, USA.

A life history modeling approach was undertaken to incorporate life stage-specific information for Atlantic salmon and simulate the life cycle of Atlantic salmon in the Penobscot River. Several modeling scenarios were run to reflect recent conditions in the Penobscot River (i.e. prior to the planned removal of specific dams) as well as possible future conditions. Adult abundance, distribution of adults throughout the watershed, and number and proportion of smolts killed by dam-induced mortality were used as performance metrics for each scenario.

The modeled population of Atlantic salmon in the Penobscot River decreased in abundance and distribution when DIA model inputs were set to reflect recent conditions, whereas abundance increased and Atlantic salmon remained distributed throughout the Penobscot River watershed when marine and freshwater survival rates were increased. The production potential of Atlantic salmon was also affected by mainstem dams more than tributary dams. Sensitivity analyses were performed on all input values to determine which model inputs had the greatest impact on the results. The DIA model results were most sensitive to the marine survival and downstream dam passage survival rates.

The DIA model can project changes in future abundance and can provide information about model inputs that can help inform recovery efforts for the modeled population. The model is not meant to predict absolute abundance, distribution, or mortality but should instead be used to evaluate the relative changes in the Penobscot River population of Atlantic salmon under different modeling scenarios.

10.1.6.2 Marine influences on North American Atlantic salmon populations

The population abundance and marine survival rates of Atlantic salmon have declined throughout their range, and limitations in our understanding of factors responsible for these declines have been widely recognised (Hansen *et al.*, 2012). A new study investigating Atlantic salmon population declines across North America and how these declines have been shaped by marine ecosystem conditions has recently been completed (Mills *et al.*, 2013). The study confirmed, through dynamic factor analysis, that abundance and productivity of Atlantic salmon populations changed in a coherent manner across major regions of North America from the US to Labrador. This is consistent with common factors acting on the marine portion of their life and points towards a likely shift in marine survival and strong influence of marine conditions.

Major changes in Atlantic salmon population characteristics were detected after 1990 and 1997 based on a chronological cluster analysis (Figure 10.1.6.2.1), and these population shifts could be linked to changes in climate, physical, and biological conditions in the marine ecosystem. The decline in salmon abundance after 1990 was preceded by a series of changes across multiple levels of the ecosystem, including climate indices (i.e. AMO and NAO); physical conditions such as temperature and salinity; and biological characteristics such as phytoplankton abundance, zooplankton community composition, and capelin size. A subsequent shift in salmon productivity in 1997 followed an unusually low NAO event in 1996.

Pairwise associations between North American Atlantic salmon population trends and a suite of climate, physical, and biological factors were further investigated to understand how marine ecosystem changes may be related to Atlantic salmon. Results of these analyses indicate that climate conditions can be directly linked to the abundance and productivity of salmon populations, but that many climate and physical influences also act indirectly through lower biological trophic levels. The strongest correlations were between salmon and capelin, sea surface temperature, and zooplankton. These results suggest that poor trophic conditions and warming water temperatures throughout their marine habitat area are constraining productivity and recovery of North American Atlantic salmon populations.

10.1.6.3 West Greenland foraging ecology and implications for survival

Declining Atlantic salmon populations throughout the species range, despite diverse population structures and management regimes, suggests reduced productivity and survival during the marine phase. During this phase, fish from North America and Europe congregate at common feeding grounds (e.g. the Norwegian Sea, the Labrador Sea, West Greenland, etc.) to consume abundant energy-rich prey that promote rapid growth and sexual maturity. Stomach samples were collected from a total of 1345 salmon in 2006–2007 and in 2009–2011 (as part of SALSEA West Greenland) from various communities along the west coast of Greenland. While annual variations in the stomach content weights and composition were documented, Atlantic salmon consumed primarily capelin and *Themisto* sp. (an amphipod); a finding consistent with historical data collected from the offshore waters of West Greenland during the 1960s.

Analysis of the standardized energy content of the prey in the stomachs of individual fish indicated substantial variability between years. Since capelin is an important resource for Atlantic salmon, and the quality of this resource is decreasing (Figure 10.1.6.3.1), effects on potential 2SW spawners from populations that feed on capelin at Greenland may be manifest. These data provide insights into the current foraging conditions off West Greenland. They also complement the documentation of the sharp stock productivity reduction that began in the early 1990s, and provide an opportunity to explore various hypotheses to examine the role energy resources play in the viability of various life history strategies in the marine phase.

10.1.6.4 Tracking and acoustic tagging studies in Greenland and Canada

Tagging adult Atlantic salmon at West Greenland with pop-up archival satellite tags (PSATs)

Return rates of the 2SW component of Atlantic salmon populations are decreasing, especially at southern latitudes and on both sides of the North Atlantic. These fish are present at West Greenland, foraging during the summer/autumn, prior to initiating a return migration to homewaters to spawn. To investigate the migration dynamics of this population over the autumn and winter, pop-up archival satellite tags (PSATs) were attached to 25 Atlantic salmon near Nuuk, West Greenland in September 2010–2012. Preliminary results suggest that two tags remained on the fish until the programmed pop-off date (April 1), three fish were predated, one tag popped off due to exceeding the emergency pop-off depth, 7 popped off for unknown reasons, and 12 did not transmit any data.

Detailed information on migration routes, migration rates, environmental conditions experienced, and habitat preferences can be obtained from the data gathered. For example, data from one fish tagged in 2010 for which the tag popped off at the full-term programmed date indicated that the fish moved north to Disko Bay immediately after tagging and its swimming depth was constrained while it remained over the shelf waters (Figure 10.1.6.4.1). After migrating into the Labrador Sea in February (as the sea ice progressed south or after it entered < 0°C water) it began to dive to depths exceeding 750 m, possibly in search of food.

Three incidences of likely predation were also inferred based on data received from the tags. Evidence of predation was determined based on significant changes in the dive profiles, recorded temperatures and the absence of any light intensity records (the tags would not detect any light if they were in the stomach of an animal). Based on these data, it is hypothesized that a Greenland shark, a large Atlantic halibut, and an unknown predator consumed three of the tagged salmon.

PSAT technology is generally suitable for work with Atlantic salmon of the size range at West Greenland. Atlantic salmon were successfully captured, tagged, released, and tracked over the winter. High quality data on movement patterns, migration behaviors, winter locations, and conditions experienced at winter habitats were collected. Based on some of these preliminary findings, and because of the cost of the equipment, refining the catch methods to reduce stress, tagging techniques, and determining reasons for failures appears to be critical for long-term success of tagging. These data are not obtainable by other means and may provide valuable information related to a critical understudied life stage of the species, aiding in the conservation and management of Atlantic salmon across the Northwest Atlantic.

Acoustic tracking update for Canada

Ongoing projects, led by the Atlantic Salmon Federation (ASF), provided updated information on the estuarine and marine survival of tagged Atlantic salmon released in rivers of the Gulf of St Lawrence. A total of 291 smolts from four rivers in Canada (42 St Jean, 64 Cascapedia, 105 Restigouche, 80 Miramichi) and 35 Miramichi kelts were sonically tagged between April and June 2012. Of the 35 kelts, 10 were tagged with archival pop-up tags set to release after four months.

The proportion of smolts detected (apparent survival) in 2012 from freshwater release points to the heads of tide, through the estuary and out of the Strait of Belle Isle was similar to previous years for the Cascapedia, Restigouche, and Miramichi rivers; as in previous years few St Jean fish were detected. As previously, smolts and kelts exited the Strait of Belle Isle at the same time. However, in 2012, this occurred approximately two weeks earlier (the last week of June and first week of July).

The detector array across the Cabot Strait, between Cape Breton, Nova Scotia and Southwest Newfoundland, was completed by the OCEAN Tracking Network (OTN) and functional in 2012 although few fish used this exit from the Gulf of St Lawrence (one Miramchi kelt in late May and one Miramichi smolt in mid-June). The satellite archival pop-up tags functioned well in 2012, with information from 7 of the 9 that left the Miramichi River being recovered. This information is still being analysed; however, preliminary results show evidence of predation on a kelt within the Gulf of St Lawrence and one fish leaving the Gulf of St Lawrence through the Strait of Belle Isle.

For the first time in 2012, new modes of detection of acoustically tagged salmon were investigated in the Gulf of St Lawrence in a collaboration with the OTN and DFO. Bioprobe receivers were mounted on grey seals by DFO; these mammals return annually to Sable Island and at least one seal receiver had detected at least two of ASF's tagged salmon within the Gulf of St Lawrence. The OTN also released a Wave Glider into the Gulf of St Lawrence along the west coast of Newfoundland in late June and the movements of the Wave Glider were controlled to pass through areas expected to contain acoustically tagged smolts and kelts on their migration through the Strait of Belle Isle. Detection of at least one of these fish did occur; however, the timing of the Wave Glider path may not have coincided with migration due to this occurring earlier.

Modelling inter-stage survival rates and detection probabilities for acoustically tracked Atlantic salmon smolts and post-smolts: model, assumptions, diagnostics, considerations for planning experiments

Studies to partition marine mortality of salmon among different phases of the marine migration remain a priority and can provide information on key parameters of salmon life history, including inter-stage survival rates, migration rates, and behavior.

A number of recent publications have used these technologies to address questions of marine mortality from estuarine and nearshore waters to large bays. Investigations on the Narraguagus River (Maine, USA) based on six years of monitoring (1997–1999 and 2002–2004) smolt survival in the Gulf of Maine (Kocik *et al.*, 2009) indicated that for every 100 smolts exiting the river, 62–74 reached the Inner Bay, 41–54 reached the Middle Bay, and 36–47 reached the Outer Bay. While mortality decreased in the marine environment, analysis indicated that less than half the smolts survived the approximately 10-day period of migration from the river to the Gulf of Maine.

Dempson *et al*. (2011) reported on a three-year initiative to track Atlantic salmon and determine migration route, residency time, and survival in a 50 km long estuarine fjord located on the southern coast of Newfoundland, Canada. Migrating smolts from two rivers in the study used different routes to reach the outer areas of the fjord. Many smolts were resident for periods of 4–8 weeks, moving back and forth in the outer part of the fjord where maximum water depths range from 300 to 700 m. Survival in the estuary zone was greater for smolts with prolonged residency in estuarine habitat. Overall smolt survival to the fjord exit was moderately high (54–85%), indicating that the initial phase of migration did not coincide with a period of unusually high mortality.

Halfyard *et al*. (2012) used acoustic tracking technologies to estimate mortality rates of Atlantic salmon smolts from four river systems in the Southern Uplands area of Nova Scotia (Canada). They reported that the cumulative survival through the river, inner estuary, outer estuary, and bay habitats averaged 59.6% (range = 39.4–73.5%).

Lacroix (2013) reported on research to describe the migration of wild and hatchery Atlantic salmon post-smolts across the Bay of Fundy (BoF), Canada. This followed on previous publications (Lacroix *et al*., 2005; Lacroix, 2008) to estimate survivals of smolt and post-smolts from the same area.

Modelling detection and survival probabilities

Kocik *et al*. (2009) and Dempson *et al*. (2011) estimated detection and survival probabilities of tagged smolts using a variant of a Cormac–Jolly–Seber capture and recapture model in a program called MARK (White and Burnham, 1999). Lacroix (2008) and Halfyard *et al*. (2012) estimated detection probabilities independently of the tagged smolts and subsequently estimated survival probabilities outside a formal model structure.

ICES was provided with an example of modelling individual fish detection data, obtained by tagging smolts from three rivers over a six-year period and detecting them at arrays more than 800 km from the point of release. A Bayesian state–space model variant of the Cormac–Jolly–Seber model described by Gimenez *et al*. (2007) and Royle (2008) was used.

This model provides a means of disentangling the imperfect detection (p) of tagged smolts on the sonic arrays from apparent survival (Ø) during their out migration.The state process (survival) is represented by a binary variable z(i,j), which takes the value one if fish i is alive at the end of the j migration leg and zero otherwise, with a probability of survival (Øj) that is similar for individual fish within a stage of migration *j*.

$$z[i,j] \mid z[i,j-1], \text{Ø}_j \sim \text{Bernoulli}(z[i,j-1]\ \text{Ø}_j)$$

The observation process (detection) is also modeled by a binary variable, where x(i,j) (observation) represents fish i being detected at array j conditional on z(i,j) (i.e. whether the fish is alive to be detected at array j) and the probability of detection (p_j) at the array for the migration leg j.

$$x[i,j] \mid z[i,j], p_j \sim \text{Bernoulli}(z[i,j]\ p_j)$$

In the first analysis, an annual model was considered in which the probabilities of detection and survival were assumed independent among rivers, years, and detection arrays (Figure 10.1.6.4.2). In the second analysis, a hierarchical structure was placed on the probabilities of detection at the arrays. In the hierarchical model, the probabilities of detection were considered exchangeable among years within a river, and among years and rivers for those that share a common bay or exit farther out at sea.

Data collected by the Atlantic Salmon Federation, obtained by tagging smolts from three rivers over a six-year period and detecting them at arrays more than 800 km from the point of release, were used to illustrate how these data could be analysed using the Bayesian state–space model formulation. A total of 1279 smolts were tagged and released with acoustic transmitters from three rivers over a period of six years. Acoustic arrays were monitored at the head of tide of each river, at the exit to the Gulf of St Lawrence (two outer arrays), and at the Strait of Belle Isle (one array) leading to the Labrador Sea.

The estimates of the probabilities of detection at each array for the annual model and for the hierarchical implementation of the Bayesian state–space model are shown in Figure 10.1.6.4.3. The most relevant features from these results are:

- There is large annual variation in the probabilities of detection among years within a river at the head of tide arrays and among years at arrays exiting to the Gulf of St Lawrence.
- The uncertainties in the estimation of probabilities of detection increase as the monitoring proceeds from the head of tide arrays, to exit to the bays to the Strait of Belle Isle. This is due mostly to the lower number of detections of smolts at the progressively further downstream arrays associated in part with fewer numbers of tagged smolts available for detection (fish die over time).
- The probability of detections at the last array at the Strait of Belle Isle are confounded with the probabilities of survival through the Gulf of St Lawrence and cannot be appropriately estimated. The range of detection probabilities vary from a high of 1.0 (perfect detection), assuming that the total fish detected corresponds to the total fish surviving the migration from the exit of the bays, to lows that correspond to the ratio of detections relative to the estimated number of smolts alive at the previous detection array (100% survival through the Gulf of St Lawrence).
- Assuming some degree of exchangeability between the probabilities of detection results in shrinkage (reduced uncertainty) and slight changes in expected values of the annual and river-specific detection probabilities at the head of tide and bay exit arrays. The posterior distribution of the Strait of Belle Isle array under the hierarchical distribution is the mean of the individual year and river distributions and the confusion between the probabilities of detection and survival persists.

The posterior distributions of the probabilities of detection at the Strait of Belle Isle array are entirely determined by the prior assumptions for this parameter. However, the probabilities of detection and the estimates of survival at all the prior/upstream arrays are insensitive and unaffected by the estimates of the probability of detection at the last array.

Experience from the last ten years of research with the use of acoustic technologies to track salmon smolts provides useful guidance in the design of such experiments and the treatment of data.

- The last array, in time and/or space is the weakest point in the experimental design. It is not possible to disaggregate the probabilities of detection from the probabilities of survival unless an informative prior is used for this parameter in the model or sampling efforts to detect tagged fish are expended downstream/later in time of the last array of interest. An informative prior could be developed by independently determining the probabilities of detection using sentinel tags (tags placed or transported across various parts of the array) as was done by Halfyard *et al*. (2012). Similar work has been initiated for the Strait of Belle Isle array.
- There will inherently be more uncertainty in estimating survival rates through the extended period of migration of salmon in the ocean; the sample size will decrease over time as fish die and fewer fish remain to be detected.
- Bayesian hierarchical models provide a flexible framework for analysing multi-year, multi-array, and multi-river designs. Bayesian models are flexible and additional variables can be introduced to further explore factors

modifying detection and survival, for example by tag release group or date of release, by size of smolt, by incorporating indices of potential predators, etc.

In this example, hierarchical estimates of detection probabilities for the exit to the Miramichi Bay arrays can be used as informative priors to estimate survival rates to exit to the Gulf of St Lawrence in years when the Strait of Belle Isle array was not installed and operating (2004 to 2006).

10.1.6.5 The impact of artificial night light on Atlantic salmon fry dispersal and the onset of smolt migration

The use of artificial night light is continuing to increase both in previously unlit regions of the developing world, but also in already heavily developed countries. Different types of lights have varying spectral compositions. The most numerous current type of street lights emit light that is narrowly concentrated in the longer wavelengths of the visible spectrum, appearing yellow or orange to the eye. Modern replacement lights emit considerably more light across the visible spectrum especially at shorter wavelengths, providing high efficiency and superior colour rendering for human vision. However, these more natural whiter lights could lead to significant changes in the impact of artificial light on natural systems, particularly aquatic ecosystems where penetration through water will be increased.

In recent investigations, the timing of Atlantic salmon fry dispersal from artificial redds (Riley *et al.*, 2013; Riley *et al.*, in prep.) and the migratory timing and behaviour of wild smolts leaving their natal stream (Riley *et al.*, 2012) were compared under both control and ecologically relevant broad spectrum street-lit intensities. Fry dispersal was found to be significantly delayed in redds exposed to artifical street light (Figure 10.1.6.5.1), and on average the fry were significantly smaller on emergence. Significant delays were recorded at light intensity levels as low as 1.0 lx, over an order of magnitude below recommended street lighting levels. In addition, migration of smolts under control conditions was found to significantly (p< 0.01, n = 170) correlated with sunset. In contrast, street lighting resulted in the timing of migration being random (p = 0.11, n = 7; p = 0.76, n = 34, respectively) with respect to time of day.

The diel timing of both behaviours is considered to be a predator avoidance tactic for these critical life history stages. Thus, any alteration or disruption to these processes may have a significant impact on recruitment. Systematic investigation is needed to determine the possible extent of this problem and the light intensities at which street lamps do not affect behaviour. Such information could then be used as a management tool to identify sites where potential problems currently exist and provide evidence-based information to guide the replacement of street lamps to lessen their impact.

10.1.6.6 Stock identification of salmon caught in the Faroes fishery

Salmon originating in rivers from both northern and southern European stock complexes have been exploited in the longline fishery that operated within the Faroes EEZ in the 1980s and 1990s, and there is a potential for this fishery to reopen if stocks recover. NASCO has asked ICES to develop a risk-based framework for the provision of catch advice for this fishery (Section 10.1.11), but this has been complicated by lack of data on the stocks exploited by the fishery. Advances in microsatellite DNA profiling methodologies and statistical genetics approaches, including work undertaken under the SALSEA–Merge programme, provide the opportunity to obtain estimates of the stock composition in the fishery area for one or more baseline years.

Preliminary results were reported from a genetic study of salmon scales (approximately 750 samples) collected in the Faroes salmon fishery in the 1980 and 1990s. Initial results have shown significant degradation of the DNA in some of the samples, but much better results in others. Further investigations are being undertaken into the cause of the degradation, and initial trials with modified protocols suggest that it may be possible to improve the extraction of useable DNA. Although no assignment analysis has been undertaken yet, a number of samples have been identified with alleles that are only expected to occur in North American salmon.

10.1.6.7 Update on EU project ECOKNOWS

ECOKNOWS is an EU 7th framework project running from 2009 to 2014, comprising thirteen research organizations with the University of Helsinki (Finland) leading. The project aim is to develop methodologies using Bayesian approaches. Developments are demonstrated in case studies, one of which is a salmon case study. In this study the salmon stock assessment models used in the Baltic (in WGBAST) and North Atlantic (in WGNAS) areas are being compared to harmonize the two approaches into comparable structures, mathematically representing salmon life cycles with freshwater and sea age cohorts. Both approaches are being developed to improve the use of ecological knowledge and available data in assessments and improve the predictive ability of models.

Models are being developed for North Atlantic salmon stocks that have the potential to provide improvements to the existing pre-fishery abundance (PFA) stock assessment models. An integrated life cycle model has been developed in a hierarchical Bayesian framework, and it is hoped this approach will facilitate the harmonization of stock assessment models used in the Baltic and North Atlantic. One of the main deliverables will be progress towards embedding Atlantic salmon stock assessment at broad ocean scales within an integrated Bayesian life cycle modelling framework consisting of two main components, as outlined below.

An integrated life cycle model as an improvement to PFA modelling

A life cycle model has been developed in a hierarchical Bayesian modelling framework. The existing biological and ecological knowledge on Atlantic salmon demography and population dynamics is first integrated into an age and stage-based life cycle population dynamic model, which explicitly separates the freshwater (egg-to-smolt) and marine phases (smolt-to-return), and incorporates the variability of life histories (river and sea ages). The marine phase accounts for natural and fishing mortality, and captures the sequential fisheries along the migration routes, including high seas, coastal and estuarine, and freshwater fisheries. This body of prior knowledge forms the prior about the population dynamics, which is then updated through the model with assimilation of the available data.

The framework offers potential improvements to the PFA stock assessment approach. The current PFA models mainly rely on a stock–recruitment concept that considers a statistical relationship between a spawning potential (lagged eggs) and a recruitment variable (PFA), both derived from the same data sources (estimates of returns based on home water catches) by a mixture of forward (lagged eggs) and backward (run reconstruction) approaches. The freshwater phase is not explicitly represented in the model. More generally, many demographic hypotheses are obscured within the data assimilation procedure, making it difficult to assess how changes in models or data may impact the results.

The new modelling approach makes it easier to assess the consequences of any changes in the data and model structure. Different demographic hypotheses can be tested without changing the data assimilation scheme, and this would also offer multiple possibilities to extend the model by adding more sources of data (e.g. data about egg-to-smolt survival, post-smolt mark–recapture data, environmental variables). As a critical improvement to the PFA models, the life cycle model explicitly separates the freshwater and the marine phases. This allows the effects of the freshwater and marine phases in the recruitment process to be separated, instead of considering a single productivity parameter that aggregates demographic processes of the different impacts encountered during the freshwater phase (from egg to smolt) and the first months of the post-smolt marine phase.

To illustrate the potential of the approach, the model has been applied to the stock complex of Eastern Scotland, the largest regional component of the southern NEAC stock complex. The model was fitted to the same data as used in the current PFA models. In addition to the hypotheses made in the current PFA model, the flexibility of the approach has been illustrated by testing different demographic hypotheses.

- Density dependence in the freshwater phase has been considered by introducing a Beverton–Holt egg-to-smolt survival. This introduced non-linearity in the dynamics and modified the inferences made on the smolt-to-PFA survival (marine productivity). Indeed, the fluctuations in number of eggs spawned over the time-series induced fluctuations in the egg-to-smolt survival rate, which is balanced by changes in the smolt-to-PFA survival relationship. Hence, considering density dependence in the freshwater phase leads to a different time-series of egg-to-smolt survival estimates. This may in turn alter the interpretation of changes in marine productivity and may also affect forecasts.

- The model was also used to contrast two hypotheses for the decline in return rates of 2SW fish: a constant natural mortality rate after the PFA stage and an increase in the proportion maturing (current hypothesis in PFA models); or an increase in the natural mortality rate of 2SW fish relative to 1SW, and a constant proportion maturing. Changing from one hypothesis to the other has no consequence on estimates of smolt return rates, but it supposes different demographic processes. It may also have management implications as a higher mortality on 2SW fish would result in a different risk to stock abundance in homewaters from high seas fisheries.

Proposed further work includes: (i) building a hierarchical model to jointly analyse the dynamics for all regions comprising the southern NEAC stock complex; (ii) enhancing the validation of the available data. Such a model has the potential to improve knowledge about the biology and ecology of Atlantic salmon. In particular, future development will consist of including region-specific egg-to-smolt productivity parameters derived from meta-analyses based on index rivers. Such a model has the potential to provide tools for assessing the effect of management measures on mixed-stock high seas fisheries.

A meta-analysis of egg-to-smolt survival

A meta-analysis of egg-to-smolt relationships for Atlantic salmon has also been carried out. Time-series of egg-to-smolt data on 21 index rivers across the Atlantic salmon range (12 rivers from North America; 9 rivers in Europe), together with several covariates associated with the index rivers, were compiled for this study:

- Total egg deposition for each cohort, derived from estimates of the number of returning spawners combined with estimates of proportion of sea age classes, proportion of females, and fecundity of each sea age class;

- The total smolt production by cohort, including age structure of the smolts;

- Associated covariates for each river: latitude (continuous), longitude (categorical with two groups, east and west side of the Atlantic ocean), wetted and lacustrine area accessible to salmon.

The meta-analysis was carried out in a hierarchical Bayesian model. The classical Beverton–Holt model was revisited through the explicit parameterisation in terms of density-independent and density-dependent mortality rates. The duration of the freshwater phase (mean age of smolt, specific to each river) is explicitly used as a covariate. A partially exchangeable hierarchical model was built to incorporate covariates (such as the longitude and the latitude) to capture part of the between-river variability.

Results highlight large between river variability in both the density-independent and density-dependent mortality rates (Figure 10.1.6.7.1). Latitude and longitude explain a great part of this variability in the density-dependent mortality rate. No useful covariates were found, however, to explain the variability in the density-dependent mortality rates. This approach offers an efficient framework to predict the parameters of density-dependent survival (and the associated uncertainty) for any new river for which the associated covariates of latitude, longitude, wetted area, and mean smolt age are known.

Outcomes of this study offer useful prior information about freshwater productivity, which may be worked into the integrated life cycle model described above which is being developed in parallel to this process.

10.1.6.8 Diseases and parasites

Red vent syndrome

Over recent years, there have been reports from a number of countries in the NEAC and NAC areas of salmon returning to rivers with swollen and/or bleeding vents. The condition, known as red vent syndrome (RVS or Anasakiasis), has been noted since 2005, and has been linked to the presence of a nematode worm, *Anisakis simplex* (Beck *et al*., 2008). This is a common parasite of marine fish and is also found in migratory species. However, while the larval nematode stages in fish are usually found spirally coiled on the mesenteries, internal organs, and less frequently in the somatic muscle of host fish, their presence in the muscle and connective tissue surrounding the vents of Atlantic salmon is unusual. The reason for their occurrence in the vents of migrating wild salmon, and whether this might be linked to possible environmental factors or to changes in the numbers of prey species (intermediate hosts of the parasite) or marine mammals (final hosts), remains unclear.

A number of regions within the NEAC stock complex observed a notable increase in the incidence of salmon with RVS during 2007 (ICES, 2008a), but levels have been lower in some NEAC countries since 2008 and evidence from rivers in UK (England & Wales), Ireland and France suggests a further reduction in 2012.

There is no clear indication that RVS affects either the survival of the fish or their spawning success. Affected fish have been taken for use as broodstock in a number of countries, successfully stripped of their eggs, and these have developed normally in hatcheries. Recent results have also demonstrated that affected vents showed signs of progressive healing in freshwater, suggesting that the time when a fish is examined for RVS, relative to its period of in-river residence, is likely to influence perceptions about the prevalence of the condition. This is consistent with the lower incidence of RVS in fish sampled in tributaries or collected as broodstock compared with fish sampled in fish traps close to the head of tide.

Monitoring of sea lice burdens on wild returning adult Atlantic salmon

There remains a paucity of studies of sea lice prevalence and intensity on Atlantic salmon in areas prior to the development of aquaculture and in areas presently without aquaculture. Powell *et al.* (1999) reported on prevalence and abundance of sea lice on Atlantic salmon monitored at a fishway near the head of tide in the Penobscot River (USA), as the aquaculture industry was developing in the area. Bjørn *et al.* (2001) report on the prevalence and abundance of sea lice on Atlantic salmon sampled from catches in various coastal and inshore fisheries in Norway from June and July 2001. Prevalence of lice on salmon ranged from 80% to 100% and the maximum numbers varied among locations, ranging from 28 to over 1000 lice. Murray and Simpson (2006) reported on monitoring of sea lice from salmon in the estuary fishery of the River North Esk (UK (Scotland)) during 2001 to 2003; this river is distant from marine salmon farms. In this study, the mean abundance of mobile lice was six to seven per fish with a prevalence of 80–90%. Jackson *et al.* (2013) reported on population structure, prevalence, and intensity of lice from salmon sampled from the drift- and draftnet fishery catches in Ireland. The authors noted that almost all fish examined had sea lice with abundance variable both within and between years, with a maximum mean abundance of 25.8 lice per fish recorded in 2004.

Monitoring of sea lice burdens on wild returning adult Atlantic salmon from the Miramichi River, New Brunswick

Results from a monitoring programme from 2005 to 2011 that developed indices of sea lice abundance on returning Atlantic salmon to the Miramichi River were presented. The river is located in the southern Gulf of St Lawrence (Canada) where there is no marine finfish aquaculture. Salmon were captured at research and monitoring estuary trapnets operated during the entire migration period for salmon (late May to late October). Sea lice on salmon were enumerated in five abundance categories (0, 1–5, 5–15, 15–50, and >50 lice). Sea lice prevalence (percentage of fish with sea lice present) was lowest in June, increasing over the summer to generally highest levels in August although in a few years, the percentage of salmon with sea lice was higher in September. Sea lice loads, expressed as the percentage of fish in the >15 sea lice category, were highest in September with as many as 5% of the sampled fish having more than 50 lice per individual fish in some years.

The increase in sea lice infection rates on returning wild adult salmon through summer and autumn could be explained by fish that collectively return to Miramichi Bay in late spring/early summer for staging in Miramichi Bay before ascending the river in late summer and autumn are exposed to sea lice in a constrained area for a longer time. The sea lice have not been identified to species so the observed lice could be either *Lepeophtheirus salmonis* or *Caligus sp.* Despite the absence of salmonids in the brackish and saltwater portions of the Miramichi River and bay which freeze over in the winter, sea lice cycles are maintained in this area. The patterns of infection are considered to indicate a “natural” state of the association between the ectoparasite and Atlantic salmon in an area without marine salmonid aquaculture.

Monitoring of sea lice burdens on Atlantic salmon from the fishery at West Greenland

Information on the prevalence of sea lice on Atlantic salmon at West Greenland has been collected as part of the Enhanced Sampling Programme (SALSEA Greenland; ICES, 2012b). The fish processed during the Enhanced programme provide a more unbiased estimate of sea lice prevalence than the Baseline fish sampled at the local market, which were sometimes cleaned prior to sampling. Enhanced-sampled fish were purchased directly from the fishers, but may still be subject to some bias as sea lice can be removed due to abrasion against the gillnet during capture. As a result, sea lice estimates from fish harvested at Greenland should be considered minimum estimates.

Samplers were instructed to document the presence and number of sea lice on each fish sampled. Sub-samples of individual sea lice were also preserved in support of two ongoing studies: a Slice® resistance study and a population genetics study. Information on sea lice prevalence is available from 1166 fish sampled between 2009 and 2011. On average, 30% of the sampled fish had no sea lice present, approximately 50% of the individuals had 1–5 lice, 12% had 6–10 lice, and the remainder had 11 lice or more. The sea lice burden per fish ranged from 2.3 (2011) to 3.0 (2009 and 2010), with an overall burden of 2.7 lice per fish.

Summary and considerations for improving sea lice monitoring

The principal concern for sea lice originating from aquaculture relates to the impact of lice on outmigrating post-smolts which are most susceptible to these infections. It is challenging, but not impossible, to sample smolts and early post-smolt stages as they migrate to the open ocean. Monitoring of sea lice burdens on adult salmon returning to rivers could be an alternate indicator of variations in abundance of sea lice among areas and among years. However, returning adults may be more indicative of the sea lice infestations in high seas than the sea lice infection pressure experienced by the outmigrating smolts.

Although sea lice infection rates can vary among locations due to differences in biological and oceanographic conditions, monitoring of sea lice infection rates on salmon populations in areas with and without salmon farms would provide information on the relative roles of salmon farms as a source of sea lice for wild salmonids. The “natural” state of the association between sea lice and Atlantic salmon in areas without marine salmonid aquaculture could be useful indicators of how these associations vary with factors unrelated to concerns about aquaculture. Sea lice development is temperature dependent and variations in lice loads on salmon may reflect variations in generation time for lice among different areas. The identification of the species and the life stage is important and in most studies, motile life stages are counted and mature females with egg cases are tabulated separately. Monitoring protocols have been developed by state agencies and industry and training courses for sea lice monitors are mandatory in some areas.

New parasite in 2011

In 2011, a parasite (*Paragnathia formica,* an estuarine crustacean isopod) was detected on 5% of salmon caught in the Scorff trap facility, France, located near the upper limit of the estuary. It was not clear whether this was a new infestation or one that had simply gone undetected until that point. Symptoms included inflammation in the genital area and on the fins and could be mistaken for sea lice scarring or red vent syndrome. *Paragnathia formica* was not detected in France in 2012.

10.1.6.9 Changing biological characteristics of salmon

Various biological characteristics of salmon have shown marked changes in recent years (ICES, 2010a). For example, mean forklengths in returning adult 1SW fish in the River Bush in UK (N. Ireland) have been decreasing since 1973, and the same trend has been observed for 1SW returning adults on the River Bann in UK (N. Ireland). Also notable has been the increase in both numbers of 2SW returns to the River Bush in UK (Northern Ireland) as well as the increase in the relative proportion of 2SW vs. 1SW, since 2003. In 2012, the percentage of River Bush 1SW returning adults decreased to the lowest point in the time-series at 66% (previous ten-year average 91%). Survival to freshwater of River Bush 2SW fish has also seen a positive trend since 2001. In Norway, PFA estimates for 1SW fish from the 2004 smolt cohort onwards have decreased to approximately 15% and have remained low. PFA estimates for 2SW and 3SW returning adults for the same period have shown an opposing trend with a 10–20% increase from 2004 (3SW) or 2005 (2SW). Angling catches in UK (England & Wales) have also recorded a marked increase in the proportion of 2SW salmon relative to 1SW salmon in the last two years. The above observations could indicate a shift in life history strategy from 1SW to MSW in some northern NEAC and southern NEAC stocks, possibly due to poor growth in the first season at sea.

Recent decreases in mean smolt age have also been noted in a number of countries (ICES, 2010a). For example, on the River Dee in UK (England & Wales) there has been a downward trend in smolt age since the late 1960s. However, since 2003–2004 this trend appears to have been reversed and mean smolt age on this and other monitored rivers in UK (England & Wales) appears to be increasing again.

10.1.6.10 New initiatives in relation to management of mixed-stock coastal fisheries in northern Norway

SALSEA–Merge, and other projects, have contributed towards the establishment of a comprehensive genetic baseline for salmon populations in northern Europe. This baseline continues to be developed as a practical and useful tool for management of mixed-stock coastal fisheries in Norway and Russia (ICES, 2010b). Power analysis of the genetic baseline indicated that with the baseline coverage, and the number of genetic markers used, approximately 50% of the samples from coastal fisheries can be reliably assigned to river (probability >90%). A total of 1900 samples from adult salmon caught in coastal fisheries in 2008 in Finnmark county, northern Norway, were genetically analysed and assigned to defined geographical regions or rivers in the baseline (Svenning *et al*., 2011). The results demonstrated that the applied method can give reliable estimates of the proportion of Russian salmon in the catches as well as estimates of how salmon from different regions are exploited in the coastal fisheries.

In 2011 a new EU project “Trilateral cooperation on our common resource; the Atlantic salmon in the Barents region” (Kolarctic Salmon) was started. The project is supported by both EU-funding (Kolarctic ENPI CBC) and national funding from Norway, the Russian Federation, and Finland. This project has extended the sampling in a number of salmon rivers in Norway and Russia to improve the spatial coverage of the baseline, the number of genetic markers, and the precision of the assignment of individuals.

Sampling in 2011 and 2012 expanded the genetic baseline in terms of both spatial coverage and completeness, and it now contains genetic data from over 180 salmon populations in northern Norway, Finland, and Russia. The number of genetic markers has been upgraded to 31 microsatellite loci. Over 17 000 samples were collected from coastal fisheries in northern Norway and Russia in 2011 and 2012, and analysis of these samples is now underway. Preliminary assignment of a subset of these samples has already provided valuable information on the composition of catches in time and space, and interesting patterns of coastal migration of different populations and sea age groups are beginning to emerge.

Moreover, the potential use of other genetic markers – single nucleotide polymorphisms (SNPs) – for genetic stock identification in Atlantic salmon was evaluated (Ozerov *et al*., 2013). This work demonstrates the possibility of cost-effective identification of dozens of informative SNPs (among thousands) for discrimination of populations at various geographical scales, as well as identification of loci controlling ecologically and economically important traits. Through the activities in this project, a foundation will be established on which a river-specific management regime for coastal and riverine fisheries for these northern populations can be implemented.

10.1.7 NASCO has asked ICES to provide a review of examples of successes and failures in wild salmon restoration and rehabilitation and develop a classification of activities which could be recommended under various conditions or threats to the persistence of populations

The Working Group on the Effectiveness of Recovery Actions for Atlantic Salmon (WGERAAS) met for the first time in Belfast, UK (Northern Ireland), from 18 to 22 February 2013. The meeting was attended by 22 delegates from 11 countries. The ToRs were as follows:

1. Develop a classification system for recovery/rebuilding programmes for Atlantic salmon, including threats to populations, population status, life history attributes, actions taken to rebuild populations, programme goals, and metrics for evaluating the success of re-building programmes.
2. Populate the system by collecting data on recovery/rebuilding programmes for Atlantic salmon populations from around the North Atlantic.
3. Summarize the resulting data set to determine the conditions under which various recovery/rebuilding actions are successful and when they are not.
4. Provide recommendations on appropriate recovery/rebuilding actions for Atlantic salmon given threats to populations, status, and life history.

WGERAAS concluded that the most appropriate way to address the first and second ToRs is to develop a database which lists threats to populations, population status, and actions taken to rebuild populations, at river level. WGERAAS recommended this database be established through an update of the NASCO river database by adding additional columns to this database. These columns will consist of: (1) ‘population status’ (this field already exists in the current version, but could usefully be updated), (2) 10 columns of population ‘stressors’ or threats, and (3) 10 columns of recovery actions. These columns will feature a drop-down menu with a limited choice of answers. For the ‘stressors’ columns for example, these answers will range from ‘Very Strong’ to ‘Unknown’; the default (no information) will be to leave the field blank. WGERAAS felt that these data would be best provided by regional or national experts. A guide on how to fill in this database (including examples) is being developed and will be provided to the people who are asked to populate the database. This will then be used to provide a broad perspective of the scale of different stressors and recovery actions being applied around the North Atlantic. To address the third ToR this data will be analysed, and together with case-studies on the effectiveness of different recovery and restoration actions, discussed in the final report. From this discussion the conditions will be determined when recovery/rebuilding actions are successful, and when not. With this information the fourth ToR can be addressed, i.e. producing recommendations on the appropriate recovery/rebuilding actions for Atlantic salmon populations. Therefore it was proposed that WGERAAS approach NASCO to allow the Group access to and utilize the existing NASCO river database.

WGERAAS is scheduled to meet again in January 2014 at ICES in Copenhagen. The Workshop on Wild Atlantic Salmon Recovery Programs (hosted by the Atlantic Salmon Federation) and scheduled for 18 and 19 September 2013 in St Andrews, New Brunswick, Canada, and a UK symposium on stocking (organized by the Atlantic Salmon Trust and The Loughs Agency and to be held 27 and 28 November 2013 in Glasgow, Scotland) are also expected to inform WGERAAS deliberations. A final report is due before the 2014 meeting of WGNAS.

The Working Group on North Atlantic Salmon (WGNAS) welcomed the progress made by WGERAAS at its first meeting and noted that work to address the ToRs was at an early stage. WGNAS had some concerns that the timeframe for WGERAAS to submit a final report might not be sufficient to gather all the data required to address the ToRs successfully. WGNAS suggests WGERAAS might want to consider an extra year to gather data and produce a final report. WGNAS also has some reservations regarding the database part of WGERAAS's chosen approach, specifically the scientific rigor of the method within and among contributors, potential issues with the quality and completeness of the answers, and how the data might be interpreted beyond the specific work of WGERAAS. WGNAS suggests WGERAAS put more emphasis on developing the case studies on recovery/restoration actions as a method to address the ToRs and in this regard offered to encourage the identification of case studies on recovery and restoration actions which may have occurred or are ongoing in their respective locations. The Working Group noted that NASCO has identified under its action plans that stock rebuilding programmes including habitat improvement, stock enhancement, and fishery management actions should be considered for stocks that are below conservation limits.

10.1.8 NASCO has asked ICES to advise on the potential threats to Atlantic salmon from exotic salmonids, including rainbow trout and brown trout where appropriate

Introduction

WGBAST noted that salmonid species had been spread widely around the globe from their original native distributions. In particular, rainbow trout (*Oncorhynchus mykiss*) and different salmon species native to the Pacific have been introduced widely to other countries for use in aquaculture and in fisheries (MacCrimmon, 1971). Similarly, brown trout (*Salmo trutta*), native to Europe, has also been introduced widely to other countries, including North America. The extent to which these introduced species have established natural populations in new areas, or subsequently become invasive, has varied. However, concerns are often raised about the impact, or potential impact, which introduced species can have on native species and ecosystems. In considering this question on the potential threats from exotic salmonids, ICES noted that species translocated into waters where they previously didn't exist, but which fell within the biogeographical range of the species, might also pose a potential threat to established native populations, and thus be considered exotic.

ICES noted that the issue of threats to Atlantic salmon by introductions and transfers of salmonids had previously been reviewed by the NASCO North American Commission (NASCO, 1992) and that this included protocols for reducing the risk of ecological effects associated with such movements. ICES considered that the recommendations from this report remained valid.

Overview of current distribution of exotic salmonids

A broad overview of the current distribution and status of exotic salmonids in the main North Atlantic salmon producing countries, is presented split into NEAC (Table 10.1.8.1a) and NAC (Table 10.1.8.1b) areas. Rainbow trout have been introduced throughout Europe and on the Atlantic coast of North America and are used extensively in both aquaculture and recreational fisheries. However, there are few records of the species establishing in NEAC areas. In contrast, Pacific pink salmon (*Oncorhynchus gorbuscha*) has been introduced and become established in Russia and parts of northern Norway. In the NAC area, brown trout introduced from Europe have become widely established and are spreading in many areas, and rainbow trout have also established in some areas. This section has focused largely on these three species; the other species referred to in the tables are not as widely distributed and only limited information was available.

Rainbow trout

Rainbow trout has been introduced to eastern Canada for recreational fishing since the 1890s and is still permitted in some areas, although forbidden in others. Rainbow trout are now present in about fifty river systems in Eastern Quebec and evidence of reproduction was found in twelve of them, suggesting the presence of self-sustained populations. According to genetic analyses, these individuals came from naturalized upstream populations following stocking conducted in the upper Saint Lawrence in the provinces of Quebec, Ontario, and in the United States (Thibault *et al.,* 2009). Otolith Sr:Ca analyses also revealed that, although all fish captured in the upstream stocking regions were freshwater residents, both anadromous and freshwater resident phenotypes were observed downstream in Eastern Quebec (Thibault *et al.,* 2010a). In fact, the proportion of fish exhibiting an anadromous phenotype increased with the distance from the stocking zone, suggesting that the development of the anadromous life cycle enables this species to colonize new rivers following long distance migration in the Saint Lawrence Estuary (Thibault *et al.,* 2010a).

According to a modelling analysis on the physical characteristics of the colonized river systems, the presence of rainbow trout is associated with the number of tributaries, warm spring and summer temperature, and negatively related to peak flood during egg deposition in May (Thibault *et al.,* 2010b). The spreading of rainbow trout is a subject of concern for the Quebec government because it represents a strong competitor and predator, which could affect indigenous species (e.g. Coghlan Jr. *et al.,* 2007). In this context, the Ministère du Développement Durable, de l'Environnement, de la Faune et des Parcs (MDDEFP) of Quebec developed an Action Plan to improve knowledge, revise stocking practices, increase total catch, limit propagation, and inform and educate citizens concerning the status of rainbow trout in the province. This Action Plan is presently in press and should be published at the end of 2013.

Rainbow trout are not widely established in NEAC countries (Table 10.1.8.1a). For example, there is currently thought to be only one small self-sustaining population in England despite widespread use of the species in aquaculture and in recreational (put-and-take) fisheries dating back for more than one hundred and fifty years. A recent review of the risk of invasion of rainbow trout in the UK (Fausch, 2007) has indicated that the species has generally failed to establish. The primary abiotic factors (e.g. temperature and flow) that commonly influence the success of many stream fishes are not thought to have been limiting. Rather, the factors considered most likely to be constraining establishment in the UK, alone or in combination, are: biotic resistance from native salmonids, parasites and diseases, and angling mortality. However, an important consideration in assessing potential threats to Atlantic salmon from exotic salmonids is that these can change over time. Thus, Fausch (2007) cautions that the current lack of establishment of rainbow trout does not equate to the absence of risk. The situation could change in future as a result of factors such as: climate change; other changes in environmental conditions; introductions of new strains of rainbow trout; declines in native salmonids; or other anthropogenic changes to river environments.

Pink salmon

Pink salmon have the shortest life cycle among species of the genus *Oncorhynchus,* as they mature and reproduce after only 2 years. Therefore, there are two reproductively isolated populations spawning in alternate even and odd years (Heard, 1991).

In Russia, pink salmon were introduced to the White Sea basin in the 1950s with annual egg transfers from the Far East of Russia into hatcheries of Murmansk and Archangelsk regions (Gordeeva and Salmenkova, 2011). Despite over 20 years of introductions, no consistent natural reproduction occurred and they disappeared when the introduction stopped in 1979. This failure was attributed to use of populations from the southern part of the native range. As time of spawning migration and spawning time are strictly fixed in salmonids, the introduced "southern" pink salmon began to spawn too late and eggs were lost as water temperatures in autumn were colder than in their native habitat, especially in even-year generations (Dyagilev and Markevich, 1979). Thus, successful natural reproduction only took place during some years of the North Atlantic warming (Karpevich *et al.,* 1991).

The introduction of odd-year pink salmon to the White Sea basin of Russia was undertaken in 1985, when a new broodstock population was selected from the northern part of the species range (Okhotsk Sea basin, Loenko *et al.,* 2000). This single pink salmon egg transfer from an odd-year population resulted in the establishment of local self-reproducing populations in the White Sea rivers of Murmansk and Archangelsk regions, with the adult returns fluctuating between 60 000 to 700 000 fish during the period 1989 through 2009 (Zubchenko *et al*., 2004; Gordeeva *et al*., 2005). Pink salmon introduced to Russia since the 1930s have resulted in catches in Norwegian waters (up to 20 t in some years). The species has also now established in 11 rivers in northern Norway (Finnmark) (Hesthagen and Sandlund, 2007). The commercial fishery for pink salmon takes place in the coastal areas of the White Sea, with the same gears and in the same season as Atlantic salmon fisheries. The total declared pink salmon catch in 2009 was 139 t, twice as much as the declared Atlantic salmon catch in the region (ICES, 2010b).

At the same time, transfers of even-year-broodlines from the same river of the Okhotsk Sea basin were unsuccessful despite the large number of eggs that were transferred and the favorable rearing conditions at hatcheries. The last egg transfer of 1998 resulted in comparatively large returns in the first generation, but the abundance of pink salmon declined in subsequent generations and after that they appeared only in small numbers in even years. No commercial fishery for pink salmon is conducted in the White Sea in even years.

Brown trout

Brown trout (*Salmo trutta)* are established in various rivers in Newfoundland and Nova Scotia. Westley and Fleming (2011) looked at landscape factors that shaped the spread of brown trout in Newfoundland, and Westley *et al*. (2011) produced a review and annotated bibliography of the impacts of invasive brown trout on native salmonids, with an emphasis on Newfoundland waters. Brown trout embryos were first shipped to Newfoundland from Scotland in 1883 and further importations continued until around 1906. The imported trout survived well and established populations in the watersheds surrounding St John's. It is believed that the trout escaped into watersheds with easy access to the sea around 1884, which provided a source of anadromous colonizers. Westley and Fleming (2011) concluded that brown trout had successfully invaded and established populations in Newfoundland and that they were slowly expanding. They also suggested that abiotic factors alone were not sufficient to prevent continued expansion and all watersheds in Newfoundland were potentially susceptible to successful invasion. Current distribution is estimated at 68 watersheds on the Avalon, Burin, and Bonavista peninsulas, compared to 16 watersheds on the Avalon Peninsula in 1883. Westley *et al.* (2011) concluded that the mechanisms determining invasion success and failure remained largely unknown, but that the outcome of interspecific competitive interactions was highly context specific, varying among habitats, continents, and scales of investigation.

Few studies on the ecological impact of brown trout on native salmonids have been carried out in Canada. However, impacts are believed to include competition and displacement of native fish (Gibson and Cunjak, 1986; Van Zyll de Jong *et al*., 2005) and hybridization with Atlantic salmon (Verspoor, 1988; McGowan and Davidson, 1992).

Potential threats posed by exotic salmonids

Non-native and translocated species can pose threats to native species and ecosystems in a number of ways. These include predation, competition, hybridization, and introduction of novel diseases and parasites. ICES noted that information presented on the effects of exotic salmonids derived from a small number of country-specific reports were largely based on incidental findings and observations rather than directed studies.

Parasites and diseases

Exotic salmonids have the potential to transfer novel parasites or diseases to native Atlantic salmon populations. Rainbow trout have a high susceptibility to salmon lice (*Lepeophtheirus salmonis)* and, where they co-occur with Atlantic salmon also host parasites such as *Gyrodactylus salaris*.

The monogean *G. salaris* is a freshwater ecto-parasite of Atlantic salmon whose natural hosts are Baltic strains of Atlantic salmon. *G. salaris* was not found to cause host mortality on rainbow trout in Norway, but this species is a suitable host for the parasite, and capable of transmitting the parasite to new localities as a consequence of stocking programmes or migratory behaviour (Bakke *et al.,* 1991). At present, *G. salaris* has been eliminated from all infected rainbow trout fish farms in Norway, and all farms producing rainbow trout in fresh water are inspected every two years for the occurrence of this parasite (Anon., 2011). However, future production of rainbow trout in aquaculture installations is of potential concern (Degerman *et al.,* 2012).

Rainbow trout may also disperse *G. salaris* between rivers through brackish water. Soleng and Bakke (1997) found *G. salaris* to survive and reproduce in 7.5‰ salinity for as long as 54 days at 12°C. Few studies have examined the behaviour and spread of escaped farmed rainbow trout at sea, but they generally conclude that they disperse relatively slowly, and they prefer the warmer freshwater surface layer (Skilbrei, 2012). Jonsson *et al.* (1993) concluded that rainbow trout were usually recaptured in the fjord area where they were released/escaped, and Skilbrei and Wennevik (2006) observed that the geographical distribution of gillnet recaptures of escaped rainbow trout agreed well with the localization of the fish farms and with escape events. Hence, the behaviour of rainbow trout in the fjord areas increases the risk of spreading *G. salaris* between rivers.

Rainbow trout have a high susceptibility to salmon lice (Fast *et al.,* 2002; Gjerde and Saltkjelvik, 2009), and farming and escapees of rainbow trout may hence contribute to high infection rates of sea lice on wild salmonids. Holst (2004) observed a mean of 4.4 adult female sea lice on 115 rainbow trout captured with gillnets in late April/early May 1999 in the Osterøy fjord system, Norway. Considering that escaped farmed rainbow trout disperse relatively slowly, and hence occupy the same coastal area for long periods, these high infection rates suggest that they may contribute significantly to the production of sea lice larvae in the area from which they have escaped (Skilbrei and Wennevik, 2006). This risk is especially high for Atlantic salmon in areas where farms are located at smolt migration routes (Krkosek *et al.,* 2009).

So far, no infections of other parasites or diseases have been reported in wild rainbow trout in Norway (Anon., 2011), although serious outbreaks of diseases like pancreas disease have been diagnosed in seawater fish farms (Taksdal *et al.,* 2007; Kristoffersen *et al.,* 2009).

Destruction of redds

Atlantic salmon spawn in autumn and the most common strains of rainbow trout spawn during spring. Thus, in places where rainbow trout exhibit a degree of spawning behaviour, they may dig up and destroy salmon redds before the salmon fry emerge from the gravel. In Norway, rainbow trout have been filmed digging up redds of Atlantic salmon and/or brown trout (Anon., 2011). In Sweden, digging up of redds of brown trout by introduced rainbow trout has been considered a threat to brown trout populations (Landergren, 1999). In New Zealand, where rainbow trout populations have established, this behaviour has been an important mechanism in completely displacing brown trout populations (Hayes, 1987; Scott and Irvine, 2000).

Rainbow trout strains in North America may spawn in both spring and autumn and may thus pose a higher risk to Atlantic salmon. While it is suggested that brown trout spawn prior to Atlantic salmon, redd superimposition is likely given that these species prefer similar spawning habitats (Heggberget *et al*., 1988; Louhi *et al*., 2008).

Pink salmon migrate a shorter distance up rivers to spawn than most other salmonids (Heard, 1991); in addition, spawning in pink salmon seems to be terminated before the spawning of Atlantic salmon starts. As such, there does not appear to be any evidence of interactions with Atlantic salmon at the spawning grounds, such as competition for spawning sites or destruction of redds.

Competition for territory and resources

Rainbow trout are considered to be generalist feeders, consuming a variety of food organisms. The species thus has the potential to have a negative influence on habitat use and nutrient availability for native fish species (Elliott, 1973; Crowl *et al*., 1992; Hasegawa and Maekawa, 2006). Therefore, in localities where rainbow trout establish self-sustaining populations, competition between rainbow trout and Atlantic salmon for habitats and food is possible. In Canada, displacement, decreases in abundance, and local extinction of other species has been observed following introduction of rainbow trout to a new ecosystem.

In North America, interactions between brown trout and Atlantic salmon are thought to be highest during the first year of life when density-dependent processes are most intense (Milner *et al*., 2003).

Pink salmon fry migrate to sea in early summer, shortly after emerging from the gravel. Due to their rapid exodus from streams at emergence, pink salmon fry feed less in freshwater than other Pacific salmon. Hence, any competition for food between pink salmon and Atlantic salmon may take place during a short period in early summer only.

In Russia, the White Sea rivers have two distinct runs of Atlantic salmon. The summer run salmon ascend the river in June–July and spawn in the autumn of the same year. Autumn run fish start their migration in early August and continue entering the river until it freezes. They do not spawn in the year they arrive. Autumn run salmon overwinter and stay in the rivers until they spawn in the autumn of the following year. Summer running fish are less numerous than autumn run fish. Pink salmon also enter the White Sea rivers in July and spawn in August, whereas Atlantic salmon spawn in September and October. Typically pink salmon prefer shallower areas and do not compete with Atlantic salmon for territory in big rivers, but competition can occur in small rivers and in tributaries of big river systems when pink salmon enter streams in large numbers and aggressively push overwintered autumn run Atlantic salmon out of holding pools to non-typical habitats (Zubchenko *et al.*, 2004).

Predation

Rainbow trout are effective predators on fish, and several studies have demonstrated that rainbow trout have impacted local fish populations (Crowl *et al.*, 1992; Behnke, 2002; Fausch, 2008). Hence, it is possible that rainbow trout may feed on Atlantic salmon eggs, fry, and parr when they are present.

Adult pink salmon do not feed after entering freshwater (Heard, 1991) and predation on Atlantic salmon fry and parr is therefore not expected to occur.

Hybridization

Hybridization rates between Atlantic salmon and brown trout are higher when one of the species is exotic compared to when both are native (Verspoor and Hammar, 1991; Allendorf *et al*., 2001). Factors influencing hybridization between Atlantic salmon and brown trout are poorly understood. However, hybrids are known to be viable (Day, 1884; Nygren *et al*., 1975; Hindar *et al.*, 1997; Castillo *et al.*, 2007). In North America, hybridization generally involves brown trout females (McGown and Davidson, 1992; Gephard *et al*., 2000) and mature male Atlantic salmon parr (Gephard *et al.*, 2000; GarciaVazquez *et al.*, 2001).

Hybridization between Atlantic salmon and rainbow trout is unlikely given that the species are from distinct genera and often have discrete spawning seasons.

The following table provides a general summary of potential threats to Atlantic salmon, and the relative likelihood of risk, from the presence of rainbow trout, pink salmon, and brown trout where these occur as exotics:

Potential threat	From rainbow trout (outside their native range)	From pink salmon (outside their native range)	From brown trout (outside their native range)
Spread of parasites	Very likely	Not evidenced	Not evidenced
Spread of diseases	Likely	Not evidenced	Not evidenced
Destruction of redds	Evidenced	Unlikely	Unlikley
Competition for resources and areas	Likely	Likely, but for short periods	Likely
Predation	Likely	Unlikely	Likely
Hydridization	Unlikely	Unlikely	Unlikely

10.1.9 Reports from ICES Expert Groups relevant to North Atlantic salmon

WGRECORDS

The Working Group on the Science Requirements to Support Conservation, Restoration, and Management of Diadromous Species (WGRECORDS) was established to provide a scientific forum in ICES for the coordination of work on diadromous species. The role of the Group is to coordinate work on diadromous species, organize Expert Groups, theme sessions, and symposia, and help to deliver the ICES Science Plan.

WGRECORDS held an informal meeting on 6 June 2012, during the NASCO Annual Meeting in Edinburgh, Scotland. Discussions were held on the requirements for Expert Groups to address new and ongoing issues on Atlantic salmon including issues arising from the NASCO Annual Meeting. The annual meeting of WGRECORDS was held in September 2012, during the ICES Annual Science Conference in Bergen, Norway. The meetings were chaired by Niall Ó Maoiléidigh (Ireland) and Atso Romakkaniemi (Finland) and attended by 10 participants from 8 countries.

The WGRECORDS Annual Meeting received reports from all the ICES Expert Groups working on diadromous species, and considered their progress and future requirements. Updates were received from a few expert groups of particular relevance to North Atlantic salmon which had been established by ICES following proposals by WGRECORDS. Summaries of all these expert groups are provided in this section.

WKADS 2

A second Workshop on Age Determination of Salmon (WKADS 2) took place 4–6 September 2012 in Derry ~ Londonderry, UK (Northern Ireland). Attended by 12 people from six countries, representing nine laboratories, the meeting addressed recommendations made at the previous WKADS meeting (ICES, 2011a) to review, assess, document, and make recommendations for ageing and growth estimations of Atlantic salmon using digital scale reading, with a view to standardization. Available tools for measurement, quality control, and implementation of inter-laboratory quality control were considered.

Information on scale-reading errors and inaccuracies was presented, including:

- possible scale deformation from jewellers press;
- differences in circuli number and spacings, on scales from different locations on smolts;
- measurements of smolt and adult scales made by different scale readers;
- measurements of adult scales made by the same scale reader.

The image collection gathered during WKADS was augmented by addition of scale images showing complexities in their growth, including scales with growth checks and repeat spawners. Available material detailing scale preparation, reading (microfiche, microscope, and digital reading), and storage was reviewed and itemized, detailing the best practice pertinent to Atlantic salmon in one place. Recommendations arising from the workshop were endorsed by WGNAS.

WKSTAR

The Workshop on Salmon Tagging Archive (WKSTAR) worked by correspondence in 2010/2011 and met at ICES Headquarters, Copenhagen, Denmark, 19–21 June 2012. The purpose of the workshop was to ensure that the data compiled previously (ICES, 2007a, 2008b, 2009) was fully archived and documented. These efforts have resulted in recent peer-reviewed publications (Reddin *et al.*, 2012; Jacobsen *et al.*, 2012) and presentations at the NASCO/ICES Salmon Symposium held in La Rochelle, France in October 2011. A resolution for ICES to record a summary of the workshops, presentations, and publications in a Cooperative Research Report was accepted by ICES and the workshop has developed an outline of the CRR. Work has progressed to further tidy up the tag recovery databases for Faroes and Greenland, identifying, correcting, and resolving various anomalies in the data sets. 'Data owners' in different countries have been consulted and permissions granted to include the data in an ICES database.

The Working Group noted that the contact list would require updating upon completion of the database.

10.1.10 NASCO has asked ICES to provide a compilation of tag releases by country in 2012

Data on releases of tagged, fin-clipped, and otherwise marked salmon in 2012 were provided by ICES and are compiled as a separate report (ICES, 2013b). A summary of tag releases is provided in Table 10.1.10.1.

10.1.11 NASCO has asked ICES to further develop a risk-based framework for the provision of catch advice for the Faroese salmon fishery, reporting on the implications of selecting different numbers of management units

In responding to this question, NASCO has specifically asked ICES to advise on:

- the limitations for defining management units smaller than the current NEAC stock complexes;
- the implications of applying probabilities of achieving CLs to separate management units versus the use of simultaneous probabilities; and
- the choice of risk levels for achieving management objectives.

Background to the risk framework model

ICES (2011b) noted that NASCO would need to agree upon the following issues before the risk framework could be finalized:

- the season to which any TAC should apply;
- a share arrangement for the Faroes fishery;
- the choice of management units for NEAC stocks; and
- specification of management objectives.

ICES (2011b) also provided an evaluation of the choice of appropriate management units to be used in the risk-based framework, taking into account relevant biological and management considerations, and noted that breaking the stock complexes down to at least the national level was desirable because many river stocks are exploited by the fishery.

In the absence of feedback from NASCO, ICES (2012a) made pragmatic decisions on these questions in order to provide full catch advice for the 2012/13 to 2014/15 fishing seasons. The advice was provided on the basis of the four management units, comprising two age groups for each of two stock complexes, because it was not possible to provide stock forecasts at a more detailed (e.g. country) level at that time. However, ICES proposed that if the risk framework was run at the stock complex level, then the proportion of rivers within each country meeting their CLs should also be considered when evaluating catch options.

The following sections provide a further discussion on the implications of basing the risk framework on different management units and management objectives to assist managers in agreeing on the risk framework to be employed in the future.

Management units and management objectives

Homewater fisheries

NASCO defines the basic unit for salmon management as the river 'stock', which comprises all salmon originating from a single catchment. NASCO also recommends that salmon fisheries should be managed on the basis of river- and age-specific conservation limits (CL). These CLs should therefore define the minimum numbers of 1SW and MSW spawners required in each river each year, and they may be treated as separate management units (for convenience they are referred to as 'stocks' below). Fisheries should therefore be regulated to ensure that these stocks have a high probability of meeting or exceeding their CLs. The probability level chosen varies among countries but has generally been above 75%.

NASCO (2009) accepts that different jurisdictions may express their management objectives for salmon fisheries in different ways, and some manage their stocks on the basis of an egg deposition conservation limit for each river. NASCO has also conceded that for severely depleted stocks, or in the absence of river- and age-specific CLs, alternative management objectives might be adopted. However, these should ideally operate in a similar way and be based on the probability of attaining a reference level.

NASCO has advised that the above principles should apply equally to single-stock and mixed-stock fisheries (MSFs), with MSFs being managed to protect the weakest stocks. This means that a homewater MSF should not operate if one or more of the individual stocks (e.g. one age group from one river stock) is not expected to achieve its management objective. For any fishery to operate, the harvest or the fishery effort should be limited to ensure that the management objective is still achieved for all stocks.

Achieving this overall management objective for the MSF should be guaranteed by limiting the harvest to just the exploitable surplus in the weakest stock. However, this may result in a very small fishery. It would also be possible to use information on the composition of the catch in the MSF and its variability over time, in order to set a harvest limit that would still result in a high probability that each stock meets its management objective.

In practice, there is a huge variation in the size of salmon river stocks, with the largest stocks being several orders of magnitude larger than the smallest ones. Stock status also varies considerably, with the ‘healthiest’ stocks exceeding their CLs by a factor of two or more. Thus, if not assessed separately, a large healthy stock may mask the shortfall in a number of weaker small stocks (or vice versa).

The above considerations mean that as the number of stocks exploited by a fishery increases, it becomes more difficult to achieve the management objectives for all contributing stocks. This is not only because of the practical difficulties of establishing the numbers of fish from each river that are taken by the mixed-stock fishery, but also because with the increasing number of stocks it becomes less and less likely that they will all be achieving their management objectives simultaneously (i.e. in the same year). MSFs might be managed on the basis of a single composite CL (e.g. the sum of the CLs of all contributing stocks). However, in such a case, a higher probability limit would need to be set for the combined ‘stock’ in order to protect the individual stocks. In a fishery exploiting a large number of stocks (e.g. tens to hundreds) the probability of achieving river-specific management objectives simultaneously (i.e. in a given year) becomes very unlikely.

Distant-water fisheries

The distant-water fishery at Faroes caught salmon originating from both northern and southern European rivers, and the fishery at West Greenland catches salmon principally from North American and southern European rivers. Both fisheries may exploit fish from well over 1000 different river stocks. If management of the fisheries at Faroes and Greenland were based on the principles described above for homewater fisheries (i.e. all contributing river stocks exceeding their river-specific CLs with a high level of probability), there would probably be no chance of a fishery ever being advised. This is because the probability of all potentially exploited stocks meeting their management objectives becomes highly unlikely with such a large number of stocks exposed to the fishery, in addition to the wide range of stock status of rivers across the North Atlantic.

Even if all the river stocks contributing to these fisheries were in good condition, generally above their CLs, there is still a very high probability that a small proportion of them (of the order of 5%) would still fail to meet their CL in any given year, just by chance. In addition, the productive capacity of rivers in both NAC and NEAC has been impacted by various anthropogenic factors for several hundred years and many rivers are not producing recruitment at rates expected under pristine conditions. As such, the likelihood of meeting the CLs in all the 1000+ rivers in the Northwest Atlantic in the past and present is nil.

NASCO has agreed that for the management of the distant-water fisheries, ‘stock complexes’ should be defined, which include larger numbers (100s) of rivers. ICES currently provides advice on the basis of six North American stock complexes (five Canadian provinces and USA) and up to 19 European stock complexes (countries and regions). For the management of the West Greenland fishery, it is only necessary to consider MSW stocks, and management decisions are based on the status of seven management units, comprising the MSW salmon in each of the six North American stock complexes and in the whole of southern Europe. For the management of the Faroes salmon fishery, management decisions take account of the status of both 1SW and MSW salmon stocks. Catch advice is currently based on the status of 1SW and MSW stocks in southern and northern Europe, making a total of four management units.

The main effect of managing on the basis of stock complexes is that a MSF can (and normally will) operate when some river stocks are not expected to achieve their management objectives. This can occur when the expected shortfall of fish in one or more stocks is compensated for by an excess in the more healthy stocks. Given the large variability in size and status of individual river stocks, this can result in the operation of the MSF when some stocks are in a severely depleted state.

The current risk framework for the provision of advice for the West Greenland fishery includes two mechanisms for mitigating (in part) this risk to weak stocks. First, the Greenland fishery is allocated only a proportion (currently 40%) of the exploitable surplus in the North American stock complexes. This means that homewater fisheries, which are allocated the balance (60%) of the available surplus, can be targeted at stocks that are above their CL, or the catches may be foregone to allow stock rebuilding.

In addition, the overall management objective for the provision of advice for the West Greenland fishery requires that there should be a greater than 75% probability of the stock complexes meeting or exceeding their CLs simultaneously. In practical terms, this means that over a period of many years, the requirement is that in at least 75% of the years *all* stock complexes should be above their CLs in that year (i.e. all stock complexes attaining their CLs in that year for at least 75% of the years). For the seven stock complexes used in the assessment, this is equivalent to requiring that each stock complex has approximately a 96% probability of exceeding its CL individually (assuming all stock complexes have the same individual probability and that the status of the different stock complexes is independent from each other, i.e. 0.96 to the power of seven is approximately equal to 0.75). This is consistent with ICES (2012c) advice that a 95% probability should be set for achieving the CL in each management unit individually. Based on the simultaneous attainment threshold only, a fishery may still be permitted if one complex has only a 75% probability of achieving its reference level as long as all other complexes are certain (100% probability) of achieving theirs.

Implications for the Faroes fishery

Limitations for defining management units smaller than the current NEAC stock complexes

For the provision of catch advice on the West Greenland fishery, the total CL for NAC (2SW salmon only) of about 152 000 fish is assessed in six management units, which means that each unit has an average CL of about 25 000 salmon. In contrast, the total CLs for each of the NEAC stock complexes are:

Northern NEAC 1SW –	158 223
Northern NEAC MSW –	131 356
Southern NEAC 1SW –	565 183
Southern NEAC MSW –	275 549

The NEAC stock complexes are between five and 22 times the size of the average NAC ones. There is also wide variation in the size and status of stocks both within and among the NEAC national stock groups. ICES (2012a) has therefore recommended that the NEAC catch advice should be based on a larger number of management units than the four stock complexes.

The use of the share allocation provides a mechanism by which risks to individual stocks may be mitigated by managers in homewaters. Since such management decisions would need to be taken at (or below) the national level, this means that it would be appropriate to disaggregate the assessment to at least the national level.

However, ICES (2012a) also noted that there are practical limitations on the extent to which the assessments can be disaggregated. The principal requirement is for information on the composition of the potential catch at Faroes by management unit. ICES proposed a method to estimate the stock composition of the Faroes catch at a national level based on tag returns and the PFA estimates. This is inevitably an approximation and it is not appropriate to apply it to stock complexes smaller than at country level. Genetic stock assignment studies are underway to analyse scale samples collected at Faroes, but these are also expected to identify no more than about ten stock complexes. Other parameter values used in the assessment are currently only available for the total fishery and not for smaller stock complexes.

ICES therefore considers that it would be informative to managers to provide the catch options tables for the four stock complexes as well as for the ten NEAC countries by sea age (i.e. 20 management units), although exploitation on maturing 1SW fish at Faroes is relatively low.

Implications of applying probabilities of achieving CLs to separate management units versus the use of simultaneous probabilities

ICES (e.g. ICES, 2012a) tabulates the catch advice for the West Greenland fishery to show the probability of each management unit achieving its CL (or alternative reference level) individually and the probability of this being achieved by all management units simultaneously (i.e. in the same given year). This allows managers to evaluate both individual and simultaneous attainment levels in making their management decisions. As indicated above, the probability of simultaneous attainment of management objectives in a number of separate management units is roughly equal to the product of the probabilities of individual attainment for each management unit. The probability threshold for each individual management unit might reasonably be set at a fixed level unless there are specific reasons for adopting an alternative (e.g. for stock rebuilding). ICES (2012a) recommended that an appropriate probability level for individual stock complexes would be 95% and this is approximately equivalent to the current management objective (75% probability of simultaneous attainment) for the West Greenland fishery. This individual probability level can be applied to each management unit regardless of the number of units used; however, this is less obvious for the probability of simultaneous attainment, as explained next.

Management decisions for the West Greenland fishery have been based on a 75% probability of simultaneous attainment of CLs. For a given probability of achieving individual stock CLs, the probability of simultaneous attainment decreases rapidly as the number of management units considered increases (Figure 10.1.11.1). For the example of 20 management units (e.g. two age groups from each of 10 countries), the use of the simultaneous probability level applied for West Greenland (75%) would correspond to the probability of individual stocks meeting the CLs being 98.6% or higher, assuming the same individual probability for all stocks (rather than the approximately 96% value that would apply in the case of West Greenland with seven stock complexes). The use of a 95% probability level for meeting the CLs individually in the 20 management unit example, implies a simultaneous attainment probability of about 36%, i.e. there would be a 64% chance that at least one stock failed to meet its CL in any given year. On the other hand, the use of a 75% probability of simultaneous attainment could result in a fishery being advised when the individual probability of one management unit is as low as 75% if all the other management units have a 100% chance of meeting the CL (as in that case, the probability of simultaneous attainment would still be 75%). This may not be an acceptable risk for managing multiple river stocks.

The probability of simultaneous attainment can provide useful information to managers of the risk of failing to meet CLs in at least one stock in the MSF. However, as the management units being considered by NASCO for managing the MSF at Faroes are still very large and each unit encompasses a large number of individual river stocks, choosing a high probability level (such as 95%) of attaining CLs in individual units would be less risky to individual stocks than the use of a simultaneous attainment objective set at the value used for the West Greenland fishery.

Choice of risk levels for achieving management objectives

On the basis of the above considerations, both individual probabilities and the probability of simultaneous attainment of the management units are provided in the catch options tables. ICES recommends that management decisions should be based principally on a 95% probability of attainment of CLs in each stock complex individually. The simultaneous attainment probability may also be used as a guide, but managers should be aware that this will generally be quite low when large numbers of management units are used (as illustrated above, in the example with 20 management units).

Modelling approach for the catch options risk framework

The process for assessing each catch option within the risk framework was described by ICES (2012a). The main changes to the approach in 2013 relate to its application at country level, although the basic model is the same. The modelling procedure involves:

- estimating the total number of 1SW and MSW salmon that could be killed as a result of any TAC at the Faroes, including catches in homewaters;
- adjusting these to their equivalent numbers at the time of recruitment to the Faroes fishery;
- subtracting the resulting numbers from the PFA estimates for maturing and non-maturing 1SW salmon in the appropriate years;
- assessing the results against the SERs (i.e. the CLs adjusted to the time of recruitment to the Faroes fishery).

Input data for the risk framework

The analysis estimates probability of each management unit achieving its SER (the overall abundance objective) for different catch options in the Faroes fishery (from 0 to 200 t). The analysis assumes:

- no fishery operated in the 2012/13 season;
- the TAC allocated to Faroes is the same in each year and is taken in full;
- homewater fisheries also take their catch allocation in full.

The analysis requires the following input data for the catch that would occur at the Faroes if a TAC was allocated:

- mean weights;
- proportion by sea age;
- discard rates (fish less than 60 cm total length);
- proportion of fish farm escapees;
- composition of catches by management unit;
- proportion of 1SW fish not maturing.

In most cases the only data available to estimate these parameters comes from sampling programmes conducted in commercial and research fisheries in Faroese waters in the 1980s and 1990s.

10.1.12 NASCO has asked ICES to update the Framework of Indicators to identify any significant change in previously provided multi-annual management advice

A Framework of Indicators (FWI) was developed by ICES in 2012 in support of developing multi-year catch advice for the Faroes fishery. Multi-year regulatory measures were approved for Faroes by NASCO in 2012, and the FWI was applied at the beginning of 2013 to evaluate the appropriateness of the 2013/2014 advice. The FWI indicated that the abundance (PFA) of one of the stock components (Southern NEAC MSW fish) had been over estimated and, thus, a full reassessment was triggered in 2013.

The FWI for the NEAC area was updated in 2013; 53 possible indicator datasets were considered, and 26 of them fulfilled the previously established criteria (ICES, 2012a) for inclusion in the FWI (five for Northern NEAC 1SW PFA, three for Northern NEAC MSW PFA, five for Southern NEAC 1SW PFA, and 13 for Southern NEAC MSW PFA). The criteria for considering a data set informative and keeping it as an indicator in the FWI requires the following conditions to be met:

- sample size (N) ≥ 10;
- $R^2 \geq 0.2$;
- data set updated annually; and
- new value available by 15 January.

The use of a stricter R^2 criterion (i.e. a higher value than 0.2) was considered, but the number of indicators included in the FWI then decreases rapidly. The criterion of $R^2 \geq 0.2$ has therefore been retained so the number of indicators is sufficient to be able to use the FWI even if one or more indicators become unavailable by the time the FWI is applied each year. The approach of using a suite of indicators is similar to a meta-analysis, meaning that the outcome of the FWI is not dependent on the result of one indicator in isolation, but rather on the combined performance of the indicator set.

ICES also proposes a slight change to the future operation of the FWI. In the event of a closed fishery, a one-tailed test should be used so that the indicators are only compared to the upper limit of the 75% predictive interval (i.e. to signal an under-estimate of forecast PFA); in the event of an open fishery a two-tailed approach would apply. Had this approach been used in 2013, the reassessment would not have been required this year. ICES further proposes that the updated FWI is applied in January 2014 to assess whether a new assessment and multi-year catch advice will be required.

10.1.13 NASCO has requested ICES to identify relevant data deficiencies, monitoring needs, and research requirements

In considering this question, ICES considered a number of issues, including the report of the NASCO Sub-Group on the Future Direction of Research on Marine Survival of Salmon which met in London in December, 2012.

NASCO Sub-Group on Marine Research

This Sub-Group was convened by the International Atlantic Salmon Research Board (IASRB) to evaluate recent scientific progress in studies of marine mortality of salmon and to provide guidance on how the Board's Scientific Advisory Group can remain an effective and productive group in the future.

The Sub-Group reviewed the findings of recent scientific investigations into the causes of increased mortality at sea and the implications of these findings for management. It noted that genetic stock identification and other advances in the field of genetics, migration modeling, tracking, and studies of the diet of salmon at sea developed under the SALSEA programme all have considerable implications for salmon management. The Sub-Group also reviewed the Board's inventory of research and identified opportunities for enhanced collaboration, gaps in the research programme, and future research needs to support management. It considered that analysing the remaining samples and data arising from the SALSEA–Merge, SALSEA West Greenland, and SALSEA North America programmes should be a priority.

The Sub-Group also proposed that a particular focus for the IASRB should be studies to partition marine mortality of salmon among the phases of the marine migration, and it recommended that the IASRB should consider facilitating a meeting of scientists and external partners to further develop a collaborative international programme of research in this area. The Sub-Group also developed an outline proposal for acoustically tagging emigrating smolts and tracking their movements with detector arrays, and other novel detector systems, noting that analytical techniques were now being applied to such data collected in North America to partition the mortality during the early stages of the marine phase.

ICES considered these recommendations alongside their own evaluation of current research needs. They endorsed the view of the Sub-Group that analysis of outstanding samples during the marine surveys under the SALSEA programme should be a priority and that mechanisms should be sought to obtain funding to support this.

ICES reviewed the proposal outlining a collaborative international programme of research on marine mortality of salmon provided by the Sub-Group. The outline described a project to estimate stage-specific mortality rates of marine salmon by using acoustic technologies to monitor migrating Atlantic salmon. The project would build on the existing infrastructure and historical data sets from index rivers in NAC and NEAC areas, would apply knowledge gained from SALSEA activities on timing and migration corridors of post-smolts in southern NEAC and from advances in acoustic tracking technologies (Whoriskey, 2011; Lacroix, 2013), and would benefit from academic, industry, and government partnerships. Emigrating smolts released from specific index rivers throughout the NAC and NEAC regions would be tagged with acoustic tags and tagged smolts would be tracked throughout the river, estuary, and marine environments via strategically placed ultrasonic telemetry receiver arrays at identified choke points along the nearshore migration paths of post-smolts and at locations associated with other marine research and monitoring activities (e.g. buoy deployments for oceanographic monitoring, research survey cruises, wave gliders, etc.). Estimates of survival probabilities could be obtained by applying a variety of statistical methods and models to the resulting data (see Section 10.1.6.4).

ICES endorsed the proposed project outline. It was noted that this type of acoustic monitoring of marine phase salmon is currently underway in NAC. Large numbers of smolts are being tagged and their migration is being monitored via ultrasonic receiver arrays hundreds of kilometres into the marine environment in Canada (see Section 10.1.6.4) and US (ICES, 2012a).

ICES recommends that the IASRB support the further development of the project outlined by the NASCO Sub-Group on the Future Direction of Research on Marine Survival of Salmon. A large international coordinated project monitoring the marine migration of many salmon stocks across the North Atlantic may provide stage-specific estimates of marine survival that would increase knowledge of marine ecology and better inform management. Stage-specific marine mortality estimates would help improve essential inputs in stock assessment models and would provide additional information for testing hypotheses on the causal mechanisms for the increase in marine mortality documented for most stocks across the North Atlantic in recent decades. These results would also be of benefit for managers trying to identify areas where action might be taken to mitigate current impacts. For managers involved in marine spatial planning detailed information on migration dynamics of salmon in nearshore waters would aid in evaluating the impacts of alternative/renewable energy projects (e.g. wind energy, tidal energy, etc.) in marine waters.

ICES encourages the IASRB to consider expanding the focus of this research project beyond the scope of salmon. Integrating the research needs across different species would increase the benefit of an effort like this and increase the likelihood of successfully competing for funding support. ICES also encourages the IASRB to consider the wide variety of resources and experiences available for an endeavour such as this. Large-scale multi-national tracking programmes are already underway in NAC and the experience gained from these efforts would increase the likelihood of success for any effort initiated in NEAC. It was noted that many tracking projects have previously been conducted in Norway and UK (Scotland) (for examples see Middlemas *et al.*, 2009; Thorstad *et al.*, 2012a, 2012b; Davidsen *et al.*, 2013) although a large international collaborative effort has not been conducted to date.

ICES recognises the value of ultrasonically tagging and releasing non-maturing salmon captured at Greenland. A significant ultrasonic array exists within the NAC area. As the North American contribution to the Greenland harvest has averaged 80% since 2003, there is a high likelihood that any tagged salmon would be of NAC origin (with the potential for determining river of origin via genetic analysis) and may be detected during their return migration to their natal river, depending on where they are migrating to and the mortality experienced from tagging to homewater. Tagging effort could be combined with future sampling satellite tagging efforts, if undertaken (see Section 10.1.6.4). Information on survival during the second winter at sea may help improve essential inputs in stock assessment models and would provide additional information for testing hypotheses on the causal mechanisms for the increase in marine mortality documented for most stocks across the North Atlantic in recent decades.

ICES noted that the NASCO Sub-Group had advised that the SAG is the only body within NASCO that identifies research needs and addresses scientific coordination. It concluded that it is the most appropriate and effective forum in which to perform this important role. ICES endorsed this view, noting that the SAG provided an essential mechanism for scientists to collaboratively work with managers to develop scientific programmes that support the conservation, protection, and enhancement of salmon stocks.

Workshop on Eel and Salmon Data Collection Framework (WKESDCF)

The Workshop on Eel and Salmon Data Collection Framework met in Copenhagen in July 2012, under the co-chairmanship of Ted Potter (UK) and Alan Walker (UK) and was attended by 23 experts in eel and salmon assessment and management, representing nine EU Member States. Changes to the EU Data Collection Framework (DCF) in 2007 introduced requirements to collect data on eel and salmon, but the specific data requested for these species did not meet the needs of national and international assessments. The EC (DG-MARE) has indicated that they intend to simplify the rules and formats within the new Data Collection–Multi-Annual Programme (DC-MAP) and increase the flexibility for data collection programmes. Thus, many of the details of the data collection programmes will be agreed by Regional Coordination Groups (RCGs). There will also be greater focus on the needs of end users (e.g. ICES) who will be asked to provide feedback on the quality of data provided for assessment purposes. The proposed development of the new DC-MAP in 2013–2014 provides the opportunity to coordinate and improve the collection of data used in assessments for these species.

The key tasks of the workshop were to:

- Determine the data required to support international obligations for the assessment of eel and salmon;
- Describe the national monitoring and survey programmes required to meet these data requirements; and
- Consider options for integrating salmon and eel surveys and monitoring.

For each species/area, the workshop considered: the national/international management objectives; the assessments undertaken to support these objectives; the data required to undertake the assessments; and proposed changes in the DC-MAP to provide these data. The existing DCF also requires the collection of data on economics and aquaculture; these data are important in the management of diadromous species, but the workshop did not contain the expertise necessary to consider these elements in detail.

Eel and salmon differ markedly from marine species in their biology, the nature and distribution of their fisheries, and the methods used to assess stock status and provide management advice. As a result, the data collection requirements do not fit well into the ‘standard’ approaches used for marine species. In particular, much of the assessment of both species is conducted at a local and national level even when the results contribute to international assessments (e.g. development of conservation limits for salmon river stocks). These approaches may differ depending upon a range of factors, including the practicalities of collecting particular data.

The workshop made detailed recommendations for several tiers of data collection. Some data (e.g. catches) are required for all stock components and are of little value if they are not collected in a consistent way for all stocks/fisheries. The collection of other data may depend on local requirements and constraints, for example to support the local development of river-specific conservation limits. WGNAS endorsed the proposals for data collection on Atlantic salmon proposed by the workshop. The Workshop Report has also been considered by the EU Scientific, Technical and Economic Committee for Fisheries (STECF) as part of the review of the DC-MAP proposals. STECF endorsed the recommendation that DC-MAP should include the requirement to collect salmon data needed for stock assessment purposes and that this should, if possible, include data collected in inland waters, also from recreational fisheries. However, STECF noted that the WKESDCF recommendations were too detailed to be included in the DC-MAP in full because the intention was to keep the DC-MAP simple and flexible. STECF therefore proposed that the details of the data collection for salmon, including the choice of index rivers and variables, should be agreed by appropriate RCGs. ICES was concerned that if these decisions were made by different RCGs for different regions, it would inevitably result in differences in the data collection procedures, which may cause problems for subsequent assessment work. ICES therefore recommended the establishment of an RCG for diadromous species to consider the unified collection of data on all salmon stocks (as well as eel).

DG-MARE has also provided feedback on the workshop report, indicating that they found Table 4.2.3.1 of the WKESDCF report, which provides an overview of the compatibility of data collected under the DCF with the data needed for the assessment of Baltic salmon by ICES, particularly helpful. Following a request from ICES a table containing an overview of the compatibility of data currently collected under the DCF with the data available, reviewed, and needed for the annual assessment of North Atlantic salmon by ICES was compiled (Table 10.1.13.1).

The workshop also identified a number of areas where coordinated data collection might offer opportunities for increased cost-effectiveness in some circumstances, including: electric fishing surveys; trapping programmes; operation of automatic counters; and habitat surveys.

Stock annex development

ICES discussed development of an Atlantic salmon stock annex. Such stock annexes have been developed for other ICES assessment WG reports and are intended to provide a complete description of the methodology used in conducting stock assessments and the provision of catch advice. These documents are intended to be informative for members of working groups and reviewers, and to aid communication with the general public. It was agreed that the development of a specific Atlantic salmon stock annex would be helpful. Initial progress was made in completing a first draft, largely by compiling information contained in earlier WGNAS reports and other sources. However, the working group had insufficient time to complete the task during the 2013 meeting. It recommended that the stock annex should be developed using an agreed template and that country-specific inputs should be prepared for the 2014 meeting with a view to finalizing the document at that time.

List of recommendations

The Working Group recommends that it should meet in 2014 to address questions posed by ICES, including those posed by NASCO. The Working Group intends to convene in the headquarters of ICES in Copenhagen, Denmark from 18 to 27 March 2014.

1. The Working Group recommends that further work be undertaken to address the issues raised by the second Workshop on Age Determination of Salmon (WKADS 2). The following issues were identified and the Working Group recommended that these should be followed up:
    - An inter-lab calibration exercise should be held remotely in the next two to four years.
    - Reference scale images and accompanying details should be hosted on ICES age readers forum website.
    - The importance of the initial positioning of the line on a scale along which measurement is made, should be emphasized to all readers.
2. The Working Group recommended the establishment of a Regional Coordination Group (RCG) for diadromous species to consider the unified collection of data on all salmon stocks (as well as eel).
3. The Working Group recommended that an Atlantic salmon stock annex should be developed using an agreed template and country-specific inputs should be prepared for the 2014 meeting with a view to finalizing the document at that time.
4. The Working Group recommends that the IASRB support the further development of the project outlined by the NASCO Sub-Group on the Future Direction of Research on Marine Survival of Salmon.
5. The Working Group welcomed the opportunistic assessment of the incidence of salmon bycatch in pelagic fisheries at Iceland and recommends that similar sampling should continue to provide further information on the bycatch of salmon in pelagic fisheries in this area.
6. The Working Group recommends that consideration be given to further investigations involving ultrasonic tagging and release of non-maturing salmon captured at Greenland.
7. The Working Group recommends that sampling of the Labrador and Saint-Pierre et Miquelon fisheries be continued and expanded (i.e. sample size, geographic coverage, tissue samples, seasonal distribution of the samples) in future years and analysed using the North American genetic baseline to improve the information on biological characteristics and stock origin of salmon harvested in these mixed-stock fisheries.
8. The Working Group recommends that additional data collection be considered in Labrador to better estimate salmon returns in that region.
9. The Working Group supports the efforts of the Greenlandic authorities to improve catch data collection and recommends that the authorities facilitate the coordination of sampling within factories receiving Atlantic salmon, if landings at factories are allowed in 2013.
10. The Working Group recommends that the Greenland catch reporting system continues and that logbooks be provided to all fishers. Efforts should continue to encourage compliance with the voluntary logbook system. Detailed statistics related to catch and effort should be made available to the Working Group for assessment.
11. The Working Group recommends that arrangements be made to enable sampling in Nuuk as a significant amount of salmon is landed in this community on an annual basis.
12. The Working Group recommends that the longer time-series of sampling data from West Greenland should be analysed to assess the extent of the variation in condition over the time period corresponding to the large variation in productivity as identified by the NAC and NEAC assessment and forecast models.
13. The Working Group recommends a continuation and expansion of the broad geographic sampling programme (multiple NAFO divisions) to more accurately estimate continent of origin in the Greenland mixed-stock fishery.

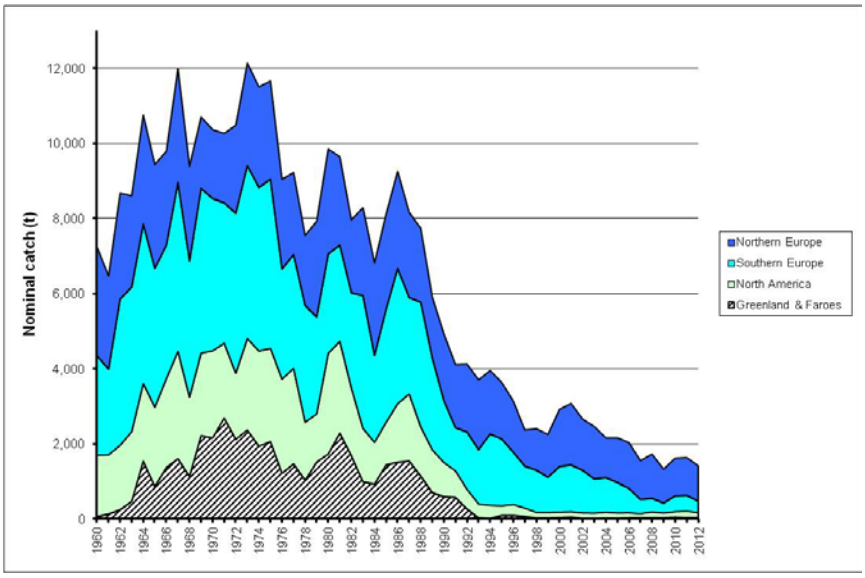


Figure 10.1.5.1 Reported total nominal catch of salmon (tonnes round fresh weight) in four North Atlantic regions, 1960 to 2012.

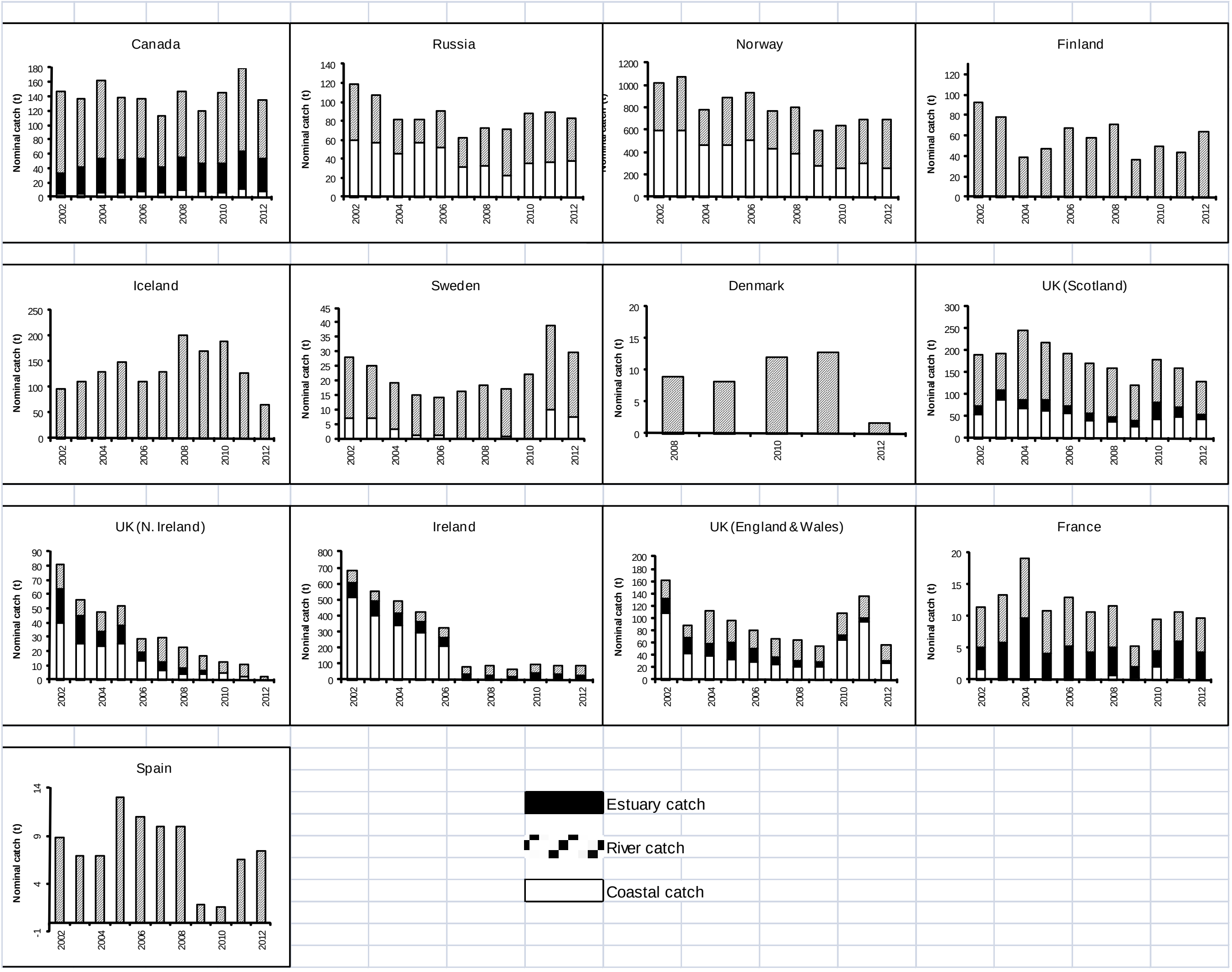


Figure 10.1.5.2 Nominal catch (t) by country taken in coastal, estuarine, and riverine fisheries, 2002–2012 (except Denmark: 2008–2012).

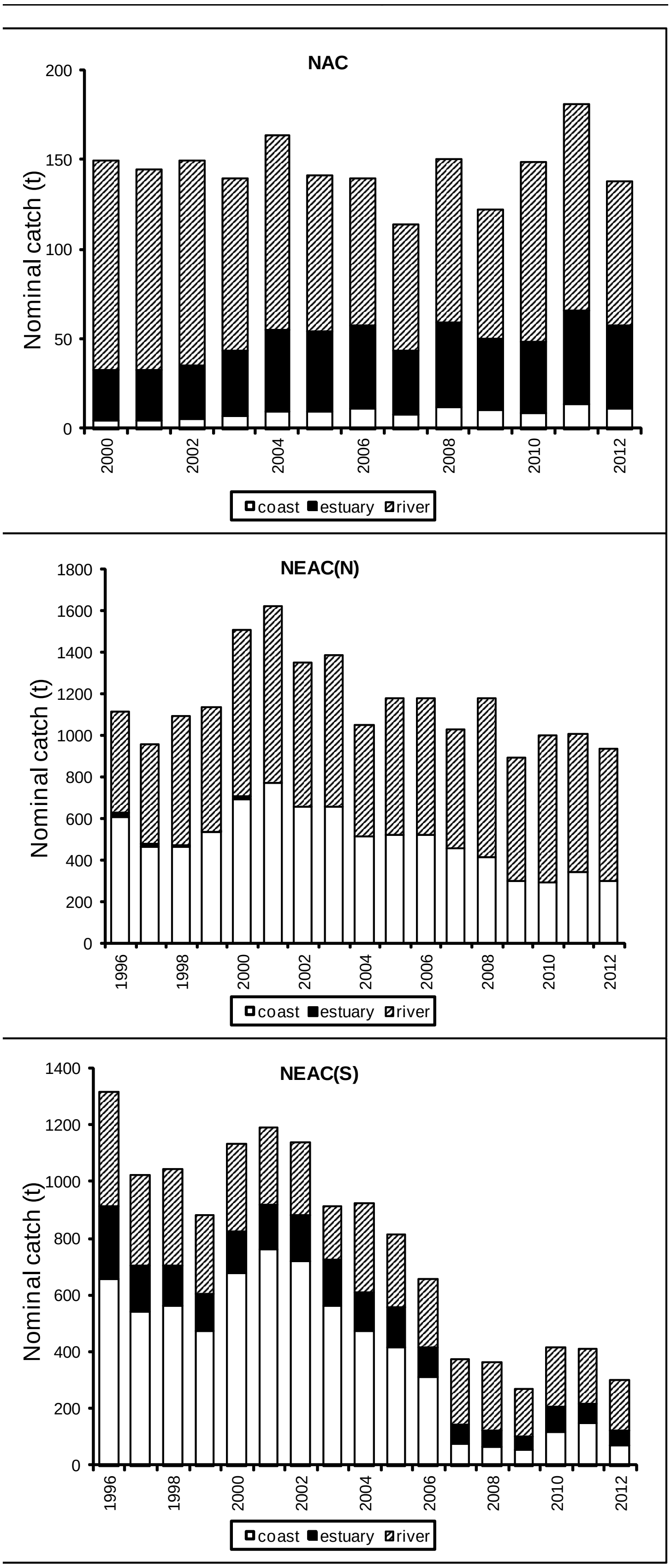


Figure 10.1.5.3 Nominal catch (t) taken in coastal, estuarine, and riverine fisheries for the NAC area, and for the northern and southern NEAC areas. Note that vertical axes scales and time-series vary.

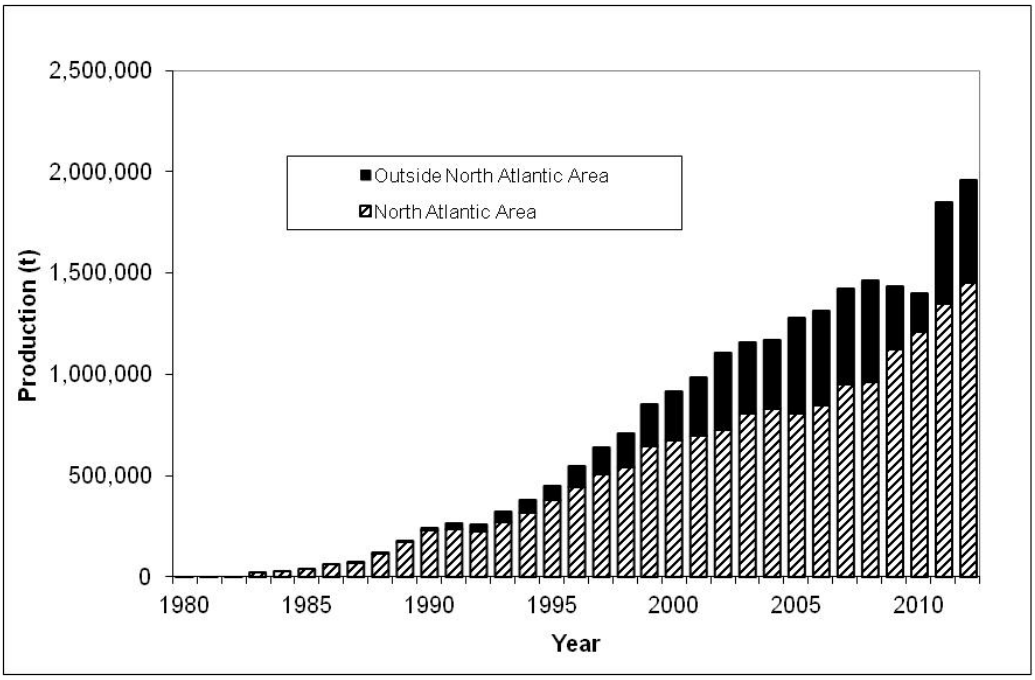


Figure 10.1.5.4 Worldwide production of farmed Atlantic salmon, 1980 to 2012.

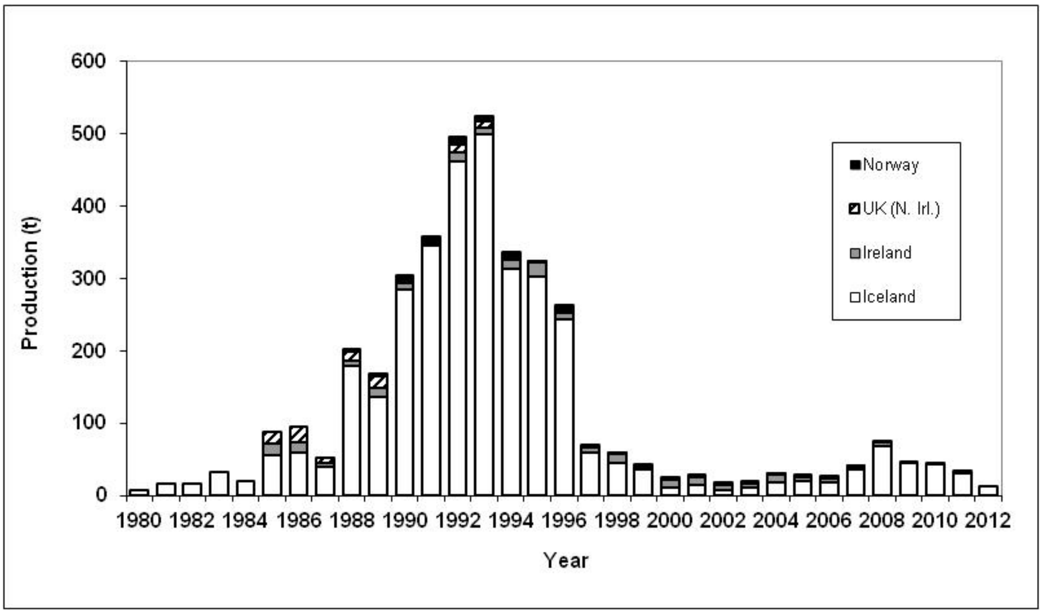


Figure 10.1.5.5 Production of ranched Atlantic salmon (tonnes round fresh weight) in the North Atlantic, 1980 to 2012.

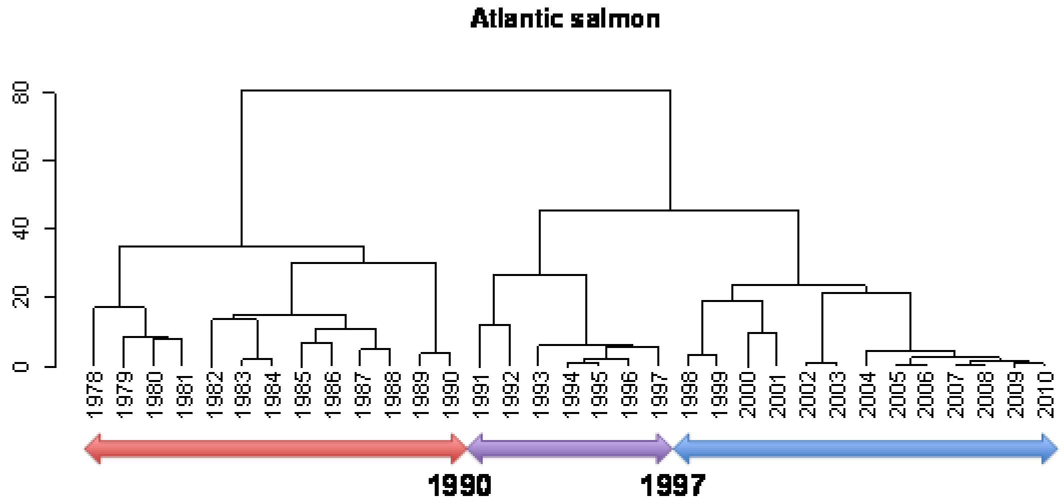


Figure 10.1.6.2.1 Chronological clustering of common trends in abundance and productivity of Atlantic salmon populations (identified from dynamic factor analysis) detects key change-points and distinguishes unique periods. The number of periods marked was determined by a broken-stick model. Units on the *y*-axis are an arbitrary scale.

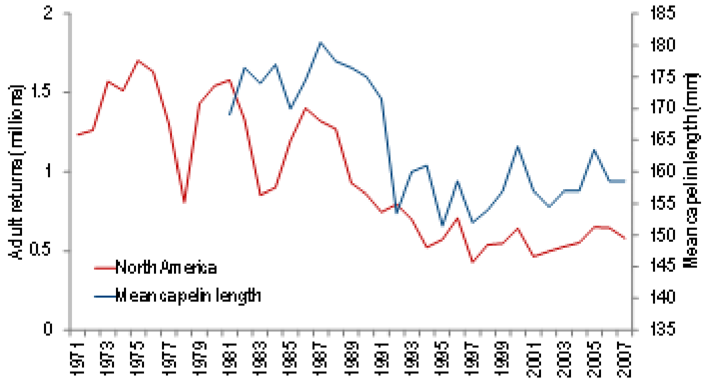


Figure 10.1.6.3.1 North American Atlantic salmon adult returns (ICES, 2012a) and mean capelin length (data obtained from DFO, 2008) over time.

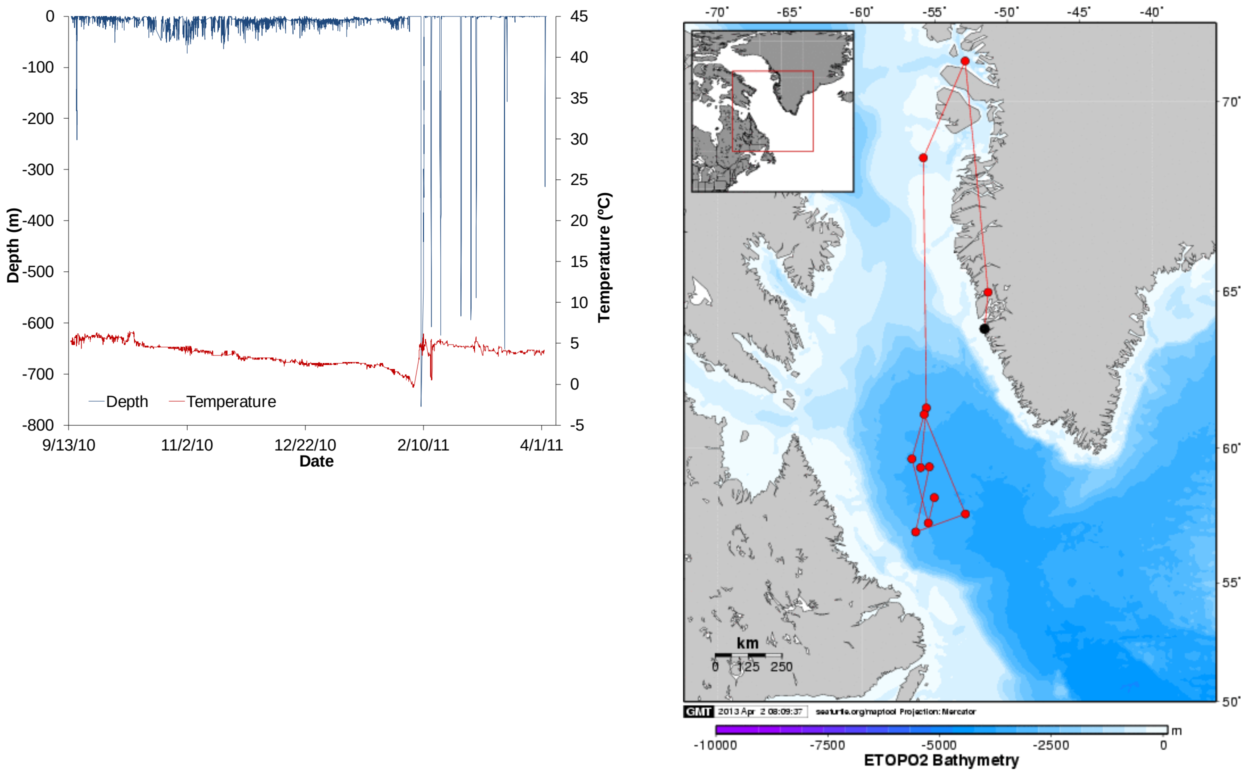


Figure 10.1.6.4.1 Geolocation positions (as determined by the methods detailed in Chittenden *et al.*, 2011) and environmental conditions experienced by an Atlantic salmon tagged at West Greenland in September 2010 with a 'pop-off' satellite tag. The tag popped off as programmed on 1 April, approximately seven months after tagging (black circle indicated the release location). Swimming depth was constrained when the fish was over the shelf until eventually migrating into the Labrador Sea, at which time depths in excess of 750 m were achieved. The thermal habitat occupied decreased from approximately 5°C to less than 0°C, but the fish again occupied 5°C water upon entering the Labrador Sea.

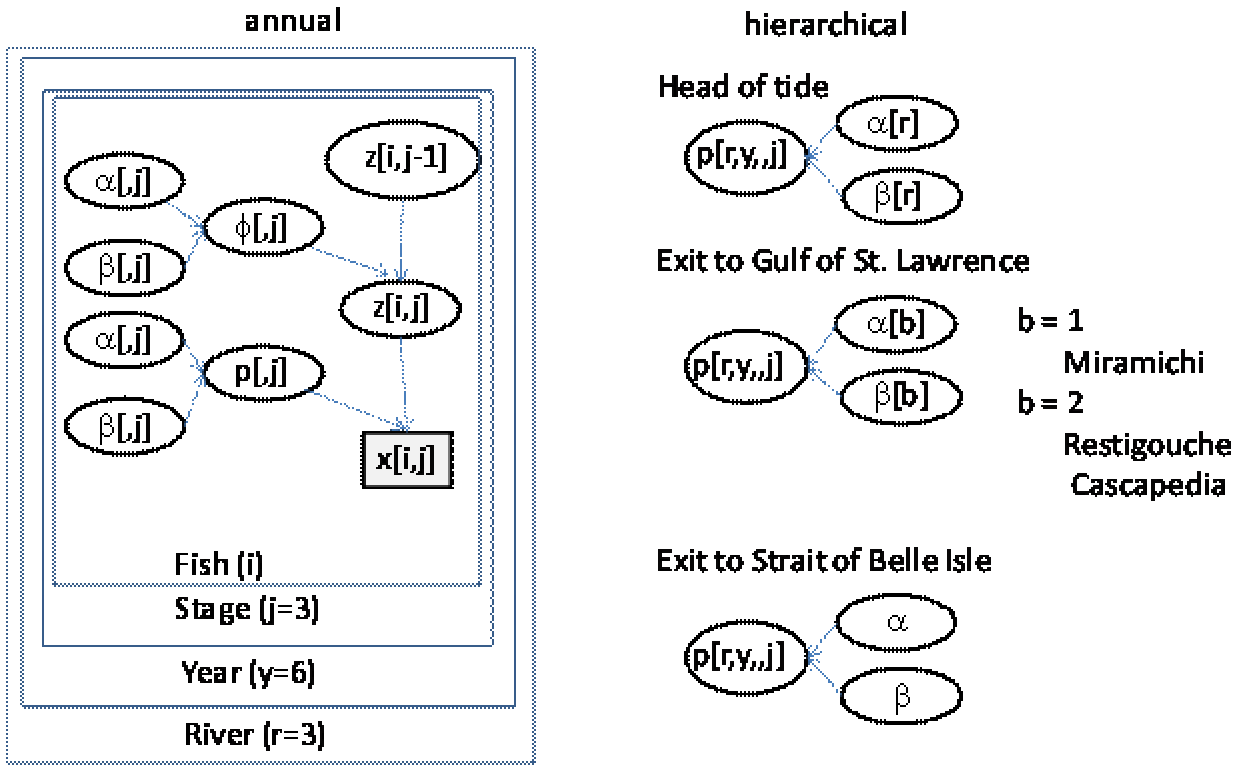


Figure 10.1.6.4.2 Directed Acyclic Graph (DAG) of the state–space implementation of the Cormac–Jolly–Seber model as an annual model (panel on the left) and the exchangeability assumptions for the probability of detections in the hierarchical Bayesian model (panel on the right).

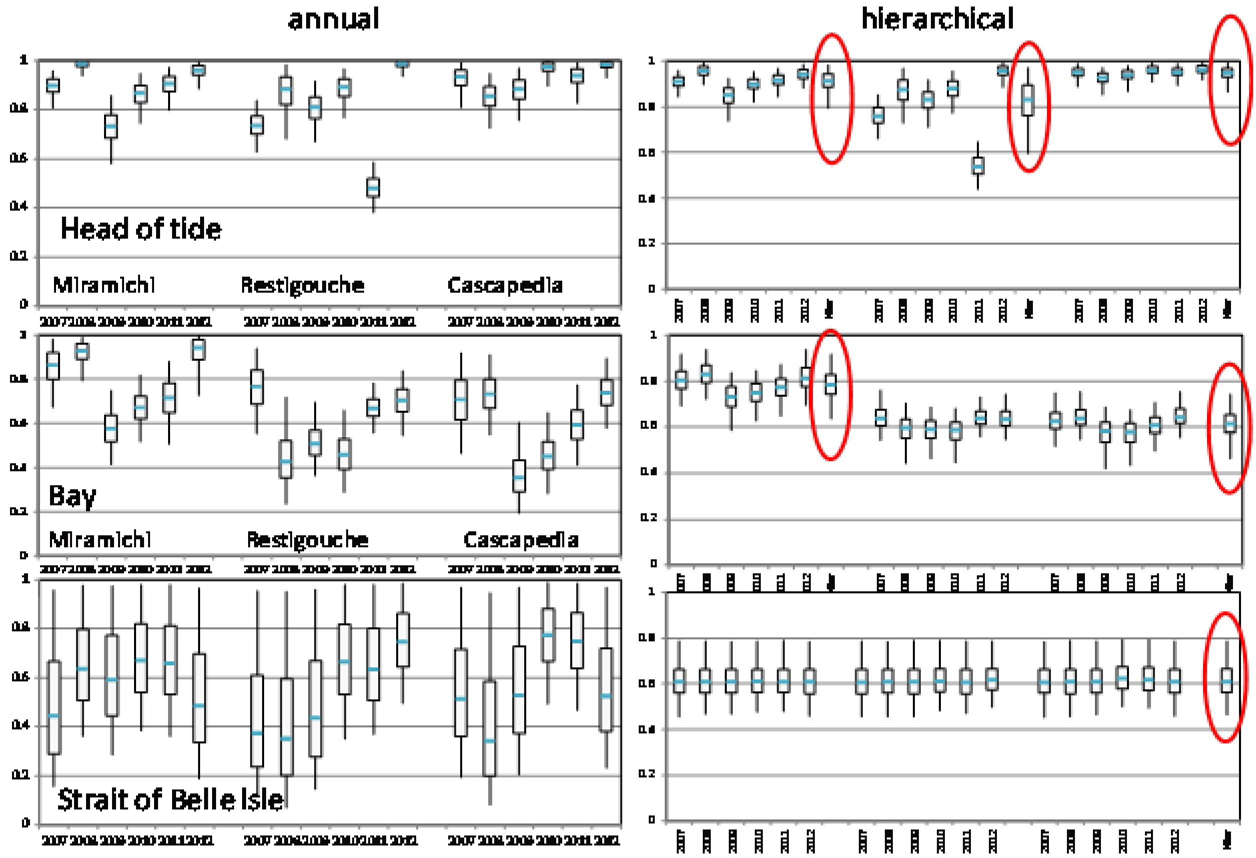


Figure 10.1.6.4.3 Posterior distributions of the annual and river origin probabilities of detection at the head of tide arrays (upper panels), the bay exit arrays (middle panels) and the Strait of Belle Isle array (lower panels). The left panels are for the annual model and the right panels are for the hierarchical model. The red ellipses in the hierarchical panels identify the posterior distributions of the hyperdistribution for the detection probabilities.

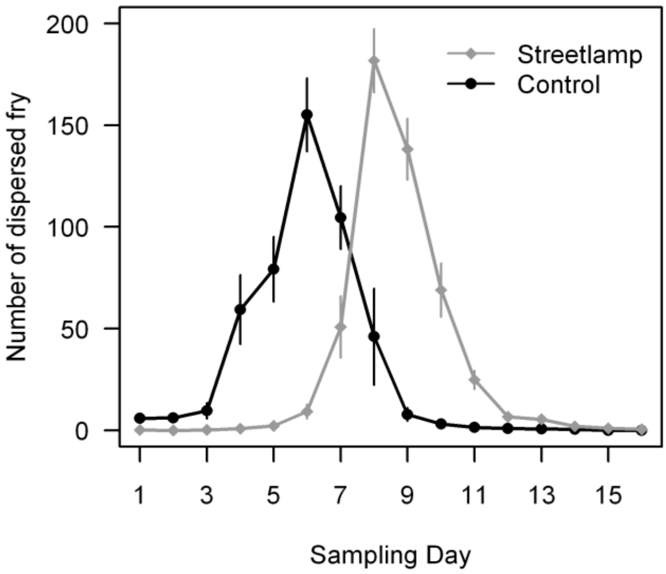
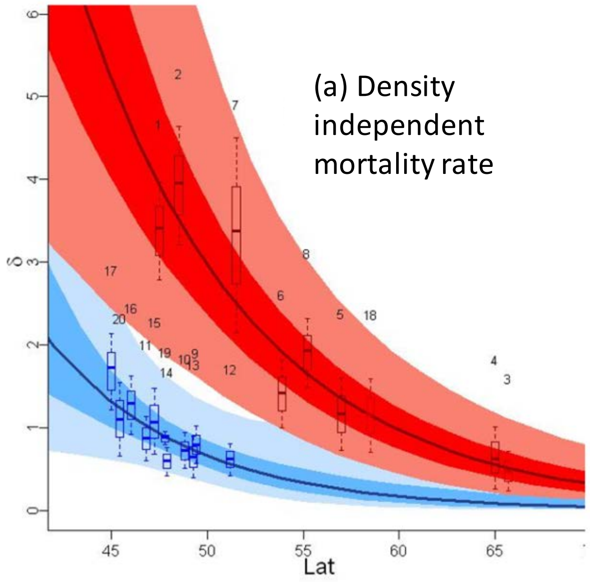


Figure 10.1.6.5.1 The mean number of fry dispersing each sampling day (24-h period) from the five control incubators and from the five incubators exposed to artificial night light. Vertical bars show ± 1 standard error.



Index	Area	River	Country/Region
1	NEAC	Scoff	France
2	NEAC	Oir	France
3	NEAC	Vesturdalsa	Iceland
4	NEAC	Elidaar	Iceland
5	NEAC	North Esk	UK(Scotland)
6	NEAC	Burrishole	Ireland
7	NEAC	Frome	UK(England&Wales)
8	NEAC	Bush	UK(N.Ireland)
9	NAC	dela Trinite	Quebec
10	NAC	St Jean	Quebec
11	NAC	Northeast Brook	Newfoundland
12	NAC	Western Arm Brook	Newfoundland
13	NAC	Campbellton	Newfoundland
14	NAC	Conne	Newfoundland
15	NAC	Rocky	Newfoundland
16	NAC	Pollett	New Brunswick
17	NAC	Nashwaak	New Brunswick
18	NEAC	Imsa	Norway
18	NAC	Little Codroy	Newfoundland
19	NAC	Big Salmon	New Brunswick

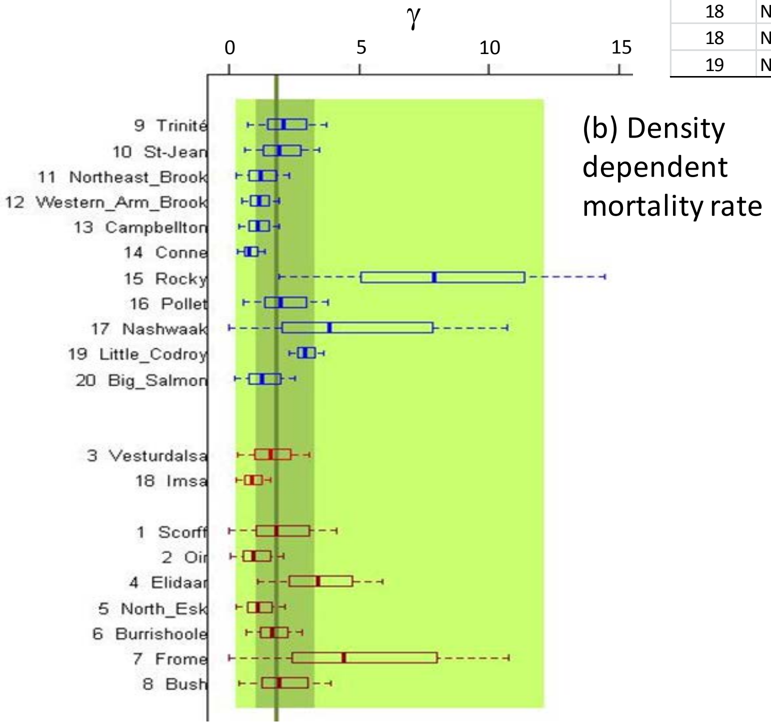


Figure 10.1.6.7.1 Boxplots: Marginal posterior distribution of: (a) the density-dependent mortality rate as a function of the latitude and longitude, and (b) the density-dependent mortality rate for 20 index rivers. Shaded areas correspond to the posterior predictive distribution of the parameters. Solid lines: posterior median values; light shaded areas are 50% posterior probability intervals; dark shaded areas 95% posterior probability intervals.

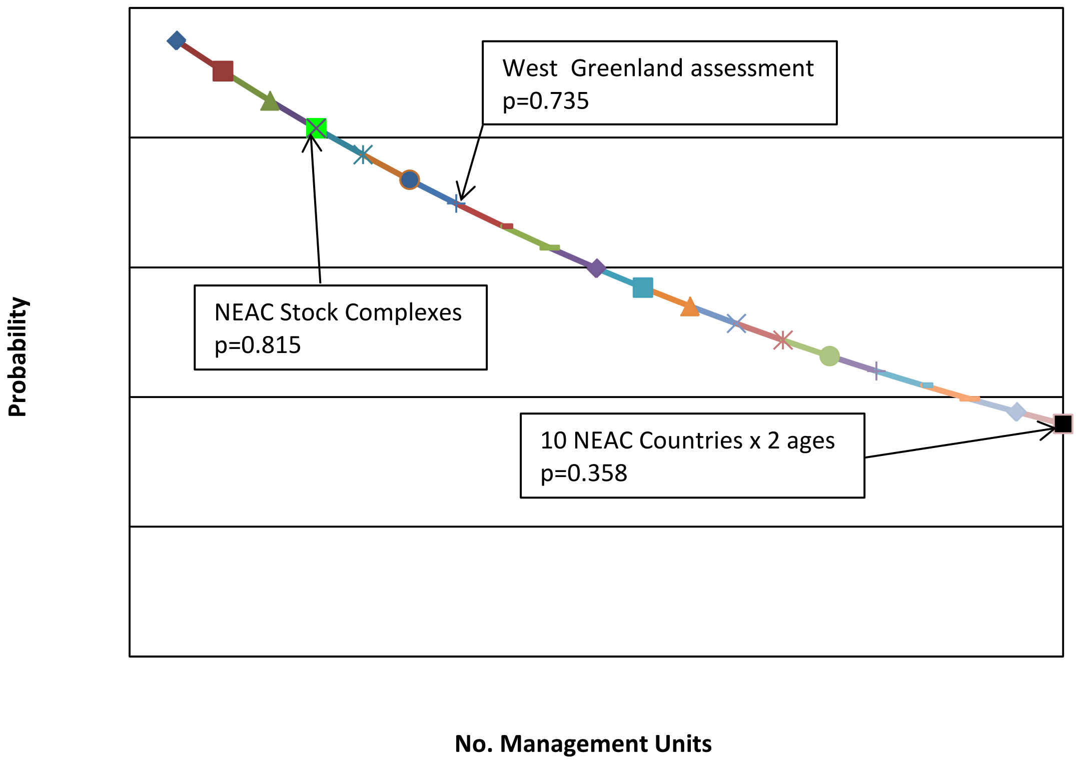


Figure 10.1.11.1 Probability of simultaneous attainment of CLs for different numbers of management units with a 95% chance of attainment in each management unit independently.

Table 10.1.5.1 Reported total nominal catches of salmon by country (in tonnes round fresh weight), 1960 to 2012 (2012 figures include provisional data).

	NAC Area			NEAC (N. Area)							NEAC (S. Area)						Faroes & Greenland				Total	Unreported catches	
Year	Canada	USA	St. P&M	Norway	Russia	Iceland Wild	Iceland Ranch	Sweden (West)	Denmark	Finland	Ireland	UK (E & W)	UK (N.Irl.)	UK (Scotl.)	France	Spain	Faroes	East Grld.	West Grld.	Other	Reported Nominal Catch	NASCO	International waters
	(1)			(2)	(3)		(4)				(5,6)		(6,7)		(8)	(9)	(10)		(11)	(12)		Areas (13)	(14)
1960	1636	1	-	1659	1100	100	-	40	-	-	743	283	139	1443	-	33	-	-	60	-	7237	-	-
1961	1583	1	-	1533	790	127	-	27	-	-	707	232	132	1185	-	20	-	-	127	-	6464	-	-
1962	1719	1	-	1935	710	125	-	45	-	-	1459	318	356	1738	-	23	-	-	244	-	8673	-	-
1963	1861	1	-	1786	480	145	-	23	-	-	1458	325	306	1725	-	28	-	-	466	-	8604	-	-
1964	2069	1	-	2147	590	135	-	36	-	-	1617	307	377	1907	-	34	-	-	1539	-	10759	-	-
1965	2116	1	-	2000	590	133	-	40	-	-	1457	320	281	1593	-	42	-	-	861	-	9434	-	-
1966	2369	1	-	1791	570	104	2	36	-	-	1238	387	287	1595	-	42	-	-	1370	-	9792	-	-
1967	2863	1	-	1980	883	144	2	25	-	-	1463	420	449	2117	-	43	-	-	1601	-	11991	-	-
1968	2111	1	-	1514	827	161	1	20	-	-	1413	282	312	1578	-	38	5	-	1127	403	9793	-	-
1969	2202	1	-	1383	360	131	2	22	-	-	1730	377	267	1955	-	54	7	-	2210	893	11594	-	-
1970	2323	1	-	1171	448	182	13	20	-	-	1787	527	297	1392	-	45	12	-	2146	922	11286	-	-
1971	1992	1	-	1207	417	196	8	18	-	-	1639	426	234	1421	-	16	-	-	2689	471	10735	-	-
1972	1759	1	-	1578	462	245	5	18	-	32	1804	442	210	1727	34	40	9	-	2113	486	10965	-	-
1973	2434	3	-	1726	772	148	8	23	-	50	1930	450	182	2006	12	24	28	-	2341	533	12670	-	-
1974	2539	1	-	1633	709	215	10	32	-	76	2128	383	184	1628	13	16	20	-	1917	373	11877	-	-
1975	2485	2	-	1537	811	145	21	26	-	76	2216	447	164	1621	25	27	28	-	2030	475	12136	-	-
1976	2506	1	3	1530	542	216	9	20	-	66	1561	208	113	1019	9	21	40	<1	1175	289	9327	-	-
1977	2545	2	-	1488	497	123	7	10	-	59	1372	345	110	1160	19	19	40	6	1420	192	9414	-	-
1978	1545	4	-	1050	476	285	6	10	-	37	1230	349	148	1323	20	32	37	8	984	138	7682	-	-
1979	1287	3	-	1831	455	219	6	12	-	26	1097	261	99	1076	10	29	119	<0,5	1395	193	8118	-	-
1980	2680	6	-	1830	664	241	8	17	-	34	947	360	122	1134	30	47	536	<0,5	1194	277	10127	-	-
1981	2437	6	-	1656	463	147	16	26	-	44	685	493	101	1233	20	25	1025	<0,5	1264	313	9954	-	-
1982	1798	6	-	1348	364	130	17	25	-	54	993	286	132	1092	20	10	606	<0,5	1077	437	8395	-	-
1983	1424	1	3	1550	507	166	32	28	-	58	1656	429	187	1221	16	23	678	<0,5	310	466	8755	-	-
1984	1112	2	3	1623	593	139	20	40	-	46	829	345	78	1013	25	18	628	<0,5	297	101	6912	-	-
1985	1133	2	3	1561	659	162	55	45	-	49	1595	361	98	913	22	13	566	7	864	-	8108	-	-
1986	1559	2	3	1598	608	232	59	54	-	37	1730	430	109	1271	28	27	530	19	960	-	9255	315	-
1987	1784	1	2	1385	564	181	40	47	-	49	1239	302	56	922	27	18	576	<0,5	966	-	8159	2788	-
1988	1310	1	2	1076	420	217	180	40	-	36	1874	395	114	882	32	18	243	4	893	-	7737	3248	-
1989	1139	2	2	905	364	141	136	29	-	52	1079	296	142	895	14	7	364	-	337	-	5904	2277	-
1990	911	2	2	930	313	141	285	33	13	60	567	338	94	624	15	7	315	-	274	-	4925	1890	180-350

Table 10.1.5.1 continued.

Year	NAC Area			NEAC (N. Area)							NEAC (S. Area)						Faroes & Greenland				Total	Unreported catches	
	Canada (1)	USA	St. P&M	Norway (2)	Russia (3)	Iceland Wild	Iceland Ranch (4)	Sweden (West)	Denmark	Finland	Ireland (5,6)	UK (E & W)	UK (N.Irl.) (6,7)	UK (Scotl.)	France (8)	Spain (9)	Faroes (10)	East Grld.	West Grld. (11)	Other (12)	Reported Nominal Catch	NASCO Areas (13)	International waters (14)
1991	711	1	1	876	215	129	346	38	3	70	404	200	55	462	13	11	95	4	472	-	4,106	1,682	25-100
1992	522	1	2	867	167	174	462	49	10	77	630	171	91	600	20	11	23	5	237	-	4,119	1,962	25-100
1993	373	1	3	923	139	157	499	56	9	70	541	248	83	547	16	8	23	-	-	-	3,696	1,644	25-100
1994	355	0	3	996	141	136	313	44	6	49	804	324	91	649	18	10	6	-	-	-	3,945	1,276	25-100
1995	260	0	1	839	128	146	303	37	3	48	790	295	83	588	10	9	5	2	83	-	3,629	1,060	-
1996	292	0	2	787	131	118	243	33	2	44	685	183	77	427	13	7	-	0	92	-	3,136	1,123	-
1997	229	0	2	630	111	97	59	19	1	45	570	142	93	296	8	4	-	1	58	-	2,364	827	-
1998	157	0	2	740	131	119	46	15	1	48	624	123	78	283	8	4	6	0	11	-	2,395	1,210	-
1999	152	0	2	811	103	111	35	16	1	62	515	150	53	199	11	6	0	0	19	-	2,247	1,032	-
2000	153	0	2	1,176	124	73	11	33	5	95	621	219	78	274	11	7	8	0	21	-	2,912	1,269	-
2001	148	0	2	1,267	114	74	14	33	6	126	730	184	53	251	11	13	0	0	43	-	3,069	1,180	-
2002	148	0	2	1,019	118	90	7	28	5	93	682	161	81	191	11	9	0	0	9	-	2,654	1,039	-
2003	141	0	3	1,071	107	99	11	25	4	78	551	89	56	192	13	9	0	0	9	-	2,457	847	-
2004	161	0	3	784	82	111	18	20	4	39	489	111	48	245	19	7	0	0	15	-	2,157	686	-
2005	139	0	3	888	82	129	21	15	8	47	422	97	52	215	11	13	0	0	15	-	2,156	700	-
2006	137	0	3	932	91	93	17	14	2	67	326	80	29	192	13	11	0	0	22	-	2,029	670	-
2007	112	0	2	767	63	93	36	16	3	58	85	67	30	171	11	9	0	0	25	-	1,548	475	-
2008	158	0	4	807	73	132	69	18	9	71	89	64	21	161	12	9	0	0	26	-	1,721	443	-
2009	126	0	3	595	71	126	44	17	8	36	68	54	17	121	4	2	0	0	26	-	1,318	327	-
2010	153	0	3	642	88	147	42	22	13	49	99	109	12	180	10	2	0	0	40	-	1,610	367	-
2011	179	0	4	696	89	98	30	39	13	44	87	136	10	159	11	7	0	0	28	-	1,629	421	-
2012	135	0	1	696	82	53	12	30	2	64	88	57	9	130	10	8	0	0	33	-	1,409	403	-
Average																							
2007-2011	146	0	3	701	77	119	44	22	9	52	85	86	18	158	9	6	0	0	29	-	1,565	407	-
2002-2011	145	0	3	820	86	112	29	21	7	58	290	97	36	183	11	8	0	0	22	-	1,928	598	-

Key:

1. Includes estimates of some local sales, and, prior to 1984, by-catch.
2. Before 1966, sea trout and sea charr included (5% of total).
3. Figures from 1991 to 2000 do not include catches taken in the recreational (rod) fishery.
4. From 1990, catch includes fish ranched for both commercial and angling purposes.
5. Improved reporting of rod catches in 1994 and data derived from carcase tagging and log books from 2002.
6. Catch on River Foyle allocated 50% Ireland and 50% N. Ireland.
7. Angling catch (derived from carcase tagging and log books) first included in 2002.
8. Data for France include some unreported catches.
9. Weights estimated from mean weight of fish caught in Asturias (80-90% of Spanish catch).
10. Between 1991 & 1999, there was only a research fishery at Faroes. In 1997 & 1999 no fishery took place; the commercial fishery resumed in 2000, but has not operated since 2001.
11. Includes catches made in the West Greenland area by Norway, Faroes, Sweden and Denmark in 1965-1975.
12. Includes catches in Norwegian Sea by vessels from Denmark, Sweden, Germany, Norway and Finland.
13. No unreported catch estimate available for Canada in 2007 and 2008. Data for Canada in 2009 and 2010 are incomplete. No unreported catch estimate available for Russia since 2008.
14. Estimates refer to season ending in given year.

Table 10.1.5.2 Estimates of unreported catches by various methods, in tonnes by country within national EEZs in the Northeast Atlantic, North American, and West Greenland Commissions of NASCO, 2012.

Commission Area	Country	Unreported Catch t	Unreported as % of Total North Atlantic Catch (Unreported + Reported)	Unreported as % of Total National Catch (Unreported + Reported)
NEAC	Denmark	6	0.3	77
NEAC	Finland	7	0.4	10
NEAC	Iceland	5	0.3	8
NEAC	Ireland	9	0.5	9
NEAC	Norway	298	16.4	30
NEAC	Sweden	3	0.2	9
NEAC	France	2	0.1	14
NEAC	UK (E & W)	15	0.8	21
NEAC	UK (N.Ireland)	0	0.0	2
NEAC	UK (Scotland)	18	1.0	12
NAC	USA	0	0.0	0
NAC	Canada	31	1.7	18
WGC	West Greenland	10	0.6	23
	Total Unreported Catch *	403	22.3	
	Total Reported Catch of North Atlantic salmon	1,409		

* No unreported catch estimate available for Russia in 2012.
Unreported catch estimates not provided for Spain & St. Pierre et Miquelon

Table 10.1.5.3 Numbers of fish caught and released in rod fisheries along with the % of the total rod catch (released + retained) for countries in the North Atlantic where records are available, 1991–2012. Figures for 2012 are provisional.

Year	Canada [4]		USA		Iceland		Russia [1]		UK (E&W)		UK (Scotland)		Ireland		UK (N Ireland) [2]		Denmark		Norway [3]	
	Total	% of total rod catch	Total	% of total rod catch	Total	% of total rod catch	Total	% of total rod catch	Total	% of total rod catch	Total	% of total rod catch	Total	% of total rod catch	Total	% of total rod catch	Total	% of total rod catch	Total	% of total rod catch
1991	22,167	28	239	50			3,211	51												
1992	37,803	29	407	67			10,120	73												
1993	44,803	36	507	77			11,246	82	1,448	10										
1994	52,887	43	249	95			12,056	83	3,227	13	6,595	8								
1995	46,029	46	370	100			11,904	84	3,189	20	12,151	14								
1996	52,166	41	542	100	669	2	10,745	73	3,428	20	10,413	15								
1997	50,009	50	333	100	1,558	5	14,823	87	3,132	24	10,965	18								
1998	56,289	53	273	100	2,826	7	12,776	81	4,378	30	13,464	18								
1999	48,720	50	211	100	3,055	10	11,450	77	4,382	42	14,846	28								
2000	64,482	56	0	-	2,918	11	12,914	74	5,959	40	21,072	32								
2001	59,387	55	0	-	3,611	12	16,945	76	4,869	41	27,724	38								
2002	50,924	52	0	-	5,985	18	25,248	80	5,910	47	24,058	42								
2003	53,645	55	0	-	5,361	16	33,862	81	4,943	53	29,170	55								
2004	62,316	57	0	-	7,362	16	24,679	76	11,516	46	46,279	50					255	19		
2005	63,005	62	0	-	9,224	17	23,592	87	10,554	54	46,165	55	2,553	12			606	27		
2006	60,486	62	1	100	8,735	19	33,380	82	9,955	55	47,669	55	5,409	22	302	18	794	65		
2007	41,192	58	3	100	9,691	18	44,341	90	9,942	53	55,660	61	13,125	40	470	16	959	57		
2008	54,887	53	61	100	17,178	20	41,881	86	11,918	54	53,347	62	13,312	37	648	20	2,033	71	5,512	5
2009	52,151	59	0	-	17,514	24	-	-	8,397	57	48,418	67	10,265	37	847	21	1,709	53	6,696	6
2010	55,895	53	0	-	21,476	29	14,585	56	13,958	59	78,304	70	15,136	40	823	25	2,512	60	15,041	12
2011	71,358	57	0	-	18,593	32	-	-	13,471	61	64,669	73	12,753	39	1,197	36	2,153	55	14,303	12
2012	50,811	57	0	-	7,963	28	4,743	43	10,967	64	66,250	74	11,891	35	5,014	59	2,153	55	18,611	14
5-yr mean 2007-2011	55,096	56	0		16,890	24			11,537	57	60,080	66	12,918	39	797	24	1,873	59	10,388	9
% change on 5-year mean	-8	+2			-53	+14			-5	+13	+10	+12	-8	-9	+529	+151	+15	-7	+79	+63

Key: [1] No data were provided by the authorities for 2009 nor for 2011 and data for 2010 and 2012 were incomplete, however catch-and-release is understood to have remained at similar high levels.

[2] Data for 2006-2009 is for the DCAL area only; the figures from 2010 are a total for UK (N.Ireland).

[3] The statistics were collected on a voluntary basis, the numbers reported must be viewed as a minimum.

[4] Released fish in the kelt fishery of New Brunswick are not included in the totals for Canada.

Table 10.1.8.1a Distribution of exotic salmonids in the NEAC Northern area.

Northern NEAC Country	Rainbow trout *Oncorhynchus mykiss*	American Brook Trout *Salvelinus fontinalis*	Lake Trout *Salvelinus namaycush*	Pink salmon *Oncorhynchus gorbuscha*	Coho Salmon *Oncorhynchus kisutch*	Chinook salmon *Oncorhynchus tshawytscha*	Landlocked Atlantic salmon *Salmo salar*	Brown trout *Salmo trutta*
Russia	Widely used in aquaculture in Karelia Republic, including farming in the White Sea. One freshwater farm in Tuloma River (Barents Sea basin) and a number of farms in inland waters of the Murmansk region. Limited production of rainbow trout in the lakes of the Archangelsk region. No population established in wild. Limited evidence of escapees.	No history of use	No history of use	Pink salmon was successfully introduced to salmon rivers of Murmansk and Archangelsk regions from the Russia's Far East from 1950 to 1990. Since 2003 no juvenile releases from hatcheries occured but pink salmon spawned naturally in salmon rivers. The commercial fishery for pink salmon is conducted in the coastal areas of the White Sea with the same gears and in the same period as for Atlantic salmon. The total declared pink salmon catch in 2009 was 139 t, twice as much as a declared Atlantic salmon catch.	Experiments with Coho salmon introductions were conducted in Murmansk region in 1930's. No evidence of adult returns.	Not present	There are wild landlocked populations of Atlantic salmon in big lakes of Karelia. Salmon population of Shuya River of Onega lake is widely used in recreational fisheries.	Native species. Widely used in commercial and recreational fisheries.
Iceland	Introduced in the mid 1950´s. Used in aquaculture in land based facitlities and in sea-cages. Production increasing to 400t/year. No evidence of impact.	Not present	Not present	Caught annually in Icelandic rivers, since the 1960´s, in low numbers 5-30/year. No evidence of impact.	Not present	Not present	Not present	Widely distrubuted native species, both resident and sea-run.
Finland	Not present	Not present	Not present	Caught occasionally in rivers. Not considered a threat currently	Not present		Not present	Native and widespread in Finland
Norway	In use for > 100 years. However, only 6 instances of natural production confirmed by mid 1990s, 2 in anadromous parts of rivers (Jonsson *et al*. 1993a; Hindar *et al*. 1996; Sægrov, Hindar & Urdal 1996; Hesthagen & Sandlund 2007)	Reported from at least 12 lakes in Norway, first reportsin 1974. Illegaly stocked; no natural spreading. Hesthagen & Sandlund, (2007).	It is at present assumed to be less than 50 populations in Norway, and the number of populations are decreasing. No information on potential	Pink salmon introduced to Russia since 1930s have resulted in catches in Norwegian waters (up to 20t in some years). The species has also now established in 11 rivers in N. Norway (Finnmark) - Hesthagen & Sandlund (2007)	Not present	Not present	Two-three stocks native to Norway	Native and widespread in Norway
Sweden	In Sweden since the 1880s. Occasional natural reproduction is rare (40 known occasions, none of which are on the Swedish west coast). No self-sustaining populations known.	Stocked since the late 1800s. Established self-reproducing populations (ca 1000) in headwaters (Öhlund et al. 2009), not in river sections with Atlantic salmon.	Stocked in the 1960s-1970s. Today self-reproducing in 16 lakes (all draining to the Baltic Sea). In some lakes, a fishery has started to deplete the	Not occurring.	Not occurring.	Not occurring.	Two indigenous stocks exist in Lake Vänern (Piccolo et al. 2012). River Klarälven stock with ca 1000 spawners annually, R. Gullspångsälven with less than 100 spawners. Stocking of reared salmon	Indigenous and widespread.

Table 10.1.8.1a (Cont'd) Distribution of exotic salmonids in the NEAC Southern area.

Southern NEAC Country	Rainbow trout *Oncorhynchus mykiss*	American Brook Trout *Salvelinus fontinalis*	Lake Trout *Salvelinus namaycush*	Pink salmon *Oncorhynchus gorbuscha*	Coho Salmon *Oncorhynchus kisutch*	Chinook salmon *Oncorhynchus tshawytscha*	Landlocked Atlantic salmon *Salmo salar*	Brown trout *Salmo trutta*
Ireland	Commonly used for small put and take fisheries. Possibly one spawning population. Not considered a threat	Not present	Not present	Not present	Not present	Not present	Not present	Native species
UK (Scotland) [1]	Reared in many fish farms and stocked into many sport fisheries for >100 years. Both stocking and the operation of fish farms is now regulated by Marine Scotland. No naturally self maintaining populations have established. Not currently stocked into rivers, but sometimes occur in rivers as a result of escapes from stocked fisheries or fish farms.	Reared in some fish farms and stocked into some sport fisheries for >100 years. Both stocking and the operation of fish farms is regulated by Marine Scotland. A few naturally self maintaining populations have established. Not currently stocked into rivers, and reports from rivers rare.	No history of presence, and not reared	Some reports of captures in the 1960s and 1970s (in net fisheries) and since 2003 (mainly by rod). No populations have established and not reared.	No history of presence, and not reared	Not present	Not currently present.	Native to all parts of Scotland. Also reared in many fish farms and stocked into many sport fisheries
UK (England & Wales)	Widely used in aquaculture and sport fisheries for >150 years. Only one small population established in wild. Limited evidence of impact.	Limited past use in aquaculture and sport fisheries, but not currently present. No evidence of impact.	No history of use	No history of use	No history of use	No history of use	Limited past use in aquaculture and sport fisheries, but not currently present. No evidence of impact.	Native species. Restrictions apply to release to minimise risk of impacts on existing wild populations
UK (N. Ireland)	Used in aquaculture and recreational put-and-take fisheries in lakes. No established self sustaining populations known. Escapees, both resident and sea-run, are occasionally encountered. Limited threat to native salmonid	No history of use	No history of use	No history of use. A few events of this species appearing in the River Bush adult trap have been documented in the recent past. These were probably strays from stocking activities of this species elsewhere in Europe	No history of use	No history of use	No history of use	Native species.
France	Widely used in farming and sport fisheries for >150 years, found in AS and Sea trout rivers. No population known to be established in wild. Some returns known in river Bresle of large steelhead, coming from rearing of Oregon steelhead strain for aqauculture. G. Euzenat, com pers)	introduced in 1876 and after.In 1930-50 in rivers and lakes in east, central, south-west. Currently present in theses areas. No incidence of reproduction have been investigated in rivers..	not present	not present	Not present currently. Escapees from hatcheries for aquaculture in 1970s and 80s in NW, W and SW rivers. Escaping fish investigated in R. Bresle (upper-Normandy) in 83s but very low returns noted. Establishment is not considered possible. Limited by failure to return due to adverse oceanic conditions.(1). No viable hybridization	Not present	not present	Native species. Wild pop. and stockings. No specific restrictions in salmon rivers. Possible problems with smolt catches by trout anglers in spring. Possible competition for food and space with sea trout in mixed pop.,especially in chalk streams where spawning grounds are limited.

N.B. Table excludes grayling (*Thymallus thymallus).* This species is native to some NEAC areas, but not UK (Scotland) where it has been introduced over the past 160 years and established self maintaining populations in several river systems.

Table 10.1.8.1b Distribution of exotic salmonids in the NAC area.

NAC Area	Rainbow trout	American Brook Trout	Lake Trout	Pink salmon	Coho Salmon	Chinook salmon	Landlocked Atlantic salmon	Brown trout
Country	*Oncorhynchus mykiss*	*Salvelinus fontinalis*	*Salvelinus namaycush*	*Oncorhynchus gorbuscha*	*Oncorhynchus kisutch*	*Oncorhynchus tshawytscha*	*Salmo salar*	*Salmo trutta*
Canada - Labrador	Not present.	Native	Native	No history of use, but incidental captures in north Labrador during the late 1970s.	No history of use.	No history of use.	Native	No history of use.
Canada - Nfld	First introduced in 1887 with stocking continuing through the first half of the 1900s. Self sustaining populations in eastern Nfld. Numerous occurrences have now been documented from various south and west coast rivers.	Native	Not present.	Introduced to Newfoundland from 1958-1966. No longer present.	No history of use.	No history of use.	Native	Introductions occurred from 1882-1906. Current distribution is estimated at 68 watersheds in eastern Nfld (2011).
Canada - Quebec	Introduced from Northern Pacific Ocean starting in 1893 for recreational fishing. Increasing prevalence in Eastern Québec since 1980s. Currently present in about 50 river systems.	Native	Native	Historically introduced in Newfoundland and some migrants were observed in Quebec. No longer present.	Historically introduced in the Great Lakes from 1873. Sometimes observed in the Saint Lawrence River.	Historically introduced in the Great Lakes from 1873. Sometimes observed in the Saint Lawrence River.	Native	Introduced in 1890. Now reproducing naturally in multiple watersheds.
Canada - Gulf	First introduced to Prince Edward Island in 1924 and self-sustaining populations now present in 18 watersheds. Observations in numerous other rivers in the region in many years. One reproducing population suspected but not confirmed in a tributary of the Restigouche River, New Brunswick.	Native, widely distributed in the region.	Native, found in a few inland lakes in New Brunswick.	No history of use.	No history of use.	No history of use.	Native in a few inland lakes of New Brunswick	Successfully introduced and self-sustaining populations found in most rivers in Nova Scotia flowing into the Gulf of St. Lawrence. Not reported from New Brunswick or Prince Edward Island rivers.
Canada - Scotia Fundy	Introduced from 1899 to early 1970s for recreational fishing. Self-sustaining populations in two sub-watersheds within the Inner Bay of Fundy New Brunswick. Direct stocking still occurs by the province of Nova Scotia in limited number of watersheds in Nova Scotia. No successful populations established in Nova Scotia. Juvenilesfound in many watersheds in the New Brunswick Bay of Fundy area.	Native	Native	Historically introduced in Newfoundland and some migrants were observed in Nova Scotia. No longer present.	Introduced in northeastern USA in early 1970s to 1990s and some successful reproductions occurred in mid-80s in Scotia Fundy. No self sustaining population present.	Historically introduced to New Brunswick. No established populations.	Native. Stocking programs occur in New Brunswick Bay of Fundy rivers.	Introduced in 1920s. Now reproducing naturally in multiple watersheds. Direct stocking still occurs by the province of Nova Scotia in limited number of watersheds in Nova Scotia. Successful populations established in Nova Scotia are rare.
USA	Stocked in lakes and rivers, produced naturalized populations, typically introduced in riverine habitat where ATS were extirpated, compete for food and space	Native in US Atlantic salmon habitat	Native to US Atlantic salmon habitat, populations in lakes, limited riverine presence	Stocked in the past in habitat where salmon were extirpated, never produced naturalized populations	Stocked in the past in habitat where salmon were extirpated, never produced naturalized populations		widely distributed outside landlocked salmon native range in Northeast US, hybridize with anadromous ATS, use same habitat as spawners and juveniles	Stocked in lakes and rivers, produced naturalized populations, typically introduced in riverine habitat where salmon were extirpated, compete for food and space, hybridize

Table 10.1.10.1 Summary of Atlantic salmon tagged and marked in 2012 – 'Hatchery' and 'Wild' refer to smolts and parr; 'Adults' relates to both wild and hatchery-origin fish.

		Primary Tag or Mark				
Country	Origin	Microtag	External mark	Adipose clip	Other Internal[1]	Total
Canada	Hatchery Adult	0	2,164	0	1,949	4,113
	Hatchery Juvenile	0	1,292	383,332	39	384,663
	Wild Adult[2]	0	2,297	0	25	2,322
	Wild Juvenile[2]	0	15,098	10,661	640	26,399
	Total	**0**	**20,851**	**393,993**	**2,653**	**417,497**
Denmark	Hatchery Adult	0	0	0	0	0
	Hatchery Juvenile	118,500	0	152,600	0	271,100
	Wild Adult	0	0	0	0	0
	Wild Juvenile	0	0	0	0	0
	Total	**118,500**	**0**	**152,600**	**0**	**271,100**
France	Hatchery Adult	0	0	0	0	0
	Hatchery Juvenile[3]	0	0	619,901	0	619,901
	Wild Adult[3]	31	0	0	279	310
	Wild Juvenile	596		0	2,391	2,987
	Total	**627**	**0**	**619,901**	**2,670**	**623,198**
Germany	Hatchery Adult	0	0	0	0	0
	Hatchery Juvenile	12,000	0	120,000	0	132,000
	Wild Adult	0	0	0	0	0
	Wild Juvenile	0	0	0	0	0
	Total	**12,000**	**0**	**120,000**	**0**	**132,000**
Iceland	Hatchery Adult	0	4	0	0	4
	Hatchery Juvenile	40,662		0	0	40,662
	Wild Adult		53	0	0	53
	Wild Juvenile	4,259		0	0	4,259
	Total	**44,921**	**57**	**0**	**0**	**44,978**
Ireland	Hatchery Adult	0	0	0	0	0
	Hatchery Juvenile	196,293	0	0	0	196,293
	Wild Adult	0	0	0	0	0
	Wild Juvenile	92	0	0	0	92
	Total	**196,385**	**0**	**0**	**0**	**196,385**
Norway	Hatchery Adult	0	0	0	0	0
	Hatchery Juvenile	91,878	13,296	91,000	0	196,174
	Wild Adult	0	739	0	0	739
	Wild Juvenile	0	2,286	0	2,746	5,032
	Total	**91,878**	**16,321**	**91,000**	**2,746**	**201,945**
Russia	Hatchery Adult	0	0	0	0	0
	Hatchery Juvenile	0	0	1,022,514	0	1,022,514
	Wild Adult	0	2,282	0	0	2,282
	Wild Juvenile	0	0	0	0	0
	Total	**0**	**2,282**	**1,022,514**	**0**	**1,024,796**
Sweden	Hatchery Adult	0	0	0	0	0
	Hatchery Juvenile	0	3000	180,343	0	183,343
	Wild Adult	0	0	0	0	0
	Wild Juvenile	0	500	0	0	500
	Total	**0**	**3,500**	**180,343**	**0**	**183,843**
UK (England & Wales)	Hatchery Adult	0	0	0	0	0
	Hatchery Juvenile	0	0	211,464	0	211,464
	Wild Adult	0	250	0	0	250
	Wild Juvenile	3,994	0	8,820	891	13,705
	Total	**3,994**	**250**	**220,284**	**891**	**225,419**
UK (N. Ireland)	Hatchery Adult	0	0	0	0	0
	Hatchery Juvenile	15,671	0	30,442	0	46,113
	Wild Adult	0	0	0	0	0
	Wild Juvenile		0	0	0	0
	Total	**15,671**	**0**	**30,442**	**0**	**46,113**
UK (Scotland)	Hatchery Adult	0	0	0	0	0
	Hatchery Juvenile	0	0	49,163	786	49,949
	Wild Adult	0	626	42	166	834
	Wild Juvenile	2990	0	9	2,411	5,410
	Total	**2,990**	**626**	**49,214**	**3,363**	**56,193**
USA	Hatchery Adult	0	1,695	0	2,057	3,752
	Hatchery Juvenile	0	0	265,458	665	266,123
	Wild Adult	0	0	10	0	10
	Wild Juvenile	0	0	0	81	81
	Total	**0**	**1,695**	**265,468**	**2,803**	**269,966**
All Countries	Hatchery Adult	0	3,863	0	4,006	7,869
	Hatchery Juvenile	475,004	17,588	3,126,217	1,490	3,620,299
	Wild Adult	31	6,247	52	470	6,800
	Wild Juvenile	11,931	17,884	19,490	9,160	58,465
	Total	**486,966**	**45,582**	**3,145,759**	**15,126**	**3,693,433**

[1] Includes other internal tags (PIT, ultrasonic, radio, DST, etc.)
[2] May include hatchery fish.
[3] Includes external dye mark.

Table 10.1.13.1 Overview of current DCF and future data needs for Atlantic salmon assessment/scientific advice

For more information about this table, see Table 4.2.3.1 in WKESDCF report (ICES, 2012d).

Type of data	Collected under DCF	Available to WG	Reviewed and evaluated by WG	Used in current assessment models	Future plans	Notes
How to be filled in	Yes/ No/ Partially	Yes/ No/ Partially	Yes/ No/ Partially	Yes/ No/ Partially used	Keep as current DCF/ Improve sampling intensity/ No need to be collected/ (other free text)	Free text
Fleet capacity	No **	No *	No	No	No need to be collected	See 'Fishing gear and effort'.
Fuel consumption	No **	No *	No	No	No need to be collected	Many salmon fisheries use unpowered vessels.
Fishing gear and effort	Partially **	Partially	Partially	Partially, but information requested by NASCO	Use for estimation of exploitation rates. Improve coverage and sampling intensity in DC-MAP	Data required for all relevant areas/fisheries.
Landings	Partially **	Yes	Yes	Yes	Improve coverage in DC-MAP	Data required on: catch in numbers and weights for recreational and commercial fisheries in rivers, estuaries, and coastal waters.
Discards	No **	No *	No	No	No need to be collected	Not relevant to salmon except (historically) in Faroes fishery. NB: 'catch and release' fish are deliberately caught and so not classed as discards.
Recreational fisheries	Partially **	Yes	Yes	Yes	Improve coverage in DC-MAP	Extent of DCF coverage unclear. Complete catch data needed for all recreational fisheries (see 'Landings').
Catch & Release	No **	Partially	Partially	No – but data requested by NASCO	Include collection in DC-MAP	Data on numbers of fish caught and released required for all recreational fisheries.
CPUE data series	Partially **	Partially	Partially	Partially	Improve sampling intensity in DC-MAP	Data used to generate national inputs to models.
Age composition	Partially ** Some ageing based on fish lengths or weights	Yes	Yes	Yes	Improve coverage and sampling intensity in DC-MAP	Extent of DCF coverage unclear; sampling intensities in other fisheries inappropriate for salmon.
Wild/reared origin (scale reading)	No **	Partially – from other sources	Partially	Partially used – information on farmed fish is requested by	Improve sampling intensity in DC-MAP	Extent of DCF coverage unclear.

Type of data	Collected under DCF	Available to WG	Reviewed and evaluated by WG	Used in current assessment models	Future plans	Notes
How to be filled in	Yes/ No/ Partially	Yes/ No/ Partially	Yes/ No/ Partially	Yes/ No/ Partially used	Keep as current DCF/ Improve sampling intensity/ No need to be collected/ (other free text)	Free text
				NASCO		
Length- and weight-at-age	Partially **	Partially	Yes	Yes – but some ageing based on fish lengths or weights	Improve sampling coverage in DC-MAP	DCF does not cover all relevant areas/fisheries; sampling intensities inappropriate for salmon.
Sex ratio	No **	Yes – from other sources	Partially	Yes	Modify sampling intensity in DC-MAP	Estimates required at national/ regional level every 5 years.
Maturity	Not known **	No *	No	No	No need to be collected – all returning adults are mature	DCF requires collection but extent of coverage unclear; data not required for assessments.
Fecundity	No **	Yes	Partially	Yes	Include collection in DC-MAP	Estimates required at national/ regional level every 5 years.
Data processing industry	No **	No **	No	No	No need to be collected	Requirement not clear.
Juvenile surveys (Electrofishing)	Partially ** – but not requested for Atlantic salmon in DCF	Yes	Partially	Partially	Include collection in DC-MAP	Data used to develop reference points and confirm stock status. Also required for assessments under WFD.
Adult census data (Counters, fish ladders, etc.)	Partially ** – but not requested for Atlantic salmon in DCF	Yes	Partially	Yes	Include collection in DC-MAP	Counts required for ~1 river in 30. Data required to provide exploitation rates for assessments.
Index river data (Smolt and adult trapping; tagging programmes; etc.)	Partially ** – but not requested for Atlantic salmon in DCF	Yes	Partially	Yes	Include collection in DC-MAP	Index rivers are identified by ICES. Data used to develop reference points and inputs to assessment models.
Genetic data (for mixed-stock analysis)	No **	Partially	Partially – for some mixed-stock fisheries	Not currently	Include collection in DC-MAP – sampling in mixed stock fisheries every 5 years	Genetic analysis is now advised to provide more reliable stock composition in mixed-stock fisheries.
Economic data	Not known **	No *	No	No – but data is of use to NASCO		Collection of economic data would be useful to managers.
Aquaculture data	Not known **	Partially – marine farm production collected	Yes	No – but information on farm production is requested by NASCO		Currently not required for freshwater.

Add other data type to the cells with light blue shading, if needed.
*   Not asked for by the ICES WGNAS.
**   Not mandatory **for some or all areas/stocks/fisheries** under the current DCF.

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.

ACOM *(Advisory Committee)* of ICES. The Committee works on the basis of scientific assessment prepared in the ICES expert groups. The advisory process includes peer review of the assessment before it can be used as the basis for advice. The Advisory Committee has one member from each ICES Member Country under the direction of an independent chair appointed by the Council.

BCI *(Bayesian Credible Interval).* The Bayesian equivalent of a confidence interval. If the 90% BCI for a parameter A is 10 to 20, there is a 90% probability that A falls between 10 and 20.

BHSRA *(Bayesian Hierarchical Stock and Recruitment Approach)*. Models for the analysis of a group of related stock–recruit datasets. Hierarchical modelling is a statistical technique that allows the modelling of the dependence among parameters that are related or connected through the use of a hierarchical model structure. Hierarchical models can be used to combine data from several independent sources.

C&R *(Catch and Release).* Catch and release is a practice within recreational fishing intended as a technique of conservation. After capture, the fish are unhooked and returned to the water before experiencing serious exhaustion or injury. Using barbless hooks, it is often possible to release the fish without removing it from the water (a slack line is frequently sufficient).

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.

COSEWIC *(Committee on the Status of Endangered Wildlife in Canada).* COSEWIC is the organization that assesses the status of wild species, subspecies, varieties, or other important units of biological diversity, considered to be at risk of extinction in Canada. COSEWIC uses scientific, Aboriginal traditional, and community knowledge provided by experts from governments, academia, and other organizations. Summaries of assessments on Atlantic salmon are currently available to the public on the COSEWIC website (www.cosewic.gc.ca)

Cpue *(Catch Per Unit of Effort).* A derived quantity obtained from the independent values of catch and effort.

CWT *(Coded Wire Tag).* The CWT is a length of magnetized stainless steel wire 0.25 mm in diameter. The tag is marked with rows of numbers denoting specific batch or individual codes. Tags are cut from rolls of wire by an injector that hypodermically implants them into suitable tissue. The standard length of a tag is 1.1 mm.

DFO *(Department of Fisheries and Oceans).* DFO and its Special Operating Agency, the Canadian Coast Guard, deliver programmes and services that support sustainable use and development of Canada's waterways and aquatic resources.

DNA *(Deoxyribonucleic Acid).* DNA is a nucleic acid that contains the genetic instructions used in the development and functioning of all known living organisms (with the exception of RNA – Ribonucleic Acid viruses). The main role of DNA molecules is the long-term storage of information. DNA is often compared to a set of blueprints, like a recipe or a code, since it contains the instructions needed to construct other components of cells, such as proteins and RNA molecules.

DST *(Data Storage Tag).* A miniature data logger with sensors including salinity, temperature, and depth that is attached to fish and other marine animals.

ECOKNOWS *(Effective use of Ecosystems and biological Knowledge in fisheries).* The general aim of the ECOKNOWS project is to improve knowledge in fisheries science and management. The lack of appropriate calculus methods and fear of statistical over partitioning in calculations, because of the many biological and environmental influences on stocks, has limited reality in fisheries models. This reduces the biological credibility perceived by many stakeholders. ECOKNOWS will solve this technical estimation problem by using an up-to-date methodology that supports more effective use of data. The models will include important knowledge of biological processes.

ENPI CBC *(European Neighbourhood and Partnership Instrument Cross-Border Cooperation).* ENPI CBC is one of the financing instruments of the European Union. The ENPI programmes are being implemented on the external borders of the EU. It is designed to target sustainable development and approximation to EU policies and standards – supporting the agreed priorities in the European Neighbourhood Policy Action Plans, as well as the Strategic Partnership with Russia.

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

GRAASP *(Genetically based Regional Assignment of Atlantic Salmon Protocol).* GRAASP was developed and validated by twelve European genetic research laboratories. Existing and new genetic data were calibrated and integrated in a purpose-built electronic database to create the assignment baseline. The unique database created initially encompassed 32 002 individuals from 588 rivers. The baseline data, based on a suite of 14 microsatellite loci, were used to identify the natural evolutionary regional stock groupings for assignment.

ICPR *(The International Commission for the Protection of the River Rhine).* ICPR coordinates the ecological rehabilitation programme involving all countries bordering the river Rhine. This programme was initiated in response to a catastrophic river pollution in Switzerland in 1986 which killed hundreds of thousands of fish. The programme aims to bring about significant ecological improvement of the Rhine and its tributaries, enabling the re-establishment of migratory fish species such as salmon.

ISAV *(Infectious Salmon Anemia Virus).* ISAV is a highly infectious disease of Atlantic salmon caused by an enveloped virus.

LE *(Lagged Eggs)*. The summation of lagged eggs from 1 and 2 sea winter fish is used for the first calculation of PFA.

LMN *(Labrador Métis Nation).* LMN is one of four subsistence fisheries harvesting salmonids in Labrador. LMN members are fishing in southern Labrador from Fish Cove Point to Cape St Charles.

MSY *(Maximum Sustainable Yield).* The largest average annual catch that may be taken from a stock continuously without affecting the catch of future years; a constant long-term MSY is not a reality in most fisheries, where stock sizes vary with the strength of year classes moving through the fishery.

MSW *(Multi-Sea-Winter).* A MSW salmon is an adult salmon which has spent two or more winters at sea and may be a repeat spawner.

NG *(Nunatsiavut Government).* NG is one of four subsistence fisheries harvesting salmonids in Labrador. NG members are fishing in the northern Labrador communities.

NSERC *(Natural Sciences and Engineering Research Council of Canada)*. NSERC is a Canadian government agency that provides grants for research in the natural sciences and in engineering. Its mandate is to promote and assist research. Council supports a project to develop a standardized genetic database for North America.

OSPAR is the mechanism by which fifteen governments of the west coasts and catchments of Europe, together with the European Community, cooperate to protect the marine environment of the Northeast Atlantic. It started in 1972 with the Oslo Convention against dumping. It was broadened to cover land-based sources and the offshore industry by the Paris Convention of 1974. These two conventions were unified, updated, and extended by the 1992 OSPAR Convention. The new annex on bio-diversity and ecosystems was adopted in 1998 to cover non-polluting human activities that can adversely affect the sea.

PFA *(Pre-Fishery Abundance).* The numbers of salmon estimated to be alive in the ocean from a particular stock at a specified time. In the previous version of the stock complex Bayesian PFA forecast model two productivity parameters are calculated, for the *maturing* (PFAm) and *non-maturing* (PFAnm) components of the PFA**.** In the updated version only one productivity parameter is calculated, and used to calculate total PFA, which is then split into PFAm and PFAnm based upon the *proportion of PFAm* (p.PFAm).

PGA *(The Probabilistic-based Genetic Assignment model).* An approach to partition the harvest of mixed-stock fisheries into their finer origin parts. PGA uses Monte Carlo sampling to partition the reported and unreported catch estimates to continent, country, and within country levels.

PGCCDBS *(Planning Group on Commercial Catches, Discards and Biological Sampling).*

PGNAPES *(Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys).* PGNAPES coordinates international pelagic surveys in the Norwegian Sea and to the West of the British Isles, directed in particular towards Norwegian spring-spawning herring and blue whiting. In addition, these surveys collect environmental information. The work in the group has progressed as planned.

PIT *(Passive Integrated Transponder).* PIT tags use radio frequency identification technology. PIT tags lack an internal power source. They are energized on encountering an electromagnetic field emitted from a transceiver. The tag’s unique identity code is programmed into the microchip’s nonvolatile memory.

PSAT (*Pop-up Satellite Archival Tags*). Used to track movements of large, migratory marine animals. A PSAT is an archival tag (or data logger) that is equipped with a means to transmit the data via satellite.

PSU *(Practical Salinity Units).* PSU are used to describe salinity: a salinity of 35‰ equals 35 PSU.

Q Areas for which the Ministère des Ressources naturelles et de la Faune manages the salmon fisheries in Québec.

RRmodel *(Run–Reconstruction model).* RR model is used to estimate PFA and national CLs.

RVS *(Red Vent Syndrome).* This condition has been noted since 2005, and has been linked to the presence of a nematode worm, *Anisakis simplex*. This is a common parasite of marine fish and is also found in migratory species. The larval nematode stages in fish are usually found spirally coiled on the mesenteries, internal organs, and less frequently in the somatic muscle of host fish.

SALSEA (Salmon at Sea). SALSEA is an international programme of cooperative research designed to improve understanding of the migration and distribution of salmon at sea in relation to feeding opportunities and predation. It differentiates between tasks which can be achieved through enhanced coordination of existing ongoing research, and those involving new research for which funding is required.

SARA *(Species At Risk Act).* SARA is a piece of Canadian federal legislation which became law in Canada on 12 December 2002. It is designed to meet one of Canada’s key commitments under the International Convention on Biological Diversity. The goal of the Act is to protect endangered or threatened organisms and their habitats. It also manages species which are not yet threatened, but whose existence or habitat is in jeopardy. SARA defines a method to determine the steps that need to be taken in order to help protect existing relatively healthy environments, as well as recover threatened habitats. It identifies ways in which governments, organizations, and individuals can work together to preserve species at risk and establishes penalties for failure to obey the law.

SCICOM *(Science Committee)* of ICES. SCICOM is authorized to communicate to third-parties on behalf of the Council on science strategic matters and is free to institute structures and processes to ensure that *inter alia* science programmes, regional considerations, science disciplines, and publications are appropriately considered.

SER *(Spawning Escapement Reserve).* The CL increased to take account of natural mortality between the recruitment date (assumed to be 1st of January) and the date of return to homewaters.

SFA *(Salmon Fishing Areas).* Areas for which the Department of Fisheries and Oceans (DFO) Canada manages the salmon fisheries.

SGBICEPS *(The Study Group on the Identification of Biological Characteristics for Use as Predictors of Salmon Abundance).* The ICES study group established to complete a review of the available information on the life-history strategies of salmon and changes in the biological characteristics of the fish in relation to key environmental variables.

SGBYSAL *(Study Group on the Bycatch of Salmon in Pelagic Trawl Fisheries).* The ICES study group that was established in 2005 to study Atlantic salmon distribution at sea and fisheries for other species with a potential to intercept salmon.

SGEFISSA (*Study Group on Establishing a Framework of Indicators of Salmon Stock Abundance*). SGEFISSA is a study group established by ICES which met in November 2006.

SGERAAS *(Study Group on Effectiveness of Recovery Actions for Atlantic Salmon).* SGERAAS is the previous acronym for WGERAAS (*Working Group on Effectiveness of Recovery Actions for Atlantic Salmon*).

SGSSAFE (*Study Group on Salmon Stock Assessment and Forecasting*). The study group established to work on the development of new and alternative models for forecasting Atlantic salmon abundance and for the provision of catch advice.

S_{lim}, i.e. CL *(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 the undesirable levels are avoided.

SSGEF *(SCICOM Steering Group on Understanding Ecosystem Functioning).* SSGEF is one of five Steering Groups of SCICOM (Science Committee of ICES). Chair: Graham Pierce (UK); term of office: January 2012–December 2014.

SST (*Sea surface temperatures*). SST is the water temperatures close to the surface. In practical terms, the exact meaning of surface varies according to the measurement method used. A satellite infrared radiometer indirectly measures the temperature of a very thin layer (about 10 micrometres thick) of the ocean, which leads to the phrase “skin temperature”. A microwave instrument measures subskin temperature at about 1 mm. A thermometer attached to a moored or drifting buoy in the ocean would measure the temperature at a specific depth, (e.g. at one meter below the sea surface). The measurements routinely made from ships are often from the engine water intakes and may be at various depths in the upper 20 m of the ocean. In fact, this temperature is often called sea surface temperature, or foundation temperature.

SVC *(Spring Viraemia of Carp)*. SVC is a contagious and potentially fatal viral disease affecting fish. As its name implies, SVC may be seen in carp in spring. However, SVC may also be seen in other seasons (especially in the fall) and in other fish species, including goldfish and the European wells catfish. Until recently, SVC had only been reported in Europe and the Middle East. The first cases of SVC reported in the United States were in spring 2002 in cultivated ornamental common carp (Koi) and wild common carp. The number of North American fish species susceptible to SVC is not yet known.

TAC *(Total Allowable Catch).* TAC is the quantity of fish that can be taken from each stock each year.

WFD *(Water Framework Directive).* Directive 2000/60/EC (WFD) aims to protect and enhance the water environment, updates all existing relevant European legislation, and promotes a new approach to water management through river-based planning. The Directive requires the development of River Basin Management Plans (RBMP) and Programmes of Measures (PoM) with the aim of achieving Good Ecological Status or, for artificial or more modified waters, Good Ecological Potential.

WGBAST *(Baltic Salmon and Trout Assessment Working Group).* WGBAST took place in Uppsala, Sweden, 15–23 March 2012, chaired by Johan Dannewitz (Sweden). Main tasks of the group are: address generic ToRs for Fish Stock Assessment Working Groups; evaluate estimates of salmon misreporting by Poland based on new data from Poland, from the EC inspections, logbooks, VMS and other relevant data sources; evaluate the possible reasons for the low at-sea survival of salmon stocks, including new information from the 2011 Salmon Summit; prepare for a benchmark assessment of the salmon stocks in the autumn of 2012; and others.

WGERAAS *(Working Group on Effectiveness of Recovery Actions for Atlantic Salmon).* WGERAAS was established by ICES. The task of the working group is to provide a review of examples of successes and failures in wild salmon restoration and rehabilitation and develop a classification of activities which could be recommended under various conditions or threats to the persistence of populations. The working group has had its first meeting in Belfast in February 2013. The next meeting is scheduled for February 2014 at ICES in Copenhagen.

WGF *(West Greenland Fishery).* Regulatory measures for the WGF have been agreed by the West Greenland Commission of NASCO for most years since the establishment of NASCO. These have resulted in greatly reduced allowable catches in the WGF, reflecting declining abundance of the salmon stocks in the area.

WGRECORDS *(Working Group on the Science Requirements to Support Conservation, Restoration, and Management of Diadromous Species).* WGRECORDS was reconstituted as a working group from the Transition Group on the Science Requirements to Support Conservation, Restoration, and Management of Diadromous Species (TGRECORDS).

WKADS *(Workshop on Age Determination of Salmon).* WKADS took place in Galway, Ireland, 18–20 January 2011, with the objectives of reviewing, assessing, documenting, and making recommendations on current methods of ageing Atlantic salmon. The workshop focused primarily on digital scale reading to measure age and growth with a view to standardization.

WKADS2 (*A second Workshop on Age Determination of Salmon*). Took place from 4 to 6 September 2012 in Derry ~ Londonderry, Northern Ireland to address recommendations made at the previous WKADS meeting (ICES, 2011a) to review, assess, document, and make recommendations for ageing and growth estimations of Atlantic salmon using digital scale reading, with a view to standardization. Available tools for measurement, quality control, and implementation of inter-laboratory quality control were considered.

WKDUHSTI (*Workshop on the Development and Use of Historical Salmon Tagging Information from Oceanic Areas*). This workshop, established by ICES, was held in February 2007.

WKSHINI (*Workshop on Salmon historical information – new investigations from old tagging data*). This workshop met from 18 to 20 September 2008 in Halifax, Canada.

WKLUSTRE *(Workshop on Learning from Salmon Tagging Records).* This ICES workshop was established to complete compilation of available data and analyses of the resulting distributions of salmon at sea.

This glossary has been extracted from various sources, but chiefly the EU SALMODEL report (Crozier *et al.*, 2003).

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ECOREGION North Atlantic
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Advice for 2013 to 2016

On the basis of the MSY approach, ICES advises that fishing should only take place on salmon from rivers where stocks have been shown to be at full reproductive capacity. Furthermore, because of the different status of individual stocks within stock complexes, mixed-stock fisheries present particular threats. The management of a fishery should ideally be based upon the individual status of all stocks exploited in the fishery.

There are no catch options for the Faroes fishery that would allow all stock complexes to achieve their conservation limits (CLs) with a greater than 95% probability in any of the seasons 2013/14 to 2015/16. In the absence of specific management objectives, ICES advises that there are no mixed-stock fishery options on the NEAC complexes at Faroes in 2013 to 2016. The results from the exploratory assessment conducted by ICES in 2013 based on smaller management units (countries) are in line with this advice.

While stocks remain in a depleted state and in the absence of a fishery at Faroes, particular care should be taken to ensure that fisheries in homewaters are managed to protect stocks that are below their CLs.

Stock status

National stocks within the NEAC area are combined into two stock groupings for the provision of management advice for the distant-water fisheries at West Greenland and Faroes. The Northern group consists of: Russia, Finland, Norway, Sweden, and the northeast regions of Iceland. The Southern group consists of: UK (Scotland), UK (England and Wales), UK (Northern Ireland), Ireland, France, Spain, and the southwest regions of Iceland.

Recruitment, expressed as pre-fishery abundance (PFA; split by maturing and non-maturing 1SW salmon, at 1 January of the first winter at sea) is estimated by stock complex (northern NEAC and southern NEAC) and interpreted relative to the spawner escapement reserve (SER) (Figures 10.2.1 to 10.2.3). SERs are the conservation limits (CLs; expressed in terms of spawner numbers) increased to take account of natural mortality ($M = 0.03$ per month) between 1 January of the first winter at sea and return time to homewaters for each of the maturing (6 to 9 months) and non-maturing (16 to 21 months) 1SW salmon from the northern NEAC and southern NEAC stock complexes.

Recruitment (PFA) of maturing 1SW salmon and of non-maturing 1SW salmon for northern NEAC shows a general decline over the time period (Figure 10.2.3), the decline being more marked in the maturing 1SW stock. Both stock complexes have, however, been at full reproductive capacity (i.e. >95% probability of achieving CL) prior to the commencement of distant-water fisheries throughout the time-series. Similarly, recruitment of maturing 1SW and non-maturing 1SW salmon for southern NEAC also demonstrate broadly similar declining trends over the time period (Figure 10.2.3). Both stock complexes were at full reproductive capacity prior to the commencement of distant-water fisheries throughout the early part of the time-series. Since the mid-1990s, however, the non-maturing 1SW stock has been at risk of suffering reduced reproductive capacity in approximately 50% of the assessment years. The maturing 1SW stock, on the other hand, was first assessed as being at risk of suffering reduced reproductive capacity in 2009. This is broadly consistent with the general pattern of decline in marine survival in most monitored stocks in the area.

Based on the NEAC run-reconstruction model, all NEAC stock complexes were considered to be at full reproductive capacity, prior to the commencement of distant-water fisheries, in the latest available PFA year.

For the northern NEAC stock complexes, 1SW spawners have been at full reproductive capacity throughout the time-series (Figure 10.2.3). In contrast, MSW spawners, while generally remaining at full reproductive capacity, have spent limited periods either at risk of suffering, or suffering, reduced reproductive capacity. Both the 1SW and MSW stock complexes were at full reproductive capacity in 2012, with the MSW spawners being among the highest in the time-series. The 1SW spawning stock in the southern NEAC stock complex has been at risk of suffering, or suffering, reduced reproductive capacity for most of the time-series (Figure 10.2.3). In contrast, the MSW stock was at full reproductive capacity for most of the time-series until 1997. After this point, however, the stock has generally been at risk of suffering, or suffering, reduced reproductive capacity.

Estimated exploitation rates have generally been decreasing over the time period in the northern and southern NEAC areas (Figure 10.2.4). Despite management measures aimed at reducing exploitation in recent years, there has been little improvement in the status of stocks over time. This is mainly a consequence of continuing poor survival in the marine environment attributed to climate effects.

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 by the use of management targets. Conservation limits (CLs) for North Atlantic salmon stock complexes have been defined by ICES as the level of 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. Advice for the Faroes fishery (both 1SW and MSW) is based upon all NEAC area stocks. The advice for the West Greenland fishery is based upon the southern NEAC non-maturing 1SW stock.

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 Northwest Russia and Iceland. Juveniles emigrate to the ocean at ages of 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 the Northeast Atlantic stocks being exploited at both West Greenland and the Faroes.

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 predator fields of salmon at sea are considered to be the main contributory factors to lower productivity, which is expressed almost entirely in terms of lower marine survival.

The fisheries

No fishery for salmon has been prosecuted at Faroes since 2000. No significant changes in gear type used were reported in the NEAC area in 2012, but a new fishery prosecuted by the local Sami communities in the Murmansk region of the Russian Federation has been reported. The NEAC area has seen a general reduction in catches since the 1980s (Figure 10.2.5; Table 10.2.4). This reflects the decline in fishing effort as a consequence of management measures, as well as a reduction in the size of stocks. The provisional total nominal catch for 2012 was 939 t in northern NEAC and 301 t in southern NEAC. The catch in the southern area, which comprised around two-thirds of the total NEAC catch in the early 1970s, has been lower than in the northern area since 1999 (Figure 10.2.5).

1SW salmon constituted 55% of the total catch in the northern area in 2012, which is among the lowest values in the time-series (Figure 10.2.6). For the southern European countries, the overall percentage of 1SW fish in the catch in 2012 (49%) was also among the lowest values in the time-series. There is considerable variability between countries (Figure 10.2.6).

The contribution of escaped farmed salmon in catches in the NEAC area in 2012 was again generally low in most countries, with the exception of Norway, Iceland, and Sweden, and similar to the values that have been reported in previous years. The estimated proportion of farmed salmon in Norwegian angling catches was among the lowest on record (5%), but, as in previous years, was higher in Norwegian rivers in the autumn (12%). Sampling in net fisheries in northern Norway indicated that 11% of the fish were escaped farmed salmon; the prevalence of farmed fish varied over time and between different areas.

Monitoring of new and expanded fisheries for mackerel in Iceland has provided samples of Atlantic salmon bycatch, primarily as post-smolts.

Effects of the fisheries on the ecosystem

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

Quality considerations

Uncertainties in input variables to the stock status and stock forecast models are incorporated in the assessment. Provisional catch data for 2011 were updated, where appropriate, and the assessment extended to include data for 2012.

Recommendations in relation to data collection for assessment needs for Atlantic salmon were provided in the report of the recent ICES Workshop on Eel and Salmon Data Collection Framework WKESDCF (ICES, 2012c).

Scientific basis

Assessment type	Run-reconstruction models and Bayesian forecasts taking into account uncertainties in data and process error. Results presented in a risk analysis framework.
Input data	Nominal catches (by sea-age class) for commercial and recreational fisheries. Estimates of unreported/illegal catches. Estimates of exploitation rates. Natural mortalities (from earlier assessments).
Discards and bycatch	Discards included in risk-based framework for Faroes fishery. Not relevant for other NEAC assessments.
Indicators	Framework of Indicators (FWI) used to indicate if a significant change has occurred in the status of stocks in intermediate years where multi-annual management advice applies. FWI was updated in 2013, with a revision suggested in the way it should be applied (see Section 10.1.12).
Other information	Advice subject to annual review. Stock annex being developed in 2013 (for completion at 2014 meeting).
Working group report	WGNAS

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STOCK Atlantic salmon from the Northeast Atlantic

Reference points

National run-reconstruction models have been used to develop national CLs for all countries that do not have river-specific values (i.e. all countries except France, Ireland, UK (England & Wales), and Norway). To provide catch options to NASCO, CLs are required for stock complexes. These have been derived either by summing individual river CLs to national level, or by taking overall national CLs as provided by the national model, and then summing to the level of the four NEAC stock complexes. The CLs have also been used to estimate the spawner escapement reserves (SERs), which are the CLs increased to take account of natural mortality (M = 0.03 per month) between 1 January of the first winter at sea and return time to homewaters for each of the maturing (6–9 months) and non-maturing (16–21 months) 1SW salmon components from the northern NEAC and southern NEAC stock complexes.

Complex	Age group	CL (number)	SER (number)
Northern NEAC	1SW	158 223	201 014
	MSW	131 356	222 888
Southern NEAC	1SW	565 183	715 358
	MSW	275 549	463 566

Outlook for 2013 to 2016

PFA (pre-fishery abundance at 1 January of the first winter at sea) forecasts for the southern and northern NEAC complexes were developed within a Bayesian model framework. Probabilities that the PFAs are above or equal to spawner escapement reserves in 2012 to 2016 are given in Table 10.2.5. Probabilities of meeting SERs are higher in the northern than in the southern complex.

MSY approach

Atlantic salmon has characteristics of short-lived fish stocks; mature abundance is sensitive to annual recruitment because there are only few age groups in the adult spawning stock. Incoming recruitment is often the main component of the fishable stock. For such fish stocks, the ICES maximum sustainable yield (MSY) approach is aimed at achieving a target escapement (MSY $B_{escapement}$, the amount of biomass left to spawn). No catch should be allowed unless this escapement can be achieved. The escapement level should be set so there is a low risk of future recruitment being impaired, similar to the basis for estimating B_{pa} in the precautionary approach. In short-lived stocks, where most of the annual surplus production is from recruitment (not growth), MSY $B_{escapement}$ and B_{pa} might be expected to be similar. Conservation limits (CLs) for North Atlantic salmon stock complexes have been defined by ICES as the level of stock (number of spawners) that will achieve long-term average maximum sustainable yield (MSY $B_{escapement}$).

To be consistent with the MSY and the precautionary approach, fisheries should only take place on salmon from stocks that can be shown to be above CLs. Due to the different status of individual stocks, mixed-stock fisheries present particular threats.

In the absence of any fisheries in 2013 to 2016, there is less than 95% probability of meeting the CLs for the two age groups of the southern NEAC complex (Table 10.2.1). In all years, there is a 55% to 59% probability of meeting the CLs for the four NEAC complexes simultaneously, in the absence of any mixed-stock fisheries. Therefore, in the absence of specific management objectives, ICES advises that there are no mixed-stock fisheries options on the NEAC complexes at Faroes in 2013 to 2016. The results from the exploratory assessment conducted by ICES in 2013 based on smaller management units (countries; see Section 10.1.11 and Tables 10.2.2 and 10.2.3 below) are in line with this advice.

Additional considerations

The national stock CLs discussed above are not appropriate for the management of homewater fisheries. This is because of the relative imprecision of the national CLs and because they will not take account of differences in the status of different river stocks or sub-river populations. Management at finer scales should take account of individual river stock status. Nevertheless, the combined CLs for the main stock groups (national stocks) exploited by the distant-water fisheries can be used to provide general management advice to the distant water fisheries.

Fisheries on mixed stocks pose particular difficulties for management, when they cannot target only stocks that are at full reproductive capacity. The management of a fishery should ideally be based upon the status of all stocks exploited in the fishery. Conservation would be best achieved if fisheries target stocks that have been shown to be at full reproductive capacity. Fisheries in estuaries and, especially, rivers are more likely to meet this requirement.

There has been an overall declining trend in marine survival rates of wild and hatchery-reared smolts in northern and southern NEAC areas (Figure 10.2.7). Focusing on return indices for individual river stocks (not shown in the figure), the average return rates in the last five years are mostly below the average in the previous five years for hatchery-reared smolts, as well as for wild smolts in northern NEAC; return rates of wild smolts in southern NEAC are more variable, with some rivers showing an increase whilst others show a decrease. Results from these analyses are consistent with the information on estimated returns and spawners as derived from the PFA model, and suggest that returns are strongly influenced by factors in the marine environment.

ICES was asked to further develop a risk-based framework for the provision of catch advice for the Faroese salmon fishery, reporting on the implications of selecting different numbers of management units, and to update the Framework of Indicators for the Faroes fishery. These issues are discussed in full in Section 10.1.11 and Section 10.1.12.

Data and methods

Input data to estimate the historical PFAs are the catch in numbers of 1SW and MSW salmon in each country, unreported catch (minimum and maximum), and exploitation rates (minimum and maximum). Data beginning in 1971 are available for most countries. In addition, catches at the Faroes and catches of NEAC-origin salmon at West Greenland are incorporated. Results are presented in Tables 10.2.6 and 10.2.7.

The Bayesian inference and forecast models for the southern NEAC and northern NEAC complexes have the same structure and are run independently. For both southern and northern NEAC complexes, PFA forecasts were derived based on lagged spawners and productivity. Forecasts for maturing and non-maturing stocks were derived for five years, from 2012 to 2016.

The risk framework was used to evaluate catch options for the Faroes fishery in the 2013/14, 2014/1, and 2015/16 fishing seasons, based on the northern and southern NEAC stock complexes of maturing and non-maturing 1SW salmon, and also based on countries, again split into maturing and non-maturing 1SW salmon. The catch options examined assumed that homewater fisheries would also take the total catch allocation based on a share of 8.4% of the total catch at Faroes. The risk analysis calculates the probability of stocks achieving the management objective for each of the age groups of the NEAC stock complexes/countries and displays the resulting probabilities in tabular and/or graphic form.

The computing platform for conducting the run-reconstruction and the derivation of CLs for jurisdictions without river-specific CLs has been moved from the Crystal Ball (CB) program to “R”.

Uncertainties in assessments and forecasts

The model estimates the PFA from the catch in numbers of 1SW and MSW salmon in each country. Uncertainties are accounted for using minimum and maximum ranges for unreported catches and exploitation rates. A natural mortality value of 0.03 (range 0.02 to 0.04) per month is applied during the second year at sea. Monte Carlo simulation is used to generate confidence intervals of the eggs from spawners and the returns to each country.

The risk framework examines for each year the posterior probability that the numbers of spawners are above the age- and stock-specific CLs under various catch scenarios.

The large uncertainty in the PFA forecasts encompasses the historical range of estimated abundance (Figures 10.2.1 and 10.2.2). This increased uncertainty also results in increased risk of not achieving the CLs. As a result, the advice is more cautious regarding fishing opportunities.

Comparison with previous assessment and catch options

ICES has investigated the limitations of defining management units smaller than the current NEAC stock complexes, and the implications of applying probabilities of achieving CLs for management units individually versus applying the probability that management units simultaneously achieve their CLs (see Section 10.1.11). On the basis of these considerations, ICES is providing both individual probabilities and the probability of simultaneous attainment in the latest catch options tables. The risk assessment framework in this year’s advice directly evaluates the probability of meeting or exceeding stock complex and country management objectives. Managers can choose the risk level which they consider appropriate. ICES considers, however, that to be consistent with the MSY and the precautionary approach, and given that the CLs are considered to be limit reference points to be avoided with high probability, managers should choose a risk level that results in a low chance of failing to meet the CLs. ICES recommends that management decisions be based principally on a 95% probability of attainment of CLs in each stock complex individually. The probability of simultaneous attainment may also be used as a guide, but managers should be aware that this probability will generally be quite low when a large number of management units is used.

ICES has also indicated that when implementing the risk framework for the provision of catch advice for the NEAC area, management objectives should be defined for each salmon management unit. Such management objectives have yet to be agreed by NASCO.

Assessment and management area

National stocks are combined into southern NEAC and northern NEAC groups. The groups fulfilled an agreed set of criteria for defining stock groups for the provision of management advice (ICES, 2005). Consideration of exploitation rates of national stocks resulted in the advice for the Faroes fishery (both 1SW and MSW) being based upon all NEAC area stocks, and the advice for the West Greenland fishery being based upon the southern NEAC non-maturing 1SW stock only.

ICES (2010, 2011, 2012b) previously emphasized the problem of basing a risk assessment and catch advice for Faroes fishery on management units comprising large numbers of river stocks. In providing catch advice at the age and stock complex levels for northern and southern NEAC areas, consideration needs to be given to the recent performance of the stocks within individual countries. This still applies for catch advice at the age and country level for northern and southern NEAC. At present, insufficient data are available to assess performance of individual stocks in all countries in the NEAC area. In some instances CLs are in the process of being developed (UK (Scotland) and Iceland).

Sources of information

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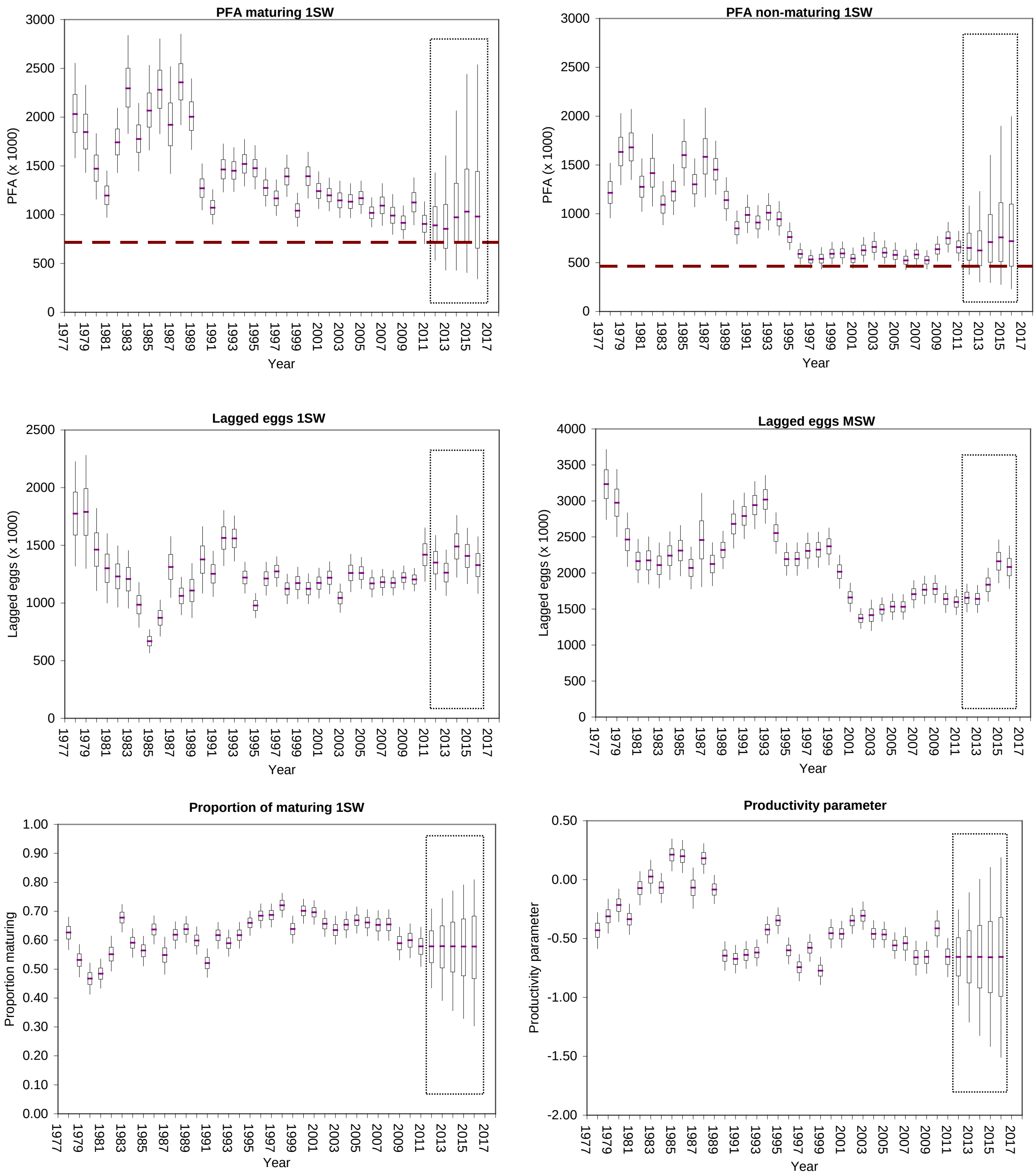


Figure 10.2.1 Southern NEAC PFA maturing and non-maturing, lagged eggs from 1SW and MSW, proportion 1SW maturing, and the productivity parameter values for PFA years 1978 to 2016. The last five years (2012 to 2016) are forecasts in all cases. The dashed horizontal lines in the upper panels are the age-specific SER values. Box and whiskers show the 5th, 25th, 50th, 75th, and 95th percentiles (Bayesian credibility intervals).

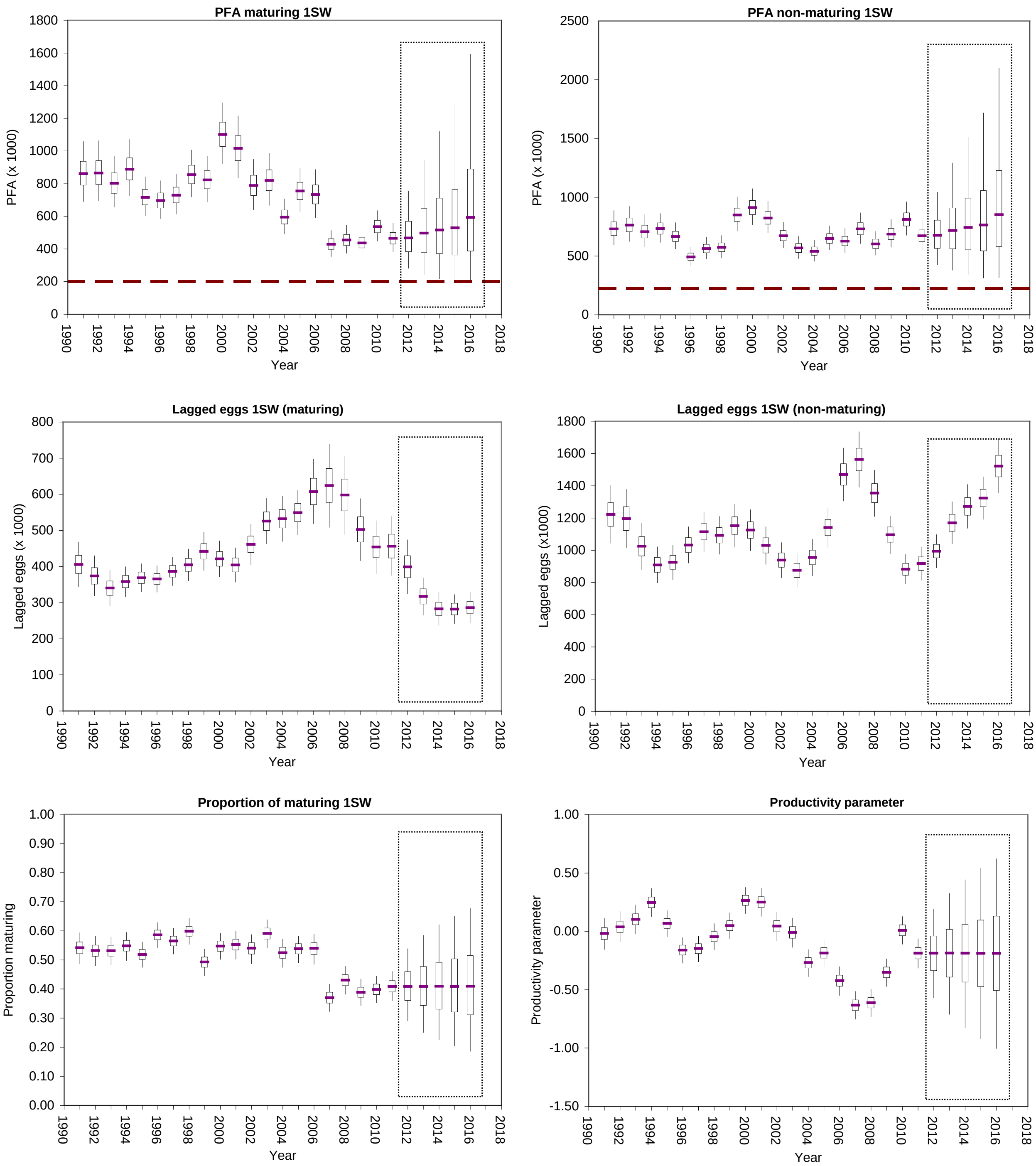


Figure 10.2.2 Northern NEAC PFA maturing and non-maturing, lagged eggs from 1SW and MSW, proportion 1SW maturing, and the productivity parameter values for PFA years 1991 to 2016. The last five years (2012 to 2016) are forecasts in all cases. The dashed horizontal lines in the upper panels are the age-specific SER values. Box and whiskers show the 5th, 25th, 50th, 75th, and 95th percentiles (Bayesian credibility intervals).

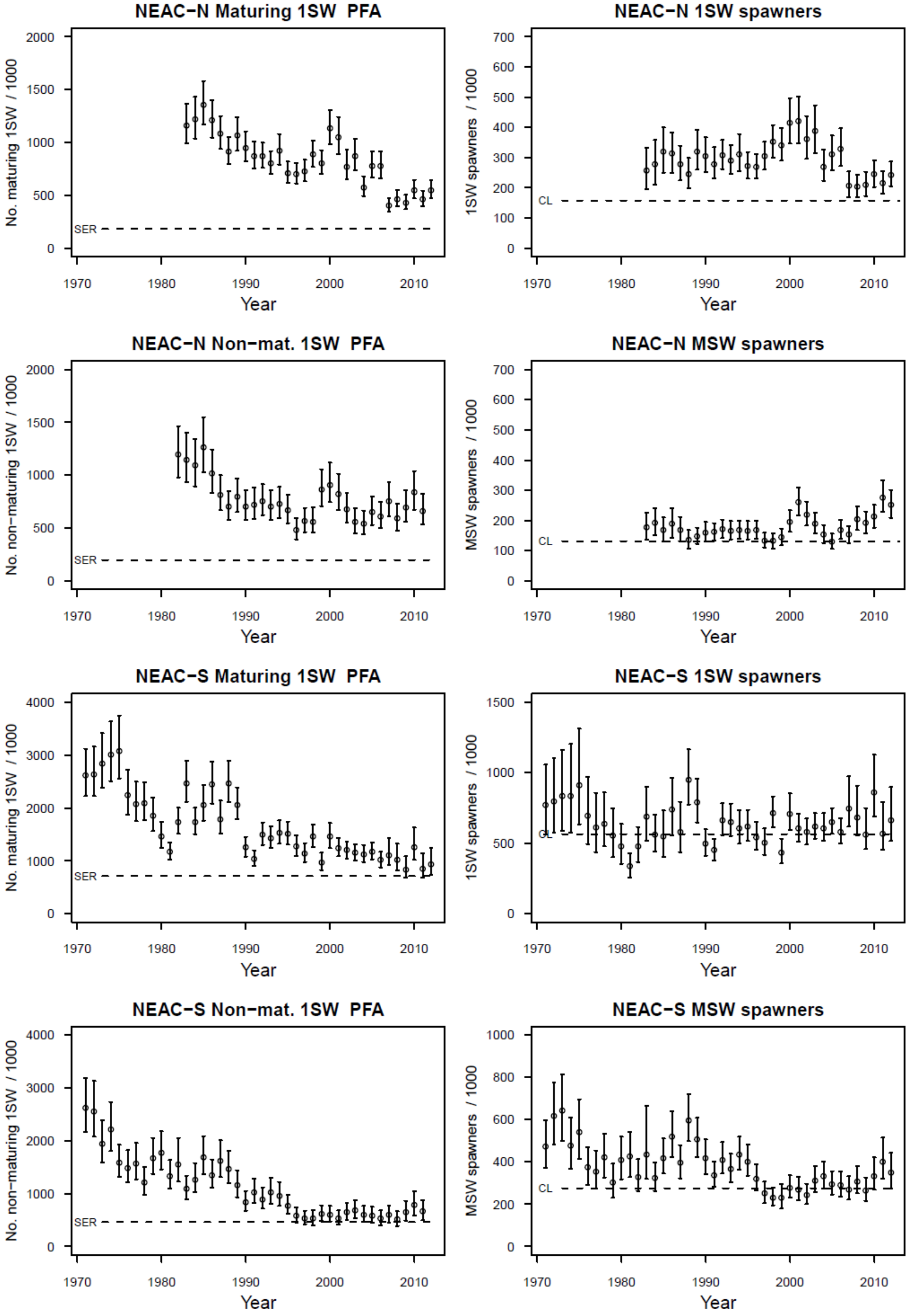


Figure 10.2.3 **Estimated PFA** (recruits; **left panels) and spawning escapement (right panels) with 90% confidence limits, for maturing 1SW (1SW spawners) and non-maturing 1SW (MSW spawners) salmon in the northern (NEAC-N) and southern (NEAC-S) NEAC stock complexes. The dashed horizontal lines in the left panels are the age-specific SER values, and in the right panels the age-specific CL values.**

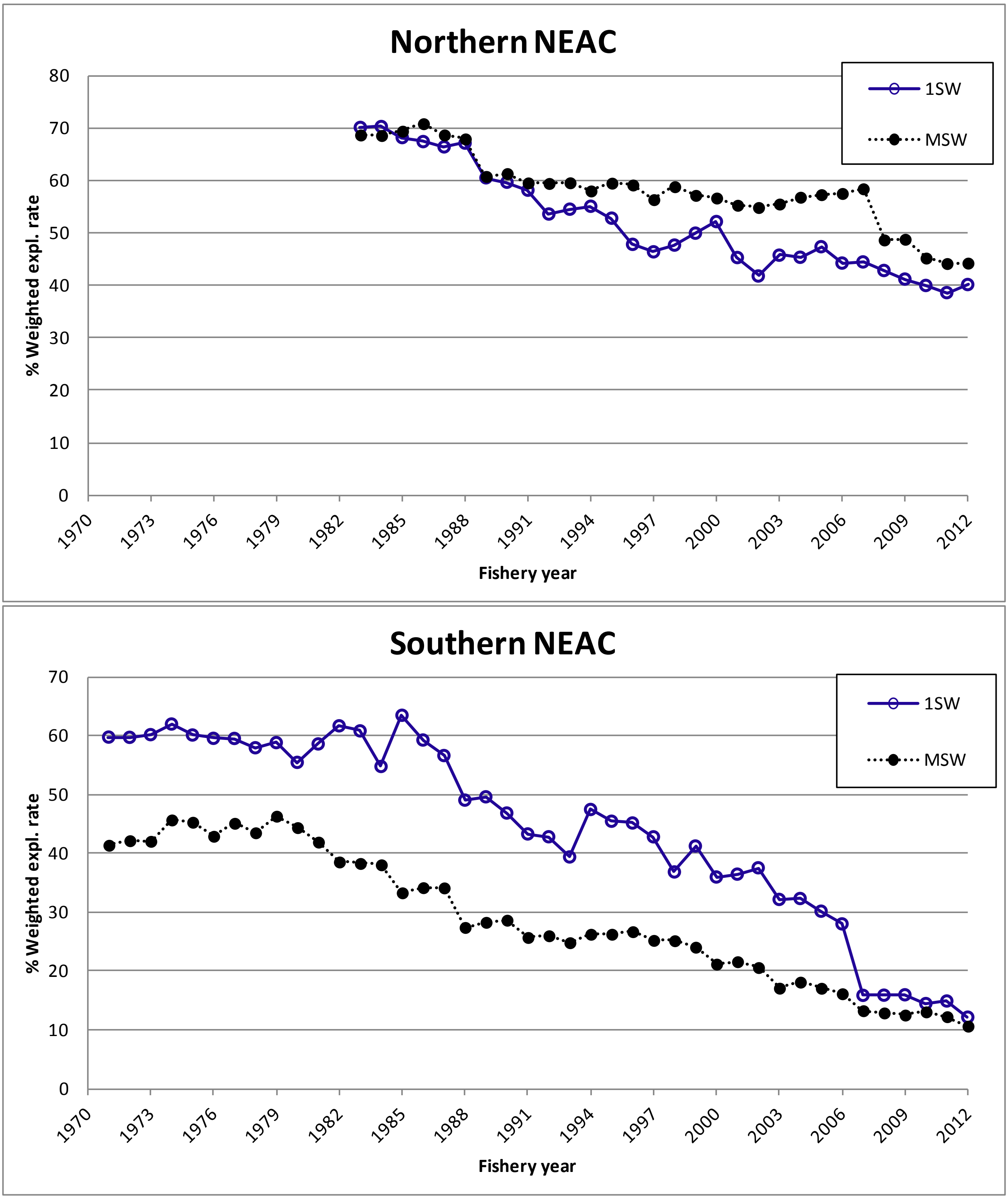


Figure 10.2.4 Mean annual exploitation rate of wild 1SW and MSW salmon by combined commercial and recreational fisheries in the northern NEAC area (upper panel), from 1983 to 2012, and the southern NEAC area (lower panel), from 1971 to 2012.

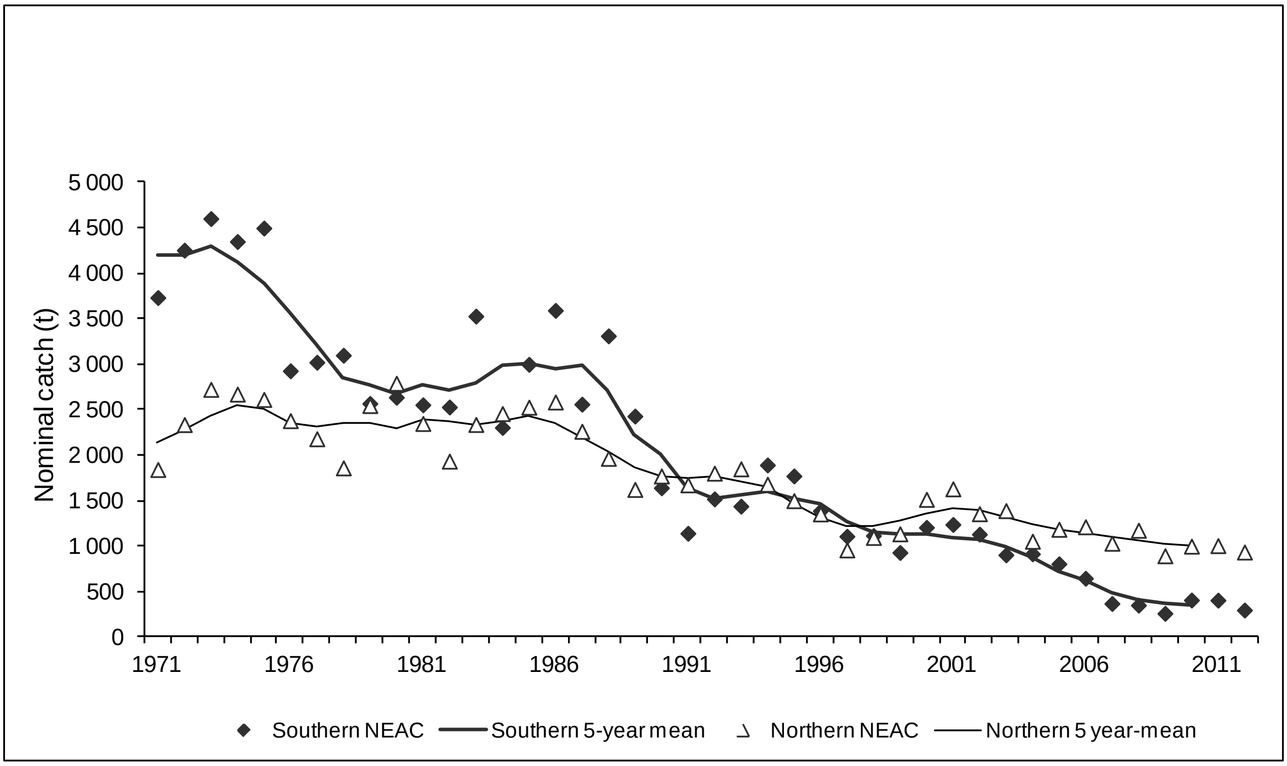
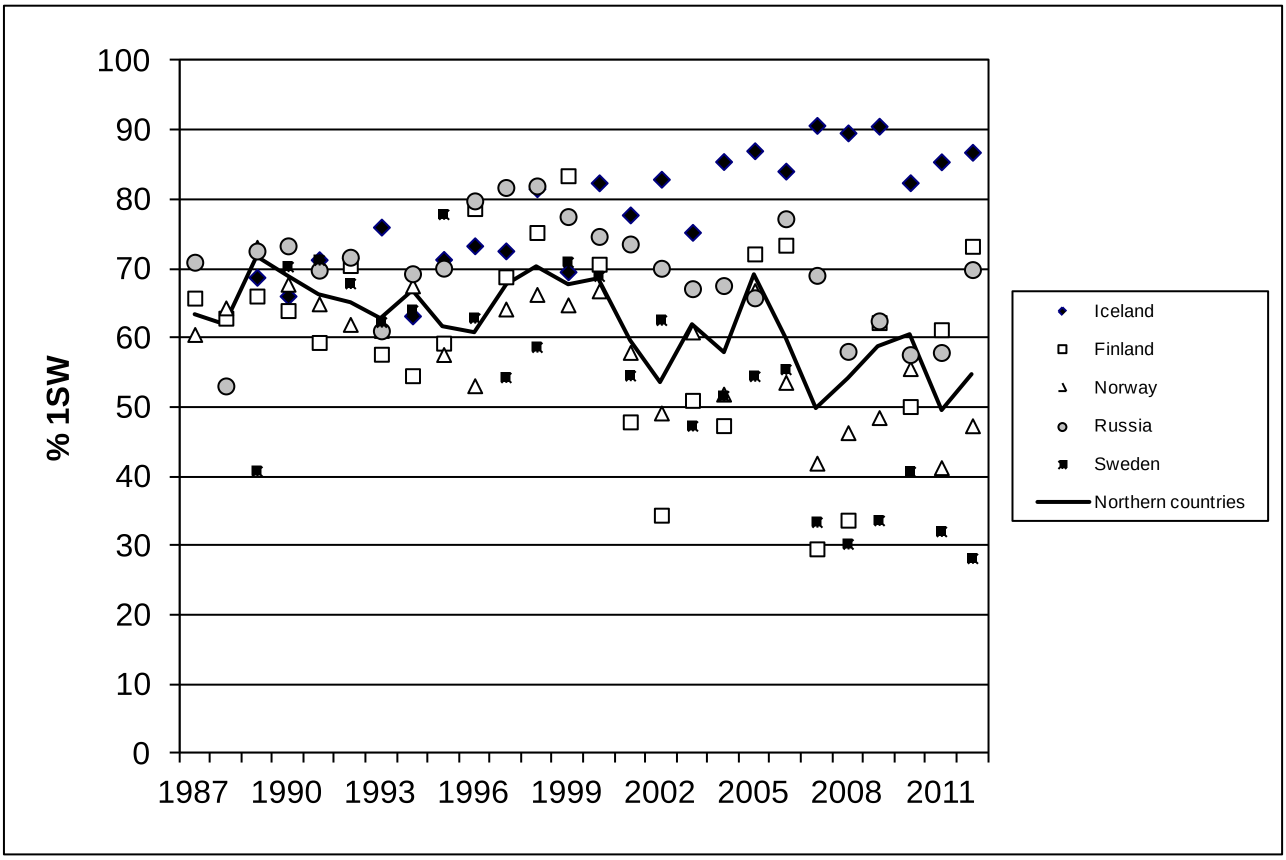


Figure 10.2.5 Nominal catch of salmon and 5-year running means in the southern NEAC and northern NEAC areas, from 1971 to 2012.



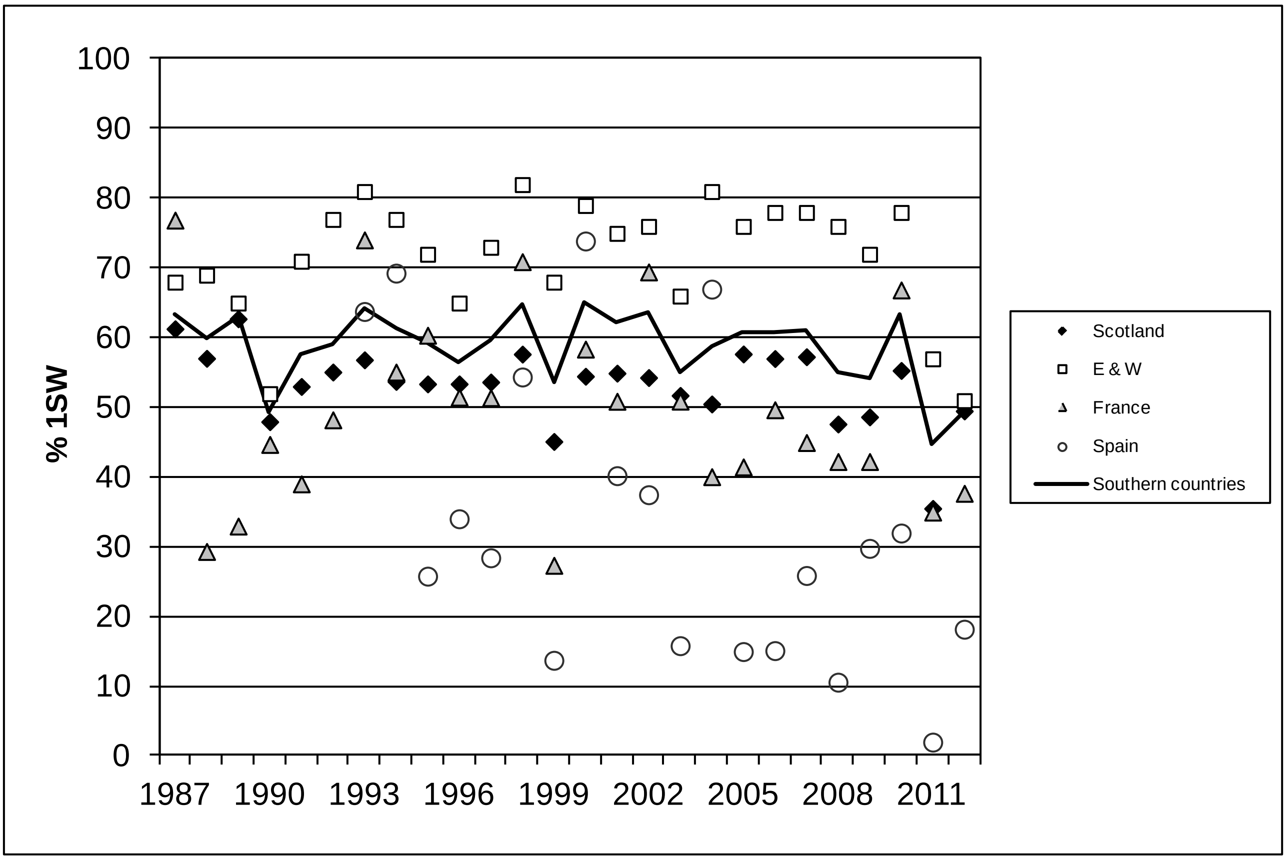


Figure 10.2.6 Percentage of 1SW salmon in the reported catch for northern NEAC countries (upper panel) and southern NEAC countries (lower panel), from 1987 to 2012. Solid line denotes mean value from catches in all countries within the complex.

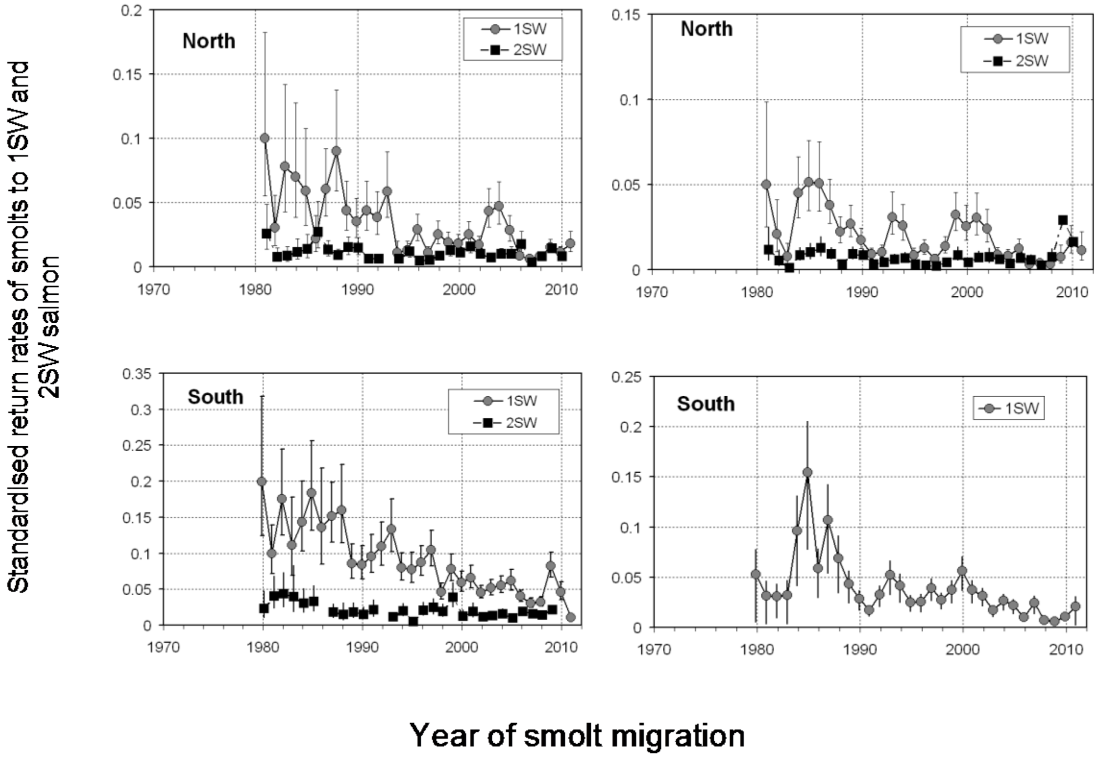


Figure 10.2.7 Standardized mean (one standard error bars) annual return rates of wild (left hand panels) and hatchery origin (right hand panels) smolts to 1SW and 2SW salmon to the northern and southern NEAC areas. The standardized values are annual means derived from a general linear model analysis of rivers in a region. Survival rates were log transformed prior to analysis. Note differences in scales in the vertical axes.

Table 10.2.1 Probability (%) of northern and southern NEAC 1SW and MSW stock complexes achieving their SERs individually (one column per stock complex) and simultaneously (right-most column) for different catch options for the Faroes fishery in the 2013/14 to 2015/16 fishing seasons.

Catch options for 2013/14 season:	TAC option (t)	NEAC-N-1SW	NEAC-N-MSW	NEAC-S-1SW	NEAC-S-MSW	All complexes simultaneous
	0	96%	100%	74%	76%	57%
	20	96%	99%	74%	70%	53%
	40	96%	98%	74%	64%	48%
	60	96%	96%	74%	58%	43%
	80	96%	93%	74%	52%	38%
	100	96%	89%	74%	47%	33%
	120	96%	84%	74%	42%	28%
	140	96%	78%	74%	37%	23%
	160	96%	72%	74%	32%	19%
	180	96%	65%	74%	28%	15%
	200	96%	58%	74%	25%	12%
Catch options for 2014/15 season:	**TAC option (t)**	**NEAC-N-1SW**	**NEAC-N-MSW**	**NEAC-S-1SW**	**NEAC-S-MSW**	**All complexes simultaneous**
	0	95%	99%	75%	80%	59%
	20	95%	98%	75%	75%	56%
	40	95%	97%	75%	71%	52%
	60	94%	94%	75%	66%	48%
	80	94%	91%	75%	62%	44%
	100	94%	87%	75%	57%	39%
	120	94%	82%	75%	53%	34%
	140	94%	77%	75%	49%	30%
	160	94%	71%	75%	45%	26%
	180	94%	66%	75%	41%	22%
	200	94%	60%	75%	38%	19%
Catch options for 2015/16 season:	**TAC option (t)**	**NEAC-N-1SW**	**NEAC-N-MSW**	**NEAC-S-1SW**	**NEAC-S-MSW**	**All complexes simultaneous**
	0	95%	99%	70%	80%	55%
	20	95%	97%	70%	76%	52%
	40	95%	95%	70%	72%	49%
	60	94%	92%	70%	68%	46%
	80	94%	89%	70%	65%	42%
	100	94%	85%	70%	61%	38%
	120	94%	81%	70%	57%	34%
	140	94%	76%	70%	53%	30%
	160	94%	71%	70%	50%	27%
	180	94%	65%	70%	47%	23%
	200	94%	60%	70%	44%	20%

Table 10.2.2 Probability (%) of national NEAC 1SW stock complexes achieving their SERs individually (one column per country) and simultaneously (right-most column) for different catch options for the Faroes fishery in the 2013/14 to 2015/16 fishing seasons.

Catch options for 2013/14 season:	TAC option (t)	Russia	Finland	Norway	Sweden	Iceland	Scotland	N. Ireland	Ireland	England & Wales	France	All MUs simultaneous
	0	87%	85%	90%	98%	75%	54%	50%	56%	58%	28%	**1.3%**
	20	87%	85%	90%	98%	75%	54%	50%	56%	58%	28%	**1.3%**
	40	87%	85%	89%	98%	75%	54%	50%	56%	58%	28%	**1.3%**
	60	86%	85%	89%	98%	75%	54%	50%	56%	58%	28%	**1.3%**
	80	86%	84%	89%	98%	75%	54%	50%	56%	58%	28%	**1.3%**
	100	86%	84%	89%	97%	75%	54%	50%	56%	58%	28%	**1.3%**
	120	86%	84%	89%	97%	75%	54%	50%	56%	58%	28%	**1.3%**
	140	86%	84%	89%	97%	75%	54%	50%	56%	58%	28%	**1.3%**
	160	86%	84%	89%	97%	75%	54%	50%	56%	58%	28%	**1.3%**
	180	86%	84%	89%	97%	75%	54%	50%	56%	58%	28%	**1.2%**
	200	86%	84%	89%	97%	75%	54%	49%	56%	58%	28%	**1.2%**

Catch options for 2014/15 season:	TAC option (t)	Russia	Finland	Norway	Sweden	Iceland	Scotland	N. Ireland	Ireland	England & Wales	France	All MUs simultaneous
	0	83%	74%	89%	97%	75%	58%	55%	53%	58%	26%	**1.2%**
	20	83%	74%	89%	97%	75%	57%	55%	53%	58%	26%	**1.2%**
	40	83%	74%	89%	97%	75%	57%	55%	53%	58%	26%	**1.1%**
	60	83%	74%	89%	96%	75%	57%	55%	53%	58%	26%	**1.1%**
	80	83%	74%	89%	96%	75%	57%	55%	53%	58%	26%	**1.1%**
	100	83%	74%	89%	96%	75%	57%	55%	53%	58%	26%	**1.1%**
	120	83%	73%	89%	96%	75%	57%	55%	53%	58%	26%	**1.1%**
	140	83%	73%	89%	96%	75%	57%	55%	53%	58%	26%	**1.1%**
	160	83%	73%	89%	96%	75%	57%	55%	53%	58%	26%	**1.1%**
	180	83%	73%	89%	96%	75%	57%	54%	53%	58%	26%	**1.1%**
	200	83%	73%	89%	96%	75%	57%	54%	53%	58%	26%	**1.1%**

Catch options for 2015/16 season:	TAC option (t)	Russia	Finland	Norway	Sweden	Iceland	Scotland	N. Ireland	Ireland	England & Wales	France	All MUs simultaneous
	0	83%	73%	90%	96%	75%	55%	61%	52%	51%	26%	**1.1%**
	20	83%	73%	90%	96%	75%	54%	61%	52%	51%	26%	**1.0%**
	40	83%	73%	90%	96%	75%	54%	61%	52%	51%	26%	**1.0%**
	60	83%	73%	90%	96%	75%	54%	61%	52%	51%	26%	**1.0%**
	80	83%	72%	90%	96%	75%	54%	61%	52%	51%	26%	**1.0%**
	100	83%	72%	89%	96%	75%	54%	61%	52%	51%	26%	**1.0%**
	120	83%	72%	89%	96%	75%	54%	61%	52%	51%	26%	**1.0%**
	140	83%	72%	89%	96%	75%	54%	61%	52%	51%	26%	**1.0%**
	160	83%	72%	89%	96%	75%	54%	61%	52%	51%	26%	**1.0%**
	180	83%	72%	89%	96%	75%	54%	61%	52%	51%	26%	**1.0%**
	200	83%	72%	89%	95%	75%	54%	61%	52%	51%	26%	**1.0%**

Table 10.2.3 Probability (%) of national NEAC MSW stock complexes achieving their SERs individually (one column per country) and simultaneously (right-most column) for different catch options for the Faroes fishery in the 2013/14 to 2015/16 fishing seasons.

	TAC option (t)	Russia	Finland	Norway	Sweden	Iceland	Scotland	N. Ireland	Ireland	England & Wales	France	All MUs simultaneous
Catch options for 2013/14 season:	0	78%	81%	99%	100%	100%	72%	88%	27%	85%	57%	5.1%
	20	69%	77%	98%	100%	100%	67%	82%	26%	83%	55%	3.4%
	40	60%	73%	96%	99%	100%	63%	77%	25%	82%	54%	2.3%
	60	51%	69%	94%	98%	99%	59%	73%	24%	81%	52%	1.4%
	80	43%	65%	92%	97%	99%	55%	68%	23%	80%	51%	0.9%
	100	36%	62%	89%	96%	98%	51%	64%	22%	78%	49%	0.5%
	120	30%	59%	87%	95%	97%	47%	61%	22%	77%	48%	0.4%
	140	25%	56%	83%	93%	96%	44%	57%	21%	75%	47%	0.3%
	160	20%	53%	80%	92%	95%	40%	55%	20%	74%	45%	0.1%
	180	17%	51%	77%	90%	94%	37%	52%	19%	73%	44%	0.1%
	200	14%	48%	73%	88%	92%	34%	49%	19%	71%	43%	0.1%

	TAC option (t)	Russia	Finland	Norway	Sweden	Iceland	Scotland	N. Ireland	Ireland	England & Wales	France	All MUs simultaneous
Catch options for 2014/15 season:	0	75%	69%	98%	100%	100%	73%	87%	29%	82%	52%	3.9%
	20	66%	64%	97%	99%	100%	69%	82%	28%	81%	50%	2.6%
	40	58%	60%	96%	98%	100%	66%	78%	27%	80%	49%	1.8%
	60	50%	56%	94%	97%	99%	62%	74%	26%	78%	47%	1.2%
	80	43%	53%	92%	96%	99%	59%	70%	25%	77%	46%	0.8%
	100	37%	49%	90%	95%	98%	56%	67%	24%	76%	45%	0.5%
	120	32%	46%	87%	93%	97%	52%	64%	24%	75%	44%	0.4%
	140	27%	44%	84%	92%	96%	49%	62%	23%	73%	43%	0.2%
	160	23%	41%	82%	90%	95%	46%	59%	22%	72%	41%	0.2%
	180	20%	39%	79%	88%	94%	44%	57%	22%	71%	40%	0.1%
	200	16%	37%	76%	87%	92%	41%	55%	21%	70%	39%	0.0%

	TAC option (t)	Russia	Finland	Norway	Sweden	Iceland	Scotland	N. Ireland	Ireland	England & Wales	France	All MUs simultaneous
Catch options for 2015/16 season:	0	75%	68%	98%	100%	100%	69%	88%	30%	75%	50%	3.2%
	20	68%	64%	97%	99%	100%	65%	84%	29%	74%	48%	2.2%
	40	61%	60%	96%	98%	100%	62%	80%	28%	72%	47%	1.5%
	60	54%	57%	94%	97%	99%	59%	76%	27%	71%	46%	1.0%
	80	48%	54%	92%	96%	99%	55%	74%	26%	70%	45%	0.7%
	100	42%	51%	90%	95%	98%	52%	71%	26%	68%	44%	0.5%
	120	37%	48%	88%	93%	97%	49%	69%	25%	67%	42%	0.4%
	140	32%	46%	86%	92%	96%	46%	66%	24%	66%	41%	0.2%
	160	28%	43%	84%	90%	95%	44%	64%	24%	64%	41%	0.2%
	180	25%	41%	82%	89%	94%	41%	62%	23%	63%	40%	0.1%
	200	22%	39%	80%	87%	92%	39%	61%	22%	62%	39%	0.1%

Table 10.2.4 Nominal catch of salmon in the NEAC area (in tonnes, round fresh weight), from 1960 to 2012 (2012 figures are provisional).

Year	Southern countries	Northern countries (1)	Faroes (2)	Other catches in international waters	Total Reported Catch	Unreported catches NEAC Area (3)	Unreported catches International waters (4)
1960	2,641	2,899	-	-	5,540	-	-
1961	2,276	2,477	-	-	4,753	-	-
1962	3,894	2,815	-	-	6,709	-	-
1963	3,842	2,434	-	-	6,276	-	-
1964	4,242	2,908	-	-	7,150	-	-
1965	3,693	2,763	-	-	6,456	-	-
1966	3,549	2,503	-	-	6,052	-	-
1967	4,492	3,034	-	-	7,526	-	-
1968	3,623	2,523	5	403	6,554	-	-
1969	4,383	1,898	7	893	7,181	-	-
1970	4,048	1,834	12	922	6,816	-	-
1971	3,736	1,846	-	471	6,053	-	-
1972	4,257	2,340	9	486	7,092	-	-
1973	4,604	2,727	28	533	7,892	-	-
1974	4,352	2,675	20	373	7,420	-	-
1975	4,500	2,616	28	475	7,619	-	-
1976	2,931	2,383	40	289	5,643	-	-
1977	3,025	2,184	40	192	5,441	-	-
1978	3,102	1,864	37	138	5,141	-	-
1979	2,572	2,549	119	193	5,433	-	-
1980	2,640	2,794	536	277	6,247	-	-
1981	2,557	2,352	1,025	313	6,247	-	-
1982	2,533	1,938	606	437	5,514	-	-
1983	3,532	2,341	678	466	7,017	-	-
1984	2,308	2,461	628	101	5,498	-	-
1985	3,002	2,531	566	-	6,099	-	-
1986	3,595	2,588	530	-	6,713	-	-
1987	2,564	2,266	576	-	5,406	2,554	-
1988	3,315	1,969	243	-	5,527	3,087	-
1989	2,433	1,627	364	-	4,424	2,103	-
1990	1,645	1,775	315	-	3,735	1,779	180-350
1991	1,145	1,677	95	-	2,917	1,555	25-100
1992	1,523	1,806	23	-	3,352	1,825	25-100
1993	1,443	1,853	23	-	3,319	1,471	25-100
1994	1,896	1,684	6	-	3,586	1,157	25-100
1995	1,775	1,503	5	-	3,283	942	-
1996	1,392	1,358	-	-	2,750	947	-
1997	1,112	962	-	-	2,074	732	-
1998	1,120	1,099	6	`	2,225	1,108	-
1999	934	1,139	0	-	2,073	887	-
2000	1,210	1,518	8	-	2,736	1,135	-
2001	1,242	1,634	0	-	2,876	1,089	-
2002	1,135	1,360	0	-	2,495	946	-
2003	908	1,394	0	-	2,302	719	-
2004	919	1,058	0	-	1,977	575	-
2005	809	1,189	0	-	1,998	605	-
2006	650	1,217	0	-	1,867	604	-
2007	373	1,036	0	-	1,409	465	-
2008	355	1,178	0	-	1,533	433	-
2009	265	898	0	-	1,163	317	-
2010	411	1,003	0	-	1,415	357	-
2011	410	1,009	0	-	1,419	382	
2012	301	939	0	-	1,240	363	
Average							
2007-2011	363	1025	0	-	1388	391	-
2002-2011	624	1134	0	-	1758	540	-

1. All Iceland has been included in Northern countries
2. Since 1991, fishing carried out at the Faroes has only been for research purposes.
3. No unreported catch estimate available for Russia since 2008.
4. Estimates refer to season ending in given year.

Table 10.2.5 Probabilities that the forecast PFA for 1SW maturing and 1SW non-maturing fish will be greater than the age-specific spawner escapement reserves (SER) for the PFA years 2012 to 2016, for the southern NEAC complex (upper table) and the northern NEAC complex (lower table).

Southern NEAC		
	1SW Maturing	**1SW Non-maturing**
Spawner escapement reserve (SER)	715 358	463 566
PFA Year	Probability of PFA meeting or exceeding SER	
2012	0.77	0.85
2013	0.67	0.76
2014	0.74	0.80
2015	0.75	0.80
2016	0.70	0.75

Northern NEAC		
	1SW Maturing	**1SW Non-maturing**
Spawner escapement reserve (SER)	201 014	222 888
PFA Year	Probability of PFA meeting or exceeding SER	
2012	1.00	1.00
2013	0.98	1.00
2014	0.96	0.99
2015	0.95	0.99
2016	0.95	0.98

Table 10.2.6 Estimated pre-fishery abundance (PFA) of maturing 1SW salmon (potential 1SW returns) by NEAC country or region and year.

	Northern Europe								Southern Europe									NEAC Area		
Year	Finland	Iceland	Norway	Russia	Sweden	Total			France	Iceland	Ireland	UK(EW)	UK(NI)	UK(Scot)	Total			Total		
		N&E				5.0%	50.0%	95.0%		S&W					5.0%	50.0%	95.0%	5.0%	50.0%	95.0%
1971	33,545	12,094		NA	22,279				63,680	79,581	1,344,969	105,202	231,178	783,005	2,272,283	**2,622,949**	3,045,619			
1972	51,958	11,092		151,275	17,659				127,611	64,806	1,427,891	101,388	202,207	683,229	2,273,962	**2,628,999**	3,086,322			
1973	47,287	13,251		223,861	21,931				76,976	69,272	1,561,580	119,489	176,586	818,985	2,443,862	**2,836,888**	3,323,639			
1974	93,670	13,254		222,530	31,449				36,228	49,587	1,774,547	149,571	193,486	781,025	2,573,849	**3,001,384**	3,531,743			
1975	65,162	16,083		340,869	33,891				72,113	76,401	1,963,846	152,978	158,674	636,008	2,624,550	**3,073,860**	3,654,325			
1976	44,934	16,150		237,065	19,205				65,917	60,402	1,335,632	102,772	110,520	548,068	1,915,099	**2,233,631**	2,642,125			
1977	23,186	22,416		151,521	9,135				51,065	61,850	1,147,164	116,360	108,769	571,532	1,789,105	**2,069,616**	2,431,613			
1978	31,303	22,772		153,140	10,356				52,340	81,015	1,007,321	133,148	141,662	654,926	1,814,605	**2,082,162**	2,415,707			
1979	36,735	21,878		212,912	10,962				60,327	74,966	930,902	126,790	99,438	539,777	1,601,026	**1,845,464**	2,137,336			
1980	17,122	3,512		151,679	13,945				124,706	34,327	707,742	119,489	126,224	337,655	1,273,286	**1,465,250**	1,698,014			
1981	26,726	17,370		127,279	25,409				98,494	44,505	374,509	126,153	99,707	418,108	1,047,724	**1,174,504**	1,317,751			
1982	8,587	8,148		111,063	22,230				61,959	45,550	771,386	106,657	143,283	597,748	1,539,868	**1,737,600**	1,963,855			
1983	37,726	11,932	895,529	184,774	29,576	1,015,958	**1,162,491**	1,332,641	65,931	57,558	1,360,399	156,317	200,326	611,390	2,161,066	**2,464,818**	2,824,543	3,247,194	**3,628,731**	4,079,555
1984	41,046	4,333	928,372	196,771	41,094	1,061,649	**1,215,676**	1,397,807	107,956	35,269	711,747	136,112	78,831	642,945	1,532,145	**1,726,587**	1,958,795	2,656,584	**2,946,593**	3,277,789
1985	61,513	28,974	944,167	269,475	48,997	1,197,824	**1,356,907**	1,547,129	40,353	56,851	1,180,700	136,450	102,145	532,277	1,800,918	**2,057,295**	2,367,564	3,067,818	**3,419,983**	3,831,519
1986	56,721	36,255	825,263	231,437	51,736	1,071,115	**1,207,354**	1,370,843	62,033	93,709	1,320,206	158,471	115,146	660,789	2,136,004	**2,439,336**	2,804,964	3,273,439	**3,651,207**	4,087,224
1987	71,562	21,293	692,725	246,317	41,952	955,930	**1,079,081**	1,221,569	110,205	58,145	850,014	163,833	62,888	510,299	1,554,607	**1,786,541**	2,081,943	2,569,259	**2,871,309**	3,227,374
1988	34,784	30,720	637,761	170,207	35,176	810,824	**911,189**	1,031,715	37,550	104,061	1,155,072	224,673	148,019	771,888	2,164,091	**2,461,118**	2,818,590	3,025,291	**3,376,883**	3,784,649
1989	80,278	16,683	700,565	252,459	11,370	941,715	**1,064,071**	1,212,042	20,724	58,322	826,033	151,186	142,436	845,082	1,827,382	**2,058,520**	2,338,339	2,822,039	**3,129,731**	3,475,861
1990	75,789	12,426	626,698	208,281	24,966	841,732	**950,600**	1,079,351	34,157	53,508	517,547	108,018	117,378	404,572	1,105,859	**1,249,138**	1,422,368	1,988,195	**2,202,641**	2,448,820
1991	91,730	17,986	545,306	178,085	30,272	770,204	**868,399**	983,364	25,074	59,177	370,250	106,811	65,611	402,321	925,226	**1,039,975**	1,176,317	1,733,913	**1,910,813**	2,114,740
1992	121,328	33,759	460,052	218,914	32,841	776,117	**872,214**	978,937	45,298	67,442	535,873	111,592	132,729	586,452	1,329,785	**1,498,163**	1,689,902	2,144,276	**2,370,101**	2,619,193
1993	85,557	27,701	461,831	188,279	35,297	717,501	**802,746**	903,033	64,900	66,333	436,160	155,024	155,518	526,015	1,269,074	**1,427,038**	1,617,808	2,020,962	**2,231,558**	2,474,740
1994	34,122	8,912	624,066	222,790	26,848	810,072	**922,727**	1,054,550	51,268	54,324	559,600	172,792	106,748	561,071	1,351,841	**1,527,357**	1,727,595	2,211,472	**2,451,959**	2,720,742
1995	33,509	25,530	407,767	200,378	38,986	631,453	**710,958**	800,232	16,863	73,791	623,375	132,015	99,017	549,907	1,335,827	**1,505,330**	1,703,831	2,000,345	**2,218,771**	2,466,790
1996	77,670	13,641	311,239	272,052	24,009	624,990	**702,275**	791,213	21,006	63,712	581,856	97,759	102,430	394,827	1,120,850	**1,271,152**	1,445,824	1,778,707	**1,977,088**	2,195,101
1997	66,109	18,651	358,917	266,938	11,016	644,004	**725,216**	818,928	10,832	46,640	579,835	87,484	121,693	284,381	999,263	**1,139,233**	1,303,129	1,677,495	**1,865,951**	2,077,904
1998	76,404	31,578	468,531	292,477	9,680	784,344	**883,567**	998,879	21,282	63,713	607,831	96,501	264,724	386,983	1,288,734	**1,451,796**	1,644,930	2,115,731	**2,339,437**	2,596,095
1999	109,190	16,102	435,452	226,187	14,291	716,860	**804,074**	905,993	7,061	51,717	565,615	76,285	68,754	191,831	841,670	**968,857**	1,119,872	1,596,492	**1,774,687**	1,979,683
2000	115,262	16,967	716,003	246,935	28,465	1,002,249	**1,129,735**	1,281,016	18,380	45,931	786,005	116,286	99,981	374,316	1,270,571	**1,451,111**	1,670,686	2,324,523	**2,587,684**	2,880,808
2001	52,170	15,380	617,427	333,014	18,526	909,342	**1,045,340**	1,210,145	15,655	41,148	626,389	101,052	79,036	366,463	1,105,307	**1,240,359**	1,398,736	2,062,515	**2,288,219**	2,550,331
2002	36,524	26,677	378,003	303,392	18,892	666,778	**769,689**	906,536	35,589	51,487	547,562	95,518	156,360	295,512	1,067,617	**1,196,382**	1,346,033	1,772,980	**1,971,660**	2,197,600
2003	42,880	14,173	523,821	270,156	11,612	755,413	**869,085**	1,005,513	23,495	61,710	535,916	74,284	102,298	335,746	1,023,088	**1,147,994**	1,288,631	1,817,428	**2,020,808**	2,243,810
2004	16,683	38,241	317,729	188,898	10,025	504,851	**575,963**	664,574	28,096	61,493	394,457	132,837	91,130	398,857	999,534	**1,124,900**	1,273,737	1,536,578	**1,704,229**	1,895,595
2005	42,502	34,068	470,470	215,551	8,490	682,656	**777,704**	892,001	18,411	90,741	394,244	108,382	116,004	432,647	1,051,910	**1,174,652**	1,319,335	1,772,082	**1,955,792**	2,169,424
2006	80,805	35,892	381,191	259,942	10,254	678,102	**774,458**	893,536	25,756	63,982	301,754	107,291	74,019	419,235	895,161	**1,008,784**	1,143,607	1,611,407	**1,786,903**	1,990,255
2007	14,960	26,606	213,046	140,489	4,875	352,004	**402,926**	465,545	20,262	73,602	345,331	101,960	120,318	411,514	938,809	**1,102,597**	1,369,678	1,322,194	**1,511,251**	1,790,576
2008	15,396	24,322	266,897	146,326	6,306	404,024	**463,352**	535,297	19,845	89,279	340,347	100,281	72,051	355,559	845,070	**1,010,048**	1,269,876	1,284,160	**1,479,699**	1,752,742
2009	31,416	39,223	214,053	137,400	6,724	378,272	**431,555**	493,193	7,123	100,756	280,015	62,853	54,682	303,320	699,644	**834,237**	1,046,344	1,108,830	**1,270,789**	1,497,160
2010	29,320	31,442	317,260	156,751	11,223	482,475	**550,298**	629,039	24,041	102,983	357,136	124,852	50,319	554,961	1,048,289	**1,259,296**	1,567,547	1,569,645	**1,814,632**	2,140,422
2011	35,990	25,821	223,284	166,719	9,308	407,397	**464,263**	531,184	16,960	72,672	314,478	72,330	43,586	295,744	698,598	**843,064**	1,095,288	1,136,871	**1,313,648**	1,578,571
2012	78,015	10,587	248,611	194,063	10,038	478,316	**546,557**	630,002	14,704	45,205	320,690	44,519	54,498	414,460	758,880	**932,133**	1,205,844	1,275,909	**1,485,806**	1,775,052
10yr Av.	38,797	28,038	317,636	187,630	8,885	512,351	**585,616**	673,988	19,869	76,242	358,437	92,959	77,891	392,204	895,898	**1,043,771**	1,257,989	1,443,510	**1,634,356**	1,883,361

Table 10.2.7 Estimated pre-fishery abundance (PFA) of non-maturing 1SW salmon (potential MSW returns) by NEAC country or region and year.

	Northern Europe								Southern Europe									NEAC Area		
Year	**Finland**	**Iceland**	**Norway**	**Russia**	**Sweden**	**Total**			**France**	**Iceland**	**Ireland**	**UK(EW)**	**UK(NI)**	**UK(Scot)**	**Total**			**Total**		
		N&E				5.0%	50.0%	95.0%		**S&W**					5.0%	50.0%	95.0%	5.0%	50.0%	95.0%
1971	71,642	27,304		262,326	5,888				54,723	63,966	385,078	361,141	34,188	1,706,302	2,211,494	**2,621,181**	3,114,208			
1972	85,035	25,819		416,715	8,857				36,778	57,936	387,828	277,581	30,494	1,742,261	2,133,614	**2,545,763**	3,038,110			
1973	118,310	23,955		387,219	5,957				20,338	49,779	400,882	200,820	32,340	1,224,912	1,626,892	**1,940,617**	2,323,575			
1974	132,943	26,771		420,624	4,625				32,178	53,173	452,287	263,424	27,375	1,370,700	1,851,248	**2,211,672**	2,655,530			
1975	107,882	21,781		358,508	5,155				27,618	45,725	337,893	173,512	18,983	979,657	1,350,596	**1,590,410**	1,875,349			
1976	66,435	29,277		248,124	3,663				19,854	44,392	279,324	177,873	18,219	934,438	1,244,998	**1,483,213**	1,771,116			
1977	42,886	37,239		211,108	2,856				18,774	56,978	239,781	149,041	23,130	1,073,242	1,307,737	**1,570,450**	1,893,733			
1978	47,692	25,304		195,502	5,638				19,415	36,910	214,905	87,133	17,124	825,847	1,005,510	**1,207,628**	1,461,069			
1979	58,678	36,673		338,621	11,067				36,692	52,685	249,761	226,476	23,678	1,073,123	1,404,331	**1,670,122**	2,001,610			
1980	71,461	16,735		240,497	9,526				27,987	37,094	201,349	299,904	21,754	1,177,592	1,489,098	**1,775,952**	2,121,774			
1981	85,067	18,153		216,893	13,373				19,719	26,898	134,290	141,749	28,298	977,060	1,124,377	**1,332,259**	1,588,506			
1982	85,464	13,918	812,981	269,475	9,875	1,001,338	**1,195,711**	1,427,316	18,962	42,276	295,953	146,278	36,096	975,721	1,264,546	**1,548,446**	1,962,953	2,307,851	**2,752,651**	3,313,079
1983	76,161	15,543	794,064	249,544	9,455	959,603	**1,147,564**	1,371,177	24,172	35,239	147,570	107,252	15,254	755,358	910,515	**1,089,767**	1,307,372	1,898,937	**2,241,462**	2,641,896
1984	62,459	11,001	740,397	270,632	6,194	918,590	**1,091,964**	1,307,897	18,597	26,118	157,438	147,136	19,156	894,363	1,052,266	**1,267,670**	1,528,349	2,000,229	**2,363,531**	2,798,288
1985	58,157	26,208	890,452	274,491	7,130	1,057,562	**1,259,598**	1,511,373	22,475	22,396	195,512	213,690	21,709	1,204,730	1,409,384	**1,687,721**	2,031,303	2,501,965	**2,952,064**	3,489,227
1986	68,501	26,896	688,984	212,506	11,706	851,138	**1,012,488**	1,210,956	15,508	19,974	237,376	182,458	12,672	869,565	1,135,596	**1,344,232**	1,602,699	2,015,133	**2,357,233**	2,778,674
1987	42,626	16,961	549,394	195,616	9,348	683,811	**816,017**	975,578	28,459	21,621	168,330	212,541	27,813	1,150,895	1,347,670	**1,617,210**	1,952,278	2,060,212	**2,432,257**	2,891,393
1988	48,770	14,943	415,549	195,507	22,286	589,629	**699,000**	831,758	16,857	19,666	164,146	182,337	22,867	1,058,317	1,232,015	**1,467,945**	1,762,075	1,843,577	**2,167,454**	2,566,086
1989	56,815	15,218	469,182	234,577	14,487	666,103	**792,189**	945,774	13,613	19,170	76,935	198,126	20,488	823,094	959,165	**1,157,089**	1,408,529	1,650,726	**1,952,323**	2,321,702
1990	64,820	10,428	387,579	223,135	15,551	591,818	**704,006**	840,655	11,452	18,758	101,354	88,323	10,661	605,171	695,371	**840,715**	1,020,033	1,306,448	**1,546,201**	1,834,314
1991	67,178	14,747	410,256	204,959	19,206	602,102	**719,086**	859,225	14,772	20,931	83,728	73,475	22,650	805,022	845,534	**1,024,021**	1,243,881	1,469,088	**1,740,799**	2,074,874
1992	77,287	16,609	392,064	241,168	25,732	637,603	**755,187**	900,180	7,533	10,336	79,188	76,858	52,763	657,438	735,268	**891,669**	1,086,335	1,391,930	**1,648,193**	1,958,535
1993	64,793	14,140	383,175	217,553	18,974	586,875	**701,254**	839,079	12,964	16,602	114,395	97,200	18,868	758,631	839,297	**1,022,546**	1,256,958	1,448,657	**1,727,111**	2,068,673
1994	41,279	10,006	413,071	246,055	13,582	608,134	**725,029**	866,981	6,359	18,735	110,967	97,693	16,123	703,821	787,551	**959,806**	1,180,353	1,417,034	**1,685,894**	2,018,806
1995	35,983	12,912	411,427	186,380	17,124	558,555	**666,407**	796,101	11,418	12,147	76,565	102,859	17,599	548,870	635,770	**774,765**	950,737	1,213,779	**1,443,386**	1,719,943
1996	49,825	7,068	265,729	147,792	10,700	404,358	**484,018**	578,717	5,922	13,377	96,028	63,737	21,244	371,845	472,352	**581,321**	719,143	892,495	**1,065,987**	1,274,632
1997	42,438	10,321	318,594	181,145	7,944	471,631	**562,554**	676,343	4,851	8,299	55,594	41,074	29,267	388,717	434,671	**532,048**	651,437	923,280	**1,095,776**	1,304,774
1998	39,433	11,824	340,502	161,922	6,800	468,296	**561,659**	675,349	10,256	16,148	86,031	80,846	13,356	298,758	413,789	**520,153**	659,954	900,798	**1,085,010**	1,308,535
1999	87,876	6,966	468,876	281,128	14,865	723,903	**861,467**	1,031,507	7,140	4,401	107,100	83,707	17,769	381,360	496,637	**608,684**	750,356	1,240,744	**1,471,499**	1,754,641
2000	126,391	7,975	554,777	199,715	17,966	760,963	**909,479**	1,094,119	8,768	7,719	97,477	91,781	13,010	372,226	486,706	**599,678**	742,425	1,272,210	**1,510,129**	1,804,231
2001	101,035	7,539	481,777	217,989	13,107	685,566	**825,068**	987,963	7,877	8,358	110,813	81,776	15,493	300,306	433,673	**535,062**	659,579	1,141,171	**1,358,997**	1,620,059
2002	71,841	7,918	425,506	152,242	14,875	563,882	**674,173**	807,421	11,360	13,304	117,115	105,170	10,119	372,391	517,849	**641,155**	797,158	1,103,019	**1,314,931**	1,574,677
2003	34,449	7,783	385,145	117,912	10,852	464,324	**557,193**	672,499	20,831	10,778	63,783	88,835	9,040	477,156	549,773	**679,614**	844,352	1,033,883	**1,239,768**	1,489,625
2004	26,578	9,654	355,166	140,680	8,232	452,535	**541,595**	648,474	12,813	9,480	82,605	95,977	11,469	375,695	484,254	**598,027**	743,554	955,969	**1,140,240**	1,366,181
2005	46,428	9,252	450,428	133,960	8,229	542,061	**650,036**	780,406	12,976	7,894	60,085	86,948	7,316	391,310	463,025	**577,776**	723,003	1,026,287	**1,230,183**	1,477,048
2006	66,497	8,851	382,963	137,972	11,371	512,433	**608,924**	727,538	12,218	4,849	27,180	84,402	10,074	375,941	418,353	**523,071**	657,016	947,329	**1,134,508**	1,358,597
2007	63,259	11,413	441,948	220,260	16,366	626,290	**755,533**	909,462	13,577	5,549	40,694	92,901	6,096	422,123	471,206	**590,627**	744,807	1,127,436	**1,349,848**	1,622,784
2008	29,447	9,211	346,777	185,339	14,631	487,426	**587,723**	709,347	7,124	8,603	45,623	70,653	7,943	357,835	402,914	**505,209**	638,388	911,126	**1,094,230**	1,320,006
2009	46,446	13,084	380,639	230,462	17,946	576,274	**690,764**	834,884	5,976	17,768	29,332	104,232	7,329	470,984	510,450	**646,728**	827,886	1,112,264	**1,342,629**	1,630,912
2010	36,678	14,607	530,311	229,083	23,359	692,941	**837,350**	1,013,814	15,549	9,042	34,314	152,102	19,148	534,375	610,891	**780,108**	1,001,921	1,338,563	**1,618,983**	1,960,017
2011	47,311	7,136	464,174	112,495	27,550	548,660	**660,922**	801,781	12,092	7,747	34,862	122,047	23,715	439,323	512,724	**657,023**	841,650	1,092,602	**1,319,950**	1,602,844
10yr Av.	46,893	9,891	416,306	166,040	15,341	546,682	**656,421**	790,562	12,452	9,501	53,559	100,327	11,225	421,713	494,144	**619,934**	781,974	1,064,848	**1,278,527**	1,540,269

10.3 Advice May 2013

ECOREGION North Atlantic
STOCK Atlantic salmon from North America

Advice for 2013

Because the NASCO Framework of Indicators of North American stocks for 2012 (run in January 2013) did not indicate the need for a revised analysis of catch options, no new management advice for 2013 is provided. The most recent multi-year advice for the North American Commission was provided by ICES (2012). In that assessment, no mixed-stock fishery catch options for 2012 to 2015 on 1SW non-maturing and 2SW salmon in North America were consistent with the management objectives defined for this stock complex. Management advice in the form of catch options is only provided by ICES for the non-maturing 1SW and maturing 2SW components, as the maturing 1SW component is not fished outside of home waters.

Stock status

The regional groupings of stock units used for management in North America is indicated at Figure 10.3.1. Estimates of pre-fishery abundance (PFA, defined as the number of maturing and non-maturing 1SW salmon on 1 August of the second summer at sea) suggest continued low abundance of North American adult salmon (Figure 10.3.2). In 2012, the estimated PFA of 1SW maturing salmon ranks 29th out of the 42-year time-series and the estimated PFA of 1SW non-maturing salmon ranks 30th out of the 41-year time-series. Egg depositions by all sea ages combined in 2012 exceeded or equalled the river-specific CLs in 31 of the 74 assessed rivers (42%) and were less than 50% of CLs in 21 other rivers (28%) (Figure 10.3.3). In 2012, 2SW spawner estimates for the six geographic areas indicated that all areas were below their CLs and are suffering reduced reproductive capacity (Figure 10.3.4). Particularly large deficits are noted in Scotia–Fundy and USA. Exploitation rates on the North American complexes of small salmon (mostly 1SW maturing) and large salmon (all other sea age groups) have declined and in the last few years have been at the lowest in the time-series, averaging 16% for small salmon and 14% for large salmon over the past ten years (Figure 10.3.6). Despite major changes in fisheries management around 20 to 30 years ago, and increasingly more restrictive fisheries measures since then, returns have remained near historical lows and many populations are currently threatened with extirpation. The continued low abundance of salmon stocks across North America, despite significant fishery reductions, further strengthens the conclusions that factors other than fisheries are constraining production.

Management plans

The North Atlantic Salmon Conservation Organisztion (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 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 risk level (probability) of 75% for simultaneous attainment of management objectives in all regional groupings (Figure 10.3.1) has been agreed for the provision of catch advice on 2SW salmon exploited at West Greenland (as non-maturing 1SW fish) and in North America (as non-maturing 1SW and 2SW salmon). For the North American Commission, the management objectives are attaining the 2SW CLs in the four northern areas (Labrador, Newfoundland, Quebec, and Gulf), and achieving a 25% increase in regional returns relative to a baseline period (average returns in 1992–1996) for the two southern regions (Scotia–Fundy and USA).

Biology

Atlantic salmon (*Salmo salar*) is an anadromous species found in rivers of countries bordering the North Atlantic. In the Northwest Atlantic they range from the Connecticut River (USA, 41.6°N) northward to 58.8°N (Quebec, Canada). Juveniles emigrate to the ocean at ages of 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 in 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 predator fields of salmon at sea are considered to be the main contributory factors to lower productivity, which is expressed almost entirely in terms of lower marine survival.

The fisheries

Three groups exploit salmon in Canada: Aboriginal peoples, residents fishing for food in Labrador, and recreational fishers. The provisional reported harvest of salmon by all users in 2012 was 135 t (Table 10.3.1). The dramatic decline in harvested tonnage since 1988 (Figure 10.3.5) is in large part the result of the reductions in commercial fisheries effort, with closure of the insular Newfoundland commercial fishery in 1992, closure of the Labrador commercial fishery in 1998, and closure of the Quebec commercial fishery in 2000. All commercial fisheries for Atlantic salmon remained closed in Canada in 2012 and the catch therefore was zero. The total reported harvests were 60.5 t for the Aboriginal peoples' food fisheries, 1.7 t for residents fishing for food in Labrador, and 72.4 t (about 37 700 small and large salmon) in the recreational fisheries. In 2012, approximately 50 800 salmon (about 32 500 small and 18 300 large) were caught and released by recreational fishers, representing about 57% of the total number caught (including retained fish). France (Islands of Saint-Pierre and Miquelon) reported a total harvest of 1.5 t in the professional and recreational fisheries in 2012 (Table 10.3.1). There are no commercial or recreational fisheries for Atlantic salmon in USA (Table 10.3.1).

	Canada				St Pierre & Miquelon	USA
	Commercial	Aboriginal	Labrador resident	Recreational		
2012 catch (t)	0	60.5	1.7	72.4	1.5	0
% of NAC total	-	45	1	53	1	-

Effects of the fisheries on the ecosystem

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

Quality considerations

Uncertainties in input variables to the stock status and stock forecast models are incorporated in the assessment. Because of the absence of catch data from some regions in Canada, the values were estimated based on historical exploitation rates. Estimates of abundance of adult salmon in some areas, in particular Labrador, are based on a small number of counting facilities raised to a large production area.

Scientific basis

Assessment type	Run-reconstruction models and Bayesian forecasts, taking into account uncertainties in the data.
Input data	Nominal catches (by sea-age class) for commercial and recreational fisheries. Estimates of unreported/illegal catches. Estimates of exploitation rates. Natural mortalities (from earlier assessments).
Discards and bycatch	There are no salmon discarded in the fisheries.
Indicators	Framework of Indicators used to indicate if 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. A stock annex is being developed in 2013 (for completion at the 2014 meeting).
Working group report	WGNAS

10.3.1 Supporting information May 2013

ECOREGION North Atlantic
STOCK Atlantic salmon from North America

Reference points

Conservation limits for 2SW salmon to North America total 152 548 fish. Management objectives for Scotia–Fundy and USA are based on an increase of 25% in returns of 2SW salmon from the mean return in the years 1992 to 1996.

Country and Comission Area	Stock Area	2SW Conservation limit (number of fish)	Management objective (Number of Fish)
	Labrador	34 746	34 746
	Newfoundland	4022	4022
	Gulf of St Lawrence	30 430	30 430
	Quebec	29 446	29 446
	Scotia–Fundy	24 705	10 976
Canada Total		123 349	
USA		29 199	2 548
North American Commission		152 548	

Outlook for 2013

No outlook is provided because the Framework of Indicators of North American stocks did not indicate the need for a reassessment this year.

MSY approach

Atlantic salmon has characteristics of short-lived fish stocks; mature abundance is sensitive to annual recruitment because there are only few age groups in the adult spawning stock. Incoming recruitment is often the main component of the fishable stock. For such fish stocks, the ICES maximum sustainable yield (MSY) approach is aimed at achieving a target escapement (MSY $B_{escapement}$, the amount of biomass left to spawn). No catch should be allowed unless this escapement can be achieved. The escapement level should be set so there is a low risk of future recruitment being impaired, similar to the basis for estimating B_{pa} in the precautionary approach. In short-lived stocks, where most of the annual surplus production is from recruitment (not growth), MSY $B_{escapement}$ and B_{pa} might be expected to be similar. Conservation limits (CLs) for North Atlantic salmon stock complexes have been defined by ICES as the level of stock (number of spawners) that will achieve long-term average maximum sustainable yield (MSY $B_{escapement}$).

ICES considers that to be consistent with the MSY and the precautionary approach, fisheries should only take place on salmon from rivers where stocks have been shown to be at full reproductive capacity. Furthermore, due to the different status of individual stocks within the stock complex, mixed-stock fisheries present particular threats to stock status.

Additional considerations

Fisheries on mixed stocks pose particular difficulties for management, as they cannot target only stocks that are at full reproductive capacity. The management of a fishery should ideally be based upon the status of all stocks exploited in the fishery. Conservation would be best achieved if fisheries target stocks that have been shown to be at full reproductive capacity. Fisheries in estuaries and, especially, rivers are more likely to meet this requirement.

Most catches (over 90%) in North America now take place in rivers or in estuaries. Fisheries are principally managed on a river-by-river basis and, in areas where retention of large salmon is allowed, it is closely controlled. The commercial fisheries are now closed and the remaining coastal food fisheries in Labrador are mainly located in bays, generally inside the headlands. The coastal fishery in St. Pierre & Miquelon (SPM) is a mixed-stock fishery which catches salmon from stocks in Canada and USA; there are no salmon producing rivers in SPM.

It would be desirable to resolve the outstanding issues regarding stock origin of the salmon caught in the estuarine and coastal fisheries at Labrador and in SPM. Genetic analysis techniques offer the opportunity to identify the origin of harvested individuals at varying levels of origin and can provide the information necessary to evaluate the effect that these mixed-stock fisheries have on the contributing populations. Sampling of catches in these fisheries and the development of appropriate baselines that represent all populations subjected to the fisheries is occurring, and the results should be available in the near future.

The returns of 2SW fish in 2012 decreased from 2011 in all six geographic areas of North America. Large declines (range 67% to 77%, and levels among the lowest in the time-series back to 1971) were estimated for the three southern areas (USA, Scotia–Fundy, and Gulf) and declines of 28%, 22%, and 9% were estimated for Quebec, Labrador, and Newfoundland, respectively (Figure 10.3.4). Returns of 1SW salmon in 2012 relative to 2011 also decreased in all areas, except for Newfoundland, and very large declines (range 77% to 98%) were estimated along a north-to-south latitude gradient from Gulf to Scotia–Fundy to USA.

The rank of the estimated returns in the 1971 to 2012 and 2003 to 2012 time-series, and the proportions of the 2SW CL achieved in 2012, for six regions in North America are shown below:

	Rank of 2012 returns in 1971 to 2012, (42 = lowest)		Rank of 2012 returns in 2003 to 2012 (10 = lowest)		Median estimate of 2SW spawners as percentage of conservation limit
Region	1SW	2SW	1SW	2SW	(%)
Labrador	7	4	6	3	63
Newfoundland	7	31	5	9	82
Québec	29	39	7	8	68
Gulf	42	36	10	9	63
Scotia–Fundy	42	41	10	10	4
USA	40	38	10	10	7

Data and methods

The returns for individual river systems and management areas for both sea-age groups were derived from a variety of methods. These methods included counts of salmon at monitoring facilities, population estimates from mark–recapture studies, and applying angling and commercial catch statistics, angling exploitation rates, and measurements of freshwater habitat. The 2SW component of the large returns was determined using the sea-age composition of one or more indicator stocks. Returns of small (1SW), large, and 2SW salmon (a subset of large) to each region were originally estimated by the methods and variables developed by Rago *et al.* (1993) and reported by ICES (1993).

Returns are the number of salmon that returned to the geographic region, including fish caught by homewater commercial fisheries, except in the case of the Newfoundland and Labrador regions, where returns do not include landings in commercial and food fisheries. This avoided double counting of fish because commercial catches in Newfoundland and Labrador and food fisheries in Labrador were added to the sum of regional returns to create the PFA of North American salmon. Total returns of salmon to USA rivers are the sum of trap catches and redd-based estimates.

Uncertainties in assessments and forecasts

To date, 1082 Atlantic salmon rivers have been recorded in eastern Canada and 21 rivers in eastern USA, where salmon are or have been present within the last half century. Conservation requirements in terms of eggs have been defined for 45% (485) of the 1082 rivers in Canada. For over 59% of the rivers with defined conservation requirements, these are less than 1 million eggs, which translates roughly into 200 to 300 spawners, depending upon life history type. Collectively, 91% of the rivers have conservation requirements of less than five million eggs. Assessments were reported for 74 of these rivers in 2012.

Recreational catch statistics for Atlantic salmon are not collected regularly in Canada and there is no mechanism in place that requires anglers to report their catches, except in Quebec. The reliability of recreational catch statistics could be improved in all areas of Canada.

The unreported catch for Canada is estimated at 30.5 t in 2012, mostly from illegal retentions in fisheries directed at salmon. No unreported catch estimate has been provided for St Pierre and Miquelon.

Comparison with previous assessment and catch options

The NASCO Framework of Indicators of North American stocks did not indicate the need for a revised analysis of catch options this year and, therefore, no new management advice for 2013 is provided. The assessment was updated to include data up to 2012 and the stock status was consistent with the previous year’s assessment.

Assessment and management area

The advice for the North America Commission is based upon the objectives defined by management in six geographic areas of North America (Figure 10.3.1).

Sources of information

ICES. 1993. Report of the North Atlantic Salmon Working Group. Copenhagen, 5–12 March 1993. ICES CM 1993/Assess:10.

ICES. 2012. ICES Advice 2012, Book 10 (North Atlantic salmon stocks). 99 pp.

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NASCO. 1998. North Atlantic Salmon Conservation Organization. Agreement on the adoption of a precautionary approach. Report of the 15th annual meeting of the Council. CNL(98)46. 4 pp.

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Rago, P. J., Reddin, D. G., Porter, T. R., Meerburg, D. J., Friedland, K. D., and Potter, E. C. E. 1993. A continental run-reconstruction model for the non-maturing component of North American Atlantic salmon: analysis of fisheries in Greenland and Newfoundland Labrador, 1974–1991. ICES CM 1993/M:25.

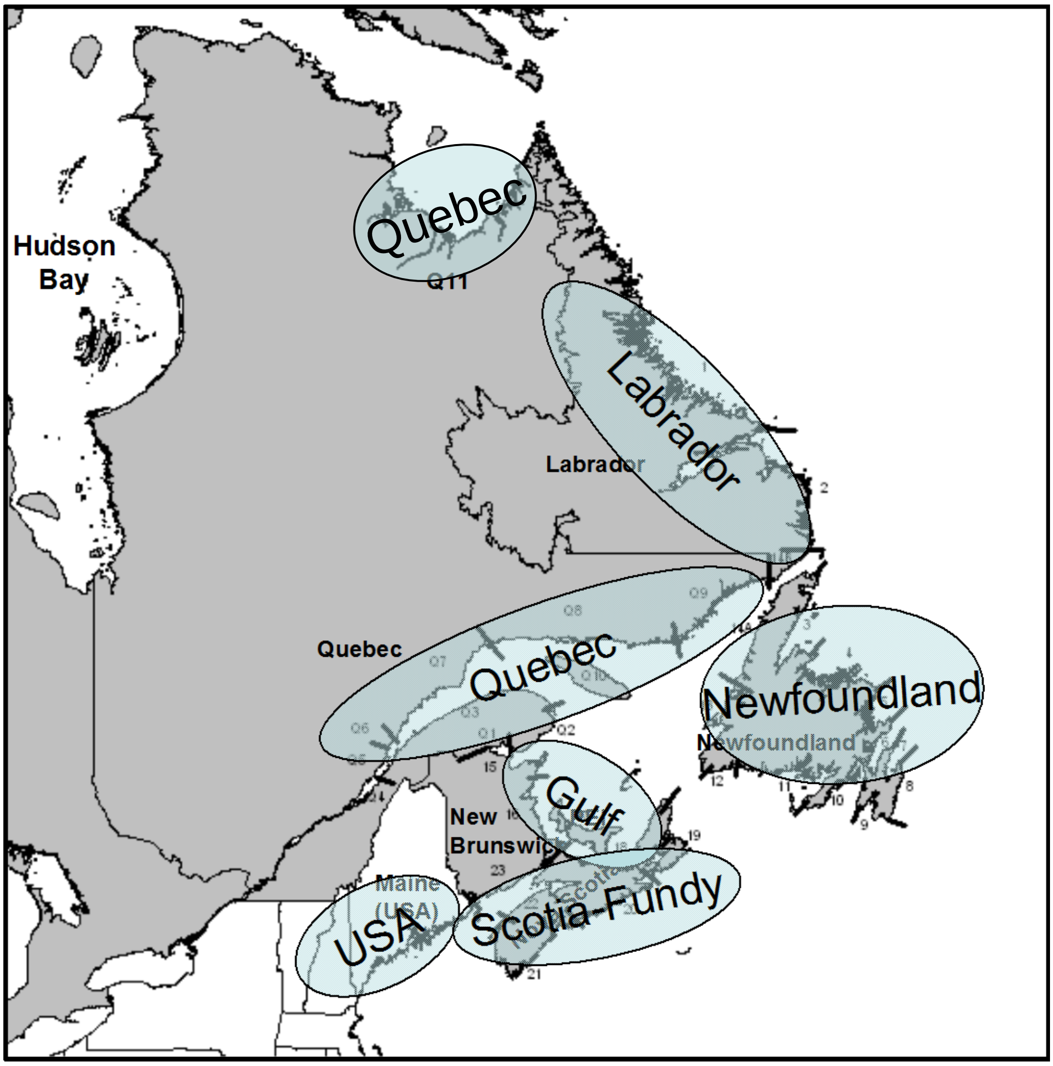

Figure 10.3.1 Regional groupings of Atlantic salmon in the North American Commission.

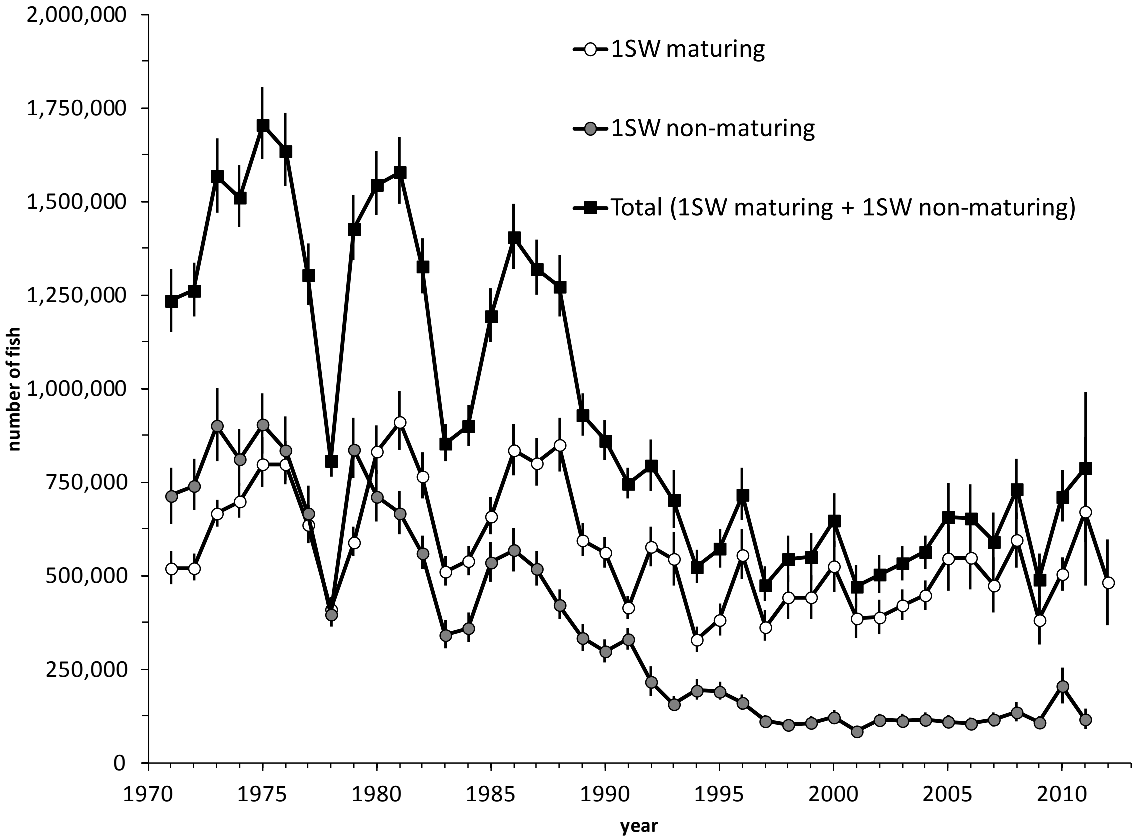

Figure 10.3.2 Estimates of PFA for 1SW maturing salmon, 1SW non-maturing salmon, and the total cohort of 1SW salmon based on the Monte Carlo simulations of the run-reconstruction model for NAC. Median and 95% CI interval ranges derived from Monte Carlo simulations are shown.

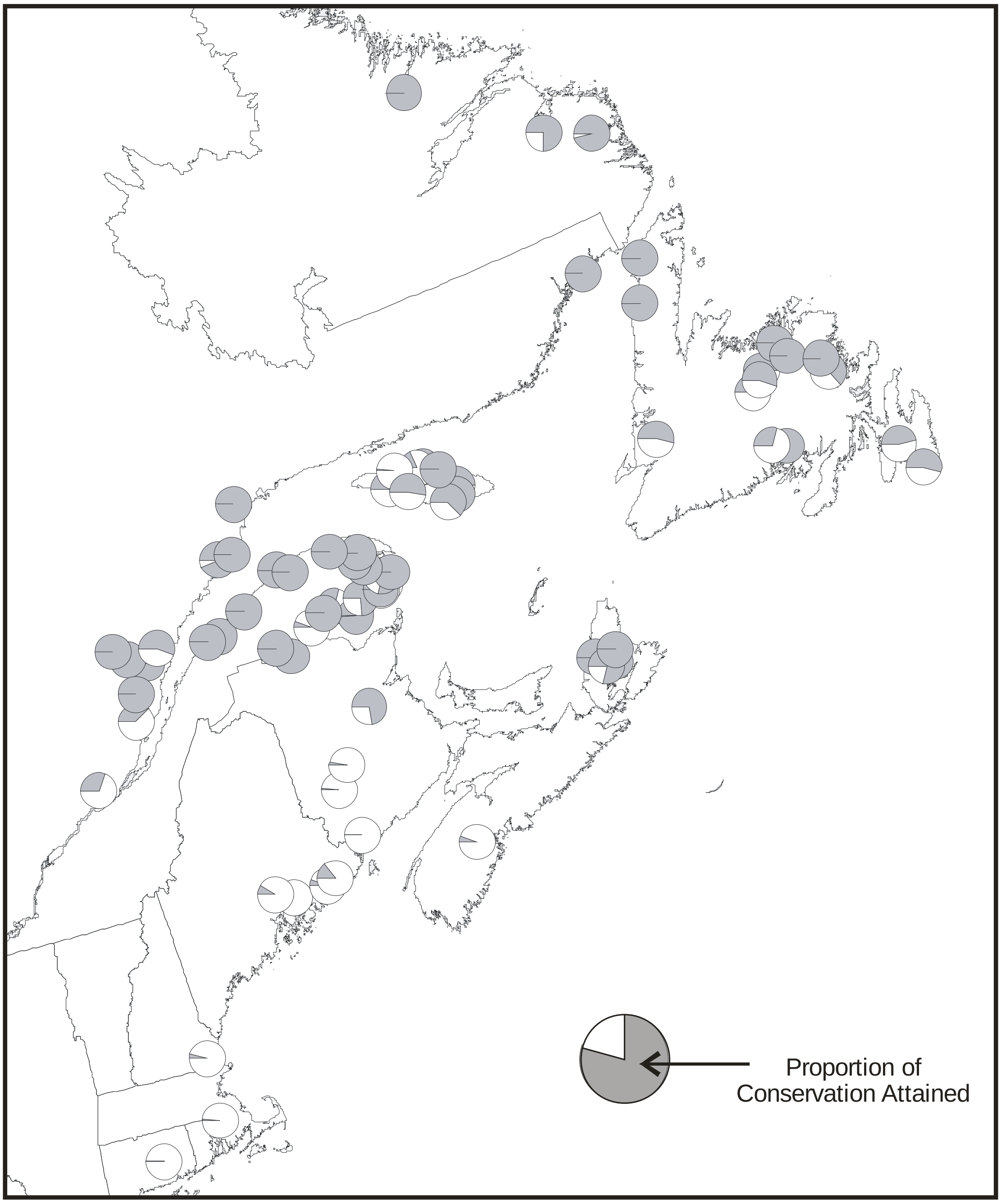

Figure 10.3.3 Proportion of the conservation egg requirement attained in assessed rivers of the North American Commission area in 2012.

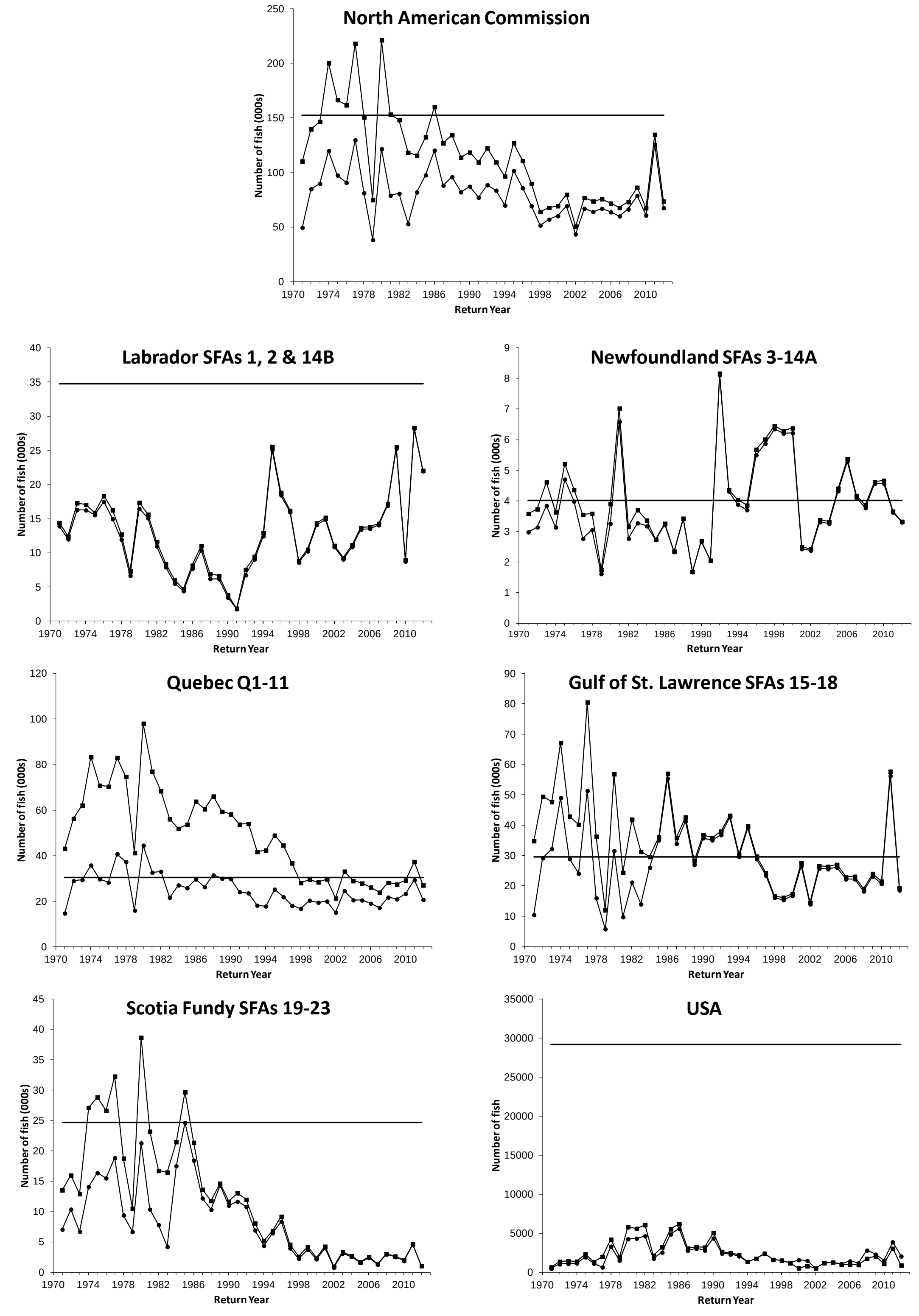

Figure 10.3.4 Comparison of the 2SW conservation limits (horizontal lines) to the estimated medians of 2SW returns (squares) and 2SW spawners (circles) in six geographic areas of North America. Returns and spawners for Scotia–Fundy do not include those from SFA 22 and a portion of SFA 23. For USA estimated spawners may exceed the estimated returns due to adult stocking restoration efforts. Also note the difference in scale for USA.

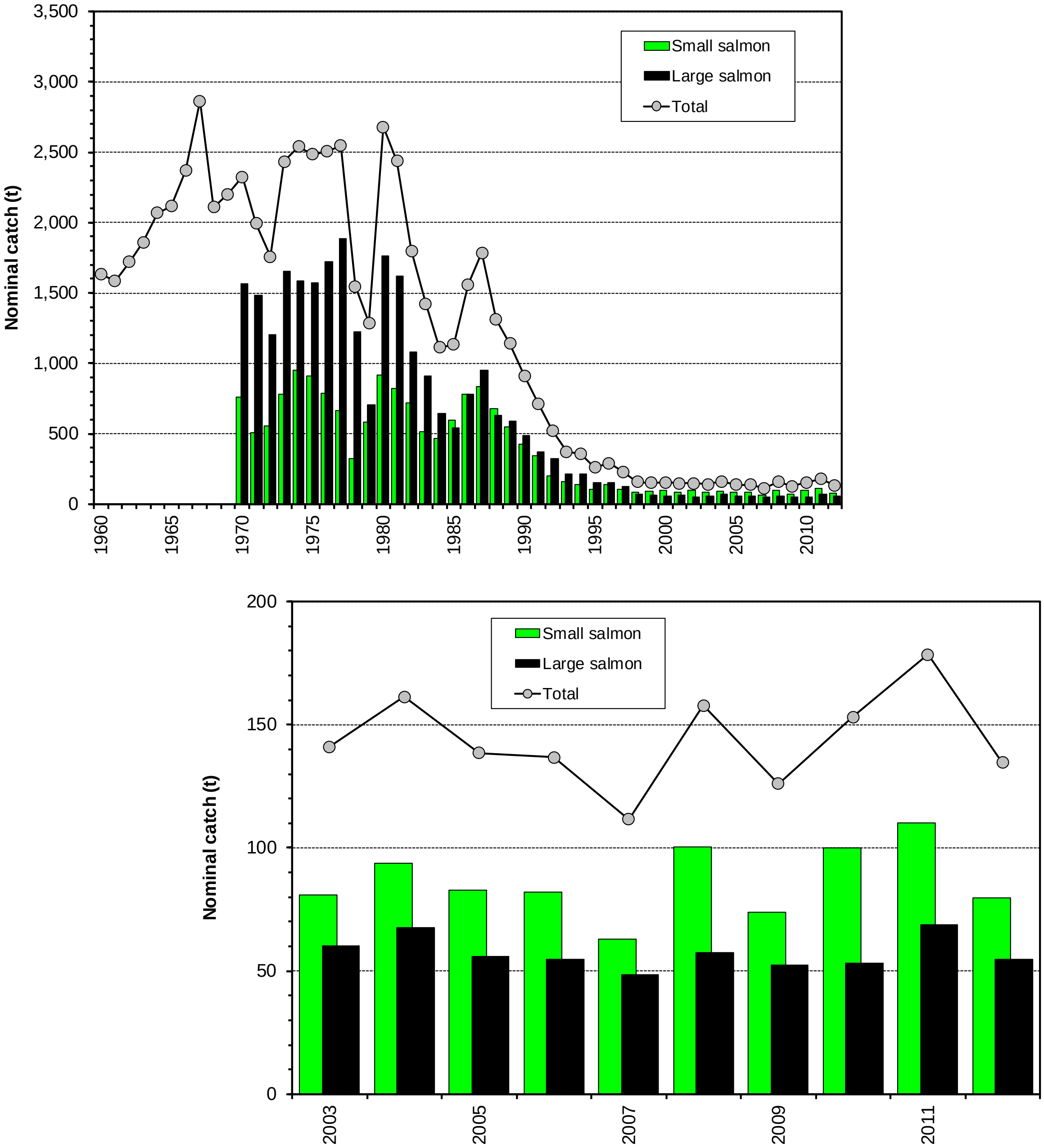

Figure 10.3.5 Harvest (t) of small salmon, large salmon, and combined for Canada, 1960 to 2012 (top panel) and 2003 to 2012 (bottom panel) by all users.

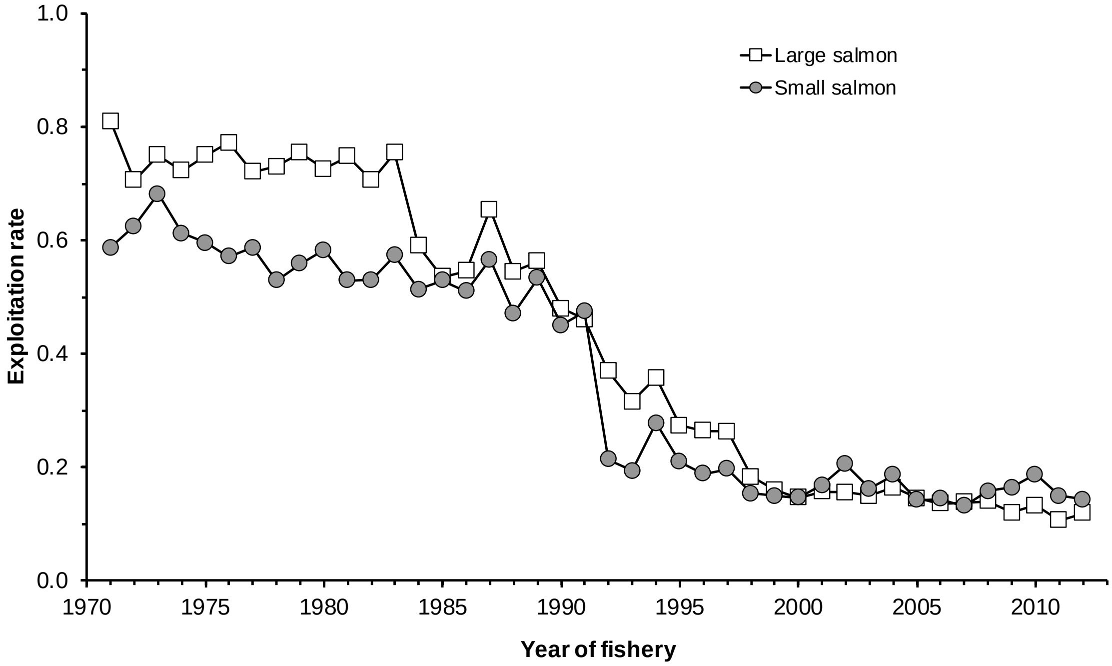

Figure 10.3.6 Exploitation rates in North America on the North American stock complex of small salmon (mostly 1SW) and large salmon (2SW, 3SW, and repeat spawners).

Table 10.3.1 Total reported nominal catch of salmon in homewaters by country (in tonnes, round fresh weight), 1980–2012 (2012 figures include provisional data).

Year	Canada			USA	St. P&M
	Total	Large	Small	Total	Total
1980	2 680	1 763	917	6	-
1981	2 437	1 619	818	6	-
1982	1 798	1 082	716	6	-
1983	1 424	911	513	1	3
1984	1 112	645	467	2	3
1985	1 133	540	593	2	3
1986	1 559	779	780	2	3
1987	1 784	951	833	1	2
1988	1 310	633	677	1	2
1989	1 139	590	549	2	2
1990	911	486	425	2	2
1991	711	370	341	1	1
1992	522	323	199	1	2
1993	373	214	159	1	3
1994	355	216	139	0	3
1995	260	153	107	0	1
1996	292	154	138	0	2
1997	229	126	103	0	2
1998	157	70	87	0	2
1999	152	64	88	0	2
2000	153	58	95	0	2
2001	148	61	86	0	2
2002	148	49	99	0	2
2003	141	60	81	0	3
2004	161	68	94	0	3
2005	139	56	83	0	3
2006	137	55	82	0	3
2007	112	49	63	0	2
2008	158	58	100	0	4
2009	126	52	67	0	3
2010	153	53	100	0	3
2011	179	69	110	0	4
2012	135	55	80	0	1

10.4 **Advice May 2013**

ECOREGION North Atlantic
STOCK Atlantic salmon at West Greenland

Advice for 2013

The previous advice provided by ICES (2012) indicated that there were no mixed-stock fishery catch options at West Greenland in the years 2012–2014. The NASCO Framework of Indicators for the West Greenland fishery did not indicate the need for a revised analysis of catch options this year and, therefore, no new management advice for 2013 is provided. This year's assessment of the status of stock complexes contributing to the West Greenland fishery confirms that advice.

Stock status

For West Greenland, stock status for 1SW non-maturing salmon (destined to be 2SW salmon) of North America and the Southern NEAC MSW stock complex are relevant.

In 2012, 2SW spawner estimates for the six geographic areas in North America indicated that all areas were below their conservation limits (CLs) and suffering reduced reproductive capacity. Estimates of pre-fishery abundance suggest continued low abundance of North American adult salmon. Recruitment patterns of non-maturing 1SW recruits (PFA) for Southern NEAC show a declining trend over time, since the early 1970s. This stock has been at full reproductive capacity for most of the time-series until 1997. Thereafter the stock has either been at risk of reduced reproductive capacity or suffering reduced reproductive capacity in most years, although slightly better in very recent years. Overall, in North American and European areas, the status of stocks contributing to the West Greenland fishery is among the lowest recorded, and as a result, the abundance of salmon within the West Greenland area is thought to be very low compared to historical levels. This is broadly consistent with the general pattern of decline in marine survival in most monitored stocks in the area.

Despite increasingly more restrictive fishery management measures in recent decades, returns in these regions have remained near historical lows and many populations are currently threatened with extirpation. The continued low abundance of salmon stocks across North America and in the Northeast Atlantic, despite these measures, further strengthens the conclusions that factors other than fisheries are constraining production.

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 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 of 75% (i.e. a 75% probability of all regions simultaneously achieving the management objective) 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 the 2SW CLs for the four northern areas of NAC (Labrador, Newfoundland, Quebec, and Gulf), to achieve a 25% increase in returns of 2SW salmon from the average returns in 1992–1996 for the Scotia–Fundy and USA regions, and to meet the MSW Southern NEAC CL.

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 Northwest Russia and Iceland. In the Northwest Atlantic they range from the Connecticut River in USA to the Leaf River in Quebec, Canada. Juveniles emigrate 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 on abundant prey 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 are considered to be the main contributory factors to lower productivity, which is expressed almost entirely in terms of lower marine survival.

The fisheries

Catches of Atlantic salmon at West Greenland (Figure 10.4.1) decreased until the closure of the commercial fishery for export in 1998, but the subsistence fishery has been increasing in recent years (Table 10.4.1). From 2002 to 2011, licensed fishers have been allowed to sell salmon to local markets. In 2012, licensed fishers were also allowed to land to factories, although the export ban persisted and the landed salmon could only be sold within Greenland. A total catch of 33 t of salmon was reported for the 2012 fishery compared to 28 t of salmon for the 2011 fishery, an increase of 18%. The increase in 2012 primarily occurred in NAFO Division 1C; the total catch reported in this division was the highest reported since 1997 at 15 t (Table 10.4.2).

In total, 82% of the salmon sampled at West Greenland were of North American origin and 18% were determined to be of European origin (Table 10.4.3). The 1SW age group dominated the catch at >93%. Approximately 7800 North American origin fish and approximately 2100 European origin fish were harvested in 2012. These totals remain among the lowest in the time-series from the early 1970s, although they are among the highest in the last decade (Figure 10.4.2).

Effects of the fisheries on the ecosystem

The current salmon fishery is practised with nearshore surface gillnets. There is no information on bycatch of other species with this gear. The fisheries probably have no, or only 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 is considered to be incomplete.

Scientific basis

Assessment type	Run reconstruction models and Bayesian forecasts, taking into account uncertainties in the data.
Input data	Nominal catches (by sea-age class) for commercial and recreational fisheries. Estimates of unreported/illegal catches. Estimates of exploitation rates. Natural mortalities (from earlier assessments).
Discards and bycatch	No salmon discards in this fishery.
Indicators	Framework of Indicators used to indicate if 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 being developed in 2013 (for completion at 2014 meeting).
Working group report	WGNAS

10.4.1 Supporting information May 2013

ECOREGION North Atlantic
STOCK Atlantic salmon at West Greenland

Reference points

For the Southern NEAC MSW stock complex, the CL is 275 549 salmon. For NAC, the CL expressed in 2SW salmon spawners totals 152 548 fish.

Outlook for 2013

No outlook is provided because the Framework of Indicators for the West Greenland fishery did not indicate the need for an updated forecast this year.

MSY approach

Atlantic salmon has characteristics of short-lived fish stocks; mature abundance is sensitive to annual recruitment because there are only a few age groups in the adult spawning stock. Incoming recruitment is often the main component of the fishable stock. For such fish stocks, the ICES MSY approach is aimed at achieving a target escapement (MSY $B_{escapement}$, the amount of biomass left to spawn). No catch should be allowed unless this escapement can be achieved. The escapement level should be set so there is a low risk of future recruitment being impaired, similar to the basis for estimating B_{pa} in the precautionary approach. In short-lived stocks, where most of the annual surplus production is from recruitment (not growth), MSY, $B_{escapement}$, and B_{pa} might be expected to be similar. CLs for North Atlantic salmon stock complexes have been defined by ICES as the level of stock (number of spawners) that will achieve long-term average maximum sustainable yield (MSY, $B_{escapement}$).

ICES considers that to be consistent with the MSY and the precautionary approach, fisheries should only take place on salmon from rivers where stocks have been shown to be at full reproductive capacity. Due to the different status of individual stocks within the stock complex, mixed-stock fisheries present particular threats to stock status. Harvest at West Greenland cannot be targeted towards individual stocks, so weaker performing stocks are at risk.

Additional considerations

The management of a fishery should ideally be based upon the status of all stocks exploited in the fishery. Conservation would be best achieved if fisheries target stocks that have been shown to be at full reproductive capacity. Fisheries in estuaries and especially rivers are more likely to meet this requirement.

Data and methods

The international sampling programme for the fishery at West Greenland agreed by the parties at NASCO continued in 2012. The sampling was undertaken in three different communities representing three different NAFO Divisions. As in previous years, no sampling occurred in the fishery in East Greenland. The decentralized landings and broad geographic distribution of the fishery causes practical problems for the sampling programme. In total, 1378 individual salmon were inspected in 2012, representing 14% by weight of the reported landings.

Uncertainties in assessments and forecasts

The fluctuations in the numbers of people reporting catches and the catches themselves in each of the NAFO Divisions at West Greenland suggest that there are inconsistencies in the catch data and highlight the need for better data. Since 2002, in at least one of the divisions where international samplers were present, the sampling team observed more fish than were reported as being landed (with the exception of 2006 and 2011). When there is this type of weight discrepancy, the reported landings are adjusted according to the total weight of the fish identified as being landed at that location during the sampling period and these adjusted landings are carried forward for all future assessments (Table 10.4.4). In 2012, this occurred in two of the three sampled communities. The total discrepancy was approximately 2 t and the catch for assessment purposes was 34.6 t.

There is presently no quantitative approach for estimating the unreported catch, but the 2012 value is likely to have been at the same level as that proposed in recent years (10 t).

There have been some recent problems in the international sampling programme at West Greenland, with regards to access to fish in one of the NAFO Divisions. This continued in 2012.

Comparison with previous assessment and catch options

The NASCO Framework of Indicators for the West Greenland fishery applied in January 2013 did not indicate the need for a revised analysis of catch options and no new management advice for 2013 is provided. The assessment was updated to include data up to 2012 and the status of stocks contributing to the West Greenland fishery was consistent with the previous year's assessment.

Assessment and management area

The advice for the West Greenland fishery is based upon the Southern NEAC MSW stock complex and the North American 2SW complex.

Sources of information

ICES. 2012. ICES Advice 2012, Book 10 (North Atlantic salmon stocks). 99 pp.

ICES. 2013. Report of the Working Group on North Atlantic Salmon. ICES Headquarters, Copenhagen, 3–12 April 2013. ICES CM 2013/ACOM:09.

NASCO 1998. North Atlantic Salmon Conservation Organization. Agreement on the adoption of a precautionary approach. Report of the 15th annual meeting of the Council. CNL(98)46. 4 pp.

NASCO 1999. North Atlantic Salmon Conservation Organization. Action plan for the application of the precautionary approach. CNL(99)48. 14 pp.

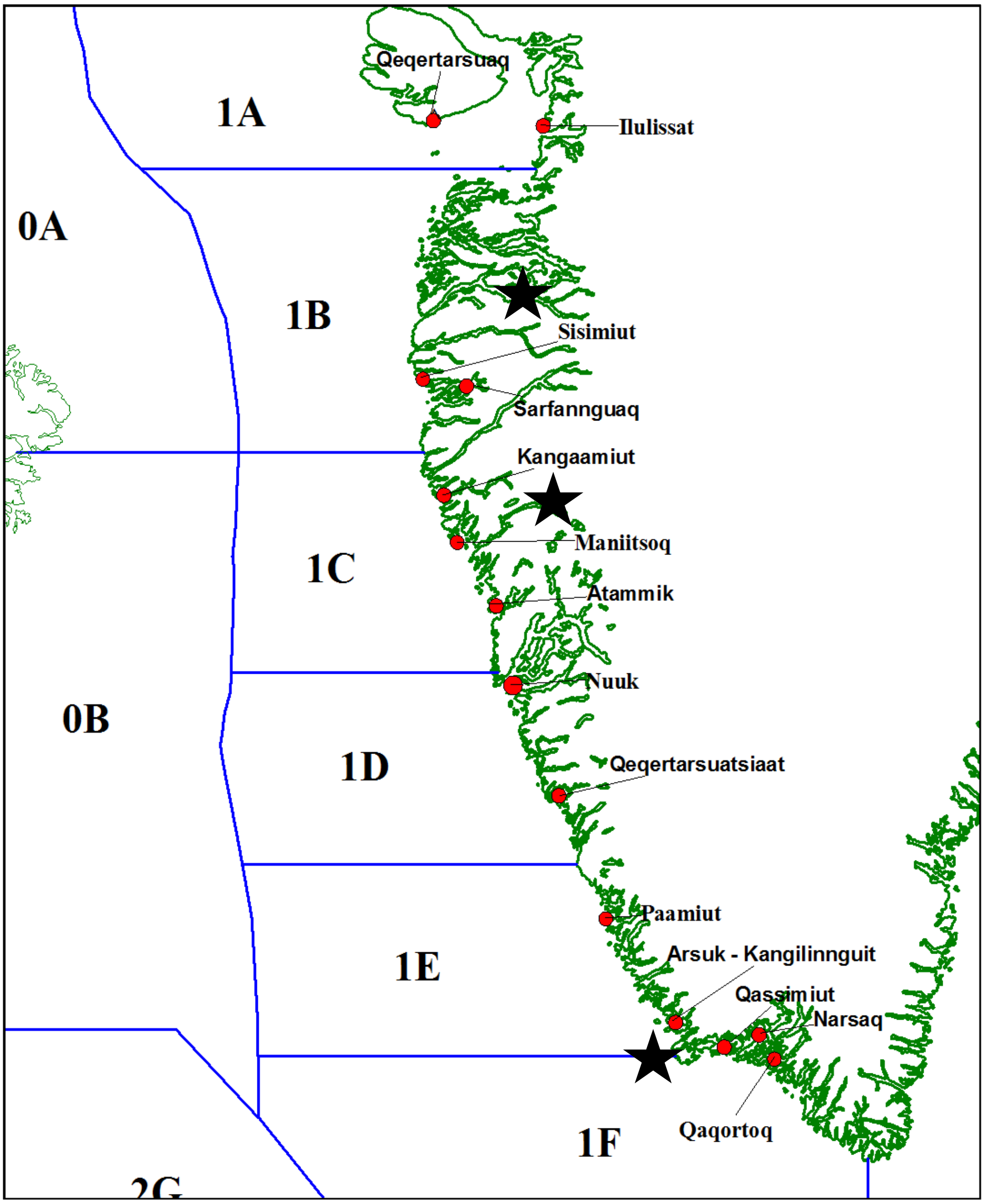

Figure 10.4.1 Location of NAFO divisions along the coast of West Greenland. Stars identify the communities where biological sampling occurred in 2012 (Sisimiut, Maniitsoq, and Qaqortoq).

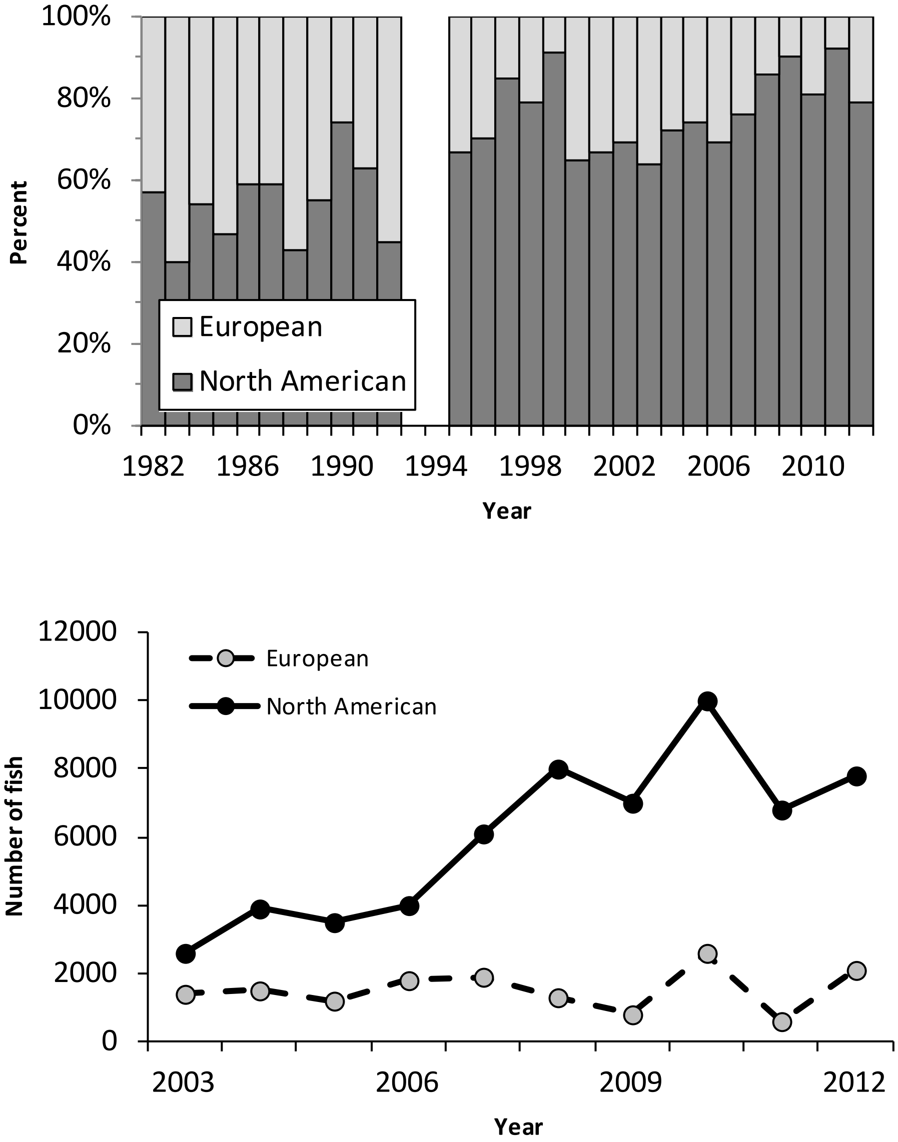

Figure 10.4.2 Percentage of catch at West Greenland by continent of origin from 1982 to 2012 (upper panel) and estimated number of salmon by continent of origin in the catches for the 2003 to 2012 fishery years (lower panel).

Table 10.4.1 Nominal catches and management of Atlantic salmon at West Greenland since 1971.

YEAR	TOTAL	QUOTA	COMMENTS
1971	2689	-	
1972	2113	1100	
1973	2341	1100	
1974	1917	1191	
1975	2030	1191	
1976	1175	1191	
1977	1420	1191	
1978	984	1191	
1979	1395	1191	
1980	1194	1191	
1981	1264	1265	Quota set to a specific opening date for the fishery.
1982	1077	1253	Quota set to a specific opening date for the fishery.
1983	310	1191	
1984	297	870	
1985	864	852	
1986	960	909	
1987	966	935	
1988	893	840	Quota for 1988–1990 was 2520 t with an opening date of August 1. 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	900	
1990	274	924	
1991	472	840	
1992	237	258	Quota set by Greenland authorities.
1993		89	The fishery was suspended. NASCO adopt a new quota allocation model.
1994		137	The fishery was suspended and the quotas were bought out.
1995	83	77	Quota advised by NASCO.
1996	92	174	Quota set by Greenland authorities.
1997	58	57	Private (non-commercial) catches to be reported from now.
1998	11	20	Fishery restricted to catches used for internal consumption in Greenland.
1999	19	20	
2000	21	20	
2001	43	114	Final quota calculated according to the ad hoc management system.
2002	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		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		Same as previous year.
2005	15		Same as previous year.
2006	22		Quota set to nil (no factory landing allowed) and fishery restricted to catches used for internal consumption in Greenland.
2007	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		Same as previous year.
2009	26		Same as previous year.

YEAR	TOTAL	QUOTA	COMMENTS
2010	40		Same as previous year.
2011	28		Same as previous year.
2012	33		Quota set to nil (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.

Table 10.4.2 Distribution of nominal catches (metric tonnes) by Greenland vessels in different NAFO Division areas since 1977.

YEAR	1A	1B	1C	1D	1E	1F	UNK.	WEST GREENLAND	EAST GREENLAND	TOTAL
1977	201	393	336	207	237	46	-	1 420	6	1426
1978	81	349	245	186	113	10	-	984	8	992
1979	120	343	524	213	164	31	-	1 395	+	1395
1980	52	275	404	231	158	74	-	1 194	+	1194
1981	105	403	348	203	153	32	20	1 264	+	1264
1982	111	330	239	136	167	76	18	1 077	+	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 [1]	-	-	-	-	-	-	-	-	-	-
1994 [1]	-	-	-	-	-	-	-	-	-	-
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	26.4
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

[1] The fishery was suspended.
+ Small catches < 5 t.
- No catch.
*** Corrected from gutted weight to total weight (factor 1.11).**

Table 10.4.3 Summary of biological characteristics of salmon caught at West Greenland in 2012.

River age distribution (%) by origin (NA – North America, E – Europe)

	1	2	3	4	5	6	7	8
NA	0.3	29.8	39.4	23.3	6.5	0.7	0	0
E	9.3	63.0	24.0	3.7	0	0	0	0

Length and weight by origin and sea age

	1 SW		2 SW		Previous spawners		All sea ages	
	Fork length (cm)	Whole weight (kg)	Fork length (cm)	Whole weight (kg)	Fork length (cm)	Whole weight (kg)	Fork length (cm)	Whole weight (kg)
NA	65.5	3.34	75.9	6.00	72.8	4.65		3.44
E	64.9	3.38	70.4	4.51	68.9	3.65		3.40

Continent of Origin (%)

North America	Europe
81.6	18.4

Sea age composition (%) by continent of origin:
North America (NA) and Europe (E)

	1SW	2SW	Previous Spawners
NA	93.2	1.5	4.7
E	98.0	1.6	0.4

Table 10.4.4 Reported landings (kg) for the West Greenland Atlantic salmon fishery from 2002 by NAFO Division and the division-specific adjusted landings where the sampling teams observed more fish landed than were reported. Adjusted landings were not calculated for 2006 and 2011 as the sampling teams did not observe more fish than were reported in those years.

YEAR		1A	1B	1C	1D	1E	1F	TOTAL
2002	Reported	14	78	2100	3752	1417	1661	9022
	Adjusted						2408	9769
2003	Reported	619	17	1621	648	1274	4516	8694
	Adjusted			1782	2709		5912	12 312
2004	Reported	3476	611	3516	2433	2609	2068	14 712
	Adjusted				4929			17 209
2005	Reported	1294	3120	2240	756	2937	4956	15 303
	Adjusted				2730			17 276
2006	Reported	5427	2611	3424	4731	2636	4192	23 021
	Adjusted							
2007	Reported	2019	5089	6148	4470	4828	2093	24 647
	Adjusted						2252	24 806
2008	Reported	4882	2210	10024	1595	2457	4979	26 147
	Adjusted				3577		5478	28 627
2009	Reported	195	6151	7090	2988	4296	4777	25 496
	Adjusted				5466			27 975
2010	Reported	17 263	4558	2363	2747	6766	4252	37 949
	Adjusted		4824		6566		5274	43 056
2011	Reported	1858	3662	5274	7977	4021	4613	27 407
	Adjusted							
2012	Reported	5353	784	14991	4564	3993	2951	32 636
	Adjusted		2001				3694	34 596