Agenda Item 4.4
For Information

Council

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Report of the ICES Advisory Committee

Extract of the Report of the ICES Advisory Committee

North Atlantic Salmon Stocks

As reported to
the North Atlantic Salmon Conservation
Organization

2009

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Contents

Executive Summary

- In the North Atlantic, exploitation remains low and nominal catch of Atlantic salmon in 2008 was the second lowest in the time-series.
- Marine survival indices remain low.
- The North American Commission 2SW stock complex is suffering reduced reproductive capacity. Factors other than fisheries (marine mortality, fish passage, water quality) are contributing to continued low adult abundance.
- Northern North-East Atlantic Commission stock complexes (1SW and MSW) are at full reproductive capacity prior to the commencement of distant water fisheries.
- Southern North-East Atlantic Commission stock complexes (1SW and MSW) are at risk of suffering reduced reproductive capacity prior to the commencement of distant water fisheries.
- There are no catch options for the fishery at the West Greenland (2009-2011) that would meet precautionary management objectives.
- 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 because of continuing poor survival in the marine environment attributed to climate effects. Efforts continue to improve our understanding of causal relationships contributing to marine mortality.

1 Introduction

1.1 Main tasks

At its 2008 Statutory Meeting, ICES resolved (C. Res. 2008/2/ACOM06) that the Working Group on North Atlantic Salmon [WGNAS] (Chair: J. Erkinaro, Finland) will meet in Copenhagen, Denmark, from the 30th March–8th April 2009 to consider questions posed to ICES by the North Atlantic Salmon Conservation Organisation (NASCO). The terms of reference were met and the sections of the report which provide the answers are identified below:

a)	With respect to Atlantic Salmon in the North Atlantic area:	Section 2
1)	provide an overview of salmon catches and landings, including unreported catches by country and catch and release, and production of farmed and ranched Atlantic salmon in 2008[1];	2.1 and 2.2
2)	report on significant new or emerging threats to, or opportunities for, salmon conservation and management[2];	2.3 and 2.4
3)	continue the work already initiated to investigate associations between changes in biological characteristics of all life stages of Atlantic salmon, environmental changes and variations in marine survival with a view to identifying predictors of abundance[3];	2.5
4)	provide a compilation of tag releases by country in 2008 and advise on progress with analysing historical tag recovery data from oceanic areas;	2.7
5)	evaluate the results of studies that estimate the level of prespawning mortality of salmon caught and released by anglers and the implications for stock assessments;	2.6
6)	identify relevant data deficiencies, monitoring needs and research requirements[4].	Sec 6

b)	With respect to Atlantic salmon in the North-East Atlantic Commission area:	Section 3
1)	describe the key events of the 2008 fisheries[5];	3.8
2)	provide any new information on the extent to which the objectives of any significant management measures introduced in recent years have been achieved;	3.9
3)	review and report on the development of age-specific stock conservation limits;	3.3

4)	describe the status of the stocks and provide annual catch options or alternative management advice for 2010-2012, if possible based on forecasts of PFA for northern and southern stocks, 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[6];	3.4, 3.6, and 3.8
5)	further develop methods to forecast PFA for northern and southern stocks with measures of uncertainty.	3.6
6)	further investigate opportunities to develop a framework of indicators that could be used to identify any significant change in previously provided multi-annual management advice	3.10

c)	With respect to Atlantic salmon in the North American Commission area:	Section 4
1)	describe the key events of the 2008 fisheries (including the fishery at St Pierre and Miquelon) [5];	4.9
2)	provide any new information on the extent to which the objectives of any significant management measures introduced in recent years have been achieved;	4.10
3)	update age-specific stock conservation limits based on new information as available;	4.3
4)	describe the status of the stocks and provide annual catch options or alternative management advice for 2009–2012 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[6].	4.6, 4.7 and 4.9

d)	With respect to Atlantic salmon in the West Greenland Commission area:	Section 5
1)	describe the key events of the 2008 fisheries[5];	5.8
2)	provide any new information on the extent to which the objectives of any significant management measures introduced in recent years have been achieved;	5.10
3)	describe the status of stocks and provide annual catch options or alternative management advice for 2009–2011 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 [6,7];	5.1, 5.4 and 5.9
4)	update the framework of indicators used to identify any significant change in the previously provided multi-annual management advice.	5.11

Notes:

1) *With regard to question a.1, ICES is asked to ensure that the terminology used in presenting the data on ranching is clearly defined. 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.*

2) *With regard to question a.2, ICES is requested to include information on any new research into the migration and distribution of salmon at sea.*

3) *With regard to question a.3, there is interest in determining if declines in marine survival coincide with changes in the biological characteristics of juveniles in freshwater or are modifying characteristics of adult fish (size at age, age at maturity, condition, sex ratio, growth rates, etc) and with environmental changes.*

4) *NASCO's International Atlantic Salmon Research Board's inventory of ongoing research relating to salmon mortality in the sea will be provided to ICES to assist it in this task.*

5) *In the responses to questions b.1, c.1 and d.1, 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, and 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.*

6) *In response to questions b.4, c.4 and d.3 provide a detailed explanation and critical examination of any changes to the models used to provide catch advice.*

7) *In response to question d.3, ICES is requested to provide a brief summary of the status of North American and North-East Atlantic salmon stocks. The detailed information on the status of these stocks should be provided in response to questions b.4 and c.4*

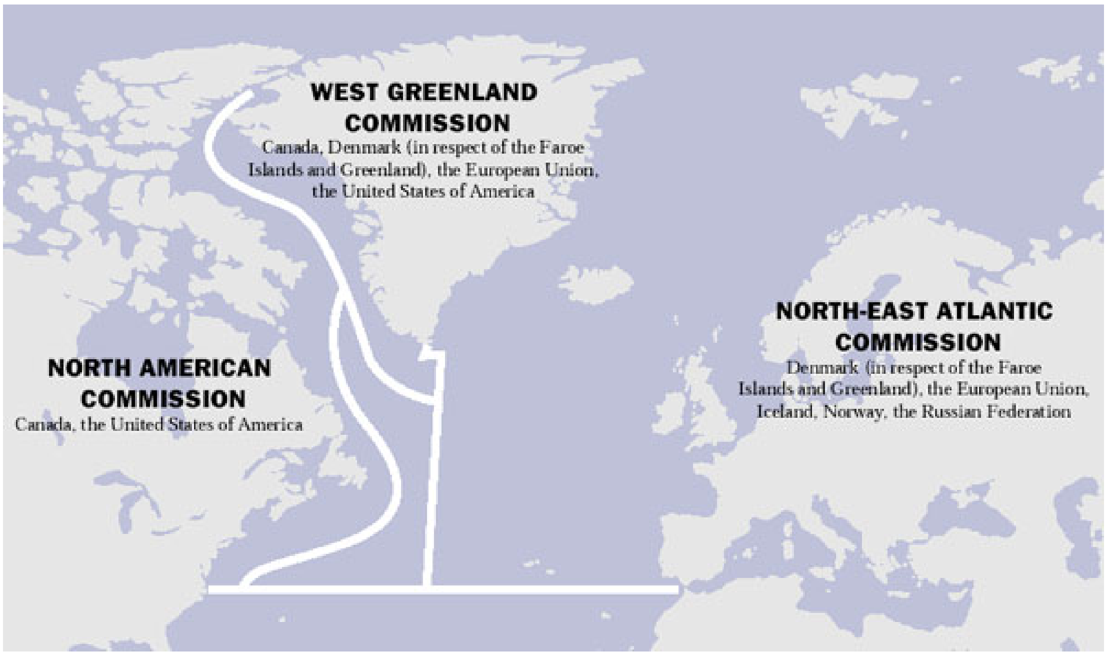
At the 2006 Annual Meeting of NASCO, conditional multi-annual regulatory measures were agreed to in the West Greenland Commission (2006–2008) and for the Faroe Islands (2007–2009) in the Northeast Atlantic Commission. The measures were conditional on a Framework of Indicators (FWI) being provided by ICES, and the acceptance of the FWI by the various parties of each commission. At the 2007 annual meeting of NASCO, Denmark (in respect of the Faroe Islands and Greenland) opted out of the multi-annual regulatory measures as a FWI was not provided by ICES for the fishery in the Faroes (ICES 2007c). In 2007 and 2008, NASCO indicated that no change to the management advice previously provided by ICES was required for the fishery at West Greenland. With the conclusion of the three-year conditional multi-annual regulatory measure agreed in 2006, NASCO requested that ICES undertake a full stock assessment, provide multi-annual catch advice and update the FWI in hopes of setting multi-annual regulatory measures for the 2009 fishing season.

In response to the remaining terms of reference, the Working Group considered 34 Working Documents submitted by participants.

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 Organisation (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 seven Parties that are signatories to the Convention, including the EU which represents its Member States.

NASCO discharges these responsibilities via three Commission areas shown below:



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 NASCOs 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, 1999) provides interpretation of how this is to be achieved, as follows:

- "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".

1.4 Reference points and application of precaution

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). In many regions of North America, the CLs are calculated as the number of spawners required to fully seed the wetted area of the river. In some regions of Europe, pseudo stock–recruitment observations are used to calculate a hockey stick relationship, with the inflection point defining the CLs. In the remaining regions, the CLs are calculated as the number of spawners that will achieve long-term average maximum sustainable yield (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.

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, where there are no specific management objectives:

- ICES requires that the lower bound of the 95% confidence interval of the current estimate of spawners is above the CL for the stock to be considered at full reproductive capacity.
- When the lower bound of the confidence limit 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.

It should be noted that this is equivalent to the ICES precautionary target reference points (S_{pa}). Therefore, stocks are regarded by ICES as being at full reproductive capacity only if they are above the precautionary target reference point. This approach parallels the use of precautionary reference points used for the provision of catch advice for other fish stocks in the ICES Area.

For catch advice on fish exploited at West Greenland (non maturing 1SW fish from North America and non maturing 1SW fish from Southern NEAC), ICES has adopted, a risk level of 75% (ICES, 2003) as part of an agreed management plan. ICES applies the same level of risk aversion for catch advice for homewater fisheries on the North American stock complex.

2 Atlantic salmon in the North Atlantic area

2.1 Catches of North Atlantic salmon

2.1.1 Nominal catches of salmon

Nominal catches of salmon reported for countries in the North Atlantic for 1960–2008 are given in Table 2.1.1.1. Catch statistics in the North Atlantic include fish-farm escapees and in some Northeast Atlantic countries also include 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 2008 and has expanded (Table 2.1.1.1). Although 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 1999–2008 are provided below.

AREA	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
NEAC	2073	2736	2876	2495	2303	1977	1998	1870	1409	1519
NAC	154	155	150	150	144	164	142	140	114	151
WGC	19	21	43	9	9	15	15	22	25	26
Total	2246	2913	3069	2654	2456	2156	2155	2032	1548	1696

The provisional total nominal catch for 2008 was 1696 tonnes, 148 t above the updated catch for 2007 (1548 t) and the second lowest in the time-series. The 2008 catch was over 370 t below the average of the last five years (2069 t), and over 660 t below the average of the last 10 years (2362 t). Catches were below the previous five- and ten-year averages in all southern NEAC countries and in two of the countries in northern NEAC.

ICES recognizes 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 2008 nominal catch (in tonnes) was partitioned accordingly and is shown below for the NEAC and NAC Commission Areas. Figure 2.1.1.1 presents these data on a country-by-country basis. There is considerable variability of 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	476	32	48	3	986	65	1509
NAC	13	8	47	31	92	61	151

Coastal, estuarine and riverine catch data aggregated by region are presented in Figure 2.1.1.2. In Northern Europe, total catches have fluctuated over the period with no apparent trend. Typically about half the catch has 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 was a small reduction in the proportion of the catch taken in coastal waters in 2008. In Southern Europe, catches in all fishery areas have declined over the period and, while coastal fisheries have historically made up the largest component of the catch, these fisheries have declined substantially, reflecting widespread measures to reduce exploitation in a number of countries. In 2008, the majority of the catch in this area was taken in freshwater.

In North America, the total catch over the period 2000–2008 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 (13 t or less), but has increased as a proportion of the total catch over the period.

2.1.2 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 practised 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 presented in Section 2.1.1 do not include salmon that have been caught and released. Table 2.1.2.1 presents C&R information from 1991 to 2008 for ten 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 2008 this ranged from 19% in Iceland to 100% in USA reflecting varying management practices and angler attitudes among these countries. Within countries, the percentage of fish released has tended to increase over time. Overall, over 204 000 salmon were reported to have been released around the North Atlantic in 2008, about 26 000 more than in 2007. There is also evidence from some countries that larger MSW fish are released in larger proportions than smaller fish. This issue of C&R is reviewed in more detail in Section 2.6.

2.1.3 Unreported catches

The total unreported catch in NASCO areas in 2008 was estimated to be 443 t however there were no estimates for Canada and Russia. The unreported catch in the North East Atlantic Commission Area in 2008 was estimated at 433 t and that for the West Greenland Commission Area at 10 t. There was no estimate for the North American Commission Area. The 2008 unreported catch by country is provided in Table 2.1.3.1. 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 carcase tagging and logbook schemes).

Area	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
NEAC	887	1135	1089	946	719	575	605	604	465	433
NAC	133	124	81	83	118	101	85	56	-	-
WGC	13	10	10	10	10	10	10	10	10	10
Int'l. waters	Not available									

2.2 Farming and sea ranching of Atlantic salmon

The provisional estimate of farmed Atlantic salmon production in the North Atlantic area for 2008 is 981 kt. This represents a 5% increase on 2007 and a 16% increase on the previous 5-year mean. Production increased slightly in Norway (up 3% on 2007) and UK (Scotland; up 5% on 2007), and these two countries continue to produce the majority of the farmed salmon in the North Atlantic (76% and 14% respectively). Farmed salmon production continued to reduce considerably in Iceland (down 44% on 2007), but increased markedly in USA.

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 2007 estimates for some countries in deriving a worldwide estimate for 2008. Noting this caveat, total production in 2008 is provisionally estimated at around 1482 kt (Figure 2.2.1), a 6% increase on 2007 and the highest in the time-series. Production outside the North Atlantic is dominated by Chile and is estimated to have accounted for 34% of the total in 2008. World-wide production of farmed Atlantic salmon in 2008 was thus over 870 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 2008 was 70 t, the majority of which (68 t) was taken by Icelandic ranched rod fisheries (Figure 2.2.2). Small catches of ranched fish were also recorded in each of the three other countries reporting such fish (Ireland, UK (N. Ireland) and Norway); the data includes catches in net, trap and rod fisheries.

2.3 Development of forecast models

ICES currently provides quantitative catch advice for the West Greenland fishery using two forecast models; one for the non-maturing 1SW salmon of North American origin, the other for 1SW non-maturing salmon from the southern NEAC complex (one of the four stock complexes in NEAC but the only one which is affected by the West Greenland fishery). ICES does not currently provide quantitative advice for the Faroes fishery because models have not been developed for the maturing 1SW stock complex from southern NEAC nor for any of sea age groups in the northern NEAC stock complex. As such, qualitative catch advice has been provided for the Faroes fishery based on the status of the stock complexes relative to stock complex conservation limits.

Following on from recommendations, a Study Group [SGSSAFE-Study Group on Salmon Stock Assessment and Forecasting] met in March 2009 to work on the development of new and alternative models for forecasting Atlantic salmon abundance and for the provision of catch advice. ICES reviewed an alternate model for the 2SW North American complex and new models for the combined maturing and non-maturing age groups of the southern NEAC and the northern NEAC stock complexes. The proposed models were fitted and forecasts derived in a single consistent Bayesian framework under the OpenBUGS 3.0.3 software (http://mathstat.helsinki.fi/openbugs/; Lunn *et al*., 2000).

The data inputs and models reviewed parallel the approaches currently used by ICES for forecasting and provision of catch advice but differ between the Commission areas:

Proposed models		
	NAC	NEAC
Data inputs		
Time period of data	1978 to 2008	1978 to 2008 for southern NEAC 1991 to 2008 for northern NEAC
Spatial aggregation	Separately for six regions of North America	By southern and northern stock complexes
Age components	2SW salmon component only	1SW and MSW age components
Spawners	Lagged spawners by region for 2SW salmon only	Lagged eggs by sea age component for the southern and northern complexes
Returns	Returns by region of 2SW salmon only	Returns of 1SW and MSW age components by stock complex
Model structure		
Spatial aggregation	Spawners and returns of 2SW salmon for six regions	Spawners and returns for two sea age components for the southern and northern NEAC complexes
Dynamic function	Random walk dynamic	Random walk dynamic
	Region-specific recruitment rates linked with an annual recruitment rate variable	Sea-age specific recruitment rates linked with a probability of maturing variable
Latent variables of interest	PFA 1SW non-maturing Recruitment rate by region and year	PFA 1SW maturing and PFA 1SW non-maturing by stock complex Recruitment rate by sea age component and the probability of maturing variable
Forecast years	2009 to 2011	2009 to 2012

2.3.1 NAC model

The model is summarized in the Directed Acyclical Graph in Figure 2.3.1.1. The year is identified by the i index.

$PFA_{i,k}$ is assumed to be proportional to lagged-spawners ($LS_{i,k}$), with independent identically distributed (i.i.d.) lognormal errors, and is modelled separately for each region (k = 6; Labrador, Newfoundland, Quebec, Gulf, Scotia-Fundy, USA).

$$PFA_{i,k} = LogN(\mu.PFA_{i,k}\ ,\ \sigma.PFA^2)$$
$$\mu.PFA_{i,k} = \log(LS_{i,k}) + a_{i,k}$$

The proportionality (log) coefficient $a_{i,k}$ between $LS_{i,k}$ and $PFA_{i,k}$ for each region is modelled dynamically as a random walk with the addition of a regionally common annually varying parameter ($e.y_i$).

$$a_{i+1,k} = a_{i,k} + e.y_{i+1} + \omega_{i+1,k} \qquad with \quad \omega_{i+1,k} \overset{i.i.d}{\sim} N(0, a.\sigma_k^2)$$
$$e.y_i \overset{i.i.d}{\sim} N(0, \sigma.y^2)$$

The common yearly variation ($e.y_i$) accounts for the fact that the fish share a common marine environment during part of their life cycle. The interaction term ($\alpha_{i,k}$) can be interpreted as accounting for regional specificities in the freshwater and / or the marine coastal environment.

The dynamic component of the model requires initialization for the first year (i = 1978) and an uninformative prior is assumed:

$$a_{1,k} \overset{i.i.d}{\sim} N(0,100)$$

$LS_{i,k}$ is a weighted sum of spawners over the years (i) having contributed to produce the $PFA_{i,k}$. The $LS_{i,k}$ are not directly observed but estimated from the run-reconstruction model developed by ICES. The model provides probability distributions of LS, conditional on observed data and expertise. The probability distributions are assumed to be normal with known mean LS.m and variance tau.LS. The use of these distributions as likelihood functions is equivalent to having pseudo-observations equal to LS.m issuing from sampling distributions with means and variances equal to LS and tau.LS (Michielsens *et al.*, 2008).

$$LS.m_{i,k} \sim N\,(LS_{i,k},\ tau.LS_{i,k})$$

Similarly, the returns of 2SW salmon to the six regions ($NR2_{i,k}$) are not directly observed but estimated from the run-reconstruction model. The probability distributions were assumed to be normal with known mean NR2.m and variance tau.NR2. As with the LS variable, the NR2 were treated as pseudo-observations equal to NR2.m issuing from normal sampling distributions with means and variances equal to NR2 and tau.NR2

$$NR2.m_{i,k} \sim N\,(NR2_{i,k},\ tau.NR2_{i,k})$$

In between the lagged spawners and returns as 2SW salmon, the catches in the various sea fisheries and conditioning for natural mortality as the fish move from the time of the PFA to homewaters are incorporated (Figure 2.3.1.1). The catches in the commercial fisheries at West Greenland and the Newfoundland and Labrador commercial and coastal fisheries (NG1.tot, NC1.tot and NC2.tot) are not directly observed but estimated with error. The catches are converted to numbers of fish of 1SW non-maturing and 2SW fish based on the characteristics of the fish in the catch. Their (prior) probability distributions are obtained from catch statistics according to a formal structure included in the model.

Catches of large salmon (assumed to be 2SW salmon) from the St Pierre and Miquelon fisheries are also included in the model as point estimates.

The natural mortality in the post-PFA time point was assumed constant between years, centred on an instantaneous rate value of 0.03 per month (95% confidence interval range of 0.02 to 0.04).

For the NAC 2SW component, the model was fitted to an historical dataseries of 30 years, lagged eggs from 1978 to 2006 (considers returns of 2SW salmon including 2007). Although the return and spawner estimates for NAC begin in 1971, the lagged eggs are only available from 1978 because of the smolt age distributions (1 to 6 years).

2.3.1.1 Comparisons with models currently used by ICES

The alternate model proposed by the Study Group differs from the model used by ICES in the way observations are considered, the procedure for model fitting, and in the way inferences are drawn on the variables of interest. The Bayesian framework considers the PFA as a latent variable i.e. a variable whose state is conditioned by several components directly influencing its distribution (the parents) and which cannot be observed directly. The model currently used by ICES considers the PFA to be an observation.

The recruitment rate dynamic between lagged spawners and returns is also modelled differently. The two phase model currently used by ICES considers that there have been (and will be) two levels of recruitment rate experienced by the populations in NAC. When the populations are in the low phase, they will either remain in the low phase or move to the high phase, there is no possibility of a further decline in recruitment rate or intermediate levels of recruitment rate. The random walk model proposed by the Study Group is more flexible. The recruitment rate may increase or decrease regardless of the present states of the populations. Abrupt changes are not adequately detected because the annual changes are smoothed and the magnitude constrained by the relative changes estimated from the past:

	Current ICES model	Alternate model
Input variables	Lagged spawners and PFA are generated from run-reconstruction and treated as observations	Distributions of lagged spawners and returns of 2SW salmon to regions are generated from run-reconstruction and treated as pseudo-observations in the model.
PFA period	August 1 of the second summer at sea for 1SW non-maturing salmon	Same as current ICES model
Model dynamic	Incorporates possibility of two phases of productivity between lagged spawners and PFA. Recruitment rate parameter can take one of two levels. NAC aggregate estimate of productivity assumed similar for all regions.	Random walk that models region specific recruitment rate in year i+1 as a function of region specific recruitment rate in year i plus an annual component of change in recruitment rate common to all regions.
Consideration of uncertainty	Uncertainty in LS and PFA are incorporated by creating multiple datasets of LS and PFA from Monte Carlo and summarizing predicted PFA from statistical fitting of the multiple datasets.	Uncertainty in lagged spawners and returns of 2SW salmon to regions are introduced as priors and can be updated. Posterior distributions of PFA and returns to regions are inferred from the model fitting.
Forecast capacity	Forecasts are based on lagged spawner values available for three years beyond the last observed 2SW return year and an estimate of the likelihood of being in the high phase or the low phase of productivity. Forecast values take one of two levels of recruitment rate.	Same forecast capacity as current ICES model excluding the need to estimate the probability of being in a high or low phase. Forecasts are based on estimated lagged spawners and the recruitment rate from the last observed year with variance from the entire time-series.

Risk analysis	Assume characteristics of the catches will be similar to the range of values observed during previous five years. Catch options scenarios are explored.	Same as current ICES model.

2.3.2 NEAC models

The proposed models for the northern NEAC complex and the southern NEAC complex have exactly the same structure and are run independently. A Directed Acyclic Graph (DAG) for the models is provided in Figure 2.3.2.1. The model considers both the maturing *PFA* (denoted *PFAm*) and the non maturing PFA (denoted *PFAnm*).

Two hypotheses about the time-structure of the productivity parameter $\alpha_{m,t}$ were contrasted: random walk and shift level model.

For each year *t*, a proportional relationship is assumed between lagged eggs (LE_t) and the expected means of the maturing PFA, with a recruitment rate factor αm_t (in the log-scale). The recruitment rate is considered to be random with i.i.d lognormal errors.

$$PFAm_t = LogN(\mu.PFAm_t\ ,\ \sigma.PFAm^2)$$
$$\mu.PFAm_t = \log(LE_i) + am_t$$

Similarly, for each year *t*, a proportional relationship is assumed between LE_t and the expected means of the non maturing *PFA*, with a productivity factor αnm_t (i.i.d. multiplicative lognormal random errors).

$$PFAnm_t = LogN(\mu.PFAnm_t\ ,\ \sigma.PFAnm^2)$$
$$\mu.PFAnm_t = \log(LE_i) + anm_t$$

The random environmental noise in the recruitment rate of maturing ($\sigma.PFAm_t$) and non maturing PFA ($\sigma.PFAnm_t$) are assumed independent.

However, the recruitment rate for the non maturing *PFA* is modelled dependently on the recruitment rate for the maturing PFA as:

$$\alpha nm_t = \alpha m_t + \log\left(\frac{1 - p.PFAm_t}{p.PFAm_t}\right)$$

The expected rate of maturing *PFA vs.* total *PFA* recruitment rate is $p.PFAm_t$:

$$\frac{e^{\alpha m_t}}{e^{\alpha m_t} + e^{\alpha nm_t}} = p.PFAm_t$$

Therefore, the hypothesis underlying this model is that the time variability of the recruitment rate for maturing and non maturing PFA will be closely related. A high recruitment rate for maturing PFA will correspond to a high productivity of non maturing PFA. However, time variations of the parameter $p.PFAm_t$ introduce some flexibility in the synchrony of the maturing and non maturing recruitment rates.

Two alternative models for the recruitment rate parameter were explored for the Southern NEAC complex: the random walk model and the shifting level model (for the Northern NEAC complex, only the random walk model was tested because of the shorter time-series available).

In the random walk (RW) hypothesis, the recruitment rates are modelled as a first order time varying parameter following a simple random walk with a flat prior on the first value of the time-series:

$$\alpha m_{t+1} = \alpha m_t + \omega_t \quad \text{with} \quad \omega_t \overset{i.i.d}{\sim} N(0, \sigma^2{}_\alpha) \qquad t = 1,\ldots,n\text{-}1$$

The model can be used both for retrospective analysis and forecasts. Provided the variance $\sigma^2{}_\alpha$ is large enough, the random walk structure will allow us to capture any kind of change in the recruitment rate along the time-series of historical data. The persistence (memory) and possibility of variation will be accounted for at any time in the forecasts. If the productivity level is α at time $t = n$, then the forecasted productivity at time $t = n+1$ is random and normally distributed around the previous level of recruitment rate.

The shifting level (SL) model supposes that the recruitment rate remains constant for periods of time, with abrupt shifts in the levels between periods (Fortin *et al.*, 2004). By contrast with the RW model, it is highly flexible because the number of periods, their duration and the corresponding levels of recruitment rates do not need to be specified *a priori*.

$$\alpha_{t+1} = \begin{cases} \alpha_t & \text{with proba } (1 - p_{shift}) \\ \alpha_t^{new} \sim N(\alpha_t, \sigma_\alpha^2) & \text{with proba } (p_{shift}) \end{cases} \qquad t = 1,\ldots,n\text{-}1$$

Retrospective analysis allows inference *a posteriori* on the phase(s) (levels, shifting points and duration) in the historical series of data. The probability of seeing a shift at any time t is also estimated, and can then be used for forecasting. As with the RW model, the persistence (memory) and possibility of a shift will be accounted for at any time in the forecasts. If the productivity level is α at time $t = n$, then the forecasted productivity at time $t = n+1$ is defined as:

$$\alpha_{n+1} \begin{cases} = \alpha_n & \text{with probability } (1 - p_{shift}) \\ = \alpha_n + \omega_n & \text{where } \omega_n \sim N(0, \sigma_\alpha{}^2) \quad \text{with probability } p_{shift} \end{cases}$$

Uncertainty in the lagged eggs were accounted for by assuming that the lagged eggs of 1SW and MSW fish were normally distributed with median and standard deviation issued from Monte-Carlo run reconstruction at the scale of the stock complex.

The model is designed to account for the uncertainty about the returns through the pseudo-observation method proposed by Michielsens *et al.*, 2008 and used in the NAC model.

In the model presented to ICES, the uncertainty in the returns was not accounted for because of difficulties in model fitting. The model was run with virtually no observation errors on returns (σ_R=1).

The natural mortality in the post-PFA time point was assumed constant among years, centred on an instantaneous rate value of 0.03 per month (95% confidence interval range of 0.02 to 0.04).

Catches of salmon at sea in the West Greenland fisheries (as 1SW non-maturing salmon) and at Faroes (as 1SW maturing and MSW salmon) were introduced as co-variates and incorporated directly within the inference and forecast structure of the model. The inputs for quantifying the uncertainties in the catches are those used for the run-reconstruction and those associated with the sampling procedures of the fisheries.

For southern NEAC, the model was fitted to a 29 year dataseries of lagged eggs and returns from 1978 to 2006. Although the return estimates to southern NEAC begin in 1971, the lagged eggs are only available from 1978 because of the smolt age distributions (1 to 5 years).

For northern NEAC, the model was fitted to a 16 year dataseries of lagged eggs and returns for 1991 to 2006. Returns and spawner estimates begin in 1983 but because of the smolt age distributions (1 to 6 years), the lagged eggs are only available from 1991 onward.

For both southern and northern NEAC complexes, forecasts were derived for 4 years of lagged eggs starting from 2007 to 2010. For illustrative purposes, forecasts were derived under the scenario of null exploitation rates (all sea catches =0).

Risks were defined each year as the posterior probability that the PFA would be below the age and stock complex specific SER levels.

2.3.2.1 Comparisons with model currently used by ICES

ICES has used a model to forecast the PFA of non-maturing (potential MSW) salmon from the Southern European stock group (ICES, 2002, 2003). The full model takes the form:

$$PFA = Spawners^{\lambda} \times e^{\beta_0 + \beta_2 \log(PFAm) + \beta_3 Year + \xi}$$

where: *Spawners* are expressed as lagged egg numbers (all age groups), *PFAm* is prefishery abundance of maturing 1SW salmon.

Parameter selection has been achieved by adding variables (*Spawners, PFAm* and *Year*) until the addition of others did not result in an increase in the explanatory power of the model. The model has been fitted to data from 1978 to the most recent year and the parameters retained have always been *Spawners* (*LSeggs*) and *Year*. The final model takes the form:

$$\mathrm{Ln}(PFA_t/LSeggs_t) = \alpha + \beta^*\mathrm{Ln}(LSeggs_t) + \delta^*Year_t + \varepsilon$$

The year coefficient estimate is negative resulting in a continued decline in recruitment rate over time.

	CURRENT ICES MODEL	ALTERNATE MODEL
Input variables	Lagged eggs and PFA are generated from run-reconstruction and treated as observations.	Distributions of lagged eggs and returns of salmon by sea age group (1SW maturing, MSW salmon) to the southern NEAC and northern NEAC complexes are generated from run-reconstruction and treated as pseudo-observations in the model.
PFA period	January 1 of the first winter at sea of 1SW salmon	Same as current ICES model

	CURRENT ICES MODEL	ALTERNATE MODEL
Model dynamic	Proportionate model with year variable that generates a time-dependent change in productivity between lagged eggs and PFA. Only one sea age group (1SW non-maturing, i.e. MSW salmon) is modelled for the southern NEAC stock complex. Lagged eggs and year are explanatory and predictive variables in the model.	Random walk model for two age components modelled from a common lagged eggs component. Recruitment rate of 1SW maturing salmon and MSW salmon are not considered independent. Probability of maturing parameter allows annual flexibility in variations in recruitment rate between maturing 1SW salmon and MSW salmon.
Consideration of uncertainty	Midpoints of LSeggs and PFA are used in the fitting. Forecast uncertainty driven by residual error term of the model fit.	Uncertainties in lagged eggs are included as priors; treated as pseudo-observations resulting from the distributions from the Monte Carlo run-reconstructions. Posterior distributions of PFA and returns to stock complexes are inferred from the model fitting. Uncertainties in returns not fully implemented currently due to model fitting constraints.
Forecast capacity	Forecasts are based on lagged egg values available for four years beyond the last observed 2SW return year. Year variable has a negative coefficient. Forecasts limited to 1SW non-maturing salmon from southern NEAC complex.	Forecasts are based on lagged egg values available for four years beyond the last observed 2SW return year. Forecasts are based on estimated lagged spawners and the sea age specific recruitment rates from the last observed year with variance from the entire time-series. Models available for all four age and stock complex components for NEAC.
Risk analysis	Risk analysis was not developed beyond describing the probability that the PFA abundance of 1SW non-maturing salmon will be below the spawner escapement reserve (SER) prior to any sea fisheries.	Same as current ICES model. Risk analysis restricted to quantifying probability that the PFA abundance of the sea age groups within the southern and northern complexes will be below the respective SERs.

2.3.3 Preliminary results of the Bayesian framework models for NAC and NEAC

In the models proposed for NAC and NEAC, there was no significant ($p > 0.05$) first order autocorrelation in the residual errors of the PFA variables, most were centered on or close to 0 as per the assumption of the model structure. Further posterior checks of the models should be completed.

NAC model

The average annual recruitment rate parameter for the six regions of North America and the posterior predicted PFA values are consistent with the levels and trends previously reported by ICES (Figure 2.3.3.1). The recruitment rate declined from just under 2 (on the log scale; or 4 on the base 10 scale) prior to 1989 to about 0.5 or less (1.5 or less on the base 10 scale) and fell as low as -0.26 (0.77 PFA fish per lagged spawner in 2001; Figure 2.3.3.1). PFA values have fallen from the high of 840 000 fish in 1979 to an average of just over 110 000 fish between 1997 and 2006 (Figure 2.3.3.1).

Recruitment rates declined in all six regions of North America with the earliest steep decline noted for the USA and Scotia-Fundy stocks (1982 to 2001; Figure 2.3.3.2). The Labrador recruitment rates remained high into 1996 and declined rapidly into 2001. The highest recruitment rates in recent years are inferred for the stocks of Labrador, Quebec, and Gulf at about 1.8 PFA recruits per lagged spawner (Figure 2.3.3.2). In 1979 and 2002, the recruitment rates demonstrated a North American wide increase from the previous year whereas Northwest Atlantic wide declines in recruitment rate from the previous year were noted for 1992, 1993 and 2001 (Figure 2.3.3.2).

The region-specific structuring of the recruitment rate parameter in the NAC model can also provide estimates of region-specific PFA, exploitation rates and compliance with the management objectives. The probability of the returns of 2SW salmon having been sufficient to meet the region-specific management objectives defined for the six regions of North America can also be assessed. Retrospectively, since 1991, the region-specific PFAs would have been insufficient for the 2SW returns to regions to be compliant with the present management objectives even in the absence of any fisheries having occurred at sea. The cumulative benefits of having attained higher spawning escapements back to rivers are not considered in this retrospective analysis. These issues will be explored after further diagnostic work.

NEAC models

The trends in the posterior estimates of PFA for both the southern NEAC and northern NEAC complexes closely match the descriptions of PFA trends previously provided by ICES.

The total PFA (mature and non-maturing 1SW salmon at January 1 of the first winter at sea) for the southern NEAC complex ranged from 3 to 4 million fish between 1978 and 1989 and declined rapidly to just over 2 million fish in 1990, and fell to its lowest level of just over one million fish in 2006. Over the entire time-series, the maturing proportions averaged about 0.6 with the smallest proportion in 1980 and the largest proportion in 1998. There is an increasing trend in the proportion maturing (8 of 13 values below the average during 1978 to 1990 compared with 3 of 16 values between 1991 and 2006; Figure 2.3.3.3). The productivity parameters for the maturing and non-maturing components peaked in 1985 and 1986, and reached the lowest values in 1997 (Figure 2.3.3.3).

The series of lagged eggs and returns for the northern NEAC complex is shorter than for the southern NEAC complex, beginning in 1991. Peak PFA abundance was estimated at about 2 million fish in year 2000 with the lowest value of the series in 2004 at over 1 million fish. The proportion maturing has varied around 0.5 over the time-series (Figure 2.3.3.4). The productivity parameter is higher on maturing 1SW salmon than on the non-maturing component (Figure 2.3.3.4). The recruitment rate parameters are higher for the northern NEAC compared with the southern NEAC complex, and particularly for the non-maturing 1SW component.

Shifting level models of the productivity parameter for southern NEAC

As mentioned previously, the shifting level (SL) model is an interesting alternative to the simple random walk model (Fortin *et al*., 2004). The SL model supposes that the level of productivity remains relatively constant for periods but can be subjected to abrupt shift in the levels. Under the SL model, the number of periods, their duration and the corresponding levels of productivity are unknown and need not be specified *a priori*.

The southern NEAC time-series of lagged spawners and returns suggested that there has been an abrupt shift in productivity between the 1989 and 1990 PFA years. Productivity was almost halved and this happened rather abruptly.

As a consequence of the shorter time-series for the northern NEAC model, the shift level dynamic was not fitted to that dataseries as there was no visual suggestion that such a shift in dynamic had occurred over the shorter time-series.

Despite there being some advantages to the SL model, it was not considered sufficiently developed for the provision of catch advice in 2009.

2.3.4 Further work

There is a need for further diagnostic evaluations and model exploration for the datasets in NAC and NEAC. The combined sea age model was not explored for the NAC complex and based on the results for NEAC, this model structure could be quite informative. The NEAC models have only been explored at the stock complex level and disaggregation to lower levels such as the national scale for returns and spawners as was done for NAC would also be a useful path of exploration.

ICES recommended that the Study Group (SGSSAFE) continue to develop the models presented for the NAC and NEAC areas, particularly for combining sea age classes and in the spatial disaggregation below the stock complex level.

2.4 NASCO has asked ICES to report on significant, new or emerging threats to, or opportunities for, salmon conservation and management

2.4.1 Genetic population structure and potential for local adaptation in Atlantic salmon

ICES noted the results from recent work to assess the genetic variability and evaluate the potential for local adaptation in wild Atlantic salmon in Canada. Analyses of neutral molecular markers in 51 salmon rivers revealed a hierarchical genetic structure and suggested the existence of seven regional groups in Québec, Labrador and New-Brunswick (Dionne *et al*., 2008). Landscape genetic analyses suggested a predominant influence of gene flow and thermal regime adaptation in maintaining genetic differentiation. Indirect evidence also suggested that immigrants from a different regional group were less successful in establishing in the new environment compared with residents. Different levels of genetic structure were also found within some river systems (Dionne *et al*., 2009). These results highlight the importance of maintaining small-scale variation at the catchment and sub-catchment level in managing Atlantic salmon populations.

Large scale genetic variability at an immunocompetence gene, the Major Histocompatibility Complex (MHC) class IIβ gene, revealed that genetic diversity increased with increasing temperature and bacterial diversity in rivers contrary to patterns with neutral microsatelite markers (Dionne *et al*., 2007). Pathogen infections in juvenile salmon were found to be more frequent at the beginning of summer in southern rather than northern rivers, in concordance with pathogen selection pressure in the wild (Dionne *et al.*, in press).

2.4.2 Investigations of Atlantic salmon feeding ecology at West Greenland

As part of the International Sampling Programme at West Greenland, additional sampling was conducted in 2006 and 2007. The objectives were to (1) develop protocols for more intense biological sampling at West Greenland to be used during SALSEA West Greenland; (2) to collect current information on the feeding ecology of Atlantic salmon at West Greenland; and (3) to augment historical diet information at West Greenland and investigate the stability of foraging regimes.

Predominantly, pelagic prey items were consumed although benthic organisms were also noted (Table 2.4.2.1). Overall, capelin was the primary item consumed in both years, followed by *Parathemisto* sp., a genus of amphipod. The composition of stomach contents differed slightly between 2006 and 2007 and was less varied than the data reported by Lear, 1980 for 1969–1970 (Table 2.4.2.1). Amphipods and capelin were both important in 2006 while capelin was the primary food item in 2007. The diet composition was similar between the stock complexes and sexes (Figure 2.4.2.1), except in 2006 when approximately 50% of the female diet consisted of *Parathemisto* sp., whereas males consumed primarily capelin (70% by weight). Additionally, MSW salmon appeared to feed almost exclusively on capelin and *Parathemisto* sp. The current data suggest that contemporary foraging conditions are similar to historical conditions.

Although evidence of a link between capelin and salmon productivity is lacking, there is evidence suggesting that the energy content of capelin has decreased. If the composition of the Atlantic salmon diet in West Greenland has not changed over time (as is suggested by historical and contemporary data), but the quality (i.e. energetic content) of the forage species has reduced, changes in body condition and productivity of salmon may be detectable through further investigations.

2.4.3 Red vent syndrome

Over recent years, there have been reports from both the NEAC and NAC areas of salmon returning to rivers with swollen and/or bleeding vents. The condition, known as red vent syndrome (RVS), has been noted since 2005, and has been linked to the presence of a nematode worm, *Anisakis simplex* (Beck *et al*., 2008). A number of NEAC countries observed a notable increase in the incidence of salmon with RVS during 2007 (ICES 2008), but levels were typically a lot lower during 2008. However, levels in UK (England and Wales) remained close to the high levels recorded in 2007 in a number of rivers, although were lower in other rivers and the severity of the symptoms was generally less prevalent in 2008 than in 2007. It remains unclear whether RVS affects the survival of the fish or their spawning success. However, 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. Provisional results also suggest no significant differences in the condition factors of affected and unaffected fish.

2.4.4 Reduced sensibility and development of resistance towards treatment in salmon louse (*Lepeophtheirus salmonis*)

In 2008, a number of cases of reduced sensitivity to emamectin benzoate, the oral treatment for sea lice, were discovered on farms located in the west and middle parts of Norway (Johansen *et al*., 2009). Most of these farms were subsequently medicated with bath treatments using pyrethroids, however, some evidence of cross-resistance was observed. The lag time between discovery of resistant lice, and bath-treatment, may have given the opportunity for the resistant lice to spread. Treatments may sometimes result in salmon lice being exposed to sublethal doses of emamectin because of the large size of net pens, and strong currents at the farm locality, and this may contribute towards the development of resistance. The number of lice reported by fish farmers on a monthly basis demonstrates that the number of adult lice on salmon in late 2008 and early 2009 were higher in several areas than in the previous two years (www.lusedata.no). This, together with a sudden increase in incidence of treatment failure and indications of resistance give cause for concern and could have severe consequences for wild salmon smolts should resistant lice become widespread (Revie *et al*., 2009).

2.4.5 Atlantic salmon stock assessment using sonar

There are few techniques for directly enumerating migrating salmon in large drainage basins. Recently, an improved sonar technology (Dual Frequency Identification Sonar -DIDSON; Sound Metrics Corporation: SMC) has become available. Ongoing trials in Canada and Ireland have demonstrated that counting efficiency can be high and that the system was capable of accurately measuring the size of fish. The development and use of these technologies will provide opportunities for assessing salmon in large rivers that are currently not being monitored and for improving advice to managers.

2.4.6 Smolt migration on the River Rhine

The downstream migration of Atlantic salmon smolts was again monitored in the River Rhine in 2008. The study aims to investigate the success of downstream migration and to assess the migration routes in relation to the obstructions within the Rhine Delta, particularly the Haringvliet sluices. Overall, 120 tagged fish were released into two tributaries of the River Rhine about 330 km from the sea. By the end of the migration period (end of April), 67% had been detected leaving the tributary and 18 % had been recorded reaching the sea after passage through the delta. Losses in 2008 were significantly higher than in 2007 when 46% were recorded reaching the sea. This may reflect higher discharge in 2007. The study will be repeated after the reopening of the Haringvliet dam by late 2010.

2.4.7 Reintroduction of salmon into the River Rhine

The programme of reintroducing Atlantic salmon to the River Rhine started 20 years ago and the first adult salmon was recorded in the River Sieg, a tributary of the Rhine, in 1990, more than 30 years after the extinction of salmon from the Rhine catchment. Naturally produced juvenile salmon were first observed in 1994 and since the start of the programme more than 5000 adult salmon have now been recorded in the Rhine and its tributaries. Stocking of juveniles is planned to continue. Access to suitable juvenile salmon habitat in the upper part of the catchment is still restricted by dams and weirs, and fish migrating downstream have to pass hydropower plants. However, future improvements in both fish passage and water quality are expected as a result of the implementation of the Water Framework Directive.

2.4.8 European regulations

ICES has previously noted the implications for salmon stocks arising from Council Directive 92/43/EEC (on the conservation of natural habitats and of wild flora and fauna) and of the Water Framework Directive (Directive 2000/60/EC).

The EU data collection regulation (EU DCR) has also been updated and expanded recently to include both salmon and eels and extended to inland waters. This will have impacts at Community level relating specifically to the requirement for a multi-annual Community programme for collection, management and use of biological, technical, environmental, and socio-economic data concerning:

a) commercial fisheries carried out by Community fishing vessels:
   i) within Community waters and commercial fisheries for eels and salmon in inland waters;
   ii) outside Community waters;
b) recreational fisheries carried out within Community waters and recreational fisheries for eels and salmon in inland waters;
c) aquaculture activities related to marine species, including eels and salmon, carried out within the Member States and the Community waters;
d) industries processing fisheries products-these to be defined in accordance with the procedure referred to in Article 27(2).

2.5 NASCO has asked ICES to continue work already initiated to investigate associations between changes in biological characteristics of all life stages of Atlantic salmon, environmental changes and variations in marine survival with a view to identifying predictors of abundance

ICES considered a preliminary report from the Study Group on the Identification Of Biological Characteristics For Use As Predictors Of Salmon Abundance [SGBICEPS] which had the following ToR:

a) identify data sources and compile time-series of data on marine mortality of salmon, salmon abundance, biological characteristics of salmon and related environmental information;
b) consider hypotheses relating marine mortality and/or abundance trends for Atlantic salmon stocks with changes in biological characteristics of all life stages and environmental changes;
c) conduct preliminary analyses to explore the available datasets and test the hypotheses.

The Study Group completed a preliminary review of the available information on the life-history strategies of salmon and changes in the biological characteristics of the fish (including freshwater and marine stages) in relation to key environmental variables. Data were also collated on:

Biological characteristics-The Study Group continued the work initiated by ICES (ICES, 2008) to compile a suite of standard biological measures over time-series (>15 years) sufficient to account for natural variability and to facilitate trend analysis. Data for various biological characteristics were provided from Canada, USA, Iceland, Russia, Finland, Norway, Sweden, UK (Scotland), UK (England and Wales), UK (N. Ireland) and France.

Abundance metrics-A series of tables were assembled relating to available abundance metrics and datasets on survival/mortality for different indicator stocks and stock complexes around the North Atlantic. Supplementary information describing the different assessment methods was also compiled.

Environmental variables-The Study Group reviewed the types of environmental information that could be employed to develop exploratory analyses, with particular emphasis on marine environmental data. Constraints were recognized including the lack of a clear understanding of the distribution of salmon at sea.

Data quality issues

A number of constraints and caveats, mostly relating to sampling programmes and methodological differences were noted. For example weight/condition metrics are likely to vary according to where fish are sampled (net *vs*. rod fisheries) and ages determined from scale readings will be more reliable than ages estimated by a size (length or weight) split. The Study Group recommended that in taking forward and extending any further analyses, all datasets should include a full description of data sources and of the methodology used to record each variable.

Assessment of Fulton's K *vs*. Relative Mass Index, W_R

The Study Group considered the use of condition factors (Fulton's K) derived from the annual mean length and mean weight of each year class within a time-series against the alternative Relative Mass Index (W_R) approach described by Todd *et al*., 2008. The latter provides a reliable measure of condition factor for individual fish, and one which is largely free of length-dependence. The Study Group concluded that the simple condition factor provides an adequate qualitative descriptor of variation in condition at the population level. However, although these condition factors provide an objective, qualitative means of deciding whether or not a population time-series is demonstrating systematic increase, decrease, or no change, this approach has limitations for between-stock comparisons.

Preliminary data analyses

Trends over time-The Study Group examined various stock-specific biological characteristics over a standardized period (1984–2007) using the Mann-Kendall statistic (Mann, 1945; Kendall, 1975) assuming a null hypothesis of no trend. The results are presented in Table 2.5.1 and indicate significant trends over time for many of the variables explored.

Wider geographical patterns-The Study Group examined changes in biological characteristics over broader spatial scales. In the first analysis, individual river stocks were grouped between NAC (Canada and USA) and NEAC north (Russia, Norway, Finland, Iceland N&E) and NEAC south (UK, France and Iceland S&W). In the second analysis the NAC rivers were further subdivided into two groups based on a latitudinal split. Thus the Rivers Western Arm Brook, Middle Brook, Conne and Miramichi were allocated to a northern NAC group and the other N American rivers to a southern NAC group.

The first approach used a standardized (z-score) analysis to examine the trend in mean smolt age. This analysis was restricted to wild stocks. For this purpose, the data for year n were standardized in relation to the mean smolt age between 1984 and 1993 as follows:

$$Z_n = (\text{Mean smolt age}_n - \text{mean smolt age}_{1983\text{-}94}) / \text{STD}_{1983\text{-}94}$$

The results of this analysis (Figures 2.5.1 to 2.5.3) indicated that there was a significant decline in mean smolt age from the 1970s and 1960s from the NAC area and the NEAC Southern areas respectively (P<0.05). In contrast the NEAC Northern area smolt age has remained constant since the early 1970s (P>0.05).

The second approach used meta-analysis to explore relationships for most of the biological characteristics available; results are summarized in Table 2.5.2. These analyses indicated a number of significant trends over time for certain variables at the stock complex level. Including a significant decrease in smolt age for the NAC Northern area.

Declines in mean smolt age may be the consequence of increased growth rate as faster growing parr migrate to sea earlier (Metcalf *et al*., 1989; Økland *et al*., 1993). The increase in growth rate may relate to an increase in temperature (Elliott *et al*., 2000), and/or an increase in growth as a result of density-dependent processes (Gibson, 1993; Jenkins *et al*., 1999; Imre *et al*., 2005; Lobón-Cerviá, 2005), and/or increased freshwater production. Increased growth rate and younger smolt age may dampen the impact of an increase in marine mortality assuming that the higher survival rate to younger smolts is not outweighed by increased marine mortality.

Two way plots-Simple linear regression models were used to test relationships between selected stock characteristics for individual rivers. Initial results suggest that, for a number of stocks, the size of returning 1SW salmon is positively correlated with the size of returning 2SW in both the same year and in the subsequent year. The former is consistent with common factors operating on the fish from the two sea-group groups during their return migration, whereas the latter may suggest that common factors operating in the first period at sea may have a larger influence on growth and size at maturity. A number of significant, but variable, relationships were also demonstrated between the river age of migrating smolts and the subsequent sea age and between the size of returning fish and the river-specific stock status variable. Further work is required to explore these relationships and to consider possible hypotheses.

Case studies-The Study Group reviewed information on biological characteristics from a number of discrete rivers and areas. On the River Frome (England) a general increase in the proportion of 1SW fish was noted with a later median date of migration into the river. Grilse size has declined while 2SW fish have increased in size. Mean size of smolts has increased after 1985 while at the same time the mean age of smolts has declined. There is also evidence of a strong link between smolt size and sea age. Small smolts have a lower probability of being grilse than large smolts. This relationship was particularly marked for females.

On the River Bush (N. Ireland) there has been a shift towards earlier smolt run timing and this has been linked to the subsequent survival of returning adults. One possible mechanism for this is a larger thermal discrepancy between river and seawater at the time of the smolt run. There have also been changes over the period in the proportion of 1SW returning salmon (increasing) and in their mean length (getting smaller).

In Norway there has been a significant positive relationship between the PFA of 1SW salmon stocks in one year and the PFA of 2SW salmon in the following year. However, in recent years there is evidence of three regions in Norway that more salmon return as 2SW fish than would be expected from the number of 1SW fish the previous year. The apparent later age at maturity may be explained both by more salmon delaying age-at-maturity, or that the survival in the second year at sea has increased relative to the survival in the first year at sea.

Baltic Salmon-The Study Group noted that WGBAST were also addressing concerns related to marine survival of salmon. To date, the key findings from WGBAST included evidence of strong year effects among stocks suggesting common factors applying at a Baltic wide level; e.g. changes in environment or factors acting in the main feeding area. Some results suggest that seals may affect survival rates of salmon.

However, the available information on grey seal diet is limited, and more information is needed on seal ecology, their spatial distribution in spring and summer, and on post-smolt migration routes in order to evaluate this.

ICES recognized the progress made by SGBICEPS and recommended that further coordinated efforts are made to collate data from stocks throughout the geographic range of Atlantic salmon and to continue with the analysis of datasets and the development of hypotheses.

2.6 NASCO has asked ICES to evaluate the results of studies that estimate the level of prespawning mortality of salmon caught and released by anglers and the implications for stock assessments

ICES reviewed information from a number of countries.

Pre-spawning mortality

Mortality of Atlantic salmon after catch and release (C&R) is highly variable, with temperature often cited as an important factor (Dempson *et al.*, 2002; Thorstad *et al.*, 2003a; Thorstad *et al.*, 2008). C&R angling at low temperatures (below 17–18°C) generally demonstrates lower post release mortalities than C&R at higher temperatures (Table 2.6.1, Figure 2.6.1). There is, however, a lack of studies on the survival after C&R at higher temperatures from release until to spawning and there are no studies on its relationship with survival to repeat spawning. Most of the studies that report mortality rates after C&R have used skilled anglers or artificially hooked already captive fish. This may lead to lower mortality than would be expected if less experienced anglers caught fish. Efforts have been made in a number of countries to inform anglers about good C&R practice through, for example, free instruction videos and advisory leaflets.

ICES considered that C&R recreational fisheries provide an intermediate management strategy between a full retention fishery and fishery closure for populations that are below target levels. Although not fully explored, its population-level effects could be evaluated using the equilibrium dynamics models used to calculate reference points such as the fishing mortality at maximum sustainable yield (Fmsy) or biomass at maximum sustainable yield (Bmsy). The effects would be conditional on life-history traits such as freshwater productivity, survival at-sea and repeat spawning frequency. C&R fisheries would be expected to result in population sizes that are higher than those in a full retention fishery, but lower than those expected to result from fishery closure (Figure 2.6.2).

Multiple recaptures

In all studies, less than 25 % of fish that had been marked upon release after capture by rod and line were caught a second time, and an even smaller proportion was caught a third time (Table 2.6.2). In most rivers where we have estimates of exploitation rates for salmon caught for the first time, the recapture rates after C&R are lower than the exploitation rate (Table 2.6.2). Thus, using marking of C&R fish to estimate exploitation rates or population size is likely to lead to underestimation of the exploitation rate and overestimation of the true population size. There is a need for further studies of the recapture rate of C&R salmon in rivers where exploitation rates are assessed with other methods in order to quantify the relationship between multiple recaptures and exploitation rate.

Implications for stock assessments

If all C&R salmon are counted as survivors, this will lead to an overestimation of the number of spawners. The reasons for this are twofold: (i) released salmon will suffer increased mortality relative to uncaught salmon and (ii) a proportion of the fish will be caught more than once.

At present, the effect of catch on stock assessment is handled differently by different countries. Given the information presented, ICES recognized the need to correct for C&R mortality. However, river-specific conditions at the time of fisheries vary; Table 2.6.1 provides general guidance on appropriate values to apply.

2.7 NASCO has asked ICES to provide a compilation of tag releases by country in 2008 and advise on progress with compiling historical tag recovery data from oceanic areas

2.7.1 Compilation of tag releases and fin clip data by ICES Member Countries in 2008

Data on releases of tagged, finclipped, and otherwise marked salmon in 2008 were provided by ICES and are compiled as a separate report (ICES, 2009b). A summary of tag releases is provided in Table 2.7.1.1.

2.7.2 Summary of the Workshop on Salmon Historical Information-New Investigations from old tagging data (WKSHINI)

The Workshop updated information from historical oceanic tagging and recovery programmes carried out by a number of countries in the format agreed at the WKDUHSTI Workshop (ICES, 2007). A number of hypotheses relating to oceanic migration and distribution were tested.

NW Atlantic

Analysis of salmon (4743) tag recoveries in the NW Atlantic indicated that tag recoveries were not uniformly distributed across the respective NAFO divisions at Greenland with Canadian and USA salmon more commonly captured in northern locations (NAFO Divisions 1B and 1C), whereas European origin fish tended to be caught further south in NAFO Divisions 1E and 1F. Collectively, 35% of North American tag recoveries originated in NAFO Divisions 1A and 1B *vs.* only 17% of European salmon; whereas 56% of the tag recoveries of European salmon came from NAFO areas 1E and 1F with only 17% of North American origin salmon reported recovered in these areas.

For both North American salmon and European salmon the distributions before and after 1989 were found to differ among NAFO Divisions. In both cases, salmon were found further south at Greenland in the later period then in the former. This may be related to temperature, as period 2 has been cooler then period 1, but may also reflect changes in fishing practices or periods.

The distribution of Canadian and USA tag recaptures at West Greenland was also found to differ, with Canadian salmon more commonly recaptured in northern areas than USA fish. A comparison of European salmon (Norway, UK (Scotland), Ireland and UK (England and Wales)) yielded similar results, with Scottish and Norwegian salmon recovered more in northern areas whereas salmon from Ireland and UK (England and Wales) were more likely to be recaptured in southwest Greenland.

NE Atlantic

In the area north of the Faroes, the distribution of tagged salmon recoveries (2509 recaptured fish) was not random, with clumping around two main areas, one northeasterly and one south-westerly. Catch areas for sea age groups 0, 1, 2 and 3 were clustered and the catches of MSW fish appear to have been more prevalent in the northeast catch area. However, sea age distribution might be confounded by the differences in the spatial distribution of the fishery in any year. Clear spatial differences were also apparent between recaptures in autumn and winter, with salmon caught early in the season clustered to the southwest, and fish caught later to the northeast. Fishing effort (cpue) needs to be incorporated to account for potential influences from changes in the fishery.

Visual inspection of the distribution of recaptures from northern (Norway, Sweden and UK (Scotland)) and southern (Ireland and UK (England and Wales)) stock groups suggests a more northerly location of recaptures from the northern group. This observation needs to be examined in more detail with significance testing and incorporation of data indicating fishing effort.

ICES has recommended that a similar Workshop be held to complete compilation of available data and analyses of the resulting distributions of salmon at sea. A Workshop on Learning from Salmon Tagging Records [WKLUSTRE]) will meet in London, UK, from 16–18 September 2009 (Chair: Lars Petter Hansen, Norway) to:

a) further develop the international database of marine tagging and tag recovery information for Atlantic salmon;

b) use the database to investigate the distribution of salmon of different river (stock) origins and sea ages in time and space, and assess changes in the distribution over time in relation to hydrographical factors;

c) investigate the use of the tagging database to verify outputs from migration models; and

d) make recommendations in relation to future salmon tagging studies and investigations of salmon mortality at sea.

WKLUSTRE will report by 30 November 2009 for the attention of the WGNAS, TGRECORDS and SCICOM.

Table 2.1.1.1 Reported total nominal catch of salmon by country (in tonnes round fresh weight), 1960–2008. (2008 figures include provisional data).

	NAC Area			NEAC (N. Area)							NEAC (S. Area)						Faroes & Greenland				Total	Unreported catches	
Year	Canada (1)	USA	St. P&M	Norway (2)	Russia (3)	Iceland Wild	Iceland Ranch (4)	Sweden (West)	Den.	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)
1960	1,636	1	-	1,659	1,100	100		40	-	-	743	283	139	1,443	-	33	-	-	60	-	7,237	-	-
1961	1,583	1	-	1,533	790	127		27	-	-	707	232	132	1,185	-	20	-	-	127	-	6,464	-	-
1962	1,719	1	-	1,935	710	125		45	-	-	1,459	318	356	1,738	-	23	-	-	244	-	8,673	-	-
1963	1,861	1	-	1,786	480	145		23	-	-	1,458	325	306	1,725	-	28	-	-	466	-	8,604	-	-
1964	2,069	1	-	2,147	590	135		36	-	-	1,617	307	377	1,907	-	34	-	-	1,539	-	10,759	-	-
1965	2,116	1	-	2,000	590	133		40	-	-	1,457	320	281	1,593	-	42	-	-	861	-	9,434	-	-
1966	2,369	1	-	1,791	570	104	2	36	-	-	1,238	387	287	1,595	-	42	-	-	1,370	-	9,792	-	-
1967	2,863	1	-	1,980	883	144	2	25	-	-	1,463	420	449	2,117	-	43	-	-	1,601	-	11,991	-	-
1968	2,111	1	-	1,514	827	161	1	20	-	-	1,413	282	312	1,578	-	38	5	-	1,127	403	9,793	-	-
1969	2,202	1	-	1,383	360	131	2	22	-	-	1,730	377	267	1,955	-	54	7	-	2,210	893	11,594	-	-
1970	2,323	1	-	1,171	448	182	13	20	-	-	1,787	527	297	1,392	-	45	12	-	2,146	922	11,286	-	-
1971	1,992	1	-	1,207	417	196	8	18	-	-	1,639	426	234	1,421	-	16	-	-	2,689	471	10,735	-	-
1972	1,759	1	-	1,578	462	245	5	18	-	32	1,804	442	210	1,727	34	40	9	-	2,113	486	10,965	-	-
1973	2,434	3	-	1,726	772	148	8	23	-	50	1,930	450	182	2,006	12	24	28	-	2,341	533	12,670	-	-
1974	2,539	1	-	1,633	709	215	10	32	-	76	2,128	383	184	1,628	13	16	20	-	1,917	373	11,877	-	-
1975	2,485	2	-	1,537	811	145	21	26	-	76	2,216	447	164	1,621	25	27	28	-	2,030	475	12,136	-	-
1976	2,506	1	3	1,530	542	216	9	20	-	66	1,561	208	113	1,019	9	21	40	<1	1,175	289	9,327	-	-
1977	2,545	2	-	1,488	497	123	7	10	-	59	1,372	345	110	1,160	19	19	40	6	1,420	192	9,414	-	-
1978	1,545	4	-	1,050	476	285	6	10	-	37	1,230	349	148	1,323	20	32	37	8	984	138	7,682	-	-
1979	1,287	3	-	1,831	455	219	6	12	-	26	1,097	261	99	1,076	10	29	119	<0,5	1,395	193	8,118	-	-
1980	2,680	6	-	1,830	664	241	8	17	-	34	947	360	122	1,134	30	47	536	<0,5	1,194	277	10,127	-	-
1981	2,437	6	-	1,656	463	147	16	26	-	44	685	493	101	1,233	20	25	1,025	<0,5	1,264	313	9,954	-	-
1982	1,798	6	-	1,348	364	130	17	25	-	54	993	286	132	1,092	20	10	606	<0,5	1,077	437	8,395	-	-
1983	1,424	1	3	1,550	507	166	32	28	-	58	1,656	429	187	1,221	16	23	678	<0,5	310	466	8,755	-	-
1984	1,112	2	3	1,623	593	139	20	40	-	46	829	345	78	1,013	25	18	628	<0,5	297	101	6,912	-	-
1985	1,133	2	3	1,561	659	162	55	45	-	49	1,595	361	98	913	22	13	566	7	864	-	8,108	-	-
1986	1,559	2	3	1,598	608	232	59	54	-	37	1,730	430	109	1,271	28	27	530	19	960	-	9,255	315	-
1987	1,784	1	2	1,385	564	181	40	47	-	49	1,239	302	56	922	27	18	576	<0,5	966	-	8,159	2,788	-
1988	1,310	1	2	1,076	420	217	180	40	-	36	1,874	395	114	882	32	18	243	4	893	-	7,737	3,248	-
1989	1,139	2	2	905	364	141	136	29	-	52	1,079	296	142	895	14	7	364	-	337	-	5,904	2,277	-
1990	911	2	2	930	313	141	285	33	13	60	567	338	94	624	15	7	315	-	274	-	4,925	1,890	180-350

Table 2.1.1.1 continued.

	NAC Area			NEAC (N. Area)							NEAC (S. Area)						Faroes & Greenland				Total	Unreported catches	
								Sweden				UK	UK	UK				East	West		Reported		
Year	Canada	USA	St. P&M	Norway	Russia	Iceland		(West)	Den.	Finland	Ireland	(E & W)	(N.Irl.)	(Scotl.)	France	Spain	Faroes	Grld.	Grld.	Other	Nominal	NASCO	International
	(1)			(2)	(3)	Wild	Ranch (4)				(5,6)		(6,7)		(8)	(9)	(10)		(11)	(12)	Catch	Areas (13)	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	3	-	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	-	2,396	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	7	0	0	9	-	2,455	847	-
2004	161	0	3	784	82	112	18	19	4	39	489	111	48	245	19	7	0	0	15	-	2,156	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	96	17	14	2	67	326	80	29	192	13	11	0	0	22	-	2,032	670	-
2007	112	0	2	767	63	91	36	16	3	58	85	71	30	169	11	10	0	0	25	-	1,548	475	-
2008	148	0	4	807	73	125	68	18	9	71	88	68	22	146	12	10	0	0	26	-	1,696	443	-
Average																							
2003-2007	138	0	3	888	85	105	20	18	4	58	375	89	43	203	13	10	0	0	17	-	2,069	676	-
1998-2007	145	0	3	946	101	99	22	21	4	71	505	128	56	221	12	9	1	0	19	-	2,362	911	-

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). No data available for Spain for 2008; catch assumed as in 2007.
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 Canada in 2007-2008 and for Russia in 2008.
14. Estimates refer to season ending in given year.

Table 2.1.2.1 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, 1991–2008. Figures for 2008 are provisional.

Year	Canada		USA		Iceland		Russia		UK (E&W)		UK (Scotland)		Ireland		UK (N Ireland) [1]		Denmark		Norway	
	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	28,497	33	239	50			3,211	51												
1992	46,450	34	407	67			10,120	73												
1993	53,849	41	507	77			11,246	82	1,448	10										
1994	61,830	39	249	95			12,056	83	3,227	13	6,595	8								
1995	47,679	36	370	100			11,904	84	3,189	20	12,151	14								
1996	52,166	33	542	100	669	2	10,745	73	3,428	20	10,413	15								
1997	57,252	49	333	100	1,558	6	14,823	87	3,132	24	10,965	18								
1998	62,895	53	273	100	2,826	8	12,776	81	5,365	31	13,464	18								
1999	55,331	50	211	100	3,055	11	11,450	77	5,447	44	14,846	28								
2000	64,482	55	0	-	2,918	12	12,914	74	7,470	42	21,072	32								
2001	59,387	55	0	-	3,607	15	16,945	76	6,143	43	27,724	38								
2002	50,924	52	0	-	5,985	19	25,248	80	7,658	50	24,058	42								
2003	53,645	55	0	-	5,361	17	33,862	81	6,425	56	29,160	56								
2004	62,316	55	0	-	7,294	17	24,679	76	13,211	48	46,279	50					255	19		
2005	63,005	62	0	-	9,224	19	23,592	87	11,983	56	45,970	55	2,553	12			606	27		
2006	60,486	62	1	100	8,735	23	33,380	82	10,959	56	47,471	55	5,409	22	302	18	794	65		
2007	44,423	59	3	100	9,263	24	44,341	90	10,913	55	55,472	61	13,125	40	470	16	959	57		
2008	58,004	57	61	100	15,398	19	41,881	86	11,947	54	55,366	63	13,312	37	648	20	2,033	71	5,512	-
Average																				
2003-2007	56,775	59	1	100	7,975	20	31,971	83	10,698	54	44,870	55								
1998-2007	57,689	56	49	100	5,827	16	23,919	80	8,557	48	32,552	43								

Key: [1] Data for FCB area only

Table 2.1.3.1 Estimates of unreported catches (tonnes round fresh weight) by various methods by country within national EEZs in the North East Atlantic, North American and West Greenland Commissions of NASCO, 2008.

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	4	0.2	31
NEAC	Finland	15	0.7	17
NEAC	Iceland	12	0.6	6
NEAC	Ireland	9	0.4	9
NEAC	Norway	346	16.2	30
NEAC	Sweden	2	0.1	10
NEAC	France	3	0.1	0
NEAC	UK (E & W)	23	1.1	25
NEAC	UK (N.Ireland)	0	0.0	0
NEAC	UK (Scotland)	20	0.9	12
NAC	USA	0	0.0	0
WGC	West Greenland	10	0.5	28
	Total Unreported Catch *	443	20.7	
	Total Reported Catch of North Atlantic salmon	1,695		

* No unreported catch estimate available for Canada and Russia in 2008.
Unreported catch estimates not provided for Spain & St. Pierre et Miquelon

Table 2.4.2.1. Stomach composition of Atlantic salmon caught with gillnets in NAFO Divisions 1C and 1D from August 15 to November 4 in 1969 and 1970 (reported in Lear 1972; 1980) compared with Atlantic salmon caught in NAFO Division 1D in from August and September in 2006 and 2007.

YEAR	1969–1970	2006	2007
Month, Day	Aug 15–Nov 4	Sep 20–Sep 28	Aug 09–Sep 05
NAFO Division	1C & 1D	1D	1D
Prey Items	Per cent Composition (by weight)		
unidentified material	4.24	0.11	2.8
fish remains	5.35	6.34	1.47
unidentified invertebrates	0.14	0.06	
capelin	64.69	38.37	92.15
lancet	1.18	-	-
arctic cod	0.39	-	-
sandlance	14.55	0.81	0.46
daubed shanny	0.15	-	-
sculpin	0.01	-	0.35
polychaete	0.04	-	-
amphipod	7.35	53.84	2.76
euphausiids	1.9	0.05	-
squid	-	0.41	-
total	100	100	100

Table 2.5.1. Trends in biological characteristics over time: 'o' means not enough evidence at the 5% level to detect a trend. '+' is a positive trend (p>0.05), '-' is a negative trend (p<0.05).

Stock complex	Country	Stock	H/W	Time series	Latitude	Stock status	Median run date	Mean run date	Mean rver age	Mean sea age	Prop. 1SW in run	Prop. 2SW in run	Prop. PS in run	1SW length	1SW weight	1SW condition	2SW length	2SW weight	2SW condition	PS length	PS weight	PS condition	Prop. female in 1SW	Prop. female in 2SW	Prop. female in PS	Prop. maiden spawners - 1SW	Prop. maiden spawners - 2SW
NAC	Canada	Western Arm Brook	W	1984-06	51.2	+	-	o	-	+	o	o	o	+	+	+	-	o	o	+	+	o	o	o		o	o
	Canada	Middle Brook	W	1984-05	48.8	o	o	o	o	o	o	o	o	+	+	o				+	+	o	-			o	o
	Canada	Conne River	W	1984-06	47.9	-	o	o	o	+	-	o	+	+	+	o	o			o	o	o	o	o		-	+
	Canada	Miramichi	W	1984-07	47.0	-			-	+	o	o	+	+	o	-	+	o	o	+	+	o	-	+	+	o	o
	Canada	Nashwaak	W	1984-07	46.0	-	o	o	-	-	+	-		o			+						o	o		+	-
	Canada	St John (Mactaquac)	W	1984-07	45.3	-	-	-	-	o	+	o		o	o	o	o	-	-				o	o		o	-
	Canada	St John (Mactaquac)	H	1984-07	45.3	-	-	-	-	-	+	-		o	o	o	-	-	-				o	o		+	-
	Canada	La Have	W	1984-07	44.4	o	-	o	+	o	o	o	o	o	+	+	o	+	+	o	+		o	+	+	o	o
	Canada	La Have	H	1984-07	44.4	o	o	o	-	o	o	+	o	o	+	+	o	+	+	o	+		o	+	o	o	o
	USA	Penobscot	H	1984-07	44.5	-	-	-	o	-	+	o	o	o	+	+	o	o	+	o	o	o	-	o	o	+	o
N NEAC	Finland/Norway	Teno	W	1984-07	70.8	o			+	-	o	o	+	o	o	+	o	o	o	o	o	o	o	o	-		
	Finland/Norway	Näätämöjoki	W	1984-06	69.7	o			+	-	+	o	o	+	o	o	o	o	o	o	o	o	o	-	o		
	Russia	Tuloma	W	1984-08	68.9	o	o	+	-	-	o	o	o	o	o	o	-	-	o	o	o	o	o	o	o	+	o
	Norway	Årgårdsvassdraget	W	1992-07	64.3	o			o	+	o	+	o	o	o	o	o	o	o	o	o	o					
	Norway	Gaula	W	1989-07	63.3	o			-	+	o	o	+	o	o	o	o	o	o	o	o	o					
	Iceland (N&E)	Laxa I Adaldalur	W	1984-07	65.6						+												o	-			
	Iceland (N&E)	Hofsa	W	1984-07	65.4						+												o	+			
S NEAC	Iceland (S&W)	Nordura	W	1984-07	64.6						+												o	+			
	Iceland (S&W)	Ellidaar	W	1984-07	64.1						+												+	o			
	UK (Scot)	N. Esk	W	1984-07	56.7						o	o		-	-	-	o	-	o								
	UK (NI)	Bush	W	1984-07	55.1	-	+	o	o	o	+	-	o	o	o	o	o	-	-	o	o	o	o	o	o	+	-
	UK (E&W)	Lune	W	1987-07	54.0	o			o	o	o	o		o	o	o	o	-	o								
	UK (E&W)	Dee	W	1984-07	53.4	-			-	-	+	-	o	o	+	+	+	+	+	-	-	-	-	+	o		
	UK (E&W)	Wye	W	1984-07	51.6	o		+	-	-	+	+	-	+	+	o	o	o	o	-	-	o					
	UK (E&W)	Frome	W	1984-08	50.7	-			-					-			+										
	France	Bresle	W	1984-08	50.1					o	o	o	o	o			o										

Table 2.5.2. Results of meta analysis at the stock complex level, indicating significant increase (+) or decrease (-) relative to the mean (o denotes non-significant relationship).

Stock complex	H/W	Time series	Latitude	Stock size - 1SW	Stock size - 2SW	Mean river age	Mean sea age	Mean total age	Median run date	Mean run date	Prop. 1SW in run	Prop. 2SW in run	Prop. PS in run	Mean length - 1SW	Mean weight - 1SW	Condition - 1SW	Mean length - 2SW	Mean weight - 2SW	Condition - 2SW	Mean length - PS	Mean weight - PS	Condition - PS	Prop. female in 1SW	Prop. female in 2SW	Prop. female in PS	Prop. maiden spawners - 1SW	Prop. maiden spawners - 2SW
NAC (N)	W	1984-07	47.0 - 51.2	**o**	**+**	**-**	**+**	**o**	**-**	**-**	**o**	**o**	**+**	**+**	**+**	**o**	**o**	**o**	**o**	**+**	**+**	**o**	**o**	**o**	**+**	**o**	**o**
NAC (S)	H/W	1984-07	44.4 - 46.0	**-**	**-**	**o**	**o**	**-**	**o**	**-**	**o**	**o**	**o**	**o**	**o**	**o**	**o**	**o**	**o**	**o**	**o**		**o**	**+**	**o**	**o**	**o**
N NEAC	W	1984-07	65.4 - 70.8	**+**	**o**	**o**	**o**	**o**			**+**	**+**	**o**	**o**	**o**	**o**	**-**	**-**	**o**	**o**	**o**	**o**	**o**	**o**	**-**		
S NEAC	W	1984-07	50.1 - 64.6	**o**	**o**	**-**	**-**	**-**		**+**	**+**	**o**	**-**	**o**	**o**	**o**	**o**	**o**	**o**	**-**	**-**	**o**	**o**	**+**	**+**		

Table 2.6.1. Summary of C&R experiments on Atlantic salmon that provide mortality rates and details of the methods used. (NS-Nova Scotia; NB-New Brunswick; NL-Newfoundland; ON-Ontario).

Author	Purpose	Method	Origin	Location	Life stage	Telemetry	Method	Numbers of fish	Study Period	Mortality Rate in %	Water Temperature
Tufts et al. 1991	Pysiology	Hatchery	Wild	LaHave R, NS	Small		Chased	6	24 hours	0	18
Booth et al. 1995	Pysiology	In-river	Wild	Miramichi R, NB	Large		Hooked	20	24 hours	0	6 ± 1
Brobbel et al. 1996	Pysiology	In-river	Wild	Miramichi R, NB	Small		Hooked	24	12 hours	0	4 ± 1
Brobbel et al. 1996	Pysiology	In-river	Wild	Miramichi R, NB	Small		Hooked	25	12 hours	12	16 ± 1
Wilkie et al. 1996	Pysiology	In-river	Wild	Miramichi R, NB	Small		Hooked	10	12 hours	40	22
Anderson et al.1998	Pysiology	Hatchery	Wild	Exploits R, NL	Small		Hooked	5	72 hours	80	20 ± 2
Anderson et al.1998	Pysiology	Hatchery	Wild	Exploits R, NL	Small		Hooked	5	72 hours	0	16.5 ± 1
Anderson et al.1998	Pysiology	Hatchery	Hatchery	Alma, ON	Small		Hooked	6	72 hours	0	8 ± 1
Wilkie et al. 1997	Pysiology	Hatchery	Hatchery	Margaree R, NS	Small		Chased	10	72 hours	0	12
Wilkie et al. 1997	Pysiology	Hatchery	Hatchery	Margaree R, NS	Small		Chased	10	72 hours	0	18
Wilkie et al. 1997	Pysiology	Hatchery	Hatchery	Margaree R, NS	Small		Chased	10	72 hours	30	23
Dempson et al. 2002	Mortality	Natural	Wild	Conne R, NL	Small		Angled	8	14-40 days	0	12.2 ± 1.7
Dempson et al. 2002	Mortality	Natural	Wild	Conne R, NL	Small		Angled	20	14-40 days	10	16.1 ± 1.4
Dempson et al. 2002	Mortality	Natural	Wild	Conne R, NL	Small		Angled	21	14-40 days	9.5	19.4 ± 1.3
Thorstad et al. 2003	Mortality	Natural	Wild	Alta R, Norway	Small&large	Telemetry	Angled	30	Up to spawning	3	12.2 ± 2.2
Mäkinen et al. 2000	Migration	Natural	Wild	R. Teno, Finland	Small	Telemetry	Angled	5	Unknown	0	9.4 ± 1.0
Whoriskey et al. 2000	Mortality	Natural	Wild	R. Ponoi, Russia	Small&large	Telemetry	Angled	62	24 hours	2	Not listed
Webb 1998	Mortality	Natural	Wild	R. Dee, Scotland	Small&large	Telemetry	Angled	25	Up to spawning	4	Not listed
Grant 1980	Stocking	Hatchery	Wild	R. Grimsa&Adaldal, Iceland	Large		Angled	30	Up to spawning	4	Not listed
Gowan 2004	Mortality	Natural	Wild	River Eden, Cumbria, UK	Small&large	Telemetry	Angled	208	Up to spawning	7-37	5-18, 11.9 ± 3
Svenning 2007	Migration	Natural	Wild	Målselva, Norway	Small&large	Telemetry	Angled	37	Up to spawning	0	12
Thorstad et al. 2007	Mortality	Natural	Wild	Alta R, Norway	Large	Telemetry	Angled	18	Up to spawning	6	12-14
Thorstad et al. 2003b	Migration	Natural	Wild	Orkla R, Norway	Small&large	Telemetry	Angled	34	Up to spawning	0	11.5-15
Davidson et al. 1994	Egg survival	Laboratory	Wild	Miramichi R, NB	Small&large		Hooked	26	Up to spawning	0	5-6
Warner & Johnson 1998	Mortality	Natural	Landlocked	Moosehead lake, Maine	Small		Angled	175	minimum 2 days	22	16.5
Warner 1976	Mortality	Laboratory	Landlocked	Cobb fish cultural station, Maine	Small		Angled	1200	minimum 9 days	3	12.5
Warner 1979	Mortality	Laboratory	Landlocked	Casco cultural fish station, Maine	Small		Angled	1221	3-5 days	5	13-15

Table 2.6.2. Information relating to multiple recaptures of salmon after C&R.

Location	Study	Method	N	Percent recaptured once	Percent recaptured twice	Percent recapture of released a second time	Estimate of exploitation rate in river (percent)
Ponoi River, Russia	Whoriskey et al 2000	Floy tags	2520	11	0.5		10-19
Ponoi River, Russia	Whoriskey et al 2000	Telmetry	Unknown	7.2			10-19
Alta River, Norway	Thorstad et al. 2003a	Ancor T-tags	353	4	0.3		50-70
Aberdeeshire Dee, Scotland	Webb 1998 and references therein	Unknown	Unknown	5-20			Unknown
Hofsa, Iceland	Gudbergsson & Einarsson 2009	Floy tags or Dart tags	592	23.5	1.7	14.3	Unknown
Sela, Iceland	Gudbergsson & Einarsson 2009	Floy tags or Dart tags	605	24.6	2.3	22.2	75-80
Grimsa, Iceland	Gudbergsson & Einarsson 2009	Floy tags or Dart tags	234	17.9	0	0	Unknown
Haffjardara, Iceland	Gudbergsson & Einarsson 2009	Floy tags or Dart tags	379	14.8	0.3	6.7	Unknown

Table 2.7.1.1 Summary of Atlantic salmon tagged and marked in 2008; '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	Pit tag[1]	Total
Canada	Hatchery	0	9,705	784,004	35	793,744
	Wild	9,804	22,610	23,521	137	56,072
	Adult	0	2,693	3,256	57	6,006
	Total	9,804	35,008	810,781	229	855,822
France	Hatchery			448,700		448,700
	Wild		1,504	1,317	483	3,304
	Adult		606			606
	Total	0	2,110	450,017	483	452,610
Germany	Hatchery	35,103		6,000	0	41,103
	Wild			0	0	0
	Adult			0	0	0
	Total	35,103	0	6,000	0	41,103
Iceland	Hatchery	44,175	0	0	0	44,175
	Wild	1,886	0	0	0	1,886
	Adult	0	4,694	0	0	4,694
	Total	46,061	4,694	0	0	50,755
Ireland	Hatchery	287,945	0	0	0	287,945
	Wild	9,580	0	0	0	9,580
	Adult	0	0	0	0	0
	Total	297,525	0	0	0	297,525
Norway	Hatchery	60,414	59,826	0	0	120,240
	Wild		1,076	0	0	1,076
	Adult		1,306	0	0	1,306
	Total	60,414	62,208	0	0	122,622
Russia	Hatchery	0	0	1,145,420	0	1,145,420
	Wild	0	0	0	0	0
	Adult	0	2,602	0	0	2,602
	Total	0	2,602	1,145,420	0	1,148,022
Spain	Hatchery	311,967	0	329,465	0	641,432
	Wild	0	0	0	0	0
	Adult	0	0	0	0	0
	Total	311,967	0	329,465	0	641,432
Sweden	Hatchery	0	3,000	149,916	0	152,916
	Wild	0	448	0	0	448
	Adult	0	0	0	0	0
	Total	0	3,448	149,916	0	153,364
UK (England & Wales)	Hatchery	30,463	0	110,032	0	140,495
	Wild	11,353	0	15,564	0	26,917
	Adult	0	758	0	0	758
	Total	41,816	758	125,596	0	168,170
UK (N. Ireland)	Hatchery	17,177	0	28,690	0	45,867
	Wild	1,410	0	0	0	1,410
	Adult	0	0	0	0	0
	Total	18,587	0	28,690	0	47,277
UK (Scotland)	Hatchery	51,810	0	0	0	51,810
	Wild	6,975	3,426	0	3,479	13,880
	Adult		726	0	0	726
	Total	58,785	4,152	0	3,479	66,416
USA	Hatchery	0	0	463,479	842	464,321
	Wild	0	0	0	46	46
	Adult	0	2,372	0	1,643	4,015
	Total	0	2,372	463,479	2,531	468,382
All Countries	Hatchery	839,054	72,531	3,465,706	877	4,378,168
	Wild	76,111	29,064	46,402	4,145	155,722
	Adult	0	15,757	3,256	1,700	20,713
	Total	915,165	117,352	3,515,364	6,722	4,554,603

[1] Includes pit tags or other internal tags

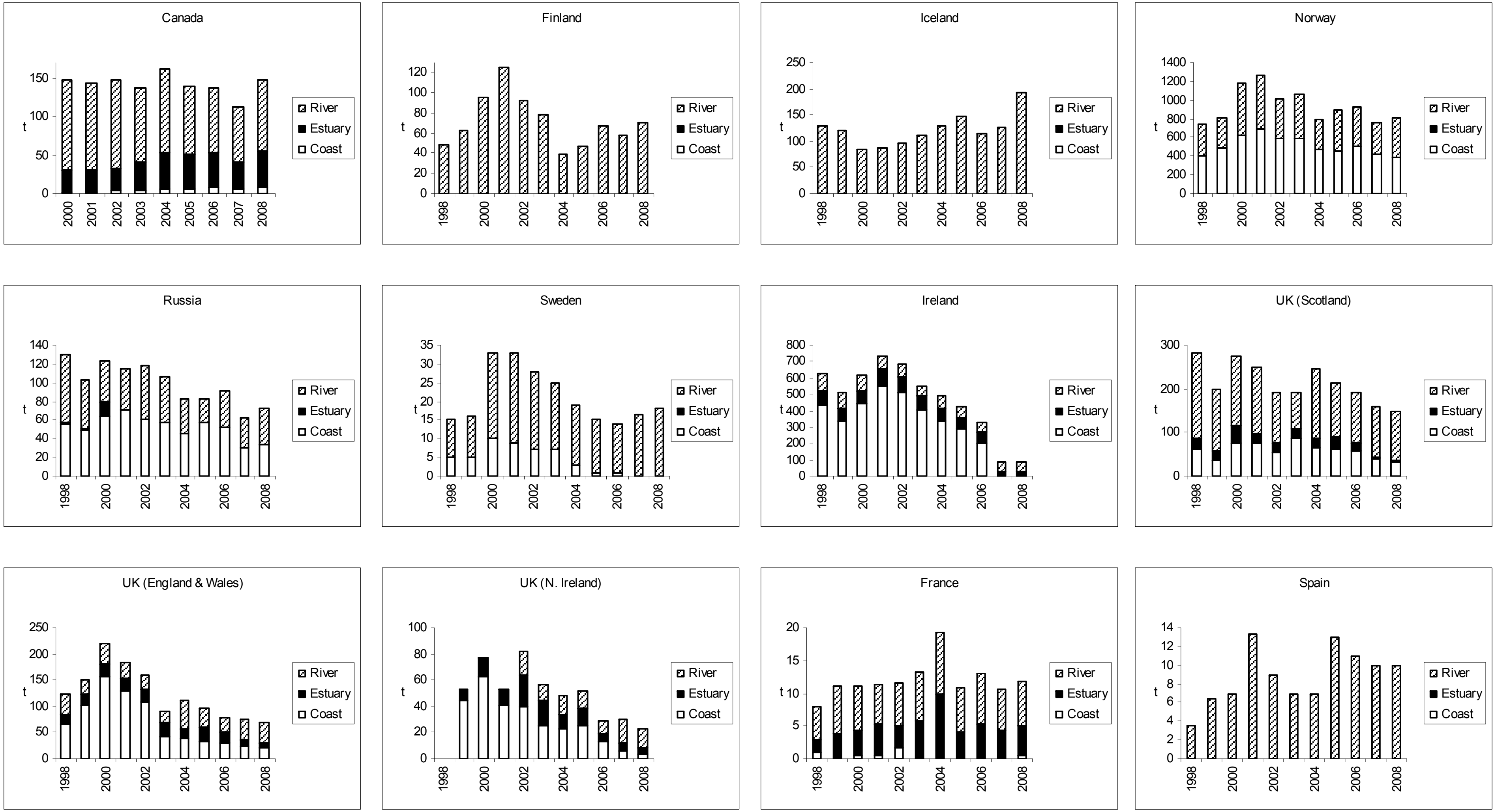


Figure 2.1.1.1. Nominal catch (tonnes) taken in coastal, estuarine and riverine fisheries by country. Note that time-series and y-axes vary.

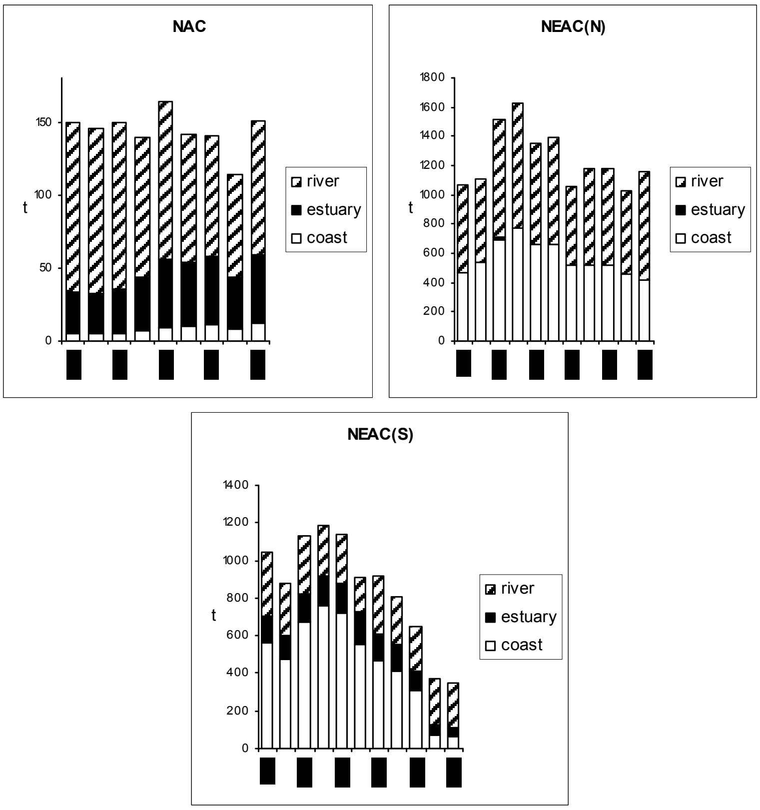


Figure 2.1.1.2. Nominal catch taken in coastal, estuarine and riverine fisheries for the NAC area, and for the NEAC northern and southern areas. Note that time-series and y-axes vary.

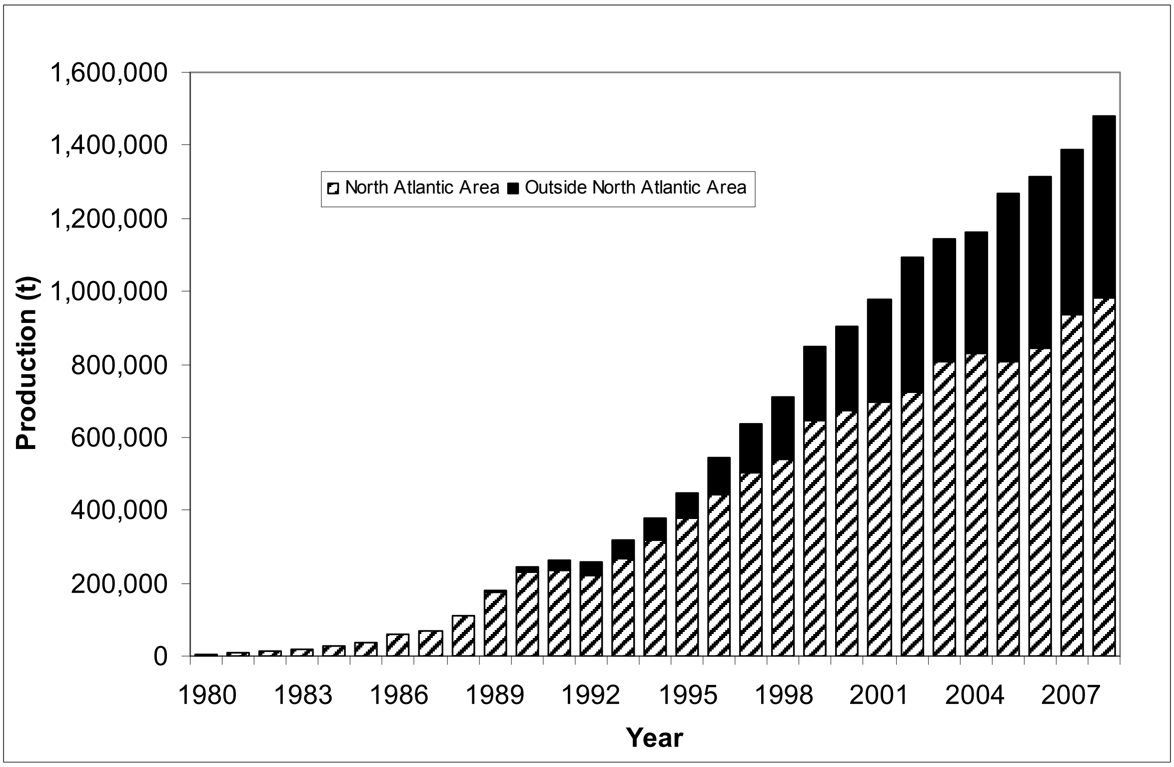


Figure 2.2.1. World-wide production of farmed Atlantic salmon, 1980–2008.

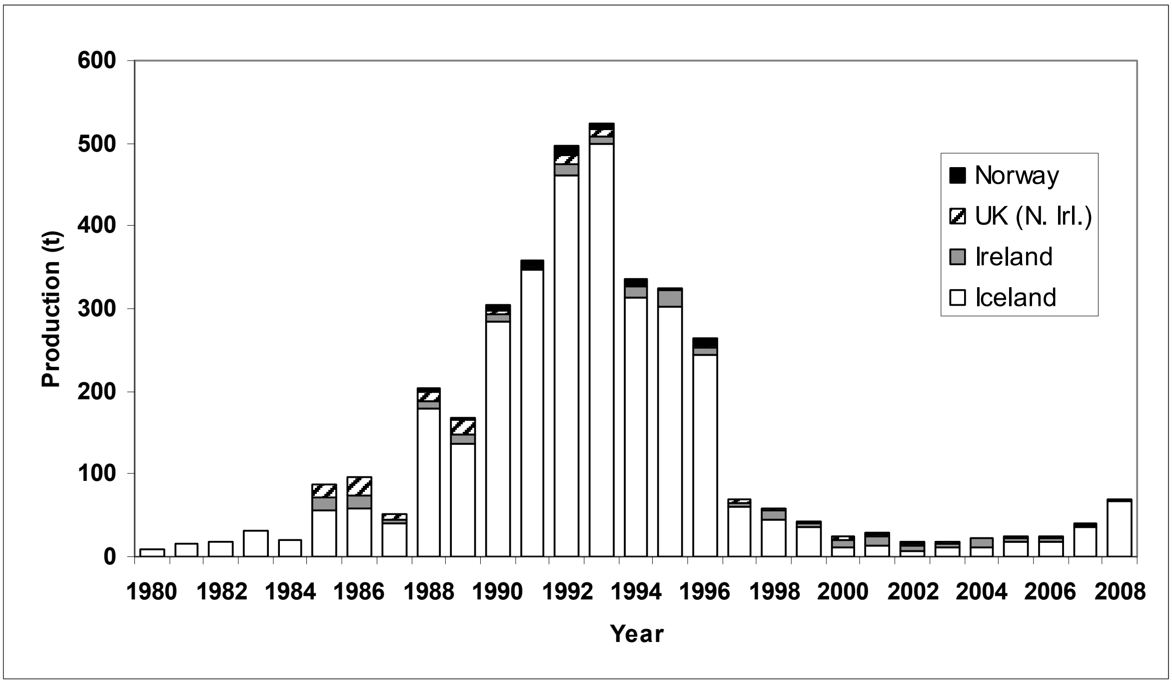


Figure 2.2.2. Production of ranched Atlantic salmon (tonnes round fresh weight) in the North Atlantic, 1980–2008.

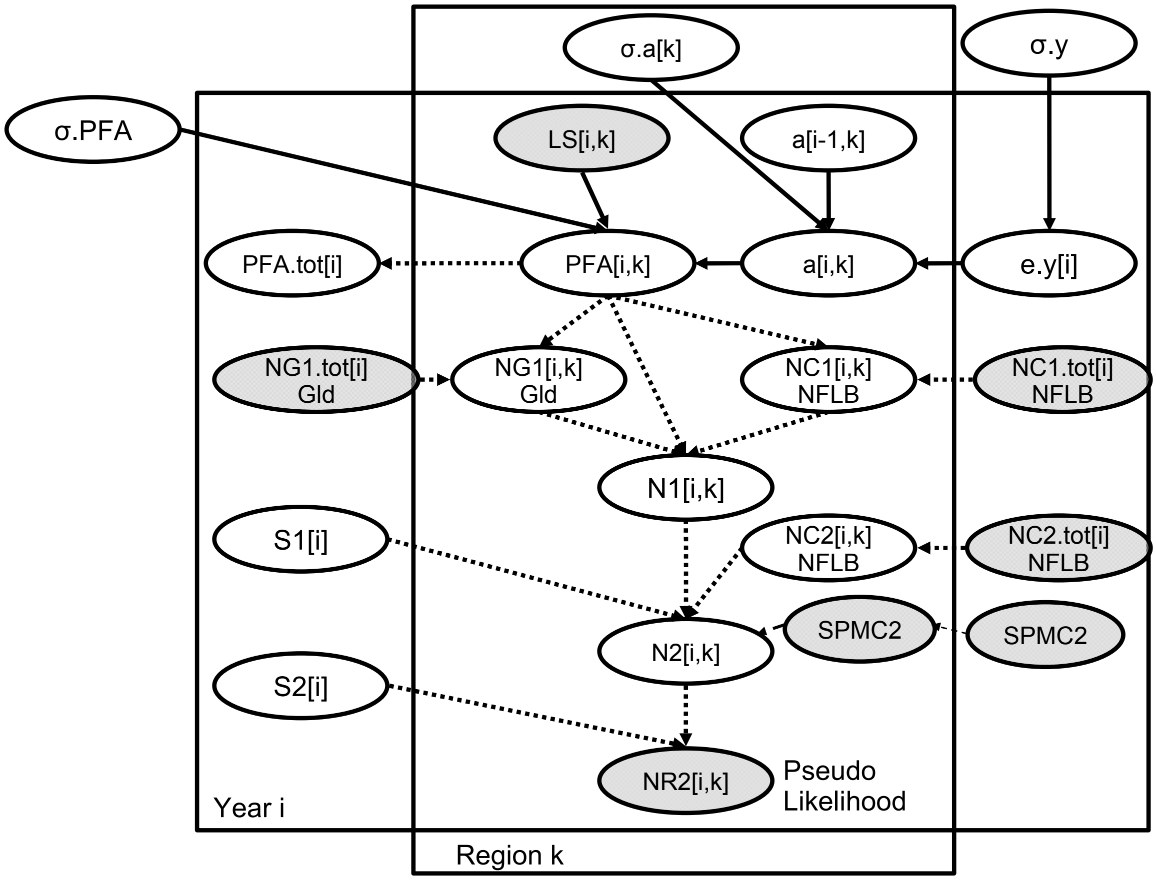


Figure 2.3.1.1 Directed Acyclical Graph (DAG) of the proposed structure of the region disaggregated forecast model for 2SW salmon of North American origin. Ellipses in grey are observations (or pseudo-observations) derived from sampling programmes or from submodels (run-reconstruction).

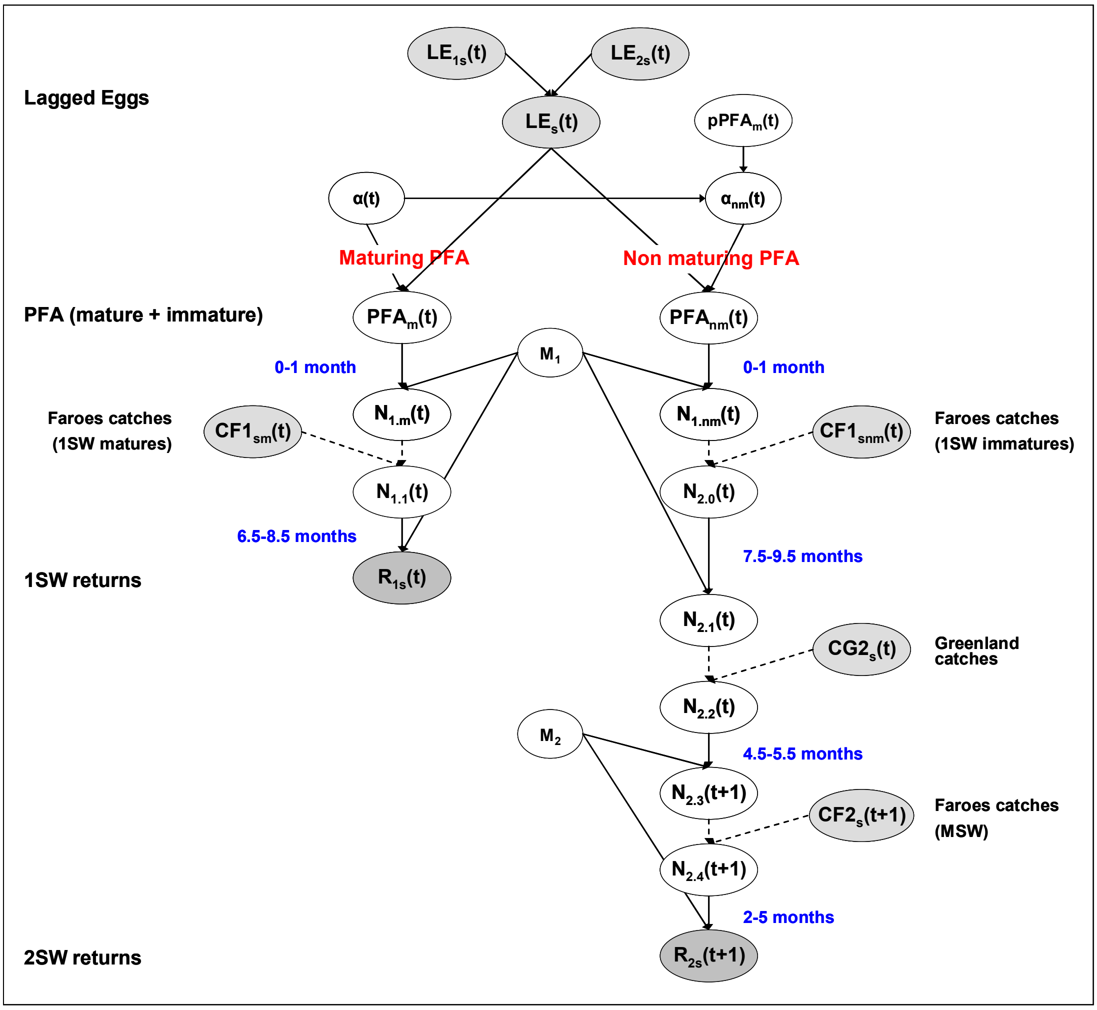
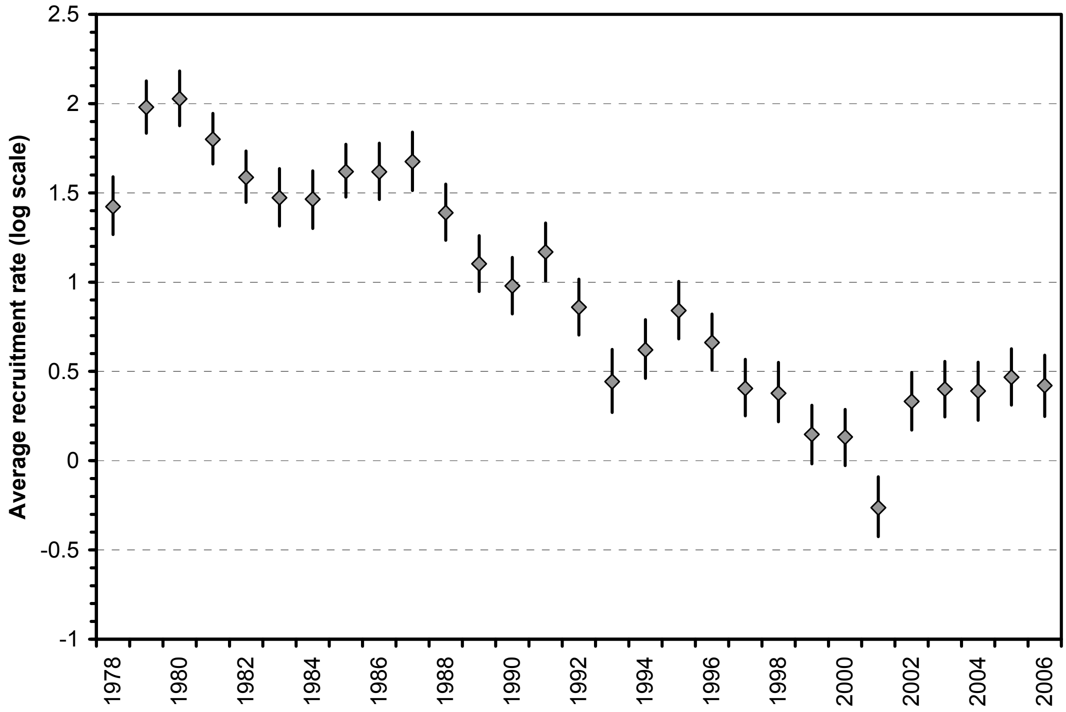


Figure 2.3.2.1 Directed Acyclical Graph (DAG) of the proposed structure of the combined sea age model for the southern NEAC and northern NEAC forecast models. Ellipses in grey are observations (or pseudo-observations) derived from sampling programmes or from submodels (run-reconstruction).



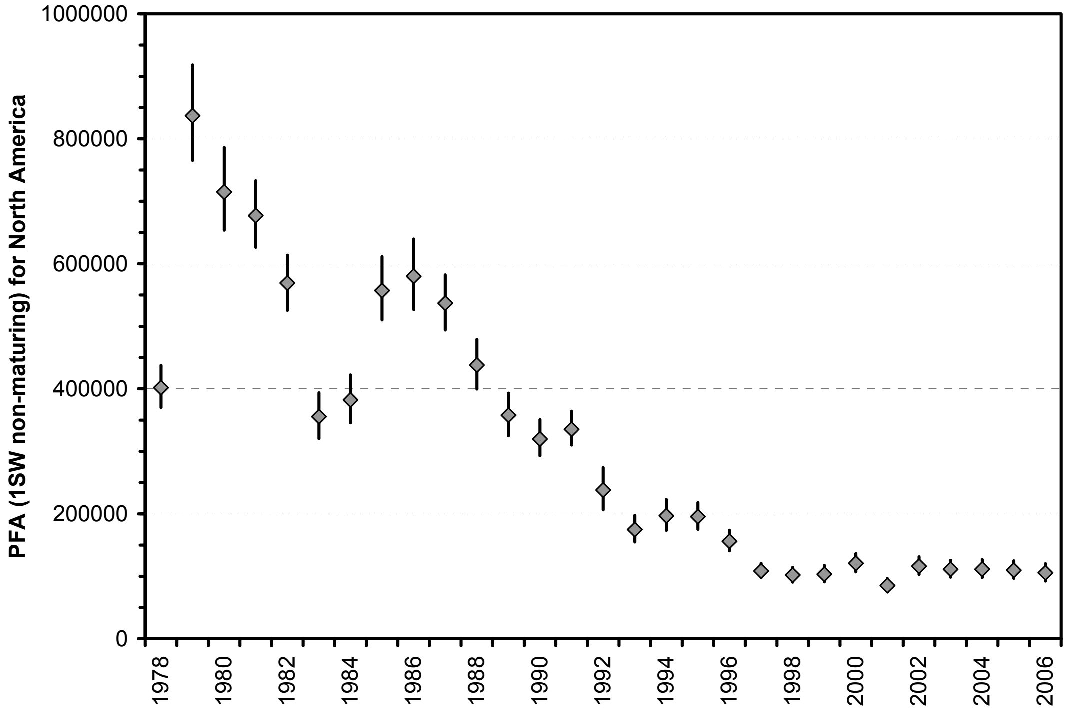
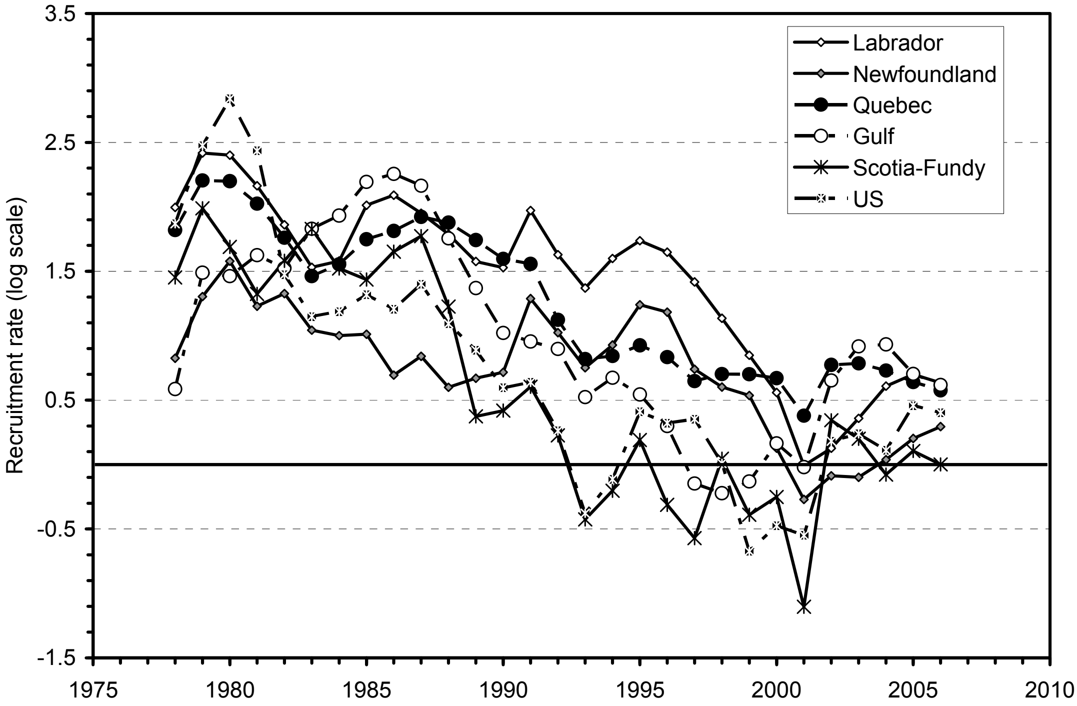


Figure 2.3.3.1 Average recruitment rate (log scale) (upper panel) and posterior distributions of PFA for North America (lower panel) based on the region-specific random walk model, for lagged eggs and PFA years 1978 to 2006. Diamond symbols are the medians and the vertical lines are the 95% Bayesian credible intervals of the posterior distributions.



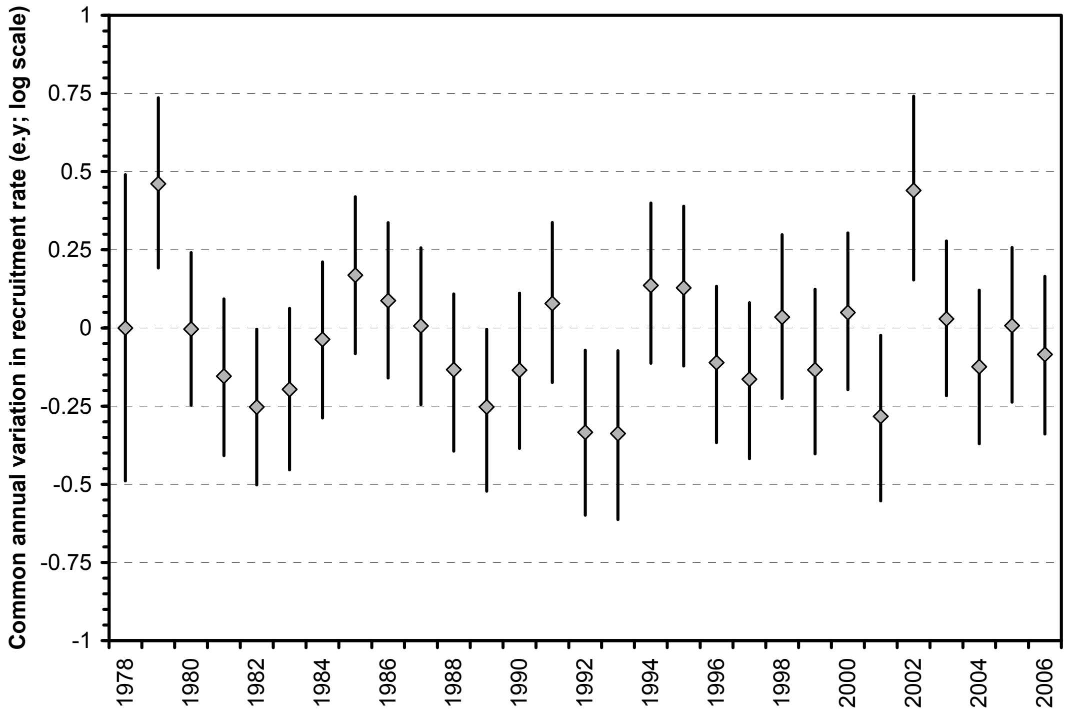


Figure 2.3.3.2 Point estimates of the region-specific recruitment rate (log scale) (upper panel) and posterior distributions of the regionally common annual variation (e.y; log scale; lower panel) based on the region-specific random walk model, for lagged eggs and PFA years 1978 to 2006. In the lower panel, diamond symbols are the medians and the vertical lines are the 95% Bayesian credible intervals of the posterior distributions.

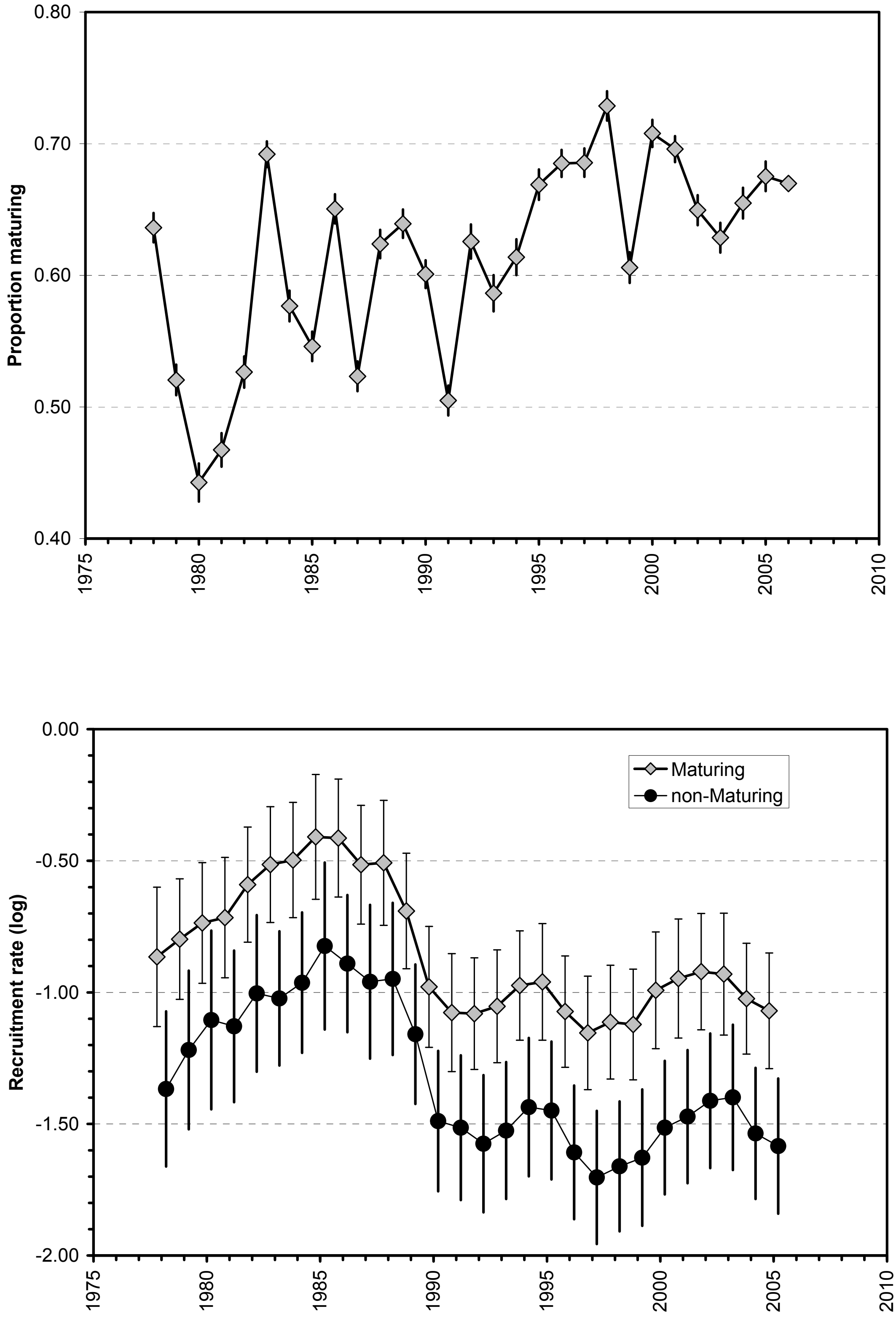


Figure 2.3.3.3 Median values (and 95% Bayesian credible interval range) of the posterior distributions of the proportion of the PFA maturing at 1SW salmon (upper panel) and of the recruitment rate parameter estimates for the maturing component and the non-maturing component (lower panel) for the southern NEAC stock complex.

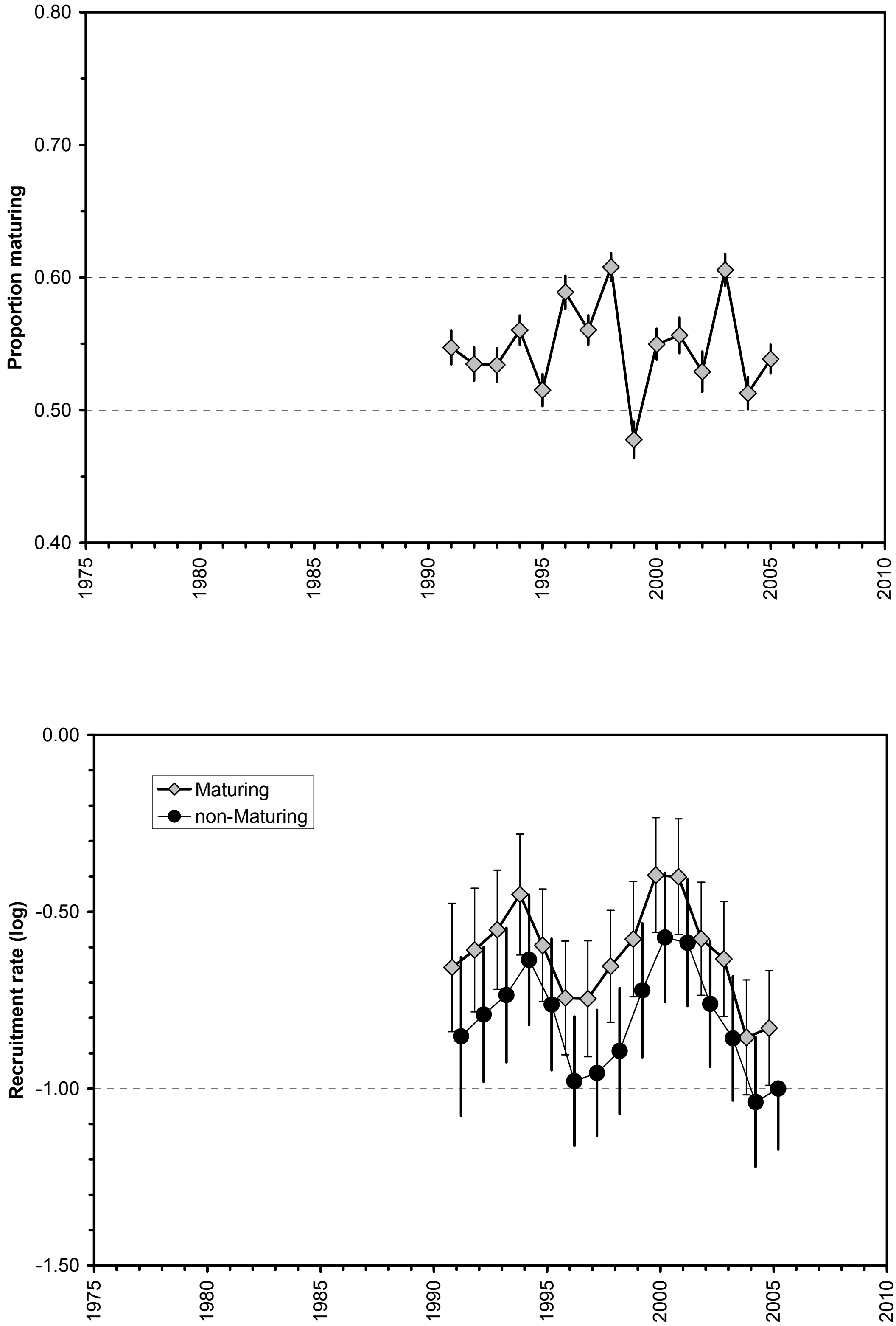


Figure 2.3.3.4 Median values (and 95% Bayesian credible interval range) of the posterior distributions of the proportion of the PFA maturing at 1SW salmon (upper panel) and of the recruitment rate parameter estimates for the maturing component and the non-maturing component (lower panel) for the northern NEAC stock complex.

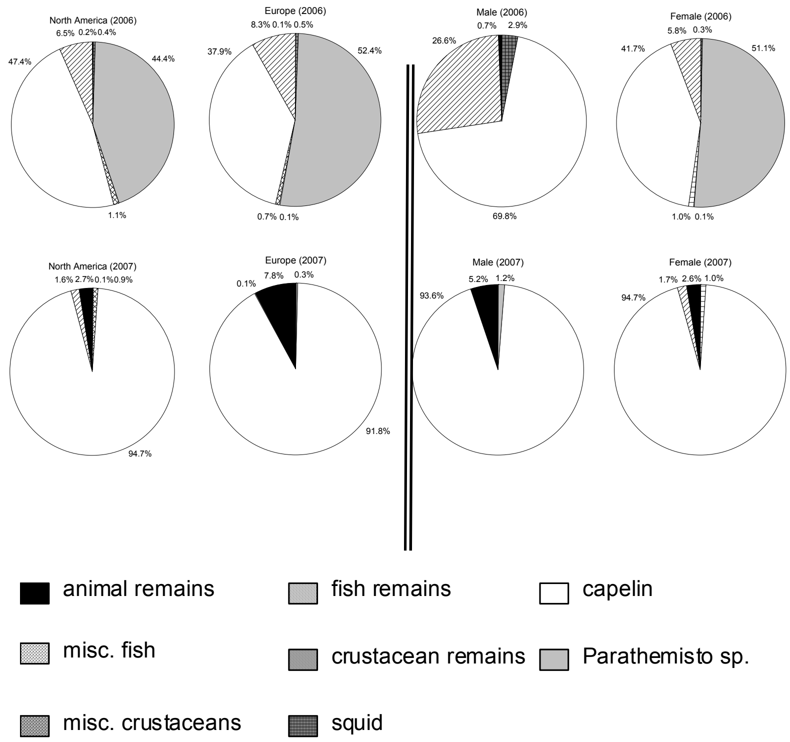


Figure 2.4.2.1. Dietary composition of North American *vs.* European (left) and male *vs.* female (right) Atlantic salmon collected from Nuuk, Greenland in 2006 and 2007. Miscellaneous fish include sculpin and sandlance. Miscellaneous crustaceans include hyperiids, gammarids and euphausiids.

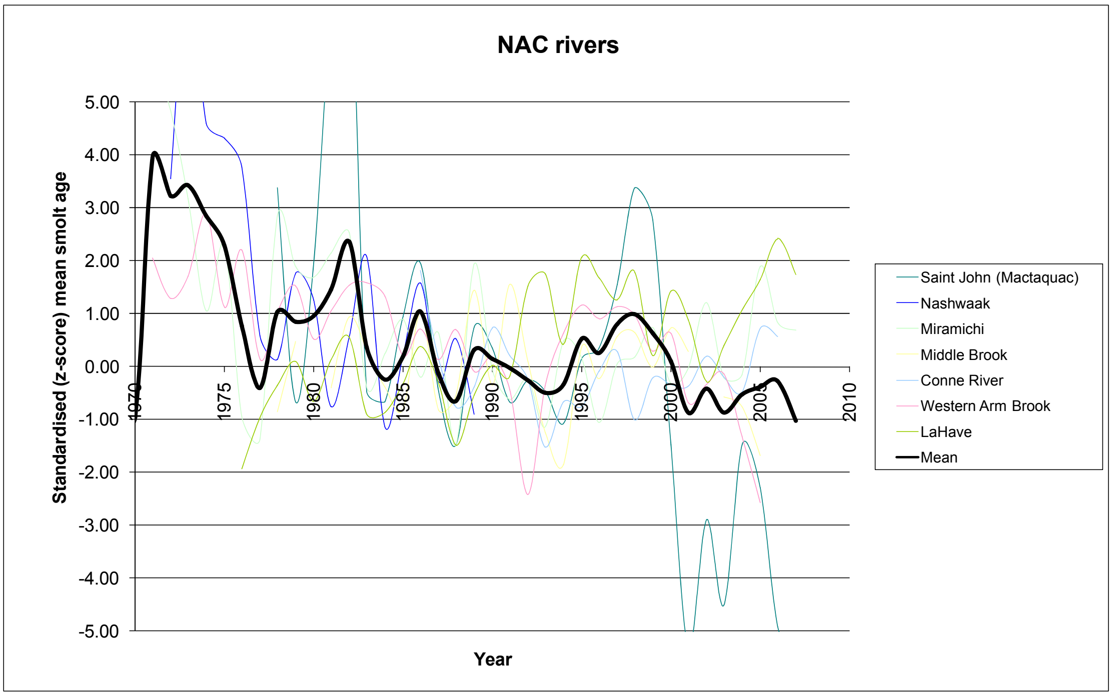


Figure 2.5.1. Standardised mean (z-score) smolt ages for available datasets from NAC rivers. Data back calculated from returning adult salmon and standardized in relation to the mean smolt age between 1984 and 1993.

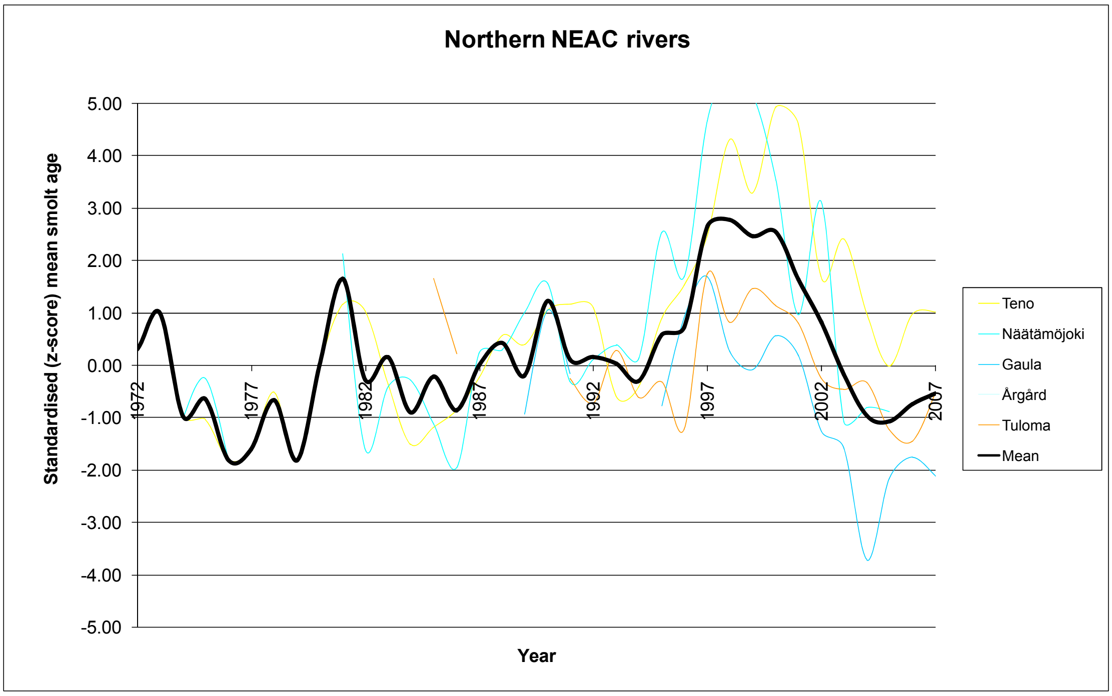


Figure 2.5.2. Standardised mean (z-score) smolt ages for available datasets from Northern NEAC rivers. Data back calculated from returning adult salmon and standardized in relation to the mean smolt age between 1984 and 1993.

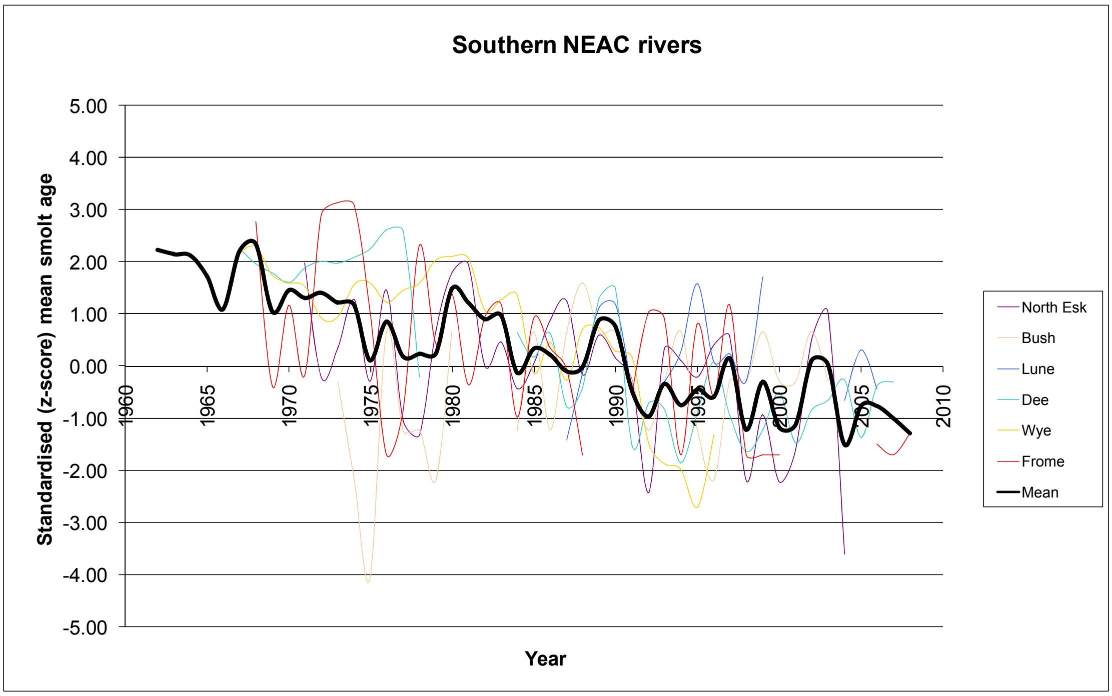


Figure 2.5.3. Standardised mean (z-score) smolt ages for available datasets from Southern NEAC rivers. Data back calculated from returning adult salmon and standardized in relation to the mean smolt age between 1984 and 1993.

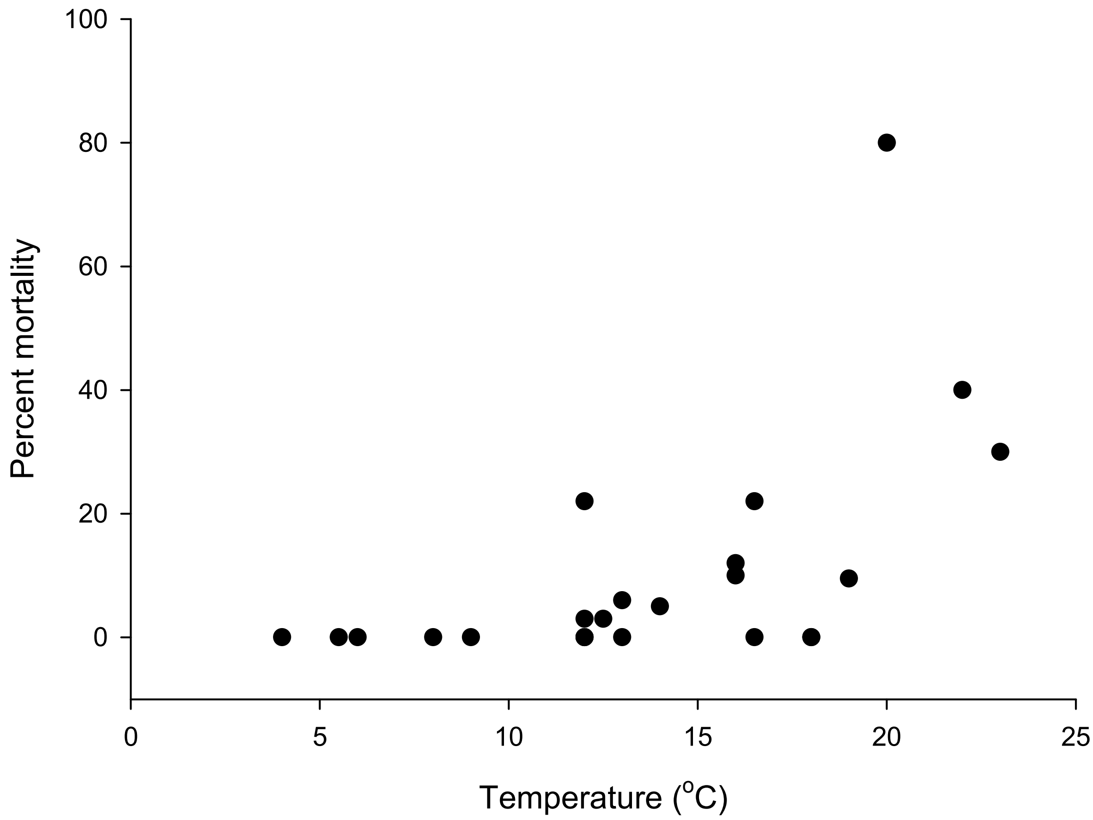


Figure 2.6.1. Mortality of Atlantic salmon after C&R at different water temperatures (average, if given, or median) (From the data presented in Table 2.6.1).

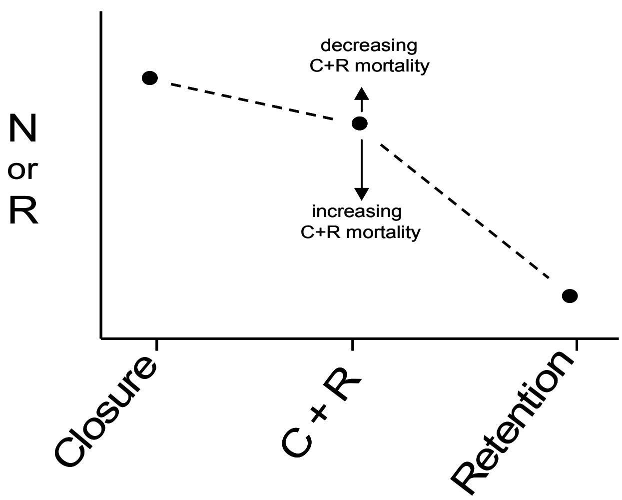


Figure 2.6.2. Schematic representation of the effect of C&R mortality on population size (N) and population growth rate (R) relative to fishery closures or full retention fisheries.

3 North East Atlantic Commission

Conservation limits (CLs) have been defined by ICES as the level of stock that will achieve long-term average maximum sustainable yield (MSY). NASCO has adopted this definition of CLs (NASCO, 1998). The CL is a limit reference point; having populations fall below these limits should be avoided with high probability. However, management targets have not yet been defined for all Atlantic salmon stocks.

Therefore:

- ICES considers homewater stocks in the NEAC Commission to be at full reproductive capacity only if the lower boundary of the confidence interval of the most recent spawner estimate is above the CL. In a similar manner, the status of stocks prior to the commencement of distant water fisheries has been interpreted to be at full reproductive capacity only if the lower boundary of the confidence interval of the most recent PFA estimate is above the Spawner Escapement Reserve (SER).
- ICES considers a stock to be at risk of suffering reduced reproductive capacity when the lower boundary of the confidence limit is below the CL/SER, but the midpoint is above.
- ICES considers a stock to be suffering reduced reproductive capacity when the midpoint is below the CL/SER.

For catch advice on fish exploited at West Greenland (non-maturing 1SW fish from North America and non-maturing 1SW fish from Southern NEAC), ICES has used the risk level of 75% that is part of the agreed management plan (ICES, 2003).

For stock assessment purposes, ICES groups NEAC stocks into two stock groupings: Northern and Southern NEAC stocks. The composition of these groups is shown below:

SOUTHERN EUROPEAN COUNTRIES:	NORTHERN EUROPEAN COUNTRIES:
Ireland	Finland
France	Norway
UK (England and Wales)	Russia
UK (Northern Ireland)	Sweden
UK (Scotland)	Iceland (north/east regions) [1]
Iceland (south/west regions)[1]	

3.1 Status of stocks/exploitation

The status of stocks is shown in Figure 3.1.1.

ICES classifies the status of stock complexes prior to the commencement of distant water fisheries with respect to the SER requirements as follows:

[1] The Iceland stock complex was split into two separate complexes for stock assessment purposes in 2005. Prior to 2005, all regions of Iceland were considered to contribute to the Northern European stock complex.

- Northern European 1SW stock complex is considered to be at full reproductive capacity.
- Northern European MSW stock complex is considered to be at full reproductive capacity.
- Southern European 1SW stock complex is considered to be at risk of suffering reduced reproductive capacity.
- Southern European MSW stock complex is considered to be at risk of suffering reduced reproductive capacity.

Estimated exploitation rates have generally been decreasing over the period for both 1SW and MSW stocks in Northern and Southern NEAC areas (Figures 3.1.2 and 3.1.3). Exploitation on Northern 1SW stocks is higher than on Southern 1SW and considerably higher for MSW stocks. The current estimates for both stock complexes are among the lowest in the time-series.

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 as a consequence of continuing poor survival in the marine environment attributed to climate effects. Efforts continue to improve our understanding of causal relationships contributing to marine mortality.

3.2 Management objectives

This Commission area is subject to the general NASCO management objectives as outlined in Section 1.3.

3.3 Reference points

Section 1.4 describes the derivation of reference points for these stocks and stock complexes.

3.3.1 National conservation limits

The national model has been run for all countries that do not have river-specific CLs (i.e. all countries except France, Ireland, and UK (England and Wales)).

Iceland, Russia, Norway, UK (N. Ireland), and UK (Scotland) have provided regional input data for the PFA analysis (1971–2007). For these countries the lagged spawner analysis has been conducted by region. The regional results were combined to estimate CLs based on a pseudo stock–recruitment relationship for the country. Outputs from the national model are only designed to provide a provisional guide to the status of stocks in the NEAC area.

To provide catch options to NASCO, CLs are required for stock complexes. These have been derived either by summing of individual river CLs to national level, or by taking overall national CLs, as provided by the national model then summing to the level of the 4 NEAC stock complexes. For the NEAC area, the CLs have been calculated by ICES as:

- Northern NEAC 1SW spawners-210 958
- Northern NEAC MSW spawners-183 198
- Southern NEAC 1SW spawners-608 246
- Southern NEAC MSW spawners-261 635

3.3.2 Progress with setting river-specific conservation limits

Specific progress in individual countries is summarized below:

Most NEAC countries have not developed river-specific CLs. In 2008, progress with setting, and developing, river-specific CLs and associated compliance assessment was reported for UK (Northern Ireland), UK (Scotland), Iceland and Norway.

In UK (Northern Ireland), conservation limits have previously been determined in the Fisheries Commission Board (FCB) area for a number of important (index) salmon rivers. CLs were established through the transport of optimal productivity metrics determined from the River Bush stock recruitment study to measured habitat parameters from each index river. Adult returns are monitored on the index catchments primarily by resistivity fish counters, although rod catch has been used to estimate spawning escapement on the Shimna River. Technical problems were encountered in 2008 on some fish counters and alternative stock assessment methods will be applied retrospectively to maintain the integrity of these time-series. Thus, the efficacy of rod catch and redd count data as auxiliary stock assessment tools on the other index rivers is currently being investigated to provide insurance against potential future counter failures.

In the Foyle area of UK (N. Ireland) and Ireland, a spawning target based management system has been operating in the Foyle fishery area for many years (Elson and Tuomi, 1975), and was revised in 1998. It is now based on juvenile salmonid habitat assessments. The Loughs Agency has established conservation limits and compliance monitoring for a number of rivers within the catchment. Fish counts were compromised on the Rivers Finn, Mourne and Faughan in 2008, preventing assessment of compliance against CL. A comprehensive independent review of the counter programme has thus been initiated by the Agency and is due to report early in 2009.

In UK (Scotland), work has continued to develop procedures for setting catchment specific CLs. GIS applications, in conjunction with field based observation and a literature review of salmon distribution, have been used to develop a map based useable wetted area model for salmon which can be used to transport CLs among catchments. A CL has been previously derived for the North Esk and this has been transported, using the useable wetted area model, to each of the 109 defined salmon fishery districts in Scotland to provide provisional CLs. Refinements to the useable wetted area transport model have been undertaken in 2008: preliminary estimates of spawning escapement in 63 of these districts have been derived and compliance with CL assessed.

In Iceland, work is progressing on several rivers to derive river-specific CLs. Several datasets and techniques (catch data, counter data, habitat mapping, wetted area and juvenile surveys) are being used to estimate salmon production, run size and spawning escapement. To date work has indicated that rivers present a wide range in salmon production, from 2.1 to 57.7 adult fish per ha wetted area, which suggests that there will also be large differences in the spawning requirements. There are relatively few rivers for which wetted area has been established, but an effort will be made to increase this number in the coming years. Juvenile surveys will be used to calculate the relationship between spawning and recruitment and rod catch statistics to transfer CL between rivers of a given type. In the salmon act of 2006, the responsibility of fishing rights requires owners to harvest their fish stocks based on sustainable principles. The fishery associations are required to make harvest plans, which subsequently need to be approved by the Competent Management Authority (Fiskistofa). This system will facilitate the setting of river-specific CLs but may take 5–10 years before being fully adopted.

In Norway, CLs have been set for 180 rivers since 2007. The CLs are based on stock recruitment relationships in nine rivers, and work is in progress to estimate conservation limits for a further 200 rivers, based on similarities in productivity and stock age structure. In 2008, stock recruitment relationships have been established for the River Imsa. The spawning target in the River Imsa is between 6 and 10 eggs per m^2, which represents between 20 and 30 females. The long-term average smolt production in the river is 15 per 100 m^2 per year. In addition, provisional stock/recruitment data from the small River Halselva, (Northern Norway), have been made available. At the mouth of the river, a trap was established in 1987 to catch all downstream migrating smolts and upstream migrating adults. The smolt age of salmon in the river is usually 4–5 years (range 3–6 years). The relationship between number of eggs laid and number of smolts descending is not linear, indicating that egg deposition, in all years except one, has been below the conservation limit. Because the relationship is heavily dependent on one single point, the conservation limit is still not considered valid.

Productivity is mostly based on catch statistics, and scale samples are used to assess the river age and sea age structure in a sub set of the populations. To derive the CLs, wetted areas have been computed from digital maps and analysis of river length accessible to adult fish. CLs for salmon populations are grouped into four categories of egg densities, approximately 1, 2, 4 and 6 eggs/m^2 wetted area. Most of the rivers fall into the 2 and 4 eggs/m^2 wetted area categories.

So far only France, Ireland, and UK (England and Wales) have implemented river-specific CLs.

3.4 Management advice

ICES has been asked to provide catch options or alternative management advice, if possible based on a forecast of PFA, with an assessment of risks relative to the objective of exceeding stock CLs in the NEAC area. However, there are no explicit management objectives for provision of advice for the Faroes fishery.

ICES emphasized that the national stock CLs discussed above are not appropriate to the management of homewater fisheries, particularly where these exploit separate river stocks. 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. Nevertheless, ICES agreed that the combined CLs for the main stock groups (national stocks) exploited by the distant water fisheries could be used to provide general management advice to the distant water fisheries.

Given the current (from the NEAC run reconstruction model) and forecasted (from the Bayesian forecast models) PFA, ICES provides the following advice on management:

- **Northern European 1SW stocks:** ICES considers that in the absence of specific management objectives for this stock complex the precautionary approach is to fish only on maturing 1SW salmon from rivers where stocks have been demonstrated to be at full reproductive capacity. Furthermore, as a consequence of the different status of individual stocks within the stock complex, mixed-stock fisheries present particular threats to stock status. The newly developed Bayesian forecast model demonstrates that the lower bounds of the forecasted PFA for 2009 to 2012 are below SER indicating that the stock may be at risk of suffering reduced reproductive capacity prior to the commencement of distant water fisheries.

- **Northern European MSW stocks:** ICES considers that in the absence of specific management objectives for this stock complex the precautionary approach is, to fish only on non-maturing 1SW salmon from rivers where stocks have been demonstrated to be at full reproductive capacity. Furthermore, as a result of the different status of individual stocks within the stock complex, mixed-stock fisheries present particular threats to stock status. The newly developed Bayesian forecast model demonstrates that the lower bounds of the forecasted PFA for 2009 to 2012 are below SER indicating that the stock may be at risk of suffering reduced reproductive capacity prior to the commencement of distant water fisheries.
- **Southern European 1SW stocks:** ICES considers that in the absence of specific management objectives for this stock complex the precautionary approach is to fish only on maturing 1SW salmon from rivers where stocks have been demonstrated to be at full reproductive capacity. Furthermore, as a consequence of the different status of individual stocks within the stock complex, mixed-stock fisheries present particular threats to stock status. The newly developed Bayesian forecast model demonstrates that the lower bounds of the forecasted PFA for 2009 to 2012 are below SER indicating that the stock may be at risk of suffering reduced reproductive capacity prior to the commencement of distant water fisheries.
- **Southern European MSW stocks:** ICES considers that in the absence of specific management objectives for this stock complex, with the exception of the West Greenland fishery, the precautionary approach is to fish only on non-maturing 1SW salmon from rivers where stocks have been demonstrated to be at full reproductive capacity. Furthermore, as a result of the different status of individual stocks within the stock complex, mixed-stock fisheries present particular threats to stock status. There are no catch options at West Greenland that would allow the management objectives to be met for this stock complex. The newly developed Bayesian forecast model demonstrates that the lower bounds of the forecasted PFA for 2009 to 2012 are below SER indicating that the stock may be at risk of suffering reduced reproductive capacity prior to the commencement of distant water fisheries.

3.5 Relevant factors to be considered in management

The management for all fisheries should be based upon assessments of the status of individual stocks. Fisheries on mixed-stocks, particularly in coastal waters or on the high seas, pose particular difficulties for management, as they cannot target only stocks that are at full reproductive capacity if there are stocks below CL within the mixed-stock being fished. Conservation would be best achieved if fisheries target stocks that have been demonstrated to be at full reproductive capacity. Fisheries in estuaries and especially rivers are more likely to meet this requirement. It should also be noted that the inclusion of farmed fish in the Norwegian data would result in the stock status being overestimated.

NEAC PFAs from the national models are combined to provide NASCO with catch advice or alternative management advice for the distant water fisheries at West Greenland and Faroes. These groups were deemed appropriate by ICES as they fulfilled an agreed set of criteria established to define stock groups for the provision of management advice, criteria that were considered in detail at the 2002 meeting (ICES, 2002) and re-evaluated at the 2005 meeting (ICES, 2005).

Consideration of the level of exploitation of national stocks in the Faroes and the West Greenland fisheries resulted in the proposal that advice for the Faroes fishery (both 1SW and MSW) should be based on all NEAC area stocks, but that advice for the West Greenland fishery should be based on Southern European MSW salmon stocks only (comprising UK, Ireland, France, and Iceland (south/west regions)).

3.6 Pre-fishery abundance forecasts

3.6.1 Pre-Fishery Abundance forecasts for the Southern NEAC stock complex using the existing regression model

ICES has previously used a regression model to forecast the PFA of non-maturing (potential MSW) salmon from the Southern European stock group (ICES, 2002, 2003). The model has been used to provide such forecasts (ICES, 2006) which are used as one of the inputs to the risk analysis of the catch options for the Greenland fishery (ICES, 2008). The full model takes the form:

$$PFA = Spawners^{\lambda} \times e^{\beta_0 + \beta_1 Habitat + \beta_2 \log(PFAm) + \beta_3 Year + noise}$$

where *Spawners* are expressed as lagged egg numbers, *PFAm* refers to pre-fishery abundance of maturing 1SW salmon (derived from NEAC PFA model) and the habitat term is the same as that previously used in the North American model (ICES, 2003). The *Habitat* parameter has not been included in the model since 2003 as a result of lack of available data and difficulties in incorporating it into the forecast.

The midpoint forecasts and 95% confidence limits of the projections are shown below:

YEAR	PFA	LOWER	UPPER	SER
2008	453 682	306 257	672 074	501 188
2009	431 220	290 303	640 539	501 188
2010	419 733	281 870	625 024	501 188
2011	392 235	262 520	586 044	501 188
2012	380 952	254 458	570 328	501 188

All PFA midpoint estimates are less than the SER and therefore there is no surplus available for exploitation.

3.6.2 New forecast models

Prior to 2009, forecast models have not been used for the maturing 1SW stock complex from southern NEAC or for sea age group in the northern NEAC stock complex. ICES reviewed an alternate Bayesian forecast model for the southern NEAC 1SW non-maturing complex and new Bayesian models for the other three complexes. The proposed models have the same structure and are run independently. Detailed descriptions are provided in Section 2.3.

For both southern and northern NEAC complexes, forecasts for maturing stocks were derived for 4 years of lagged eggs starting from 2009 to 2012 and for non-maturing stocks for 5 years, from 2008 to 2012. Risks were defined each year as the posterior probability that the PFA would be below the age and stock complex specific SER levels. For illustrative purposes, risk analyses were derived based on the probability that the PFA abundance would be greater than or equal to the SER under the scenario of no exploitation.

3.6.3 Results of the NEAC Bayesian forecast models

For the southern NEAC stock complex, the productivity parameters for the maturing and non-maturing components peaked in 1985 and 1986, and reached the lowest values in 1997 (Figure 3.6.3.1). There was a sharp drop in the productivity parameter during 1989 to 1991, the median values post-1991 are all lower than during the previous period (Figure 3.6.3.1). Over the entire time-series, the maturing proportions averaged about 0.6 with the smallest proportion in 1980 and the largest proportion in 1998. There is an increasing trend in the proportion maturing (8 of 13 values below the average during 1978 to 1990 compared with 3 of 16 values between 1991 and 2006; Figure 3.6.3.2).

The proportion maturing in Northern NEAC has varied around 0.5 over the time-series but in 2007 there was an abrupt drop in the proportion maturing (Figure 3.6.3.2). The productivity parameter is higher for maturing 1SW salmon than for the non-maturing component, as was the case for the southern NEAC stock complex (Figure 3.6.3.1). The productivity parameters are higher for the northern NEAC compared with the southern NEAC complex, particularly for the non-maturing 1SW component.

The trends in the posterior estimates of PFA for both the southern NEAC and northern NEAC complexes closely match the descriptions of PFA trends previously developed by ICES (Section 3.8.13). The total PFA (maturing and non-maturing 1SW salmon at January 1 of the first winter at sea) for the southern NEAC complex ranged from 3 to 4 million fish between 1978 and 1989, declined rapidly to just over 2 million fish in 1990, and fell to its lowest level of just over one million fish in 2006 (Figure 3.6.3.3). For the northern NEAC complex, peak PFA abundance was estimated at about 2 million fish in year 2000 with the lowest value of the series in 2004 at over 1 million fish (Figure 3.6.3.4).

Forecasts from these models into 2008 to 2012 for the non-maturing age group and for 2009 to 2012 for the maturing age group were developed within the Bayesian model framework. Variations in the median abundance over the forecasts are related to variations in lagged eggs (Figures 3.6.3.3 and 3.6.3.4) as the productivity parameters are set at the level of the last year with available data (Figures 3.6.3.1). The variability of the productivity parameters increase sequentially over the forecasts.

For the southern NEAC stock complex, the 25th percentiles of the posterior distributions of the forecasts are below the SER for both the maturing and non-maturing age components (Figure 3.6.3.3). The abundances of the northern NEAC age components have declined over the 1983 to 2008 period. The lower bound of the 95% Bayesian credible interval has fallen below the age-specific SERs for 2009 to 2012 but the expectation is for the 2008 abundance of non-maturing salmon to remain above the SER (Figure 3.6.3.4).

3.6.4 Comparison with the regression forecast model

The regression forecast model used by ICES provides PFA forecasts for only one (Southern NEAC non-maturing 1SW stock) of the four stock complexes currently used to assess the status of stocks in the NEAC commission area. These forecasts were compared with those available from the Bayesian model (Figure 3.6.3.5).

As previously noted, the structure of the ICES regression model generally leads to a forecast of declining PFA with time. This trend is not apparent in forecasts from the Bayesian model where the most credible estimates remain stable for the period from 2008 to 2012 and are consistently higher than those given by the regression model. This difference in the forecasts results from differences in the model structures: in the regression model, the negative value of the year coefficient leads to reduced PFA in the forecast, whereas in the Bayesian model the median productivity parameter estimate remains constant and the forecast tracks changes in lagged spawner abundance. The uncertainty in the forecasts from the Bayesian models is greater than for the log-linear model used by ICES; part of the reason is that the input data used by ICES are the midpoints of the lagged eggs and run-reconstructed PFA compared with the Bayesian model that incorporates uncertainty in the lagged eggs variable.

The probability that the PFA of the southern NEAC 1SW non-maturing component will be above the SER in 2009 to 2012 ranges from 0.36 to 0.59 for the regression model. In contrast, the Bayesian model provides a probability range of 0.61 to 0.68.

Probability that the PFA will be greater than or equal to the complex and age specific SERs

		Maturing	Non-Maturing	
Southern complex	SER	834 586	501 086	
	Model	Bayesian	Bayesian	Regression model
	2008		0.71	0.70
	2009	0.68	0.68	0.59
	2010	0.59	0.61	0.55
	2011	0.64	0.66	0.41
	2012	0.60	0.62	0.36
		Maturing	Non-Maturing	
Northern complex	SER	291 212	216 904	
	Model	Bayesian	Bayesian	
	2008		0.99	
	2009	0.88	0.95	
	2010	0.74	0.87	
	2011	0.74	0.86	
	2012	0.72	0.85	

3.6.5 Use of the NEAC Bayesian forecast models in catch advice

In the absence of specific management objectives for the Faroes fishery, ICES requires that the lower bound of the 95% confidence interval of the PFA estimate be above the SER for the stock to be considered at full reproductive capacity. ICES noted that, although the levels of uncertainty are greater in the Bayesian model, both models predict similar values for this lower bound in each of the 5 forecast years. In addition, for the southern NEAC complex, the 25th percentile of the PFA abundances are below the respective SER values. For the West Greenland Commission area, the probability of achieving management objectives has been set to 0.75 (see Section 5.2).

NASCO has not yet defined management objectives for the NEAC stock complexes. A risk framework for the Faroes fishery could be developed in a similar way to that for West Greenland. The risk framework would present the probabilities that the number of fish escaping the high seas fisheries would be sufficient to meet the management objective for each stock complex. In the case of the Southern NEAC non-maturing 1SW complex, this probability will also be conditional on the harvest at West Greenland. Thus, for any harvest scenario at Faroes there would be a probability of meeting the management objective in each of the stock complexes. In order for this approach to be implemented, the following will be required:

- management objectives for the Northern NEAC maturing stock complex;
- management objectives for the Northern NEAC non-maturing stock complex;
- management objectives for the Southern NEAC maturing stock complex;
- management objectives for the Southern NEAC non-maturing stock complex;
- pre-agreed levels of risk for each management objective;
- pre-agreed sharing arrangements among all parties to NASCO.

3.7 Comparison with previous assessment

3.7.1 National PFA model and national conservation limit model

Provisional catch data for 2007 were updated where appropriate. The equation for estimating the proportion of maturing salmon in the 1SW catches at Faroes was corrected. The impact of the correction on 1SW maturing catches at Faroes was small because the catch of 1SW maturing fish was also small. In addition, catches at Greenland were treated as point estimates for the 2008 assessment to allow updated data from the NAC assessment to be incorporated into the NEAC assessment.

3.7.2 PFA regression forecast model

The midpoints of updated forecasts of the Southern NEAC MSW PFA for the years 2008 to 2011 were all within 3% of the forecasts provided last year (ICES, 2008).

3.8 NASCO has requested ICES to describe the key events of the 2008 fisheries and the status of the stocks

3.8.1 Fishing at Faroes in 2007/2008

No fishery for salmon has been prosecuted since 2000. A compensation payment had been made to "Felagið Laksaskip" during the years 1991–1999 and 2001–2008 (i.e. not in 2000).

3.8.2 Significant events in NEAC homewater fisheries in 2008

In several countries, measures aimed at reducing exploitation were implemented or extended in 2008. These include a reduction of net fisheries in UK (England and Wales), a reduction in the extent of mixed-stock fisheries in Norway and the continued closure of the driftnet fishery in Ireland.

3.8.3 Gear and effort

No significant changes in the types of gear used for salmon fishing were reported in the NEAC area in 2008. The number of licensed gear units has, in most cases, continued to fall, and for Ireland, where the driftnet fishery was closed, effort was completely removed for this fishery. There are no such consistent trends for the rod fishing effort in NEAC countries over this period.

3.8.4 Catches

The NEAC area has seen a general reduction in catches since the 1980s (Section 2.1.1). 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 reported catch in the NEAC area in 2008 was 1519 tonnes, 8% higher than the 2007 value (1410 t) but 21% lower than the previous 5-year mean. The catch in the Southern area has declined over the period from about 4500 t in 1972–1975 to below 1500 t since 1986, and is now below 400 t. The catch declined particularly sharply in 1976, 1989–1991 and again in 2007. The catch in the Northern area also demonstrates an overall decline over the time-series, but this decline is less pronounced than for the Southern area. The catch in the Northern area varied between 2000 t and 2800 t from 1971 to 1988, fell to a low of 962 t in 1997, then increased to over 1600 t in 2001 although it has exhibited a downward trend since this time. The catch in the Southern area, which in the early 1970s comprised around two-thirds of the NEAC total, has thus, since 1999, been lower than the catch in the Northern area.

3.8.5 Catch per unit effort (cpue)

Cpue can be influenced by various factors, and it is assumed that the cpue of net fisheries is a more stable indicator of the general status of salmon stocks than rod cpue because the latter may be more affected by varying local factors.

An overview of the cpue data for the NEAC area was undertaken. In the Southern NEAC area, cpue demonstrate a general decrease in UK (Scotland) and UK (England and Wales) net fisheries. Cpue for the net fishery revealed mostly lower values compared with 2007 and the previous 5-year averages. In the Northern NEAC area, there has been an increasing trend in the cpue values for Norwegian net fisheries and Russian rod fisheries in Barents Sea rivers. A decreasing trend was noted for rod fisheries in Finland (River Teno).

3.8.6 Age composition of catches

1SW salmon comprised 54% of the total catch in the Northern area in 2007 which was below the 5- and 10-year means (61% and 64%, respectively). In general, there has been greater variability of the proportion of 1SW fish between countries in recent years (since 1994) than prior to this time. For the Southern European countries, the overall percentage of 1SW fish in the catch (53%) is below the 5- and 10-year mean (59% and 60%, respectively).

3.8.7 Farmed and ranched salmon in catches

The contribution of farmed and ranched salmon to national catches in the NEAC area in 2008 was again generally low (<2% in most countries) and is similar to the values that have been reported in previous years (e.g. ICES, 2008). Thus, the occurrence of such fish is usually ignored in assessments of the status of national stocks. However, in Norway farmed salmon continue to form a large proportion of the catch in coastal (23% in 2008), fjordic (30% in 2008) and rod fisheries (9% in 2008). The level of escaped farmed salmon in Norwegian catches has been lower in recent years than during the period 1989–2002. An assessment of the likely effect of these fish on the output data from the PFA model has been reported previously (ICES, 2001).

3.8.8 National origin of catches

There is direct evidence of Russian origin salmon being caught in coastal mixed-stock fisheries in northernmost Norway. This is on the basis of tagging experiments conducted prior to 1974. The data strongly indicates that during the period of tagging the bycatch of Russian origin salmon was relatively high in northernmost Norway.

The bycatch of Swedish salmon was high on the west and southwest coast of Norway in the 1970s. However given the subsequent ban on the driftnet fishery along the Norwegian coast, a significant reduction of the coastal bagnets in the west and southwest area and the general ban on bendlnets in Norway (with the exception of the fishery in Finnmark County) present bycatch of Swedish salmon in Norway is probably small.

ICES summarized the results from 14 508 adult recaptures of smolts tagged and released in different rivers in Norway during 1990–1996 (ICES 1998). The great majority were recaptured in Norway (98.77%), 0.59% in Sweden, 0.30% in Denmark and 0.21% in Ireland. Examination of the NINA tag database of about 60 000 adult recoveries from smolt tagging in Norway indicated that most of the foreign recaptures were made in Sweden and Denmark, although these accounted for a very small overall proportion. Very few recaptures were reported from other countries.

In summary, the provisional analysis of the available information suggests that exploitation of foreign origin salmon in Norway is low with the exception of salmon originating in Russia. Exploitation of Norwegian origin salmon in neighboring countries appears to be limited. There may be local issues which are difficult to detect and assess, for example the interception of fish in border rivers which are captured in one jurisdiction and originate in another.

3.8.9 Trends in the PFA for NEAC stocks

In the evaluation of the status of stocks in Figure 3.1.1, estimated recruitment (PFA) values should be assessed against the SER values, whereas the estimated spawning escapement values should be compared with the CL.

Northern European 1SW and MSW stocks: Recruitment patterns of maturing 1SW salmon and of non-maturing 1SW recruits for Northern Europe (Figure 3.1.1) demonstrate broadly similar patterns. The general decline over the period is interrupted by a short period of increased recruitment from 1998 to 2003. Both stock complexes have been at full reproductive capacity prior to the commencement of distant water fisheries throughout the time-series. Trends in spawner number for the Northern stock complexes for both 1SW and MSW are similar. Throughout most of the time-series, both 1SW and MSW spawners have been either at full reproductive capacity or at risk of reduced reproductive capacity. However, in both 2007 and 2008, the 1SW spawner estimate indicated that the stock complex was suffering reduced reproductive capacity. These patterns are broadly consistent with the general pattern of decline in marine survival of 1SW and 2SW returns in most monitored stocks in the area (Section 3.8.10).

Southern European 1SW and MSW stocks: Recruitment patterns of maturing 1SW salmon and of non-maturing 1SW recruits for Southern Europe (Figure 3.1.1) demonstrate broadly similar declining trends over the period. The maturing 1SW stock complex has been at full reproductive capacity over most of the period with the exception of 2006 and 2008 when it was at risk of suffering reduced reproductive capacity prior to the commencement of distant water fisheries. The non-maturing 1SW stock has been at full reproductive capacity over most of the period but has been at risk of suffering reduced reproductive capacity before homewater fisheries took place in nine of the twelve years between 1996 and 2007 and was suffering reduced reproductive capacity for the first time in 2006.

Declining trends in spawner number are evident in the Southern stock complexes for both 1SW and MSW. However the 1SW stock has been at risk of reduced reproductive capacity or suffering reduced reproductive capacity for most of the time-series. In contrast, the MSW stock has been at full reproductive capacity for most of the time-series until 1997 when the stock was either at risk of reduced reproductive capacity or suffering reduced reproductive capacity. This is broadly consistent with the general pattern of decline in marine survival of 1SW and 2SW returns in most monitored stocks in the area (Section 3.8.10).

3.8.10 Survival indices for NEAC stocks

An overview of the trends of marine survival for wild and hatchery-reared smolts returning to homewaters (i.e. before homewater exploitation) for the 2007 and 2006 smolt year classes (returning 1SW and 2SW salmon, respectively) is presented in Figure 3.8.14.1. The survival indices presented are the annual rates of change in marine survival. The original survival indices for different rivers and experimental facilities are presented in Tables 3.8.10.1 and 3.8.10.2.

The overall trend in for Northern and Southern NEAC areas, in both wild and hatchery smolts, is indicative of a decline in marine survival. The decline across the time-series varies between 1% and 20% (Figure 3.8.14.1). Most of the survival indices for wild and reared smolts were below the previous 5- and 10-year averages. Some increases in survival were detected in Iceland for 1SW fish on the Vesturdalsa River and for hatchery reared grilse on the Ranga River (Tables 3.8.10.1 and 3.8.10.2).

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.

3.9 NASCO has requested ICES to provide any new information on the extent to which the objectives of any significant management measures introduced in recent years have been achieved

Most management measures introduced in recent years in relation to international, national and local objectives have aimed to reduce levels of exploitation on NEAC stocks, to increase freshwater escapement and in some countries specifically to meet river-specific CLs. Many of the inputs relate specifically to national plans or strategies or to commitments under National or EU directives. Although some local measures have had notable success (Table 3.9.1) ICES notes that three of the four NEAC stock complexes are currently suffering reduced reproductive capacity after homewater fisheries have taken place (Section 3.4).

3.10 NASCO has requested ICES to further investigate opportunities to develop a framework of indicators that could be used to identify any significant change in previously provided multi-annual management advice

In 2006, ICES developed a generalized Framework of Indicators (FWI) which would indicate if any significant change in the status of stocks used to inform the previously provided multi-annual management advice had occurred (ICES, 2007a). This was adopted for the Greenland fishery based on the seven contributing regions/stock complex with direct links to the three management objectives established by NASCO for that fishery. However, ICES was unable to develop a FWI for the Faroese fishery for a number of different reasons. Among these were the lack of quantitative catch advice, the absence of specific management objectives and a sharing agreement for this fishery and the fact that none of the available indicator datasets met the criteria for inclusion in the FWI. In the absence of a FWI for the Faroese fishery, ICES recommended that annual assessments be conducted to verify the multiyear catch advice.

ICES updated the NEAC datasets previously examined in the FWI. However, these still did not satisfy the criteria for inclusion in the FWI as being informative of a significant change, because over the time-series the PFA estimates have predominately remained above the SER. ICES considered that these datasets would need to be re-evaluated for use in future, should PFA estimates decline to levels consistently below the limit reference points for each stock complex. In the absence of a FWI, the only indication of a change would be provided by a full assessment of the NEAC stock complexes. ICES considers that this is the preferred option, given that the PFA of these complexes remain close to SERs.

Table 3.9.1. Summary of national objectives, recent management measures and attainment of management objectives.

Country	Objective	Introduced	Assessment period	Measure Taken	Assessment	Outcome/extent achieved	Further consideration
Russia	Reduce commercial fishing effort and enhance recreational fisheries based mostly on catch-and-release principles	1994	Annually	Various management measures including closure of some important commercial in-river fisheries and reductions in quotas for coastal mixed-stock fisheries	Examination of catch statistics	Mean total commercial catch reduced by 50% and mean in-river commercial catch reduced by 83%, while recreational catches increased by 56% (2004-2008 compared to 1999-2003). The percentage of the total recreational catch that was released has ranged from 74% to 90% in the last ten years.	Further restrictions will be considered for fisheries which take mixed stocks and stocks below their Conservation Limits.
Norway	Reduce mixed stock fisheries, and reduce exploitation on MSW salmon.	2008	2008	Along the coast in all counties except Finnmark: Fishing season for bag-nets reduced at the beginning of the season or fisheries closed. In fjords in all counties except Finnmark: Fishing season reduced by at least 14 days at the beginning of the season. Finnmark: Smaller reductions in fishing season and number of fishing-days per week for both bend-nets and bag-nets.	Examination of catch statistics	Mean proportion of the total catch taken in the sea reduced from a mean of 49 % in the period 2003-2007 to 42 % in 2008 based on the number salmon caught, and from 56 % to 47 % based on the weight of the catch.	A new licence scheme for netsmen is under developement, which may reduce the future netting effort.
	Reduce exploitation in rivers to increase the number of spawners.	2008		Fisheries regulations for individual rivers set in accordance with their assumed stock status. Introduction of daily bag-limits in many rivers, and closure of fisheries in rivers with low population levels.			Compliance of CL's in individual rivers will be assessed.
Iceland	Formally record restrictions on the numbers of rods and nets allowed in individual rivers in an effort regulation plan aimed at providing a fundamental basis for a sustainable salmon fishery.	2008-2009 (based on Fishing Act of 2006)	Every 8 years	Fishery associations or the owners of fishing rights on rivers or lakes are responsible for introducing effort plans. These specify the maximum number of rods and nets allowed on individual rivers or lakes, as well as the annual and daily fishing periods allowed, restrictions on bait, bag limits, catch and release, minimum or maximum landing sizes of fish, etc. Effort plans need to be approved by the Competent Management Authority (CMA) after review by the Institute of Freshwater Fisheries (IFF)	Examination of available information from catch statistics, stock size estimates, exploitation rates, parr densities, historic catch or effort information, etc.	Introduction of effort plans is intended to further underline the responsibilities of owners of fishing rights for sustainable management. The effort plan needs to be taken in to account when fishing rights are leased to anglers or syndicates.	The Competent Management Authority (CMA) can introduce further restrictions at any time as necessary.
Ireland	To conserve the inland fisheries resource in its own right and its viability and economic and social contribution at national, local and community level.	2006	post 2006	Closure of mixed stock fishery in marine and coastal waters. Fisheries only allowed on single stocks which are shown to have a harvestable surplus over the Conservation Limit. These are operated in rivers and estuaries only	Harvest rule based on a catch option which provides at least a 75% chance that the CL will be met.	Commercial catch reduced from over 70% of total catch. Rod catch now 68% of total catch. Catch and release 54% of total rod catch and 35% of the total catch. Increase in river returns and spawners in virtually all rivers assessed with counters or traps in 2007 and 2008.	57 of 80 stocks where a direct assessment can be made are meeting CL. There are also about 60 small rivers (annual rod catch < 10) with uncertain status. Information is being acquired for these
	Maintain salmon stocks in SAC rivers at favourable conservation status	2002	2002 to present	Closure of mixed stock fishery as above.	Examination of counter (14 rivers) or rod catch (16 rivers) data to assess CL compliance for 30 SAC rivers	Following re-appraisal in 2008 and with the closure of the Irish coastal and marine mixed stock fishery, 23 of the 30 SAC rivers are estimated to be meeting CLs	Under the EU Water Framework Directive water quality and fish passage are expected to improve
	To reduce the exploitation of stocks from other countries in Irish fisheries	1979	Annually	Closure of mixed stock fishery as above.	Coded wire tagging returns to Irish and non-Irish rivers pre and post imposition of TACs.	Only 1 tag originating from a country other than Ireland was recaptured in the Irish fishery in 2007. No foreign tags were recaptured from the 2008 fishery.	Catch scanning for Coded Wire Tags in the commercial fisheries should be maintained
Ireland/UK N.Ireland	Development of fisheries and aquaculture, conservation and protection of inland fisheries and sustainable development of marine tourism.	2006	Post 2006	Lough Foyle area which is under the jurisdiction of a joint cross boarder Ireland/UK agency. Commercial fishing resricted to insde the Lough to target single stocks only. Number of drift net and draft net licences reduced.	Fisheries in the Foyle area managed in-season based on counter. Carcass tagging and logbook scheme in place.	Inceased escapement to River Foyle epected	Further development and improvements to in fisheries assessments being undertaken

Table 3.9.1 Cont'd. Summary of national objectives, recent management measures and attainment of management objectives.

Country	Objective	Introduced	Assessment period	Measure Taken	Assessment	Outcome/extent achieved	Further consideration
UK (England & Wales)	Meet objectives of National Salmon Management Strategy (launched in 1996) and ensure stocks meet or exceed CLs in at least 4 years out of 5.	1996	Annually	Programme of Salmon Action Plans (SAPs) for each of the 64 principal salmon rivers to provide prioritised list of actions for each river.	Examination of catch statistics, monitoring data and completion of annual compliance assessment	Programme of SAPs was finalised in 2004 and these are now subject to annual review to ensure they match current circumstances and provide a realistic programme to address issues facing each river.	Continue with targeted actions identified in SAPs and review annually. Process to be progressively linked to Water Framework Directive requirements.
	Safeguard MSW stock component	1999	2008	National spring salmon measures introduced in 1999 (restricted net fishing before June and required compulsory catch & release by anglers up to June 16)	Estimated 800 salmon saved from net fisheries and 1,600 saved from rod fisheries in 2007 due to these measures	Spawning escapement of spring salmon may have increased by up to one third on some rivers due to measures	Approval to renew these measures for a further 10 years was given in December 2008.
	Phase out mixed stock fisheries	1993	Annually	Mixed stock fishery measures imposed since 1993, including phase outs, closures, buy outs and reductions in fisheries.	Examination of catch statistics, monitoring data and completion of annual compliance asessment	Coastal fishery catch reduced from average of 41,000 (88-92) to under 32,000 (98-02) and to about 8,600 (03-08) Declared rod catch in 5 north east rivers 58% higher on average in the 6 years since net buy out in 2003, relative to average of 5 years before buy out. Recorded runs (salmon & sea trout) into the River Tyne 79% higher since NE net buy out in 2003 compared with mean of previous 5 years.	Continuing to phase out remaining mixed stock fisheries and focus on other limiting factors. Annual application of decision structure to assess need for effort controls.
	Reduce exploitation rates and increase freshwater returns leading to compliance with CLs.	1993	Annually	Promote catch and release (mainly voluntary), including 100% catch and release in some catchments.	Examination of catch statistics, release rates and annual compliance	Catch and release increased to over 50% of rod caught fish in recent years & 100% C&R on some catchments. Estimated to have contributed an extra 38 million eggs in 2008.	Continuing promotion of C&R at national and local levels.
	Maintain salmon stocks in SAC rivers at favourable conservation status	1996	annually	Fishing controls, catch and release and addressing issues identified in Salmon Action Plans as appropriate.	Examination of counter/rod data to assess CL compliance for 18 rivers designated as SACs	2 rivers are currently considered to be complying with the management objective of passing the CL 4 years out of 5.	Continue with targeted actions as identified in Salmon Action Plans in order to meet management objectives.
UK (Northern Ireland)	To conserve, enhance, restore and manage salmon stocks in catchments throughout UK (NI) through two salmon management plans (FCB and Loughs Agency areas).	2001	annually	Commercial and recreational fishing restrictions in both areas. Voluntary buyout of coastal netting licences in FCB area 2002.	Examination of recreational and commercial exploitation data collated through carcass tagging schemes in FCB and LA areas	Increased escapement of salmon following commercial and recreational fishing restrictions. Efficacy of FCB measure reported to ICES in 2008.	Continue monitoring and management protocols under the salmon management plans.
	To ensure that in most rivers in most years sufficient adult salmon are spawning to maximise output of smolts from freshwater.	2001	annually	Range of measures to enhance escapement including angling restrictions (daily & seasonal catch limits and seasonal restrictions) Ban on sale of rod caught salmon in LA area in 2008.	Examination of fish counter & rod catch datasets to assess escapement on index rivers with defined CLs.	Increased compliance against CL in many catchments in N. Ireland in 2008.	Further develop monitoring mechanisms and define/refine CLs.
	To monitor escapement and where CLs are not attained to identify and address limitations.	2005-07	2008-2010	Habitat enhancement measure funded by European Economic Area on several selected catchments in Loughs Agency and FCB areas.	Fully quantative electro-fishing	Ongoing	Monitor effect of habitat enhancement schemes.
Ireland/UK N.Ireland	Development of fisheries and aquaculture, conservation and protection of inland fisheries and	2006	Post 2006	Lough Foyle area which is under the jurisdiction of a joint cross boarder Ireland/UK agency. Commercial fishing resricted to insde the Lough to target single	Fisheries in the Foyle area managed in-season based on counter. Carcass tagging	Inceased escapement to River Foyle epected	Further development and improvements to in fisheries assessments being undertaken

Table 3.9.1 Cont'd. Summary of national objectives, recent management measures and attainment of management objectives.

Country	Objective	Introduced	Assessment period	Measure Taken	Assessment	Outcome/extent achieved	Further consideration
UK (Scotland)	Improve status of early running MSW salmon	2000	2007	Agreement by Salmon Net Fishing Association (most, but not all, net fishing operations are members) to delay fishing until the beginning of April. Introduced in 2000	Examination of catch statistics	Annual assessment. Reduction in MSW net fishery catch in February to March relative to period prior to 2000.	Further reduction in exploitation
		2005	Not yet evaluated	Bervie, N.and S. Esk salmon district net fishery delayed until 1st May with catch and release only in the rod fishery until 1st June	Examination of catch statistics	Exploitation removed for both nets and rods for respective periods.	Measure in place for 5 years. Re-evaluation after this period
France	Reduce exploitation on MSW salmon and increase escapement in the Loire basin	1994	2007	Catching salmon has been forbidden in the Loire-Allier catchment since 1994; fishing for other species continues	Salmon counter operating in Vichy (River Allier) since 1996	This did not seem to enhance salmon numbers to the expected level	Illegal exploitation, physical obstructions (e.g. Poutès-Monistrol Hydropower Dam) & other environmental factors, including higher temperatures and fish disease are also concerns and under investigation
	For Brittany and Lower Normandy stocks to comply with river-specific CLs. Reduce exploitation of MSW salmon and target fishing more on 1SW fish	1996, 2000	2000 to 2003	TACs introduced in 1996 in Brittany and Lower Normandy and MSW TACs introduced in 2000. These have lead to temporary closures on some rivers and in some years	Examination of catch statistics	Reduced catches have probably increased spawning numbers. Reduced catch of MSW fish in Brittany since 2000 and Lower Normandy since 2003, but MSW TACS are frequently exceeded on some rivers.	Monitored river (Scorff) has failed to meet CL consistently since 1994. However, the Scorff is not typical of the exploitation pattern in the area (small fishery)
	Reduce exploitation of MSW salmon in the Adour basin	1999	2007	Closure of net and rod fisheries for two days each week with days varying since 1999	Examination of catch statistics	Some reduction in rod catch but current regulations have been unable to reduce the exploitation rate on MSW stocks as expected	Specific limitations on MSW catches should be considered and a CL set for this basin
Germany	Reintroduction of Atlantic salmon. Salmon stocks extinct since the middle of 20th century but improvements in conditions and water quality were thought to be sufficient to support salmon	1988	Annually	Restocking of rivers running into North Sea (Rhine, Ems, Weser and Elbe). Two million juveniles (mainly fry) released annually	Trap and counter data (Sieg, upper Rhine)	300-700 adults recorded annually. Return rates of less than 1%. Records of natural production in some tributaries show an Increase.	Low return rates thought to reflect obstructions to upstream and downstream migration in the Rhine and its Delta as well as spawning tributaries and probably due to by-catch in non-target fisheries
	Establish free migration routes for salmon and other migratory fishes, protection of downstream migrants at power plants and rehabilitation of habitat in rivers basins	1988	Annually	Collaborative programme has started e.g. Rheinprogramm 2020 (ICPR) International Commission for the Protection of the River Rhine	Assessment in progress	Assessment in progress	Improvements expected with measures required under Water Framework Directive.

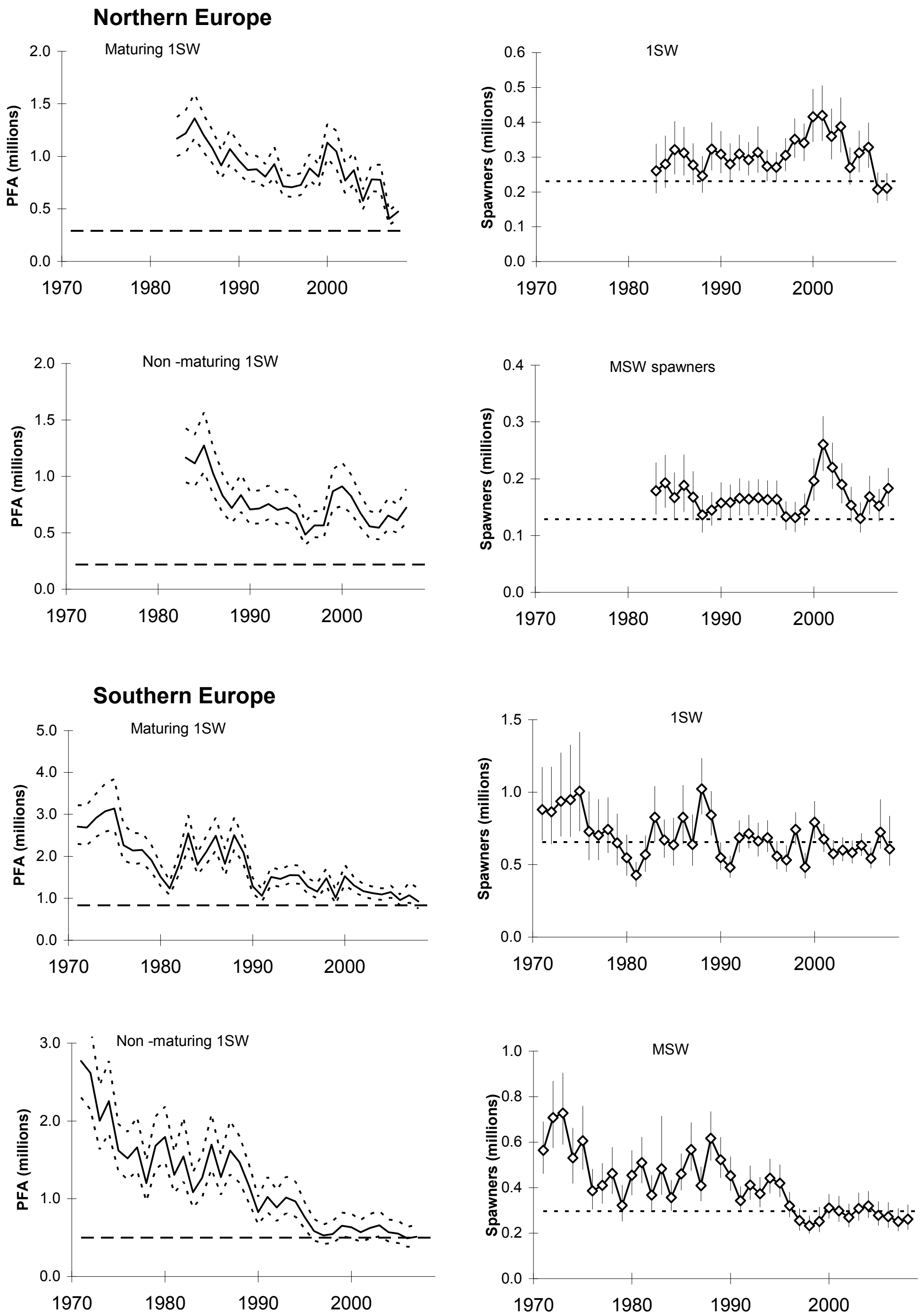


Figure 3.1.1. Estimated PFA (recruits) (left panels) and spawning escapement (right panels), with 95% confidence limits, for maturing 1SW and non-maturing 1SW salmon in Northern and Southern Europe.

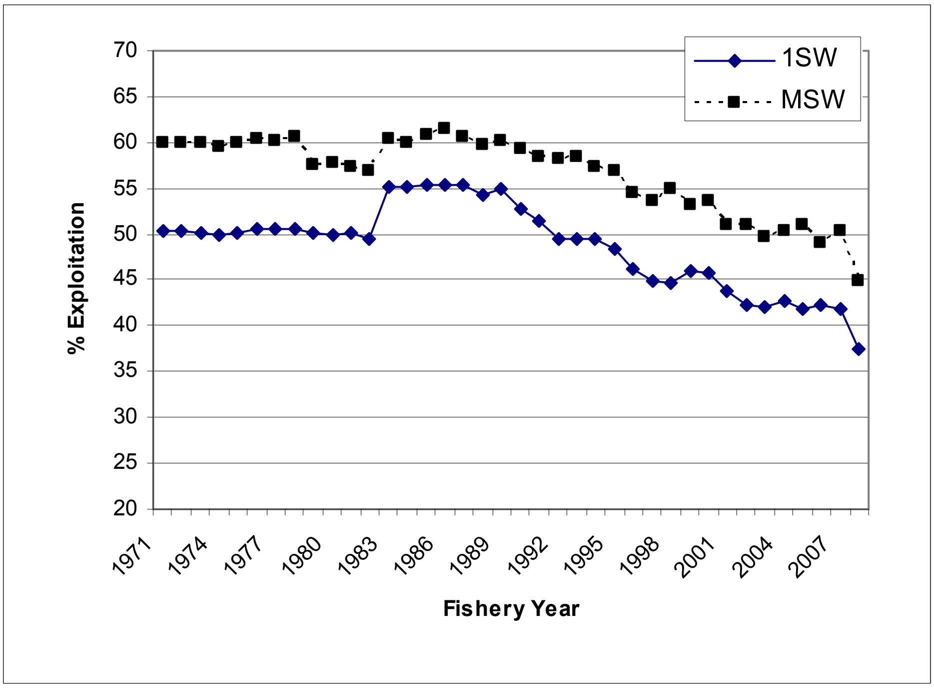


Figure 3.1.2. Exploitation rates of wild 1SW and MSW salmon by commercial and recreational fisheries in the Northern NEAC area from 1971–2008.

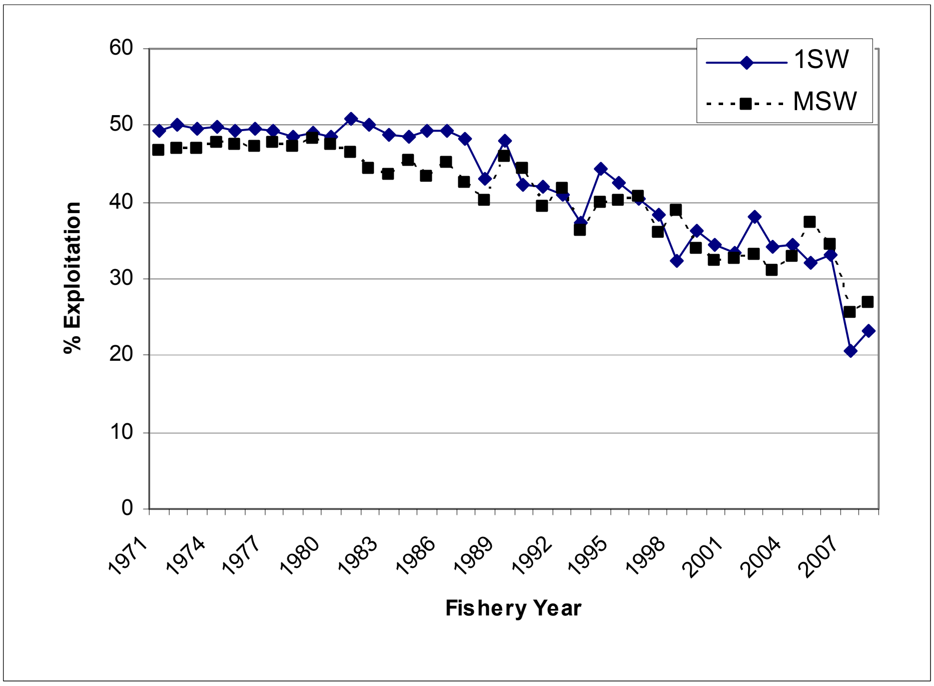


Figure 3.1.3. Exploitation rates of wild 1SW and MSW salmon by commercial and recreational fisheries in the Southern NEAC area from 1971–2008.

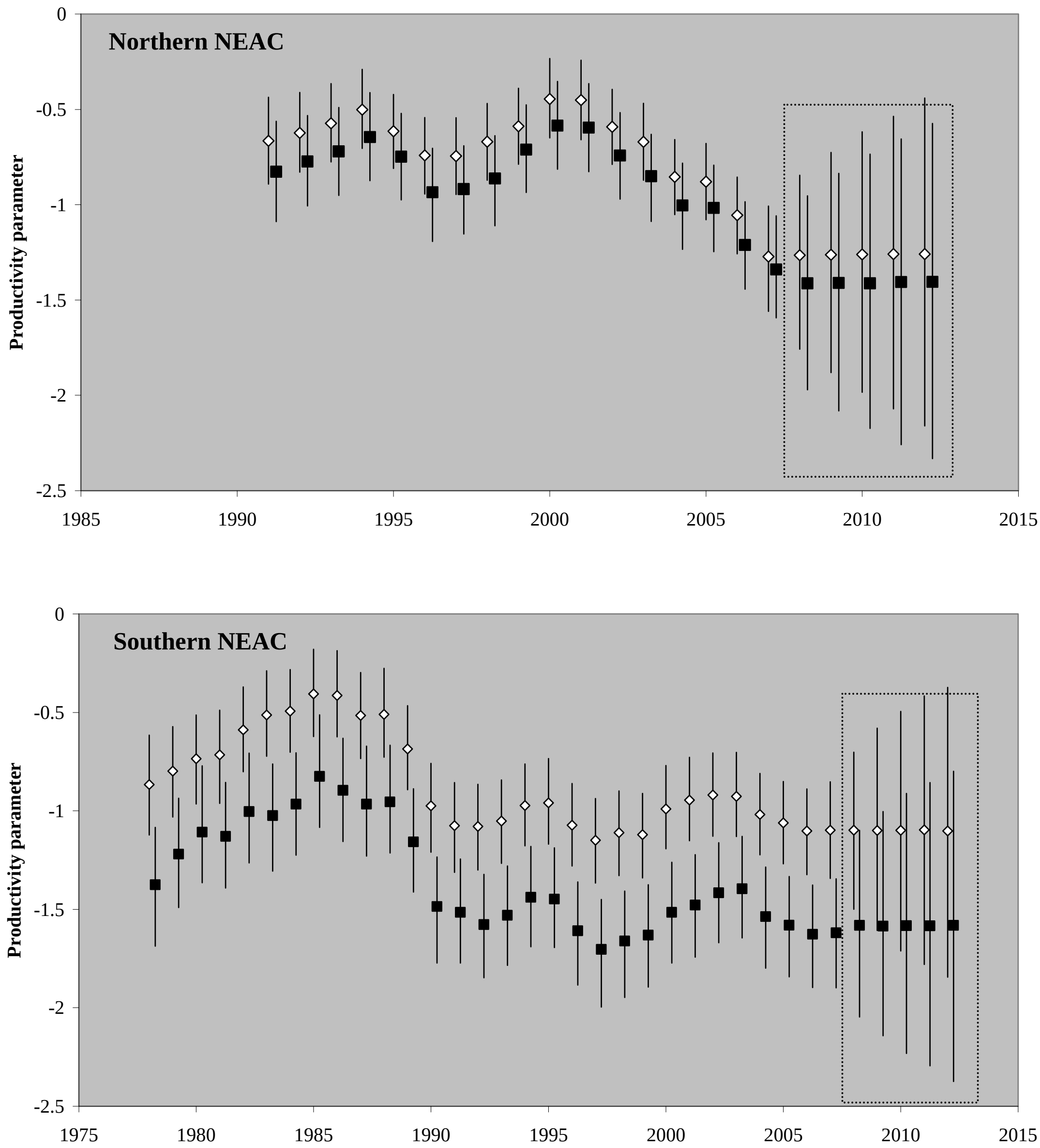
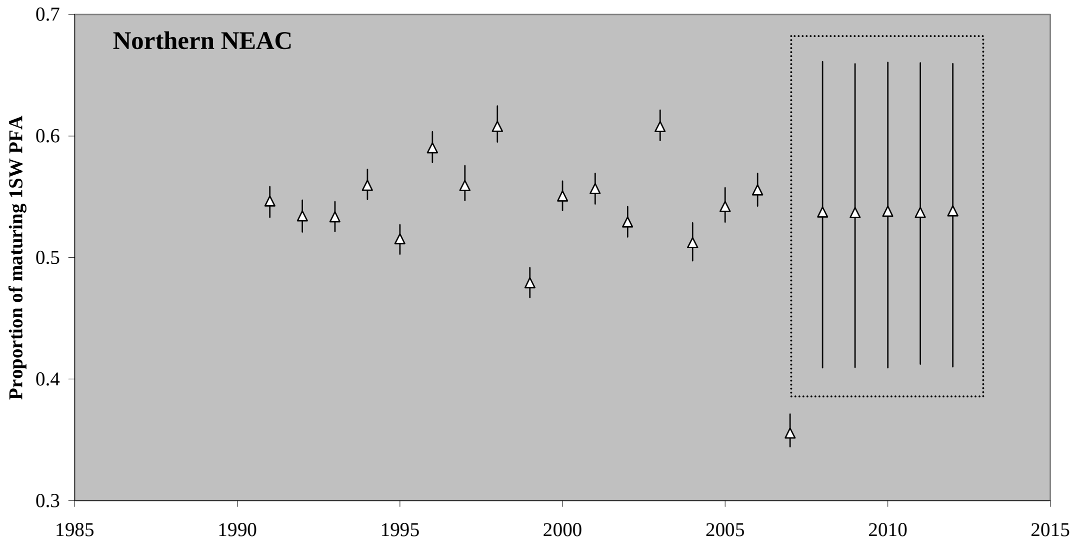


Figure 3.6.3.1. Productivity parameters by year for the maturing (◊) and non-maturing (▪) Northern and Southern NEAC forecast models. The extents of the whiskers represent the 2.5 and 97.5 BCI. Model forecasts are enclosed within the boxed areas.



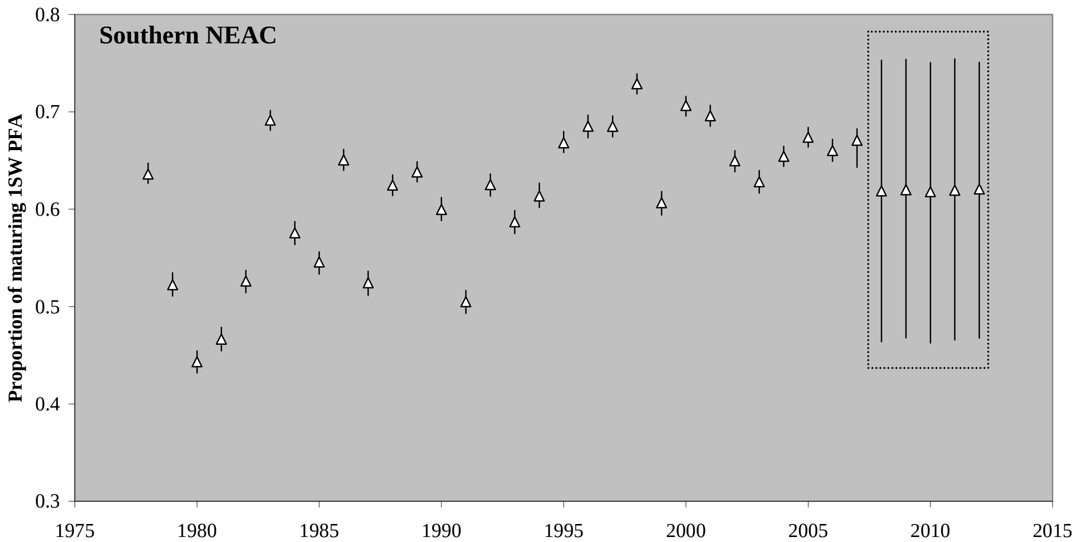


Figure 3.6.3.2. Proportion of maturing 1SW parameter by year for the Northern and Southern NEAC forecast models. The extents of the whiskers represent the 2.5 and 97.5 BCI. Model forecasts are enclosed within the boxed areas.

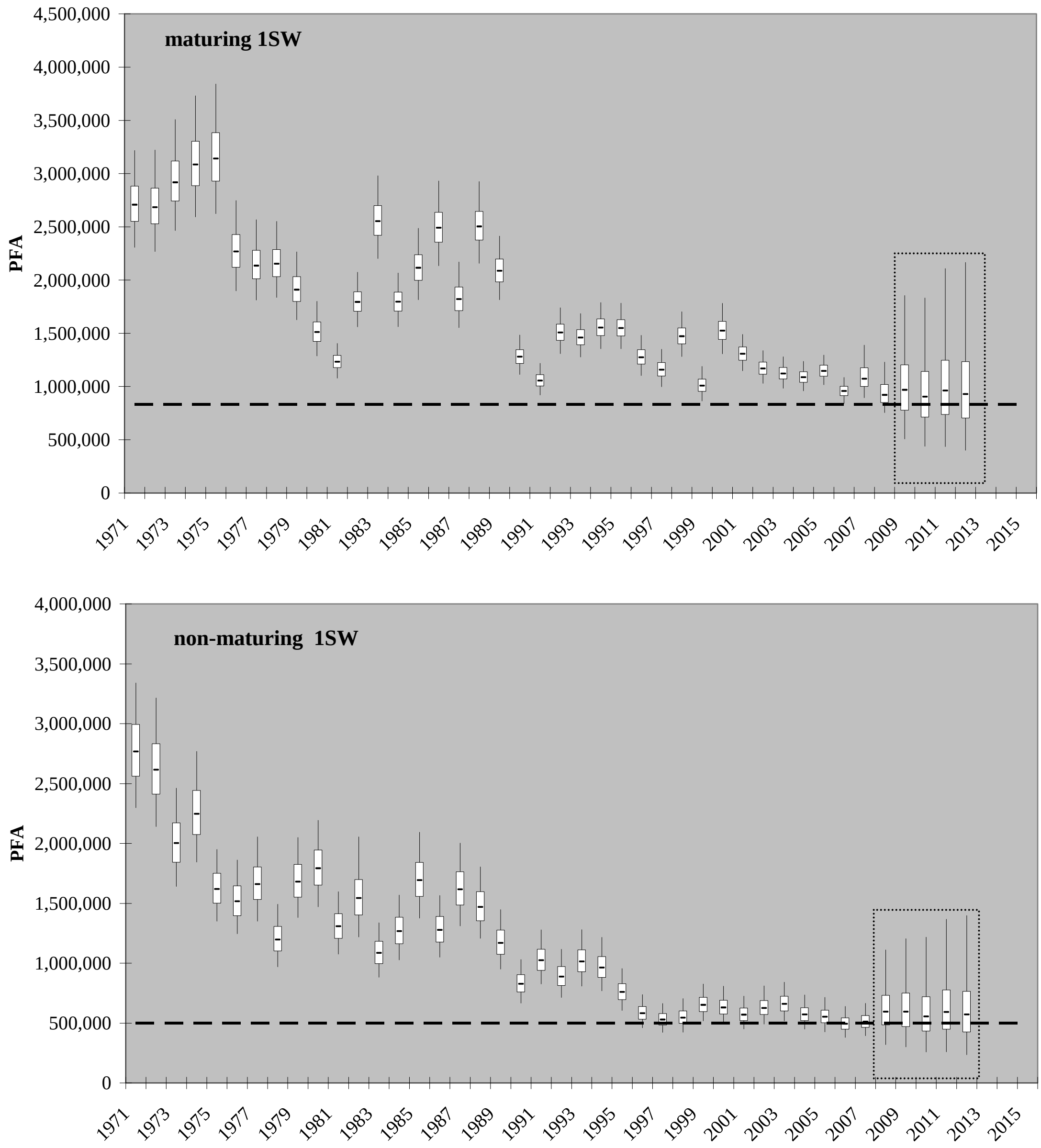
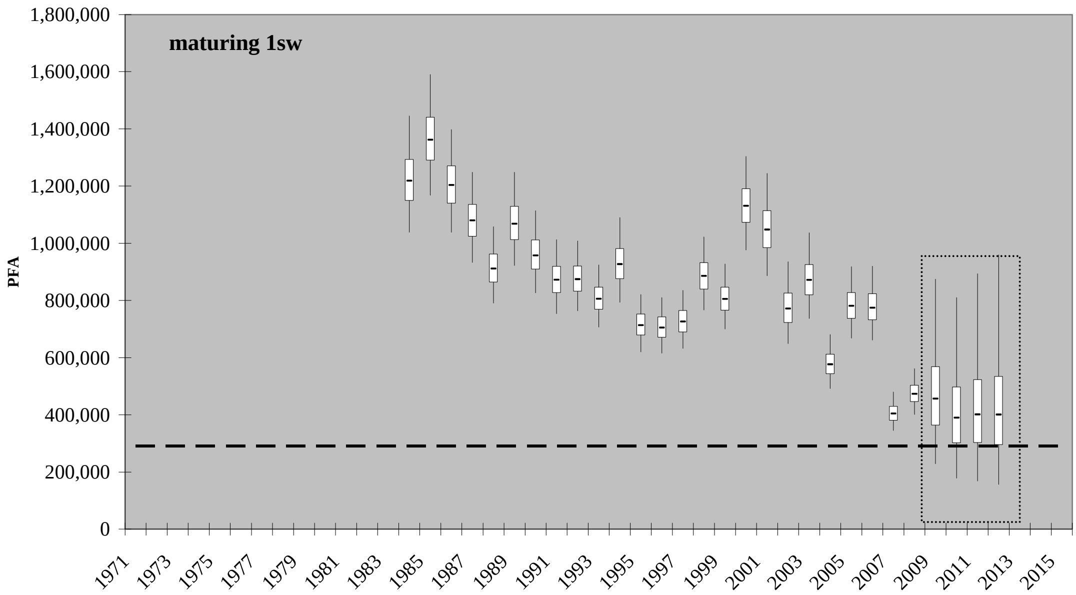


Figure 3.6.3.3. Southern NEAC PFA estimates by year. The extents of the whiskers represent the 2.5 and 97.5 BCI. The SER for the stock complex is represented by the dashed line. Model forecasts are enclosed within the boxed areas.



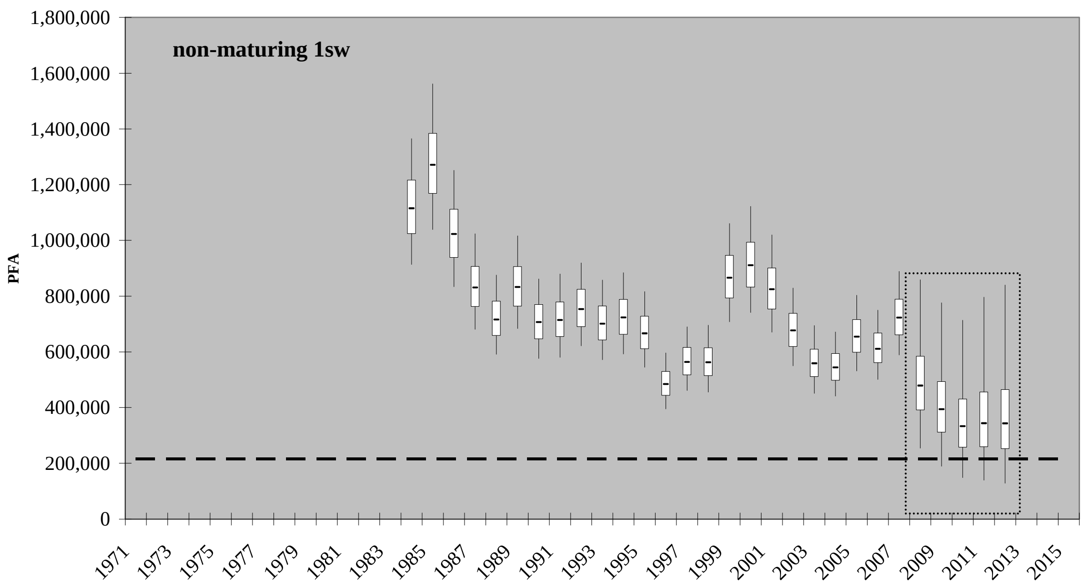


Figure 3.6.3.4. Northern NEAC PFA estimates by year. The extents of the whiskers represent the 2.5 and 97.5 BCI. The SER for the stock complex is represented by the dashed line. Model forecasts are enclosed within the boxed areas.

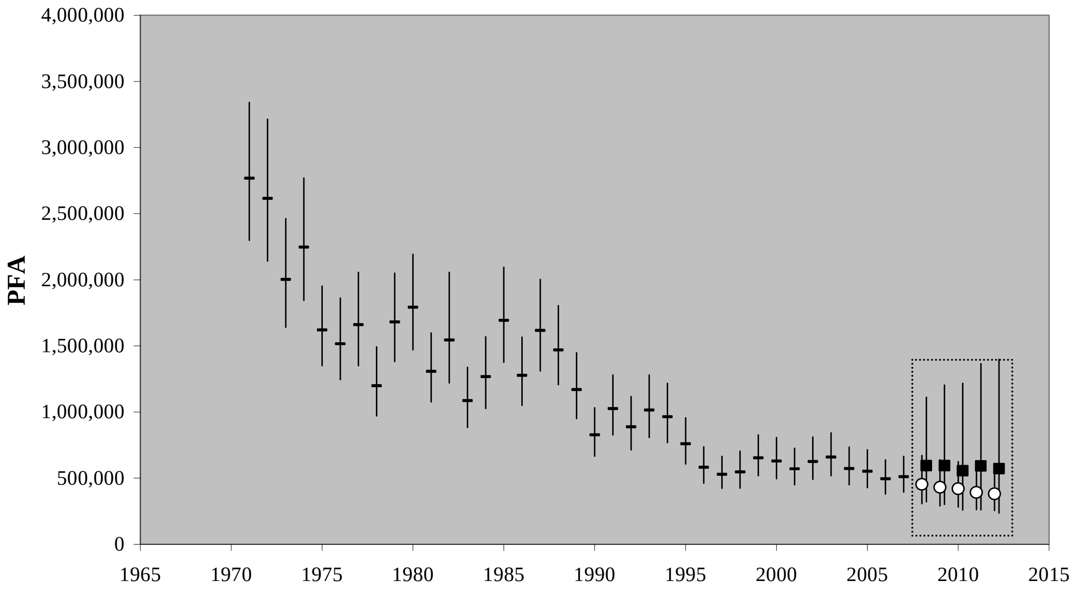


Figure 3.6.3.5. Comparison of model estimates of PFA for the Southern NEAC non-maturing 1SW stock complex. Run reconstruction median estimates (-) together with 95% confidence intervals are shown from 1971 to 2007. Forecasts from the regression model (o) together with 95% confidence intervals and from the Bayesian forecast model (▪) together with 2.5% to 97.5% BCI are shown from 2008 to 2012. Model forecasts are enclosed within the boxed areas.

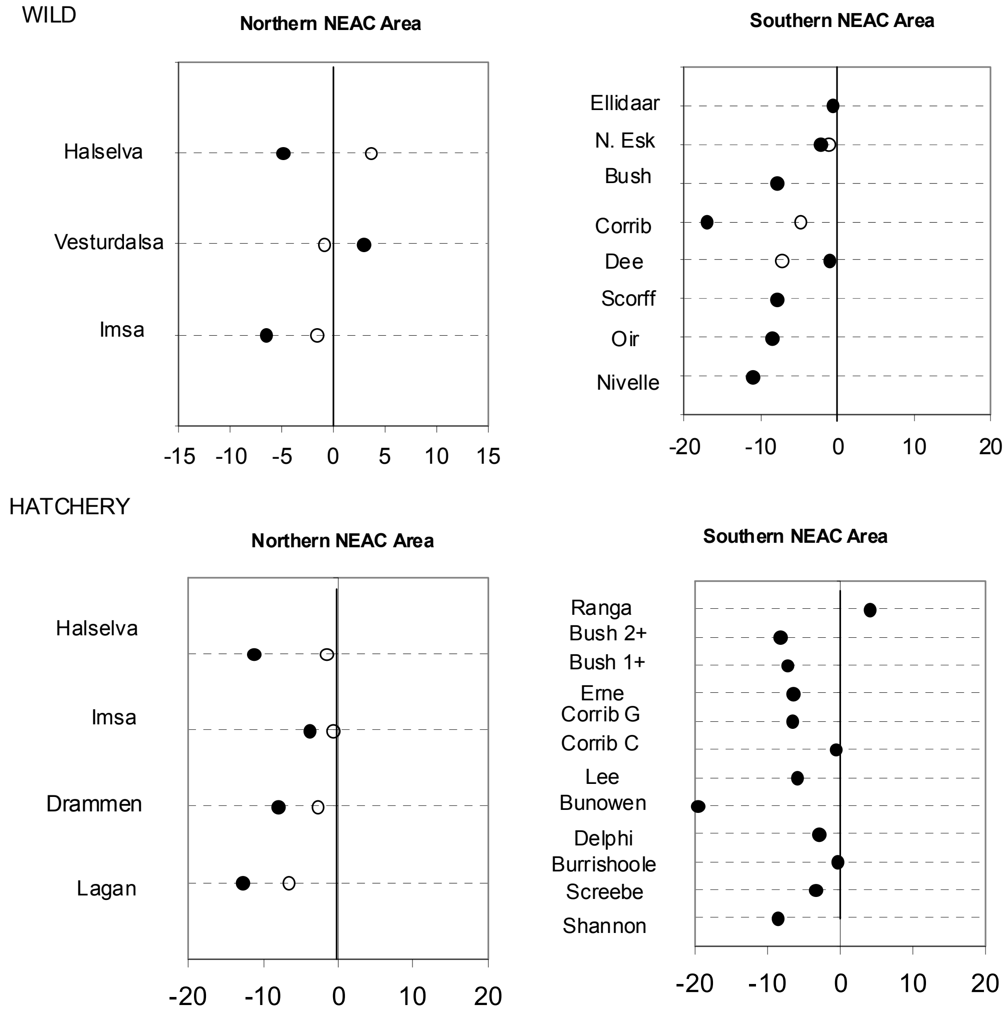


Figure 3.8.10.1. Annual rates of change (%) in marine survival indices of wild and hatchery smolts to adult returns to homewaters (prior to coastal fisheries) in different rivers in northern and Southern NEAC areas. Filled circle = 1SW salmon; open circle = 2SW salmon. NB. The annual rates of change presented come from datasets of variable durations. Therefore comparisons between rivers are not appropriate.

4 North American Commission

4.1 Status of stocks/exploitation

In 2008, 2SW spawner estimates for the six geographic areas indicated that all areas were below their conservation limit (Figure 4.1.1) and are suffering reduced reproductive capacity.

The estimated exploitation rate of North American origin salmon in North American fisheries has declined (Figure 4.1.2) from approximately 79% to 14% for 2SW salmon and from approximately 69% to 14% for 1SW salmon over the period 1971–2008. In 2008, exploitation rates on 1SW and 2SW salmon remained among the lowest in the time-series.

The stock status is elaborated in Section 4.9.

4.2 Management objectives

Management objectives are included in Section 1.3.

4.3 Reference points

There are no changes recommended in the 2SW salmon conservation limits (CLs) from those identified previously. CLs for 2SW salmon for Canada total 123 349 and for the USA, 29 199 for a combined total of 152 548.

4.4 Management advice

As the predicted number of 2SW salmon returning to North America in 2009 is substantially lower than the 2SW CL there are no catch options for the composite North American fisheries. Where spawning requirements are being achieved, there are no biological reasons to restrict the harvest.

Wild salmon populations are now critically low in extensive portions of North America and remnant populations require alternative conservation actions in addition to very restrictive fisheries regulation to maintain their genetic integrity and persistence and where necessary habitat restoration.

Advice regarding management of this stock complex in the fishery at West Greenland is provided in Section 5.

4.5 Relevant factors to be considered in management

The management for all fisheries should be based upon assessments of the status of individual stocks. Fisheries on mixed-stocks, particularly in coastal waters or on the high seas, pose particular difficulties for management as they cannot target only stocks that are at full reproductive capacity if there are stocks below conservation limit within the mixed-stock being fished. Conservation would be best achieved if fisheries target stocks that have been demonstrated to be at full reproductive capacity. Fisheries in estuaries and especially rivers are more likely to meet this requirement.

4.6 Updated forecast of 2SW maturing fish for 2009

The updated forecast for 2009 2SW maturing fish is based on an updated forecast of the 2008 pre-fishery abundance and accounting for fish which were already removed from the cohort by fisheries in Greenland and Labrador in 2008 as 1SW non-maturing fish.

The updated forecast of the 2008 pre-fishery abundance provides a PFA midpoint of 110 100, about 7% lower than the forecast provided in the 2007 assessment. The 2008 pre-fishery abundance of maturing 2SW salmon will be available in homewaters in 2009.

4.6.1 Catch options for 2009 fisheries on 2SW maturing salmon

As the predicted number of 2SW salmon returning to North America in 2009 is substantially lower than the 2SW CL, there are no catch options that would provide a high probability of achieving conservation limits. Catch options refer to the composite North American fisheries. As the biological objective is to have all rivers reaching their conservation requirements, river-by-river management is necessary. On individual rivers, where spawning requirements are being achieved, there are no biological reasons to further restrict the harvest.

4.7 Pre-fishery abundance of 2SW salmon for 2009–2011

Previously, ICES (2007) used a two-phase regression between pre-fishery abundance (PFA_{NA}) and lagged spawners (LS_{NA}) to model the dynamics of PFA abundance and to provide forecasts (Chaput et al. 2005). This relationship was examined again in this assessment. With this model, the lagged spawner variable was informative for PFA_{NA} and the proportional model with the intercept through the origin was selected most often (91% of all models). An alternative model that considered regionally disaggregated lagged spawners and returns of 2SW salmon for the six regions of North America was also examined by the Working Group (see Section 2.3).

	Median (95% credible interval range)	
Forecasts of PFA_{NA}	Spatially aggregated phase-shift model	Region-disaggregated random walk model
2008	110 100 (67 250–180 700)	137 500 (80 000–242 000)
2009	107 500 (59 600–193 500)	137 500 (66 000–294 000)
2010	107 300 (60 000–194 600)	140 000 (58 000–355 000)
2011	110 200 (61 300–199 500)	149 000 (55 000–430 000)

For the 2009 to 2011 forecasts of PFA_{NA}, the probability (runs/10 000) of being in lower productivity phase was over 99%. The phase-shift models forecast PFA abundances in the range of 110 000 fish over the next three years (Figure 4.7.1). Based on the Bayesian region-disaggregated model, the PFA_{NA} abundance during 2009 to 2011 is expected to be between 140 000 and 150 000 non-maturing 1SW salmon, a value within the range of PFA for the period 1996 to 2007. At the 25th percentile range, abundance is expected to be just above 110 000 fish.

4.7.1 Catch options for 2010–2012 fisheries on 2SW maturing salmon

As the number of 2SW salmon returning to North America in 2010 to 2012 predicted by both models is substantially lower than the 2SW CL, there are no catch options that would provide a high probability of achieving CLs. Catch options refer to the composite North American fisheries. As the biological objective is to have all rivers reaching their conservation requirements, river-by-river management is necessary. On individual rivers, where spawning requirements are being achieved, there are no biological reasons to further restrict the harvest.

4.8 Comparison with previous assessment and advice

Updated forecasts of the pre-fishery abundance for 2008 and forecasts for 2009–2011 were provided using the model used by ICES in previous years and an alternate model based on a regionally disaggregated productivity structure. There is no significant change in the interpretation of stock status or of expected abundance based on the updated data, and the models used. The catch advice remains unchanged from previous years.

4.9 NASCO has requested ICES to describe the key events of the 2008 fisheries and the status of the stocks

4.9.1 Fisheries in 2008

Canada

Three user groups exploited salmon in Canada in 2008: Aboriginal peoples, residents fishing for food in Labrador, and recreational fishers. There were no commercial fisheries in Canada in 2008. There was no harvest of sea-run Atlantic salmon in the USA in 2008.

The provisional harvest of salmon in 2008 by all users was 148 t (Table 2.1.1.1, Figure 4.9.1.1), about 32% higher lower than the 2007 harvest (112 t). The 2008 harvest was 52 362 small salmon and 11 737 large salmon, 41% more small salmon and 14% more large salmon, compared with 2007. The dramatic decline in harvested tonnage since 1988 is in large part because of major reductions in commercial fishery effort throughout Canada, introduced as a result of declining abundance of salmon.

The Aboriginal peoples' harvests in 2008 were 62.4 t (Table 4.9.1.1), approximately 30% higher than 2007 and 14% higher than the previous 5-year mean. The estimated harvest for residents fishing for food in Labrador was 2.2 t, about 2200 fish (75% small salmon by number). The recreational fisheries harvest totalled 43 301 small and large salmon, approximately 83 t (Figure 4.9.1.2). This is a 45% increase over the 2007 harvest and an 11% increase over the previous 5-year average. The small salmon harvest of 40 461 was 54% above the 2007 and 15% above the previous 5-year mean. The large salmon harvest of 2840 fish was 5% below the 2007 harvest and 29% below the previous five-year mean. The small salmon size group has contributed 88% on average of the total harvests because the imposition of catch-and-release recreational fisheries in the Maritimes and insular Newfoundland in 1984.

USA

There was no harvest of sea-run Atlantic salmon in the USA in 2008.

France (Islands of Saint-Pierre and Miquelon)

The total reported harvest in 2008 was 3.54 t (Table 4.9.1.2), approximately 82% higher than 2007 and the 2nd highest catch reported since 1983 (Table 2.1.1.1). There was no information reported as to the number of professional and recreational gillnet licenses issued or their respective harvests.

It is unknown if a biological sampling programme was conducted in 2008.

4.9.2 Status of stocks

In 2008, the midpoints of the spawner abundance estimates for six geographic areas indicated that all areas were below their 2SW CLs and are suffering reduced reproductive capacity (Figure 4.1.1).

Estimates of pre-fishery abundance suggest continued low abundance of North American adult salmon (Figure 4.9.2.1). The total population of 1SW and 2SW Atlantic salmon in the Northwest Atlantic has oscillated around a generally declining trend since the 1970s. During 1993 to 2008, the total population of 1SW and 2SW Atlantic salmon was about 600 000 fish, about half of the average abundance during 1972 to 1990. The maturing 1SW salmon in 2008 has increased to the highest level since 1989 although it has declined by 39% over the time-series. The non-maturing has declined by 93% and the total abundance of 1SW salmon has declined 72%.

The estimated returns of 1SW fish in 2008 increased in all 6 regions over the 2007 returns. Returns in Labrador were 5% higher than in 2007 and 26% higher than the recent 5-year average. Returns in Newfoundland were 36% higher than in 2007 and 16% higher than the recent 5-year average. Returns in Québec were 59% higher than in 2007 and 27% higher than the recent 5-year average. Returns in the Gulf of St Lawrence were 55% higher than in 2007 and 10% higher than the recent 5-year average. Returns in Scotia–Fundy were 99% higher than in 2007 and 94% higher than the recent 5-year average. Returns in USA were 174% higher than in 2007 and 151% higher than the recent 5-year average.

The estimated returns of 2SW fish in 2008 increased over the 2007 returns in 4 regions and decreased in 2 regions. Returns in Labrador were 19% higher than in 2007 and 38% higher than the recent 5-year average. Returns in Newfoundland were 4% lower than in 2007 and 3% lower than the recent 5-year average. Returns in Québec were 22% higher than in 2007 and 3% higher than the recent 5-year average. Returns in the Gulf of St Lawrence were 19% lower than in 2007 and 22% lower than the recent 5-year average. Returns in Scotia–Fundy were 121% higher than in 2007 and 32% higher than the recent 5-year average. Returns in USA were 85% higher than in 2007 and 71% higher than the recent 5-year average.

Egg depositions by all sea ages combined in 2008 exceeded or equalled the river-specific conservation limits in 33 of the 77 assessed rivers (45%) and were less than 50% of CLs in 22 other rivers (30%, Figure 4.9.2.2).

Return rate data in 2008 were available from 11 wild and three hatchery populations from rivers distributed among Newfoundland, Québec, Scotia-Fundy and USA. In the 10 wild stocks with data in both 2007 and 2008, return rates to 1SW fish in 2008 increased greatly relative to 2007 (33% to 290%). A similar large increase was noted in two of the hatchery stocks (209% to 246%), whereas the return rates for the other stock declined by 25%.

In contrast, return rates in 2008 for 2SW salmon from the 2006 smolt class decreased relative to the 2005 smolt class for all five wild stocks (-3% to -59%) and one hatchery stock (-50%), but increased in the other two hatchery stocks (44% to 118%).

4.10 NASCO has requested ICES to evaluate the extent to which the objectives of any significant management measures introduced in recent years have been achieved

There have been no significant management measures introduced within the NAC in recent years.

Table 4.9.1.1. Harvests in 2008 (by weight) and the percent large by weight and number in the Aboriginal Peoples' Food Fisheries in Canada including the Resident Food Fishery in Labrador.

Aboriginal peoples' food fisheries			
Year	Harvest (t)	% large	
		by weight	by number
1990	31.9	78	
1991	29.1	87	
1992	34.2	83	
1993	42.6	83	
1994	41.7	83	58
1995	32.8	82	56
1996	47.9	87	65
1997	39.4	91	74
1998	47.9	83	63
1999	45.9	73	49
2000	45.7	68	41
2001	42.1	72	47
2002	46.3	68	43
2003	44.3	72	49
2004	60.8	66	44
2005	56.7	57	34
2006	61.4	60	39
2007	48.0	62	40
2008	62.4	66	44

Table 4.9.1.2. The number of professional and recreational gillnet licenses issued at St Pierre and Miquelon and landings, 1995–2008.

	Number of licenses		Reported Landings (tonnes)		
Year	Professional	Recreational	Professional	Recreational	Total
1990			1.146	0.734	1.880
1991			0.632	0.530	1.162
1992			1.295	1.024	2.319
1993			1.902	1.041	2.943
1994			2.633	0.790	3.423
1995	12	42	0.392	0.445	0.837
1996	12	42	0.951	0.617	1.568
1997	6	36	0.762	0.729	1.491
1998	9	42	1.039	1.268	2.307
1999	7	40	1.182	1.140	2.322
2000	8	35	1.134	1.133	2.267
2001	10	42	1.544	0.611	2.155
2002	12	42	1.223	0.729	1.952
2003	12	42	1.620	1.272	2.892
2004	13	42	1.499	1.285	2.784
2005	14	52	2.243	1.044	3.287
2006	14	48	1.730	1.825	3.555
2007	13	53	0.970	0.977	1.947
2008	na	na	na	na	3.540

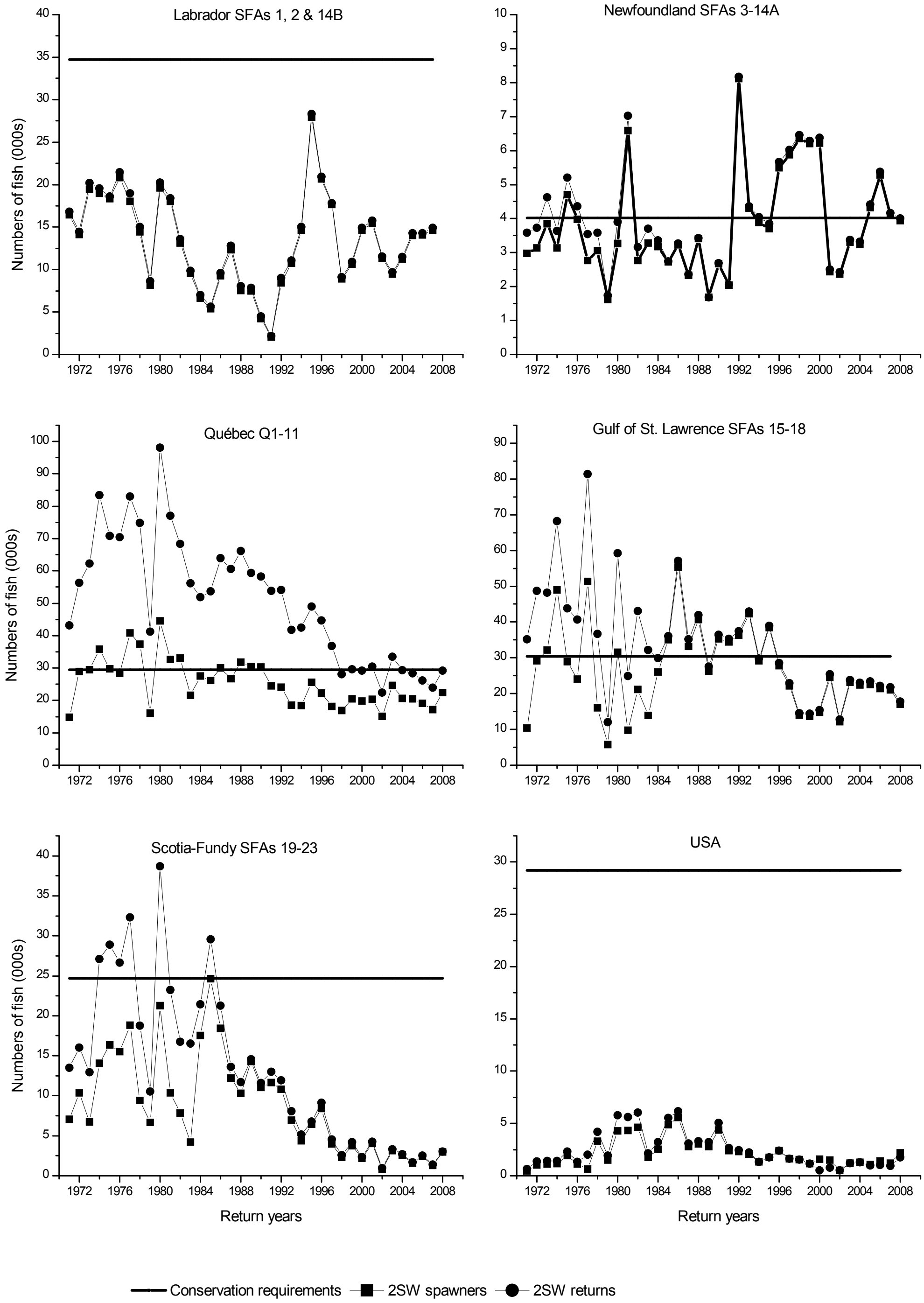


Figure 4.1.1. Comparison of estimated midpoints of 2SW returns to and 2SW spawners in six geographic areas of North America. Returns and spawners for Scotia-Fundy do not include those from SFA 22 and a portion of SFA 23. Note the difference in scale for USA.

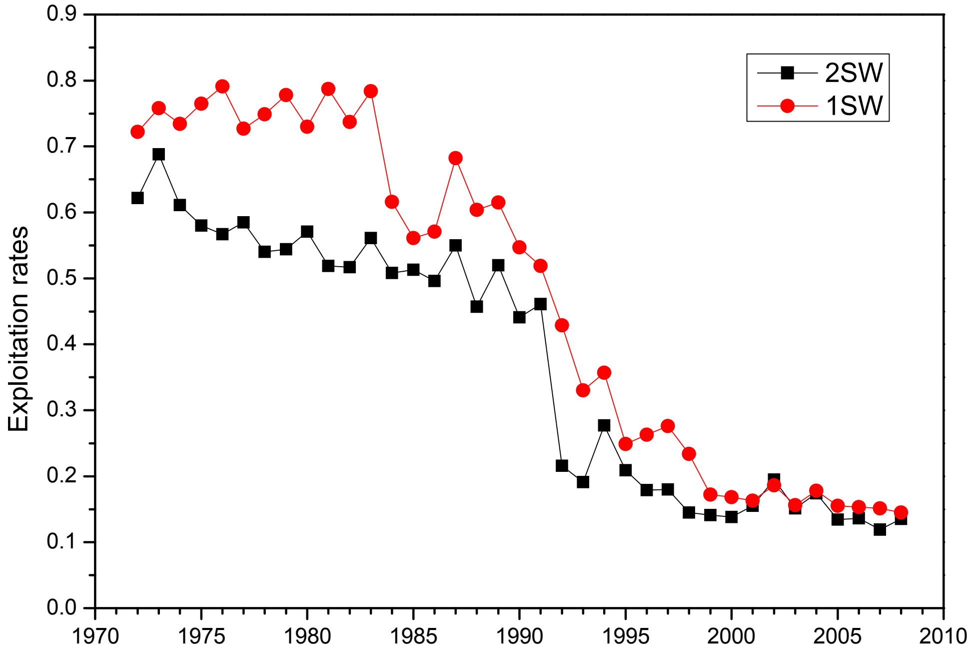


Figure 4.1.2. Exploitation rates in North America on the North American stock complex of 1SW and 2SW salmon.

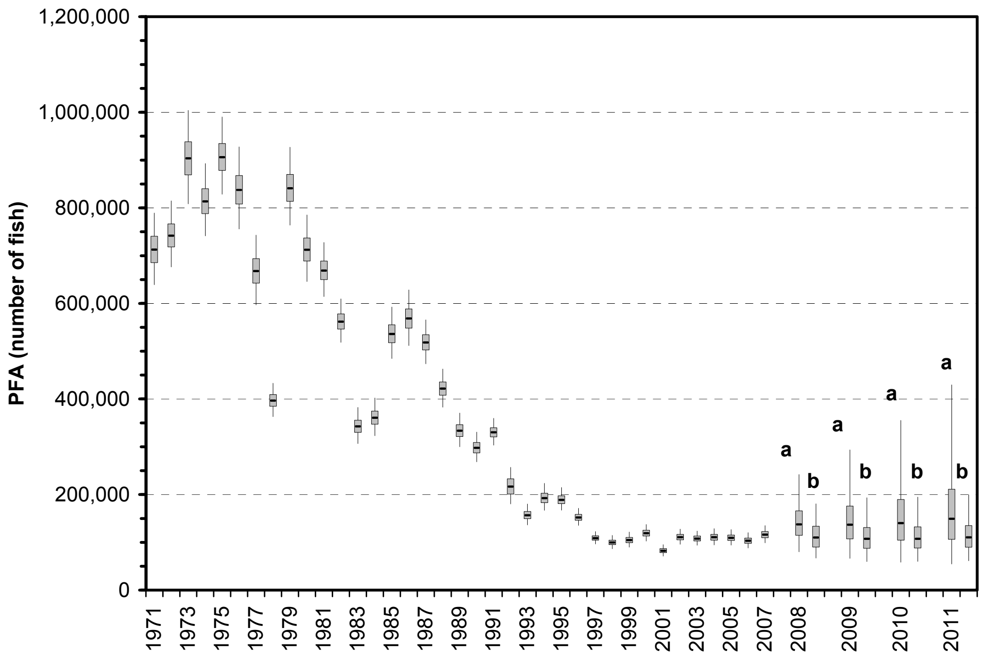


Figure 4.7.1. Run reconstructed PFA (1971 to 2007) and forecasts of PFA for 2008 to 2011 based on models of lagged 2SW spawners and 2SW returns to six regions of North America. The box plots labelled "a" are from the regionally disaggregated random walk model presented in 2009. The box plots labelled "b" are outputs from the phase shift model previously used by ICES for providing catch advice for West Greenland fisheries.

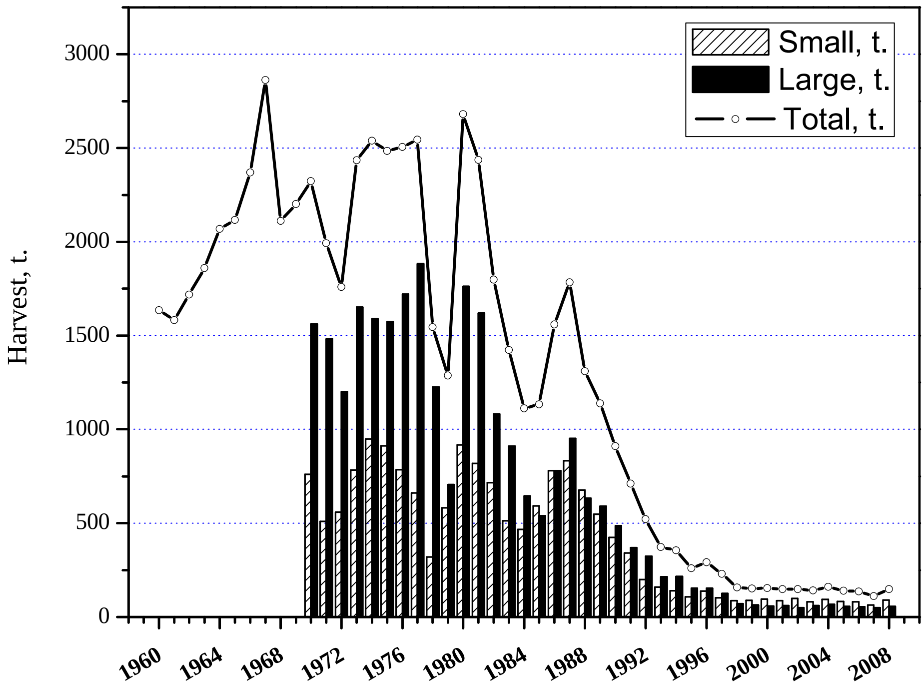


Figure 4.9.1.1. Harvest (t) of small salmon, large salmon and combined for Canada, 1960–2008 by all users.

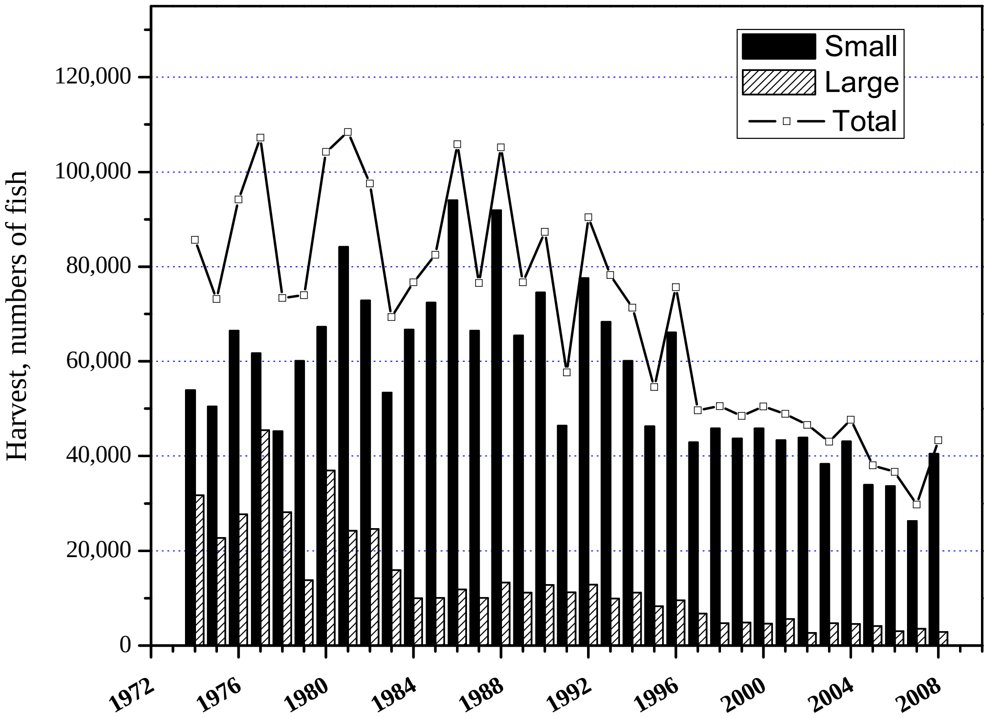


Figure 4.9.1.2. Harvest (number) of small salmon, large salmon and both sizes combined in the recreational fisheries of Canada, 1974–2008.

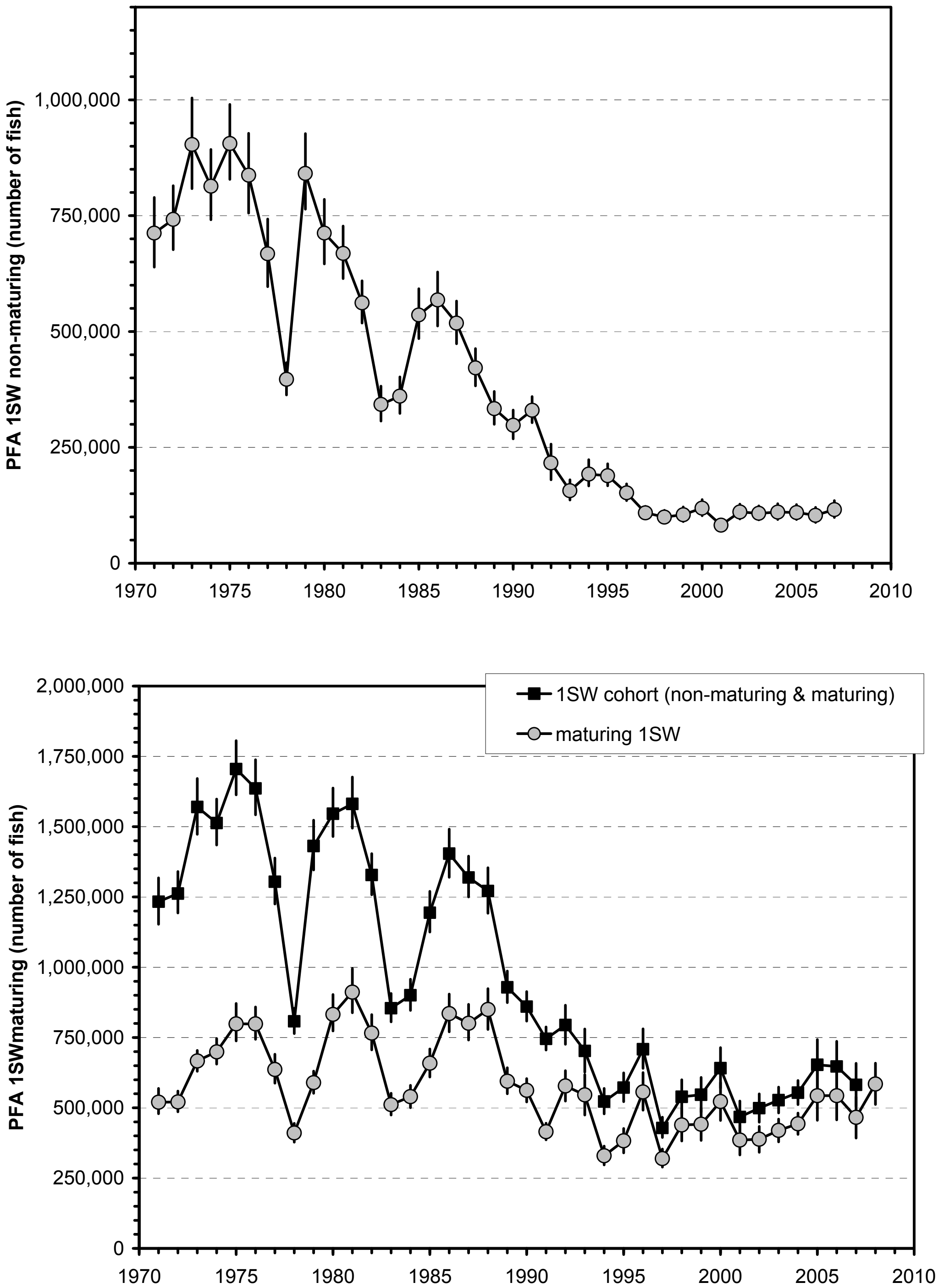


Figure 4.9.2.1.Estimates of PFA for 1SW non-maturing (upper panel) and 1SW maturing salmon and total cohort of 1SW salmon (lower panel) based on the Monte Carlo simulations of the run-reconstruction model for NAC. Median and 95% CI interval ranges derived from Monte Carlo simulations are shown.

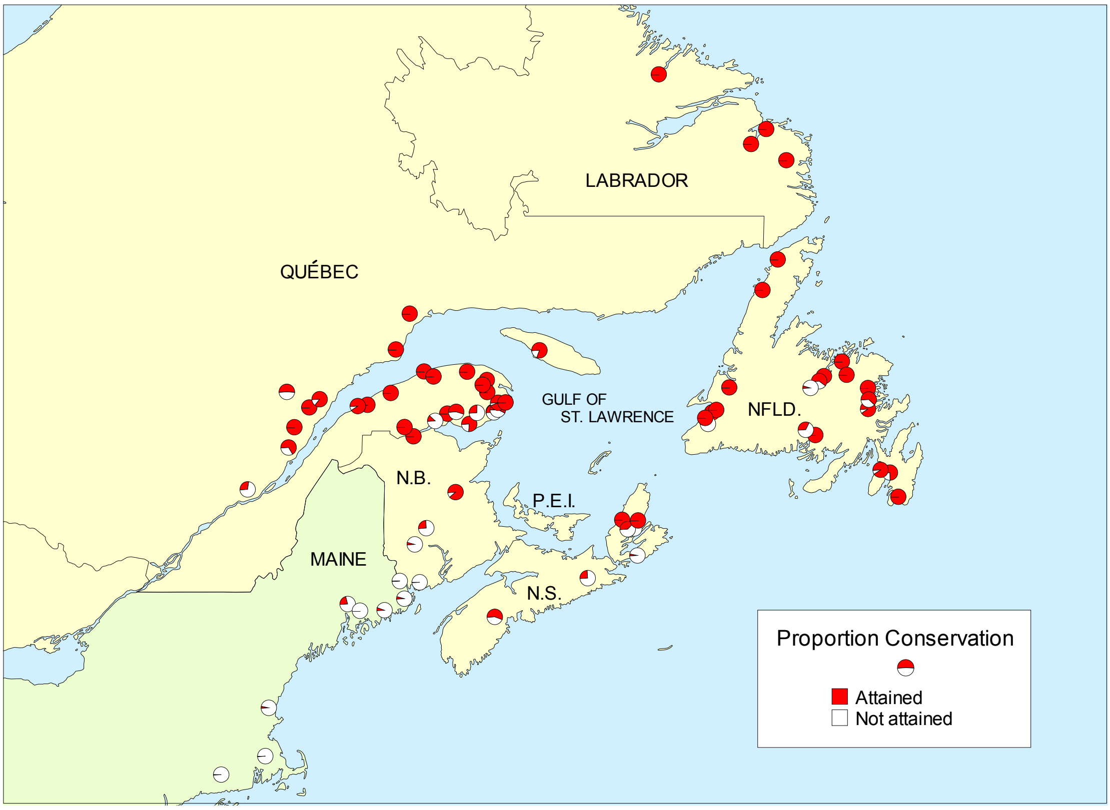


Figure 4.9.2.2. Proportion of the conservation requirement attained in assessed rivers of the North American Commission in 2008.

5 Atlantic salmon in the West Greenland Commission

5.1 Status of stocks/exploitation

ICES considers the stock complex at West Greenland to be below conservation limits and thus suffering reduced reproductive capacity.

North American stock

Estimates of pre-fishery abundance suggest a continuing decline of North American adult salmon over the last 10 years. The total population of 1SW and 2SW Atlantic salmon in the Northwest Atlantic has declined since the 1970s (Figure 4.9.10.1). During 1994–2007, the total population of 1SW and 2SW Atlantic salmon was about 600 000 fish, about half of the average abundance during 1972–1990. The decline from earlier higher levels of abundance has been more severe for the 2SW (i.e. the component of the stock that goes to Greenland) salmon component than for the small salmon (maturing 1SW salmon) age group.

In most regions, the returns of 2SW fish in 2008 increased from 2007, however, they are still less than the median of the recent 30-year time-series (1979–2008). In 2008, the estimated overall spawning escapement was below the conservation limit for the stock complex. Specifically 2SW spawners in the regions are:

- **Newfoundland:** suffering reduced reproductive capacity (98% of 2SW CL)
- **Labrador:** suffering reduced reproductive capacity (50% of 2SW CL)
- **Québec:** suffering reduced reproductive capacity (74% of 2SW CL)
- **Gulf of St Lawrence**: suffering reduced reproductive capacity (56% of 2SW CL)
- **Scotia-Fundy:** suffering reduced reproductive capacity (12% of 2SW CL)
- **United States:** suffering reduced reproductive capacity (7% of 2SW CL)

The exploitation rate for North American non-maturing 1SW fish at West Greenland has averaged around 3.7% in the last four years (Figure 5.1.1).

European stocks

Estimates of pre-fishery abundance suggest a downward trend in Southern European MSW adult salmon (i.e. the component of the stock that goes to Greenland) over the last 10 years. The midpoint of spawners has been close to or below conservation limits in recent years. Specifically:

- **Southern European stock complex:** at risk of suffering reduced reproductive capacity (102% of 2SW CL)

Status of stocks in the NEAC and NAC areas are presented in the relevant Commission sections (Sections 3 and 4).

5.2 Management objectives

For management advice for the West Greenland fishery, NASCO has adopted a precautionary management plan requiring at least a 75% probability of achieving three management objectives:

- Meeting the conservation limits simultaneously in the four northern regions of North America: Labrador, Newfoundland, Quebec, and Gulf.

- For the two southern regions in North America, Scotia-Fundy and USA, where there is a zero chance of meeting conservation limits: achieve increases in returns relative to previous years with the hope of rebuilding the stocks. In 2004, ICES established 1992–1996 as the range of years to define the baseline for the Scotia-Fundy and USA regions to assess PFA_{NA} abundance and fishery options. Improvements of greater than 10% and greater than 25% relative to returns during this base period are evaluated. The 25% increase is the limiting factor because if it is achieved, by definition the 10% increase is also achieved.
- Meeting the conservation limit for the Southern NEAC MSW complex.

Although not a formal management objective, ICES also provides the probability of returns to North America being equal or less than the previous five-year average.

5.3 Reference points

The reference points for West Greenland catch options are the conservation limits (CLs) for North American and southern European stock complexes. Region-specific conservation limits are derived in three ways:

- In many regions of North America, the CLs are calculated as the number of spawners required to fully seed the wetted area of the river;
- In some regions of Europe, pseudo stock–recruitment observations are used to calculate a hockey stick relationship, with the inflection point defining the CLs;
- In the remaining regions, the CLs are calculated as the number of spawners that will achieve long-term average maximum sustainable yield (MSY), as derived from the adult-to-adult stock and recruitment relationship (Ricker, 1975; ICES, 1993).

NASCO has adopted region-specific CLs (NASCO, 1998). These regional CLs are limit reference points; having populations fall below these limits should be avoided with high probability.

CLs for the West Greenland fishery for North America are limited to 2SW salmon and for southern European stocks are limited to MSW fish, because fish at West Greenland are primarily (> 90%) 1SW non-maturing salmon destined to mature as either 2SW or 3SW salmon.

The North America 2SW CL is 152 548 fish, with 123 349 required in Canadian rivers and 29 199 in USA rivers (see Section 4.3). The CL for the southern European MSW stocks is 296 000 fish (Section 3.3). There is still considerable uncertainty in the CLs for European stocks and estimates may change from year to year because of new data in the pseudo stock–recruitment relationship.

5.4 Management advice

None of the stated management objectives which would allow a fishery at West Greenland would be met in 2009, 2010, or 2011.

In the absence of any marine fishing mortality, there is a very low probability (<2% to 3 %) that the returns of 2SW salmon to North America in 2010, 2011, and 2012 will be sufficient to meet the conservation requirements of the four northern regions (Labrador, Newfoundland, Quebec, and Gulf; Table 5.4.1). There is essentially no chance (near zero) that the returns in the southern regions (Scotia-Fundy and USA) will be greater than the returns observed in the 1992–1996 base period in any of the three years. Lastly, in the absence of a fishery, the probability that returns in all regions of North America will decline further from the average of the period 2004 to 2008 is 45% for 2009, 45% for 2010, and 42% for 2011 (Table 5.4.2).

In the absence of any fisheries, there is only a 54% chance that the MSW conservation limit for southern Europe will be met in 2009 (Table 5.4.1). For 2010 and 2011, the probability that the MSW returns for southern Europe will meet or exceed the conservation limit in the absence of fisheries declines to 49% and 36%, respectively (Tables 5.4.1).

5.5 Relevant factors to be considered in management

The management for all fisheries should be based upon assessments of the status of individual stocks. Fisheries on mixed-stocks, particularly in coastal waters or on the high seas, pose particular difficulties for management as they cannot target only stocks that are at full reproductive capacity if there are stocks below conservation limit within the mixed-stock being fished. Conservation would be best achieved if fisheries target stocks that have been demonstrated to be at full reproductive capacity. Fisheries in estuaries and especially rivers are more likely to meet this requirement.

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

5.6 Pre-fishery abundance forecasts 2009, 2010, and 2011

Two forecasts for each area (NEAC Section 3.6 and NAC Section 4.9) are presented; one based on the previous models used by the Working Group (the regression forecast model for NEAC and the phase shift model for NAC) and one on the newly developed Bayesian forecast models (Section 2.3). Further details on the models used and their application are in Section 5.9. The PFA forecasts for the West Greenland stock complex are among the lowest in the time-series (Figures 4.7.1 and 3.6.3.3).

5.6.1 North American stock complex

The PFA_{NA} forecast for 2009 from the phase shift model has a median value of 107 500. For 2010 and 2011, the PFA_{NA} forecasts remain among the lowest in the time-series. For 2010, the median value is 107 300 fish and is highly unlikely to meet the 2SW spawner reserve of 212 189 salmon to North America. For 2011, the median forecast value is 110 200, also highly unlikely to meet the 2SW spawner reserve to North America. These values are all below the spawning escapement reserve for North America.

5.6.2 Southern European MSW stock complex

The southern European PFA forecast for 2009 has a median value of 431 220 (Table 3.6.1.2). The spawning escapement to southern Europe MSW stocks has not exceeded conservation limits throughout most of the period (Figure 3.1.1). The PFA for the

NEAC MSW southern stock complex is expected to decline in 2010 and 2011 (Figure 3.6.3.3.). For 2010, the median value is 419 733 fish and for 2011, the median forecast value is 392 235 fish. It is unlikely that spawner escapement reserves (501 086) will be met in either year.

5.7 Comparison with previous assessment and advice

The management advice for the West Greenland fishery for 2009 is based on the models previously used by the Working Group. For 2009, the median value of the updated analysis from the phase shift model for NAC has decreased to 107 500 fish from the 114 200 predicted in the 2007 assessment analysis. The variability of the two predictions was similar. The revised forecast from the regression model of the southern NEAC MSW PFA for 2009 provides a PFA midpoint of 483 700. This is close to the value forecast last year at this time of 489 000.

The forecasts for 2009 to 2011 for NAC based on the regionally disaggregated Bayesian model (Section 2.3; Section 4.7) are more optimistic about the median expectations (Figure 3.6.3.3; Figure 4.7.1) but the 25th percentile of the Bayesian credible intervals from this model remain below 110 000 fish. The 25th percentile of the distribution in the posterior forecast predictions represents the 75% threshold for evaluating stock status relative to conservation limits.

For the southern NEAC area, the 25th percentile of the posterior distributions of the forecasts of an alternate Bayesian model are below the SER for 2009 to 2011 (Figure 3.6.3.3). The Working Group noted that, although the levels of uncertainty are greater in the Bayesian model, both the regression forecast model and the Bayesian forecast model provide similar predictions of the lower bound of the forecast values in the three years of interest.

5.8 NASCO has requested ICES to describe the events of the 2008 fishery and status of the stocks

The international sampling programme for landings at West Greenland initiated by NASCO in 2001 was continued in 2008. In addition to the Baseline Sampling Programme described above, an 'Enhanced Sampling Programme' (SALSEA West Greenland) was developed to conduct broader and more detailed sampling on a fixed number of fish harvested from the waters off West Greenland. It was designed to be integrated within the baseline sampling programme. Concerns were raised by the North Atlantic Salmon Fund, the Atlantic Salmon Federation and the Organization of Fishermen and Hunters in Greenland that the Enhanced Sampling Programme could result in an increased harvest for the internal use only fishery and counteract their efforts to reduce the annual harvest of salmon in Greenland under the North Atlantic Salmon Conservation Agreement. Efforts are underway to develop a workable solution to ensure that the Enhanced Sampling Programme can be implemented in 2009 with the full cooperation of all participating parties.

At its annual meeting in June 2006 NASCO agreed to restrict the fishery at West Greenland *to that amount used for internal subsistence consumption in Greenland*. Consequently, the Greenlandic authorities set the commercial quota to nil, i.e. landings to fish plants, resale in grocery shops/markets, and commercial export of salmon from Greenland was forbidden. Licensed fishers were allowed to sell salmon at the open markets, to hotels, restaurants, and institutions. A private fishery for personal consumption without a license was allowed. All catches, licensed and private were to be reported to the License Office on a daily basis. In agreement with the Organization for Fishermen and Hunters in Greenland the fishery for salmon was allowed from August 1 to October 31.

5.8.1 Catch and effort in 2008

In all 26 t of salmon were reported during the 2008 fishery (Table 5.8.1.1). Catches were distributed among the six NAFO divisions on the west coast of Greenland (Figure 5.8.1.1), with approximately 60% of the catches coming from divisions 1B–1E (Table 5.8.1.2). There is currently no quantitative approach for estimating the unreported catch but the 2008 value is likely to have been at the same level proposed in recent years (10 t).

In total, 259 reports were received by the Fisheries license office in 2008. Reports were provided by 143 people with 4 of these reporting 0 catch. The number of fishers reporting catches has steadily increased from a low of 41 in 2002 to its current level. These levels remain well below the 400–600 people reporting landings in the commercial fishery from 1987 to 1991. Since October 2006, the Greenland Home Rule License Office has broadcast TV requests that catch reports be submitted for the season. Thus, it is possible that the increase in the number of people reporting catches, and hence the increased reported landings, reflect changes in reporting practices *vs*. increased harvest.

5.8.2 Biological characteristics of the catches

Tissue and biological samples were collected from three landing sites: Sisimiut (NAFO Div. 1B), Nuuk (NAFO Div. 1D), and Qaqortoq (NAFO Div. 1F, Figure 5.8.1.1). In total 2086 salmon were inspected for the presence of tags, representing 29% by weight of the reported landings. Of these, 1866 were measured for fork length and weight (Table 5.8.2.1). Scales samples were taken from 1866 salmon for age and origin determination and tissue was removed from 1865 for DNA analysis, 1853 samples of which were subsequently used for assignment to continent of origin. The broad geographic distribution of the subsistence fishery caused practical problems for the sampling teams. However, temporal coverage was adequate to assess the fishery. As in previous years, the Working Group needed to adjust the total landings by replacing the reported catch with the weight of fish sampled for use in assessment calculations (Table 5.8.2.2). In 2008 this adjustment was necessary in two NAFO divisions (1D and 1F) and represented an increase of 2.5 t.

The average weight of fish from the 2008 catch was 3.08 kg across all ages, with North American 1SW fish averaging 64.6 cm and 3.04 kg whole weight and European 1SW salmon averaging 63.9 cm and 3.03 kg (Table 5.8.2.3). The mean lengths and mean weights for the 2008 samples are an increase over the 2007 values, but remain close to the previous 10 year mean. It should be noted that the size data are not adjusted for standard week and may not represent a true increase.

North American salmon up to river age 6 were caught at West Greenland in 2008 (Table 5.8.2.4), with 25.1%, 51.9% and 16.8% being river ages 2, 3 and 4 respectively. The river ages of European salmon ranged from 1 to 4 (Table 5.8.2.3). Almost three-quarters (72.8%) of the European fish in the catch were river-age 2 and 19.3% were river age 3. The percentage of the European origin river age 1 salmon was 7.0%, the same as in 2007 and the second lowest in the time-series (Table 5.8.2.3).

In 2008, the North American samples were 97.4 % 1SW salmon, 0.5% 2SW and 2.2% previous spawners (Table 5.8.2.3). The European samples were 98.8% 1SW salmon, 0.5% 2SW and 1.9% previous spawners (Table 5.8.2.3).

Of the 1865 samples collected for genetic characterization, most (1853) were genotyped at between seven and ten microsatellites and assigned to a continent of origin. In total, 86% of the salmon sampled from the 2008 fishery were of North American origin and 14% fish were of European origin.

The division-specific and overall continent of origin assignments for the samples collected in 2008 are listed below. The Working Group recommends a broad geographic sampling programme (multiple NAFO divisions) to more accurately estimate continent of origin in the mixed-stock fishery.

	North America		Europe	
NAFO division	Number	%	Number	%
1B	483	85%	84	15%
1D	660	87%	97	13%
1F	450	85%	79	15%
Total	1593	86%	260	14%

Applying the continental percentages for the NAFO division catches resulted in estimates of 24.6 t of North American origin and 4.0 t of European origin fish (8000 and 1300 rounded to the nearest 100 fish, respectively) landed in West Greenland in 2008.

5.9 NASCO has requested ICES to provide a detailed explanation and critical examination of any changes to the models used to provide catch options

5.9.1 Run-reconstruction models

The run-reconstruction models to estimate pre-fishery abundance of 1SW non-maturing and maturing 2SW fish adjusted by natural mortality to the time prior to the West Greenland fishery follow the same structure as used since 2003 (ICES, 2003, 2004, 2005, 2006) but incorporated the recommendations from ICES (2008) to improve the models.

5.9.2 Forecast models for pre-fishery abundance of 2SW salmon

The forecast models to estimate pre-fishery abundance of non-maturing 1SW salmon from the southern NEAC complex and for the NAC area used by ICES since 2002 were used again in this assessment. The overall approach for the southern NEAC model is to select the best model by adding variables (e.g. spawners, habitat, PFA of maturing 1SW salmon and year) until addition of any other parameter was not significant. The forecast models used to estimate pre-fishery abundance of non-maturing 1SW salmon (potential MSW) for North America were the same as those used since 2004. The overall approach of modelling the natural log transformed PFA_{NA} and LS_{NA} using linear regression and the Monte Carlo method used to derive the probability density for the PFA_{NA} forecast was also retained from previous years.

In addition, the Working Group reviewed alternate models for both the NAC and southern NEAC areas. For NAC, a regionally disaggregated random walk model for 2SW salmon was developed whereas a combined 1SW cohort model was developed and used for the southern NEAC complex. Details of the model structures and the differences between these new models and those previously used by the Working Group are provided in Section 2.3. The forecasts from these alternate models provided higher median estimates of PFA but the conclusions on the probabilities of meeting the management objectives for both the NAC and southern NEAC 1SW non-maturing complex are similar to those from the ICES models; there are no catch options which provide a 75% chance of attaining the management objectives.

5.9.3 Development and risk assessment of catch options

The 2009–2011 PFA estimates were used to develop the risk analysis and catch options presented in Section 5.4. The risk assessment for the two stock complexes in the West Greenland fishery is developed in parallel then combined at the end of the process into a single summary plot or catch options table. The primary inputs to the risk analysis for the complex at West Greenland are:

- PFA forecast for the year of the fishery; PFA_{NA} and PFA_{NEAC};
- Harvest level being considered (t of salmon);
- Conservation spawning limits.

The final step in the risk analysis of the catch options involves combining the conservation requirement with the probability distribution of the returns to North America for different catch options. The returns to North America are partitioned into regional returns based on the regional proportions of 2SW returns of the last five years, 2004 to 2008. Estimated returns to each region are compared with the conservation objectives of Labrador, Newfoundland, Quebec, and Gulf. Estimated returns for Scotia–Fundy and USA are compared with the objective of achieving an increase of 10% and 25% relative to average returns of the base period, 1992–1996.

There were no changes to the risk assessment of catch options model.

5.10 NASCO has requested ICES to provide any new information on the extent to which the objectives of any significant management measures introduced in recent years have been achieved

NASCO management is directed at reducing exploitation to allow river-specific conservation limits to be achieved. The first measurable outcome of management at West Greenland is that the exploitation in the fishery has declined (Figure 5.1.1). The other measures relate to increasing spawning escapement in homewaters. Although influenced by measures taken in homewaters, it is possible to directly evaluate the extent to which management at West Greenland successfully achieved the objectives (Table 5.10.1).

To date the objective of simultaneous attainment of conservation limits in Labrador, Newfoundland, Quebec and Gulf of St Lawrence has not been achieved. Nor has there been a 10% or 25% increase in spawners to either Scotia-Fundy or the USA. The objective of consistently meeting the conservation limits for the Southern NEAC MSW complex has not as yet been achieved.

5.11 NASCO has asked ICES to update the framework of indicators used to identify any significant change in the previously provided multi-annual management advice

In 2007, ICES developed and presented to NASCO a framework of indicators (FWI) which could be used in interim years to determine if there is an expectation that the previously provided management advice for the Greenland fishery is likely to change in subsequent years (Figure 5.11.1).

As the 2009 assessment begins the cycle of forecasting and catch advice for the 2009 to 2011 fishing years, ICES has been asked to update the FWI in support of the multiyear catch advice and the potential approval of multiyear regulatory measures. Under the current management agreement, if the output from the FWI is accepted at the 2009 NASCO meeting it will be applied for January 2010 for the 2010 fishery and January 2011 for the 2011 fishery.

The Working Group updated the FWI in support of the West Greenland fishery management. The update consisted of:

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

Table 5.4.1. Catch options (t) for West Greenland harvest in 2009, 2010, and 2011 with the probability of meeting management objectives: meeting the 2SW conservation limits simultaneously in the four northern areas of North America; achieving increases in returns from base year average (1992–1996) in the two southern areas; and meeting the MSW conservation limit of the southern European stock complex relative to quota options.

2009				
West Greenland	Simultaneous	Improvement (SF, USA)		Conservation
Harvest	Conservation	of Returns		MSW Salmon
(t)	(Lab, NF, Queb, Gulf)	> 10%	> 25%	Southern NEAC
0	0.021	0.000	0.000	0.539
5	0.019	0.000	0.000	0.534
10	0.016	0.000	0.000	0.530
15	0.015	0.000	0.000	0.525
20	0.013	0.000	0.000	0.520
25	0.011	0.000	0.000	0.514
30	0.010	0.000	0.000	0.509
35	0.008	0.000	0.000	0.505
40	0.007	0.000	0.000	0.499
45	0.006	0.000	0.000	0.495
50	0.006	0.000	0.000	0.488
100	0.003	0.000	0.000	0.438
2010				
West Greenland	Simultaneous	Improvement (SF, USA)		Conservation
Harvest	Conservation	of Returns		MSW Salmon
(t)	(Lab, NF, Queb, Gulf)	> 10%	> 25%	Southern NEAC
0	0.023	0.000	0.000	0.490
5	0.021	0.000	0.000	0.486
10	0.018	0.000	0.000	0.480
15	0.015	0.000	0.000	0.475
20	0.013	0.000	0.000	0.472
25	0.012	0.000	0.000	0.466
30	0.010	0.000	0.000	0.460
35	0.010	0.000	0.000	0.455
40	0.008	0.000	0.000	0.450
45	0.007	0.000	0.000	0.444
50	0.007	0.000	0.000	0.440
100	0.003	0.000	0.000	0.395

Cont.

Table 5.4.1. Continued. Catch options (t) for West Greenland harvest in 2009, 2010, and 2011 with the probability of meeting management objectives: meeting the 2SW conservation limits simultaneously in the four northern areas of North America; achieving increases in returns from base year average (1992–1996) in the two southern areas; and meeting the MSW conservation limit of the southern European stock complex relative to quota options.

2011				
West Greenland	Simultaneous	Improvement (SF, USA)		Conservation
Harvest	Conservation	of Returns		MSW Salmon
(t)	(Lab, NF, Queb, Gulf)	> 10%	> 25%	Southern NEAC
0	0.027	0.000	0.000	0.356
5	0.024	0.000	0.000	0.353
10	0.022	0.000	0.000	0.349
15	0.019	0.000	0.000	0.345
20	0.018	0.000	0.000	0.342
25	0.016	0.000	0.000	0.336
30	0.014	0.000	0.000	0.333
35	0.012	0.000	0.000	0.329
40	0.011	0.000	0.000	0.324
45	0.010	0.000	0.000	0.320
50	0.009	0.000	0.000	0.315
100	0.003	0.000	0.000	0.274

(Lab, NF, Queb, Gulf) = Labrador, Newfoundland, Quebec, Gulf

(SF, USA) = Scotia-Fundy and USA

A sharing arrangement of 40:60 (Fna) was assumed.

Table 5.4.2. Probability of 2SW returns in 2009, 2010, and 2011 being less than the previous five-year average (2004–2008) returns to regions of North America, relative to catch options at West Greenland.

West Greenland Harvest	2009	2010	2011
Tons	Probability	Probability	Probability
0	0.453	0.451	0.418
5	0.490	0.488	0.452
10	0.526	0.528	0.491
15	0.558	0.562	0.528
20	0.593	0.596	0.563
25	0.626	0.630	0.595
30	0.659	0.657	0.626
35	0.689	0.686	0.655
40	0.717	0.712	0.683
45	0.743	0.737	0.708
50	0.766	0.760	0.734
100	0.918	0.915	0.905

Table 5.8.1.1 Nominal catches of salmon, West Greenland 1971–2008 (metric tons round fresh weight).

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	
1989	337	900	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.
1990	274	924	
1991	472	840	
1992	237	258	Quota set by Greenland authorities
1993		895	The fishery was suspended
1994		137	The fishery was suspended and the quotas were bought out
1995	83	77	
1996	92	174	Quota set by Greenland authorities
1997	58	57	
1998	11	206	
1999	19	206	
2000	21	206	
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

Table 5.8.1.1 cont'd Nominal catches of salmon, West Greenland 1971–2008 (metric tons round fresh weight).

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

Table 5.8.1.2 Distribution of nominal catches (rounded to nearest metric tonne) by Greenland vessels (1977-2008).

	NAFO Division							West	East	Total
Year	1A	1B	1C	1D	1E	1F	NK	Greenland	Greenland	Greenland
1977	201	393	336	207	237	46	-	1420	6	1426
1978	81	349	245	186	113	10	-	984	8	992
1979	120	343	524	213	164	31	-	1395	+	1395
1980	52	275	404	231	158	74	-	1194	+	1194
1981	105	403	348	203	153	32	20	1264	+	1264
1982	111	330	239	136	167	76	18	1077	+	1077
1983	14	77	93	41	55	30	-	310	+	310
1984	33	116	64	4	43	32	5	297	+	297
1985	85	124	198	207	147	103	-	864	7	871
1986	46	73	128	203	233	277	-	960	19	979
1987	48	114	229	205	261	109	-	966	+	966
1988	24	100	213	191	198	167	-	893	4	897
1989	9	28	81	73	75	71	-	337	-	337
1990	4	20	132	54	16	48	-	274	-	274
1991	12	36	120	38	108	158	-	472	4	476
1992	-	4	23	5	75	130	-	237	5	242
1993 [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	5	2	10	2	2	5	-	26	-	26

[1] The fishery was suspended

+ Small catches <0.5 t

- No catch

Table 5.8.2.1. Size of biological samples and percentage (by number) of North American and European salmon in research vessel catches at West Greenland (1969–1982) from commercial samples (1978–1992, 1995–1997 and 2001) and from local consumption samples (1998–2000 and 2002–2008).

		Sample Size			Continent of origin (%)			
Source		Length	Scales	Genetics	NA	(95%CI)[1]	E	(95%CI)[1]
Research	1969	212	212		51	(57,44)	49	(56,43)
	1970	127	127		35	(43,26)	65	(75,57)
	1971	247	247		34	(40,28)	66	(72,50)
	1972	3488	3488		36	(37,34)	64	(66,63)
	1973	102	102		49	(59,39)	51	(61,41)
	1974	834	834		43	(46,39)	57	(61,54)
	1975	528	528		44	(48,40)	56	(60,52)
	1976	420	420		43	(48,38)	57	(62,52)
	1978[2]	606	606		38	(41,34)	62	(66,59)
	1978[3]	49	49		55	(69,41)	45	(59,31)
	1979	328	328		47	(52,41)	53	(59,48)
	1980	617	617		58	(62,54)	42	(46,38)
	1982	443	443		47	(52,43)	53	(58,48)
Commercial	1978	392	392		52	(57,47)	48	(53,43)
	1979	1653	1653		50	(52,48)	50	(52,48)
	1980	978	978		48	(51,45)	52	(55,49)
	1981	4570	1930		59	(61,58)	41	(42,39)
	1982	1949	414		62	(64,60)	38	(40,36)
	1983	4896	1815		40	(41,38)	60	(62,59)
	1984	7282	2720		50	(53,47)	50	(53,47)
	1985	13272	2917		50	(53,46)	50	(54,47)
	1986	20394	3509		57	(66,48)	43	(52,34)
	1987	13425	2960		59	(63,54)	41	(46,37)
	1988	11047	2562		43	(49,38)	57	(62,51)
	1989	9366	2227		56	(60,52)	44	(48,40)
	1990	4897	1208		75	(79,70)	25	(30,21)
	1991	5005	1347		65	(69,61)	35	(39,31)
	1992	6348	1648		54	(57,50)	46	(50,43)
	1995	2045	2045		68	(72,65)	32	(35,28)
	1996	3341	1297		73	(76,71)	27	(29,24)
	1997	794	282		80	(84,75)	20	(25,16)
Local consumption	1998	540	406		79	(84,73)	21	(27,16)
	1999	532	532		90	(97,84)	10	(16,3)
	2000	491	491		70		30	
Commercial	2001	4721	2655		69	(71,67)	31	(33,29)
Local consumption	2002	501	501	501	68		32	
	2003	1743	1743	1779	68		32	
	2004	1639	1639	1688	73		27	
	2005	767	767	767	76		24	
	2006	1209	1209	1193	72		28	
	2007	1116	1110	1123	82		18	
	2008	1854	1866	1853	86		14	

[1] CI - confidence interval calculated by method of Pella and Robertson (1979) for 1984 -86 and binomial distribution for the others.

[2] During 1978 Fishery

[3] Research samples after 1978 fishery closed

Table 5.8.2.2. Reported landings provided by the Home Rule Government at West Greenland Atlantic salmon fisheries (kg) by NAFO Division for the 2002–2008 and adjusted landings for divisions where the sampling teams observed more fish landed than were reported.

		NAFO Division						
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				1595		4979	26 147
	Adjusted				3577		5478	28 627

Table 5.8.2.3 Biological characteristics of Atlantic salmon sampled during the 2007 West Greenland Atlantic salmon fishery.

Distribution of 2008 nominal catch (metric tons) among NAFO Divisions.

Total	NAFO Division					
	1A	1B	1C	1D	1E	1F
26	5	2	10	2	2	5

River age distribution (%) by origin

	1	2	3	4	5	6	7	8
NA	0.9	25.1	51.9	16.8	4.7	0.6	0	0
E	7.0	72.8	19.3	0.8	0.0	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	Fork length (cm)	Whole weight (kg)	Fork length (cm)	Whole weight (kg)	Fork length (cm)	Whole weight (kg)
NA	64.6	3.04	80.1	6.35	71.1	3.82	64.7	3.08
E	63.9	3.03	85.5	7.47	73.0	3.39	64.1	3.07

Biological Characteristics of Atlantic salmon sampled from the 2008 West Greenland food fishery.

Continent of Origin (%)

North America	Europe
86.0	14.0

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

Sea-age composition (%)

	1SW	2SW	Previous Spawners
NA	97.4	0.5	2.2
E	98.8	0.8	0.4

Table 5.10.1. Assessing the objectives of management of the West Greenland Fishery.

Country	Objective	Introduced	Assessment period	Measure Taken	Assessment	Outcome/extent achieved	Further consideration
West Greenland	Reduce harvest and exploitation.	1972	Annually	Quota for the commercial fishery is negotiated, and since 2002 has been zero. Consequently, the fishery at West Greenland has been restricted to that amount used for internal subsistence consumption in Greenland. Licensed fishermen were allowed to sell salmon at the open markets, to hotels, restaurants, and institutions. A private fishery for personal consumption without a license was allowed.	Assessment, reported and unreported landings compared to negotiated catch quotas for the fishery.	There in no Commercial Fishery (quota set at nil). The internal consumption fishery has no quota.	Reporting rate for the internal consumption fishery and reported catch increased in 2008. Estimates of unreported catch are unchanged.
	75% chance of meeting the conservation limits simultaneously in the four northern regions of North America:Labrador, Newfoundland, Quebec, and Gulf.	2001	Annually	As above	Assessment of returns to North America. Run reconstruction to estimate overall returns (Sec. 4.9) related to estimated spawning escapement reserve at West Greenland.	This objective has not been achieved.	Fisheries should be further restricted where they take salmon from stocks which are below Conservation Limits. Examine other limiting factors such as causes of increased marine mortality, habitat quality, predators etc.
	75% chance of achieving increases in returns relative to 1992-1996 with the hope that this leads to the rebuilding Scotia-Fundy and USA stocks.	2004	Annually	As above	Assessment of returns to North America. Run reconstruction to estimate overall returns (Sec. 4.9). Improvements of greater than 10% and greater than 25% relative to returns are evaluated (Sec 4.9)	This objective has not been achieved.	Fisheries should be further restricted where they take salmon from stocks which are below Conservation Limits. Examine other limiting factors such as causes of increased marine mortality, habitat quality, predators etc. Recovery plans developed for the stocks listed as endangered/ at risk.
	75% chance of meeting spawner escapement requirement for the Southern NEAC MSW complex.	2005	Annually	As above	Assessment of returns to Southern NEAC. Run reconsruction to estimate overall returns (Sec. 3.3) related to estimated spawning escapement reserve at West Greenland.	This objective has not been achieved.	Fisheries should be further restricted where they take salmon from stocks which are below Conservation Limits. Examine other biologically limiting factors such as causes of increased or high marine mortality, habitat quality, by-catch, predators etc.

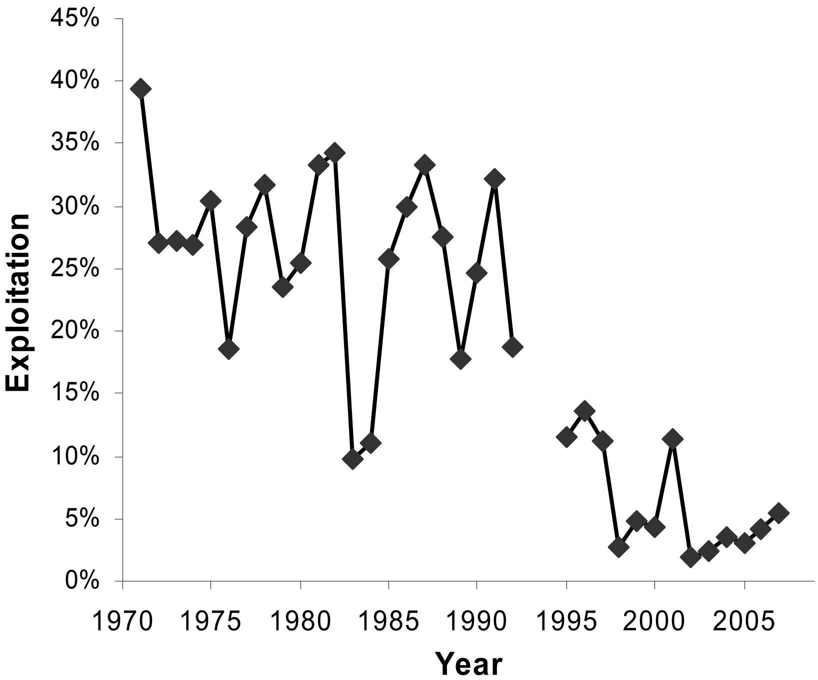


Figure 5.1.1. Exploitation rate for non-maturing 1SW Atlantic salmon at West Greenland, estimated from harvest and PFA of North American non-maturing 1SW salmon.

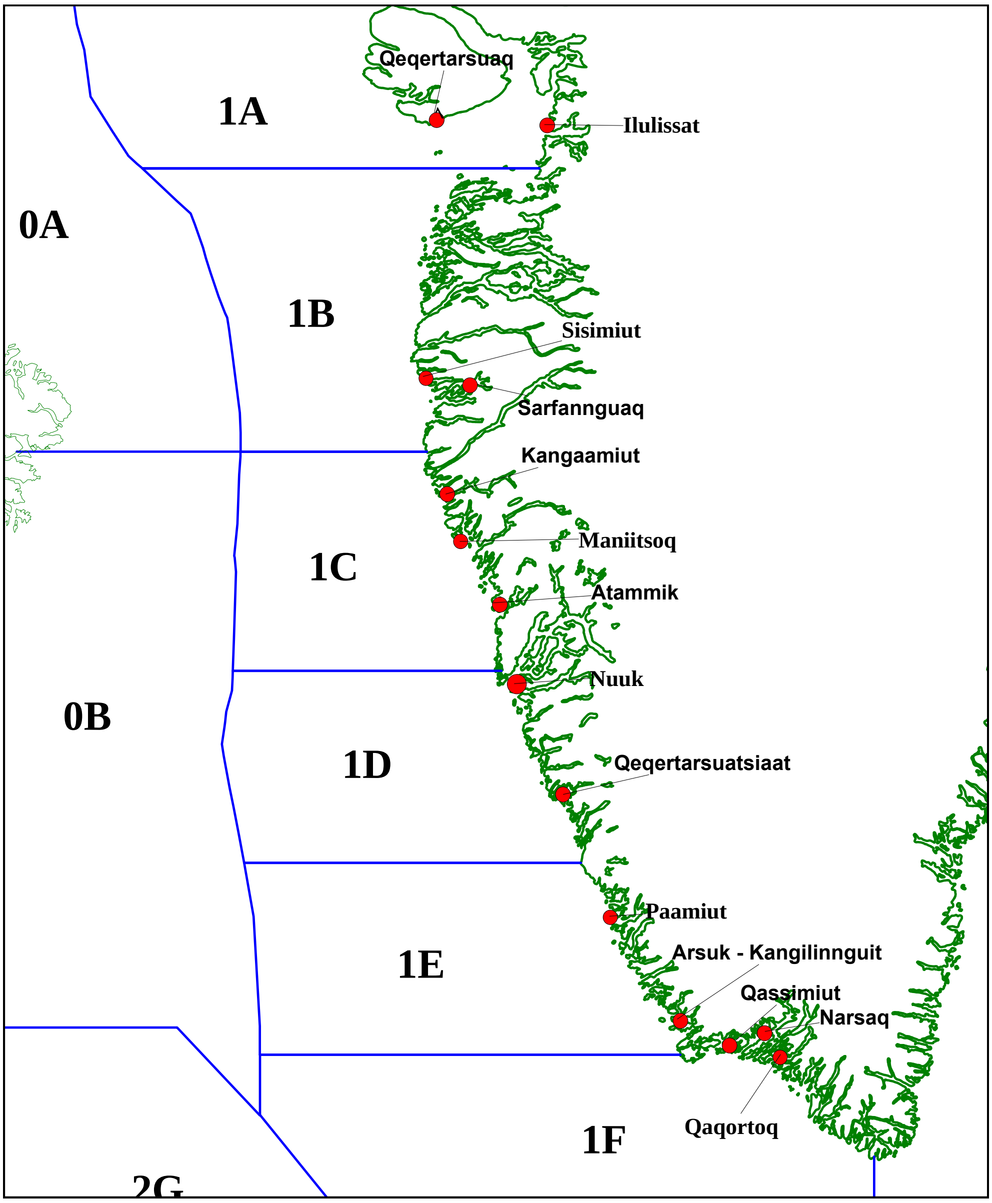


Figure 5.8.1.1. Location of NAFO divisions along the coast of West Greenland.

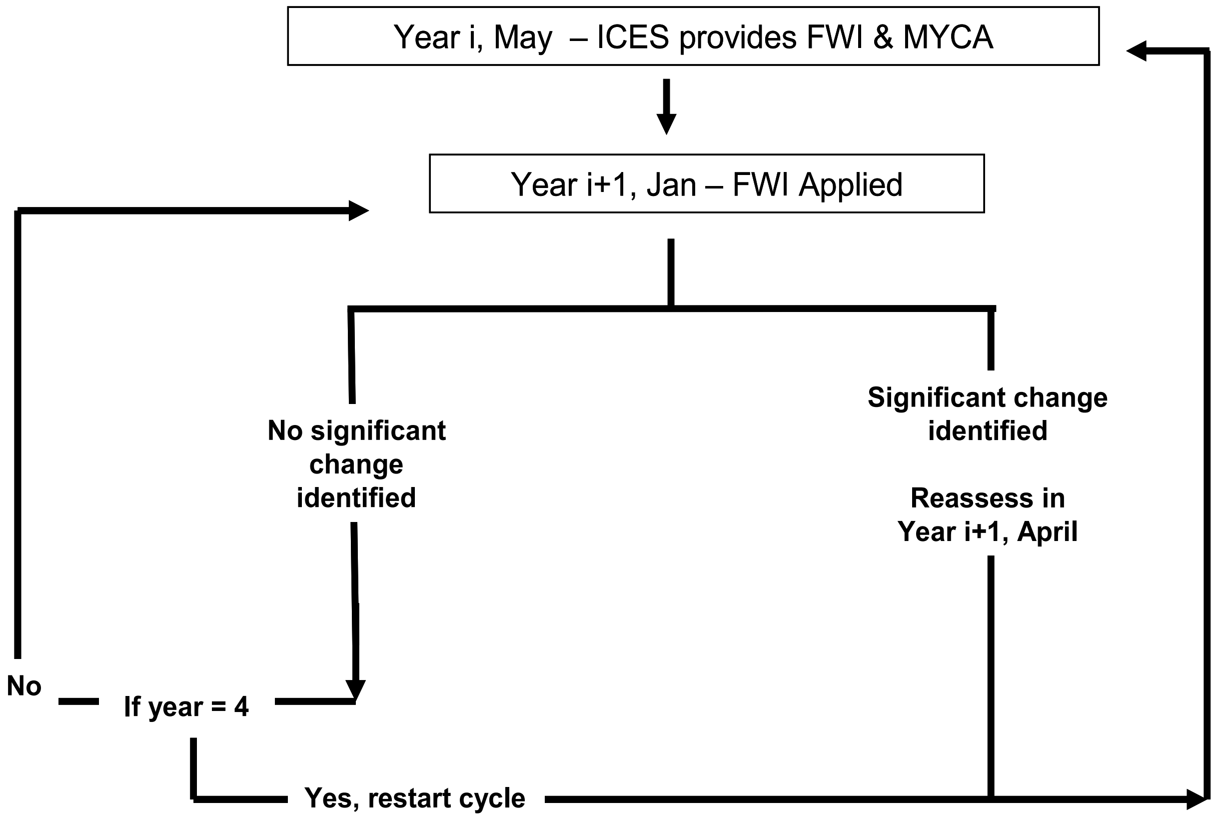


Figure 5.11.1. Suggested timeline for employment of the Framework of Indicators (FWI). In Year i, ICES provides multiyear catch advice (MYCA) and an updated FWI which re-evaluates the updated datasets and is summarized in an Excel worksheet. In January of Year i+1 the FWI is applied and two options are available depending on the results. If no significant change is detected, no reassessment is necessary and the cycle continues to Year i+2. If no significant change is detected in Year i+2, the cycle continues to Year i+3. If a significant change is detected in any year, then reassessment is recommended. In that case, ICES would provide an updated FWI the following May. ICES would also provide an updated FWI if year equals 4.

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

ICES recommends that The Working Group on North Atlantic salmon should meet in 2010 to address questions posed by ICES, including those posed by NASCO. ICES intends for the Working Group to convene in the headquarters of the ICES in Copenhagen, Denmark from 7th April to 16th April 2010.

List of recommendations

1) ICES acknowledges progress on the development of pre-fishery abundance (PFA) modelling approaches inclusive of both NAC and NEAC areas. ICES recommends that the Study Group on Salmon Stock Assessment and Forecasting (SGSSAFE) meet to continue the efforts to:

- develop the models formulated for the NAC and NEAC areas, particularly with regard to combining sea age classes and in the spatial disaggregation below the stock complex level.
- incorporate physical and biological variables into the models that will allow prediction of salmon survival and thus provide a more realistic simulation of the recruitment process and

The Study Group will report back to the WGNAS in April 2010.

2) ICES recognized the work undertaken by the Study Group on the Identification of Biological Characteristics for use as Predictors of Salmon Abundance (SGBICEPS). ICES recommends that a further study group is held to collate additional data from stocks throughout the biogeographical range of Atlantic salmon and to continue with development of hypothesis and subsequent data analysis. Further investigations into the potential associations between biological characteristics of all life stages of salmon, environmental data, marine survival, and measures of abundance should be developed. The Study Group will report back to the WGNAS in April 2010.

3) ICES advises that additional information be requested from fishers in West Greenland. These data will help characterize the nature and extent of the current fishery and should include reference to catch site, catch date, numbers of nets, net dimensions, and numbers of hours the nets were fished.

4) ICES recommends the continuation of the broad geographic sampling programme (multiple NAFO divisions) to more accurately estimate continent of origin in the mixed-stock fishery at West Greenland. The Enhanced Sampling Programme designed for the 2008 fishery should be applied in 2009.

5) ICES noted that the sampling programme conducted in the Labrador subsistence fishery during 2008 provided biological characteristics of the harvest and that the information may be useful for updating parameters used in the Run Reconstruction Model for North America. As well it provides material to assess the origin of salmon in this fishery. ICES recommends that sampling be continued and expanded in 2009 and future years.

6) ICES recognizes that river-specific, regional and international management requires extensive monitoring and recommends expanded monitoring programmes across all stock complexes.

7) ICES recommends that specific management objectives for NEAC be developed in accordance with Section 3.6 to allow ICES to develop quantitative catch advice.

Annex 1 Glossary of acronyms used in this report

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.

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.

CPUE *(Catch Per Unit 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.

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

EU DCR *(The EU Data Collection Regulation)* DCR established a community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy.

FV *(Fishing Vessel)* A vessel that undertakes cruise for commercial fishing purposes.

GIS *(Geographic Information Systems)* A computer technology that uses a geographic information system as an analytic framework for managing and integrating data.

GSI *(Genetic Stock Identification)* Methods used to 'genetically type' salmon from particular regions and rivers across Atlantic.

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 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 allowing the re-establishment of migratory fish species such as salmon.

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

MHC *(The Major Histocompatibility Complex)* MHC is a large genomic region or gene family found in most vertebrates. It is the most polymorphic region of the mammalian genome and plays an important role in the immune system, autoimmunity, and reproductive success. The proteins encoded by the MHC are expressed on the surface of cells in all jawed vertebrates, and display both self antigens (peptide fragments from the cell itself) and nonself antigens (e.g. fragments of invading microorganisms) to a type of white blood cell called a T cell that has the capacity to kill or coordinate the killing of pathogens and infected or malfunctioning cells.

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)* An adult salmon which has spent two or more winters at sea or a repeat spawner.

NLO *(Net Limitation Order)* NLO came into force in UK (England and Wales) to reduce netting effort and phase out various net fisheries.

PFA *(Pre-Fishery Abundance)* The numbers of salmon estimated to be alive in the ocean from a particular stock at a specified time.

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.

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.

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

RT-PCR *(Reverse Transcription-Polymerase Chain Reaction)* is the most sensitive technique for mRNA detection and quantitation currently available. Compared with the two other commonly used techniques for quantifying mRNA levels, Northern blot analysis and RNase protection assay, RT-PCR can be used to quantify mRNA levels from much smaller samples.

RV *(Research Vessel)* A vessel that undertakes cruises to conduct scientific research.

RVS *(Red Vent Syndrome)* The condition, known as RVS, 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.

RW *(The Random Walk)* In the RW hypothesis, the recruitment rates are modelled as a first order time varying parameter following a simple random walk with a flat prior on the first value of the time-series. The model can be used both for retrospective analysis and forecasts.

SAC *(Special Areas of Conservation)* To comply with the EU Habitats Directive (92/43/EEC) on Conservation of Natural Habitat and of Wild Fauna and Flora, which stipulates that member states maintain or restore habitats and species to favourable conservation status, a number of rivers in the NEAC area that support important populations of vulnerable qualifying species have been designated SACs. Where salmon is a "qualifying species", additional protection measures specifically for salmon are required.

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

SL *(The Shifting Level)* The shifting level model supposes that the recruitment rate remains constant for periods of time, with abrupt shifts in the levels between periods. By contrast with the RW model, it is highly flexible because the number of periods, their duration and the corresponding levels of recruitment rates do not need to be specified a priori.

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 for intercepting salmon.

SGEFISSA (Study Group on Establishing a Framework of Indicators of Salmon Stock Abundance) A Study Group established by ICES and met in November 2006.

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.

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

VHSV *(Viral Haemorrhagic Septicaemia Virus)* VHS is a highly infectious virus disease caused by the virus family *Rhabdoviridae*, genus *Novirhabdovirus*.

VIE *(Visual Implant Elastomer)* The VIE tags consist of fluorescent elastomer material which is subcutaneously injected as a liquid into transparent or translucent tissue via a hand-held injector.

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.

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

WKSHINI (*Workshop on Salmon historical information-new investigations from old tagging data*) The Workshop is set to meet from 18–20 September 2008 in Halifax, Canada.

WKLUSTRE *(Workshop on Learning from Salmon Tagging Records)* The ICES Workshop established to complete compilation of available data and analyses of the resulting distributions of salmon at sea. WKLUSTRE will report by 30 November 2009 for the attention of the WGNAS.

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

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