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EXTRACT OF THE REPORT

OF

THE **A**DVISORY **C**OMMITTEE ON **F**ISHERY **M**ANAGEMENT

NORTH ATLANTIC SALMON STOCKS

TO

THE NORTH ATLANTIC SALMON CONSERVATION ORGANIZATION

ICES
Palægade 2–4
DK-1261 Copenhagen K
Denmark

1 INTRODUCTION

The present report has been produced by ICES in response to requests from the North Atlantic Salmon Commission (NASCO). The report has been prepared by the Advisory Committee on Fisheries Management on basis of analysis undertaken by the Working Group on Atlantic Salmon. This report represents summaries of background and conclusions regarding issues on which information has been requested. Details of the underlying analysis and detailed data are available in the report of the Working Group (ICES CM 2003/ACFM:19). The analysis undertaken and the advice given has been subject to independent peer review.

2 REQUESTS FROM NASCO TO ICES

NASCO has requested ICES to provide advice on the following issues (CNL(02)51July 2002). The section in which this request is addressed is indicated in brackets.

a) with respect to Atlantic salmon in the North Atlantic area:
   - i) provide an overview of salmon catches and landings, including unreported catches by country and catch and release, and worldwide production of farmed and ranched salmon in 2002; (4.1)
   - ii) report on significant developments which might assist NASCO with the management of salmon stocks; (4.3)
   - iii) provide long-term projections for stock re-building, focusing on trajectories for restoring stocks to target levels above conservation limits; (4.4)
   - iv) provide a compilation of tag releases by country in 2002 (4.6)

b) with respect to Atlantic salmon in the North-East Atlantic Commission area:
   - i) describe the key events of the 2002 fisheries and the status of the stocks; (5.1, 5.9.1)
   - ii) evaluate the extent to which the objectives of any significant management measures introduced in the last five years have been achieved; (5.9.2)
   - iii) further develop the age-specific stock conservation limits where possible based upon individual river stocks; (5.3, 5.8)
   - iv) 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 conservation limits; (5.4, 5.5, 5.6)
   - v) further refine the estimate of by-catch of salmon post-smolts in pelagic trawl fisheries for mackerel and provide estimates for other pelagic fisheries that may catch salmon; (5.9.3)
   - vi) advise on an appropriate methodology to improve knowledge on the distribution and movements of escaped farmed salmon; (4.5)
   - vii) identify relevant data deficiencies, monitoring needs and research requirements. (4.7)

c) with respect to Atlantic salmon in the North American Commission area
   - i) describe the key events of the 2002 fisheries and the status of the stocks; (6.1, 6.9.1)
   - ii) evaluate the extent to which the objectives of any significant management measures introduced in the last five years have been achieved; (6.9.3)
   - iii) update age-specific stock conservation limits based on new information as available; (6.3)
   - iv) provide catch options or alternative management advice with an assessment of risks relative to the objective of exceeding stock conservation limits; (6.4, 6.5, 6.6)
   - v) provide an analysis of existing biological and/or tag return data, and recommendations for required data collections, to identify the origin of Atlantic salmon caught at St Pierre and Miquelon; (6.9.4)
   - vi) identify relevant data deficiencies, monitoring needs and research requirements. (4.7)

d) with respect to Atlantic salmon in the West Greenland Commission area

i) describe the events of the 2002 fisheries and the status of the stocks; (7.1, 7.9.1)

ii) evaluate the extent to which the objectives of any significant management measures introduced in the last five years have been achieved; (7.9.3)

iii) provide information on the origin of Atlantic salmon caught at West Greenland at a finer resolution than continent of origin (river stocks, country or stock complexes); (7.9.2)

iv) provide catch options or alternative management advice with an assessment of risks relative to the objective of exceeding stock conservation limits; (7.4, 7.5, 7.6)

v) provide a detailed explanation and critical examination of any changes to the model used to provide catch advice and of the impacts of any changes to the model on the calculated quota; (7.8, 7.9.4)

vi) identify relevant data deficiencies, monitoring needs and research requirements. (4.7)

Notes:

1. *In the responses to questions i) under b), c) and d) 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 by-catch of other species in salmon gear and of salmon in any new fisheries for other species is also requested.*

2. *With regard to question b) v), descriptions (gear type; and fishing depth, location and season) should be provided for all pelagic fisheries that may catch salmon post-smolts.*

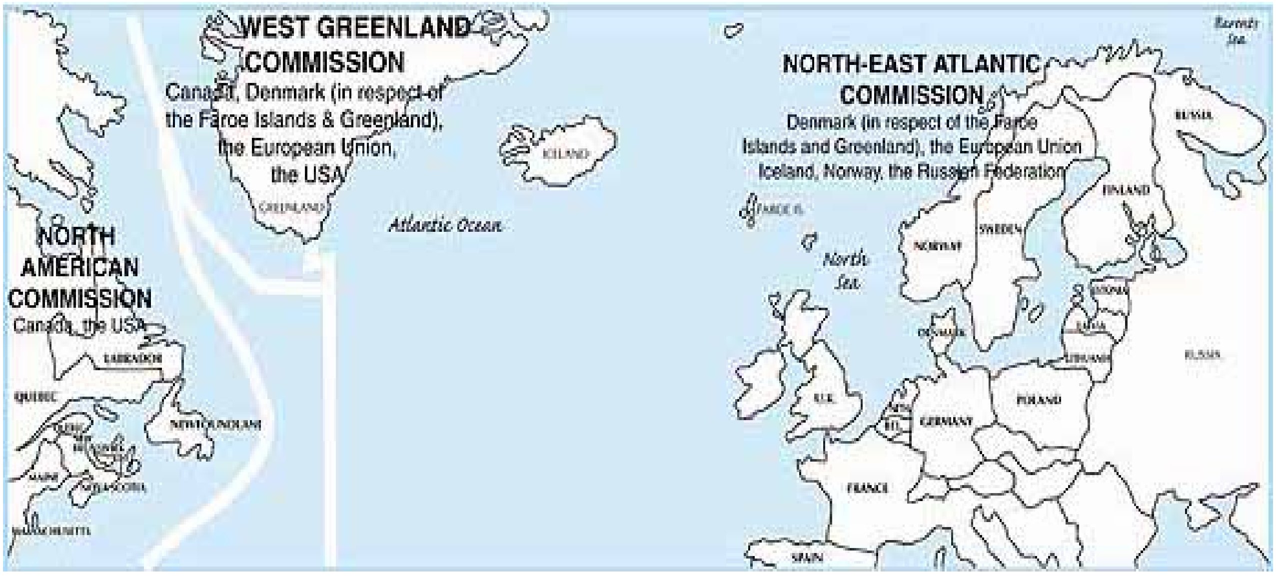
3. *In response to question d) i), ICES is requested to provide a brief summary of the status of North American and North-East Atlantic salmon stocks. The detailed information on the status of these stocks should be provided in response to questions I) in b) and c).*

4. *With regard to question d).v), "changes to the model" would include the development of any new model.*

3 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. While sovereign states retain their role in the regulation of salmon fisheries for salmon originating from their own rivers, distant water salmon fisheries, such as those at Greenland and Faroes, which take salmon originating from 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:



3.1 Management objectives

NASCO (NASCO CNL31.210) has identified the primary management objective of that organisation as:

“To contribute through consultation and co-operation 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’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”.

Conservation limits (CLs) have been defined by ICES as the level of stock that will achieve long term average maximum sustainable yield (MSY), as derived from the adult to adult stock and recruitment relationship. NASCO has adopted this definition of CLs (NASCO, 1998). The CL is a limit reference point (S_{lim}). However, management targets have not yet been defined for N Atlantic salmon stocks. ICES has interpreted stocks to be within safe biological limits only if the lower bound of the confidence interval of the most recent spawner estimate is above the CL.

4 ATLANTIC SALMON IN THE NORTH ATLANTIC AREA

4.1 Catches of North Atlantic Salmon

4.1.1 Nominal catches of salmon

Nominal catches of salmon reported for each salmon-producing country in the North Atlantic are given in Table 4.1.1.1 for the years 1960 to 2002. These catches (in tonnes) are illustrated in Figure 4.1.1.1 for four North Atlantic regions. Catch statistics in the North Atlantic also include fish farm escapees and, in some north-east Atlantic countries, also ranched fish. Reported Catches for the three NASCO Commission Areas for 1994-2002 are provided below:

Area	1994	1995	1996	1997	1998	1999	2000	2001	2002
NEAC	3581	3277	2753	2074	2220	2073	2728	2876	2464
NAC	358	261	294	231	159	154	155	150	152
WGC		85	92	59	11	19	21	43	9
Total	3945	3628	3138	2364	2397	2246	2913	3069	2625

The catch data for 2002 are provisional, but the total nominal catch of 2,625 t is amongst the lowest on record. However, catches in a number of countries were above the recent 5 and 10 year averages.

The nominal catch (in tonnes) of wild fish in 2002 was partitioned according to whether the catch was taken in coastal, estuarine or riverine fisheries. These are shown below for the NEAC and NAC Commission Areas. It was not possible to apportion the small Danish catch in 2002 and this has been excluded from the calculation. The percentages accounted for by each fishery varied considerably between countries. In total, however, coastal fisheries accounted for 57% of catches in North East Atlantic countries compared to 10% in North America, whereas in-river fisheries took 37% of catches in North East Atlantic countries compared to 76% in North America. The percentage of the catch taken in coastal fisheries in the southern part of the NEAC area has increased over recent years, despite reductions in catches and fishing effort. This is believed to reflect the large increase in catch-and-release in rod fisheries.

Area	Coast		Estuary		River		Total
	Weight	%	Weight	%	Weight	%	Weight
NEAC	1378	57	158	6	901	37	2437
NAC	16	10	21	14	115	76	152

4.1.2 Catch and release

Catch and release data have been provided since the early 1990s by 6 countries. In 2002, the percentage of the total rod catch that was released ranged from 16% in Iceland to 80% in Russia. Catch and release rates generally indicate an increasing trend over the last decade and the values reported in 2002 are among the highest in each time series.

4.1.3 Unreported catches of salmon

The estimated unreported catch within the NASCO Commission Areas in 2002 was 1,033 t (Table 4.1.1.1), or 28 % of the total catch (reported and unreported). Unreported catch has comprised a reasonably consistent percentage of the total catch since 1987. The introduction of carcase tagging programmes in Ireland and UK (N. Ireland) in the last two years is expected to lead to reductions in unreported catches in these countries. After 1994 there are no available data on the extent of possible salmon catches in international waters. Limited surveillance flights, which were the basis of past estimates of catches in international waters, have not reported any such salmon fishing in recent years. Estimates (in tonnes) of unreported catches for the three Commission Areas for the period 1994-2002 are given below:

Area	1994	1995	1996	1997	1998	1999	2000	2001	2002
NEAC	1157	942	947	732	1108	887	1135	1089	940
NAC	107	98	156	90	91	133	124	81	83
WGC	<12	20	20	5	11	12	10	10	10
Interntl. waters	25-100	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Expressed as a percentage of the total North Atlantic catch, national unreported catch estimates range from 0% to 15%. However, it should be noted that methods of estimating unreported catch vary both within and among countries. The non-reporting rates range from 2% to 64% of the total national catch in individual countries. An allowance for unreported catch is included in the assessments and catch advice for each Commission area.

4.1.4 Production of farmed and ranched salmon

The production of farmed Atlantic salmon in the North Atlantic area was 705,307 t in 2002, a small increase over 2001 (697,679 t), but 15% above the average of the past five years (610,716 t). Most of the production in the North Atlantic took place in Norway (62%) and Scotland (23%). Production increased over previous years in most countries; in relation to the average of the past five years reported increases ranged from 9% in Norway to 43% in the Faroes. However, production fell by around a half in both Iceland and the USA.

The world-wide production of farmed Atlantic salmon in 2002 topped one million tonnes for the first time. Total production was estimated at 1,058,307 t, an increase of 30% compared with 2001 (Figure 4.1.4.1). Production outside the North Atlantic area increased by 74% on 2001 to 353,000t; Chile was the biggest producer, accounting for 273,000 t. Overall, world-wide production of farmed Atlantic salmon in 2002 exceeded the reported nominal catch of Atlantic salmon in the North Atlantic by over 400 times. As a result, farmed salmon dominate world markets.

Catches of ranched salmon have declined substantially from a high of over 500 t in 1993 to around 10 t in 2002 (Figure 4.1.4.2). This is due to the cessation of salmon ranching in Iceland from 1999.

4.2 Update on the estimation of natural mortality at sea of Atlantic salmon

4.2.1 Methods and estimates of natural mortality (M) at sea

In 2002 the ICES endorsed the inverse-weight method as the basis of estimating M and determined that the most appropriate growth function for use with inverse-weight method was linear rather than the previously used exponential function. This change in growth function, plus analysis of data from additional rivers, resulted in the instantaneous monthly mortality rate used in the run-reconstrunction model for the North American and NEAC areas to be changed from 0.01 to 0.03. Details of the methods used and choice of preferred method are given in ICES CM 2002/ACFM:14.

ICES reviewed an analysis of a more extensive data set from 5 rivers on the NEAC area and 6 rivers in the NAC area. The rivers with suitable data extended from the Scorff (France) to the North Esk (Scotland) and north to the Vesturdalsa River (Iceland). On the North American side, hatchery and wild stock data sets extended from the Scotia-Fundy region to the north shore of the St. Lawrence (Quebec). The time period analysed was from 1981 to 1999 in the NEAC area and 1970 to 1999 in the NAC area.

The analysis of the river-specific growth data supported the previous conclusion that a linear function characterized the observed weights at age in the marine phase better than the exponential function. The estimates of integrated monthly mortality in the second year at sea ranged from 1.4% to 4%, increasing from south (Scorff in France) to north (Vesturdalsa in Iceland). The mortality rate on the hatchery stock (Shannon River) was higher than on the wild stocks of the southern NEAC area.

For North America, the monthly mortality rates in the second year at sea ranged from 1.5% (de la Trinite River) to a high of just under 8% for the wild stocks but ranging to just under 10% for the hatchery stock of the LaHave River (Figure 4.2.1.1). The hatchery stock mortality rates were higher than the wild stock mortality rates.

ICES acknowledged that the additional analyses confirmed the previous conclusion that monthly mortality in the second year at sea was greater than 1% and distributed around 3%, at least for the wild fish. There are important differences among stocks and even regions which are not accounted for in the generalization over the entire NEAC and NAC areas.

4.3 Significant developments towards the management of salmon

4.3.1 Trends in sub-catchment populations of salmon in the River North Esk, UK (Scotland)

Ideally, management units should correspond to the way in which the salmon resource is structured. Our current understanding of the population structure of salmon returning to rivers in UK (Scotland) has been informed by a number of scientific investigations. Long term tagging studies associated with fish traps on upper catchment tributaries suggest that homing units, or populations, are spatially distributed over distances as small as ca. 10km and that, within each sea age class, early running salmon tend to spawn in the upper areas of catchments while later running salmon, spawn in the lower reaches. This pattern is consistent among a range of river types (eg. large/small, complex/simple). Thus, run-timing is related to spawning destination, and furthermore, run timing has been shown to be a heritable attribute (Stewart *et al*, 2000).

On the North Esk, on the east coast of Scotland, a fish counter allows a direct count of adult fish past a particular point on the lower reaches of the river throughout the year. Such counts, together with the catch data from local fisheries allows estimates to be made of the fishery performance and stock levels at identifiable points within the lower river. Further, partitioning these counts and catches into seasonal components, permits such assessments to be made at sub-catchment scales. In the current study, trends in the fisheries and stock of the North Esk were assessed at a whole river level and for four age/seasonal run-timing components (early 1SW, late 1SW, early MSW and late MSW) for the period 1981-2001.

Analysis of annual count and catch data at whole river level shows that there has been a decreasing trend in the abundance of North Esk salmon to coastal waters, and similar decreasing trends in exploitation and catch, resulting in a stable number of salmon entering the river. Decreasing trends in in-river exploitation and catch have resulted in an increasing trend in potential spawners.

Although it was not possible to estimate the abundance of each seasonal component in coastal waters, analysis of the trends in abundance, exploitation and catch in the lower river for each of the four age/seasonal components of the stock suggest that there has been no trend in abundance over the study period. However, the significance of the observed downward trends in lower river exploitation varies among the groups and as a result, increasing trends in the upper river abundance are significant for only the early 1SW and early MSW components. Due to the absence of any significant trends in exploitation and catch in the upper river, the increasing trends in lower abundance for the two early running components are also evident in the estimated abundance of potential spawners.

In summary, the results show that although the overall abundance of North Esk salmon returning to coastal waters has decreased, reduced exploitation has resulted in an increasing trend in the abundance of potential spawners. Further, local management actions to protect early running fish, the stock component thought to be most at rapidly declining (Youngson *et al*, 2002), appear to be having some effect. More generally, the analysis illustrates that trends in the abundance may vary among different stock components within a river system, as will the results of management measures that are implemented non-uniformly over a fishing season. There is thus a need to develop assessment methods that operate at scales that more closely mirror the population structure within river systems.

4.3.2 *Gyrodactylus salaris* in Sweden

The monogenean parasite *Gyrodactylus salaris* spread from the Baltic region to Norwegian rivers in the 1970s and its devastating impact on Norwegian wild salmon is well known (Johnsen and Jensen 1991). However, the effects of the parasite on Swedish west coast salmon have not been well described. The parasite was first found in this region in 1989 and since that time it has spread gradually. By autumn 2002, 11 out of a total of 23 wild salmon rivers harboured the parasite. These rivers are mainly located along the southern part of the Swedish west coast. A programme implemented to monitor the spread of the parasite to new rivers has been gradually improved, and parasite infestations in three infected rivers are also monitored annually.

Evidence that the parasite has had a negative impact on salmon in the region comes from trends in parr densities over time in infected and uninfected populations. In uninfected rivers, densities of older salmon parr, and to a smaller extent also 0+ parr, have generally been trending upwards between 1988 –2002, whereas in the same time period a number of infected rivers have had exhibited significant downward trends in parr densities. However, other factors such as low water discharges, may be partially responsible for the observed decreases.

A large scale survey of the parasite in the Baltic river Torneälven in 2001 revealed that the parasite was common on salmon parr. This was in contrast to earlier investigations. The prevalence and intensity varied among different parts of the river (from 0% infected to 100% infected with up to 330 parasites per fish) which suggested that earlier studies on geographically limited scales studies may not have been able to adequately describe infestation levels. It is also possible that the abundance of the parasite has increased in recent years, when the parr densities in most Baltic rivers have increased dramatically, boosting the probability of transmission. It is not known if the parasite is also common in other Baltic salmon rivers.

In the last few years Sweden has begun to take the threat of the parasite more seriously, and infection with *Gyrodactylus salaris* became a notifiable disease in Sweden in 2002. There are also regulations concerning the release of fish in non-infected wild salmon rivers of the west coast. Releases of fish are allowed if they are from a hatchery free of the parasite. At this time it is also allowed to treat infected fish to kill the parasites before release, but this option is under debate and may be abolished.

4.3.3 Considerations for examining the effects of fisheries on biological characteristics of Atlantic salmon stocks

In 1984, the commercial fisheries of the Maritime provinces (Canada) were closed and anglers were prohibited from retaining large salmon (>= 63 cm fork length). The Newfoundland commercial fisheries were closed in 1992, in 1998 in Labrador, and by 2000 in all of eastern Canada. Fisheries can be selective for particular sizes of fish, because of the gear being used, or selective to particular run components because of restrictions in seasons. As a result responses to fisheries in addition to returns and spawners may be evident in other features of the salmon stock such as :

Returns as indicators of stock responses to variations in fisheries exploitation:

b) Egg depositions and juvenile abundance:

For both of these indices the analyses indicated variations in responses following the closure periods but no consistant pattern was evident for all areas potentially benefiting from the closures.

c) Increases in occurrence, abundance and return rates of repeat spawners:

Atlantic salmon returning to the Miramichi have been sampled during the entire spawning migration period at estuary trapnets from 1971 to 2002. After the closures of the commercial fisheries in 1984 and the mandatory release of all large salmon, the relative proportion and the absolute abundance of repeat spawners in the returns of large salmon have increased. Since 1995, salmon with six previous spawnings have been observed in the returns to the Miramichi and salmon on the third to fifth spawnings are more abundant since 1992 (Figure 4.3.3.1). There are fewer repeat spawner components in the Saint John River than in the Miramichi and there has not been any change in relative proportions over time as was seen in the Miramichi. The post-spawner survival in the Saint John River is likely constrained by downstream fish passage through 2 to 3 hydro-generating facilities which cannot be managed like the fishing exploitation rates on the Miramichi stock. For the Saint John River, therefore, reduced fisheries exploitations have not resulted in improved post-spawner survivals.

In addition to being more abundant in recent years, repeat spawners from the Miramichi grow substantially between spawning events and 1SW maiden salmon on their second spawning are as large as 2SW maiden fish and 2SW salmon are as large or larger than comparative 3SW salmon in other rivers. These larger fish of proportionally greater abundance in the river are of interest to the recreational fishermen, produce more eggs per fish than maiden spawners, and provide a buffer to the annual spawning escapement when smolt to maiden spawner survivals are low.

d) Change in size-at-age resulting from size-selective fishing:

Salmon fishing gears are potentially size-selective. In the Miramichi, the mean size of 2SW salmon increased in 1986. The 2SW salmon from 1999 to 2002 are the largest of the time series. The mean size of the 1SW salmon of the last four years is the largest of the time series and the change in size was also first observed in 1986. An increase in mean size of 1SW salmon was observed in the Nashwaak River where mean size in 1972 and 1973 was 53-54 cm in contrast to the 56-58 cm mean size in the 1990s. In the Saint John River, the mean size of 1SW salmon averaged between 58 and 59 cm prior to 1986 and increased from 60 and 62 cm since. The change in mean size occurred in 1986 in both the Saint John and Miramichi samples when the commercial fisheries were supposedly closed in 1984. It is possible that exploitation with nets was still taking place on these stocks in 1984 and 1985.

e) Variations in run-timing:

Many historical commercial fisheries were prosecuted early in the season and frequently not in proportion to the timing of the fish entering the river. Evidence of the effect of fisheries exploitation in coastal waters relative to the time of entry of salmon to rivers is available from the Millbank index trapnet in the Miramichi River. The date of the 50th percentile of the count of large salmon at Millbank in the 1950 and 1960s was post Sept. 1 and it got rapidly earlier in 1970 to 1972 to the end of June or middle of July. Since 1984, the date of the median count has varied between the end of June and the end of August while in the 1990s,the median date oscillated around mid-August. Run-timing of both small and large salmon is currently bimodal with a peak in July and a second peak in late September.

f) Indications of homewater effects relative to variations in high seas exploitation:

The fishery at West Greenland exploits predominantly 1SW salmon destined to mature and return as 2SW salmon the following year. Significant associations between 1SW salmon returning to rivers in any given year and 2SW salmon returns the following year have been reported, which suggests that there is an underlying stock-specific average maturation schedule for 1SW and 2SW age groups. Deviations from the relationship would result from disproportionate variations in first year and second year mortalities both natural and fisheries induced (because the fishery exploits one age group and not the other), changes in maturation profiles of males and females leading to deviations from average 1SW/2SW relationships (as influenced by the environment, for example). If a fishery exploits the 2SW age group but not the 1SW age group, then the 1SW/2SW ratio should be unnaturally high. If fisheries exploit 1SW age group preferentially, then the 1SW/2SW ratio would be unnaturally low. The absence of exploitation on one age group can be used to assess the relative impacts of the fishery on the other age group. Since 1992, there is essentially no exploitation on 1SW salmon in the marine environment. Variations in 2SW returns to eastern Canada, but specifically variations from the 1SW/2SW relationship, may be exaggerated by variations in fisheries harvests at West Greenland.

This effect was examined using data from the LaHave River, Saint John River at Mactaquac, and the Miramichi River. In both the LaHave and Southwest Miramichi relationships, the 2SW returns in 1993 are exceptionally low relative to the 1SW returns in 1992. There is a negative association between the level of harvest at West Greenland and the difference from expected (based on the 1SW/2SW relationship) in the 2SW returns (Figure 4.3.3.2). For all rivers and stocks (wild, hatchery) examined, the correlation coefficient of GN1 was consistently negative.

For the Southwest Miramichi, Northwest Miramichi, and LaHave River wild salmon, including Greenland catch of North American origin 1SW salmon resulted in a reduction in the residuals of the 2SW prediction. For the Nashwaak River and the hatchery salmon from the Saint John River, consideration of the Greenland harvest did not contribute to describing the variations in 2SW return corrected for variation in 1SW return the previous year (Figure 4.3.3.2). Variations in high seas exploitation at Greenland can be detected in the returns of 2SW salmon in home waters in the Maritimes, but only after correcting for the 1SW abundance of the same cohort.

4.3.4 Data Storage Tag (DST) tagging of pre-adult salmon

As part of a Nordic DST tagging programme started in 2002, a new salmon trawl design and a modified "Fish-lifter" (after Holst & McDonald 2000) was developed for the live capture of fish in post-smolt and mackerel investigations in the Norwegian Sea This was used by Norway, Faroes and Iceland to capture fish for tagging with DSTs during 2002-2003. The modified "Fish Lifter" allows most of the salmon to be taken with little or no external damage, making the catch fit for tagging and release.

Faroese and Icelandic research vessels captured a significant number of large "autumn" post-smolts/ pre adults during late October 2002 to January 2003. As the Norwegian research vessel was fishing in the mid part of the Norwegian Sea in June and July, the catches of adult salmon were low, although a large number of post-smolts were taken. In the summer, however, the post-smolts were too small to be tagged with the DSTs available (38.4 x 12.5 mm).

The tags were placed in the body cavity of the salmon through a small incision above the pelvic fins. Two types of tags were used, an "I- button" tag (Dallas Semiconductor) recording only temperature (memory capacity approx. 12,000 recordings) and a depth and temperature recording tag with a memory capacity of 21,738 measurements per parameter (Star Oddi "Micro"). The tags will record these parameters for two years during the time lapse from tagging to retrieval of the tags. The temperature regime encountered and the vertical migration patterns of the salmon can thus be followed for the marine feeding cycle, and in most cases also for the homing back to the river.

A total of 197 post-smolts, pre-adults (fish < 45 cm) and 26 adults were taken; 76 of these were tagged with the "Micro" tags, and 51 with "I-buttons". About 50 % of the 17 adult salmon taken in the Norwegian cruise were fish farm escapees or maturing fish. This, together with the low number captured indicates that the areas around the Voering Plateau probably were surveyed too late to allow for sampling the densest cohorts of wild adult immature fish anticipated to be migrating northwards through these waters. One of the four fish tagged in the Norwegian Sea, turned up 18 days later in the bag net fishery in the Nansenfjord, Norway- a distance of ~ 480 km. The salmon taken in the Faroese tagging expedition were dominated by fish with 2 year smolt age, while 3 year and 1 year smolts made up ~ 20% and ~10 % respectively of the material analysed. In the Icelandic expedition, one fish carried an Irish microtag. All DST tagged fish were adipose fin clipped, but in the Icelandic expedition they were tagged with external tags (Floy tags) in addition. Once the fish are opened, the DST tags will be easily visible due to a fluorescent plastic tube attached to the tag body. The DSTs have a contact address and a reward announcement.

These results represent a breakthrough in marine tagging of pre-adults and adults. Once the tags start to be returned expectedly starting with the fishing season in 2002, they will yield results of significance for the knowledge of the marine life cycle of the salmon.

4.4 Long-term projections for stock rebuilding

Trajectories for stock rebuilding depend on many parameters which are not known with certainty or which may change over time. It is not possible to establish generalised trajectories for all stocks contributing to national or continental stock complexes as the range of uncertainty, both presently and in the future would lead to spurious projections over time on these larger scales. This is because the rate at which a stock complex will recover depends on the existing productive capacity of each individual stock under the prevailing conditions e.g. of exploitation, marine survival and effective intervention. Therefore, ICES considered theoretical rebuilding trajectories for stocks with known stock and recruitment parameters and the probability of extinction under different circumstances for some stocks in the USA which are well below their conservation limits. An example of a large-scale international stock rebuilding programme for Baltic salmon stocks is also provided to illustrate the rate of recovery of stocks currently undergoing restoration and rebuilding.

4.4.1 Recovery trajectories for reductions in exploitation of Atlantic salmon across a range of stock recruitment functions and uncertainty

Stock and recruitment curves representing highly productive stocks through low productive stocks were applied to a forward projecting stochastic framework that could produce recovery trajectories for a variety of states and exploitations. The purpose of this exercise was to estimate recovery times and frequency of achieving conservation over a 50 year time frame under a range of exploitation.

Parameters for Ricker stock and recruitment functions were obtained from SALMODEL (Anon 2003, Table 4.2) for the rivers Bush, North Esk and Nivelle. Although no North American river examples are presented, the H' parameters (exploitation at optimum spawning stock abundance) were within the known range of 11 North American rivers. Similarly, the age structure of the River Esk population is only out of phase by 1 age class compared to many North American stocks.

Projections were dependent on partial recruitment vectors particular for the river i.e. age structure, relative fecundity and mortality. A fully recruited age structure (i.e. all age classes expected are present and in the correct proportion) is assumed prior to initialisation of the model. Therefore, obtaining recruits for 7 years (the longest period required to obtain complete recruitment) initializes projections at the selected starting stock size before accumulating recruits for any trajectory. Error in trajectories was introduced by selecting a new value of *alpha* and *beta* for each year from the normal distribution of H' and the log normal distribution of R' reported. The reported stock recruitment scale was eggs*m^{-2}. Preliminary exploration of the models indicated the need for an egg density cap to constrain depositions in the stochastic trajectories. This was accomplished by constraining alpha to values less than 20.

Starting spawning stock sizes were 10% of S_{lim} and 50% of S_{lim}. Projections were run using exploitations of 0% (no exploitation), 50% of the current river exploitation, at the current exploitation rate and at H'. Forward simulations were run 10,000 times in an @Risk© framework in Excel© and the aggregated output collected to produce a trajectory with mean and variance for each year. The number of years required to rebuild to S_{lim} as well as the number of years during the 50 year projection below the S_{lim} were recorded for each simulation.

The alpha determinations ranged from a high of 14.93 for the Bush River, 2.13 for the North Esk and a low of 1.85 for the Nivelle (Table 4.4.1.1). Projections typically resulted in occasional highs and lows in a single trajectory however the 90% range of values generally followed the deterministic function (Figure 4.4.1.1). The years to recovery ranged from 1 to 50 years, the limit of the projections (Table 4.4.1.2); (Figure 4.4.1.2).

The proportion of years with values lower than S_{lim} ranged from 0.13 to 1 depending mostly on alpha and exploitation. This proportion for populations at less than S_{lim} and at H' was 0.49 for the high alpha, which is the expectation for a productive population managed at H' and based on well-defined parameters (Table 4.4.1.3). However, at lower alpha the frequencies were much greater (0.97 and 1) indicating high sensitivity of S_{lim} to variance in the parameters at low alpha values.

The number of years to recovery was unobtainable in fifty-year projections in a low productivity and possibly unobtainable in a moderate productivity river. This was because the recovery time in years was more dependent on the value of alpha (productivity) than the start point. The time to recovery and the proportion of annual recruitment less than the S_{lim} increased with lower productivity and the starting point. Recovery was particularly sensitive to increasing exploitation at lower alpha.

The data and analysis indicate that there is an increased probability of not achieving S_{lim} with increased exploitation and lower alpha. The model did not incorporate demographic stocasticity i.e. uncertainty in sex ratio, fecundity etc. or environmental stocasticity i.e. annual variations in survival that could eliminate a year class at low populations, that can lead to extirpations. Therefore while this model may not be a reliable indicator of population viability, it can provide reasonable indications of management actions concerning S_{lim} and exploitation. The analysis suggests that increased caution needs to be taken when assigning exploitation to low productivity stocks. It also suggests that current management strategies for mixed stock fisheries are likely to fail to protect "the weakest link" i.e. those stocks that are far below their S_{lim} and of low productivity. Similarly, expected contributions to rebuilding from restocking programmes may also be confounded by prevailing low levels of marine survival, high or variable exploitation rates and even negative interactions between hatchery reared fish and their wild counterparts (McGinnity et al, 1998, Ferguson et al, 2002).

4.4.2 Atlantic salmon population viability analysis for Maine (USA) distinct population segment

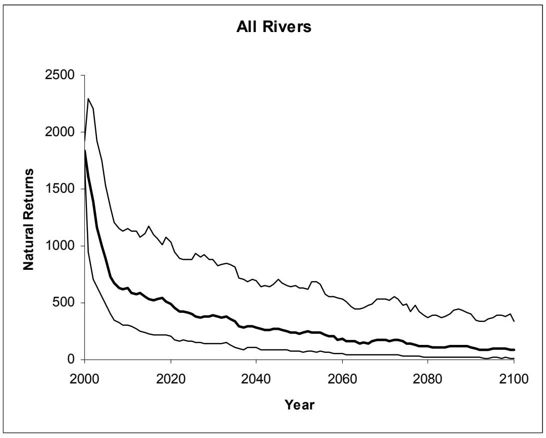
A population viability analysis (PVA) model has been developed for Atlantic salmon in Maine. This model incorporates uncertainty in juvenile and adult survival rates, direct and indirect linkages among populations in different rivers, and a number of potential human removals or stocking in a flexible, modular Fortran program named SalmonPVA. The structure of the model is based on a state-space approach with a detailed life history cycle. Multiple cohorts in multiple rivers progress through their life history based on stage specific survival rates and fecundity with limits imposed by riverine habitat capacity. The model projects the populations forward in time, usually 100 years, numerous times with stochastic variables selected based on a Monte Carlo approach to calculate the probability of extinction. Results from this model will form the basis for delisting criteria in the Recovery Plan for the Maine Distinct Population Segment which was listed as Endangered in 1999.

The SalmonPVA model was run using example ranges of survival rates for all life stages under conditions of no stocking and initial population sizes set at the conservation spawning escapement levels (CSE) for the eight rivers in the Maine DPS. Assumptions were made regarding straying, fishing, broodstock removal, etc. to demonstrate the bottom line predictive power of the model. Projecting the populations for 100 years for 10,000 iterations produced a low probability (0.2%) of all eight rivers going extinct, with high probabilities (45-84%) of individual rivers becoming extinct (see text table below).

Probability of extinction when all rivers seeded with CSE levels of 2SW returns, no stocking occurs, and example ranges of survival by life stage are assumed.

Rivers : DE=Dennys, EM=East Machias, MC=Machias, PL=Pleasant, NG=Narraguagus, CB=Cove Brook, DT=Ducktrap, SHP=Sheepscot

River	Probability
DE	18.2
EM	12.2
MC	6.1
PL	27.9
NG	6.7
CB	83.7
DT	44.7
SHP	18.3
ALL	0.2



Although the probability of extinction for all eight rivers combined is low, examination of the time trend during the 100 year projection shows that the combined returns are continuing to decline and may go extinct if more years were projected (see panel above).

4.4.3 Baltic Salmon Action Plan

The Baltic Salmon Action Plan (SAP), launched by the International Baltic Sea Fishery Commission (IBSFC) in 1997, aims to prevent extinction of wild salmon populations, to increase the natural smolt production of wild Baltic salmon to a level of 50% of the estimated potential capacity in each salmon river selected for the programme by 2010, and to re-establish wild populations in potential salmon rivers (Ranke 2002, www.ibsfc.org). A central element of the SAP was the reduction of the annual TAC in accordance with the SAP objectives, from the level of 760 000 salmon in early 1990’s to a range of 510-540,000 salmon since 1997. Other measures taken to reach the SAP targets include stocking programmes, freshwater habitat restoration and national fishery regulations.

Some national restrictions of fishing effort in the Gulf of Bothnia have been launched in both Sweden and Finland, but the most significant development has been since Finland introduced the new temporal regulations for the Gulf of Bothnia coastal trap net fishery in 1996. After this the wild salmon stocks of many of the northern wild salmon rivers in Sweden and Finland have improved substantially (Romakkaniemi et al. 2003). In a recent EU Study project, the effects of fishing mortality on the returning salmon were modelled and it was shown to have reduced substantially after the coastal fishery regulations were introduced (Anon. 2002). As an example, the salmon catch in the River Tornionjoki, a border river between Finland and Sweden, increased three-to fivefold in 1996-1997 compared to the levels of the early 1990’s. As well as the increased catches, the juvenile salmon (0+) densities also showed a marked increase as the mean density in 1998 was 30-fold higher than in early 1990's. Wild smolt production (Ranke 2002), has also increased substantially, and the estimated smolt run in e.g. Rivers Tornionjoki and Simojoki (Finland) have exceeded the 50% SAP reference level during the past three years (2000-2002). The increase in the wild smolt production was thus detectable after only four years following the corresponding management actions taken. It should be emphasised that this fast recovery was possible when the reduction in fishing mortality coincided with the return of the fish from the strong brood-year class of 1990 (Ranke 2002, Romakkaniemi et al. 2003).

The positive development in the Baltic salmon stocks has, however, been most pronounced in large, wild salmon rivers in the northern Gulf of Bothnia. Many potential salmon rivers in the Gulf of Bothnia have shown little or no signs of recovery. The status of many potential rivers prior to the SAP was very different from the wild salmon rivers, as the stocks were completely extinct and stock rebuilding started from introducing salmon from nearby stocks. The slow development in these rivers compared to that of the wild rivers can be attributed to several factors, ranging from genetic adaptation of the introduced stocks to smaller scale local problems in freshwater environment and fishery management (Erkinaro et al. 2003).

Direct extrapolation of the results from the Baltic SAP to Atlantic salmon situations would require more in-depth comparison of the underlying dynamics (i.e. mortality rates, exploitation rates and productivity) which may be very different. Despite this, it is clear that stock rebuilding is feasible and significant increases in wild stocks can be achieved over a short time frame provided the initial productivity is sufficiently high. Rebuilding from low productivity or even restoring extinct stocks appears to pose similar difficulties in both the Baltic and Atlantic areas. In this regard, the theoretical approaches presented in the previous two sections result in predictions which are consistent with the actual outcome from an ongoing stock rebuilding programme and illustrate the difficulties in rebuilding salmon stocks when stock levels fall below $S_{lim.}$ ICES therefore notes that in the provision of advice S_{lim} (MSY) point is the most appropriate limit reference points for Atlantic salmon populations.

4.5 Distribution, behavior and migration of farmed salmon

4.5.1 Methodology to improve knowledge on the distribution and movements of escaped farmed salmon

Farmed salmon that have escaped from sea cages can easily be identified in fisheries and stocks, but it is more difficult to detect fish that escaped as parr or smolt. Sampling and examination of salmon in marine areas at different times of the year, especially in areas that have not been sampled before, would improve the general knowledge of the spatial and temporal distribution of farmed salmon.

At present it is difficult to determine from which country or area farmed fish caught in the ocean originated from. To approach this problem, it would be feasible to tag farmed fish, conduct experimental "escapes", and determine the ultimate fate of the fish. Recoveries could come from existing fisheries, and planned scientific sampling programmes. A number of different tags and tagging procedures could be used, including:

- External tags (Carlin, Lea, Floy, etc.)
- Visible implant tags (including visual implant elastomers)
- Coded wire tags (CWT)
- Passive Integrated Transponder (PIT) tags
- Sonic tags
- Data storage tags (DST)
- Genetic tags
- Physiological tags (otholith marking, trace elements in bones and otoliths, fatty acids, etc.)

External tags can be reliably detected in fisheries and scientific sampling programmes. Visible implant tags can be recovered in sampling programmes, but may be difficult to detect for fishermen.

CWT tags are cheap, easy and quick to apply, and suitable for large numbers of fish. They can be easily detected providing an additional external mark is applied, but the removal of CWTs is time consuming. They are usually detected in scientific sampling programmes. In Iceland a mandatory 10 % of the farmed salmon released to coastal net pens are required to be CWT tagged.

PIT tags are easy to implant and detect, but have to be recovered in sampling programmes.

Sonic tags can be used to examine the behaviour of escaped farmed salmon following their escape providing the fish remain within receiver detection range. Fish can be actively tracked, or detected at fixed locations where receivers are moored, however detection ranges may be short (500m). Acoustic tags and equipment are very expensive, which limits the number of fish that can be marked and released.

Data storage tags are new technologies, and are still expensive. However, information on the behaviour (postion, environmental conditions, movements) of the recovered fish will be significant. Tagged fish can be recovered in sampling programmes or by fishermen.

Genetic and physiological tagging are new methods that can be used for mass marking. However, ”tagged” individuals have to be recovered in sampling programmes, and the marks are expensive to identify.

4.5.2 Experimental tagging programme for investigating the behaviour of escaped farmed salmon

To test the hypotheses that salmon escaping from fish farms in the Northeast Atlantic are homeless, transported with the currents, enter fisheries and rivers in other countries than the one they escaped from, or are lost in the Arctic, several tagging programmes using different tag types could be developed. Below a simple programme using individually numbered external tags that can be recovered both from fishermen and in sampling programmes is outlined, including a pilot project to be expanded to a main project. The programme is expected to give information on migration, distribution, survival and growth of escaped farmed salmon.

1. Pilot project

This should be carried out to compare migration and distribution of one single group (500-1000) of farmed salmon released in each of the countries producing farmed salmon (i.e. Ireland, Scotland, Faroes, Iceland and Norway). To maximise the probability for recaptures ((ICES CM 2001/ACFM:15; Hansen 2002) the farmed salmon to be released should be expected to be sexually mature the following autumn and should preferably be released in March/April. External tags of the same origin and type should be used, and the releases should be co-ordinated in time. The recovery information should be used for developing a detailed design of the main project.

2. Main project

Groups of externally tagged farmed salmon should be released sequentially over the year (e.g. monthly, bimonthly etc), or over periods when escapes from salmon farms are known to occur, usually during the winter. The fish should be released in the same countries as suggested above, and the numbers of tagged fish in each group should be optimised based on results from the pilot project. The releases should be coordinated and the same types of tags should be applied. This exercise is expected to give information on variation in migration, distribution, survival and growth of salmon escaping from fish farms at different times of the year.

Given the large numbers of farmed salmon escaping from cages in the Northeast Atlantic, the number of farmed salmon released for the purpose of this experiment will only be a small fraction of the total number of escaping salmon.

4.5.3 Sonic tracking of escapees in Maine (USA)

An experimental release of farmed salmon fitted with acoustic tags is planned to start in the Cobscook Bay region of Maine in autumn, 2003. This region produces the majority of the USA’s east coast farmed Atlantic salmon, and adjoins Canada’s Bay of Fundy region where the Canadian east coast industry is concentrated. The goals of the study are to:

Document the residency time of “escaped” fish in the vicinity of the cages following the release.
Track the directions and rates of any movements that the fish exhibit, and correlate them with tidal currents and other environmental cues.
Based on histories of detection of the tagged fish on the receiver grid, attempt to determine their survival time at sea.
Maintain a cross border detection grid in order to document the degree to which escapees stray between US and Canadian waters.
Determine if the fish tend to move to particular rivers in the region at spawning time, presuming they survive for this long.

The project will provide short to medium term information about rates of dispersal of farmed fish, post-escape. Results should help with the development of recapture strategies, or if the program shows that the fish in this region are not likely to be recaptured, it will refocus efforts and scarce resources on insuring containment.

4.6 Compilation of Tag Releases and Finclip Data by ICES Member Countries in 2002

4.6.1 Compilation of tag releases and finclip data for 2002

Data on releases of tagged, fin-clipped, and marked salmon in 2002 were provided by ICES and are compiled as a separate report. A summary of Atlantic salmon marked in 2002 is given in Table 4.6.1. About 4.1 million salmon were marked in 2002, an increase from the 3.88 million fish marked in 2001. Tagging with data storage tags (DSTs) is not presently recorded on the database, but ICES will include these tags from 2004. The Working Group noted that a number of commercial fish farms are applying tags to fish placed in sea cages in some countries and hence these might appear in fisheries if escapes occurred. ICES recommended that state agencies should provide information on tag codes applied in these instances and this should be included in the tag compilation.

4.7 General recommendations, Data deficiencies and research needs

Note: Recommendations in bold italics refer to items which may involve or be of particular relevance to NASCO

<u>Recommendations from Section 4- Atlantic salmon in the North Atlantic Area:</u>

1. ***ICES recommends that information on the application of tags to salmon placed in sea cages by commercial companies should be made available through State agencies and included in the tag compilation database, and requests that NASCO put this recommendation to its Aquaculture Liaison Committee.***

2. Given the importance of M in the provision of catch advice and in the understanding of the dynamics of Atlantic salmon in the ocean, and in order to refine the assessment of M with the maturity schedule method, hatchery stocking programs should attempt to confirm the sex ratio of the released smolts

3. ICES recommends that life history characteristics of salmon stocks including age structure, length at age, relative and absolute abundance of repeat spawners, run-timing and other such features be examined for Atlantic salmon stocks to ensure that conservation of salmon extends beyond abundance.

4. ***A coordinated tagging study should be designed and carried out to give information on migration, distribution, survival and growth of escaped farmed salmon from the NEAC countries.***

<u>Recommendations from Section 5 - Fisheries and Stocks from the North East Atlantic Commission Area:</u>

1. Further progress should be made in establishing a PFA predictive model using the PFA of maturing 1SW salmon, in addition to the spawner term, as a predictor variable for the PFA of non-maturing 1SW in the Northern NEAC area.

2. ***Surveys should be extended to provide better temporal and spatial information on the distribution of post-smolts in relation to pelagic fisheries .***

3. ***Experimental trawling surveys should be conducted to evaluate the vertical distribution of post-smolts and older salmon in the sea, if possible in combination with tagging of post-smolt and salmon with depth and temperature recording tags (DSTs).***

4. ***Studies on post-smolts and older salmon should be extended to elucidate behaviour patterns at sea and to investigate their behaviour in relation to different commercial gear types (e.g. pelagic trawls, purse seines)***

<u>Recommendations from Section 6- Fisheries and Stocks from the North American Commission Area:</u>

1. Estimates of total returns to Labrador no longer exist. There is a critical need to develop alternate methods to derive estimates of salmon returns and develop habitat-based spawner requirements in Labrador, and to monitor salmon returns in the Ungava region of Québec.

2. There is a need to investigate changes in the biological characteristics (mean weight, sex ratio, sea-age and river-age composition) of returns to rivers, of smolt output, of spawning stocks of Canadian and US rivers, and the harvest in food fisheries in Labrador. These data and new information on measures of habitat and stock

recruitment are necessary to re-evaluate existing estimates of spawner requirements in Canada and USA and for use in the run reconstruction model.

3. There is a requirement for additional smolt-to-adult survival rates for wild salmon. As well, sea survival rates of wild salmon from rivers stocked with hatchery smolts should be examined to determine if hatchery return rates can be used as an index of sea survival of wild salmon elsewhere.

4. ***Further basic research is needed on the spatial and temporal distribution of salmon and their predators at sea to assist in explaining variability in survival rates.***

5. Return estimates for the few rivers (Annapolis, Cornwallis and Gaspereau) in SFA 22 that contribute to distant fisheries should be developed and when these are available, the SFA 22 spawning requirements for these rivers (476 fish) should be included in the total.

6. A consistent approach to estimating returns is needed for instances in which offspring from broodstock are stocked back into the management area from which their parents originated.

<u>Recommendations from Section 7 - Atlantic Salmon in the West Greenland Commission Area:</u>

1. ***Continued efforts should be made to improve the estimates of the annual catches of salmon taken for private sales and local consumption in Greenland.***

2. ***The mean weights, sea and freshwater ages and continent of origin are essential parameters to provide catch advice for the West Greenland fishery. ICES recommends that the sampling program be continued and closely coordinated with fishery harvest plan to be executed annually in West Greenland.***

3. ***Scale analysis of salmon captured at West Greenland indicated an infrequent appearance of escaped-farm salmon. To investigate this observation, farmed salmon need to be genetically characterized and included as baseline populations in continent of origin analyses of samples collected at West Greenland.***

4. ***Continue testing for ISAv and other diseases in Atlantic salmon caught in West Greenland.***

5. ***CPUE was not available in 2002 in West Greenland. Thus, there is a need to collect more refined data characterizing fishing effort to characterize availability of Atlantic salmon.***

6. Development of alternative in-season measures of abundance such as relationships between 1SW returns to rivers from the same cohort should be investigated as a future source of confirmatory information of abundance.

7. ***Further basic research is needed on the spatial/temporal distribution and migration patterns of salmon and their predators at sea to assist in explaining variability in survival rates. Other indices of change, i.e. changes in age composition, size at age and sea survival, should also be included in this analysis.***

8. ICES endorses the continued development of genetic methods that will increase the precision and accuracy of the classification of stock complexes within and among continents, countries, and individual rivers, and recommends

    - to further evaluate the extent to which the genetics of stocks have been characterized within each country, and share that information at the ICES Working Group meeting in 2004.

    - that all efforts be made to extend the spatial and temporal coverage of existing baseline genetic dataset for North Atlantic salmon stocks, especially those vulnerable to mixed stock fisheries, while making efforts to duplicate tissue sample representation across different laboratories.

    - that an inventory of genetic material, particularly from historic scale samples and samples taken prior to significant management measures or ecological events, be assembled and that inter-laboratory calibration and standardization should be carried out to ensure optimal use of existing samples and samples to be taken in future.

9. ***To compute the probability of of achieving a given level of stock increase for the USA and Scotia-Fundy regions of North America, ICES used the recent 5 year average of returns. ICES notes that if a moving average continues to be used, and these stocks continue to decline then the baseline average will also***

decline. ICES, therefore, draws the attention of NASCO of the need to establish the range of years to define the baseline and the percentage increase in stocks required for their management objectives (currently ICES have arbitrarily used 10% or 25% examples in the advice to NASCO). This will provide ICES with the criteria to assess performance of these fisheries relative to the management objective.

Table 4.1.1.1 Nominal catch of SALMON by country (in tonnes round fresh weight of fish caught and retained), 1960 – 2002. (2002 figures include provisional data).

	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.	Norway	Russia	Iceland		(West)	Den.	Finland	Ireland	(E & W)	(N.Irl.)	(Scotl.)	France	Spain	Faroes	Grld.	Grld.	Other	Nominal	NASCO	International
	(1)		& M.	(2)	(3)	Wild	Ranch				(4,5)		(5,6)			(7)	(8)		(9)	(10)	Catch	Areas	waters (11)
1960	1636	1	-	1659	1100	100		40	-	-	743	283	139	1443	-	33	-	-	60	-	7237	-	-
1961	1583	1	-	1533	790	127		27	-	-	707	232	132	1185	-	20	-	-	127	-	6464	-	-
1962	1719	1	-	1935	710	125		45	-	-	1459	318	356	1738	-	23	-	-	244	-	8673	-	-
1963	1861	1	-	1786	480	145		23	-	-	1458	325	306	1725	-	28	-	-	466	-	8604	-	-
1964	2069	1	-	2147	590	135		36	-	-	1617	307	377	1907	-	34	-	-	1539	-	10759	-	-
1965	2116	1	-	2000	590	133		40	-	-	1457	320	281	1593	-	42	-	-	861	-	9434	-	-
1966	2369	1	-	1791	570	104	2	36	-	-	1238	387	287	1595	-	42	-	-	1370	-	9792	-	-
1967	2863	1	-	1980	883	144	2	25	-	-	1463	420	449	2117	-	43	-	-	1601	-	11991	-	-
1968	2111	1	-	1514	827	161	1	20	-	-	1413	282	312	1578	-	38	5	-	1127	403	9793	-	-
1969	2202	1	-	1383	360	131	2	22	-	-	1730	377	267	1955	-	54	7	-	2210	893	11594	-	-
1970	2323	1	-	1171	448	182	13	20	-	-	1787	527	297	1392	-	45	12	-	2146	922	11286	-	-
1971	1992	1	-	1207	417	196	8	18	-	-	1639	426	234	1421	-	16	-	-	2689	471	10735	-	-
1972	1759	1	-	1578	462	245	5	18	-	32	1804	442	210	1727	34	40	9	-	2113	486	10965	-	-
1973	2434	2.7	-	1726	772	148	8	23	-	50	1930	450	182	2006	12	24	28	-	2341	533	12670	-	-
1974	2539	0.9	-	1633	709	215	10	32	-	76	2128	383	184	1628	13	16	20	-	1917	373	11877	-	-
1975	2485	1.7	-	1537	811	145	21	26	-	76	2216	447	164	1621	25	27	28	-	2030	475	12136	-	-
1976	2506	0.8	2.5	1530	542	216	9	20	-	66	1561	208	113	1019	9	21	40	<1	1175	289	9327	-	-
1977	2545	2.4	-	1488	497	123	7	10	-	59	1372	345	110	1160	19	19	40	6	1420	192	9414	-	-
1978	1545	4.1	-	1050	476	285	6	10	-	37	1230	349	148	1323	20	32	37	8	984	138	7682	-	-
1979	1287	2.5	-	1831	455	219	6	12	-	26	1097	261	99	1076	10	29	119	<0,5	1395	193	8118	-	-
1980	2680	5.5	-	1830	664	241	8	17	-	34	947	360	122	1134	30	47	536	<0,5	1194	277	10127	-	-
1981	2437	6	-	1656	463	147	16	26	-	44	685	493	101	1233	20	25	1025	<0,5	1264	313	9954	-	-
1982	1798	6.4	-	1348	364	130	17	25	-	54	993	286	132	1092	20	10	606	<0,5	1077	437	8395	-	-
1983	1424	1.3	3	1550	507	166	32	28	-	58	1656	429	187	1221	16	23	678	<0,5	310	466	8755	-	-
1984	1112	2.2	3	1623	593	139	20	40	-	46	829	345	78	1013	25	18	628	<0,5	297	101	6912	-	-
1985	1133	2.1	3	1561	659	162	55	45	-	49	1595	361	98	913	22	13	566	7	864	-	8108	-	-
1986	1559	1.9	2.5	1598	608	232	59	54	-	37	1730	430	109	1271	28	27	530	19	960	-	9255	315	-
1987	1784	1.2	2	1385	564	181	40	47	-	49	1239	302	56	922	27	18	576	<0,5	966	-	8159	2788	-
1988	1310	0.9	2	1076	420	217	180	40	-	36	1874	395	114	882	32	18	243	4	893	-	7737	3248	-
1989	1139	1.7	2	905	364	141	136	29	-	52	1079	296	142	895	14	7	364	-	337	-	5904	2277	-
1990	911	2.4	1.9	930	313	146	280	33	13	60	567	338	94	624	15	7	315	-	274	-	4924	1890	180-350

Table 4.1.1.1 cont'd.

	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.	Norway	Russia	Iceland		(West)	Den.	Finland	Ireland	(E & W)	(N.Irl.)	(Scotl.)	France	Spain	Faroes	Grld.	Grld.	Other	Nominal	NASCO	International
	(1)		& M.	(2)	(3)	Wild	Ranch				(4,5)		(5,6)			(7)	(8)		(9)	(10)	Catch	Areas	waters (11)
1991	711	0.8	1.2	876	215	130	345	38	3.3	70	404	200	55	462	13	11	95	4	472	-	4106	1682	25-100
1992	522	0.7	2.3	867	167	175	461	49	10	77	630	171	91	600	20	11	23	5	237	-	4119	1962	25-100
1993	373	0.6	2.9	923	139	160	496	56	9	70	541	248	83	547	16	8	23	-	-	-	3696	1644	25-100
1994	355	0	3.4	996	141	141	308	44	6	49	804	324	91	649	18	10	6	-	-	-	3945	1276	25-100
1995	260	0	0.8	839	128	150	298	37	3.1	48	790	295	83	588	9	9	5	2	83	-	3628	1060	-
1996	292	0	1.6	787	131	122	239	33	1.7	44	687	183	77	427	14	7	-	0.1	92	-	3138	1123	-
1997	229	0	1.5	630	111	106	50	19	1.3	45	570	142	93	296	8	3	-	1	58	-	2364	827	-
1998	157	0	2.3	740	131	130	34	15	1.3	48	624	123	78	283	9	4	6	0	11	-	2397	1210	-
1999	152	0	2.3	811	103	120	26	16	0.5	62	515	150	53	199	11	6	0	0.4	19	-	2246	1032	-
2000	153	0	2.3	1176	124	83	2	33	5.2	95	621	219	78	274	11	7	8	0	21	-	2913	1269	-
2001	148	0	2.2	1267	114	88	0	33	6.4	126	730	184	53	251	11	13	0	0	43	-	3069	1180	-
2002	148	0	3.6	1019	118	92	0	28	5.3	93	673	161	64	190	12	9	0	0	9	-	2625	1033	-
Average																							
1997-2001	168	0	2	925	117	105	22	23	3	75	612	164	71	261	10	7	4	0	30	-	2598	1104	-
1992-2001	264	0	2	904	129	128	191	33	4	66	651	204	78	411	13	8	9	1	71	-	3151	1258	-

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 recently developed recreational (rod) fishery.
4. From 1994, includes increased reporting of rod catches.
5. Catch on River Foyle allocated 50% Ireland and 50% N. Ireland.
6. Not including angling catch (mainly 1SW).
7. Weights prior to 1990 are estimated from 1994 mean weight. Weights from 1990 to 1999 based on mean weight for R. Asturias.
8. 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 in 2001 or 2002.
9. Includes catches made in the West Greenland area by Norway, Faroes, Sweden and Denmark in 1965-1975.
10. Includes catches in Norwegian Sea by vessels from Denmark, Sweden, Germany, Norway and Finland.
11. Estimates refer to season ending in given year.

Table 4.1.3.1 Estimates of unreported catches by various methods in tonnes within national EEZs in the North-East Atlantic, North American and West Greenland Commissions of NASCO, 1987-2002.

Year	North-East Atlantic	North-American	West Greenland	Total
1987	2,554	234	-	2,788
1988	3,087	161	-	3,248
1989	2,103	174	-	2,277
1990	1,779	111	-	1,890
1991	1,555	127	-	1,682
1992	1,825	137	-	1,962
1993	1,471	161	< 12	1,644
1994	1,157	107	< 12	1,276
1995	942	98	20	1,060
1996	947	156	20	1,123
1997	732	90	5	827
1998	1,108	91	11	1,210
1999	887	133	12.5	1,032
2000	1,135	124	10	1,269
2001	1,089	81	10	1,180
2002	946	83	10	1,039
Mean 1997-2001	990	104	10	1104

Table 4.4.1.1. Stock and recruitment (Ricker) parameters and standard deviations of parameters for Atlantic salmon in 3 rivers of western Europe (Anon 2003).

River	H'	SDH'	R'	SDR'	Alpha	Beta	S_{lim}
Bush	0.73	0.07	13.64	11.57	14.93	0.20	3.6828
North Esk	0.43	0.17	27.51	29.44	2.13	0.03	15.6807
Nivelle	0.38	0.11	0.94	0.28	1.85	0.65	0.5828

Table 4.4.1.2. Mean number of years to attain recruitment of Atlantic salmon to S_{lim} with 90% confidence ranges in three rivers with high to low productivity (alpha) using their respective fitted stock and recruitment curves for two starting points and three fisheries exploitation scenarios.

River			Start at 0.1 of S_{lim}		Start at 0.5 of S_{lim}	
	Exploitation	Rate	Mean	5th - 95th	Mean	5th - 95th
Bush						
alpha	Zero	0	1.4	(1 - 4)	1.0	(1 - 1)
(14.93)	Half Current	0.2645	2.6	(1 - 5)	1.0	(1 - 1)
beta	Current	0.529	5.0	(4 - 7)	1.1	(1 - 2)
(0.20)	H'	0.73	8.6	(5 - 14)	2.5	(1 - 7)
North Esk						
alpha	Zero	0	13.6	(6 - 24)	5.2	(1 - 14)
(2.13)	Half Current	0.079	15.9	(6 - 28)	6.7	(1 - 18)
beta	Current	0.158	19.3	(7 - 37)	9.1	(1 - 25)
(0.03)	H'	0.430	41.1	(15 - 50)	29.1	(1 - 50)
Nivelle						
alpha	Zero	0	13.7	(9 - 18)	4.8	(1 - 8)
(1.85)	Half Current	0.011	14.1	(9 - 19)	5.0	(1 - 8)
beta	Current	0.022	14.5	(10 - 19)	5.2	(1 - 9)
(0.65)	H'	0.380	49.4	(50 - 50)	46.4	(16 - 50)

Table 4.4.1.3. Proportion of annual recruitment in 10,000 fifty year projections of Atlantic salmon that were below S_{lim} with 90% confidence ranges in three rivers with high to low productivity (alpha) using their respective fitted stock and recruitment curves for two starting points and three fisheries exploitation scenarios.

River			Start at 0.1 of S_{lim}		Start at 0.5 of S_{lim}	
	Exploitation	Rate	Mean	5th - 95th	Mean	5th - 95th
Bush						
alpha	Zero	0	0.14	(0.06 - 0.22)	0.13	(0.06 - 0.22)
(14.93)	Half Current	0.2645	0.18	(0.1 - 0.26)	0.14	(0.06 - 0.24)
beta	Current	0.529	0.25	(0.16 - 0.36)	0.19	(0.1 - 0.3)
(0.20)	H'	0.73	0.49	(0.32 - 0.66)	0.42	(0.26 - 0.58)
North Esk						
alpha	Zero	0	0.52	(0.32 - 0.74)	0.41	(0.2 - 0.66)
(2.13)	Half Current	0.079	0.62	(0.38 - 0.84)	0.52	(0.28 - 0.76)
beta	Current	0.158	0.73	(0.5 - 0.94)	0.64	(0.4 - 0.88)
(0.03)	H'	0.430	0.97	(0.88 - 1)	0.95	(0.84 - 1)
Nivelle						
alpha	Zero	0	0.27	(0.2 - 0.36)	0.10	(0.04 - 0.16)
(1.85)	Half Current	0.011	0.28	(0.2 - 0.38)	0.10	(0.04 - 0.18)
beta	Current	0.022	0.29	(0.2 - 0.38)	0.11	(0.04 - 0.18)
(0.65)	H'	0.380	1.00	(1 - 1)	1.00	(0.98 - 1)

Table 4.6.1. Summary of Atlantic salmon tagged and marked in 2002. 'Hatchery' and 'Wild' refer to smolts or parr; 'Adult' refers to wild and hatchery fish. Data from Belgium were not available. Fish were not tagged in Finland or Denmark. PIT tags were not included.

		Primary Tag or Mark			
Country	Origin	Microtag	External mark	Adipose clip	Total
Canada	Hatchery	0	45,346	2,328,471	2,373,817
	Wild	0	28,194	501	28,695
	Adult	0	5,777	0	5,777
	Total	0	79,317	2,328,972	2,408,289
Spain	Hatchery	18,150	0	67,700	85,850
	Wild	0	0	0	0
	Adult	0	0	0	0
	Total	18,150	0	67,700	85,850
France	Hatchery	0	39,950	405,482	445,432
	Wild	0	0	0	0
	Adult	0	0	0	0
	Total	0	39,950	405,482	445,432
Iceland	Hatchery	142,777	0	0	142,777
	Wild	1,218	0	0	1,218
	Adult	0	355	0	355
	Total	143,995	355	0	144,350
Ireland	Hatchery	348,949	0	0	348,949
	Wild	3,610	0	0	3,610
	Adult	0	0	0	0
	Total	352,559	0	0	352,559
Norway	Hatchery	41,308	48,714	0	90,022
	Wild	0	5,038	0	5,038
	Adult	0	178	0	178
	Total	41,308	53,930	0	95,238
Russia	Hatchery	0	2,000	130,400	132,400
	Wild	0	0	0	0
	Adult	0	2,208	0	2,208
	Total	0	4,208	130,400	134,608
Sweden	Hatchery	0	4,966	24,994	29,960
	Wild	0	497	0	497
	Adult	0	0	0	0
	Total	0	5,463	24,994	30,457
UK (England & Wales)	Hatchery	57,056	4,304	119,081	180,441
	Wild	6,082	0	1,515	7,597
	Adult	0	1,418	0	1,418
	Total	63,138	5,722	120,596	189,456
UK (N. Ireland)	Hatchery	28,035	0	18,128	46,163
	Wild	1,043	0	0	1,043
	Adult	0	0	0	0
	Total	29,078	0	18,128	47,206
UK (Scotland)	Hatchery	17,045	0	0	17,045
	Wild	15,974	0	0	15,974
	Adult	0	1,120	0	1,120
	Total	33,019	1,120	0	34,139
USA	Hatchery	0	137,920	0	137,920
	Wild	0	1,280	0	1,280
	Adult	0	2,787	0	2,787
	Total	0	141,987	0	141,987
All Countries	Hatchery	653,320	283,697	3,094,256	4,030,776
	Wild	27,927	34,512	2,016	64,952
	Adult	0	13,843	0	13,843
	Total	681,247	332,052	3,096,272	4,109,571

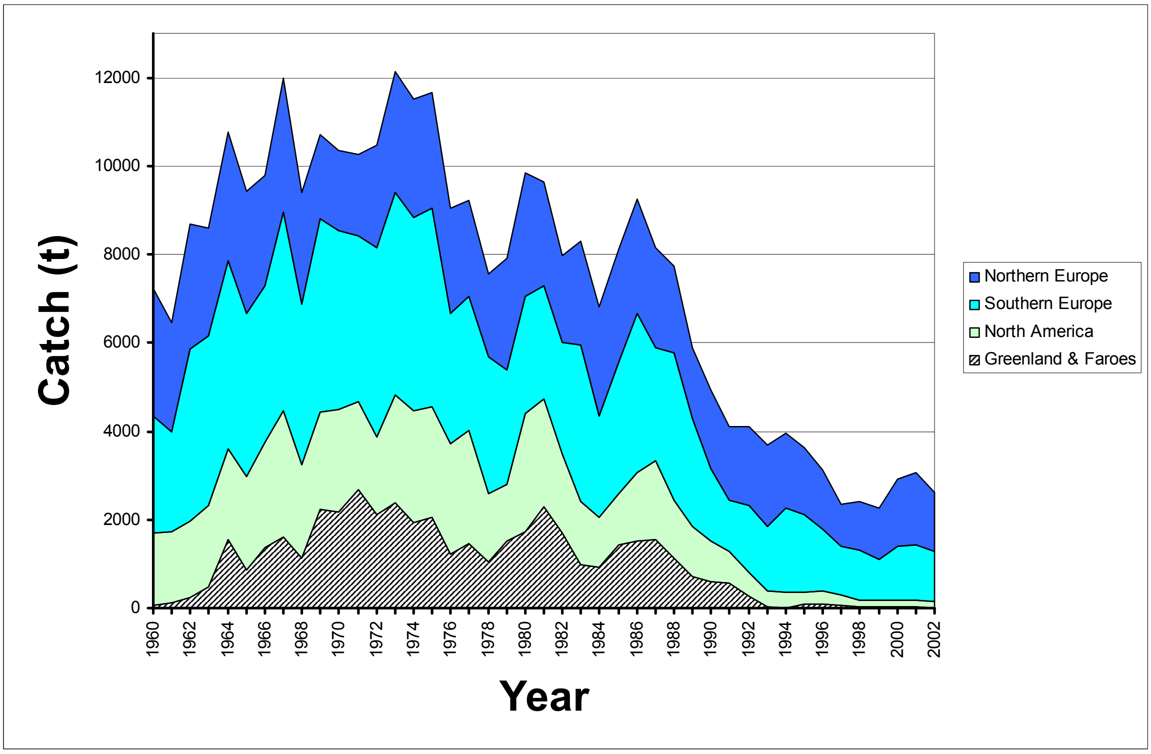


Figure 4.1.1.1 Nominal catch of salmon (tonnes round fresh weight) in four North Atlantic regions, 1960-2002

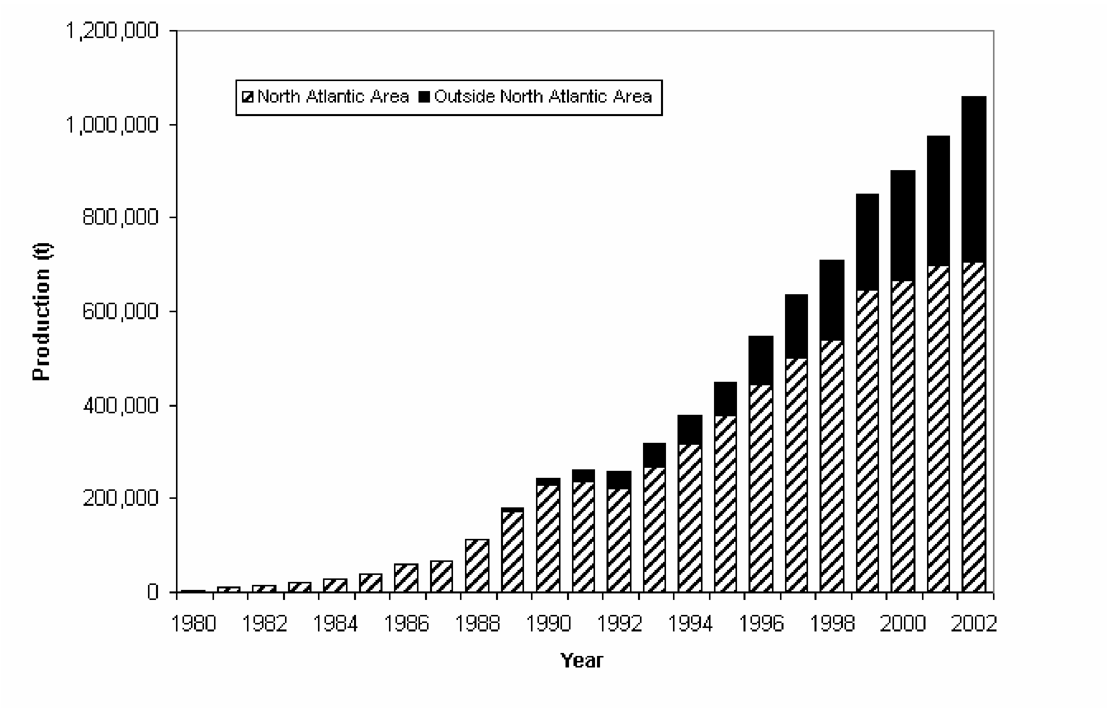


Figure 4.1.4.1 World-wide production of farmed Atlantic salmon.

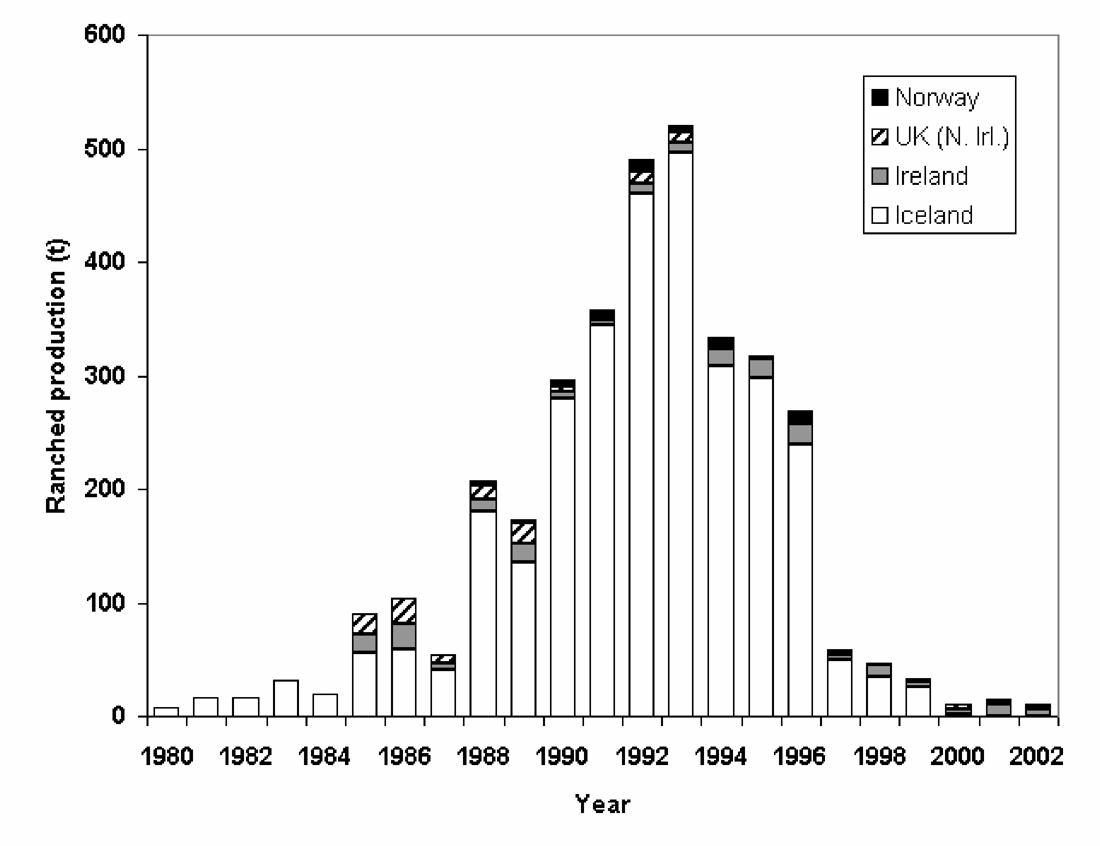


Figure 4.1.4.2 Production of ranched salmon in the North Atlantic, 1980-2002

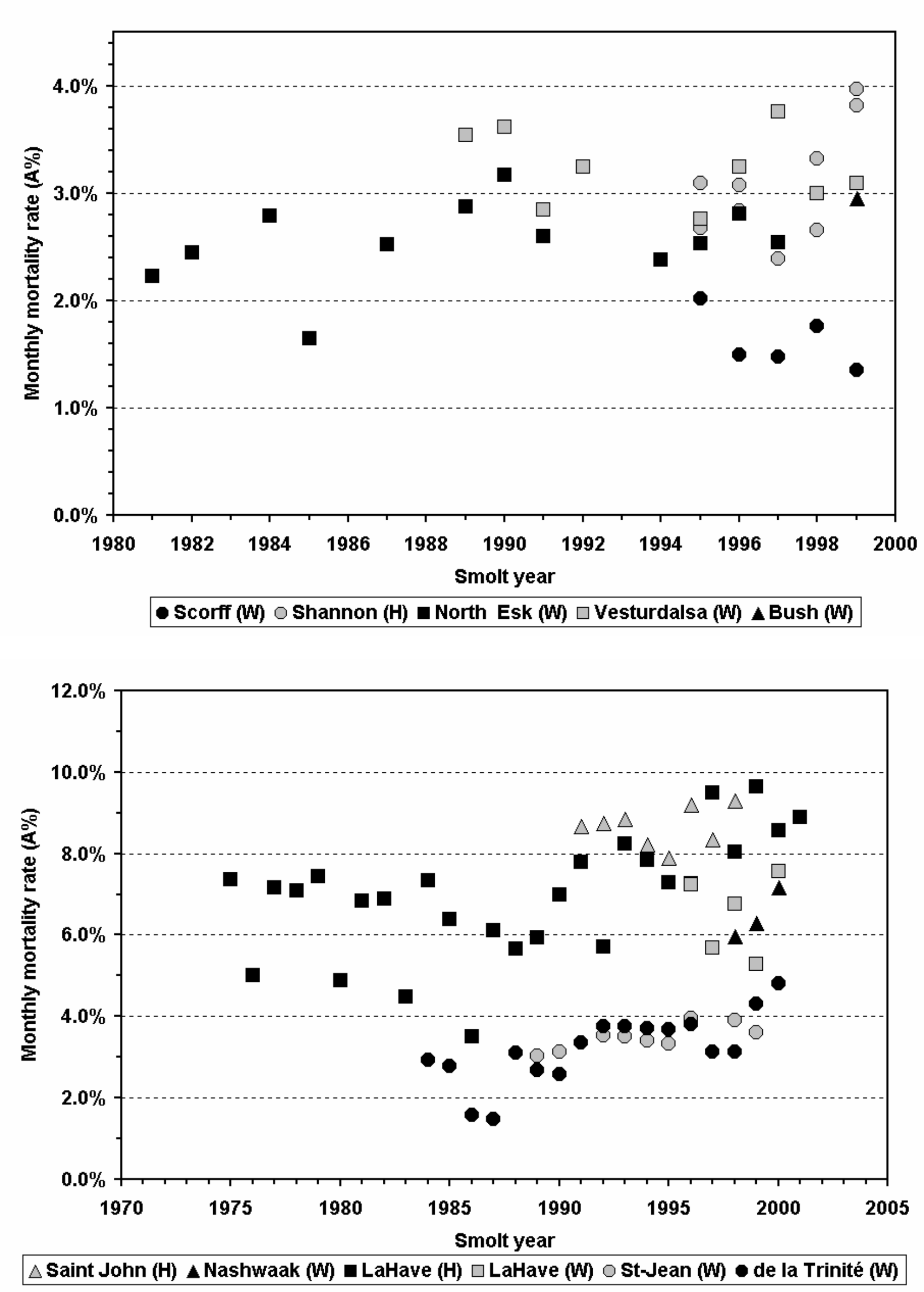


Figure 4.2.1.1. Monthly mortality (A%) estimates in the second year at sea derived from the inverse-weight model assuming a linear growth function for NEAC stocks (upper panel) and for NAC stocks (lower panel).

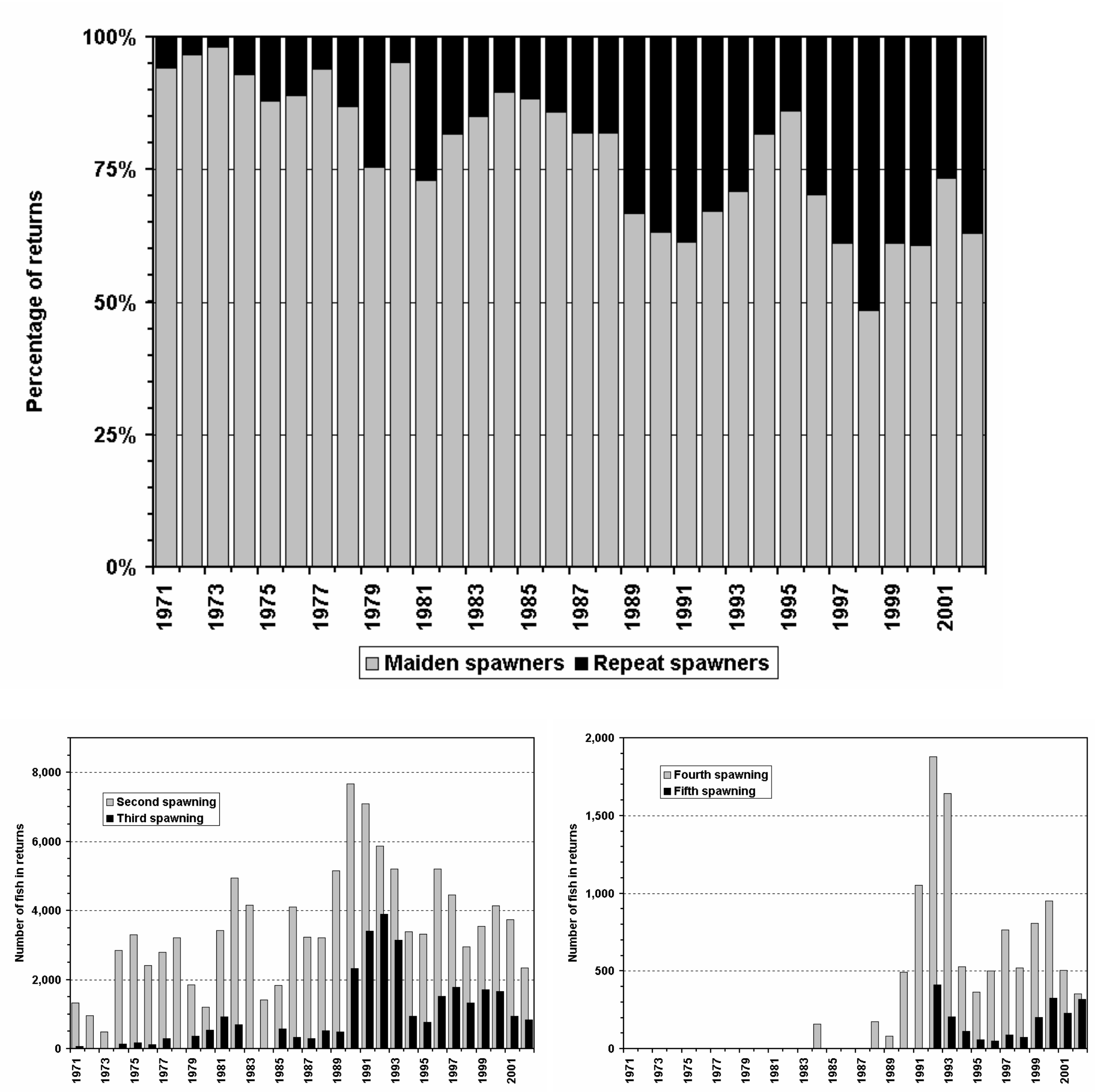


Figure 4.3.3.1. Relative abundance of maiden and repeat spawning large salmon (upper panel) and estimates of absolute abundance (lower abundance) of repeat spawning large salmon by spawning history returning to the Miramichi River, 1971 to 2002.

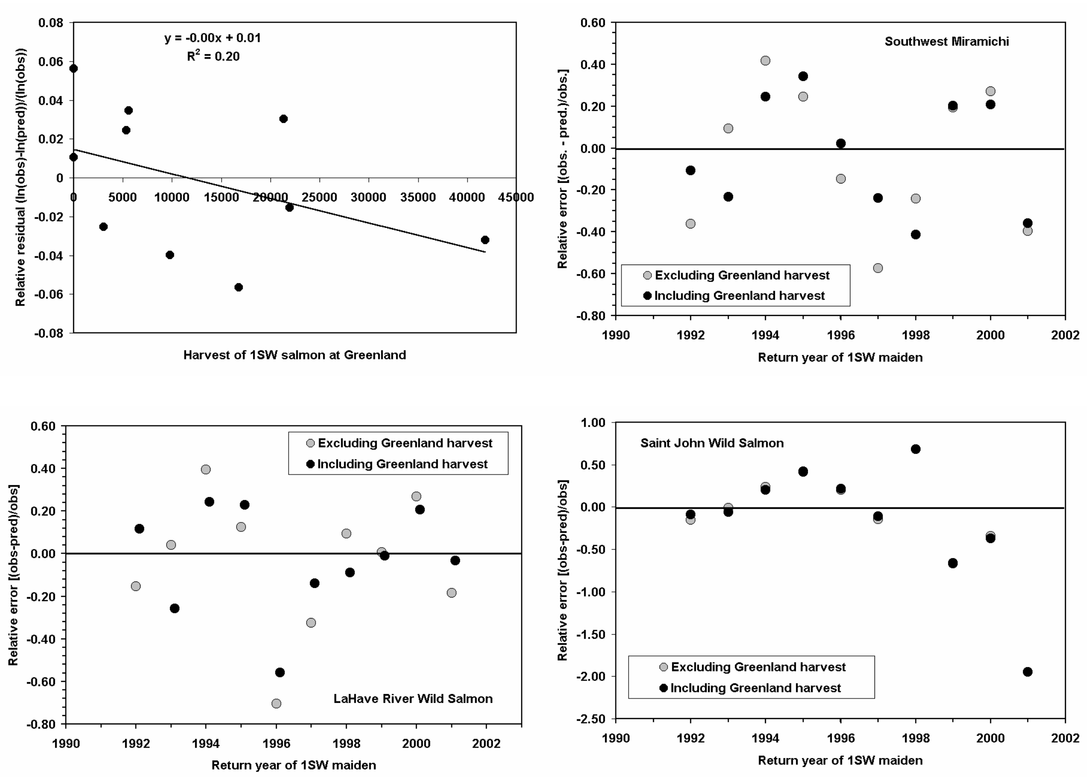


Figure 4.3.3.2. Linear association between residuals from the 1SW/2SW association and harvest of 1SW salmon at Greenland for Southwest Miramichi (upper left panel) and relative error [(obs. – pred.) / obs.] of predicted 2SW return when Greenland harvest of North American 1SW salmon is excluded or included in the 1SW/2SW association for the Southwest Miramichi (upper right panel), LaHave River wild salmon (lower left panel) and Saint John wild salmon (lower right panel).

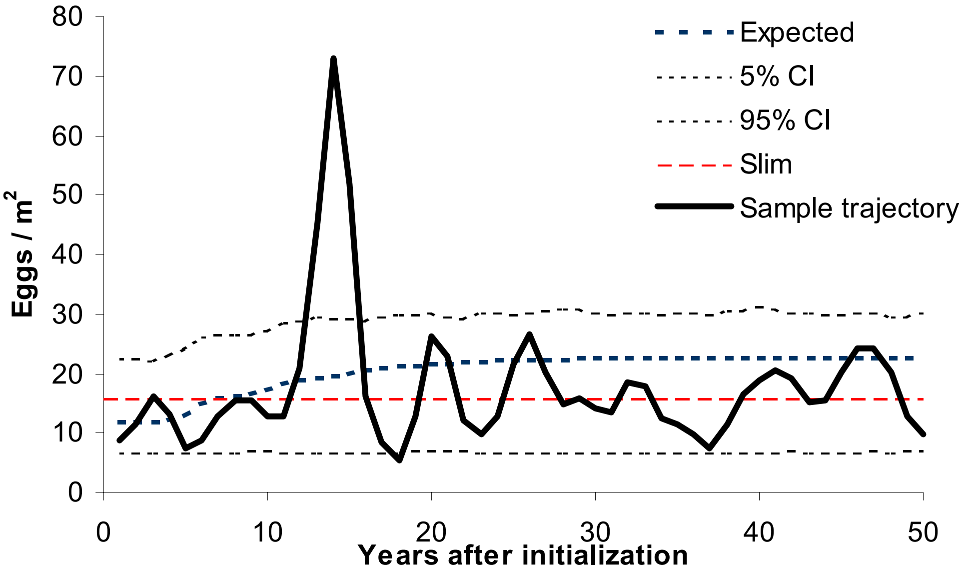


Figure 4.4.1.1. Typical single run trajectory and 90% range of 10,000 simulations of an expected stock and recruitment curve in relation to its conservation requirement S_{lim}.

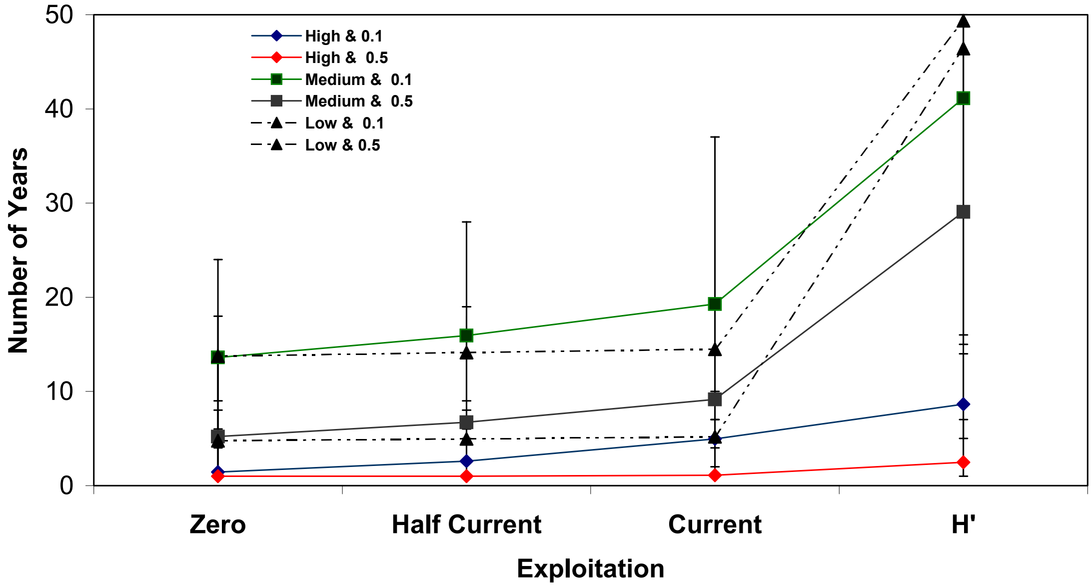


Figure 4.4.1.2. Number of years to attain S_{lim} in 50 years for High (14.93), Medium (2.13) and Low (1.85) alpha values in a Ricker stock and recruitment function over 10,000 simulations with uncertain parameters.

5 NORTH-EAST ATLANTIC COMMISSION

5.1 Status of stocks/exploitaton

The status of this stock complex with respect to conservation requirements is:
Northern European 1SW stocks fell sharply below the Conservations limit (CL) in 2002.
Northern European MSW stocks were above CL in 2002 and are within safe biological limits.
Southern European 1SW and MSW stocks were close to CL in 2002

Therefore, with the exception of northern MSW stocks, these stocks are considered outside safe biological limits.

The status of stocks is shown in Figures. 5.1.1 to 5.1.4 and is elaborated upon in Section 5.9.1.

5.2 Management objectives

The general NASCO management objectives apply (See Section 3).

5.3 Reference points

As precautionary reference points have not been developed for these stocks, management advice is therefore referenced to the S_{lim} conservation limit. Thus, these limits should be avoided with high probability (ie at least 75%).

Development of age-specific conservation limits

In all, there are around 15-25 stock and recruitment datasets in the NEAC area, ranging from long time series to rivers where stock-recruitment (S/R) relationships are in the process of being (or could be) developed. These include a mixture of smaller rivers and tributaries of large river systems. Given the time and resource difficulties with collecting meaningful S/R data, it is unlikely that many further datasets will be developed in the near future. However, as these rivers are spread throughout the NEAC area and cover a wide array of river types and productivity levels, even incomplete S/R datasets may provide useful information for helping to identify BRPs for transport of conservation limits to rivers with little or no data.

River-specific conservation limits

General developments and progress with setting of conservation limits in the NEAC area have been reported in the draft final report of the EU-funded SALMODEL concerted action (Anon., 2003). Specific progress in individual countries in 2002 is summarised below:

In UK (England & Wales) the river-specific assessment procedures have been modified by addition of a Management Target (MT) for each river. The MT is a spawning stock level for managers to aim at, to ensure that the objective of exceeding the conservation limit (CL) is met in four years out of five (i.e. 80% of the time). It provides an additional mechanism to assist managers in safeguarding stocks.

In UK (N. Ireland), the most comprehensively developed conservation limit for N. Ireland at present is that for the R. Bush, derived from a whole river stock/recruitment relationship. Work is in progress to extend CL setting to all salmon producing rivers in the Fisheries Conservancy Board (FCB) area of N. Ireland, and to install fish counters to enable compliance to be assessed in key indicator rivers. Provisional CLs for all other rivers in the FCB area have been set by transporting the Bush CL on the basis of catchment area (ICES 1998/ACFM:13). These CLs are indicative only and not presently used for management. However, further work to refine these CLs by using available river-specific habitat data is in progress, with revised CLs being set for the Blackwater, Maine and Glendun rivers in 2002. Counters installed on these rivers to assess compliance with the CLs were operated for the first full year in 2002.

National Conservation Limits

The national model has been run for the countries for which no river-specific conservation limits have been developed (i.e. all countries except France, UK (England & Wales), and Sweden). For Iceland, Russia, Norway, UK (Northern Ireland), and UK (Scotland) the input data for the PFA analysis (1971-2002) have been provided separately for more than one region; the lagged spawner analysis has therefore been conducted for each region separately and the estimated conservation limits summed for the country. ICES has previously noted that outputs from the national model are only designed to provide a provisional guide to the status of stocks in the NEAC area and that this approach only provides a basis for qualitative catch advice.

CLs for NEAC stock complexes

For catch advice to NASCO, conservation limits are required for stock complexes. These have been derived either by summing of individual river CLs to national level, or taking overall national CLs, as provided by the national CL model.

For the NEAC area, the conservation limits have been calculated by ICES as 299,760 1SW spawners and 151,676MSW spawners for the northern NEAC stock grouping, and 510,709 1SW spawners and 262,935 MSW spawners for the southern NEAC stock grouping.

5.4 Advice on management

ICES has been asked to provide catch options or alternative management advice, if possible based on a forecast of pre-fishery abundance (PFA), with an assessment of risks relative to the objective of exceeding conservation limits in the NEAC area.

ICES emphasises that the national stock conservation limits discussed above may not be appropriate for the management of homewater fisheries because of the relative imprecision of the national conservation limits 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 conservation limits 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.

Due to the preliminary nature of the conservation limit estimates, ICES is unable to provide quantitative catch options for most stock complexes at this stage. An exception is the provision of a quantitative prediction of PFA for southern European MSW stocks (Figure 5.4.1).

Given the state of the stocks ICES provides the following advice on management:

Northern European 1SW stocks: ICES recommends that the overall exploitation of the stock complex be decreased so as to meet conservation limits. It should be noted, however, that the inclusion of farmed fish in the Norwegian data will result in the exploitable surplus being over-estimated. Since very few of these salmon have been caught outside homewater fisheries in Europe, even when fisheries were operating in the Norwegian Sea, management of maturing 1SW salmon should be based upon local assessments of the status of river or sub-river stocks.

Northern European MSW stocks: ICES recommends that caution should be exercised in the management of these stocks particularly in mixed stock fisheries and exploitation should not be permitted to increase to ensure that conservation limits continue to be met.

Southern European 1SW stocks: ICES recommends that the overall exploitation of the stock complex be decreased so as to meet conservation limits. ICES considers that mixed stock fisheries present particular threats to conservation and recommends that reductions in exploitation rate be implemented for as many stocks as possible.

Southern European MSW stocks: The preliminary quantitative prediction of PFA for this stock complex indicates that PFA will remain close to present low levels in 2003 (prediction 524,000) (Figure 5.4.1). There is evidence from the prediction that PFA will decrease in the near future and the spawning escapement has not been significantly above conservation limit for the last seven years (Figure 5.1.4b and 5.4.1). **ICES recommends that the overall exploitation of the stock complex be decreased so as to meet conservation limits. ICES considers that mixed stock fisheries present particular threats to conservation and recommends that reductions in exploitation rate be implemented for as many stocks as possible.**

5.5 Relevant factors to be considered in management

For all fisheries, ICES considers that management of single stock fisheries should be based upon assessments of the status of individual stocks. Conservation would be best achieved if fisheries can be targeted at stocks that have been shown to be above biologically based escapement requirements. Fisheries in estuaries and rivers are more likely to fulfil this requirement.

Based on recent work on resolving the most appropriate stock groupings for management advice for the distant water fisheries, ICES agreed that advice for the Faroese fishery (both 1SW and MSW) should be based upon all NEAC stocks. Advice for the West Greenland fishery should be based upon southern European MSW salmon stocks only (comprising UK, Ireland and France).

5.6 Catch forecast for 2003

In order to develop quantitative catch options for NEAC stock complexes, forecasts of PFA are required for each stock complex and for each sea age component. These are currently only available for the MSW component of the southern European stock complex. The forecast of PFA for 2003 has been used in the catch advice for West Greenland for 2003 (section 7). The development of this forecast is summarised below:

ICES had previously considered the development of a model to forecast the pre-fishery abundance of non-maturing (potential MSW) salmon from the Southern European stock group (comprising Ireland, France and all parts of UK) (ICES 2002/ACFM:14). Stocks in this group are the main European contributors to the West Greenland fishery. This year, the model was fitted to data from 1977-2001 and used to predict PFA in the years 2002-2003 (Table 5.6.1, Figure 5.4.1). These predictions were used, together with PFA forecasts from North America, to provide quantitative catch advice for the 2003 West Greenland fishery.

5.7 Medium to long term projections

The quantitative prediction for the southern NEAC MSW stock component gives a projected PFA (at 1st January 2003) of 524,000 fish for catch advice in 2003. No projections are available beyond that, or for other stock components or complexes in the NEAC area.

5.8 Comparison with previous assessment

National PFA model and national conservation limit model

Some changes were made to the input data to these models by several countries. To run the NEAC PFA model most countries are required to input the following time-series information (beginning in 1971) for 1SW and MSW salmon:

Catch in numbers
Unreported catch levels (min and max)
Exploitation levels (min and max)

In some instances, the above information has been supplied in two or more regional blocks per country. In these instances, the model output is combined to provide one set of output variables per country. Descriptions of how the model input has been derived were presented in detail at the in ICES 2002/ACFM:14. Where there have been modifications to these derivation methods an explanation is given below.

Changes were made to the exploitation and unreported inputs for the Swedish data based on re-consideration of information available for wild salmon. In the case of UK (England & Wales) minor modifications were made to the values of unreported catch for the earlier part of the time series.

Changes were made to the Russian Kola Peninsula: Barents Sea Basin input data for 2003. In previous years, catches taken in the recently developed recreational rod fishery were not included, as the numbers were insignificant. Account was taken of these recreational catches in the "unreported catch" term in the model. As recreational catches are now substantial, they are now included in the 2003 catch input and the exploitation rate is adjusted accordingly.

As a result of these changes, conservation limits for the overall NEAC area increased by 7% for 1SW fish and by 1.2% for 2SW fish.

PFA forecast model

The model developed in 2002 to forecast PFA for southern NEAC MSW stocks was modified in 2003 to reflect the non-informative role of the previously used habitat variable. The model therefore used lagged spawners and year as the main input variables, together with the historical PFA values obtained from the run-reconstruction model. The revised forecast for 2002 PFA of southern NEAC MSW stocks was within 1.3% of the previous forecast.

5.9 Response to specific requests for information from NASCO:

5.9.1 NASCO has requested ICES to: describe the key events of the 2002 fisheries and the status of the stocks

Key events of the 2002 fisheries:

Fishing in the Faroese area 2001/2002 commercial fishery

No fishery for salmon was carried out in 2002 or, to date, in 2003. Consequently, no biological information is available from the Faroese area for this season. No buyout arrangement has been made since 1999.

Homewater fisheries in the NEAC area:

Significant events in NEAC homewater fisheries in 2002:

A range of measures aimed at reducing exploitation were implemented or strengthened in the NEAC area in 2002. These included: the prohibition of particular fishing gears, restrictions on fishing seasons, buy-out arrangements, the provision of protected areas, voluntary restrictions, and increasing use of catch and release. In Russia, in-river gill nets were prohibited in the Archangel Region to reduce unreported catches. In addition, ongoing efforts are being made to enhance the development of recreational catch-and-release fisheries on the Kola Peninsula. A carcass tagging and logbook scheme was introduced in UK (N. Ireland). This is designed to improve records/returns for rod caught fish and to facilitate regulation of catches (by quota) should this prove necessary.

Gear and effort: Apart from the prohibition of gill nets in parts of Russia, there have been no other changes in the types of commercial fishing gear used in the NEAC area. The number of licensed gear units has, in most cases, continued to fall; most fisheries for which data are available record a reduction of over 40% in gear units operated over the last 10 years. There are no such consistent trends for the rod fishing effort in NEAC countries over this period. Further initiatives to reduce fishing effort were introduced in several countries.

Catches: In the NEAC area there has been a general reduction in catches since the 1980s (Table 4.1.1.1). This reflects a decline in fishing effort as a consequence of management measures and the reduced commercial viability of some fisheries, as well as a reduction in the size of stocks. The overall nominal catch in the NEAC area in 2002 (2,464 t) was reduced on 2001 (2,876 t), but remained above the mean of the previous five years. Catches in both the NEAC northern and southern areas fell in comparison with 2001 (down 17% and 11% respectively). However, while the catch in the northern area was 7% above the five-year average, catches in the southern area were just below the average.

CPUE: CPUE data for various net and rod fisheries in the NEAC area do not indicate any consistent pattern. The reduction in the number of fisheries operating can benefit those fisheries still in operation and the lack of consistent trends in CPUE may reflect the imprecise nature of these indices.

Composition of catches: The percentage of MSW salmon in the catches in Northern Europe increased in 2002 to 46%, the highest value in the available time series. The percentage of MSW salmon in catches in Southern Europe remained close to the five and ten year average. Despite the continued high levels of production in the salmon farming industry, the incidence of farmed salmon in NEAC homewater fisheries was generally low (<2%) and similar to recent years. The exception to this is Norway, where farmed salmon continue to form a large proportion of the catch in coastal, fjord and rod fisheries.

Origin of catch: In 2002, a number of tags originating from other countries (UK (N. Ireland), UK (England & Wales), UK (Scotland) and Spain) were recovered in Irish coastal fisheries. An update of the adult recovery information derived from tagged smolts released in Norway was made available to ICES. Between 1996 and 2001 a total of 532,742 smolts, mainly hatchery-reared, were tagged and released. A total of 5,065 adult recoveries were reported from Norway and 24 from other countries (0.5% of the total number of salmon recovered). This is consistent with previous observations that very few Norwegian salmon are intercepted in other countries.

Summary of homewater fisheries in the NEAC area: In the NEAC area, there has been a general reduction in catches since the 1980s. This reflects a decline in fishing effort, as well as a reduction in the size of stocks. The overall nominal catch in the NEAC area in 2002 (2,464 t) represented a 14% decrease on the catch for 2001. The percentage of MSW salmon in 2002 was the highest (46%) since 1987 in catches in the NEAC Northern area and has increased sharply since 2000. The percentage of MSW salmon has been more stable in Southern Europe and the 2002 figure is close to the mean of the previous five years.

***Elaboration of s*tatus of stocks in the NEAC area**

In the evaluation of the status of stocks, PFA or recruitment values should be assessed against the spawner escapement reserve values while the spawner numbers should be compared with the conservation limits.

Northern European 1SW stocks: The PFA of 1SW salmon from the Northern European stock complex has been above the spawning escapement reserve throughout the time series (Figure 5.1.1a). However, the spawning escapement was at or below the conservation limit until 1997 (Figure 5.1.2a). There has been an upward trend throughout the time series until 2002 when there was a sharp decline taking the stock complex below the conservation limit again**.**

Northern European MSW stocks: The PFA of non-maturing 1SW salmon from Northern Europe has been declining since the mid 1980s and the exploitable surplus has fallen from around 1 million recruits in the 1970s to about half this level in recent years (Figure 5.1.1b). ICES considers the Northern European MSW stock complex to be within safe biological limits, as spawners are above CL and trending in a positive direction (Figure 5.1.2b) although the 2002 value shows a decrease on the previous year. However, it should be noted that the status of individual stocks may vary considerably. In addition, the inclusion of farmed fish in the Norwegian data will result in the exploitable surplus being over-estimated.

Southern European 1SW stocks: Recruitment of maturing 1SW salmon in the Southern European stock complex has shown a strong decreasing trend throughout most of the time series (Figure 5.1.3a). Moreover, the spawning escapement for the whole stock complex has fallen below the conservation limit in three of the past five years, although a small improvement was noted in 2002 (Figure 5.1.4a). Despite a small surplus above SER of around 300,000 fish during the last three years, exploitation in these years was clearly high enough to prevent conservation limits being consistently met.

Southern European MSW stocks: The PFA of non-maturing 1SW salmon from Southern Europe has been declining steadily since the 1970s (Figure 5.1.3b). The spawning escapement has for the last 6 years been at or below the conservation limit.

This applies to the total stock complexes. ICES notes that the national conservation limits may not be appropriate for quantitative catch advice at national level, however they are regarded as useful indicators of overall stock status. Stock status summaries are presented by country below:

Northern NEAC area

Finland

- 1SW spawners below CL in 2002.
- MSW spawners at or above CL in 2002.

Iceland

- 1SW spawners below CL in 2002.
- MSW spawners below CL in 2002.

Norway

- 1SW spawners below CL in 2002.
- MSW spawners at or above CL in 2002.

Russia

- 1SW spawners at or above CL in 2002.
- MSW spawners at or above CL in 2002.

Sweden

- 1SW spawners at or above CL in 2002.
- MSW spawners at or above CL in 2002.

Southern NEAC area

France:

- 1SW spawners at or above CL in 2002.
- MSW spawners below CL in 2002.

Ireland:

- 1SW spawners at or above CL in 2002.
- MSW spawners at or above CL in 2002.

UK (England & Wales):

- 1SW spawners at or above CL in 2002.
- MSW spawners at or above CL in 2002

UK (Northern Ireland):

- 1SW spawners at or above CL in 2002.
- MSW spawners at or above CL in 2002

UK (Scotland):

- 1SW spawners at or above CL in 2002.
- MSW spawners below CL in 2002

For individual rivers the status with respect to conservation requirements may vary considerably from this picture.

Survival indices

A majority of the survival indices for the latest smolt year classes for both the wild and hatchery-reared smolts were below the previous year as well as the 5- and 10-year averages. These observations are consistent with the numbers of returning and spawning fish derived from the PFA model and is consistent with the view that returns are strongly influenced by factors in the marine environment.

The status of stocks, as derived from the NEAC PFA model is described above.

5.9.2 NASCO has requested ICES to: evaluate the extent to which the objectives of any significant management measures introduced in the last five years have been achieved.

The effect of specific management measures on stocks and fisheries has been evaluated in a number of NEAC countries. In summary:

NEAC northern area
Russia - commercial catches declining as a result of various management changes. Mean catch in last five years (1998-2002) is 15% below that of the previous five years (1993-1997).
Norway - large decline in the fishing effort along part of the Norwegian coast in 1997. Effect not quantified, but exploitation has fallen markedly.

NEAC southern area
Ireland - management measures in the commercial fishery in 1997 effectively reduced effort by at least 20%. Fishing effort on spring salmon also reduced. Measures have contributed to a reduction in both the overall catch and the exploitation rate on Irish stocks.

UK (N. Ireland) - significant management introduced in the Fisheries Conservancy Board area in 2002. The number of netting licences reduced and accompanying measures to regulate angling also introduced on a voluntary code-of-practice basis, pending introduction of appropriate byelaws. While the effects of these measures on stock status will require some years to fully evaluate, this probably contributed to the reduction in net catch in the FCB area from 23.4t in 2001 to 9.4t in 2002.

UK (England and Wales) - in 2002, national measures to protect spring salmon are estimated to have saved around 2,800 salmon from capture by net fisheries and around 1,300 by rod fisheries before June 1. A policy to phase out coastal mixed stock salmon fisheries has continued. There have been large annual fluctuations in declared catches, but the overall effect of these measures has been to reduce catches in these coastal fisheries from an average of about 39,000 fish (1993-97) to a little under 32,000 (1998-2002). These measures have had more of an impact at the local level.

Scotland - voluntary agreement to delay start of fishing has resulted in about an 80% reduction in the catch of MSW salmon by nets and fixed engines in February and March, compared with the five years previous.

France - TACs have operated in several regions in an effort to reduce exploitation of spring salmon. However, catch data suggest this merely delayed exploitation in these small rivers. New closed periods for the net fishery in the Adour estuary resulted in a higher proportion of 1SW salmon in the catch (58%) than in 2001 (16%), but did not reduce the level of exploitation on 2SW salmon.

ICES noted that management measures introduced in the last 5 years and the overall reduction in gear units have continued to reduce levels of exploitation on NEAC stocks.

5.9.3 NASCO has requested ICES to: further refine the estimate of by-catch of salmon post-smolts in pelagic trawl fisheries for mackerel and provide estimates for other pelagic fisheries that may catch salmon

Atlantic salmon post-smolts have been observed to overlap in time and space with some of the mackerel fishing areas in the North east Atlantic, and both species appear to follow the warm and saline Atlantic current on their northward migration. The potential risk of salmon post-smolts being taken in commercial fisheries has been a concern for some time and initial, highly provisional, estimates for 2001 suggested by-catch might be significant. ICES was requested to further refine this estimate and provide estimates for other pelagic fisheries that may catch salmon.

Research surveys and distribution of salmon

Norwegian research surveys carried out since 1990 using a specially designed “salmon trawl” have captured a total of 4,164 post-smolts and 171 older salmon in 2,438 surface trawl hauls in the northern Norwegian Sea (Figure 5.9.3.1). Since the start of dedicated salmon cruises in the Norwegian Sea in 1999, CPUE values for post-smolts (number caught per trawl hour) have been relatively high, reaching a peak of 28 in 2001. In 2002, values were lower (Table 5.9.3.1, Figure 5.9.3.2), but more evenly distributed over the area than in 2001, indicating that the timing of the cruise must have been favourable in relation to the density of post-smolt cohorts passing through the survey area. The largest densities of post-smolts were recorded from June 21 to 24 around 68°N, earlier and further north than previously recorded. The smolt age distribution of these fish indicated a southern origin; this was supported by the fact that 9 of the 10 microtagged fish retrieved were of Irish origin.

It had previously been thought that the surface ‘salmon trawl’ would not catch larger adult salmon due to the relatively low trawling speed (3.2 – 3.8 kt), and video recordings performed in the trawl in 2000-2002 seemed to support this. As a result, no efforts had previously been made to calculate CPUE values for larger salmon. However, in a Nordic Data storage tag (DST) tag and release experiment to the north of the Faroes in the period October to January, substantial numbers of pre-adult and adult salmon were captured using a modified salmon trawl. This raised the additional concern that larger salmon may also be subject to by-catch in pelagic fisheries.

One of the objectives of a Russian pelagic fish survey in the Norwegian Sea from 29 May to 26 July 2002 was to map the distribution of post-smolts in the area. This survey was completed as part of an annual international research programme to study commercial species (herring, blue whiting and mackerel) in the Norwegian and Barents Seas. Hauls were taken by a pelagic research trawl according to agreed survey protocols; both surface and non-surface hauls were completed. In surface hauls the headline moved at depths from 0 to 5 m; most non-surface hauls were at depths of 5 to 40 m, but a small number of hauls were made at depths of 190-290 m. In all cases, the whole catch was screened and each fish was handled and identified to species. In June hauls were taken mainly in the southern part of the Norwegian Sea, and 14 of the 30 hauls contained mackerel. Mackerel were mainly taken in hauls with the headline towed at a depth of 0-5 m. No post-smolts were recorded in these hauls, although one adult salmon was caught in international waters. In July fishing took place in the mid-part of the Norwegian Sea, up to the island of Jan Mayen, and mackerel were found in 26 of 52 hauls. Another two adult salmon were caught in two of these hauls. The highest catches of post-smolts were made in July, north of 69°N. In four hauls on 8, 9 and 15 July, 32 post-smolts were recovered. In the two most northern hauls (2 and 17 post-smolts) no mackerel were caught, while in the other two (2 and 11 post-smolts) the catch of mackerel was 3 and 28 kg respectively.

By-catches of post-smolts and salmon

A dedicated Norwegian salmon and mackerel research cruise was completed in 2002 in the Norwegian Sea in the international area to the west and north of the Voeringplateau and the Norwegian EEZ (66°N – 69.7°N and 1°W – 17.4° E). In total, 44 tows were carried out between 21st June and 1st July to investigate by-catch: 590 post-smolts, 8 salmon and 19,125 kg mackerel were caught. Post-smolt catches were higher in the north, at the beginning of the cruise, and declined as the cruise moved southwards approaching 66°N. Post-smolt captures in single tows were smaller in the Norwegian EEZ than in the international zone, but every haul in this area contained post-smolts. In contrast, 56 % of the hauls in the international zone contained post-smolts. Large catches of mackerel were made in the same tows. Average CPUE was 10 post-smolts per trawl hour in the international zone and 11.9 post-smolts per trawl in the Norwegian EEZ. The mean CPUE (catch per trawl hour) for mackerel was 224 kg in the Norwegian EEZ and 598 kg in the international zone.

The ratio of post-smolt numbers per kg of mackerel was 0.026 in the international zone in 2002; this area was not surveyed in 2001. In the Norwegian EEZ, 0.057 post-smolts per kg of mackerel were caught in 2002 compared with 0.025 in 2001 (Table 5.9.3.2). The 2002 investigations confirm there is some degree of spatial and temporal overlap between the mackerel distribution and the northward migration routes for the post-smolts from south and central Europe and southern Norway. However, both mackerel and salmon post-smolts were found earlier in the year and further to the north and north-west than noted during previous cruises.

In 2002, the Russian Federation carried out a comprehensive programme in the Norwegian Sea to study the potential by-catch of Atlantic salmon and post-smolts in the Russian mackerel fishery. In the period June to August 16 scientific observers and fisheries inspectors were deployed on Russian fishing vessels, and their tasks included screening the mackerel catch for potential by-catch of salmon. Approximately 50 Russian vessels fished for mackerel in the Faroese fishing zone and international waters in 2002 and catches were screened on 20 of these. Scanning was carried out both on individual vessels during the discharging of the trawl into bins and at a factory ship during grading. The vessel's crew assisted in this work. The catch in the screened hauls varied from a few hundred kilos to 87 t; the average catch per haul for inspected vessels was 17.5 t and varied from 2 t to 42 t among vessels. For larger catches (> 10 t), sub-sampling was necessary and one to three samples of 3 t each were taken for screening. Catches from a total of 1,070 hauls, 25% of all hauls taken by Russian vessels during the fishing season, were screened. As a result of the screening, 15 adult salmon (one of which carried a Swedish Carlin tag) and 12 post-smolts were recorded (Table 5.9.3.3). The highest occurrence of post-smolts was recorded in June (0.065 per haul), this fell to 0.015 post-smolts per haul in July and no post-smolts were found in August. The by-catch of post-smolts, except one, and salmon was taken along the Norwegian 200-mile limit in the area bounded by co-ordinates 65°30' to 66°30'N and 01°00' to 03°00'E.

ICES also received additional information on by-catch in other fisheries. Almost 200 salmon (1 – 2 kg) were reported from an Icelandic herring catch of 800 metric tonnes taken in the Spitsbergen area in August 2002. The fish were captured by a multi-gear-vessel in a mid-water trawl. One of the salmon caught was tagged as a smolt in the River Drammen, Norway. Historical information from the 1960s also indicated a by-catch of up to 30 salmon per haul in the herring fishery in Iceland. No specific screening for salmon post-smolts has been initiated in recent years in the Faroes. However, routine sampling of catches of herring, blue whiting and mackerel at a fish-meal factory has not revealed any salmon by-catch.

The discrepancy between the large numbers of post-smolts caught with mackerel in the Norwegian research fishery and the low by-catch observed in the commercial mackerel fishery may have a number of possible explanations:

- Detection rates may decrease with increasing sample size. Therefore the rate of non-detection may be higher in the Russian survey as larger numbers of fish were sampled in the catches. However, Russian samplers considered it unlikely that significant numbers of post-smolts were overlooked.
- The targeted research fishery, and the trawl methods used, may lead to over-estimation of the salmon by-catch in commercial pelagic fisheries as these fisheries are expected to be more effective in targeting and catching mackerel.
- Most of the post-smolts may have migrated through international waters before the large-scale mackerel fishery starts. In contrast, the research fishery specifically aims to sample the peak post-smolt migration in the area.

There are substantial differences between the Norwegian research trawl and the gear used in the commercial mackerel fishery. The behaviour of post-smolts in relation to these different gears is not known.

The best method to estimate by-catches in the commercial fishery is undoubtedly direct observation onboard the commercial vessels.

Given the large differences between the results from the Norwegian by-catch studies in 2001-02 and the Russian research trawling and screening of commercial catches, ICES agreed it was necessary to continue to collect data on the biology and distribution of post-smolts and older Atlantic salmon in the sea.

ICES made a number of recommendations for further research on this topic (Section 4.7).

Description of mackerel and other commercial pelagic fisheries

ICES noted that there are many pelagic fisheries operating in the North Atlantic. Information on those that might overlap with the known distribution of salmon post-smolts in the sea, and thus could have potential implications with regard to the by-catch of salmon, was reviewed. The Russian Federation provided a detailed description of the Russian mackerel fishery in the Norwegian Sea (Figure 5.9.3.3). Details for other fisheries were taken from the reports of the Working Group on Mackerel, Horse Mackerel, Sardine and Anchovy (ICES CM2003/ACFM:07) and the Working Group on Northern Pelagics and Blue Whiting (ICES CM2002/ACFM:19). Information on the following fisheries was compiled and is presented in the Working Group report (ICES CM 2003/ ACFM 19):

Mackerel (678,000 t in 2001);
Norwegian spring-spawning herring (756,845 t in 2001);
Blue-Whiting (1,780,000 t in 2001);
Horse mackerel (283,000 t in 2001);
Icelandic summer-spawning herring (95,278 t in 2001);
Capelin in the Iceland, East Greenland and Jan Mayen area (276,000 t in June/July 2001 and 955,000 t in the 2002 winter season).

Table 5.6.1 Predictions and 95% bootstrap confidence limits (thousands) of *PFA non-m* using *Year* and *Spawners*.

Year	Egg Numbers	Prediction	Lower limit	Upper limit
2002	2481	537	345	847
2003	2020	524	315	840

Table 5.9.3.1. Catch numbers, weight and catch per unit of effort (CPUE, trawl hours) of post-smolts and mackerel in the international area of the Norwegian Sea, 21st June – 01st July 2002.

Fished area	Date, YYMMDD	Tow time Hrs	Station no.	Mackerel		Post-smolts		
				Catch, kg	CPUE, kg h^{-1}	Catch, no.	CPUE, No. h^{-1}	No. per CPUE of mackerel
Internat. Zone	020622	2.0	235	61.1	31.31	49	25.13	1.56
- " -	020622	2.0	236	293.4	146.70	133	66.50	0.91
- " -	020622	2.1	237	272.0	131.61	40	19.35	0.30
- " -	020623	1.0	238	14.0	14.18	2	2.00	0.14
- " -	020623	1.0	239	1,152.0	1,152.00	11	11.00	0.01
- " -	020623	1.0	241	272.0	276.61	0	0.00	0.00
- " -	020623	1.0	242	92.0	92.00	6	6.00	0.07
- " -	020623	1.0	243	858.0	858.00	86	86.00	0.10
- " -	020624	0.9	244	95.7	106.33	29	32.22	0.27
- " -	020624	1.0	245	1,100.0	1,100.00	18	18.00	0.02
- " -	020624	1.0	247	14.9	14.86	0	0.00	0.00
- " -	020625	1.0	249	96.5	96.50	0	0.00	0.00
- " -	020625	1.3	252	195.0	153.95	0	0.00	0.00
- " -	020625	1.1	253	1,386.0	1,320.00	11	10.48	0.01
- " -	020626	1.0	254	1,000.0	1,000.00	0	0.00	0.00
- " -	020626	1.0	255	92.6	94.17	0	0.00	0.00
- " -	020626	1.1	256	95.0	87.69	1	0.92	0.01
- " -	020626	1.2	257	45.2	36.62	10	8.11	0.27
- " -	020626	1.2	258	66.5	57.83	6	5.22	0.10
- " -	020627	0.9	260	320.0	342.86	0	0.00	0.00
- " -	020627	1.0	261	1,330.0	1,330.00	3	3.00	0.00
- " -	020628	1.0	268	2,300.0	2,300.00	0	0.00	0.00
- " -	020629	0.5	271	198.0	396.00	0	0.00	0.00
- " -	020629	0.6	272	81.0	142.94	0	0.00	0.00
- " -	020629	1.0	274	198.0	198.00	1	1.00	0.01
- " -	020629	1.0	275	530.0	530.00	1	1.00	0.00
- " -	020629	1.0	276	640.0	640.00	0	0.00	0.00
- " -	020630	0.5	277	2,200.0	4,400.00	0	0.00	0.00
- " -	020630	0.5	278	480.0	929.03	0	0.00	0.00
- " -	020630	1.0	279	560.0	560.00	0	0.00	0.00
- " -	020701	1.0	280	190.0	190.00	14	14.00	0.07
- " -	020701	1.0	282	120.0	120.00	10	10.00	0.08
Internat. zone, Sum		33.7	32	16,348.9	Mean, 589.04	431	Mean, 10.00	Mean, 0.12

Ratio of total no of post-smolts captured per total catch of mackerel = 0.026
Mean number of post-smolts per haul = 13.47

Table 5.9.3.1. contd. Catch numbers, weight and catch per unit of effort (CPUE, trawl hours) of post-smolts and mackerel in the Norwegian EEZ of the Norwegian Sea, 21st June – 01st July 2002.

Fished area	Date YYMMDD	Tow time hours	Station no.	Mackerel Catch, kg	Mackerel CPUE, kg h^{-1}	Post-smolts Catch, no.	Post-smolts CPUE, no. h^{-1}	Post-smolts No. per CPUE of mackerel
Norw. EEZ	020621	2.0	234	24.4	12.21	36	18.00	2.95
- " -	020624	1.0	246	264.0	264.00	47	47.00	0.18
- " -	020624	1.0	248	759.0	759.00	5	5.00	0.01
- " -	020625	1.0	250	280.5	275.90	2	1.97	0.01
- " -	020625	1.0	251	95.5	93.93	9	8.85	0.10
- " -	020627	1.0	262	27.6	27.56	20	20.00	0.73
- " -	020627	1.0	263	363.0	363.00	4	4.00	0.01
- " -	020628	1.0	265	231.0	231.00	8	8.00	0.03
- " -	020628	1.0	266	39.3	39.34	12	12.00	0.31
- " -	020628	1.0	267	185.0	185.00	13	13.00	0.07
- " -	020628	1.5	269	429.0	286.00	1	0.67	0.00
	020629	0.5	273	78.5	151.94	2	3.87	0.01
Norw. EEZ, Sum		13.0	12	2,776.8	Mean, 224.07	159	Mean, 11.86	Mean, 0.37
Total fished area		46.7	44	19,125.7	Mean, 89.50	590	Mean, 10.51	Mean, 0.14

Ratio of total no of post-smolts captured per total catch of mackerel = 0.057
Mean number of post-smolts per haul= 13.25

Table 5.9.3.2. Ratio between post-smolts and mackerel in Norwegian research trawl captures in the Norwegian Sea

Year	Norwegian zone Total ratio	Norwegian zone Unwght. mean	International zone Total ratio	International zone Unwght. mean
2001	0.016	0.025	-	-
2002	0.057	0.370	0.026	0.120

Table 5.9.3.3. Details of the screening of catches from the Russian mackerel fishery in the Norwegian Sea in June-August 2002.

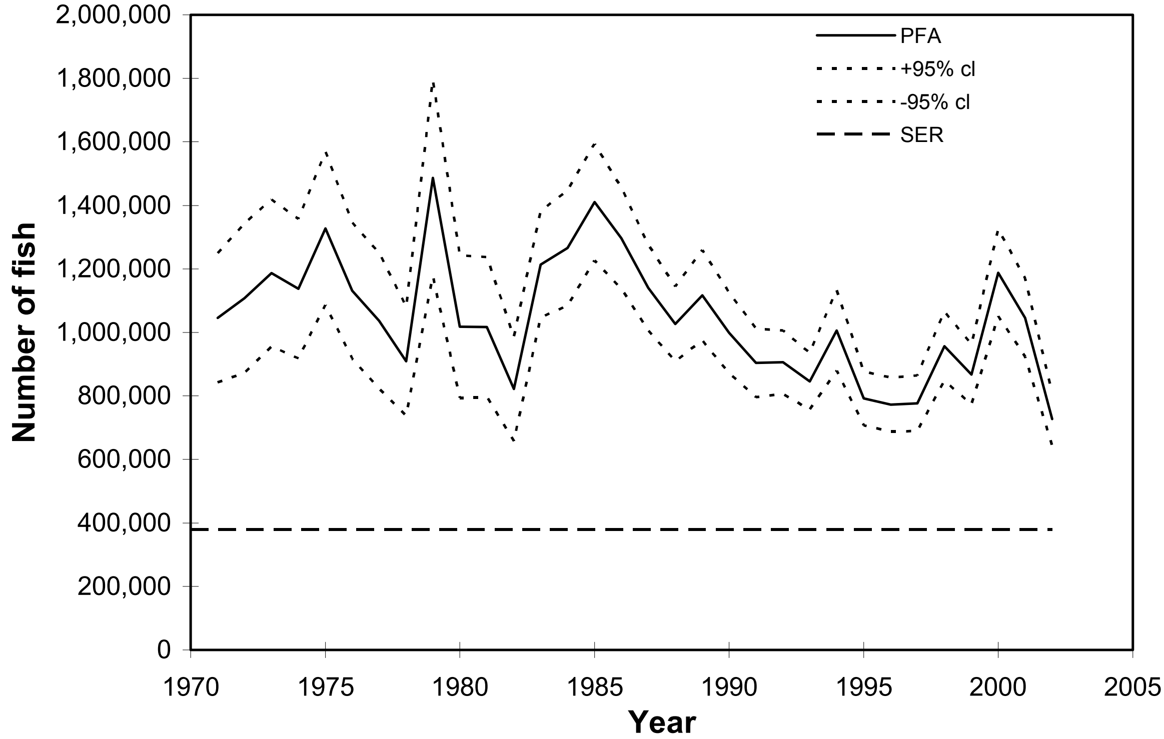
Month	Number of hauls		Catch, t					
	Total	Screened	Total*		In screened hauls			
			All species	Mackerel	All species	Mackerel	Post-smolts, indiv.	Salmon, indiv.
June	232	46 (5 vessels)	2,344	2,135	289	245	3	3
July	2897	595 (20 vessels)	35,744	29,802	5,683	4,156	9	9
August	1222	429 (14 vessels)	14,334	7,509	4,940	3,359	0	3
Total	4351	1070 (20 vessels)	52,422	39,446	10,912	7,760	12	15

* Provisional figures

Figure 5.1.1 Estimated recruitment (PFA) and Spawning Escapement Reserve (SER) for maturing and non-maturing salmon in Northern Europe, 1971-2002

a) Maturing 1SW recruits (potential 1SW returns)

(Recruits in Year N become spawners in Year N)



b) Non-maturing 1SW recruits (potential MSW returns)

(Recruits in Year N become spawners in Year N+1)

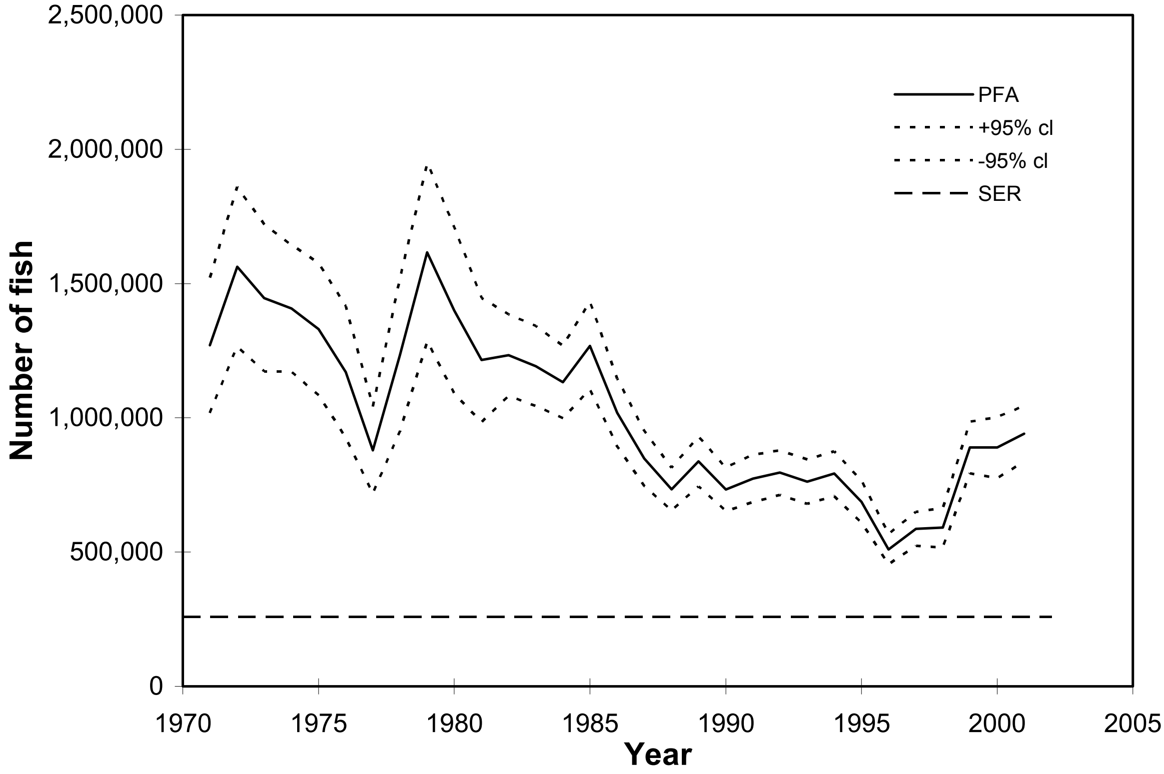
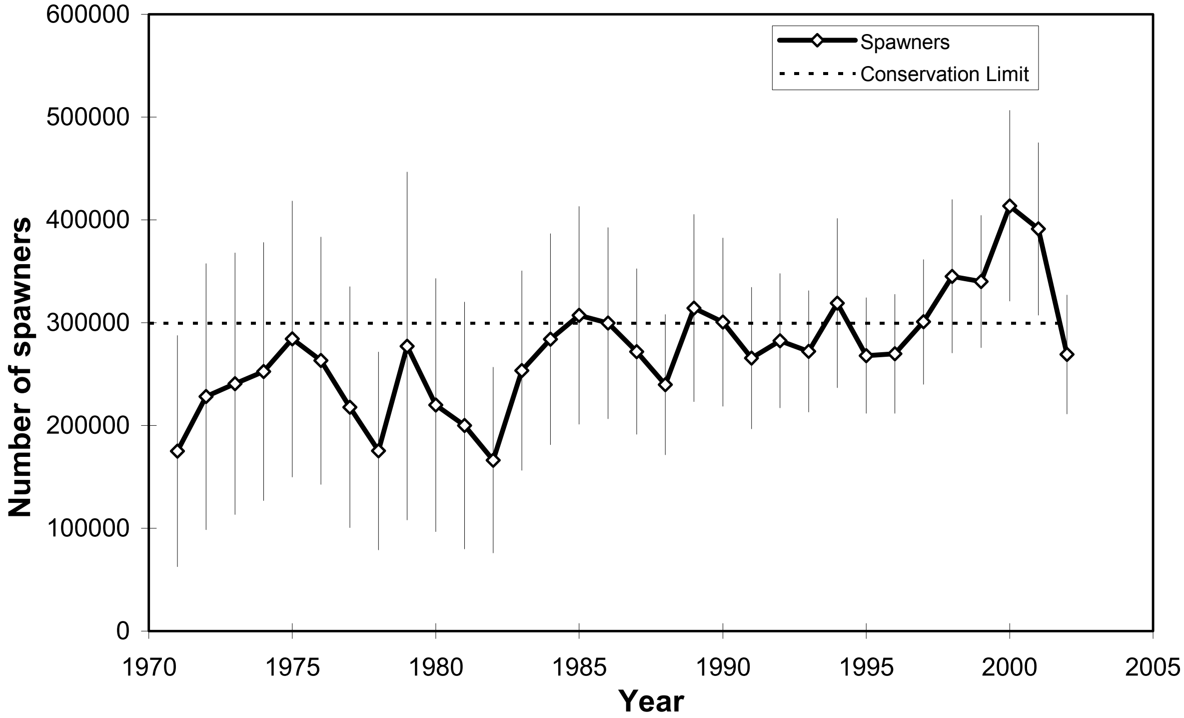


Figure 5.1.2 Estimated spawning escapement of maturing and non-maturing salmon in Northern Europe, 1971-2002

a) 1SW spawners (and 95% confidence limits)



b) MSW spawners (and 95% confidence limits)

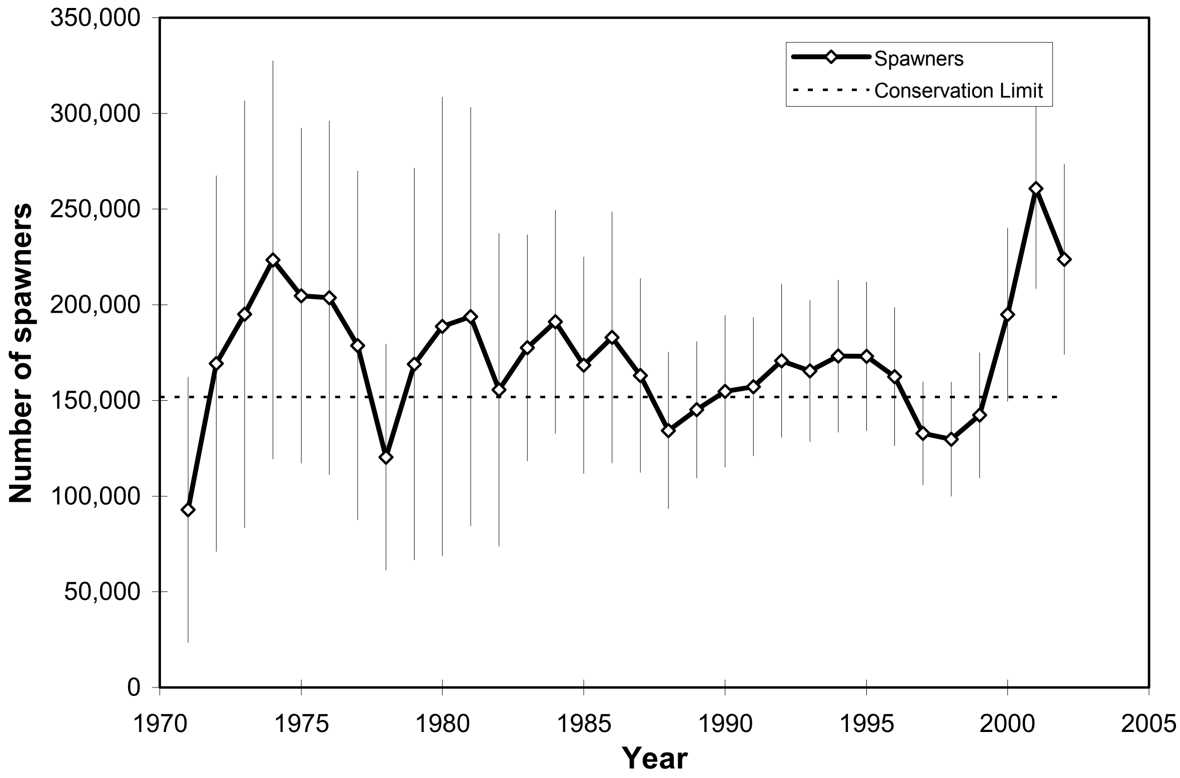
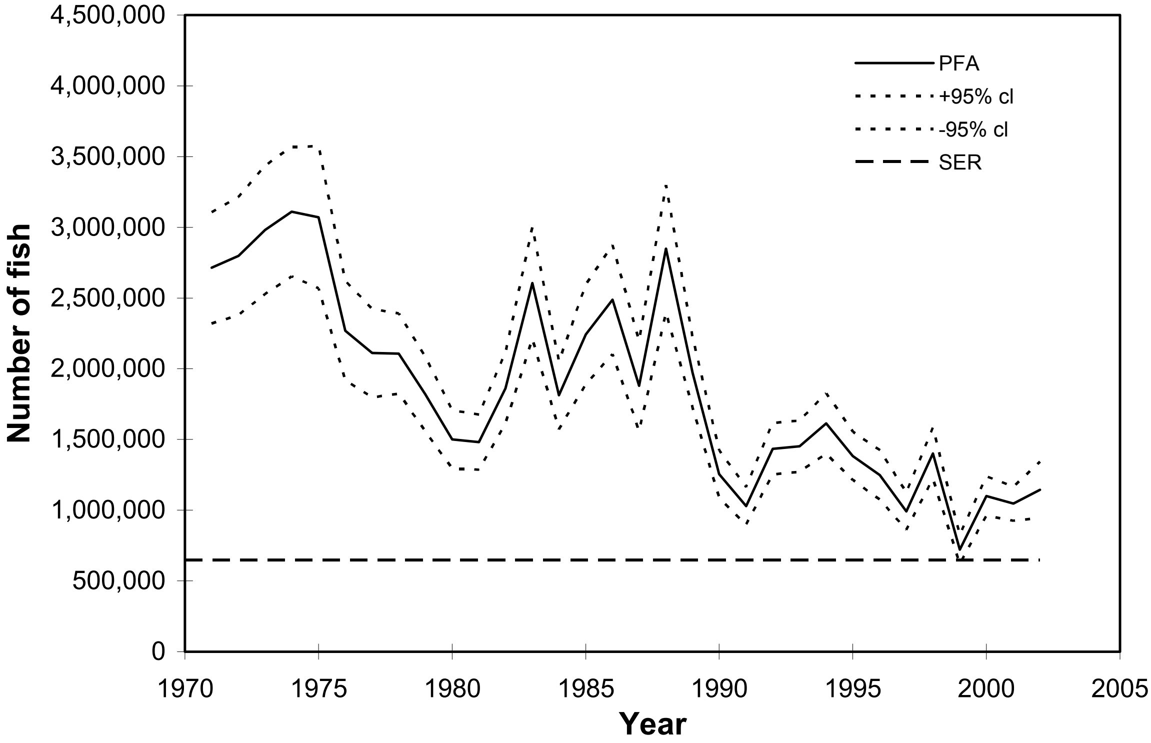


Figure 5.1.3 Estimated recruitment (PFA) and Spawning Escapement Reserve (SER) for maturing and non-maturing salmon in Southern Europe, 1971-2002

a) Maturing 1SW recruits (potential 1SW returns)

(Recruits in Year N become spawners in Year N)



b) Non-maturing 1SW recruits (potential MSW returns)

(Recruits in Year N become spawners in Year N+1)

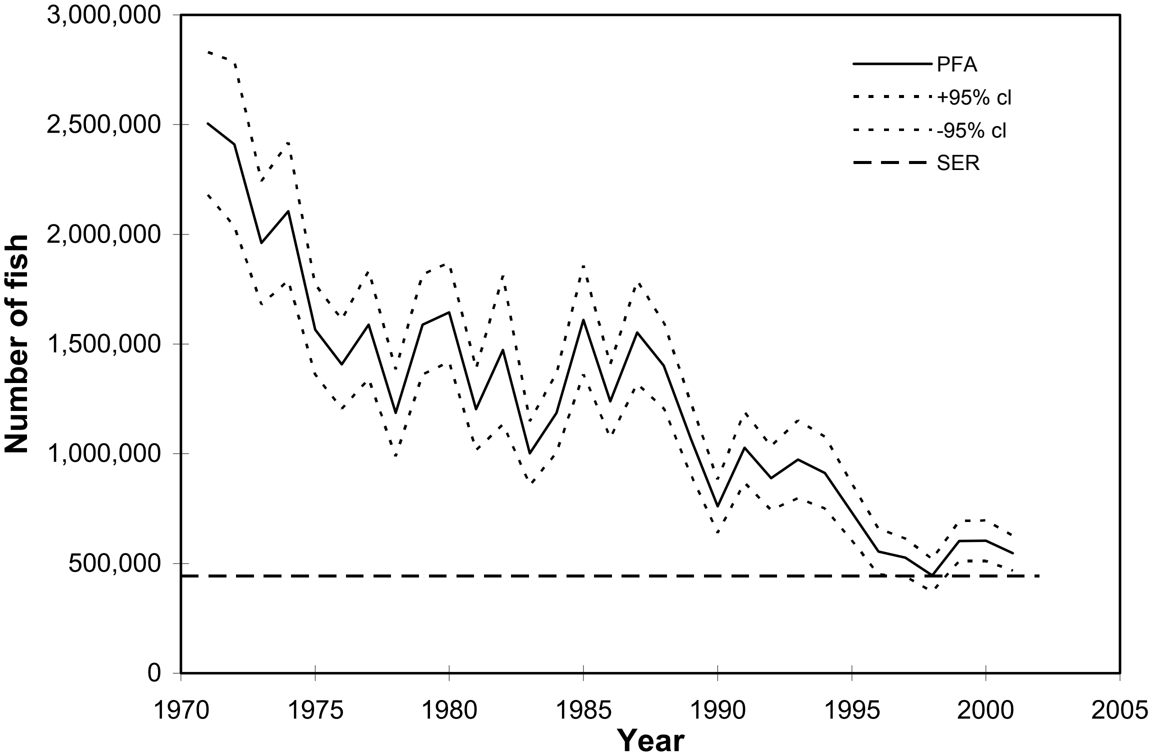
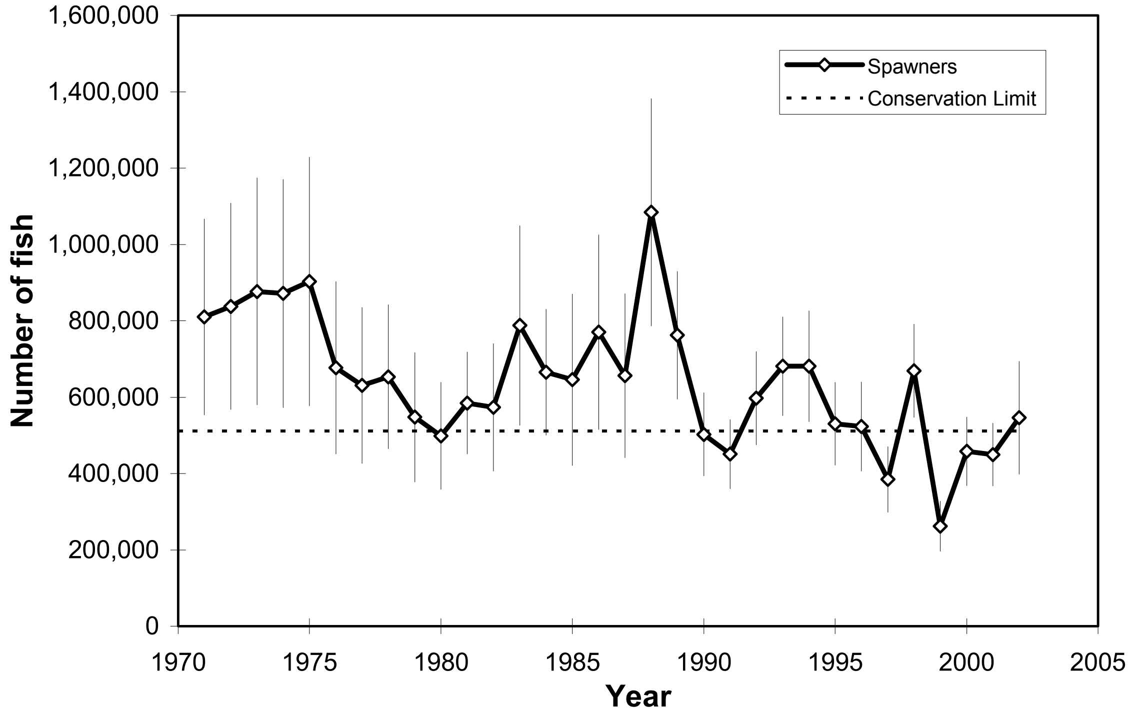


Figure 5.1.4 Estimated spawning escapement of maturing and non-maturing salmon in Southern Europe, 1971-2002

a) 1SW spawners (and 95% confidence limits)



b) MSW spawners (and 95% confidence limits)

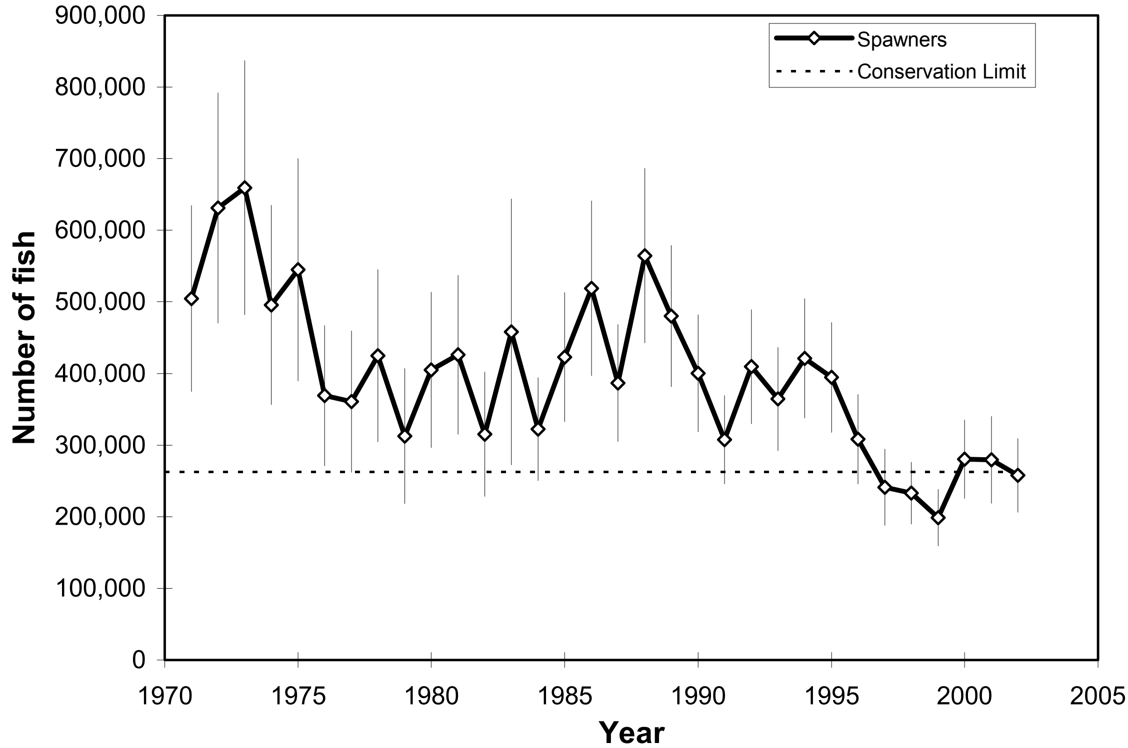


Figure 5.4.1 *PFA non-maturing* trends and predictions (+/- 95% confidence intervals) for Southern European stock complex.

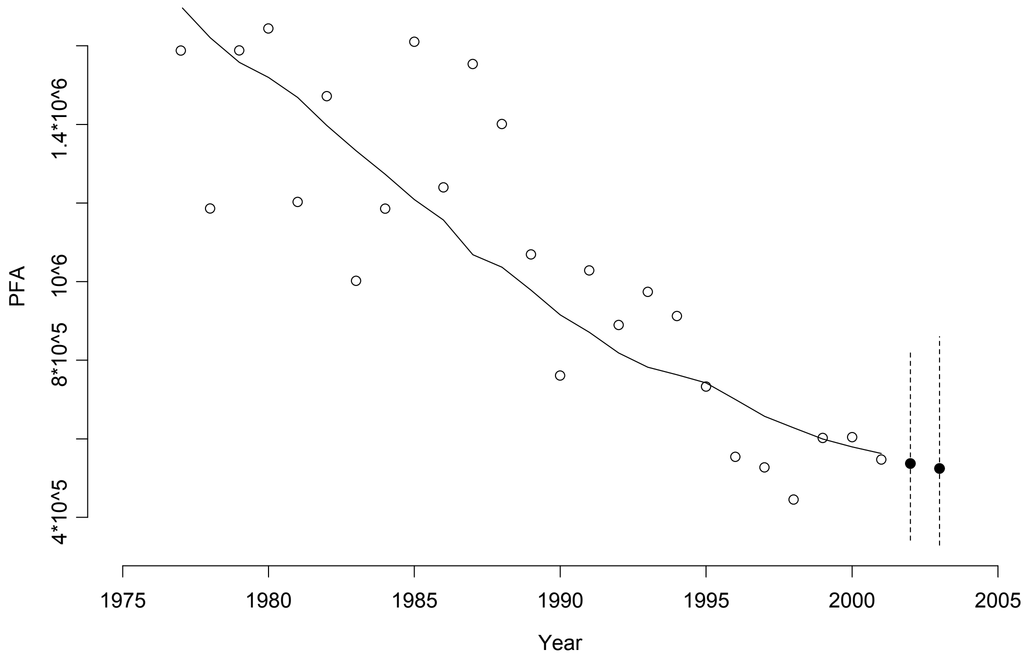


Figure 5.9.3.1. Distribution of Scottish and Norwegian post-smolt captures 1990 – 2001 (Holm et al. 2003; Shelton 1997). Numbers of post-smolts in catches presented as symbols, legends in figure.

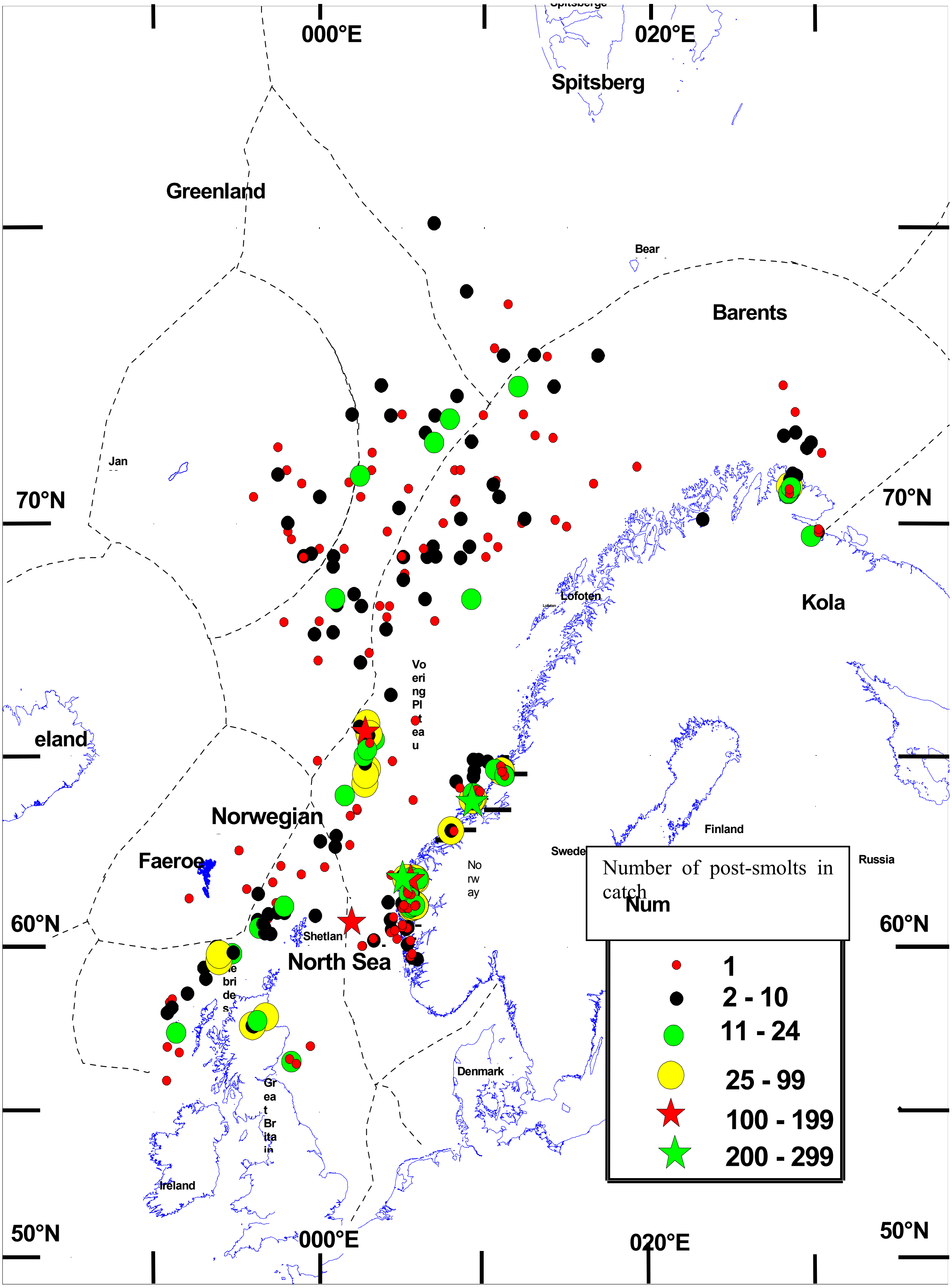


Figure 5.9.3.2 Catch per unit of effort (CPUE, number per nautical miles) of post-smolts by latitude. Timing of peak CPUE in 2000 (upper panel), 2001 (mid panel) and 2002 (lower panel). All cruises have been going from north to south.

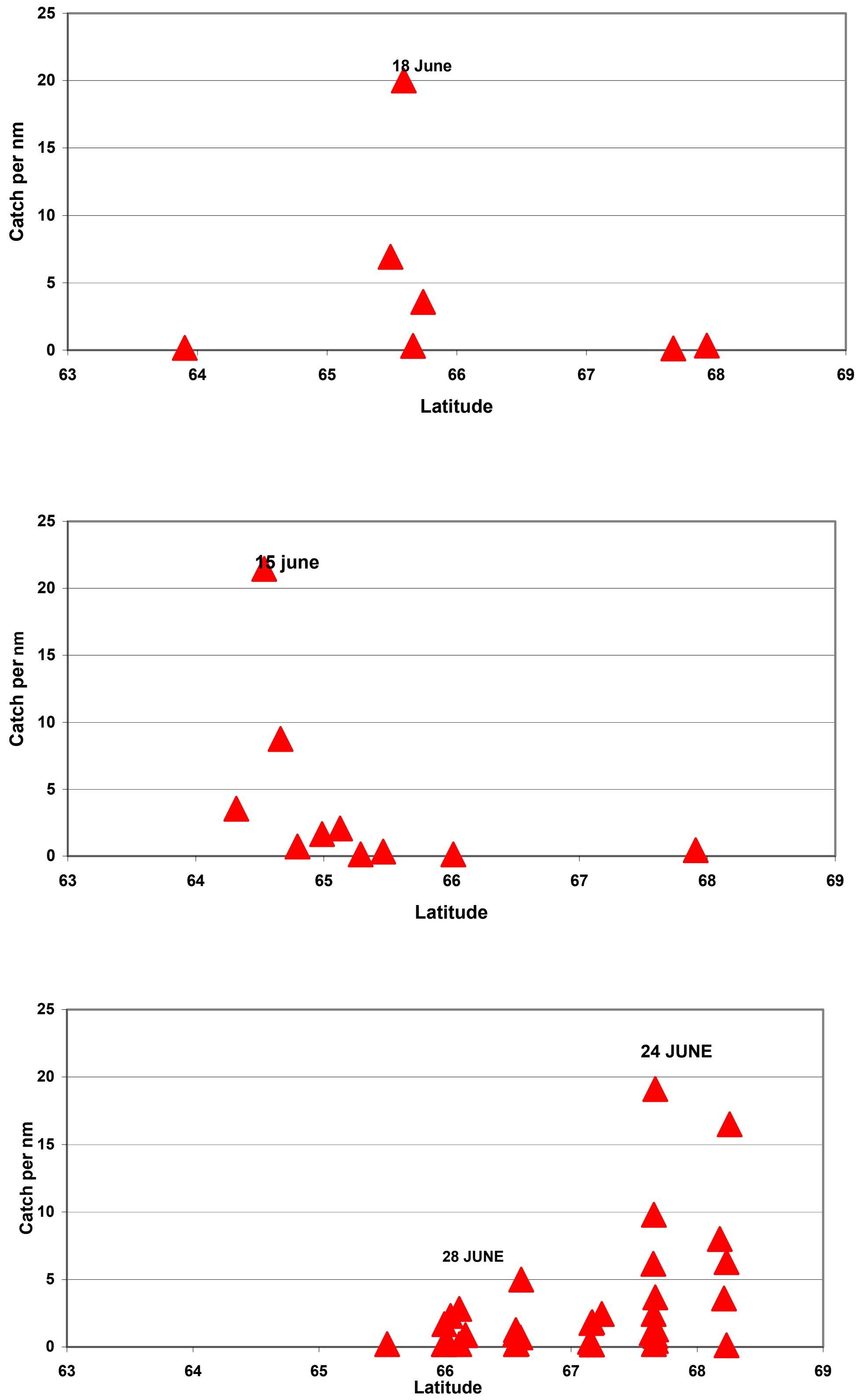
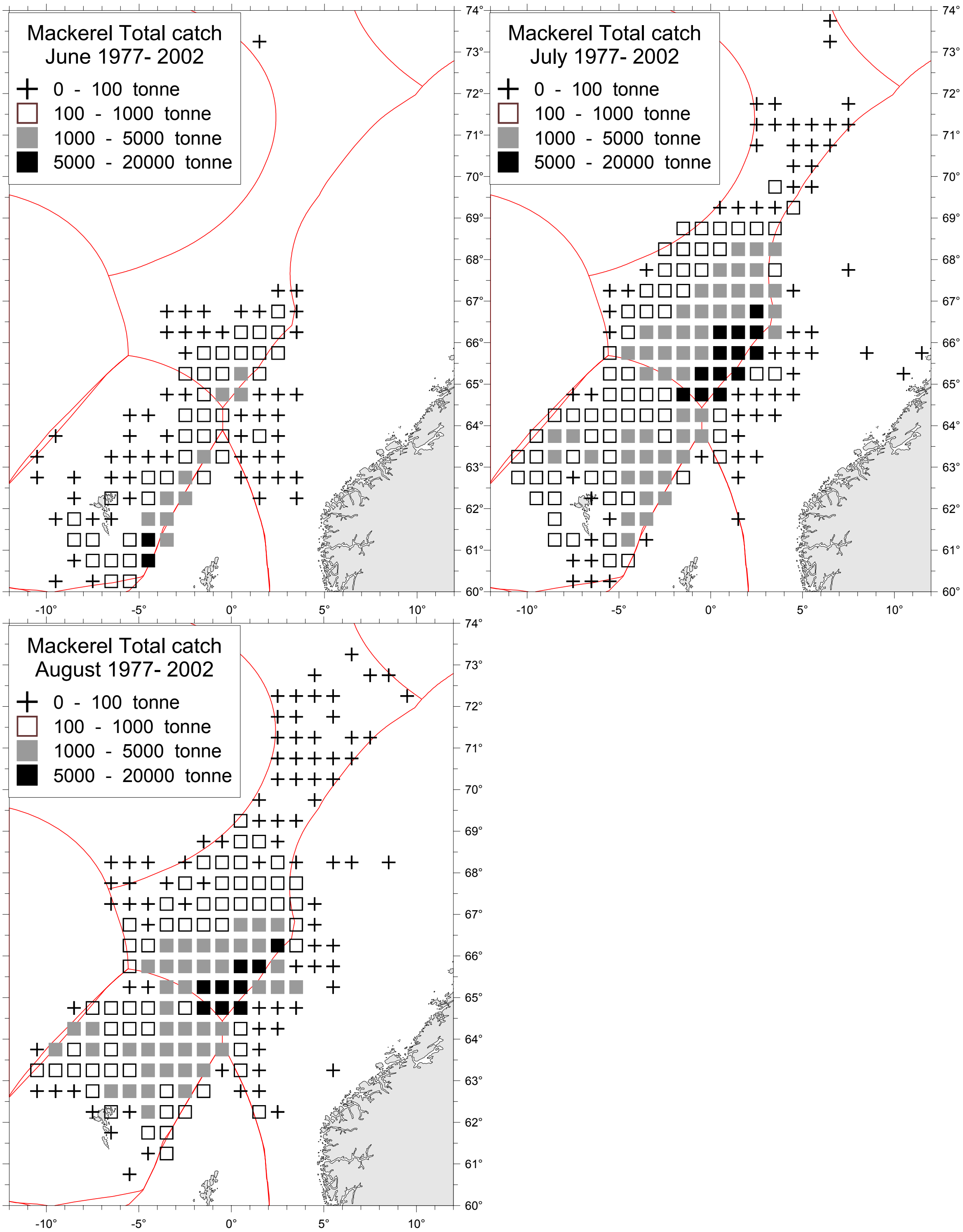


Fig. 5.9.3.3. Russian mackerel catches in 1977-2001. (1977-1997 NEAFC database, 1998-2001 WGMHSA 1999-2002).



6 ATLANTIC SALMON IN THE NORTH AMERICAN COMMISSION AREA

6.1 Status of stocks/exploitaton

In 2002, the overall conservation limit (S_{lim}) for 2SW salmon was not met in any area except for Newfoundland, therefore the stock complexes in these regions are considered to be outside safe biological limits. However, for the Newfoundland region, although the mid-point estimate of spawners in 2002 was above CL, it is not known if this overall stock complex is within safe biological limits, as the statistical confidence intervals of the spawner estimates are not available.

The stock status is elaborated in section 6.9.1.

6.2 Management objectives

The general NASCO management objectives apply (See Section 3).

6.3 Reference points

As precautionary reference points have not been developed for these stocks, management advice is therefore referenced to the S_{lim} conservation limit. Thus, these limits should be avoided with high probability (i.e. at least 75%).

In Atlantic Canada, CLs have been set on the basis of stock and recruitment studies which provided for MSY on a limited number of river stocks where data was available, and these derived egg deposition rates were used on the remainder of rivers where only habitat area and spawner demographics were available, as documented in O'Connell, et al. (1997). The added production from lacustrine areas in Labrador and Newfoundland was also accommodated. In USA, conservation limits were set following a similar approach. Recently, for stocks in Quebec, stock-recruitment analysis for six local rivers was used to define the CL, defined as the S_{MSY} level at 75% probability level, calculated by Bayesian analysis. For the purposes of management, egg deposition requirements are converted into 2SW fish equivalents. These are presented by fishery management zone in Table 6.3.1.

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

6.4 Advice on management

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 restrict the harvest. Advice regarding management of this stock complex in the fishery at West Greenland is provided in Section 7.

6.5 Relevant factors to be considered in management

For all fisheries, ICES considers that management of single stock fisheries should be based upon assessments of the status of individual stocks. Conservation would be best achieved if fisheries can be targeted at stocks that have been shown to be above biologically-based escapement requirements. Fisheries in estuaries and rivers are more likely to fulfil this requirement.

Reduced exploitation on large salmon in the in-river and estuarine fisheries of the Miramichi has resulted in an expanded age structure in which repeat spawners have comprised as much as 50% of the large salmon returns. It is therefore necessary to consider that if this is a widespread response to fishery closures, a large proportion of the actual egg deposition may in future be provided by fish which are not presently considered in setting CLs and assessing whether CLs have been achieved.

6.6 Catch forecast for 2003

Catch options are only provided for the non-maturing 1SW and maturing 2SW components as the maturing 1SW component is not fished outside of home waters, and in the absence of significant marine interceptory fisheries, is managed in homewaters by the producing nations.

It is possible to provide catch advice for the North American Commission area for two years. The revised forecast for 2003 for 2SW maturing fish is based on a new forecast of the 2002 pre-fishery abundance and accounting for fish which were already removed from the cohort by fisheries in Greenland and Labrador in 2002 as 1SW non-maturing fish. The second is a new estimate for 2004 (see section 6.7) based on the pre-fishery abundance forecast for 2003 from Section 7. A consequence of these annual revisions is that the catch options for 2SW equivalents in North America may change compared to the options developed the year before.

Catch advice for 2003 fisheries on 2SW maturing salmon

The revised forecast of the pre-fishery abundance for 2002 provides a PFA mid-point of 133,087.

In order to compare the PFA to conservation limits, the pre-fishery abundance of 133,087 can be expressed as 2SW equivalents by considering natural mortality of 3% per month for 11 months (a factor of 0.72), resulting in 95,679 2SW salmon equivalents. There have already been harvests of this cohort as 1SW non-maturing salmon in 2002 for both the Labrador (299) and Greenland (1,499) fisheries (Tables 6.3.1 and 6.6.1) for a total of 1,798 2SW salmon equivalents already harvested, when the mortality factor is considered, leaving 93,881 2SW salmon returning to North America.

As the predicted number of 2SW salmon returning to North America (93,881) is substantially lower than the 2SW conservation limit (S_{lim}) of 152,548, there are no harvest possibilities at forecasted levels considered risk-averse (at probability levels of 75% and below). The numbers provided for 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 restrict the harvest.

6.7 Medium to long term projections

Catch advice for 2004 fisheries on 2SW maturing salmon

Most catches (92%) in North America now take place in rivers or in estuaries. The commercial fisheries are now closed and the remaining coastal food fisheries in Labrador are mainly located close to river mouths and likely harvest few salmon from other than local rivers. Fisheries are principally managed on a river-by-river basis and, in areas where retention of large salmon is allowed, it is closely controlled.

Catch options which could be derived from the pre-fishery abundance forecast for 2003 (111,042) would apply principally to North American fisheries in 2004 and hence the level of fisheries in 2003 needs to be accounted for before providing them.

Accounting for mortality and the conservation limit and considering an allocation of 60% of the surplus to North America, the only risk averse catch option for 2SW salmon in 2004 is “zero” catch. This “zero” catch option refers to the composite North American fisheries. As the biological objective is to have all rivers reaching or exceeding their conservation limits, river-by-river management will be necessary. On individual rivers, where conservation limits are being achieved, there are no biological reasons to restrict the harvest.

6.8 COMPARISON WITH PREVIOUS ASSESSMENT AND ADVICE

The revised forecast of the pre-fishery abundance for 2002 provides a PFA mid-point of 133,087. This is much lower than the value forecast last year at this time of 329,552. This is mainly due to changes to the model used to forecast PFA for these stocks, as detailed in Section 7.

6.9 Response to specific requests for information from NASCO

6.9.1 NASCO has requested ICES to describe the key events of the 2002 fisheries and the status of the stock

Key events of the 2002 fisheries

Catch histories of North American salmon

Catch histories for this stock complex are provided in Tables 6.9.1.1 and 6.9.1.2, expressed as 2SW salmon equivalents. The Newfoundland-Labrador commercial fisheries were, historically, a mixed stock fishery and harvested both maturing and non-maturing 1SW salmon as well as 2SW maturing salmon. Mortalities within North America peaked at about 365,000 in 1976 and are now about 10,000 2SW salmon equivalents. In the most recent four years estimated (that is those since the closure of the Labrador commercial fishery), those taken as non-maturing fish in Labrador comprise 3%, or less, of the total in North America.

Of the North American fisheries on the cohort destined to be 2SW salmon, 86% of the catch comes from terminal fisheries in the most recent year. This value has ranged from as low as 20% in 1973, 1976 and 1987 to values of 77-91% in 1996-2002 fisheries (Table 6.9.1.1). The percentage increased significantly with the reduction and closures of the Newfoundland and Labrador commercial mixed stock fisheries, particularly since 1992.

The percentage of the total 2SW equivalents that have been harvested in North American waters has ranged from 48-100%, with the most recent year estimated at 58% (Table 6.9.1.2.).

Gear and effort

The 23 areas for which the Department of Fisheries and Oceans (DFO) manages the salmon fisheries are called Salmon Fishing Areas (SFAs); for Québec, the management is delegated to the Société de la Faune et des Parcs du Québec and the fishing areas are designated by Q1 through Q11 (Figure 6.9.1.1). Three user groups exploited salmon in Canada in 2002: Aboriginal peoples, residents fishing for food in Labrador, and recreational fishers. There were no commercial fisheries in **Canada** in 2002.

Aboriginal peoples' food fisheries: In Québec, Aboriginal peoples' food fisheries took place subject to agreements or through permits issued to the bands. In the Maritimes and Newfoundland (SFAs 1 to 23), food fishery harvest agreements were signed with several Aboriginal peoples groups (mostly First Nations) in 2002. The signed agreements often included allocations of small and large salmon and the area of fishing was usually in-river or estuaries, except in Labrador. In Labrador (SFAs 1 and 2), food fishery arrangements with the Labrador Inuit Association and the Innu resulted in fisheries in estuaries and coastal areas. Under agreements reached in 2002, several Aboriginal communities in Nova Scotia agreed to retain only "adipose clipped" 1SW salmon from five Atlantic coast rivers using methods that allowed live release of wild fish.

Residents food fisheries in Labrador: In the Lake Melville (SFA 1) and the coastal southern Labrador (SFA 2) areas, DFO allowed a food fishery for local residents. Residents who requested a license were permitted to retain a maximum of four salmon of any size. All licensees were to complete logbooks.

Recreational fisheries: Unless otherwise determined by management authorities, licenses are required for all persons fishing recreationally for Atlantic salmon, gear is generally restricted to fly fishing and there are restrictive daily/seasonal bag limits. Recreational fisheries management in 2002 varied by area. Except in Québec and Labrador (SFA 1 and some rivers of SFA 2), only small salmon could be retained in the recreational fisheries. Other measure included seasonal and daily bag limits, hook and release fisheries and total closures.

There was no fishery for sea-run Atlantic salmon in the **USA** in 2002 as a result of angling closures that have been in place since 1999.

For the **Saint-Pierre and Miquelon** fisheries in 2002, there were 12 professional and 42 recreational gillnet licenses issued. Since 1997, the number of professional fishermen has doubled from six to 12 and the number of recreational licenses has increased by six to 42. There is no legal limit on the number of professional and recreational licences. However, local authorities have restricted these numbers to 12 (professional) and 42 (recreational) so far, based on the maxima observed since the beginning of the statistics recording on salmon fishing at SPM in 1990. Due to a sharp decline in other fish resources exploited by the professional fishermen (lumpfish, snow crab and cod), more of them have expressed interest in having salmon licenses and have asked for an increase in the number of licences that could be compensated by a reduction in the number of recreational licences.

Catches in 2002

The provisional harvest in Canada of salmon in 2002 by all users was 148 t, the same as the 2001 harvest (ie retained fish) (Table 4.1.1.1, Figure 6.9.1.2). The 2002 harvest was 53,832 small salmon and 8,401 large salmon, 5% more small salmon and 27% fewer large salmon, compared to 2001. The dramatic decline in harvested tonnage since 1988 is in large part the result of the reductions in commercial fisheries effort, the closure of the insular Newfoundland commercial fishery in 1992, the closure of the Labrador commercial fishery in 1998, and the closure of the Québec commercial fishery in 2000. These reductions were introduced as a result of declining abundance of salmon.

The 2002 harvest of small and large salmon, by number, was divided among the three user groups in different proportions depending on the province and the fish-size group exploited. Newfoundland reported the largest proportion of the total harvest of small salmon and Québec reported the greatest share of the large salmon harvest. Recreational fisheries exploited the greatest number of small salmon in each province, accounting for 83% of the total small salmon harvests in eastern Canada. Unlike years previous to 1999 when commercial fisheries took the largest share of large salmon, food fisheries (including the Labrador resident food fishery) accounted for the largest share in 2002 (69% by number).

Aboriginal peoples' food fisheries: Harvests in 2002 of 45.9 t, about 12,400 fish (57% small by number) were up 9 % from 2001 and 3 % above the previous 5-year average harvest.

Residents fishing for food in Labrador: The estimated catch in 2002 was 5.9 t, about 2,700 fish (83% small salmon by number).

Recreational fisheries: Harvest in recreational fisheries in 2002 totaled 47,140 small and large salmon, 5 % below the previous 5-year average and 4 % below the 2001 harvest level and the lowest total harvest reported (Figure 6.9.1.3). The small salmon harvest of 44,518 fish was about the same as the previous 5-year mean. The large salmon harvest of 2,622 fish was a 51 % decline from the previous five-year mean. Small and large salmon harvests were up 3 % and down 53 % from 2001, respectively (Figure 6.9.1.3).

Hook-and-release salmon fisheries: In 2002, about 54,400 salmon (about 18,700 large and 35,700 small) were caught and released (Table 6.9.1.3), representing about 54% of the total number caught, including retained fish. This was a 7 % decrease from the number released in 2001. Most of the fish released were in Newfoundland (53 %), followed by New Brunswick (33%), Québec (10%), Nova Scotia (4%), and Prince Edward Island (0.4%). Expressed as a proportion of the fish caught, that is, the sum of the retained and released fish, Nova Scotia released the highest percentage (87%), followed by Prince Edward Island (67%), New Brunswick (57%), Newfoundland (55%), and Québec (37%). There is some mortality on these released fish, which is accounted for when individual rivers are assessed for their attainment of conservation limits.

Unreported catches: Canada's unreported catch estimate for 2002 was about 83 t and no estimates were available for New Brunswick or for parts of Nova Scotia. Estimates provided for Newfoundland and Labrador were the same as those estimated in 2001 and estimates were available for only three of five SFAs in Nova Scotia. By stock groupings used for Canadian stocks throughout the report, the unreported catch estimates for 2002 were:

Stock Area	Unreported Catch (t)
Labrador	4
Newfoundland	45
Gulf	< 1
Scotia-Fundy	< 1
Québec	34
Total	83

All fisheries (commercial and recreational) for sea-run Atlantic salmon within the **USA** are now closed, including rivers previously open to catch-and-release fishing. Thus, there was no harvest of sea-run Atlantic salmon in the USA in 2002. Unreported catches were estimated to be zero t.

The harvest for **Saint-Pierre and Miquelon** in 2002 was reported to be 3.6 t from professional and recreational fishermen, 67% higher than in 2001 and the largest catch recorded since before 1960 (Table 4.1.1.1). Professional and recreational fishermen reported catching 2,437 kg and 1,153 kg of salmon, respectively. There was no estimate available of unreported catch for 2002.

Origin and composition of catches: In the past, salmon from both Canada and the USA have been taken in the commercial fisheries of eastern Canada. These fisheries have been closed. The Aboriginal Peoples' and resident food fisheries that exist in Labrador may intercept some salmon from other areas of North America although there are no reports of tagged fish being captured there in 2002. The fisheries of Saint-Pierre and Miquelon catch salmon of both Canadian and US origin. Little if any sampling occurs in these remaining marine fisheries.

The returns in 2002 to the majority of the rivers in Newfoundland and to most rivers of the Gulf of St. Lawrence and Québec were comprised exclusively of wild salmon. Hatchery-origin salmon made up varying proportions of the total returns and were most abundant in the rivers of the Bay of Fundy, the Atlantic coast of Nova Scotia and the USA. Aquaculture escapees were noted in the returns to five rivers of the Bay of Fundy and the coast of USA (Saint John, Magaguadavic, St. Croix, Dennys, Union).

In the Magaguadavic River which is located in close proximity to the center of both the Canadian and USA east coast salmon farming areas, the proportion of the adult run composed of fish farm escapees has been high (greater than 50%) since 1994. However, while fish farm escapees have dominated the run in terms of percentages, in absolute terms, their numbers have been trending downwards, with the exception of 2000. Fish farm escapees were also monitored in the St. Croix River (Canada/USA border), and Maine's Dennys, Narraguagus and Union rivers. The St. Croix and Dennys rivers are also in close proximity to the principal USA and Canadian salmon farming areas, whereas the Narraguagus and Union are more to the south, but have a few farm sites located in their vicinity. Percentages of returns that were fish farm escapees in the returns to the St. Croix and Dennys rivers in 2002 were 66% and 20% respectively. In the Union and Narraguagus rivers, fish farm escapees in 2002 made up 55% and 0% of the runs, respectively.

Elaboration on status of stocks in the NAC area

Information is provided below on *returns, recruits and spawners*.

The status of the stocks in geographical regions can be summarized as:

Newfoundland:
- 2SW returns third lowest in the last 10 years
- 2SW spawners in 2002 at approximately 1.5 times the 2SW stock conservation limits (S_{lim})

Labrador:
- 2SW returns peaked in 1995, and decreased again in 1996 and 1997
- no estimate is given after 1997 from this area when the commercial fishery, the basis for the return and spawner model for Labrador has ended.

Québec:
- 2SW returns lowest in a 32-year time-series
- 2SW spawners in 2002 at 52% of 2SW conservation limit (S_{lim})

Gulf of St. Lawrence:
- 2SW returns second lowest in a 32-year time-series
- 2SW spawners in 2002 at 38% of 2SW conservation limit (S_{lim})

Scotia-Fundy:
- 2SW returns lowest in a 32-year time-series
- 2SW spawners in 2002 at 6% of 2SW conservation limit (S_{lim})
- inner Bay of Fundy stocks listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada

United States:
- 2SW returns second lowest in a 32-year time-series
- 2SW returns in 2002 at 3% of 2SW conservation limit (S_{lim})
- stocks in 8 rivers listed as Endangered under the Endangered Species Act

Based on the genera1ly increased 1SW returns in 2002, some modest improvement is expected for large salmon in 2003; however, this improvement will be from usually record low returns of large salmon in 2002. An additional concern is the low abundance levels of many salmon stocks in rivers in eastern Canada, particularly in the Bay of Fundy and Atlantic coast of Nova Scotia. USA salmon stocks exhibit these same downward trends. Most salmon rivers in the USA are hatchery-dependent and remain at low levels compared to conservation requirements. Despite major changes in fisheries management, returns have continued to decline in these areas and many populations are currently threatened with extirpation.

Exploitation rates: There is no exploitation in Canada by commercial fisheries and the only remaining fisheries are for recreation and food. In the Newfoundland recreational fishery, exploitation rates ranged from 7% to 41% with a mean value of 14%. In the Québec recreational fishery, exploitation rates of small salmon ranged from 3% to 69% with a mean of 38%; exploitation rate for large salmon ranged from 1% to 25% with a mean of 12%. Overall exploitation rates by the Québec recreational fishery, using mid-point estimates of total returns and recreational landings, were 23% for small salmon and 8% for large salmon.

There was no exploitation of USA salmon in homewaters, and no salmon of USA origin were reported in Canadian fisheries in 2002.

However, there is potential for exploitation on these stock complexes if fishing takes place at west Greenland.

Estimated (mid-point) 1SW and 2SW returns, spawners, and spawner requirements are shown for five of six regions in North America in Figures 6.9.1.4 and 6.9.1.5. Labrador returns and thus total North American returns have been unavailable since 1998.

Estimates of pre-fishery abundance suggest a continuing decline of North American adult salmon over the last 10 years (Figure 6.9.1.6). The total population of 1SW and 2SW Atlantic salmon in the northwest Atlantic has oscillated around a generally declining trend since the 1970s, and the abundance recorded in 1993–2001 was the lowest in the time-series (Figure 6.9.1.7) with 2001 at 428,300 being the lowest point. During 1993 to 2000, the total population of 1SW and 2SW Atlantic salmon was about 600,000 fish, about half of the average abundance during 1972 to 1990. A further 50% decrease has occurred between 2000 and 2001, the most recent year for which it is possible to estimate the total population. The decline has been more severe for the 2SW salmon component than for the small salmon (maturing as 1SW salmon) age group.

In most regions the returns in 2002 of 2SW fish are at or near the lower end of the 32-year time-series (1971-2002). In Newfoundland, the 2 SW salmon are a minor age group component of the stocks in this area and even here, decreases of about 30% have occurred from peak levels of a few years ago. Returns of 1SW salmon generally increased from the extremely low values of 2001 in all areas except Newfoundland.

The rank of the estimated returns in 2002 in the 1971–2002 time-series for six regions in North America is shown below:

Region	Rank of 2002 returns in 1971-2002 (1=highest)		Rank of 2002 returns in 1993-2002 (1=highest)		Mid-point estimate of 2SW spawners as proportion of conservation limit (S_{lim})
	1SW	2SW	1SW	2SW	(%)
Labrador	Unknown	Unknown	Unknown	Unknown	Unknown
Newfoundland	25	11	8	8	144
Québec	13	32	4	10	52
Gulf	21	31	5	10	38
Scotia-Fundy	28	32	7	10	6
USA	12	31	2	9	2

Trends in abundance of small salmon and large salmon within the geographic areas show a general synchronicity among the rivers. Returns of large salmon in North America were generally decreased from 2001 often to record low values, while small salmon returns increased. Any increases however in small salmon returns were from often record low values in 2001. For the rivers of Newfoundland, large salmon returns decreased from 2001, but remained high relative to the years before the closure of the commercial fisheries. Large salmon in Newfoundland are predominantly repeat-spawning 1SW salmon, while in other areas of eastern Canada, 2SW and 3SW salmon make up varying proportions of the returns.

Egg depositions in 2002 exceeded or equaled the river-specific conservation limits (S_{lim} for eggs) in 23 of the 85 assessed rivers (27%) and were less than 50% of conservation in 40 other rivers (47%)(Figure 6.9.1.8). Large deficiencies in egg depositions were noted in the Bay of Fundy and Atlantic coast of Nova Scotia where 10 of the 11 rivers assessed (91%) had egg depositions that were less than 50% of conservation limits. Proportionally fewer rivers in Gulf (0%) and Québec (38%) had egg depositions less than 50% of conservation. Only 40% of the Gulf rivers and 33% of the Québec rivers had egg depositions that equaled or exceeded conservation. In Newfoundland, 30% of the rivers assessed met or exceeded the conservation egg limits, and 35% had egg depositions that were less than 50% of limits. The deficits mostly occurred in the east and southwest rivers of Newfoundland (SFA 13) and in Labrador. All USA rivers had egg depositions less than 5% of conservation limits.

In 2002, the overall conservation limit (S_{lim}) for 2SW salmon was not met in any area except Newfoundland. The overall 2SW conservation limit for North America could have been met or exceeded in only nine (1974-78, 1980-82 and 1986) of the past 31 years (considering the mid-points of the estimates) by reduction of terminal fisheries (Figures 6.9.1.5 and 6.9.1.9). In the remaining years, conservation limits could not have been met even if all terminal harvests had been eliminated. It is only within the last decade that Québec and the Gulf areas have failed to achieve their overall 2SW salmon conservation limits.

Measures of marine survival rates over time indicate that survival of North America stocks to home waters has not increased as expected as a result of fisheries changes**.** There have been no significant increasing trends in survival indices of any of the stock components since commercial closures in 1992.

Substantive increases in spawning escapements in recent years in northeast coast Newfoundland rivers and high smolt and juvenile production in many rivers, in conjunction with suitable ocean climate indices, were suggestive of the potential for improved adult salmon returns for 1998 through 2002. Colder oceanic conditions both nearshore and in the Labrador Sea in the early 1990s are thought to have contributed to lower survival of salmon stocks in eastern Canada during that period.

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

The management of Atlantic salmon in eastern North America has focused on the management of spawning escapement to meet or exceed conservation limits. Significant measures introduced in the last five years in order to meet this objective have included the closure of all commercial fisheries in eastern Canada as of 2000, the complete closure of numerous rivers to any fishing including Native and recreational fisheries, and the imposition of catch and release only access in others. Within Newfoundland, the commercial fishery closure resulted in increased escapements of both small and large salmon, increased catches of large salmon increased escapements of both size groups. However in some areas, the increased escapements did not always result in increased smolt production nor were the increased escapements realized in all areas. The latter response indicates that factors other than fishing were impacting on survival of Atlantic salmon at sea.

Management measures may have impacts on Atlantic salmon stocks beyond changes in abundance of returning and spawning Atlantic salmon. Of the changes resulting from reductions in fisheries, changes in spawning escapement and subsequently juvenile production are the most anticipated. Looking back three decades at the performance of some Maritime provinces stocks to changes in fisheries management, spawning escapements responded initially to the 1984 management plan (closure of commercial fisheries and mandatory catch and release of large salmon throughout the Maritimes) but the higher escapements were not sustained into the 1990s. Juvenile abundance has generally increased in the Miramichi River but a statistically significant response in this abundance was not observed until six years after the increases in escapement.

Reduced exploitation on large salmon in the in-river and estuarine fisheries of the Miramichi has resulted in an expanded age structure in which repeat spawners have comprised as much as 50% of the large salmon returns. Particularly notable is that since 1995, salmon with six previous spawnings have been observed in the returns to the Miramichi and salmon on the third to fifth spawnings are more abundant (Fig. 4.3.3.1). That it took over 11 years after the management plan of 1984 to see these older salmon is consistent with the time required for the first maiden fish of 1984 to reach that sea age (9 sea years of age).

There are fewer repeat spawner components in the Saint John River than in the Miramichi and there has not been any change in relative proportions over time as was seen in the Miramichi. The post-spawner survival in the Saint John River is likely constrained by downstream fish passage through 2 to 3 hydro-generating facilities which cannot be managed like the fishing exploitation rates on the Miramichi stock. For the Saint John River, therefore, reduced fisheries exploitations have not resulted in improved post-spawner survivals.

The repeat spawning return rates of 1SW maiden salmon have not increased significantly over the past 30 years. The returns rates are relative to maiden fish prior to in-river exploitation, and since there is exploitation of this age group by both the Native and recreational fisheries, survival of maiden fish to a second return was expected to be lower. In addition to being more abundant in recent years, repeat spawners from the Miramichi grow substantially between spawning events. These larger fish of proportionally greater abundance in the river are of interest to the recreational fishermen, produce more eggs per fish than maiden spawners, and provide a buffer to the annual spawning escapement when smolt to maiden spawner survivals are low.

Over the 1971 to 2002 period, the average length of 1SW and 2SW maiden salmon has increased. The 2SW salmon from the Miramichi River during 1999 to 2002 are the largest of the time series and the mean size increased in 1986, two years after the home water commercial fishery moratorium. The mean size of 1SW salmon of the last four years were also the largest of the time series and the change in size was also first observed in 1986. The change in size was also observed for the 2SW fish, however, it is not obvious how the fishing gear could have been selecting the larger 2SW salmon. Similar increases in mean size of 1SW salmon were observed in the Nashwaak River and the Saint John River, both Bay of Fundy stocks. The mean size in the last three years of both 1SW and 2SW salmon have been average to less than average for the 1986 to 2002 period. Similar to the Miramichi, the change in mean size also first occurred in 1986. It is possible that exploitation with nets was still taking place on these stocks in 1984 and 1985.

Many historical commercial fisheries were prosecuted early in the season and frequently not in proportion to the timing of the fish entering the river. Evidence of the effect of fisheries exploitation in coastal waters on time of entry of salmon to rivers was evident in the time series of catches at the estuary trapnet in the Miramichi. The 50^{th} percentile count of large salmon at the trapnet in the 1950s and 1960s was post Sept. 1 but became progressively earlier in 1970 to 1972 following the closure of the directed commercial fisheries in the Maritimes and in the last part of the time series, the median date oscillated around mid-August.

With management of salmon fisheries in eastern Canada now restricted mainly to home rivers, a number of stock characteristics were expected to have changed. Most notably, the mean size-at-age of salmon has increased in many rivers in which net fisheries of salmon historically occurred. Reduced exploitation in both the marine and freshwater environments has benefited the Miramichi River by providing repeat spawners as a buffer to the maiden salmon population when the latter is low.

6.9.3 NASCO has requested ICES to provide an analysis of existing biological and/or tag return data, and recommendations for required data collections, to identify the origin of Atlantic salmon caught at St Pierre and Miquelon

A small Atlantic salmon fishery occurs off the coast of Saint-Pierre and Miquelon. A total of six tag returns of North American origin have been reported from this fishery since 1976.

Tag code	Country of origin	River of release	Year of release	Recovery date	Total length (cm)	Total weight (g)
BBS75332	CAN	Miramichi River, NB	1974	05/23/1976[1]	77	4,200
BBS84564	CAN	Miramichi River, NB	1973	5/28/1976	80	4,200
BBK78583	CAN	Morell River, PEI	1976	05/21/1977	76	3,975
BBX00427	CAN	Liscomb River, NS	1980	06/17/1981	51	1,200
AW14198	CAN	St John River, NB	1984	06/25/1985	85	3,966
A3458	USA	Penobscot River, ME	1980[2]	06/27/1981	80	3,600[3]

[1]capture response indicates that catch occurred in a research net
[2]fish was tagged as returning adult captured at the Veazie Trap
[3]estimated gutted weight

Fishery generated tag return data are not necessarily representative of the occurrence of tags within the catch. Not all countries/regions have large scale tagging operations, tagging operations are often not representative of countries/regions and internal tags, such as coded wire tags, would not have been detected as there was not a system set up to identify and recover these tags. As well, publicity concerning the existence of past tagging programs and instructions on the procedure to return tags from this fishery was not targeted on this area. Catch composition in terms of country/region of origin can therefore not be determined from these data. However, these types of data do confirm that North American fish from both Canada and USA have both been historically susceptible to capture in the Saint-Pierre and Miquelon fishery.

Given the increase in the number of licensed Saint-Pierre and Miquelon gillnet fishermen, the increase in reported catch and the historic tag return data, a biological sampling program is needed to investigate the composition and origin of the Saint-Pierre and Miquelon Atlantic salmon catches. These data are essential to characterize the effects that this fishery may have on the Atlantic salmon populations of North America and, in particular, on their “endangered” populations.

The following types of data are essential to gaining a better understanding of the composition of the Saint-Pierre and Miquelon Atlantic salmon fishery and for determining the effect that this fishery has on the Atlantic salmon resources of North America.

A biological sampling program for the Saint-Pierre and Miquelon gillnet fishery should be an international cooperative effort between USA, Canada, France and the local government of Saint-Pierre and Miquelon. At a minimum, an individual sampler will need to be coupled with a local contact and stationed in Saint-Pierre for a period of 2-3 weeks during the period when the fishery is expected to be prosecuted (June through August). The local contact would be essential for connecting the sampler with individuals who would likely be gillnetting during this period. The sampler would collect information related to fishing effort (description of gear, number of nets fished, soak time etc.) as well as catch (type and amount of species caught). In addition, detailed biological data needs to be collected for each individual Atlantic salmon sampled: including individual length and individual weight data plus a scale and genetic sample. The presence or absence of any external tags, clips or marks should also be noted for each individual as well as any abnormal physical features. Additional support from the countries involved could result in an increase of the number of sampling teams. This increase could be used to widen the sampling coverage in both time and space. Increased sampling may be valuable, depending on the spatial and temporal occurrence of the fishery, which is currently unknown.

Table 6.3.1. 2SW spawning requirements for North America by country, management zone and overall. Management zones are shown in Figure 6.9.1.1.

Country	Stock Area	Management zone	2SW spawner requirement	
Canada	Labrador	SFA 1	7,992	
		SFA 2	25,369	
		SFA 14B	1,390	
	Subtotal			34,746
	Newfoundland	SFA 3	240	
		SFA 4	488	
		SFA 5	233	
		SFA 6 to 8	13	
		SFA 9 to 12	212	
		SFA 13	2,544	
		SFA 14A	292	
	Subtotal			4,022
	Gulf of St. Lawrence	SFA 15	5,656	
		SFA 16	21,050	
		SFA 17	537	
		SFA 18	3,187	
	Subtotal			30,430
	Québec	Q1	2,532	
		Q2	1,797	
		Q3	1,788	
		Q5	948	
		Q6	818	
		Q7	2,021	
		Q8	11,195	
		Q9	3,378	
		Q10	1,582	
		Q11	3,387	
	Subtotal			29,446
	Scotia-Fundy	SFA 19	3,138	
		SFA 20	2,691	
		SFA 21	5,817	
		SFA 22	0	
		SFA 23	13,059	
	Subtotal			24,705
Total				123,349
USA	Connecticut		9,727	
	Merrimack		2,599	
	Penobscot		6,838	
	Other Maine rivers		9,668	
	Paucatuck		367	
Total				29,199
North American Total				152,548

Table 6.9.1.1

Fishing mortalities of 2SW salmon equivalents by North American fisheries, 1972-2002.
Only mid-points of the estimated values have been used.

Year	CANADA										USA	Total	
	MIXED STOCK				TERMINAL FISHERIES IN YEAR i								
	NF-LAB Comm 1SW (Yr i-1) (b)	% 1SW of total 2SW equivalents	NF-LAB Comm 2SW (Yr i) (b)	NF-Lab comm total	Labrador rivers (a)	Nfld rivers (a)	Quebec Region	Gulf Region	Scotia - Fundy Region	Canadian total	Year i		Terminal Fisheries as a % of Total
1972	20,857	9	153,775	174,632	314	633	27,417	22,389	6,801	232,186	346	232,532	25
1973	17,971	6	219,175	237,146	719	895	32,751	17,914	6,680	296,105	327	296,433	20
1974	24,564	7	235,910	260,475	593	542	47,631	21,430	12,734	343,405	247	343,652	24
1975	24,181	7	237,598	261,779	241	528	41,097	15,677	12,375	331,696	389	332,085	21
1976	35,801	10	256,586	292,388	618	412	42,139	18,090	11,111	364,758	191	364,949	20
1977	27,519	8	241,217	268,736	954	946	42,301	33,433	15,562	361,932	1,355	363,287	26
1978	27,836	11	157,299	185,135	580	559	37,421	23,806	10,781	258,281	894	259,175	29
1979	14,086	10	92,058	106,144	469	144	25,234	6,300	4,506	142,798	433	143,231	26
1980	20,894	6	217,209	238,103	646	699	53,567	29,832	18,411	341,257	1,533	342,789	31
1981	34,486	11	201,336	235,822	384	485	44,375	16,329	13,988	311,383	1,267	312,650	25
1982	34,341	14	134,417	168,757	473	433	35,204	25,709	12,353	242,929	1,413	244,342	31
1983	25,701	12	111,562	137,263	313	445	34,472	27,097	13,515	213,105	386	213,491	36
1984	19,432	14	82,807	102,238	379	215	24,408	6,040	3,971	137,252	675	137,927	26
1985	14,650	11	78,760	93,410	219	15	27,483	2,741	4,930	128,798	645	129,443	28
1986	19,832	12	104,890	124,723	340	39	33,846	4,575	2,824	166,346	606	166,952	25
1987	25,163	13	132,208	157,371	457	20	33,807	3,790	1,370	196,814	300	197,115	20
1988	32,081	21	81,130	113,211	514	29	34,262	3,916	1,373	153,304	248	153,552	26
1989	22,197	16	81,355	103,551	337	9	28,901	3,507	265	136,569	397	136,966	24
1990	19,577	18	57,359	76,937	261	24	27,986	2,841	593	108,642	696	109,338	30
1991	12,048	14	40,433	52,481	66	16	29,277	1,934	1,331	85,106	231	85,337	39
1992	9,979	14	25,108	35,087	581	67	30,016	4,405	1,114	71,271	167	71,438	51
1993	3,229	7	13,273	16,502	273	63	23,153	2,971	1,110	44,072	166	44,238	63
1994	2,139	5	11,938	14,077	365	80	24,052	2,376	756	41,706	1	41,707	66
1995	1,242	3	8,677	9,918	420	92	23,331	2,022	330	36,113	0	36,113	73
1996	1,075	3	5,646	6,721	320	108	22,413	2,577	766	32,905	0	32,905	80
1997	969	3	5,390	6,360	175	136	18,574	2,072	581	27,898	0	27,898	77
1998	1,155	7	1,872	3,027	276	129	11,256	2,283	322	17,293	0	17,293	82
1999	179	1	894	1,073	311	111	9,032	1,380	450	12,355	0	12,355	91
2000	152	1	1,115	1,267	404	372	9,425	2,048	193	13,709	0	13,709	91
2001	286	2	1,380	1,666	336	277	10,104	1,970	255	14,608	0	14,608	89
2002	263	3	1,158	1,421	221	264	7,297	526	273	10,002	0	10,002	86
2003	299	-	-	-	-	-	-	-	-	-	-	-	-

NF-Lab comm as 1SW = NC1(mid-pt) * 0.677057 (M of 0.03 per month for 13 months to July for Canadian terminal fisheries)
NF-Lab comm as 2SW = NC2 (mid-pt) * 0.970446 (M of 0.03 per month for 1 month to July of Canadian terminal fisheries)
Terminal fisheries = 2SW returns (mid-pt) - 2SW spawners (mid-pt)
a - starting in 1993, includes estimated mortality of 10% on hook and released fish
b - starting in 1998, there was no commercial fishery in Labrador; numbers reflect size of aboriginal fish harvest in 1998-2002 and resident food fishery harvest in 2000-2002

Table 6.9.1.2 History of fishing-related mortalities of North American salmon as 2SW equivalents, 1972-2002.

Year	Canadian total	USA total	North America Grand Total	% USA of Total North America	Greenland total	NW Atlantic Total	Harvest in homewaters as % of total NW Atlantic
1972	232,186	346	232,532	0.15	206,814	439,346	53
1973	296,105		296,433	0.11	144,348	440,781	67
1974	343,405	247	343,652	0.07	173,615	517,267	66
1975	331,696	389	332,085	0.12	158,583	490,668	68
1976	364,758	191	364,949	0.05	200,464	565,413	65
1977	361,932	1,355	363,287	0.37	112,077	475,364	76
1978	258,281	894	259,175	0.34	136,386	395,561	66
1979	142,798	433	143,231	0.30	85,446	228,677	63
1980	341,257	1,533	342,789	0.45	143,829	486,618	70
1981	311,383	1,267	312,650	0.41	135,157	447,807	70
1982	242,929	1,413	244,342	0.58	163,718	408,060	60
1983	213,105	386	213,491	0.18	139,985	353,476	60
1984	137,252	675	137,927	0.49	23,897	161,824	85
1985	128,798	645	129,443	0.50	27,978	157,421	82
1986	166,346	606	166,952	0.36	100,098	267,050	63
1987	196,814	300	197,115	0.15	123,472	320,586	61
1988	153,304	248	153,552	0.16	124,868	278,420	55
1989	136,569	397	136,966	0.29	83,947	220,913	62
1990	108,642	696	109,338	0.64	43,634	152,972	71
1991	85,106	231	85,337	0.27	52,560	137,897	62
1992	71,271	167	71,438	0.23	79,571	151,008	47
1993	44,072	166	44,238	0.38	30,091	74,329	60
1994	41,706	1	41,707	0.00	0	41,707	100
1995	36,113	0	36,113	0.00	0	36,113	100
1996	32,905	0	32,905	0.00	15,343	48,247	68
1997	27,898	0	27,898	0.00	15,776	43,674	64
1998	17,293	0	17,293	0.00	12,088	29,381	59
1999	12,355	0	12,355	0.00	2,175	14,530	85
2000	13,709	0	13,709	0.00	3,863	17,572	78
2001	14,608	0	14,608	0.00	4,005	18,613	78
2002	10,002	0	10,002	0.00	6,989	16,992	59
2003	299	-	299	-	1,499	-	-

Greenland harvest of 2SW equivalents = NG1 * 0.718924 (M of 0.03 per month for 11 months to July of Canadian terminal fisheries)

Table 6.9.1.3. Hook-and-release Atlantic salmon caught and released by recreational fishermen in Canada, 1984 – 2002.

Year	Newfoundland			Nova Scotia			New Brunswick					Prince Edward Island			Quebec			CANADA*		
	Small	Large	Total	Small	Large	Total	Small Kelt	Small Bright	Large Kelt	Large Bright	Total	Small	Large	Total	Small	Large	Total	**SMALL**	**LARGE**	**TOTAL**
1984				939	1,655	2,594	661	851	1,020	14,479	17,011							**2,451**	**17,154**	**19,605**
1985		315	315	1,323	6,346	7,669	1,098	3,963	3,809	17,815	26,685			67				**6,384**	**28,285**	**34,669**
1986		798	798	1,463	10,750	12,213	5,217	9,333	6,941	25,316	46,807							**16,013**	**43,805**	**59,818**
1987		410	410	1,311	6,339	7,650	7,269	10,597	5,723	20,295	43,884							**19,177**	**32,767**	**51,944**
1988		600	600	1,146	6,795	7,941	6,703	10,503	7,182	19,442	43,830	767	256	1,023				**19,119**	**34,275**	**53,394**
1989		183	183	1,562	6,960	8,522	9,566	8,518	7,756	22,127	47,967							**19,646**	**37,026**	**56,672**
1990		503	503	1,782	5,504	7,286	4,435	7,346	6,067	16,231	34,079			1,066				**13,563**	**28,305**	**41,868**
1991		336	336	908	5,482	6,390	3,161	3,501	3,169	10,650	20,481	1,103	187	1,290				**8,673**	**19,824**	**28,497**
1992	5,893	1,423	7,316	737	5,093	5,830	2,966	8,349	5,681	16,308	33,304			1,250				**17,945**	**28,505**	**46,450**
1993	18,196	1,731	19,927	1,076	3,998	5,074	4,422	7,276	4,624	12,526	28,848							**30,970**	**22,879**	**53,849**
1994	11,105	2,343	13,448	796	2,894	3,690	4,153	7,443	4,790	11,556	27,942	577	147	724				**24,074**	**21,730**	**45,804**
1995	12,383	2,588	14,971	979	2,861	3,840	770	4,260	880	5,220	11,130	209	139	348		922	922	**18,601**	**12,610**	**31,211**
1996	22,227	3,092	25,319	3,526	5,661	9,187						472	238	710		1,718	1,718	**26,225**	**10,709**	**36,934**
1997	17,362	3,810	21,172	717	3,358	4,075	3,457	4,870	3,786	8,874	20,987	210	118	328	182	1,643	1,825	**26,798**	**21,589**	**48,387**
1998	25,314	4,351	29,665	687	2,520	3,207	3,154	5,760	3,452	8,298	20,664	233	114	347	297	2,680	2,977	**35,445**	**21,415**	**56,860**
1999	18,119	4,534	22,653	591	2,161	2,752	3,155	5,631	3,456	8,281	20,523	192	157	349	298	2,693	2,991	**27,986**	**21,282**	**49,268**
2000	27,778	6,030	33,808	407	1,303	1,710	3,154	6,689	3,455	8,690	21,988	101	46	147	445	4,008	4,453	**38,574**	**23,532**	**62,106**
2001	21,969	5,137	27,106	527	1,199	1,726	3,094	6,166	3,829	11,252	24,341	202	103	305	809	4,674	5,483	**32,767**	**26,194**	**58,961**
2002	23,993	4,574	28,567	936	1,196	2,132	2,362	7,351	2,927	5,349	17,989	207	31	238	812	4,687	5,499	**35,661**	**18,764**	**54,425**

* totals for all years prior to 1997 are incomplete and are considered minimal estimates
blank cells indicate no information available

Figure 6.9.1.1. Map of Salmon Fishing Areas (SFAs) and Quebec Management Zones (Qs) in Canada.

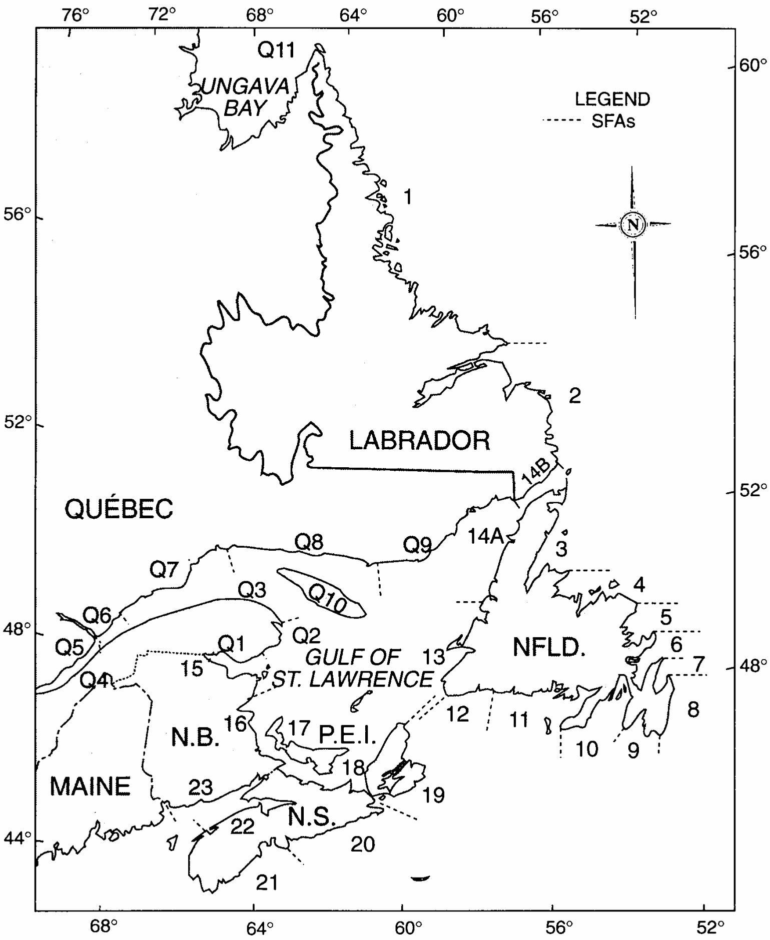


Figure 6.9.1.2. Harvest (t) of small salmon, large salmon, and combined in Canada, 1960-2002 by all users.

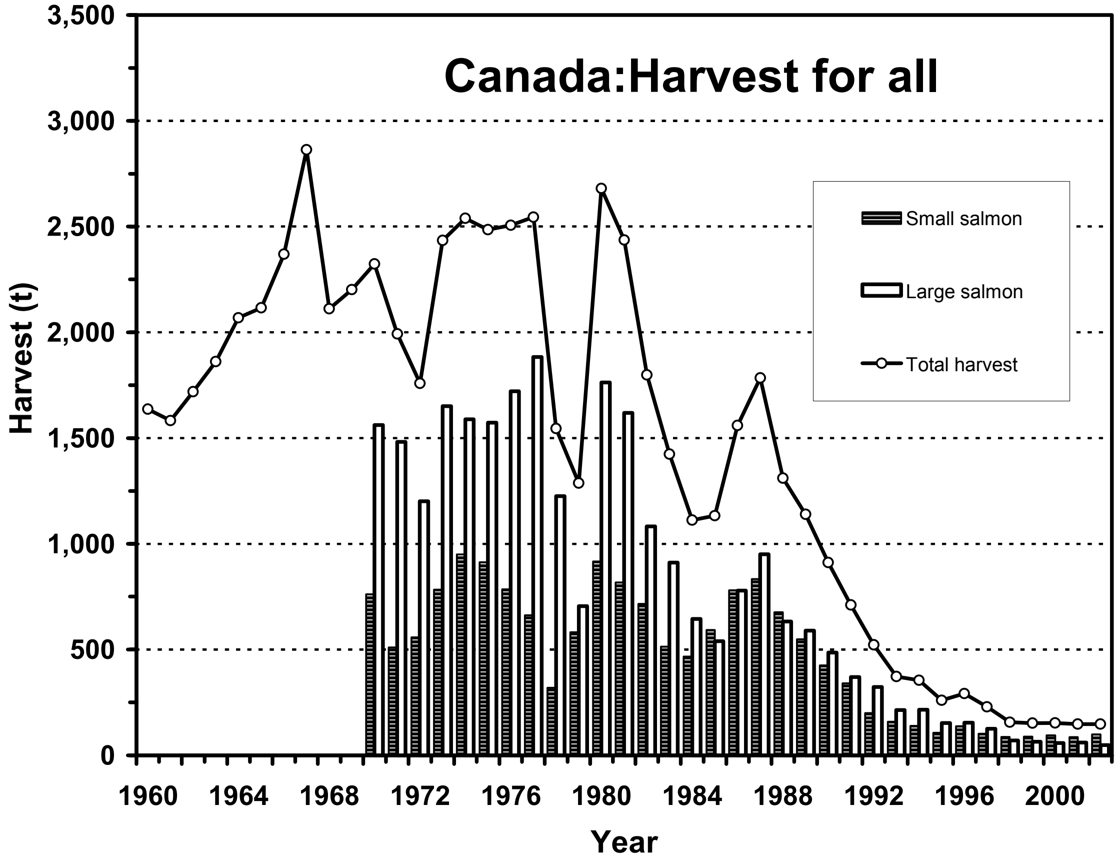


Figure 6.9.1.3 Harvest (number) of small and large salmon and both sizes combined in the recreational fisheries of Canada, 1974 to 2002.

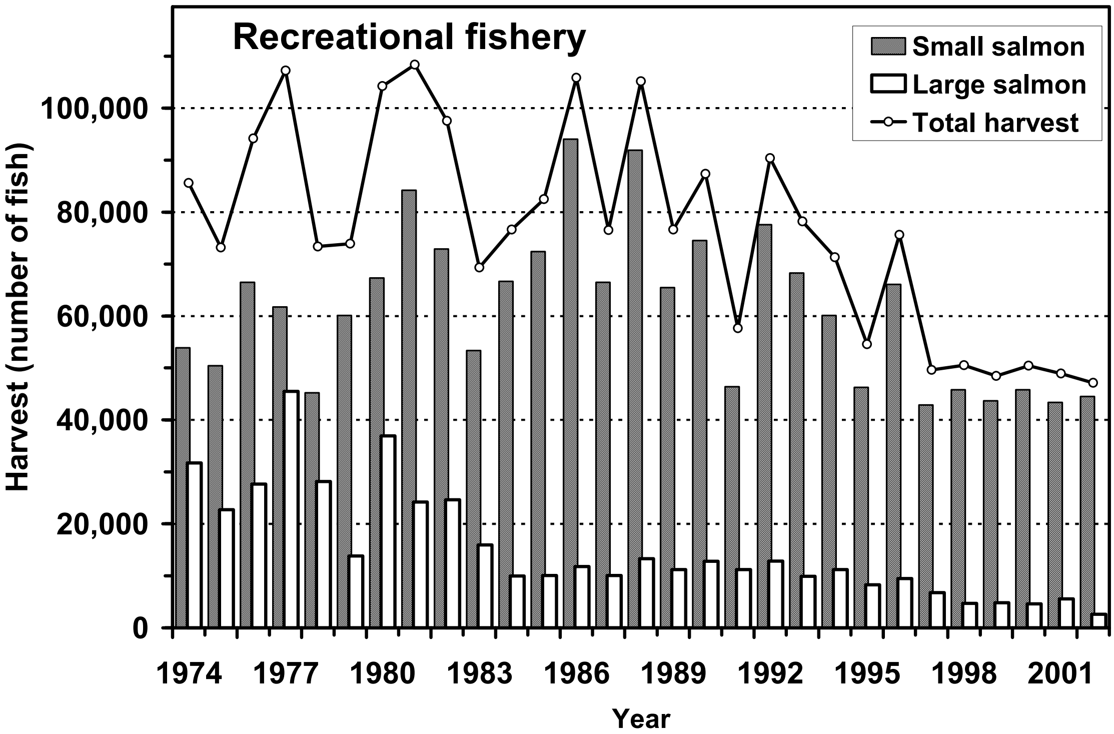


Figure 6.9.1.4 Comparison of estimated mid-points of 1SW returns to and 1SW spawners in rivers of six geographic areas in North America. Returns and spawners for Scotia-Fundy do not include those from SFA 22 and a portion of SFA 23.

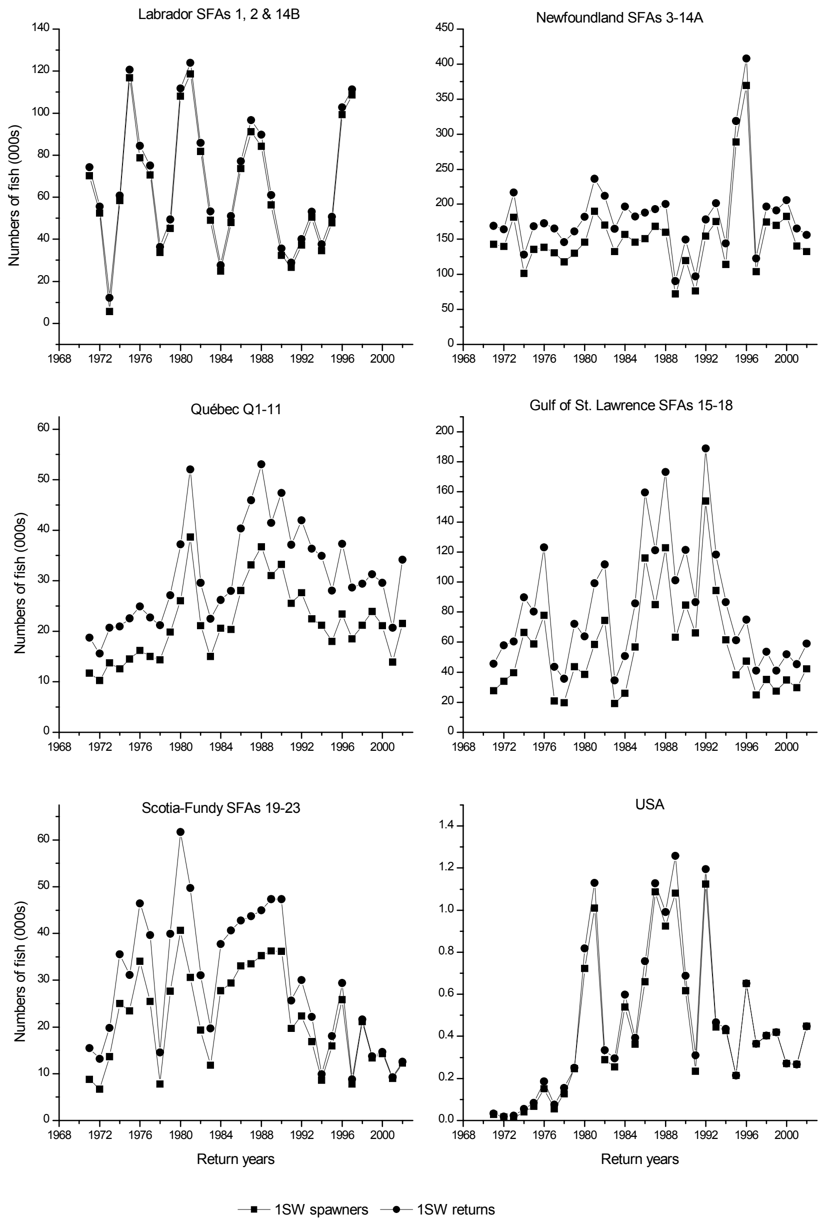


Figure 6.9.1.5 Comparison of estimated mid-points of 2SW returns, 2SW spawners, and 2SW conservation requirements for six geographic areas in North America. Returns and spawners for Scotia-Fundy do not include those from SFA 22 and a portion of SFA 23.

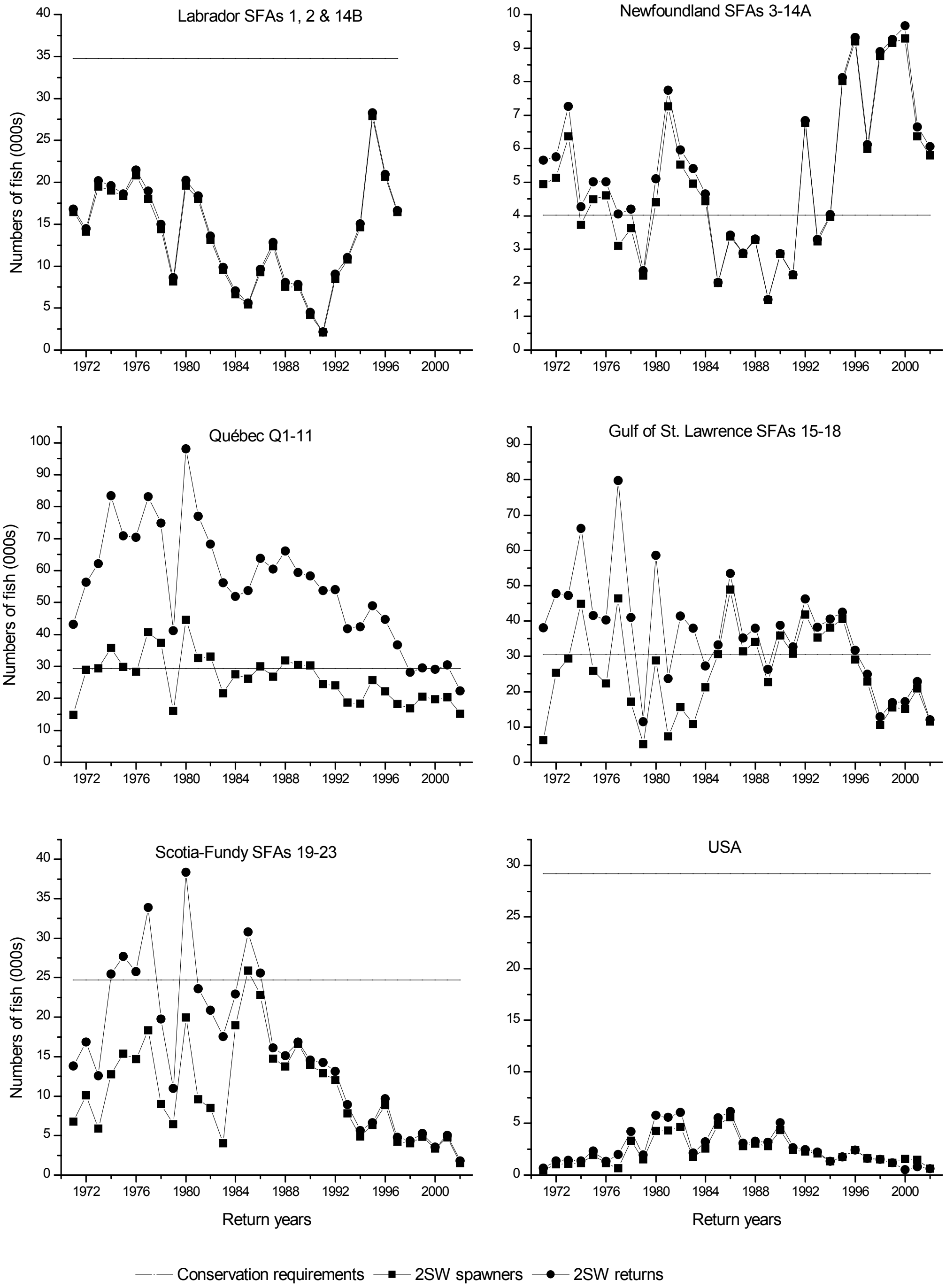


Fig. 6.9.1.6. Prefishery abundance estimate of maturing and non-maturing salmon in North America. Open symbols are for the years that returns to Labrador were assumed as a proportion of returns to other areas in North America.

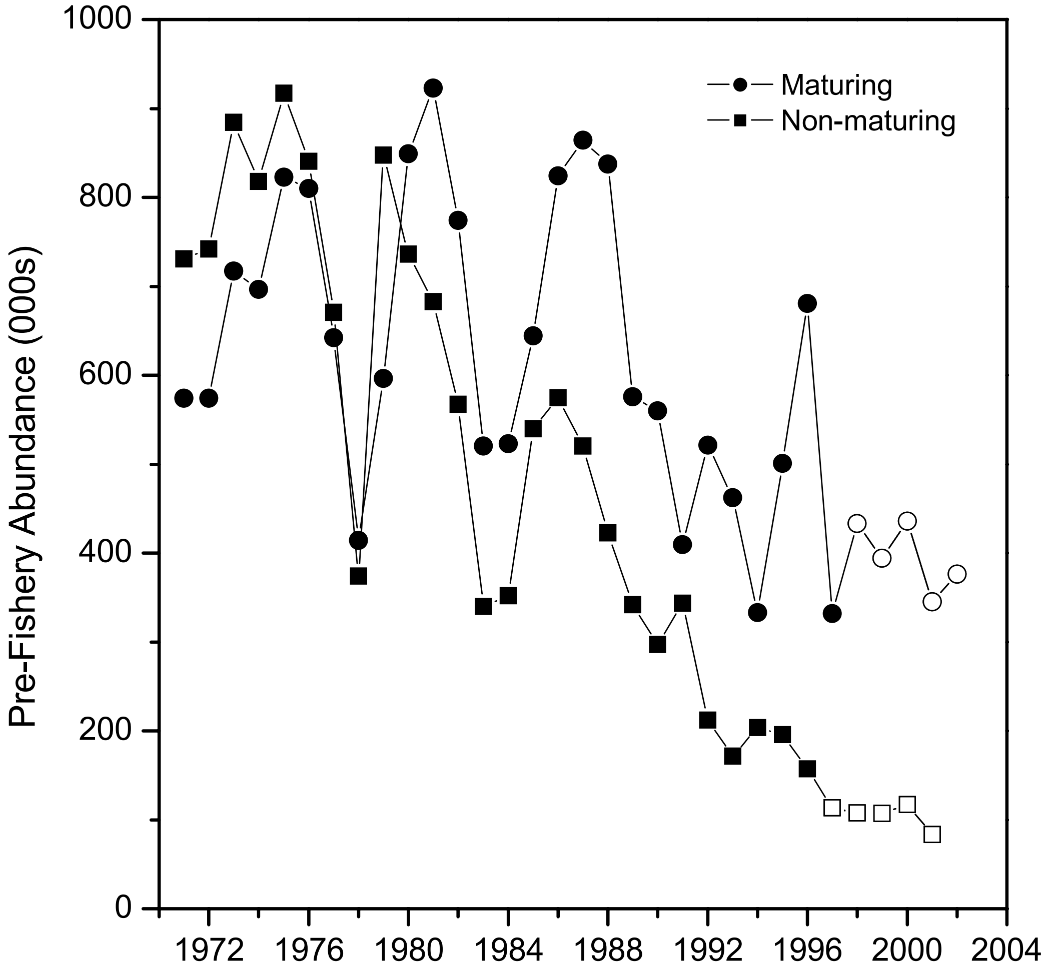


Fig. 6.9.1.7. Total 1SW recruits (non-maturing and maturing) originating in North America.

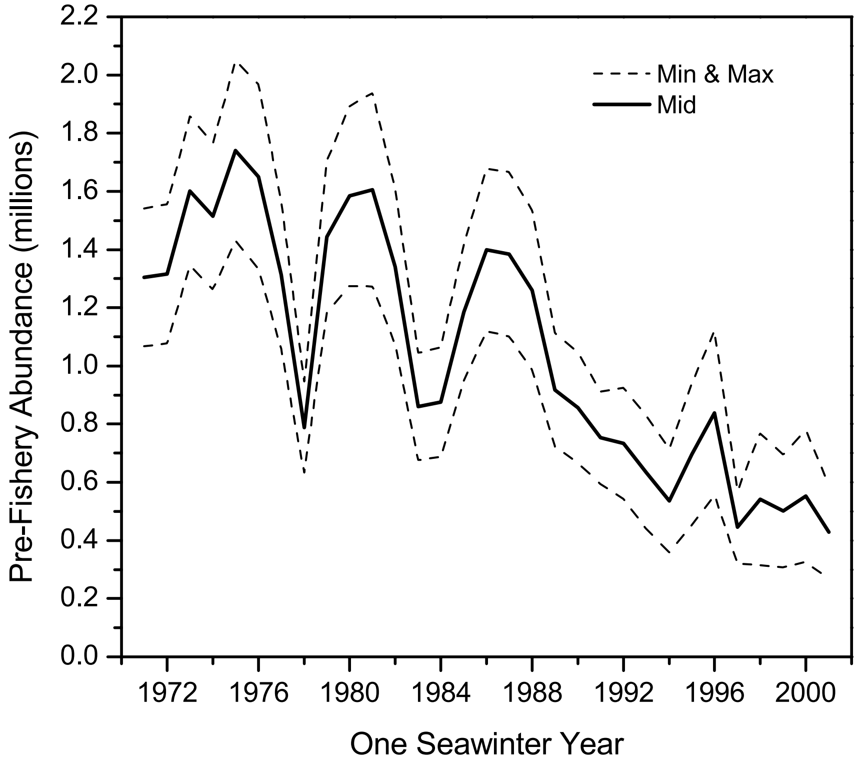


Figure 6.9.1.8. Egg depositions relative to conservation limits in 85 rivers of North America in 2002. The black slice represents the proportion of the limit achieved. A solid black circle indicates the egg deposition limit was attained or exceeded.

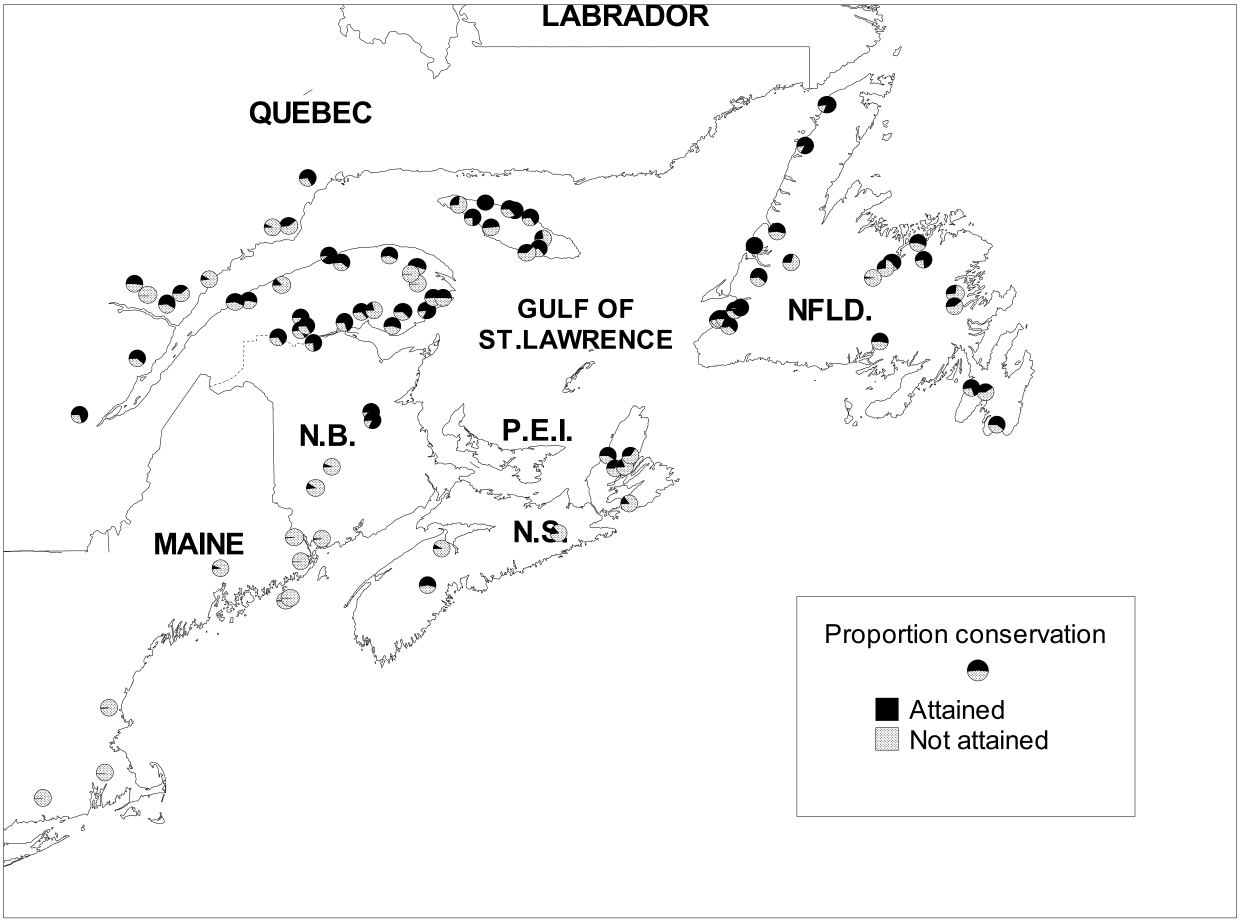
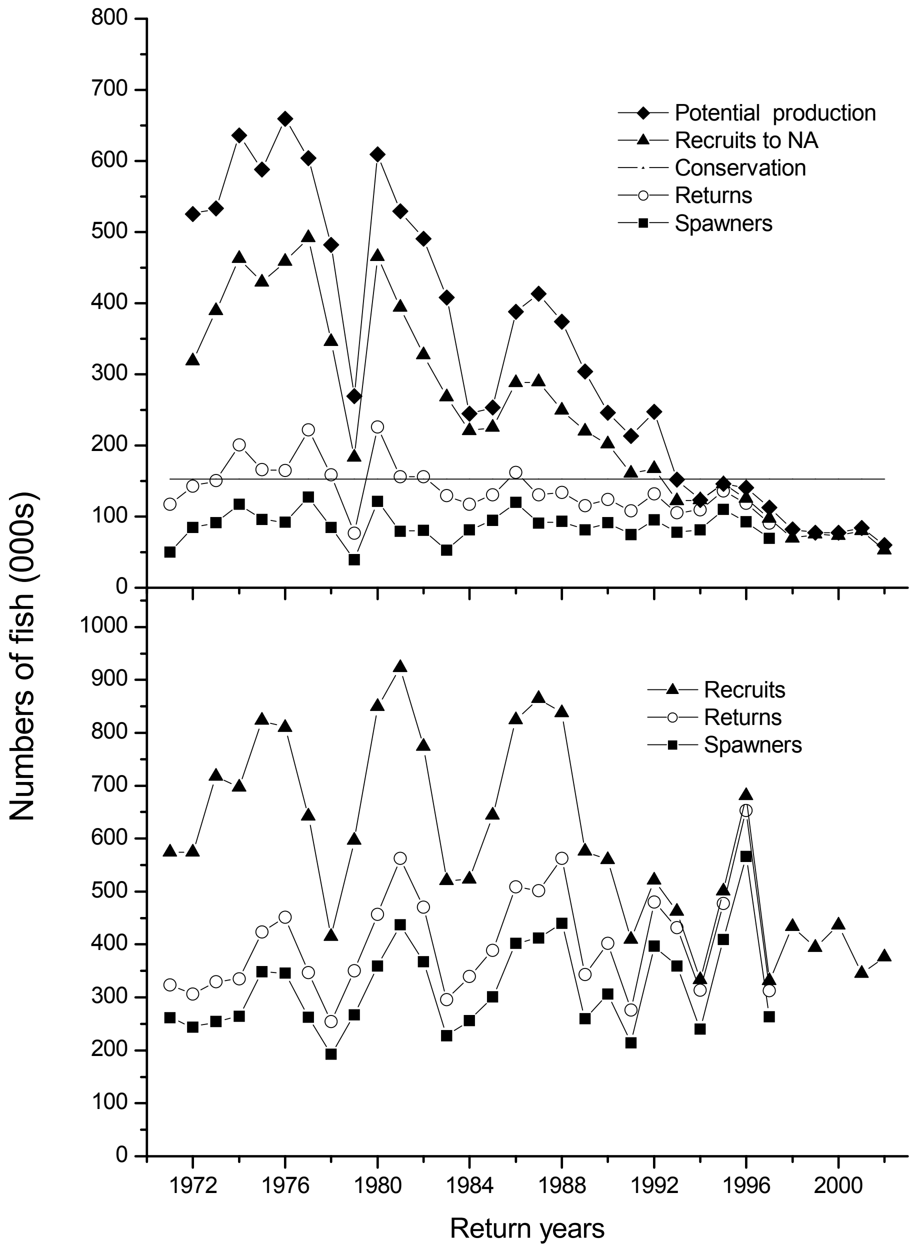


Figure 6.9.1.9 Top panel: comparison of estimated potential 2SW production prior to all fisheries, 2SW recruits available to North America, 1971-2002 and 2SW returns and spawners for 1971-97, as 1998-2002 data for Labrador are unavailable. The horizontal line indicates the 2SW conservation limits. Bottom panel: comparison of potential maturing 1SW recruits, 1971-2002 and returns and 1SW spawners for 1971-97 return years as Labrador data for 1998-2002 are unavailable.



7 WEST GREENLAND COMMISSION

7.1 Status of stocks/exploitaton

ICES considers the stock complex at West Greenland to be outside safe biological limits.

The salmon caught in the West Greenland fishery are mostly (>90%) non-maturing 1SW salmon, many of which would return to homewaters in Europe or North America as MSW fish if they survived the fishery. There are also 2SW salmon and repeat spawners, including salmon that had originally spawned for the first time after 1-sea-winter. The most abundant European stocks in West Greenland are thought to originate from the UK and Ireland, although low numbers may originate from northern European rivers. Most MSW stocks in North America are thought to contribute to the fishery at West Greenland.

ICES notes that the North American stock complex of non-maturing salmon has declined to record levels and is in tenuous condition. Increased spawning escapements to rivers of some areas of eastern North America resulted in improved abundance of the juvenile life stages. Despite the closure of Newfoundland commercial fisheries in 1992 and subsequently in Labrador in 1998 and Québec in 2000, sea survival of adults returning to rivers has not improved and in some areas has declined further. The abundance of maturing 1SW salmon has also declined in many areas of eastern North America. Associations between 1SW returns in year i and 2SW returns in year i+1 observed in several rivers in eastern Canada suggest that abundance of 2SW salmon in 2003 in eastern Canada will be slightly improved from 2002 . Smolt production in 2001 and 2002 in monitored rivers of eastern Canada were less than or similar to the average of the last five years and unless sea survival improves, the abundance of non-maturing 1SW salmon in the Northwest Atlantic is not expected to improve above the levels of the last five years.

The Working Group also noted that the PFA of non-maturing 1SW salmon from Southern Europe has been declining steadily since the 1970s (Figure 5.1.3), and the preliminary quantitative prediction of PFA for this stock complex indicates that PFA will remain close to present low levels for each of the next two years (537,000 and 524,000 fish) (Figure 5.4.1). There is evidence from the prediction that PFA will decrease in the near future and the spawning escapement has not been significantly above the conservation limit for the last six years (Figure 5.1.4). ICES advises that precautionary reductions in exploitation rates be pursued for as many stocks as possible, in order to ensure that conservation requirements are met for each river stock with high probability. ICES also notes that mixed stock fisheries present particular threats to conservation.

In European and North American areas, the overall status of stocks contributing to the West Greenland fishery is at the lowest level recorded, and as a result, the status of stocks within the West Greenland area is thought to be extremely low compared to historical levels. There has been no significant increase in survival index for the stock. Status of relevant stocks in the NEAC and NAC areas are presented in the relevant commission sections of this report.

ICES noted that tentative exploitation rates for non-maturing 1SW fish at West Greenland can be calculated by dividing the harvest of 1SW salmon of N. American origin at West Greenland by the PFA estimate for the corresponding year. This indicates exploitation rates in recent years have averaged around 10%. Compared to values prior to 1993, which averaged 26%, this suggests that recent management measures in this fishery have reduced exploitation in this stock complex.

7.2 Management objectives

The general NASCO management objectives apply (See Section 3). However, based on past performance, there is no reason to expect the abundance of salmon in the North Atlantic to be proportional to the regional 2SW spawner requirements. Assuming that the abundance of Atlantic salmon in 2003 will be proportional to the abundance of lagged spawners in the last five years when lagged spawner estimates across regions were available, it is possible to calculate the number of salmon required to return to North America to achieve region-specific conservation requirements. For example, to achieve the Newfoundland 2SW requirement of 4,022 2SW salmon, a total of 72,062 fish would be required to leave West Greenland at the PFA_{NA} stage (See Section 4). In the regions with lower stock performance, total PFA_{NA} abundance of about 454,000 fish would be required for the Scotia-Fundy region, and PFA_{NA} abundance of almost 1.9 million fish would be required for achieving the USA conservation requirements (See Section 4).

There is a zero chance that the returns to USA rivers will meet or exceed the conservation limit, about 29,000 2SW salmon, in 2004. There is little chance of returns in 2004 being sufficient to meet the Scotia-Fundy requirement even in the absence of high seas fisheries. There would be a small chance that the PFA_{NA} abundance in 2003 would be sufficient to meet the conservation requirements based on the realized returns in recent years and the anticipated PFA of salmon in 2003 (See Section 4).

NASCO has therefore considered that Alternative Management Objectives could be to meet the conservation limits simultaneously in the four northern regions of North America: Labrador, Newfoundland, Quebec, and Gulf. For the two southern regions, Scotia-Fundy and USA, an alternate objective to that of achieving the conservation requirement would be to achieve increases in returns relative to previous years with the intention that this will lead to the rebuilding of stocks, i.e. assess fisheries relative to the objective of achieving a pre-agreed increase in returns relative to the realized returns of a previous time. Rates of improvement from previous years could be as low as 10% for those stocks that are approaching a stock status objective. A greater improvement as might be associated with more aggressive rebuilding rates might be to seek a 25% improvement over returns of a previous time period. These rates of increase refer to current stock size and not to percent of conservation limits. In Section 4, it was shown that stocks with low productivity such as these take a long time to rebuild to conservation limits.

ICES noted that if a moving average is used, and these stocks continue to decline, so will the baseline value. ICES therefore draws to the attention of NASCO the need to establish the range of years to define the baseline and the percentage increase from that baseline. This will provide ICES with the criteria to assess performance of the fisheries management

7.3 Reference points

As precautionary reference points have not been developed for these stocks, management advice is therefore referenced to the S_{lim} conservation limit. Thus, these limits should be avoided with high probability (ie at least 75%).

Sampling of the fishery at West Greenland since 1985 has shown that both European and North American stocks harvested are primarily (greater than 90%) 1SW non-maturing salmon that would mature as either 2 or 3SW salmon, if surviving to spawn. Usually less than 3% of the harvest is composed of salmon that have previously spawned and a few percent are 2SW salmon that would mature as 3SW or older salmon. For this reason, conservation limits defined previously for North American stocks have been limited to this cohort (2SW salmon on their return to homewaters) that may have been at Greenland as 1SW non-maturing fish. These numbers have been documented previously by ICES and are in Section 6.3. The 2SW spawner limits of salmon stocks from North America total 152,548 fish, with 123,349 and 29,199 required in Canadian and USA rivers, respectively.

Conservation limits for the NEAC area have been split into 1SW and MSW components on the basis of the average age composition of catches in the past ten years. The stocks have also been partitioned into northern and southern stock complexes, and tagging information and biological sampling indicates that the majority of the European salmon caught at West Greenland originate from the southern stock complex. The current conservation limit estimate for southern European MSW stocks is approximately 263,000 fish. There is still considerable uncertainty in the conservation limits for European stocks and estimates may change from year to year as the input of new data affects the 'quasi-stock-recruitment relationship'. ICES has previously noted that outputs from the national PFA model are only designed to provide a guide to the status of stocks in the NEAC area. Previously, the conservation limits for MSW salmon in the NEAC area have not been incorporated into the modeling of catch options for West Greenland.

7.4 Advice on management

ICES has provided management advice for the West Greenland fishery, based on NAC stocks as before, and for the first time in 2003 for the NAC and NEAC stock complexes combined:

NAC
Even in the absence of fisheries on the non-maturing 1SW salmon at West Greenland in 2003 and subsequently on the returning 2SW salmon to North America in 2004, there is only a 28% chance that the abundance of salmon will be sufficient to achieve the conservation requirements for 2SW salmon in the four northern regions. There is a better chance of realizing increases in returns to the southern North American stocks however at a fishery of 50 t in West Greenland in 2003, the chance of an improvement of 25% or more in both regions falls to less than 50% (Table 7.4.1).

There are no fishery allocations that would ensure the objective of achieving the conservation requirements for 2SW salmon in the four northern regions or an alternative objective of seeing an increased number of 2SW salmon returning to the under-escaped southern regions of North America. ICES recommends that there should be no exploitation of the 2002 smolt cohort as non-maturing 1SW fish in North America or at West Greenland in 2003 and also recommends that the cohort should not be exploited as mature 2SW fish in North America in 2004. Exceptions are in-river harvests from stocks which can be shown to be above biologically-based spawning escapement requirements. Furthermore, exploitation rates on this cohort (including possible by-catch in other fisheries) should be minimized in the North American and West Greenland commission areas. ICES reiterates that, in order to meet the primary NASCO objective of meeting conservation limits in all areas of North America, there should be no catch at West Greenland.

NEAC

In the absence of any fishery at West Greenland, there is a less than 75% probability that the MSW conservation limit for southern Europe will be met (Table 7.4.1). ICES recommends that there should be no exploitation of the 2002 smolt cohort as non-maturing 1SW fish at West Greenland in 2003 and also recommends that the cohort should not be exploited as mature 2SW fish in the southern NEAC area in 2004. Exceptions are in-river harvests from stocks which can be shown to be above biologically-based spawning escapement requirements. ICES reiterates that, in order to meet the primary NASCO objective of meeting conservation limits in all areas of southern NEAC, there should be no catch at West Greenland.

NAC/NEAC combined

There are no fishery allocations that would ensure the objective of achieving the conservation requirements for 2SW salmon in the NAC or NEAC areas (Table 7.4.1).

7.5 Relevant factors to be considered in management

For all fisheries, ICES considers that management of single stock fisheries should be based upon assessments of the status of individual stocks. Conservation would be best achieved if fisheries can be targeted at stocks that have been shown to be above biologically-based escapement requirements. Fisheries in estuaries and rivers are more likely to fulfil this requirement.

7.6 Catch forecast for 2003

Catch Advice for the NAC

The pre-fishery abundance of salmon in 2003 is expected to be among the lowest on record (Figure 7.9.4.10). In the absence of any marine-induced fishing mortality, there is a low probability (28% probability) that the returns of 2SW salmon to North America in 2004 will be sufficient to meet the conservation requirements of the four northern regions (Labrador, Newfoundland, Quebec, and Gulf) (Table 7.4.2). There is a higher probability (71%) that the returns in the southern regions (Scotia-Fundy and USA) will increase by at least 10% relative to the returns of the previous five years if the predicted PFA abundance is realized (Table 7.4.2).

The model presently describes two phases of salmon production in the Northwest Atlantic. Our ability to detect a phase shift in recruitment per spawner in the northwest Atlantic during the last two decades was enhanced with the passage of time. The lower recruitment rates, which may not replace the spawners that generated them, are evident throughout eastern Canada and U.S., especially so in the southern regions. The reduced relative rate of recruitment does not suggest that the problem is entirely in the marine environment. The problem may be an integration of factors across all aquatic habitats of Atlantic salmon. Large areas of production have been lost or are severely impacted by anthropogenic factors. Given the presently described condition of salmon stocks, there is no evidence in the stock status from any of the regions in North America that there will be a turnaround in productivity in the ocean in 2003.

Combining catch advice for NAC/NEAC

ICES also considered for the first time a process for the provision of catch advice for West Greenland based on the combined PFA and CLs of the NAC and NEAC areas, in which the PFA for NAC and NEAC are applied in parallel to the Greenland fishery and then combined at the end of the process into a single catch advice table.

The parameters of the NAC risk analysis have not changed and are described in Section 7.9.4.

For the NEAC evaluation, the following parameter inputs were used.

- For 2003, the forecast for the southern Europe MSW salmon on January 1 of the first sea-winter year is 524,000 fish (95% C.I. 315,000 to 840,000).
- The PFA_{NEAC} for 2003 is adjusted for 8 months of natural mortality (0.03 per month) which equates to 79% survival to bring the fish to August of the fishery year at Greenland.
- The sharing arrangement for the West Greenland fishery used in this example corresponds to the sharing arrangement used for the provision of catch advice for the NAC area. The sharing arrangement negotiated with one of the commission areas automatically determines the arrangement for the other area as the West Greenland fishery cannot selectively harvest fish on the basis of their continent of origin. Historically, the West Greenland share of the total NEAC MSW harvest was on average 40% from 1970 to 1993.
- The biological characteristics of the fish at West Greenland are simultaneously derived for fish from both continents.
- The conservation limit for the southern NEAC MSW salmon is 262,935 fish.

7.7 Medium- to long-term projections

North American stocks
Catch options which could be derived from the prefishery abundance forecast for 2003 (111,042) would apply principally to North American fisheries in 2004 and hence the level of fisheries in 2003 needs to be accounted for before providing these catch options.

Accounting for mortality and the conservation limit and considering an allocation of 60% of the surplus to North America, the only risk averse catch option for 2SW salmon in 2004 is zero catch. This zero catch option refers to the composite North American fisheries. As the biological objective is to have all rivers reaching or exceeding their conservation limits, river-by-river management will be necessary. On individual rivers, where conservation limits are being achieved, there are no biological reasons to restrict the harvest.

NEAC stocks
The quantitative prediction for the southern NEAC MSW stock component gives a projected PFA (at 1st January 2003) of 524,000 fish for catch advice in 2003. No projections are available beyond that for this stock complex.

7.8 Comparison with previous assessment and advice

An evaluation of the effect of the updates to the model used to provide catch advice for North American 2SW stocks at West Greenland is provided in Section 7.9.4, below.

7.9 Response to specific requests for information from NASCO:

7.9.1 NASCO has requested ICES to: describe the events of the fisheries in 2002 and the status of stocks

Catch and effort in 2002

At its annual meeting in June 2002 NASCO agreed to a revised ad hoc management programme for the 2002 fishery at West Greenland that as in the previous year incorporated the use of real-time data to allocate quota for the commercial fishery. The commercial fishery is defined as landings sold to processing plants and excludes reported private landings (not sold to plants) and unreported catch. The commission noted that the forecast pre-fishery abundance is considered to be highly uncertain, but also that there appears to be a relationship between the estimated pre-fishery abundance and catch per unit of effort in West Greenland, measured as average daily landings per licensed fisherman. Two harvest periods were implemented with quotas dependent on the observed average CPUE during the fishery in the first harvest period.

The initial quota for the first quota period of up to two weeks was set at 20 t, and additional quota was allocated for the subsequent harvest period of a maximum of five weeks based on catch per unit effort observed in the fishery. The maximum quota for the fishery as a whole would have depended on the observed average commercial CPUE during the first period of fishing, being 20, 38 and 55 t, respectively for three levels of CPUE.

Shortly before the opening date of the fishing season (August 12) the Organization of Fishermen and Hunters in Greenland and the North Atlantic Salmon Fund agreed to suspend the commercial fishery for salmon in 2003. The subsistence fishery was not affected by this agreement. As is the past, there was no quota limit set for the subsistence fishery. The authorities did not apply a closing date for the fishing season, i.e. the season was open till the end of the year.

By regulation, all catches including landings to local markets, privately purchased salmon, and salmon caught by food fishermen, are to be reported on a daily basis to the Fishery Licence Office. By the end of the year a total of 9 t of landed salmon was reported (Table 7.9.1.1). The geographical distribution of catches by Greenland vessels is given in Table 7.9.1.2 for the years 1977-2002. The unusually high proportion of catch observed in southern Greenland in 2000 and 2001 is not indicated for the 2002 season, being close to the average for the period 1995-1999.

Licences for the salmon fishery were issued to fishers fishing for factories, local markets, hotels, hospitals etc., while fishing for personal use was permitted without licence for residents of Greenland. The number of reporting fishers in the salmon fishery has decreased sharply since 1987, when a catch of more than 900 t was allowed and more than 500 licenses were active in the fishery. During the 2002 season 41 fishers reported catches, the lowest number on record.

Landing reports were received from August 15 until December 11. Due to a lesser incentive for a thorough and early reporting of catches many of the reports combined more than one landing of salmon. Some of the reports were probably also sent to the License Office with a considerable delay in relation to the time of fishing. Because of these changes in reporting, the Working Group was unable to estimate average CPUE values for that part of the fishery in 2002, which is comparable with the commercial fishery in preceding years. As a result, it was not possible to update the data series used to develop the *ad hoc* management programme used in the previous two years.

Due to the character of this fishery, which includes provisions for personal consumption, some unreported catch likely occurs. Unreported catch is primarily associated with personal consumption or subsistence fishing, which appears to have remained relatively stable through time. There is presently no quantitative approach for estimating the magnitude of unreported catch; however, based on local knowledge it is at the same level used for recent years (around 10 t).

Biological characteristics of the catches

Biological characteristics (length, weight, and age) were recorded from 1,297 fish in catches from NAFO Div. 1C, 1D and 1F in 2002 and presented in Tables 7.9.1.3 to 7.9.1.5 together with corresponding data from sampling in Greenland since 1968.

The general downward trend in mean length and weight (unadjusted for sampling date) of both European and North American 1SW salmon observed from 1969–1995 reversed in 1996, when mean lengths and weights increased (Table 7.9.1.3, Section 7.9.1.4). In 2000, a decrease was observed, mainly in the North American component where the mean lengths and weights were among the lowest observed in the time series. In 2001 and 2002, mean lengths and mean weights increased again to a level close to the overall average for the recent decade.

Distribution of the catch by river age in 1968-2002 as determined from scale samples is shown in Table 7.9.1.4. The percentage of the <u>European origin</u> salmon that were river age-1 fish has been quite variable through the later years with relatively high values in 1998-2000, the 2000 value being the highest on record, but the percentage decreased thereafter to 10 % in 2002. A low percentage of this group suggests a low contribution from Southern European stocks. In 1998 and 1999 low percentages of 7.6 and 7.2 %, respectively, of river age-3 were observed, the lowest on record. In 2002, the percentage was 18 %, close to the overall mean of 16.9 %. The mean river age of the contribution from Southern European stocks reflects these changes in percentages, with the overall mean age of 2.0 years. The percentage of river age-2 salmon of <u>North American</u> origin declined somewhat from 1998, which was close to the overall mean value of 33.5 %, to 26.7 in 2002. In 2001 the lowest value on record was observed (15.2 %). The mean river age of the catch has varied throughout the last 10 years, but in 2002 is above age 3.0, the overall mean.

The sea-age composition of the samples collected from the West Greenland fishery showed no significant changes in the percentages in the North American component of fish from 1998 to 2002 (Table 7.9.1.5). The percentage of 1SW salmon in the European component has been very high since 1997 (99.3 %), and was 100 % from 1999 to 2000.

Continent of Origin of catches at West Greenland

In total, 1,374 specimens, representing 44 % by number of the landings, were sampled for presence of tags, fork length, weight, scales, and tissue samples for DNA analysis. The limitation of the fishery to subsistence fishing caused severe practical problems for the sampling teams; however, the sampling program was successful in adequately sampling the Greenland catch temporally and spatially.

No disease sampling was conducted in 2002 because of logistical difficulties, however, the Working Group recommends that it be done in 2003.

In total, 338 (67.5 %) of the salmon sampled from the 2002 fishery were of North American (NA) origin and 163 (32.5 %) fish were determined to be of European origin .

Applying the continental percentages for reported catch by NAFO Division results in estimates of 6.4 t (2200 salmon) of North American origin and 2.6 t (900 salmon) of European origin fish landed in West Greenland in 2002. For divisions without samples the overall average weight and continent of origin splits were assumed. Quota reductions have resulted in an overall reduction in the numbers of both North American and European salmon landed at West Greenland until 1999. The number of North American salmon remained about the same in 1999 and 2000 (5-6,000 salmon), but increased in 2001. In 2002, the number of landed salmon decreased to the lowest number on record. A high percentage of European salmon in Div. 1F was observed in 2000-2002 (Table 7.9.1.6, Figure 7.9.1.1).

Elaboration on Status of the stocks in the West Greenland Commission area

Southern European Stock

The main contributor to the abundance of the European component of the West Greenland stock complex is non-maturing 1SW salmon from southern Europe. The percentage of European fish in catches at West Greenland was around 30% in the early 1990's and the 2000's, but was below 20% from 1996 to 1999. A Run-Reconstruction Model was used to estimate the pre-fishery abundance of non-maturing 1SW salmon from 1971 to the present. These have declined since the 1970s, with the 2001 abundance of 546,939 being the 3rd lowest estimate on record (Figure 5.1.3b). The contributions of countries within NEAC to this PFA, based on tagging data are: France, 2.7%; Ireland, 14.7%; UK (England &Wales), 14.9%; UK (Northern Ireland), <0.01%; UK (Scotland), 64.5%; and northern NEAC countries, 3.2%. Southern European MSW salmon stocks in the Southern NEAC area show a consistent decline over the past 10-15 years, and the estimated overall spawning escapement has been below conservation limits (S_{lim}) in four out of the past six years. Information from individual countries is summarized below:

France:
- MSW returns second lowest in the time series
- MSW spawners below CL in 2002.

Ireland:
- MSW returns above the median value for the time series
- MSW spawners above the median value for the time series
- MSW numbers subject to considerable uncertainty as the sea age composition of the catch is not known accurately
- MSW spawners at or above CL in 2002.

UK (England & Wales):
- MSW returns 20% below the median value for the time series
- MSW spawners close to the median value for the time series
- MSW spawners at or above CL in 2002

UK (Northern Ireland):
- Historical trends unclear as the sea age composition of the catch is unknown for most of the time series.
- MSW spawners at or above CL in 2002

UK (Scotland):
- MSW fish estimated to contribute between 40% & 70% of the spawning stock
- MSW returns second lowest in the time series
- MSW spawners below CL in 2002

North American Stock

The North American Run-Reconstruction Model was used to update the estimates of pre-fishery abundance of non-maturing and maturing 1SW salmon from 1971-2001. The total population of 1SW and 2SW Atlantic salmon in the northwest Atlantic has declined since the 1970s, with the 2001 abundance of 428,300 being the lowest estimate (Figure 6.9.1.7). The percentage of North American salmon in the West Greenland catch was less than 70 % for all but one year until 1992, and then increased from 60% to 90% from 1995 to 1999, and has averaged approximately 67% from 2000 to 2002 (Table 7.9.1.6). In 2002, the overall conservation limit (S_{lim}) for 2SW salmon was not met in any area except Newfoundland. Specifically:

Newfoundland:
- 2SW and 3SW salmon are a relatively small component of this stock complex
- 2SW returns third lowest in the last 10 years
- 2SW spawners in 2002 at approximately 1.5 times the 2SW stock conservation limits (S_{lim})

Labrador:
- 2SW salmon historically an important part of this stock complex
- 2SW returns peaked in 1995, and decreased again in 1996 and 1997
- no estimate is given after 1997 from this area when the commercial fishery, the basis for the return and spawner model for Labrador, ended

Québec:
- 2SW and 3SW salmon an important part of this stock complex
- 2SW returns lowest in a 32-year time-series
- 2SW spawners in 2002 at 52% of 2SW conservation limit (S_{lim})

Gulf of St. Lawrence:
- 2SW salmon an important part of this stock complex
- 2SW returns second lowest in a 32-year time-series

- 2SW spawners in 2002 at 38% of 2SW conservation limit (S_{lim})

Scotia-Fundy:

- 2SW salmon historically an important part of this stock complex
- 2SW returns lowest in a 32-year time-series
- 2SW spawners in 2002 at 6% of 2SW conservation limit (S_{lim})
- inner Bay of Fundy stocks listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada

United States:

- 2SW salmon historically an important part of this stock complex
- 2SW returns second lowest in a 32-year time-series
- 2SW returns in 2002 at 3% of 2SW conservation limit (S_{lim})
- stocks in 8 rivers listed as Endangered under the Endangered Species Act

7.9.2 NASCO has requested ICES to: provide information on the origin of Atlantic salmon caught at West Greenland at a finer resolution than continent of origin (river stocks, country or stock complexes)

Within a mixed stock fishery, the identification of the origin and composition of the exploited resource is essential for the responsible management of the shared resource. This is especially true for stocks that are protected under various nation-specific Endangered species legislations. In addition, the NASCO Decision Structure requires that the stock composition of mixed stock fisheries be considered while developing management plans. As an example, the West Greenland Atlantic salmon fishery falls within this category.

A major genetic dichotomy exists between populations from either side of the North Atlantic Ocean and between European populations in Baltic and Atlantic drainages (Ståhl 1987). One microsatellite locus has shown almost perfect separation of North American and European Atlantic salmon (Taggart et al. 1995; Koljonen et al. 2002). Such hypervariable nuclear DNA marker types can in theory be used to distinguish any distinct population group from one another, provided that there is a demonstrated positive correlation between genetic and geographic distance and that a sufficient number of unlinked loci are studied. However, it remains to be seen how well these markers estimate finer scale composition within a mixed stock fishery where a large number of populations are contributing.

Data collected for continent of origin assignments for the West Greenland mixed stock fishery have been based on 4,373 Atlantic salmon genotypes (individuals): 459 from Europe and 3,914 from North America with 600 of these from Canadian stocks. These data have also been used to do preliminary assignments of countries, and thus stock complex within Europe, and between Canada and USA. What follows describes an approach for estimating the catch of fish from the USA Distinct Population Segment (DPS), eight rivers in Maine collectively listed as Endangered.

All genetically characterized individuals from the 2002 West Greenland fishery were assigned to continent of origin and country of origin (for NA assigned individuals only). Unanalysed individuals from the catch were assigned to continent of origin (COO) according to a binomial distribution from known (genetically analysed) COO assignments. Furthermore, all North American (NA) origin individuals were assigned to country of origin according to a binomial distribution from the country of origin assignments provided. The regional assignments within the USA were calculated according to the proportion of the 2SW adult returns to all Atlantic salmon rivers within the USA. For the DPS estimate, a Pert distribution, based on the mean estimate, 90% confidence intervals and a truncation of the minimum value (at 0) generated from the linear regression model was used to generate the estimate. Finally the regional assignments were adjusted for natural mortality to estimate the increase in returns that would have resulted with no commercial harvest.

It is estimated that the reference dataset correctly assigns continent of origin 100% of the time whereas the country of origin assignments (USA vs. Canada) are estimated to be 92.2% for assigning USA samples back to the USA and 88.0% for assigning Canadian samples back to Canada (Spidle et al. 2003). These accuracies reflect the high degree of genetic separation between continents and the much lower separation on the country scale (Figure 7.9.2.1). The composition of the reference dataset greatly affects its assignment accuracy, both in terms of the spatial coverage of samples within the dataset as compared with the unknown samples and the quantity of samples within these reference sets. If a reference dataset is used to classify unknown samples, but the reference dataset does not include known samples from the range of possible populations or there are a disproportionate number of samples from one known group or another, the misclassification rate can rise significantly above that recorded through cross validation procedures on the reference dataset. However, if the classification accuracies of the reference dataset are known, the misclassification rates can be accounted for and the tallies produced for the PGA can be adjusted.

While trying to identify USA origin fish in the 2002 West Greenland catch, biological inconsistencies were identified that confounded the model outputs. The cause of these inconsistencies appears to be related to the assignment accuracy of the reference dataset as determined by cross validation procedures. Whenever using genetic data to assign individuals to continent, country or region, external supporting data should be used to corroborate your assignments. Supporting evidence can come from past tagging studies or biological characteristics.

Classifying Southern and Northern European stock complexes in the West Greenland catch has direct applicability to the forecast of PFA. However, finer scale classification within continent will also be useful in evaluating the effects of other fisheries on salmon stocks.

This example shows the need for the identification of country or region of origin for the management of mixed stock fisheries. Presently, the reference datasets used for these assignments lack adequate spatial and temporal sample coverage to consistently assign to finer scale with acceptable assignment accuracy. This is especially true for the European and Canadian stock complexes. Efforts need to be taken to bolster these reference datasets by collecting and analysing samples from additional populations over as wide a geographic scale as possible.

7.9.3 NASCO has requested ICES to: evaluate the extent to which the objectives of any significant management measures introduced in the last five years have been achieved.

There have been the following significant changes in the management regime at West Greenland since 1993:

- First, NASCO adopted a new management model (Anon. 1993) based upon ICES' assessment of the PFA of non-maturing 1SW North American salmon and the spawner escapement requirements for these stocks. This resulted in a substantial reduction in the TAC agreed to by NASCO from 840 t in 1991 to 258 t in 1992, and further reductions in subsequent years.
- The next change in management was the suspension of fishing in 1993 and 1994 following the agreement of compensation payments by the North Atlantic Salmon Fund. Due to the closure of the fishery in the two years no sampling could be carried out in Greenland, and no biological data were collected.
- In 1998, NASCO agreed on a subsistence fishery of 20 t, which in the past has been estimated for internal consumption at Greenland. In 1999, a multi-year management was agreed restricting the annual catch to that amount used for internal consumption.
- An *ad hoc* management arrangement for 2001 was agreed by NASCO, implementing an adaptive quota calculation, based upon three harvest periods. The resulting total quota for all harvest periods was 114 t.
- A revised *ad hoc* management arrangement for 2002 was agreed to by NASCO. In addition, an agreement was negotiated between the North Atlantic Salmon Fund and its partners, and the Greenland Association of Hunters and Fishers (KNAPK), to suspend the commercial part of the salmon fishery. The agreement is for a total of five years, and is automatically renewed annually unless one of the parties gives notice in advance of the fishing season of their intention to withdraw.

To calculate a possible TAC for those years according to the agreed quota allocation model (Anon. 1993) biological parameters from sampling in 1992 were used (Table 7.9.3.1). The variables in the table (percent of origin, mean weights, and percent of 1SW fish) are used in the analyses.

The numbers of fish spared by the 1993-1994 closures are shown in Table 7.9.3.1. The potential catches in the years 1993 and 1994 of 89 and 137 t, respectively correspond to the TACs calculated in accordance with the quota allocation computation model that was agreed by NASCO at its annual meeting in 1993. For the successive years nominal catch figures are used. The table contains the number of salmon returning to home waters provided no fishing of the given magnitude took place in Greenland. The biological parameters given in the table represent the annual sampling data.

The mean number for 1993-2002 of potentially returning fish per ton caught at Greenland is calculated to 166 and 92 salmon for North America and Europe, respectively.

To estimate the number of salmon spared by the suspension of the fishery in 2002 the following assumptions are made:

- Excluding year 2000 the availability of salmon and the potential effort in 2002 is assumed to be close to average for the recent five years (1997-2001).
- The non-commercial landings in 2002 would have been close to average for the recent five years (as above) had there been a commercial fishery.

The average commercial catch for the period was 27,900 kg, and the non-commercial part was 4,800 kg. The difference between the reported non-commercial catch in 2002 and the five-year average is 4,200 kg, leaving 23,700 kg as a potential commercial landing in 2002. The corresponding number of salmon is 5,400 and 2,500 salmon of North American and European origin, respectively.

In the current analysis the effects of the management measures taken at West Greenland have been examined in terms of numbers of fish only. Thus it has been difficult to show direct benefits to home-water stocks from these measures.

The Working Group recommends that other indices of change, i.e. changes in age composition, size at age and sea survival, should also be included in this evaluation.

Following on the above recommendation, ICES reviewed an analysis of the impacts of variations of the West Greenland fishery on expected returns to rivers. The analysis was based on an examination of the 1SW to 2SW relationship demonstrated for several stocks in eastern Canada and focused on the explanatory power of the West Greenland catches on the residuals of the relationship (Figure 4.3.3.2).

The analysis indicated that the variations in high seas exploitation at Greenland could be detected in the returns of 2SW salmon in home waters in the Maritimes, but only after correcting for the 1SW abundance of the same cohort. The benefits of reduced exploitation can only be appropriately evaluated if the variations in natural mortality are accounted for, as is the case for the 1SW-2SW associations. This also requires that the returns of one age group, in this case the 1SW age group, be exempt from exploitation, which has been the case for the 1SW maturing age group in North America since the closure of the commercial fisheries in 1992-1998. The reduced exploitations at West Greenland has benefited the rivers of the Maritimes although it is clear that fishing at West Greenland does not seem to be the major constraint on 2SW salmon in some areas of eastern Canada.

7.9.4 NASCO has requested ICES to: provide a detailed explanation and critical examination of any changes to the model used to provide catch advice and of the impacts of any changes to the model on the calculated quota.

The following updates were made in the model to forecast PFA for the North American Commission Area.

- Labrador was not included in the lagged spawners index due to lack of data
- Returns to Gulf and USA regions, excluded in previous years, were included in the lagged spawners index
- A two phase regression between PFA and lagged spawners was used to account for phases in productivity
- The habitat index did not provide a statistical improvement to the model and so was not included

These developments are described fully below, together with the integration of the model results into a risk framework for providing catch advice:

Evaluating Atlantic salmon biological data for phase shifts

For the past two years ICES has noted that there is a potential problem of non-stationary relationships in spawners to PFA. In 2002, the report included regressions of CPUE (kg/reported landings) and North American and Southern European PFA, with residuals demonstrating a shift in the relationship following the 1992-1993 closure (ICES 2002/ACFM:14, Figure 5.1.2.1). This year, ICES examined biological data from all three Commission areas for non-stationarity, specifically attempting to identify the transition year(s) where a phase shift was evident. It was hoped that this evaluation would inform the modeling process and facilitate change to integrate trends contained in the time-series of PFA and lagged spawner in NEAC and NAC.

North-East Atlantic Commission

Anon. (2003) provides a critical examination of selected NEAC stock and recruitment relationships Six rivers were considered: the R. Frome UK (England and Wales), the Girnock Burn and the R. North Esk UK (Scotland), the R. Bush and R. Burrishoole (Ireland) and the R. Ellidaar (Iceland). Stock (S) and recruits (R) were expressed in eggs. Recruitment was estimated from estimated returns of adult salmon back to the coast, prior to any homewater fishery.

For all the six rivers analysed, there is a drop in the recruitment process occurring in the mid 1980s. In four of the six instances, the productivity (Ricker α parameter - recruits produced per stock unit at low egg depositions) has also dropped significantly. Causes for this phenomenon are unclear although it certainly relates, at least partly, to changes in marine survival observed over the last three decades and to habitat changes (degradation of spawning areas or loss of specific spawning areas).

A non-parametric ratio test (NPRATIO) was used to investigate phase changes in time series of marine survival for salmon stocks in the southern part of the NEAC area Rago (1993).

Data for 1SW survival rates were available for five Irish stocks (Shannon hatchery, Screebe hatchery, Burrishoole hatchery, Corrib hatchery and wild), two UK (N. Ireland) stocks (Bush hatchery and wild) and one UK (Scotland) stock (N. Esk wild), while survival data were available for 2SW fish from four Irish stocks (Shannon hatchery, Burrishoole hatchery, Corrib Hatchery and Corrib wild), and one UK (Scotland) river (N. Esk wild). The time series extended from 1980 through 1998 smolt migration years. The results of this analysis provide some support of a phase change in marine survival consistent with other observed stock dynamic changes occurring in other stocks from the North East Atlantic and North America, particularly around the 1989/1990 period for 2SW stocks and possibly earlier for 1SW stocks. The percentage of Southern NEAC stock caught in the Greenland fishery has ranged from 10% to 66% and is estimated to be 33% presently. Therefore, the results of the 2SW analysis may be particularly pertinent to the identification of phase shifts affecting the dynamics of the Greenland fishery.

North American Commission

The relation between the returns of 1SW and MSW from a given smolt cohort was examined for three data sets from Québec for 1980 – 2001. The data were: estimates of total salmon returns in Québec and of returns from two index rivers. Returns were corrected based on estimates of captures made in home water, but not those in the distant fisheries. The regressions of 1SW to 2SW returns for a cohort were developed and residuals plotted against year (Figure 7.9.4.1). In each analysis the residuals for the regressions demonstrate two periods, namely from 1980 and 1990 and the period starting in 1991. A similar regression approach did not produce evidence for a shift in survival rate of hatchery 2SW returns to the Penobscot River. However, inverse weight estimates for North America show an increase in theoretical M in the second year over the last decade (Figure 4.2.1.1).

On the LaHave River, Nova Scotia, the natural log of recruits per spawner (survival index) determined at Morgans Falls had normal variance to 1986 but has been below replacement (zero line) ever since (Figure 7.9.4.2). The shift in population stability was not associated with an acute loss in freshwater productivity monitored by both juvenile densities and smolt emigration. However, the drop in the survival index (Ln(R/S)) in 1986 is associated with the decline in smolt age two-sea age two (age 2.2) and is equivalent to the 1990 PFA year.

Greenland Commission Area

The whole weight of 1SW North American salmon in the West Greenland fishery (uncorrected for sampling date) was examined in two independent tests. Mean 1SW salmon whole weights from 1969-2002 were regressed against year to determine when the relationship became significant by casting forward in groups of four years. There was a significant decline in weight from 1969 to the early 1990's, followed by a significant increase in weight. These data were also analyzed using the randomization method described for Southern NEAC survival, identifying the break in the same time period.

Therefore ICES concluded that the phase shift, which occurred around the end of the 1980s to early 1990s, needed to be considered when providing catch advice for the West Greenland fishery in 2003.

Overview of provision of catch advice

Although advances have been made in our understanding of the population dynamics of Atlantic salmon and the exploitation occurring in the fisheries, the concerns about the implications of applying TACs to mixed-stock fisheries are of concern. In principle, adjustments to catches in mixed-stock fisheries provided by means of an annually adjusted TAC would reduce mortality on the contributing populations. However, benefits to particular stocks would be difficult to demonstrate, in the same way that damages to individual stocks are difficult to identify.

The aim of management is to regulate catches while achieving overall spawning escapement reflecting the spawner limits in individual North American and European rivers. In order to achieve the desired level of exploitation for a given level of predicted abundance, a TAC could be fixed or some form of effort adjustment introduced. Such an assessment would also depend on a forecast of pre-fishery abundance for both North American and European salmon stocks.

To date, the advice for any given year has been dependent on obtaining a reliable predictor of the abundance of non-maturing 1SW North American stocks prior to the start of the fishery in Greenland. Gill net fisheries in Greenland harvest one-sea-winter (1SW) salmon about one year before they mature and return to spawn in North American rivers. This component was also harvested on their return as 2SW salmon in commercial fisheries in eastern Canada, angling and native fisheries throughout eastern Canada, and angling fisheries in the northeastern USA. The fishery in Greenland harvests salmon that would not mature until the following year, while the fishery in Labrador (closed in 1998) harvested a mix from the non-maturing component as well as maturing 1SW and MSW salmon. The commercial fisheries in Québec and the Maritime provinces of Canada harvested maturing 1SW and MSW salmon.

ICES had advocated models based on thermal habitat in the northwest Atlantic and spawning stock indices to forecast pre-fishery abundance and provide catch advice for the West Greenland fishery. While the approach had been consistent since 1993, the models themselves have varied slightly over the years. Changes have been made to these models in attempts to improve their predictive capabilities and add more biological reality. In particular, the models since 1996 have used a spawning stock surrogate variable (lagged spawners) in an attempt to describe the variations in parental stock size of the non-maturing 1SW component (PFA). The models of previous years included the following predictor variables: 1993 - thermal habitat in March; 1994 - thermal habitat in March; 1995 -thermal habitat in January, February, and March; and 1996-2001 - thermal habitat in February and lagged spawners from the Labrador, Newfoundland, Québec, and Scotia-Fundy regions of Canada. In 2000-2001, the model was based on the natural log of PFA relative to the natural log of spawners and habitat variables. In this way, the survival rate of salmon (PFA / Spawners) has a mean survival level that is modified by the habitat environmental variable.

ICES had previously noted that because the method of estimating spawning escapement for Labrador was based on commercial catches and exploitation rates which ended in 1997 following closure of the commercial fishery, lagged spawner values would have missing components in year 2003. Thus, an alternative index of salmon abundance is required and described below.

North American run-reconstruction model

ICES has used the North American run-reconstruction model 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 (Section 6.9.1). Region-specific estimates of 2SW returns are shown in Figs. 6.9.1.4 and 6.9.1.5. Estimates of 2SW returns prior to 1998 in Labrador are derived from estimated 2SW catches in the fishery using a range of assumptions regarding exploitation rates and origin of the catch. With the closure of the Labrador fishery, 1998 to 2000 returns were estimated as a proportion of the total for other areas based on historical data.

Update of thermal habitat

ICES has been using the relationship between marine habitat, an index of 2SW lagged spawners and estimated pre-fishery abundance to forecast pre-fishery abundance in the year of interest (ICES 1993/Assess:10; 1994/Assess:16; 1995/Assess:14; 1996/Assess:11, 1997/Assess:10; 1998/ACFM:15, 1999/ACFM:14; 2000/ACFM:13, and 2001/ACFM:15). Marine habitat is measured as a relative index of the area suitable for salmon at sea, termed thermal habitat, and was derived from sea surface temperature (SST) data obtained from the National Meteorological Center of the National Ocean & Atmospheric Administration and previously published catch rates for salmon from research vessels fishing in the northwest Atlantic (Reddin *et al*. 1993 and ICES 1995/Assess:14). The SST data were determined by optimally interpolating SSTs from ships of opportunity, earth observation satellites (AVHRR), and sea ice cover data. The area used to determine available salmon habitat encompassed the northwest Atlantic north of 41°N latitude and west of 29°W longitude and includes the Davis Strait, Labrador Sea, Irminger Sea, and the Grand Bank of Newfoundland.

Thermal habitat has been updated to include 2002 and January and February 2003 year data. Two periods of decline in the available habitat are identified (1980 to 1984 and 1988 to 1995) in the February index (Table 7.9.4.1 and Figure 7.9.4.3). Available habitat for February is unchanged from 2002. The 2003 February value is more than 10% higher than the long-term mean of 1,661.

Update of Lagged Spawners

The lagged spawner variable used in the model is an index of the 2SW parental stock of the PFA. It provides a means of examining the value in managing for spawning escapement and predicting recruitment in the extant seas fisheries. Previous analyses indicated that the sum of lagged spawner components from Labrador, Newfoundland, Québec, and Scotia-Fundy, and excluding Gulf and U.S., was the strongest explanatory variable for the model. Inclusion of the Gulf spawning component reduced the explanatory power of the variable.

ICES recognized the problems inherent in this variable. The exclusion of a major component of the spawning stock contributing to the PFA was less than satisfactory. As well, spawning escapement estimates for Labrador are not available for the years 1998-2001. The previously formulated lagged spawner variable is therefore not available beyond 2002.

ICES investigated two approaches to resolve the issue: 1) estimating lagged spawners for Labrador using data from other areas to develop a relative spawner index, and 2) continue the lagged spawner index and exclude the Labrador time series.

A relative (time) index of spawners is sufficient to assess population dynamics or recruits per spawner. Covariance models can be used to derive relative indices and are used extensively in fisheries assessment for standardizing catch rates by vessel type or gear type or for season or area effects (Hilborn and Walters 1992; Gavaris 1980). An analysis using simulated series indicated that the covariance models could not account for missing components of index series when there are trends present. The ratio of Labrador spawners to the sum of the remaining region spawners fluctuated around 0.2 from 1978 to 1988, decreased and fluctuated around 0.1 from 1989 to 1999 and rose rapidly to over 0.4 in 2002. Such variation is difficult to capture in any model and the subsequent behaviour of the ratio beyond the measured year is unpredictable. If a ratio were used to fill in the missing years for Labrador, the Labrador spawner values would simply be adjusted as a fixed proportion of the trend in the sum of the spawners in the remaining regions, an assumption which cannot be tested with existing information or verified until alternative indices of spawner abundance for Labrador become available.

Patterns of standardized spawner indices (annual number/mean for period) without Labrador did not differ greatly from the sequence of spawner abundance with Labrador included. The trends in lagged spawners have fluctuations that demonstrate consistent patterns among adjacent areas. The trend is down since 1989 for USA and Scotia-Fundy spawners. There is a downward trend for Quebec spawners since the mid-1980s whereas Gulf spawners recovered quickly after the 1984 management plan, remained high through 1990 to 2000 and are declining into 2003. Newfoundland, like Labrador, has an increasing trend in spawner abundance since the mid-1990s, consistent with the management plan that increased escapement.

The variation in Labrador spawners has been much greater than the variation of the sum of the regions (Figure 7.9.4.4). The sum of the other region spawners declined from 1978 to 1988 and rose rapidly in 1989, directly as a response to the management plan of 1984 which imposed the closure of the commercial fishery and the mandatory release of large salmon in the Maritimes – the stepped increase in 1989 was driven by the Gulf stock. Subsequent to 1989, lagged spawners have been declining almost continually and most rapidly into 1992 (Figure 7.9.4.4). The exclusion of the Labrador time series in the North American spawner index is not ideal but is easier to defend in the context of the information available. Excluding the spawner series from Labrador is equivalent to assuming that the trend in Labrador is correlated with the trend of the remaining five regions.

In light of the analyses conducted, ICES developed a new lagged spawner index for North America, which consists of the sum of the lagged spawners from the five regions (US, Scotia-Fundy, Gulf, Quebec, Newfoundland) excluding Labrador (Table 7.9.4.1). Spawner estimates are available for these regions and are anticipated to continue into the future. ICES recognized however that this is not an ideal situation as this spawner index may not be an unbiased measure of the overall lagged spawner abundance from North America, particularly as the impression into the late 1990s was that spawning escapement in Labrador was estimated to have been rising rapidly. However, the exclusion of Labrador did allow the lagged spawner series to be extended back in time one more year, the 1977 year of PFA.

Forecast models for pre-fishery abundance of 2SW salmon

North American Forecast Model

The 2002 forecast of pre-fishery abundance was based on a modeling approach where habitat acts on PFA through survival rather than on absolute abundance.

This model relates directly to a survival relationship, whereby the survival rate of salmon (PFA / Spawners) has a mean survival level that is modified by the habitat variable.

The basis for the model was the same two predictor variables as used from 1999 to 2001: thermal habitat for February (term H2) and lagged spawners (sum of lagged spawners from Labrador, Newfoundland, Scotia-Fundy, and Quebec, term SLNQ) (ICES 1996/Assess:11). This was justified on the basis of studies showing that salmon stocks over wide geographic areas tend to have synchronous survival rates and that the winter period may be the critical stage for post-smolt survival and maturation (Scarnecchia et al. 1989; Reddin and Shearer 1987; Friedland et al. 1993; Friedland et al. 1998).

With the development of an alternative lagged spawner index for 2003, the model was fitted with the new lagged index series and the February habitat index, as in previous years. Revised PFA values (based on updated information from previous years) were also used . The data are summarized in Table 7.9.4.1 and Figure 7.9.4.4. **The model was not significant ($p = 0.27$) with an r^2 value of 0.11.**

The absence of a significant association between the PFA, lagged spawner index and habitat was expected given the analyses from previous years which indicated that the inclusion of Gulf Region lagged spawners resulted in a non-significant model. However, an analysis of the sequence of PFA and lagged spawner values revealed structure within the data set that had not appeared previously and that could not be accounted for by the model used in previous years. Specifically, when perceived over time, two states of Atlantic salmon production become evident with a transition state from 1988 to 1990 (Figure 7.9.4.5). Other indicators of a change in stock dynamics were examined by ICES and many were consistent with this time period (see above). Average relative production, expressed as PFA / lagged spawner index, was 7.6 during 1977 to 1988 and averaged only 1.9 during the 1992 to 2001 period (Figure 7.9.4.5). This dynamic indicates that mortality of salmon between the spawner and PFA recruit stage has changed in the last 15 years. To capture this dynamic, a model that incorporated a break into two time periods, termed phases, was fitted to the data. The position of the change between the high production phase and the lower, more recent production phase was considered to be 1989 as this PFA year is the midpoint in the slide from a low spawner index and high PFA abundance to a high spawner index and unchanged PFA abundance (Figure 7.9.4.5).

The model fitted was similar to the previous year models with the addition of an "indicator variable" to capture the change between the phases. The year 1989 was considered transitional. It was alternatively placed in either the upper phase or lower phase in two runs of the model. The model was fitted initially using the annual mid-point values of PFA_{NA} and LS_{NA} (Table 7.9.4.1).

The thermal habitat variable was not a significant (P > 0.50) explanatory variable of PFA variability after accounting for the lagged spawners and the phase shift. Lagged spawner index and the phase shift were highly significant and accounted for more than 82% of the variance in Ln(PFA_{NA}). The year 1989, in either the first phase or the second phase, did not affect the overall explanatory power of the lagged spawner and phase shift variables. Therefore, the model selected for generating the PFA_{NA} for 2003 and the catch advice included Ln(LS_{NA}) and a phase shift variable set around 1989 (Figure 7.9.4.6). The two phases share a common PFA_{NA}/LS_{NA} slope but with an intercept change which describes the large change in productivity between the two phases. The year 1989 is allocated to either phase using an uninformative prior.

Using the current model to estimate the 2002 pre-fishery abundance using the updated value for 2001 yields a PFA_{NA} prediction that is less than half of the previous year value (Figure 7.9.4.7). The impact of the change in the model and the hypothesis of the change in dynamic are evident in the PFA prediction.

For 2003, the PFA_{NA} forecast is among the lowest of the time series with a median value of 111,000 fish and about a 10% chance the abundance will be sufficient to meet the spawner reserve of 212,000 2SW salmon to North America (Figure 7.9.4.8).

Stochastic Analyses for North American PFA

Although the exact error bounds for the estimates of pre-fishery abundance (NN1(i)) are unknown, minimum and maximum values of component catch and return estimates have been estimated. Simulation methods were used to generate the probability density function of NN1(i) (PFA_{NA}). These estimates were then used to develop the risk analysis and catch advice presented in Section 7.6. Managers may use this information to determine the relative risks borne by the stock (i.e., not meeting spawning limits S_{lim}) versus the fishery (e.g., reduced catches).

Determining the probability of 2003 being in one of the phases

In the case of the phases described by the lagged spawner and PFA_{NA} model, it seems reasonable to expect that 2003 will be in the lower phase, as observed over the last ten years. However, to provide a PFA_{NA} for 2003, a quantification of the probability of being in either phase is required. The approach taken to estimate this probability was to examine the historical changes in PFA_{NA} from year t to year t+2. The two-year lag is used because current year PFA (i.e 2002) is not available due to its dependence upon 2SW returns in the next year. These historical observations are used to estimate the possible values of PFA_{NA} in the predicted year from the observed PFA_{NA} two years earlier under the assumption that the rate of change in PFA_{NA} is stationary over time. Application of these observed rates of change to last year's PFA_{NA} results in a distribution of potential PFA_{NA} values for the forecast year. These values are not used for catch advice, but rather to determine the probability of being in each phase of the two-phase regression.

For the 2003 forecast of PFA_{NA}, the probability of being in the first phase (similar to 1977-1988 time period) is 4.8% and the probability of being in the lower productivity phase is 95.2% . The predicted PFA_{NA} is then a modeled average distribution, which can be thought of as a weighted combination of the two possible predicted PFA distributions from the two regressions, with weights determined by the probability of being in each phase.

The NEAC forecast model

ICES has previously considered the development of a model to forecast the pre-fishery abundance of PFA non-m (PFA of non-maturing potential MSW) salmon from the Southern European stock group (comprising Ireland, France, and all parts of UK) (ICES 2002/ACFM:14). Stocks in this group are the main European contributors to the West Greenland fishery (See Section 7.9.1). The model took a similar form to that used for North American PFA forecasts, with lagged spawners and the same habitat index as that used in the North American model. Both year and spawner terms were found to be significant predictors but the habitat variable had no significant effect. Therefore, this year, lagged spawners and year were used as the main input variables, together with the historical PFA values obtained from the run-reconstruction model. ICES therefore considered an alternative model for 2003 that used only the year and spawner terms to predict PFA. The model was fitted to data from 1977-2002 to provide a revised PFA prediction for 2002 and a forecast of PFA in 2003. ICES noted that the revised prediction of 2002 PFA for southern NEAC MSW stocks was within 1.3% of the previous forecast.

The predictions using this model and the bootstrapped 95% confidence intervals are given in Section 5, together with the trend in PFA non-m. It should be noted that the confidence intervals are wide and this reflects the uncertainty around the point estimate. These predictions have been used as an input to the provision of quantitative catch advice for this stock complex for 2003.

Development of catch advice for 2003 in a risk framework

The provision of catch advice in a risk framework involves incorporating the uncertainty in all the factors used to develop the catch options. The ranges in the uncertainties of all the factors will result in assessments of differing levels of precision. The analysis of risk involves four steps: 1) identifying the sources of uncertainty; 2) describing the precision or imprecision of the assessment; 3) defining a management strategy; and 4) evaluating the probability of an event (either desirable or undesirable) resulting from the fishery action. Atlantic salmon are managed with the objective of achieving spawning conservation limits. The undesirable event to be assessed is that the spawning escapement after fisheries will be below the conservation limit.

A composite spawning limit (S_{lim}) for the North American 2SW stock complex was developed by summing the spawning limits of Salmon Fishing Areas in Canada and river basins within the USA. Details on the methodology to estimate and update the spawner limits are provided in (ICES 1996/Assess:11).

The fishery allocation for West Greenland is for fisheries on 1SW non-maturing salmon in 2003, whereas the allocation for North America can be harvested in fisheries on 1SW salmon in 2003 and/or in fisheries on 2SW salmon in 2004. To achieve spawner limits, a reserve of fish must be set aside prior to fishery allocation in order to meet spawner limits and allow for natural mortality in the intervening months between the fishery and return to river. The spawner limit for North America is 152,548 2SW fish. Thus, 212,189 pre-fishery abundance fish must be reserved ($152{,}548/\exp^{(-.03*11)}$) to equate to inriver S_{lim} because of natural mortality between Greenland and Canada (Table 7.9.4.2a).

Fisheries are managed for harvests of fish, not for escapes of fish. As such the development of catch advice in a risk analysis framework considers the consequences to the objective of meeting conservation limits in the rivers of North America of catching different quantities of fish. The risk consists of not having sufficient numbers of fish returning after the harvesting has taken place and the evaluation of the risk of not meeting the conservation limits depends upon the degree of uncertainty associated with the predicted number of salmon returning to the rivers to spawn.

The risk analysis of catch options for Atlantic salmon from North America incorporates the following input parameter uncertainties:

- the uncertainty in attaining the conservation requirements simultaneously in different regions,
- the uncertainty of the pre-fishery abundance forecast, and
- the uncertainty in the biological parameters used to translate catches (weight) into numbers of North American origin salmon.

The three primary inputs are the PFA_{NA} forecast for the year of the fishery, the harvest level being considered (t of salmon), and the spawner requirements in the rivers of North America. The uncertainty in the PFA_{NA} is accounted for in the resampling approach described above. The number of fish of North American and European origin in a given catch (t) is conditioned by the continent of origin of the fish (propNA, propE), by the average weight of the fish in the fishery ($Wt1SW_{NA}$, $Wt1SW_{E}$) and a correction factor by weight for the other age groups in the fishery (ACF). These parameters define how many fish originating from the NAC and NEAC areas will be in the fishery. Since these parameters are not known, they must be borrowed from previous year values. For the 2003 fishery, it was assumed that the parameters for $Wt1SW_{NA}$, $Wt1SW_{E}$, propNA, and propE, and the ACF could vary uniformly within the values observed in the past five years (Tables 7.9.3.1, 7.9.1.6).

Harvest

For a level of fishery under consideration, the weight of the catch is converted to fish of each continent's origin and subtracted from one of the simulated forecast values of PFA_{NA}. The fish that escape the Greenland fishery are immediately discounted by the fixed sharing fraction (Fna) historically used in the negotiations of the West Greenland fishery. The sharing fraction chosen is the 4:6 West Greenland:North America split. Any sharing fraction can be considered and incorporated at this stage of the risk assessment. After the fishery, fish returning to home waters are discounted for natural mortality from the time they leave West Greenland to the time they return to rivers, a total of 11 months at a rate of M = 0.03 (equates to 28.1% mortality). The fish that survive to homewaters are then distributed among the regions and the total fish escaping to each region is compared to the region's 2SW spawning requirements.

Spawning Requirements

The spawning requirement risk profile for North America was described previously in ICES 1997/Assess:10. Briefly, North America is divided into six stock areas that correspond to the areas used to estimate returns and spawning escapements . Under the assumption of equal production from all stock areas (i.e., recruitment in direct proportion to the spawner requirement) just over 172,000 fish should escape to North America as spawners to achieve the spawner requirement in all six stock areas at a 50% probability level. This value is higher than the point estimate for the North American stock complex (152,548 2SW salmon,) because it includes the annual variation in proportion female and the objective to have sufficient escapement in six stock areas simultaneously.

ICES had previously expressed concerns that the spawning requirement used for North America is for the continent as a whole and does not reflect the expected returns to the six regions, i.e. even if 172,000 2SW salmon reach the coast of North America, there will likely be severe under-escapement in some regions. Specifically, the 2SW returns to Scotia-Fundy, and USA have been below their corresponding conservation limits since 1985. For the 1998 to 2002 PFA years, the most recent years when estimates of lagged spawners are available for all regions of North America, the Quebec and Gulf regions have accounted for a disproportionate number of lagged spawners relative to their 2SW requirements (Figure 7.9.4.9). Alternative management objectives have therefore been considered (Section 7.2).

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 (Table 7.9.4.2c). The returns to North America are partitioned into regional returns based on the regional proportions of lagged spawners for the 1998 to 2002 period (Table 7.9.4.2b). Estimated returns to each region are compared to the conservation objectives of Labrador, Newfoundland, Quebec, and Gulf. Estimated returns for Scotia-Fundy and US are compared to the objective of achieving at least a 10% increase or a 25% increase relative to average returns of the previous five years. The management objectives are shown in Table 7.9.4.2c.

Critical evaluations of updates to the model

Critical evaluations of the various updates to the model were carried out during the process of developing catch advice, and are summarized below:

- A comparison of the 2003 PFA estimates from the updated model to the configuration of the model used last year is not possible because the lagged spawner index for Labrador cannot be estimated. However, application of the updated model to estimate the 2002 PFA produced a lower estimate (median 135,000) than the estimate provided last year (median 325,000). (Figure 7.9.4.10)
- The lagged spawner variable used in the model declines in 2003 to its lowest value and is used to predict PFA using relative spawner abundances that are outside the range of previously observed values. The uncertainty of associations increases as the predictor variable gets farther from the mean, which is the case for the 2003 projection.
- A jack-knife analysis of the two-phase regression model demonstrated that the model has better predictive capacity for the more recent years than for the earlier years. The 1989 value seems to fit better with the second phase than with the first phase (Figure 7.9.4.11 and Figure 7.9.4.12). However, residuals were positive for the years 1989 to 2001, demonstrating that the model underestimates subsequent PFA values.
- To compute the probability of achieving a given level of stock increase for the USA and Scotia-Fundy regions of North America, ICES used the recent a 5-year average of returns. ICES noted that if a moving average is used, and these stocks continue to decline, so will the baseline value. ICES draws attention of managers of the need to establish the range of years to define the baseline and the percentage increase from that baseline. This will provide the ICES with the criteria to assess performance of the fisheries management.

Continuing Model Development

ICES previously considered, juvenile abundance indices as an alternative to the lagged spawner variable. As surrogates of potential smolt production, a juvenile index model is conceptually more attractive because juveniles represent a life-stage closer to the PFA than the lagged spawner variable currently used. Consequently, some of the noise corresponding to the stochasticity in the recruitment process should be reduced, favoring a more direct link between the predictors and the PFA. Unfortunately, the Working Group has noted that alternate variables do not negate any of the assumptions within a model, and are also influenced by non-stationarity. Therefore ICES, suspended investigation of juvenile abundance indices to focus on issues of non-stationarity that may apply to any relationship between a predictive variable and PFA.

Table 7.4.1. Probability profiles for the management objectives of achieving the 2SW conservation limits simultaneously in the four northern areas of North America (Labrador, Newfoundland, Quebec, Gulf) and achieving increases in returns from the previous five-year average (examples: minimally 10% or minimally 25% increase in returns of 2SW salmon in 2003) in the two southern areas (Scotia-Fundy and USA) relative to quota options for West Greenland. A sharing arrangement of 40:60 (Fna) of the salmon from North America was assumed.

Probability of meeting management objectives			
West Greenland Harvest Tons	Simultaneous Conservation (Lab, NF, Queb, Gulf)	Simultaneous Improvement (SF, USA) of Returns in 2004	
		>=10% of prev. avg.	>=25%of prev. avg.
0	**0.28**	0.71	0.62
5	0.26	0.68	0.60
10	0.25	0.66	0.58
15	0.24	0.64	0.55
20	0.23	0.61	0.53
25	0.22	0.59	0.50
30	0.21	0.56	0.48
35	0.20	0.54	0.46
40	0.19	0.52	0.44
45	0.19	0.49	0.42
50	0.18	0.47	0.40
100	0.12	0.29	0.25
500	0.02	0.03	0.02

Table 7.4.2. Probability profiles for the management objectives of achieving the 2SW conservation limits simultaneously in the four northern areas of North America (Labrador, Newfoundland, Quebec, Gulf), achieving increases in returns from the previous five-year average (examples: minimally 10% or minimally 25% increase in returns of 2SW salmon in 2003) in the two southern areas (Scotia-Fundy and USA), and achieving the MSW conservation limit for southern Europe relative to quota options for West Greenland. A sharing arrangement of 40:60 (Fna) of the salmon at West Greenland, regardless of continent of origin was assumed.

Probability of meeting management objectives				
West Greenland Harvest Tons	NAC Conservation (Lab, NF, Queb, Gulf)	Simultaneous Improvement (SF, USA) of Returns in 2004		Southern Europe Conservation MSW
		>=10% of prev. avg.	>=25%of prev. avg.	
0	**0.28**	0.71	0.62	0.73
5	0.26	0.68	0.60	0.72
10	0.25	0.66	0.58	0.72
15	0.24	0.64	0.55	0.71
20	0.23	0.61	0.53	0.71
25	0.22	0.59	0.50	0.71
30	0.21	0.56	0.48	0.70
35	0.20	0.54	0.46	0.70
40	0.19	0.52	0.44	0.70
45	0.19	0.49	0.42	0.69
50	0.18	0.47	0.40	0.69
100	0.12	0.29	0.25	0.65
500	0.02	0.03	0.02	0.37

Table 7.9.1.1. Nominal catches of salmon, West Greenland 1977-2002 (metric tons round fresh weight).

Year	Total	Quota
1977	1,420	1,191
1978	984	1,191
1979	1,395	1,191
1980	1,194	1,191
1981	1,264	1,265[2]
1982	1,077	1,253[2]
1983	310	1,191
1984	297	870
1985	864	852
1986	960	909
1987	966	935
1988	893	-[3]
1989	337	-[3]
1990	274	-[3]
1991	472	840
1992	237	258[4]
1993	0[1]	89[5]
1994	0[1]	137[5]
1995	83	77
1996	92	174[4]
1997	58	57
1998	11	20[6]
1999	19	20[6]
2000	21	20[6]
2001	43	114[7]
2002	9	- [5,8]

[1] The fishery was suspended.
[2] Quota corresponding to specific opening dates of the fishery.
[3] Quota for 1988-90 was 2,520 t with an opening date of 1 August and annual catches not to exceed the annual average (840 t) by more than 10%. Quota adjusted to 900 t in 1989 and 924 t in 1990 for later opening dates.
[4] Set by Greenland authorities.
[5] Quotas were bought out.
[6] Fishery restricted to catches used for internal consumption in Greenland.
[7] Calculated final quota in *ad hoc* management system.
[8] No factory landing allowed.

Table7.9.1.2. Distribution of nominal catches (metric tons), Greenland vessels (1977-2002).

	NAFO Division							Total	East	Total
Year	1A	1B	1C	1D	1E	1F	NK	Westgrl.	Greenland	Greenland
1977	201	393	336	207	237	46	-	1,420	6	1,426
1978	81	349	245	186	113	10	-	984	8	992
1979	120	343	524	213	164	31	-	1,395	+	1,395
1980	52	275	404	231	158	74	-	1,194	+	1,194
1981	105	403	348	203	153	32	20	1,264	+	1,264
1982	111	330	239	136	167	76	18	1,077	+	1,077
1983	14	77	93	41	55	30	-	310	+	310
1984	33	116	64	4	43	32	5	297	+	297
1985	85	124	198	207	147	103	-	864	7	871
1986	46	73	128	203	233	277	-	960	19	979
1987	48	114	229	205	261	109	-	966	+	966
1988	24	100	213	191	198	167	-	893	4	897
1989	9	28	81	73	75	71	-	337	-	337
1990	4	20	132	54	16	48	-	274	-	274
1991	12	36	120	38	108	158	-	472	4	476
1992	-	4	23	5	75	130	-	237	5	242
1993[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

[1]) The fishery was suspended
+) Small catches <0.5 t
-) No commercial landings

Table 7.9.1.3. Annual mean fork lengths and whole weights of Atlantic salmon caught at West Greenland, 1969-1992 and 1995-2002. Fork length (cm); whole weight (kg). NA = North America; E = Europe.

	Whole weight (kg)									Fork length (cm)					
	Sea age & origin									Sea age & origin					
	1SW		2SW		PS		All sea ages		TOTAL	1SW		2SW		PS	
Year	NA	E	NA	E	NA	E	NA	E		NA	E	NA	E	NA	E
1969	3.12	3.76	5.48	5.80	-	5.13	3.25	3.86	3.58	65.0	68.7	77.0	80.3	-	75.3
1970	2.85	3.46	5.65	5.50	4.85	3.80	3.06	3.53	3.28	64.7	68.6	81.5	82.0	78.0	75.0
1971	2.65	3.38	4.30	-	-	-	2.68	3.38	3.14	62.8	67.7	72.0	-	-	-
1972	2.96	3.46	5.85	6.13	2.65	4.00	3.25	3.55	3.44	64.2	67.9	80.7	82.4	61.5	69.0
1973	3.28	4.54	9.47	10.00	-	-	3.83	4.66	4.18	64.5	70.4	88.0	96.0	61.5	-
1974	3.12	3.81	7.06	8.06	3.42	-	3.22	3.86	3.58	64.1	68.1	82.8	87.4	66.0	-
1975	2.58	3.42	6.12	6.23	2.60	4.80	2.65	3.48	3.12	61.7	67.5	80.6	82.2	66.0	75.0
1976	2.55	3.21	6.16	7.20	3.55	3.57	2.75	3.24	3.04	61.3	65.9	80.7	87.5	72.0	70.7
1977	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	2.96	3.50	7.00	7.90	2.45	6.60	3.04	3.53	3.35	63.7	67.3	83.6	-	60.8	85.0
1979	2.98	3.50	7.06	7.60	3.92	6.33	3.12	3.56	3.34	63.4	66.7	81.6	85.3	61.9	82.0
1980	2.98	3.33	6.82	6.73	3.55	3.90	3.07	3.38	3.22	64.0	66.3	82.9	83.0	67.0	70.9
1981	2.77	3.48	6.93	7.42	4.12	3.65	2.89	3.58	3.17	62.3	66.7	82.8	84.5	72.5	-
1982	2.79	3.21	5.59	5.59	3.96	5.66	2.92	3.43	3.11	62.7	66.2	78.4	77.8	71.4	80.9
1983	2.54	3.01	5.79	5.86	3.37	3.55	3.02	3.14	3.10	61.5	65.4	81.1	81.5	68.2	70.5
1984	2.64	2.84	5.84	5.77	3.62	5.78	3.20	3.03	3.11	62.3	63.9	80.7	80.0	69.8	79.5
1985	2.50	2.89	5.42	5.45	5.20	4.97	2.72	3.01	2.87	61.2	64.3	78.9	78.6	79.1	77.0
1986	2.75	3.13	6.44	6.08	3.32	4.37	2.89	3.19	3.03	62.8	65.1	80.7	79.8	66.5	73.4
1987	3.00	3.20	6.36	5.96	4.69	4.70	3.10	3.26	3.16	64.2	65.6	81.2	79.6	74.8	74.8
1988	2.83	3.36	6.77	6.78	4.75	4.64	2.93	3.41	3.18	63.0	66.6	82.1	82.4	74.7	73.8
1989	2.56	2.86	5.87	5.77	4.23	5.83	2.77	2.99	2.87	62.3	64.5	80.8	81.0	73.8	82.2
1990	2.53	2.61	6.47	5.78	3.90	5.09	2.67	2.72	2.69	62.3	62.7	83.4	81.1	72.6	78.6
1991	2.42	2.54	5.82	6.23	5.15	5.09	2.57	2.79	2.65	61.6	62.7	80.6	82.2	81.7	80.0
1992	2.54	2.66	6.49	6.01	4.09	5.28	2.86	2.74	2.81	62.3	63.2	83.4	81.1	77.4	82.7
1995	2.37	2.67	6.09	5.88	3.71	4.98	2.45	2.75	2.56	61.0	63.2	81.3	81.0	70.9	81.3
1996	2.63	2.86	6.50	6.30	4.98	5.44	2.83	2.90	2.88	62.8	64.0	81.4	81.1	77.1	79.4
1997	2.57	2.82	7.95	6.11	4.82	6.90	2.63	2.84	2.71	62.3	63.6	85.7	84.0	79.4	87.0
1998	2.72	2.83	6.44	-	3.28	4.77	2.76	2.84	2.78	62.0	62.7	84.0	-	66.3	76.0
1999	3.02	3.03	7.59	-	4.20	-	3.09	3.03	3.08	63.8	63.5	86.6	-	70.9	-
2000	2.47	2.81	-	-	2.58	-	2.47	2.81	2.57	60.7	63.2	-	-	64.7	-
2001	2.89	3.03	6.76	5.96	4.41	4.06	2.95	3.09	3.00	63.1	63.7	81.7	79.1	75.3	72.1
2002	2.84	2.92	7.12	-	5.00	-	2.89	2.92	2.90	62.6	62.1	83.0	-	75.8	-

Table 7.9.1.4. River age distribution (%) and mean age for all North American origin salmon caught a West Greenland, 1968-1992 and 1995-2002.

	River age								Mean
Year	1	2	3	4	5	6	7	8	age
North American origin									
1968	0.3	19.6	40.4	21.3	16.2	2.2	0.0	0.0	3.4
1969	0.0	27.1	45.8	19.6	6.5	0.9	0.0	0.0	3.1
1970	0.0	58.1	25.6	11.6	2.3	2.3	0.0	0.0	2.6
1971	1.2	32.9	36.5	16.5	9.4	3.5	0.0	0.0	3.1
1972	0.8	31.9	51.4	10.6	3.9	1.2	0.4	0.0	2.9
1973	2.0	40.8	34.7	18.4	2.0	2.0	0.0	0.0	2.8
1974	0.9	36.0	36.6	12.0	11.7	2.6	0.3	0.0	3.1
1975	0.4	17.3	47.6	24.4	6.2	4.0	0.0	0.0	3.3
1976	0.7	42.6	30.6	14.6	10.9	0.4	0.4	0.0	3.0
1977	-	-	-	-	-	-	-	-	-
1978	2.7	31.9	43.0	13.6	6.0	2.0	0.9	0.0	3.0
1979	4.2	39.9	40.6	11.3	2.8	1.1	0.1	0.0	2.7
1980	5.9	36.3	32.9	16.3	7.9	0.7	0.1	0.0	2.9
1981	3.5	31.6	37.5	19.0	6.6	1.6	0.2	0.0	3.0
1982	1.4	37.7	38.3	15.9	5.8	0.7	0.0	0.2	2.9
1983	3.1	47.0	32.6	12.7	3.7	0.8	0.1	0.0	2.7
1984	4.8	51.7	28.9	9.0	4.6	0.9	0.2	0.0	2.6
1985	5.1	41.0	35.7	12.1	4.9	1.1	0.1	0.0	2.7
1986	2.0	39.9	33.4	20.0	4.0	0.7	0.0	0.0	2.9
1987	3.9	41.4	31.8	16.7	5.8	0.4	0.0	0.0	2.8
1988	5.2	31.3	30.8	20.9	10.7	1.0	0.1	0.0	3.0
1989	7.9	39.0	30.1	15.9	5.9	1.3	0.0	0.0	2.8
1990	8.8	45.3	30.7	12.1	2.4	0.5	0.1	0.0	2.6
1991	5.2	33.6	43.5	12.8	3.9	0.8	0.3	0.0	2.8
1992	6.7	36.7	34.1	19.1	3.2	0.3	0.0	0.0	2.8
1995	2.4	19.0	45.4	22.6	8.8	1.8	0.1	0.0	3.2
1996	1.7	18.7	46.0	23.8	8.8	0.8	0.1	0.0	3.2
1997	1.3	16.4	48.4	17.6	15.1	1.3	0.0	0.0	3.3
1998	4.0	35.1	37.0	16.5	6.1	1.1	0.1	0.0	2.9
1999	2.7	23.5	50.6	20.3	2.9	0.0	0.0	0.0	3.0
2000	3.2	26.6	38.6	23.4	7.6	0.6	0.0	0.0	3.1
2001	1.9	15.2	39.4	32.0	10.8	0.7	0.0	0.0	3.4
2002	0.6	26.7	44.8	16.9	10.1	0.9	0.0	0.0	3.1
Mean	3.0	33.5	38.2	17.2	6.8	1.3	0.1	0.0	3.0

cont.

Table 7.9.1.4. cont. River age distribution (%) and mean age for all European origin salmon caught a West Greenland, 1968-1992 and 1995-2002.

Year	River age 1	2	3	4	5	6	7	8	Mean age
European origin									
1968	21.6	60.3	15.2	2.7	0.3	0.0	0.0	0.0	2.0
1969	0.0	83.8	16.2	0.0	0.0	0.0	0.0	0.0	2.2
1970	0.0	90.4	9.6	0.0	0.0	0.0	0.0	0.0	2.1
1971	9.3	66.5	19.9	3.1	1.2	0.0	0.0	0.0	2.2
1972	11.0	71.2	16.7	1.0	0.1	0.0	0.0	0.0	2.1
1973	26.0	58.0	14.0	2.0	0.0	0.0	0.0	0.0	1.9
1974	22.9	68.2	8.5	0.4	0.0	0.0	0.0	0.0	1.9
1975	26.0	53.4	18.2	2.5	0.0	0.0	0.0	0.0	2.0
1976	23.5	67.2	8.4	0.6	0.3	0.0	0.0	0.0	1.9
1977	-	-	-	-	-	-	-	-	-
1978	26.2	65.4	8.2	0.2	0.0	0.0	0.0	0.0	1.8
1979	23.6	64.8	11.0	0.6	0.0	0.0	0.0	0.0	1.9
1980	25.8	56.9	14.7	2.5	0.2	0.0	0.0	0.0	1.9
1981	15.4	67.3	15.7	1.6	0.0	0.0	0.0	0.0	2.0
1982	15.6	56.1	23.5	4.2	0.7	0.0	0.0	0.0	2.2
1983	34.7	50.2	12.3	2.4	0.3	0.1	0.1	0.0	1.8
1984	22.7	56.9	15.2	4.2	0.9	0.2	0.0	0.0	2.0
1985	20.2	61.6	14.9	2.7	0.6	0.0	0.0	0.0	2.0
1986	19.5	62.5	15.1	2.7	0.2	0.0	0.0	0.0	2.0
1987	19.2	62.5	14.8	3.3	0.3	0.0	0.0	0.0	2.0
1988	18.4	61.6	17.3	2.3	0.5	0.0	0.0	0.0	2.1
1989	18.0	61.7	17.4	2.7	0.3	0.0	0.0	0.0	2.1
1990	15.9	56.3	23.0	4.4	0.2	0.2	0.0	0.0	2.2
1991	20.9	47.4	26.3	4.2	1.2	0.0	0.0	0.0	2.2
1992	11.8	38.2	42.8	6.5	0.6	0.0	0.0	0.0	2.5
1995	14.8	67.3	17.2	0.6	0.0	0.0	0.0	0.0	2.0
1996	15.8	71.1	12.2	0.9	0.0	0.0	0.0	0.0	2.0
1997	4.1	58.1	37.8	0.0	0.0	0.0	0.0	0.0	2.3
1998	28.6	60.0	7.6	2.9	0.0	1.0	0.0	0.0	1.9
1999	27.7	65.1	7.2	0.0	0.0	0.0	0.0	0.0	1.8
2000	36.5	46.7	13.1	2.9	0.7	0.0	0.0	0.0	1.8
2001	16.0	51.2	27.3	4.9	0.7	0.0	0.0	0.0	2.2
2002	10.1	65.2	18.4	6.3	0.0	0.0	0.0	0.0	2.2
Mean	18.8	61.7	16.9	2.4	0.3	0.0	0.0	0.0	2.0

Table 7.9.1.5. Sea-age composition (%) of samples from commercial catches at West Greenland, 1985-2002.

Year	North American			European		
	1SW	2SW	Previous Spawners	1SW	2SW	Previous spawners
1985	92.5	7.2	0.3	95.0	4.7	0.4
1986	95.1	3.9	1.0	97.5	1.9	0.6
1987	96.3	2.3	1.4	98.0	1.7	0.3
1988	96.7	2.0	1.2	98.1	1.3	0.5
1989	92.3	5.2	2.4	95.5	3.8	0.6
1990	95.7	3.4	0.9	96.3	3.0	0.7
1991	95.6	4.1	0.4	93.4	6.5	0.2
1992	91.9	8.0	0.1	97.5	2.1	0.4
1993	-	-	-	-	-	-
1994	-	-	-	-	-	-
1995	96.8	1.5	1.7	97.3	2.2	0.5
1996	94.1	3.8	2.1	96.1	2.7	1.2
1997	98.2	0.6	1.2	99.3	0.4	0.4
1998[1]	96.8	0.5	2.7	99.4	0.0	0.6
1999[1]	96.8	1.2	2.0	100.0	0.0	0.0
2000[1]	97.4	0.0	2.6	100.0	0.0	0.0
2001	98.2	1.3	0.5	97.8	2.0	0.3
2002[1]	97.3	0.9	1.8	100.0	0.0	0.0

[1] Catches for local consumption only.

Table 7.9.1.6. The weighted proportions and numbers of North American and European Atlantic salmon caught at West Greenland 1982 -1992 and 1995 -2002. Numbers are rounded to the nearest hundred fish.

	Proportion weighted by catch in number		Numbers of Salmon caught	
Year	NA	E	NA	E
1982	57	43	192,200	143,800
1983	40	60	39,500	60,500
1984	54	46	48,800	41,200
1985	47	53	143,500	161,500
1986	59	41	188,300	131,900
1987	59	41	171,900	126,400
1988	43	57	125,500	168,800
1989	55	45	65,000	52,700
1990	74	26	62,400	21,700
1991	63	37	111,700	65,400
1992	45	55	46,900	38,500
1993	-	-	-	-
1994	-	-	-	-
1995	67	33	21,400	10,700
1996	73	27	22,400	9,700
1997	85	15	18,000	3,300
1998	79	21	3,100	900
1999	91	9	5,700	600
2000	65	35	5,100	2,700
2001	69	31	9,400	4,700
2002	68	32	2,200	900

Table 7.9.3.1. Number of salmon returning to home waters provided no fishery took place at Greenland. The average number of potentially returning salmon per ton caught in Greenland is also given.

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Nominal catch at Greenland (tons) [1]:	89	137	83	92	58	11	19	21	43	9
Proportion of NA fish in catch (PropNA):	0.540	0.540	0.680	0.732	0.796	0.785	0.910	0.650	0.670	0.680
Proportion of EU fish in catch (PropEU):	0.460	0.460	0.320	0.268	0.204	0.215	0.090	0.350	0.330	0.320
Mean weight, NA fish, all sea ages (kg):	2.655	2.655	2.450	2.830	2.630	2.760	3.090	2.470	2.950	2.890
Mean weight, EU fish, all sea ages (kg):	2.745	2.745	2.750	2.900	2.840	2.840	3.030	2.810	3.090	2.920
Mean weight of all sea ages (NA+EU fish):	2.696	2.696	2.546	2.849	2.673	2.777	3.085	2.589	2.996	2.900
Proportion of 1SW NA-fish in catch:	0.919	0.919	0.968	0.941	0.982	0.968	0.968	0.974	0.982	0.973
Catch of 1SW NA fish:	16635	25607	22300	22392	17238	3029	5416	5383	9590	2066
Catch of 1SW EU fish:	13706	21098	9349	8000	4091	806	546	2548	4510	962
Natural mortality during migration to NA:	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Natural mortality during migration to EU:	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Additional fish if no fishery at Greenland:										
2SW fish returning to NA (numbers):	**11960**	**18410**	**16032**	**16098**	**12393**	**2177**	**3894**	**3870**	**6895**	**1485**
Percent of conservation limit [2]:	**6.2**	**9.5**	**8.6**	**8.9**	**6.9**	**1.2**	**2.1**	**2.5**	**4.5**	**1.0**
2SW fish returning to EU (numbers):	**10782**	**16597**	**7354**	**6293**	**3218**	**634**	**430**	**2004**	**3547**	**757**
Percent of conservation limit [3]:	**4.1**	**6.3**	**2.8**	**2.4**	**1.2**	**0.2**	**0.2**	**0.8**	**1.3**	**0.3**

[1] Figures for 1993 and 1994 correspond to calculated quotas.

[2] As estimated annually by ICES

[3] Conservation limit for Southern Europe, Table 3.4.3.1

Average number of salmon potentially returning to home waters per ton caught in Greenland:	
2SW fish returning to NA (numbers per ton, average of 1993-2002):	**166**
2SW fish returning to EU (numbers per ton, average of 1993-2002):	**92**

Table 7.9.4.1. Pre-fishery abundance estimates, thermal habitat index for February based on sea surface temperature (H2), lagged spawner index for North America excluding Labrador, and the phase shift indicator set in its initial state.

Year	Pre-fishery abundance Low	Pre-fishery abundance High	Pre-fishery abundance Mid-point	Thermal Habitat February (H2)	Lagged spawners minus Labrador Low	Lagged spawners minus Labrador High	Lagged spawners minus Labrador Mid-point	Initial Phase
1977	574,920	766,372	670,646	1915	45,090	80,829	62,960	1
1978	325,305	423,344	374,325	1951	58,384	103,147	80,766	1
1979	725,526	969,725	847,626	2058	66,110	112,944	89,527	1
1980	626,689	845,357	736,023	1823	57,102	97,266	77,184	1
1981	589,902	775,292	682,597	1912	62,334	108,205	85,270	1
1982	491,624	642,955	567,290	1703	64,593	110,555	87,574	1
1983	279,866	399,920	339,893	1416	47,729	79,186	63,458	1
1984	290,764	413,708	352,236	1257	48,387	80,341	64,364	1
1985	455,247	624,679	539,963	1410	54,463	93,169	73,816	1
1986	490,306	658,712	574,509	1688	48,067	83,130	65,599	1
1987	443,842	596,469	520,156	1627	44,071	77,569	60,820	1
1988	359,581	485,900	422,740	1698	47,579	80,871	64,225	1
1989	278,895	404,946	341,920	1642	61,637	104,129	82,883	1
1990	249,811	344,253	297,032	1503	69,100	121,987	95,544	2
1991	281,550	405,602	343,576	1357	66,400	120,760	93,580	2
1992	167,152	256,606	211,879	1381	58,010	104,664	81,337	2
1993	118,437	224,357	171,397	1252	58,993	103,174	81,084	2
1994	136,738	270,339	203,538	1329	57,595	101,676	79,636	2
1995	144,226	247,195	195,710	1311	58,448	105,458	81,953	2
1996	121,464	192,680	157,072	1470	57,314	102,216	79,765	2
1997	80,262	147,151	113,706	1594	57,149	102,362	79,756	2
1998	68,710	147,114	107,912	1849	48,723	91,197	69,960	2
1999	66,708	147,773	107,241	1741	45,750	94,631	70,191	2
2000	77,373	156,796	117,084	1634	50,240	98,612	74,426	2
2001	54,615	111,372	82,993	1685	46,422	85,616	66,019	2
2002	.	.	.	1865	36,092	66,200	51,146	1
2003	.	.	.	1864	31,356	58,249	44,803	1

Table 7.9.4.2. A - Regional spawner requirement (2SW salmon), lagged spawners contributed by each region to PFA in last five years with available data, and the PFA number of fish required to meet region specific conservation limits if the returns to the regions are in proportion to the average lagged spawner distributions of 1992 to 2002. B - 2SW returns to the regions of North America, 1998 to 2002. C – Management objectives for the NAC area used to develop the risk analysis of catch options for the 2003 fishery.

A

Achieved lagged spawners by PFA year

	Region Labrador	Newfoundland	Quebec	Gulf	Scotia-Fundy	US	North America
1998	6285	4368	21312	36629	6080	1571	76245
1999	9930	3994	19459	39019	5764	1954	80120
2000	14098	6574	22055	35913	7845	2039	88524
2001	22118	8490	22898	26914	6056	1661	88137
2002	22527	7215	20286	18113	4133	1400	73672
Total	74957	30641	106010	156588	29878	8625	406698
% of total NA	18.4%	7.5%	26.1%	38.5%	7.3%	2.1%	
Sum of LNQG	90.5%						
2SW Conservation Limit							
Number of fish	34,746	4,022	29,446	30,430	24,705	29,199	152,548
Prop. of NA	0.228	0.026	0.193	0.199	0.162	0.191	
Spawner Reserve corrected for 11 months of M at 0.03 per month							212,189
PFA required to meet regional 2SW requirements based on average from 1998 to 2002	254,479	72,062	152,490	106,685	453,940	1,858,520	

B

2SW Returns to regions in past five years

	Region Labrador	Newfoundland	Quebec	Gulf	Scotia-Fundy	US
1998	.	8887	28095	12838	4366	1526
1999	.	9258	29562	16933	5295	1168
2000	.	9660	29155	17145	3559	533
2001	.	6654	30480	22826	5001	788
2002	.	6066	22404	11996	1770	617
Average		8105	27939	16348	3998	926

C

Management objectives for NAC area

	Region				**Region**		
	Labrador	**Newfoundland**	**Quebec**	**Gulf**	Scotia-Fundy	US	
	2SW Conservation Limit				**Average returns**		
Number of fish	34,746	4,022	29,446	30,430	3,998	926	
	2SW Conservation Limit				**Increase relative to previous five years**		
					4,398	**1,019**	**+10%**
Total	**98,644**				**4,997**	**1,158**	**+25%**

Figure 7.9.1.1. Number of North American and European salmon caught at West Greenland 1982-1992 and 1995-2002.

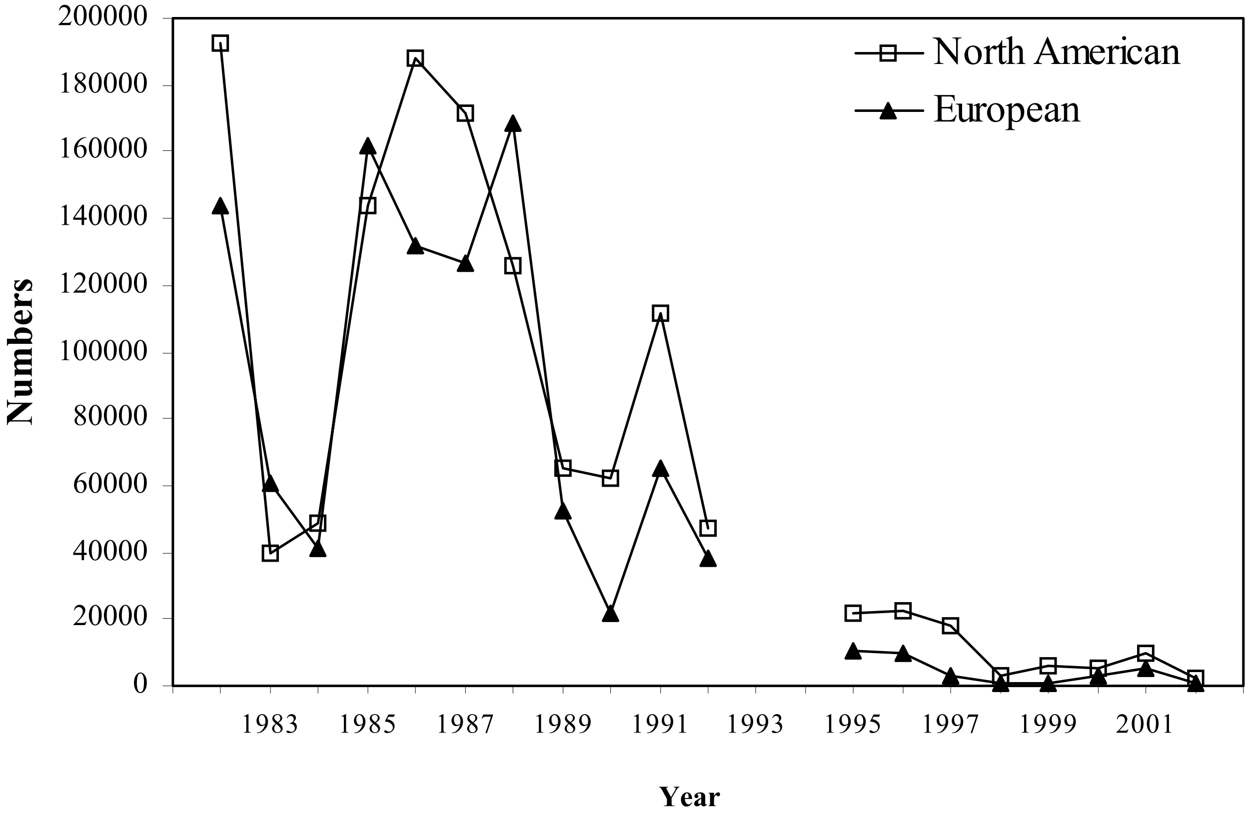
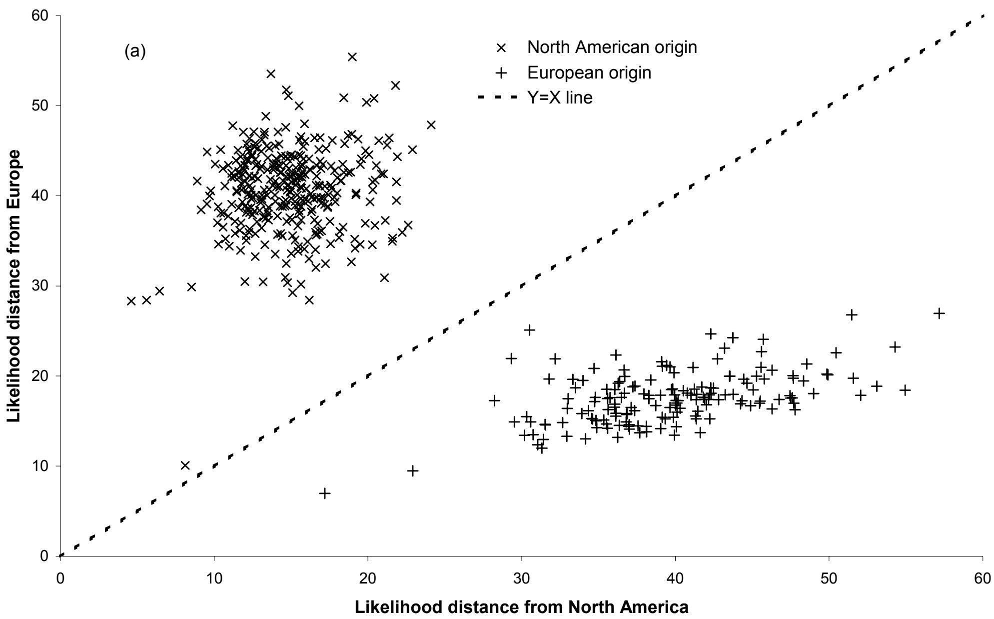


Figure 7.9.2.1. (a) Maximum likelihood distances from North American and European assigned samples collected from the 2002 West Greenland Atlantic salmon fishery. Points above the Y=X line are assigned North America origin. (b) Maximum likelihood distances from Canada and Maine assigned samples collected from the 2002 West Greenland Atlantic salmon fishery. Points above the Y=X line are assigned Maine origin.



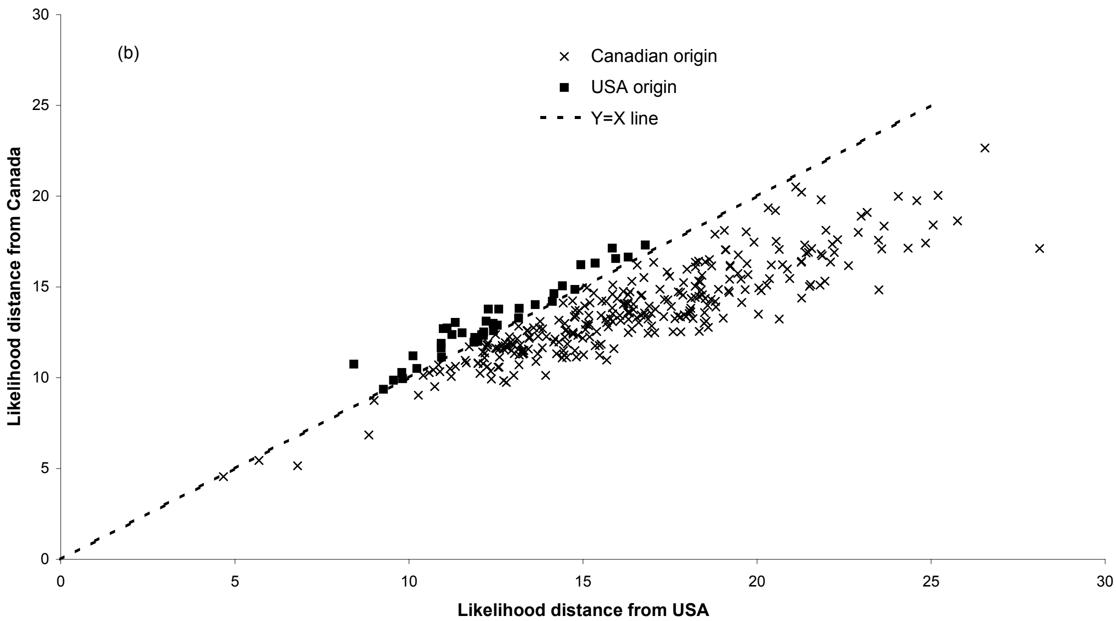


Fig 7.9.4.1. Relation between 1SW returns and corresponding MSW for total Québec returns (A) and 1SW and corresponding 2SW returns on St-Jean (B) and the Trinité Rivers (C).

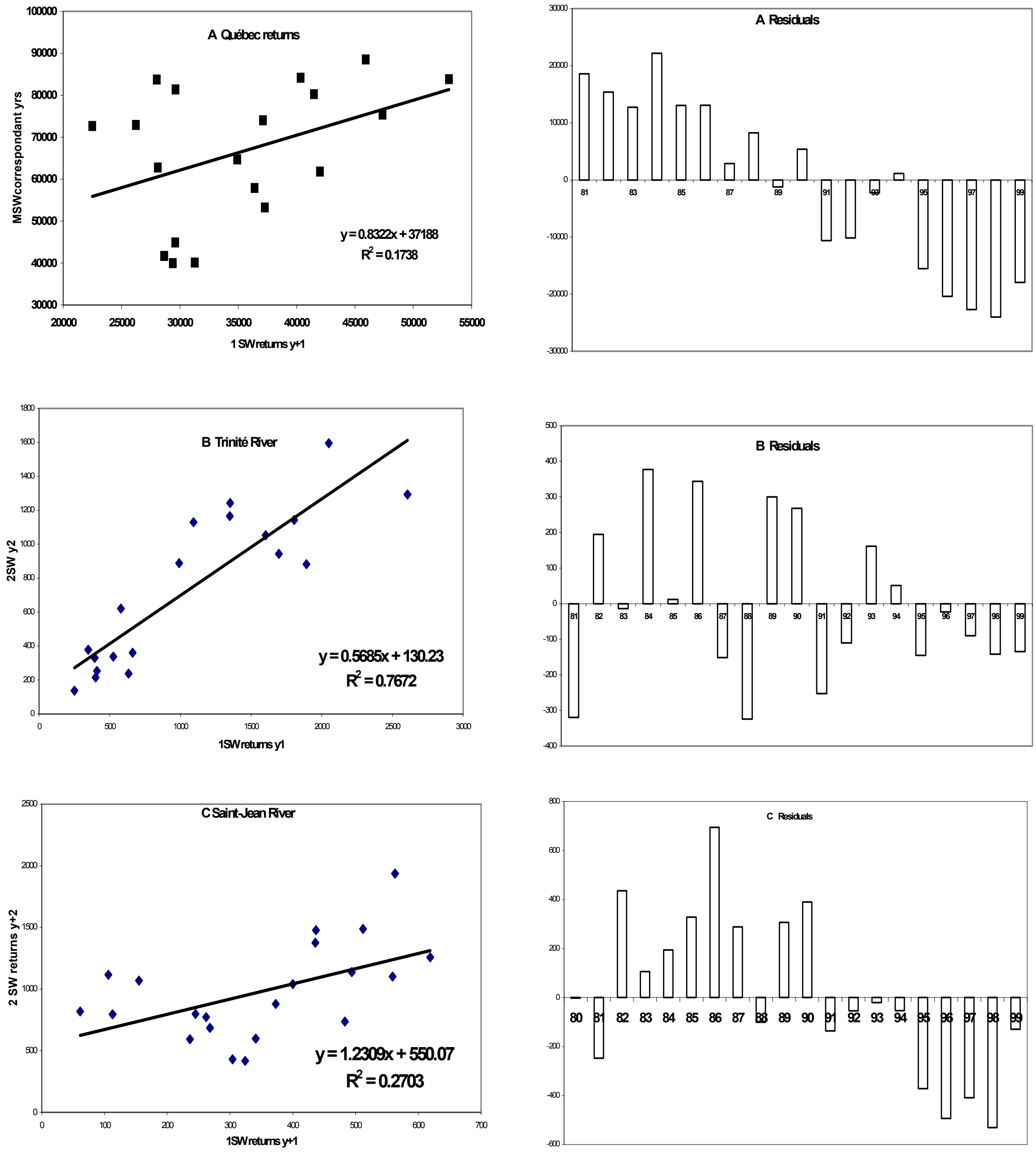


Figure 7.9.4.2. Phase shift in recruits per spawner for wild salmon in the LaHave River, NB Canada.

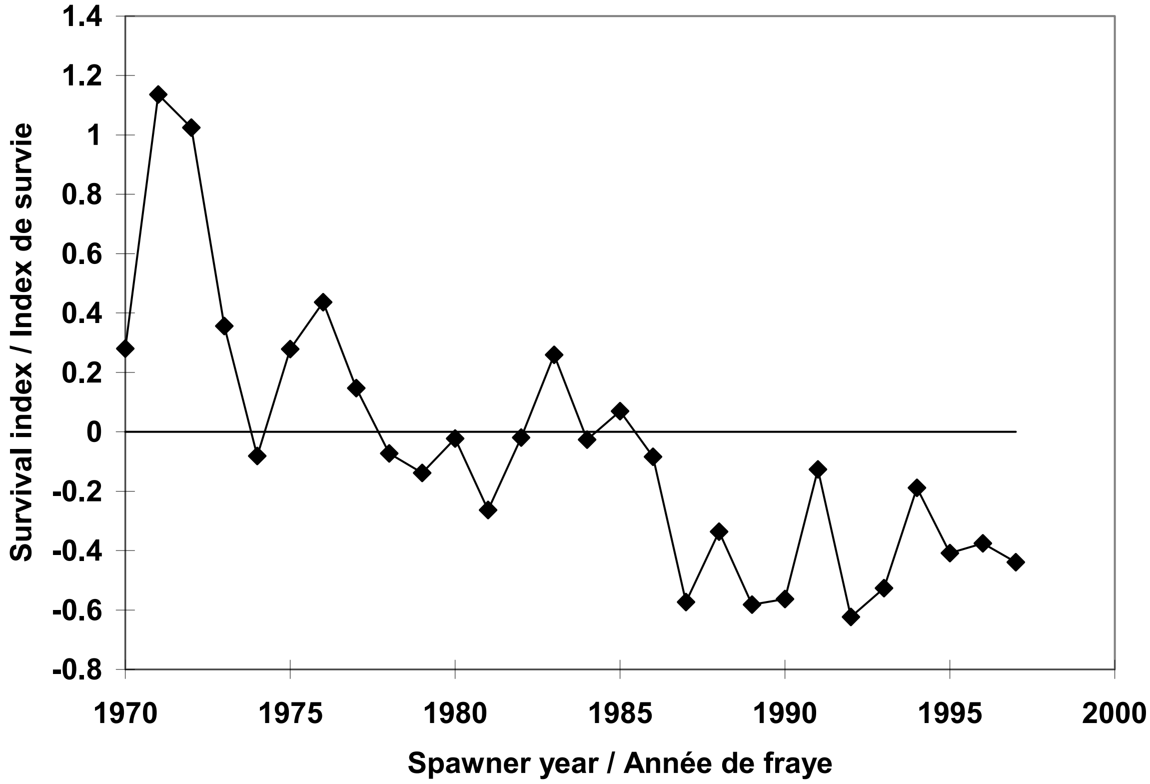


Figure 7.9.4.3. Lagged spawner index (upper panel), PFA (middle) and February habitat index (lower) used in the forecasting of PFA abundance for the NAC area.

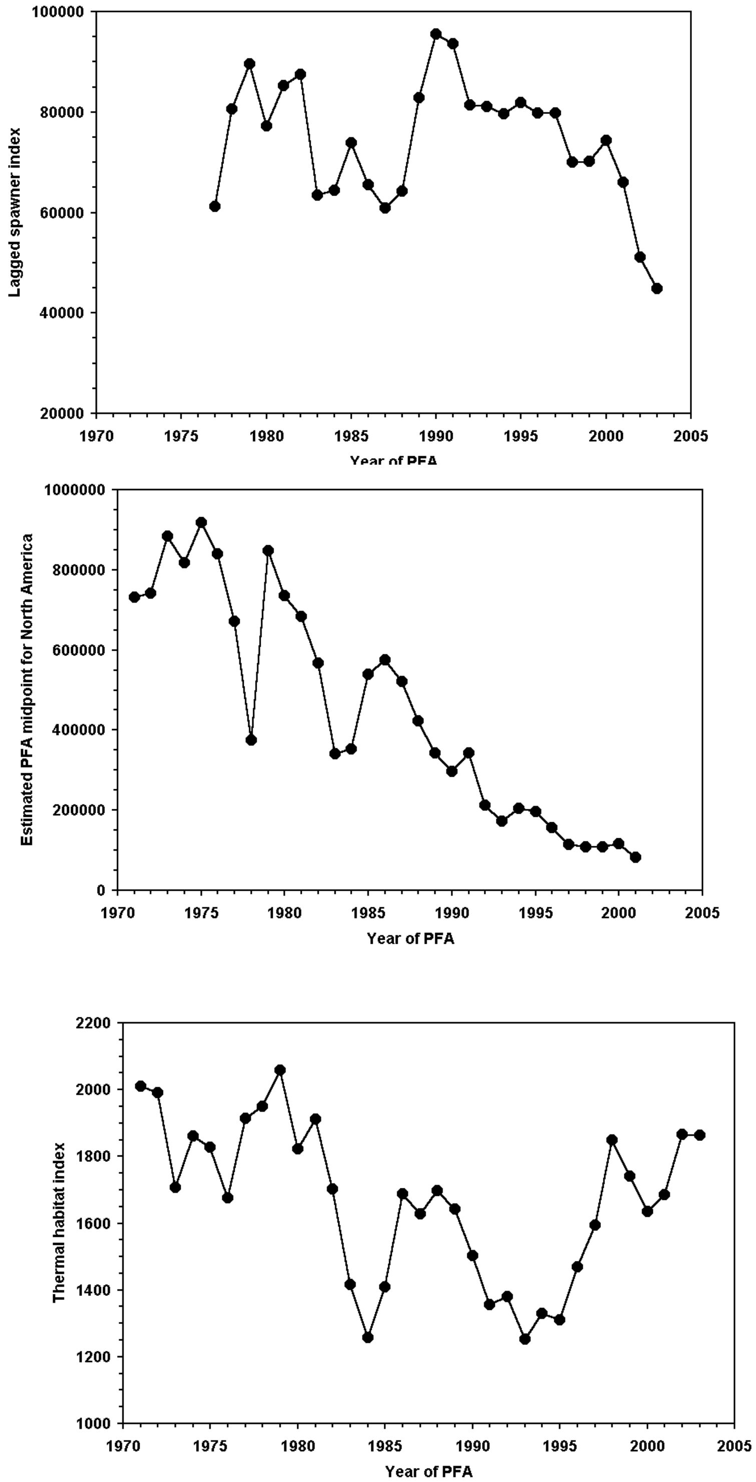


Figure 7.9.4.4. Standardized lagged spawners for Labrador, sum of other regions, and total for North America. Open symbols are data without Labrador spawner estimates.

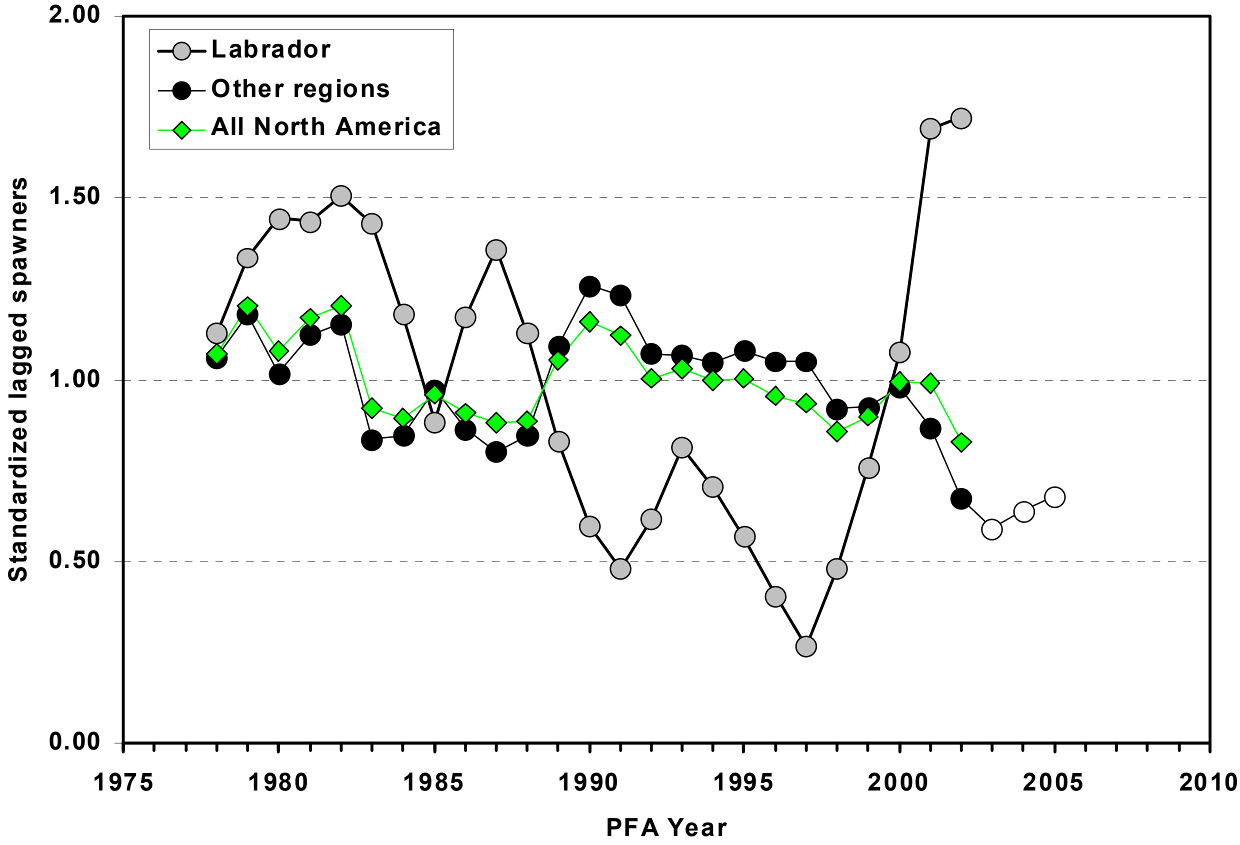


Figure 7.9.4.5. PFA (mid-point) and lagged spawner (mid-point) association for the NAC area showing the sequence from 1977 to 2001 (upper panel) and the relative change of the PFA (recruit) to lagged spawner index over the time series (lower panel).

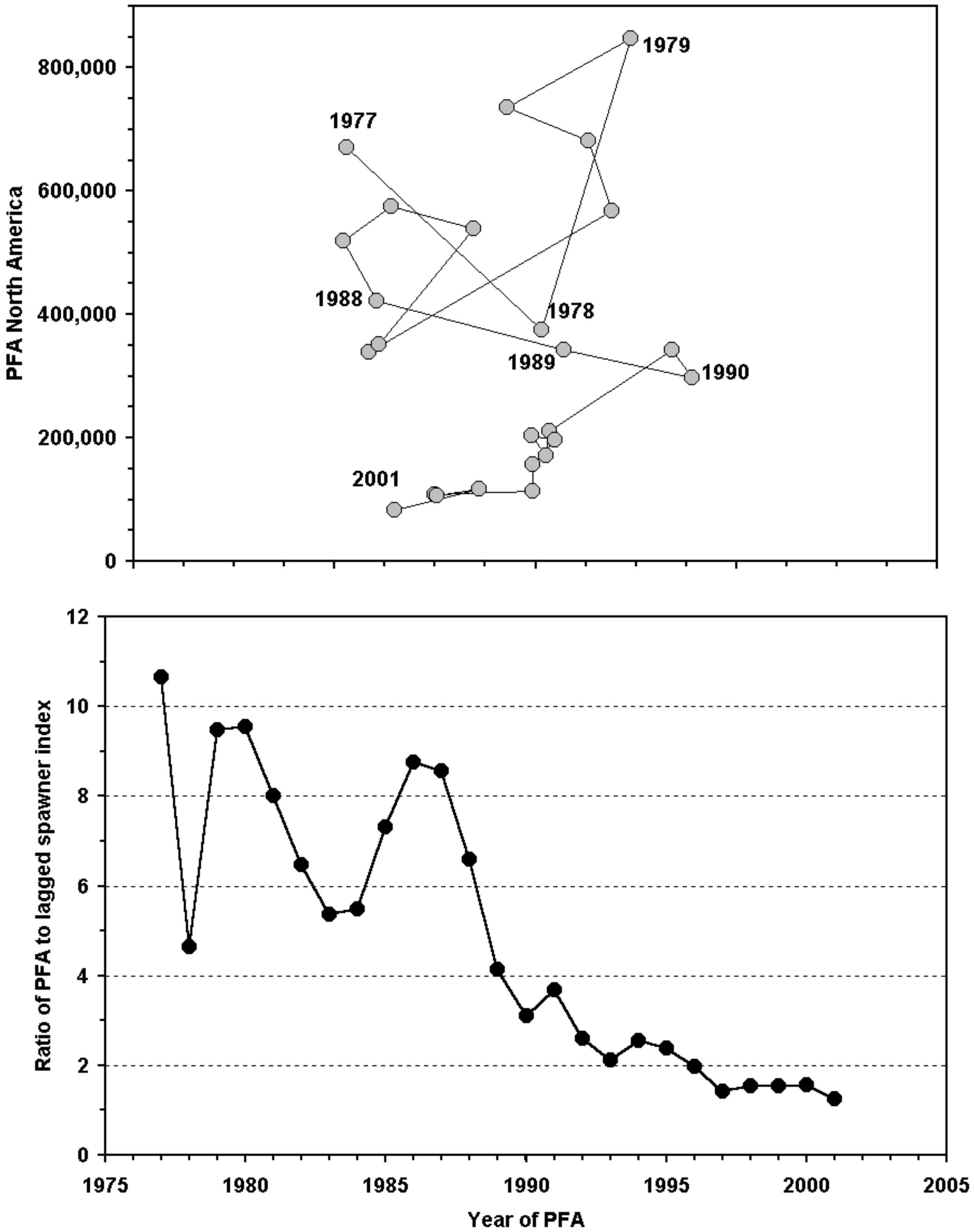


Figure 7.9.4.6. PFA (mid-point) and lagged spawner (mid-point) association for the NAC area modeled using an intercept variable to capture the dynamic change in productivity among the two time periods. The 1989 year was assigned using an uninformative prior to the time periods. The trend lines in the graph illustrate the PFA_{NA}/LS_{NA} trajectories for the two time periods.

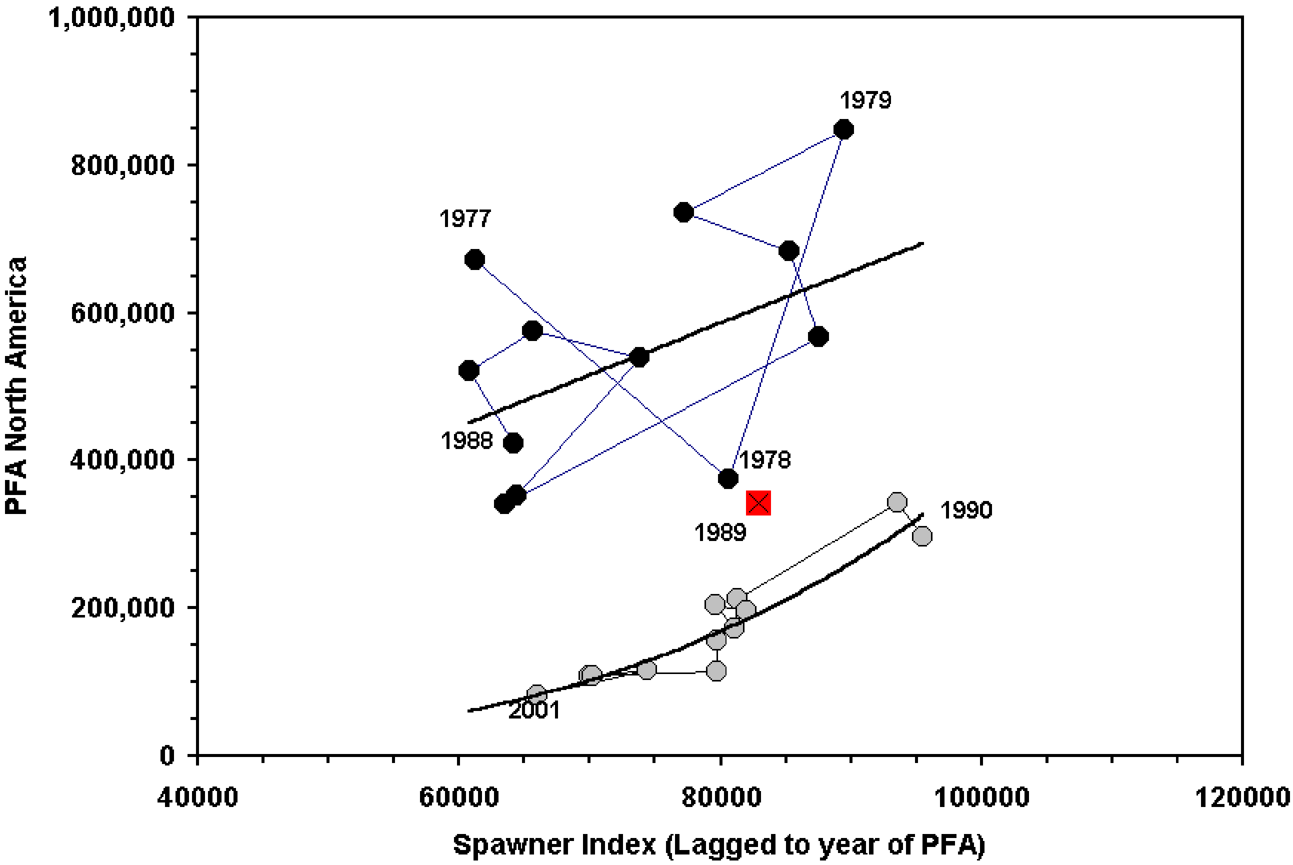
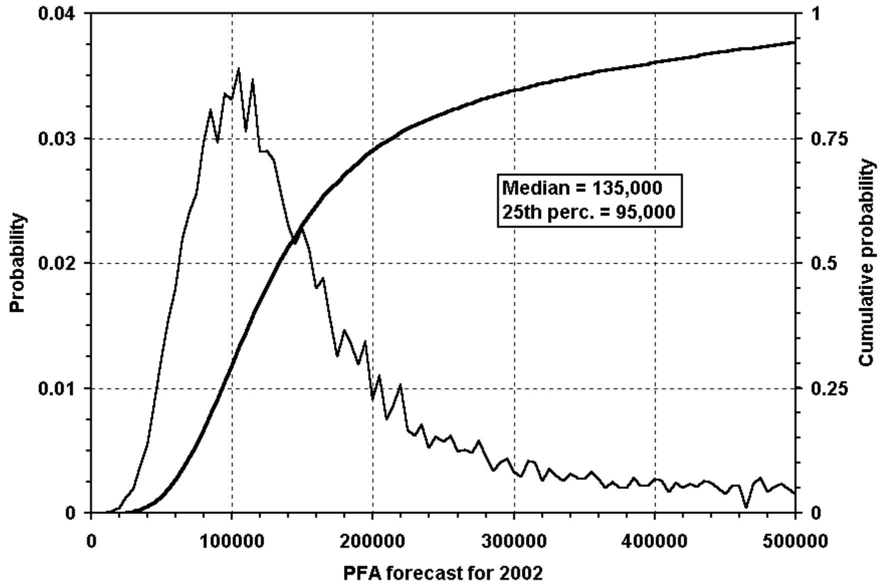


Figure 7.9.4.7. Revised PFA_{NA} estimate for the 2002 PFA year using the updated model (upper panel) and value forecast using the previous year's formulation (lower panel).



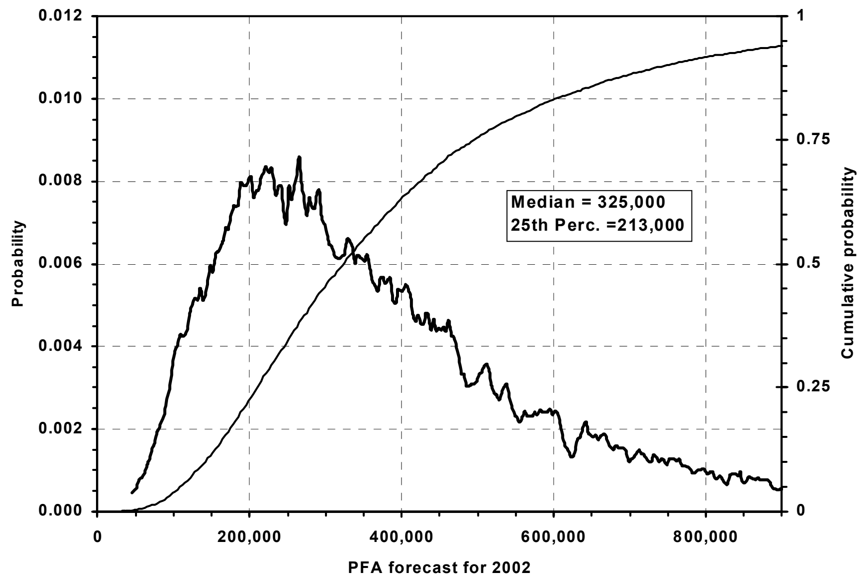
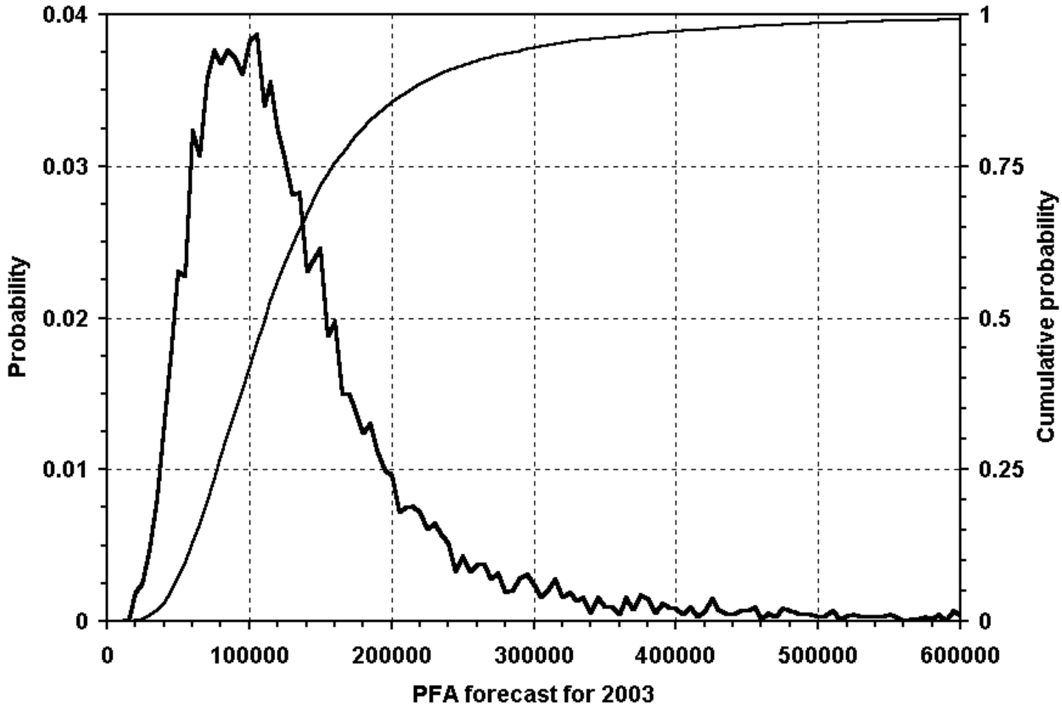


Figure 7.9.4.8. PFA_{NA} forecast estimate distribution for the year 2003 non-maturing 1SW salmon based on the phase shift and lagged spawner index model of 2003. The percentile of the forecast by 5% percentiles is shown in the lower panel.



Percentiles	PFA
5	45200
10	55800
15	63900
20	70800
25	77300
30	84200
35	90800
40	97800
45	104100
50	111400
55	118700
60	127000
65	136000
70	146400
75	158600
80	175400
85	196700
90	231900
95	311000

Figure 7.9.4.9. Average lagged spawners in the six regions of North America for the PFA years 1998 to 2002 and the 2SW spawner requirement in each region expressed as a proportion of the total for North America.

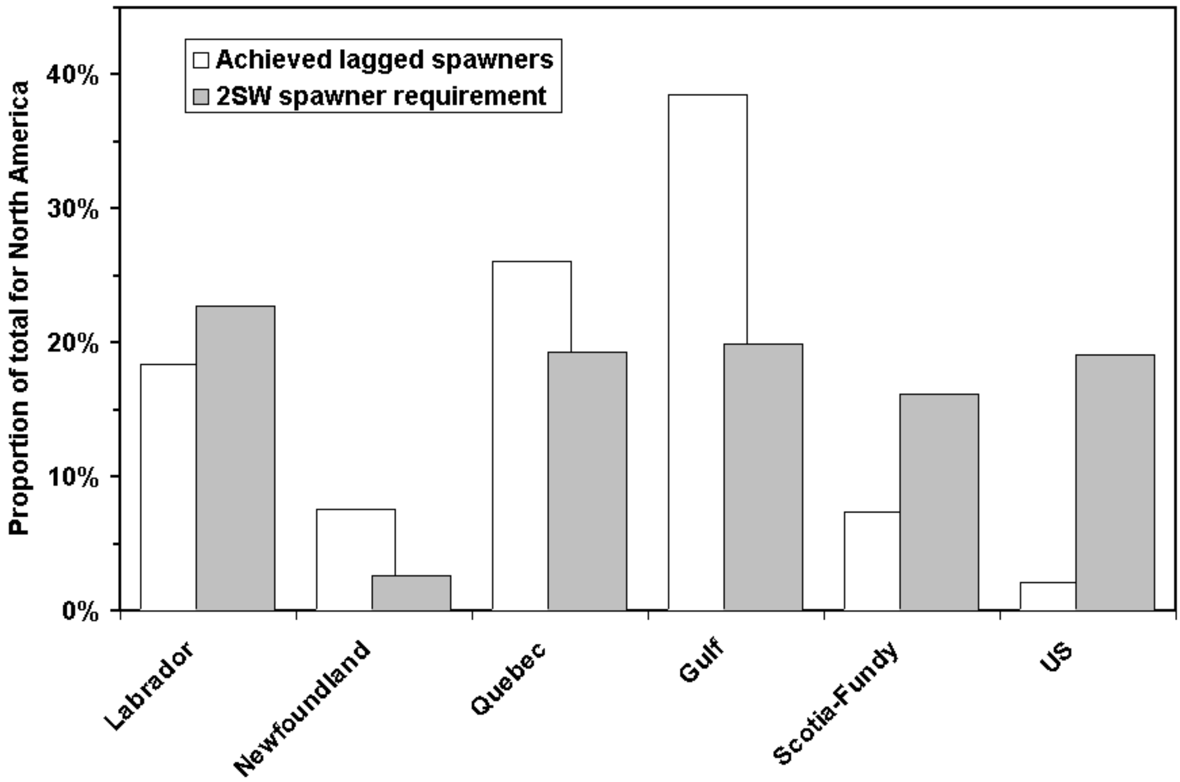


Figure 7.9.4.10. PFA_{NA} estimated for 1971 to 2001 and predicted PFA_{NA} for 2002 and 2003. There are two PFA_{NA} predictions for 2002. The open square is the value from the 2002 assessment using the lagged spawner variable, which included Labrador and excluded Gulf and US and the thermal habitat index. The dashed lines encompass the minimum to maximum range of the PFA estimated value. The shaded circles are the new model estimates for 2002 and 2003 using the revised lagged spawner index and a phase shift variable. The error bars on the predicted values describe the 5^{th} to 95^{th} percentile range.

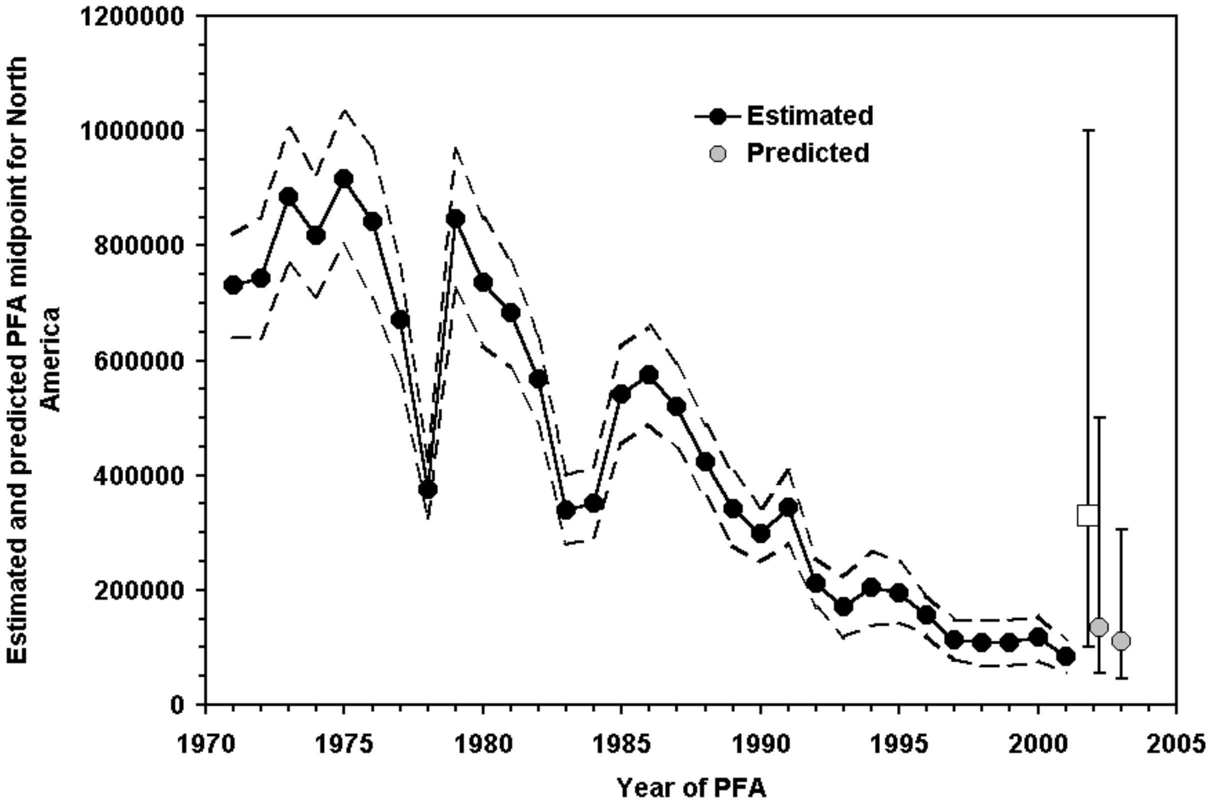


Figure 7.9.4.11. Observed estimates, jacknifed historical predictions, and simulated forecasts (Upper Panel A) of pre-fishery abundance from the multiplicative model with 1989 in Phase 1. The residual pattern from the jacknifed predictions is shown in the lower panel (Lower Panel B).

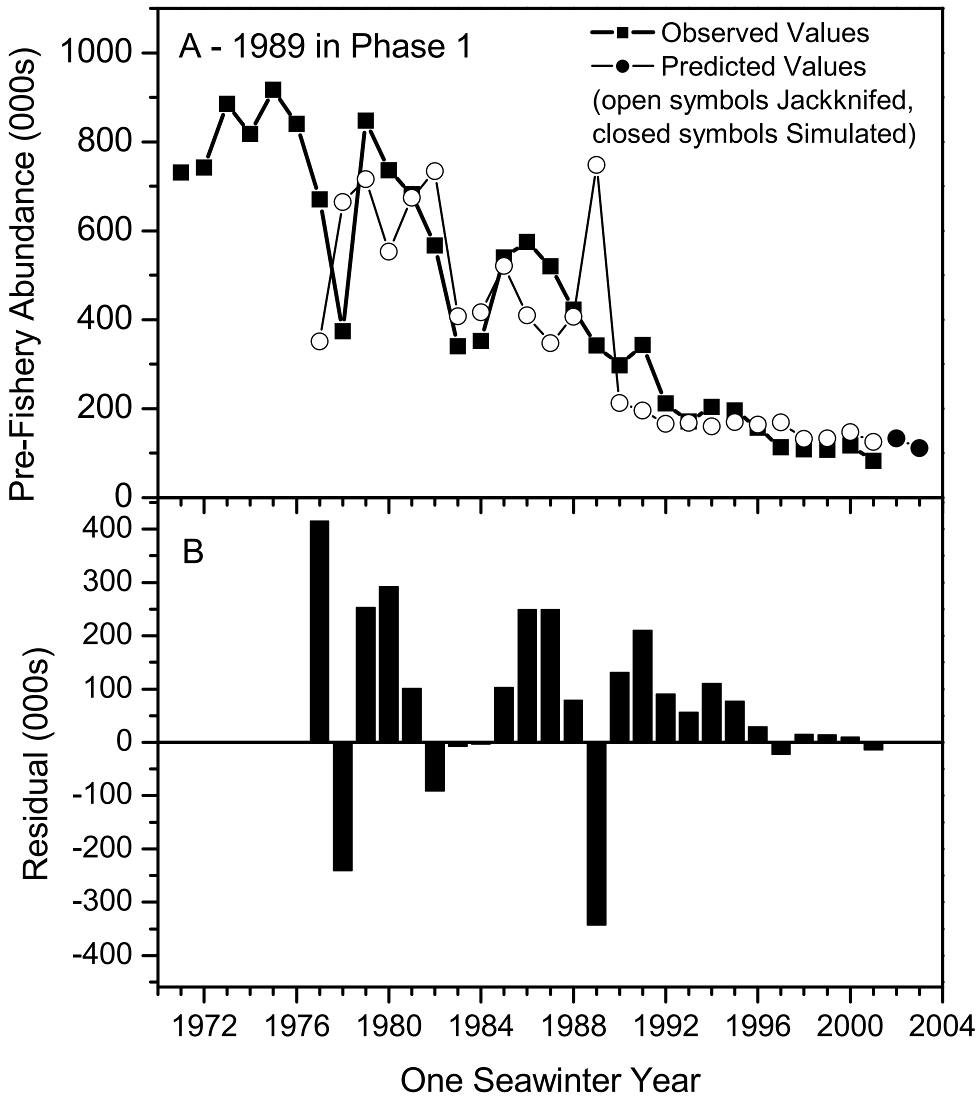
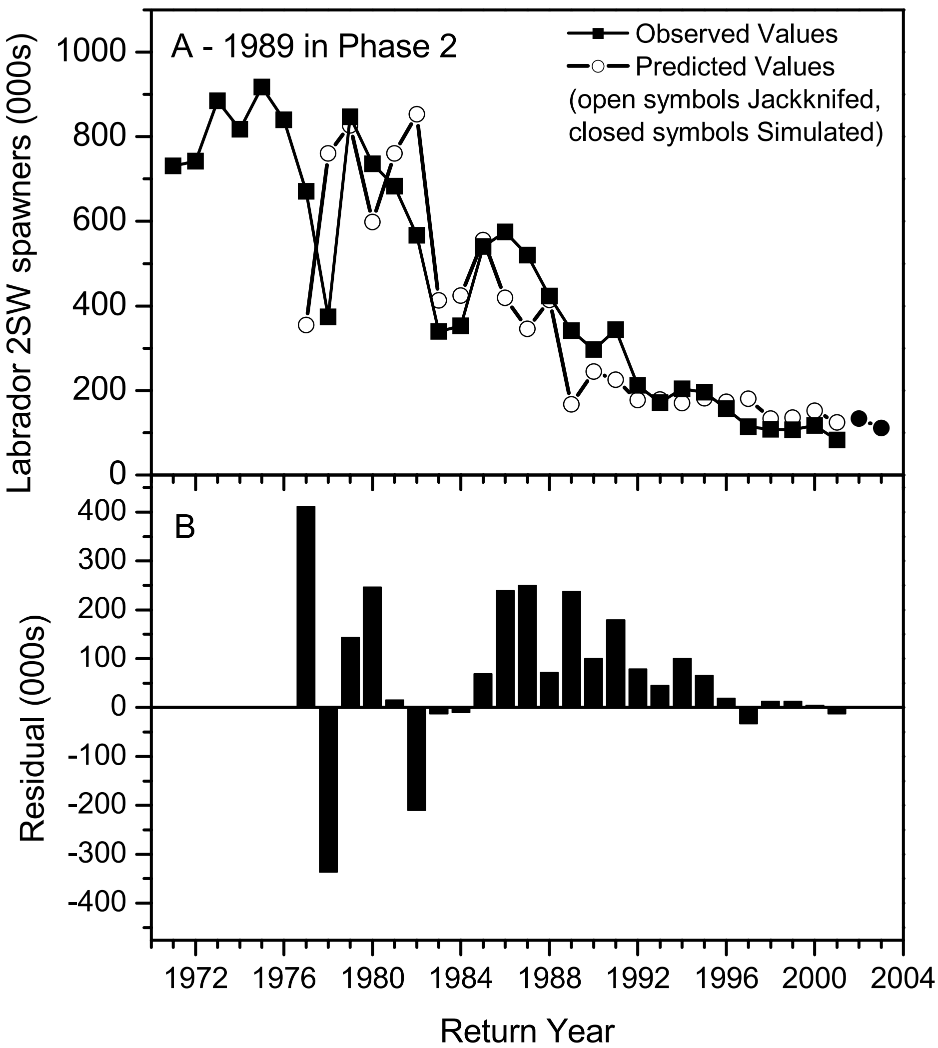


Figure 7.9.4.12. Observed estimates, jackknifed historical predictions, and simulated forecasts (Upper Panel A) of pre-fishery abundance from the multiplicative model with 1989 in Phase 2. The residual pattern from the jackknifed predictions is shown in the lower panel (Lower Panel B).



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