Agenda Item 4.1
For Information

Council

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Report of the ICES Advisory Committee on Fishery Management

REPORT TO THE NORTH ATLANTIC SALMON CONSERVATION ORGANIZATION

Source of information: Report of the Working Group on North Atlantic Salmon, April 1997 (ICES Doc. CM 1997/Assess:10).

Sections 1–4 of this report are set out in the order of the questions from NASCO to ICES (Appendix 1).

1 ATLANTIC SALMON IN THE NORTH ATLANTIC AREA

1.1 Overview of Catches

1.1.1 Nominal catches

Nominal catches of salmon by country in the North Atlantic (including ranched salmon in Iceland) for 1960-1996 are given in Table 1.1.1.1. Reported catches by NASCO Commission Areas are illustrated in Figure 1.1.1.1, and those for 1991–1996 are shown below (in tonnes (t)):

Area	1991	1992	1993	1994	1995	1996
NEAC	2947	3366	3340	3578	3283	2711
NAC	713	524	375	358	260	293
WGC	476	242	0	0	85	92
Total	4136	4132	3715	3936	3628	3096

The catch data for 1996 (Table 1.1.1.1) are provisional and incomplete, but the final figures are unlikely to exceed the low value of 1995. Catches in most countries remain below the averages of the previous 5 and 10 years. Some of the decline in catches in recent years can be accounted for by management plans which have reduced fishing effort in several countries.

1.1.2 Unreported catches of salmon

The total guess-estimate of unreported catch by fishery managers/protection officers or bailiffs within the NASCO Commission areas in 1996 was 1,123 t (Table 1.1.1.1), an increase of 6% compared with 1995 but 26% below the 1991–1995 mean of 1,525 t. There are no data available on salmon catches in international waters in 1996. Guess-estimates for the Commission Areas are given below (in tonnes):

Area	1991	1992	1993	1994	1995	1996
NEAC	1555	1825	1471	1157	942	947
NAC	127	137	161	107	98	156
WGC	n/a	n/a	12	12	<20	<20
International waters	25-100	25-100	25-100	25-100	n/a	n/a

1.1.3 Production of farmed and ranched salmon

The production of farmed salmon in the North Atlantic area in 1996 was 450,394 t. This is the largest production in the history of the farming industry (Figure 1.1.1.3) and represented a further 9% increase compared to 1995 (411,580 t) and a 54% increase on the 1991–1995 average (292,632 t).

The total production of ranched salmon in countries bordering the North Atlantic in 1996 was 266 t which is the lowest value since 1989. The majority (89%) of the ranching is conducted in Iceland, where ranched production is almost double the nominal catch of wild fish.

1.2. Recent Research Developments

Stock discrimination at West Greenland: Since 1969, discriminant analysis of scale characteristics of salmon at West Greenland has been conducted to determine the proportions of the two continental stock groups in this fishery. Scale characteristics are annually variable and discriminant functions have been parameterized using scale characters of known-origin fish.

Protein polymorphisms in tissue (starch gel electrophoresis of liver and muscle tissue) would not be expected to vary annually. Beginning in 1986 and continuing through 1991, a genotypic approach using protein polymorphisms was used to expand the database of known-origin scales for the discrimination between fish of different continents of origin.

In 1995, samples of muscle tissue (and scales) were taken from salmon landed in Nuuk, Greenland and assayed for microsatellite and mitochondrial DNA markers. Of 120 fish, 107 (89%) were of North American and 13 (11%) were of European origin.

To provide information on the reliability of scale classifications, the samples of 110 assayed fish with readable scales were classified using the same discriminant functions as were used to determine the continent of origin of scales sampled in 1995. Ninety percent were classified as North American and 10% as European salmon. A mis-classification rate of 14.5% and an error rate of ± 9.1% was deemed to be acceptable given the low number of European salmon in the test sample.

In-season identification to continent of origin using genetic techniques to calibrate scale-based identification of the catch at Greenland remains important (despite difficulties of cost and implementation). Investigation of environmental predictors of the scale-based features used in the classification is encouraged.

Neural networks to predict pre-fishery abundance: ICES examined the efficacy of predicting Atlantic salmon abundance in West Greenland with neural network models as well as the currently used linear regression models. The neural network was developed using four independent variables. The four variables were thermal habitat index values for March of the current year and May, June, and July values for the previous year when the pre-recruits were smolts.

The model was evaluated and out-performed a linear model fit with respect to two criteria: it provided the best reconstruction of observed patterns using unbiased fits and showed no bias associated with the magnitude of residuals. These characteristics are potentially critical at low population levels when estimation error puts the population at greater risk. However, the precision of these models cannot be estimated at this time and thus they cannot yet provide a basis for advice.

1.3 Causes of Long-Term Changes in Sea-Age Composition

Possible explanations for changes in sea-age at maturity, including the likely roles of genetic and environmental (including fishery) effects, were tabled in Section 2.1 of the 1996 Report. No new information is available.

The 1996 Report stressed differences between the sexes and the multiplicity of possible interactive effects acting at every level and throughout life which determine age at maturity. In particular, data sets that have measures of absolute abundance and measures of maturity rate are not generally available. It was not possible therefore to assess these effects because there were not sufficient data to do so.

1.4 Causes of Changes in Abundance

Temporal changes in marine abundance at sea-age may relate to variation in smolt production, marine survival and maturation. Causes of marine mortality were discussed in Section 1.2.4 of the 1996 Report to NASCO. No new information on the effects on abundance of diseases, pathogens or predators has been made available to ICES.

1.4.1 Mortality and ocean climate

Attention has been directed at modelling the responses of North-east Atlantic salmon populations to marine environmental change. Trophic studies off the Faroes indicate that feeding cycles and potential prey abundance are changing and that this will affect salmon growth and survival.

Sea surface temperatures and post-smolt survival in the North-east Atlantic: Marine natural mortality in salmonid populations is believed to be highest during the first weeks to months at sea. It is also believed that mortality effects are growth mediated during this period due to variation in ocean productivity, interspecific competition, size-dependent predation or intraspecific interactions. Broad scale processes like ocean climate that may affect salmon growth, mortality and maturation mechanisms are of particular interest.

Return rates of tagged wild salmon smolts from the rivers Figgjo (southern Norway) and North Esk (eastern Scotland) since 1965 were used to evaluate survival conditions for this region. Survival rates were correlated between rivers and among sea ages (Figure 1.4.1.1) and were compared to the extent of thermal habitat in the North-east Atlantic Ocean. The strongest positive correlations between survival rate and extent of thermal habitat occurred during the month of May (8–10°C water). A reciprocal negative correlation was also found between survival and 5–7°C water in the same month.

Sea surface temperature distributions along a segment of the Norwegian coast from which post-smolts have been reported were contrasted between periods of good and poor salmon survival. The analyses showed that salmon survival has been poor when cool surface waters dominate the Norwegian coast and North Sea during May (Figure 1.4.1.2). Conversely, survival was good when the 8 °C isotherm extended northward along the Norwegian coast during May. Thus, the variation in temperature conditions for this segment of the Norwegian coast during spring appears to be critical to the survival of post-smolts.

Sea temperatures and adult survival in the Barents Sea: Mean annual water temperatures in the 0–200 m depth interval along the Kola Meridian transect in the Barents Sea were shown to be linearly correlated with the abundance of spawning stock in the Tuloma River.

A comparison of recruits from all year classes and water temperatures at sea and in the river showed weak cyclical variations. Abundant year classes appeared in the years when mean yearly water temperature at sea was about 4^{o} C or higher.

1.4.2 Smolt production

The number of salmon at sea depends on several variables, including the number of smolts which leave the river systems. Smolt production is dependent on adult numbers through levels of egg deposition. Declines in spawner numbers caused by declining trends in marine survival have the potential to feed-back negatively on marine abundance.

On the Girnock Burn, a tributary of the River Dee (UK, Scotland), smolt numbers are declining in response to a sequence of years in which egg deposition has been marginal or inadequate in relation to a threshold value (ca. 40 females). Reductions in spawners are attributed to increased natural mortality at earlier life stages.

The Girnock Burn produces mainly 2 or 3-year-old smolts and interactions among juvenile cohorts and changes in age composition at smolting buffer the effect of episodes of inadequate spawning. However, smolt production is not expected to be robust to a series of marginal or inadequate spawning years and reduced egg depositions are likely to reduce future recruitment.

1.5 Precautionary Approach and the Development of Assessments and Management Advice

Management of Atlantic salmon requires that the spawning populations of each river (and possibly subcatchments within the river) be conserved. This necessitates setting a **conservation limit** or minimum threshold (reference point) below which populations should not fall, and a higher **target reference** point for managing fisheries. Both reference points are consistent with the "precautionary approach"; limit reference points are intended to constrain harvesting within **safe biological limits** (above minimum biologically acceptable level [MBAL]). However, the life cycle of the salmon and the nature of the fisheries limit the possible management approaches and tools.

Anadromous Atlantic salmon leave their rivers to undertake feeding migrations in the ocean. Most are at sea for 1 (1SW fish) or 2 (2SW fish) years before returning to spawn for the first time. Fish returning after 2 or more years (MSW) generally undertake more distant migrations than those that return after 1 year. In the ocean, fish from many different populations mix together and catches are probably not proportionately distributed among individuals from all the contributing populations. There is therefore the potential to overexploit less productive stocks in mixed stock fisheries.

One-sea winter and MSW cohorts are for the most part exploited by sea and home water fisheries in a single year. This means that independent verifications of projections of pre-fishery abundances are not available until after the fisheries. In addition, the salmon will not react like many other species in that, if disproportionate catches on one river's population are taken, there will not be compensatory shifts in growth and recruitment among the juveniles in other rivers. Thus, management of salmon has focused on a **fixed escapement strategy** designed to prevent salmon populations from falling below MBAL. In accordance with these considerations the following biological reference points have been established.

1.5.1 Conservation limit

MBAL for salmon has been suggested as a threshold below which spawning biomasses should not fall and has been defined from a fitted stock-recruitment relationship as the stock level that produces maximum gain (MSY). MSY can be defined and methodologically consistent MBAL values can therefore be derived wherever appropriate data are available. This choice is also consistent with ICES advice where "MBAL can be defined by the level of spawning stock below which the data indicated that the probability of poor recruitment increases as the spawning stock size decreases." MBAL is considered to be the conservation limit.

In Canada stock-recruitment relationships are available for a number of rivers. These supported a target egg deposition rate of 2.4 eggs/m^2 of fluvial habitat and, for two geographic areas of Newfoundland where many juveniles rear in lakes, either an additional 368 (south) or 105 (north) eggs/ha of lacustrine habitat. Egg needs are determined as the product of habitat area and the appropriate deposition value and are converted to female requirements (usually MSW fish) on the basis of fecundity. Where possible, one male is provided for each female. These spawner requirements serve as conservation limits and can be summed by region or country. A similar approach is used in the USA.

Countries in the North-east Atlantic are in various stages of developing conservation limits (Table 1.5.1.1) and are focusing on ensuring appropriate egg deposition rates. Long-term databases for calculating stock-recruitment relationships are rare and from geographically limited areas, and it is difficult to extrapolate from them to the very different river structures and climates found throughout the North-east region. In the UK (England and Wales), detailed methodologies have been developed to use data from rivers with established stock-recruitment relationships and reference points to establish reference points for other systems. Runs with unique characteristics (e.g. "springers" and "normal salmon") may be present within one system, and genetics studies are revealing substructures within catchment populations which may require approaches at the sub-catchment level. This complicates the task of setting reference points.

1.5.2 Target reference point

ICES has used a fixed escapement policy to provide advice on Atlantic salmon. Where conservation limits are valid and met, then in theory all fish exceeding this number are available for harvest. However, this may not always be appropriate. In practice, natural perturbations and imperfect management and enforcement tools do not permit such precise management. To manage using the precautionary approach it will be necessary to set higher targets to reduce the probability of falling below the conservation limit. The targets will be river specific depending on the quality of data available and the extent of exploitation in mixed stock fisheries and in the river. The target is best set locally by scientists and managers who are most familiar with the biological characteristics of the population, the stock-recruitment relationship, and the realities of implementing and enforcing the management plan. Managers of in-river fisheries have the final responsibility for ensuring compliance with the targets and allocating surpluses among the needs of competing user groups. In addition, they may need to curtail in-river fisheries to compensate for management failures in sea fisheries and/or environmental conditions which have reduced anticipated fish returns.

1.5.3 Problems and constraints

To cope with unexpected events, the number of fish required to ensure that spawning escapement exceeds a set conservation limit may have to be considerably higher than the theoretical minimum.

Genetics considerations may also require higher conservation limits for some rivers. Where distinct populations exist within a catchment, more spawning fish may be required to maintain genetic diversity than would be called for by a simple reference point based on whole catchment egg depositions. Further, fisheries for Atlantic salmon that operate on a mixture of populations are by definition higher risk than those on single stocks (i.e., non-precautionary), particularly when reference points for individual stocks are combined. Accepting the individual river as a management unit requires that managers ensure sufficient escapement for all rivers to meet their conservation limits. Thus, as reference points are defined on increasingly fine scales (e.g., smaller and smaller tributaries), the number of fish required to escape all fisheries so as to meet the requirements of the weakest stock rapidly increases.

Finally, there is concern that management practice pays too little heed to the risk associated with management options, e.g., selection of mid point pre-fishery abundance value to set quotas (50% probability of failing to reach the conservation requirement) and fixed point spawner requirements (absence of advice on variability in the proportion of females, fecundity, origin of fish in the fishery etc.). For these reasons new methodologies are being developed to provide catch advice based on the probability of not meeting spawner requirements.

1.6 Compilation of Tag Release and Finclip Data for 1996

Data on releases of tagged and finclipped salmon in 1996 were compiled by ICES and provided under separate cover. In 1996, a total of nearly 3.4 million salmon were marked, nearly equal to the number marked in 1995. Finclips (1.63 million) and microtags (0.82 million) were the most frequently used marks. Most marks were applied to reared parr and smolts (3.33 million); only small numbers of wild parr and smolts (49 thousand) and adult fish (20 thousand) were marked.

2 ATLANTIC SALMON IN THE NORTH-EAST ATLANTIC COMMISSION AREA

2.1 Events in Fisheries and Status of Stocks

2.1.1 Fishing in the Faroese area 1995/1996

In accordance with the agreement between the Faroese Salmon Fishermen's Association and the North Atlantic Salmon Fund, commercial fishing for salmon in Faroese territorial waters was suspended for the years 1991 to 1996. A research fishery for salmon last operated in the Faroes area in December 1995. One research vessel fished a total of 8 long-line sets (8 days).

The total catch in the research fishery in December 1995 was 282 salmon (1 t). That value is too small to be considered representative of the size and age distribution of fish in the area or of catch rates (CPUE) that might have been expected in all or part of the 1995/1996 season. No fishing has taken place in the 1996/1997 season.

Origin of the catch: In the 1992/1993 to 1994/1995 fishing seasons, a total of about 5,500 salmon caught on long-line were tagged and released in the open sea north of the Faroes. After four fishing seasons (i.e. 1993–1996) 85 wild tagged fish (2.2%) have been reported recaptured in 10 countries. The estimated proportions of wild salmon from different countries, based on recoveries adjusted for homewater exploitation and tag reporting rates were as follows:

	Recaptures	
Country	**Total to date**	**%**
Norway	46	41.7
Scotland	12	20.7
Russia	5	16.5
Ireland	9	6.2
Denmark	2	5.1
Canada	4	3.5
Sweden	4	2.5
England	1	2.4
Spain	1	0.7
Iceland	1	0.7
Total	**85**	**100**

Of 19 tagged farmed/reared fish recovered (1.9% of those tagged), 18 were reported from Norway whereas one was recovered from the west coast of Sweden.

2.1.2 Homewater fisheries in the NEAC area

Gear and effort: Minor changes in commercial and recreational salmon fishing effort were reported in 1996, continuing the reduction in commercial fishing effort in the North-East Atlantic area in recent years. These reductions mainly arise from conservation measures in the respective countries and the reduced value of commercially caught salmon. Rod and line fishing has been increasing in some areas.

Catch: Provisional figures suggest that nominal catches of salmon in North-East Atlantic countries in 1996 were generally below the 1995 values and for most countries still below the previous 5 and 10 year averages. In general, fishing effort in terms of licences issued has been declining substantially over the years for commercial fisheries and increasing for recreational fisheries. The final value (including ranched fish) of 2,711 t for 1996 was below the 1995 value of 3,283 t.

CPUE: CPUE from recreational fisheries can be difficult to interpret. Catch-per-unit effort in rod fisheries in Finland, France and UK (Northern Ireland) show no trend for rod catch/**angler day** over the last 10 years. However, analysis of rod catch/**angler season** data which are available for rod fisheries in Finland and France indicate a significant upward trend in CPUE for the same period. CPUE for fixed engine fisheries in England and Wales shows no trend. For Scotland, there is a significant downward trend in CPUE in the net fishery.

Composition of catch: The proportion of 1SW fish in catches has increased for Russia and Finland, and decreased for Norway, Sweden and France. The proportion of 1SW fish in national catches varied among countries from 58% to over 90%. The lowest proportions of 1SW fish in catches were reported in Norway, Finland and France (rod fishery) and the highest in Ireland, France (net fishery), Iceland and Russia.

Origin of catch: Although it is known that there are wild fish from neighbouring countries in homewater catches, no new analyses on the distribution or number of these fish have been carried out since 1994. Farmed salmon continue to represent a large percentage of the national reported catch in both Norway (28%) and Faroes (20%) and ranched salmon now account for 65% of the national catch in Sweden. Although Iceland produces a large tonnage of ranched salmon, practically all this is harvested at the production sites. Farmed fish formed less than 3% of the national catches in Ireland, UK (Northern Ireland and Scotland).

Exploitation rates: Exploitation rates in homewater fisheries vary considerably among different river stocks. Mean rates (1991–1995) for a small number of monitored stocks range from less than 20% to over 80%. Increases in exploitation rates on stocks from Irish and UK (N Ireland) rivers have been shown in recent years, whereas a decrease is noted for one river in UK (Scotland) and one river in Russia. Although reported exploitation in some fisheries has changed, analyses indicate that there has been no overall trend in exploitation in fisheries over the last 10-year or 5-year periods for either 1SW or 2SW stocks in rivers for which data are available.

2.1.3 Status of stocks in the NEAC area

There are well over 1,000 rivers supporting salmon in the NEAC area, but for most of these there is no information on the status of the stocks. Estimates of pre-fishery abundance in the NEAC area have been updated and are now bounded by empirically derived precision estimates from a Monte Carlo analysis. Survival indices for combined river data for the NEAC area indicate a downward trend in survival to homewaters for the last 10 years for 2SW stocks. No trend was noted in the most recent 5 year period.

Figures 2.1.3.1 and 2.1.3.2 show the range of estimates of the pre-fishery abundance of maturing (1971–1996) and non-maturing (1970–1995) 1SW salmon in the NEAC area for northern and southern European stocks as defined below:

Southern European countries:	**Northern European countries:**
Ireland	Iceland
France	Finland
UK(England & Wales)	Norway
UK(Northern Ireland)	Russia
UK(Scotland)	Sweden
(Greenland catches)	(Faroes catches)

Trendlines (based on mean values) are shown in Figure 2.1.3.1 where the relationship for southern stocks over the 25 years is significant. The maturing component of the southern European stocks declined by more than 50% from the early 1970s to the early 1990s, although stocks appear to have stabilised at a low level in recent years. The non-maturing 1SW component of the southern European stocks, which is expected to contribute to West Greenland, has also declined and over the past 25 years now appears to be near the lowest level in the time series (Figure 2.1.3.1).

Estimates of both maturing and non-maturing pre-fishery abundance for the northern European stocks show less clear trends (Figure 2.1.3.2). Nevertheless, there appears to have been a steady decline in the maturing component of the stocks over the last nine years and in a similar period the abundance of non-maturing recruits has dropped to the lowest level in the series.

In 1996, estimates of spawner requirements were presented for seven rivers. Spawning thresholds were only exceeded in the Scorff and Nivelle (France) and the N. Esk (Scotland). A significant downward trend in egg deposition was noted for the previous 5-year period for all rivers combined.

Examination of the general trends suggests that there has been no significant change in smolt production in the north-east Atlantic as a whole. Adult runs in western European rivers showed no significant trend in run size over the last 10 years. For Russian rivers, an increasing trend in spawning escapement was noted over the previous 20- and 30-year periods. Over the most recent 10-year period, a decreasing trend has been noted. No trend is apparent for the previous 5-year period.

2.2 Effects of the Suspension of Commercial Fishing Activity at Faroes

Since 1991, the Faroese fishermen have agreed to suspend commercial fishing for the salmon quota set by NASCO in exchange for compensation payments. The number of fish saved from the fishery is estimated by subtracting the numbers of fish taken in the research fishery from the number that would have been expected to be caught if the commercial fishery had operated. The increase in returns to all homewaters is then estimated by subtracting the fish that would have died on their homeward migration. The great majority of these fish would be expected to return to European rivers although a small number of salmon tagged in the fishery have returned to North America.

The expected catch in the Faroese fishery was estimated to be equal to the mean catch in the 1988/1989 to 1990/1991 seasons (87,484 fish). Use of this average assumes that the total number of salmon available to the Faroese fishery has not changed since 1988. This assumption will be examined in future analyses. The estimated increased returns of wild 1SW and MSW salmon to homewaters in Europe and their contribution to the total estimated returns to the NEAC area for the years 1992–1996 follow:

	Estimated increased returns to home waters in Europe			
	1SW	**%**	**MSW**	**%**
1992	1,618	<1	40,327	3
1993	5,852	<1	55,466	5
1994	9,967	<1	64,207	5
1995	6,412	<1	67,936	6
1996	6,504	<1	71,389	7

In 1996, an additional 18,000 farm fish (nearly 107,000 over the 5 seasons of the suspension) will have escaped capture because the fishery did not take place.

Suspension of the fishery increased MSW returns to all European rivers by 3-7% and 1SW returns by less than 1%. However, analyses of smolt tagging data and results from the adult tagging studies (Section 2.1) indicate that 65-75% of the MSW salmon caught in the Faroes fishery would return to Scandinavian countries, Finland and Russia (northern Europe). If this were the case, increased returns might have represented 4% to 9% of the MSW returns to northern Europe between 1992 and 1996. If stocks and fisheries had remained stable, total catches would have been expected to increase by approximately the same proportions in the respective areas. However, any increase in catches either has been too small to be detected as a statistically significant change above the normal annual variation or has been masked by other factors such as reduced marine survival or reduced exploitation rates in homewaters.

2.3 Development of Age Specific Spawning Targets

A number of countries in the NEAC area have made considerable progress toward the development of biological reference points (MBALs and target fishing levels as opposed to *spawning targets;* see Section 1.5) for salmon (Table 1.5.1.1). In its 1995 report to NASCO, ICES recommended that "all countries should establish preliminary spawning targets for all their rivers as soon as possible". Subsequently NASCO requested ICES to "provide estimates of age specific spawning targets". In order to be consistent with present ICES terminology, we have used the term "conservation limits" instead of "spawning targets". ICES advises against defining conservation limits on an age specific basis at present. In some catchments genetically distinct populations inhabiting subcatchments within a river system have been identified. Age specific reference points are not sufficient to provide adequate protection for those populations and other approaches need to be developed.

Certain countries, however, are faced with complicating factors and do not foresee having significant numbers of reference points in place within the next 5 years. Complicating factors include:

i) Paucity of databases for calculating stock-recruitment relationships or long-term trends;

ii) Uncertainty in extrapolating information from the limited number of rivers where relatively complete information is available to other rivers of different physical characteristics or in different geographic areas;

iii) The possibility of a single conservation limit compromising discrete populations which occupy spatially distinct areas within a river system, or which differ in their biological characteristics and do not interbreed (e.g. spring salmon versus autumn salmon). Hence, conservation limits may have to be set for each discrete population.

2.4 Provision of Catch Options with Assessment of Risk

2.4.1 Levels of exploitation by Faroes fishery

The levels of exploitation in the Faroes fishery on salmon from six monitored rivers in the NEAC area have been estimated from microtag and external tag recoveries for a number of years. Catch data from the Faroes fishery, including recent years with only small research catches, were positively correlated with exploitation rates for wild and hatchery 2SW from the R. Imsa (a small stock in Norway) and for wild 2SW salmon from the N. Esk, UK (Scotland). The correlation was not significant with the River Imsa hatchery data when years with small research-only catches were removed. Faroes catches were not correlated with 2SW exploitation rates of either the R. Drammen (Norway) or the R. Lagan (Sweden); few tags were returned from 2SW stocks of the Burrishole (Ireland) and R. Bush, UK (N. Ireland). At a catch of 500 t in the Faroes, the R. Imsa data are suggestive of 20-40% exploitation levels on hatchery and wild fish of that river; in the case of the N. Esk the data are suggestive of 4–8% exploitation on 2SW fish of that river.

2.4.2 Catch advice

Estimates of pre-fishery abundance suggest that numbers of maturing and non-maturing recruits in the NEAC area are around their lowest in the past 25 years (Figures 2.1.3.1 and 2.1.3.2). The maturing component of the northern European stock complex appears to show an alarming downward trend in recent years. The southern European stock complex (maturing and non-maturing) and the non-maturing component of the northern stock complex may have stabilised at their current depressed levels.

Although data are inadequate to relate pre-fishery abundance to actual spawning escapements, pre-fishery abundance data for northern and southern stocks suggest that a precautionary approach is called for in the management of fisheries - particularly where they exploit mixed river stocks.

2.5 Potential By-Catch of Post-Smolts in Pelagic Fisheries

Since 1991, experimental trawls have located post-smolts in the area from the south-west of Ireland at 50 ° N up to 75 ° N. Over 404 post-smolts have been caught along with small numbers of 1SW salmon.

Both the fishery for mackerel and herring in the Norwegian Sea overlap spatially and temporally with the suggested routes of European post-smolts on their northward feeding migration. To date, however, there is only one record of a Carlin-tagged smolt taken in the mackerel fishery in International Waters in the Norwegian Sea.

The evidence that the season and location of significant pelagic fisheries overlap the documented and presumed occurrence of post-smolts suggest the potential for as yet undescribed by-catch mortality on post-smolts.

2.6 Data Deficiencies and Research Needs in the NEAC Area

ICES recognises the importance of the results generated from the research fishery programme in the Faroes area and recommends a continuation of the research fishery at a scale that will provide sufficient data for analyses.

Further information is required on the by-catch of post-smolts in marine fisheries. ICES endorses post-smolt surveys and the search for by-catch of salmon post-smolts in pelagic fisheries. Comparison of commercial fishing practices (depth, tow speeds etc.) and catch with research survey catches may provide a means of developing estimates of post-smolt mortality and further describing thermal preferences in marine thermal habitat.

In consultation with the Coordinating Working Party on Fishery Statistics (CWP), efforts should be made to standardise the way that catch-and-release data are handled in the catch statistics. The objective will be to provide an unbiased estimate of mortality due to fishing.

ICES requires guidance on the way NASCO would like the production of ranched fish to be reported in the catch tables.

Further work is required on the development of biological reference points for stocks in the NEAC area.

Efforts should be made to provide more accurate estimates of the level of catch by each country of stocks originating from other countries.

Relationships between environmental parameters and marine survival of salmon stocks in the NEAC area need to be further developed.

Efforts should be made to improve estimates of unreported catches in the Commission Area.

3 ATLANTIC SALMON IN THE NORTH AMERICAN COMMISSION AREA

3.1 Events in Fisheries and Status of Stocks

3.1.1 Fisheries in the NAC area

Gear and effort: Restrictions on commercial and recreational fisheries introduced in Canada in 1992 remained in force. In addition, further regulations were introduced in Labrador: in the commercial fishery the quota was reduced from 73.5 t to 55 t (the opening date was advanced by 2 weeks). In Québec the commercial fishery continued in zones Q9 and Q11, but in zone Q9 it was reduced from 15,175 fish to 12,068 fish. In the recreational fishery, hook-and-release regulations for small salmon were extended to more rivers of the Maritimes Region; the retention of large salmon continued only in Québec and Labrador.

In the USA there is no commercial fishery for salmon and angling (catch-and-release only) for sea-run salmon in 1996 was permitted only in the State of Maine. In Saint-Pierre and Miquelon (France) 10 professional fishermen used an estimated 10,400 m of surface gillnet and 42 licensed recreational gillnet fishermen used an estimated 7,560 m of surface gillnet.

Catch: The provisional landings for Canada in 1996 were 291 t, an increase of 12% from 1995 (Table 1.1.1.1). The landings of small salmon (87,141) and large salmon (30,066) represented an increase of 41% and a reduction of 12%, respectively, from those of 1995. Native Peoples' landings were almost 40 t, 84% of which was large salmon. The recreational landings totalled 80,438 small and large salmon, 14% above the previous 5-year mean. Commercial landings in Labrador and Québec declined to 81 t in 1996 from a peak of more than 2,400 t in 1980. Licence retirements and reduced quotas were partly responsible for the reduction in commercial catches. Unreported catch for the NAC area was guess-estimated at 156 t.

In the USA the estimated number of salmon caught and released in 1996 was 542 fish - 46% higher than in 1995 and 154% higher than in 1994. In the islands of Saint-Pierre and Miquelon (France) the harvest of salmon by commercial nets in 1996 is estimated to have been 950 kg - about double that of 1995. Recreational fishermen using gillnets harvested an estimated 560 kg of salmon.

Composition and origin of catch: No tagged fish of USA origin were reported from Canadian fisheries in 1996. This is consistent with the suspension, in 1995, of smolt tagging in USA rivers.

In Canada, returns to the majority of rivers in Newfoundland and Labrador are comprised exclusively of wild salmon. Hatchery-origin fish were most abundant in returns to rivers in the Bay of Fundy and along the Atlantic coast of Nova Scotia. Aquaculture escapees were sampled from the St. Croix, Magaguadavic and Saint John rivers in the Bay of Fundy as well as in the Baddeck River, Cape Breton and Conne River, Newfoundland.

In the USA, some salmon that were caught in the sport fishery in 1996 were escapees from aquaculture operations in Maine and New Brunswick (Canada).

3.1.2 Status of stocks in the NAC area

In most regions the returns of 2SW fish are near the lower end of the range of the twenty-five year time series. However, returns of 2SW salmon to Labrador in 1995 and 1996 were the highest in the time series. Returns of 1SW salmon improved in all areas in 1996 relative to 1995 and in some regions (Labrador, Newfoundland and Québec) were near the highest in the time series and may indicate improved marine survival of this cohort. If this is the case, 2SW salmon returns and spawners may be expected to increase in 1997.

The North American Run-Reconstruction Model was used to estimate 1SW and 2SW returns and 1SW and 2SW "recruits" (fish prior to the Newfoundland and Labrador commercial fisheries) from 1971–1996. The rank of the estimated *returns* in 1996 in the 1971–1996 time series (Figures 3.1.2.1 and 3.1.2.2; inc. spawning targets) for 6 regions in North American is shown below. In the table the closer the rank is to 1 the better the relative performance of the stock:

	Rank of 1996 returns in 1971–1996 time series (1=highest)		Mid-point estimate of 2SW spawners as proportion of escapement requirement
Region	**1SW**	**2SW**	**(%)**
Labrador	3	3	60
Newfoundland	3	6	137
Québec	7	24	20
Gulf (Mainland)	16	22	95
Scotia-Fundy	17	23	44
USA	8	15	8

The above text table also shows the estimated total spawning escapement of 2SW salmon in each region expressed as a percentage of the spawning escapement requirement. Requirements in 1996 were only exceeded in Newfoundland and approached in the Gulf of St. Lawrence. Mid-point estimates of 2SW spawners for Canada could have been met or exceeded in only 3 of the past 26 years (1974, 1977 and 1980) by reduction of in-river fisheries. In the remaining years, spawning requirements could not have been met even with the elimination of in-river harvests (Figure 3.1.2.2).

The North American Run-Reconstruction Model was also used to update the estimate of pre-fishery abundance of non-maturing (prior to Greenland and North American fisheries) and maturing 1SW salmon from 1971-1996 (Figure 3.1.2.3). The 1996 estimate of pre-fishery abundance of **non-maturing** 1SW salmon was 8% above the record low estimate in 1994. Similarly, the 1996 estimate of abundance of **maturing** 1SW salmon increased by 46% over the record low 1994 estimate. Estimates for 1995 and 1996 suggest an end to the historically low values of non-maturing 1SW salmon and, in the case of 1SW maturing salmon, a clear increase. The decline in total recruits over the last 10 years has been accompanied by an increase in the proportion of the North American stock maturing as 1SW fish. This proportion has risen from about 45% at the beginning of the 1970s to around 70% in the last 4 years.

The estimate of the total number of 1SW salmon returning to Labrador and Newfoundland rivers and coastal waters of other areas of North America in 1996 (Figure 3.1.2.4) is 44% higher than the estimate for 1995 and 20% higher than the average of the previous years (1971–1995). The estimate is the fourth highest observed in the past 10 years and seventh highest in the 26-year time series, 1971–1996. The estimated 2SW returns (Figure 3.1.2.4) are 10% lower than the total returns for 1995 but similar to those of 1994 and the average of the past 10 years.

The majority of the USA returns were recorded in the rivers of Maine, with the Penobscot River accounting for about 74% of the total USA catch. Salmon returns to the Penobscot River were 52% higher than in 1995, 23% higher than the 1991–95 average and 17% lower than the

1986-95 average. Returns to most USA rivers are hatchery-dependent and remain at low levels compared to spawning requirements.

Egg depositions exceeded or equalled the specific river requirements in 32 of the 85 rivers which were assessed in Canada and were less than 50% of requirements in 22 other rivers. Large deficiencies in egg depositions were noted in the Bay of Fundy and Atlantic coast of Nova Scotia where 10 of the 20 rivers assessed had egg depositions which were less than 50% of requirements (Figure 3.1.2.5).

3.2 Effects of Quota Management and Closure after 1991 in Canadian Commercial Salmon Fisheries

In 1992, a 5-year moratorium was placed on the commercial Atlantic salmon fishery in insular Newfoundland while in Labrador and Québec North-Shore and Ungava, fishing continued under quota or allowance catch. In conjunction with the commercial salmon fishing moratorium, a commercial licence retirement programme went into effect in insular Newfoundland, in SFAs 1, 2 and 14B of Labrador, and in Q7, Q8 and a part of Q9 in Québec; there were no changes in the management measures in Q11.

Newfoundland: The effect of the 5-year moratorium on the commercial salmon fishery in insular Newfoundland in 1992 was evaluated by comparing index ratio values developed from counts of small and large salmon at facilities on different rivers for pre-moratorium (1984-1991) and moratorium (1992-1996) periods. The year 1992 was treated as the base year and the index value was contrasted between the periods before and after the moratorium. Index ratios increased between pre-moratorium (pre) and moratorium (mor) years (see text table below); most moratorium values exceeded "1", i.e. returns exceeded the 1992 base year.

	Small salmon		Large salmon	
River/(coast)	**Pre**	**Mor**	**Pre**	**Mor**
Exploits (NE)	0.80	1.52	0.73	3.09
Gander/Salm NE)	0.76	1.07	0.18	1.01
Gander (NE)	0.40	1.18	0.13	0.47
Middle (NE)	0.72	1.28	0.52	2.55
Terra Nova (NE)	0.84	1.38	0.47	1.54
NE Placentia (S)	0.54	0.94	0.43	1.64
Humber (W)	0.51	1.17	0.22	0.64
Lomond(W)	0.82	1.50	0.31	0.88
Torent (W)	0.84	1.93	0.54	2.18
Western Arm (W)	0.70	1.85	0.08	3.25

Many stocks reached their lowest or second lowest level of abundance in 1991. Three south coast rivers, not tabled above, had average index values during the moratorium that were lower than the pre-moratorium period. Estimates of commercial exploitation rates for pre-moratorium years on the above rivers averaged 49% (range 29-66%) for small salmon and 76% (range 64-98%) for large salmon.

Labrador: There were reductions in the commercial exploitation rates (1992–1995) and reductions of up to 31 t in commercial landings in 1995; no new information was tabled for the 1996 season.

Québec: In zones Q7 and Q8, the mean annual commercial catches before closure from 1984–1991 were 389 small and 8,893 large salmon. During the same years, the annual mean recreational catch was 1,596 small salmon and 3,167 large salmon. Full commercial closure was in effect in 1993-96 when mean recreational fisheries landings were down by 20% from pre-moratorium years. Assuming that exploitation rates in commercial fisheries declined in the same proportion as the recreational fisheries, the 1993 closure may have resulted in an annual savings of 311 small and 7,195 large salmon.

In zone Q9, the commercial quota was reduced by 20%, from 15,175 fish in 1995 to 12,068 fish in 1996. The opening date was also delayed by 7 days. The quota reduction is assumed to have reduced the catch by 20% because more than 90% of the quota was reached in the four previous years and 95% of the quota was reached in 1996. Delays in the opening date could have contributed to a reduction in the proportion of large salmon in the catch. From 1984-1995, large salmon averaged 73% of the landings. In 1996, the proportion of large salmon in the commercial fisheries dropped to 61% even though the proportion of large salmon in the recreational catch remained unchanged from that of the 5 previous years.

Other Areas: ICES previously indicated that there was an increase in size-at-age and in the proportion of previously spawned 1SW and 2SW salmon returning to the Miramichi River. These observations are consistent with reduced commercial exploitation, which was thought to be size selective. Similar trends to those reported for the Miramichi River have been reported for the Restigouche River. However, other factors such as natural mortality may have contributed to the decline in returns.

Although the Newfoundland and Labrador commercial salmon fisheries used to harvest small and large salmon with origins in Nova Scotia, New Brunswick, Québec, and USA, the benefits in returns to these provinces cannot be quantified. The estimates of returns of 2SW salmon to

SFAs 19-23, Q1-Q11, and USA from 1992–1996 are lower than the returns from 1987–1991 which is not consistent with a reduction in marine fishing mortality.

3.3 Spawning Requirements

As discussed in Section 2.3, the spawning requirement is now considered as a conservation limit. In Canada, the threshold reference point has been synonymously defined as the **conservation requirement** or **conservation limit**. The conservation requirements for North America have been previously expressed in terms of the number of 2SW fish (180,495) required for all production areas in North America. No new requirements for North American rivers have been proposed.

3.4 Development of Catch Options

Catch options for 2SW salmon in North America in 1998 have been developed from 1997 estimates of pre-fishery abundance for 1SW non-maturing salmon. Only a small proportion of the cohort would be expected to be harvested (in Labrador in 1997) as 1SW non-maturing salmon if exploitation and stock composition patterns were similar to recent years.

Mortalities in mixed stock and terminal fisheries in Canada were summed with those of USA to estimate total 2SW equivalent mortalities for the 6 regions of North America for the period 1972–1996. The mid-point estimates of i) harvests of 1SW non-maturing salmon in Newfoundland-Labrador commercial fisheries (adjusted by natural mortalities of 1% per month for 11 months), ii) 2SW harvests in these same fisheries (adjusted by 1 month) and iii) 2SW fish in terminal fisheries (2SW returns - 2SW spawners) were summed. Mortalities within North America peaked at almost 375,000 fish in 1976 and are now around 30,000 2SW salmon equivalents. In the most recent two years estimated, those taken as non-maturing fish in Labrador constituted only 5 % of the total catch of 2SW fish.

In-river fisheries accounted for from as little as 18% of the cohort destined to be 2SW salmon (in 1973, 1975 and 1987) to the highest value yet of 75% in the 1996 fisheries. The percentage taken in in-river fisheries increased significantly with the reduction and closures of the Newfoundland and Labrador commercial fisheries, particularly since 1992.

North American 2SW salmon equivalent mortalities in Canadian and USA fisheries (based on the 2SW return year) from 1972–1996, indicate that harvests within the USA approached 0.05 % of the total on just a few occasions (and some of this would also have been harvested in Canada). The percentage of the total (Canada, USA and Greenland) 2SW equivalents that has been taken in North American waters was 60% in 1996 and has ranged from 41–100%. Values of 100% coincided with the closure of the Greenland commercial fishery in 1994 and 1995.

The pre-fishery abundance forecast for 1SW non-maturing salmon in 1997 is 196,858 fish (50% probability level; see Section 4.2). Assuming a 40% Greenland/ 60% North America division of the surplus for harvest (after reserving the spawner requirement of 201,483) catch options as 2SW salmon equivalents were developed for North America in 1998 (surplus reduced by 11 months of mortality at 1% per month). As there is a wide variability in the forecast of pre-fishery abundance, a precautionary approach would utilize probabilities much lower than 50%, at least for composite (mixed stock) fisheries.

Catch Options for 1998 North American Fisheries (Probability levels refer to probability density function estimates of pre-fishery abundance)	
Probability Level %	Catch Options in 2SW Salmon Equivalents (no.)
25	0
30	0
35	0
40	0
45	0
50	0
55	6,396
60	15,535
65	24,857
70	34,666
75	45,427

An update of projections, with associated probabilities of achieving spawner requirements, can be provided at the conclusion of the Greenland and North American fisheries on non-maturing 1SW fish in 1997.

3.5 Multi-Year Projections of Salmon Abundance

Quantitative forecasts of abundance are restricted to previously described pre-fishery abundances for 1SW non-maturing salmon in 1997. These projections are dependent on the winter marine habitat in the same year. As it is not possible to determine sea surface temperature in advance, the predictive power of this model is restricted to the current year.

Various indicators of stock strength in future years, including juvenile densities and 2SW lagged spawners, were considered as possible long-term predictors. However, none were found to be particularly useful. Increased juvenile densities in many monitored rivers, an increase in 2SW spawning escapement in some rivers, increased fry stocking in USA rivers and recent signs that marine survival of smolts has increased all support the view that abundance may increase. Notable exceptions are the stocks of the Atlantic coast of Nova Scotia and the Bay of Fundy where juvenile densities and marine survival rates are low, the hatcheries cannot sustain themselves because there is insufficient money for production, and the populations are impacted by industrial activities.

3.6 Data deficiencies and research needs

It would be instructive to compare current estimates of returns and escapements in Labrador with those values estimated by summing the individual estimates for SFAs 1, 2 and 14B calculated from SFA-specific exploitation rates for fishing effort within each of the respective areas.

There is a need for improved habitat surveys for rivers in Labrador and Ungava so that spawner requirements can be based on habitat characteristics.

Possible changes in the biological characteristics (mean weight, sex ratio, sea-age composition) of returns to rivers, spawning stocks, and total recruits prior to fisheries should be investigated. As new information becomes available, refined estimates of spawning requirements in USA and Canada will be obtained by incorporating new information such as biological characteristics for individual stocks, habitat measurements and stock and recruitment analysis.

Annual estimates of wild smolt-to-adult salmon survival rates need to be obtained for rivers in Labrador, New Brunswick and Nova Scotia. In addition, sea survival rates of hatchery and wild salmon should be examined to determine if changes in survival of hatchery releases can be used as an index of sea survival of wild salmon. Efforts should be made to improve estimates of unreported catches.

4 ATLANTIC SALMON IN THE WEST GREENLAND COMMISSION AREA

4.1 Events in Fisheries and Status of Stocks

4.1.1 Fishery in WGC area

Catch: In 1996, no agreement was obtained on a quota for salmon in the West Greenland Commission. Greenland authorities permitted a fishery of up to 174 t. The fishery began on 12 August and ended on 11 November after a long period with low catches. Nominal catches were 92 t (Table 1.1.1.1), the majority being landed in August and September. As in recent years, most of the catch (79%) was landed in NAFO Divisions 1C and 1E. The unreported catch was guess-estimated at less than 20 t.

Gear and effort: Only vessels less than 42 ft (<12.8 m) were allowed to participate in the commercial salmon fishery in Greenland coastal waters in 1996. The fishery was conducted under quotas distributed at the community level and assessed through daily licensee reports to the Licence Control Office. Entry into the fishery was limited to professional fishers or hunters fishing their own gear (single hook and line; 2,000 knot 140 mm stretched mesh fixed or drifting gill net of any length) within 40 nautical miles of the west coast or 12 nautical miles of the east coast. Licences for salmon fishing were not issued to vessels with licences for the shrimp fishery.

Fishing for private consumption was restricted to residents of Greenland. Permitted gear is hook and line, one fixed gillnet (2,000 knot 140 mm stretched mesh), or a similar 30 fathom drift net, tended daily. Private harvests are not permitted to be sold and are not counted against the quota.

Permits may be issued for tourists to fish with hook and line only. There is no daily catch limit, but the catch may not be sold. Very few tourist licences were issued in 1996.

Origin of catches: Based on a discriminant analysis of characteristics from scales sampled in the fishery in 1996, 42% of the catch was of North American origin - down from the 65% value in 1995 and the lowest since 1983. (Low values were a more frequent occurrence during the mid 1970s.) The catch at West Greenland in 1996 was estimated to consist of 37.5 t (12,900 salmon) of North American and 54.7 t (19,150 salmon) of European origin.

Seven Canadian-origin salmon (external tags) were captured at West Greenland in 1996. Six of the fish had been among 7,500 adults tagged in 1995 for mark-and-recapture estimates of returns to the Miramichi and Margaree rivers.

Biological characteristics of the catch: Mean lengths of 1SW North American (63.4 cm) and European (63.0 cm) fish in 1996 exceeded all previous values for the 1990s and may signal an end to the downward trend in mean length from 1969–1995. Mean weights of 1SW salmon at West Greenland also increased in 1996. Mean lengths and weights of 2SW salmon were similar to values observed in recent years.

The proportion of river age 3 fish among European origin salmon was 31.5% - well above the mean value from 1968–1995 of 17.3%, but within the range exhibited since 1991. River age 4 fish (10.2%) were the most abundant on record; river age 1 fish (7.6%) comprised the smallest proportion in 25 years. Among North American fish, river age 2 fish (23.8%) were the lowest in 20 years. Proportions of other river ages were not appreciably different from the 1968–1995 means.

The sea-age composition of European samples in 1996 (97.1% 1SW, 1.7% 2SW and 1.2% previous spawners) was similar to values observed since 1985. North American samples (92.1% 1SW, 5.4% 2SW and 2.5% PS) consisted of about 3% more 2SW and older fish than the average from 1985–1995.

4.1.2 Status of stocks in the WGC area

Salmon caught in the West Greenland area are non-maturing 1SW salmon or older destined to return to homewaters in Europe or North America as MSW fish if they survived. A small population exists in a river in NAFO Division 1D, Greenland. Despite some improvements in the annual returns to a number of rivers, both in European and North American areas, the overall status of the stocks contributing to the West Greenland fishery remains poor. As a result, the status of stocks within the West Greenland area is thought to be low compared to historical levels.

Stocks originating in the North-east Atlantic: The most abundant European stocks in West Greenland are thought to originate from the UK and Ireland. Survival indices for combined river data for the NEAC area indicate a downward trend in survival to homewaters for the last ten years for 2SW wild stocks. No trend was noted in the most recent 5-year period. This is consistent with the estimates that have been made of the pre-fishery abundance of non-maturing 1SW salmon from southern Europe; these have declined over the past 25 years and now appear to be near the lowest level in the time series (see Section 2.4.1 and Figure 2.1.3.1).

Conservation reference points have been presented for only 7 European stocks and these do not generally provide separate reference levels for 1SW and 2SW salmon. As a result, they cannot be used to assess the status of the stock components contributing to the West Greenland fishery.

In general, there has been no significant change in smolt production in the North-east Atlantic, and adult runs in western European rivers showed no significant trend in run sizes over the last 10 years.

Stocks originating in North America: The North American Run-Reconstruction Model was used to update the estimates of pre-fishery abundance of non-maturing and maturing 1SW salmon from 1971–1996 (Section 3.1.2 and Figure 3.1.2.3a). The 1996 estimate of pre-fishery abundance of non-maturing 1SW salmon was 8% above the record low value for 1994. The results suggest a levelling off of a decline to historically low levels for 1SW non-maturing salmon. In addition to the steady decline in total recruits (both maturing and non-maturing 1SW salmon) over the last 10 years, there has been a steady increase in the proportion of the North American stock maturing as 1SW fish. This proportion has risen from about 45% at the beginning of the 1970s to around 70% in the last four years (Figure 3.1.2.3b).

The estimate of the total number of maturing 1SW salmon returning to Labrador and Newfoundland rivers and coastal waters of other areas of North America in 1996 (Figure 3.1.2.4) is 44% higher than the estimate for 1995 and 20% higher than the average of the years 1971–1995. The estimate is the fourth highest observed in the past 10 years and seventh highest in the 26-year time series, 1971–1996. The estimated 2SW returns (Figure 3.1.2.4) are 10% lower than the total returns for 1995 but similar to both the 1994 returns and the average for the past 10 years.

In most regions the returns of 2SW fish are near the lower end of the twenty-five year time series. However, returns of 2SW salmon to Labrador in 1995 and 1996 were the highest in the time series. Returns of 1SW salmon improved in all areas in 1996 relative to 1995 and in some regions (Labrador, Newfoundland, and Québec) were close to the highest levels in the time series (see text table Section 3.1.2).

The majority of the USA returns were recorded in the rivers of Maine, with the Penobscot River accounting for about 74% of the total. Salmon returns to the Penobscot River were 52% higher than in 1995, 23% higher than the average, 1991–1995, and 17% lower than the average, 1986–1995. Returns to most rivers are hatchery-dependent and remain at low levels compared to spawning requirements.

Egg depositions exceeded or equalled the specific river requirements in 32 of the 85 rivers which were assessed in Canada and were less than 50% of requirements in 22 other rivers. Large deficiencies in egg depositions were noted in the Bay of Fundy and Atlantic coast of Nova Scotia where 10 of the 20 rivers assessed had egg depositions which were less than 50% of requirements (Figure 3.1.2.5).

North American salmon stocks remain at low levels relative to production in the 1970s. The 1SW non-maturing component continues to be depressed with river returns and total production amongst the lowest recorded. Returns of maturing 1SW salmon to North American rivers in 1996, however, are quite high in many areas, notably Labrador, Newfoundland, Québec and USA which may indicate improved marine survival rates of this cohort. If this is the case, improvement in 2SW salmon returns and spawners may be expected in 1997. Only two areas achieved or came close to achieving their spawning requirements for 2 SW salmon in 1996. They were Newfoundland, where 2SW salmon make up only a small proportion of salmon production, and the Gulf of St. Lawrence, where 2SW salmon are a high proportion of production and very important in terms of their contribution to both North American and Greenland fisheries.

4.2 Catch Options with an Assessment of Risks

4.2.1 Introduction

ICES has used models based on thermal habitat in the north-west Atlantic to forecast pre-fishery abundance, in order to provide catch advice for the West Greenland fishery. While the approach has been consistent since 1993, the models themselves have varied slightly over the years. Changes have been made to the model formulation in an attempt to improve its predictive capability and to include biological mechanisms. In each of the years the models used the following predictor variables: 1993 and 1994 — thermal habitat in March; 1995 — thermal habitat in January, February, and March, and 1996 — thermal habitat in February and lagged spawners from the Labrador, Newfoundland, Québec, and Scotia-Fundy regions of Canada.

Update of thermal habitat: Marine habitat is measured as a relative index of the area suitable for salmon overwintering, termed "thermal habitat", and is derived from sea surface temperature data and previously published catch rates for salmon from research vessels fishing in the north-west Atlantic. Thermal habitat for February was updated to include data for 1997. Two periods of decline (1980 to 1984 and 1988 to 1995) are apparent (Table 4.2.1.1). The value for 1997 increased from that of 1996 and is the highest value in the previous 7 years.

4.2.2 Pre-fishery abundance forecast

ICES reviewed the procedures used to forecast pre-fishery abundance in 1996 and considered alternative model formulations that may be useful in future assessments. A review of potential thermal habitat and lagged spawner variables did not reveal any data relationships not previously detected, or result in a new linear model significantly more robust than that used in 1996. Thus the model (thermal habitat for February and lagged spawners [sum of lagged spawners from Labrador, Newfoundland, Scotia-Fundy and Québec]) was updated to reflect the addition of the new data (Figure 4.2.2.1).

The linear fit to the model of pre-fishery abundance versus February thermal habitat and lagged spawners produced a significant relationship between observed and predicted values at less than the 5% level ($F_{(2,15)}$=18.7). With the addition of the data for 1995, there is an improvement in fit over that of last year (r^2=0.71 in 1997 versus 0.68 in 1996). The forecast estimate of pre-fishery abundance for 1997 is about 197,000 fish at the 50% probability level (Table 4.2.2.1 and Figure 4.2.2.2). Despite the considerable increase in thermal habitat, the low values of lagged spawners and the decrease in the proportion of North American stock at West Greenland have resulted in a modest 11% gain in estimated pre-fishery abundance over that of 1996.

4.2.3 Development of catch options for 1997

The spawning requirement for all North American rivers is currently set at 180,495 2SW fish which is the equivalent of 201,483 pre-fishery recruits prior to natural mortality between Greenland and home waters. To achieve the management goal, these fish must be reserved to meet spawning requirements.

The procedure for estimating the quota for West Greenland is summarised in Appendix 2. Forecast parameter values for the proportion of the stock at West Greenland which is of North American origin [PropNA], mean weights of North American and European 1SW salmon [WT1SWNA and WT1SWE, respectively], and a correction factor for the expected sea age composition of the total landings [ACF] used in the procedure are given in Table 4.2.3.1.

Greenland quota levels for the forecast of pre-fishery abundance were computed with the revised model and are shown in Table 4.2.3.1. Values are given for different probabilities of failing to achieve the summed North American spawning requirements. Nevertheless, even with a zero TAC on non-maturing 1SW salmon, the overall spawning target for North American 2SW salmon is not expected to be met.

4.2.4 Risk assessment of catch options

The provision of catch advice in a risk framework involves the incorporation of the uncertainty in all the factors used to develop the catch options. An analysis of the probability of not meeting the conservation requirements in the six stock areas of North America was conducted by incorporating the uncertainty in all the parameters used to evaluate the spawning escapement to North America. They included i) uncertainty of the pre-fishery abundance forecast, ii) variability in the biological characteristics (proportion North American origin, weight of 1SW North American origin, weight of 1SW European origin, age correction factor), iii) variability in the exploitation rates in North America and iv) the spawner requirement probability plot.

Under the assumption of recruitment in direct proportion to the spawner requirement, just over 200,000 fish are required to escape to North America to produce a 50% probability of achieving the spawner requirement concurrently in six stock areas. This value is higher than the 180,495 fish point estimate of total requirements to North America because it incorporates the annual variation in the proportion of females in each of the stock areas.

The risk analysis assumed that the management of West Greenland and North American fisheries in 1998 would be similar to that of 1996 and that exploitation in North America would be between 0.15 and 0.28. The impact of these fisheries on the salmon returning to homewaters in 1998 in the absence of any fishery at Greenland in 1997 results in a 65% probability of not meeting the conservation requirements in at least one of the six stock areas (Figure 4.2.4.1). This analysis assumes that salmon will return to each geographic area in proportion to the relative spawning requirements in each area and that the exploitation rates in each of the six stock areas are similar.

The cumulative consequences of fisheries at Greenland in 1997 and in North America in 1998 on the potential spawning escapements to North American stock areas increase the probability of escapement falling below 50% of requirements in North America. There is a 22% probability of escapement below 50% of requirements with no fisheries and the probability rises to greater than 50% at a Greenland catch option of 400 t and exploitation rates between 0.15 and 0.28 in North America (Figure 4.2.4.1).

Even if fisheries are restricted to levels which provide a 50% probability that the overall escapement requirements are achieved, it is likely that some stocks will fail to meet their individual spawner requirements while others will exceed requirement levels. This unequal achievement of escapement goals may result from random variation between years or from systematic differences in the patterns of exploitation on fish from different rivers or regions. In the latter case, adoption of a 50% probability level may result in some stocks failing to meet requirement levels over several consecutive years if the full TAC is harvested. This would be likely to result in a long-term decline in those stocks.

4.2.5 Catch advice

It is evident from indicators of stock status, including the current and predicted estimates of pre-fishery abundance, that the North American stock complex is in a tenuous condition. The resource is close to record low abundance, despite almost complete closures of mixed and single stock fisheries, because of the continuing trend of below-requirement spawning escapements for 2SW salmon, and the low marine survival rates for some monitored stocks. The increasing advantage associated with each additional spawner in under-seeded river systems makes a strong case for a conservative management strategy. **ICES recommends that there should be no exploitation of the 1996 smolt cohort as non-maturing 1SW fish in North America or at Greenland in 1997, and also recommends that the cohort should not be exploited as mature 2SW fish in North America in 1998. Exceptions are in-river harvests from stocks which are above biologically-based escapement requirements. Further, fishing mortality on this cohort should be minimised in the North American Commission and in the West Greenland Commission Areas by controlling by-catch in other fisheries.**

4.3 Data deficiencies and research needs in the WGC area

The mean weights, sea ages and proportion of fish originating from North America and Europe are essential parameters to provide catch advice for the West Greenland fishery. As these parameters are known to vary over time, ICES recommends that the sampling programme which was carried out in 1995 and 1996 be continued and improved to cover as much of the landings as possible.

Effort should be made to improve the estimates of unreported catches.

The catch options for the West Greenland fishery are based almost entirely upon data derived from North American stocks. In view of the evidence of a long-term decline in the European stock components contributing to this fishery (southern European non-maturing 1SW recruits) ICES emphasises the need for information from these stocks to be incorporated into the assessments as soon as possible.

5 OTHER ISSUES

5.1 Joint meeting

The North Atlantic Salmon Working Group and the Baltic Salmon and Trout Assessment Working Group had a joint session at ICES Headquarters during their 1997 meetings to discuss problems common to both Working Groups. Two issues were considered which may be of interest to NASCO.

5.2 Spawning Targets

Progress on the Implementation of Spawning Targets: Summary conclusions and recommendations from the Spawning Target Workshop held in Pont-Scorff (France) in June 1996 were presented. The Group reviewed progress in the development and application of spawning requirement reference points. There has been substantial progress in the establishment of reference points in the NEAC area. There were no changes in the spawning requirements for rivers in North America.

One of the conclusions of the Spawning Target Workshop was that further progress in the development and transportation of reference points would occur with collection and analysis of additional data sets rather than refinements in analytical methods. There are few relevant data sets (long-term with large contrast in spawning escapement levels) in either the NAC or the NEAC areas. A number of recommendations were made by the participants of the joint session. They were:

1. Data series which were being used to provide reference points should be continued.

2. Probability analyses and similar approaches to quantify uncertainty should be used on existing stock-recruitment relationships.

3. The development of new data series and stock-recruitment relationships should be encouraged.

4. A list of rivers where sufficient information is available to establish reference points should be compiled. Contact individuals who are involved in the collection of data or involved in the development of methods/models should be identified and progress in transporting reference points for Atlantic salmon stocks should also be recorded to encourage the dissemination of data, information and methodologies. A preliminary list was developed at the meeting.

5.3 Definition of terms

It was agreed that the goal of current wild salmon management practices is to maintain self sustaining populations, and to try to ensure that populations retain characteristics as close to those of "native" salmon as possible. To respond to management needs, biologists must define a variety of salmon types as "wild". Both Working Groups agreed that the term is best used to describe populations which are (or are making progress towards becoming) self-sustaining. In a management context, all categories of "wild salmon" require a precautionary approach with appropriate measures taken to protect them.

The Group defined Atlantic salmon "types", based upon parental origin and the amount of their life cycle spent in the wild:

> ***Native salmon*** are wild salmon which are members of a population with no known effects from intentional or accidental releases.
>
> ***Wild salmon*** are fish that have spent their entire life cycle in the wild and originate from parents which were also spawned and continuously lived in the wild.
>
> ***Naturalized salmon*** are fish that have spent their entire life cycle in the wild and originate from parents, one or both of which were not wild or native salmon.
>
> ***Stocked salmon*** are fish that have had artificial spawning and/or rearing techniques applied at some point in their life cycle and/or originate from intentional releases to the wild.

Escaped salmon are fish that have spent part or all of their life cycle undergoing artificial propagation and originate from accidental or unplanned releases into the wild.

APPENDIX 1
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REQUEST FOR SCIENTIFIC ADVICE FROM ICES

1. With respect to Atlantic salmon in the North Atlantic area:

   1.1 provide an overview of salmon catches, including unreported catches, and production of farmed and ranched salmon in 1996;
   1.2 report on significant developments which might assist NASCO with the management of salmon stocks;
   1.3 describe the causes of long-term changes in sea-age composition of salmon stocks;
   1.4 describe the causes of changes in abundance of salmon with special reference to changes in natural mortality and ocean climate;
   1.5 review the development of assessments and management advice from the perspective of the precautionary approach;
   1.6 provide a compilation of microtag, finclip and external tag releases by ICES member countries in 1996.

2. With respect to Atlantic salmon in the North-East Atlantic Commission area:

   2.1 describe the events of the 1996 fisheries and the status of the stocks;
   2.2 update the evaluation of the effects on stocks and homewater fisheries of the suspension of commercial fishing activity at Faroes since 1991;
   2.3 develop age specific spawning targets;
   2.4 provide catch options with an assessment of risks relative to the objective of achieving spawning targets;
   2.5 evaluate the potential by-catch of post-smolts in pelagic fisheries;
   2.6 identify relevant data deficiencies and research requirements.

3. With respect to Atlantic salmon in the North American Commission area:

   3.1 describe the events of the 1996 fisheries and the status of the stocks;
   3.2 update the evaluation of the effects on US and Canadian stocks and fisheries of quota management and closures implemented after 1991 in the Canadian commercial salmon fisheries;
   3.3 update age specific spawning targets based on new information as available;
   3.4 provide catch options with an assessment of risks relative to the objective of achieving spawning targets;
   3.5 provide multi-year projections of salmon abundance;
   3.6 identify relevant data deficiencies and research requirements.

4. With respect to Atlantic salmon in the West Greenland Commission area:

   4.1 describe the events of the 1996 fisheries and the status of the stocks;
   4.2 provide catch options with an assessment of risks relative to the objective of achieving spawning targets;
   4.3 identify relevant data deficiencies and research requirements.

APPENDIX 2

COMPUTATION OF CATCH ADVICE FOR WEST GREENLAND

The North American Spawning Target (SpT) for 2SW salmon stands at 180,495 fish.

This number must be divided by the survival rate for the fish from the time of the West Greenland fishery to their return of the fish to home waters (11 months) to give the Spawning Requirement Reserve (SpR). Thus:

Eq. 1. SpR = SpT * (exp(11*M) (where M = 0.01)

The Maximum Allowable Harvest (MAH) may be defined as the number of non-maturing 1SW fish that are available for harvest. This number is calculated by subtracting the Spawning Target Reserve from the pre-fishery abundance (PFA).

Eq. 2. MAH = PFA - SpR

To provide catch advice for West Greenland it is then necessary to decide on the proportion of the MAH to be allocated to Greenland (f_{NA}). The allowable harvest of North American non-maturing 1SW salmon at West Greenland NA1SW) may then be defined as

Eq. 3. NA1SW = f_{NA} * MAH

The estimated number of European salmon that will be caught at West Greenland (E1SW) will depend upon the harvest of North American fish and the proportion of the fish in the West Greenland fishery that originate from North America [PropNA][1]. Thus:

Eq. 4. E1SW = (NA1SW / PropNA) - NA1SW

To convert the numbers of North American and European 1SW salmon into total catch at West Greenland in tonnes, it is necessary to incorporate the mean weights (kg) of salmon for North America [WT1SWNA][1] and Europe [WT1SWE][1] and an age correction factor for multi-sea winter salmon at Greenland based on the total weight of salmon caught divided by the weight of 1SW salmon [ACF][1] .

The quota (in tonnes) at Greenland is then estimated as

Eq. 5. Quota = (NA1SW * WT1SWNA + E1SW * WT1SWE) * ACF/1000

[1] New sampling data from the 1996 fishery at West Greenland were used to update the forecast values of the proportion of North American salmon in the catch (PropNA), the mean weights by continent [WT1SWNA, WT1SWE] and the age correction factor [ACF] in 1997.

PropNA =	0.557
WT1SWNA =	2.647
WT1SWE =	2.750
ACF =	1.133