The Standing Scientific Committee on Salmon

Independent Scientific Report to Inland Fisheries Ireland

The Status of Irish Salmon Stocks in 2011 with Precautionary Catch Advice for 2012

2012

Draft Report of the Standing Scientific Committee on Salmon to Inland Fisheries Ireland

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Executive Summary

A **National Salmon Commission** was established in 1999 under the 1999 Fisheries (Amendment) Act along with a **Standing Scientific Committee** "***to advise and assist the Commission on all technical and scientific matters in relation to the performance of the Commission's functions."***

In 2008, the National Salmon Commission was dissolved but the Standing Scientific Committee was retained by the Department of Communications, Energy and Natural Resources with the same terms of reference.

In 2010, the Standing Scientific Committee on Salmon (SSCS) was re-established under Section 7.5 (a) and (b) of the 2010 Inland Fisheries Act:

The full Terms of reference of the SSC are provided in this report.

The purpose of this report, therefore, is to provide IFI with the technical and scientific information required in order to meet its terms of reference under the Act. This includes information on Irish salmon stocks, the current status of these stocks relative to the objective of meeting biologically referenced "Conservation Limits" and the catch advice which will allow for a sustainable harvest of salmon in 2012 and into the future.

The Conservation Limit applied by the Standing Scientific Committee to establish the status of individual stocks is the "maximum sustainable yield" (MSY) also known as the stock level that maximizes the long-term average surplus, as defined and used by the International Council for the Exploration of the Sea (ICES) and the North Atlantic Salmon Conservation Organisation (NASCO). The SSC advise that the methodology for estimating conservation limits for Irish salmon stocks needs to be and modified to improve the estimates for 2013 advice.

The report also outlines the scientific advice process leading to the formulation and presentation of the catch advice for the 2012 season. In line with the Government decision to move to single stock fishing on stocks meeting and exceeding Conservation Limits by 2007, it is necessary to examine river specific information and provide precautionary catch advice, river by river, on a forecasted estimate of the availability of salmon in each individual river for the fishery year (season) in question.

Therefore, on the basis of the best information available on catches, counts or other estimates and application of a forecast model to these data, the Standing Scientific Committee advises that in 2012:

(a) The catch advice is based on :
   a. 141 assessments on 125 rivers with combined 1 Sea Winter/Multi-Sea Winter with 16 rivers assessed separately as 1 Sea Winter stocks
   b. 16 rivers assessed separately as Multi-Sea Winter stocks.
   c. 3 stocks in the Erne, upper Lee and upper Shannon (above hydro stations). A separate is made for stocks in the lower Lee and Shannon and this is included in the combined 1 Sea Winter/Multi-Sea Winter assessment.

- Of the 141 stocks, there are 58 stocks which are forecast to have an identifiable surplus over the Conservation Limit and a harvest fishery can proceed in 2012. This is two less than in 2011.
- There are 83 stocks which do not have an identifiable surplus over the Conservation Limit. In this instance, there are no harvest options available which will allow a 75% chance that the Conservation Limit will be met and no harvest fisheries should take place on these rivers.
- In addition, of the 16 rivers assessed separately for Multi-Sea Winter stocks or "spring salmon" stocks there are 13 rivers where there will be a surplus over the MSW Conservation Limit and therefore a harvest of spring fish is possible compared to 12 in 2011.
- There are also three MSW or "spring salmon" stocks failing to meet Conservation Limits.
- For rivers where a robust catchment wide electrofishing (CWE) estimate is available, SSC advise that catch and release only fishing be allowed if the CWE index is above 17 fry. Similarly, IFI management may allow rivers to open for catch and release only if 65% of the Conservation Limit is being achieved. Therefore using these criteria, catch and release fishing can occur on a further 25 combined 1SW/MSW stocks and three MSW stocks.
- Amongst the stocks being assessed are 59 small river stocks where the most recent annual average rod catch has been less than 10 salmon, making a direct assessment difficult. Therefore, the majority are assumed to be failing to meet Conservation Limits. Although these are insignificant fisheries (accounting for less than 0.5% of the total national rod catch when combined), their stocks are important as spawning populations in their own right which must be maintained for biodiversity as required under the EU Habitats Directive. The Standing Scientific Committee advise that additional information should be made available to assess stock status relative to their Conservation Limits for these small rivers.
- There are three major rivers with hydro-electric generating stations where significant numbers of hatchery fish are being released to mitigate against the loss of wild salmon *i.e.* the Liffey, Lee, Shannon and Erne. The stocks in the areas above the impoundments are significantly below their Conservation Limits and following the scientific advice already provided for other rivers, there should be no harvest fisheries on wild salmon in these specific rivers.
- There are currently 30 Irish salmon rivers which are listed under the specifically under the EU Habitats directive. Of these, 21 are above their CL, while a further two are meeting the 2SW CL.

While the main focus of this report is on fisheries and fisheries effects, there are real concerns relating to factors causing mortality at sea such as predation by seals, diseases and parasites, marine pollution and climate change. Presently, there is insufficient empirical information to allow anything other than general advice to be given on these factors *i.e.* the more the effects of each individual factor can be reduced the more salmon will return to our coasts and rivers. Clearly, more directed investigations need to be carried out on these other factors and this is outside the scope of this report.

Despite the closure of mixed stock fisheries in 2007 and an increase in runs in most rivers following this closure, most Irish salmon stocks are still failing to meet their Conservation Limits. Given the persistently poor marine survival experienced by most monitored stocks in the North Atlantic and forecasts of low stock abundance for all North Atlantic salmon stocks until at least 2015 (ICES advice to NASCO 2012), the expectation of large catches is unrealistic at present and there should be a priority given to conservation objectives rather than increasing catch.

The Standing Scientific Committee note however that by closing rivers to harvest, there will be an absence of catch data and it will not be possible to provide a direct assessment of the status of some stocks. Therefore alternative stock assessment techniques and information will be required over a number of years. The Standing Scientific Committee recommends that information is made available to allow the committee to provide a stock assessment for all rivers annually. This should be based on at least two of the following indices collected over a suitable time period:

- Adult counts from new and existing fish counter installations (including both main stems and/or tributaries).
- Adult stock indices from existing traps
- Juvenile assessment surveys benchmarked against an indices of total stock from index rivers.
- Redd count surveys benchmarked against other indices of total stock for index rivers.
- Survey draft netting and mark recapture assessments.
- Rod catch data – where catch and release fishery is allowed on these rivers.

In this regard, significant progress was made between 2009 and 2012 with the further development of a national electro-fishing programme benchmarked against index rivers (with known juvenile production to adult return relationships) and the installation of several new fish counters under the nation salmon Stamp Conservation Fund administered by IFI. In the short term, these indices may indicate if these rivers are meeting their Conservation Limits. However, further statistical analyses confirming the relationship between these indices and the stock size will be required to estimate the number of fish in excess of the Conservation Limit and set harvestable surpluses. Work is ongoing by the Standing Scientific Committee in this regard.

The Status of Irish Salmon Stocks in 2011 and Precautionary Catch Advice for 2012

Introduction

Up to 2001, the Irish fishery for salmon (*Salmo salar*) was managed by a combination of effort limitation and the application of technical conservation measures relating to size and type of fishing gear. While these measures regulate the efficiency of the fishery, they are not sensitive to the stock available and allow the same level of fishing even when stocks are low. In recognition of this and growing evidence both nationally and internationally of a widespread decline in salmon stocks, a **National Salmon Commission** was established in 1999 under the 1999 Fisheries (Amendment) Act. Under this Act, provision was made for the establishment of a **Standing Scientific Committee (SSC).** While the National Salmon Commission was dissolved in 2008, the Standing Scientific Committee continued to function under the aegis of the Department of Communications, Energy and Natural Resources.

In 2010, the Standing Scientific Committee on Salmon (SSCS) was re-established under Section 7.5 (a) and (b) of the 2010 Inland Fisheries Act:

(*a*) IFI may establish a Standing Scientific Committee to advise and assist it on all technical and scientific matters relating to the management of the State's inland fisheries resource.

(*b*) The terms of reference including the composition and membership of a Committee established under *paragraph (a)* will be set by IFI with the agreement of the Minister.

The purpose of the Standing Scientific Committee is to provide scientific advice to guide Inland Fisheries Ireland in the management decisions and policy development aimed at ensuring the conservation and sustainable exploitation of the Ireland's salmon stocks. IFI requests the SSCS to provide an annual report on the status of salmon stocks for the purpose of advising IFI on the sustainable management of Irish salmon stocks. IFI may also request the SSCS to offer scientific advice on the implications of proposed management decisions or policies on salmon or seek advice on scientific matters in relation to salmon. All scientific advice provided by SSCS is considered as independent advice by IFI.

The Terms of Reference of the SSC are as follows:

- For the purpose of advising the IFI, the SSCS shall develop age specific conservation limits for individual river stocks and estimate the overall abundance of salmon returning to rivers in the State.

- The SSCS shall carry out an assessment of salmon stocks using internationally accepted best scientific practice which should demonstrate whether:

    - conservation limits are being or likely to be attained on an individual river basis and

- favourable conservation status is being attained within special areas of conservation (SACs) and nationally as required under the habitats directive or otherwise -

- The assessment shall take account of mixed stock fishing on salmon stocks including the potential effects on freshwater salmon populations from rivers other than those targeted.

- In cases where stocks are determined to be below the conservation limits the Committee shall advise the level to which catches should be reduced or other measures adopted on a fishery basis in order to ensure a high degree of probability of meeting the conservation limits.

- The Committee shall provide the IFI with an independent report, which contains the following information:

  (a) an annual overview of the status of Irish salmon stocks and catches on an individual river basis.

  (b) catch advice with an assessment of risks associated with the objective of meeting conservation limits in all rivers,

  (c) an evaluation of the effects on salmon stocks and fisheries of management measures or policies.

  (d) advice on significant developments and other relevant factors which might assist the IFI in advising the Minister on methods he or she might adopt for the management of salmon stocks.

The SSC comprises scientific advisers drawn from the State Agencies with responsibility for salmonid research, management, protection and restoration i.e. Marine Institute (MI), Inland Fisheries Ireland, the Environmental Protection Agency (EPA), National Parks and Wildlife Service (NPWS), Bord Iascaigh Mhara (BIM), the Electricity Supply Board (ESB), The Loughs Agency, the Agriculture, Food and Biosciences Institute for Northern Ireland (AFBINI), (see Appendix I). Although the scientists are drawn from these agencies, the advice from the SSC is independent of the parent agencies and is considered as independent advice by IFI.

The purpose of this report, therefore, is to provide the technical and scientific information required in order to meet these terms of reference. This includes information on Irish salmon stocks, the current status of these stocks relative to the objective of meeting Conservation Limits (CLs), and the catch advice which will allow for a sustainable harvest of salmon into the future. The report also outlines the scientific advice process leading to the formulation and presentation of the catch advice for the 2012 season following the Irish Government’s decision in 2006 to move towards single stock fisheries on stocks meeting Conservation Limits and to end mixed stock fishing at sea.

National Objectives

Government Policy

http://www.dcenr.gov.ie/Natural/Inland+Fisheries+Division/Inland+Fisheries+Division.htm

In 2008, the responsibilities for inland fisheries including the governance of salmon fisheries was transferred to a new department *i.e.* the Department of Communications, Energy and Natural Resources, DCENR.

Government policy is to conserve the inland fisheries resource through effective corporate governance of the agencies operating under the aegis of the Department and to facilitate exploitation of the resource on an equitable and sustainable basis.

The Governments strategic objectives are to**:**

- Ensure the effective conservation, primarily through Inland Fisheries Ireland and the Loughs Agency, of inland fish habitats and stocks.
- Deliver effective legislative and regulatory framework and value for money management for the inland fisheries sector.

International Obligations

In the provision of advice the IFI and the DCENR must also consider Irelands international obligations regarding catch advice and attainment of Conservation Limits. Some of these are outlined below.

The North Atlantic Salmon Conservation Organisation (NASCO)

Ireland, as part of the EU, is also a signatory to the NASCO Convention. The primary management objective of NASCO is:

'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'.

In 1998, the North Atlantic Salmon Conservation Organisation (NASCO, 1998) to which the EU is a Contracting Party on behalf of member States, adopted the "precautionary approach" to fisheries management (as outlined in FAO, 1995, 1996). The NASCO Agreement on the Adoption of the Precautionary approach states, that:

'*an objective for the management of salmon fisheries is to provide the diversity and abundance of salmon stocks'*

or in other words to maintain both the productive capacity and diversity of salmon stocks. NASCO provides interpretation of how this is to be achieved. Management measures should be aimed at maintaining all stocks above their Conservation Limits by the use of management targets. Socio-economic factors could be taken into account in applying the Precautionary Approach to fisheries management issues. The precautionary approach is an integrated approach that requires, *inter alia*, that stock rebuilding programmes (including as appropriate, fishery management actions, habitat improvements and stock enhancement) be developed for stocks that are below Conservation Limits.

In 2008, NASCO indicated that the recent Irish salmon management procedures

" fully comply with NASCOs agreements and guidelines."

The International Council for the Exploration of the Sea (ICES)

ICES provides scientific advice to NASCO for the management of fisheries in the North Atlantic with particular reference to the mixed stock fisheries of West Greenland and Faroes. In 2011, ICES provided specific advice to NASCO for the stocks of salmon from southern Europe *i.e.* the stock complex representing salmon originating from rivers in Ireland, UK, France and Spain.

Advice for 2012 to 2015 from ICES to NASCO (NASCO CNL(11)

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

A more complete summary is provided in Appendix II.

The EU Habitats Directive

Council Directive 92/43/EEC (on the conservation of natural habitats and of wild flora and fauna) states that:

"*If a species is included under this directive, it requires measures to be taken by individual member states to maintain or restore them to favourable conservation status in their natural range".*

The North Atlantic salmon (*Salmo salar* L.) has been included as one of the species covered by the directive. From an Irish perspective, there are currently 30 Irish salmon rivers listed which fall specifically under the directive (Appendix III). However, in applying the directive consideration must be given to all of the populations and not just specifically to these 30 rivers.

The conservation status of a species means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within its territory (also defined) and this *conservation status* will be taken as 'favourable' when:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future

- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis…"

The directive specifically allows for provision to be made for management measures for salmon, if their conservation status so warrants, including the prohibition of certain means of capture or killing, whilst providing for the possibility of derogations on certain conditions.

Under the terms of the directive, every 6 years member states are obliged to submit a report detailing the conservation status of their salmon stocks. The first such report was submitted in 2007 to the Commission (as part of Irelands reporting requirements under Article 17 of the European Councils Directive) and states that :

"The salmon population in Ireland has declined by 75% in recent years and although salmon still occur in 148 Irish rivers, only 43 of these have healthy populations". (Anon. 2008)

Note: The analysis carried out by the SSC in 2011 for 2012 indicates that the number of rivers with "healthy populations" i.e. meeting Conservation Limits has now risen to 58.

Factors leading to this decline are described such as reduced marine survival (probably as a result of climate change), poor river water quality (resulting from factors such as inadequate sewage treatment, agricultural enrichment, acidification, erosion and siltation), forestry related pressures and over-fishing. Concerns related to factors causing mortality at sea, such as diseases, parasites and marine pollution are noted. Although the range where salmon were to be found was classified as good, the population size was considered bad, habitat condition was considered poor with future prospects also considered poor. The overall classification for the Atlantic salmon in Ireland was therefore described as "Bad".

Member States will be obliged to take measures to ensure that the exploitation of salmon stocks is compatible with their being maintained at a favourable conservation status. Such measures may include:

- temporary or local prohibition of the taking of salmon in the wild and exploitation of certain populations,
- regulation of the periods and/or methods of taking salmon,
- application, when salmon are taken, of hunting and fishing rules which take account of the conservation of such populations,
- establishment of a system of licences for taking salmon or of quotas,
- regulation of the purchase, sale, offering for sale, keeping for sale or transport for sale of salmon.

Conservation Limits and Scientific Advice

It is clear from the Government's strategy and international advice that the ***conservation*** of salmon stocks is the primary consideration and that there is an aspiration to ensure that national and international obligations are being met. However, in order to provide advice on conservation, it is necessary to establish a conservation "reference point" or "Conservation Limit" which can be measured and used to assess the status of stocks. The following concepts were used by the SSC when considering a Conservation Limit for Irish salmon stocks and for use in the provision of precautionary catch advice.

The Salmon Management Task Force (Anon., 1996) provided the following advice regarding conservation of stocks:

- *Salmon Management will be based on the premise that there is a definable number of spawners for a given river*
- *Sustainable exploitation can take place if there is a surplus of fish over spawning requirements*

The Task Force proposed the application of a Total Allowable Catch (TAC) to allow sufficient fish to spawn to meet these "spawning requirements".

In 1998, the **North Atlantic Salmon Conservation Organisation** (NASCO, 1998) adopted the precautionary approach to fisheries management (as outlined in FAO, 1995, 1996). Central to this was the agreement that management measures should be aimed at maintaining all salmon stocks in the NASCO Convention Area above pre-agreed Conservation Limits. The Conservation Limit for Atlantic salmon is defined by NASCO as:

"the spawning stock level that produces long term average maximum sustainable yield as derived from the adult to adult stock and recruitment relationship".

Both the Salmon Management Task Force and NASCO describe a biological reference point, which can be used to assess if salmon stocks are reproducing in sufficient quantities to generate the next generation of salmon. Salmon home to their natal river to spawn and as the number of spawning fish increases, then the number of juveniles increases and also the number of migrating smolts increases. This generally means that the number of adults returning in the following year as 1 sea-winter salmon (or grilse) or in subsequent years as multi-sea winter salmon (2 sea-winter, 3 sea-winter *etc.*) also increases. These older and larger fish usually return in the springtime and are often referred to as spring salmon.

However, there is a limit to the number of juvenile salmon any river can support due to competition for food and space. The addition of more spawning salmon can reach a point where they are not contributing to additional production of juveniles. In this regard, there is a surplus of spawning fish and these can be harvested in a sustainable manner. As each river holds a unique spawning population, which has evolved to survive best in that rivers environment, and there is little straying of salmon from one river to another, a Conservation Limit (CL) of the number of spawning salmon appropriate for each individual river can be calculated.

As both the Salmon Management Task Force advice and the NASCO definition are compatible, the reference point chosen by the SSC to establish the status of individual stocks is the maximum sustainable yield or MSY as described by ICES (2005).

This point can be clearly identified from Stock – Recruitment curves, which are used extensively in fisheries science and fisheries management. ICES in particular has stressed that this is a **Limit Reference Point** *i.e.* it sets a boundary that defines safe biological limits within which the stock can produce a long term maximum sustainable yield. It therefore delimits the constraints within which the management strategy must operate to maintain a sustainable resource. Individual salmon stocks may well exceed this limit but should not be allowed to fall below the Conservation Limit (ICES 2005). Given the poor returns and low marine survival which prevail currently the SSC advice therefore is to meet the Conservation Limit in the shortest possible time period rather than over a protracted time period. The exception here might be the impounded rivers i.e. Erne, Lee, Shannon, Liffey where due to the specific problems associated with fish passage in these rivers, plans may require restoration of individual tributaries upstream of the impoundments on a phased basis initially.

Ideally river specific stock and recruitment analysis would be the most accurate way to determine river specific Conservation Limits (Crozier *et al.,* 2004). However, the acquisition of these relationships are resource intensive as they require a long time scale to cover many generations and a wide range of stock levels. Typical relationships are based on 20 to 30 years of stock and recruitment data. It will, for the foreseeable future, be necessary to transport CLs from data-rich rivers to data-poor rivers (Prévost *et al*., 2004). To this end a "Bayesian" hierarchical modelling framework has been developed to transport stock and recruitment information between rivers and to set Conservation Limits accordingly (Crozier *et al.,* 2004, Ó Maoiléidigh *et al.,* 2004). It is important to note that that "wetted area" is the only common parameter for all rivers (Irish rivers and European index rivers) available to the SSC for these analyses (and most other European rivers). More refined models based on available spawning habitat, river grades or quality etc will require that these measures are available for both the subject rivers and the monitored rivers and at present this is not the case. Standardised surveys will be required for this in the future.

Establishment of Conservation Limits for all Irish salmon rivers.
Statistical techniques were developed within the context of the EU funded concerted action i.e. SALMODEL (A co-ordinated approach to the development of a scientific basis for management of wild salmon in the North-East Atlantic, Crozier *et al.*, 2004).

The Bayesian analysis of this hierarchical model has been developed from a set of 13 stock and recruitment data series from monitored salmon rivers located in the Northeast Atlantic. The model yields a set of predicted stock and recruitment parameters for new rivers, provided information is available on the size of the river (in this case usable habitat or wetted area is used) and on the rivers latitude. Details of the model specification and its Bayesian treatment are given in Prevost *et al.*, (2003) and their application to Irish rivers in Ó Maoiléidigh *et al*., 2004. The wetted area is computed from statistically combined parameters: the length of upstream river, upstream catchment area, stream order, and local gradient interpolated from aerial photography within a GIS platform (McGinnity *et al.,* 2003). The latitude value used is the river catchment area mid-point. A description of the Bayesian Hierarchical Stock and Recruitment Analysis is given in Appendix IV.

Defining Mixed Stock Fisheries and Catch Advice

The migratory behaviour of the Atlantic salmon presents many opportunities for their interception, and a wide range of fisheries have developed, operating in rivers, estuaries, coastal waters and the open ocean. Two contemporary definitions for mixed stock salmon fisheries are given below.:

1. From Potter and Ó Maoiléidigh (2006)

"…MSFs might be defined as any fisheries operating outside estuary limits. The majority of fisheries operating outside river estuaries are known to take salmon from more than one river stock, while within estuary limits, it is unusual (where data are available) for fisheries not to be taking predominantly fish from a single river. This conforms to ICES (2005) advice which states that fisheries in estuaries and rivers are more likely to fulfil the requirement of targeting stocks that have been shown to be within precautionary limits".

2. From NASCO 1998

The North Atlantic Salmon Conservation Organisation (NASCO) has defined mixed stock fishing as:

"any fishery exploiting a significant number of salmon from two or more river stocks".

Any definition should be related to the primary fishery management objective, which is to maintain river stocks above precautionary limits.

In 2006, the Standing Scientific Committee (Anon. 2006) provided the following advice to the National Salmon Commission:

- The overall exploitation in most districts should be immediately reduced, so that Conservation Limits can be consistently met.
- Furthermore, due to the different status of individual stocks within the stock complex, mixed stock fisheries present particular threats to the status of these individual stocks.
- Thus, the most precautionary way to meet national and international objectives is to operate fisheries on river stocks that are shown to be within precautionary limits *i.e.* those stocks which are exceeding their Conservation Limits.
- Fisheries operated in estuaries and rivers are more likely to fulfil these requirements.

The Irish Government committed to aligning with scientific advice in 2006 and essentially closed the Irish marine mixed stock salmon fishery (principally drift nets and some coastal draft nets), thus implementing NASCO and ICES recommendations and complying with the Habitats Directive. The Government also recognised that compliance with scientific advice from 2007 onwards would mean hardship for commercial fishermen and vulnerable coastal communities. Accordingly, the Government appointed an Independent Group to examine all the implications of aligning with scientific advice for commercial fishermen salmon fishing. The Independent Group reported to the Minister in October 2007 and a hardship scheme was introduced for the fishermen affected by the Government decision to move towards single stock salmon fishing only (Collins *et al*, 2006).

Assessment Methodology for 2012 Catch Advice

There was no change to the methodology used to provide catch advice in 2011 for the 2012 season. A summary of the approach is shown below in Figure 1. In the absence of a drift net fishery (or any other net fishery) at sea, in-river or estuarine measures of abundance have been used (*i.e.* fish counter data and rod/net catch data) to provide a primary measure of spawning stocks and attainment of Conservation Limits.

With the operation of fisheries restricted to estuaries and rivers from 2007, the assessment is now focussed primarily on estimating individual river returns from catch data, counter data (if available) and ranges of rod catch exploitation rates derived from observed values in Irish rivers in recent years.

A more comprehensive description of the data used and the assessment in 2011 for the 2102 fishery is provided in the relevant section below.

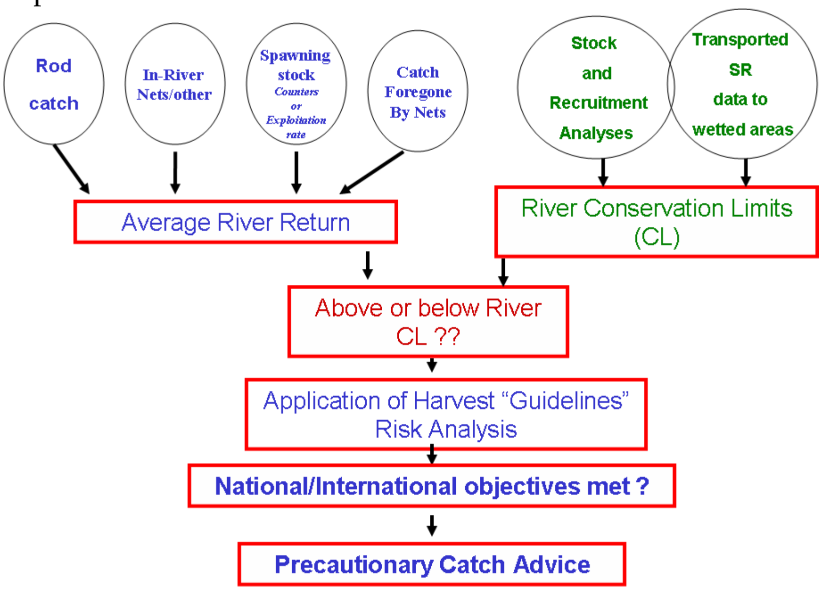

Figure 1. The Scientific Process for 2012 catch advice.

Information and data

Every effort is made to obtain relevant data and monitor the performance of stocks (attainment of Conservation Limits) at the river level and consequently to assess the status of individual riverine stocks. Several sources of information are used in this process.

Commercial catch data – Despite the closure of the mixed stock fisheries, the catch statistics derived from the estuarine commercial fisheries (principally draft nets) will remain an important source of quantitative information if fished, particularly in determining the overall size of the returning stock and the attainment of river Conservation Limits. Following implementation of the wild salmon and sea trout tagging scheme which commenced in 2001 (Ó Maoiléidigh *et al.*, 2001; Anon 2004), the catch data are derived from the logbook returns of commercial fishermen.

Rod catch data – The reported rod catch from the wild salmon and sea trout tagging scheme (Anon. 2003 to 2010) is adjusted to take into account the numbers of fish that have been caught by anglers who have not returned their logbook. The adjustment follows Small (1991). In some instances, directly reported rod catches from IFI Regional Fisheries officers or rod catch data from managed fisheries (clubs, private owners who maintain reliable records), provided these have been vouched for by IFI officers, have also been used.

Total traps and counters – Data are available from several counters (see below) and salmon traps including the national and international salmon research and monitoring facility on the Burrishoole River in Mayo, which provides a direct measure of the total adult returns and smolt migrations annually. Similarly, data from an adult salmon trap on the River Screebe (Connemara) are also available for some years.

In addition to direct counts from these traps, count data are available for 21 fish counters for a number of years. These are:
Dee (Dundalk), Boyne (Drogheda), Liffey (Dublin), Slaney (Wexford), Blackwater (Lismore), Bandon (Cork), Blackwater, Maine, Waterville/Currane (Kerry), Feale, Mulkear (Limerick), Corrib (Galway), Casla, Ballinahinch (Connemara), Erriff (Ballinakill), Owenmore (Bangor), Ballysadare (Sligo), Eske, Eany (Ballyshannon) and Clady (Letterkenny).

The following approach has been adopted in interpreting the count data and utilising these to measure the attainment of Conservation Limit:

- Fish counter data are provided by the seven regional fisheries boards (or the Marine Institute in the case of the Liffey in Dublin) and some private fishery owners. A process of validation is carried out during the year whereby a proportion of the counter data is examined in relation to contemporaneous video footage (resistivity counters) or self generated infra-red images (infra-red counters). A value representing the "validated" count is generally used for subsequent analyses.
- It is assumed that all of the downstream counts up to the end of May represent out-migrating kelts *i.e.* fish ascending the river in the previous year.
- The downstream count from June to December is then subtracted from the upstream count in the same period, correcting for fish counted upstream but which may then come back downstream.
- The ratio of salmon to sea trout, obtained during video analysis (resistivity counters) or image analysis (infra-red counters) is generally applied to fish observed over the entire run in order to determine the number of salmon in the run.
- The Cork Blackwater and Slaney are raised by a factor of two to allow for the partial nature of these counts.
- Raising factors may be applied to those counters where the possibility of fish moving over the weir without being counted has been reported, the recorded count is raised by a further percentage depending on observations. However, it is essential that these observations are based on assessments carried out by local fisheries authorities or the agencies involved in salmon stock assessment. Examples where raising factors have been applied include the Bandon count from 2010 which was multiplied by 2 based on the fact that part of the weir had collapsed. Similarly, observations by the IFI suggests that up to 70%

more fish pass over the counting weir on the Boyne than are counted through the counter. In 2012, data for the Eany were modified to include the possibility of fish by-passing the weir without being counted (12%). These values will be improved following ongoing counter validation work by Inland Fisheries Ireland and the Marine Institute.

- In those situations where the majority of the rod catch is made above the counter, the rod catch is subtracted from the fish counter record.
- In the case of the River Slaney where the proportion of spring salmon to grilse is much higher than most other rivers in Ireland, a specific analysis was carried out which allows the specific numbers of grilse and spring salmon to be allocated over the season with greater precision than in previous assessments. In this instance, River Slaney rod catch data (2002 to 2006) from the salmon carcass tag and logbook scheme, draft net catch data (2006) and video counter verification data were analysed to determine the monthly proportions of grilse and salmon and the total annual run apportioned accordingly and compared to the 1SW and MSW Conservation Limits.
- Partial counter information for the River Maine in 2009 and a more complete count in 2010 and 2011 were also considered in the assessment for catch advice in 2011 and 2012.

National Coded Wire Tagging and Tag Recovery – The programme was initiated in 1980 to estimate marine survival of Irish salmon stocks and exploitation rates by high seas fisheries, and home water commercial and recreational fisheries (Browne, 1982. Despite the closure of the mixed stock fisheries in 2007, information from this programme will continue to inform on marine survival rates and exploitation in some estuarine and rod fisheries and more importantly indicates whether fluctuations in the numbers of returning adukts are as a result of management measures of changes in factors occurring outside of management control i.e. environmental/climate changes. A 1 mm long magnetised tag, etched with a specific batch code is injected into the nose cartilage of juvenile fish, usually pre-smolts. The code identifies the origin and release conditions of any fish subsequently recaptured. The adipose fin is removed to facilitate the identification of these fish in the recovery programmes. Tagging has taken place using 10 hatchery stocks and between 1 and 3 wild salmon stocks. Since 1980, up to 200,000 salmon representing over 50% of the national catch in some years, have been individually examined each year to identify coded wire tagged salmon and recover these tags. Due to the closure of the mixed stock fisheries significantly more tags are being recovered recovered from broodstock collections in rivers where hatchery fish had been tagged and released in the previous year. This provides invaluable information on marine survival and exploitations rates for these tagged stocks which can be applied more generally to other rivers systems where these data are not available.

Other data – Information on juvenile abundance indices derived from electro-fishing surveys carried out annually by IFI are examined as a surrogate of stock abundance and this method was applied in conjunction with other indicators in 2007, 2008, 2009, 2010 for the 2011 advice. A summary of the methodology is provided in Appendix VI.

Water Quality Assessment – The Environmental Protection Agency (EPA) carries out a triennial survey of the biological elements of water quality at over 3,300 monitoring stations on main river channels. These surveys derive a biological quality rating or 'Q value' of waters at each monitoring station. Recent studies carried out by the Central Fisheries Board (T. Champ, *pers. comm.*) correlating the presence or absence of individual fish species to water quality (Q values) indicate that there is a relationship between juvenile salmon distribution and water quality. A GIS database was developed to link river habitat with water quality data provided in the Environmental Protection Agency's (EPA) 'Biological River Monitoring Programme'. A custom GIS automated function determines the Q value for each river by a geographical cross-reference to the corresponding element in the water quality database. Water quality statistics are taken directly from McGinnity *et al.* (2003).

Status of individual rivers relative to Conservation Limits

In line with international advice on salmon stocks, the SSC advise that the best way to meet national and international objectives of conserving salmon stocks in all salmon rivers is to allow fisheries only in rivers or the estuary of that river, where there is a greater probability of targeting only the stocks originating from these rivers (*i.e.* single stock fisheries). The SSC also advise that fisheries should take place only on stocks that are shown to be meeting their Conservation Limit with the catch restricted to the estimated surplus above Conservation Limit. This advice follows from International best practice as advised by ICES and NASCO.

The main objective of the SSC advice therefore, is to ensure that there are sufficient spawning salmon remaining after commercial and recreational fisheries to meet the required Conservation Limit for that river. In order to do this, the number of salmon which will be available before the fishery takes place must be "forecast" for each river annually, based on the average returns in recent years (usually the most recent 5 years provided sufficient information is available). The information required for this forecast is:

Total returns = Total reported catch + Total spawners

Estimating the total catch in each river

As stated previously the catch data for draft nets, other commercial engines (snap nets, bag nets *etc.*) and rods, derive from mandatory fishing logbooks or from vouched information supplied by the IFI directly. The forecast model requires the inclusion of the fish taken by the commercial fisheries in each river. For the purposes of analysis, it is assumed that the spawning stock of any river with a rod catch of less than 10 salmon per annum is 33% of its Conservation Limit until further information is made available. An allocation of fish from net catches in mixed stock fisheries (when operated) may also be included depending on the geographic region of these rivers.

Estimating the spawning stock in each river using rod exploitation rates

Rod exploitation rates derive from observed exploitation rate values from fish counters or traps on Irish rivers and supported by information from the scientific literature and the National Coded Wire tagging and Tag Recovery Programme. Exploitation by angling on grilse stocks varies but is generally between 10% and 30% of the total river stock available (Milner *et al.*, 2001). These authors quote mean values of 19% for UK rivers, while values for specific Irish grilse (1SW salmon) fisheries have been estimated for the River Erriff at 19% between 1986 and 2000 (Gargan *et al.*, 2001), and 15% for the Burrishoole between 1970 and 2000 (Whelan *et al.*, 2001). However, in 2008, the SSC evaluated all existing information on individual rod fisheries made available by IFI, including field observations of fisheries which have known high or low intensity, to derive more precise estimates of the likely rod exploitation rate on a river by river basis. Estimates of angling exploitation on multi-sea winter stocks are generally higher than those reported for grilse (Solomon and Potter 1992) and this has also been observed from Irish fish counter data.

This assessment is best applied where there is a consistent level of fishing activity in the river system. For many small rivers this will not be the case and this assessment approach is not used for rivers where the average reported rod catch for the most recent 5 year period is 10 or less. In this instance, a fixed value for the spawning stock of 33% attainment of the Conservation Limit is applied as there is a strong case to have these more vulnerable stocks protected until specific information on stock status is made available to the SSC. If no new rod catch or counter data is available since 2006, the assessment includes any additional fish which may have been intercepted in the mixed stock fisheries when these were taking place up to 2006.

Provided the catch in a river is known, the total stock can be estimated by extrapolation using an appropriate exploitation rate in the fishery *e.g.*:

> *If the rod catch of salmon was 150 fish and the exploitation rate in the fishery was 10%, then the total stock of salmon available to generate this catch would be estimated as the catch raised by the exploitation rate:*
>
> *Catch / Exploitation rate * 100*
>
> *In this case 150 / 10 * 100 = 1,500 salmon.*

Estimating the spawning stock remaining after the fishery has taken place is obtained by subtracting the catch from the total stock available

> *i.e. 1,500 - 150 = 1,350 salmon remaining for spawning.*

For most rivers, the specific exploitation rates are not known and therefore a range of values is applied within which the true value is expected to be. Further, as there is now specific rod exploitation data for Irish rivers with fish counters, it has been possible to allocate all rivers into specific groups representing heavily fished (higher exploitation rate) to lightly fished rivers (low exploitation rate). This restricts the overall range of values being used to a more likely range rather than applying the entire range of values observed. Table 1 in Appendix VII provides the exploitation rate range used for each river.

While these exploitation rate ranges are believed to provide a reasonable estimate of the likely number of spawning salmon, a further step is taken by applying a forecast model (Monte Carlo simulation) to forecast a single value for the total stock available and a catch option which will provide at least a 75% chance of meeting the Conservation Limit if harvested.

A brief explanation of the risk analysis and an example of the data used for the model is provided in Appendix V for the Dundalk District based on the 2008 catch advice.

Provision of Harvest Guidelines

Once estimates of average spawners, average catch, and river specific Conservation Limit have been derived, harvest options are provided along with the associated probability of meeting the Conservation Limit at various catch options (example in Appendix V). Where estimates were available for both a counter (or trap) and a rod catch, the values for the counter only are used.

Following the procedure used by ICES for the provision of catch advice for West Greenland, the harvest option that provides a 0.75 probability level (or 75% chance) of meeting the Conservation Limit for a given stock is recommended. Where there is no harvest option which will provide a 75% chance of meeting the Conservation Limit, then there is no surplus of fish to support a harvest (commercial or rod). Examples of the risk outputs and application of the harvest guidelines are shown in Appendix V. It should be noted that as the harvest increases, the probability or chance of meeting the required Conservation Limit decreases.

Given the uncertainty in the data and the use of a risk analysis to allow for some of this uncertainty, a further limitation is applied to the recruit per spawner index of each river. The SSC currently apply a maximum recruit per spawner value to the abundance outputs derived from the risk assessment of 3 i.e. for every one spawner three recruits may be produced. This is considered to reflect better the overall status of salmon stocks both nationally and internationally.

An objective of the catch advice from the SSC is to ensure that harvest fisheries only take place on river stocks meeting and exceeding Conservation Limits. The means to achieve this objective is to only allow harvest fisheries which can specifically target single stocks which are meeting their Conservation Limits. Up to 2010, only two specific “mixed stock fisheries” were considered, each containing only two contributing single stocks, each stock meeting Conservation Limits and a harvestable surplus identified based on best available fisheries and counter data. Mixed stock fisheries advice was provided for the Castlemaine Harbour area in 2011 and 2012 following a specific request from IFI.

However, mixed stock fisheries will always present greater risks than when stocks are exploited separately because of uncertainties, or variability, in the proportion of the catch originating from the weaker of the stocks. This is particularly true when there are large differences in the relative numbers of fish in each stock as it may be difficult to estimate the impacts on the smaller stocks. Therefore, to avoid intercepting fish from other rivers, particularly those which are not meeting Conservation Limits, the advice of the SSC is to operate all fisheries within the estuary of the river stock for which the catch advice is being given and not a common bay or estuary where several rivers stocks may be present. Careful consideration must be made of local topography, fishing practices, number of contributing stocks and their status and the ability to discriminate the contributing stocks and manage the fishery effectively.

In a number of rivers the Conservation Limit will be achieved by the contributions of both 1SW (grilse) and MSW (spring fish). There is conservation of biodiversity and fisheries development value in identifying and protecting both life history types. It is important for the fisheries management to be able to determine how much of the Conservation Limit is likely to be met by either MSW or 1SW fish and to regulate fisheries for both components separately. More information is required on the proportions of each component of the stock being exploited and the timing of their entry into estuaries and freshwater.

The SSC have provided advice on 1SW and MSW separately in a number of instances where data were available on the assumption that:

- all fish counted or caught before 31st May are spring fish (except for the Slaney where in-season data are available on proportions of 1SW and MSW salmon.
- rod exploitation rates can be generated from counter information for both stock components.
- 20% of draft net catch is allocated as spring fish as these nets operate from May 12th and MSW salmon (or spring salmon) did not contribute significantly to drift net catches when operated.

Overview of Status of Stocks and Precautionary Catch Advice for 2011

<u>Changes from 2011 catch advice procedure for the 2012 catch advice.</u>

There were few changes to the catch advice procedure for the 2012 season. The present system of updating previous years catch data to reflect official logbook returns was maintained (unless indicated otherwise by local inspectors) while the catch data for the most recent year was based on local inspectors estimates. Data from fish counters were updated for the previous year to include October to December values if available, while provisional counts for the current year were based on estimates to October. Values for October to December were extrapolated from the mean of the previous five years where appropriate. Any further information received which indicated changes to previous catch or counter estimates were incorporated where indicated by IFI.

Therefore, counting each of the combined rivers above as one stock, catch advice for the 2011 season is provided for 140 rivers which includes the impounded waters of the Lee, Shannon, Liffey and the River Erne.

Of these:

- 21 rivers have counter data (includes rivers with large hydro-electric impoundments)
- 2 rivers have trap data.

In a number of instances separate information is provided for stocks above and below hydro-electricity dams in the same river and 1SW and MSW stocks in the same river i.e. the Lee and the Shannon.

Scientific advice is provided in the context of meeting both National and International obligations with the recommendation that this is best achieved by only fishing in the river or the estuary of the river. Where there is no clearly defined estuary limit, fishing should take place within the river. As national and international obligations require that individual stocks should meet Conservation Limits, the only situation where these obligations can be met is where fisheries take place on stocks that are exceeding Conservation Limits, with the catch being limited to or less than the number of fish in excess of these Conservation Limits.

Details of the catch advice for 2012 provided by the Standing Scientific Committee on Salmon in Ireland is given in Tables 1 through 5:

<u>Catch Advice for 2011.</u>

The number stocks with a potential harvestable surplus in 2012 fishery is 58 (Table 1) down from 60 rivers in 2011.

The number of stocks where there is no harvestable surplus forecast for 2012 was 83 (Table 3). This was three more than in 2011.

Catch and release may be permitted by Inland Fisheries Ireland if the estimated stock size is likely to be above 65% of its CL. The number of 1SW stocks meeting this criterion for the 2012 fishery was 15. In addition 9 rivers have been assessed by means of electrofishing indices to meet criteria for catch and release fishing.

There are 16 stocks for which a separate assessment is made for the 1SW and the Multi Sea Winter salmon separately. MSW salmon spend more than one winter at sea before returning to spawn, Generally they comprise less than 7% of the total salmon returning to any given river population but in some instances there may be a significant contribution to the fishery from the MSW cohort suggesting a high proportion of this stock component in the population. Of these MSW stocks, 13 are forecasted to have a harvestable surplus in 2012 (Table 2) which is one less than in previous years. The remaining stocks have had a mixed status but it is estimated that 3 of these can open for catch and release fishery in 2012 (Table 4).

There are currently 30 Irish salmon rivers listed which fall specifically under the EU Habitats directive (Appendix III). Of these, 21 are above their CL, while a further two are meeting the 1SW CL.

Amongst the stocks being assessed are 59 small river stocks where the most recent annual average rod catch has been less than 10 salmon, making a direct assessment difficult. Therefore, the majority are assumed to be failing to meet Conservation Limits. Although these are insignificant fisheries (accounting for less than 0,5% of the total national rod catch when combined), their stocks are important as spawning populations in their own right which must be maintained for biodiversity as required under the EU Habitats Directive. The Standing Scientific Committee advise that additional information should be made available to assess stock status relative to their Conservation Limits for these small rivers.

Finally, there are 4 major rivers with hydro-electric generating stations where significant numbers of hatchery fish have been or are being released to mitigate against the loss of wild salmon *i.e.* the Liffey, Lee, Shannon and Erne (Table 5). The stocks in the areas above the impoundments are significantly below their Conservation Limits and following the scientific advice already provided for other rivers, there should be no harvest fisheries on wild salmon in these specific rivers. However, it is also recognised that the release of so many hatchery reared salmon has resulted in fishery opportunities within these rivers for these stocks. The Standing Scientific Committee has met with the DCENR and its agencies (Regional Fisheries and Central Fisheries Boards, the Marine Institute, BIM,) as well as the Dept. of the Environment (NPWS) and ESB to review the objectives behind these hatchery programmes. In the main, the consensus view is that the primary objective of the hatchery programmes is to re-establish self-sustaining salmon populations in these rivers (which has not to date been achieved). Therefore, restoration programmes should be given precedence until such time as significant improvements to generation of self-sustaining runs of salmon above these impoundments has been made within the context of agreed restoration plans. In this regard, issues relating to the suitability of hatchery reared stocks for rebuilding wild stocks need to be addressed and the possible negative effects of allowing hatchery fish to interbreed with the small remaining populations of wild or at "established" salmon populations in these rivers also needs to be considered.

The Standing Scientific Committee advises that:

- Harvest of salmon should only be allowed on stocks from rivers where there is a surplus above the Conservation Limit identified and that no more than this surplus should be harvested *i.e.* those rivers detailed in Table 1 and 2.
- Harvest fisheries should not take place on stocks from rivers without an identifiable surplus above the Conservation Limit *i.e.* those rivers identified in Table 3, 4 and 5.
- No harvest fisheries should take place on those stocks from rivers where the average rod catch has been less than 10 salmon annually and which are not meeting Conservation Limits, until such time as additional information becomes available to assess the status of these stocks relative to their Conservation Limits.

Due to the different status of individual stocks within the stock complex, mixed stock fisheries present particular threats to stock status (ICES 2012, Appendix II). The objective of the catch advice from the SSC is to ensure that harvest fisheries only take place on river stocks meeting and exceeding Conservation Limits. The means to achieve this objective is to only allow harvest fisheries which can specifically target single stocks which are meeting their Conservation Limits. The SSC strongly advise that all fisheries should operate only on the target stock as close to the river mouth or within the river to achieve this.

<u>Mixed Stick Fisheries Advice</u>

In the case of the Killary Harbour (Ballinakill) fishery, there are two contributing stocks (Delphi and Erriff) both of which are meeting and exceeding their Conservation Limits. Similarly, the draft net fishery operating in the Bangor District predominantly exploits stocks from either the Owenmore and the Owenduff rivers, again both of which are meeting and exceeding their Conservation Limits.

Up to 2010, these were the only such mixed stock fishery situations considered by the SSC, as in other instances there were more than three contributing stocks and/or one or all of the contributing rivers are failing to meet Conservation Limits or given the disproportionate size of the contributing stocks, a potential mixed stock fishery would pose a threat to the attainment of Conservation Limits immediately or in the future.

Subsequent to the SSC advice being given for 2011 and by request from IFI, a mixed stock fishery analysis was carried out for the Castlemaine Harbour area on the understanding that it was ***not possible*** to fish within the estuaries of the three main contributing rivers (Caragh, Laune and Maine) catch options were provided by the SSC for this area under current legislation i.e.

Section 94 of the 1959 Fisheries Act states ‘’ it shall not be lawful for any person (other than the owner of a several fishery within the limits thereof) to shoot, draw ,or use any net for the taking of salmon at the mouth of any river or within half a mile seaward or half a mile inwards or along the coast from the mouth of any river.’’

Even where all exploited stocks in a common estuary are meeting their Conservation Limits, as may occur if there is a return to conditions of higher marine survival of salmon stocks or when the full effects of the recent fishery closures, mixed stock fisheries introduce greater uncertainty into predicting the effects of management measures and pose a greater threat to small stocks or populations, especially if these are of low relative productivity and/or subject to high exploitation. As the number of stocks (or populations) increases, the number of fish that must be released from the fisheries in order to meet Conservation Limits must also increase. When the number of populations is too large, it may be impossible to ensure a high probability of the simultaneous achievement of spawner requirements in each individual unit. The overall objective should be to achieve a flexible but sustainable fishery without compromising conservation goals by fishing only single stocks salmon stocks which are shown to have a harvestable surplus over the Conservation Limit. The best way to achieve this is to fish within the river or as close to the river as possible (i.e. the estuary of that river).

Monitoring the changes to the status of stocks since the closure of the mixed stocks fishery at sea in 2007.

Information from the National Fish Counter Programme operated by the IFI for recent years is presented below. The mean count (nett upstream stock of salmon) for the years prior to the closure of the mixed stock fishery at sea fishery from 2007 were compared with counts for the subsequent years to 2011. In most instances there were more than four years of counts available for the pre-2007 period. Three years were available for the Dee, two years were available for Boyne while the comparison for the Mulkear, Ballinahinch, Owenmore and Eske is based on the 2006 cont only.

Given that exploitation rates on wild stocks averaged approximately 50% in the years when mixed stock fisheries were operating at sea, (based on coded wire tag returns), an increase of 100% (i.e. a doubling of counts indicated in the figure below) might have been expected in 2007 following the closure of this fishery. This was achieved or exceeded for many counters rivers in that year. In 2008, although most rivers counts were higher than in the pre-2006 period, some decreases were evident and several had counts which were lower than in the pre-2006 period. In 2009, virtually all counts were down on the previous two years with some counts again being even lower than the pre-closure period. In 2010 the situation improved with most rivers again showing increased counts over the previous year and the pre-2006 period. In summary, the closure of the mixed stock fishery at sea for salmon in 2006 resulted in generally increased runs to the rivers with counters and probably therefore to most rivers, particularly on the southern and western coasts. Counts in 2011 were generally lower than in 2010. Since 2007 the returns have fluctuated with most rivers maintaining a substantial improvement in counts while a small number have declined in at least one year of the last fiver.

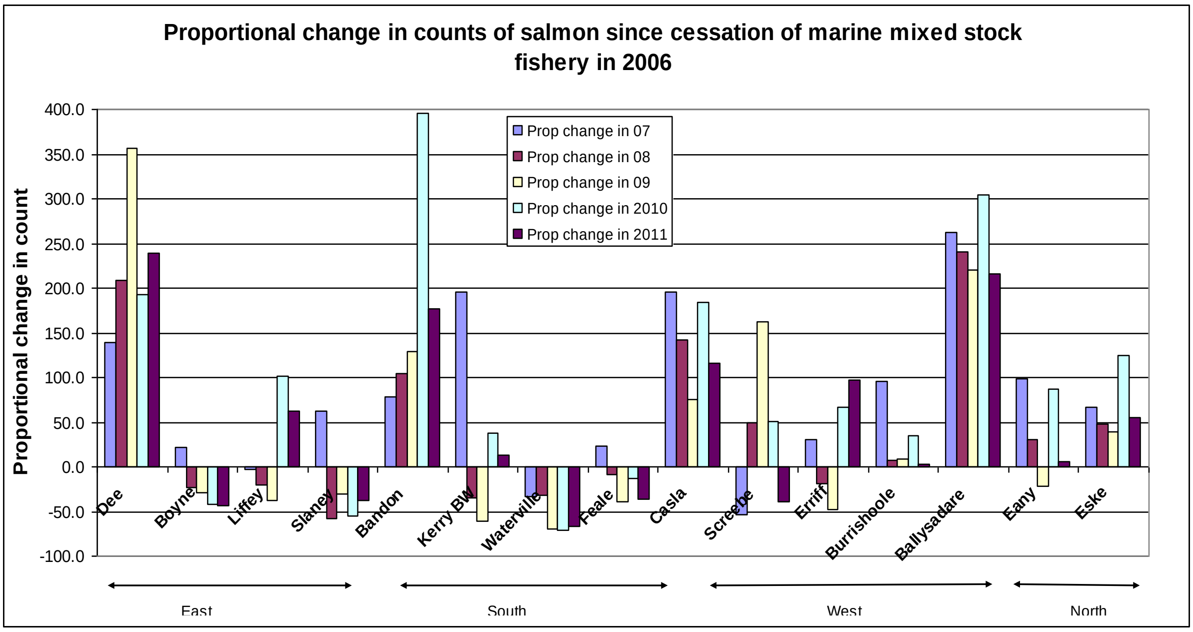

Table 1. Irish rivers meeting Conservation Limits and the estimated surplus for 1SW and MSW stocks combined unless otherwise indicated.

District	Predicted Recruits	CL	Surplus
Dundalk	Castletown	197	59
Dundalk	Fane	543	300
Waterford	Nore	11958	4816
Waterford	Suir, Clodiagh, Lingaun, Blackwater	16808	1975
Waterford	Colligan	338	118
Lismore	1SW Blackwater, Glenshelane, Finisk	12103	3114
Cork	Owennacurra	179	127
Cork	Lower Lee (Cork)	1184	2369
Cork	1SW Bandon counter	1742	933
Cork	Ilen	1014	351
Cork	Mealagh	88	176
Cork	Owvane	401	348
Cork	Coomhola	306	126
Cork	Glengarriff	229	67
Cork	Adrigole	169	29
Kerry	Kealincha	124	19
Kerry	Lough Fada	91	14
Kerry	Croanshagh	301	76
Kerry	Roughty	1245	800
Kerry	Blackwater (Counter)	539	79
Kerry	Sneem	371	742
Kerry	1SW Waterville counter	336	523
Kerry	Inney	649	500
Kerry	Ferta	197	76
Kerry	1SW Caragh	872	404
Kerry	1SW Laune and Cottoners	2555	5110
Kerry	Maine	1487	1510
Kerry	Owenmore	102	205
	Common Embayment Castlemaine		6246
Limerick	Feale counter, Galey and Brick	3491	3208
Limerick	Mulkear Counter	5390	1304
Galway	Corrib counter	7589	4371
Connemara	Cashla counter	349	573
Connemara	L.Na Furnace	66	12
Connemara	Ballynahinch counter	1088	1557
Ballinakill	Owenglin	372	528
Ballinakill	Dawros	582	709
Ballinakill	Culfin	144	289
Ballinakill	Erriff counter	1300	600
Ballinakill	1SW Bundorragha (Wild Rod)	162	241
Ballinakill	*Common Embayment Killary*		751
Bangor	1 SW Newport R. (Lough Beltra)	523	492
Bangor	1SW Owenduff (Glenamong)	925	1732
Bangor	1SW Owenmore/Muinhin	947	1895
Bangor	*Common Embayment*		3367
Bangor	Glenamoy	630	198
Ballina	1SW Moy	16974	25397
Ballina	Easky	1297	1272
Sligo	Ballysadare counter	5098	4485
Sligo	1 SW Garvogue (Bonnet)	2262	143
Sligo	Drumcliff	474	143
Ballyshannon	Duff	1182	390
Ballyshannon	1 SW Drowes	704	1409
Ballyshannon	Eske Counter	823	164
Ballyshannon	Eany counter	1740	653
Ballyshannon	Glen	957	506
Letterkenny	Owenea and Owentocker	2231	1315
Letterkenny	1SW Gweebarra	445	669
Letterkenny	Gweedore (Crolly R.)	325	351
Letterkenny	Tullaghobegly	226	9
Letterkenny	Crana	1119	458

Table 2. MSW rivers above Conservation Limits. Forecasted Returns, Conservation Limits and Estimated Surplus above the required Conservation Limit for MSW stocks only.

District	Predicted Recruits	CL	Surplus
Lismore	Blackwater	1045	341
Kerry	2SW Waterville counter	57	114
Kerry	2SW Caragh	234	270
Kerry	2SW Laune	715	610
Shannon	Feale counter, Galey and Brick	842	541
Galway	Corrib counter	843	815
Ballinakill	Bundorragha (Wild Rod)	42	84
Bangor	2SW Owenduff (Glenamong)	389	462
Bangor	Owenmore R.	632	617
Ballina	Moy	1188	2376
Sligo	2SW Garvogue (Bonnet)	566	37
Ballyshannon	2SW Drowes	302	604
Letterkenny	2SW Gweebarra	118	220

Table 3. Status of rivers below Conservation Limits ranked by the % CL attainment. 1SW and MSW combined unless otherwise shown.

District	Predicted Recruits	CL	Deficit	*Proportion of CL being achieved*
Waterford	**Mahon**	442	**-387**	***0.12***
Dublin	**Liffey counter**	4391	**-3549**	***0.19***
Dundalk	**Glyde**	2172	**-1752**	***0.19***
Limerick	**Maigue**	3907	**-3123**	***0.20***
Lismore	**Bride**	1379	**-1038**	***0.25***
Dundalk	**Dee Counter New Wetted area**	2195	**-1607**	***0.27***
Letterkenny	**Leannan**	3619	**-2613**	***0.28***
Limerick	**Fergus**	2391	**-1702**	***0.29***
Letterkenny	**Swilly**	1083	**-757**	***0.30***
Limerick	**Inagh**	1033	**-668**	***0.35***
Ballina	**Cloonaghmore (Palmerstown)**	1261	**-794**	***0.37***
Ballina	**Brusna**	1113	**-692**	***0.38***
Ballina	**Leaffony**	218	**-135**	***0.38***
Ballina	**Ballinglen**	396	**-245**	***0.38***
Dublin	**Dargle**	639	**-394**	***0.38***
Lismore	**Lickey**	115	**-69**	***0.40***
Lismore	**Tourig**	90	**-54**	***0.40***
Lismore	**Womanagh**	293	**-177**	***0.40***
Drogheda	**Boyne counter**	13831	**-8284**	***0.40***
Waterford	**Barrow and Pollmounty**	12117	**-7135**	***0.41***
Kerry	**Owenshagh**	324	**-184**	***0.43***
Waterford	**Corock R**	734	**-406**	***0.45***
Waterford	**Tay**	278	**-152**	***0.45***
Waterford	**Owenduff**	201	**-110**	***0.45***
Dundalk	**Flurry**	123	**-65**	***0.48***
Limerick	**Owenagarney**	814	**-423**	***0.48***
Limerick	**Annageeragh**	302	**-154**	***0.49***
Limerick	**Doonbeg**	426	**-217**	***0.49***
Wexford	**Avoca**	2959	**-1500**	***0.49***
Wexford	**Owenavorragh**	810	**-411**	***0.49***
Ballyshannon	**Ballintra (Murvagh R).**	407	**-197**	***0.52***
Limerick	**Aughyvackeen**	226	**-109**	***0.52***
Limerick	**Deel**	2462	**-1188**	***0.52***
Limerick	**Skivaleen**	372	**-180**	***0.52***
Letterkenny	**Lackagh**	1083	**-503**	***0.54***
Dublin	**Vartry**	189	**-87**	***0.54***
Bangor	**Owengarve R.**	194	**-89**	***0.54***
Bangor	**Muingnabo**	351	**-161**	***0.54***
Kerry	**Emlaghmore**	73	**-33**	***0.55***
Kerry	**Emlagh**	130	**-58**	***0.55***
Kerry	**Finnihy**	141	**-63**	***0.55***
Ballyshannon	**Laghy**	479	**-211**	***0.56***
Ballyshannon	**Abbey**	276	**-122**	***0.56***
Kerry	**Milltown**	83	**-36**	***0.56***
Galway	**Knock**	123	**-54**	***0.56***
Kerry	**Feohanagh**	157	**-69**	***0.56***
Galway	**Owenboliska R (Spiddal)**	550	**-241**	***0.56***
Galway	**Clarinbridge**	63	**-27**	***0.56***
Ballyshannon	**Bungosteen**	418	**-182**	***0.57***
Galway	**Aille (Galway)**	76	**-32**	***0.57***
Kerry	**Owenascaul**	193	**-82**	***0.58***
Letterkenny	**Clonmany**	465	**-195**	***0.58***
Letterkenny	**Culoort**	223	**-93**	***0.58***
Letterkenny	**Straid**	196	**-82**	***0.58***
Letterkenny	**Donagh**	418	**-175**	***0.58***
Letterkenny	**Isle (Burn)**	510	**-213**	***0.58***
Letterkenny	**Mill**	272	**-113**	***0.58***
Letterkenny	**Glenna**	207	**-86**	***0.59***
Galway	**Kilcolgan**	1682	**-695**	***0.59***
Letterkenny	**Glenagannon**	355	**-147**	***0.59***
Kerry	**Lee**	586	**-229**	***0.61***
Kerry	**Owenreagh**	106	**-42**	***0.61***
Kerry	**Cloonee**	75	**-29**	***0.61***
Letterkenny	**Owenamarve**	160	**-62**	***0.61***
Ballinakill	**Carrownisky**	365	**-138**	***0.62***
Wexford	**1SW Slaney (counter)**	609	**-208**	***0.66***
Sligo	**Grange**	356	**-111**	***0.69***
Ballinakill	**Owenwee (Belclare)**	378	**-112**	***0.70***
Kerry	**Carhan**	93	**-26**	***0.73***
Ballyshannon	**Owenwee (Yellow R)**	184	**-50**	***0.73***
Letterkenny	**Ray**	433	**-98**	***0.77***
Ballyshannon	**Oily**	549	**-114**	***0.79***
Ballinakill	**Bunowen**	619	**-128**	***0.79***
Kerry	**Behy**	142	**-27**	***0.81***
Letterkenny	**Clady**	515	**-92**	***0.82***
Kerry	**Sheen**	600	**-105**	***0.83***
Letterkenny	**Bracky**	305	**-47**	***0.85***
Connemara	**Screebe trap**	155	**-22**	***0.86***
Cork	**Argideen**	391	**-50**	***0.87***
Bangor	**Srahmore (Burrishoole counts)**	615	**-7**	***0.99***

Table 4. Status of MSW salmon rivers below Conservation Limits ranked by the % CL attainment.

District	Predicted Recruits	CL	Deficit	*Proportion of CL being achieved*
Wexford	2SW Slaney (counter)	1827	-1063	*0.42*
Cork	2SW Bandon counter	332	-116	*0.65*
Bangor	2SW Newport R. (Lough Beltra)	258	-30	*0.89*

Table 5. Stocks above large rivers impounded for hydro-electric schemes. Counts are average counts for the most recent 5 years with the exception of the Liffey (Islandbridge) which is the most recent 4 years.

River	Wetted Area U/S Dams	Total CL	1SW CL	2SW CL	Average Count
Shannon	30,895,619	49,524	45,909	3,729	707
Erne	6,457,264	16,554	15,345	1,247	1445
Liffey	2,308,361	4,391	4,062	329	1157
Lee	1,923,476	2,789	2,585	210	57

Other Factors Affecting Rebuilding Programmes for Irish Salmon Stocks

Closure of marine mixed stock fisheries for salmon and even complete closure of some salmon rivers to harvest fisheries may not ensure that all rivers will meet or exceed Conservation Limits in the short term. There are several identifiable problems mitigating against immediate recovery and this must be taken into account for future management over and above management of fisheries. In some instances, such as climate changes leading to poorer marine survival of salmon, it may not be possible to tackle the specific problems directly. Some of these specific problems are outlined below.

Marine Survival

Although there has been considerable fluctuation, estimates of marine survival prior to 1996 for wild stocks were generally higher compared to more recent years with survival rates in excess of 15% in many years (*i.e.* 15 adult returns to the coast for every 100 smolts migrating, Figure 2).

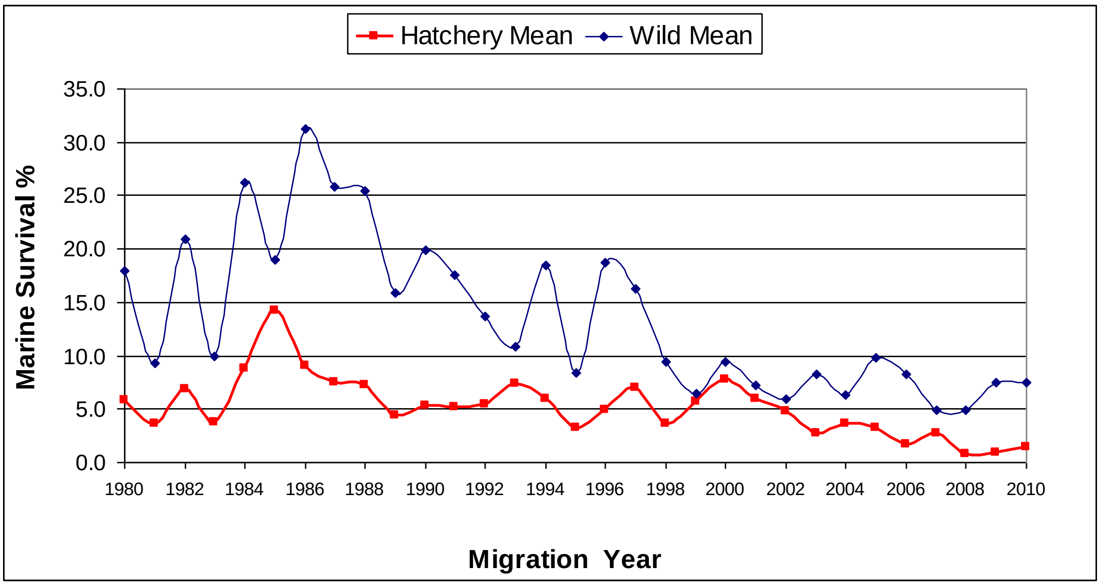

Figure 2. Marine survival (from smolt release to return to the coast) for wild and hatchery salmon.

The current estimates which are amongst the lowest in the time series suggest that on average less than 5% of the wild smolts that go to sea from Irish rivers are surviving (*i.e.* less than 5 adults returning for every 100 smolts migrating). Survival rates from hatchery fish are usually lower than for wild fish. The decline in hatchery salmon survival is becoming more apparent with recent years values also the lowest in the time series. Returns in the following year from releases of hatchery smolts from 2008 to 2010 suggest very poor marine conditions leading to poor survival.

Marine survival is influenced by many factors (Figure 3). While the main focus of this report is on fisheries and fisheries effects, there are real concerns relating to factors causing mortality at sea such as predation by seals, diseases and parasites, estuarine pollution *etc.* However, there is insufficient empirical information to allow anything other than general advice to be given on these at this stage *i.e.* the more the effects each individual factor can be reduced the more salmon will return to our coasts and rivers. Clearly more directed investigations need to be carried out on these other factors.

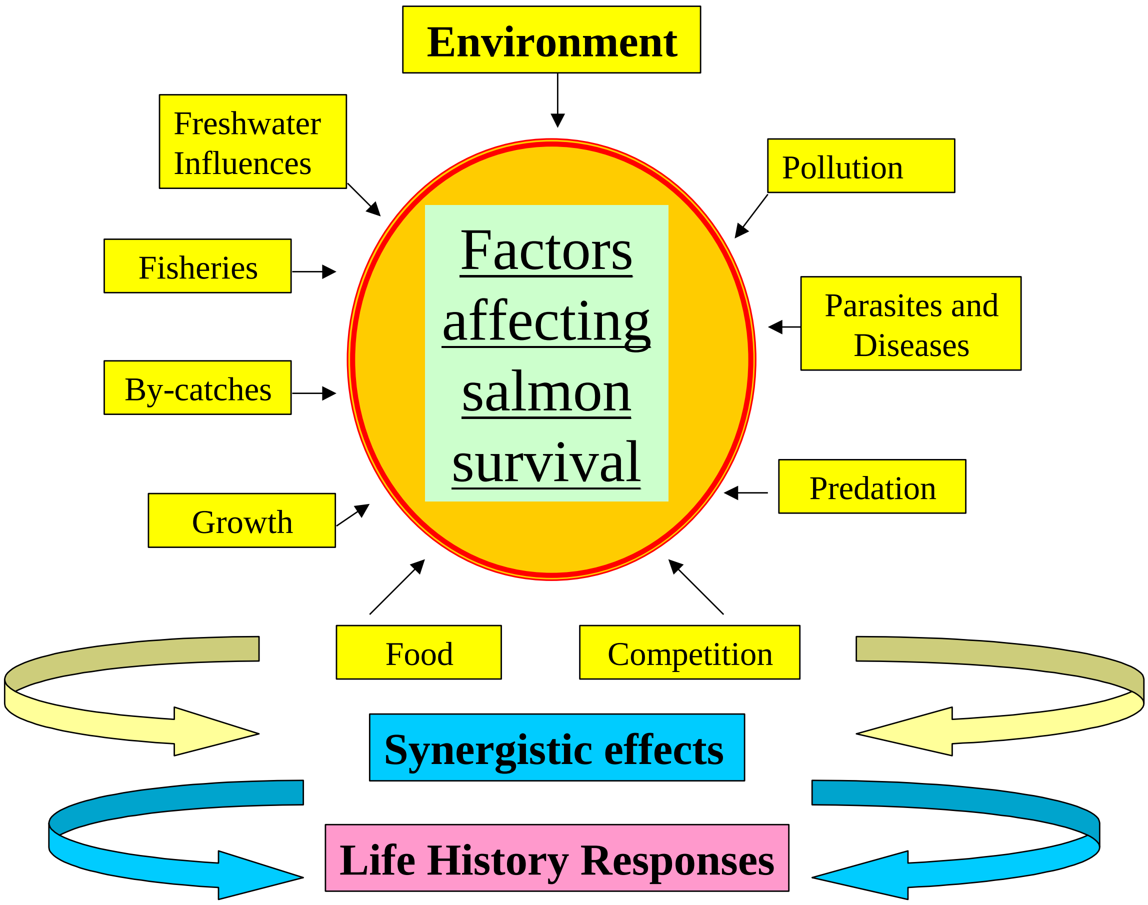

Figure 3. The factors which individually and synergistically affect the marine survival of salmon and which cause significant changes to life history responses such as population structure, fitness and size.

Water Quality

Nationally, the water quality in 82.7% of the habitat available for salmon production is unpolluted, a further 12.8% is considered slightly polluted, the remaining 4.5% is considered to be moderately or seriously polluted. Recent studies carried out by the Central Fisheries Board (T. Champ, *pers comm.*) suggest that salmon distribution and productively are significantly impaired in both of the latter categories. The EPA has recently updated the 2002 data to cover the period up to 2006.

Conclusions

As the terms of reference of the National Salmon Commission now require assessments for each ecosystem (*i.e.* each river), information for individual rivers (*e.g.* fish counts, in-river catch *etc*.) is required to form the basis of the catch advice. While information is lacking for many rivers, this is being rectified by active programmes of monitoring (counters and electrofishing) and efforts to improve the quality and quantity of catch returns (i.e. logbooks) from anglers.

Despite the recent reduced fisheries exploitation on stocks and small improvements in the number of rivers meeting Conservation Limits, only 58 1SW stocks and 13 MSW stocks are considered to be meeting biologically based Conservation Limits with 83 1SW stocks and 3 MSW stocks considered to be below these Conservation Limits.

Marine survival is presently the lowest it has been since the National Coded Wire Tagging Programme for Salmon commenced in 1980 and probably since the 1970's based on a longer time series of information available for the Burrishoole salmon census index site. While there are indications that the 1970's and 1980's were a period of unusually high salmon abundance (Boylan and Adams, 2006 for River Foyle catch data from the early 1900's), recent stock forecasts (Appendix II, ICES advice to NASCO) indicates that this low stock situation will prevail at least until 2015. Given the current levels of poor survival, the expectation of large catches is unrealistic at present and priority should be given to conservation objectives rather than catch increases until there is a noticeable improvement in stock size.

Requirements for future assessments

There are at least 143 separate 1SW stocks (including upstream of rivers with large hydro-dams, Shannon, Erne and Lee) and 16 MSW stocks for which the SSC provide the status of stocks relative to the attainment of biologically based Conservation Limits. Of these 59 have average rod catches of less than 10 salmon. As the combined rod catch for all of these rivers together averages less than 100 salmon in total (compared to the National rod catch of just over 26,000 salmon annually) they must be considered as marginal salmon fisheries only. However, if the salmnon stocks in these small rivers are viable sustainable populations, they are important from a biological and biodiversity perspective and should be afforded the same protection as those rivers supporting large fisheries. The SSC currently advise that there should be no harvest fisheries on these stocks until their status can be ascertained.

From a fisheries management perspective and for the purposes of ongoing assessment and provision of catch advice, the remaining rivers support more significant fisheries requiring assessment and specific catch advice. Amongst these, there are the four major rivers (Shannon, Erne, Lee and Liffey) with hydro-electrical power generating impoundments where programmes to rehabilitate or restore some wild stocks are required. Of this total, it is possible to provide an assessment based on counters (20) or traps (2) currently in operation, with the remaining stocks being assessed based on an average rod catch and a range of exploitation rates derived from the rivers with fish counters and literature sources. If a fishery can proceed, it will be possible to provide ongoing assessments based on the following:

- The existing counters.

- Rod catch assessments, provided the rod catch remains lower than the recommended surplus for harvest (*i.e.* to allow an assumed exploitation rate to be applied to derive a total stock size) or if a subsequent catch and release fishery is allowed.
- Any new counters to be installed and operated by the Regional Fisheries Boards.

In the absence of a fishery or counter an alternative assessment for 2011 season and possibly future years will be required based on at least one of the following:

- Redd count surveys as indices of total stock.
- Juvenile assessment surveys as indices of total stock.
- Survey draft netting and mark recapture assessments.
- Adult counts from new counter installations (including both main stems and/or tributaries).
- Adult stock indices from existing traps
- Adult stock indices from new traps – this should be considered while other surveys are being developed.
- Rod catch data – where catch and release fishery is allowed on these rivers.

For the rivers where the average annual rod catch has been less than 10 in the most recent 5 year period, the general assumption that spawning stocks in these rivers are only attaining 33% of the Conservation Limits has been supported by the electrofishing surveys (see Appendix VI). However, efforts should be made to assess the status of these specific rivers. Some progress has been made in this regard with the inclusion of several of these in the catchment wide electro-fishing carried out by IFI.

For these rivers it is important to:

a) provide an assessment of their current status based on a dedicated stock survey (electro-fishing, trap or counter or redd count) or,
b) establish if these small river stocks are genetically distinct from the main rivers in the vicinity. If the stocks are determined to be of the same genetic origin then depending on other biological information a single Conservation Limit could be considered and the fishery managed so that the combined returns were sufficient to meet and (in order for a fishery to proceed) and exceed the combined Conservation Limit.

- The assessment of attainment of Conservation Limits should also be undertaken with regard to the potential for populations from different rivers to be distinct genetic entities, for multiple populations to exist within single river systems and for distinct life history types (*e.g.* Spring salmon) that require additional management protection to coexist within river systems.

<u>Changes to future assessments</u>

A revised wetted area analysis is being developed to take account of regional variation in river dimensions which contributes to accuracy of Conservation Limits and will be applied for catch advice in 2012. In this regard, this will result in some changes to the Conservation Limits currently derived and changes to the individual river advice in some instances.

The importance of larger MSW stocks in some stocks currently assessed in terms of the overall stock has been highlighted. SSC will try to identify stocks where contributions from the MSW is a significant contribution to the overall population size and provide catch options on these stock components separately. This will require a method to split the catches or counts into stock components can be made annually (most likely based on the weight of the fish or the proportion of fish counted by a certain date in the run) . Currently, only the early running "spring" component is assessed for 16 rivers by the SSC.

Reductions in the average weights of returning adult salmon have been noted in recent years. This will have a profound effect on the average egg deposition as an average weight has been used for females by the SSC. SSC will revise the average weights used in the current assessment model and revise Conservation Limits accordingly.

The data used to transport Conservation limits from data rich to data poor rivers will be revised and updated with the addition of more Irish indices based on output from fish counters over the past decade or so. Presently the variation around Conservation Limit estimates for individual rivers which is derived from several index rivers has not been incorporated into the risk assessment. With the availability of more Irish index rivers and several years of data from logbooks on weights and age distribution of salmon, this will be considered for future applications of statistical models and risk assessment.

In-season or "real-time"management

The requirement for real time management of in-river quotas was highlighted by the Independent Group (Collins *et al.*, 2006). Redd counts, juvenile indices *etc.*, by their nature retrospectively determine attainment or otherwise of required spawning escapements. Counter data will provide real time information but should be used in the context of the five year average to allow for seasonal variability in marine and freshwater survival. Consequently management decisions on exploitation rates must be made prior to the fishing season without the potential to make adjustments to catch rates in season and consequently the effectiveness of those decisions to provide for sufficient spawning fish can only be made after the event. This delay or restriction on the availability of information on stock strength in the current year may cause significant opportunity costs both for recreational and commercial fisheries. The ability to assess the size of the rod catch relative to the Conservation Limit within season would be important to support management on a real time basis. With the move to single stock fisheries some consideration should be given to redefining fishing seasons. However, any changes to the current season should only be considered when a mechanism is in place to evaluate the proportion of the Conservation Limit being met for all stock components at various times throughout the season. In this way maximum benefit can be accrued from the stock without compromising conservation goals.

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Appendix I. Members of the Standing Scientific Committee of the National Salmon Commission 2000 to 2012

Dr. N. Ó Maoiléidigh (Chair) – Marine Institute
Dr. P. Boylan – The Loughs Agency
Dr. N. Connolly (to 2001) – Coastal Research Centre, University College, Cork
Dr. W. Crozier – Agri-food and Biosciences Institute for Northern Ireland (AFBINI)
Ms. M. Dromey (to 2005) – National Parks and Wildlife Service
Dr. P. Gargan – Inland Fisheries Ireland
Dr. M. McGarrigle – Environmental Protection Agency
Dr. P. McGinnity – NUI , Cork
Dr. B. Kennedy (from 2007) – Environmental Protection Agency
Dr. F. Marnell (from 2005) – National Parks and Wildlife Service
Dr. V. O'Donovan (to 2007) – Bord Iascaigh Mhara
Dr. C. O'Keeffe (to 2002) – National Parks and Wildlife Service
Dr. E. de Eyto (from 2007) – Marine Institute
Dr. W. Roche (from 2007) – Inland Fisheries ireland
Dr. I. Lawler (from 2007) – Bord Iascaigh Mhara
Dr. D. Doherty (from 2008) – Electricity Supply Board
Dr. J. White (from 2009) – Marine Institute
K. O'Higgins (from 2009) – Inland Fisheries Ireland

Appendix II. Annotated advice from ICES to NASCO for 2012 (source NASCO CNL(12)8)

10.2 Stock summaries

10.2.1 Advice May 2012

ECOREGION North Atlantic

STOCK Atlantic salmon from the Northeast Atlantic

Advice for 2012 to 2015

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

In the absence of any fisheries in 2012 to 2015, there is less than 95% probability of meeting the CL (full reproductive capacity) in the two age groups of the southern NEAC stock complex. Therefore, in the absence of specific management objectives, ICES advises that there are no mixed-stock fisheries options on the NEAC complexes at Faroes in 2012 to 2015. In all years, there is 71% to 73% probability of meeting the CLs for the NEAC complexes simultaneously, in the absence of any mixed-stock fisheries (Table 10.2.1).

A Framework of Indicators (FWI) has been developed in support of the multi-year catch advice and the potential approval of multi-year regulatory measures for Faroes. The FWI can be applied at the beginning of 2013, with the returns or return rate data for 2012, to evaluate the appropriateness of the 2013/2014 advice, and again at the beginning of 2014, with the returns or return rate data for 2013, to evaluate the appropriateness of the 2014/2015 advice.

Stock status

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

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

Recruitment (PFA) of maturing 1SW salmon and of non-maturing 1SW salmon for northern NEAC shows broadly similar patterns of a general decline during 1983-2010, interrupted by a short period of increased recruitment from 1998 to 2003 (Figure 10.2.3). Both components (1SW maturing and 1SW non-maturing) have been at full reproductive capacity prior to the commencement of distant water fisheries throughout the time-series. Recruitment of maturing 1SW salmon and of non-maturing 1SW salmon for southern NEAC also shows broadly similar declining trends during 1971-2010 (Figure 10.2.3). Both components have been at full reproductive capacity over most of the time period, but the non-maturing 1SW component has been at risk of suffering reduced reproductive capacity before any fisheries took place in two (2006 and 2008) of the last five PFA years. This is broadly consistent with the general pattern of decline in marine survival in most monitored stocks in the area.

Trends in spawner numbers for the Northern stock complex for 1SW and MSW salmon are similar (Figure 10.2.3). Throughout most of the time-series, both 1SW and MSW spawners have been either at full reproductive capacity or at risk of reduced reproductive capacity. The spawner estimates indicated that the 1SW and MSW stock complexes were both at full reproductive capacity in 2011, with the MSW complex showing a further improvement since 2010. Declining trends in spawner numbers are evident in the southern NEAC stock complex for 1SW and MSW salmon. The 1SW stock has been at risk of reduced reproductive capacity or suffering reduced reproductive capacity for most of the time-series. In contrast, the MSW stock has been at full reproductive capacity for most of the time-series until 1997. Thereafter, the stock was either at risk of reduced reproductive capacity or suffering reduced reproductive capacity, with the exception of 2004 and 2011 when the stock was at full reproductive capacity.

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

Management plans

The North Atlantic Salmon Conservation Organization (NASCO) has adopted an Action Plan for Application of the Precautionary Approach which stipulates that management measures should be aimed at maintaining all stocks above their conservation limits by the use of management targets. Conservation limits (CLs) for North Atlantic salmon stock complexes have been defined by ICES as the level of stock (number of spawners) that will achieve long-term average maximum sustainable yield (MSY). NASCO has adopted the region-specific CLs as limit reference points (S_{lim}); having populations fall below these limits should be avoided with high probability. Advice for the Faroes fishery (both 1SW and MSW) is based upon all NEAC area stocks. The advice for the West Greenland fishery is based upon the southern NEAC non-maturing 1SW stock.

Biology

Atlantic salmon (*Salmo salar*) is an anadromous species found in rivers of countries bordering the North Atlantic. In the Northeast Atlantic area, their current distribution extends from northern Portugal to the Pechora River in Northwest Russia and Iceland. Juveniles emigrate to the ocean at ages of one to eight years (dependent on latitude) and generally return after one or two years at sea. Long distance migrations to ocean feeding grounds are known to take place, with adult salmon from the Northeast Atlantic stocks being exploited at both West Greenland and the Faroes.

Environmental influence on the stock

Environmental conditions in both freshwater and marine environments have a marked effect on the status of salmon stocks. Across the North Atlantic, a range of problems in the freshwater environment play a significant role in explaining the poor status of stocks. In many cases river damming and habitat deterioration have had a devastating effect on freshwater environmental conditions. In the marine environment, return rates of adult salmon have declined through the 1980s and are now at the lowest levels in the time-series for some stocks, even after closure of marine fisheries. Climatic factors modifying ecosystem conditions and predator fields of salmon at sea are considered to be the main contributory factors to lower productivity, which is expressed almost entirely in terms of lower marine survival.

The fisheries

No fishery for salmon has been prosecuted at Faroes since 2000. No significant changes in gear type used were reported in the NEAC area in 2011. The NEAC area has seen a general reduction in catches since the 1980s. This reflects the decline in fishing effort as a consequence of management measures, as well as a reduction in the size of stocks. The provisional total nominal catch for 2011 was 1003 t in northern NEAC and 422 t in southern NEAC. The catch in the southern area, which comprised around two-thirds of the total NEAC catch in the early 1970s, has been lower than in the northern area since 1999.

Quality considerations

Uncertainties in input variables to the stock status and stock forecast models are incorporated in the assessment. Provisional catch data for 2010 were updated, where appropriate, and the assessment extended to include data for 2011.

Scientific basis

Assessments are carried out using common input variables across stock complexes. Run-reconstruction models and Bayesian forecasts are performed taking into account uncertainties in the data and process error, and the results are presented in a risk analysis framework.

Supporting information: WGNAS.

Reference points

Complex	Age group	CL (number)	SER (number)
Northern NEAC	1SW	167 615	212 986
	MSW	128 778	218 259
Southern NEAC	1SW	599 197	758 477
	MSW	241 269	406 436

Outlook for 2012 to 2015

PFA (pre-fishery abundance at 1 January of the first winter at sea) forecasts for the southern and northern NEAC complexes were developed within a Bayesian model framework. Probabilities of meeting SERs are higher in the northern than in the southern complex.

MSY approach

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

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

In the absence of any fisheries in 2012 to 2015, there is less than 95% probability of meeting the CLs for the two age groups of the southern NEAC complex (Table

10.2.1). Therefore, in the absence of specific management objectives, ICES advises that there are no mixed-stock fisheries options on the NEAC complexes at Faroes in 2012 to 2015.

Additional considerations

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

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

There has been an overall declining trend in marine survival rates of hatchery smolts in northern and southern NEAC areas. Most of the survival indices for wild and reared smolts are below the previous 5- and 10-year averages. For wild smolts the decline is also apparent for the northern NEAC areas; however, for the southern NEAC areas the trends are more variable (Figure 10.2.7). Comparison of survival indices for the 2008 and 2009 smolt years show a general increase in 2009 compared to 2008 for wild smolts in northern and southern NEAC areas, but a decline in 2010. Results from these analyses are consistent with the information on estimated returns and spawners as derived from the PFA model, and suggest that returns are strongly influenced by factors in the marine environment.

Scientific basis

Data and methods

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

The Bayesian inference and forecast models for the southern NEAC and northern NEAC complexes have the same structure and are run independently. For both southern and northern NEAC complexes, PFA forecasts were derived based on lagged spawners and productivity. PFA was forecasted from 2012 to 2015 for maturing 1SW salmon and and from 2011 to 2015 for non-maturing 1SW salmon.

The risk framework was used to evaluate catch options for the Faroes fishery in the 2012/13, 2013/14, and 2014/15 fishing seasons, based on the northern and southern NEAC stock complexes of maturing and non-maturing 1SW salmon. The catch options examined assumed that homewater fisheries would also take the total catch allocation based on a share of 8.4% of the total catch at Faroes. The risk analysis calculates the probability of stocks achieving the management objective for each of the age groups of the NEAC stock complexes and can display the resulting probabilities in tabular and/or graphic form. Further work is required to permit running the risk framework based on management units defined at finer scales, to improve the data in order to attribute the historical Faroes catch to these management units, and to seek additional data to improve the quality of the assessment.

The computing platform for conducting the run-reconstruction and the derivation of CLs for jurisdictions without river-specific CLs is being moved from Crystal Ball (CB) to "R". During that transition, modifications to the algorithms have been implemented, particularly in the derivation of CLs from the pseudo stock-recruitment relationships. Differences in CLs derived for countries as a whole can be attributed to changes in the methods used to aggregate regional CLs. For countries with more than one region, the CB model derives CLs from the national CL model aggregated over all regions. In the R model, the method more closely matches how stock complex CLs are derived from regional data, with CLs estimated for each region separately and then summed to produce the overall country CL. This modification will be implemented for the next assessment.

Uncertainties in assessments and forecasts

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

Risks were defined each year as the posterior probability that the number of spawners would be above the age- and stock-specific CLs under various catch scenarios.

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

The surpluses to SER for the northern NEAC complex forecasted for 2012 to 2015 arise because of the high productivity estimated for 2010, which is applied when forecasting PFA in future years. Productivity increased in 2010 for the northern and southern NEAC areas, but increases and decreases have been noted in the past. The returns of 1SW maturing salmon to NEAC countries in 2011, the first indication of the possible strength of the MSW returns to homewaters in 2012, were lower than in 2010 but at similar levels to 2009, a year when the non-maturing PFA age group was estimated to have been above SERs prior to any exploitation in high seas fisheries and in homewaters.

ICES (2010, 2011) previously emphasized the problem of basing the risk analysis on management units comprising large numbers of river stocks. However, at present, the performance of individual stocks in all countries in the NEAC area cannot be assessed.

Comparison with previous assessment and catch options

Previously, ICES assessed the status of stocks and provided advice on management of the stock complexes in the NEAC area based on the uncertainties in the estimates of spawners relative to CLs. Specifically, if the lower bound of the 95% confidence interval of the current estimate of spawners was above the CL, then the stock was considered at full reproductive capacity. When the lower bound of the confidence limit was below the CL, but the midpoint was above, the stock was considered to be at risk of suffering reduced reproductive capacity. Finally, when the midpoint was below the CL, the stock was considered to be suffering reduced reproductive capacity.

The risk assessment framework in this year's advice directly evaluates the risk of meeting or exceeding the stock complex objectives. Managers can choose the risk level which they consider appropriate. ICES considers, however, that to be consistent with the MSY and the precautionary approach, and given that the CLs are considered to be limit reference points to be avoided with high probability, managers should choose a risk level that results in a low chance of failing to meet the CLs. ICES recommends that the probability of meeting or exceeding CLs for individual stocks should be greater than 95%.

Assessment and management area

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

ICES (2010, 2011) previously emphasized the problem of basing a risk assessment and catch advice for Faroes fishery on management units comprising large numbers of river stocks. In providing catch advice at the age and stock complex levels for northern and southern NEAC, consideration needs to be given to the recent performance of the stocks within individual countries. At present, insufficient data are available to assess performance of individual stocks in all countries in the NEAC area. In some instances CLs are in the process of being developed (UK (Scotland) and Iceland). Alternatively, the probability that the country-specific PFAs have exceeded their SERs should be assessed for a recent time period (five years) and consideration given to simultaneously attaining the management objectives for the four large management units.

Sources of information

b) ICES. 2001. Report of the Working Group on North Atlantic Salmon. Aberdeen, 2-11 April 2001. ICES CM 2001/ACFM:15. 290 pp.

c) ICES. 2003. Report of the Working Group on North Atlantic Salmon. ICES Headquarters, Copenhagen, 31 March-10 April 2003. ICES CM 2003/ACFM:19. 297 pp.

d) ICES. 2005. Report of the Working Group on North Atlantic Salmon. Nuuk, Greenland, 4-14 April 2005. ICES CM 2005/ACFM:17. 290 pp.

e) ICES. 2010. Report of the Working Group on North Atlantic Salmon. ICES Headquarters, Copenhagen, 22-31 March 2010. ICES CM 2010/ACOM:09. 302 pp.

f) ICES. 2011. Report of the Working Group on North Atlantic Salmon. ICES Headquarters, Copenhagen, 22-31 March 2011. ICES CM 2011/ACOM:06. 283 pp.

g) ICES. 2012. Report of the Working Group on North Atlantic Salmon. ICES Headquarters, Copenhagen, 26 March-4 April 2012. ICES CM 2012/ACOM:09. 337 pp.

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

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

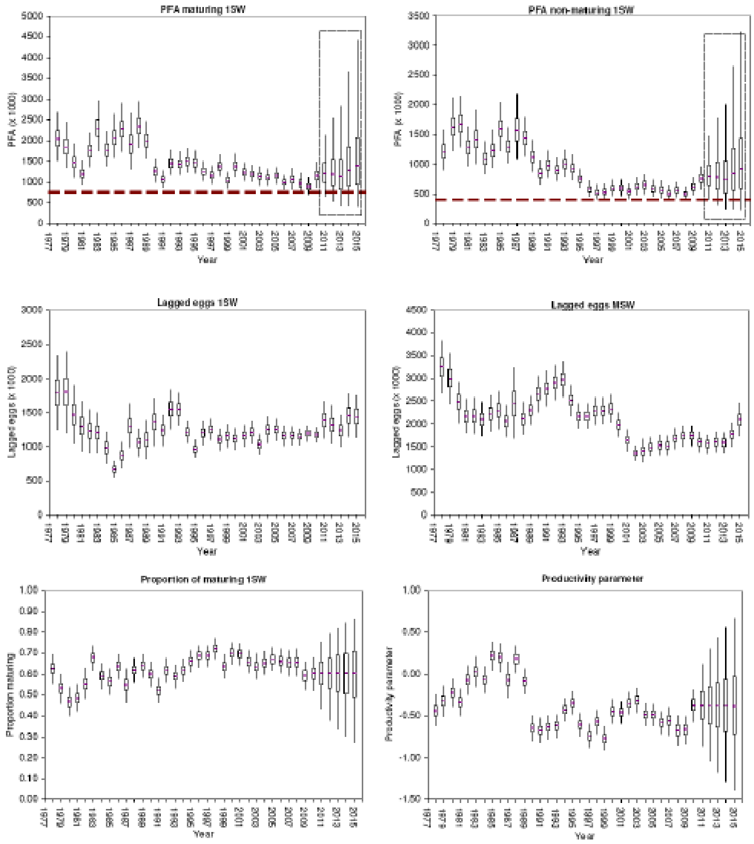


Figure 10.2.1 Southern NEAC PFA for maturing 1SW and non-maturing 1SW fish, lagged eggs from 1SW and MSW, proportion 1SW maturing, and productivity (in logarithmic scale, i.e. logarithm of PFA per lagged egg), for PFA years 1978 to 2015. The last five years (2011 to 2015) are forecasts in all cases. The dashed horizontal lines in the upper panels are the age-specific SER values.

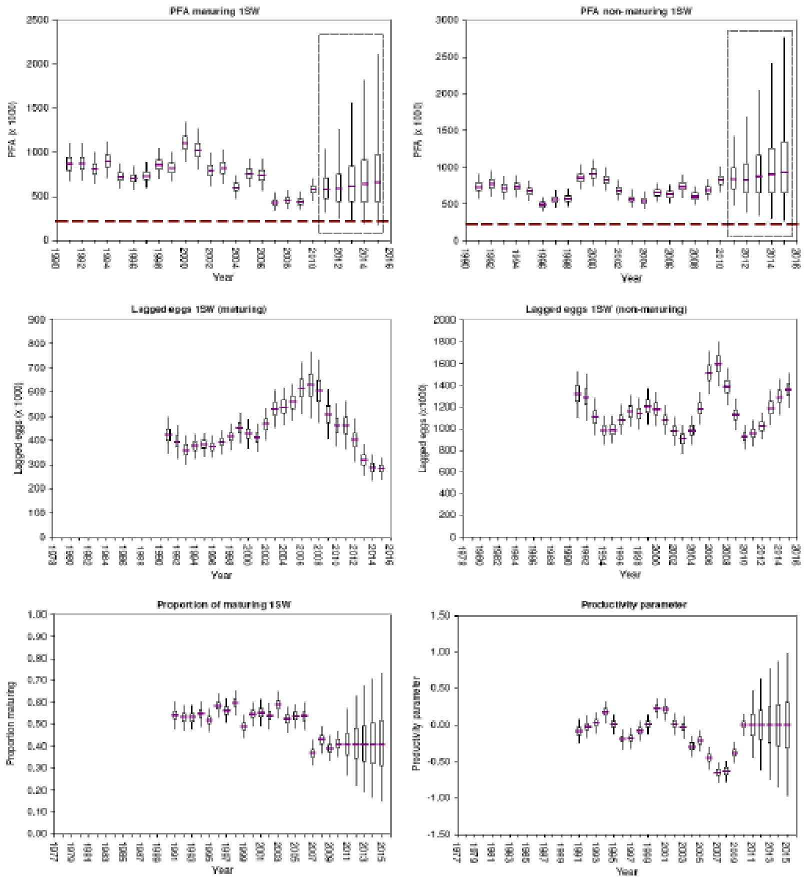


Figure 10.2.2 Northern NEAC PFA for maturing 1SW and non-maturing 1SW fish, lagged eggs from 1SW and MSW, proportion 1SW maturing, and productivity (in logarithmic scale, i.e. logarithm of PFA per lagged egg), for PFA years 1991 to 2015. The last five years (2011 to 2015) are forecasts in all cases. The dashed horizontal lines in the upper panels are the age-specific SER values.

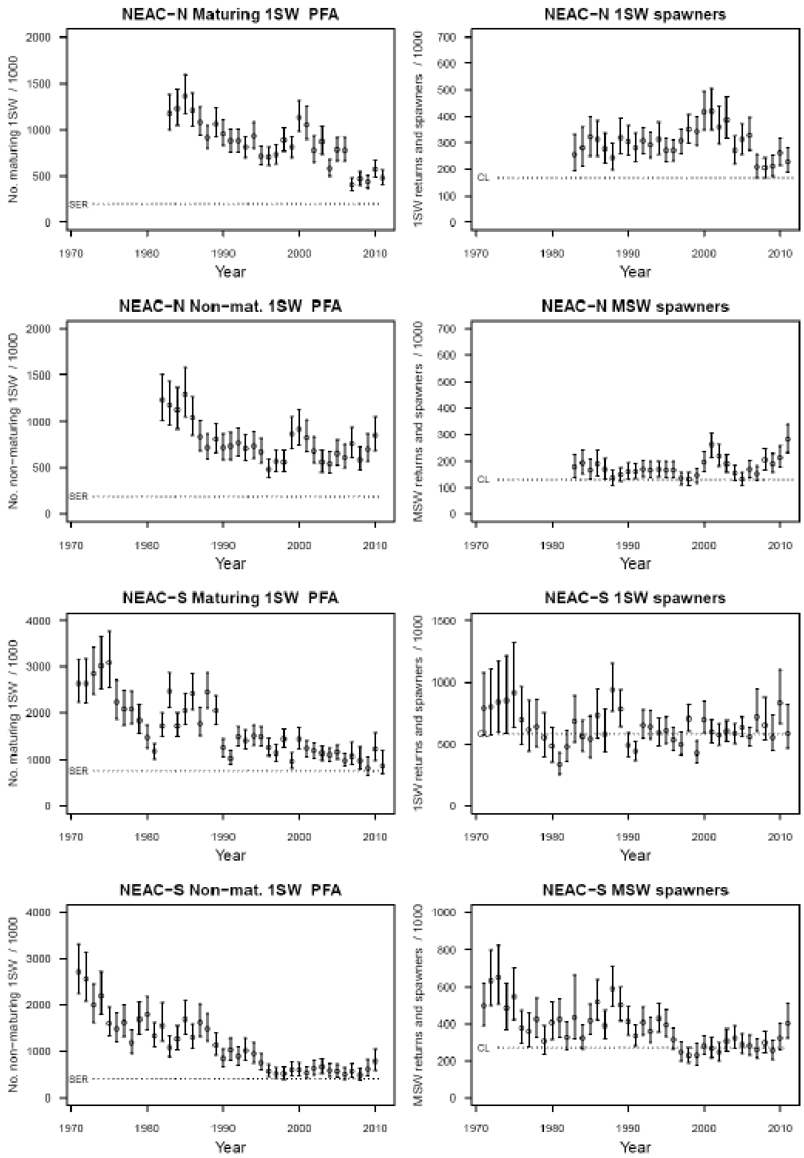


Figure 10.2.3 Estimated PFA (recruits; left panels) and spawning escapement (right panels), with 95% confidence limits, for maturing 1SW (1SW) and non-maturing 1SW (MSW) salmon in northern Europe (NEAC-N) and southern Europe (NEAC-S). **The dashed horizontal lines in the left panels are the age-specific SER values, and in the right panels the age-specific CL values.**

Table 10.2.1 Probability (%) of 1SW and MSW salmon spawner abundance in northern and southern NEAC areas being at or above the CLs for different catch options in Faroes for the 2012/2013, 2013/2014 and 2014/2015 fishing seasons.

Catch options for 2012/13 season: (2013 PFA)	TAC option (t)	NEAC-N-1SW	NEAC-N-MSW	NEAC-S-1SW	NEAC-S-MSW	All complexes
	0	98	100	81	87	71
	20	97	99	80	85	69
	40	97	99	80	82	66
	60	97	98	80	80	64
	80	97	97	80	77	61
	100	97	96	80	74	58
	120	97	95	80	71	55
	140	97	93	79	68	52
	160	97	91	79	65	49
	180	96	89	79	62	46
	200	96	86	79	59	43

Catch options for 2013/14 season: (2014 PFA)	TAC option (t)	NEAC-N-1SW	NEAC-N-MSW	NEAC-S-1SW	NEAC-S-MSW	All complexes
	0	96	99	84	88	73
	20	96	99	84	86	71
	40	96	98	84	84	69
	60	96	97	84	82	67
	80	96	96	83	80	64
	100	96	95	83	78	62
	120	96	93	83	75	59
	140	95	92	83	73	56
	160	95	89	83	71	53
	180	95	87	83	68	50
	200	95	84	82	66	47

Catch options for 2014/15 season: (2015 PFA)	TAC option (t)	NEAC-N-1SW	NEAC-N-MSW	NEAC-S-1SW	NEAC-S-MSW	All complexes
	0	95	99	84	88	72
	20	95	98	84	87	70
	40	95	97	84	85	68
	60	95	96	84	83	66
	80	95	95	84	81	64
	100	94	94	84	79	62
	120	94	92	84	77	59
	140	94	90	84	75	56
	160	94	88	83	73	54
	180	94	86	83	71	51
	200	93	84	83	69	48

Appendix III. Rivers designated as Special Areas of Conservation for Salmon in Ireland (EU Habitats Directive), wetted area and associated Conservation Limit in number of fish

District	River	Wetted area m^2	CL	Total CL
Drogheda	Boyne	6,695,412	Below	13,831
Wexford	Slaney	4,945,255	Below	2,436
Waterford	Barrow, Pollmounty	6,495,633	Below	12,117
Waterford	Nore	6,796,230	Above	11,958
Waterford	Suir, Clodiagh,Linguan	8,795,447	Below	16,462
Lismore	Blackwater, Glenshalane, Finisk	7,701,703	Above	13,148
Kerry	Blackwater	353,999	Above	539
Kerry	Cummeragh/Currane	266,976	Above	336
Kerry	Laune	2,265,312	Above	3,270
Kerry	Caragh	586,454	Above	1,106
Shannon	Feale, Galey, Brick	2,019,244	Above	4,333
Shannon	Mulkear	3,702,750	Above	5,390
Galway	Corrib	4,038,058	Above	8,432
Connemara	Cashla	178,862	Above	349
Connemara	Owenmore	524,049	Above	1,579
Ballinakill	Owenglin	186204	Above	372
Ballinakill	Erriff	606,758	Above	1,300
Bangor	Newport	493,143	1SW Above, 2SW Below	781
Bangor	Srahmore	196,105	Above	615
Bangor	Owenduff	645,812	Above	1,314
Bangor	Glenamoy	260,000	Above	630
Ballina	Moy	7,075,959	Above	18,162
Sligo	Ballysadare	2,190,538	Above	5,098
Sligo	Garvogue	1,376,884	1SW Above 2SW Below	2,828
Ballyshannon	Eske	431,848	Above	823
Ballyshannon	Drowes	562,314	Above	1,006
Letterkenny	Owenea,Owentocker	616,966	Above	2,231
Letterkenny	Gweebarra	248,480	Above	563
Letterkenny	Lackagh	375,778	Below	1,083
Letterkenny	Leannan	1,167,125	Below	3,619

Appendix IV. Transporting Biological Reference Points (BRPs): the Bayesian Hierarchical Stock and Recruitment Analysis (BHSRA)

The following description of the model used to transport Biological Reference Points (in this instance stock and recruitment parameters) from monitored rivers to rivers without these data is extracted from several sources:

Crozier, W. W., Potter, E. C. E., Prévost, E., Schon, P–J., and Ó Maoiléidigh, N. 2003. A co-ordinated approach towards the development of a scientific basis for management of wild Atlantic salmon in the north-east Atlantic (SALMODEL – Scientific Report Contract QLK5–1999–01546 to EU Concerted Action Quality of Life and Management of Living Resources). Queen's University of Belfast, Belfast. 431 pp.

Prévost, E., Parent, E., Crozier, W., Davidson, I., Dumas, J., Gudbergsson, G., Hindar, K., McGinnity, P., MacLean, J., and Sættem, L. M. 2003. Setting biological reference points for Atlantic salmon stocks: transfer of information from data-rich to sparse-data situations by Bayesian hierarchical modelling. e ICES Journal of Marine Science, 60: 1177-1193.

McGinnity, P., Gargan, P., Roche W., Mills, P., and McGarrigle M. 2003. Quantification of the freshwater salmon habitat asset in Ireland using data interpreted in a GIS platform. Irish Freshwater Fisheries Ecology and Management Series, Central Fisheries Board, Dublin, 3. 131 pp.

Ó Maoiléidigh, N., McGinnity, P., Prévost, E., Potter, E. C. E., Gargan, P., Crozier, W. W., Mills, P., and Roche, W. 2004. Application of pre-fishery abundance modelling and Bayesian hierarchical stock and recruitment analysis to the provision of precautionary catch advice for Irish salmon (Salmo salar L.) fisheries. e ICES Journal of Marine Science, 61:1370-1378.

For a more complete description of the techniques, models and underlying assumptions readers are advised to consult these primary texts.

Introduction

The analysis of stock and recruitment (SR) data is the most widely used approach for deriving BRPs for Atlantic salmon (*Salmo salar*) (Prévost and Chaput 2001). SR data are routinely collected on monitored rivers. On these rivers, adult returns, spawning escapement and sometimes smolt production are estimated yearly. Potter (2001) reviewed the various approaches currently applied for determining BRPs from SR data. They fall into two categories: the classical parametric SR models and alternative non-parametric approaches. Walters and Korman (2001) give a full and critical exposure of the procedures relying on the classical SR models. Such an extensive review does not exist for non-parametric approaches, but Potter (2001) provides a clear presentation of the various options proposed and used for stock assessment at ICES. Despite their many pitfalls, the classical SR models have the great advantage over non-parametric approaches that they offer a formal framework to account for sources of uncertainty in the derivation of BRPs. Walters and Korman (2001) advocate the use of the Bayesian approach for uncertainty assessment: our knowledge/uncertainty about BRPs should be reflected by probability distributions given the SR data in hand.

There are several hundreds of salmon stocks across the North East Atlantic area, each having its own characteristics with regard to SR relationships. However, resources to collect SR data are limited and there are only a limited number of monitored rivers. Suitable SR series (both in terms of length and reliability of observations) are available for about 15 monitored rivers. Extrapolation of knowledge gained from monitored rivers to rivers for which SR data are not available is therefore required. This extrapolation process is also called transport of BRPs.

SR information from the monitored rivers can be used to set BRPs for all the North East Atlantic salmon rivers while accounting for the major sources of uncertainty. Until recently, this issue was essentially addressed in practice by extrapolating the BRPs determined from a single river SR series to an entire region or country while accounting for the variations of size between rivers. When SR data are available from several rivers which are considered to be representative of an assemblage of rivers, the question can be asked as to what can be inferred about the nature of the SR relationship for any new river of the assemblage based on data from the sampled rivers. There are two nested sources of uncertainty in this situation. The first level of uncertainty is associated with the fact that there is relevant SR information available from a limited number of rivers within the assemblage of rivers. The second level of uncertainty relates to the limited number of SR observations available within each river. Bayesian meta-analysis using hierarchical modelling (Bayesian Hierarchical Analysis) provides a framework for integrating these two levels of uncertainty. It incorporates the nested structure of the uncertainty to derive a probability distribution of BRPs for a river with no SR data. Prévost *et al.* (2001) illustrated this approach with a case study on the salmon rivers of Québec. Crozier *et al* (2003) further applied and extended it to the rivers in the North East Atlantic area and Ó Maoiléidigh *et al.* considered the specific application of this approach in an Irish context.

Bayesian approaches are now widely applied in fish population and fisheries dynamics studies (Punt and Hilborn 1997; McAllister and Kirkwood 1998). It is also an active field of investigation in itself. Bayesian reasoning aims at making inferences about any unknown quantity of interest (*U*) conditionally on observed data (*D*). It considers probabilities as comparative degrees of belief. Although not specific to it, the bayesian approach requires the initial setting of a probability model representing our prior understanding of the process giving rise to the data. From this prior setting, posterior inferences are derived conditionally on the data using Bayes theorem:

$$P(U|D) = P(U)P(D|U)/P(D) \propto P(U)P(D|U)$$

Setting up a Bayesian Hierarchical Stock and Recruitment Model

To make inferences from data in a Bayesian framework, a probabilistic (*i.e.* stochastic) model representing the prior understanding of the process generating the observed data must be set. The data are Stock and Recruitment (SR) observations. Standard SR models such as a Ricker curve with lognormal random errors (Walters and Korman 2001) can be use to represent the link between the stock and the subsequent recruitment within any single river. Such a single river SR model is controlled by a few parameters, which are either Biological Reference Points (BRPs) or from which BRPs can be computed. Let θ_i denote the SR parameters vector of the river *i*. In this case, inferences based on the data from the monitored rivers about the other rivers of the NEAC area are of special interest. The model must therefore specify the link between salmon rivers irrespective of whether SR data are available for them. The idea that all salmon rivers belong to a common family or an assemblage of rivers is translated by considering them as issuing from a single probability distribution. More precisely, it is the θ_i's which are seen as realizations from a common probability distribution. This probability distribution is itself controlled by parameters, also called hyper-parameters. Denoting Θ the vector of hyper-parameters.

The conditioning structure corresponding to this general setting can be represented by a Directed Acyclic Graph (DAG; Figure 1). It is a hierarchical setting because:

- the distribution of the recruitment for any given level of stock is controlled by the θ_i parameters,
- the distribution the θ_i parameters is controlled by the Θ hyper-parameters.

This hierarchical structure organizes the transfer of information brought by the monitored rivers SR data towards the other rivers. The SR data from the monitored rivers improve the information about the θ_i's. This information gained about the θ_i's allows improvements in turn in the information about Θ. This information gained on Θ provides insight into the SR parameters of any new river for which no SR data are available.

The hierarchical setting is midway between a complete pooling of SR data sets and the independent treatment of each single river SR series. Complete pooling of SR data sets relies on the assumption that there is a unique SR relationship common to all rivers, *i.e.*, $\theta_i = \theta_j$ for any $i \neq j$. This is certainly an oversimplifying assumption. Conversely, full independence between rivers would mean there is nothing to learn from the monitored rivers about the SR relationship of the other rivers. This is not sensible either and contradictory to the very essence of monitored rivers projects. By considering the θ_i's as realizations from a common probability distribution it acknowledges that they can be different between rivers while at the same time they are not fully unrelated. This intermediary assumption allows the transfer of information between rivers. Any increase in information about a θ_i consequentially provides information about the probability distribution of the θ_i's, thus bringing information about any θ_j $j \neq i$. The Bayesian treatment of a hierarchical model allows the data to used to learn from the monitored rivers.

Implicit but crucial to the above concepts is the hypothesis of exchangeability of the rivers with regards to their SR parameters. This is a common assumption when little is known about the differences between units (Gelman *et al.* 1995). In this case it means that, apart from the SR data, there is no insight provided into the phenomena causing variations in the SR relationship among rivers. In terms of modelling, exchangeability translates into independent identical distribution (iid) of the θ_i's. If covariates informative about the variations in θ_i's are available, then exchangeability can still be assumed, conditionally on the covariate. It must be stressed that, in practice, it is not enough to know that a given variable influences the SR relationship (from some experimental or detailed single site studies). To be able to take advantage of this knowledge it must be possible to measure the covariates on every river of interest, *e.g.*, all the salmon rivers in the North East Atlantic area, and also model the nature of the link between the covariates and the θ_i's. It is clear that these two conditions shall limit the number of covariates which can be used in practice, especially if inferences are to be made for many rivers for which there is little known. The basic concept and model are presented below in Figure 1.

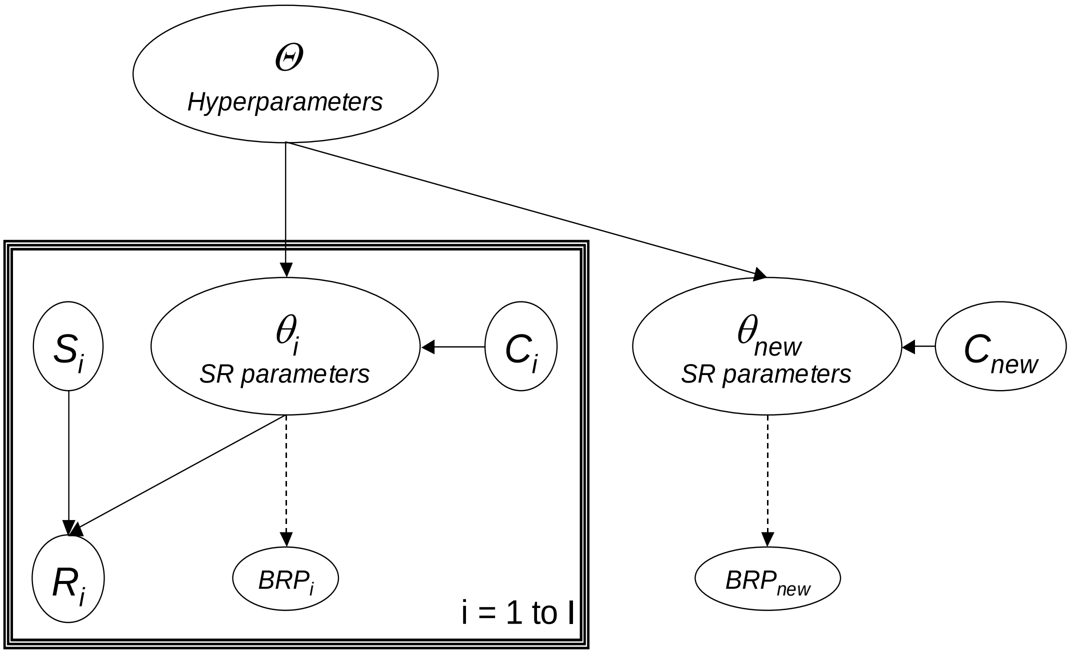


Figure 1. The conditioning structure of the BHSRA as represented in a Directed Acyclic Graph (DAG). Nodes (ellipses) are random variables. The plain arrows represent stochastic links, *i.e.* the distribution of a child node depends on its parents. Dashed arrows represent deterministic links, *i.e.* the BRPs are functions of the θ_i's. S_i and R_i are the series of observed stock and recruitment for the monitored river *i*. C_i is a vector of explanatory covariate of the θ_i's. The frame means there are *I* monitored rivers with SR data. The "*new"* subscript index refers to any river with no SR data but belonging to the family from which the monitored rivers are a representative sample.

Treating the rivers as exchangeable in their SR parameters implies that the monitored rivers are a representative sample from the broad family, *e.g.* the North East Atlantic area or Irish rivers specifically, about which inferences are required to be made. The principles presented and discussed above are the fundamentals of the joint treatment of several SR series, called a Bayesian Hierarchical SR Analysis (BHSRA). Such an approach does not, in itself, solve all the problems encountered in the analysis of SR data. BHSRA is, however, a step forward from the previous approach for setting and transporting BRPs in Atlantic salmon. It sets a consistent framework for learning from monitored rivers SR data, while previous practices essentially relied on the unrealistic premise that there is a common SR relationship across broad regions. Ample room is left for improvement in the single river SR modelling, but this approach now provides a hierarchical setting which can accommodate any new SR model for (Bayesian) learning from monitored rivers.

Introduction of Covariates – Wetted Area and Latitude

The BHSRA as used for the transport of SR parameters to Irish rivers is detailed below (Figure 2). Among the many covariates to explain differences between rivers in their SR parameters, river size is the most evident. It would be irrelevant to set escapement reference points irrespective to the size of the rivers considered. Indeed, the size of a stock is constrained by the size of its river of origin because of the specificities of the riverine Atlantic salmon ecology. For instance, individuals have a territorial behaviour at the juvenile stage and during spawning, and compete for limited spatial resources (Elliott, 2001). Prévost *et al.* (2001) reviewed the many ways of assessing river size as a limiting factor for salmon production. Currently, the riverine wetted surface area accessible to salmon appears to be the "smallest common denominator" which can be used across the North East Atlantic area. This measurement is readily available for Irish rivers (McGinnity *et al.*, 2005) by means of Geographical Information Systems (GIS) applications. More refined measures of river size, incorporating information about the habitat quality within the wetted area, have been proposed. The methods, however, vary among regions and rivers and in the vast majority of rivers the data requirements cannot currently be achieved.

Given the very limited information available on the bulk of the NEAC salmon rivers, geographical location is probably the only variable readily accessible for explaining variations in SR parameters among rivers. Latitude has been investigated because it influences the ecology of Atlantic salmon. For instance, it is well known that mean smolt age increases with latitude (Metcalfe and Thorpe 1990). Koenings *et al.* (1993) also found a positive latitudinal gradient for smolt-to-adult survival in sockeye salmon (*Oncorhynchus nerka*).

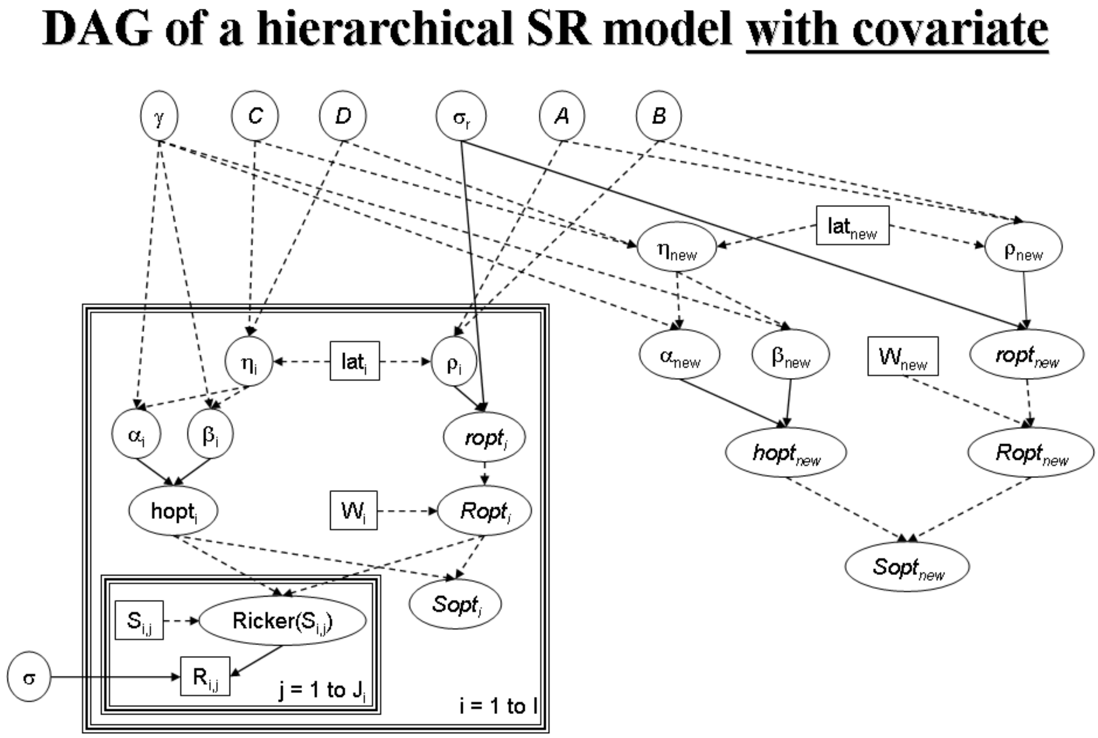


Figure 2. DAG of the hierarchical SR model with covariates used to transport stock and recruitment parameters to Irish rivers. The same graphical conventions are applied as in Figure 1. Naming of the nodes are explained below.

Brief explanation of terms used in the DAG.

$R_{i,j} \sim lognormal(log(Ricker(S_{i,j}), \sigma)$

$\text{Ricker}(S_{i,j}) = (exp(h_{opt}i)/(1 - h_{opt}i))\ S_{i,j}\ exp(-((h_{opt}i/((1 - h_{opt}i)R_{opt}i))S_{i,j})$

where:

$R_{i,j}$ is the recruitment of the cohort born in year j from the river i,

$S_{i,j}$ is spawning stock of year $j-1$ from the river i,

$Ricker(S_{i,j})$ is the value of a Ricker function with parameters ($h_{opt}i$, $R_{opt}i$) at $S_{i,j}$,

σ is the standard deviation of the normal distribution of $log(R_{i,j})$, whose mean is $log(Ricker(S_{i,j}))$,

$h_{opt}i$ is the exploitation rate at MSY for the river i,

$R_{opt}i$ is the value of the Ricker function at MSY for the river i.

Any other SR related parameter or BRP can be calculated from $h_{opt}i$ and $R_{opt}i$. NASCO recommended the use of the stock level that maximizes the long-term average surplus (MSY) as the standard Conservation Limit (CL; Potter 2001).

Denoting $S_{opt}i$ this BRP for the river i:

$S_{opt}i = (1 - h_{opt}i)R_{opt}i$

At the upper level, the parameters of the Ricker function are assumed to be different between rivers, but drawn from a common probability distribution:

$R_{opt}i \sim lognormal(A, B)$

$h_{opt}i \sim beta\ (C,D)$

where:

A and B are the mean and standard deviation of the normal distribution of $log(R_{opt}i)$.

C and D are the parameters of the beta distribution of $h_{opt}i$,

The basic model formulation above was improved by the use of additional co-variables, which would be informative about SR related parameters. In this case it is obvious that the river size must be most influential on $R_{opt}i$, *i.e.* the bigger the river the higher should $R_{opt}i$ be.

This can be translated into replacing assumption:

$R_{opt}i \sim lognormal(A, B)$ above

by:

$R_{opt}i = r_{opt}i\ WA_i$

where:

WA_i is the wetted area accessible to salmon (m^2).

$ropt_i$ is the egg recruitment rate per m2 of riverine wetted area accessible to salmon at MSY

lat_i is the latitudinal location of river i.

ρ_i is the mean of the *log(ropt$_i$)* distribution and is a linear function of latitude.

α_i and β_i is the beta distribution assigned to *hopt$_i$* (which varies between 0 and 1).
η_i is the mean of the beta distribution or

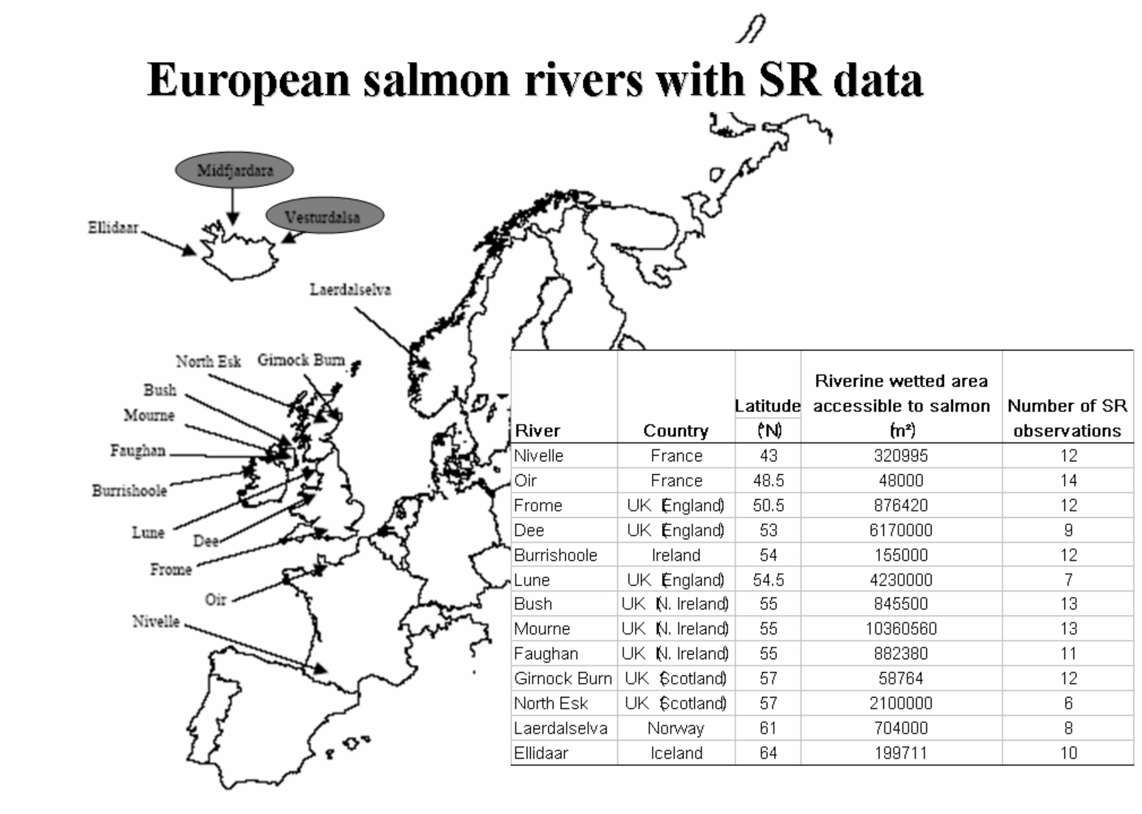
$$\alpha_i / (\alpha_i + \beta_i)$$

γ is a scale parameter directly connected to the "sample size" of the beta distribution

The "new" subscript denotes the posterior distributions of all the parameters for any new river based on the posterior distributions of the monitored rivers.

Data available to apply the BHSRA to the North East Atlantic monitored rivers

Egg-to-egg SR series can be obtained from monitored rivers, *i.e.* any river where at least the adult returns and the fisheries are surveyed (Figure 3). Rivers colonized mainly by sea trout and holding a comparatively small salmon population were not considered. In-river adult returns were quantified by full counting (from trapping, electronic counters or even visual counts) or by estimation from tagging/recapture experiments. Combined with information on the catch or the exploitation rate in freshwater, spawning escapement can be calculated. Biological data, *i.e.* sex ratio and average fecundity per female, were used to express spawning escapement in eggs. Recruitment can also be derived from adult returns. Returns back to the coast were calculated using estimates of the catch or of the exploitation rate in coastal/estuarine fisheries. Information on the age composition of the returns allows derivation of adult returns per spawning year, *i.e.* homewater recruitment. Data on sex ratios and fecundity of females were used to express recruitment in eggs. In the case of monitored rivers, which are only spawning tributaries, adult spawning escapement was obtained directly without having to account for riverine exploitation. Recruitment was then estimated from smolt counts or production estimates (tagging/recapture). Sea survival estimates from neighbouring rivers were used to convert smolts into adults.



River	Country	Latitude (°N)	Riverine wetted area accessible to salmon (m²)	Number of SR observations
Nivelle	France	43	320995	12
Oir	France	48.5	48000	14
Frome	UK (England)	50.5	876420	12
Dee	UK (England)	53	6170000	9
Burrishoole	Ireland	54	155000	12
Lune	UK (England)	54.5	4230000	7
Bush	UK (N. Ireland)	55	845500	13
Mourne	UK (N. Ireland)	55	10360560	13
Faughan	UK (N. Ireland)	55	882380	11
Girnock Burn	UK (Scotland)	57	58764	12
North Esk	UK (Scotland)	57	2100000	6
Laerdalselva	Norway	61	704000	8
Ellidaar	Iceland	64	199711	10

Figure 3. European rivers used for the provision of stock and recruitment parameters. The two most northerly Icelandic rivers were not included in the Irish model.

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Appendix V. Derivation of river-specific catch advice for Atlantic salmon fisheries in Ireland for 2011

River-specific fisheries advice is provided for the forthcoming season based on a forecast of the abundance of salmon which will return to each river in that year, comparison of the estimated abundance to the river-specific Conservation Limit, and determination of harvest of salmon which could be made while allowing a high probability that the Conservation would be met.

Predicted abundance in each river for the fishing season in question is taken as the average abundance of salmon from each river prior to any national fisheries (recruits) in recent 5 years period where data (counter, trap or rod catch) are available.

River-specific recruitment of salmon is estimated as follows:

- Estimates of spawners and returns in most rivers have been updated since 2006 and are based on an extrapolation of rod catch figures using specific exploitation rate bands identified from rivers with counters (Table 1).
- For rivers with counter data, the spawners from the counter monitoring are used rather than rod catch and extrapolation using rod exploitation rate data.
- For rivers with no counters or a rod catch of less than 10 annually, it is assumed that they are meeting 33% of the in-river stocks requirement.
- River specific catches in draft nets and other estuarine fisheries are derived from actual reported catches from carcass tagging and logbooks.
- Total annual abundance for the most recent five year average prior to any national fisheries is the sum of river-specific spawners, river-specific rod catches, river-specific draft net and other estuary catches, and river-specific driftnet catch where present.

Risk analysis leading to the provision of catch advice

The text and methodologies below are derived primarily from:

Crozier, W. W., Potter, E. C. E., Prévost, E., Schon, P–J., and Ó Maoiléidigh, N. 2003. A co-ordinated approach towards the development of a scientific basis for management of wild Atlantic salmon in the north-east Atlantic (SALMODEL – Scientific Report Contract QLK5–1999–01546 to EU Concerted Action Quality of Life and Management of Living Resources). Queen's University of Belfast, Belfast. 431 pp.

Readers are advised to consult this text for a more complete explanation of methods and formulas used in the calculations.

The use of reference points in fisheries management requires that the probability of achieving the objectives is taken into account. Spawning requirement reference points from stock and recruitment analysis are established on the basis of an egg deposition rate weighted by area measures of freshwater habitat available for juvenile production (see Appendix III). Because fisheries exploit fish, the egg requirements are translated to the number of salmon required to achieve that egg deposition using the average biological characteristics of the stock. This is the approach used to manage some homewater fisheries on both sides of the Atlantic and the high seas fishery of west Greenland.

Fish are discrete units and Atlantic salmon stocks generally consist of relatively small numbers of animals, in the order of 100s to 1000s for most rivers of the north Atlantic. Managing to achieve spawning escapement reference points must consider the probability of obtaining at least the required number of fish to achieve the egg deposition. Since only females contribute eggs, fisheries should be managed to ensure that the required number of females are available for spawning.

The probability profiles for achieving the spawning requirement objective in a specific year are defined by the stochastic properties of small numbers and additional factors including the size of the river stock (estimated directly from counters/traps or extrapolated from rod exploitation rates) and proportion female in the stock (proportions taken from known proportions in broodstock recovery programmes). In the management of mixed stock fisheries, the aggregation of individual river requirements into a regional objective introduces additional uncertainty to the achievement of the individual river objectives. There are curently two estuary fisheries (Killary harbour, Owenmore/Owenduff common estuary) which exploit stocks from more than one river where advice is provided. The aggregation of spawner requirements into regional requirements changes the probability profiles and the profiles are affected by: the number of rivers which are aggregated, relative size of the rivers, disproportionate productivity rates among the rivers, and the possibility of straying between rivers in the aggregated complex.

Monte Carlo methods for estimating probabilities under binomial and multinomial models

The description of the probability profiles are based on application of the binomial and multinomial distributions of the fate of fish released to spawn. For the single river case, the simplest situation, the fish released to spawn are of two types: males and females. The probability of a given number of females within a specified group of fish is described by the binomial distribution:

$$Pr(Z = k) = [N! / (k! (N – k)!)] p^k (1 – p)^{N-k}$$

where:

Z = number of female fish

N = number of fish in the group, males and females

p = probability that a fish is female (*i.e.* proportion female in the stock)

The binomial distibution has the following properties:

1) For a fixed p, the coefficient of variation decreases as N increases,
2) The variance is greatest when p = 0.5.

For the aggregated stock example, the binomial is extended to the multinomial distribution for which there are more than two possible outcomes (*i.e.* female from river A, male from river A, female from river B, male from river B,…). The probability of a given set of outcomes is given by:

$$Pr(Z_1=k_1, Z_2=k_2, \ldots Z_M=k_M) = [N! / (k_1! \, k_2! \ldots k_M!)] \, p_1^{k1} \, p_2^{k2} \ldots p_M^{kM}$$

where:

$Z_1, Z_2, \ldots Z_M$ = are outcomes in M stocks

N	= number of fish in total
$p_1, p_2, \ldots, p_M$	= proportion female in rivers 1, 2, …, M

For the simple case of one river, exact probabilities of meeting or exceeding the spawner requirements (Pr(Z >= k) can be calculated from the binomial formula for an assumed proportion female (p) and for a given number of fish released to the river (N).

In the more complicated situation in which more than one stock is being considered (and for which the sum of a large number of probabilities must be calculated) or when including annual variations in the biological characteristics of the stock, the probabilities can be conveniently approximated using Monte Carlo techniques.

The spawner requirements are defined on the basis of the number of female fish (S_{optf}) required to achieve the egg requirements at the reference point. The proportion of females in the stock is assumed known (or expected) (p). In the simulation, this female proportion represents the probability of a fish being female. The simulation proceeds as follows (for the single river example):

1. A number (j) is drawn from a random uniform distribution between 0 and 1.
2. If j <= p (proportion female in the stock), then that fish is considered a female and the female counter for that fish is set at 1 ($sex_f = 1$). If j > p, then the fish is considered male and the counter is set to 0 ($sex_f = 0$).
3. Repeat steps 1 and 2 a total of N times (N = number of fish released to the river) using independent random uniform numbers.
4. The total number of females released to the river from step 3 is the sum of sex_f for the N random number assignments.
5. If Σsex_f from step 4 >= S_{optf} , then the spawner requirement has been met (*i.e.* $SpawnerMet_i = 1$, for i = 1 to M simulations).
6. Repeat steps 1 to 5 a large number of times (M = 10,000).
7. Calculate the number of times the spawner requirement was met or exceeded (Σ $SpawnerMet_I$ from step 5).
8. Calculate and store the probability of meeting or exceeding the spawner requirement for N releases of fish to the river (P_N)as Σ $SpawnerMet_i$ divided by M (from step 6 and 7).
9. Release N + c fish to the river with c > 0.
10. Repeat steps 1 to 9 until the desired probability of meeting or exceeding the spawner requirement is attained.
11. Estimate the probability of meeting the spawner requirement (P_N, P_{N+c}, …) versus the number of fish released to the river (N, N+c, ….) to describe the probability profile for the specificed conditions (S_{optf}, p).
12. Plot the probability of meeting spawning requirements versus various catch options with the catch option providing at least a 75% probability of meeting the Conservation Limit being advised by the SSC for each fishery.

In all the analyses, a total of 10,000 Monte Carlo simulations were performed for each fixed release of fish to the river(s).

Example from the Dundalk District (based on the 2008 catch advice)

- There are five salmon producing rivers in Dundalk, ranging in size (based on CL) from 123 salmon (Flurry) to 2410 salmon (Dee) – Table 2.

- Rod catches are less than 10 on average annually for the Flurry river, therefore it is not possible to estimate river-specific spawners or returns to this river. In this instance a spawning stock representing 33% of the total CL is applied on the basis that many rivers on the east coast are well below CL.
- Exploitation rates in the rod fisheries are assumed to follow a triangular distribution with the most likely rate within a minimum to maximum range based on average exploitation rates for known rivers or based on in-river counter in the case of the River Dee.
- Exploitation rate in the rod fisheries is the only variable with parameterized uncertainty:
    - exploitation rate varies independently among rivers and among years
    - Estimated abundance of Flurry origin fish in 2008 is based on the assumption that only 33% of CL is being met on average in recent years.
- The catch options for the all rivers in the Dundalk District which provide a 75% chance (0.75 probability) of meeting the Conservation Limit are shown in Figure 1.
- In the case of the Castletown River this equates to approximately 43 salmon. A higher catch will result in less than 75% chance that the Conservation Limit will be met. Conversely, a lower catch will result in a greater than 75% chance that the Conservation Limit will be met.
- Similarly, for the River Fane, the catch option which provides a 75% chance that the Conservation Limit will be met is 214 salmon.
- The other rivers in the district (Flurry, Glyde and Dee) do not have a catch option which allows a 75% chance of meeting the Conservation Limit. In fact, even in the absence of any fishery there is little chance that the Conservation Limit will be met given the average returns in the past 5 years.
- Therefore, there should be no harvest fisheries in these rivers or any mixed stock fishery until the Conservation Limits have been exceeded.

(Appendix V). Table 1 Exploitation rates used for catch advice.

Exploitation rates used in the catch advice for 2009

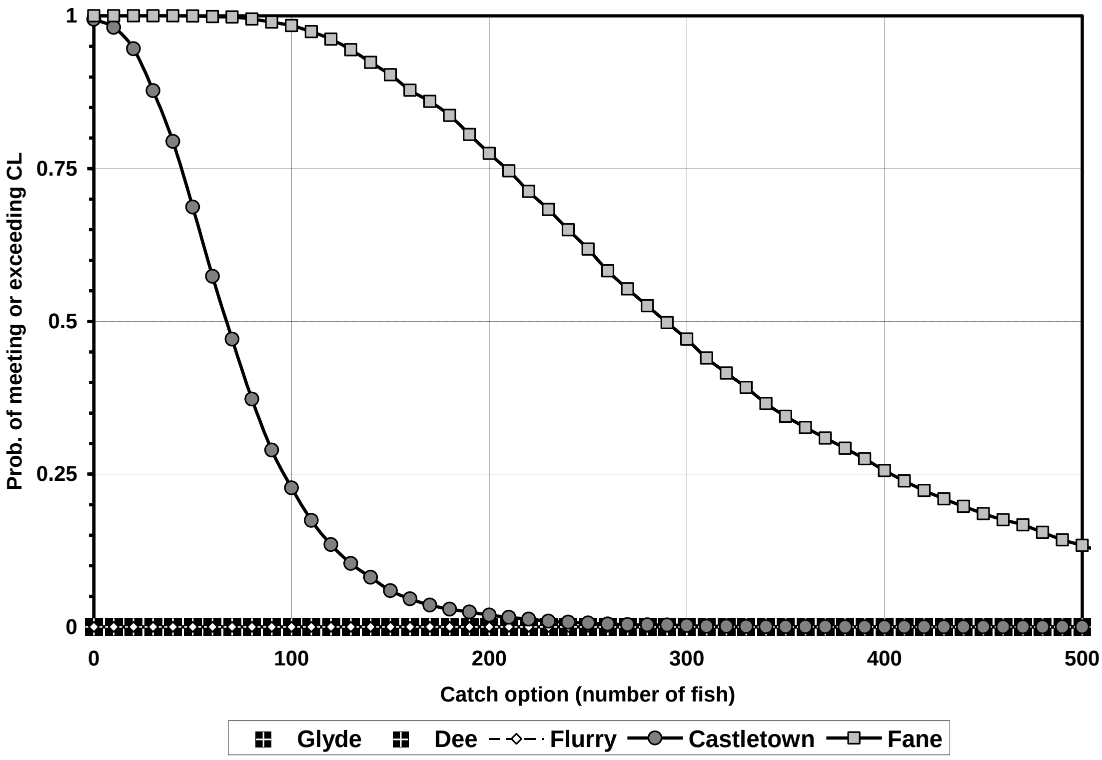
River name	District	Rod exploitation rate 1SW Mean	Min	Max	Rod exploitation rate MSW Mean	Min	Max
Flurry	Dundalk	0.05	0.01	0.12			
Castletown	Dundalk	0.15	0.07	0.35			
Fane	Dundalk	0.15	0.07	0.35			
Glyde	Dundalk	0.15	0.07	0.35			
Dargle	Dublin	0.05	0.01	0.12			
Vartry	Dublin	0.05	0.01	0.12			
Avoca	Wexford	0.05	0.01	0.12			
Owenavorragh	Wexford	0.05	0.01	0.12			
Corock R	Waterford	0.05	0.01	0.12			
Owenduff	Waterford	0.05	0.01	0.12			
Barrow, Pollmounty	Waterford	0.05	0.01	0.12			
Nore	Waterford	0.05	0.01	0.12			
Black Water	Waterford	0.05	0.01	0.15			
Suir, Lingaun	Waterford	0.10	0.05	0.15			
Mahon	Waterford	0.05	0.01	0.12			
Tay	Waterford	0.05	0.01	0.12			
Colligan	Waterford	0.05	0.01	0.12			
Lickey	Lismore	0.18	0.10	0.35			
Bride	Lismore	0.18	0.10	0.35			
Tourig	Lismore	0.18	0.10	0.35			
Womanagh	Lismore	0.18	0.10	0.35			
Owennacurra	Cork	0.05	0.01	0.12			
Lower Lee (Martin, Shornach, Bride)	Cork	0.15	0.07	0.35			
Argideen	Cork	0.05	0.01	0.12			
Ilen	Cork	0.15	0.07	0.35			
Mealagh	Cork	0.05	0.01	0.12			
Owvane	Cork	0.05	0.01	0.12			
Coomhola	Cork	0.15	0.07	0.35			
Glengarriff	Cork	0.05	0.01	0.12			
Adrigole	Cork	0.05	0.01	0.12			
Kealincha	Kerry	0.05	0.01	0.12			
Lough Fada	Kerry	0.05	0.01	0.12			
Croanshagh (Glanmore R. and L.)	Kerry	0.05	0.01	0.12			
Owenshagh	Kerry	0.05	0.01	0.12			
Cloonee	Kerry	0.05	0.01	0.12			
Sheen	Kerry	0.05	0.01	0.12			
Roughty	Kerry	0.05	0.01	0.15			
Finnihy	Kerry	0.05	0.01	0.12			
Sneem	Kerry	0.05	0.01	0.12			
Owenreagh	Kerry	0.05	0.01	0.12			
Inney	Kerry	0.15	0.07	0.35			
Emlaghmore	Kerry	0.05	0.01	0.12			
Carhan	Kerry	0.05	0.01	0.12			
Ferta	Kerry	0.05	0.01	0.12			
Behy	Kerry	0.05	0.01	0.12			
Caragh	Kerry	0.15	0.07	0.35	0.31	0.15	0.46
Laune, Cottoners	Kerry	0.15	0.07	0.35	0.31	0.15	0.46
Maine	Kerry	0.15	0.07	0.35			
Emlagh	Kerry	0.05	0.01	0.12			
Owenascaul	Kerry	0.05	0.01	0.12			
Milltown	Kerry	0.05	0.01	0.12			
Feohanagh	Kerry	0.05	0.01	0.12			
Owenmore	Kerry	0.05	0.01	0.12			
Lee	Kerry	0.05	0.01	0.12			

Appendix V – Table 1 cont'd.

Brick	Limerick	0.05	0.01	0.12			
Galey	Limerick	0.05	0.01	0.12			
Deel	Limerick	0.05	0.01	0.12			
Maigue	Limerick	0.05	0.01	0.12			
Owenagarney	Limerick	0.05	0.01	0.12			
Fergus	Limerick	0.15	0.07	0.35			
Doonbeg	Limerick	0.05	0.01	0.12			
Skivaleen	Limerick	0.05	0.01	0.12			
Annageeragh	Limerick	0.05	0.01	0.12			
Inagh	Limerick	0.05	0.01	0.12			
Aughyvackeen	Limerick	0.05	0.01	0.12			
Aille (Galway)	Galway	0.05	0.01	0.12			
Kilcolgan	Galway	0.05	0.01	0.12			
Clarinbridge	Galway	0.05	0.01	0.12			
Knock	Galway	0.05	0.01	0.12			
Owenboliska R (Spiddal)	Galway	0.05	0.01	0.12			
L.Na Furnace	Connemara	0.05	0.01	0.12			
Owenglin (Clifden)	Ballinakill	0.15	0.07	0.35			
Dawros	Ballinakill	0.10	0.05	0.15			
Culfin	Ballinakill	0.05	0.01	0.12			
Bundorragha	Ballinakill	0.15	0.07	0.35	0.31	0.15	0.46
Carrownisky	Ballinakill	0.05	0.01	0.12			
Bunowen	Ballinakill	0.10	0.05	0.15			
Owenwee (Belclare)	Ballinakill	0.10	0.05	0.15			
Newport R. (Lough Beltra)	Bangor	0.05	0.01	0.12	0.31	0.15	0.46
Owengarve R.	Bangor	0.05	0.01	0.12			
Owenduff (Glenamong)	Bangor	0.15	0.07	0.35	0.31	0.15	0.46
Glenamoy	Bangor	0.15	0.07	0.35			
Ballinglen	Ballina	0.05	0.01	0.12			
Cloonaghmore (Palmerstown)	Ballina	0.05	0.01	0.12			
Moy	Ballina	0.15	0.07	0.35			
Brusna	Ballina	0.05	0.01	0.12			
Leaffony	Ballina	0.05	0.01	0.12			
Easky	Ballina	0.15	0.07	0.35	0.31	0.15	0.46
Garvogue (Bonnet)	Sligo	0.05	0.01	0.12			
Drumcliff	Sligo	0.15	0.07	0.35			
Grange	Sligo	0.05	0.01	0.12			
Duff	Ballyshannon	0.33	0.10	0.50			
Drowes	Ballyshannon	0.15	0.07	0.35	0.31	0.15	0.46
Erne	Ballyshannon	0.05	0.01	0.12			
Abbey	Ballyshannon	0.05	0.01	0.12			
Ballintra (Murvagh R).	Ballyshannon	0.05	0.01	0.12			
Laghy	Ballyshannon	0.05	0.01	0.12			
Oily	Ballyshannon	0.05	0.01	0.12			
Bungosteen	Ballyshannon	0.05	0.01	0.12			
Glen	Ballyshannon	0.15	0.07	0.35			
Owenwee (Yellow R)	Ballyshannon	0.05	0.01	0.12			
Bracky	Letterkenny	0.05	0.01	0.12			
Owenea, Owentocker	Letterkenny	0.15	0.07	0.35			
Gweebarra	Letterkenny	0.20	0.10	0.40	0.12	0.06	0.27
Owenamarve	Letterkenny	0.05	0.01	0.12			
Gweedore (Crolly R.)	Letterkenny	0.05	0.01	0.12			
Clady	Letterkenny	0.15	0.07	0.35			
Glenna	Letterkenny	0.05	0.01	0.12			
Tullaghobegly	Letterkenny	0.33	0.10	0.50			
Ray	Letterkenny	0.15	0.07	0.35			
Lackagh	Letterkenny	0.15	0.07	0.35			
Leannan	Letterkenny	0.15	0.07	0.35			
Swilly	Letterkenny	0.15	0.07	0.35			
Isle (Burn)	Letterkenny	0.05	0.01	0.12			
Mill	Letterkenny	0.05	0.01	0.12			
Crana	Letterkenny	0.15	0.07	0.35			
Clonmany	Letterkenny	0.05	0.01	0.12			
Straid	Letterkenny	0.05	0.01	0.12			
Donagh	Letterkenny	0.05	0.01	0.12			
Glenagannon	Letterkenny	0.05	0.01	0.12			
Culoort	Letterkenny	0.05	0.01	0.12			

Appendix V Table 2. Example of data inputs for the Dundalk district (2008 advice)

Dundalk	River name		Flurry	Castletown	Fane	Glyde	Dee Counter
	Common estuary		Dun-A	Dun-A	Dun-B	Dun-C	
	Fisheries Board Code		2	3	4	5	6
	OS River Number		91	92	94	95	96
	Type of monitoring		Catch	Catch	Catch	Catch	Counter
Rod harvests / counts by year						02 to 06	
2003			0	12	30	43	118
2004			0	41	126	63	84
2005			0	18	73	36	161
2006			2	12	14	70	211
2007			0	0	100	33	376
Catch and Release							
2003			0	0	3	0	
2004			0	0	2	7	
2005			0	1	3	0	
2006			0	1	11	1	
2007			0	42	40	1	
Catches, corrected for released fish							
2003		2003	0	12	33	43	40
2004		2004	0	41	128	70	55
2005		2005	0	19	76	36	57
2006		2006	2	13	25	71	23
2007		2007	0	42	140	34	0
Exploitation rates in the rod fisheries (Forecast assumptions)							
Triangular	Likely		0.05	0.15	0.15	0.15	
Distribution	Minimum		0.01	0.02	0.02	0.02	
	Maximum		0.12	0.35	0.35	0.35	
			Forecasted Expltt'n Rates draws based on assumptions above				
2003		0	0.230	0.277	0.273	0.315	
2004		0	0.298	0.146	0.110	0.206	
2005		0	0.240	0.141	0.181	0.326	
2006		0	0.254	0.145	0.188	0.311	
2007		0	0.201	0.127	0.136	0.100	
Estimated spawners			33% of CL				
2003		0	41	31	91	93	118
2004		0	41	240	1043	276	84
2005		0	41	117	347	74	161
2006		0	41	77	119	158	211
2007		0	41	331	932	307	376
Conservation limits							
	Total CL		123	197	543	2172	2410
	1SW CL		114	182	502	2009	2229
	2SW CL		9	15	41	163	181
	within district		0.023	0.036	0.100	0.399	0.443
Draft / snap / other catches (by river)							
	Draft prop by river		0.00	0.00	0.41	0.31	0.14
	Snap prop by river		0	0	0	0	0
	Other prop by river		0	0	0	0	0
2003		0	0	0	205	159	70
2004		0	0	0	305	152	103
2005		0	0	0	219	226	74
2006		0	0	0	128	162	44
2007		0	0	0	0	95	0
Driftnet catches (using river specific proportions of national catch based on CWT analysis)							
	Prop by river		0.04	0.15	0.33	0.25	0.11
2003		0	16	67	145	108	49
2004		0	16	67	145	108	49
2005		0	16	67	145	108	49
2006		0	16	67	145	108	49
2007		0	0	0	0	108	0



Appendix V - Figure 1. Examples of river specific risk plot for the Dundalk District (2008 advice).

Appendix VI. Summary results from the catchment wide electro-fishing

Analysis of salmon fry index

In cases where the current Standing Scientific Committee (SSC) forecast of returning salmon recruits to a river provides a catch option resulting in less than a 75% chance of the river meeting its Conservation Limit (CL), the SSC recommend that the river is closed for fishing. As a separate recommendation, Inland Fisheries Ireland (IFI) advise that if a river is meeting more than 65% of its CL the river can open for Catch and Release (C&R). There are many rivers where a direct assessment is not possible due to a very low or inconsistent reported angling catch (i.e. less than 10 on average annually), In these instances, based on the observation that many of the smaller rivers are below CL, the river is assumed to be meeting only 1/3 of CL and therefore not capable of supporting a fishery. Therefore, advised closures of rivers with very low rod catches, or which have been closed over a period due to the absence of new and alternative information (e.g. fish counter information, redd count or other population indicator) poses a problem for assessing the status of the rivers salmon population and CL attainment over time as there are no new data for updating the forecast and risk analysis method currently employed by the SSC.

A relative index of fry abundance based on semi-quantitative electrofishing technique (Crozier and Kennedy, 1994 and Gargan *et al.* 2008) was developed by the SSC in 2009 and 2010 to provide an alternative method for assessing attainment of Conservation Limits in rivers closed for angling or where there was no counting facility. Electrofishing of juveniles presents an alternative (and fisheries independent) source of population information as the numbers of juveniles should be a good reflection of the number of adults which produced them and the relative productive capacity of that river. This method is based on a relationship between fry abundance (which may be measurable annually) and adult returns for rivers with information on rod catches or counters over a number of years was available. Although the Standing Scientific Committee advise that assessments should preferentially be based on a recent five year average and to date the results from the catchment wide electro-fishing provide an assessment for a single year for some rivers, it is expected that more robust assessments can be made over the coming years as more surveys are carried out.

The method is only used for rivers where there is no other index of stock. Currently an index of at least 17 fry per 5 minute standardised electrofishing is used by the SSC as the cut-off between rivers where the stock is clearly below Conservation Limits and those where it is more likely that the stock is meeting Conservation Limits. If the fry index is above the threshold only catch and release fishing in the following year is advised. The information from this fishery, when combined with the other most recent catch data allows a forecast of adult returns to be made in the next fishing season. This provides a safeguard against opening a river prematurely, while still allowing some fishery activity and the subsequent collection of catch data.

Catchment-wide electro-fishing is also important in providing managers with information on the distribution and abundance of salmon fry and to identify management issues in a catchment or tributary. The absence or low density of salmon fry may be related to water quality issues, obstructions, or habitat damage and areas of low abundance can be investigated.

During 2011, 586 sites were surveyed in 34 salmon catchments nationally, Fig 1. Ten catchments surveyed in 2011 had a mean catchment wide salmon fry average of 17 fry or greater, (Corock, Oily, Colligan, Bungosteen, Cloonaghmore, Erriff, Dee, Roughty, Barrow and Avoca).

12 rivers predicted not to have a salmon surplus in 2011, that had an average salmon fry index ≥ 17 over the 2007-2011 period were recommended for opening on a catch & release basis in 2012, this would provide rod catch data for estimation of stock size. The rivers were Castletown, Glyde, Boyne, Slaney, Corock, Colligan, Bride, Owenascaul, Milltown (Kerry), Carrowinsky, Oily and Bungosteen.

References:

Crozier, W.W. and Kennedy G.J.A (1994). Application of semi-quantitative electro-fishing to juvenile salmonid stock surveys. J. Fish Biol (1994), 45, 159-164.

Gargan, P., Roche, W., Keane, S. and Stafford, T. (2008). Catchment-wide electrofishing Report. Central Fisheries Board, Mobhi Boreen, Dublin 9.

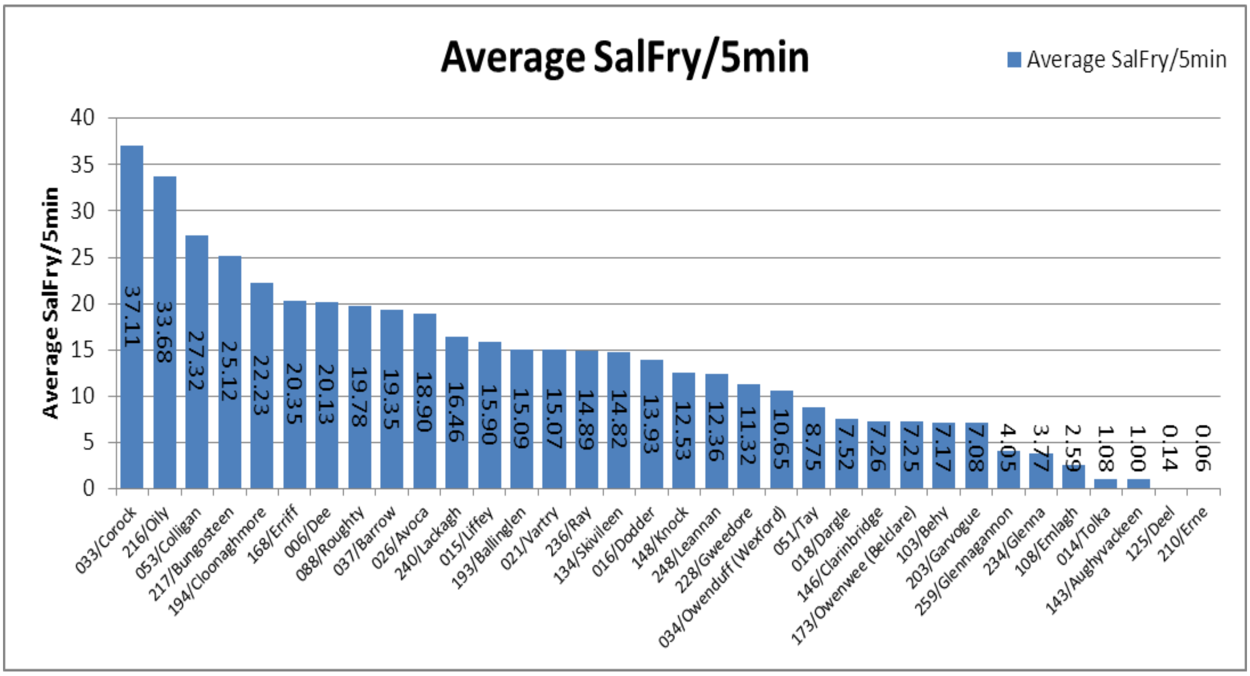


Figure 1. Results of catchment wide electro-fishing programme in 2011.

River	2007		2008		2009		2010		2011		Total	Surveys Mean
	# Sites	Avg	# Sites	Avg	# Sites	Avg	# Sites	Avg	# Sites	Avg	# Sites	
Corock									4	37.11	4	37.11
Castletown					6	28.59					6	28.59
Colligan									5	27.32	5	27.32
Bungosteen									10	25.12	10	25.12
Oily					11	9.49			7	33.68	18	21.59
Owenascaul	5	20.41			10	22.27					15	21.34
Milltown			6	12.94			7	26.44			13	19.69
Boyne			126	21.92	141	17.60	142	19.46			409	19.66
Carrownisky			16	18.25							16	18.25
Slaney	8	19.05			31	15.94	79	18.40			118	17.80
Bride			19	10.40			25	24.70			44	17.55
Glyde			16	2.49	14	17.08	14	31.61			44	17.06

Table 1. Summary of Catchments predicted not to have a salmon surplus in 2011 with Cumulative Mean of greater than 17 salmon fry per 5min.