The Standing Scientific Committee on Salmon

Independent Scientific Report to
Inland Fisheries Ireland

The Status of Irish Salmon Stocks in 2012 with Precautionary Catch Advice for 2013

2013

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 the forthcoming fishing season and into the future. The report also outlines the scientific advice process leading to the formulation and presentation of the catch advice for the 2013 season.

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 methodology for establishing Conservation Limits was modified for the 2013 catch advice by deriving new estimates of fecundity, average weights, sex and age ratio for Irish index rivers. Similarly, new wetted areas were derived based on a more robust statistical approach and these were also incorporated into the assessment for 2013. Therefore, on the basis of these modifications and 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 2013:

Since 2007 there has been a general increase in the number of rivers open for a harvest fishery (either rod and line or estuarine/riverine fishing engines).

The stock status and catch advice for the 2013 fishery is that :

- 57 rivers have an advised harvestable surplus as they are exceeding their Conservation Limits.

- A further 15 rivers could open for catch and release only based on exceeding a minimum fry threshold in catchment wide electrofishing surveys or based on IFI management criteria that they meet over 65% of their Conservation Limits.
- 71 rivers should be closed for fishing entirely as they do not exceed 65% of Conservation Limits and electrofishing thresholds have not been met.

There are 16 rivers for which a separate assessment is made for MSW (Spring) salmon where there are significant fisheries. Of these:

- 11 have an advised harvestable surplus as they are exceeding their Conservation Limits.
- A further 2 could open for catch and release only based on exceeding a minimum fry threshold in catchment wide electrofishing surveys or based on IFI management criteria that they meet over 65% of their Conservation Limits.
- 3 should be closed for harvest as they do not exceed 65% of their Conservation Limits.

There are currently 30 rivers in 26 SACs where salmon have a qualifying interest under the EU Habitats directive. Of these, 25are above their CL.

Amongst the stocks being assessed are over 55 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.

In addition, there are four assessments on major rivers used for hydro power which have been assessed as being below their conservation limits i.e. Upper Liffey (Dublin), Upper Lee (Cork), Upper Shannon (Limerick) and the River Erne. The stocks in 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.

It is also recognised however, that the release of hatchery reared salmon has resulted in fishery opportunities within these rivers for these stocks. Restoration programmes should therefore 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 "established" salmon populations in these rivers also needs to be considered.

While the main focus of this report is on fisheries and fisheries effects, there are real concerns relating to quality of freshwater environment, factors causing mortality at sea such as diseases and parasites, marine pollution, availability of prey, predator populations 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**.**

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
- Rod catch data – where catch and release fishery is allowed on these rivers.
- Juvenile assessment surveys benchmarked against an indices of total stock from index rivers.
- Mark recapture assessments.
- Redd count surveys benchmarked against other indices of total stock for index rivers.

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. 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 Salmon 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.

Despite the considerable reductions in catches, and increased runs to many rivers following the closure of the mixed stock fishery at sea, only 40% of Irelands rivers are estimated to be meeting biologically based Conservation Limits. Marine survival values in the past 5 years are amongst the lowest recorded since the coded wire tagging 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. Changes in oceanic conditions leading to poor recruitment of salmon have been implicated by the North Atlantic Salmon Conservation Organisation (NASCO) following international investigations into the decline of salmon stocks (e.g. SALSEA Merge). Recent stock forecasts from the International Council for the Exploration of the Seas (ICES) for stocks in the southern range of the North East Atlantic, indicate 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 abundance.

The Status of Irish Salmon Stocks in 2012 and Precautionary Catch Advice for 2013

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 Terms of Reference of the SSC are as follows:
The Standing Scientific Committee on Salmon (SSCS) is established under Section 7.5 (a) of the 2010 Inland Fisheries Act. The purpose of the committee is to provide scientific advice to guide IFI 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 will be considered as independent advice by IFI.

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:

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

b. 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 Electric Ireland (ESB Ireland), 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 2013 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 2012, 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))

"*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…"

While not a formal "appropriate assessment" as required under the Habitats Directive, the assessment by the SSC relating to attainment of Conservation Limits can inform on the first of the three criteria above, while inference can made regarding the latter two criteria in this regard. 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 2012 for 2013 indicates that the number of rivers with "healthy populations" on the basis of attainment of Conservation Limits has now risen to 57.

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".

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, in some larger rivers (such as the Boyne, Nore, Suir) multi-sea-winter salmon may return primarily in summer and autumn.

There is a limit to the number of juvenile salmon any river can support however, 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 or additional smolt output. 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 and 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 would be the major impounded rivers i.e. Erne, Lee, Shannon, Liffey where due to the specific problems associated with fish passage in these rivers, plans may require improvement in fish passage and restoration of individual tributaries upstream of the impoundments on a phased basis initially taking into account freshwater quality.

Ideally river specific stock and recruitment analysis would be the most accurate way to determine river specific Conservation Limits (Crozier *et al.,* 2004). The acquisition of these relationships are, however, 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 multiple 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 wetted area and latitude are the only common parameters 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 gradient 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).

Conservation limits (CLs) were updated in 2012 for calculation of 2013 catch advice. This was undertaken for a number of reasons:

- to update reference rivers providing stock-recruitment indices to a more Irish orientated set in light of new Irish river counter data.
- to ensure that CLs are based on up-to-date, river specific biological information, (e.g. river specific salmon weight rather than national averages).
- in light of updated river wetted areas.

Prior to the 2012 analyses for 2013, the Bayesian Hierarchical Stock and Recruitment Analysis (BHSRA) model was developed for a set of 13 stock and recruitment data series from monitored salmon rivers located in the Northeast Atlantic. For the 2012 analyses for the 2013 season the index rivers were updated, to a more Irish based series comprising 22 rivers, of which 17 are in the island of Ireland, four in the England/Wales (UK) and one in Scotland (UK). The time series of spawner – recruits for each river was updated and the model re-run. This 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 accessible habitat or wetted area is used) and on the rivers latitude.

Details of the BHSRA model specification are given in Prevost et al., (2003) and their application to Irish rivers in Ó Maoiléidigh et al., 2004. A summary description and the updated reference rivers are presented in Appendix IV.

The most current biological information was used in establishing river salmon populations, in terms of the ratio of 1SW to MSW fish; the weights of each and their associated fecundities. Prior to the 2012 analyses these values were estimated, and set nationally base upon best available information. For the 2012-2013 analyses values are river specific where catches of fish less than 4kg, and greater than 4kg were each greater than 100 salmon between 2006 and 2011 and for rivers with smaller catches, national averages were applied. More detail of the updated CL calculations are given in Appendix VI. A summary is provided in the table below.

Conservation Limits	Old Model data input	New Model data input	Advantage
Wetted Area	Based on groundtruthing from rivers in Mayo only - CFB published report 2003	Groundtruthing based on larger sample and other imprvements to original approach - peer review publication McGinnity et al 2011	Provides more accurate wetted areas
Age composition	Assumed single values for most rivers of 93% 1SW and 7% 2SW. For a selected 16 rivers age split based on assuming all fish entering between January and May were "spring" or MSW salmon	Values have been calculated for all rivers individually where rod catch data have more than 100 fish. Split is based on weight derived from national catch dataset from IFI	Age composition data are more reflective of individual rivers
Egg deposition	Single value applied to all rivers of 3,400 per female 1SW and 8,000 eggs 2SW from hatchery stripping	Estimates calculated from a revised national dataset (de Eyto et al, in prep) and applied to new weight and age composition data for individual rivers from IFI catch database based on 5 year averages. 1SW fecundity average = 3,057, 2SW fecundity average = 6,184.	Provides the mean and estimates of variation around the mean for individual rivers rather than fixed values
Sex ratio	Based on local observations 60% Male	No change	No change
Monitored rivers used to transport Stock and Recruitment parameters	Based on 13 stock and recruitment series from monitored rivers in the North Atlantic including 4 Irish rivers	New data from 13 Irish counter rivers used and previous Irish rivers updated. Rivers at extreme latitudes were removed.	Provides a more accurate estimate of Irish Stock and Recruitment parameters and a more appropriate relationship between salmon productivity and latitude for Irish rivers
Transport of Stock and Recruitment parameters	Mean egg depositions/msq used	Median egg deposition/msq used	More statistically robust and represent the underlying data and variation more accurately
Catch advice	**Old Model data input**	**New Model data input**	**Advantage**
Estimates of total returns	Based upon the mean of the most recent five years catch, raised by estimated exploitation rates or counter data, in a Monte-Carlo simulation to predict probable returns for the next year.	No change	No change
Estimating returns of 1SW and 2SW salmon	Assumed single values for most rivers of 93% 1SW and 7% 2SW. For a selected 16 rivers age split based on assuming all fish entering between January and May were "spring" or MSW salmon	Values have been calculated for all rivers individually where rod catch data have more than 100 fish. Split is based on weight derived from national catch dataset from IFI or run timing where appropriate and based on local and expert review by IFI	Estimates of returning salmon can be split more accurately and therefore surpluses/deficits can be calculated to provide advicefor managemet of stock components
Calculation of surpluse/deficits	Fixed values used for CLs and the catch option providing a 75% chance that this CL will be met based on the predicted estimated returns is advised	Variation in both returns and the CLs are incoroprated in the risk analysis i.e predicted CLs are used and the catch option providing a 75% chance the this predicted CL will be met based on the predicted returns is advised	This provides a more realistic risk analysis as possible variation in most of the biological parameters has been incorporated

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 2013 Catch Advice

There was no change in principle to the methodology used to provide catch advice in 2012 for the 2013 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. For the 2012 analyses for 2013 advice, river specific Conservation Limits were updated. Updates are detailed in the relevant sections below.

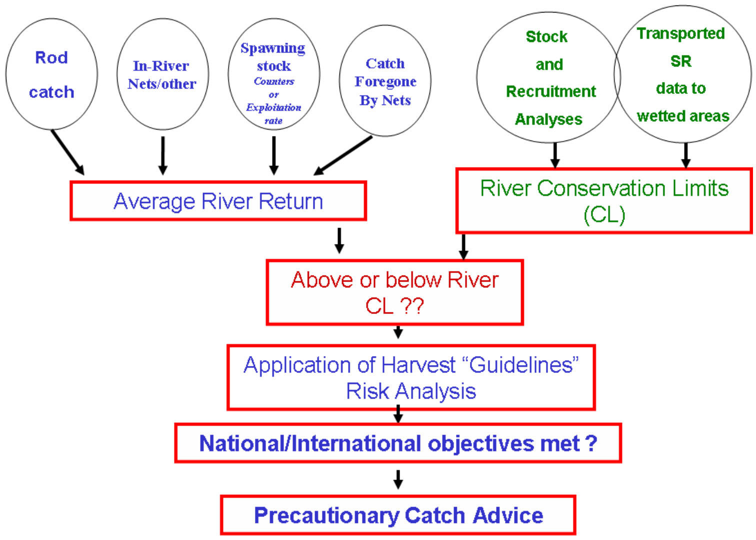


Figure 1. The Scientific Process for catch advice from 2006 to present.

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 2012 for the 2013 fishery is provided in the relevant sections below.

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. Reporting rates are at 100% from this fishery.

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. Logbook returns are increasing in recent years and reached a return rate of 75% in 2012.

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 Erriff river (Ballinakill District) are available annually.

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.

Fish counter data are provided by the IFI (or ESB/Marine Institute) in the case of the Liffey in Dublin and some private fishery owners. In total, counts from 29 fish counters were used in 2012 – 2013 assessments, an increase of 8 counters on the 2011 – 2012 assessment. These are the: *Dee (Dundalk), Boyne (Drogheda), Lower Liffey (Dublin), Upper Liffey US Leixlip (Dublin), Slaney (Wexford), Bandon and Upper Lee (Cork), Blackwater (Kerry), Waterville/Currane (Kerry), Maine (Kerry), Feale (Limerick), Mulkear (Limerick), Shannon Upstream Ardnacrusha/Parteen (Limerick), Corrib (Galway), Casla (Connemara), Ballynahinch (Connemara), Owenglin (Ballinakill), Dawros (Ballinakill), Culfin (Ballinakill), Erriff (Ballinakill), Bunowen (Ballinakill), Srahmore/Burrishoole traps (Bangor), Owenduff/ Glenamong (Bangor), Owenmore (Bangor), Carrowmore (Bangor), Ballysadare (Sligo), Erne and Eske (Ballyshannon) and Eany (Ballyshannon).*

Counts from the Screebe trap in Connemara were not used in 2012 as this trap requires upgrading.

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

- Fish are initially separated into salmon & sea trout by signal strength generated by the fish passing the counting electrodes and video images.
- A process of validation of the numbers of salmon and sea trout is carried out during the year whereby a proportion of the counter data (usually 15-20%) is examined in relation to contemporaneous video footage (resistivity counters) or self generated infra-red images (infra-red counters).
- The initial numbers of salmon and sea trout are corrected after video verification and this correction factor is applied to the remainder of the data.
- 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 (except for the Lee, Shannon and Erne counters).

- 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 estimated upstream run of fish from the counter is corrected to included salmon caught and killed downstream of the counter and excludes salmon caught and killed above the counter.
- 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. The Boyne, Corrib, Bandon and Slaney counts are raised by a factor of two to allow for the partial nature of these counts. These values will be improved following ongoing counter validation work by Inland Fisheries Ireland and the Marine Institute.
- 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 numbers of grilse and spring salmon to be allocated over the season with greater precision than in previous assessments based on scale analyses. 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 Partial counter information for the River Maine in 2009 and a more complete count in 2010, 2011 and 2012 were also considered in the assessment for catch advice in 2013.
- Where counters are used the Conservation Limit relates to the area above the counter. In the event that the count is below CL, it is assumed that the overall stock is below CL.

<u>National Coded Wire Tagging and Tag Recovery</u> – The programme provides an index of marine survival over a long time period and information on exploitation rates in marine and freshwater fisheries. 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 adults are as a result of management measures or changes in factors occurring outside of management control i.e. environmental/climate changes.

<u>Other data</u> – Information on juvenile abundance indices derived from electro-fishing surveys carried out annually by IFI are examined to indicate stock status. This information is used primarily where new information has not been available for rod catches. A summary of the 2012 programme is provided in Appendix VIII.

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 derived either from extrapolation of rod catch information using exploitation rates or from estimates based on fish counter information.

<u>Estimating the total catch in each river</u>

As stated previously the catch data for draft nets, other commercial engines (snap nets) 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 the estuaries of each river if present. 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.

<u>Estimating the returns of adult salmon in each river using rod exploitation rates</u>

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). 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. 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.

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.

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.*

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) based on field observations. This restricts the overall range of values being used to a more likely range rather than applying the entire range of values observed. Table VI-1 in Appendix VI provides the exploitation rate range used for each river.

Provision of Harvest Guidelines

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

- Examples where catch and exploitation rates are used to establish stock status relative to conservation limits:
  - River Easky (Ballina district) meeting CL with a surplus of 863 fish.
  - Owenwee/Bleclare river (Ballinakill district) below CL with a deficit of 36 fish.
- Examples where counter data are used to establish stock status relative to CL:
  - Cashla River (Connemara district) meeting CL with a surplus of 446 fish.
  - Blackwater River (Kerry district) .below CL with a deficit 3 fish.

It should be noted in these examples 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. Where a fishery comprises of more than one stock, the risk analysis is based on the simultaneous attainment of CL for all contributing stocks. For the 2013 advice, only Killary harbour (Bundorragha and Erriff stocks) and the Castlemaine harbour area (Maine, Laune and Caragh river stocks) were considered as true mixed stock fisheries. The fisheries in the common estuary of the Owenmore/Carrowmore and Owenduff were reviewed by the SSC and considered to be made up of discrete fisheries with only a small degree of mixing. Separate advice was provided on each stock in this instance.

Mixed stock fisheries will always present greater risks than when stocks are exploited separately however, 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 where a significant early run component has been identified and can be managed separately on the assumption that:

- all fish counted or caught before 31st May are considered to be MSW fish (except for the Slaney where in-season data are available on proportions of 1SW and MSW salmon.

Overview of Status of Stocks and Precautionary Catch Advice for 2013

Changes from 2012 catch advice procedure for the 2013 catch advice.

Changes to the approach used for 2013 compared to previous years are outlined in sections below. Although new Conservation Limits were calculated and the basis for the risk assessment was modified, there were few changes to the actual catch advice procedure for the 2013 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 2013 season is provided for 141 separate rivers which includes the impounded waters of the Lee, Shannon, Liffey and the River Erne. Furthermore, separate assessments are made on 16 rivers for the 2SW component of the stock in question.

Of these:

- 29 rivers have counter data (includes rivers with large hydro-electric impoundments)
- 2 rivers have trap data (Burrishoole and Erriff).

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, Shannon and Liffey.

Details of the catch advice for 2013 provided by the Standing Scientific Committee on Salmon in Ireland is given in Tables 1 through 4:

<u>SSC catch Advice for 2013.</u>

Generally, 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 Tables 3 and 4.
- 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.

Owing 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.

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).

Scientifically based catch advice for the 2013 season is provided for 139 rivers. In addition there are three upstream catchments on impounded rivers for which advice is given separately. This is one more than in 2012 as the Owenmore and Carrowmore Rivers were assessed separately for 2013 advice:

The Standing Scientific Committee have been providing catch advice to the Department of Communications Energy and Natural Resources since 2002 and with specific catch advice for individual rivers provided since 2007. Over this period the CLs and the assessments for some smaller rivers entering into larger estuaries have been combined leading to changes in the overall number of separate “rivers” for which catch advice is provided.

Since 2007 (see text figure below) there has been a general increase in the number of rivers open for a harvest fishery (either rod and line or estuarine/riverine fishing engines.

The stock status and catch advice for the 2013 fishery is that :

- 57 rivers have an advised harvestable surplus as they are exceeding their Conservation Limits (Table 1).
- A further 15 rivers could open for catch and release only based on exceeding a minimum fry threshold in catchment wide electrofishing surveys or based on IFI management criteria that they meet over 65% of their Conservation Limits.
- 71 rivers should be closed for fishing entirely as they do not exceed 65% of Conservation Limits and electrofishing thresholds have not been met (Table 3).

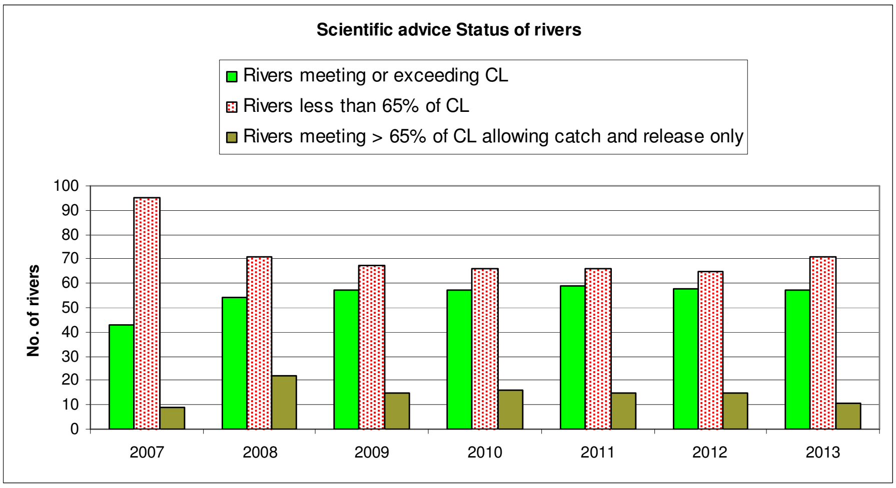
There are 16 rivers for which a separate assessment is made for MSW (Spring) salmon where there are significant fisheries. Of these:

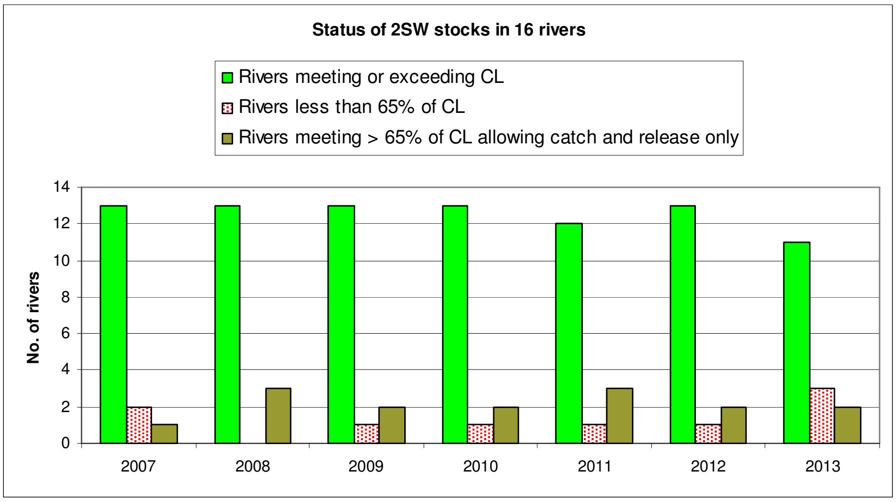
- 11 have an advised harvestable surplus as they are exceeding their Conservation Limits (Table 2).
- A further 2 could open for catch and release only based on exceeding a minimum fry threshold in catchment wide electrofishing surveys or based on IFI management criteria that they meet over 65% of their Conservation Limits.
- 3 should be closed for harvest as they do not exceed 65% of their Conservation Limits (Table 4).

There are currently 30 Irish salmon rivers listed which are listed under the EU Habitats directive (Appendix III). Of these, 25 are above their CL.

Amongst the stocks being assessed are over 55 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.

Summary of status of stocks and scientific catch advice provided for 2013 fishery





In addition, there are four assessments (Table 3) on rivers used for hydro power which have been assessed as being below their conservation limits i.e. Upper Liffey (Dublin), Upper Lee (Cork), Upper Shannon (Limerick) and the River Erne., 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.

It is also recognised however, that the release of hatchery reared salmon has resulted in fishery opportunities within these rivers for these stocks. The Standing Scientific Committee has sought feedback from DCENR and its agencies (Inland Fisheries Ireland, the Marine Institute, BIM) as well as the Dept. of the Environment (NPWS) and ESB regarding 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 these fish should not be harvested 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 "established" salmon populations in these rivers also needs to be considered.

Mixed Stock Fisheries Advice

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 (Table 1). Similarly, the draft net fishery operating in Tullaghan Bay, Bangor District, predominantly exploits stocks from the Owenmore, Owenduff and Carrowmore system, all of which are meeting and exceeding their Conservation Limits. Following a review of this fishery in 2012, the SSC determined that the main bulk of the catch was made within the estuaries of the individual rivers, so individual catch options were provided rather than a combined catch option as in previous years. There is a small overlapping fishery which takes some stock from each river but a local arrangement for the quota for this fishery was determined by IFI.

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 were 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.

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) 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.''

Catch options were provided by the SSC for this area for 2012 and 2013 (Table 1).

Monitoring the changes to the status of stocks since the closure of the mixed stock 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 prior to 2007 were compared with counts for the subsequent years to 2012. 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 count 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 proportional increase of 1, equating to a doubling of counts as indicated in the Figure 2 below) might have been expected in 2007 following the closure of this fishery. This was achieved or exceeded for seven counters in 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. Of the 16 counters run since 2006, six showed counts less than that in 2006 and 10 showed higher counts. 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 six.

Conclusions

Despite the considerable reductions in catches, and increased runs to many rivers following the closure of the mixed stock fishery at sea, only 40% of Irelands rivers are estimated to be meeting biologically based Conservation Limits. Marine survival values in the past 5 years are amongst the lowest recorded since the coded wire tagging 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. Changes in oceanic conditions leading to poor recruitment of salmon have been implicated by the North Atlantic Salmon Conservation Organisation (NASCO) following international investigations into the decline of salmon stocks (e.g. SALSEA Merge). Recent stock forecasts from the International Council for the Exploration of the Seas (ICES) for stocks in the southern range of the North East Atlantic, indicate 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 abundance.

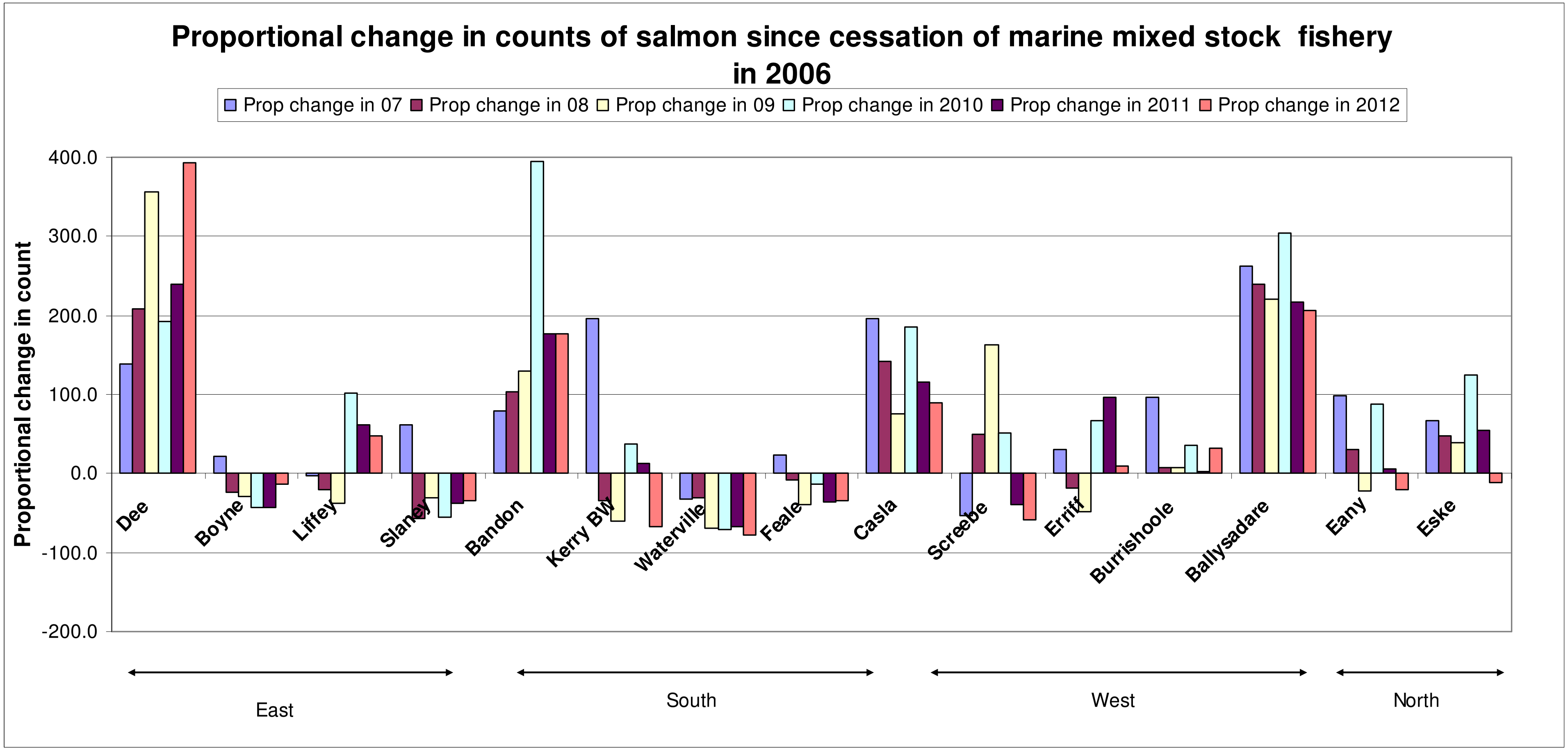


Figure 2. Proportional changes in counter figures relative to the count in 2006, closure of the mixed stocks fishery at sea in 2007.

Table 1. Rivers with a forecasted surplus above the required Conservation Limit for 2012. This is the catch option which provides a 75% chance that Conservation Limit will be met. (Note: 1SW and 2SW combined unless other wise noted in italics).

District	River	CL	Surplus	Prop CL achieved
Dundalk	Fane	1173	264	1.23
Waterford	Nore	10467	5548	1.53
Waterford	Suir, Clodiagh, Lingaun, Blackwater	14051	2371	1.17
Lismore	Blackwater, Glenshelane, Finisk	12057	6631	1.55
Cork	Owennacurra	293	71	1.24
Cork	Lower Lee (Cork)	1895	1830	1.97
Cork	Bandon	1631	1162	1.71
Cork	*1SW Ilen*	*1101*	*406*	*1.37*
Cork	Mealagh	96	192	3.00
Cork	Owvane	372	399	2.07
Cork	Coomhola	309	185	1.60
Cork	Glengarriff	166	127	1.76
Cork	Adrigole	166	8	1.05
Kerry	Lough Fada	88	3	1.04
Kerry	Croanshagh	275	124	1.45
Kerry	Roughty	1536	622	1.40
Kerry	Sneem	346	691	3.00
Kerry	*1SW Waterville*	*119*	*237*	*3.00*
Kerry	Inney	630	689	2.09
Kerry	*1SW Caragh*	*395*	*789*	*3.00*
Kerry	*1SW Laune and Cottoners*	*2070*	*4140*	*3.00*
Kerry	Maine	1178	1709	2.45
Kerry	Owenmore	105	210	3.00
Kerry	*Common Embayment Castlemaine*		6395	
Limerick	*1SW Feale, Galey and Brick*	*2849*	*1790*	*1.63*
Limerick	Mulkear	4228	1609	1.38
Galway	Corrib	6364	4235	1.67
Connemara	Cashla	438	446	2.02
Connemara	Ballynahinch	982	1473	2.50
Ballinakill	Owenglin	423	362	1.86
Ballinakill	Dawros	493	571	2.16
Ballinakill	Culfin	135	245	2.81
Ballinakill	Erriff	1382	520	1.38
Ballinakill	*1SW Bundorragha*	*94*	*189*	*3.00*
Ballinakill	Bunowen	462	69	1.15
Ballinakill	*Common Embayment Killary*		611	
Bangor	*1 SW Newport R. (Lough Beltra)*	*506*	*305*	*1.60*
Bangor	*1SW Owenduff (Glenamong)*	*711*	*1423*	*3.00*
Bangor	Owenmore	2078	739	1.36
Bangor	*1SW Carrowmore*	*230*	*330*	*2.43*
Bangor	Glenamoy	623	285	1.46
Ballina	Moy	16708	26009	2.56
Ballina	Easky	1398	863	1.62
Sligo	Ballysadare	6381	3214	1.50
Sligo	*1 SW Garvogue (Bonnet)*	*2563*	*372*	*1.15*
Sligo	Drumcliff	511	85	1.17
Ballyshannon	Duff	1068	286	1.27
Ballyshannon	*1 SW Drowes*	*1062*	*2125*	*3.00*
Ballyshannon	Eske	602	99	1.16
Ballyshannon	Eany	1316	326	1.25
Ballyshannon	Glen	1017	351	1.34
Letterkenny	Bracky	200	9	1.05
Letterkenny	Owenea and Owentocker	1692	1281	1.76
Letterkenny	*1SW Gweebarra*	*611*	*204*	*1.33*
Letterkenny	Gweedore (Crolly R.)	344	385	2.12
Letterkenny	Clady	345	120	1.35
Letterkenny	Tullaghobegly	223	99	1.44
Letterkenny	Ray	435	21	1.05
Letterkenny	Crana	1074	635	1.59

Table 2. Irish rivers meeting Conservation Limits and estimated surplus and proportion of CL achieved for MSW stocks only.

District	Predicted Recruits	CL	Deficit/ Surplus	Prop CL achieved
Kerry	2SW Waterville	83	166	3.00
Kerry	2SW Caragh	281	317	2.13
Kerry	2SW Laune	813	618	1.76
Shannon	2SW Feale , Galey and Brick	863	202	1.23
Ballinakill	2SW Bundorragha	70	139	3.00
Bangor	2SW Owenduff (Glenamong)	402	502	2.25
Bangor	2SW Carrowmore	121	242	3.00
Sligo	2SW Garvogue (Bonnet)	289	140	1.48
Ballyshannon	2SW Drowes	425	531	2.25
Cork	2SW Ilen	212	222	2.05
Letterkenny	2SW Gweebarra	116	213	2.84

Table 3. Irish rivers below Conservation Limits and the estimated deficits and proportion of CL achieved for 1SW and MSW stocks combined unless otherwise indicated.

District	Predicted Recruits	CL	Deficit/	Prop CL
Dundalk	Flurry	428	-329	0.23
Dundalk	Castletown	1451	-713	0.51
Dundalk	Glyde	1857	-368	0.80
Dundalk	*1SW Dee*	*943*	*-635*	*0.33*
Drogheda	Boyne	10236	-5857	0.43
Dublin	Lower Liffey Inc Rye	1711	-1291	0.25
Dublin	Upper Liffey US Lexlip	5389	-4030	0.25
Dublin	Dargle	731	-606	0.17
Dublin	Vartry	274	-175	0.36
Wexford	Avoca	3945	-3054	0.23
Wexford	Owenavorragh	944	-715	0.24
Wexford	*1SW Slaney*	*917*	*-740*	*0.19*
Waterford	Corock R	837	-589	0.30
Waterford	Owenduff	300	-217	0.28
Waterford	Barrow and Pollmounty	11737	-8299	0.29
Waterford	Mahon	442	-302	0.32
Waterford	Tay	318	-222	0.30
Waterford	Colligan	424	-96	0.77
Lismore	Lickey	147	-111	0.25
Lismore	Bride	1570	-641	0.59
Lismore	Tourig	118	-89	0.25
Lismore	Womanagh	366	-276	0.25
Cork	Upper Lee	2789	-2440	0.13
Cork	Argideen	467	-29	0.94
Kerry	Kealincha	128	-2	0.99
Kerry	Owenshagh	302	-210	0.30
Kerry	Cloonee	61	-28	0.54
Kerry	Sheen	626	-87	0.86
Kerry	Finnihy	144	-76	0.47
Kerry	Blackwater ()	435	-3	0.99
Kerry	Owenreagh	87	-41	0.53
Kerry	Emlaghmore	68	-39	0.43
Kerry	Carhan	88	-34	0.61
Kerry	Ferta	225	-44	0.81
Kerry	Behy	177	-79	0.55
Kerry	Emlagh	136	-74	0.46
Kerry	Owenascaul	181	-98	0.46
Kerry	Milltown	87	-51	0.41
Kerry	Feohanagh	161	-93	0.42
Kerry	Lee	509	-247	0.51
Limerick	Deel	2824	-1821	0.36
Limerick	Maigue	4634	-3850	0.17
Limerick	Upper Shannon (Above Parteen)	49638	-47646	0.04
Limerick	Owenagarney	629	-344	0.45
Limerick	Fergus	2449	-2222	0.09
Limerick	Doonbeg	524	-353	0.33
Limerick	Skivaleen	457	-299	0.35
Limerick	Annageeragh	320	-210	0.34
Limerick	Inagh	1095	-860	0.21
Limerick	Aughyvackeen	222	-137	0.38
Galway	Aille (Galway)	105	-66	0.37
Galway	Kilcolgan	2071	-1236	0.40
Galway	Clarinbridge	489	-377	0.23
Galway	Knock	132	-78	0.41
Galway	Owenboliska R (Spiddal)	594	-352	0.41
Connemara	L.Na Furnace	71	-3	0.96
Connemara	Screebe trap	155	-33	0.79
Ballinakill	Carrownisky	365	-285	0.22
Ballinakill	Owenwee (Belclare)	373	-36	0.90
Bangor	Srahmore (Burrishoole)	616	-81	0.87
Bangor	Owengarve R.	227	-143	0.37
Bangor	Muingnabo	336	-198	0.41
Ballina	Ballinglen	409	-312	0.24
Ballina	Cloonaghmore (Palmerstown)	1324	-1098	0.17
Ballina	Brusna	1096	-834	0.24
Ballina	Leaffony	241	-184	0.24
Sligo	Grange	330	-141	0.57
Ballyshannon	Abbey	333	-207	0.38
Ballyshannon	Erne	16554	-14640	0.12
Ballyshannon	Ballintra (Murvagh R).	546	-321	0.41
Ballyshannon	Laghy	447	-253	0.44
Ballyshannon	Oily	628	-375	0.40
Ballyshannon	Bungosteen	374	-205	0.45
Ballyshannon	Owenwee (Yellow R)	183	-66	0.64
Letterkenny	Owenamarve	204	-119	0.42
Letterkenny	Glenna	215	-123	0.43
Letterkenny	*1SW Lackagh*	*235*	*-118*	*0.50*
Letterkenny	*1SW Leannan*	*516*	*-410*	*0.21*
Letterkenny	Swilly	1104	-615	0.44
Letterkenny	Isle (Burn)	520	-294	0.43
Letterkenny	Mill	312	-185	0.41
Letterkenny	Clonmany	443	-242	0.45
Letterkenny	Straid	184	-101	0.45
Letterkenny	Donagh	427	-244	0.43
Letterkenny	Glenagannon	378	-219	0.42
Letterkenny	Culoort	252	-149	0.41

Table 4. Irish rivers below Conservation Limits and estimated deficits and proportion of CL achieved for MSW stocks only.

District	Predicted Recruits	CL	Deficit	Prop CL achieved
Wexford	2SW Slaney	2750	-2142	0.22
Bangor	2SW Newport R. (Lough Beltra)	367	-120	0.67
Dundalk	2SW Dee	718	-488	0.32
Letterkenny	2SW Lackagh	279	-90	0.68
Letterkenny	2SW Leannan	1197	-822	0.31

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 3).

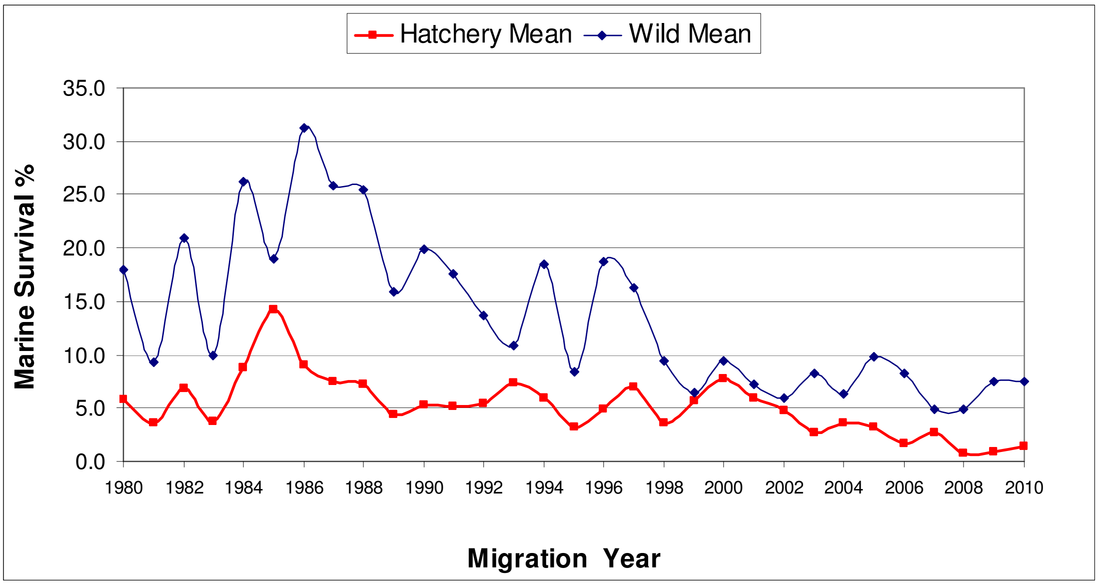


Figure 3. Marine survival (from smolt release to return to the coast) for wild and hatchery salmon.

The current estimates which are amongst the lowest in the time series suggest that based on recent years just over 5% of the wild smolts that go to sea from Irish rivers are surviving (*i.e.* 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 4). 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.

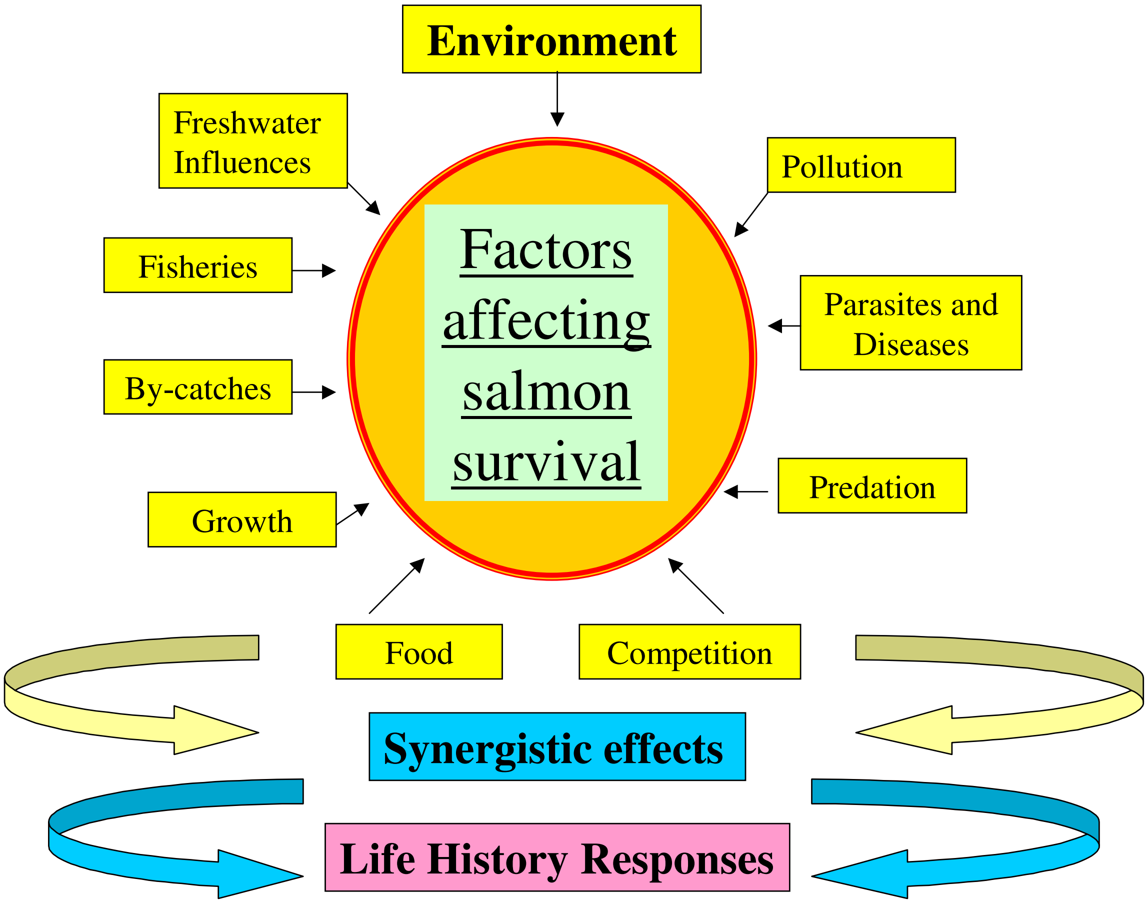


Figure 4. The factors which individually and synergistically affect the marine survival of salmon and which cause significant changes to life history responses such as population structure, fitness and size.

Requirements for future assessments

There are 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, over 55 have average rod catches of less than 10 salmon the general assumption that spawning stocks in these rivers are only attaining 33% of the Conservation Limits has been generally supported by the electrofishing surveys (see Appendix VIII). 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 salmon 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. No new information has been available to assess stock status since 2006 but these rivers should continue to be protected from a biodiversity perspective. Given such small stock sizes, it may be inappropriate to have harvest fisheries. However, efforts should be made, to assess the status of these specific rivers using catchment wide electro-fishing or collection of redd count data

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 (27) 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.
- Any new counters to be installed.

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

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

Changes to assessments in future years

New developments in the provision of catch advice for international and homewater fisheries are ongoing in the context of ICES and EU 7th Framework programmes (ECOKNOWS). The main goals of these programmes is to develop life-history forecast models including production at all life stages of salmon life history. The approaches will allow more data to be included in assessments and underlying assumptions to be tested and validated. It is envisaged that the new approaches for the provision of Irish catch advice will be developed within the next three years.

Until such time, the existing forecast model based on fisheries data or count data will be applied using the currently derived conservation limits for the next 5 year period. Data will continue to be updated and where appropriate improved to provide catch advice.

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Appendix I. Members of the Standing Scientific Committee of the National Salmon Commission 2000 to 2013

This could be updated to 2012 committee
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 (to 2007) – Environmental Protection Agency
Dr. P. McGinnity – NUI, Cork
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

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

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. 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.

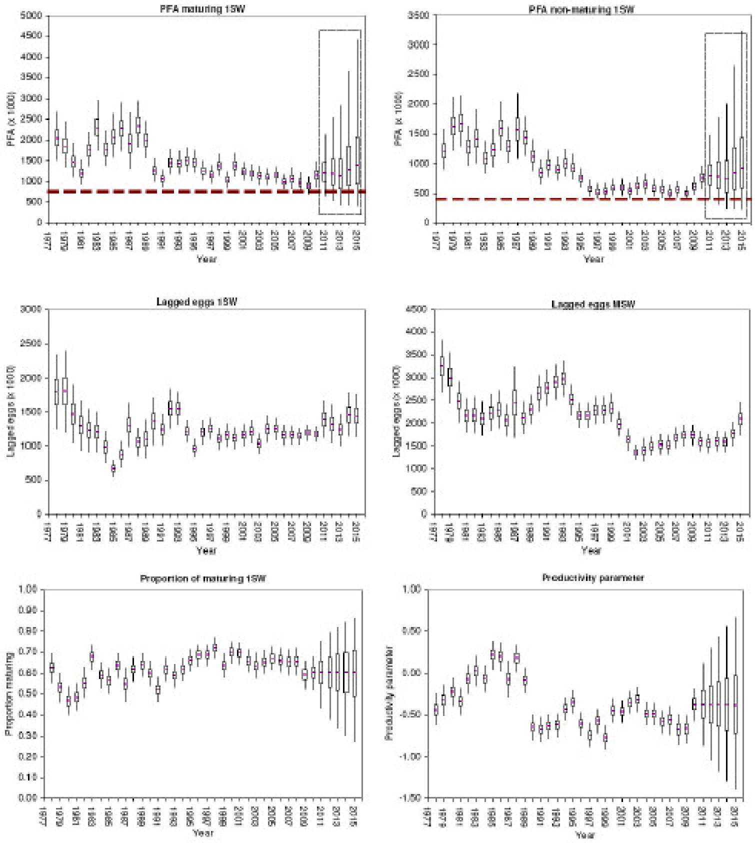

Figure 10.2.1 Southern NEAC PFA for maturing 1SW and non-maturing 1SW fish, lagged eggs from 1SW and MSW, proportion 1SW maturing, and productivity (in logarithmic scale, i.e. logarithm of PFA per lagged egg), for PFA years 1978 to 2015. The last five years (2011 to 2015) are forecasts in all cases.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

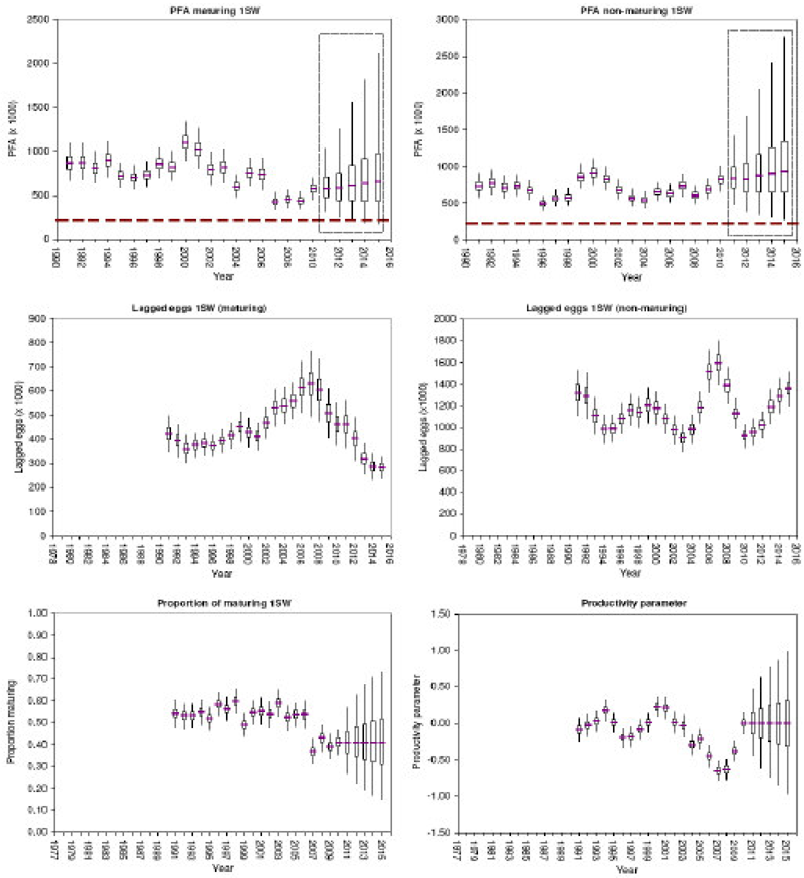

Figure 10.2.2 **Northern NEAC PFA for maturing 1SW and non-maturing 1SW fish, lagged eggs from 1SW and MSW, proportion 1SW maturing, and productivity (in logarithmic scale, i.e. logarithm of PFA per lagged egg), for PFA years 1991 to 2015. The last five years (2011 to 2015) are forecasts in all cases.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

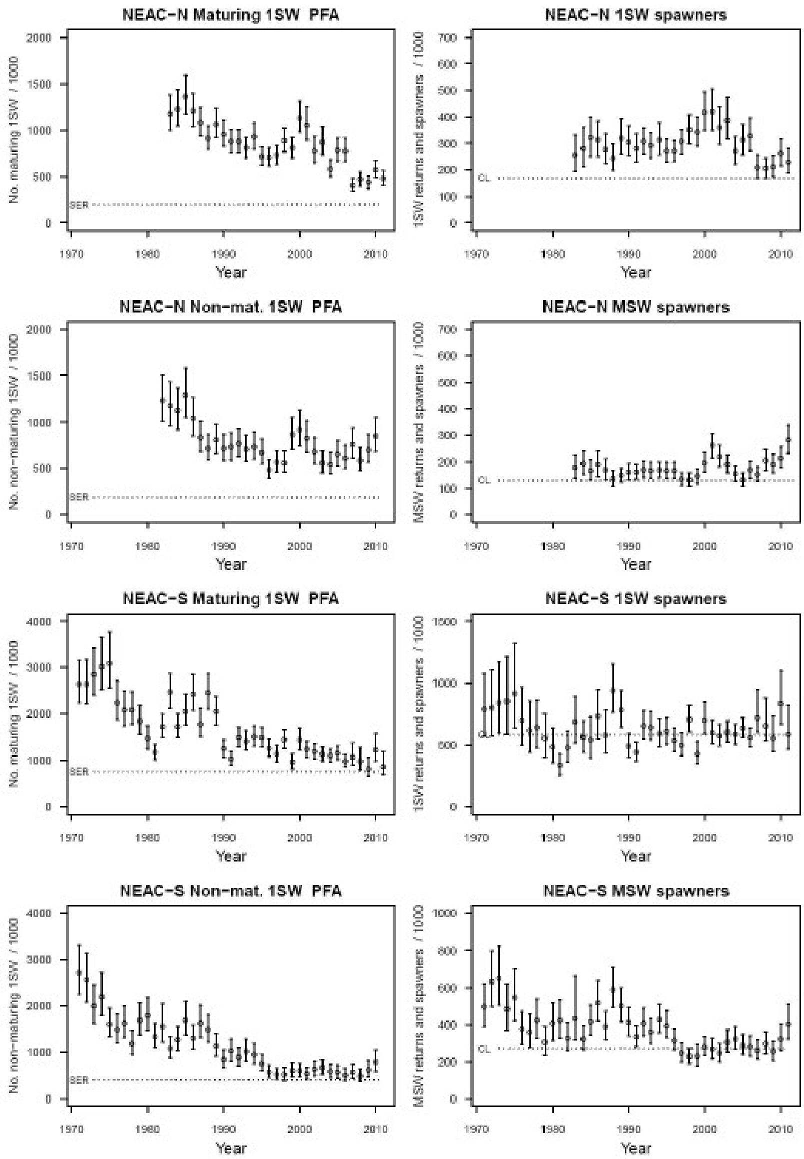

Figure 10.2.3 Estimated PFA (recruits; left panels) and spawning escapement (right panels), with 95% confidence limits, for maturing 1SW (1SW) and non-maturing 1SW (MSW) salmon in northern Europe (NEAC-N) and southern Europe (NEAC-S). **The dashed horizontal lines in the left panels are the age-specific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

District	River	CL	Total CL
Drogheda	Boyne	Below	10,236
Wexford	Slaney	Below	3,667
Waterford	Barrow, Pollmounty	Below	11,737
Waterford	Nore	Above	10,467
Waterford	Suir, Clodiagh,Linguan	Above	14,051
Lismore	Blackwater, Glenshalane, Finisk	Above	12,057
Kerry	Blackwater	Above	435
Kerry	Cummeragh/Currane	Above	202
Kerry	Laune	Above	2,883
Kerry	Caragh	Above	676
Shannon	Feale, Galey, Brick	Above	3,712
Shannon	Mulkear	Above	4,228
Galway	Corrib	Above	6,364
Connemara	Cashla	Above	438
Connemara	Owenmore	Above	982
Ballinakill	Owenglin	Above	423
Ballinakill	Erriff	Above	1,382
Bangor	Newport	1SW Above,	506
		2SW Below	367
Bangor	Srahmore	Below	615
Bangor	Owenduff	Above	1,113
Bangor	Glenamoy	Above	623
Ballina	Moy	Above	16,708
Sligo	Ballysadare	Above	6,381
Ballyshannon	Eske	Above	602
Ballyshannon	Drowes	Above	1,487
Letterkenny	Owenea,Owentocker	Above	1,692
Letterkenny	Gweebarra	Above	727
Letterkenny	Lackagh	Below	514
Letterkenny	Leannan	Below	1,713

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

Prior to the 2012 analyses for 2013, the Bayesian analysis of this hierarchical model was developed from a set of 13 stock and recruitment data series from monitored salmon rivers located in the Northeast Atlantic. For the 2012 analyses for the 2013 season the index rivers were updated, to a more Irish based series comprising 22 rivers, of which 17 are in the island of Ireland, four in the UK and one in Scotland. The time series of spawner – recruits for each river was updated and the model re-run. This 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.

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.

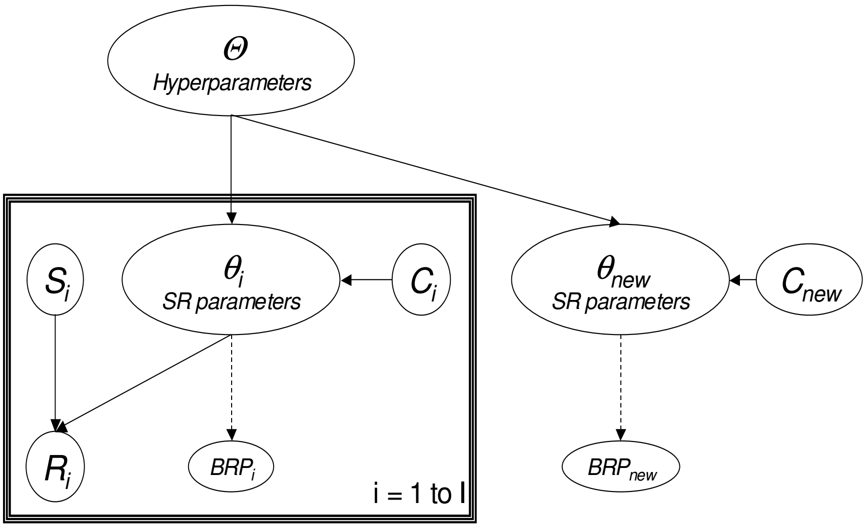

Figure IV.1. The conditioning structure of the BHSRA as represented in a Directed Acyclic Graph (DAG). Nodes (ellipses) are random variables. The plain arrows represent stochastic links, *i.e.* the distribution of a child node depends on its parents. Dashed arrows represent deterministic links, *i.e.* 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*).

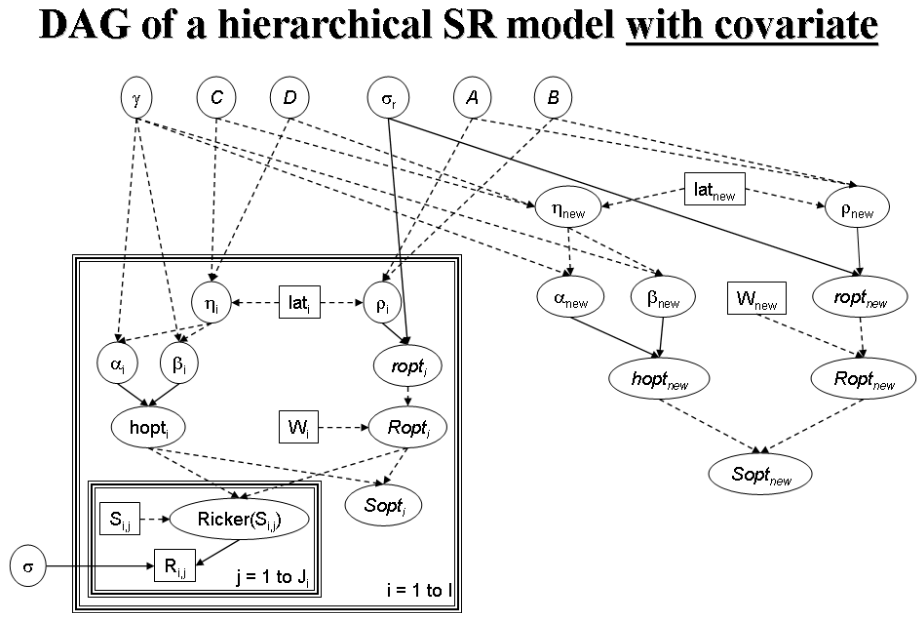

Figure IV.2. DAG of the hierarchical SR model with covariates used to transport stock and recruitment parameters to Irish rivers. The same graphical conventions are applied as in Figure 1. Naming of the nodes are explained below.

Brief explanation of terms used in the DAG.

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

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 (m²).
$ropt_i$ is the egg recruitment rate per m^2 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 monitored rivers

Prior to 2012 Egg-to-egg Stock-Recruitment (SR) time series from 13 European rivers were used in the analysis, from: two French rivers, three UK, three Northern Ireland, two Scottish, one from Norway. one from Iceland and one from Ireland. To give a more Irish – centric analysis, and in light of newly available data from counters on Irish rivers, the input data was re-worked to 22 rivers, and the analysis re-run. Rivers, their latitude and wetted areas and the number of SR observations are detailed in Table IV-1 and Figure IV-1.

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. Rivers colonized mainly by sea trout and holding a comparatively small salmon population were not considered. 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. 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.

Table IV.1. Stock-Recruitment index rivers, latitudes, wetted areas and number of observations.

Index rivers:	Country	Latitude (decimal degrees N)	Wetted Area (ha)	Number of SR Obs
Bandon	Ireland	51.74	136.04	4
Waterville Curraune	Ireland	51.84	20.16	4
Lismore (Munster) Blackwater	Ireland	51.91	888.25	4
Kerry Blackwater	Ireland	51.91	27.61	3
Feale	Ireland	52.34	211.81	4
Slaney	Ireland	52.60	321.93	4
Liffey	Ireland	53.20	233.78	4
Casla	Ireland	53.34	17.62	3
Screebe Trap	Ireland	53.44	6.19	6
Erriff	Ireland	53.67	54.04	21
Dee	Ireland	53.84	94.68	3
Burrishoole	Ireland	53.99	12.77	26
Ballysadare	Ireland	54.12	214.72	3
Eany	Ireland	54.71	45.75	3
Bush	UK (N. Ireland)	55.00	84.55	21
Faughan	UK (N. Ireland)	55.00	88.24	11
Mourne	UK (N. Ireland)	55.00	1036.06	13
Frome	UK (England)	50.50	87.64	20
Tamar	UK (England)	50.58	292.57	13
Dee	UK (England)	53.00	617.00	15
Lune	UK (England)	54.50	423.00	18
North Esk	UK (Scotland)	57.00	210.00	16

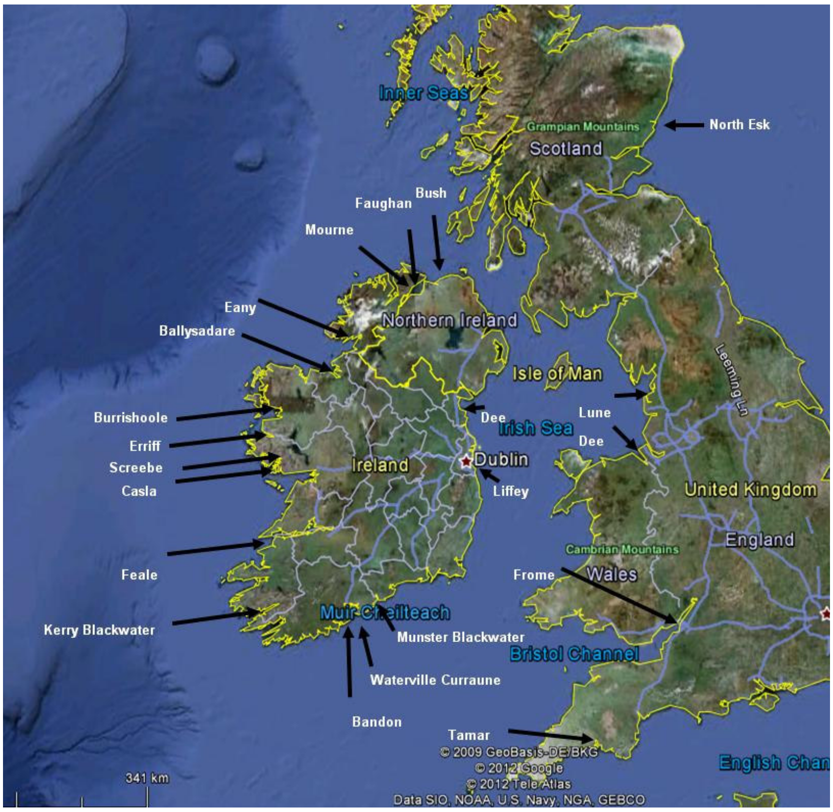

Figure IV. 3. Locations of rivers used for the provision of stock and recruitment parameters for BHSRA.

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Appendix V. Calculation of river specific Conservation Limits

The process of calculating river conservation limits is displayed in figure V-1 and detailed below.

Step 1. Fecundity:

The IFI Wild Salmon and Sea Trout tagging scheme itemises Salmon rod catch and weights by River and catch date, providing the most contemporary data set on salmon populations available. Six recent years of this data (2006 and 2011) were used to detail river specific variability in salmon populations. River catch weights were split at 4kg to initially differentiate between 1SW and MSW groups. For rivers where greater than 100 fish above 4kg, and below 4kg, were reported over the time period, river specific values were used. Where fewer than 100 fish > or < 4kg were reported the national average values were used. From these bimodal weight data sets, normal frequency distributions were constructed from the means and standard deviations of the fish greater than and less than 4kg (Elliott, 1977; Fowler and Cohen, 1990) describing the weight ranges of 1SW and MSW fish for each river population. From these the 10th percentile, 50th percentile (median) and 90th percentile weights were taken as the range in weights (example in Figure V-2).

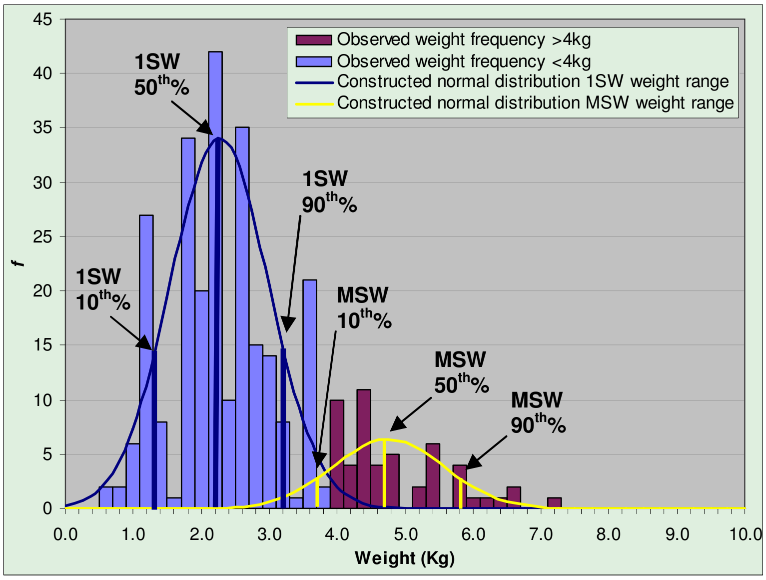

Figure V-2. Example of river specific observed weight frequency ranges and constructed normal distribution weight ranges of 1SW and MSW based upon initial weight splits of less than and greater then 4kg respectively. 10th, 50th and 90th percentile weights of each age group indicated.

The weight to fecundity relationship was established from 336 wild fish stripped by hatcheries between 1992 and 2011. The linear relationship between recorded fish weights and number of stripped eggs was found to be significant (Figure V-3). The resulting linear regression relationship provides means to calculate fecundity in number of eggs from fish weights:

$$\text{No. of eggs} = 1250.83*(\text{Weight kg}) + 505.56$$

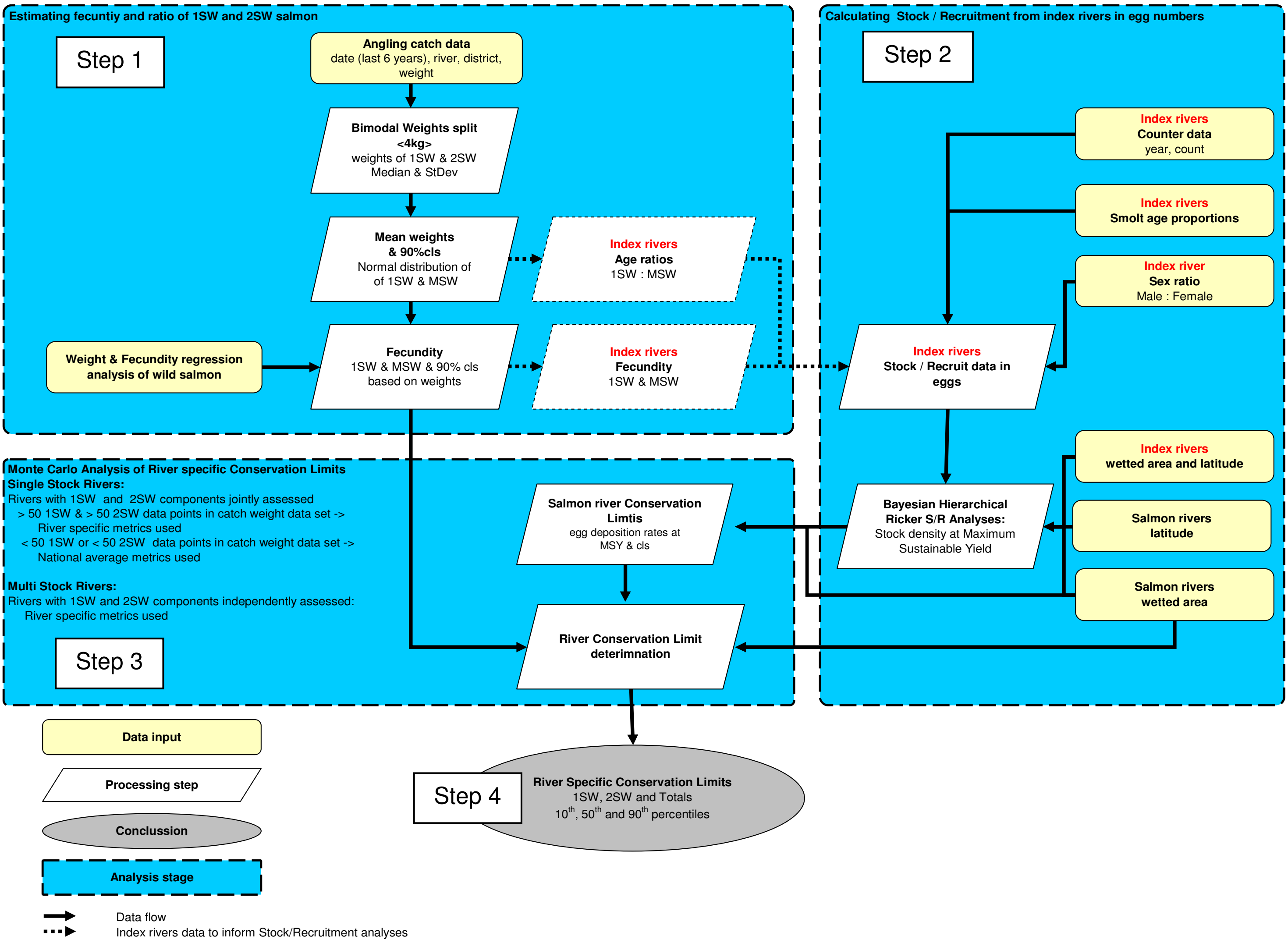

Figure V-1. Diagrammatic display of information flow in estimation of river specific conservation limits.

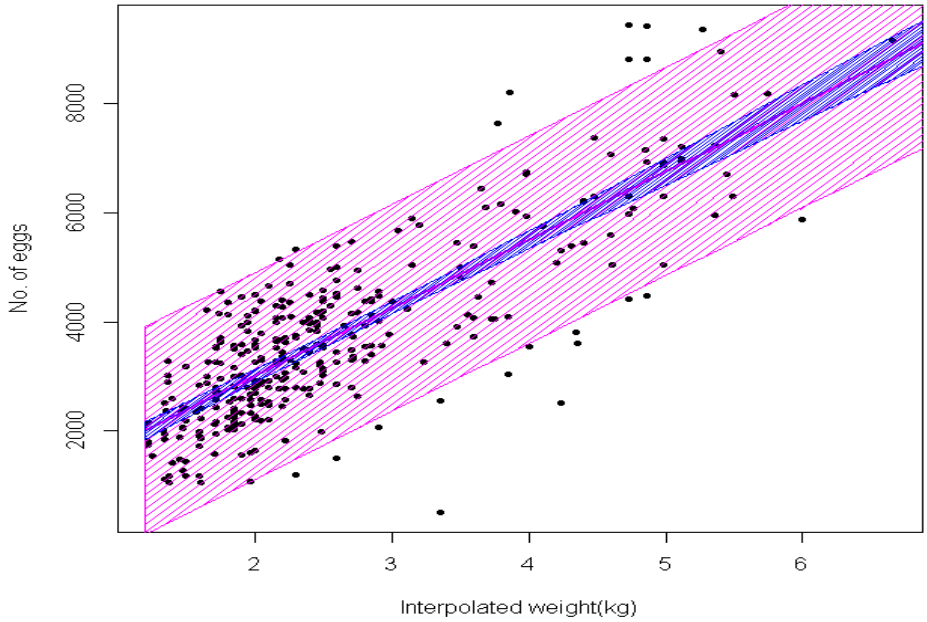

Figure V-3. Stripped number of eggs in Irish wild salmon, 1992 - 2011, against weight (kg) of fish. Fitted line is calculated from the model. Pink are = 95% prediction intervals, blue area = 95% confidence intervals. n=336

Age Ratio, 1SW:MSW fish

The number of fish over 4kg and below 4kg for each river was used to construct binomial frequency distributions (Elliott, 1977; Fowler & Cohen, 1990) of the ratio of 1SW to MSW fish for each river. From these the 10^{th} percentile, 50^{th} percentile (median) and 90^{th} percentile were taken as the ranges in the ratios of 1SW:MSW fish for each river n (Figure **V-4**).

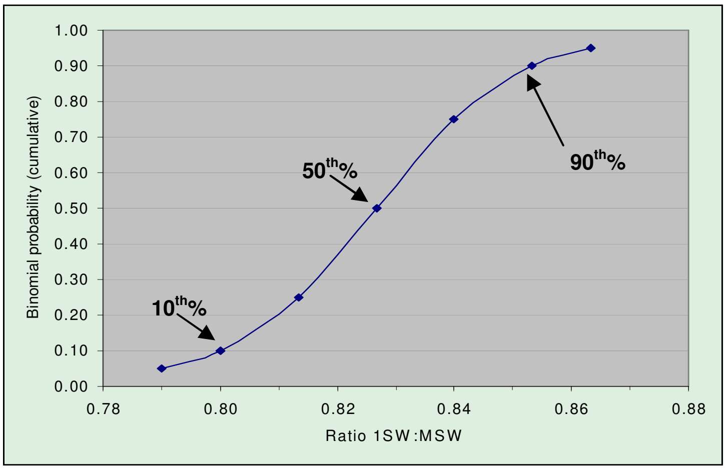

Figure V-4. Cumulative Binomial frequency distribution of the ratio of 1SW salmon in a river based upon the count of fish below 4kg and total number of recorded as caught in a river in catch statistics. MSW ratios are the inverse, hence 0.83 1SW: 0.17 MSW. 10^{th}, 50^{th} and 90^{th} percentiles indicated.

Step 2. Calculating Stock/ Recruitment from index rivers

The Bayesian Hierarchical Stock and Recruitment Analysis (BHSRA) of index rivers, and transport of Biological reference points to other rivers, gives a required egg deposition rate per metre squared, specific to each river and the necessary quantity defining each rivers conservation limit (Appendix IV). These calculations are based upon index river data, and associated smolt ages, age ratios and fecundities. Specific data were used where available for these from counter/ trap monitoring station records or up to date scientific monitoring. . Where no such data existed the river specific rod catch data set were used to provide them.

Egg deposition rates at Maximum Sustainable Yield

Variability in the egg deposition rates at Maximum Sustainable Yield (MSY), as part of the output from the BHSRA were also taken at the 10th percentile, 50th (median) and 90th percentiles of the river specific range (Figure V-5). These approximate negative binomial frequency distributions and are appropriate for describing the culmed (also known as contagious) distribution (Elliott, 1977) of dispersal of salmon redds and eggs in streams and rivers (after Armstrong et al., 2003 and Bardonnet & Baglinière 2000).

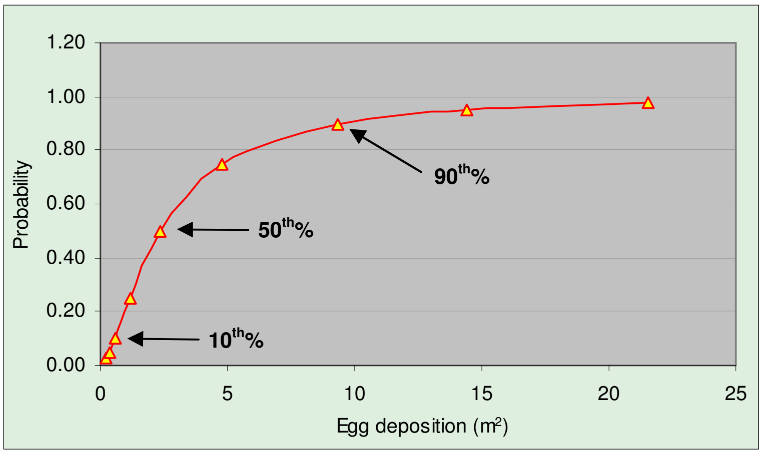

Figure V-5. Cumulative frequency egg deposition rate from BHSRA. 10th, 50th and 90th percentiles indicated.

Wetted areas:

Following the 2012 season the wetted areas of rivers was updated. Prior to 2012 these were 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 according to McGinnity *et al.,* (2003). This approach was updated for the 2013 assessment, incorporating a national database of 1767 individual river width reference measurements, from 340 reaches according to McGinnity (2012) who identified that:

The best model to predict wetted width of rivers included two explanatory variables: upstream catchment area and Shreve index (Table 1). These two variables explained 88% of the variation in the wetted width measured in the field using:

$$\log_{10}(\text{Wetted width} + 1) = 0.22734 + 0.20045(\log_{10}\text{catchment area}) + 0.25939(\log_{10}\text{Shreve index})$$

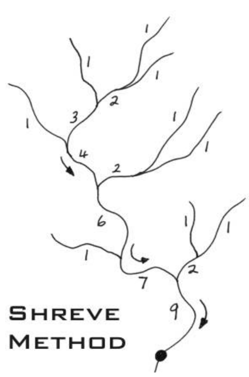

Table 1. Best fit model (ANOVA) explaining the response variable, Log_{10} (wetted width + 1), using multiple linear regression of explanatory GIS-derived variables

	d.f.	Sum Square	Mean Square	F	P
Log_{10} Catchment Area	1	29.67	29.67	2223.13	<0.0001
Log_{10} Shreve	1	1.82	1.82	136.10	<0.0001
Residuals	321	4.28	0.01		
Adj. R^2 = 0.88; F = 1180 (2, 321 d.f.); P < 0.0001					

	Estimate	SE	t-value	P
Coefficients				
Intercept	0.22734	0.01721	13.21	<0.0001
Log_{10} Catchment Area	0.20045	0.01891	10.60	<0.0001
Log_{10} Shreve	0.25939	0.02224	11.67	<0.0001

These updated wetted areas were applied in the BHSRA the model specification (as described presented in Appendix IV) with regard to the index rivers, all other Irish salmon rivers for which stock-recruitment indices were derived by the BHSRA and in raising the results to river specific CLs.

Step 3. Monte Carlo Analysis of CLs
The salmon conservation limits, in eggs per m^2 at MSY are raised to the wetted area of each river to give the total necessary egg deposition for each river, *i.e.* the rivers conservation limits. These values are calculated as number of eggs, and then converted to numbers of fish. Calculations to establish the conservation limits in numbers of fish are based upon:

- proportion of 1SW and MSW fish
- fecundity of 1SW and MSW fish

Variation around ratios of 1SW: MSW, their fecundities and egg deposition requirements were incorporated in Monte Carlo analysis. Ranges were truncated to triangular distributions taking the 10th percentile and 90th percentile as upper and lower limits and the 50th percentile (median) as the most likely, to derive total river conservation limits and their 1SW and MSW components, where:

Conservation Limit in total number of eggs =

(Prop. 1SW * Prop. Female * 1SW Fecundity * X) + (Prop. 2SW * Prop. Female * 2SW Fecundity * X)

Where the proportion of females to males in 1SW fish is taken as 0.6:0.4 and in MSW as 0.85:0.15 and X is the relative value of number of fish, which is subsequently split by the ratio of 1SW to 2SW to give the conservation limit of each, and summed to give the total river conservation limits against which returns are compared.

Step 4. River specific Conservation Limits
The Monte Carlo analyses also provides confidence bounds around mid point CL estimates, which were subsequently incorporated into the catch advice assessment methodology. The 50th percentile (median value) is implemented as the most likely values and the 10th and 90th percentiles as minimum and maximum values in triangular distributions in the risk analysis leading to provision of catch advice (Appendix VI).

This approach recognises and incorporates appropriate biology and ecology variability in salmon river populations in order to take it into consideration when establishing surplus and deficits in returning river specific salmon stocks. By estimating salmon fecundities and 1SW:MSW ratios from greater than 100 records of fish, empirically recognised as most probably of 1SW and MSW origin by splitting data sets at 4kg, from the most up-to-date catch statistics, this approach provides substantial, relevant and reliable, quantitative information on a river by river basis. While for rivers with smaller catches, national average values are implemented to ensure that the most probable ranges in variability are incorporated.

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Appendix VI. Derivation of river-specific catch advice for Atlantic salmon fisheries in Ireland for 2013

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 (at least 75% recommended) that the Conservation Limit (CL) 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 the most recent 5 years 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 (Appendix VI-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 IV). Because fisheries exploit fish, the egg requirements are translated to the number of salmon required to achieve that egg deposition using the 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, which 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:

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

where:

$Z_1, Z_2, \dots Z_M$	= are outcomes in M stocks
N	= number of fish in total
$p_1, p_2, \dots, p_M$	= 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. Introduced in 2012 for the 2013 season, ecological/ bogical variability about conservatin limtis (S_{optf}) was introduced to incorporate the range of 1SW:MSW fish, their respective fecundities and variability in egg deposition from stock-recreuitment analyses (Appendix V).
7. Repeat steps 1 to 5 a large number of times (M = 10,000).
8. Calculate the number of times the spawner requirement was met or exceeded (Σ $SpawnerMet_I$ from step 5).
9. 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).
10. Release N + c fish to the river with c > 0.
11. Repeat steps 1 to 9 until the desired probability of meeting or exceeding the spawner requirement is attained.
12. 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).
13. 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).

Table VI-1. River Exploitation rates applied for 2013 advice.

District	River	1SW Exploitation rates Likely	Minimum	Maximum	MSW Exploitation rates Likely	Minimum	Maximum
Dundalk	Flurry	0.05	0.01	0.12			
Dundalk	Castletown	0.05	0.01	0.12			
Dundalk	Fane	0.15	0.07	0.25	0.12	0.06	0.27
Dundalk	Glyde	0.05	0.01	0.12	0.12	0.06	0.27
Dublin	Dargle	0.05	0.01	0.12			
Dublin	Vartry	0.05	0.01	0.12			
Wexford	Avoca	0.05	0.01	0.12			
Wexford	Owenavorragh	0.05	0.01	0.12			
Waterford	Corock R	0.05	0.01	0.12			
Waterford	Owenduff	0.05	0.01	0.12			
Waterford	Barrow and Pollmounty	0.05	0.01	0.12	0.12	0.06	0.27
Waterford	Nore	0.05	0.01	0.12	0.12	0.06	0.27
Waterford	Lingaun	0.05	0.01	0.12			
Waterford	Suir, Clodiagh, Lingaun & Blackwater	0.05	0.01	0.12	0.12	0.06	0.27
Waterford	Clodiagh	0.05	0.01	0.12			
Waterford	Mahon	0.05	0.01	0.12			
Waterford	Tay	0.05	0.01	0.12			
Waterford	Colligan	0.05	0.01	0.12			
Lismore	Lickey	0.05	0.01	0.12			
Lismore	Bride	0.05	0.01	0.12			
Lismore	Tourig	0.05	0.01	0.12			
Lismore	Womanagh	0.05	0.01	0.12			
Cork	Owennacurra	0.05	0.01	0.12			
Cork	Lower Lee (Cork)	0.15	0.07	0.35	0.12	0.06	0.27
Cork	Argideen	0.05	0.01	0.12			
Cork	Ilen	0.15	0.07	0.35	0.12	0.06	0.27
Cork	Mealagh	0.05	0.01	0.12			
Cork	Owvane	0.05	0.01	0.12			
Cork	Coomhola	0.15	0.07	0.35			
Cork	Glengarriff	0.05	0.01	0.12			
Cork	Adrigole	0.05	0.01	0.12			
Kerry	Kealincha	0.05	0.01	0.12			
Kerry	Lough Fada	0.05	0.01	0.12			
Kerry	Croanshagh (Glanmore R. and L.)	0.05	0.01	0.12			
Kerry	Owenshagh	0.05	0.01	0.12			
Kerry	Cloonee	0.05	0.01	0.12			
Kerry	Sheen	0.04	0.01	0.1			
Kerry	Roughty	0.1	0.05	0.15			
Kerry	Finnihy	0.05	0.01	0.12			
Kerry	Sneem	0.05	0.01	0.12			
Kerry	Owenreagh	0.05	0.01	0.12			
Kerry	Inney	0.15	0.07	0.35			
Kerry	Emlaghmore	0.05	0.01	0.12			
Kerry	Carhan	0.05	0.01	0.12			
Kerry	Ferta	0.05	0.01	0.12			
Kerry	Behy	0.05	0.01	0.12			
Kerry	Cottoners	0.05	0.01	0.12			
Kerry	Caragh	0.15	0.07	0.35	0.31	0.15	0.46
Kerry	Laune and Cottoners	0.15	0.07	0.35	0.31	0.15	0.46

Table VI-1 (Cont.). River Exploitation rates applied for 2013 advice.

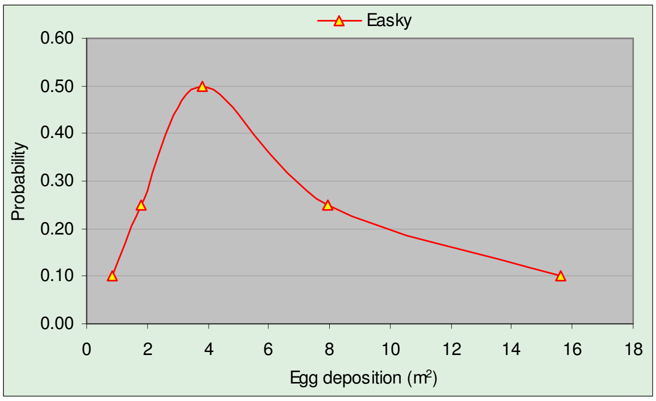
		1SW Exploitation rates			MSW Exploitation rates		
District	**River**	**Likely**	**Minimum**	**Maximum**	**Likely**	**Minimum**	**Maximum**
Kerry	Emlagh	0.05	0.01	0.12			
Kerry	Owenascaul	0.05	0.01	0.12			
Kerry	Milltown	0.05	0.01	0.12			
Kerry	Feohanagh	0.05	0.01	0.12			
Kerry	Owenmore	0.05	0.01	0.12			
Kerry	Lee	0.05	0.01	0.12			
Limerick	Brick	0.05	0.01	0.12			
Limerick	Deel	0.05	0.01	0.12			
Limerick	Maigue	0.05	0.01	0.12			
Limerick	Owenagarney	0.05	0.01	0.12			
Limerick	Fergus	0.15	0.07	0.35			
Limerick	Doonbeg	0.05	0.01	0.12			
Limerick	Skivaleen	0.05	0.01	0.12			
Limerick	Annageeragh	0.05	0.01	0.12			
Limerick	Inagh	0.05	0.01	0.12			
Limerick	Aughyvackeen	0.05	0.01	0.12			
Galway	Aille (Galway)	0.05	0.01	0.12			
Galway	Kilcolgan	0.05	0.01	0.12			
Galway	Clarinbridge	0.05	0.01	0.12			
Galway	Knock	0.05	0.01	0.12			
Galway	Owenboliska R (Spiddal)	0.05	0.01	0.12			
Connemara	L.Na Furnace	0.05	0.01	0.12			
Ballinakill	Owenglin	0.15	0.07	0.35			
Ballinakill	Bundorragha (Wild Rod)	0.15	0.07	0.35	0.31	0.15	0.46
Ballinakill	Carrownisky	0.05	0.01	0.12			
Ballinakill	Bunowen	0.1	0.05	0.12			
Ballinakill	Owenwee (Belclare)	0.05	0.01	0.12			
Bangor	Newport R. (Lough Beltra)	0.1	0.05	0.12	0.31	0.15	0.46
Bangor	Owengarve R.	0.05	0.01	0.12			
Bangor	Glenamoy	0.15	0.07	0.35			
Bangor	Muingnabo	0.05	0.01	0.12			
Ballina	Ballinglen	0.05	0.01	0.12			
Ballina	Cloonaghmore (Palmerstown)	0.05	0.01	0.12			
Ballina	Moy	0.15	0.07	0.35	0.31	0.15	0.46
Ballina	Brusna	0.05	0.01	0.12			
Ballina	Leaffony	0.05	0.01	0.12			
Ballina	Easky	0.15	0.07	0.35			
Sligo	Garvogue (Bonnet)	0.05	0.01	0.12	0.12	0.06	0.27
Sligo	Drumcliff	0.15	0.07	0.35			
Sligo	Grange	0.05	0.01	0.12			
Ballyshannon	Duff	0.33	0.1	0.5			
Ballyshannon	Drowes	0.15	0.07	0.35	0.31	0.15	0.46
Ballyshannon	Erne	0.05	0.01	0.12			
Ballyshannon	Abbey	0.05	0.01	0.12			
Ballyshannon	Ballintra (Murvagh R).	0.05	0.01	0.12			
Ballyshannon	Laghy	0.05	0.01	0.12			
Ballyshannon	Oily	0.05	0.01	0.12			
Ballyshannon	Bungosteen	0.05	0.01	0.12			
Ballyshannon	Glen & Owenwee (Yellow)	0.15	0.07	0.35			

Table VI-1 (Cont.). River Exploitation rates applied for 2013 advice.

		1SW Exploitation rates			MSW Exploitation rates		
District	**River**	**Likely**	**Minimum**	**Maximum**	**Likely**	**Minimum**	**Maximum**
Ballyshannon	Owenwee (Yellow R)	0.05	0.01	0.12			
Letterkenny	Bracky	0.05	0.01	0.12			
Letterkenny	Owentocker	0.05	0.01	0.12			
Letterkenny	Owenea and Owentocker	0.15	0.07	0.35			
Letterkenny	Gweebarra	0.15	0.07	0.35	0.12	0.06	0.27
Letterkenny	Owenamarve	0.05	0.01	0.12			
Letterkenny	Gweedore (Crolly R.)	0.05	0.01	0.12			
Letterkenny	Clady	0.05	0.01	0.12			
Letterkenny	Glenna	0.05	0.01	0.12			
Letterkenny	Tullaghobegly	0.15	0.07	0.35			
Letterkenny	Ray	0.05	0.01	0.12			
Letterkenny	Lackagh	0.15	0.07	0.35	0.12	0.06	0.27
Letterkenny	Leannan	0.15	0.07	0.35	0.12	0.06	0.27
Letterkenny	Swilly	0.15	0.07	0.35			
Letterkenny	Isle (Burn)	0.05	0.01	0.12			
Letterkenny	Mill	0.05	0.01	0.12			
Letterkenny	Crana	0.15	0.07	0.35			
Letterkenny	Clonmany	0.05	0.01	0.12			
Letterkenny	Straid	0.05	0.01	0.12			
Letterkenny	Donagh	0.05	0.01	0.12			
Letterkenny	Glenagannon	0.05	0.01	0.12			
Letterkenny	Culoort	0.05	0.01	0.12			

Appendix VII. Worked assessment examples

Easky (Ballina):
An example of a river assessment made by angling catch with a surplus
The Bayesian Hierarchical Stock and Recruitment Forecast Analysis (BHSRA) details the egg deposition per m^2 for each river, based upon its latitude and wetted area and transportation of MSY from Ricker stock/recruitment analysis of index rivers:



Egg deposition rate /m^2 frequency distribution for the river Easky.

The total number of eggs required for the whole river, and variation, is calculated from the required eggs/m^2 and the wetted area of the river:

Details for the Easky river and median egg requirements per m^2 and full river area.

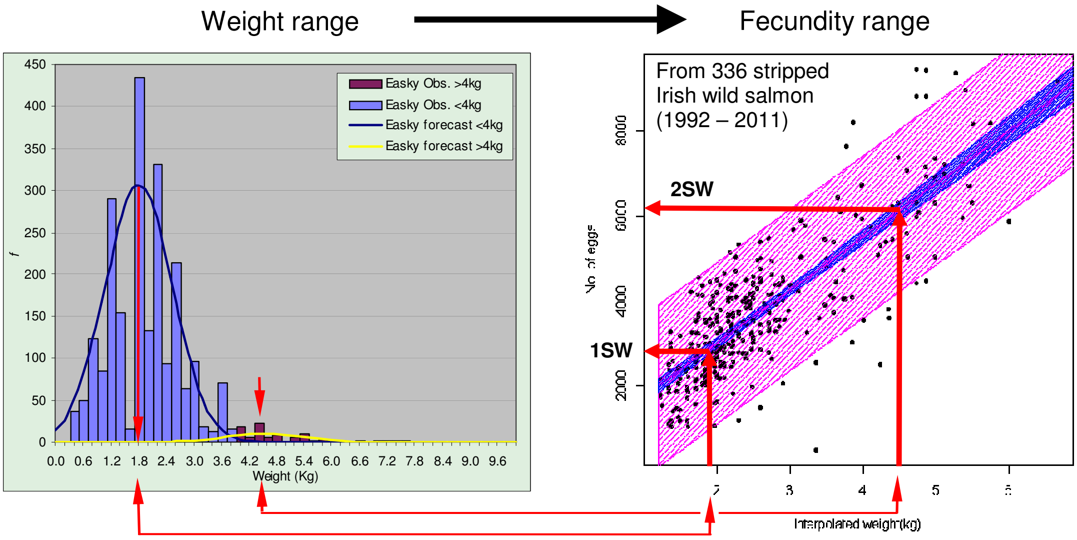
Variable	Value
Wetted area (ha)	53.90
Fluvial accessible area (ha)	46.56
Latitude (Deg N)	54.17
Median required egg deposition (eggs/m^2)	3.8
Median No. eggs required by the river (eggs /m^2 * fluvial accessible area)	1,779,447

The total number of eggs required is then apportioned into 1SW and 2SW egg requirements from the proportion of 1SW and 2SW salmon in the run (from rod catch or counter):

Sea age proportions and egg requirements per age class.

	1SW	2SW
Sea age proportions	0.83	0.17
Egg requirement	1,470,874	308,572

The fecundities of 1SW and 2SW salmon in the river are calculated from weight frequency distribution of fish caught in the river (as eggs per 1SW and 2SW):



Weight range of 1SW and 2SW salmon in the Easky and associated fecundities.

Median weights of 1SW and 2SW salmon in the Easky and 10th and 90th percentiles.

1SW			2SW		
Median	**10th**	**90th**	**Median**	**10th**	**90th**
1.81	0.87	2.75	4.54	3.47	5.61

Median fecundities of 1SW and 2SW salmon in the Easky and 10th and 90th percentiles

1SW			2SW		
Median	**10th**	**90th**	**Median**	**10th**	**90th**
2770	1594	3945	6184	4846	7523

Eggs numbers are converted into fish numbers and the total number of spawning fish (males and females) required is calculated using fecundity values, 1SW: MSW ratios and proportion of males to females based on observed ratios in broodstocks and sampling, to calculate 1SW, 2SW and total conservation limits in number of fish.

Required number of female 1SW and 2SW salmon in the Easky.

	1SW	**2SW**	**Total**
Required females	693	206	899

Proportion females and males in 1SW and 2SW age groups

	1SW	**2SW**
Proportion female	0.60	0.85
Proportion male	0.40	0.15

Conservation limits of 1SW, 2SW and total salmon

	1SW	2SW	Total
Required females	693	206	899
Required males	462	36	499
Total	1156	242	1398

Catch Advice

The number of salmon likely to return in the next fishing season is calculated from the most recent 5 year catch.

Angling catch in the river Easky

	2008	2009	2010	2011	2012
Rod catch: Killed	353	257	355	226	268
Rod catch: Catch & Release	152	115	158	118	155

No Commercial catch in the river Easky

	2008	2009	2010	2011	2012
Add catch from Draft net	0	0	0	0	0

The total rod catch is raised using exploitation rate values and added to the commercial catch to provide the estimate of returns prior to homewater fisheries.

Fishing exploitation rate on the river Easky

	Min	Most likely	Max
Exploitation rate	0.07	0.15	0.35

The estimated Recruits (i.e. returns of salmon) must exceed the CL if there is to be an allowable catch. A catch option which provides a high probability that the CL will be attained is advised. If returns are likely to be less than the CL then harvest fishing is not advised.

Easky is estimated to have a 75% probability of attaining its CL with a surplus of 863 fish.

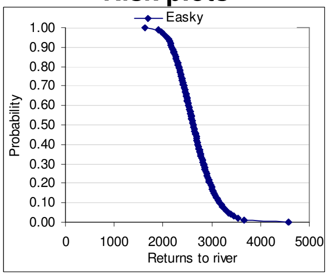
The CL used for Irish rivers are Limit Reference points i.e. stocks should not be allowed to fall below this limit but should be maintained above the limit with a high probability. In the assessment of international salmon fishing quotas, ICES recommends catch options which allow at least a 75% chance that the CLs will be met.

The SSC adopt a similar precautionary risk level when providing catch advice based on a risk assessment **<u>which includes the annual variation in RECRUITS and in the estimated CLs</u>** (shown in the following figures).

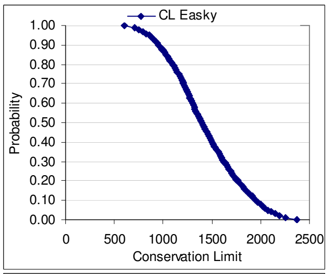
The catch option which provides a 75% chance that the CL will be attained is advised to IFI by the SSC.

Risk plots

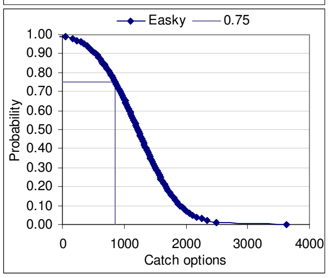
Predicted recruits	**Easky**
Percentiles	
100%	1622
90%	2188
75%	2380
50%	2625
25%	2896
10%	3164
0%	4576



CL	**Easky**
Percentiles	
100%	601
90%	954
75%	1160
50%	1398
25%	1691
10%	1951
0%	2372



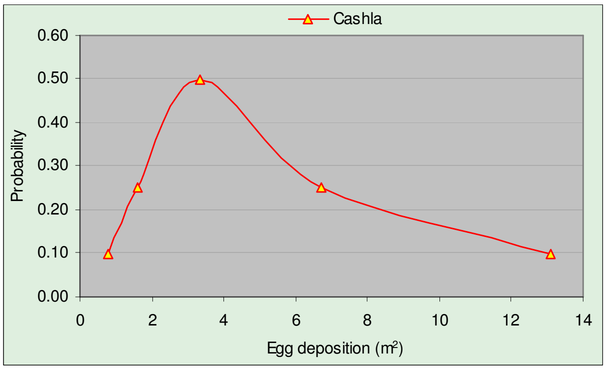
Surplus/Deficit	**Easky**
Percentiles	
100%	-626
90%	537
75%	**863**
50%	1226
25%	1588
10%	1914
0%	3642



Risk plot For Catch Advice

Percentiles and risk plots of the predicted recruits, conservation limits and resulting surplus/ deficits in relation to a range of catch options for the river Easky. Predicted recruits and CL risk plots are calculated from 50,000 draws in Monte Carlow analysis, with each paired draw compared to calculate the surplus/ deficit risk plot and hence catch advice. Note that the presented risk plots and values for predicted recruits and CLs are the percentiles of their 50,000 draws independently and direct comparison of these do not equate to the surplus/ deficit percentiles, which are the percentiles of the 50,000 comparisons of each of the paired predicted recruit to CL draws.

Cashla (Connemara):
An example of a river assessment made by counter with a surplus
The Bayesian Hierarchical Stock and Recruitment Forecast Analysis (BHSRA) details the egg deposition per m^2 for each river, based upon its latitude and wetted area and transportation of MSY from Ricker stock/recruitment analysis of index rivers:



Egg deposition rate /m^2 frequency distribution for the river Cashla.

The total number of eggs required for the whole river and variation is calculated from the required eggs/m^2 and the wetted area of the river:

Details for the Cashla river and median egg requirements per m^2 and full river area.

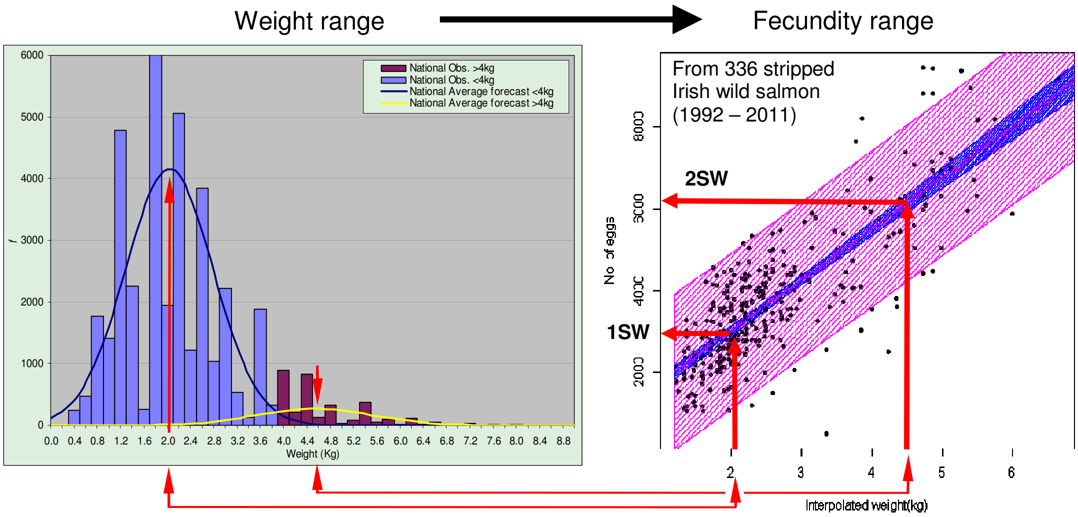
Variable	Value
Wetted area (ha)	23.96
Fluvial accessible area (ha)	19.21
Latitude (Deg N)	52.34
Median required egg deposition (eggs/m^2)	3.32
Median No. eggs required by the river (eggs /m^2 * fluvial accessible area)	637,872

The total number of eggs required is then apportioned into 1SW and 2SW egg requirements from the proportion of 1SW and 2SW salmon in the run (from rod catch or counter):

Sea age proportions and egg requirements per age class.

	1SW	2SW
Sea age proportions	0.83	0.17
Egg requirement	529,433	108,438

The fecundities of 1SW and 2SW salmon in the river are calculated from weight frequency distribution of fish caught in the river (as eggs per 1SW and 2SW):



National average **weight range of 1SW and 2SW salmon and associated fecundities applied to the Cashla.**

Median weights of 1SW and 2SW salmon in the Cashla and 10th and 90th percentiles.

1SW			2SW		
Median	**10th**	**90th**	**Median**	**10th**	**90th**
2.04	1.07	3.01	4.54	3.27	5.81

Median fecundities of 1SW and 2SW salmon in the Cashla and 10th and 90th percentiles

1SW			2SW		
Median	**10th**	**90th**	**Median**	**10th**	**90th**
3057	1844	4271	6184	4596	7773

Eggs numbers are converted into fish numbers and the total number of spawning fish (males and females) required is calculated using fecundity values, 1SW: MSW ratios and proportion of males to females based on observed ratios in broodstocks and sampling, to calculate 1SW, 2SW and total conservation limits in number of fish.

Required number of female 1SW and 2SW salmon in the Cashla.

	1SW	**2SW**	**Total**
Required females	218	63	281

Proportion females and males in 1SW and 2SW age groups

	1SW	**2SW**
Proportion female	0.60	0.85
Proportion male	0.40	0.15

Conservation limits of 1SW, 2SW and total salmon.

	1SW	2SW	Total
Required females	218	63	281
Required males	145	11	157
Total	363	74	**438**

Catch Advice

The number of salmon likely to return in the next fishing season is calculated from the most recent 5year counts.

Counts on the river Cashla

	2008	2009	2010	2011	2012
Trends in counts	353	257	355	226	268
Add catch killed above counter	20	22	21	47	26

The average of the Counter, along with rod catch and any commercial catch taken provide the estimate of returns prior to homewater fisheries.

No commercial fisheries intercepting Cashla salmon

	2008	2009	2010	2011	2012
Add catch from Draft net	0	0	0	0	0

The estimated Recruits (i.e. returns of salmon) must exceed the CL if there is to be an allowable catch. A catch option which provides a high probability that the CL will be attained is advised. If returns are likely to be less than the CL then harvest fishing is not advised.

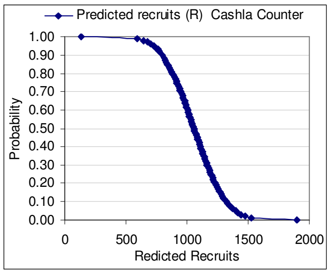
Cashla is estimated to have a 75% probability of attaining its CL with a surplus of 446 fish.

The CL used for Irish rivers are Limit Reference points i.e. stocks should not be allowed to fall below this limit but should be maintained above the limit with a high probability. In the assessment of international salmon fishing quotas, ICES recommends catch options which allow at least a 75% chance that the CLs will be met.

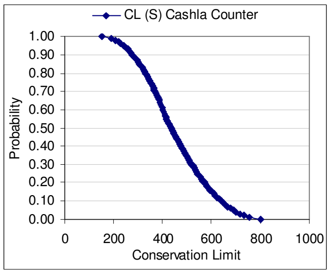
The SSC adopt a similar precautionary risk level when providing catch advice based on a risk assessment **which includes the annual variation in RECRUITS and in the estimated CLs** (shown in the following figures).

The catch option which provides a 75% chance that the CL will be attained is advised to IFI by the SSC.

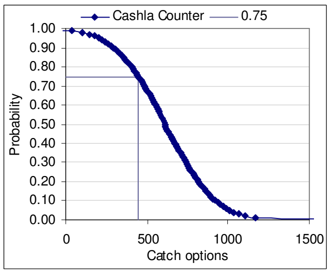
Predicted recruits Percentiles	**Cashla Counter**
100%	139
90%	798
75%	924
50%	1060
25%	1199
10%	1323
0%	1900



CL Percentiles	**Cashla Counter**
100%	152
90%	276
75%	349
50%	438
25%	545
10%	641
0%	804



Surplus/Deficit Percentiles	**Cashla Counter**
100%	-401
90%	294
75%	**446**
50%	614
25%	779
10%	924
0%	1692



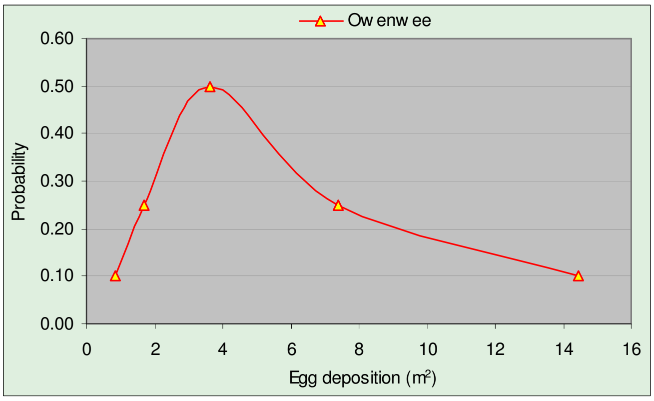
Risk plot For Catch Advice

Percentiles and risk plots of the predicted recruits, conservation limits and resulting surplus/ deficits in relation to a range of catch options for the river Cashla. Predicted recruits and CL risk plots are calculated from 50,000 draws in Monte Carlow analysis, with each paired draw compared to calculate the surplus/ deficit risk plot and hence catch advice. Note that the presented risk plots and values for predicted recruits and CLs are the percentiles of their 50,000 draws independently and direct comparison of these do not equate to the surplus/ deficit percentiles, which are the percentiles of the 50,000 comparisons of each of the paired predicted recruit to CL draws.

Owenwee (Belclare) (Ballinakill)

An example of a river assessment made by angling catch with a deficit

The Bayesian Hierarchical Stock and Recruitment Forecast Analysis (BHSRA) details the egg deposition per m^2 for each river, based upon its latitude and wetted area and transportation of MSY from Ricker stock/recruitment analysis of index rivers:



Egg deposition rate /m^2 frequency distribution for the river Owenwee (Belclare)

The total number of eggs required for the whole river and variation is calculated from the required eggs/m^2 and the wetted area of the river:

Details for the Owenwee river and median egg requirements per m^2 and full river area.

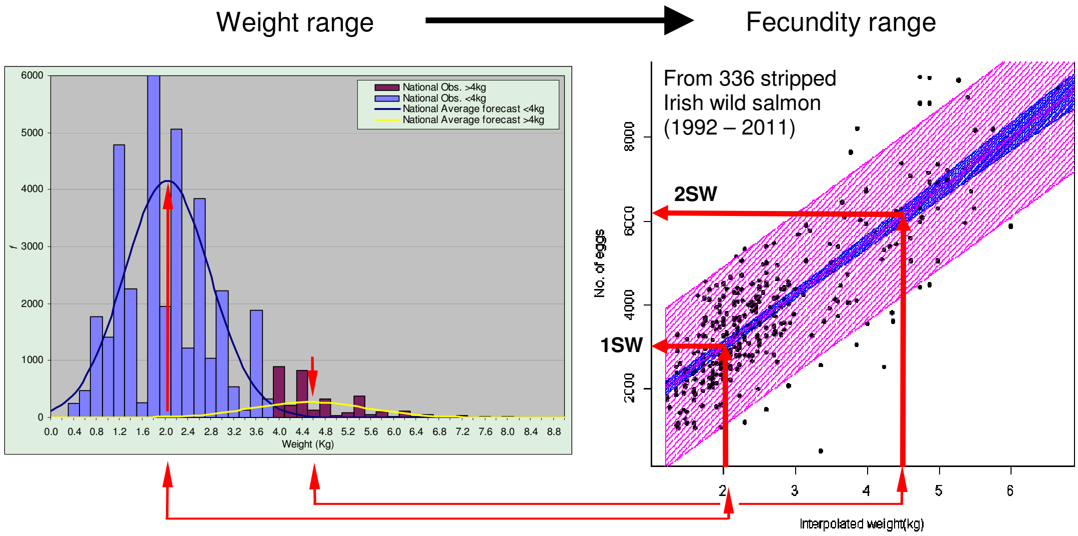
Variable	Value
Wetted area (ha)	17.81
Fluvial accessible area (ha)	14.34
Latitude (Deg N)	53.75
Median required egg deposition (eggs/m^2)	3.6
Median No. eggs required by the river (eggs /m^2 * fluvial accessible area)	516,746

The total number of eggs required is then apportioned into 1SW and 2SW egg requirements from the proportion of 1SW and 2SW salmon in the run (rod catch or counter):

Sea age proportions and egg requirements per age class.

	1SW	2SW
Sea age proportions	0.83	0.17
Egg requirement	427,137	89,608

The fecundities of 1SW and 2SW salmon in the river are calculated from weight frequency distribution of fish caught in the river (as eggs per 1SW and 2SW):



National average **weight range of 1SW and 2SW salmon and associated fecundities applied to the Owenwee.**

Median weights of 1SW and 2SW salmon in the Owenwee and 10th and 90th percentiles.

1SW			2SW		
Median	**10th**	**90th**	**Median**	**10th**	**90th**
2.04	1.07	3.01	4.54	3.27	5.81

Median fecundities of 1SW and 2SW salmon in the Owenwee and 10th and 90th percentiles

1SW			2SW		
Median	**10th**	**90th**	**Median**	**10th**	**90th**
3057	1844	4271	6184	4596	7773

Eggs numbers are converted into fish numbers and the total number of spawning fish (males and females) required is calculated using fecundity values, 1SW: MSW ratios and proportion of males to females based on observed ratios in broodstocks and sampling, to calculate 1SW, 2SW and total conservation limits in number of fish.

Required number of female 1SW and 2SW salmon in the Owenwee.

	1SW	**2SW**	**Total**
Required females	185	55	240

Proportion females and males in 1SW and 2SW age groups

	1SW	**2SW**
Proportion female	0.60	0.85
Proportion male	0.40	0.15

Conservation limits of 1SW, 2SW and total salmon

	1SW	2SW	Total
Required females	185	55	240
Required males	123	10	133
Total	309	65	**373**

Catch Advice

The number of salmon likely to return in the next fishing season is calculated from the most recent 5 year catch.

Angling catch in the river Owenwee

Catch	2008	2009	2010	2011	2012
Rod catch: Killed	0	0	0	6	7
Rod catch: Catch & Release	10	3	24	22	25

Commercial catch in the river Owenwee

	2008	2009	2010	2011	2012
Add catch from Draft net	87	103	0	0	0

The total rod catch is raised using exploitation rate values and added to the commercial catch to provide the estimate of returns prior to homewater fisheries.

Fishing exploitation rate on the river Owenwee

	Min	Most likely	Max
Exploitation rate	0.01	0.05	0.12

The estimated Recruits (i.e. returns of salmon) must exceed the CL if there is to be an allowable catch. A catch option which provides a high probability that the CL will be attained is advised. If returns are likely to be less than the CL then harvest fishing is not advised.

The Owenwee (Belclare) is not estimated to have a surplus of fish with a 75% probability of attaining its CL, with a deficit of 36 fish.

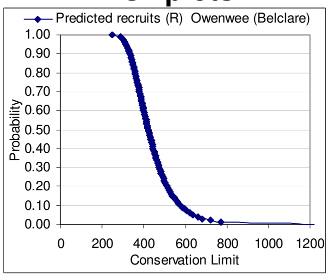
The CL used for Irish rivers are Limit Reference points i.e. stocks should not be allowed to fall below this limit but should be maintained above the limit with a high probability. In the assessment of international salmon fishing quotas, ICES recommends catch options which allow at least a 75% chance that the CLs will be met.

The SSC adopt a similar precautionary risk level when providing catch advice based on a risk assessment **which includes the annual variation in RECRUITS and in the estimated CLs** (shown in the following figures).

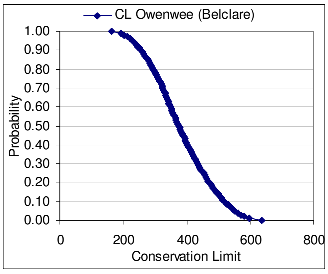
The catch option which provides a 75% chance that the CL will be attained is advised to IFI by the SSC.

Risk plots

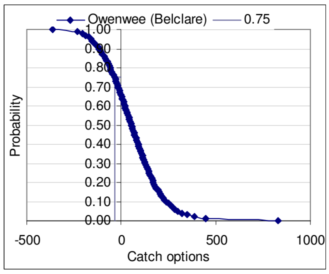
Predicted recruits Percentiles	**Owenwee (Belclare)**
100%	249
90%	333
75%	369
50%	422
25%	492
10%	576
0%	1231



CL Percentiles	**Owenwee (Belclare)**
100%	162
90%	254
75%	308
50%	373
25%	450
10%	517
0%	634



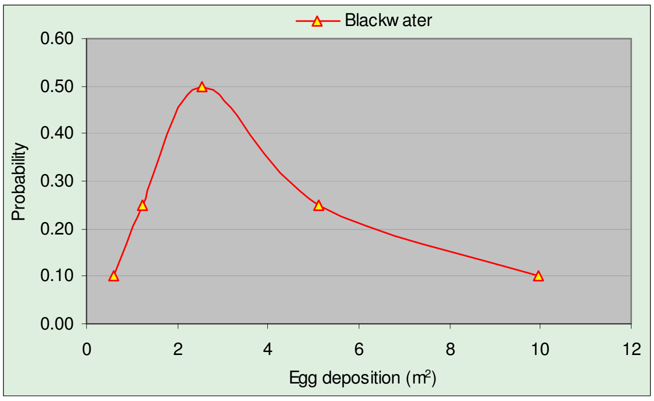
Surplus/Deficit Percentiles	**Owenwee (Belclare)**
100%	-363
90%	-117
75%	**-36**
50%	54
25%	148
10%	238
0%	832



Risk plot For Catch Advice

Percentiles and risk plots of the predicted recruits, conservation limits and resulting surplus/ deficits in relation to a range of catch options for the river Owenwee. Predicted recruits and CL risk plots are calculated from 50,000 draws in Monte Carlow analysis, with each paired draw compared to calculate the surplus/ deficit risk plot and hence catch advice. Note that the presented risk plots and values for predicted recruits and CLs are the percentiles of their 50,000 draws independently and direct comparison of these do not equate to the surplus/ deficit percentiles, which are the percentiles of the 50,000 comparisons of each of the paired predicted recruit to CL draws.

Blackwater (Kerry)
An example of a river assessment made by counter with a deficit
The Bayesian Hierarchical Stock and Recruitment Forecast Analysis (BHSRA) details the egg deposition per m^2 for each river, based upon its latitude and wetted area and transportation of MSY from Ricker stock/recruitment analysis of index rivers:



Egg deposition rate /m^2 frequency distribution for the river Blackwater (Kerry)

The total number of eggs required for the whole river and variation is calculated from the required eggs/m^2 and the wetted area of the river:

Details for the Blackwater river and median egg requirements per m^2 and full river area.

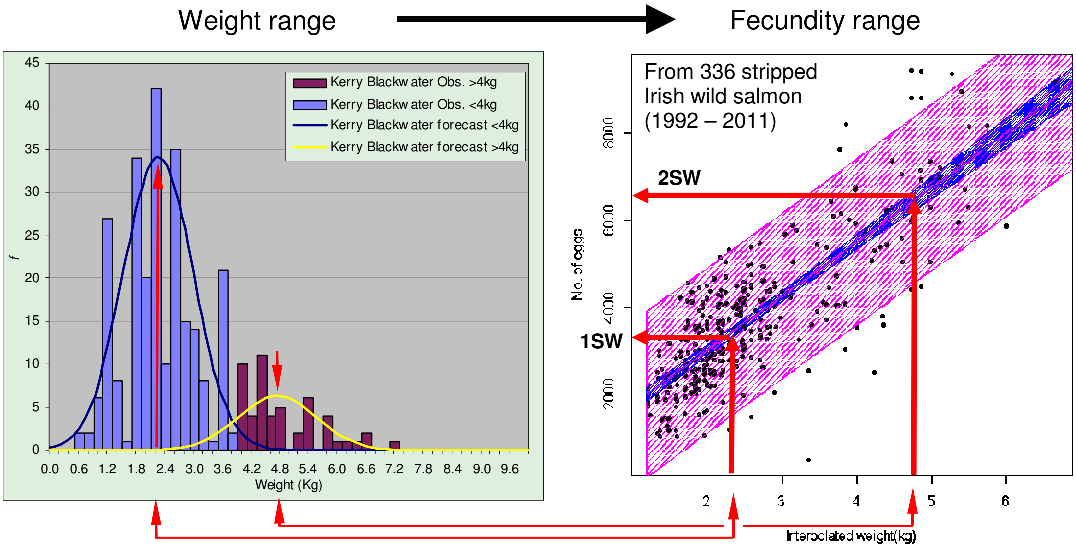
Variable	Value
Wetted area (ha)	36.06
Fluvial accessible area (ha)	29.16
Latitude (Deg N)	27.61
Median required egg deposition (eggs/m^2)	2.36
Median No. eggs required by the river (eggs /m^2 * fluvial accessible area)	651,886

The total number of eggs required is then apportioned into 1SW and 2SW egg requirements from the proportion of 1SW and 2SW salmon in the run (rod catch or counter):

Sea age proportions and egg requirements per age class.

	1SW	2SW
Sea age proportions	0.83	0.17
Egg requirement	541,066	110,821

The fecundities of 1SW and 2SW salmon in the river are calculated from weight frequency distribution of fish caught in the river (as eggs per 1SW and 2SW):



Weight range of 1SW and 2SW salmon in the Blackwater and associated fecundities.

Median weights of 1SW and 2SW salmon in the Blackwater and 10th and 90th percentiles.

1SW			2SW		
Median	**10th**	**90th**	**Median**	**10th**	**90th**
2.27	1.34	3.20	4.76	3.71	5.81

Median fecundities of 1SW and 2SW salmon in the Cashla and 10th and 90th percentiles

1SW			2SW		
Median	**10th**	**90th**	**Median**	**10th**	**90th**
3345	2182	4508	6460	5146	7773

Eggs numbers are converted into fish numbers and the total number of spawning fish (males and females) required is calculated using fecundity values, 1SW: MSW ratios and proportion of males to females based on observed ratios in broodstocks and sampling, to calculate 1SW, 2SW and total conservation limits in number of fish.

Required number of female 1SW and 2SW salmon in the Blackwater.

	1SW	**2SW**	**Total**
Required females	217	63	279

Proportion females and males in 1SW and 2SW age groups

	1SW	**2SW**
Proportion female	0.60	0.85
Proportion male	0.40	0.15

Conservation limits of 1SW, 2SW and total salmon.

	1SW	2SW	Total
Required females	217	63	279
Required males	144	11	156
Total	361	74	**435**

Catch Advice

The number of salmon likely to return in the next fishing season is calculated from the most recent 5year counts.

Counts on the river Blackwater

	2008	2009	2010	2011	2012
Trends in counts	575	347	1205	914	291
Add catch killed above counter	52	48	35	65	30

The average of the Counter, along with rod catch and any commercial catch taken provide the estimate of returns prior to homewater fisheries.

No commercial fisheries intercepting Blackwater salmon

	2008	2009	2010	2011	2012
Add catch from Draft net	0	0	0	0	0

The estimated Recruits (i.e. returns of salmon) must exceed the CL if there is to be an allowable catch. A catch option which provides a high probability that the CL will be attained is advised. If returns are likely to be less than the CL then harvest fishing is not advised.

The Kerry Blackwater is not estimated to have a surplus of fish with a 75% probability of attaining its CL, with a deficit of 3 fish.

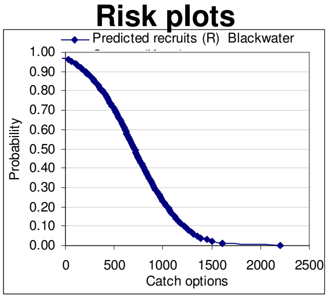
The CL used for Irish rivers are Limit Reference points i.e. stocks should not be allowed to fall below this limit but should be maintained above the limit with a high probability. In the assessment of international salmon fishing quotas, ICES recommends catch options which allow at least a 75% chance that the CLs will be met.

The SSC adopt a similar precautionary risk level when providing catch advice based on a risk assessment **which includes the annual variation in RECRUITS and in the estimated CLs** (shown in the following figures).

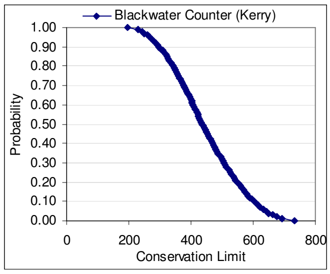
The catch option which provides a 75% chance that the CL will be attained is advised to IFI by the SSC.

Risk plots

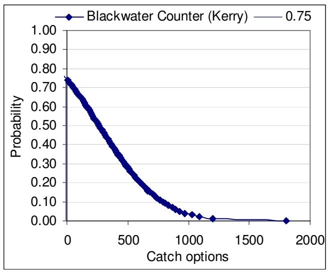
Predicted recruits	**Blackwater Counter**
Percentiles	
100%	-701
90%	212
75%	452
50%	712
25%	979
10%	1219
0%	2211



CL	**Blackwater Counter**
Percentiles	
100%	202
90%	303
75%	365
50%	442
25%	531
10%	608
0%	739



Surplus/Deficit	**Blackwater Counter**
Percentiles	
100%	-1292
90%	-250
75%	-3
50%	270
25%	541
10%	797
0%	1806



Risk plot For Catch Advice

Percentiles and risk plots of the predicted recruits, CLs and resulting surplus/ deficits in relation to a range of catch options for the Kerry Blackwater. Predicted recruits and CL risk plots are calculated from 50,000 draws in Monte Carlow analysis, with each paired draw compared to calculate the surplus/ deficit risk plot and hence catch advice. Note that the presented risk plots and values for predicted recruits and CLs are the percentiles of their 50,000 draws independently and direct comparison of these do not equate to the surplus/ deficit percentiles, which are the percentiles of the 50,000 comparisons of each of the paired predicted recruit to CL draws.

Appendix VIII. 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 primarily used for rivers where there is no other index of stock. Some catchments are electro-fished annually as index catchments. Currently an index of at least 17 salmon fry per 5 minute standardised electrofishing is used by the SSC as the cut-off between rivers below this threshold where the stock is clearly below Conservation Limits and those rivers above the threshold 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 2012, catchment wide electro-fishing was completed in 24 catchments to assess abundance and distribution of salmon fry (Figure VIII-1). A total of 530 sites were visited. In the first six years of the programme (2007-2012), 238 catchment surveys in 124 catchments have been undertaken comprising 4958 site surveys.

Five rivers, predicted not to have a salmon surplus in 2012, had an average salmon fry index ≥ 17 over the 2007-2012 period. These rivers (Liffey lower, Barrow, Carrownisky, Clady and Lackagh) were recommended for opening on a catch & release basis in 2012 to provide rod catch data for estimation of overall stock size. (Table VIII-1).

For the 24 salmon catchments surveyed in 2012, the salmon fry abundance for **this year alone** ranged from an average of zero fry on the Erne, to a catchment average of 37.21 salmon fry on the Clady. The Cloonaghmore, Garvogue, Bracky, Owenwee (Yellow), Leannan, Fane, Lackagh, Barrow, Erriff, Eany and Clady all recorded an annual catchment wide average of >17 fry. Salmon fry densities of over 15 Salfry/min were also recorded on the Owenwee (Belclare), Owenduff and Cloonee catchments.

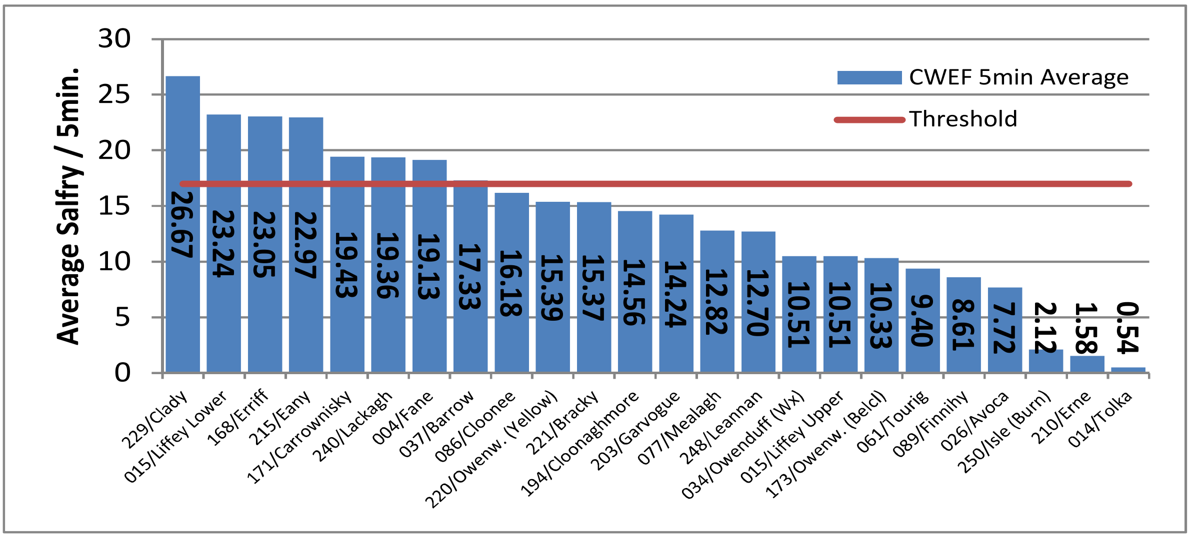


Figure VII -1. Results of catchment wide electro-fishing programme in 2012

Catchment Wide Electro-fishing programme	2007	2008	2009	2010	2011	2012	Average
Lower Liffey		21.3	40.1	27.4	16.1	12.1	23.42
Barrow	18.92		11.1	8.81	20.48	27.39	17.34
Carrownisky		18.25				20.6	19.43
Clady		16.12				37.21	26.67
Lackagh		18.9	15.8		19.2	23.6	19.36

Table VIII- 1. Summary of Catchments predicted not to have a salmon surplus in 2012 with Cumulative Mean of greater than 17 salmon fry per 5min.

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.