The Standing Scientific Committee on Salmon

Independent Scientific Report to Inland Fisheries Ireland

The Status of Irish Salmon Stocks in 2013 with Precautionary Catch Advice for 2014

2014

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

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Executive Summary

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

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

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

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

The purpose of this report, therefore, is to provide IFI with the technical and scientific information required in order to meet its terms of reference under the Act. This includes information on Irish salmon stocks, the current status of these stocks relative to the objective of meeting biologically referenced "Conservation Limits" and the catch advice which will allow for a sustainable harvest of salmon in 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 2014 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 2014:

- 57 rivers have an advised harvestable surplus as they are exceeding their Conservation Limits.
- A further 30 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.
- 56 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 3 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.
- 2 should be closed for harvest as they do not exceed 65% of their Conservation Limits.

There are currently 40 rivers or river tributaries in SACs where salmon have a qualifying interest under the EU Habitats directive. Of these, 25 are above their CL. Amongst the stocks being assessed are 55 small river stocks where the most recent annual average rod catch (covering the 2002-2006 period) 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 SSCS recommends that information is made available to allow the committee to provide a stock assessment or index of stock status for all rivers annually. This should be based on the following indices collected over a suitable time period:

Primary Assessment data for stock assessment

- 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.
- Mark recapture assessments.

Data required for stock status indices

- Juvenile assessment surveys benchmarked against an indices of total stock from index rivers.
- Redd count surveys benchmarked against other indices of total stock for index rivers.

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 2013 with the further development of a national electro-fishing programme benchmarked against index rivers (with known juvenile production to adult return relationships). In the short term, this index can provide an assessment as to whether significant spawning took place in the previous year based on salmon fry abundance. However, further statistical analyses confirming the relationship between these indices and the stock size will be required to estimate the number of fish in excess of the Conservation Limit and set harvestable surpluses. Work is ongoing by the Standing Scientific Committee in this regard. The installation of six new fish counters since 2010 under the Salmon Conservation Fund administered by IFI will provide a direct assessment of attainment of conservation limit on these rivers.

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 2013 and Precautionary Catch Advice for 2014

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 SSCS 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 SSCS 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 2014 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 40 Irish salmon rivers or their tributaries in SAC's where salmon have a qualifying interest under the Habitats Directive (Appendix III). However, in applying the Directive consideration must be given to all of the populations and not just specifically to these 41 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 143 Irish rivers, only 43 of these have healthy populations”. (Anon. 2008)

Note: The analysis carried out by the SSC in 2013 for 2014 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 were described in the 2007 report 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 were 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”.

In the second Article 17 report on the status of Irish salmon stocks (Anon 2013) submitted as a requirement under the Habitats Directive in 2013, factors considered as threats to salmon populations are described. These include factors such as agricultural intensification, diffuse pollution to surface waters (resulting from factors such as inadequate sewage treatment, agricultural enrichment, acidification, erosion and siltation), forestry related pressures, pressures related to intensive fish farming and peat extraction, and poaching. Concerns were expressed about the poor levels of marine survival; despite the removal of the drift net fishery from Irish coastal waters in 2006 salmon numbers have not increased. The range where salmon were found was classified as favourable, the population size was considered stable, habitat condition was considered favourable with future prospects considered stable. The overall classification for the Atlantic salmon in Ireland was therefore described as “Stable”, an improvement on the 2007 overall classification of “Bad” status. It was noted that this current period of stability has to be set against the context of a long trend of population decline.

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, etc) 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 and advice in future years. 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 and for future years, 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).

The SSCS catch advice provided in 2006 remains in place and advises that fisheries should only be targeted on river stocks shown to be above CL. Commercial fisheries operating in estuaries should only take place if all contributing river stocks are meeting conservation limits. Where fisheries operate on more than one stock, the SSCS provide advice on simultaneous attainment of meeting CL for each contributing stock.

Assessment Methodology for 2014 Catch Advice

There was no change in principle to the methodology used to provide catch advice in 2013 for the 2014 season. A summary of the approach is shown below in Figure 1. , In-river or estuarine measures of abundance are 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 and these updated CL's will apply in future years. Updates are detailed in the relevant sections below.

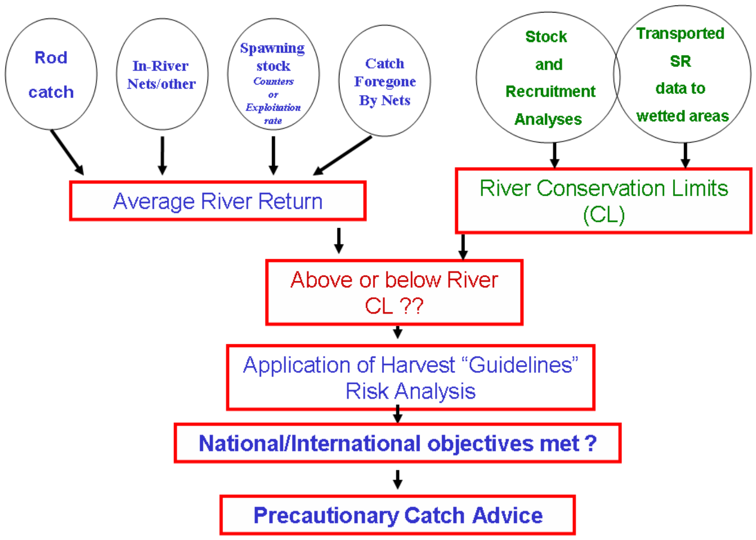


Figure 1. The Scientific Process for catch advice from 2006 to present.

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 2013 for the 2014 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 (draft nets & snap 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) was 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 (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 and 74% in 2013.

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 31 fish counters were used in 2013 – 2014 assessments, an increase of 10 counters on the 2011 – 2012 assessment. These are the: *Dee and Fane (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 and Dunkellin (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).*

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 Corrib, 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 include 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. Where counters are used the Conservation Limit relates to the area above the counter. In the event that the count is above or below CL, it is assumed that the overall stock is above or below CL.

National Coded Wire Tagging and Tag Recovery – 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.

Other data – 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 2013 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 from commercial catch data, 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 for 2013:
    - 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 for 2013:
    - 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 2014 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 for the 2013 advice 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 2014

<u>Changes from 2013 catch advice procedure for the 2014 catch advice.</u>

Changes to the approach used for 2014 compared to previous years are outlined in sections below. Although new Conservation Limits were calculated in 2013 and the basis for the risk assessment was modified, there were few changes to the actual catch advice procedure for the 2014 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 2014 season is provided for 141 separate rivers and additionally advice is also given for the upper Liffey and upper Lee. Furthermore, separate assessments are made on 16 rivers for the early running 2SW component of the stock in question.

Of these:

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

Details of the catch advice for 2014 provided by the Standing Scientific Committee on Salmon in Ireland is given in Tables 1 through 4:

<u>SSC catch Advice for 2014.</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 2014, 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).

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 2014 fishery is that :

- 57 rivers have an advised harvestable surplus as they are exceeding their Conservation Limits (Table 1).
- A further 30 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.
- 56 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:

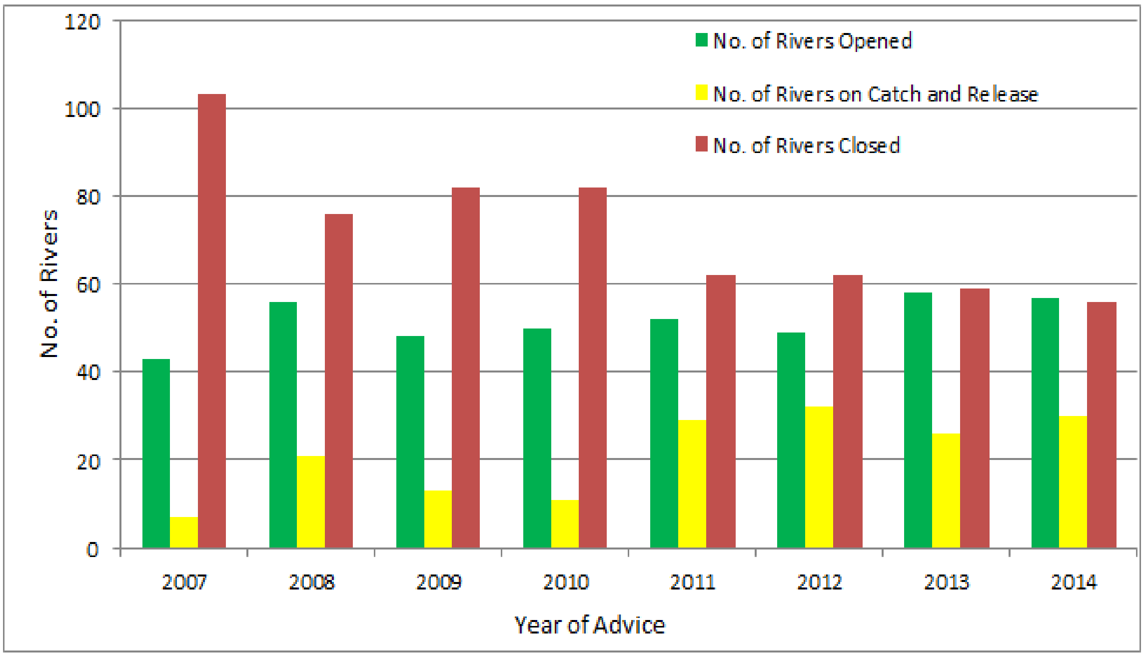
- 11 have an advised harvestable surplus as they are exceeding their Conservation Limits (Table 2).

- A further 3 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.
- 2 should be closed for harvest as they do not exceed 65% of their Conservation Limits (Table 4).

There are currently 40 rivers or river tributaries in SACs where salmon have a qualifying interest under the EU Habitats directive. 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 2014 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.

<u>Mixed Stock Fisheries Advice</u>

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. There are potentially three mixed stock commercial fisheries operating in estuaries.

Killary Harbour

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 in 2014 (Table 1). The SSCS provide advice on the Killary common embayment based on the CL being met on both rivers simultaneously.

Tullaghan Bay

The draft net fishery operating in Tullaghan Bay, Bangor District, exploits stocks from the Owenmore, Owenduff and Carrowmore systems, 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 common embayment 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 for 2013. For the 2014 SSCS advice, one of these river stocks, the Owenmore was only marginally (63 fish) above conservation limit From a management perspective, this surplus was too low to allow a fishery in inner Tullaghan bay or the small overlapping fishery in the outer bay and no TAC was provided for this fishery in 2014. The Owenduff river had a substantial surplus and a TAC was allocated to the Owenduff estuary in 2014.

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.

Castlemaine Harbour

In 2010, the Minister of State at the Department of Communications, Energy & Natural Resources requested advice on how a commercial salmon fishery could be operated on stocks in Castlemaine Harbour in a sustainable manner, maximizing the opportunities for commercial fishing whilst ensuring that stocks are not overexploited. In this context, a pilot fishery was operated in Castlemaine Harbour in 2010 in order to determine the composition of the various stocks in the fishery. The results indicated that at least 94% of the catch in the fishery derived from salmon stocks entering Castlemaine Harbor (Laune, Caragh and Maine). All three rivers have been above CL since 2011 and a mixed stock fishery has operated. The SSCS provide advice annually on this common embayment fishery based on all three rivers simultaneously achieving conservation limit.

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 for recent years is presented below. The mean counts for the years prior to the closure of the mixed stock fishery at sea fishery in 2007 were compared with counts for the subsequent years to 2011. In most instances there were more than five years of counts available for the pre-2007 period. Given that exploitation rates in this fishery on wild stocks averaged approximately 50% up to 2006, (based on coded wire tag returns), an increase of 100% (i.e. a doubling of counts) might have been expected in 2007 and subsequent years following the management measures. While an increase were noted in the counts for 13 of the 15 rivers in 2007, a doubling of the count or higher was only noted in 6 of these. Increases in counts compared to the mixed stock fishery period were noted again in 2008. However, only 8 of the 15 rivers showed an increase with only four doubling or more than doubling. In 2009, only 7 rivers showed an increase with only three with more than double counts. In 2010, numbers improved with 10 of the rivers maintaining the increase in numbers and six doubling or more. Ten rivers also showed an increase in 2011, but only three had double or more fish compared to the period when the mixed stock fishery was operating. The 2012 and 2013 changes in proportion indicated only 6 rivers maintaining an increase following the closure of the mixed stock fishery and few maintaining with a doubling or more in counts relative to the pre-fishery closure period. The absence of a consistent response in counts following the closure of a major fishery indicates strongly that marine survival continues to decline and stocks are still vulnerable.

Conclusions

Despite the considerable reductions in catches, and increased runs to many rivers following the closure of the mixed stock fishery at sea in 2006, only 40% of Irelands 143 rivers are estimated to be meeting biologically based Conservation Limits, while 30 more rivers could open for catch and release angling as they indicate relatively high juvenile densities. This compares with only 15 rivers open for C&R in 2013 and the information will provide information on stock status.

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.

In this regard, the ongoing management policy of adopting the scientific advice to only allow exploitation on stocks above conservation limit is central to ensuring continued recovery of salmon stocks nationally. With this policy in place, any improvement in marine survival will be reflected in greater numbers of rivers achieving conservation limit and will contribute to meeting ICES advice and achieving NASCO objective of providing for the diversity and abundance of salmon stocks and the national and international objectives for salmon conservation.

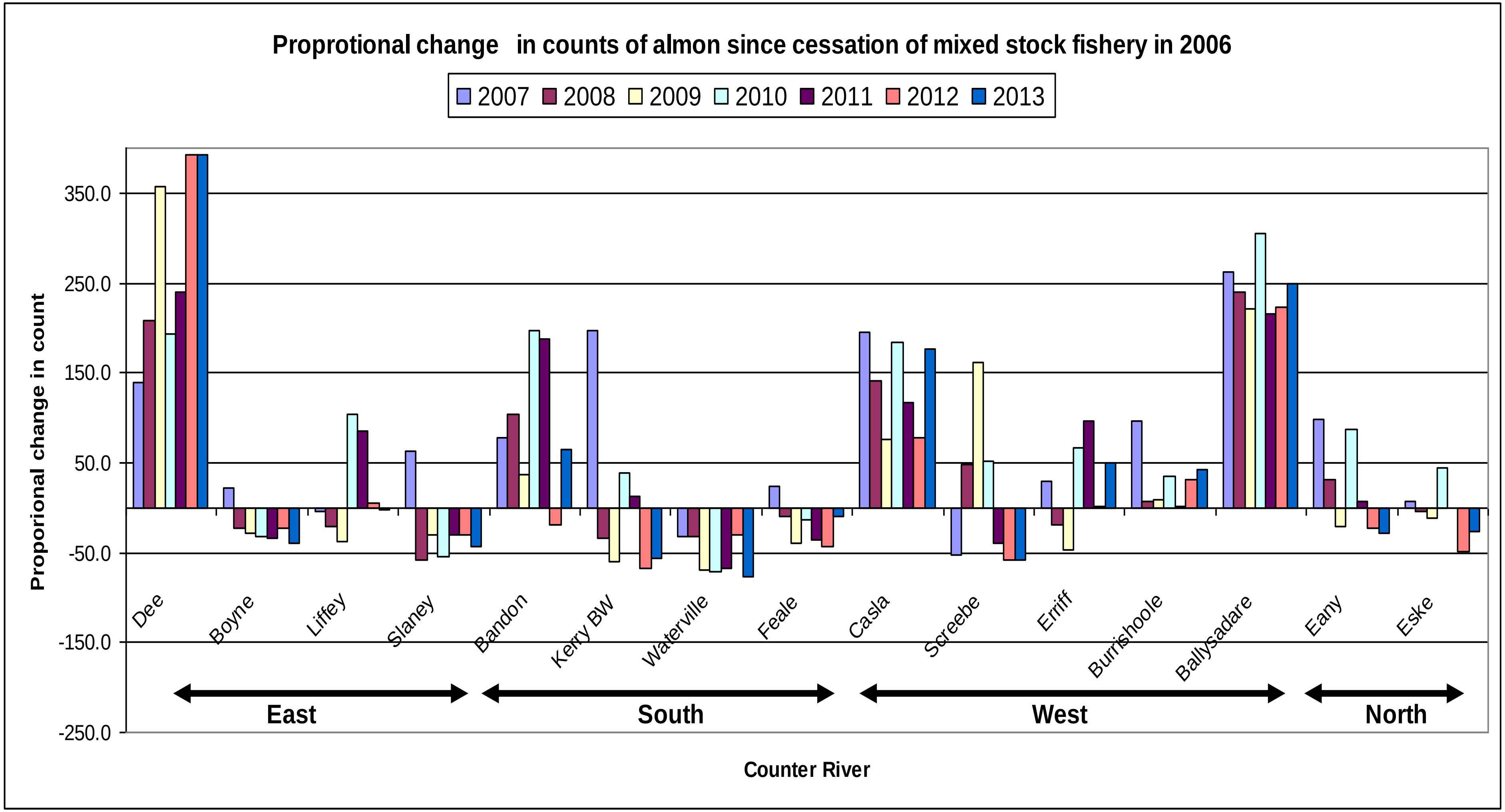


Figure 2. Proportional changes in counter figures relative to the count in 2006, closure of the mixed stocks fishery at sea in 2007.

Table 1. Rivers with a forecasted surplus above the required Conservation Limit for 2014. This is the catch option which provides a 75% chance that Conservation Limit will be met. (Note: 1SW and 2SW combined unless otherwise noted in italics).

District	River	CL	Deficit/ Surplus	Prop CL achieved
Dundalk	**Fane**	1177	411	1.35
Dundalk	**Glyde**	1856	201	1.11
Waterford	**Nore**	10464	2214	1.21
Lismore	**Blackwater, Glenshelane, Finisk**	12024	6902	1.57
Cork	**Owennacurra**	293	45	1.15
Cork	**Lower Lee**	1897	2177	2.43
Cork	**Bandon**	1636	752	1.46
Cork	**Argideen**	468	125	1.27
Cork	**1SW Ilen**	888	238	1.27
Cork	**Mealagh**	96	192	3.00
Cork	**Owvane**	371	502	2.35
Cork	**Coomhola**	310	96	1.31
Cork	**Glengarriff**	166	331	2.99
Cork	**Adrigole**	166	10	1.06
Kerry	**Lough Fada**	88	4	1.04
Kerry	**Croanshagh**	275	102	1.37
Kerry	**Sheen**	624	103	1.17
Kerry	**Roughty**	1539	463	1.30
Kerry	**Sneem**	347	694	3.00
Kerry	**1SW Waterville**	118	237	3.00
Kerry	**Inney**	629	394	1.63
Kerry	**Ferta**	225	8	1.04
Kerry	**1SW Caragh**	395	790	3.00
Kerry	**1SW Laune and Cottoners**	2073	4145	3.00
Kerry	**Maine**	1181	1639	2.39
Kerry	**Owenmore**	105	211	3.00
	Common Embayment Castlemaine	**4743**	6235	
Limerick	**1SW Feale, Galey and Brick**	2847	2226	1.78
Limerick	**Mulkear**	4214	645	1.15
Galway	**Corrib**	7581	6246	1.82
Connemara	**Cashla**	421	379	1.90
Connemara	**Screebe**	151	57	1.38
Connemara	**Ballynahinch**	837	1262	2.51
Ballinakill	**Owenglin**	423	643	2.52
Ballinakill	**Dawros**	493	697	2.41
Ballinakill	**Culfin**	136	270	2.99
Ballinakill	**Erriff**	1383	669	1.48
Ballinakill	**1SW Bundorragha**	95	190	3.00
Ballinakill	**Bunowen**	462	335	1.73
Ballinakill	**Owenwee (Belclare)**	374	45	1.12

Table 1 continued				
	Common Embayment Killary	**1627**	831	
Bangor	**1 SW Newport R.**	508	538	2.06
Bangor	**1SW Owenduff**	713	1425	3.00
Bangor	**Owenmore**	2075	63	1.03
Bangor	**1SW Carrowmore**	231	344	2.49
Bangor	**Glenamoy**	621	153	1.25
Ballina	**Moy**	16730	25803	2.54
Ballina	**Easky**	1399	418	1.30
Sligo	**Ballysadare**	6363	3195	1.50
Sligo	**1 SW Garvogue**	2543	420	1.17
Sligo	**Drumcliff**	510	151	1.30
Ballyshannon	**Duff**	1064	305	1.29
Ballyshannon	**1 SW Drowes**	1061	2122	3.00
Ballyshannon	**Eske**	732	43	1.06
Ballyshannon	**Eany**	1317	128	1.10
Ballyshannon	**Glen**	1199	219	1.18
Letterkenny	**Bracky**	200	9	1.04
Letterkenny	**Owenea and Owentocker**	1690	936	1.55
Letterkenny	**1SW Gweebarra**	611	215	1.35
Letterkenny	**Gweedore (Crolly R.)**	342	417	2.22
Letterkenny	**Clady**	345	83	1.24
Letterkenny	**Tullaghobegly**	223	103	1.46
Letterkenny	**Ray**	435	19	1.04
Letterkenny	**Crana**	1074	160	1.15

Table 2. Irish rivers meeting Conservation Limits and estimated surplus and proportion of CL achieved for MSW stocks only in 2014.

District	**River**	**CL**	**Deficit/ Surplus**	**Prop CL achieved**
Kerry	2SW Waterville	83	167	3.00
Kerry	2SW Caragh	280	380	2.36
Kerry	2SW Laune	815	598	1.73
Limerick	2SW Feale, Galey and Brick	864	646	1.75
Ballinakill	2SW Bundorragha	70	140	3.00
Bangor	2SW Owenduff	402	421	2.05
Bangor	2SW Carrowmore	122	243	3.00
Sligo	2SW Garvogue	289	107	1.37
Ballyshannon	2SW Drowes	426	553	2.30
Cork	2SW Ilen	212	233	2.10
Letterkenny	2SW Gweebarra	116	117	2.01

Table 3. Irish rivers below Conservation Limits in 2014 and the estimated deficits and proportion of CL achieved for 1SW and MSW stocks combined unless otherwise indicated.

District	River	CL	Deficit/ Surplus	Prop CL achieved
Dundalk	**Flurry**	427	-328	**0.23**
Dundalk	**Castletown**	1449	-844	**0.42**
Dundalk	**1SW Dee**	945	-471	**0.50**
Drogheda	**Boyne**	10239	-6445	**0.37**
Dublin	**Lower Liffey Inc Rye**	1703	-1111	**0.35**
Dublin	**Upper Liffey US Lexlip**	5383	-4908	**0.09**
Dublin	**Dargle**	734	-609	**0.17**
Dublin	**Vartry**	274	-174	**0.36**
Wexford	**Avoca**	3945	-3050	**0.23**
Wexford	**Owenavorragh**	945	-713	**0.25**
Wexford	**1SW Slaney**	915	-770	**0.16**
Waterford	**Corock R**	836	-590	**0.29**
Waterford	**Owenduff**	300	-217	**0.28**
Waterford	**Barrow and Pollmounty**	11725	-8284	**0.29**
Waterford	**Suir, Clodiagh, Lingaun, Blackwater**	14048	-2449	**0.83**
Waterford	**Mahon**	443	-302	**0.32**
Waterford	**Tay**	319	-222	**0.30**
Waterford	**Colligan**	423	-77	**0.82**
Lismore	**Lickey**	148	-111	**0.25**
Lismore	**Bride**	1567	-634	**0.60**
Lismore	**Tourig**	118	-89	**0.25**
Lismore	**Womanagh**	368	-278	**0.25**
Cork	**Upper Lee**	2789	-2441	**0.13**
Kerry	**Kealincha**	128	-2	**0.99**
Kerry	**Owenshagh**	304	-211	**0.31**
Kerry	**Cloonee**	61	-28	**0.54**
Kerry	**Finnihy**	143	-76	**0.47**
Kerry	**Blackwater**	436	-69	**0.84**
Kerry	**Owenreagh**	87	-41	**0.53**
Kerry	**Emlaghmore**	68	-39	**0.43**
Kerry	**Carhan**	88	-34	**0.61**
Kerry	**Behy**	176	-82	**0.53**
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**	510	-246	**0.52**
Limerick	**Deel**	2823	-1816	**0.36**
Limerick	**Maigue**	4632	-3849	**0.17**
Limerick	**Upper Shannon (Above Parteen)**	49638	-47156	**<5%**
Limerick	**Owenagarney**	630	-344	**0.45**
Limerick	**Fergus**	2445	-2223	**0.09**
Limerick	**Doonbeg**	525	-354	**0.33**

Table 3 continued				
Limerick	**Skivaleen**	458	-299	**0.35**
Limerick	**Annageeragh**	321	-210	**0.34**
Limerick	**Inagh**	1096	-858	**0.22**
Limerick	**Aughyvackeen**	223	-137	**0.39**
Galway	**Aille (Galway)**	105	-66	**0.37**
Galway	**Kilcolgan**	2079	-1241	**0.40**
Galway	**Clarinbridge**	487	-378	**0.22**
Galway	**Knock**	132	-78	**0.41**
Galway	**Owenboliska R (Spiddal)**	595	-352	**0.41**
Connemara	**L.Na Furnace**	71	-3	**0.96**
Ballinakill	**Carrownisky**	365	-70	**0.81**
Bangor	**Srahmore (Burrishoole)**	617	-84	**0.86**
Bangor	**Owengarve R.**	227	-142	**0.37**
Bangor	**Muingnabo**	336	-199	**0.41**
Ballina	**Ballinglen**	411	-313	**0.24**
Ballina	**Cloonaghmore (Palmerstown)**	1323	-1098	**0.17**
Ballina	**Brusna**	1096	-830	**0.24**
Ballina	**Leaffony**	241	-184	**0.24**
Sligo	**Grange**	330	-140	**0.58**
Ballyshannon	**Erne**	16551	-14772	**0.11**
Ballyshannon	**Abbey**	333	-207	**0.38**
Ballyshannon	**Ballintra (Murvagh R).**	549	-321	**0.41**
Ballyshannon	**Laghy**	450	-254	**0.43**
Ballyshannon	**Oily**	629	-330	**0.48**
Ballyshannon	**Bungosteen**	374	-201	**0.46**
Ballyshannon	**Owenwee (Yellow R)**	183	-66	**0.64**
Letterkenny	**Owenamarve**	205	-120	**0.41**
Letterkenny	**Glenna**	215	-122	**0.43**
Letterkenny	**1SW Lackagh**	236	-117	**0.51**
Letterkenny	**1SW Leannan**	516	-409	**0.21**
Letterkenny	**Swilly**	1105	-616	**0.44**
Letterkenny	**Isle (Burn)**	521	-294	**0.43**
Letterkenny	**Mill**	312	-184	**0.41**
Letterkenny	**Clonmany**	443	-244	**0.45**
Letterkenny	**Straid**	184	-101	**0.45**
Letterkenny	**Donagh**	429	-246	**0.43**
Letterkenny	**Glenagannon**	377	-218	**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 in 2014.

District	River	CL	Deficit/ Surplus	Prop CL achieved
Wexford	2SW Slaney	2749	-2222	0.19
Bangor	2SW Newport R.	366	-99	0.73
Dundalk	2SW Dee	715	-363	0.49
Letterkenny	2SW Lackagh	278	-97	0.65
Letterkenny	2SW Leannan	1199	-828	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).

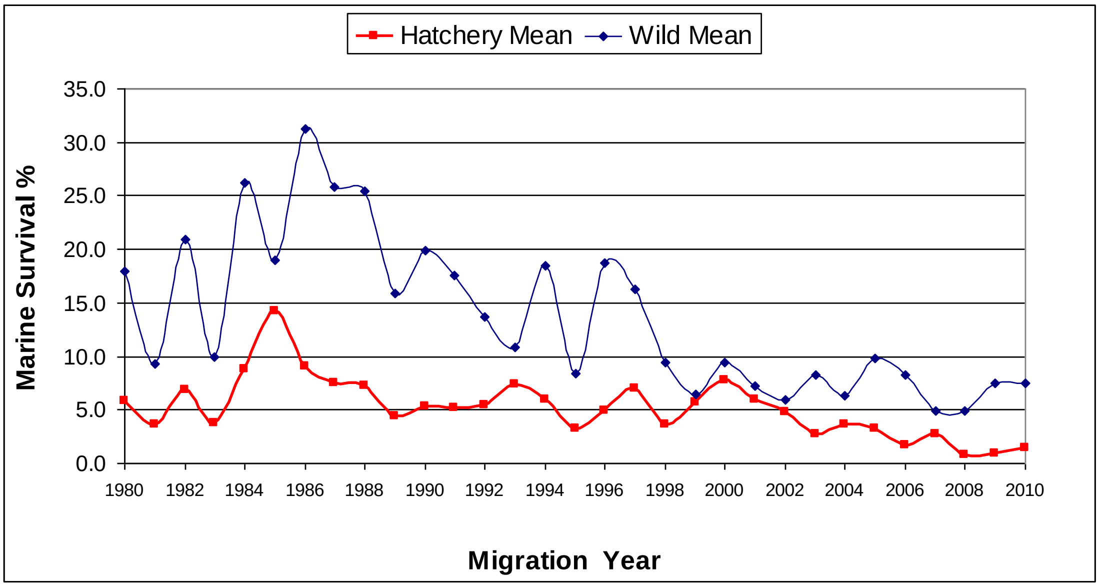


Figure 3. Marine survival (from smolt release to return to the coast) for wild and hatchery salmon.

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.

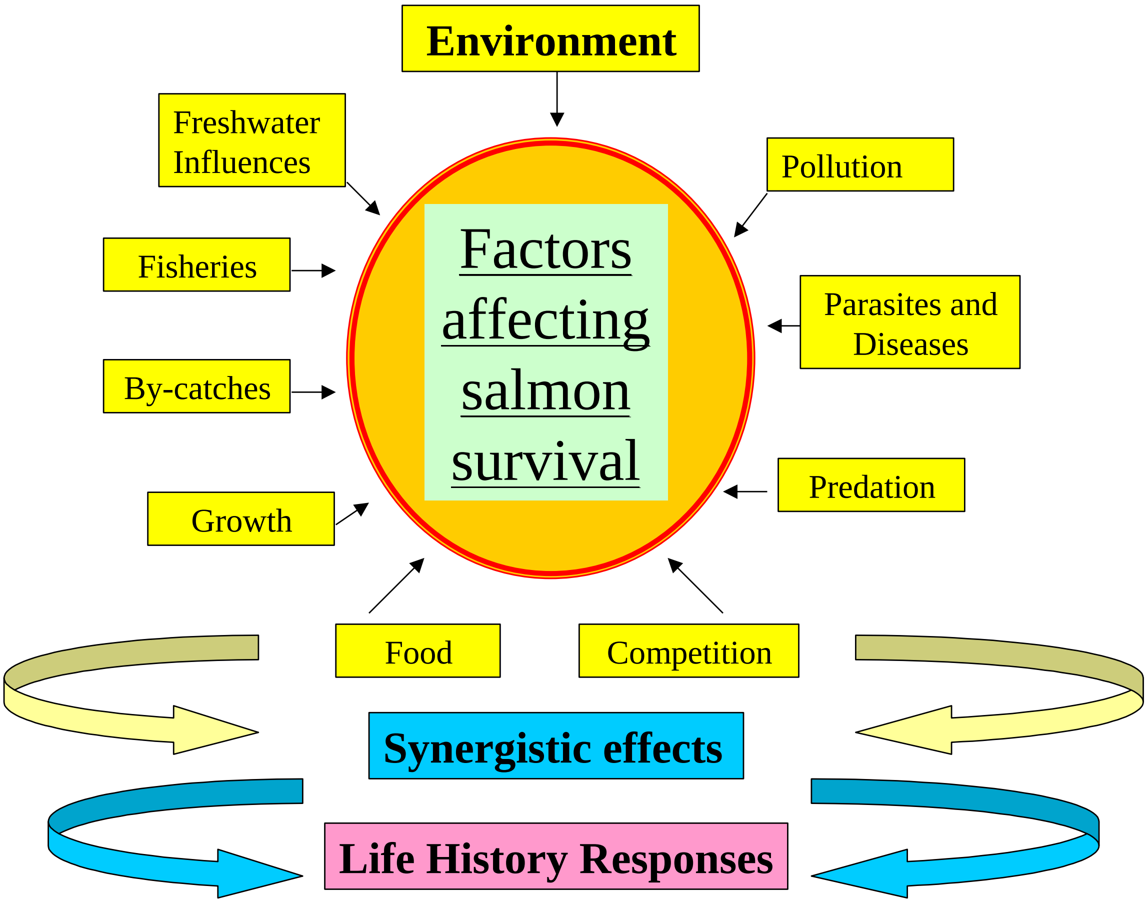


Figure 4. The factors which individually and synergistically affect the marine survival of salmon and which cause significant changes to life history responses such as population structure, fitness and size.

Requirements for future assessments

There are 143 separate 1SW stocks (including upstream of rivers with large hydro-dams, Liffey, 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 (31) 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 2014

Dr. P. Gargan, (Chair) - Inland Fisheries Ireland
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)
Dr. D. Doherty (from 2008) – Electricity Supply Board
Ms. M. Dromey (to 2005) – National Parks and Wildlife Service
Dr. E. de Eyto (from 2007) – Marine Institute
B. Kennedy (from 2007) – Environmental Protection Agency
Dr. I. Lawler (from 2007) – Bord Iascaigh Mhara
Dr. D. Lyons (from 2013) National Parks and Wildlife Service
Dr. M. McGarrigle (to 2007) – Environmental Protection Agency
Dr. P. McGinnity – NUI, Cork
Dr. F. Marnell (from 2005- 2013) – National Parks and Wildlife Service
Dr. V. O'Donovan (to 2007) – Bord Iascaigh Mhara
K. O'Higgins (from 2009) – Inland Fisheries Ireland
Dr. C. O'Keeffe (to 2002) – National Parks and Wildlife Service
Dr. N. Ó Maoiléidigh, Marine Institute
Dr. W. Roche (from 2007) – Inland Fisheries Ireland
Dr. J. White (from 2009) – Marine Institute

APPENDIX II - ICES Advice - May 2014

ECOREGION North Atlantic
STOCK Atlantic salmon from the Northeast Atlantic

Advice for 2014

The NASCO Framework of Indicators for North East Atlantic stocks for 2013 was run in January 2014, and did not indicate the need for a revised analysis of catch options. Thus, no new management advice is provided for 2014. The most recent multi-year advice for the North East Atlantic Commission was provided by ICES (2013). In that assessment, there were no catch options for the Faroes fishery that would allow all stock complexes to achieve their conservation limits (CLs) with a greater than 95% probability in any of the seasons 2013/14 to 2015/16. In the absence of specific management objectives, ICES advised that there were no mixed-stock fishery options on the NEAC complexes at Faroes in 2013 to 2016. The results from the exploratory assessment conducted by ICES in 2013 based on smaller management units (countries) were in line with this advice.

While stocks remain in a depleted state and in the absence of a fishery at Faroes, particular care should be taken to ensure that fisheries in homewaters are managed to protect stocks that are below their CLs.

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 (N. Ireland), Ireland, France 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) (Figure 10.2.1). 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 a general decline over the time period (Figure 10.2.1), the decline being more marked in the maturing 1SW stock. Both stock complexes have, however, been at full reproductive capacity (i.e. >95% probability of achieving CLs) prior to the commencement of distant-water fisheries throughout the time-series. Recruitment of maturing 1SW and non-maturing 1SW salmon for southern NEAC also demonstrate broadly similar declining trends over the time period (Figure 10.2.1). Both stock complexes were at full reproductive capacity prior to the commencement of distant-water fisheries throughout the early part of the time-series. Since the mid-1990s, however, the non-maturing 1SW stock has been at risk of suffering reduced reproductive capacity in approximately 50% of the assessment years. The maturing 1SW stock, on the other hand, was first assessed as being at risk of suffering reduced reproductive capacity in 2009. This is broadly consistent with the general pattern of decline in marine survival in most monitored stocks in the area.

Based on the NEAC run-reconstruction model, three of the NEAC stock complexes (both northern NEAC stock complexes and the southern NEAC maturing 1SW stock) were considered to be at full reproductive capacity, prior to the commencement of distant-water fisheries, in the latest available PFA year. However, the southern NEAC non-maturing 1SW stock was considered to be at risk of suffering reduced reproductive capacity, prior to the commencement of distant-water fisheries, in the latest available PFA year.

For the northern NEAC stock complexes, 1SW spawners have been at full reproductive capacity throughout the time-series (Figure 10.2.1). In contrast, MSW spawners, while generally remaining at full reproductive capacity, have spent limited periods either at risk of suffering, or suffering, reduced reproductive capacity. Both the 1SW and MSW stock complexes were at full reproductive capacity in 2013. The 1SW spawning stock in the southern NEAC stock complex has been at risk of suffering, or suffering, reduced reproductive capacity for most of the time-series (Figure 10.2.1). In contrast, the MSW stock was at full reproductive capacity for most of the time-series until 1997. After this point, however, the stock has generally been at risk of suffering, or suffering, reduced reproductive capacity. Of the two southern NEAC stock complexes only the 1SW complex was at full reproductive capacity in 2013.

Estimated exploitation rates have generally been decreasing over the time period in the northern and southern NEAC areas (Figure 10.2.2). 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.

Management plans

The North Atlantic Salmon Conservation Organisation (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 North East 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 take place, with adult salmon from the North East 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, factors such as 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 important 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 2013. The NEAC area has seen a general reduction in catches since the 1980s (Figure 10.2.3; Table 10.2.1). This reflects the decline in fishing effort as a consequence of management measures, as well as a reduction in the size of stocks. The provisional total nominal catch for 2013 was 778 t in northern NEAC and 329 t in southern NEAC; the total NEAC area catch (1107 t) is the lowest in the time series. The catch in the southern area, which represented around two-thirds of the total NEAC catch in the early 1970s, has been consistently lower than that in the northern area since 1999 (Figure 10.2.3).

1SW salmon constituted 62% of the total catch in the northern NEAC area in 2013, compared with 54% for the southern area (Figure 10.2.4). There has been an overall decline in the percentage of 1SW fish in northern NEAC catches in recent years, when greater variability between countries has also been apparent. The percentage of 1SW fish in southern NEAC has remained reasonably consistent over the time series, although with considerable variability among individual countries (Figure 10.2.4).

The contribution of escaped farmed salmon in catches in the NEAC area in 2013 was again generally low in most countries, with the exception of Norway, Iceland, and Sweden, and similar to the values that have been reported in previous years. The estimated proportion of farmed salmon in Norwegian angling catches was the lowest on record (3.5%), whereas the proportion in samples taken from Norwegian rivers in the autumn was higher than in most recent years (21%). The number of salmon provisionally reported to have escaped from Norwegian farms in 2013 was 198 000, up from the previous year (38 000).

ICES reviewed the information on by-catch of Atlantic salmon in pelagic fisheries, primarily for mackerel, and concluded that estimates of total salmon by-catch were highly uncertain. ICES identified a number of tasks that could be undertaken to provide more reliable estimates and recommended that further investigations would be informative (see Section 10.1.11).

Effects of the fisheries on the ecosystem

The current salmon fishery probably has no, or only minor, influence on the marine ecosystem. However, the exploitation rate on salmon may affect the riverine ecosystem through changes in species composition. There is limited knowledge on the magnitude of any such effects.

Quality considerations

Uncertainties in input variables to the stock status and stock forecast models are incorporated in the assessment. Provisional catch data for 2012 were updated, where appropriate, and the assessment extended to include data for 2013.

Recommendations in relation to data collection for assessment needs for Atlantic salmon were provided in the report of the ICES Workshop on Eel and Salmon Data Collection Framework WKESDCF (ICES, 2012c) and discussions have continued with the European Commission in relation to future monitoring requirements.

Scientific basis

Assessment type	Run-reconstruction models and Bayesian forecasts taking into account uncertainties in data and process error. Results presented in a risk analysis framework.
Input data	Nominal catches (by sea-age class) for commercial and recreational fisheries. Estimates of unreported/illegal catches. Estimates of exploitation rates. Natural mortalities (from earlier assessments).
Discards and bycatch	Discards included in risk-based framework for Faroes fishery. Not relevant for other NEAC assessments.
Indicators	Framework of Indicators (FWI) is used to indicate if a significant change has occurred in the status of stocks in intermediate years where multi-annual management advice applies.
Other information	Advice subject to annual review. Stock annex developed in 2014.
Working group report	WGNAS

Supporting information May 2014

ECOREGION North Atlantic
STOCK Atlantic salmon from the Northeast Atlantic

Reference points

National run-reconstruction models have been used to develop and update national CLs for all countries that do not have river-specific values (i.e. all countries except France, Ireland, UK (England and 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.

Complex	Age group	CL (number)	SER (number)
Northern NEAC	1SW	155 581	196 550
	MSW	129 820	221 222
Southern NEAC	1SW	561 771	708 823
	MSW	275 348	462 347

Outlook for 2014

No outlook is provided because the Framework of Indicators of North East Atlantic stocks did not indicate the need for a reassessment this year.

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 $B_{escapement}$).

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. Furthermore, due to the different status of individual stocks within the stock complex, mixed-stock fisheries present particular threats to stock status.

Additional considerations

The national stock CLs are not appropriate for the management of homewater fisheries. 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 can be used to provide general management advice to the distant water fisheries.

Fisheries on mixed stocks pose particular difficulties for management, when they cannot 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 wild and hatchery-reared smolts in northern and southern NEAC areas, particularly for maturing 1SW salmon (Figure 10.2.5). Five-year average return rates for individual river stocks (not shown in the figure) are also mostly below the average of the previous five years for the majority of monitored hatchery-reared and wild populations in the NEAC area. 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.

Data and methods

Input data to estimate the historical PFAs are the catch in numbers of 1SW and MSW salmon in each country, unreported catch (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. Results are presented in Tables 10.2.2 and 10.2.3.

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 returns to each country.

Comparison with previous assessment and catch options

The NASCO Framework of Indicators of North East Atlantic stocks did not indicate the need for a revised analysis of catch options this year and, therefore, no new management advice for 2014 is provided. The assessment was updated to include data up to 2013 and the stock status was consistent with the previous year's assessment.

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 exploitation rates 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 (2012a) developed a risk framework for providing catch advice for the Faroes fishery at the age and country level for northern and southern NEAC, as well as at the stock complex level. This risk framework has not been formally adopted by NASCO.

ICES (2010, 2011, 2012b) previously emphasized the problem of basing a risk assessment and catch advice for the Faroes fishery on management units comprising large numbers of river stocks. In providing catch advice at the age and stock complex or country levels for northern and southern NEAC areas, 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 river-specific CLs are in the process of being developed.

Sources of information

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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.

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

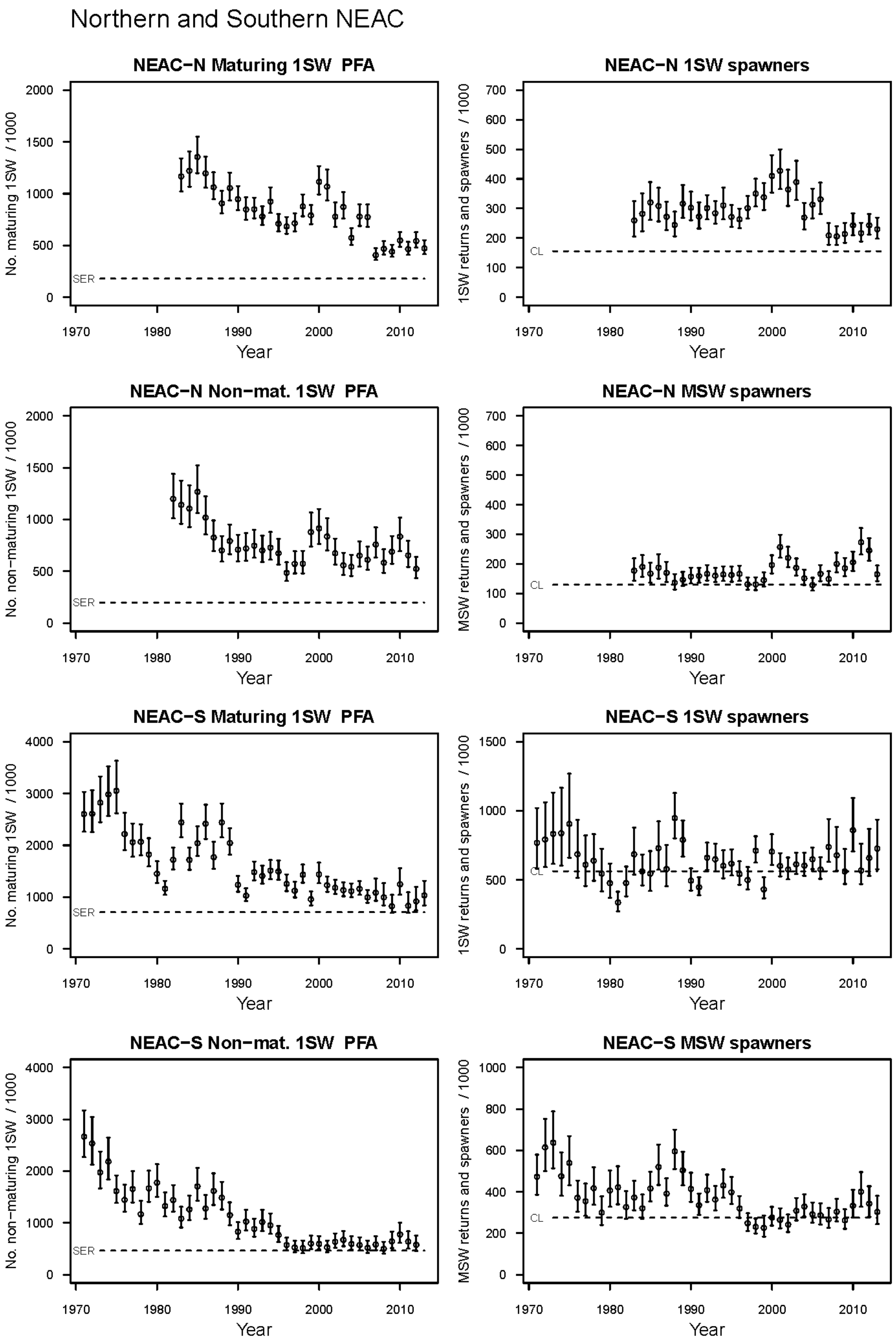


Figure 10.2.1 Estimated PFA (**recruits;** left panels) and spawning escapement (right panels) with 90% confidence limits, for maturing 1SW (1SW spawners) and non-maturing 1SW (MSW spawners) salmon in the northern (NEAC-N) and southern (NEAC-S) NEAC stock complexes. The dashed horizontal lines in the left panels are the age-specific SER values, and in the right panels the age-specific CL values.

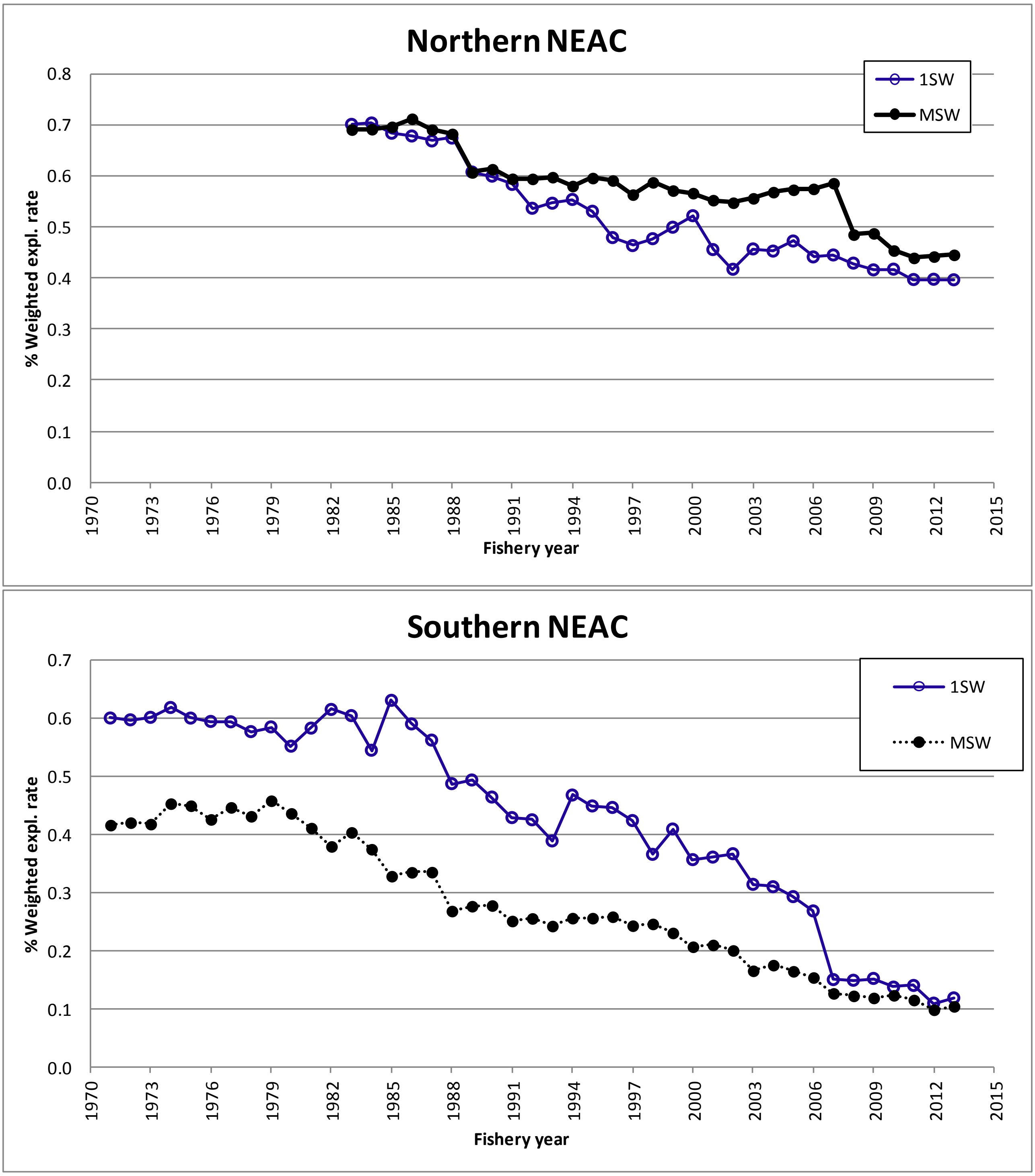


Figure 10.2.2 Mean annual exploitation rate of wild 1SW and MSW salmon by combined commercial and recreational fisheries in the northern NEAC area (upper panel), from 1983 to 2013, and the southern NEAC area (lower panel), from 1971 to 2013.

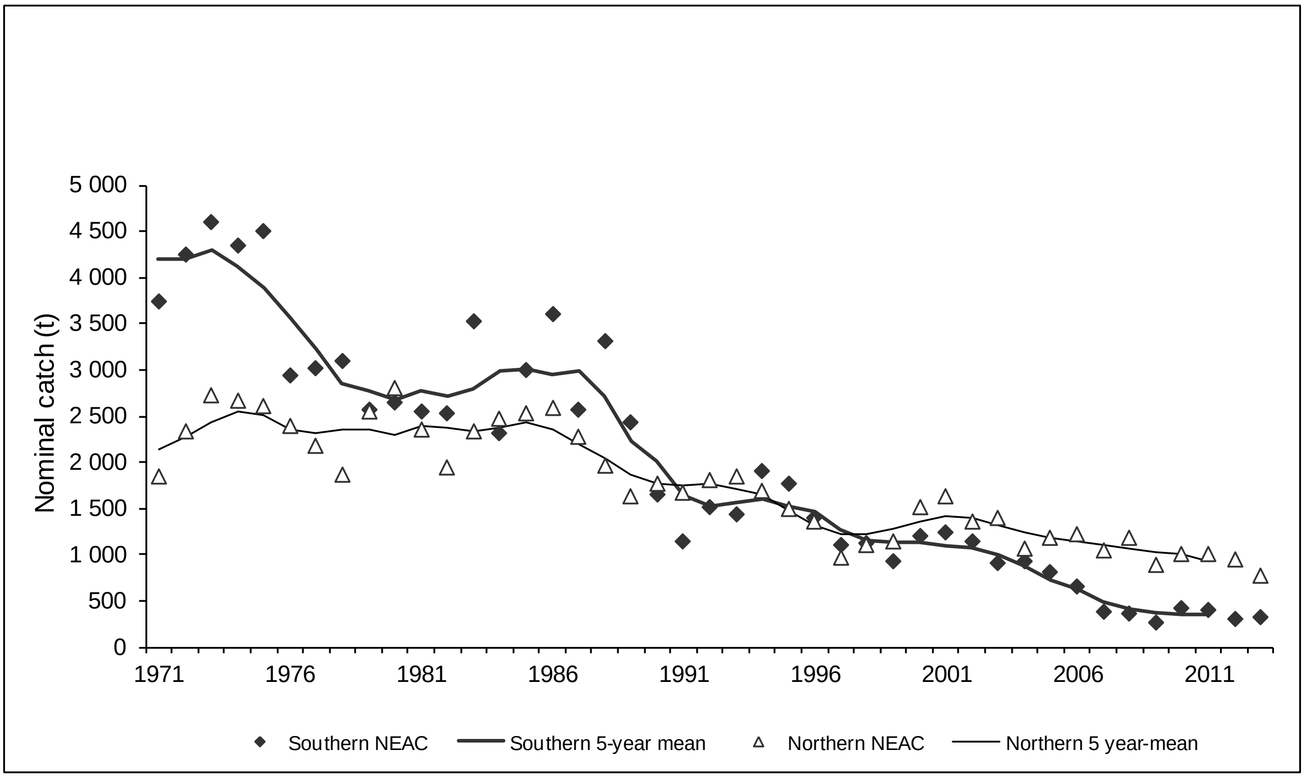
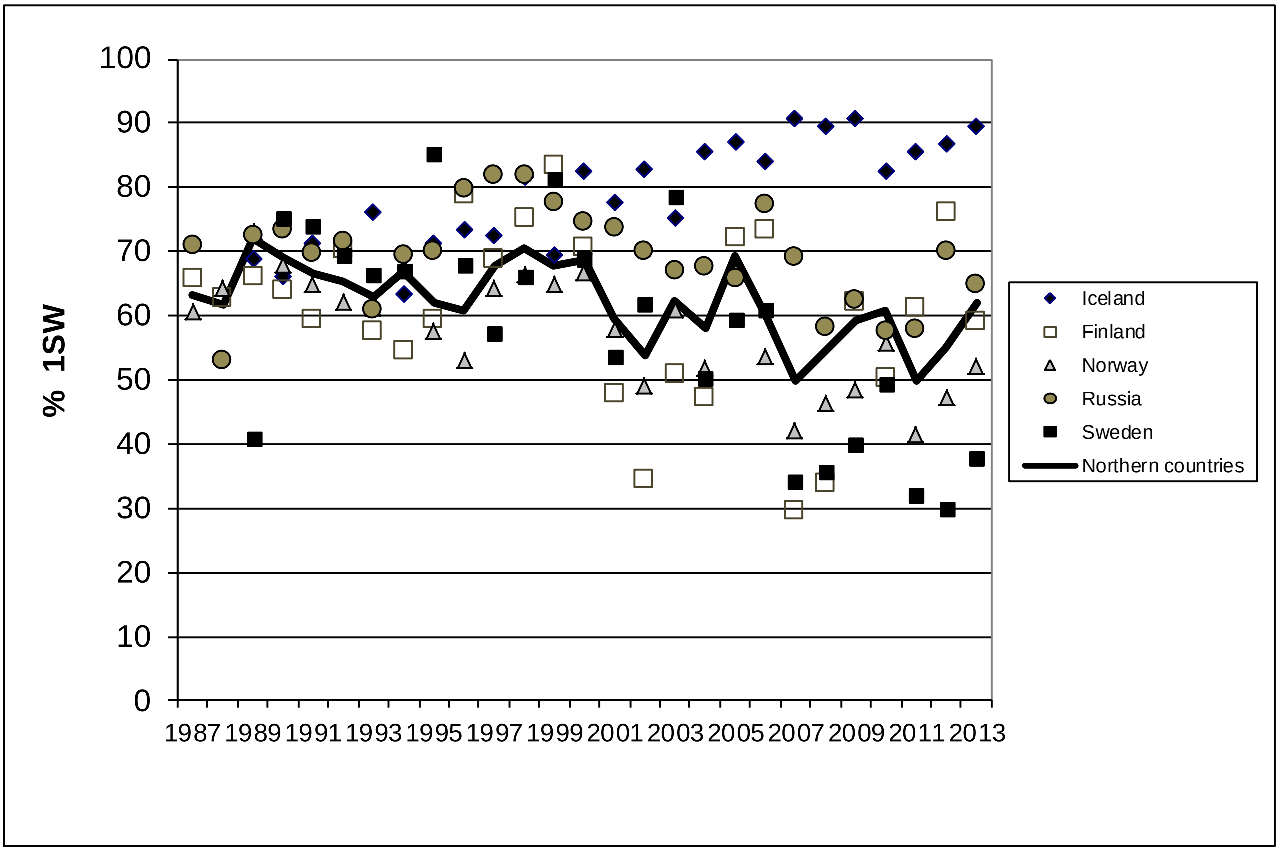


Figure 10.2.3 Nominal catch of salmon and 5-year running means in the southern NEAC and northern NEAC areas, from 1971 to 2013.



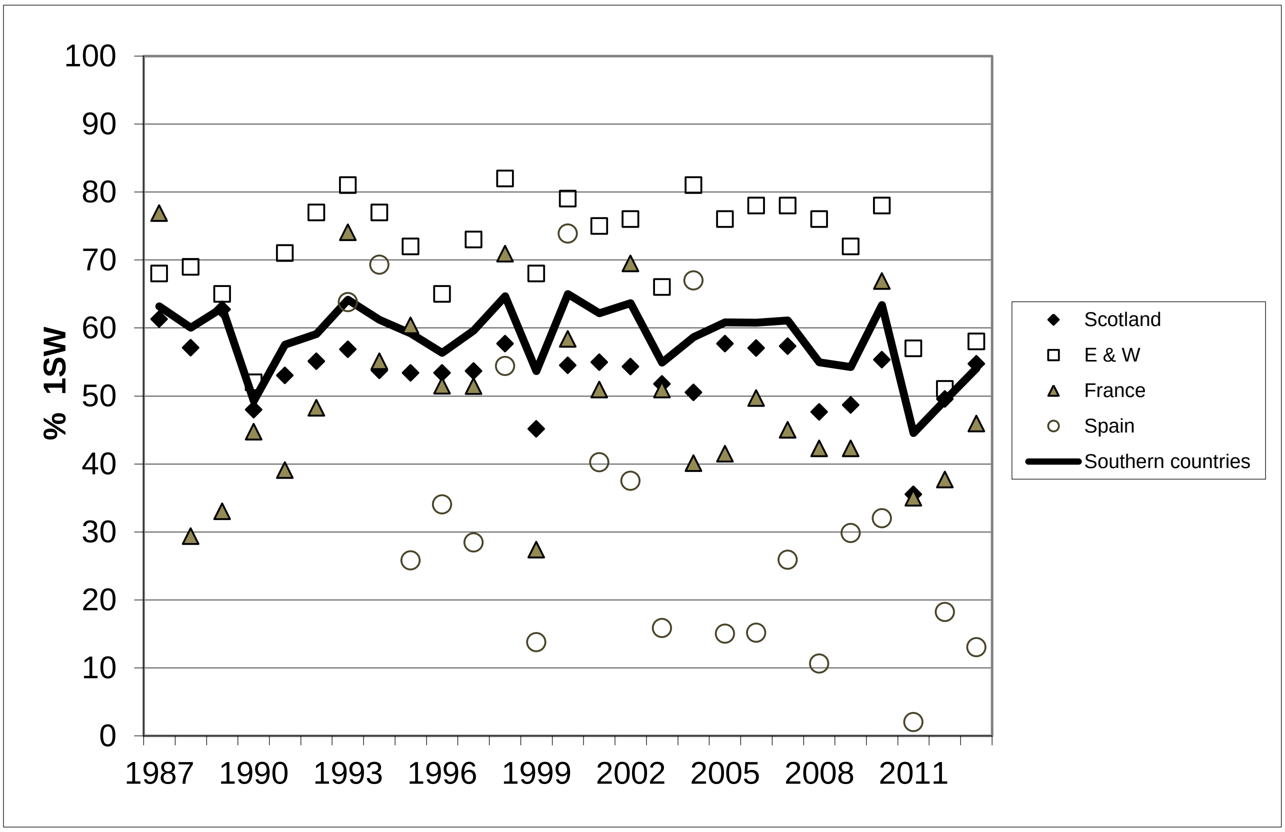


Figure 10.2.4 Percentage of 1SW salmon in the reported catch for northern NEAC countries (upper panel) and southern NEAC countries (lower panel), from 1987 to 2013. Solid line denotes mean value from catches in all countries within the complex.

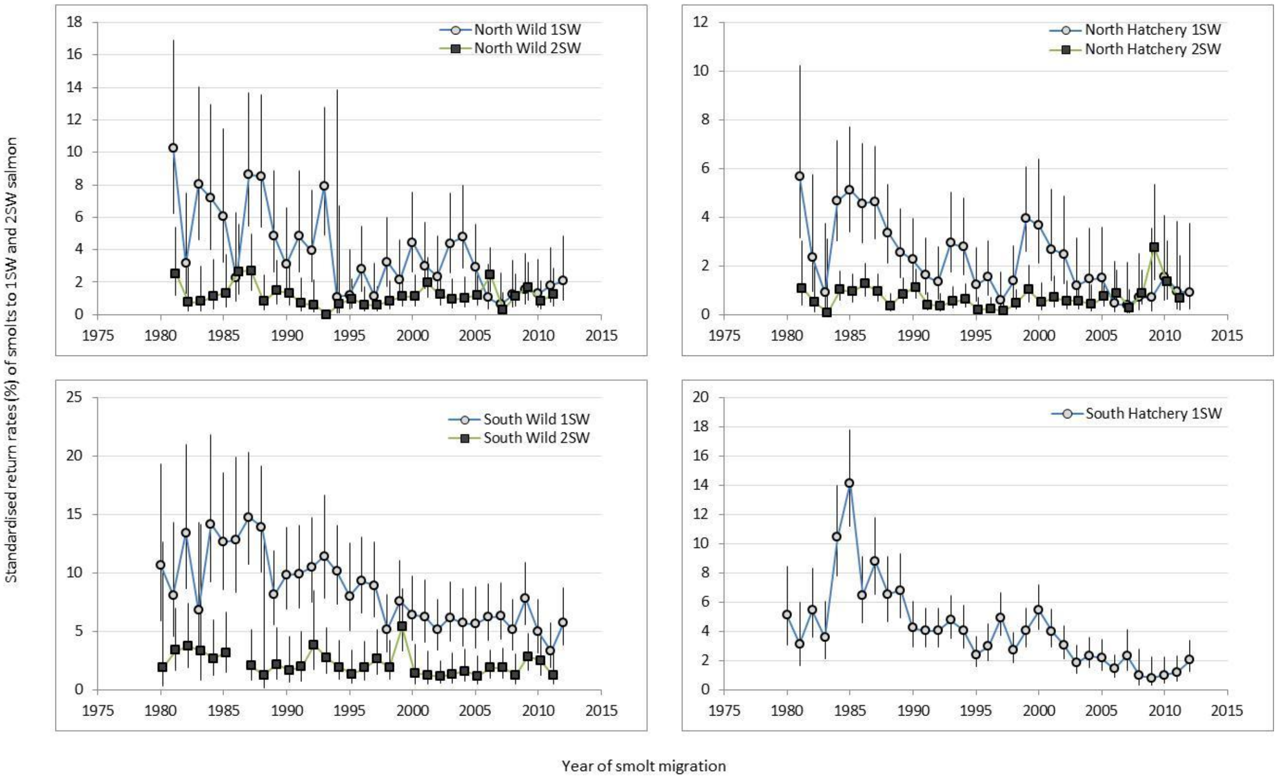


Figure 10.2.5 Standardised mean annual survival indices (%) of wild (left hand panels) and hatchery origin (right hand panels) smolts to 1SW and 2SW salmon to northern (top panels) and southern (bottom panels) NEAC areas. The standardised values are annual means derived from a general linear model analysis of rivers in a region. Error values are 95% confidence limits. Note the scale of the vertical axis differs among panels.

Table 10.2.1 Nominal catch of salmon in the NEAC area (in tonnes, round fresh weight), from 1960 to 2013 (2013 figures are provisional).

Year	Southern countries	Northern countries (1)	Faroes (2)	Other catches in international waters	Total Reported Catch	Unreported catches NEAC Area (3)	Unreported catches International waters (4)
1960	2 641	2 899	-	-	5 540	-	-
1961	2 276	2 477	-	-	4 753	-	-
1962	3 894	2 815	-	-	6 709	-	-
1963	3 842	2 434	-	-	6 276	-	-
1964	4 242	2 908	-	-	7 150	-	-
1965	3 693	2 763	-	-	6 456	-	-
1966	3 549	2 503	-	-	6 052	-	-
1967	4 492	3 034	-	-	7 526	-	-
1968	3 623	2 523	5	403	6 554	-	-
1969	4 383	1 898	7	893	7 181	-	-
1970	4 048	1 834	12	922	6 816	-	-
1971	3 736	1 846	-	471	6 053	-	-
1972	4 257	2 340	9	486	7 092	-	-
1973	4 604	2 727	28	533	7 892	-	-
1974	4 352	2 675	20	373	7 420	-	-
1975	4 500	2 616	28	475	7 619	-	-
1976	2 931	2 383	40	289	5 643	-	-
1977	3 025	2 184	40	192	5 441	-	-
1978	3 102	1 864	37	138	5 141	-	-
1979	2 572	2 549	119	193	5 433	-	-
1980	2 640	2 794	536	277	6 247	-	-
1981	2 557	2 352	1 025	313	6 247	-	-
1982	2 533	1 938	606	437	5 514	-	-
1983	3 532	2 341	678	466	7 017	-	-
1984	2 308	2 461	628	101	5 498	-	-
1985	3 002	2 531	566	-	6 099	-	-
1986	3 595	2 588	530	-	6 713	-	-
1987	2 564	2 266	576	-	5 406	2 554	-
1988	3 315	1 969	243	-	5 527	3 087	-
1989	2 433	1 627	364	-	4 424	2 103	-
1990	1 645	1 775	315	-	3 735	1 779	180-350
1991	1 145	1 677	95	-	2 917	1 555	25-100
1992	1 523	1 806	23	-	3 352	1 825	25-100
1993	1 443	1 853	23	-	3 319	1 471	25-100
1994	1 896	1 684	6	-	3 586	1 157	25-100
1995	1 775	1 503	5	-	3 283	942	-
1996	1 392	1 358	-	-	2 750	947	-
1997	1 112	962	-	-	2 074	732	-
1998	1 120	1 099	6	`	2 225	1 108	-
1999	934	1 139	0	-	2 073	887	-
2000	1 210	1 518	8	-	2 736	1 135	-
2001	1 242	1 634	0	-	2 876	1 089	-
2002	1 135	1 360	0	-	2 495	946	-
2003	908	1 394	0	-	2 302	719	-
2004	919	1 059	0	-	1 978	575	-
2005	809	1 189	0	-	1 998	605	-
2006	650	1 217	0	-	1 867	604	-
2007	373	1 036	0	-	1 409	465	-
2008	355	1 178	0	-	1 533	433	-
2009	265	898	0	-	1 163	317	-
2010	411	1 003	0	-	1 415	357	-
2011	410	1 009	0	-	1 419	382	-
2012	296	955	0	-	1 250	363	-
2013	329	778	0	-	1 107	272	-
Average							
2008-2012	347	1009	0	-	1356	370	-
2003-2012	540	1094	0	-	1633	482	-

1. All Iceland has been included in Northern countries
2. Since 1991, fishing carried out at the Faroes has only been for research purposes.
3. No unreported catch estimate available for Russia since 2008.
4. Estimates refer to season ending in given year.

Table 10.2.2 Estimated pre-fishery abundance (PFA) of maturing 1SW salmon (potential 1SW returns) by NEAC country or region and year.

	Northern Europe								Southern Europe									NEAC Area		
Year	**Finland**	**Iceland**	**Norway**	**Russia**	**Sweden**	**Total**			**France**	**Iceland**	**Ireland**	**UK(EW)**	**UK(NI)**	**UK(Scot)**	**Total**			**Total**		
		N&E				5.0%	50.0%	95.0%		**S&W**					5.0%	50.0%	95.0%	5.0%	50.0%	95.0%
1971	32,074	11,735		NA	22,321				63,331	76,233	1,345,148	105,231	221,904	782,559	2,263,292	**2,610,195**	3,032,226			
1972	123,528	10,720		151,281	17,727				127,354	61,978	1,428,796	101,014	194,318	683,714	2,255,414	**2,616,311**	3,064,007			
1973	57,652	12,866		222,746	21,886				77,568	66,128	1,562,053	119,345	169,888	818,907	2,442,628	**2,831,594**	3,330,607			
1974	79,736	12,856		222,520	31,746				35,986	47,278	1,775,894	149,416	185,863	780,467	2,567,779	**2,989,715**	3,528,552			
1975	95,040	15,686		341,098	34,377				72,191	73,188	1,956,894	153,131	152,812	636,840	2,616,451	**3,059,188**	3,631,857			
1976	86,950	15,741		237,309	19,460				66,277	57,875	1,329,232	102,549	106,177	549,019	1,906,685	**2,224,559**	2,629,032			
1977	48,979	21,735		151,187	8,824				51,178	59,224	1,154,550	116,348	104,554	570,889	1,781,030	**2,066,454**	2,419,114			
1978	46,611	22,145		152,731	10,456				52,274	77,910	1,006,582	132,930	136,153	654,808	1,807,117	**2,073,587**	2,406,392			
1979	42,156	21,268		211,832	10,810				59,401	71,761	924,438	127,316	95,573	539,870	1,593,431	**1,829,694**	2,136,277			
1980	33,637	3,413		151,690	13,897				124,424	32,852	706,378	119,541	121,066	338,416	1,269,988	**1,457,752**	1,691,296			
1981	30,997	16,906		127,411	25,516				99,707	42,766	374,799	125,760	95,715	418,810	1,042,885	**1,168,340**	1,313,254			
1982	18,692	7,951		111,257	22,407				61,258	43,602	770,477	106,729	137,390	598,236	1,535,138	**1,728,485**	1,955,221			
1983	44,194	11,548	896,493	184,824	29,678	1,022,387	**1,169,737**	1,341,314	66,263	54,839	1,357,134	156,160	192,545	610,534	2,153,231	**2,450,179**	2,806,028	3,244,186	**3,625,483**	4,058,432
1984	47,330	4,207	930,150	196,552	41,409	1,067,404	**1,223,646**	1,407,435	106,923	33,717	713,003	136,400	75,576	643,726	1,526,826	**1,723,967**	1,953,993	2,655,244	**2,949,234**	3,282,662
1985	62,112	28,161	944,112	269,277	49,426	1,198,252	**1,358,234**	1,549,133	40,138	54,223	1,178,557	136,982	97,948	530,719	1,792,928	**2,048,372**	2,365,207	3,060,340	**3,413,537**	3,820,069
1986	50,025	35,134	825,671	231,964	51,545	1,057,858	**1,200,472**	1,356,827	62,185	89,701	1,321,020	157,698	110,586	661,153	2,120,986	**2,424,991**	2,784,572	3,246,287	**3,628,740**	4,064,033
1987	59,510	20,700	693,619	246,589	40,974	946,398	**1,065,725**	1,205,507	108,425	55,659	851,369	163,673	60,474	508,562	1,543,135	**1,778,834**	2,071,768	2,549,416	**2,846,731**	3,208,446
1988	35,351	29,879	637,443	170,243	34,406	809,412	**909,951**	1,028,295	37,520	99,563	1,153,687	224,742	141,798	770,115	2,153,188	**2,449,040**	2,805,836	3,014,290	**3,363,834**	3,770,403
1989	76,262	16,169	699,839	252,420	10,203	936,303	**1,058,060**	1,204,688	20,701	55,716	828,573	151,812	136,123	846,297	1,820,552	**2,052,974**	2,326,406	2,811,115	**3,117,562**	3,458,891
1990	76,143	12,025	628,244	208,522	23,341	841,507	**950,255**	1,072,818	34,339	50,970	518,753	108,172	112,665	404,950	1,103,905	**1,243,700**	1,409,112	1,987,214	**2,197,350**	2,429,927
1991	74,711	17,420	546,214	178,127	29,395	750,052	**849,451**	963,677	24,714	56,372	370,913	107,228	62,900	401,883	922,518	**1,034,694**	1,167,185	1,710,420	**1,886,798**	2,084,748
1992	105,298	32,812	459,820	219,173	32,281	761,254	**853,173**	960,271	45,514	64,685	534,215	111,977	127,002	585,575	1,321,912	**1,488,470**	1,684,229	2,120,919	**2,343,346**	2,598,039
1993	70,791	26,933	462,197	188,263	32,227	699,304	**783,880**	879,478	64,661	63,426	436,514	154,821	148,910	525,591	1,260,399	**1,416,509**	1,604,682	1,995,643	**2,201,902**	2,439,315
1994	39,415	8,631	625,625	223,124	24,959	814,332	**926,548**	1,060,820	51,119	52,098	558,215	172,710	102,288	560,470	1,346,558	**1,518,527**	1,717,843	2,213,188	**2,446,242**	2,712,895
1995	39,432	24,793	407,879	200,626	36,569	637,721	**712,734**	801,404	16,998	70,644	624,899	131,469	95,159	551,717	1,333,637	**1,502,092**	1,703,019	2,003,445	**2,217,560**	2,460,703
1996	66,696	13,214	311,183	271,994	21,729	613,502	**687,806**	774,566	21,111	60,818	581,365	97,987	98,274	395,047	1,116,684	**1,264,365**	1,438,168	1,765,443	**1,954,188**	2,171,214
1997	60,336	18,057	358,619	266,999	9,846	637,740	**718,084**	810,622	10,767	44,568	578,929	87,990	116,295	283,783	991,817	**1,130,185**	1,297,438	1,665,879	**1,850,610**	2,066,146
1998	75,965	30,786	467,769	293,457	7,931	781,834	**881,160**	993,318	21,060	61,095	609,056	96,121	253,544	386,518	1,277,568	**1,440,283**	1,628,251	2,101,193	**2,322,617**	2,572,721
1999	101,649	15,628	434,052	225,467	12,553	706,807	**793,078**	892,539	7,039	49,592	567,754	76,014	66,093	191,683	840,915	**963,730**	1,113,582	1,585,993	**1,761,092**	1,961,852
2000	110,045	16,462	716,695	247,130	22,986	993,246	**1,118,635**	1,265,894	18,215	43,870	785,774	116,084	95,819	374,027	1,266,505	**1,446,338**	1,664,964	2,310,388	**2,566,948**	2,865,555
2001	79,866	14,942	618,988	333,072	14,301	933,373	**1,071,085**	1,233,636	15,816	39,212	626,800	101,205	75,849	366,948	1,102,633	**1,236,769**	1,393,005	2,084,172	**2,310,421**	2,563,442
2002	54,190	25,923	378,142	304,312	13,707	679,451	**781,752**	915,723	35,639	49,050	548,027	95,350	149,939	295,526	1,061,668	**1,187,449**	1,334,651	1,782,749	**1,973,877**	2,195,497
2003	53,800	13,744	523,212	269,995	7,485	761,325	**875,556**	1,014,634	23,356	58,553	536,323	73,865	97,879	335,296	1,016,119	**1,139,555**	1,282,982	1,819,161	**2,017,792**	2,244,049
2004	22,698	37,184	317,531	189,241	6,265	505,430	**577,515**	666,293	28,317	58,827	395,624	133,598	87,546	398,064	996,787	**1,120,604**	1,264,599	1,533,897	**1,700,274**	1,887,282
2005	49,959	32,943	470,778	216,437	6,131	688,705	**782,552**	898,129	18,505	86,637	393,164	109,373	111,076	432,607	1,042,957	**1,166,547**	1,308,460	1,769,192	**1,951,798**	2,164,306
2006	87,511	34,784	381,524	260,839	6,828	680,484	**777,662**	895,792	25,952	61,375	301,642	106,792	71,092	419,113	890,925	**1,001,657**	1,137,679	1,608,262	**1,785,278**	1,985,209
2007	25,539	25,757	213,532	140,828	2,118	359,057	**410,177**	473,241	20,160	70,121	343,073	101,703	115,356	411,495	928,986	**1,091,785**	1,358,502	1,317,924	**1,507,604**	1,782,981
2008	27,537	23,556	267,363	146,077	3,303	412,146	**471,500**	541,299	19,923	84,843	340,529	100,218	68,920	354,379	841,458	**1,001,687**	1,267,654	1,290,553	**1,480,203**	1,758,283
2009	48,645	37,971	213,824	137,107	3,498	391,162	**444,185**	506,281	7,088	95,833	282,951	63,073	52,543	302,986	695,557	**829,844**	1,042,210	1,118,674	**1,278,051**	1,504,308
2010	39,362	30,422	316,608	156,670	5,976	486,662	**552,705**	628,763	24,387	98,503	357,527	124,767	48,109	552,776	1,042,633	**1,255,400**	1,561,340	1,569,278	**1,811,077**	2,133,934
2011	44,508	24,986	223,470	167,141	5,106	410,279	**467,781**	535,390	17,020	69,493	314,270	72,871	41,801	295,993	695,753	**838,483**	1,092,132	1,140,705	**1,312,810**	1,577,845
2012	76,941	13,089	248,568	195,257	7,216	479,637	**546,612**	626,843	14,631	39,402	320,185	44,871	63,232	394,460	742,840	**924,002**	1,197,017	1,263,841	**1,475,242**	1,766,643
2013	44,493	36,170	233,981	151,858	4,144	416,672	**475,480**	549,277	20,673	91,775	298,881	56,245	46,858	471,255	836,320	**1,040,599**	1,313,309	1,291,359	**1,519,800**	1,810,767
10yr Av.	46,719	29,686	288,718	176,145	5,059	483,023	**550,617**	632,131	19,666	75,681	334,785	91,351	70,653	403,313	871,422	**1,027,061**	1,254,290	1,390,369	**1,582,214**	1,837,156

Table 10.2.3 Estimated pre-fishery abundance (PFA) of non-maturing 1SW salmon (potential MSW returns) by NEAC country or region and year.

	Northern Europe								Southern Europe									NEAC Area		
Year	Finland	Iceland	Norway	Russia	Sweden	Total			France	Iceland	Ireland	UK(EW)	UK(NI)	UK(Scot)	Total			Total		
		N&E				5.0%	50.0%	95.0%		S&W					5.0%	50.0%	95.0%	5.0%	50.0%	95.0%
1971	52,462	28,471		268,996	5,689				56,319	66,084	394,140	368,775	34,351	1,743,860	2,273,240	**2,672,992**	3,170,521			
1972	79,456	26,908		431,948	8,436				36,821	59,602	387,869	278,078	30,707	1,737,269	2,128,562	**2,541,517**	3,049,789			
1973	125,860	24,989		399,600	5,754				21,488	51,386	409,247	207,150	32,458	1,251,038	1,664,744	**1,982,272**	2,375,330			
1974	160,608	27,852		433,313	4,584				31,562	54,599	448,220	259,231	27,572	1,356,569	1,836,071	**2,190,324**	2,645,600			
1975	125,094	22,679		369,349	5,308				28,547	47,097	342,119	178,828	19,007	1,000,092	1,386,435	**1,621,047**	1,914,244			
1976	86,392	30,586		254,230	2,945				18,964	45,605	274,946	171,818	18,284	912,503	1,217,414	**1,451,483**	1,736,908			
1977	45,458	38,924		219,382	3,086				21,372	58,746	253,761	163,404	23,261	1,134,320	1,393,914	**1,659,812**	1,999,738			
1978	47,158	26,460		200,637	5,034				18,579	37,996	210,155	82,286	17,196	804,618	977,500	**1,175,425**	1,430,168			
1979	55,453	38,144		351,297	10,715				36,725	54,282	249,357	225,420	23,772	1,075,048	1,407,923	**1,676,175**	2,008,349			
1980	71,209	17,284		246,836	9,085				28,252	38,161	202,556	301,473	21,858	1,182,416	1,499,643	**1,783,588**	2,132,425			
1981	85,524	18,747		221,125	13,240				19,601	27,581	133,568	140,961	28,337	978,862	1,124,675	**1,333,147**	1,588,600			
1982	88,288	14,357	812,705	274,489	9,580	1,010,339	**1,203,436**	1,439,918	19,261	43,514	215,636	147,167	36,201	980,605	1,219,169	**1,448,005**	1,730,907	2,260,693	**2,652,248**	3,129,621
1983	70,572	16,126	793,213	253,815	8,984	958,278	**1,145,101**	1,376,093	24,223	36,382	147,264	107,342	15,312	752,742	910,535	**1,090,063**	1,309,640	1,893,875	**2,237,738**	2,644,758
1984	68,807	11,364	740,653	279,853	5,749	927,010	**1,109,217**	1,329,815	18,683	26,864	157,211	146,983	19,220	890,029	1,051,940	**1,267,116**	1,528,900	2,011,988	**2,376,639**	2,820,457
1985	61,210	27,292	890,168	284,308	5,834	1,063,155	**1,270,907**	1,522,972	22,960	23,017	198,632	217,503	21,873	1,219,740	1,425,745	**1,711,353**	2,062,595	2,530,224	**2,987,338**	3,538,070
1986	75,327	27,958	687,158	219,256	9,078	855,673	**1,022,289**	1,223,320	13,863	20,543	227,444	172,960	12,726	831,224	1,078,623	**1,284,407**	1,540,025	1,962,676	**2,307,951**	2,727,311
1987	50,512	17,681	550,709	199,439	7,437	693,243	**829,106**	990,653	28,442	22,283	168,811	212,320	27,874	1,153,677	1,346,457	**1,623,852**	1,956,772	2,069,902	**2,453,552**	2,910,615
1988	51,003	15,543	415,761	199,823	20,520	593,986	**705,468**	840,713	17,452	20,219	167,842	186,971	22,974	1,072,638	1,259,531	**1,493,674**	1,791,961	1,870,243	**2,199,948**	2,608,613
1989	53,532	15,862	469,797	243,145	11,240	666,016	**795,457**	952,467	13,484	19,752	76,756	196,750	20,525	821,857	957,879	**1,155,922**	1,396,486	1,647,804	**1,952,895**	2,322,202
1990	67,498	10,838	386,836	231,015	13,567	595,575	**712,309**	852,056	11,363	19,349	100,484	87,272	10,691	603,537	689,561	**836,390**	1,015,820	1,302,775	**1,550,415**	1,844,582
1991	64,061	15,442	410,713	214,358	17,921	603,852	**724,529**	869,922	15,125	21,518	84,846	74,490	22,682	809,734	856,259	**1,031,608**	1,257,221	1,484,085	**1,756,844**	2,099,135
1992	66,649	17,362	392,217	252,688	20,051	630,587	**750,547**	900,335	7,507	10,660	79,098	76,469	52,788	656,358	732,190	**889,031**	1,080,139	1,382,457	**1,640,663**	1,954,080
1993	62,970	14,730	383,270	226,162	15,389	588,708	**704,736**	845,700	13,017	17,134	114,357	98,052	18,884	758,284	842,296	**1,024,119**	1,258,065	1,450,371	**1,730,738**	2,075,127
1994	42,217	10,442	412,548	257,421	8,011	612,941	**732,198**	879,733	6,405	19,317	110,804	98,411	16,208	703,344	787,352	**960,389**	1,181,157	1,420,704	**1,694,290**	2,031,675
1995	43,048	13,480	410,925	194,442	12,561	566,713	**677,298**	812,792	11,363	12,467	76,253	101,637	17,656	547,898	634,815	**771,889**	945,857	1,222,187	**1,452,077**	1,734,737
1996	49,927	7,402	265,517	154,751	8,708	407,145	**488,220**	588,545	5,928	13,797	96,062	63,587	21,379	370,927	472,688	**580,164**	716,861	894,927	**1,068,905**	1,283,575
1997	47,929	10,807	318,729	191,727	4,854	480,069	**575,405**	692,103	4,925	8,536	55,617	41,355	29,341	388,756	435,789	**532,675**	654,836	931,748	**1,110,559**	1,327,110
1998	50,860	12,351	339,793	168,424	3,441	478,514	**576,689**	695,996	10,320	16,645	85,505	80,205	13,368	297,719	414,110	**519,036**	656,279	912,547	**1,098,022**	1,324,045
1999	96,989	7,267	470,781	294,620	12,227	737,533	**882,026**	1,065,749	7,187	4,536	107,092	83,380	17,852	380,459	495,666	**608,282**	754,079	1,256,789	**1,491,425**	1,791,965
2000	129,108	8,314	555,704	207,203	14,539	763,589	**916,778**	1,101,738	8,712	7,941	97,771	92,332	13,101	372,602	487,074	**601,110**	744,400	1,275,585	**1,518,523**	1,819,458
2001	113,394	7,879	481,499	225,356	9,945	699,734	**839,495**	1,011,031	7,847	8,621	110,787	82,094	15,502	299,890	434,185	**535,015**	659,828	1,154,808	**1,376,807**	1,642,221
2002	81,553	8,258	426,059	158,132	2,390	564,352	**678,181**	815,297	11,292	13,751	116,503	104,631	10,132	372,993	517,614	**641,592**	795,898	1,103,258	**1,321,140**	1,582,890
2003	36,944	8,143	385,369	121,470	7,316	465,470	**560,371**	678,446	20,834	11,137	63,908	88,000	9,065	476,803	549,373	**679,480**	845,541	1,036,427	**1,242,164**	1,497,028
2004	30,716	10,081	354,923	145,203	4,907	455,002	**547,646**	658,891	12,788	9,813	82,700	96,780	11,480	376,109	486,712	**599,585**	743,964	959,220	**1,147,191**	1,378,821
2005	48,546	9,677	449,819	139,379	5,129	545,357	**653,899**	787,595	12,932	8,131	60,310	87,773	7,354	389,837	463,180	**579,288**	722,664	1,030,918	**1,234,578**	1,482,118
2006	69,928	9,294	382,642	145,516	4,815	513,110	**614,359**	737,372	12,249	5,004	27,389	84,018	10,114	375,747	418,284	**523,832**	658,256	951,789	**1,137,844**	1,369,187
2007	70,900	11,979	441,733	229,520	6,794	632,212	**762,463**	923,669	13,518	5,739	40,608	92,517	6,126	421,929	471,352	**590,560**	742,293	1,129,652	**1,356,388**	1,631,164
2008	30,309	9,648	345,457	194,053	5,934	485,379	**587,219**	711,838	7,084	8,873	45,766	71,471	7,995	356,911	403,778	**505,667**	636,350	910,456	**1,094,136**	1,319,153
2009	48,708	13,718	380,737	239,970	6,891	572,488	**692,428**	840,421	5,982	18,366	29,457	103,948	7,365	471,676	512,819	**648,560**	832,118	1,115,928	**1,342,939**	1,634,115
2010	37,585	15,238	531,287	239,642	12,982	692,465	**838,509**	1,018,899	15,544	9,323	34,234	154,179	19,161	534,564	612,884	**782,689**	1,002,388	1,342,607	**1,625,956**	1,971,524
2011	45,218	8,606	464,146	117,101	18,514	541,114	**656,797**	794,919	12,070	5,313	35,928	126,547	28,432	418,192	504,107	**646,865**	838,921	1,076,305	**1,306,347**	1,592,173
2012	43,521	10,328	328,574	134,338	7,855	434,998	**526,728**	638,533	12,068	11,314	36,422	113,370	13,346	382,009	454,236	**583,605**	759,457	913,835	**1,113,217**	1,364,639
10yr Av.	46,238	10,671	406,469	170,619	8,114	533,760	**644,042**	779,058	12,507	9,301	45,672	101,860	12,044	420,378	487,672	**614,013**	778,195	1,046,714	**1,260,076**	1,523,992

Appendix III. Rivers where salmon have a qualifying interest in Special Areas of Conservation (EU Habitats Directive) and status relative to Conservation Limit in 2014

District	River	Status Re CL in 2014	SAC
Drogheda	Boyne	Below	RIVER BOYNE AND RIVER BLACKWATER SAC
Wexford	Slaney	Below	SLANEY RIVER VALLEY SAC
Waterford	Barrow	Below	RIVER BARROW AND RIVER NORE SAC
Waterford	Nore	Above	RIVER BARROW AND RIVER NORE SAC
Waterford	Suir	Below	LOWER RIVER SUIR SAC
Lismore	Blackwater	Above	BLACKWATER RIVER (CORK/WATERFORD) SAC
Cork	Mealagh	Above	KILLARNEY NATIONAL PARK, MACGILLYCUDDY'S REEKS & CARAGH R. SAC
Kerry	Kerry Blackwater	Below	BLACKWATER RIVER (KERRY) SAC
Kerry	Emlagh	Below	CASTLEMAINE HARBOUR SAC
Kerry	Owenascaul	Below	CASTLEMAINE HARBOUR SAC
Kerry	Owenreagh	Below	KILLARNEY NATIONAL PARK, MACGILLYCUDDY'S REEKS & CARAGH R SAC
Kerry	Caragh	Above	KILLARNEY NATIONAL PARK, MACGILLYCUDDY'S REEKS & CARAGH R SAC
Kerry	Ferta	Above	KILLARNEY NATIONAL PARK, MACGILLYCUDDY'S REEKS & CARAGH R SAC
Limerick	Shannon	Below	LOWER RIVER SHANNON SAC
Galway	Owenboliska	Below	CONNEMARA BOG COMPLEX SAC
Galway	Corrib	Above	LOUGH CORRIB SAC
Galway	Corrib	Above	Maumturk Mountains
Connemara	Cashla	Above	CONNEMARA BOG COMPLEX SAC
Ballinakill	Culfin	Above	THE TWELVE BENS/GARRAUN COMPLEX SAC
Ballinakill	Dawros	Above	THE TWELVE BENS/GARRAUN COMPLEX SAC
Ballinakill	Bundorragh	Above	MWEELREA/SHEEFFRY/ERRIFF COMPLEX SAC
Ballinakill	Bunowen	Above	MWEELREA/SHEEFFRY/ERRIFF COMPLEX SAC
Ballinakill	Carrownisky	Below	MWEELREA/SHEEFFRY/ERRIFF COMPLEX SAC
Ballinakill	Erriff	Above	MWEELREA/SHEEFFRY/ERRIFF COMPLEX SAC
Bangor	Srahmore	Below	OWENDUFF/NEPHIN COMPLEX SAC
Bangor	Owenduff	Above	MWEELREA/SHEEFFRY/ERRIFF COMPLEX SAC
Bangor	Owenmore	Above	MWEELREA/SHEEFFRY/ERRIFF COMPLEX SAC
Bangor	Glenamoy	Above	GLENAMOY BOG COMPLEX SAC
Bangor	Muingnabo	Below	GLENAMOY BOG COMPLEX SAC
Bangor	Newport	Above	NEWPORT RIVER SAC
Ballina	Moy	Above	RIVER MOY SAC
Sligo	Garavogue	Above	LOUGH GILL SAC
Sligo	Ballysadare	Above	UNSHIN RIVER SAC
Ballyshannon	Eske	Above	LOUGH ESKE AND ARDNAMONA WOOD SAC
Ballyshannon	Glen	Above	CLOGHERNAGORE BOG AND GLENVEAGH NATIONAL PARK SAC
Ballyshannon	Drowes	Above	LOUGH MELVIN SAC
Letterkenny	Leannan	Below	LEANNAN RIVER SAC
Letterkenny	Gweebarra	Above	WEST OF ARDARA/MAAS ROAD SAC
Letterkenny	Owenea	Above	WEST OF ARDARA/MAAS ROAD SAC
Letterkenny	Owennamarve	Below	CLOGHERNAGORE BOG AND GLENVEAGH NATIONAL PARK SAC
Letterkenny	Clady	Above	LOUGH ESKE AND ARDNAMONA WOOD SAC

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.

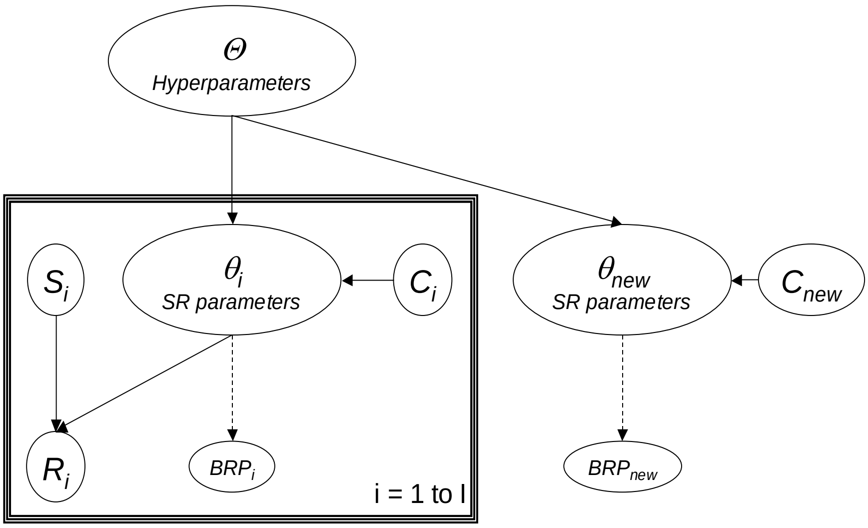


Figure IV.1. The conditioning structure of the BHSRA as represented in a Directed Acyclic Graph (DAG). Nodes (ellipses) are random variables. The plain arrows represent stochastic links, *i.e.* the distribution of a child node depends on its parents. Dashed arrows represent deterministic links, *i.e.*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

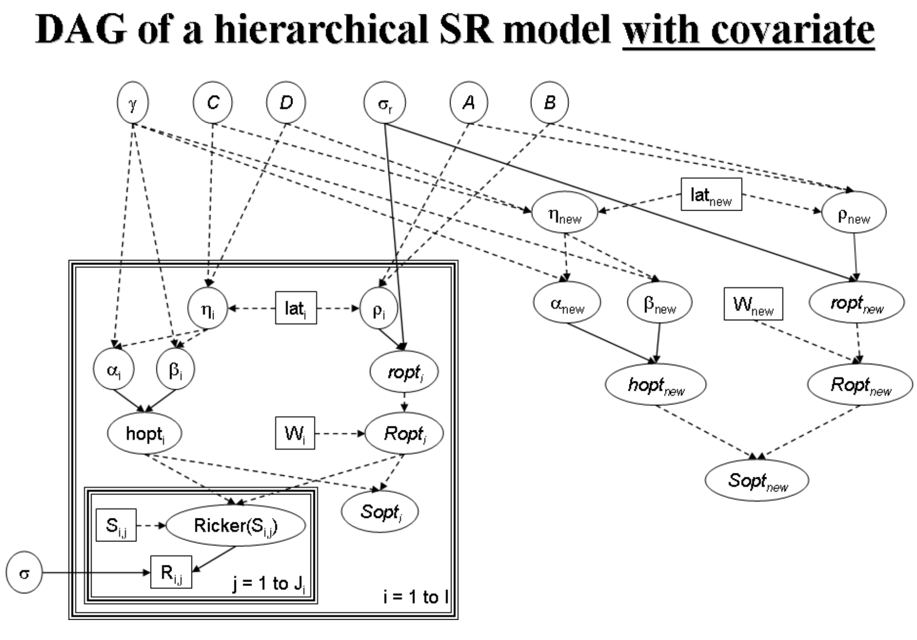


Figure IV.2. DAG of the hierarchical SR model with covariates used to transport stock and recruitment parameters to Irish rivers. The same graphical conventions are applied as in Figure 1. Naming of the nodes are explained below.

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 (m^2).
$ropt_i$ 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

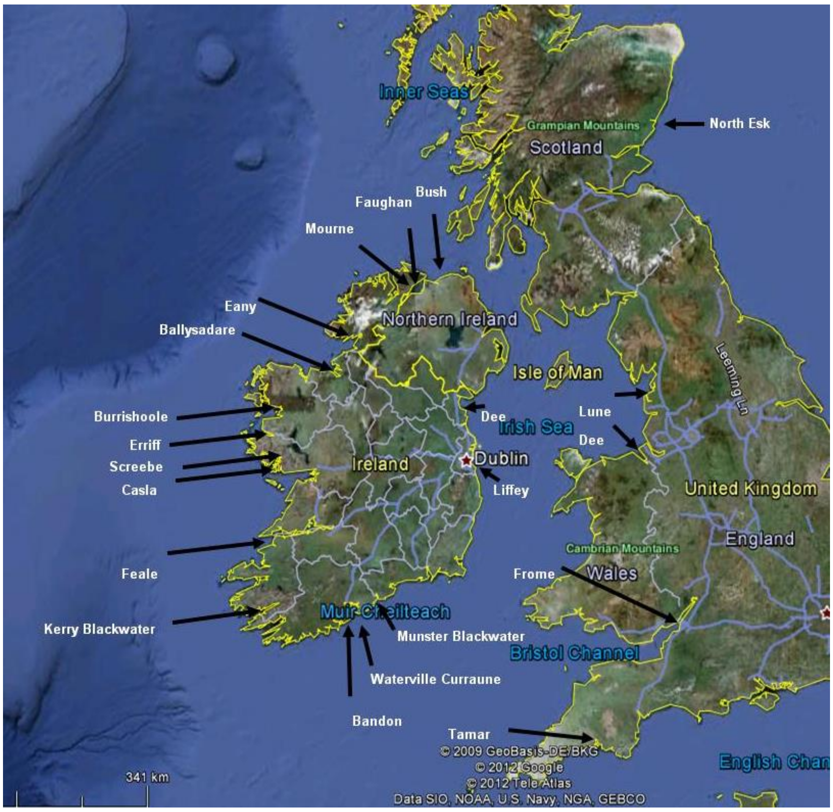


Figure IV. 3. Locations of rivers used for the provision of stock and recruitment parameters for BHSRA.

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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 10^{th} percentile, 50^{th} percentile (median) and 90^{th} percentile weights were taken as the range in weights (example in Figure V-2).

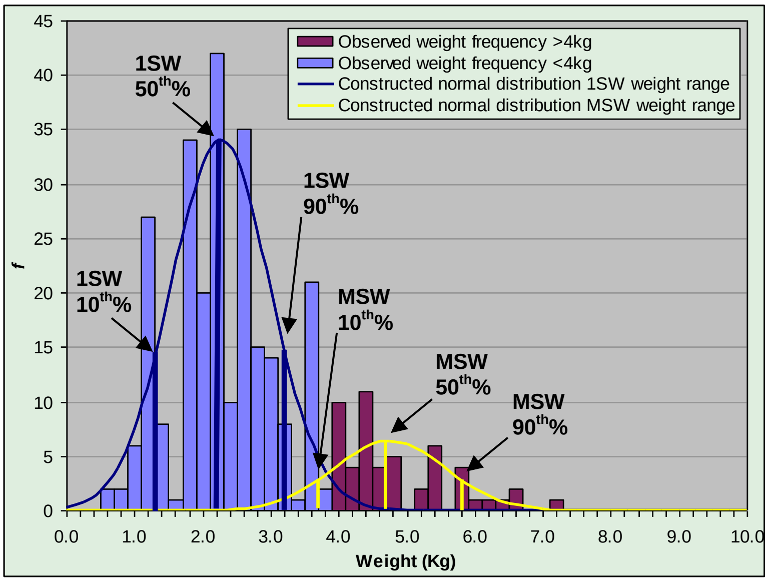

Figure V-2. Example of river specific observed weight frequency ranges and constructed normal distribution weight ranges of 1SW and MSW based upon initial weight splits of less than and greater then 4kg respectively. 10^{th}, 50^{th} and 90^{th} percentile weights of each age group indicated.

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:

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

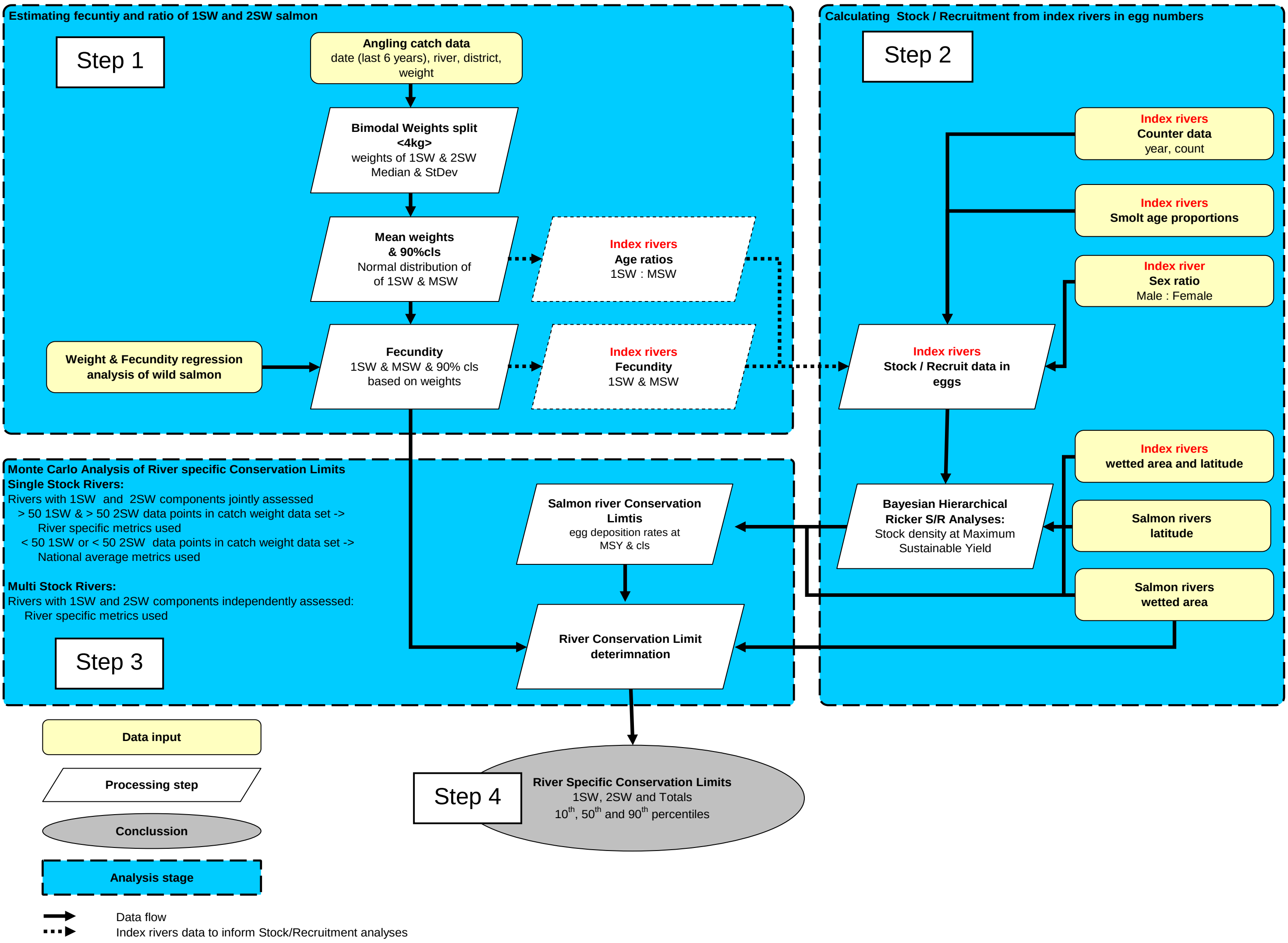

Figure V-1. Diagrammatic display of information flow in estimation of river specific conservation limits.

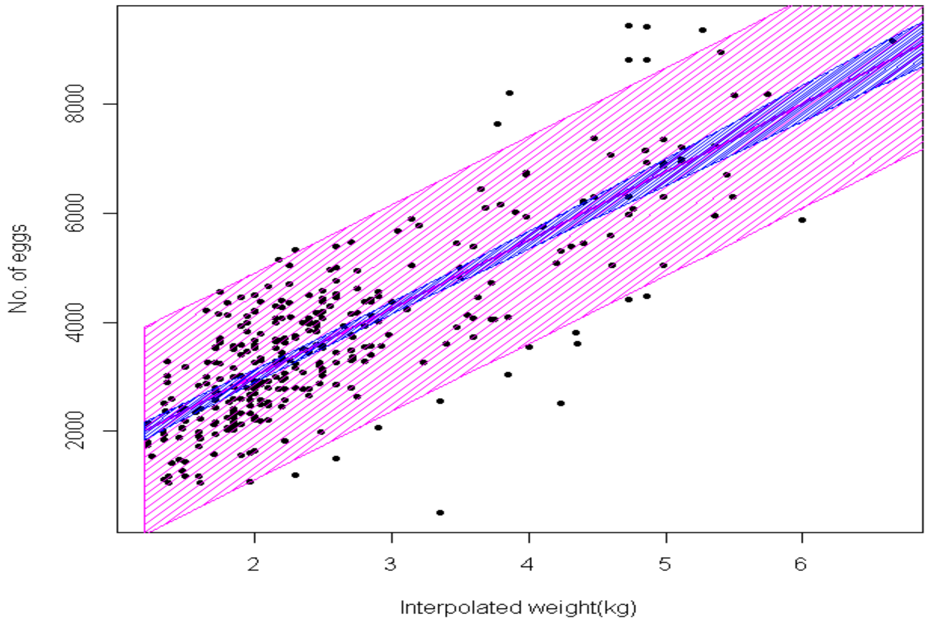

Figure V-3. Stripped number of eggs in Irish wild salmon, 1992 - 2011, against weight (kg) of fish. Fitted line is calculated from the model. Pink are = 95% prediction intervals, blue area = 95% confidence intervals. n=336

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**).

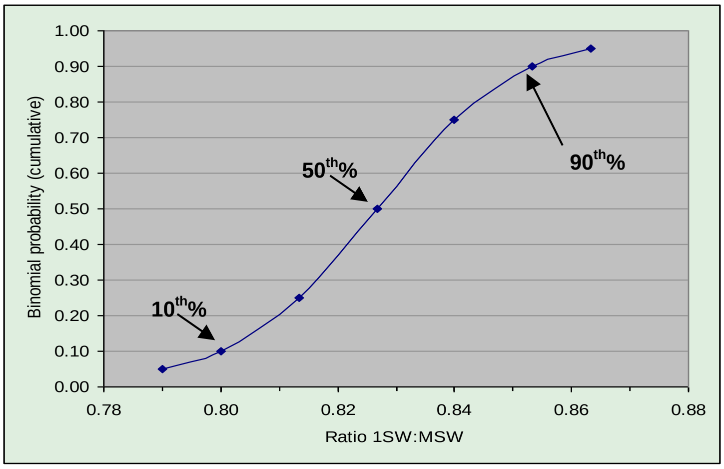

Figure V-4. Cumulative Binomial frequency distribution of the ratio of 1SW salmon in a river based upon the count of fish below 4kg and total number of recorded as caught in a river in catch statistics. MSW ratios are the inverse, hence 0.83 1SW: 0.17 MSW. 10^{th}, 50^{th} and 90^{th} percentiles indicated.

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).

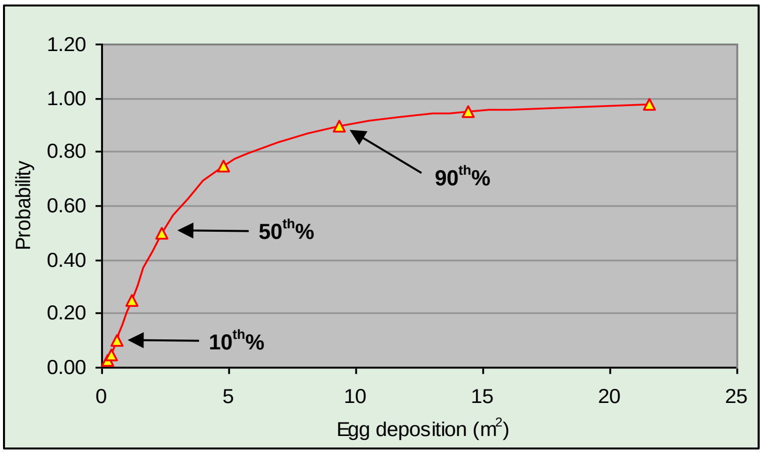

Figure V-5. Cumulative frequency egg deposition rate from BHSRA. 10th, 50th and 90th percentiles indicated.

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 2014

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:

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

where:

$Z_1, Z_2,\ldots Z_M$ = are outcomes in M stocks
N = number of fish in total
$p_1, p_2,\ldots, p_M$ = proportion female in rivers 1, 2, …, M

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

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

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

1. A number (j) is drawn from a random uniform distribution between 0 and 1.
2. If j <= p (proportion female in the stock), then that fish is considered a female and the female counter for that fish is set at 1 ($sex_f = 1$). If j > p, then the fish is considered male and the counter is set to 0 ($sex_f = 0$).
3. Repeat steps 1 and 2 a total of N times (N = number of fish released to the river) using independent random uniform numbers.
4. The total number of females released to the river from step 3 is the sum of sex_f for the N random number assignments.
5. If Σsex_f from step 4 >= S_{optf} , then the spawner requirement has been met (*i.e.* $SpawnerMet_i = 1$, for i = 1 to M simulations).
6. 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 2014 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 (2009-2010)**	0.05	0.01	0.12	0.12	0.06	0.27
Waterford	**Nore (2011-2013)**	0.15	0.7	0.35	0.12	0.06	0.27
Waterford	**Siur, Clodiagh,Lingaun & Blackwater(2009-2010)**	0.05	0.01	0.12	0.12	0.06	0.27
Waterford	**Siur, Clodiagh,Lingaun & Blackwater(2011-2013)**	0.15	0.7	0.35	0.12	0.06	0.27
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**	**0.03**	0.01	**0.05**			
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	0.10			
Kerry	**Roughty**	0.10	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
Kerry	**Emlagh**	0.05	0.01	0.12			
Kerry	**Owenascaul**	0.05	0.01	0.12			

		1SW Exploitation rates			MSW Exploitation rates		
District	**River**	**Likely**	**Minimum**	**Maximum**	**Likely**	**Minimum**	**Maximum**
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**	0.10	0.05	0.12			
Ballinakill	**Owenwee (Belclare)**	0.05	0.01	0.12			
Bangor	**Newport R. (Lough Beltra)**	0.10	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	0.10	0.50			
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**	**0.09**	**0.08**	**0.10**			
Ballyshannon	**Glen & Owenwee (Yellow)**	0.15	0.07	0.35			
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			

		1SW Exploitation rates			MSW Exploitation rates		
District	**River**	**Likely**	**Minimum**	**Maximum**	**Likely**	**Minimum**	**Maximum**
Letterkenny	**Gweedore (Crolly R.)**	0.05	0.01	0.12			
Letterkenny	**Clady**	**0.03**	0.01	**0.05**			
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			

Following review exploitation rates in bold were updated in 2013 for the 2014 assessment:

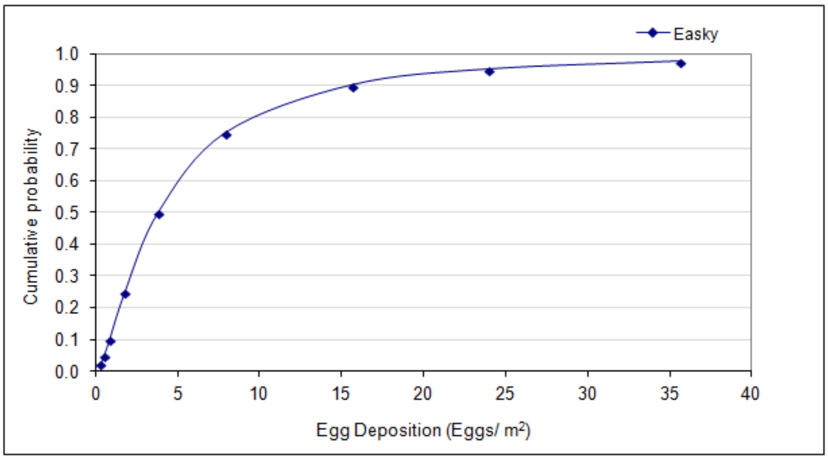
- Cork Owenacurra: most likely and maximum decreased from 0.05 and 0.12 respectively.
- Ballyshannon Bungosteen: most likely, minimum and maximum increased from 0.05, 0.01 and 0.12 respectively.
- Letterkenny Clady: most likely and minimum decreased from 0.05 and 0.12 respectively.

Appendix VII. Worked assessment examples

Easky (Ballina):

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 at maximum sustainable yield (MSY) for each river, based upon latitude and wetted area (fluvial accessible area), transported from the MSY point of Ricker stock/recruitment analysis of index rivers. This is equivalent to the conservation limit (CL) in number of eggs per m^2.

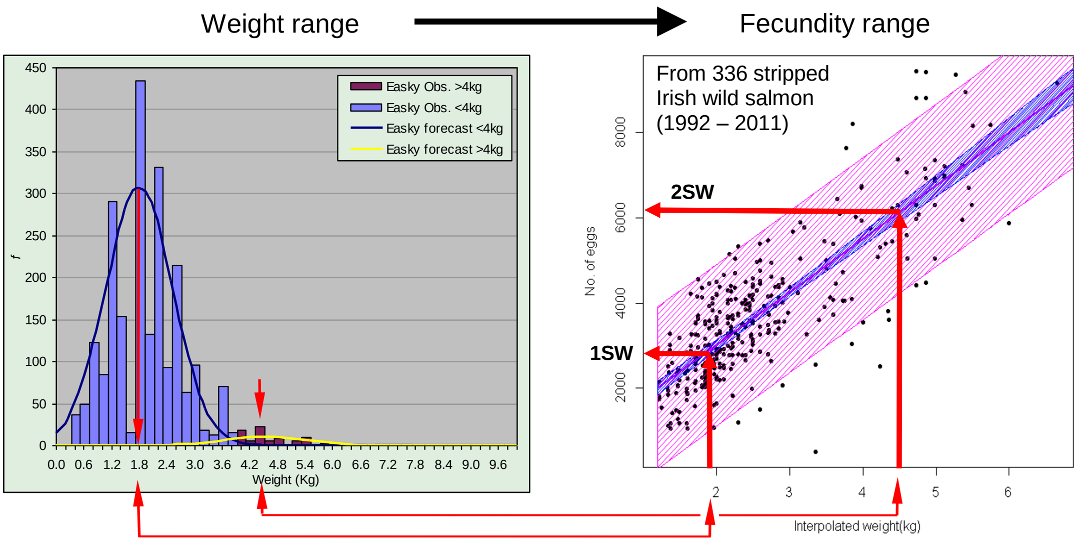


Egg deposition rate /m^2 frequency distribution for the river Easky.

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

Variable	Value
Wetted area (ha)	53.90
Fluvial accessible area (ha)	46.56
Latitude (Deg N)	54.17
Median (50th percentile) required egg deposition (eggs/m^2)	3.8

The ratio of 1SW:2SW and fecundities of salmon in the river (as eggs per 1SW and 2SW female fish) are calculated from the weight frequency distribution of fish caught in the river (between 2006 and 2011) and a relationship between weight and fecundity developed from wild stripped salmon:



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

Proportion 1SW: 2SW

Median	10th	90th
0.827	0.825	0.828
0.173	0.172	0.175

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

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

The conservation limit (CL) in number of eggs per m^2 is converted into numbers of 1SW, 2SW and total number of salmon, and variability, for the whole river following Equation 1 in a Monte Carlo simulation of 75,000 iterations. The conversion from eggs to fish incorporates: the egg deposition rates at MSY (with variability); the proportion of the stock that are age 1SW (with variability); the proportion of the stock that are age 2SW (with variability); the proportion of each age group that are female; the fecundity of each age group (with variability).

Variability around estimates are incorporated as the 10th and 90th percentiles of the observed ranges, set as minimums and maximums in triangular distributions.

CL in No. of Fish (± 90th%) =

MSY (No. of Eggs/m^2) ±90th% /

(Sea-Age $Prop_{1SW}$ ±90th % * Female $Prop_{1SW}$ * $Fecundity_{1SW}$ ±90th %

\+ Sea-Age $Prop_{MSW}$ ± 90th % * Female $Prop_{MSW}$ * $Fecundity_{MSW}$ ±90th%)

* River wetted area (m^2)

Equation 1.

Conservation limits of 1SW, 2SW and total salmon

Sea age	1SW	2SW	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.

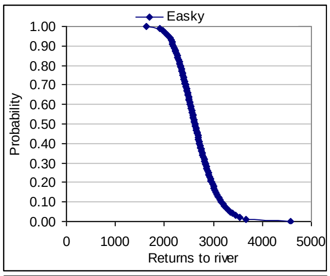
The CL used for Irish rivers are Limit Reference points i.e. stocks should not be allowed to fall below this limit but should be maintained above the limit with a high probability. In the assessment of international salmon fishing quotas, ICES recommends catch options which allow at least a 75% chance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

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

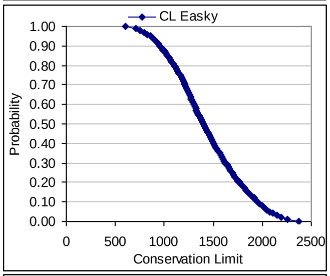
The catch option which provides a 75% chance that the CL will be attained is advised to IFI by the SSC.

Risk plots

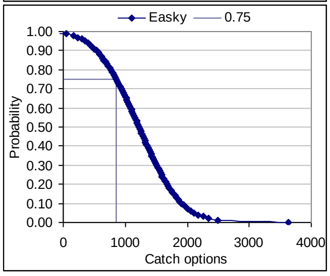
Predicted recruits	Easky
Percentiles	
100%	1622
90%	2188
75%	2380
50%	2625
25%	2896
10%	3164
0%	4576



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



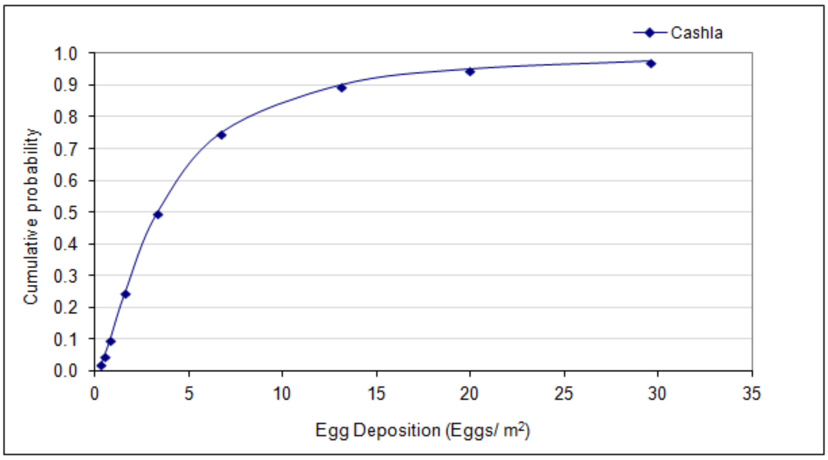
Risk plot for Catch Advice

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):

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 at maximum sustainable yield (MSY) for each river, based upon latitude and wetted area (fluvial accessible area), transported from the MSY point of Ricker stock/recruitment analysis of index rivers. This is equivalent to the conservation limit (CL) in number of eggs per m^2.

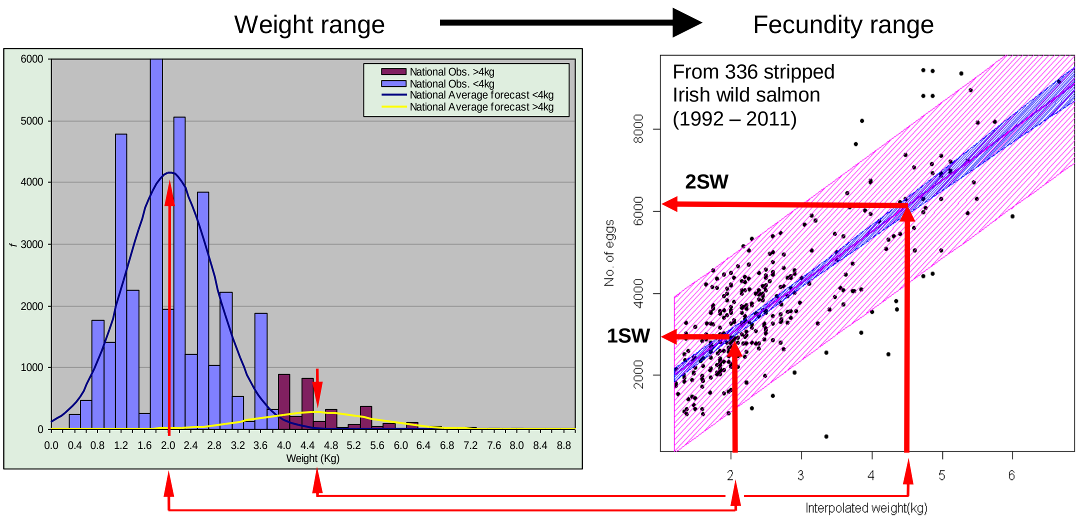


Egg deposition rate /m^2 frequency distribution for the river Cashla.

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

Variable	Value
Wetted area (ha)	23.96
Fluvial accessible area (ha)	19.21
Latitude (Deg N)	52.34
Median (50th percentile) required egg deposition (eggs/m^2)	3.32

The National average ratio of 1SW:2SW and fecundities of salmon (as eggs per 1SW and 2SW female fish) are calculated from the weight frequency distribution of fish caught (between 2006 and 2011) and a relationship between weight and fecundity developed from wild stripped salmon:



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

Median weights of 1SW and 2SW salmon (national average) and 10^{th} and 90^{th} percentiles.

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

Median fecundities of 1SW and 2SW salmon (national average) and 10^{th} and 90^{th} percentiles

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

Proportion 1SW: 2SW (national average)

Median	10^{th}	90^{th}
0.825	0.827	0.828
0.175	0.172	0.173

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

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

The conservation limit (CL) in number of eggs per m^2 is converted into numbers of 1SW, 2SW and total number of salmon, and variability, for the whole river following Equation 1 in a Monte Carlo simulation of 75,000 iterations. The conversion from eggs to fish incorporates: the egg deposition rates at MSY (with variability); the proportion of the stock that are age 1SW (with variability); the proportion of the stock that are age 2SW (with variability); the proportion of each age group that are female; the fecundity of each age group (with variability).

Variability around estimates are incorporated as the 10^{th} and 90^{th} percentiles of the observed ranges, set as minimums and maximums in triangular distributions.

CL in No. of Fish (± 90^{th}%) =

MSY (No. of Eggs/m^2) ±90th% /

(Sea-Age $Prop_{1SW}$ ±90^{th} % * Female $Prop_{1SW}$ * $Fecundity_{1SW}$ ±90^{th} %

\+ Sea-Age $Prop_{MSW}$ ± 90^{th} % * Female $Prop_{MSW}$ * $Fecundity_{MSW}$ ±90^{th}%)

* River wetted area (m^2)

Equation 1.

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

Sea age	1SW	2SW	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.

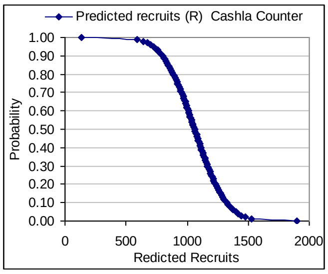
The CL used for Irish rivers are Limit Reference points i.e. stocks should not be allowed to fall below this limit but should be maintained above the limit with a high probability. In the assessment of international salmon fishing quotas, ICES recommends catch options which allow at least a 75% chance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

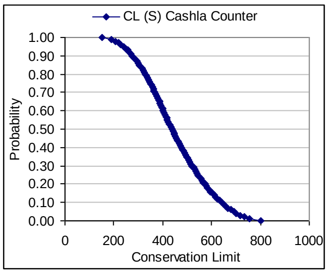
The catch option which provides a 75% chance that the CL will be attained is advised to IFI by the SSC.

Risk plots

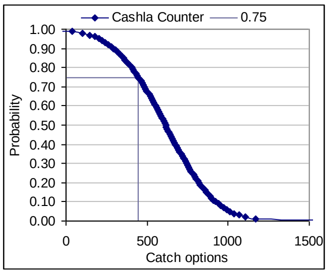
Predicted recruits Percentiles	Cashla Counter
100%	139
90%	798
75%	924
50%	1060
25%	1199
10%	1323
0%	1900



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



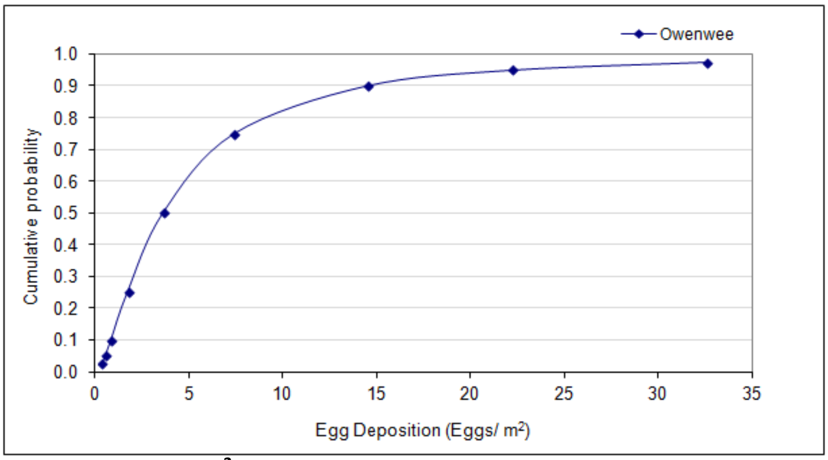
Risk plot for Catch Advice

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)

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 at maximum sustainable yield (MSY) for each river, based upon latitude and wetted area (fluvial accessible area), transported from the MSY point of Ricker stock/recruitment analysis of index rivers. This is equivalent to the conservation limit (CL) in number of eggs per m^2.

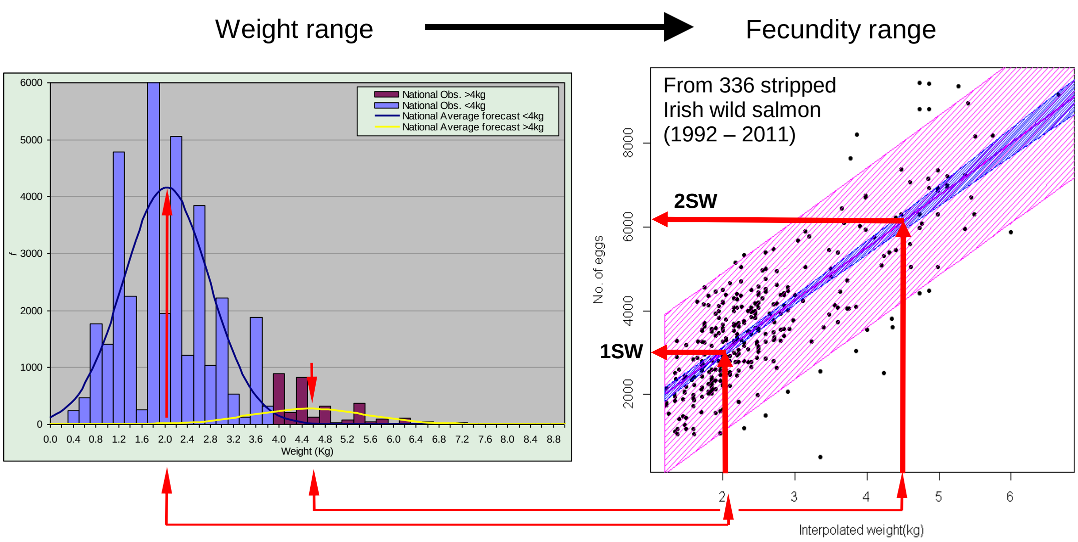


Egg deposition rate /m^2 frequency distribution for the river Owenwee (Belclare)

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

Variable	Value
Wetted area (ha)	17.81
Fluvial accessible area (ha)	14.34
Latitude (Deg N)	53.75
Median (50th percentile) required egg deposition (eggs/m^2)	3.6

The National average ratio of 1SW:2SW and fecundities of salmon (as eggs per 1SW and 2SW female fish) are calculated from the weight frequency distribution of fish caught (between 2006 and 2011) and a relationship between weight and fecundity developed from wild stripped salmon:



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

Median weights of 1SW and 2SW salmon (national average) and 10^{th} and 90^{th} percentiles.

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

Median fecundities of 1SW and 2SW salmon (national average) and 10^{th} and 90^{th} percentiles

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

Proportion 1SW: 2SW (national average)

Median	10^{th}	90^{th}
0.825	0.827	0.828
0.175	0.172	0.173

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

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

The conservation limit (CL) in number of eggs per m^2 is converted into numbers of 1SW, 2SW and total number of salmon, and variability, for the whole river following Equation 1 in a Monte Carlo simulation of 75,000 iterations. The conversion from eggs to fish incorporates: the egg deposition rates at MSY (with variability); the proportion of the stock that are age 1SW (with variability); the proportion of the stock that are age 2SW (with variability); the proportion of each age group that are female; the fecundity of each age group (with variability).

Variability around estimates are incorporated as the 10^{th} and 90^{th} percentiles of the observed ranges, set as minimums and maximums in triangular distributions.

CL in No. of Fish (± 90^{th}%) =

MSY (No. of Eggs/m^2) ±90th% /

(Sea-Age $Prop_{1SW}$ ±90^{th} % * Female $Prop_{1SW}$ * $Fecundity_{1SW}$ ±90^{th} %

\+ Sea-Age $Prop_{MSW}$ ± 90^{th} % * Female $Prop_{MSW}$ * $Fecundity_{MSW}$ ±90^{th}%)

* River wetted area (m^2)

Equation 1.

Conservation limits of 1SW, 2SW and total salmon

Sea Age	1SW	2SW	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.

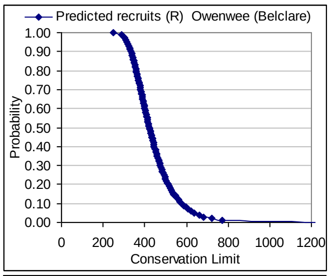
The CL used for Irish rivers are Limit Reference points i.e. stocks should not be allowed to fall below this limit but should be maintained above the limit with a high probability. In the assessment of international salmon fishing quotas, ICES recommends catch options which allow at least a 75% chance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

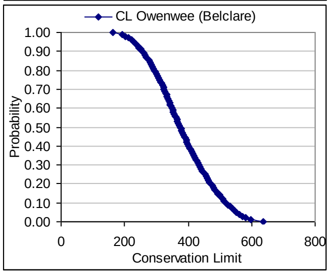
The catch option which provides a 75% chance that the CL will be attained is advised to IFI by the SSC.

Risk plots

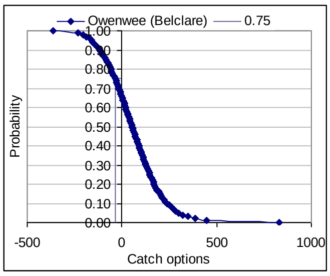
Predicted recruits	Owenwee (Belclare)
Percentiles	
100%	249
90%	333
75%	369
50%	422
25%	492
10%	576
0%	1231



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



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



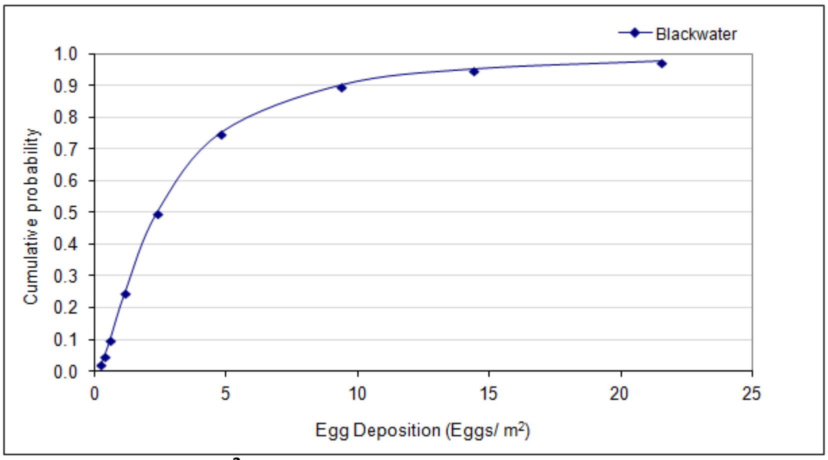
Risk plot for Catch Advice

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)

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 at maximum sustainable yield (MSY) for each river, based upon latitude and wetted area (fluvial accessible area), transported from the MSY point of Ricker stock/recruitment analysis of index rivers. This is equivalent to the conservation limit (CL) in number of eggs per m^2.

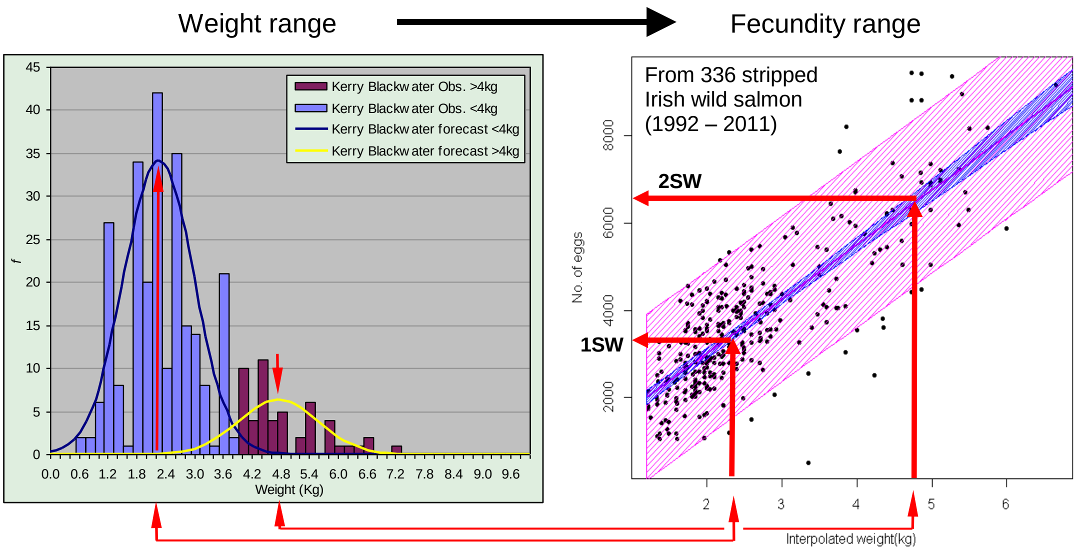


Egg deposition rate /m^2 frequency distribution for the river Blackwater (Kerry)

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

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

The ratio of 1SW:2SW and fecundities of salmon in the river (as eggs per 1SW and 2SW female fish) are calculated from the weight frequency distribution of fish caught in the river (between 2006 and 2011) and a relationship between weight and fecundity developed from wild stripped salmon:



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

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

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

The conservation limit (CL) in number of eggs per m^2 is converted into numbers of 1SW, 2SW and total number of salmon, and variability, for the whole river following Equation 1 in a Monte Carlo simulation of 75,000 iterations. The conversion from eggs to fish incorporates: the egg deposition rates at MSY (with variability); the proportion of the stock that are age 1SW (with variability); the proportion of the stock that are age 2SW (with variability); the proportion of each age group that are female; the fecundity of each age group (with variability).

Variability around estimates are incorporated as the 10th and 90th percentiles of the observed ranges, set as minimums and maximums in triangular distributions.

CL in No. of Fish (± 90th%) =

MSY (No. of Eggs/m^2) ±90th% /

(Sea-Age Prop$_{1SW}$ ±90th % * Female Prop$_{1SW}$ * Fecundity$_{1SW}$ ±90th %

\+ Sea-Age Prop$_{MSW}$ ± 90th % * Female Prop$_{MSW}$ * Fecundity$_{MSW}$ ±90th%)

* River wetted area (m^2)

Equation 1.

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.

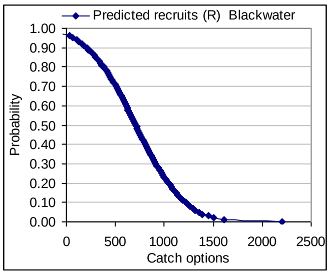
The CL used for Irish rivers are Limit Reference points i.e. stocks should not be allowed to fall below this limit but should be maintained above the limit with a high probability. In the assessment of international salmon fishing quotas, ICES recommends catch options which allow at least a 75% chance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

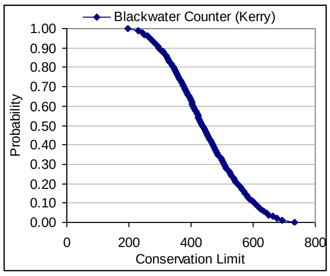
The catch option which provides a 75% chance that the CL will be attained is advised to IFI by the SSC.

Risk plots

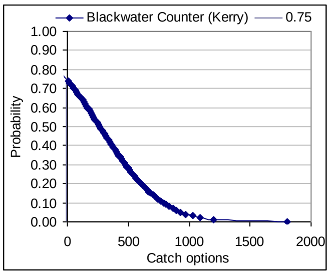
Predicted recruits Percentiles	Blackwater Counter
100%	-701
90%	212
75%	452
50%	712
25%	979
10%	1219
0%	2211



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



Surplus/Deficit Percentiles	Blackwater Counter
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 programme in 2013.

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 2013 Catchment Wide electro-fishing was completed in 34 catchments to assess abundance and distribution of salmon fry (Figure VIII-1). A total of 787 sites were visited. In the first seven years of the programme (2007-2013) 274 catchment surveys in 127 catchments have been undertaken comprising 5745 site surveys.

7 rivers predicted not to have a salmon surplus in 2013, that had an average salmon fry index ≥ 17 over the 2009-2013 period were recommended for opening on a catch & release basis in 2013, this would provide rod catch data for estimation of stock size. The rivers were Owenagarney (index =16.97 Salfry/5min), Bungosteen, Carrownisky, Owenascaul, Owenwee (Yellow), Milltown (Kerry), Cloonee. (Table VIII-1).

For the 34 salmon catchments surveyed in 2013, the salmon fry abundance for **this year alone** ranged from an average of zero fry on the Erne, to a catchment average of 33.06 salmon fry on the Cloonee. The Bungosteen, Swilly, Carrownisky, Leannan, Owenwee (Yellow), Castletown, Feale, Owenmore, Erriff and Cloonee all recorded an annual catchment wide average of >17 fry. Salmon fry densities of over 15 Salfry/min were also recorded on the Clooghnamore, Owenascaul, Owenagarney and Bungosteen catchments.

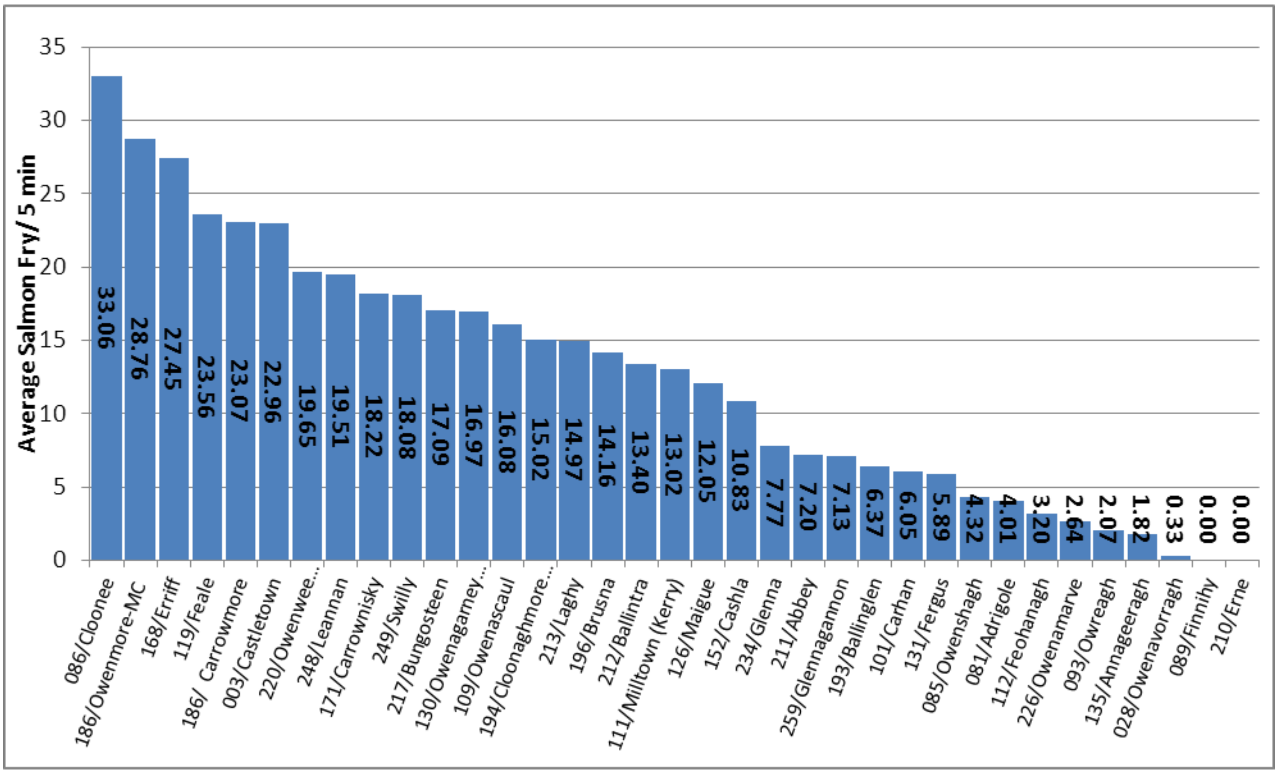


Figure VII -1. Results of catchment wide electro-fishing programme in 2013.

IFI Code/River	2009	2010	2011	2012	2013	Average
086/Cloonee				16.18	33.06	24.62
109/Owenascaul	22.27				16.08	19.18
111/Milltown (Kerry)		26.44			13.02	19.73
130/Owenagarney (Ratty)					16.97	16.97
171/Carrownisky				20.60	18.22	19.41
217/Bungosteen			25.12		17.09	21.11
220/Owenwee (Yellow R)	14.81			20.31	19.65	18.26

Table VIII- 1. Summary of Catchments predicted not to have a salmon surplus in 2013 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.