IP(08)13

Fisheries Management Focus Area Report

European Union - Ireland

Focus Area Report on Management of Salmon Fisheries

IRELAND

Background
The NASCO Council requested that fisheries management focus area reports should be completed to provide an in-depth assessment of:

- the measures already in place that address the NASCO agreements relating to fisheries management;
- further actions proposed within their Implementation Plan to meet these agreements;
- progress with implementing these actions.

The elements listed in sections I to X below are as per the Council Decision on what should be included in the Focus Area Report (CNL(07)47)).

SECTION 1
A brief description of the fisheries, including an overview of the stocks exploited, gear types, fishery location, magnitude of the fishery, current management restrictions and others planned.

Note on 1: Sufficient information is required to explain the full nature of the fisheries being managed, the management systems in place (including the control and reporting systems) and any planned actions to review or modify these. It should not be necessary to break this down to a highly detailed level. Some of this information could be provided in tabular form.

Details of the fisheries (rivers name) stocks (1 and 2SW separately), locations (fishery districts), magnitude of the fishery (surplus or catch option providing a 75% chance that CL will be met) with restrictions relating to catch and release are shown in Tables 1 through 4. Supplementary information is provided below along with a summary of the catch advice for 2008.

- There are 53 rivers which will have an identifiable surplus over the Conservation Limit in 2008 and a harvest fishery can proceed in 2008.
- In addition, there are 13 rivers with 2 Sea Winter or "spring salmon" stocks where there will be a surplus over the 2SW Conservation Limit and therefore a harvest of spring fish is possible.
- There are 25 rivers which do not have an identifiable surplus over the Conservation Limit. In this instance, there are no harvest options available which will allow a 75% chance that the Conservation Limit will be met and no harvest fisheries should take place on these rivers.
- In addition there are three 2SW or "spring salmon" stocks which are also failing to meet Conservation Limits.
- In addition to the main fisheries above there are approximately 70 small rivers where the average rod catch has been less than 10 salmon annually since 2001. The rod catch from these rivers combined is less than 0.5% of the current estimated national rod catch. While these are not significant fisheries they are important as spawning populations in there own right and for proper maintenance of biodiversity as required under the EU Habitats directive. The Standing Scientific Committee advised that no harvest fisheries should take place in these rivers until such time as additional information becomes available to assess the status of these stocks relative to their Conservation Limit

Current management measures for conservation and protection of salmon
The Minister for Communications, Energy and Natural Resources has a wide range of powers for the conservation, protection, management and exploitation of salmon and other inland fish stocks under the Fisheries Acts 1959-2003. A brief outline of some of the Minister's powers are set out below. The measures adopted by the Minister, to date, for the management of the salmon fishery for 2008 are set out at Appendix 1.

Power to make bye-laws for the government, management, protection and improvement of fisheries.
Section 9 of the Fisheries (Consolidation) Act 1959, as amended by section 3 of the Fisheries (Amendment) Act 1962, and section 33 of the Fisheries (Amendment) Act 1962, empowers the Minister to make such bye-laws as are in his opinion expedient for the more effectual government, management, protection and improvement of the fisheries of the State. Such bye-laws may, inter alia, specify seasons for the taking of fish, the time, place, and manner where fishing may take place, the type of nets that may be used, and any other matter or thing relating in any manner to the protection of the fisheries as well as bye-laws of an emergency character.

Further measures
A wide range of measures have already been adopted for the 2008 fishing season. Any additional measures, for example, closing fisheries, changing seasons, prohibiting use of certain types of bait in individual rivers, that may be required will be taken in line with management and scientific advice as the 2008 fishery season progresses.

Provisions in relation to salmon fishing licences
Fishing for salmon, whether for commercial or recreational purposes, is prohibited without a licence. (The Fisheries Boards' powers in this regard are set out in Section 67 of the Fisheries (Consolidation) Act 1959, as amended.)

Powers in relation to fishing for salmon at sea and landing and possession of salmon caught at sea.
Section 29 of the Fisheries (Amendment) Act 1962, as amended by paragraph 4 of Part II of the Fourth Schedule to the Fisheries Act 1980, provides that the Minister may by order prohibit, restrict or otherwise control fishing for salmon at sea and prohibit, restrict or otherwise control the having in possession of salmon caught or landed contrary to an order under this section. An order under this section may prescribe the classes of persons to whom fishing licences may be issued, the classes of boats and the kind of fishing engines in respect of which licences may be issued, the maximum number of such licences which may be issued in any year by the regional board the time and manner of application for such licences, and the manner in which such licences shall be allocated.

Conservation of fish stocks and rational exploitation of fisheries.
Section 35 of the Fisheries (Amendment) Act 1962 provides that the Minister may, having regard to any international agreement to which the State is a party, by order prescribe and adopt such measures for the conservation of fish stocks and rational exploitation of fisheries as the Minister thinks proper.

Establishment of the National Salmon Commission (NSC) and the Standing Scientific Committee (SSC)
The NSC and the SSC were established under sections 55A-55C of the Fisheries (Consolidation) Act 1959 (as amended by section 22(1) of the Fisheries (Amendment) Act 1999). Section 55D

empowered the Minister to adopt Terms of Reference for both the NSC and the SSC. In 2006, the Minister adopted the Terms of Reference for the NSC and the SSC in consultation with DG Environment of the European Commission of the EU. They are the National Salmon Commission and Standing Scientific Committee (Terms of Reference and Procedure) Order 2006 (S.I. No. 483 of 2006) A copy of the Order is attached at Appendix 2.

Management of Wild Salmon and Sea Trout
Part 3 (section 24) of the Fisheries (Amendment) Act 1999, as amended by section 3 of the Fisheries (Amendment) Act 2000, provides that the Minister may, after consultation with the National Salmon Commission, make regulations to provide for a scheme for the management, development and conservation of stocks of wild salmon and sea trout (Wild Salmon and Sea Trout Tagging Scheme) and in particular to provide for the gathering of information by the tagging of such fish. Total Allowable Catches (TACs) for each river are specified in these Regulations together with a mechanism for the allocation of the TACs between commercial and recreational anglers for each river that has a harvestable surplus. Where rivers are below the CL the TAC for these rivers is set at zero.

SECTION 11
Identification of exploited stocks and the reference points (conservation limit and/or management target) or alternative measures used to define adequate abundance of the stock.

Stocks (by river and age group where available) which will be exploited in 2008 are shown in detail in Tables 1 and 2. Stocks where catch and release will be permissible are shown in Tables 3 and 4. Rivers and stocks which will be closed to fishing are shown in Table 5. In all tables, conservation limits (i.e. the stock size which produces maximum sustainable yield S_{msy}), status of stocks and fishery type if applicable are shown.

SECTION 111
The status of the stock relative to the abundance criteria specified.

Note on 2 and 3: The use of reference points or alternative measures is a key element of the NASCO Agreements on managing fisheries. Information is therefore required on the methods being used or proposed, their state of development or implementation, and any planned actions to further develop or modify these. Information on specific reference points and the current status of stocks could be provided in tabular form.

A measure of the attainment of these conservation limits on average in recent years is shown in Tables 1 through 5.

Establishment of Conservation Limits for all Irish salmon rivers.
The principal development of these statistical techniques and subsequent model occurred within the context of the EU funded concerted action SALMODEL (a co-ordinated approach to the development of a scientific basis for management of wild salmon in the North-East Atlantic).

The Bayesian analysis of this hierarchical model has been developed from a set of 13 stock and recruitment data series from monitored salmon rivers located in the Northeast Atlantic. The model yields a set of predicted stock and recruitment parameters for new rivers, provided information is available on the size of the river (in this case usable habitat or wetted area is used) and on the rivers

latitude. Details of the model specification and its Bayesian treatment are given in Prevost et al, (2003) and their application to Irish rivers in Ó Maoileidigh *et al.*, 2004. The wetted area is computed from statistically combined parameters: the length of upstream river, upstream catchment area, stream order, and local gradient interpolated from aerial photography within a GIS platform (McGinnity *et al.*, 2003). The latitude value used is the river catchment area mid-point. A description of the Bayesian Hierarchical Stock and Recruitment Analysis is given in Appendix 3 attached.

SECTION IV

The extent to which the stock is meeting other diversity criteria (e.g. age groups, size groups, populations), if such information is available.

Note on 4: It would be useful to provide a general description of those diversity criteria that have been evaluated, their current status and any proposed actions to extend or modify the evaluation of stock diversity. (The way that this information is used in making management decisions is considered below).

A description of the assessment methodology is given in Appendix 4. Where possible an assessment is made for each river individually and in many instances for 1SW and 2SW stocks separately based on a direct count from a counter or experimental trap, or by extrapolation of rod catches from a range of exploitation rates. There are however approximately 69 or so small rivers with no counter or an average rod catch of less than 10 salmon per annum. It should be noted that the total rod catch associated with these smaller rivers annually is between 79 and 124 salmon, a very small fraction of the estimated total rod catch reported (e.g. estimated rod catch in 2005 was 22,361 salmon). Currently in the absence of any specific information on spawning stocks it is assumed that these rivers were only meeting 33% of their Conservation Limits. A tentative indication of the status of these stocks in the absence of the mixed stock fishery is shown. Given the tenuous state of many of the smaller rivers, general advice is that there should be no harvest fishery until other information is made available to indicate that these rivers are exceeding their Conservation Limits.

SECTION V

For mixed stock fisheries, the information in numbers 3 and 4 above should be presented for each contributing stock.

Note on 5: It has been noted that mixed stock fisheries may create particular problems for fisheries management and the report should therefore describe those mixed stock fisheries that still operate within the jurisdiction, the overall management approach to these fisheries and future actions that are planned. It should be made clear what criteria are used to define mixed stock fisheries.

Defining Mixed Stock Fisheries and Catch Advice for Irish Salmon Fisheries

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. While there is no agreed definition of mixed stock fisheries for salmon, two recent definitions 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 within 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 2007 and essentially closed the Irish mixed stock salmon fishery (principally drift nets and some coastal draft nets), thus implementing NASCO and ICES recommendations and complying with the Habitats Directive. (See details of legislation adopted at Appendix 1) 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 salmon fishermen.

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.

SECTION VI

The management actions that will be employed to control harvest, including measures that will be used to address any failure or trend in abundance or diversity.

Note on 6: The Review Group will need sufficient information to be able to evaluate the powers for regulating fishing activity and/or harvest that are available or planned within the jurisdiction, any additional measures that may be used to protect and restore stocks, and any further actions that are planned (including measures to further reduce unreported catches).

Details of powers to take any measures necessary for the conservation, protection and management of salmon stocks together with the measures adopted for the 2008 fishery season to date are set out under point 1 above and Appendix 1 respectively. Any additional measures that may be required, such as, for example, the closure of a fishery, or placing a river on catch and release only, can be taken under existing legislation. The Department of Communications, Energy and Natural Resources is advised of any measures that may be

required for the management of salmon stocks by the 7 Regional Fisheries Boards. Prior to the adoption of any such measure the Department obtains advice from scientific advisers.

Any additional measures that might be taken to protect or restore stocks depend, in the first instance on scientific advice, provided in accordance with the terms of reference of the Standing Scientific Committee or advice from the Regional Fisheries Boards. See details of the Terms of Reference for the SSC at Appendix 2. Only measures that comply with the requirements of NASCO, ICES and EU environmental law, such as the Habitats and Water Framework Directives, are taken.

The Department is advised that the commercial sector makes complete returns of catches. Recreational anglers' catch returns are in the region of 68% and scientists estimate the full catch by recreational fishermen. The adjustment follows Small (1991) It is expected that there will be further improvements in the rate of return of logbooks by recreational fishermen for 2007. In these circumstances it is not considered necessary to take any further actions in relation to unreported catches by anglers.

SECTION VII

The extent to which the following issues are taken into account:

a. uncertainty in the assessments;
b. abundance of the stock/diversity of the stock;
c. selectivity of the fisheries;
d. any non-fishery factors affecting the stock;
e. other fisheries exploiting the stock.

Uncertainty relating to a, b and c above are considered. For the provision of catch advice, the variation in the average count (or catch and exploitation rates) which are based on the most recent 5 years is taken into account in a risk analysis using a Monte Carlo simulation to generate the catch option providing a 75% chance that the CL will be met. As fishing is restricted to estuaries and rivers and only on stocks which are meeting conservation limits, there are two estuaries presently where the analysis is extended to generate the catch option providing a 75% chance that each contributing river (in this case there are two rivers entering the Killary Harbour (Erriff and Delphi) and two rivers entering the common estuary of the Owenmore and Owenduff) rivers will meet their respective conservation limits. Details of the risk assessment methodology are given in *Crozier et al 2004,* SALMODEL).

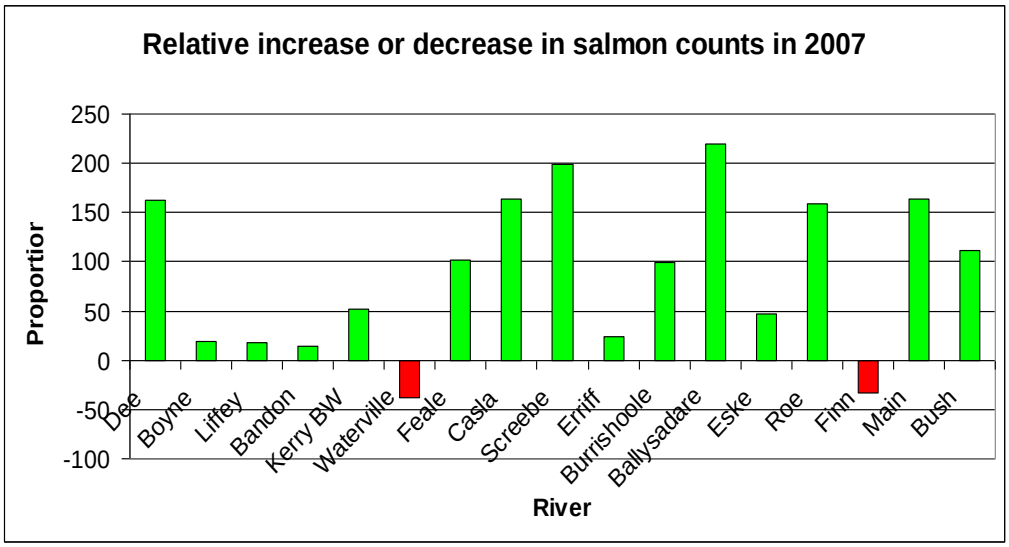
For d above, uncertainty in the size of the rivers, the latitude and variations in stock and recruitment parameters for rivers where stock and recruitment parameters have been transported for setting conservation limits has also been taken into account within the Bayesian Hierarchical Stock and Recruitment model. Other factors affecting salmon stocks in Ireland are outlined generally in Appendix 5 along with general catch advice relating to these factors.

For e above, there are not thought to be any significant non-directed fisheries on wild salmon stocks in Irish waters.

SECTION VIII

The expected extent and timescale of effects.

The extent to which the closure of the Irish mixed stock fishery has affected several specific stocks where counts can be made is shown below. It is clear that the majority of rivers in 2008 showed increased escapement. These increases were only modest in some instances and some of these remain below their conservation limits. Other rivers showed considerable increases which allow them to reach their conservation limits if this was not already the case. Some rivers in the UK (N. Ireland) clearly benefited from the closure of the mixed stock fishery in a similar manner. As 2007 was the first year where the full closure of the mixed stock fishery would have been expected to impact on stocks, the extent of these changes over time will be monitored over the coming years.



SECTION IX

An explanation of how socio-economic factors are applied in the development of fisheries management actions and how this affects the attainment of NASCO's goals.

Note on 7, 8 and 9: These are key elements within the NASCO Decision Structure, so the report will need to explain how they are, or will be, taken into account in the management process within the jurisdiction and any actions that are planned for the future. Under element 8, information is requested on the expected effects of the management actions identified in element 6

Ireland's new management regime is designed for the conservation and protection of salmon stocks in line with NASCO, ICES, and EU requirements. Our system operates in the following way. The Standing Scientific Committee, acting in accordance with its Terms of Reference, reports to both the National Salmon Commission (NSC) and the Minister on the status of salmon stocks. This report identifies the status of salmon stocks on a river by river basis and whether stocks are meeting their Conservation Limits (as defined by NASCO and ICES). The Report also identifies if there is any surplus that may be exploited for harvest on a river by river basis. The NSC and the Regional Fisheries Boards' managers give their advice on the measures they consider should be taken having regard to the report of the SSC.

On the basis of the Report the Minister adopts the Wild Salmon and Sea Trout Tagging Scheme Regulations. These Regulations make provision for the total allowable catch that may be taken on individual rivers as advised by the SSC, and also specify the rivers that have no harvestable surplus. The Regulations contain provisions for the allocation of the available surpluses between the commercial and recreational fishermen for each river. The Regulations also make provision for the protection of Spring salmon and where appropriate specify a quota for Spring salmon on individual rivers.

Other conservation measures are adopted on the basis of the advice of fishery managers, such as Bye-laws allowing catch and release fishing on specified rivers, the type of bait that may be used, open and closed seasons etc. Byelaws are also adopted closing rivers that are below their CL and deemed unsuitable for catch and release. Rivers are only opened for catch and release if they are meeting 65% of their CL. For the 2008 salmon fishing season 21 rivers have been opened on a catch and release basis.

Details of the type of measures adopted are set out at Appendix 1.

The only time that socio-economic factors may be considered in the decision making process is in the allocation of the surplus identified by scientists (i.e., the total allowable catch for each river) between commercial and recreational users. Otherwise the management system is based exclusively on scientific advice provided in accordance with the Terms of Reference of the Standing Scientific Committee which, in turn, are in accordance with NASCO/ICES requirements and the Habitats Directive (as implemented in Ireland).

Following the cessation of the mixed stock fishery, previous trends in relation to the share of the total allowable catch were reversed and the bulk of salmon that was harvested in 2007 was taken by the recreational sector. The Minister for Communications, Energy and Natural Resources has directed that there should be a re-balancing of the allocation of salmon quotas between competing interests. A public consultation on possible measures to give effect to the Minister's direction will be held later this year. Socio-economic factors will be among the range of aspects that will be considered in delivering on the direction.

SECTION X
Programs that will be used to monitor the effect of the management measures and identify information deficiencies and timeframe for resolution.

Note on 10: The NASCO Agreement on the Precautionary Approach calls for the assessment of the effectiveness of management actions in all salmon fisheries. The report should therefore provide an overview of how this is or will be achieved.

The scientific process leading to the assessment of stocks and the provision of catch advice is outlined in 3. This process will be maintained for the foreseeable future. A summary of this process is provided in Figure 1 below.

Figure 1 The Scientific Process for 2008 catch advice used in Ireland

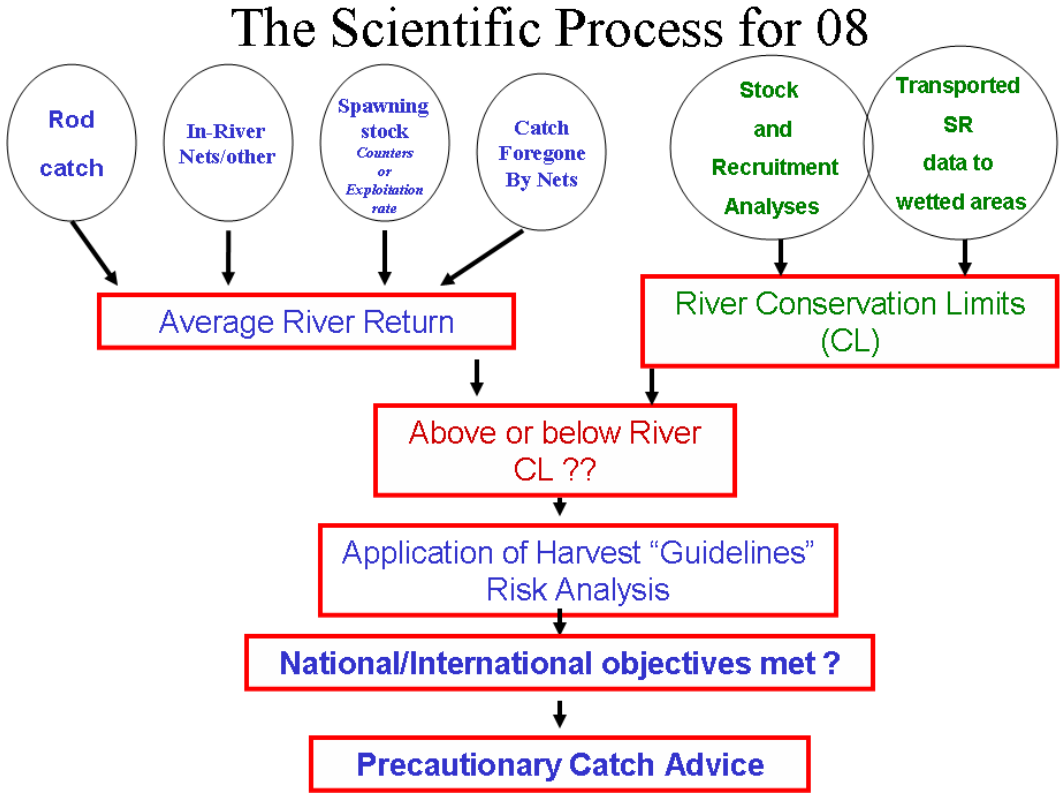


Table 1 Information on 1SW salmon rivers open for harvest in 2008

Location i.e. District	Stock Exploited i.e. River	Magnitude of the Stock i.e. Estimated 2008 Returns	Reference Point i.e. CL SMSY	Magnitude of the Fishery i.e. Estimated Surplus 2008	Gear Types
Dundalk	Castletown	239	197	42	Rod
Dundalk	Fane	757	543	214	Rod
Wexford	Slaney (counter)	1,319	829	490	Rod
Lismore	Blackwater (counter)	18,785	11,503	7,283	Rod
Cork	Owennacurra	607	179	428	Rod
Cork	Lower Lee (Cork)	3,393	1,184	2,208	Rod and draft
Cork	Bandon (counter)	2,751	1,556	1,196	Rod and draft
Cork	Argideen	484	391	93	Rod
Cork	Ilen	1,395	1,014	381	Rod and draft
Cork	Mealagh	284	88	196	Rod and draft
Cork	Owvane	467	401	66	Rod
Cork	Coomhola	480	306	174	Rod and draft
Cork	Glengarriff	304	229	75	Rod
Cork	Adrigole	192	169	24	Rod
Kerry	Kealincha	143	124	19	Rod
Kerry	Lough Fada	105	91	14	Rod
Kerry	Sheen	757	600	157	Rod
Kerry	Roughty	1,917	1,245	672	Rod and draft
Kerry	Blackwater (counter)	1,178	1,159	621	Rod and draft
Kerry	Sneem	965	371	594	Rod and draft
Kerry	Waterville (counter)	2,029	279	558	Rod and draft
Kerry	Caragh	1,300	297	1,034	Rod and draft
Kerry	Laune	8,266	1,840	6,426	Rod and draft
Kerry	Owenmore	211	102	108	Rod and draft
Shannon	Feale (counter)	8,887	1,641	3,283	Rod and draft
Shannon	Mulkear (counter)	8,411	6,284	2,127	Rod
Galway	Corrib (counter)	9,905	7,589	2,315	Rod
Connemara	Cashla (counter)	1,335	349	300	Rod
Connemara	Screebe (trap)	370	155	215	Rod
Connemara	Ballynahinch (counter)	2,516	1,088	1,427	Rod
Ballinakill	Owenglin	719	372	347	Rod and draft
Ballinakill	Dawros	1,080	582	498	Rod and draft
Ballinakill	Culfin	239	144	94	Rod
Ballinakill	Erriff (counter)	3,645	1,300	2,346	Rod and draft
Ballinakill	Bundorragha	768	120	360	Rod and draft
Ballinakill	Common Embayment Killary	4,160	1,700	2,460	Rod and draft
Bangor	Newport R. (Lough Beltra)	638	319	319	Rod
Bangor	Srahmore (Trap)	804	615	189	Rod
Bangor	Owenduff (Glenamong)	1,974	537	1,437	Rod and draft
Bangor	Owenmore/Muinhin count	5,048	2,136	2,912	Rod and draft
Ballina	Moy	37,228	15,786	21,442	Rod
Ballina	Easky	2,630	1,297	1,333	Rod
Sligo	Ballysadare (counter)	6,124	5,098	1,027	Rod
Sligo	Garvogue (Bonnet)	1,346	1,048	298	Rod
Sligo	Drumcliff	628	474	154	Rod
Ballyshannon	Duff	1,655	1,182	473	Rod
Ballyshannon	Drowes	4,111	704	3,406	Rod
Ballyshannon	Eany (counter)	3,127	1,740	1,386	Rod and draft
Ballyshannon	Glen	1,274	957	316	Rod
Letterkenny	Owenea	3,506	1,713	1,794	Rod
Letterkenny	1SW Gweebarra	1,193	445	749	Rod and draft
Letterkenny	Gweedore (Crolly R.)	819	325	494	Rod
Letterkenny	Clady	689	515	174	Rod
Letterkenny	Tullaghobegly	347	226	121	Rod
Letterkenny	Crana	1,731	1,119	611	Rod

Table 2 Information on MSW salmon rivers open for harvest in 2008

Location i.e. District	Stock Exploited i.e. River	Magnitude of the Stock i.e. Estimated 2008 Returns	Reference Point i.e. CL S_{MSY}	Magnitude of the Fishery i.e. Estimated Surplus 2008	Gear Types
Lismore	Blackwater (counter)	1,504	1,000	504	Rod
Cork	Bandon (counter)	300	275	25	Rod
Kerry	Waterville (counter)	423	57	114	Rod
Kerry	Caragh	320	234	87	Rod
Kerry	Laune	1,554	715	839	Rod
Shannon	Feale counter	2,002	703	1,298	Rod
Galway	Corrib counter	1,212	843	369	Rod
Ballinakill	Bundorragha (Wild Rod)	188	42	146	Rod
Bangor	Owenduff (Glenamong)	542	389	153	Rod
Bangor	Owenmore/Muinhin (counter)	1,509	275	550	Rod
Ballina	Moy	3,310	1,188	2,122	Rod
Ballyshannon	Drowes	741	302	439	Rod
Letterkenny	Gweebarra	218	118	100	Rod

Table 3 Information on 1SW salmon rivers open for catch and release only in 2008

Location i.e. District	Stock Expoited i.e. River	Reference Point i.e. CL S_{MSY}	Status of Stock i.e. % of CL	Gear Types
Connemara	L.Na Furnace	66	100	Rod
Kerry	Inney	649	99	Rod
Letterkenny	Ray	433	97	Rod
Ballyshannon	Eske (Counter)	823	89	Rod
Letterkenny	Bracky	305	85	Rod
Waterford	Colligan	338	84	Rod
Kerry	Behy	142	83	Rod
Kerry	Ferta	197	83	Rod
Waterford	Nore	11,958	81	Rod
Kerry	Carhan	93	81	Rod
Ballinakill	Carrownisky	365	79	Rod
Waterford	Suir	14,752	79	Rod
Ballyshannon	Owenwee (Yellow R)	184	77	Rod
Ballyshannon	Oily	549	72	Rod
Ballinakill	Owenwee (Belclare)	378	70	Rod
Kerry	Croanshagh	301	70	Rod
Bangor	Glenamoy	630	69	Rod
Sligo	Grange	356	68	Rod
Ballinakill	Bunowen	619	68	Rod
Drogheda	Boyne	13,831	67	Rod
Kerry	Maine	1,487	Electrofishing index 65%	Rod

Table 4 Information on MSW salmon rivers open for catch and release only in 2008

Location i.e. District	Stock Expoited i.e. River	Reference Point i.e. CL S_{MSY}	Status of Stock i.e. % of CL	Gear Types
Sligo	2SW Garvogue (Bonnet)	957	93	Rod
Wexford	2SW Slaney (counter)	1827	74	Rod
Bangor	2SW Newport R. (Lough Beltra)	319	67	Rod

Table 5 Information on salmon rivers closed for fishing in 2008

Location i.e. District	Stock Expoited i.e. River	Reference Point i.e. CL S_{MSY}	Status of Stock i.e. % of CL
Connemara	L.Na Furnace	66	100
Kerry	Inney	649	99
Letterkenny	Ray	433	97
Sligo	2SW Garvogue (Bonnet)	957	93
Ballyshannon	Eske Counter	823	89
Letterkenny	Bracky	305	85
Waterford	Colligan	338	84
Kerry	Behy	142	83
Kerry	Ferta	197	83
Waterford	Nore	11958	81
Kerry	Carhan	93	81
Ballinakill	Carrownisky	365	79
Waterford	Suir	14752	79
Ballyshannon	Owenwee (Yellow R)	184	77
Wexford	2SW Slaney (counter)	1827	74
Ballyshannon	Oily	549	72
Ballinakill	Owenwee (Belclare)	378	70
Kerry	Croanshagh	301	70
Bangor	Glenamoy	630	69
Sligo	Grange	356	68
Ballinakill	Bunowen	619	68
Bangor	2SW Newport R. (Lough Beltra)	319	67
Drogheda	Boyne	13831	67
Kerry	Maine	1487	Electrofishing index
Ballyshannon	Ballintra (Murvagh R).	407	64
Kerry	Owenascaul	193	63
Letterkenny	Owenamarve	160	61
Kerry	Cloonee	75	61
Letterkenny	Lackagh	1083	61
Kerry	Feohanagh	157	61
Kerry	Finnihy	141	61
Kerry	Lee	586	61
Kerry	Owenreagh	106	61
Kerry	Emlaghmore	73	61
Kerry	Cottoners	166	61
Kerry	Milltown	83	61
Kerry	Emlagh	130	61
Galway	Kilcolgan	1682	60
Letterkenny	Swilly	1083	59
Letterkenny	Glenagannon	355	59
Letterkenny	Glenna	207	59
Letterkenny	Mill	272	58
Letterkenny	Owentocker	519	58
Letterkenny	Isle (Burn)	510	58
Letterkenny	Straid	196	58
Letterkenny	Donagh	418	58
Letterkenny	Clonmany	465	58
Letterkenny	Culoort	223	58
Dublin	Vartry	189	58

Table 5 continued Information on salmon rivers closed for fishing in 2008

Location i.e. District	Stock Expoited i.e. River	Reference Point i.e. CL S_{MSY}	Status of Stock i.e. % of CL
Galway	Aille (Galway)	76	57
Ballyshannon	Bungosteen	418	57
Galway	Clarinbridge	63	56
Galway	Owenboliska R (Spiddal)	550	56
Galway	Knock	123	56
Connemara	L.Na Furnace		
Ballyshannon	Abbey	276	56
Ballyshannon	Laghy	479	56
Bangor	Muingnabo	351	54
Bangor	Owengarve R.	194	54
Shannon	Doonbeg	426	53
Shannon	Annageeragh	302	53
Shannon	Owenagarney	814	52
Shannon	Skivaleen	372	52
Shannon	Deel	2462	52
Shannon	Brick	800	52
Shannon	Galey	1049	52
Shannon	Aughyvackeen	226	52
Wexford	Owenavorragh	810	49
Wexford	Avoca	2959	49
Dundalk	Flurry	123	46
Kerry	Owenshagh	324	45
Waterford	Mahon	442	44
Waterford	Owenduff	201	44
Waterford	Tay	278	44
Waterford	Corock R	734	43
Waterford	Lingaun	353	43
Waterford	Clodiagh	666	43
Waterford	Pollmounty	93	43
Waterford	Barrow	12026	42
Lismore	Finisk	456	42
Lismore	Glenshelane	145	41
Lismore	Womanagh	293	41
Lismore	Tourig	90	41
Lismore	Lickey	115	41
Ballina	Cloonaghmore (Palmerstown)	1261	40
Ballina	Ballinglen	396	38
Ballina	Brusna	1113	38
Ballina	Leaffony	218	38
Dublin	Dargle	639	38
Dublin	Liffey	4391	33
Lismore	Bride	1379	32
Shannon	Fergus	2391	29
Letterkenny	Leannan	3619	28
Dundalk	Glyde	2172	27
Shannon	Maigue	3907	16
Dundalk	Dee	2410	12
Shannon	Inagh	1033	10
River withy hydro-electric generating and dams			
Shanno n	Upper Shannon	49,524	2
Ballyshannon	Erne	16,554	6
Cork	Upper Lee	2,789	18
Liffey	Liffey	4,391	11

APPENDIX 1

LEGISLATION FOR THE MANAGEMENT OF SALMON FISHING FOR THE 2008 SEASON

The following general Bye-Laws were adopted under section 9 of the Fisheries (Consolidation) Act 1959 for the 2008 season:

- **Conservation of Salmon and Sea Trout Bye-law No. (C.S. 293, 2007)**
  This Bye-law prohibits the taking or attempting to take by rod and line salmon and sea trout over 40 cm in the 86 rivers specified in the Bye-law

- **Conservation of Salmon and Sea Trout Bye-law (No. 831, 2007)**
  This Bye-Law provides for catch and release in respect of Salmon and Sea Trout (over 40 cm) in the Newport River (Lough Beltra) and Garavogue River (Lough Gill and River Bonnet) during the period 1 January to 11 May in order to protect spring fish as identified by the SSC. The Byelaw also incorporates the provisions of the existing annual bag limit of 10 fish and the daily bag limits of 3 fish and 1 fish during the periods 12 May to 31 August and 1 September to the end of the season respectively. The Bye-law also provides for the use of single hooks and prohibits the use of worms as bait in angling for salmon and sea trout over 40 cm or once the specified number of fish have been caught in the specified periods.

- **Conservation of Salmon and Sea Trout Bye-law (No. 830, 2007)**
  This Bye-law provides for catch and release in respect of salmon and sea trout (over 40 cm) in the 21 rivers mentioned in the Bye-law. The Byelaw also provides for the use of single hooks and prohibits the use of worms as bait in angling for salmon and sea trout over 40 cm.

- **Conservation of Salmon and Sea Trout Bye-law (No. 829, 2007)**
  This Bye-Law provides for an annual bag limit of 10 fish being either salmon or sea trout (over 40 cm) per angler for the 2008 season and provides for a season bag limit of 3 fish in the period 1 Jan to 11 May, a daily bag limit of 3 fish from 12 May to 31 August and a daily bag limit of 1 fish from 1 September to the end of the season. The Bye-law also provides for the use of single hooks and prohibits the use of worms as bait once the specified number of fish have been caught in the specified periods. The Bye-law applies to 40 rivers.

Additional protection measures were adopted for individual rivers for the 2008 fishing season

- **Conservation of Salmon and Sea Trout (River Bandon) Bye-law (No. 835, 2008)**
  This Bye-Law provides for catch and release in respect of Salmon and Sea Trout (over 40 cm) and prohibits the use on any fish hooks other than single barbless hooks or worms as bait in angling for salmon and sea trout (over 40 cm) in the River Bandon during the period 14 March to 11 May. The Byelaw also incorporates the provisions of the existing annual bag limit of 10 fish and the daily bag limits of 3 fish and 1 fish during the periods 12 May to 31 August and 1 September to the end of the season respectively. The Bye-law also provides for the use of single hooks and prohibits the use of worms as bait in angling for salmon and sea trout over 40 cm or once the specified number of fish have been caught in the specified periods.

- **Conservation of Sea Trout Bye-law (No. 834, 2008)**
  This Bye-law prohibits the retention and possession of sea trout taken in the fishery districts specified in the Bye-law.

- **Eastern Fisheries Region (River Slaney) Angling Bye-law (No. C.S. 296, 2008)**
  This Bye-law provides that the annual close season for angling for salmon and trout in the River Slaney and its tributaries shall be extended from 26 February, 2008 to 9 March, 2008 both dates inclusive.

- **Conservation of Salmon and Sea Trout Bye-law (No. 833, 2008)**
  The Bye-law provides for catch and release in respect of salmon and sea trout (over 40 cm) in the portion of the Lower Shannon from O' Briens Bridge downstream on the downstream face of the bridge, to Thomond Bridge. The Bye-law also prohibits the use of worms as bait and any fish hooks other than single barbless hooks in angling for salmon and trout in those waters.

- **North Western Fisheries Region River Deel Bye-law (No. C.S. 295, 2008)**
  This Bye-law provides that the annual close season in angling for any kind of fish commences on 1 September in any year and ends on 31 May in the following year and prohibits the use of any prawn, shrimp or any crustaceans as bait in the River Deel. The Bye-law came into effect on 1 February 2008 and will cease to have effect on 1 June 2011

- **Conservation of Salmon and Sea Trout Bye-law (No. 832, 2007)**
  This Bye-law provides for catch and release in respect of salmon and sea trout and provides for the use of single hooks and prohibits the use of worms as bait in angling for salmon and sea trout in the River Slaney.

- **Conservation of Salmon and Sea Trout Bye-law (No. C.S. 294, 2007)**
  This Bye-law prohibits the taking or attempting to take by rod and line salmon and sea trout in the River Liffey.

The following measures were adopted in relation of fishing licences for 2008.

- **Fisheries Commercial Fishing Licences Alteration of Duties Order 2007. (S.I. No. 812 of 2007)**
  This Order prescribes the licence fees payable from 1 January 2008 in respect of salmon commercial fishing licences. The licence fees payable include a salmon conservation component equivalent to 50% of the licence fee, the proceeds of which will be invested exclusively in rehabilitation initiatives for wild salmon stocks and habitats.

- **Special Tidal Waters Special Local Licences Alteration of Duties Order 2007 (S.I. No. 795 of 2007)**
  This Order prescribes the licence fees payable from 1 January 2008 in respect of special local salmon fishing licences. The licence fees payable include a salmon conservation component equivalent to 50% of the licence fee, the proceeds of which will be invested in rehabilitation initiatives for wild salmon stocks and habitats.

- **Salmon Rod Ordinary Licences Alteration of Duties Order 2007 (S.I. No. 794 of 2007)**
  This Order prescribes the licence fees payable from 1 January 2008 in respect of salmon rod ordinary fishing licences. The licence fees payable include a salmon conservation levy

equivalent to 50% of the licence fee, the proceeds of which will be invested in rehabilitation initiatives for wild salmon stocks and habitats.

Section 29 of the Fisheries (Amendment) Act 1962, as amended by paragraph 4 of Part II of the Fourth Schedule to the Fisheries Act 1980, provides that the Minister may by order prohibit, restrict or otherwise control fishing for salmon at sea and prohibit, restrict or otherwise control the having in possession of salmon caught or landed contrary to an order under this section. The following Order was made for the 2008 salmon fishing season.

- **Control of Fishing for Salmon Order 2008 (S.I. No. 98 of 2008)**
  This Order authorises the issue of commercial fishing licences by regional fisheries boards and sets out the criteria under which those licences may be issued and prescribes the maximum number of commercial licences which may be issued by regional boards in respect of salmon fisheries in each regional board's area.

The following measures (total allowable catches + tagging regime) were adopted under section 24 of the Fisheries (Amendment) Act 1999, as amended by section 3 of the Fisheries (Amendment) Act 2000, for 2008

- **Wild Salmon and Sea Trout Tagging Scheme Regulations 2007 (S.I. No. 849 of 2007)**
  The Wild Salmon and Sea Trout Tagging Scheme Regulations provide for, among other things, the quotas of fish that can be harvested by commercial fishing engines and rod and line from those rivers identified in Schedule 2. Quotas are fixed for each individual river in accordance with scientific advice. The Regulations also provide for the use of additional tags in rivers that have been identified as requiring close monitoring to ensure that quotas are not overfished. In addition provision is made for setting a zero quota for rivers that are not meeting their CL. Individual rivers are identified in the Schedules to the regulations. These regulations also establish quotas for spring fish and contain measures for the protection of the spring fishery.

- **Inland Fisheries (Fixed Payment Notice) Regulations 2007 (S.I. No. 850 of 2007)**
  These Regulations make provision for on the spot fines for offences under the fisheries legislation for inland fisheries. The fine system is administered by the regional fisheries boards.

APPENDIX 2

National Salmon Commission and Standing Scientific Committee (Terms of Reference and Procedure) Order 2006 (S.I. No. 483 of 2006)

I, John Browne, Minister of State at the Department of Communications, Marine and Natural Resources, in exercise of the powers conferred on me by section 55D (inserted by section 22(1) of the Fisheries (Amendment) Act 1999 (No. 35 of 1999)) of the Fisheries Act 1980 (No. 1 of 1980) (as adapted by the Marine and Natural Resources (Alteration of Name of Department and Title of Minister) Order 2002 (S.I. No. 307 of 2002)), and the Marine (Delegation of Ministerial Functions) Order 2006 (S.I. No. 82 of 2006), hereby order as follows:

1. This Order may be cited as the National Salmon Commission and Standing Scientific Committee (Terms of Reference and Procedure) Order 2006.

2. In this Order -

"Commission" means National Salmon Commission;

"Committee" means Standing Scientific Committee;

"conservation limits" means the spawning stock level that produces long term average maximum sustainable yield as derived from a stock and recruitment relationship;

"Regulations of 1997" means European Communities (National Habitat) Regulations 1997 (S.I. No. 94 of 1997).

3. The terms of reference and procedure of the Commission are set out in Schedule 1.

4. The terms of reference and procedure of the Committee are set out in Schedule 2.

5. The National Salmon Commission (Terms of Reference) Order 2005 (S.I. No. 627 of 2005) is revoked.

Schedule 1

Article 3

Terms of reference of Commission

1. To consider how best the wild salmon resource may be managed, conserved and exploited on a sustainable basis, having regard in particular to Government policy and Regulation 31 of the Regulations of 1997.

2. To provide the Minister with any appropriate assessment prepared by the Committee for purposes of Regulation 31 of the Regulations of 1997.

3. To consider what conservation management mechanism might be required to achieve the alignment of total allowable catches and quotas with scientific advice provided by the Committee.

In particular, where possible, the Commission should provide its advice on total allowable catches and quotas on an individual river basis.

Where it is not possible to tender advice on the basis of individual rivers advice should tendered on the basis of fishery districts.

Advice on total allowable catches and quotas shall reflect the imperative of ensuring that stocks are maintained above their conservation limits.

Where stocks are below conservation limits, advice on total allowable catches and quotas should be to ensure a high probability of meeting conservation limits.

4. To propose, how an objective balance between competing interests in the salmon fishery may be obtained within the framework of the conservation management mechanism as necessary.

5. To engage, as appropriate, in a proactive dialogue with representatives of bodies and organisations prescribed for the purposes of section 55A(2)(b) of the Fisheries Act 1980 and other relevant persons and objectively evaluate any proposals they may have to achieve the alignment referred to in paragraph 3, having regard to the conservation, management, protection and development of the national salmon resource and to make practical recommendations to the Minister in this regard.

6. To consider in relation to the making of any recommendations the following points:

(a) best practice internationally,

(b) technical rules such as net size, lure type, etc.,

(c) enforcement measures,

(d) catchment management,

(e) single stock management,

(f) adjustments to fishing seasons,

(g) compensatory measures, including detailed costings and details of how they are to be resourced,

(h) obligations of the Minister under Regulation 31 of the Regulations of 1997,

(i) how the private sector may best contribute to the promotion of effective management, development, sustainable exploitation and conservation of wild stocks of salmon, and

(j) a timeframe within which the Commission considers specific recommendations should be implemented.

7. To have regard to the fact that any recommendations concerning compensatory measures must be predicted on the basis that the Minister will not contribute to any funding that may be required for any measures that may be recommended unless a public good is identified, justified and quantified.

Schedule 2

Article 4

Terms of Reference of Committee

1. The Committee shall carry out an appropriate assessment of salmon stocks in accordance with Regulation 31 of the Regulations of 1997.

The appropriate assessment using internationally accepted best scientific practice should demonstrate whether conservation limits are being or likely to be attained or otherwise -

(a) in special areas of conservation designated under Regulation 9 of the Regulations of 1997, and

(b) on an individual river basis or on a fishery district basis in areas other than special areas of conservation.

The appropriate assessment for special areas of conservation and for all fishery districts shall take account of the interceptory effects on mixed salmon stocks including the potential effects on freshwater salmon in other jurisdictions.

2. 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 or district basis in order to ensure a high degree of probability of meeting the conservation limits.

3. In cases of identified small scale artisanal fisheries, which may impact on stocks that are below the conservation limits, the Committee shall advise on the impact such a fishery has and in what circumstances, if any, it may be allowed to continue.

4. For the purpose of advising the Commission, the Committee shall develop age specific conservation limits where possible on individual river stocks and estimate the overall abundance of salmon returning to rivers in the State.

5. The Committee shall provide the Commission with a report, which contains the following information:

(a) an annual overview of salmon catches by district and region and an estimate of the number of "catch and release" salmon,

(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 stocks and homewater fisheries of significant management measures introduced in certain periods, and

(d) advice on significant developments, which might assist the Commission in advising the Minister on methods he or she might adopt for the management of salmon stocks.

GIVEN under my hand,

18 September 2006.

John Browne,
Minister of State at the Department of Communications,
Marine and Natural Resources

APPENDIX 3

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

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

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.

O ´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 under 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 peculiarities with regards to SR relationships. But 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 by a case study on the salmon rivers of Québec. SALMODEL further applied and extends 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 raise 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 (or 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 BRPs or from which BRPs can be computed. Let θ_i denote the SR parameters vector of the river i. In our 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. Let's denote Θ the vector of hyper-parameters.

The conditioning structure corresponding to this general setting can be represented by a Directed Acyclic Graph (DAG; See figure 2 on page 26). 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 our knowledge about the θ_i's. This information gained about the θ_i's allows improvements in turn in the knowledge 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 acknowledge 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 inform on how much can be learned 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 we are interested in making inferences for many rivers which we know very little about. The basic concept and model are presented below in Figure 1.

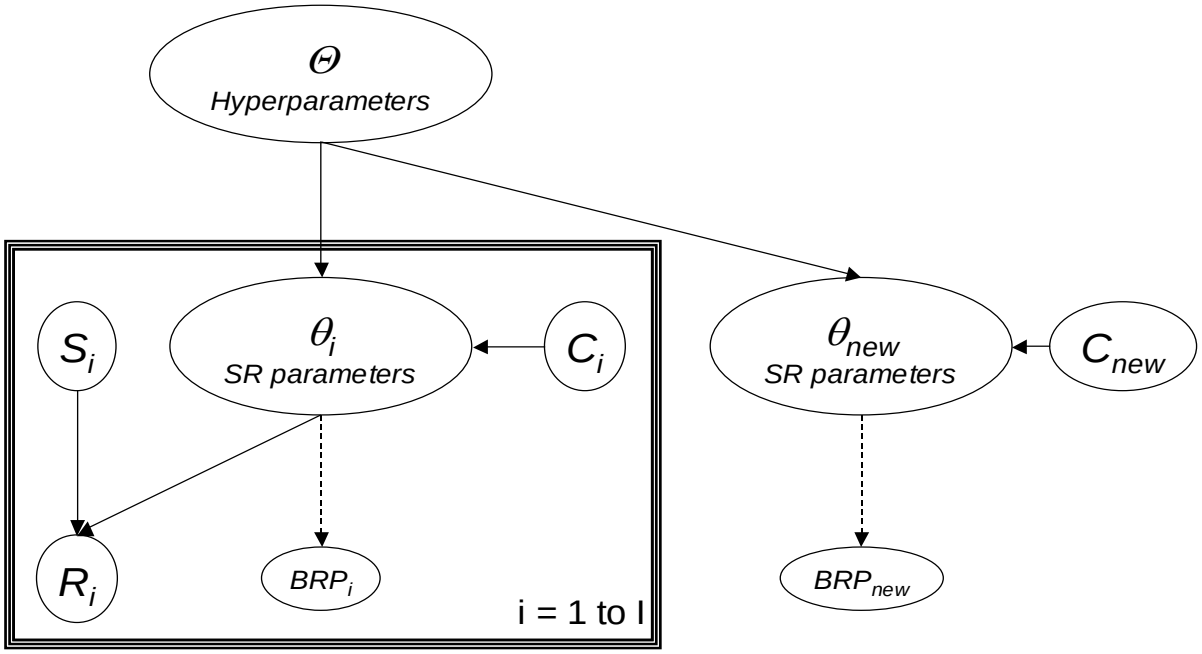


Figure 1 The conditioning structure of the BHSRA as represented in a Directed Acyclic Graph (DAG). Nodes (ellipses) are random variables. The plain arrows represent stochastic links, i.e. the distribution of a child node depends on its parents. Dashed arrows represent deterministic links, i.e. the BRPs are functions of the θi'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 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 what is currently done for setting and transporting BRPs in Atlantic salmon. It sets a consistent framework for learning from monitored rivers SR data, while current practices essentially rely on the unrealistic premise there is a common SR relationship across broad regions. Ample room is left for improvement in the single river SR modelling, but there is now a hierarchical setting which can accommodate any new SR model for (Bayesian) learning from the monitored rivers.

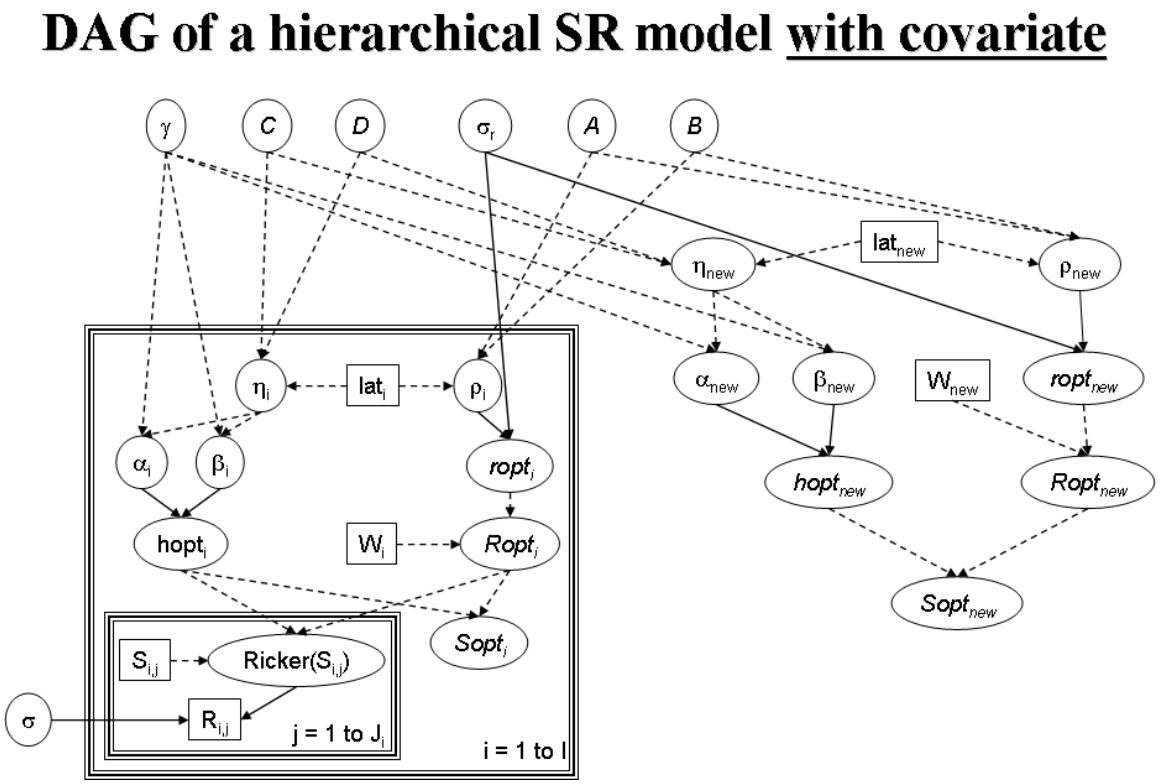
Introduction of Covariates – Wetted Area and Latitude

The BHSRA as used for the transport of SR parameters to Irish rivers is detailed below (Figure 2). The main difference is in the specific inclusion of covariates. 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 requirement cannot be achieved in the foreseeable future.

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

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



Brief explanation of terms used in the DAG.

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

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

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

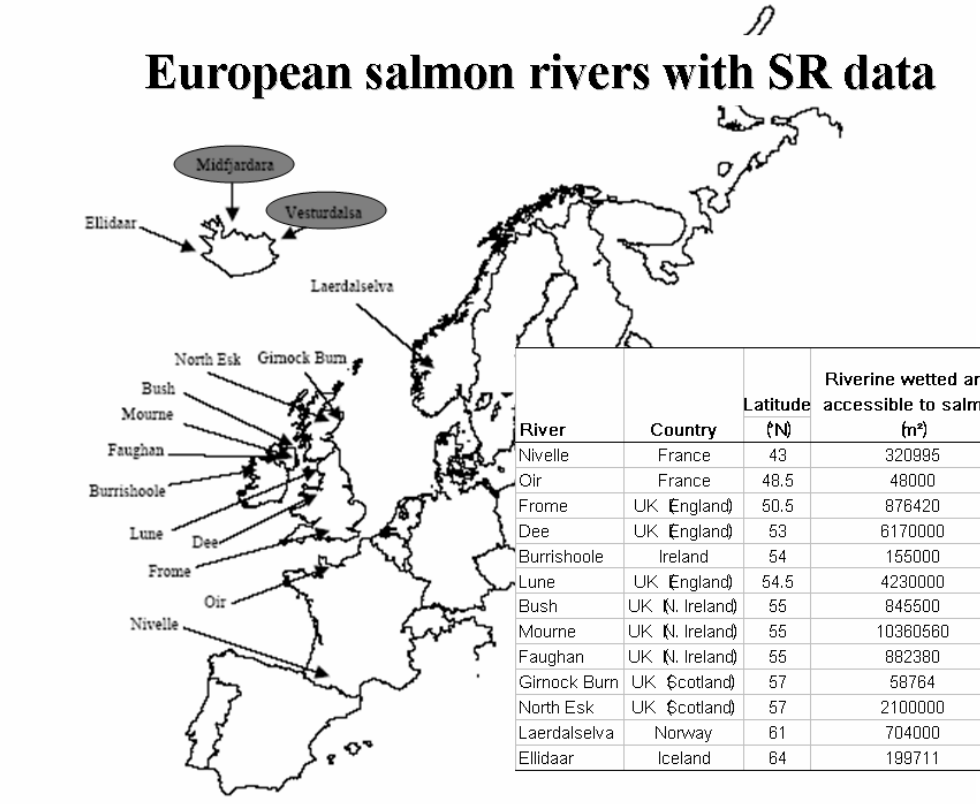
The "new" superscript denotes the posterior distributions of all the parameters for any new river based on the posterior distributions of the monitored rivers.

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

Egg-to-egg SR series can be obtained from monitored rivers, i.e. any river where at least the adult returns and the fisheries are surveyed (Figure 3). Rivers colonized mainly by sea trout and holding a

comparatively small salmon population were not considered. In-river adult returns were quantified by full counting (from trapping, electronic counters or even visual counts) or by estimation from tagging/recapture experiments. Combined with information on the catch or the exploitation rate in freshwater, spawning escapement can be calculated. Biological data, i.e. sex ratio and average fecundity per female, were used to express spawning escapement in eggs. Recruitment can also be derived from adult returns. Returns back to the coast were calculated using estimates of the catch or of the exploitation rate in coastal/estuarine fisheries. Information on the age composition of the returns allows derivation of adult returns per spawning year, i.e. homewater recruitment. Data on sex ratios and fecundity of females were used to express recruitment in eggs. In the case of monitored rivers, which are only spawning tributaries, adults spawning escapement was obtained directly without having to account for riverine exploitation. But straying within the hydrographic network may result in spawning runs comprising an important but unknown proportion of fish not originating from the tributary. Recruitment was then estimated from smolt counts or production estimates (tagging/recapture). Sea survival estimates from neighbouring rivers were used to convert smolts into adults.

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



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

Other references cited

Elliott, J.M. 2001. The relative role of density in the stock-recruitment relationship of salmonids. *In* Stock, recruitment and reference points – Assessment and management of Atlantic salmon. *Edited by* E. Prévost and G. Chaput. Hydrobiologie et aquaculture, INRA, Paris. pp. 25-66.

Gelman, A., Carlin, J.B., Stern, H.L., and Rubin, D.B. 1995. Bayesian data analysis. Chapman and Hall, London.

Koenings, J.P., Geiger, H.J., and Hasbrouck, J.J. 1993. Smolt-to-adult survival patterns of sockeye salmon (*Oncorhynchus nerka*): effects of smolt length and geographic latitude when entering the sea. Canadian Journal of Fisheries and Aquatic Science **50**: 600-611.

McAllister, M.K., and Kirkwood, G.P. 1998. Bayesian stock assessment: a review and example application using the logistic model. ICES Journal of Marine Science **55**: 1031-1060.

Metcalfe, N.B., and Thorpe, J.E. 1990. Determinants of geographical variation in the age of seaward-migrating salmon (*Salmo salar*). Journal of Animal Ecology **64**: 2339-2346.

Potter, T. 2001. Past and present use of reference points for Atlantic salmon. *In* Stock, recruitment and reference points – Assessment and management of Atlantic salmon. *Edited by* E. Prévost and G. Chaput. Hydrobiologie et aquaculture, INRA, Paris. pp. 195-223

Prévost, E., and Chaput, G. (*Editors*). 2001. Stock, recruitment and reference points – Assessment and management of Atlantic salmon. Hydrobiologie et aquaculture, INRA, Paris.

Prévost, E., Chaput, G., and Chadwick, E.M.P. 2001. Transport of stock-recruitment reference points for Atlantic salmon. *In* Stock, recruitment and reference points – Assessment and management of Atlantic salmon. *Edited by* E. Prévost and G. Chaput. Hydrobiologie et aquaculture, INRA, Paris. pp. 95-135.

Punt, A.E., and Hiborn, R. 1997. Fisheries stock assessment and decision analysis: the Bayesian approach. Reviews in Fish Biology and Fisheries **7**: 35-63.

Walters, C., and Korman, J. 2001. Analysis of stock-recruitment data for deriving escapement reference points. *In* Stock, recruitment and reference points – Assessment and management of Atlantic salmon. *Edited by* E. Prévost and G. Chaput. Hydrobiologie et aquaculture, INRA, Paris. pp. 67-94.

APPENDIX 4

Assessment Methodology for 2008 Catch Advice

A summary of the approach is shown below in Figure 1 on page 9 of this report. In the absence of a drift net fishery (or any other net fishery) at sea, in-river measures of abundance have been used (i.e. fish counter data and rod catch data) to provide a primary measure of spawning stocks and attainment of Conservation Limits. With the operation of fisheries restricted to estuaries and rivers from 2007, the assessment is now focussed primarily on estimating individual river returns from catch data, counter data (if available) and ranges of rod catch exploitation rates derived from observed values in Irish rivers in recent years.

For the 2007 catch advice it was necessary to provide an estimate of the likely extra return of salmon to each river in the absence of a commercial fishery at sea. This was based on the catch by this sector in 2006. No such adjustment is required in 2008 as the 2007 catch statistics and counts will reflect any increase due to the closure of the mixed stock fishery. Therefore, the process leading to the estimation of Conservation Limits remains unchanged as does the assessment of whether the individual river stock is above or below its Conservation Limit. A more comprehensive description of the data used and the assessment in 2008 is provided in the relevant section 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 - The catch statistics derived from the estuarine commercial fisheries (principally draft nets, snap nets, head weirs, bag nets and loop nets) remain an important source of quantitative information, 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 Maoileidigh *et al.*, 2001; Anon 2004), the catch data are derived from the logbook returns of commercial fishermen.

Rod catch data - The reported rod catch from the wild salmon and sea trout tagging scheme (Anon. 2003 to 2007) is adjusted to take into account the numbers of fish that have been caught by anglers who have not returned their logbook. The adjustment follows Small (1991). In some instances, directly reported rod catches from Regional Fisheries Officers and rod catch data from the records kept by managed fisheries have also been used if available provided these have been vouched for by Regional Fisheries Officers .

Total traps and counters - Data are available from several counters (see below) and salmon traps including the national and international monitoring station on the Burrishoole river, Newport Co. Mayo , which provides a direct measure of the total adult returns and smolt migrations annually. Similarly, data from an adult salmon trap on the River Screebe (Connemara) are also available.

In addition to direct counts from these traps, count data are available for 15 fish counters for a number of years. These are:
Dee (Dundalk), Boyne (Drogheda), Liffey (Dublin), Slaney (Wexford), Blackwater (Lismore), Bandon (Cork), Blackwater (Kerry), Waterville/Currane (Kerry), Feale (Limerick), Casla (Connemara), Erriff (Ballinakill), Ballysadare (Sligo), Eske, Eany (Ballyshannon) and Clady (Letterkenny).

Count data in recent years were also made available for the Mulkear, Ballinahinch, Corrib, by the relevant Fisheries Boards.

National Coded Wire Tagging and Tag Recovery - The programme was initiated in 1980 to estimate marine survival of Irish salmon stocks and exploitation rates by high seas fisheries, and home water commercial and recreational fisheries (Browne, 1982). Despite the closure of the mixed stock fisheries in 2007, information from this programme will continue to inform on marine survival rates and exploitation in some estuarine and rod fisheries. A 1 mm long magnetised tag, etched with a specific batch code is injected into the nose cartilage of juvenile fish, usually pre-smolts. The code identifies the origin and release conditions of any fish subsequently recaptured. The adipose fin is removed to facilitate the identification of these fish in the recovery programmes. Tagging has taken place using 10 hatchery stocks and between 1 and 3 wild salmon stocks. Since 1980, up to 200,000 salmon representing over 50% of the national catch in some years, have been individually examined each year to identify coded wire tagged salmon and recover these tags. In 2007, approximately 3,000 salmon were examined in estuarine or in-river commercial catches and recreational fisheries with over 300 tags recovered. Due to the closure of the mixed stock fisheries significantly more tags were recovered from broodstock collections in rivers where hatchery fish had been tagged in the previous year. This provides invaluable information on marine survival and exploitations rates for these tagged stocks which can be applied more generally to other rivers systems where these data are not available.

Other data - Information on juvenile abundance indices derived from electro-fishing surveys carried out annually are examined as a surrogate of stock abundance and this method was applied in conjunction with other indicators in 2007 for the 2008 advice.

APPENDIX 5

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 20% (i.e. 20 adult returns to the coast for every 100 smolts migrating, Figure 9).

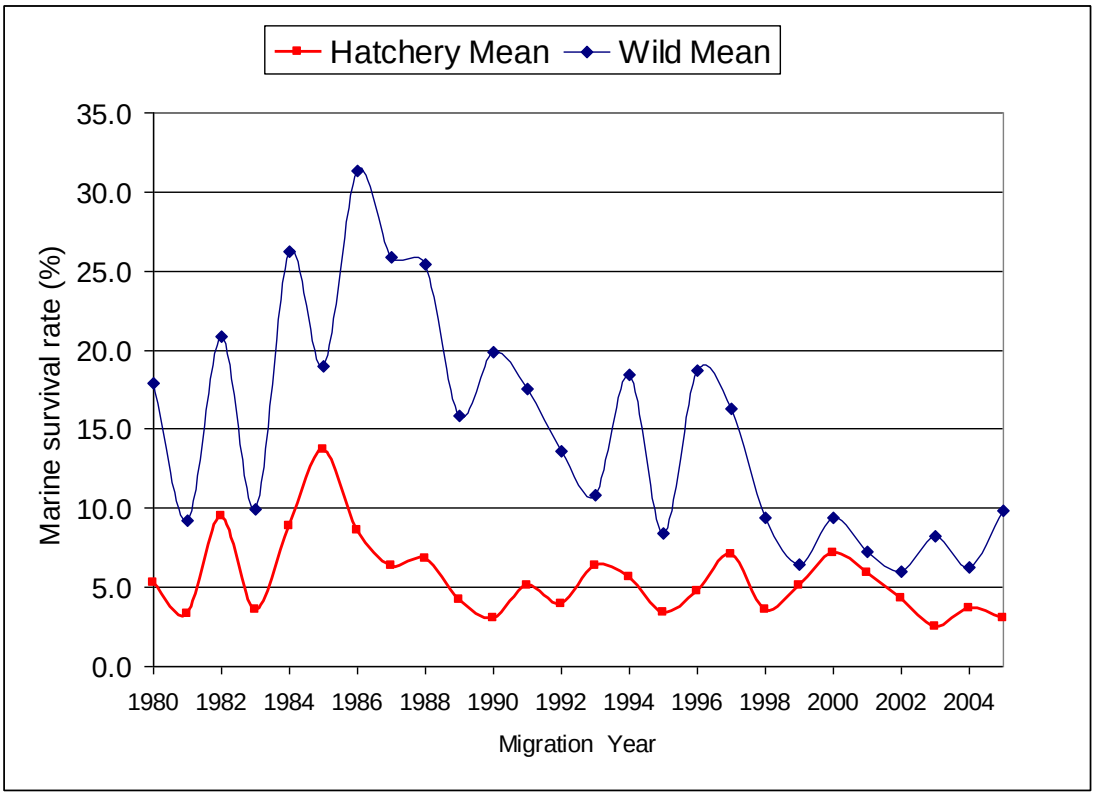


Figure 3 Marine survival (from smolt release to return to the coast) for wild and hatchery salmon.

The current estimates suggest that less than 10% of the wild smolts that go to sea from Irish rivers are surviving (i.e. less than 10 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 being among the lowest in the time series.

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, marine 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.

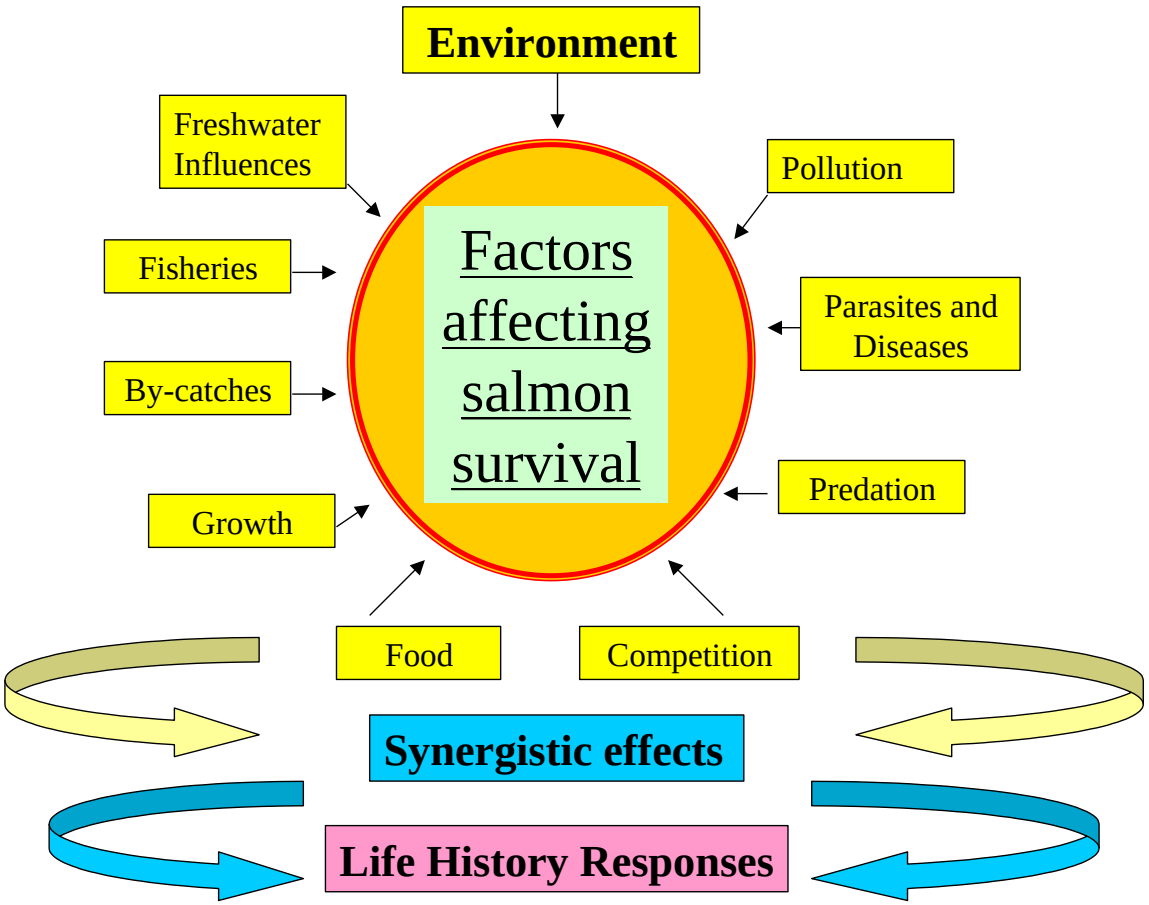


Figure 4 The factors which individually and synergistically affect the marine survival of salmon and which cause significant changes to life history responses such as population structure, fitness and size.

Water Quality

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

Conclusions

Despite the recent reduced exploitation on stocks, only 53 rivers from approximately 150 Irish salmon rivers are meeting biologically based Conservation Limits. Marine survival is presently the lowest it has been since the National Coded Wire Tagging Programme for Salmon commenced in

1980 and probably since the 1970's also based on a longer time series of information available for the Burrishoole index site. There are also indications from data sets going back further than 1970, that the 1970s and 1980's were a period of unusually high abundance with high marine survivals (Boylan and Adams, *in press*). Given the current levels of poor survival, the expectation of large catches is unrealistic at present and priority should be given to conservation rather than catch.