Report to the European Commission in line with Article 9 of the Eel Regulation 1100/2007

Implementation of Ireland's Eel Management Plans including the transboundary IE_NorW Eel Management Plan.

June 2015

Contents

Executive Summary

This report, and accompanying electronic data tables (Annex 2), outlines the monitoring, effectiveness and outcome of the Eel Management Plans (EMPs) implemented within the River Basin Districts (RBDs), including one transboundary EMP (IE_NorW) shared with Northern Ireland and also reported on by the UK. This is in accordance with Article 9 of Council Regulation (EC) No 1100/2007 and as set out in the reporting guidance provided by the European Commission in 2012.

The methodology and full report on the monitoring programme is given in Annex 1. Tables 1.1-1.3 summarise the best available estimates of silver eel escapement biomass, mortality rates due to fisheries and other anthropogenic factors for the six Eel management Units (EMUs) in Ireland during the most recent 3-year period (2012 to 2014).

In general, Ireland has demonstrated the increase in biomass of silver eel escaping and the marked reduction in fishing and hydropower mortality. Ireland has reduced its mortality rate to well below A_{lim} of 0.92 (the rate equivalent to the biomass EU 40% target). Therefore, Ireland is fulfilling its EMP commitment to recovering the stock in the fastest time possible. While further reduction in mortality is unlikely, it possible that additional biomass from the closure of the yellow eel fishery will continue to feed through in the coming years (circa 5 years). However, it is unclear how the collapse in recent recruitment will impact on silver eel biomass and whether density dependent effects (change from small males to higher proportions of larger females) will buffer the collapse in recruitment by temporarily increasing biomass of silver eels, even with falling numbers.

The low recruitment levels of the recent past leads to a low adult yellow eel stock and consequently a low stock of silver eel returning to the ocean to spawn. Under these circumstances, it is unlikely that that the 40% target SSB can be sustained into the near future. Recruitment has now become the limiting factor for recovery in Ireland.

Chapter 2 documents Ireland’s progress regarding implementation of the management actions identified under the Irish Eel Management Plan as submitted to the EU in January 2009 and formally accepted in June 2009. Difficulties encountered regarding implementation of the Eel Management Plan are also identified. A summary of the management actions completed for each EMU is provided in Annex 2.

Proposed amendments to the Regulation (Council Regulation 1100/2007) are provided in Chapter 3.

As Ireland’s EMPs do not include glass eel stocking as a management action this report provides a Nil return in relation to (i) assessment of the potential net benefit of eel stocking in terms of silver eel escapement or (ii) Glass Eel Pricing as specified in the guidance document.

See Stock Annex (Annex 1) for full glossary.

In accordance with ICES common practice, the Irish Eel Management Units have been coded as follows:

Name	RBD	ICES EMU Code
Eastern Eel Management Unit	EMU	IE_East
South Eastern RBD	SERBD	IE_SouE
South Western RBD	SWRBD	IE_SouW
Shannon IRBD	SHIRBD	IE_Shan
Western RBD	WRBD	IE_West
North Western IRBD (transboundary)	NWIRBD	IE_NorW

1 Provide best available estimates of stock indicators and associated information

1.1 Background

The EC Regulation (Council Regulation 1100/2007) for the recovery of the eel stock required Ireland to establish eel management plans for implementation in 2009. Under the Regulation, Ireland should monitor the eel stock, evaluate current silver eel escapement and post-evaluate implemented management actions aimed at reducing eel mortality and increasing silver eel escapement.

The Irish Eel Management Plan submitted to the EU on the 9th January 2009 and accepted by the EU in June 2009 outlined the main management actions aimed at reducing eel mortality and increasing silver eel escapement to the sea.

Under the EC Regulation (EC No. 1100/2007), each Member State shall report to the Commission initially every third year until 2018 and subsequently every six years. The second report is due by 30th June 2015.

The Irish Eel Management Plan (EMP) outlines a national programme for sampling catch and surveys of local eel stocks. Appropriate scientific assessment will monitor the implementation of the plans. The Standing Scientific Committee for Eel (SSCE) was established under Section 7.5 (a) of the Inland Fisheries Act 2010. Consultation with the Department of Culture, Arts and Leisure in Northern Ireland ensures the co-operation with Northern Ireland agencies to cover the specific needs of the trans-boundary North Western International River Basin District eel management plan.

1.2 Standing Scientific Committee on Eel

The SSCE has undertaken a full assessment of the available eel data and other information available to it as outlined in its Terms of Reference and this is produced in annual science reports. The SSCE reports provide the most current scientific advice on the status of the eel stock. All data referred to here has been assessed and referenced in the SSCE Reports and can be sourced through those documents (Anon. 2012a, 2013, 2014, 2015).

This management report should be read in conjunction with the SSCE Stock Annex (Annex 1) and the three annual SSCE Reports (Anon 2013, 2014, 2015).

1.3 Ireland's Eel Management Plan

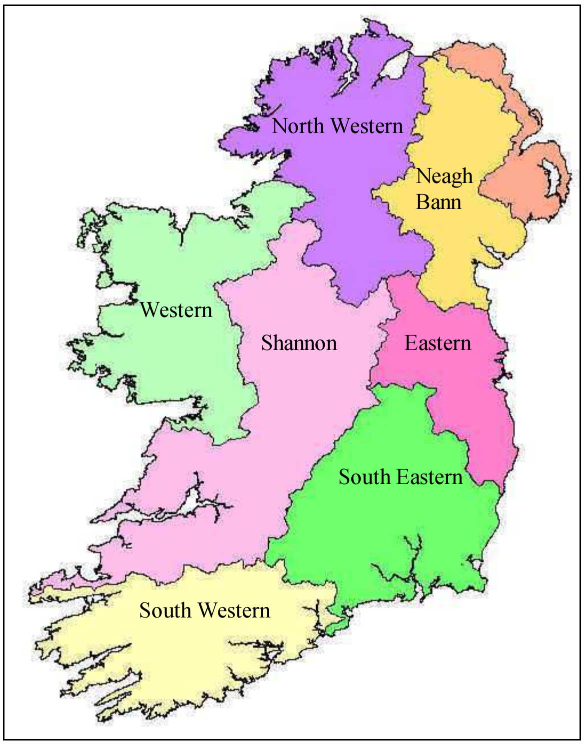
The Irish Eel Management Plan, included two cross-border agreements, with the Neagh Bann IRBD rivers flowing into Carlingford Lough from the Republic of Ireland and into Dundalk Bay being reported in a plan for the Eastern RBD (the Eastern Eel Management Unit) and one transboundary eel management plan in respect of the North Western IRBD and prepared by the Northern Regional Fisheries Board (now Inland Fisheries Ireland), the Loughs Agency and DCAL (Figure 1.1).

The four main management actions in the Irish Eel Management Plan were as follows;

- a cessation of the commercial eel fishery and closure of the market
- mitigation of the impact of hydropower, including a comprehensive trap and transport plan to be funded by the ESB
- ensure upstream migration of juvenile eel at barriers
- improvement of water quality

The Irish Eel Management Plan (EMP) also outlined a national monitoring programme for sampling catch and surveys of local eel stocks. Appropriate scientific assessment will monitor the implementation of the plans.

Given the implications of the scientific advice, the consideration of practical management implications and the need to conserve and recover the stock in the shortest possible timeframe (contingent upon equivalent actions across Europe), the precautionary approach was adopted in accordance with the recommendations of the National Eel Working Group 2008 and the eel fishery was ceased. The eel fisheries in tidal and transitional waters were managed under the Inland Fisheries legislation and management structures and given the absence of appropriate methods for estimating eel stock densities and silver eel escapement in transitional waters, the precautionary approach was also adopted in accordance with the recommendations of the National Eel Working Group and the eel fishery in transitional and tidal waters was also ceased.



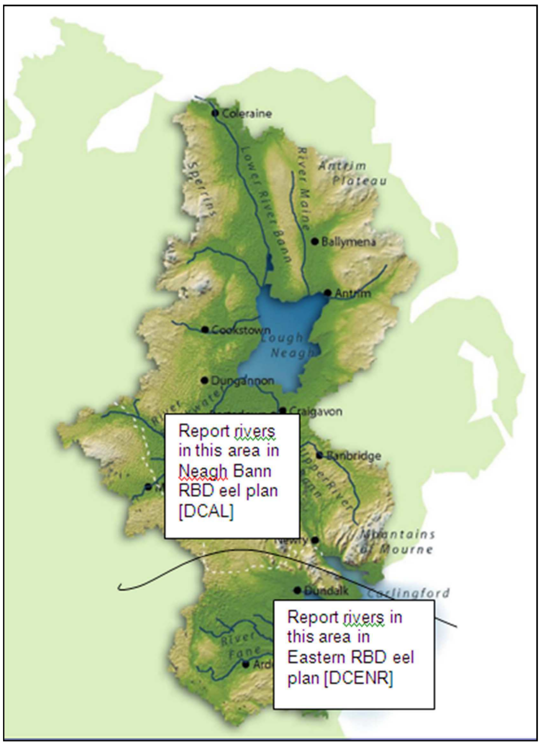


Figure 1-1: Map (left) showing the River Basin Districts and the map (right) showing the transboundary agreement between the Neagh/Bann RBD and the Eastern RBD.

1.4 Monitoring 2012-2014

As outlined in Chapter 7 of the Irish National EMP, a comprehensive monitoring programme was put in place to assess the local recruitment (glass eel/elver), yellow eel and silver eel stocks and to set a bench mark for evaluating future changes to the stocks. Determination of silver eel production and escapement was undertaken on the Burrishoole (IE_West) and in conjunction with the silver eel trap and transport programmes on the Shannon (IE_Shan) and Erne (IE_NorW). Additional index sites are being developed on other rivers such as the Fane (IE_East) and the Barrow (IE_SouE) but the time series were too new and unverified for them to be included in the 2012-2014 assessment as calibrating sites.

Mortality estimates for Hydropower Stations were determined for the Shannon and the Erne and a figure for eels bypassing Ardnacrusha on the Shannon was also determined. These have been retrospectively incorporated into the previous estimates of escapement reported in the Irish Eel Management Plan (2008).

These monitoring programmes and estimates of escapement allow for the outcome of the main management actions (e.g. closure of the fishery, silver eel trap and transport) to be post-evaluated.

1.5 Status of the Irish Stocks 2012-2014

A full description of the annual monitoring and assessment is given in the annual SSCE Reports and is synthesised in Annex 1 of this report. The following sections provide an overview of the required stock indicator data.

1.5.1 Recruitment

Recruitment over the 2012-2014 period was patchy with some locations faring better than others. The Liffey, Shannon (Ardnacrusha), Ballysadare and Feale had relatively lower catches than those observed at the Erne, Maigue, Inagh and Burrishoole. There was a general increase in recruitment to Ireland in 2013 and 2014, although there was some local variation in abundance between sites and between years, often due to seasonal variations in water levels.

The average recruitment for the 2009-2011 period was at about 7% of historic and this increased to about 20% for the 2012-2014 period (Annex 1: Table 3.1; Fig. 3.1). The recruitment in 2014 was on average at 27% of historic levels, compared to 15% for "Elsewhere" Europe (Elsewhere = non-North Sea Europe).

1.5.2 Yellow Eel Monitoring

During the last three year cycle of fieldwork seven lakes were repeatedly sampled for yellow eels; Lough Muckno, Lough Feeagh, Lough Bunaveela, Lough Oughter, Meelick Bay in Lough Derg, Lough Key and Lough Ramor. A three year fyke netting survey in the freshwater and transitional water of the River Barrow was undertaken to compare with historical data available. The South Sloblands and Lough Furnace are both brackish lagoons that were surveyed in 2010 and were resurveyed in 2014 to compare with historic data. Lough Furnace was surveyed in 2012, 2013 & 2014. Locations are listed in Annex 1: Table 3.2 and Figure 3.2.

A semi quantitative electrofishing survey was undertaken in two catchments (Fane and Kells Blackwater) in order to determine the extent of eel distribution in the rivers around Lough Muckno and Lough Ramor (both subject to intensive fyke netting surveys).

The data from the lake fyke nets surveys indicate a decrease in the proportion of small eels (~<40cm) being caught by the fyke nets compared with the 1960's and 1980's. Within the data we are seeing a gradual progression from the 1960's to 1980's, 1990's to the 2010's of an increase in the average length of eels in our freshwater lakes. The proportion of smaller eels has been declining since the 1980's and corresponds to the dramatic decline in recruitment. It is important to note, however, that this change in length structure is not observed in all lakes possibly due to manipulation through stocking upstream assisted migrants at hydropower stations.

Some relatively high catch per unit of effort (CPUE) were recorded during the 2012-2014 period. Lower Lough Erne (transboundary) had an average CPUE of 17 eels per net per night, the Lough Muckno 2012 survey had a CPUE of 8.9 followed by the Barrow Transitional waters 2014 with 6.9. The lowest CPUE recorded was Lough Bunaveela with 0.4 and Lough Furnace with a CPUE of 1.0. Some transitional waters exhibited high CPUEs (Barrow) while others where CPUEs were traditionally high have now fallen to low levels (e.g. L. Furnace).

The results of the fyke net surveys to date highlight the transient nature of the results and the importance of spreading the surveys through time both within years and between years. To fully understand and interpret the CPUE values it is important to take into account the location of the waterbody within a catchment, the productivity of the catchments themselves and whether there has been assisted migration stocking from elver trapping downstream, such as on the Shannon and Erne.

1.5.3 Silver Eel Monitoring

Silver eels are being assessed by fishing of index stations on the Corrib (2009 only), Erne, Shannon and Burrishoole catchments (Annex 1 Table 3.5), all of which have a long-term history of eel catch and data collection. Fishing and assessments using mark-recapture commenced on the Fane (Muckno) in 2011, on the R. Barrow in 2014 and on Baronscourt lakes in the IE_NorW and it is hoped in the future to include these as index locations in the future.

In 2009, the wetted area of the four index catchments (Burrishoole, Corrib, Shannon and Erne) accounts for 64% of the wetted area in Ireland and the Northern Irish portion of the IE_NorW. Since 2010, the index catchments represent 45% of the wetted area.

The full assessments are synthesised in Annex 1 of this report. The Shannon, Erne and Burrishoole all showed an increase in silver eel production (Bbest) in the 2012-2014 period compared to the previous three years (Annex 1 Table 3.7). Part of that increase could be attributed to the closure of the yellow eel fishery beginning to feed through to an increase in silver eel output, but as the unexploited Burrishoole also witnessed an increase it is also possible that it was a natural increase in production.

Silver eel production in the Shannon increased from 1.64kg/ha in 2009-2011 to 1.72kg/ha in 2012-2014 with a peak of 1.9kg/ha in 2013.

The Erne increased from 1.62kg/ha in 2009-2011 to 2.91kg/ha in 2012-2014 with a peak of 3.29kg/ha in 2014, an increase that was more or less expected due to previous recruitment patterns and the closure of the fisheries.

The Burrishoole increased from 0.96kg/ha in 2009-2011 to 1.19kg/ha in 2012-2014 with a peak of 1.22kg/ha in 2014.

The plots (Annex 1: Figure 4.7 and Table 3.7) and the accompanying electronic tables (Annex 2) show the Erne and Burrishoole to be above 40% SSB, with a marked decrease in eel mortality in the Erne to a level well below A_{lim} of 0.92.

The escapement biomass in both the Erne and the Shannon has increased, with the Erne going from 36.3% to 58.4% SSB and the Shannon going from 32.6% to 34.0% SSB.

1.6 Silver Eel Production and Escapement

1.6.1 Introduction

The EU Regulation (No. 1100/2007) sets a long-term objective which is the protection and sustainable use of the stock of European Eel. A target is set for the biomass of silver eel escaping from each eel management unit, at 40% of the pristine biomass. Pristine biomass is generally regarded as the biomass of silver eel without human impact and at recruitment levels before the sudden decline in the early 1980s.

Ireland used a system of extrapolating from index data rich catchments to data poor catchments for calculating estimates of pristine and current biomass as described in the Irish Eel Management Plan (Chapter 5), the WGEEL report (ICES, 2009) and Annex 1 to this report.

As set out in the EU template for the National Report 2012, the following definitions are adhered to:

B_0	The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock.
$B_{current}$	The amount of silver eel biomass that currently escapes to the sea to spawn.
B_{best}	The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock.
ΣF	The fishing mortality rate, summed over the age-groups in the stock, and the reduction effected.
ΣH	The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock, and the reduction effected.
R	The amount of glass eel used for restocking within the country.
ΣA	The sum of anthropogenic mortalities, i.e. $\Sigma A = \Sigma F + \Sigma H$.

1.6.2 Biomass and Mortality Overview

No assessments were made of the stock indicators for transitional or coastal waters. Preliminary analysis indicated that it would be unwise to extrapolate directly from freshwater into the transitional zone.

In this report, the Irish eel stock in inland waters has been quantified and time trends presented (Tables 1.1, 1.2 and 1.3 and the electronic tables). In this chapter, the state of the stock will be compared with the targets. This involves the comparison of the actual state of the stock to the state it is intended to have, comparing the observed mortalities to the targets set in the management plans. The precautionary diagram introduced in Annex 1: Section 2.6 will be used using the EU management target (40% SSB) as the reference point and a calculated mortality reference point based on the EU management target (A_{lim} 0.92) for 2008 and the averages for 2009-2011 and 2012-2014. On the horizontal axis, the status of the stock is plotted (low versus high spawning stock biomass determining whether the stock is in good condition or not; logarithmic scale, percent of pristine biomass) and on the vertical axis the impact of fishing and hydropower generation (low versus high mortality determining whether the management regime is sustainable or not; mortality rates are logarithmic by definition). The diagrams presented in the Stock Annex (Annex 1: Fig. 4.8 & 4.9) plot the most recent stock assessments (2009-2011 and 2012-2014), along with those presented in the EMP (2008).

In the IE_East, the IE_Shan, IE_West and IE_NorW, the mortality was clearly reduced as indicated by the downward direction of the bubbles and this led to increased escapement shown by right hand horizontal movement towards the 40% target. In some cases the bubbles did not respond as expected, by not moving as much to the right. This may due to some yellow eel still to feed through increasing the %SSB and moving the bubbles to the right in coming years. Or the negative impact of falling recruitment may now be leading to lower silver eel production, or there may be problems with some of the estimates as mentioned previously. Extrapolation to the East and Southern EMUs will need to be reviewed in the light of future additional data.

There is some anecdotal evidence to suggest higher than previously thought yellow eel exploitation. It is also possible that the historical production without anthropogenic mortality (Bo) may be too low. The estimates for undeclared or illegal catches included in the historical model were 40% of the declared catch but anecdotal information would suggest that this could have been as high as 200% or 300%. Fixing a value for Bo is fundamental to determining a realistic %SSB, although this has always been a challenge.

In general, there has been an increase in biomass of silver eel escaping and the marked reduction in fishing and hydropower mortality. While further reduction in mortality is unlikely, it possible that additional biomass from the closure of the yellow eel fishery will continue to feed through in the coming years (circa 5 years). However, it is unclear how the collapse in recent recruitment will impact on silver eel biomass and whether density dependent effects (change from small males to higher proportions of larger females) will buffer the collapse in recruitment by temporarily increasing biomass of silver eels, even with falling numbers.

Ireland has reduced its mortality rate to well below A_{lim} of 0.92 (the rate equivalent to the biomass EU 40% target). Therefore, Ireland is fulfilling its EMP commitment to recovering the stock in the fastest time possible.

The low recruitment levels of the recent past leads to a low adult yellow eel stock and consequently a low stock of silver eel returning to the ocean to spawn. Under these circumstances, it is unlikely that that the 40% target SSB can be sustained into the near future. Recruitment has now become the limiting factor for recovery in Ireland.

1.6.3 Summary of individual RBD targets

No assessments were made of the stock indicators for transitional or coastal waters. Preliminary analysis indicated that it would be unwise to extrapolate directly from freshwater into the transitional zone.

In Chapter 5.2.4.4 of the Irish Eel Management Plan, summary plots of the 2008 status of each EMU were presented, including projections for different management scenarios (no action, full fishery closure, full removal of hydropower mortality) and these were scaled according to the previous recruitment history (with no density dependence assumed) (See figures in Ch. 5.2.4.4 of the EMP 2008).

These plots have now been updated with the revised historic estimates of silver eel production and the new % SSB averages for 2009-2011 and 2012-2014 have been inserted. These are shown in Annex 1: Figures 4.11 & 4.12.

With the exception of the IE_Shan all other EMUs are above the EU target in 2012-2014. It is not expected that this can be sustained due to the history of recruitment, although density dependent changes to some of the stocks, such as sex ratio change to female and increase in eel size, are making it difficult to project further into the future. It should be noted, as mentioned in Annex 1 Section 4.6, that three EMUs (IE_East, IE_SouE and IE_SouW) were assessed using the IMESE model with no local calibrating index.

In 2008, the total for <u>all</u> EMUs was projected into the future to peak at 36% before falling again due to lack of recruits; the average for 2009-2011 was 36.7%. This has now increased, however, to 54.5% average for 2012-2014 period. The 2012-2014 estimates here are also possibly unduly influenced by the Corrib catchment modelled estimate, as discussed earlier (Annex 1: Sec 4.6).

Table 1-1: Historic (Bo) and current silver eel production (Bbest) (kg) and escapement (Bcurrent) (kg) for 2008-2014 and average production and escapement for 2009-2011 and 2012-2014 calculated using the IMESE model and inserting actual catchment data where they exist. These data are extracted from the electronic tables.

EMU Code	EMU Name	Bo Prod	Production (Bbest)							Av 2009-2011	Av 2012-2014
		kg	2008	2009	2010	2011	2012	2013	2014		
IE_East	EEMU	20,517	16,768	14,755	10,865	9,928	13,936	15,079	14,756	10,484	14,592
IE_NorW	NWIRBD	135,732	102,502	57,295	52,447	52,956	82,099	89,376	87,747	52,883	86,286
IE_Shan	SHIRBD	201,401	95,979	83,464	75,608	71,669	76,507	89,250	80,151	76,073	81,855
IE_SouE	SERBD	14,836	11,229	9,877	7,271	6,645	9,333	10,098	9,878	7,018	9,774
IE_SouW	SWRBD	24,577	15,914	13,975	10,274	9,395	13,230	14,312	13,978	9,932	13,864
IE_West	WRBD	192,377	101,892	83,128	98,543	90,029	126,447	136,795	133,872	69,545	132,404
	Total	589,440	344,285	262,494	255,010	240,623	321,553	354,910	340,383	225,936	338,776
EMU Code	EMU Name	Bo Prod	Escapement (Bcurrent)							Av 2009-2011	Av 2012-2014
		kg	2008	2009	2010	2011	2012	2013	2014		
IE_East	EEMU	20,517	9,557	14,561	10,722	9,798	13,753	14,881	14,562	10,346	14,401
IE_NorW	NWIRBD	135,732	47,787	47,554	49,348	50,515	71,817	80,494	81,817	50,035	77,921
IE_Shan	SHIRBD	201,401	21,636	79,369	67,398	63,996	67,412	80,055	72,213	69,414	73,112
IE_SouE	SERBD	14,836	9,867	9,877	7,271	6,645	9,333	10,098	9,878	7,018	9,774
IE_SouW	SWRBD	24,577	15,379	13,576	10,067	9,389	12,910	14,189	13,807	9,767	13,659
IE_West	WRBD	192,377	46,546	83,128	98,543	90,029	126,447	136,795	133,872	69,545	132,405
	Total	589,440	150,771	248,064	243,350	230,372	301,673	336,512	326,149	216,126	321,272

Table 1-2: The % Bcurrent/Bbest (%EU target) for each EMU and for the total production, for 2008 to 2014 and for the average for 2009-2011 and 2012-2014. The data come from Table 1.1. These data are extracted from the electronic tables.

EMU Code	EMU Name	Bo Prod	%Bcurrent/Bbest (EU Target)							Av 2009-2011	Av 2012-2014
		kg	2008	2009	2010	2011	2012	2013	2014		
IE_East	EEMU	20517	46.6	71.0	52.3	47.8	67.0	72.5	71.0	50.4	70.2
IE_NorW	NWIRBD	135732	35.2	35.0	36.4	37.2	52.9	59.3	60.3	36.9	57.4
IE_Shan	SHIRBD	201401	10.7	39.4	33.5	31.8	33.5	39.7	35.9	34.5	36.3
IE_SouE	SERBD	14836	66.5	66.6	49.0	44.8	62.9	68.1	66.6	47.3	65.9
IE_SouW	SWRBD	24577	62.6	55.2	41.0	38.2	52.5	57.7	56.2	39.7	55.6
IE_West	WRBD	192377	24.2	43.2	51.2	46.8	65.7	71.1	69.6	36.2	68.8
	Total	589,440	25.6	42.1	41.3	39.1	51.2	57.1	55.3	36.7	54.5

Table 1-3: Annual fishing (∑F), other anthropogenic (∑H) and total mortality (∑A) rates for each Eel Management Unit and the total annual mortality rate for all EMUs. These data are extracted from the electronic tables.

Indicator	∑F	∑F	∑F	∑F	∑F	∑F	∑F	∑H	∑H	∑H	∑H	∑H	∑H	∑H	∑A	∑A	∑A	∑A	∑A	∑A	∑A
Unit	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate
Year	pre-EMP	2009	2010	2011	2012	2013	2014	pre-EMP	2009	2010	2011	2012	2013	2014	pre-EMP	2009	2010	2011	2012	2013	2014
EMU_code																					
IE_East	0.539	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.013	0.013	0.013	0.013	0.013	0.013	0.559	0.013	0.013	0.013	0.013	0.013	0.013
IE_NorW	0.584	0.000	0.000	0.000	0.000	0.000	0.000	0.186	0.186	0.061	0.047	0.134	0.105	0.070	0.770	0.186	0.061	0.047	0.134	0.105	0.070
IE_Shan	1.240	0.000	0.000	0.000	0.000	0.000	0.000	0.242	0.050	0.115	0.113	0.127	0.109	0.104	1.482	0.050	0.115	0.113	0.127	0.109	0.104
IE_SouE	0.129	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.129	0.000	0.000	0.000	0.000	0.000	0.000
IE_SouW	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.048	0.029	0.020	0.001	0.024	0.009	0.012	0.054	0.029	0.020	0.001	0.024	0.009	0.012
IE_West	0.783	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.783	0.000	0.000	0.000	0.000	0.000	0.000
Total															0.83	0.06	0.05	0.04	0.06	0.05	0.04

1.7 Overall Conclusions

Ireland has implemented a full monitoring programme as outlined in the EMP aimed at delivering the biomass, mortality and stock information required under EU Regulation (No. 1100/2007). No assessments were made of the stock indicators for transitional or coastal waters. Preliminary analysis indicated that it would be unwise to extrapolate directly from freshwater into the transitional zone.

While **recruitment** remains low, improvements were noted in some catchments in 2013 and 2014. Increase to between 2.8% and 49.5% compared to pre-1995 averages were noted for the 2012-2014 period. In 2014, increases to between 3.2% and 47.1% of pre-1994 levels were observed and these compare favourably with the European data.

Yellow eel monitoring has shown a complex picture of eel stocks across Ireland, with some good stocks of eel along with some quite low stocks. The impact of low recruitment has been observed with lower numbers of small eels when compared to surveys in the 1960s and '70s. Some catchments are also seeing the disappearance of very large eels such as Burrishoole transitional lagoon (Furnace), possibly due to silvering rate overtaking growth rate. Some very good catches of yellow eel have been observed, such as in L. Muckno and Lower Lough Erne. Good catches of eel, including smaller eels, have also been recorded in transitional waters such as Waterford harbour and the Slaney.

Silver eel: The Shannon, Erne and Burrishoole all showed an increase in silver eel production (Bbest) in the 2012-2014 period compared to the previous three years. Part of that increase could be attributed to the closure of the yellow eel fishery beginning to feed through to an increase in silver eel output, but as the unexploited Burrishoole also saw an increase it is also possible that it was a natural event.

Silver eel production in the Shannon increased from 1.64kg/ha in 2009-2011 to 1.72kg/ha in 2012-2014 with a peak of 1.9kg/ha in 2013. The Erne increased from 1.62kg/ha in 2009-2011 to 2.91kg/ha in 2012-2014 with a peak of 3.29kg/ha in 2014, an increase that was more or less expected due to previous recruitment patterns and the closure of the fisheries. The Burrishoole increased from 0.96kg/ha in 2009-2011 to 1.19kg/ha in 2012-2014 with a peak of 1.22kg/ha in 2014.

The Erne and Burrishoole were above the 40%SSB, with a marked decrease in eel mortality in the Erne to a level well below Alim of 0.92.

The escapement biomass in both the Erne and the Shannon has increased with the Erne going from 36.3% to 58.4% SSB and the Shannon going from 32.6% to 34.0% SSB.

National Silver Eel Production, Escapement and Mortality: Current escapement is expressed as a percentage of the historic production, given for 2008 and for the 2009-2011 period as an average. The positive effect of the implemented management measures (fishery closure and silver eel trap and transport) can be seen by the total %SSB increasing from 25.6% (2008) to 36.7% (2009-2011).

The two EMUs where the impacts were severest with both fisheries and hydropower were the IE_Shan and IE_NorW. In the IE_Shan the %SSB went from 10.7% to 34.5% (2009-2011) to 36.3% (2012-2014) and in the IE_NorW the %SSB went from 35.2% to 36.9% (2009-2011) to 57.4% (2012-2014), also reflecting the anticipated increase in output due to past recruitment history in the mid-1990s.

The IE_West also showed a large increase in SSB although this should be treated with some caution as the model may have over-estimated production from the very large area of the Corrib catchment.

While Ireland has reduced its anthropogenic mortality to low levels, it is unlikely that the increase in biomass in the last three years can be sustained much into the future due to the legacy of poor recruitment. The international view is the stock is still below safe biological limits. A preliminary analysis of available data (post 2012 reporting) indicated that current (2012) silver eel escapement biomass was at approximately 6% of the historical 'pristine' state.

2 Implementation of management measures

Describe the measures implemented since the adoption of your eel management plan, including the year of implementation and, where practical, realised or anticipated effect on silver eel escapement biomass.

The EC Regulation (Council Regulation 1100/2007) for the recovery of the eel stock required Ireland to establish eel management plans for implementation in 2009. Under the EC Regulation, Ireland should monitor the eel stock, evaluate current silver eel escapement and post-evaluate implemented management actions aimed at reducing eel mortality and increasing silver eel escapement.

The Irish Eel Management Plan which was submitted to the EU on the 9th January 2009 and accepted by the EU in June 2009 outlined the main management actions aimed at reducing eel mortality and increasing silver eel escapement to the sea. The four main management actions were as follows;

1. A cessation of the commercial eel fishery and closure of the market
    - Action 1a: Closure of fishery
    - Action 1b: Recreational Fishery
    - Action 1c: Diversification of the Fishery

2. Mitigation of the impact of hydropower, including a comprehensive trap and transport plan to be funded by the ESB
    - Action 2a: Trap and transport
    - Action 2b: Quantify turbine mortality
    - Action 2c: Engineered solutions
    - Action 2d: Other solutions

3. To ensure upstream migration of juvenile eel at barriers
    - Action 3a: Existing barriers (including small weirs)
    - Action 3b: New potential barriers
    - Action 3c: Assisted migration and stocking

4. To improve water quality
    - Action 4a: Compliance with Water Framework Directive
    - Action 4b: Fish health and biosecurity

2.2 Reduction of Fishery – Management Action #1

2.2.1 Introduction

The first Management Action set out in the Irish Eel Management Plan (2009) was to eliminate fishing mortality and to reduce illegal capture and trade to as near zero as possible with a view to promoting a recovery of the stock in the shortest time possible.

In May 2009, the Minister for Communications, Energy and Natural Resources passed two Bye laws closing the commercial and recreational eel fishery in Ireland.

- **Bye-Law No 858, 2009** prohibits the issue of eel fishing licences by the regional fisheries boards in any Fishery District.

- **Bye-law No C.S. 303, 2009** prohibits fishing for eel, or possessing or selling eel caught in a Fishery District in the State until June 2012.

In the transboundary areas 'The Foyle Area and Carlingford Area (Conservation of Eels) Regulations 2009' was created which prohibits the taking or killing of eels within the FCILC area.

The Northern Ireland portion of the of the Erne was closed from April 2010 following ratification of UK submitted Eel Management Plans in March 2010 which included the Ireland/UK IE_NorW transboundary plan. The Erne fishery (both north and south) has remained closed from April 2010 to date.

Bye-law 303 of 2009 was renewed in 2012 extending the prohibition on fishing for eel, or possessing or selling eel caught in a Fishery District in the State until June 2015.

- **Bye-law No C.S. 312, 2012** prohibits fishing for eel, or possessing or selling eel caught in a Fishery District in the State until 30 June 2015.

2.2.2 Action 1a: Closure of fishery

See Section 1.4 for the description of the Eel Management Units and for the transboundary agreement with Northern Ireland. All management regions confirmed total closure of the eel fishery for the period 2009 to 2014 with no commercial or recreational licences issued. In the transboundary region, there were no licences and no legal fishery in the Foyle and Carlingford areas from 2009 to 2014. The Northern Ireland portion of the Erne fishery has remained closed from April 2010 to date.

Annual returns from each of the EMUs have indicated levels of illegal eel fishing activity to have remained low or very low over the period from 2009 to 2014. Over the past three years there has been some evidence of an increase in levels of illegal activity from the lower Shannon and Upper Erne areas as confirmed by periodic detection and seizure of illegal fyke nets, long lines and coghill nets in these fisheries (Table 2.1).

Table 2-1: Summary of illegal eel fishing activity recorded and eel dealer movements encountered by IFI regions and Loughs Agency from 2009-2014.

	Year	ERBD	Loughs Agency	NWRBD	SHRBD	SERBD	SWRBD	WRBD
Est. level of Illegal fishing	**2009**	Low	None	Low	Medium	None	None	None
	2010	Low	None	Low-medium	Low (Shannon & East Clare lakes)	None	None	Low
	2011	Low-medium	None	Low	Medium	None	None	None
	2012	Low	None	Low	Low (Shannon & East Clare lakes)	None	None	Low (mainly L. Corrib)
	2013	Low	None	Low	Medium (mainly L. Ree)	None	None	None
	2014	None	Low	Low	Medium (mainly L. Ree)	None	Low-nil	Low-nil
Number of gear seizures	**2009**	0		3	3 (L Derg & L Cutra)	0	0	2
	2010	2	0	2	0	0	0	2
	2011	7	0	2	8	0	0	5
	2012	3	0	1	5	0	0	1
	2013	0	0	4	6	0	0	2
	2014	0	2	3	12	0	0	0
Gear types seized	**2009**	0		2 fykes, 1 longline	4 fykes, 3 longlines	0	0	9 fykes
	2010	11 fykes, 6 longlines	0	40 fykes, 1 boat	0	0	0	29 fykes
	2011	3 fykes, 4 longlines	0	2 fykes, 3 longlines	8 fykes, 3 coghills, 1 angling rod	0	0	5 fykes
	2012	3 fykes	0	1 coghill	5 fykes	0	0	50 fykes (possibly lost)
	2013	0	0	12 fykes, 2 coghills	110 fykes, 800 m longlines	0	0	2 fykes
	2014	None	2 Angling rods	20 fykes	54 fykes, 2010 m longlines	0	0	1 fyke (probably lost)
No. of dealer interceptions	**2009**	1	0	1	0	0	0	0
	2010	0	0	0	0	0	0	0
	2011	0	0	1	0	0	0	0
	2012	0	0	0	0	0	0	0
	2013	0	0	0	0	0	0	0
	2014	0	0	0	0	0	0	0
Estimated tonnage on board		858 kg (2009)		2,000 kg (2009)				
				113 kg (2011)				

2.2.3 Action 1b: Recreational Fishery

The legislation prohibits the possession of eel caught in Ireland and this extends to cover recreational angling. All other forms of recreational gear were legislated for along with the commercial fishery and are currently prohibited under the eel legislation. There is little tradition of recreational angling for eel in Ireland and there is little evidence to suggest that eels are captured in significant numbers as by-catch of angling for other fish species. Bye laws prohibiting the possession of eel caught in Ireland are enforced and require any eels accidentally caught as bycatch to be immediately returned. However where eels are captured on rod and line and returned with hook still attached (due to difficulty in disgorging the hook) it is likely that such eels may be moribund.

2.2.4 Action 1c: Diversification of the Fishery

No formal diversification programme for former licenced eel fishermen was introduced on closure of the commercial fishery. Some commercial fishermen have availed of temporary seasonal contracts offered by the ESB for conservation fishing of silver eel on the Shannon, Erne and Lee catchments as part of the ongoing annual trap and transport programme implemented by the ESB. Additional short term contracts were also made available through Inland Fisheries Ireland (IFI) to former commercial eel fishermen to assist in periodic surveys of yellow and silver eel as part of the national eel monitoring programme.

2.3 Mitigation of Hydropower – Management Action #2

2.3.1 Action 2a: Trap & Transport

Silver eel trap and transport programmes, to mitigate against Hydropower Station induced mortality, took place in the Shannon (IE_Shan), Erne (IE_NorW) and Lee (IE_SouW).

In both the Shannon and Erne catchments, anthropogenic mortality during 2012-2014 was kept as low as possible by closing the fishery and transporting silver eels around the HPSs, and this is evident by examining the biomass data (see Table 1.1 & 1.3 and Annex 1).

In the EMP, the objective set by the national WG on Eel was to aim to recover the stock in the shortest time practicable. Trap and Transport amounts of silver eel were set by agreement between DCENR, DCAL and ESB, with the 30% of the production in the Shannon and three fixed annual catch quota in the Erne for 2009, 2010 & 2011 (Table 2.2).

Following assessment of eel production from the Erne for the initial period from 2009-2011 it was decided to adopt a target based on silver eel production (similar to that operated on the Shannon) rather than a fixed annual target weight as previously used. The target adopted for the Erne was 50% of silver eel production. This target is more adaptable to annual fluctuations in eel production and silver eel escapement as influenced by environmental factors (such as winter floods and ambient temperatures). The achievement of the target is also presented as a rolling three year average (whereby annual surpluses or deficits above/below the target can be compensated for the following season).

Taken into account in setting these quotas were the estimated eel production, recent past recruitment history, practicable feasibility and infrastructure/fishing experience on each catchment.

The targets set in the Irish Eel Management Plan for the trap and transport of silver eels 2009-2011 and modified for 2012 – 2014 were as follows:

Table 2-2: Silver eel trap and transport targets and proportion of EU H achieved for the Rivers Shannon, Erne and Lee from 2009 to 2014

***Shannon**: Trap and transport 30% of the annual escapement*

	catch target (t)	% of expected silver eel run
2009	not defined	30
2010	not defined	30
2011	not defined	30
2012	not defined	30
2013	not defined	30
2014	not defined	30

Erne: Trap and transport 50% of the annual escapement from 2012-2014

	catch target (t)	% of expected silver eel run
2009	22	36
2010	34	54
2011	39	63
2012	not defined	50
2013	not defined	50
2014	not defined	50

**Erne Fishery not closed in N. Ireland in 2009; closed 2010-2014*

Lee: Trap and transport 500kg of the annual escapement

	catch target (t)	% of expected silver eel run
2009	0.5	34
2010	0.5	34
2011	0.5	34
2012	0.5	not defined
2013	0.5	not defined
2014	0.5	not defined

The total amounts of silver eel trapped and transported in each of the three rivers from 2009 to 2014 are presented in Table 2.3. Further details of the amounts transported from each site on each date for each year are available in the relevant SSCE annual activity reports.

The transport target was achieved in the R. Shannon in five of the 6 years and the 3 year running average was above target for the whole time period.

The transport target was not achieved in the Erne between 2009 and 2011, but was achieved in each year from 2012 to 2014. The 3 year running average was above target from 2011 to 2014.

The transport target on the River Lee was achieved in three of the six years (2011, 2013 and 2014). The 3 year running average was above target from 2011 to 2014.

In the R. Shannon, the existing structures and experience in silver eel fishing contributed to the success of the programme. Combining the upstream fisheries with the fishery in Killaloe ensured that the 30% of the run target was achieved and also ensured a better spread of capture dates and high quality of eel.

In the R. Erne, the target for 2009-2011 was set as a fixed amount per annum based on the estimate of the run for 2001-2007 and an expectation that the silver eel production would remain high due to the history of recruitment in the 1990s. For the period 2012-2014 a trap and transport target of 50% of the silver eel production was adopted, similar to the methodology operated on the Shannon. This is more adaptable to changing eel production and facilitates incorporation of inter-annual fluctuation in silver eel runs. A rolling target (applied on a 3-year basis) allowed shortfalls in trapping targets in one year to be made up the following year. A consistent long-term shortfall cannot be carried forward indefinitely. Both the experience and level of fishing effort increased on the Erne and this led to improved catches of eels for transport. Along with the increased experience, the inclusion of additional fishing sites in the upper catchment improved the success of the Erne silver eel trap and transport programme from 2011 to 2014.

In the River Lee where there was no history of silver eel fishing, the trap and transport programme was undertaken with a view to capturing potential spawners in the areas above the hydropower facilities and releasing them downstream. Fishing in 2009 was hampered by unusually high floods and in 2010 by very low water levels. A different approach was employed in 2011 and thereafter with fishing taking place by fyke net in July or August. The annual catch and transport target of 0.5 t was achieved in each of the years 2012 to 2014. Analysis of the catches indicates that a very high proportion of the eels transported on the Lee can be expected to migrate as potential spawners in the year of transport as evidenced by the proportion of captured eels displaying classic silvering characteristics (e.g. skin colouration, increased eye diameter).

Table 2-3: Total amounts (t) of silver eel trapped and transported in the Shannon, Erne and Lee, 2009-2014, and the success relative to the target set in the EMPs.

Catchment	Year	T&T Target	Amount Transported (kg)	Relation to target	Status	3 yr Running Average
R. Shannon	2009	30% of run	23,730	31%	Achieved	37%
R. Shannon	2010	30% of run	27,768	40%	Achieved	38%
R. Shannon	2011	30% of run	25,680	39%	Achieved	34%
R. Shannon	2012	30% of run	24,228	36%	Achieved	34%
R. Shannon	2013	30% of run	22,561	28%	Not achieved	33%
R. Shannon	2014	30% of run	26,438	37%	Achieved	37%
R. Erne	2009	22t	9,383	42.6	Not achieved	
R. Erne	2010	34t	19,334	56.9	Not achieved	46.9
R. Erne	2011	39t	25,405	65.1	Not achieved	59.3
R. Erne	2012	50% of run	34,660	51.2%	Achieved	57.1%
R. Erne	2013	50% of run	39,319	53.6%	Achieved	60.0%
R. Erne	2014	50% of run	48,126	66.4%	Achieved	66.4%
R. Lee	2009	0.5t	79	16%	Not achieved	73%
R. Lee	2010	0.5t	278	56%	Not achieved	83%
R. Lee	2011	0.5t	731	146%	Achieved	119%
R. Lee	2012	0.5t	230	46%	Not achieved	115%
R. Lee	2013	0.5t	824	165%	Achieved	150%
R. Lee	2014	0.5t	670	134%	Achieved	134%
National Annual Totals						
Total	2009		33,192			
Total	2010		47,380			
Total	2011		51,816			
Total	2012		59,090			
Total	2013		62,704			
Total	2014		75,192			

2.3.2 Action 2b: Quantify turbine mortality

Acoustic tag telemetry was used to determine migration routes and mortality of migrating silver eel at ESB hydropower stations on both the Shannon and the Erne. Studies were conducted on the Shannon between 2006 and 2011 and on the Erne in 2010 and 2011 (Table 2.4).

Shannon

Summarising the annual data gives mortality ranges of 16.6% to 25% and an overall average mortality of 21.15 ± 8% for 104 tagged eel arriving at Ardnacrusha HPS. This average has been used in the assessments for 2012-2014.

In the Eel Management Plan, a figure of 30% was used to account for the amount of eel potentially using the bypass route down the old river channel and around Ardnacrusha HPS. For 2009 – 2011, the actual amount of eels recorded to have used the bypass route was 59%, 4.4% & 12.5% respectively. A general figure for eels estimated to use the bypass in recent years is 17.8%. Between 2012 and 2014, 1.6%, 24.3% and 15.9% respectively were estimated to have used the bypass channel.

Erne

Summarising the data from 2009 to 2011 for the Erne gives mortality ranges for Cliff HPS of between 6.9% and 8.5% and an average of 7.8% ± 5% and mortality for Cathaleen's Fall of 22% (9 tags) in 2009. In 2010 and 2011, one turbine was removed for renovation at Cathaleen's Fall HPS and therefore the mortalities were lower at 6.1% and 7.7%. It is likely that mortality rates will at least double when both turbines return to full operation which will necessitate further assessment to confirm site-specific mortality rates.

During the 2013 and 2014 silver eel seasons the patterns of generation and spillage at the River Erne hydropower stations were similar. In the analyses of eel hydropower passage, varying mortality levels were incorporated, per calendar day, into the escapement model. These were based on dusk-dawn hydrometric data, power generation activity and results of previous years silver eel acoustic telemetry. Generation protocols and associated mortality rates have been described in previous reports. For the 2013 and 2014 seasons different mortality rates were applied as follows: ***Cliff HPS*** (0%, only spillage); 7.9% (Generation plus spillage) and 26.7% (Only generation), ***Cathaleen's Fall HPS***: 0% (only spillage; 7.7% (spillage plus half generation load); 15.4% spillage plus full generation load); 27.3% (only generation).

Currently there is no solid information about the proportions of eel that migrate via spillways compared to via the turbine passages. There may be selective migration towards the spillways, especially at Cliff, which may help to explain the low HPS mortality levels observed on the Erne to date. On return to full generation protocols additional work will be needed to confirm eel migration routes and overall HPS mortality rates on the Erne.

Table 2-4: Summary mortality data for acoustic telemetry on the Shannon (mortality and bypass) and Erne (2 Stations- Cliff & Cathaleen's Fall stations).

	Year	Number of tagged eel	Mortality*	Number of tagged Eel	Mortality		% using bypass
Shannon	2006						
	2007						
	2008						
	2006-2009	44	20.4%	-	-		59%
	2010	40	22.5%	-	-		4%
	2011	20	20.6%	-	-		13%
Average 2006-2011			**21.15%**				
	2012	No direct assessment, 21.15% used in estimating escapement					1.6%
	2013	No direct assessment, 21.15% used in estimating escapement					24.3%
	2014	No direct assessment, 21.15% used in estimating escapement					15.9%
		Number of tagged eel	**Mortality***	**Number of tagged Eel**	**Mortality****		
		Cliff HPS		**Cathaleen's Fall HPS**			
Erne	2009	13	7.7%	9	22		
	2010	29	6.9%	26	7.7	one turbine	
	2011	60	8.5%	49	6.1	one turbine	
	2012	30	26.7%	No assessment; 8% used in estimating escapement			
	2013		26.7%/7.9%/0% used***	0%/7.7%/15.4%/27.3% used****			
	2014		26.7%/7.9%/0% used***	0%/7.7%/15.4%/27.3% used***			

* Ardnacrusha on the R. Shannon; Cliff on the R. Erne

** Cathaleen's Fall on the R. Erne

*** Cliff HPS Estimates applied with and without spillage, no direct assessment

**** Cathaleen's Fall HPS Estimates applied with and without spillage, no direct assessment

2.3.3 Action 2c: Engineered Solutions

Over the period 2009-2014 mitigation of HP induced eel mortalities has been addressed primarily through the expansion of trap and truck measures on the River Shannon, and initiation of truck and trap measures on both the Erne and Lee river systems. The potential for engineered solutions to contribute to improved silver eel escapement through HP facilities and defray the ongoing costs of trap and truck programmes is recognised by the ESB and is being actively considered in conjunction with various technologies trialled to date (see below).

Preliminary silver eel deflection experiments, using weir-mounted LED floodlights, were undertaken at Killaloe, River Shannon in 2014. A more extensive series of eel deflection experiments are planned for the autumn 2015 at Killaloe and additional sites.

Future application of new technologies will require further analysis to determine their efficacy and suitability at different facilities and flow regimes, in advance of significant engineered modification of existing HP facilities.

2.3.4 Action 2d: Other Solutions

Migromat®

Evaluation of the capacity of a commercially available biomonitoring tool (Migromat®) to predict eel migration peaks was undertaken by NUI Galway researchers at Killaloe (2008–2010). The Migromat® system involves analysis of, with special software, activity patterns of PIT tagged eels contained in special tanks equipped with PIT tag detectors between chambers in the tanks. The Migromat® equipment (Fig. 2.1) was located at the ESB owned Pier Head site, located on the western bank of the River Shannon 0.5km upstream of the Killaloe eel weir. The experimental evaluation of the technology involved collaboration between Irish, French and German partners and detailed results are being presented elsewhere.

Figure 2-1: Migromat® eel biomonitoring equipment at Pier Head, Killaloe during 2008-2010.

The Killaloe Migromat® research involved evaluation of the prediction capacity of the technology, with respect to daily catch records at the Killaloe weir. The analytical protocol assumed existence of a hypothetical ("run of the river") hydropower station at Killaloe Bridge. The evaluation involved analysis of catch data, as a proxy for numbers of eels approaching the hypothetical power station, and the presumed capacity of station management to reduce eel turbine passage mortality by various responses (e.g. temporary shutdown). The results indicated that this technology was not very effective at the experimental location and that, where data allows, predictive modelling along the lines undertaken in respect of Killaloe would allow for more accurate prediction of migration peaks at Irish hydropower stations. Models developed by NUI Galway, using detailed data compiled during 2008–2012, and historical records will provide a better capacity for prediction of the effects of hydrometric/spillage patterns on silver eel migration. Increased knowledge of the environmental factors determining peak migration events will facilitate silver eel conservation.

Deflection Technology and bypasses

Preliminary experiments using eel deflection technologies (light, infrasound) were undertaken on the lower River Shannon in 2011/2012, 2012/2013 and was this work was extended in 2014/2015 with a view to evaluating options for development of 'engineered solutions' to the problems faced by downstream migrating silver eels. Light deflection experiments that were undertaken on the Killaloe eel weir (Fig. 2.2) involved evaluation of eel responses with respect to catches made in each of a series of nets during periods when a light array was either switched on or off. Clear evidence of eel deflection, in response to light, was demonstrated.

DIDSON™ (Dual Frequency Identification Sonar) camera observations on downstream natural migrating silver eels at the Pier Head site on the Shannon and Lower River Erne, Roscor Bridge, have been linked to daily silver eel catches at these sites. Work is currently in progress on the evaluation of DIDSON™ technology for quantification of the numbers and biomass of eels migrating via the Ardnacrusha headrace canal. Ongoing research by NUI Galway and ESB, on analysis of eel responses to spillage, involves use of telemetry and experimental fishing. However, the preliminary results from DIDSON™ silver eel surveys at Clonlara suggests that use of this technology will permit better predictive capacity in respect of eel migration route selection at sites such as the Parteen Regulating Weir.

Figure 2-2: Experimental use of a light array and DIDSON™ camera at Killaloe for investigation of silver eel responses to light.

2.3.5 Action 2e: New turbine installations

There has been limited interest in development of small-scale hydropower facilities in Ireland over the period 2009-2014 with seven new turbine developments recorded nationally in the RoI over the 2009-2014 period (Annex 2). As a prescribed body under the Planning Acts, Inland Fisheries Ireland (IFI) comments and provides advice on all developments which may impact or impinge on fisheries or fisheries habitat. Guidelines exist for the planning, design, construction and operation of small-scale hydroelectric schemes with regards to fisheries protection (Anon, 2007).

2.4 Ensure Upstream Migration at Barriers – Management Action #3

2.4.1 Action 3a: Existing barriers (including small weirs)

Under the National Eel Management Plan, Objective 7 requires the evaluation of upstream colonisation: migration and water quality effects. Lasne and Laffaille (2008) found that while eels are capable of overcoming a wide array of obstacles the resulting delay in migration can have an impact on the eel distribution in the catchment. Knowledge of what constitutes a barrier for eels (at different life stages) will assist in the estimation of eel population densities and escapement for future management plan reviews.

The EU Habitats Directive (Directive 92/43/EEC) and Water Framework Directive (2000/60/EC) both require the assessment of barriers to fish migration. In order to tackle the issue on a multispecies level IFI established a National Barriers Group in 2011. This group is building on the earlier work to develop a standardised assessment of barriers nationally and is currently evaluating an IFI survey sheet and assessment methodology. The long term aim is to develop a national database of barriers for rating fish pass ability which in turn will provide information to target mitigation measures at the most significant obstructions.

IFI continue to roll out barrier assessment training to staff around the country. Barriers are assessed on a multispecies level with an initial assessment to determine if a structure is a barrier. Once a barrier has been documented as a problem the detailed Scottish and Northern Ireland Forum for Environmental Research (SNIFFER) assessment tool is applied in order that adequate solutions can be put in place. Barrier removal and mitigation measures are being taken on a case by case basis around the country. The mitigating measures include the creation of rock ramps, removal of weirs or sections of weirs, remedial works on existing fish passes and improved fish passage at bridges and culverts. Successful movement of fish as a result of barrier mitigation works is visible in the River Tolka with the presence of salmon in the river after a long absence and in the Mulkear River with the successful passage of sea lamprey over the Annacotty weir. IFI are committed to the long term objective of ensuring fish passability and re-establishing the connectivity within our wetted areas.

Northern Ireland – Existing barriers

The Northern Ireland Environment Agency WFD hydro-morphology group have been trialling the new Scottish and Northern Ireland Forum for Environmental Research (SNIFFER) assessment tool in ongoing surveys in Northern Ireland, but as eel are considered capable of finding their way round most conventional barriers they are not including them in their assessments. In the NE River Basin District (Lagan and Quoile) the Agri-Food and Biosciences Institute (AFBI) have taken a different approach: rather than walk the rivers and assess all barriers they are trialling a quick assessment by setting fyke nets in the most upstream lakes. Length / frequency and age data of eels are collected. If eels are present with a "conventional" length-frequency and age profile then the river system is deemed passable to that point. So far, this technique has worked well. If no eel were recorded, further investigations would be triggered. An abnormal age profile (e.g. high numbers of older eel and absence or reduced numbers of younger age classes) indicates some land locking (e.g. Castlewellan lake where there are controlled outlets). This approach has since been adopted by other Northern Ireland authorities.

In the cross-border Foyle and Carlingford area, the Loughs Agency area has undertaken a prioritisation assessment of 78 barriers using a version of the SNIFFER assessment tool. In addition under an EU INTERREG IVA project a Ph.D student is currently investigating barriers and salmon migration on the River Mourne and it is planned to conduct similar research on eels and the potential impact of barriers on eel migration.

2.4.2 Action 3b: New potential barriers

New barriers are subject to existing fisheries legislation such as the Fisheries (Consolidation) Act, 1959, together with requisite planning regulations and guidelines. The decline of European eel stocks has heightened awareness of the requirement for eel passage provision on any new planning proposals for instream structures which may form potential barriers to migration.

2.4.3 Action 3c: Assisted migration and stocking

Assisted upstream migration takes place at the ESB Hydropower Stations on the Shannon (Ardnacrusha, Parteen), Erne (Cathaleen's Fall), Liffey and Lee. This has been a long-term objective to mitigate against the blockage of the HPSs under ESB Legislation (Section 8, 1935). On the Erne and Shannon, elver and bootlace eel are transported upstream from the fixed elver traps. On the Erne, the distribution of elver throughout the catchment is by cross-border agreement between the ESB, IFI and DCAL. These programmes, which were outlined in the EMP, were continued in 2012-2014.

Due to concerns relating to the possible introduction of pathogens and/or non-invasive species to Irish waters, the Standing Science Committee on Eel **advises against any introductions of live eel** imported from outside Ireland and especially from the continent. The SSCE **also advises against inter-catchment translocations** of live eel and/or water to minimise the spread of already introduced non-native species.

2.4.4 Legislation relating to fisheries, fish passage and abstraction

2.4.4.1 Ireland

Conservation, management and development of Ireland's inland fisheries resource (including eel) is the responsibility of Inland Fisheries Ireland as provided for under the Inland Fisheries Act (No. 10 of 2010).

In accordance with Ireland's Eel Management Plan which was submitted to the EU in January 2009, the following Conservation of Eel fishing bye laws were enacted in May 2009:-

- Bye-Law No 858, 2009 prohibits the issue of eel fishing licences in any Fishery District.
- Bye-law No C.S. 303, 2009 prohibits fishing for eel, or possessing or selling eel caught in a river in the State.- This bye law was replaced by Bye-law No C.S. 312, 2012 which extends the provisions to 30 June 2015.

The Electricity Supply Board (ESB) has statutory responsibility for the management and preservation of fisheries throughout the Shannon catchment as well as fisheries responsibilities on the Erne, Lee, Liffey and Clady/Crolly which are impounded by large-scale hydropower facilities. Relevant legislation includes:- the Electricity Supply Act (1925 and 1945), the Shannon Fisheries Act (No.4 of 1935; and the Shannon Fisheries Act (No.7 of 1938).

The primary fisheries legislation in relation to hydropower dams is provided in Part 8, Chapter 5 of the Fisheries (Consolidation) Act 1959. In addition to the 1959 Act the Fisheries Act 1980 charged the Fisheries Boards with the protection, conservation and management of fisheries (Section 18). The Fisheries (Amendment) Act, 1999 further expanded this remit to include Sustainable Development of the Inland Fishery Resource (this included inter alia other species of fauna and flora, habitats and the biodiversity of inland water ecosystems (Section 8(1) (i)). Consideration must also be given to protection of fisheries afforded by other relevant legislation including the Water Framework Directive, Habitats Directive and other EU legislation.

As a prescribed body under the Planning Acts, Inland Fisheries Ireland comments and provides advice on all developments which may impact or impinge on fisheries or fisheries habitat. Guidelines exist for the planning, design, construction and operation of small-scale hydroelectric schemes with regards to fisheries protection (Anon, 2007). There has been limited interest in development of small-scale hydropower facilities in Ireland over the period 2009-2011 (with fewer than 10 developments nationally over the period).

The legislation relating to fish passage requires that every dam in or across any salmon river shall be constructed as to permit and allow, in one or more parts thereof, the free and uninterrupted migration of all fish at all periods of the year, (Section 115 subsection 2 and 3) of the Fisheries (Consolidation) Act 1959. Fish passes must be approved individually by the Minister for Communications, Energy & Natural Resources, (1842 Act, Section 62/63). Good practice requires that fish passes be capable of being negotiated by fish without undue effort, should not expose the fish to risk or injury, and be easily located by the fish. Section 116 relates to fish passage over dams and requires free passage of fish as in Section 115. There is provision within Section 116 for penalties to be imposed and this section is useful when operators fail to comply with a notice from the Minister.

Upstream passage of juvenile eel, migrating as either elvers or juvenile "bootlace" yellow eel, requires a fundamentally different approach to that for upstream migrating adult "swimming" fish such as salmon, trout or coarse fish. Therefore, traditional upstream passes designed for salmon, such as pool passes or Denil type ladders are largely ineffective for eel.

The primary aim in the design of upstream eel passes is to provide suitable conditions to allow the ascent of a hydraulic drop, natural or man-made, or where ascent may be difficult and upstream recruitment rendered sub-optimal, such as at a road culvert. Eels are incapable of jumping, or swimming through strong laminar flows, so vertical falls of more than 50% of their body length (an elver is approximately 75mm in length) represent a barrier to upstream migration (Knights & White 1998). However, they are adept at exploiting boundary layers and rough substrates which can be utilized in eel pass design. Solomon & Beach (2004) presented a comprehensive review of the design of eel and elver passes including facilities based on ramps with substrate, pipe passes, lifts and locks, easements or complete barrier removals. This important manual is available from the Environment Agency, UK.

A site specific approach should be taken in relation to addressing downstream passage when evaluating the impact of existing installations and proposing mitigating measures. The Environmental Impact Assessment for any new barriers and/or turbine installations should include an evaluation of their potential impact on direct and indirect mortality of silver eel and should also be included in any catchment based plans for the management of eel stocks.

2.4.4.2 N. Ireland

Eel Fisheries legislation, fish passage, and water abstraction in NI

The River Basin Eel Management Plans drawn up under the EU eel regulation were incorporated into Northern Ireland law with the enactment of the Eel Fishing Regulations (Northern Ireland) 2010. (*Statutory Rules of Northern Ireland 2010 no 166).* Under these regulations, which came into operation in April 2010, all commercial eel fishing is prohibited in Northern Ireland with the exception of in Lough Neagh and the existing eel weirs on the Lower River Bann.

Fishing for trap-and transport of silver eel past the River Erne hydro-electric stations is permitted under special permission given under section 14 of the NI fisheries act (1966), as can be any fishery activity for the purposes of research or monitoring of stocks.

In relation to barriers to migration, legal provisions exist in the 1966 fisheries act to enforce fitting of eel passes to weirs or other man made barriers built after 1842. For weirs built before that date, construction of a pass can be legally enforced where the weir is modified, repaired or water abstracted for a changed use (e.g. hydropower generation).

Currently there is significant interest in new small scale hydropower in Northern Ireland, encouraged by the premiums payable for electricity generated without the use of fossil fuels. New hydropower constructions are subject to planning approval, which also requires that water abstraction licenses fishery protection and passage requirements required by fisheries legislation are in place. Gradients and flow requirements mean that many of the new hydro developments are on existing or former mill sites, on rivers with relatively minor interest for eel.

2.5 Improve water quality – Management Action #4

2.5.1 Action 4a: Compliance with the Water Framework Directive

The improvement of water quality in Ireland is primarily being dealt with under the workprogramme for the implementation of the Water Framework Directive (WFD). The objectives of the Water Framework Directive (WFD) are to protect all high status waters, prevent further deterioration of all waters and to restore degraded surface and ground waters to good status by 2015. A major programme is under way to achieve this target, with monitoring beginning in Dec 2006. National regulations for implementing the directive were put in place in 2003. The WFD reporting and monitoring runs on a six year cycle, so the next opportunity to assess whether water quality is improving will be with the publication of the second River Basin Management Plans (RBMP) in 2015.

In the interim period, the Environmental Protection Agency (EPA) compile statistics on water quality in Ireland, the most recent of which covers the period 2007-2009 (McGarrigle *et al.* 2011; Table 2.5). The ecological quality of monitored water bodies was determined using a combination of biological and physicochemical metrics. 1550 river water bodies were included in this report, with 52% being classified as being of high or good ecological status. 26 river sites were classified as having bad ecological status. 105 (47.3%) lakes were of high or good status with the majority, 38.3 per cent, being in the latter category. A total of 121 transitional and coastal water bodies were assessed between 2007 and 2009 for WFD status classification. Of these, 55 were classed as either high (16%) or good (30%) ecological status with the remainder being classed as moderate or worse. Sewage and diffuse agricultural sources continue to be the main threat to the quality of Ireland's waters.

The Irish EPA reports (summarised above) refer to waterbodies within seven RBD's (Eastern, Neagh Bann, North Western, South Eastern, Shannon, South Western, Western). The Neagh Bann, Shannon and North Western IRBD's are transboundary, in that there are portions of them in Northern Ireland. Only a very small portion of the Shannon IRBD is in Northern Ireland, while the Northern Irish catchments in the Neagh Bann IRBD are not included in the Irish Eel Management reports. Therefore, the implementation of the WFD in the Northern Irish part of the North Western IRBD is also of interest in this report, as it is the major international RBD which is considered in this eel management report. Interim classification of the ecological quality of the North Western IRBD (north of the border) indicates that the majority of waterbodies are of high, good or moderate quality. However, it is noted that 60% of rivers, 81% of lake area, all transitional waters and all coastal waterbodies, will need to have their status improved to meet the requirements of the WFD (NIEA NSSHARE 2008).

2.5.2 WFD monitoring – fish.

Inland Fisheries Ireland has been assigned the responsibility for delivering the fish monitoring element of the WFD in Ireland. Eel are included in the WFD (fish) monitoring of rivers, lakes and transitional waters. While this data will be included in the overall assessment of the second cycle of WFD reporting for 2015, summary reports are available (www.wfdfish.ie). The most relevant of these summary reports is the report for 2013 (Kelly *et al.* 2014). In 2013, a comprehensive fish surveillance monitoring programme was conducted, with 63 river sites, 24 lakes and 2 transitional waters successfully surveyed throughout the country (Table 2.5). Eel are ubiquitous across all catchments, and were found in 83.3% of lakes surveyed and 69.8% of rivers.

Table 2-5: Interim assessment of Irish waterbodies according to fish metrics, 2007-2013, and as part of the WFD monitoring program carried out by Inland Fisheries Ireland (Kelly et al. 2014) for the full suite of metrics carried out by the Environmental Protection Agency (McGarrigle *et al*. 2011).

Period	Components monitored		No. of sites surveyed	% High	% Good	% Moderate	% Poor	% Bad	Source	Number of fish kills reported to IFI
2007-2009	**Fish only**	**Rivers**	134	8	49	40	2	1	IFI	
		Lakes	70	14	30	49	6	1		
		Transitional	72	1	51	32	13	3		
2010	**Fish only**	**Rivers**	43	9	39	42	0	0		
		Lakes	25	24	32	4	4	40		
		Transitional	25	0	52	36	8	4		
2011	**Fish only**	**Rivers**	65	12	32	43	9	2	IFI	31
		Lakes	29	28	34	17	24			
		Transitional	2	0	50	50	0	0		
2012	**Fish only**	**Rivers**	58	14	59	26	9		IFI	10
		Lakes	23	43	17	13	17	9		
		Transitional	3	0	33	66				
2013	**Fish only**	**Rivers**	63	10	41	44	5	0	IFI	52
		Lakes	24	25	33	4	25	8		
		Transitional	10	0	60	40	0	0		
2007-2009	**Full suite**	**Rivers**	1564	13	39	28	19	1	EPA	
		Lakes	222	9	38	41	9	<1		
		Transitional	121	16	30	51	3			

2.5.3 Fish kills

A total of 16 fish kills were reported in 2009, 38 in 2010, 31 in 2011, 10 in 2012 and 52 in 2013 (IFI Annual Reports). There were 24 reported fish kills in 2014 (IFI preliminary data). The majority of these fish kills were attributed to a cause other than those related to agriculture, industry or local authority infrastructure. While none of these fish kills refer specifically to eel, it is likely that where conditions result in a kill of any fish species, there are likely to be detrimental impacts on all species in the waterbody. The impact on eel has not been quantified. The data suggest that fish kills are becoming less common over the last decade.

2.5.4 Action 4b: Fish Health and biosecurity issues

Toxins

The EPA carried out surveillance monitoring in 2007-2009 of 180 river sites and 76 lake sites for what are known as dangerous substances (i.e. priority substances and priority hazardous substances). Monitoring was undertaken at each site with a frequency of 12 times per year once the programme commenced in mid-2007. Generally, the occurrence of environmentally significant metals was found to be low in Ireland. In addition, the levels of priority pollutants (plant protection products, biocides, metals and other groups such as combustion byproducts, polyaromatic hydrocarbons (PAHs), and the flame retardants polybrominated diphenyl ethers (PBDEs)) were generally very low with very few exceedances being found (McGarrigle *et al*. 2011). This data confirms that bioaccumulation of toxins of eels in Ireland is likely to be less significant than that observed in many other EU countries.

Prevalence of Anguillicola crassus

A comprehensive review of the distribution, prevalence and intensity of *A. crassus* in Ireland by Inland Fisheries Ireland has recently been published in the *Journal of Fish Biology (Beccera-Jurado et al. 2014)*. The abstract is included below:

"This study is the first comprehensive documentation of the geographical range of *Anguillicola crassus* in its host, the European eel *Anguilla anguilla* in the Republic of Ireland. The prevalence and intensity of infections across 234 sites and 93 river basins in Ireland comprising rivers, lakes and transitional waters (estuaries) were analyzed. While only 32% of the river basins were affected by this nematode, they correspond to 74% of the total wetted area. Significant differences in infection levels among water body types were found with lakes and transitional waters yielding the highest values, which can be attributed to the proportions of juvenile (LT < 300 mm) *A. anguilla* caught. There were no significant differences in infection levels between water body types for adult *A. anguilla* or between sexes for any water body type. Prevalence was significantly lower in juvenile compared to adult *A. anguilla* captured in rivers and a positive correlation between infection levels and host size-classes was found. Future efforts should focus on monitoring the spread of *A. crassus* infections and assessing the swimbladder health of *A. anguilla* in Ireland."

Biosecurity

Closure of the commercial eel fishery has significantly reduced the biosecurity issues assocated with eel dealers moving from catchment to catchment. Strict biosecurity protocols are followed by both IFI survey crews and by ESB contracted silver eel fishermen as a condition of the DCENR authorisation issued to the ESB in respect of silver eel trap and truck operations.

The National Scientific Committee for Eel has issued the advice: Due to concerns relating to the possible introduction of pathogens and/or non-invasive species to Irish waters, the Standing Science Committee on Eel **advises against any introductions of live eel** imported from outside Ireland and especially from the continent. The SSCE **also advises against inter-catchment translocations** of live eel and/or water to minimise the spread of already introduced non-native species. The SSCE recommends that this advice should apply to the island of Ireland, especially in relation to transboundary catchments.

2.6 Provide an explanation for any planned measure not implemented, and list any difficulties encountered in the implementation of the plan.

2.6.1 Closure of fishery

Considerable resistance was raised by commercial eel fishermen to the total cessation of commercial eel fishing in Ireland in 2009, which culminated in a legal challenge to the Minister of DCENR in relation to closure of the fishery. This was exacerbated by the commercial eel fishery continuing in 2009 in the Northern Ireland portion of the River Erne in the transboundary IE_NorW, before closure of the fishery in the northern portion of the IE_NorW the following season in April 2010.

2.6.2 Traceability

Despite the closure of commercial eel fishing in Ireland, a small number of instances occurred whereby eel transport vehicles were detected transferring eels apparently from N. Ireland (L. Neagh fishery) to Britain or mainland Europe. Current legislation in Ireland only prohibits possession of eel caught in the Republic of Ireland, but there is no means for fisheries protection staff to determine the origin of eel consignments as to whether or not they originated in Ireland or are of legitimate origin. IFI fisheries protection staff also encountered a number of individuals purchasing relatively small quantities of eels (<100 kg) from L. Neagh for import into Ireland for sale or local smoking, which whilst confirmed with N. Ireland authorities, raises concerns as to how to discern between legal and illegal eel consignments.

Similar traceability legislation as enacted for England, Wales and Northern Ireland (Amendment to the Eels (England and Wales) Regulations 2009) will be required for Ireland to fully monitor and cross-check eel imports and exports from/to Ireland, particularly in light of the continued operation of the L. Neagh eel fishery.

Amending legislation to require eel exporters and importers to supply consignment details of the origin and destination of eel shipments is essential to fully meet the EU Eel Regulation. Ideally, an agreed traceability programme should be agreed for all Member States to permit eel imports and exports of each Member State to be cross-checked between country of origin and recipient country.

2.6.3 Silver Eel Trap and truck programmes

Significant resources were committed by the ESB in establishing and developing extensive trap and truck programmes on the Shannon, Erne and Lee river systems for downstream transport of silver eel around hydroelectric facilities for release to sea. Whilst a silver eel trap and truck programme had previously been instigated on the Shannon by the ESB (prior to the EC Regulation), equivalent programmes had not been undertaken on either the Lee or the Erne.

Initial challenges arose, particularly on the Erne, with regard to identification of suitable silver eel capture sites, obtaining necessary land owners permissions for access, and recruitment of suitably experienced fishermen prepared to undertake conservation fishing. Very significant progress was made over 2009-2011 in relation to identifying optimal eel capture and monitoring sites, expanding the number of sites fished, and increasing fishing efficiency as fishermen gained experience in fishing new capture sites. This resulted in a year on year increase in the quantities of silver eels trapped and transported on the Erne and Lee from 2009-2011.

Since 2012 three year rolling averages have been utilised in setting trap and transport targets for each of these fisheries for 2012-2014 (thereby allowing surpluses or deficits to be carried forward to the following year). The overall trap and transport targets for each of the three fisheries were successfully achieved over the 2011-2014 period.

Considerable ESB, IFI and (in the case of the Erne transboundary fishery) DCAL staff time and resources were committed to ensure all catches landed were accurately recorded, stored correctly and released to sea as soon as practicable. Particular emphasis and care was taken in these programmes to ensure catches were handled and stored appropriately to ensure viability of released stock for spawning purposes.

Overall productivity levels from the Erne, and consequent trap and truck targets, were reviewed by the SSCE in light of work completed during 2009-2011. As a result the target for trap and truck programme on the Erne for 2012-2014 was amended (from a fixed annual tonnage) to an annual target based on a proportion (30%) of the annual production, as similarly applied on the Shannon.

2.6.4 Fisheries protection

The combination of a moratorium on staff recruitment announced in 2009 together with an early retirement scheme implemented in February 2012 has resulted in a decline of approximately 25% in IFI staff numbers representing a significant impact on fisheries protection resources. To date levels of illegal eel fishing activity have remained low, however some evidence for increased illegal fishing was recorded particularly in the mid-Shannon (mainly L. Ree) and Upper Erne systems in recent years.

2.6.5 Silver eel escapement

Quantitative estimates of silver eel escapement are required to establish and monitor changes in escapement relative to the EU 40% SSB target. Long term data series exist for the Shannon, Erne, Corrib and Burrishoole fisheries. Following the closure of the Irish commercial eel fishery in 2009, the Galway weir at the base of the Corrib system was fished as a catch and release fishery for scientific purposes. However, due to structural defects identified in 2010 the Galway weir fishery was unable to be fished since 2010 for safety reasons. This has resulted in the loss of an important long term index site for assessment of silver eel from this formerly productive and un-impounded eel fishery. The high capital costs of restoration of the Corrib site may require an alternative index site to be identified.

2.6.6 Monitoring

Transitional waters

While monitoring and surveys were carried out on transitional waters, suitable methodologies for reliably assessing status of the yellow eel stock, silver eel production and spawner escapement from transitional and coastal marine waters is lacking.

Significant progress has been made however over the 2012-2014 period in terms of stock assessment (densities, size and age structure) through fyke net surveys conducted at three sites – South Sloblands, Wexford; R. Barrow estuary and Burrishoole/L. Furnace transitional waters.

To date surveying of large water bodies (Transitional waters and large rivers) has been conducted using fyke nets which provide results in catch per unit of effort. There is still an issue with converting catch per unit of effort to population biomass and this will need to be addressed over the coming years.

Extension of the National Eel Monitoring Programme

A number of Ireland's EMUs have no long term index sites either in terms of monitoring of juvenile recruitment or assessment of silver eel escapement (particularly on the east and south coasts).

Over recent seasons the national elver monitoring programme has expanded to include additional elver trapping sites (partial counts) on the Liffey (IE_East), Corrib and Ballysadare rivers (both in the IE_West).

Additional silver eel index (catch and release) fisheries have been instigated on the R. Fane (2011) and R. Barrow (2014), however an important long term silver eel index site on the Corrib was closed in 2010 (due to health and safety concerns) which may require and alternative site to be identified.

The SSCE has identified the need for additional elver recruitment monitoring sites nationally to provide sufficient data to enable reliable modelling estimates to be derived for all EMUs.

The lack of resources and the recruitment embargo outlined in Section 6.4 also applies to the research and monitoring sectors of IFI, which has resulted in a reduced yellow eel field work programme and prioritisation of key eel catchments.

2.7 Provide any data and/or other information that would support the analysis of the potential net benefit of eel stocking in terms of silver eel escapement.

There is no stocking of juvenile eel in Ireland.

There is no authorised commercial or recreational catch of juvenile eel in Ireland as fishing in Ireland for juvenile eel remains prohibited under the Fisheries (Consolidation) Act, 1959, (section 173). Fishing for juvenile eel is also prohibited under the eel conservation bye-laws introduced in 2009. There are currently no eel aquaculture facilities in Ireland.

Capture of glass eel, elver and bootlace eel is conducted by ESB staff chiefly at the ESB Hydropower Stations on the Shannon (Ardnacrusha, Parteen), Erne (Cathaleen's Fall) and Lee (Iniscarra) for the purposes of assisted upstream migration. This has been a long-term objective to mitigate against the blockage of the HPSs under ESB Legislation (Sec 8, 1935). On the Erne and Shannon, elver and bootlace eel are transported upstream from the fixed elver traps. These programmes outlined in the EMP were continued in 2012-2014. On the Erne, the distribution of elver throughout the catchment is by cross-border agreement between the ESB, IFI and DCAL.

Ramp traps were deployed at 6 sites: - the Inagh, Maigue, Feale, Corrib, Ballisodare and Liffey systems to provide indicative (partial count) glass eel/elver recruitment data for these rivers (as described in Ireland's annual SSCE activity reports). Catches were typically small and were released immediately upstream of the respective capture sites.

3 Proposed amendments of the Regulation

Do you have any indication/evidence/data to suggest that an amendment of the Regulation [and consequently the eel management plans] is necessary to achieve the objective set out in Article 2(4) of the Regulation and to ensure the recovery of the species?

3.1 Target and Timeframe

Given the continued critically low levels in recruitment of European eels stocks the EU biomass target (40% of pristine SSB) must be questioned as to whether this target is sufficient to reverse the current serious decline in stocks of European eel.

The lack of a timeframe in the Regulation within which to achieve the 40% target should be addressed to ensure the necessary concerted and widespread management action across EU Member States to promote stock recovery. While significant and costly management measures (i.e. total cessation of fishing, trap and transport around hydropower stations) implemented in Ireland have led to considerable improvements in silver eel escapement to date, equivalent EU-wide actions have not, to the best of our knowledge, taken place. Further improvement in silver eel production in future years is contingent upon increased recruitment of juvenile eels to Irish waters, which in turn is dependent on the collective management actions of all EU member states.

It is not clear from the conclusion of the EU 2012 reporting and evaluation process whether the initial implementation of the Regulation is likely to lead to an improvement in overall recruitment or what action is to be taken in the event some Members States do not provide evidence of effective implementation of EMPs as originally submitted.

3.2 Reporting

The need for clear and consistent reporting is clearly outlined in the Regulation, but there has been no international co-ordination of reporting and a formal EU guidance template is lacking. It is essential that both the report template and electronic reporting of standardised data are put in place ahead of the next three year cycle to facilitate evaluation of the effectiveness of Eel Management Plans submitted.

3.3 Traceability

International traceability is required to determine movements and quantities of eel between States (EU Regulation 1100/2007 – Article 12). There is currently no traceability scheme in place in Ireland which is required under the EU Regulation. Limited trade data made available to the group by the Central Statistics Office (CSO) for the period 2008 to 2014 were difficult to interpret and insufficient to ascertain illegal eel movements.

Amending legislation to require eel exporters and importers to supply consignment details of the origin and destination of eel shipments is essential to fully meet the EU Eel Regulation. A standardised and uniformly implemented EU traceability programme is required for all Member States to permit eel imports and exports of each Member State to be recorded and cross-checked between country of origin and recipient country.

4 Glass eel pricing

Attach as an annex the annual report required in line with Article 7(5).

This is not applicable to Ireland as there are no commercial, or recreational, fisheries for glass eel.

5 References

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Source Material also used in the SSCE Report included annual reports from Inland Fisheries Ireland on the national monitoring programme, from the National University of Ireland Galway/Electricity Supply Board on silver eel trap and transport and escapement in the Shannon, Erne and Lee and the Marine Institute on Burrishoole and on International Scientific Advice (ICES).

Annex 1: Stock Annex

Annex 1:

Stock Annex for the Assessment of the Eel Stock in Ireland, including the transboundary IE_NorW (NWIRBD)

2012-2014.

Contents

1 Introduction

1.1 EU Regulation

The EC Regulation (Council Regulation 1100/2007) for the recovery of the eel stock required Ireland to establish eel management plans for implementation in 2009. Under the EC Regulation, Ireland should monitor the eel stock, evaluate current silver eel escapement and post-evaluate implemented management actions aimed at reducing eel mortality and increasing silver eel escapement.

The Irish Eel Management Plan submitted to the EU on the 9th January 2009 and accepted by the EU in June 2009 outlined the main management actions aimed at reducing eel mortality and increasing silver eel escapement to the sea. The four main management actions were as follows;

- a cessation of the commercial eel fishery and closure of the market
- mitigation of the impact of hydropower, including a comprehensive trap and transport plan to be funded by the ESB
- to ensure upstream migration of juvenile eel at barriers
- to improve water quality

Under the EC Regulation (EC No. 1100/2007), each Member State shall report to the Commission initially every third year until 2018 and subsequently every six years. The first report was submitted in June 2012 and the second report will be due by 30th June 2015. This report will address the following;

- monitoring
- the effectiveness and outcome of the Eel Management Plans
- contemporary silver eel escapement
- non-fishery mortality
- policy regarding enhancement/stocking

The Irish Eel Management Plan outlines a national programme for sampling catch and surveys of local eel stocks. Appropriate scientific assessment will monitor the implementation of the plans. The Scientific Eel Group (SEG) was established by the Department of Energy, Communications and Natural Resources in March 2009 and appointed by the Minister. Consultation with the Department of Culture, Arts and Leisure in Northern Ireland ensures the co-operation with Northern Ireland agencies to cover the specific needs of the trans-boundary North Western International River Basin District eel management plan. In 2010 the SEG was reconstituted as a Standing Scientific Committee for Eel under the Inland Fisheries Ireland legislation with a revised Term of Reference. The SSCE comprises scientific advisers drawn from the Marine Institute (MI), Inland Fisheries Ireland (IFI), The Loughs Agency, the Agriculture, Food and Biosciences Institute for Northern Ireland (AFBINI) and the Electricity Supply Board (ESB). Although the scientists are drawn from these agencies, the advice from the SSCE is independent of the parent agencies.

This report provides an assessment of the status of the Irish eel stocks 2012-2014 and provides the information on biomass and mortality for 2012-2014. Annual data for 2009 to 2014 are presented in the accompanying electronic tables.

1.2 Glossary

Leptocephalus larva.	Ocean pelagic. Deep-bodied, strongly compressed, transparent 'willow-leaf' shape
Glass eel	Small eel, less than one year post metamorphosis. Continental shelf waters to lower reaches of rivers. Body form as in adult, largely transparent but with localised pigment. Term also used to define the zero age class recruitment cohorts, including zero age 'elvers'.
Elver	Migrating eel to 2 years post metamorphosis. Coastal and freshwater. This term is not strictly defined and is frequently used to include glass eel. Fully pigmented eel, blackish colour: <length 10cm.
Bootlace eel, snig	Small growing, sedentary or upstream migrating eel. Coastal and freshwater. Pigmented eel, yellow or brown colour: length 9<25cm.
Yellow (brown) eel	Large growing, sedentary eel. Coastal and freshwater. Fully pigmented eel, yellow or brown colour: length greater than 20cm. Eyes small, body soft.
Silver (bronze) eel	Migrating, non-feeding eel. Freshwater to oceanic. Silver or bronze colour: length rarely less than 25 cm. Eyes large, body firm, lateral line prominent.

Acronyms in the Report

ACOM (ICES)	Advisory Committee on Fishery Management
AFBINI	Agri-food and Biosciences Institute, Northern Ireland
DARD	Dept. of Agriculture and Rural Development
DCAL	Dept. of Culture, Arts and Leisure
DCENR	Dept. of Communications, Energy and Natural Resources
EEEP	Erne Eel Enhancement Programme
EIFAAC	European Inland Fisheries & Aquaculture Advisory Commission
EMP	Eel Management Plan
EMU	Eel Management Unit
ESB	Electricity Supply Board
FAO	Food and Agriculture Organisation
FCB (NI)	Fisheries Conservancy Board
FCILC	Foyle & Carlingford Irish Lights Commission
HPS	Hydropower Station
ICES	International Council for Exploration of the Seas
IFI	Inland Fisheries Ireland
IMESE	**I**rish **M**odel for **E**stimating **S**ilver Eel **E**scapement
IUU	**I**llegal, **U**nidentified and **U**nregulated fisheries
LNFCS	Lough Neagh Fishermen's Co-operative Society Ltd
MI	Marine Institute
NUIG	National University of Ireland
RBD	River Basin District
SNIFFER	**S**cotland and **N**orthern **I**reland **F**orum **F**or **E**nvironmental **R**esearch
SSB	Spawning Stock Biomass
SSCE	Standing Scientific Committee for Eel

Definition

40% Target: *"The objective of each Eel Management Plan shall be to reduce anthropogenic mortalities so as to permit with high probability the escapement to the sea of at least 40 % of the silver eel biomass relative to the best estimate of escapement that* ***would have existed if no*** *anthropogenic influences had impacted the stock".*

2 Eel Management Plan Monitoring Objectives

2.1 Introduction to Stock Status and Management Targets

Ireland outlined the following objectives in the National eel management Plan (2008) for monitoring the status of the stock and for providing data to comply with the reporting requirements (silver eel biomass, mortality) under EU Regulation (No. 1100/2007).

1. Synthesise available information into a model based management advice tool.
2. Estimate silver eel escapement (in collaboration with ESB, NUIG, Marine Institute).
   2.1 Estimate silver eel escapement indirectly using yellow eels.
3. Monitor the impact of fishery closure on yellow eel stock structure, CPUE, age and growth studies
4. Inter-Calibration with Water Framework Sampling.
5. Compare current and historic yellow eel stocks.
6. Establish baseline data to track changes in eel stock over time.
7. Evaluate impedance of upstream colonisation: migration and water quality effects.
8. Determine parasite prevalence and eel quality (Prevalence of *Anguillicola crassus*, (swimbladder parasite) age and growth analysis).

In later sections of this report reference is made to the status of the Irish stocks in relation to the EU target and to biomass and mortality reference points. A modified ICES precautionary diagram, or "bubble plot", is used to demonstrate these features. The following sections introduce these concepts and explain how the "bubbles work". This section is drawn from ICES (2010, 2011a, b) and summarised from Dekker *et al.* (2011).

2.2 The EU Regulation

The objectives of the EU Regulation are to protect and restore the eel stock. The Regulation sets a common target for all Eel Management Units across Europe for the escapement of silver eels, at 40% of the natural escapement. Before discussing the state of the eel stock (below), the objectives and target are illustrated in more general terms.

2.3 A general stock-recruitment relation

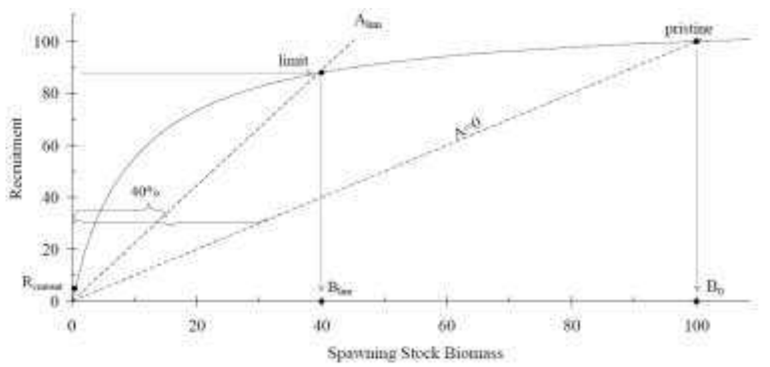


Figure 2-1: Hypothetical Stock-Recruitment relationship. The drawn line indicates what recruitment is produced at what spawning stock size; the dashed lines indicate what spawning stock can be derived from a given recruitment, at no fishery (A=0) or at maximal, just sustainable fishery (Alim). Both Recruits and Spawning Stock Biomass are given in arbitrary units. The EU Regulation sets the minimum target at 40% of the pristine spawning stock biomass, which is aimed keep recruitment close to its maximum (after Dekker *et al.* 2011).

Consider a fish of any species. Under natural circumstances, the number of young fish surviving is much lower than the numbers that were initially born. Basically, this is just bad luck for most juveniles: a high percentage will die under all circumstances. However, when shortage of food or lack of space is involved, the risk of dying may depend on the abundance of the fish stock (density dependence). If there are more youngsters in a particular year, they will not find more food, and thus some more will have to die; fewer youngsters in another year will find plenty of food and space, and survival will improve (Fig. 2.1).

At very low adult density, however, the number of offspring produced is simply too low. Any youngster born finds enough space and food to survive, but few youngsters will remain. In this case, the number of youngsters depends on the adult stock abundance. The fewer adults there are, the fewer eggs will be produced, and the fewer youngsters will be born – each of them finding enough food and space to survive. Shortage of food or space at high abundance and insufficient youngsters at low abundance - a critical threshold can be found at intermediate levels. Above this critical threshold, the number of youngsters surviving is at its maximum; below this critical threshold, the next generation is limited by the number of adults reproducing. In practice, a really sharp critical level cannot be found, but many commercial fish stocks have shown a break-point around 30% of the pristine stock size. Thus, reducing the adult stock to about 30% of its natural abundance does not markedly affect the number of youngsters surviving, but further reductions to the adult stock limits the new generation.

2.4 Stock-recruitment and eel

For eel, the international scientific advice assumes that a likewise relation between adult stock and youngster generation also holds, even though no evidence for that is available. Because of the many uncertainties specifically for eel, an extra safety-margin of 20% was added in the advice: the scientific advice was to protect a spawning stock biomass of 50% of the natural, pristine condition.

The EU Regulation decided on a final level of 40%, half the safety margin. In this report, the 40% limit of the EU Regulation will be shown (Figure 2.1) and used as a management target in the precautionary diagrams. ICES have not evaluated the EU target as to whether it is precautionary and sufficient to achieve the objectives of the Regulation and therefore the targets and limits used in this report are management derived and not scientific reference points.

Current (2014) European recruitment of glass eel from the ocean is at 6-15% of the historical level (Table 3.1). This low recruitment leads to a low adult stock, and in turn a low number of adults returning to the ocean. Under these circumstances, it is highly unlikely that the 40% adult stock can be maintained: low recruitment is now limiting the number of adults and the stock is most likely suffering from reduced reproductive capacity. Recovery of the European eel stock is expected to be a slow process.

2.5 Biomass and Mortality

At low spawning stock biomass, the focus shifts from the absolute abundance of the stock towards the survival of individual youngsters. If less than 40% survives (relative to the survival under natural conditions), it would not be possible to maintain a healthy stock, even if the adult stock would have been healthy initially. If more than 40% survives, even a low stock might have some capability to recover, though it may take a long time. Hence, there is a critical threshold for survival, corresponding to the 40% adult stock abundance. If less than 40% of the youngsters survives (relative to natural circumstances, without anthropogenic impacts), the stock is not likely to recover. Above the 40% survival, we expect a recovery. The higher the survival, the faster the recovery is expected to be. Because of the stock currently being so low, the scientific advice is to improve survival beyond the 40% level (the wording in the scientific advice was: “mortality be reduced to the lowest possible level”), which intends to achieve a recovery of the stock within a foreseeable future (decades rather than centuries). Once more, the 40% is probably not an exact value, and estimates of survival are definitely not that precise, but the target for survival is 40%.

Survival of whom? In nature, survival of wild animals is generally low: the vast majority of all animals die at a young age, due to natural causes (the bad luck, mentioned above). The 40% survival target is not saying that nature should be a bit less harsh, but that anthropogenic impacts (coming on top of nature) must be limited. The actual escapement should come at 40% of the escapement-without-anthropogenic-impacts (Bo). It is the ratio of the actual biomass of silver eels escaping ($B_{current}$) to the calculated biomass without anthropogenic impacts (B_0) that should come at 40%. For glass eel fisheries in southern Europe, for instance, natural mortality of over-abundant glass eels might be very high even under natural conditions; it is the added fishing impact that counts, not the net survival of these individuals.

2.6 The Precautionary Diagram

For the international advice on fish stock management, ICES (2004) applies a traffic light colouring scheme, signalling the status of the stock and the impact of exploitation. The information on the stock status and the reference points are presented in a so-called Precautionary Diagram (Fig. 2.2), in which the criteria and status are summarised. This diagram presents the status of the stock (horizontal, low versus high spawning stock biomass determining whether the stock has full reproductive potential) and the impact of fishing (vertical, low versus high anthropogenic mortality determining whether the exploitation is sustainable or not). Obviously, the green zone is the recommended status, the red zone indicates unsustainable conditions, and the orange zones show various intermediate risk-zones. For the case of the eel, a slightly modified diagram is used, but the basic colour coding is kept and the limits between the zones are the management Biomass limit set in the Regulation (40% SSB) and a derived equivalent mortality (ICES 2011b).

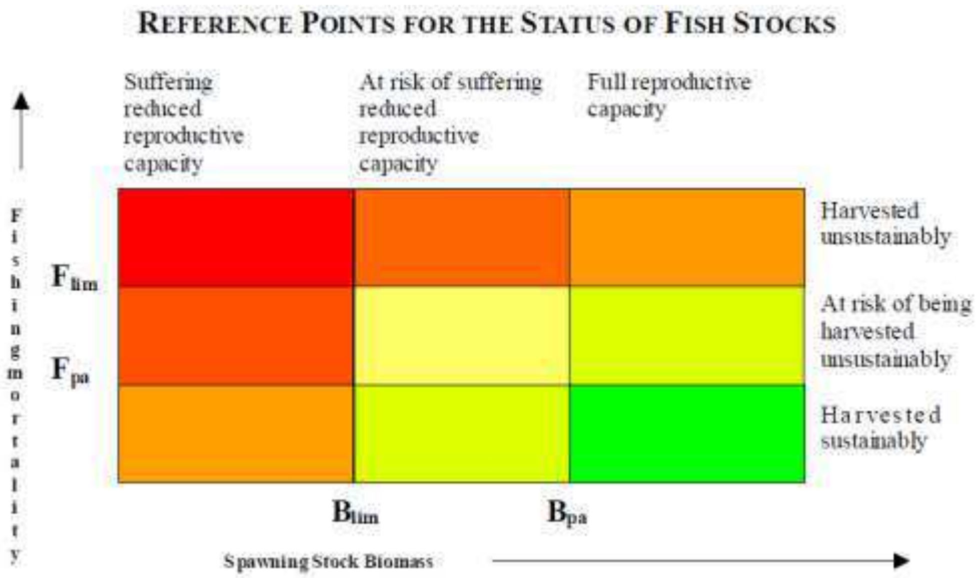
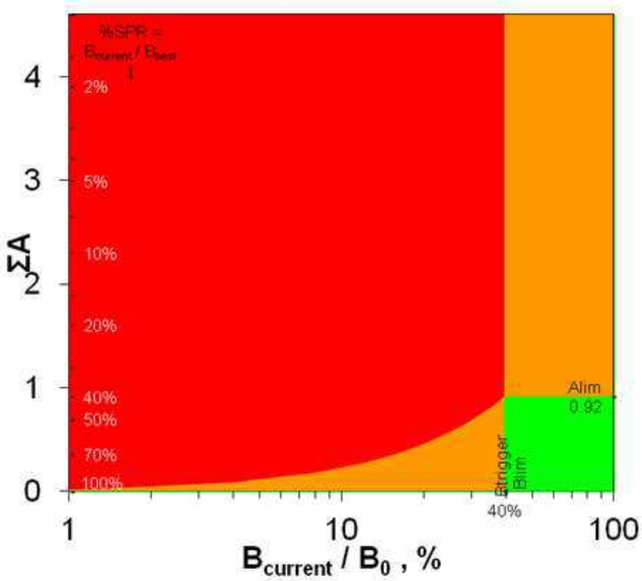


Figure 2-2: This "precautionary diagram" is used to summarise the state of the stock (horizontal) and the anthropogenic impacts (vertical).

The objective of the Eel Regulation is to protect and restore the stock. The common target for all countries is to restore escapement of silver eels to 40% of the natural escapement. On theoretical grounds, this corresponds to a lifetime mortality limit of 0.92 at maximum. A lifetime anthropogenic mortality of exactly 0.92 is expected to stabilise the stock; a further reduction is required, to enable recovery. ICES (2011b) proposes to apply the standard ICES protocol to the eel too, i.e. a linear relation (curved in this diagram due to the log axes) between stock biomass and targeted mortality below the trigger of 40% biomass but this approach has yet to be benchmarked as precautionary.

The background colours in these diagrams reflect the target of the EU Regulation (the target in the green zone) and the precautionary advice given by ICES (a much lower mortality, to recover the stock)[1]. For each part (EMU/RBD) of the stock (and for the whole of Ireland), the status of the stock is represented by a bubble, as for example in Figure 2.3.



The position of the bubble indicates the status of the stock in 2001-2007, or subsequent years, relative to the biomass (horizontal) and mortality (vertical) targets, while the size of the bubble indicates the relative importance of that part of the stock (B_{best}, the potential production from the current stock, if no anthropogenic impacts would have occurred).

Additionally, each bubble has an arrow, indicating what effect the planned measures of the Eel Management Plan are expected to have – that is: where the bubble is supposed to be in 2012.

Downward movement of the bubble indicates lower anthropogenic mortality (fishing and turbine) and horizontal movement is indicative of the current spawning stock biomass. Right hand movement indicates more silver eels escaping from the potential production (Bo) due to lower mortality and/or higher recruitment. Left hand movement indicates falling escapement. Left hand movement accompanied by downward movement (lower mortality) is not good news and is probably related to the impact of lower recruitment.

2.7 Single reference points for multiple eel management units

Note: These precautionary diagrams are intended as a visual guide to interpreting the biomass and mortality data.

Due to the panmixia and shared nature of the eel stock (i.e. local silver eel production contributes an unknown fraction to the entire European eel spawning stock, which in turn generates new glass eel recruitment), the efficacy of local protective actions (single EMPs, national export regulation) cannot be post-evaluated without considering the overall efficacy of all protective measures taken throughout the distribution range.

The precautionary diagrams allow for comparisons between EMUs (%-wise SSB; lifetime summation of anthropogenic mortality) and comparisons of the status to limit/target values, while at the same time allowing for the integration of local stock status estimates (by region, EMU or country) into status indicators for larger geographical areas (ultimately: population wide).

This might imply that the individual EMUs/Countries that are in the green be allowed to *expand* their exploitation, or increase their mortality rates, while the overall status of the stock is still outside safe biological bounds. This would probably be unwise until the entire stock is with safe biological limits, and at least European mortality rates are low enough to be contributing to the longterm recovery of the stock ICES (2012).

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[1] The orange/yellow intermediate zones bordering the red area in the ICES precautionary diagram reflect statistical uncertainty in the stock assessment. For eel stock assessments, the magnitude of the statistical uncertainties is simply unknown, and therefore, these in-between zones have been left out.

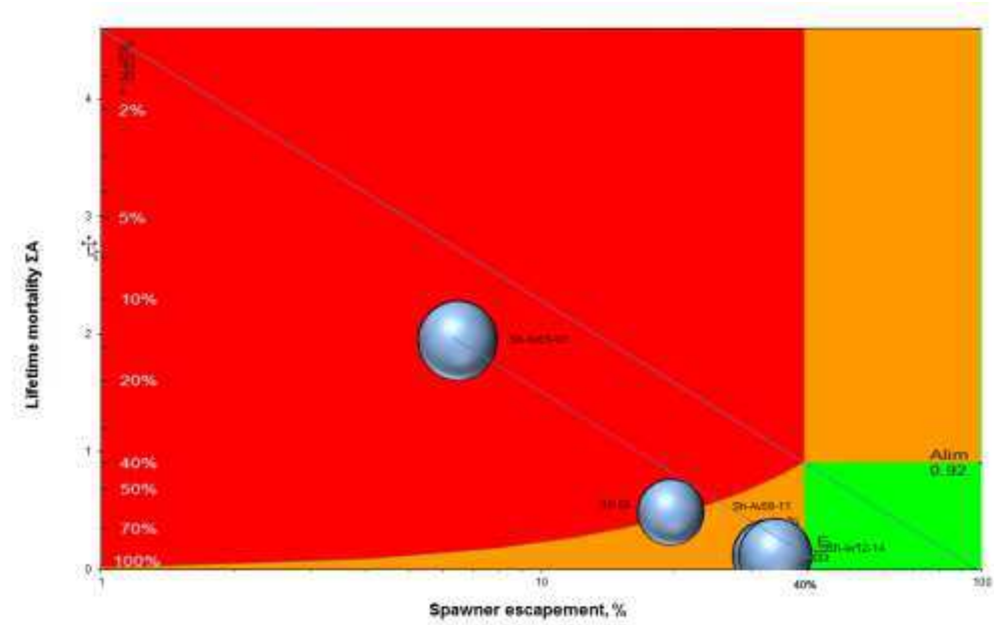


Figure 2-3: Precautionary diagram for the Shannon silver eel biomass. The downward movement of the bubble indicates lower mortality and to the right indicates increasing spawning stock biomass. The arrow indicates what effect the implementation of the EMP was expected to have.

2.8 Introduction to 2012-2014 Assessment

The assessment of the status of the Irish eel stocks for the 2012 to 2014 period broadly follows the procedures described in the Eel Management Plan and in the Stock Status report in 2012 (Anon, 2012)

2.8.1 Background

The EC Regulation (Council Regulation 1100/2007) for the recovery of the eel stock required Ireland to establish eel management plans for implementation in 2009. Under the EC Regulation, Ireland should monitor the eel stock, evaluate current silver eel escapement and post-evaluate implemented management actions aimed at reducing eel mortality and increasing silver eel escapement.

The Irish Eel Management Plan submitted to the EU on the 9th January 2009 and accepted by the EU in June 2009 outlined the main management actions aimed at reducing eel mortality and increasing silver eel escapement to the sea.

The Irish Eel Management Plan outlines a national programme for sampling catch and surveys of local eel stocks. Appropriate scientific assessment will monitor the implementation of the plans. The Standing Scientific Committee for Eel (SSCE) was established by the Department of Energy, Communications and Natural Resources in March 2009 and appointed by the Minister. Consultation with the Department of Culture, Arts and Leisure in Northern Ireland ensures the co-operation with Northern Ireland agencies to cover the specific needs of the trans-boundary North Western International River Basin District eel management plan. The SSCE comprises scientific advisers drawn from the Marine Institute (MI), Inland Fisheries Ireland (IFI), The Loughs Agency, the Agriculture, Food and Biosciences Institute for Northern Ireland (AFBINI) and the Electricity Supply Board (ESB). Although the scientists are drawn from these agencies, the advice from the SSCE is independent of the parent agencies.

2.8.2 Standing Scientific Committee on Eel

The SSCE has undertaken a full assessment of the available eel data and other information available to it as outlined in its Terms of Reference and this is produced in annual science reports. The SSCE reports provide the most current scientific advice on the status of the eel stock. All data referred to here has been assessed and referenced in the SSCE Reports and can be sourced through those documents (Anon., 2012a, 2013, 2014, 2015).

2.8.3 Biology

The European eel *Anguilla anguilla* (L.) is found and exploited in fresh, brackish and coastal waters in almost all of Europe and along the Mediterranean coasts of Africa and Asia. The life cycle has still not been fully elucidated but current evidence supports the view that recruiting eel to European continental waters originate from a single spawning stock in the Atlantic Ocean, presumably in the Sargasso Sea area, where the smallest larvae have been found. The newly hatched leptocephalus larvae drift with the ocean currents to the continental shelf of Europe and North Africa where they metamorphose into glass eels that enter continental waters. The growth stage, known as yellow eels, may take place in marine, brackish or freshwaters. This stage typically lasts from 2-25 years (even more than 50 years) prior to metamorphosis to the silver eel stage and maturation. Age at maturity varies according to latitude, ecosystem characteristics and density-dependent processes. The European eel life cycle is shorter for populations in the southern part of their range compared to the north. At the end of the continental growing period, the eels mature and return from the coast to the Atlantic Ocean; this stage is known as the silver eel. Female silver eels grow larger and may be twice as old as males. The biology of the returning silver eel in ocean waters is almost completely unknown.

The European eel is a single, panmictic stock distributed from Northern Africa and the Mediterranean in the south to Northern Norway and Iceland in the north, including the Baltic Sea. Recent genetic evidence has confirmed the shared nature of the stock, with slight temporal variation between cohorts but no geographical differentiation (Palm *et al.* 2009).

2.9 Ireland's Eel Management Plan

The EC Regulation (Council Regulation 1100/2007) for the recovery of the eel stock required Ireland to establish eel management plans for implementation in 2009. Under the EC Regulation, Ireland should monitor the eel stock, evaluate current silver eel escapement and post-evaluate implemented management actions aimed at reducing eel mortality and increasing silver eel escapement. The Irish Eel Management Plan, submitted to the EU on the 9th January 2009 and accepted by the EU in June 2009, outlined the main management actions aimed at reducing eel mortality and increasing silver eel escapement to the sea. The EMP included two cross-border agreements, with the Neagh Bann IRBD rivers flowing into Carlingford Lough from the Republic of Ireland and into Dundalk Bay being reported in a plan for the Eastern RBD (the Eastern Eel Management Unit) and one transboundary eel management plan in respect of the North Western IRBD and prepared by the Northern Regional Fisheries Board, the Loughs Agency and DCAL (Figure 2.4).

The four main management actions in the Irish Eel Management Plan were as follows;

- a cessation of the commercial eel fishery and closure of the market
- mitigation of the impact of hydropower, including a comprehensive trap and transport plan to be funded by the ESB
- ensure upstream migration of juvenile eel at barriers
- improvement of water quality

The Irish Eel Management Plan (EMP) also outlined a national monitoring programme for sampling catch and surveys of local eel stocks. Appropriate scientific assessment will monitor the implementation of the plans.

Given the implications of the scientific advice, the consideration of practical management implications and the need to conserve and recover the stock in the shortest possible timeframe (contingent upon equivalent actions across Europe), the precautionary approach was adopted in accordance with the recommendations of the National Eel Working Group and the eel fishery was ceased. The eel fisheries in tidal and transitional waters are managed under the Inland Fisheries legislation and management structures and given the absence of appropriate methods for estimating eel stock densities and silver eel escapement in transitional waters, the precautionary approach was also adopted in accordance with the recommendations of the National Eel Working Group and the eel fishery in transitional and tidal waters was also ceased.

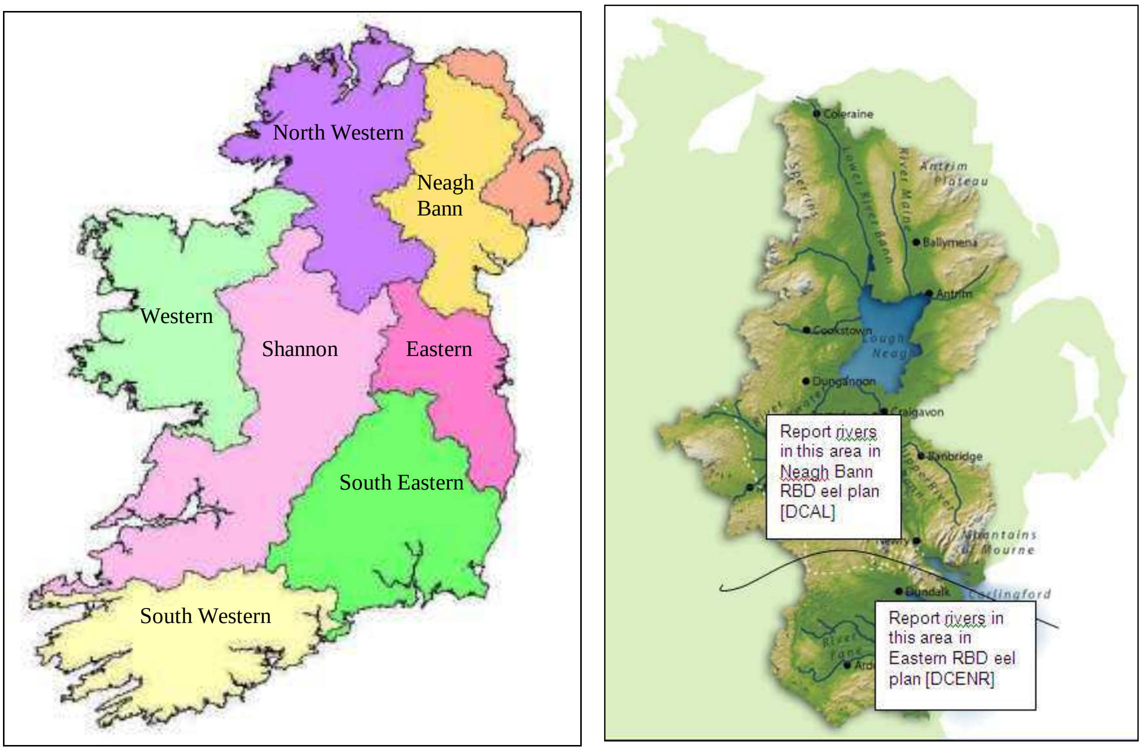


Figure 2-4: Map (left) showing the River Basin Districts and the map (right) showing the transboundary agreement between the Neagh/Bann RBD and the Eastern RBD.

In accordance with ICES common practice, the Irish Eel Management Units have been coded as follows:

Name	RBD	ICES EMU Code
Eastern Eel Management Unit	EMU	IE_East
South Eastern RBD	SERBD	IE_SouE
South Western RBD	SWRBD	IE_SouW
Shannon IRBD	SHIRBD	IE_Shan
Western RBD	WRBD	IE_West
North Western IRBD	NWIRBD	IE_NorW

2.10 Monitoring 2012-2014

As outlined in Chapter 7 of the Irish EMP, a comprehensive monitoring programme was put in place to assess the local recruitment (glass eel/elver), yellow eel and silver eel stocks and to set a bench mark for evaluating future changes to the stocks. Determination of silver eel production and escapement was undertaken on the Burrishoole (IE_West) and in conjunction with the silver eel trap and transport programmes on the Shannon (IE_Shan) and Erne (IE_NorW). Additional index sites are being developed on other rivers such as the Fane (IE_East) and the Barrow (IE_SouE) but the time series were too new and unverified for them to be included in the 2012-2014 assessment as calibrating sites.

Mortality estimates for Hydropower Stations were determined for the Shannon and the Erne and a figure for eels bypassing Ardnacrusha on the Shannon was also determined. These have been retrospectively incorporated into the previous estimates of escapement reported in the Irish Eel Management Plan (2008).

These monitoring programmes and estimates of escapement allow for the outcome of the main management actions (e.g. closure of the fishery, silver eel trap and transport) to be post-evaluated.

3 Status of the Irish Stocks 2012-2014

The following sections present a synthesis from the annual status reports (Anon, 2013, 2014, 2015) which reviewed reports and analysis by IFI, MI, ESB and NUIG. The national eel (Compass Informatics, 2011) and wetted area (McGinnity *et al*. 2011) databases were also used in the assessment.

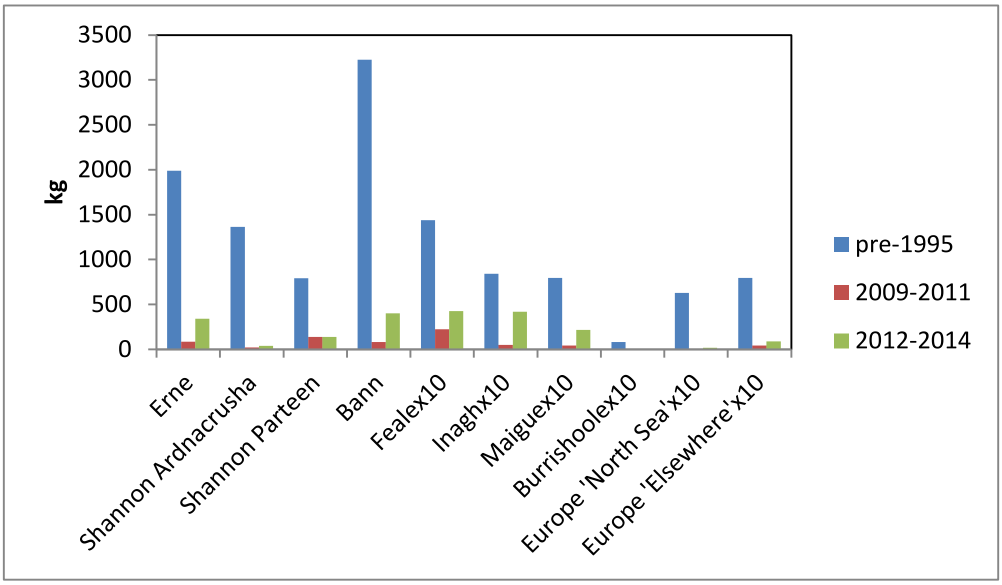
3.1 Recruitment

Recruitment of glass eel to Ireland depends on European wide management actions and natural fluctuations in larval survival and will not provide a resource to post-evaluate Irish management actions specifically. However, monitoring of recruitment is critical to evaluating the overall success of the eel regulation and is required by ICES for future stock assessment. This information is also required to assess and model future changes in the Irish eel stocks.

Recruitment has been declining at many Irish monitoring sites since the mid 1980s. In the 2000-2011 period, the glass eel catch in the Shannon was at 2% of the pre-1980 average and in 2009-2011 it was <1%. The Feale, Inagh and the Erne show a slower rate of decline, but in the 2009-2011 period these also declined to low levels. For comparison, catches of glass eel in the Bann (NI) for the 2009-2011 period were at about 2.5% of the pre-1995 level and these increased to 12.4% in 2012-2014.

Recruitment over the 2012-2014 period was patchy with some locations faring better than others (Anon, 2012, 2013, 2014, 2015). The Liffey, Shannon Ardnacrusha, Ballysadare and Feale had relatively lower catches than those observed at the Erne, Maigue, Inagh and Burrishoole. There was a general increase in recruitment to Ireland in 2013 and 2014, although there was some local variation in abundance between sites and between years, often due to seasonal variations in water levels.

The average recruitment for the 2009-2011 period was at about 7% of historic and this increased to about 20% for the 2012-2014 period (Table 3.1; Fig. 3.1). The recruitment in 2014 was on average at 27% of historic levels, compared to 15% for “Elsewhere” Europe (Elsewhere = non-North Sea Europe).



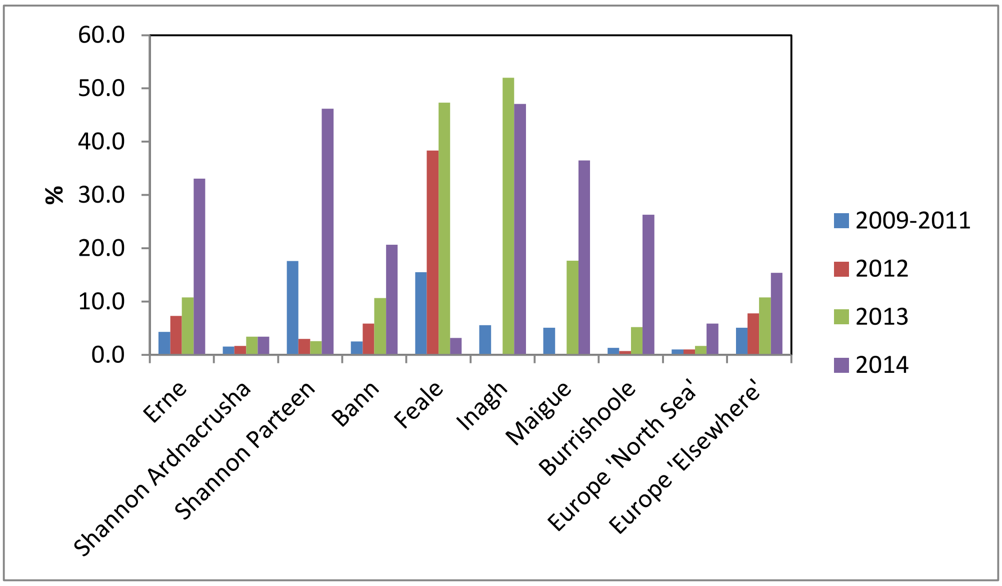


Figure 3-1: Top Graph: Average recruitment for time series in Ireland (kg) and in Europe (Average GLM) for the pre-1995 period and for 2009-2011 and 2012-2014. Note some series are x10 for visibility on the graph. Bottom graph: Annual recruitment expressed as a %, scaled against the average recorded before 1995.

Table 3-1: Summary recruitment time series data for 2009-'11 and 2012-'14, and for individual years 2012-2014, comparing with historical data. R. Bann and Europe data included for comparison.

Year	Location	Average Weight (kg)	% Diff compared to historic level	2012%	2013%	2014%
pre-1995	Erne	1989				
2009-'11	Erne	86	4.3			
2012-'14	Erne	340	17.1	7.3	10.8	33.1
pre-1995	Shannon Ardnacrusha	1362				
2009-'11	Shannon Ardnacrusha	22	1.6			
2012-'14	Shannon Ardnacrusha	38	2.8	1.7	3.4	3.4
pre-1995	Shannon Parteen	790				
2009-'11	Shannon Parteen	139	17.6			
2012-'14	Shannon Parteen	137	17.3	3.0	2.6	46.2
pre-1995	Bann (N. Ireland)	3224				
2009-'11	Bann (N. Ireland)	81	2.5			
2012-'14	Bann (N. Ireland)	400	12.4	5.9	10.7	20.7
pre-2004	Feale	144				
2009-'11	Feale	22	15.5			
2012-'14	Feale	43	29.6	38.4	47.3	3.2
pre-1995	Inagh	84				
2009-'11	Inagh	5	5.6			
2012-'14	Inagh	42	49.5		52.0	47.1
pre-1995	Maigue	80				
2009-'11	Maigue	4	5.1			
2012-'14	Maigue	22	27.1		17.7	36.5*
pre-1995	Burrishoole	8				
2009-'11	Burrishoole	0.1	1.3			
2012-'14	Burrishoole	1	10.0	0.7	5.2	26.3
pre-1995	Europe 'North Sea'	63**				
2009-'11	Europe 'North Sea'	1	1.0			
2012-'14	Europe 'North Sea'	2	2.9	1.0	1.7	5.9
pre-1995	Europe 'Elsewhere'	79**				
2009-'11	Europe 'Elsewhere'	4	5.1			
2012-'14	Europe 'Elsewhere'	9	11.3	7.8	10.8	15.4

**The Europe data are GLM averages *partial effort

3.2 Yellow Eel Monitoring

3.2.1 Introduction

During the last three year cycle of fieldwork seven lakes were repeatedly sampled for yellow eels; Lough Muckno, Lough Feeagh, Lough Bunaveela, Lough Oughter, Meelick Bay in Lough Derg, Lough Key and Lough Ramor. A three year fyke netting survey in the freshwater and transitional water of the River Barrow was undertaken to compare with historical data available. The South Sloblands and Lough Furnace are both brackish lagoons. South Sloblands was surveyed in 2010 and was resurveyed in 2014 to compare with historic data. Lough Furnace was surveyed in 2012, 2013 & 2014. Locations are listed in Table 3.2 and Figure 3.2.

A semi quantitative electrofishing survey was undertaken in two catchments (Fane and Kells Blackwater) in order to determine the extent of eel distribution in the rivers around Lough Muckno and Lough Ramor (both subject to intensive fyke netting surveys). The yellow eel surveys need to meet a number of objectives, to monitor the impact of fishery closure on yellow eel stock structure, compare with historic eels stocks, establish baseline data set, evaluate impedance of upstream migration and determine parasite prevalence within Ireland.

An additional objective of the yellow eel study was to carry out an indirect estimation of silver eel escapement. A long-term tagging programme was initiated in key lakes with a silver eel conservation fishery sampled since 2009. In Lough Derg, Lough Oughter, Lough Feeagh and Bunaveela Lough, all yellow eels captured in the fyke nets were tagged using Trovan Passive Integrated Transponders (PIT tags). The detection of these tagged eels in the silver eel run over subsequent years will provide information regarding the maturation rate of the yellow eel population.

3.2.2 Yellow Eel Catches

Details of the fishing effort, catches and sizes of eel are presented in Table 3.3 for the period 2012 to 2014.

For the yellow eel surveys, the Lough Muckno 2012 survey had the largest catch per unit of effort (8.85) followed by the Barrow Transitional waters 2014 with 6.87. The smallest cpue recorded was Lough Bunaveela with 0.4 and Lough Furnace with a cpue of 1.0. The average cpue across all surveys was 2.38.

Lough Key had the largest average length of 54.2 this is as expected due to the location of Lough Key in the Upper reaches of the Shannon Catchment (>150kms from the sea). The Barrow Transitional waters had the lowest average length (36.3cm) and lowest minimum length (21.1cm).

The Barrow transitional waters 2014 survey recorded the highest average individual weight for eels with 0.293kg followed by Lough Key with 0.288kg and Lough Muckno with 0.238 kg.

The Barrow transitional waters 2013 also recorded the lowest average individual weight for eels with 0.103kg. The largest eel weighed 2.043kg and was recorded in Lough Muckno in 2012.

The results of the fyke net surveys to date highlight the transient nature of the results and the importance of spreading the surveys through time both within years and between years. To fully understand and interpret the CPUE values it is important to take into account the location of the waterbody within a catchment, the productivity of the catchments themselves and whether there has been assisted migration stocking from an elver trap downstream, such as on the Shannon and Erne.

Table 3-2: Yellow eel survey locations for 2012-2014 and the monitoring objectives in the EMP.

Location	Water body	Life stage	1	2.1	3	4	5	6	7	8	2012	2013	2014
Meelick Bay, L. Derg	Lake	Yellow	√	√	√	√	√	√	√	√	√	√	
Erne	Lake & River	Yellow	√	√	√	√	√	√	√	√	√	ULE WFD	LLE AFBI
Barrow R.	River	Yellow	√	√	√	√	√	√	√	√	√	√	√
Blackwater	River	Yellow	√		√		√	√		√		†	
Nore R.	River	Yellow	√		√		√	√		√		†	
L. Ramor	Lake	Yellow	√		√			√		√			√
Kells Blackwater Catchment	River	Yellow	√	√	√			√	√	√			√
L. Ree	Lake	Yellow	√	√	√	√	√	√		√		WFD	
L. Feeagh	Lake	Yellow	√	√		√	√	√		√			
L. Gill	Lake	Yellow	√		√	√	√	√		√			WFD
L. Inchiquin	Lake	Yellow	√				√	√		√	†		
L. Key	Lake	Yellow	√	√	√		√	√		√		√	
Dromore L. (Fergus)	Lake	Yellow	√		√	√	√	√		√			†
L. Bunny	Lake	Yellow	√		√	√	√	√		√	WFD		
L. Arrow	Lake	Yellow	√		√	√	√	√		√	WFD		
South Sloblands	Lagoon	Yellow	√		√		√	√		√			√
Lady's Island	Lagoon	Yellow	√		√		√	√		√			†
Lough Furnace	Brackish lagoon	Yellow	√	√			√	√		√	√		
Blackwater Estuary	T. water	Yellow	√				√	√		√			†
Fane	River & Lake	Yellow	√	√	√			√	√	√	√	√	√
Cullin	Lake	Yellow	√								WFD		
Derg	lake	Yellow	√								WFD		

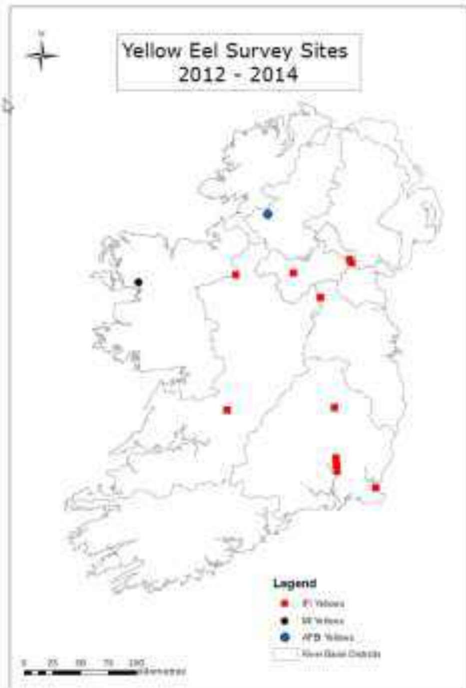


Figure 3-2: Locations of yellow eel surveys, 2012-2014.

Table 3-3: Catch details of the yellow eel surveys in the national EMP Survey, 2012-2014.

Site	Year	No. Eels	Net*Nights	Av CPUE	Total Weight (kg)	Mean Length (cm)	Min. Length (cm)	Max. Length (cm)	Mean Weight (kg)	Min. Weight (kg)	Max. Weight (kg)
Lough Muckno	2012	540	55	8.9	111.765	46.7	24.8	91.0	0.207	0.029	2.043
Lough Muckno	2013	1007	210	4.8	150.325	48.9	26.7	82.8	0.225	0.042	1.133
Lough Muckno	2014	221	120	1.8	52.710	50.2	32.7	76.1	0.238	0.050	0.834
Meelick Bay, Lough	2012	745	300	2.5	113.237	43.2	28.5	69.2	0.152	0.037	0.509
Meelick Bay, Lough	2013	409	180	2.3	55.389	41.9	25.3	63.8	0.135	0.024	0.497
Lough Oughter	2012	267	240	1.1	62.159	49.7	31.1	70.2	0.233	0.046	0.774
Lough Key	2013	375	210	1.8	108.134	54.2	36.9	80.2	0.288	0.071	0.907
Lough Ramor	2014	214	120	1.8	56.201	51.1	23.1	81.8	0.263	0.051	1.141
South Sloblands	2014	147	58	2.5	24.235	42.7	28.6	66.5	0.165	0.032	0.708
Barrow Freshwater	2012	148	40	3.7	23.000	42.3	28.8	83.8	0.155	0.038	1.116
Barrow TW	2012	435	120	3.4	49.000	38.1	23.7	75.8	0.112	0.017	0.710
Barrow TW*	2013	137	100	1.5*	14.159	36.3	21.1	67.0	0.103	0.015	0.620
Barrow TW	2014	206	30	6.9	60.407	39.5	22.6	75.4	0.293	0.052	1.806
Bunaveela L.	2012	13	30	0.4		42.7	36.5	53.4	-	-	-
Lough Feeagh	2012	83	60	1.4	10.455	40.8	30.2	62.4	O.125	0.045	0.375
L. Furnace tidal	2012	45	60	1.0	5.975	41.5	31.4	59.8	0.133	0.050	0.375
Lwr Furnace tidal	2012	19	20	1.0	2.655	43.0	33.3	54.4	0.140	0.055	0.290
Bunaveela L.	2013	15	30	0.5	3.000	45.8	37.8	57.5	-	-	-
Lough Feeagh	2013	96	60	1.6	13.640	40.3	31.3	93.2	0.142	0.050	2.270
L. Furnace tidal	2013	145	60	2.4	21.820	43.1	29.1	73.0	0.151	0.040	0.695
Lwr Furnace tidal	2013	54	20	2.7	10.460	45.3	29.8	77.8	0.194	0.040	0.940
Bunaveela Lough	2014	11	30	0.4	2.130	47.3	35.7	61.1	-	-	-
Lough Feeagh	2014	47	60	0.8	6.370	41.5	30.6	54.8	0.130	0.045	0.290
L. Furnace tidal	2014	76	60	1.3	12.000	41.6	30.4	78.0	0.140	0.040	1.135
Lwr. L. Furnace tidal	2014	47	20	2.4	5.050	45.0	21.9	78.0	0.183	0.015	0.810

*2 surveys from May resulted in 17 eels, majority of eel caught in july

3.2.3 Yellow Eel Stock Structure

3.2.3.1 Introduction

Neumann and Allen (2007) reported that the size structure of a fish population at any one time is a snapshot that reflects the interactions of the dynamic rates of recruitment, growth and mortality. However changes to the stock structure can highlight inconsistent size class strength, slow growth and excessive mortality (Anderson & Neumann 1996). One of the monitoring objectives of the national eel management plan is to examine the stock structure of the eel population and determine if there are any changes as a result of the fishery closure. It is possible to examine the changes to the structure of the eel population over the last 4 decades with the availability of historical data from the Fisheries Research Centre dating from the 1960's.

It is expected that the stock structure of the eel population will have changed as a result of the reduced recruitment for the last 30 years. Density dependence influences the population structure with an increase in female eels recorded with decreasing density (Bark *et al.* 2007). It is also anticipated to see changes in the stock structure due to the closure of the fishery in 2009 with eels remaining in the system that would have been removed historically by the fishery. However it remains to be seen over what time scale these changes will occur and if the changes will be detected by the survey methods employed in the programme. An increase in recruitment as a result of increased silver eel escapement may not be visible in Ireland due to the panmictic nature of the species and crediting the increase in recruitment visible over the last 2-3 years to management measures is difficult to quantify.

Bark *et al.* 2007 suggest that changes in length frequency distribution as a result of changes in recruitment or fishing pressure may be more sensitive and easier to detect and corroborate statistically than changes in biomass.

3.2.3.2 Methods and Results

3.2.3.3 Freshwater Lakes

In the 2012 eel monitoring report there was a section on comparing current and historical data. The general conclusion was that the eels caught in fyke nets in the recent surveys have a greater average length and weight compared with the eels caught in fyke nets in the 1960's and 1970's (Fig. 3.3). A second analysis showed no significant change in the length weight relationship for eels in the lakes surveyed. The fyke nets are size selective but as seen in the transitional waters, if smaller eels are present in the area then they are caught in the nets. The catch of small eels is not reflective of the population due to their ability to escape the nets however the absence of these small eels in the recent surveys of key lakes is of concern.

The dataset available for examining the change in length structure of eels in a fyke net survey of key lakes has increased since the 2012 report. Historical data from the 1960's, 1980's and 1990's were available for five lakes surveyed by the Eel Monitoring Programme over the years 2009 – 2014 (Lough Conn, Inchiquin, Ree, Upper and Lower Lough Corrib) Lough Derg was not included in the analysis due to the limited location of sites within the lake (Meelick Bay) and the unbalanced sample size. An analysis into changes in the length frequency of eels caught by fyke nets over the decades was investigated.

The data was pooled together to determine if a statistically significant difference in length is observed across all lakes through time (Conn, Corrib Upper, Corrib Lower, Inchiquin and Ree). The data was not normally distributed and despite transformations a Levanes test and Kolmogorov Smirnov test indicated deviations from normality. Therefore a non-parametric Kruskal Wallis test was performed on the length data by decade.

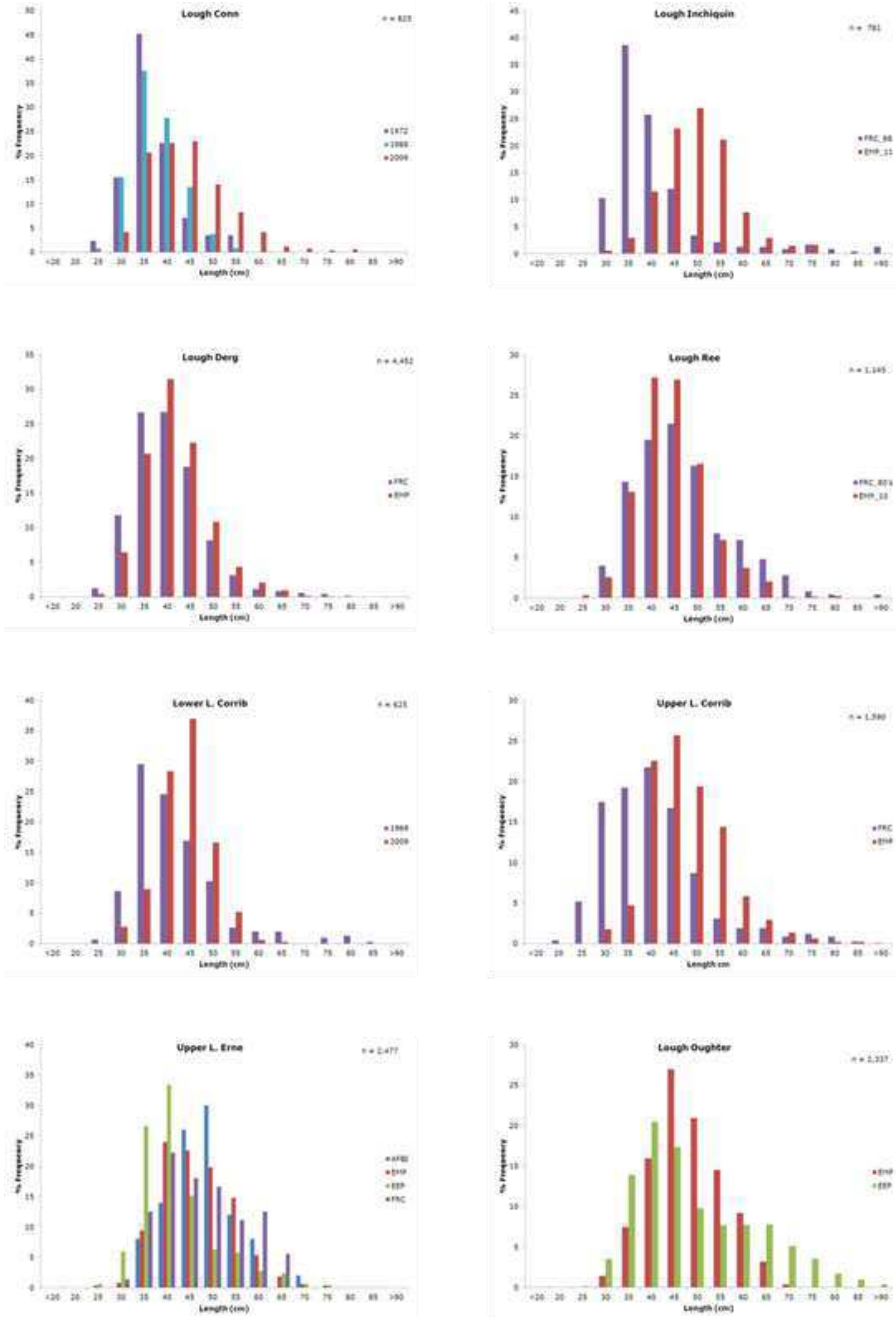


Figure 3-3: Length frequency of selected lakes.

A significant difference in length was found for the Kruskal Wallis test (test statistic X= 739.390, df = 3, p<0.001; Table 3.4). There was a significant difference in average length between the eels caught in the 1960's compared with the recent surveys (Mann Whitney test U=1432007, p<0.001; p<0.0125bc; r=0.326). A medium effect size was calculated for this analysis, supporting the significant difference in length from the 1960's and present data surveys. A significant difference in length was calculated for eels surveyed in 1960's and in the 1990's (Mann Whitney test U=1402787.5, p<0.01; p<0.0125bc, r=0.25). There is a small to medium effect size for this analysis indicating that the result is not as pronounced as it is in the 2010 surveys.

A significant difference was also found for the eels measured in 1990 and the 2010's. However, the effect size is low (U = 279950, p<0.001, r = .09). A similar significant result was found when analysing the length of eels from 1960's and 1980's; a significant result was calculated but the effect size is low (U = 668620, z=-2.758, r=.05). The stock structure of the eels has been changing gradually since the 1960's and is showing a medium effect size when the two extreme time periods are examined (1960's and 2010's; Fig. 3.4).

Table 3-4: Summary data of eel length and decade.

Length	1960	1980	1990	2010
Mean	43.4	42.1	47.3	48.4
Median	41.6	40	46.1	47.5
Minimum	23	28	29.2	28.2
Maximum	97.8	94	85.6	87.5
Count	1721	833	2297	2713

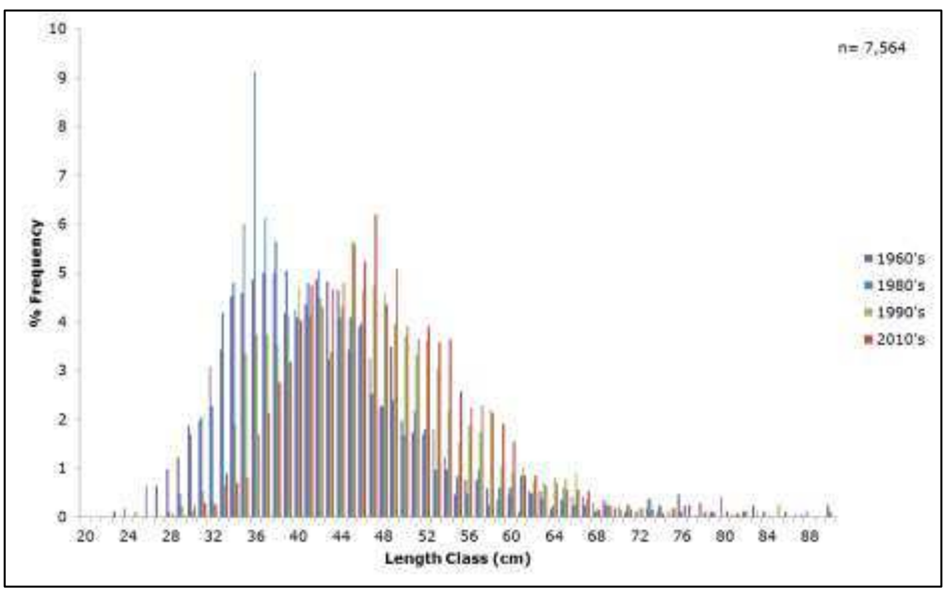


Figure 3-4: Length frequency of eel length by decade.

3.2.3.4 Barrow River and Transitional Waters

For the Barrow catchment, historical data were available for a number of locations in the freshwater and the upper transitional waters.

An examination of the historical and current data from the River Barrow indicates no significant difference in the length frequency for the eels in the freshwater sites (Fig. 3.5). However, there is an indication that there are greater numbers of smaller eels present in the transitional waters in the recent surveys (Fig. 3.6). A significant difference in length of eels between 1970's and 2010's was observed for the Barrow transitional waters, although it is in the opposite direction to that observed in the lakes (Mann Whitney test $U=35833.5$, $p<0.001$, $r=0.19$, Fig. 3.6). The average length for the 1970's eels is 46.57cm compared with 42.27 for the 2012 survey. This difference in length could be an artefact of the unequal sample size and the fact that the 2010's sample is from one location and one nights fishing. It indicates an increase in the smaller size class of eels. This could be a result of the reduced density present in the transitional waters following the extended period of poor recruitment, with enough space for eels to stay in the estuary rather than move into freshwater, due to recent increases in glass eel and /or a result of reduced fishing pressure following the cessation of commercial eel fishing.. These are preliminary data and need further investigation.

3.2.3.5 South Sloblands

The length frequency for the South Sloblands from 1970's and 2010's show a slight increase in the proportion of smaller eels in the recent survey compared with the 1970's (Fig. 3.7). However the data set is unbalanced, with 1,989 eels measured for the 1970's and 171 eels for the 2010's survey and therefore no statistical analysis was carried out.

3.2.4 Discussion - Yellow eel

The data from the lake fyke net surveys indicate a decrease in the proportion of small eels being caught by the fyke nets compared with the 1960's and 1980's. There was a gradual progression from the 1960's to 1980's, 1990's to the 2010's of an increase in the average length of eels in freshwater lakes. The proportion of smaller eels has been declining since the 1980's and corresponds to the decline in recruitment. It must be taken into account that the fyke nets are size selective and eels smaller than 30 cm can escape the nets however the data does suggest a trend that should be investigated further. The opposite trend is indicated for transitional waters, especially in the south east.

The fishery independent nature of the work carried out over the last six years and the availability of historical data from 1960's, 1970's, 1980's and 1990's, using similar mesh size fyke nets, coupled with the broad range of lakes surveyed enable us to investigate the effects on the population structure of eels.

It is important to note that this change in length structure was not observed in all lakes. The difference in length frequency in Meelick Bay (L. Derg; Fig. 3.3) is not as pronounced as it is in other lakes. The effect in Lough Ree, while significant, was not as pronounced. This could be the result of the modified nature of the Shannon Catchment with the presence of a hydro scheme affecting the natural recruitment of eels upstream and the assisted migration upstream for juvenile eel.

In order to observe any further changes in population structure as a result of the removal of fishing mortality since 2009 coupled with changes in the recruitment levels as seen in the last 2-3 years, it will be necessary to continue to monitor the stock structure of yellow and silver eels in key locations into the future. These surveys will cover all waterbodies – estuaries, rivers and lakes.

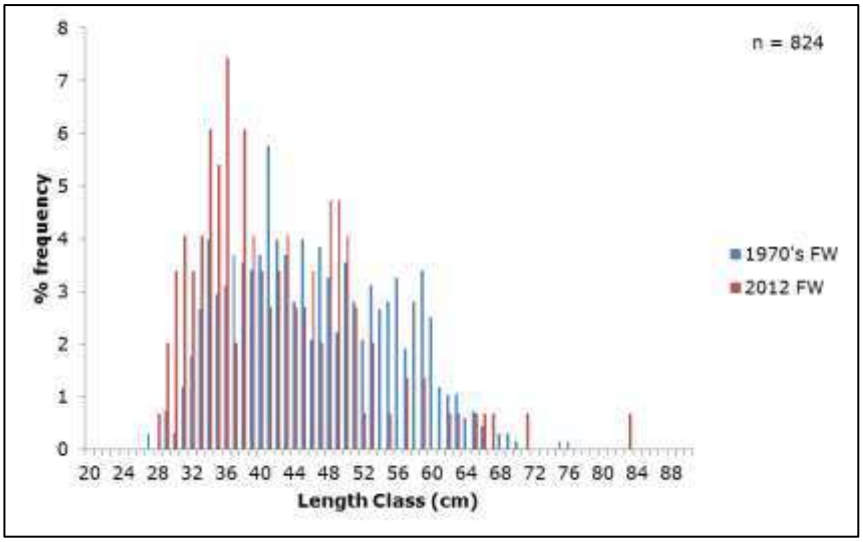


Figure 3-5: Length Frequency River Barrow Freshwater sites.

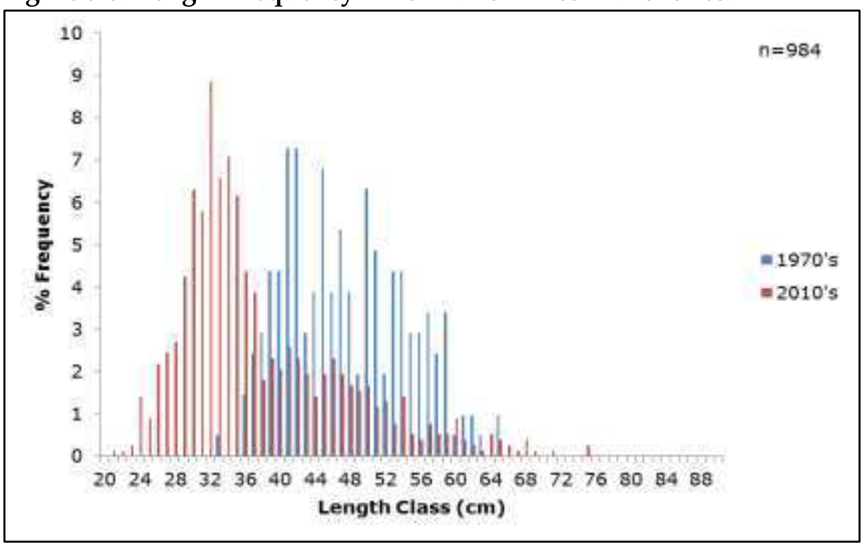


Figure 3-6: Length Frequency Upper Barrow transitional waters.

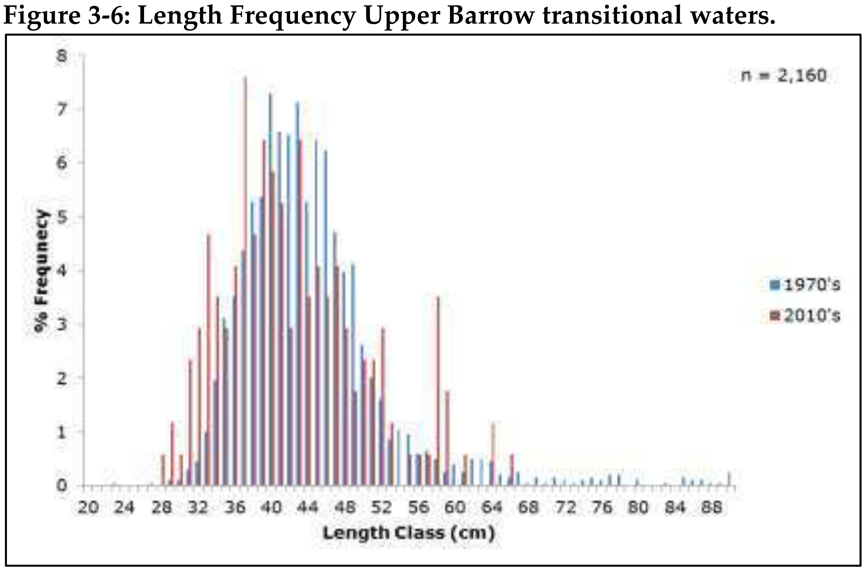
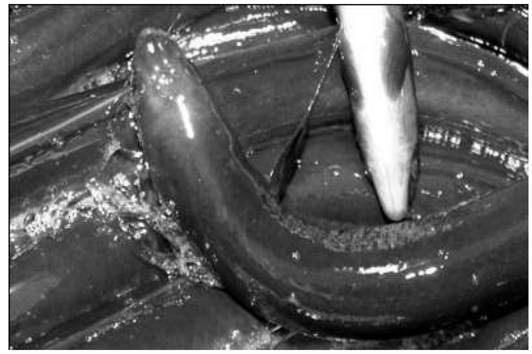


Figure 3-7: Length Frequency South Sloblands.

3.3 Silver Eel Monitoring

3.3.1 Introduction



The Council Regulation (EC) No 1100/2007 sets a target for silver eel escapement to be achieved in the long-term. Ireland is therefore required to provide an estimate of contemporary silver eel escapement. The Regulation also requires post-evaluation of management actions by their impact directly on silver eel escapement. Quantitative estimates of silver eel escapement are required both to establish current escapement and to monitor changes in escapement relative to this benchmark. Furthermore, the sex, age, length and weight profile of migrating silver eels are important for relating recruitment or yellow eel stocks to silver eel escapement. Quantifying migrating silver eel between August and December/January each year is a difficult and expensive process but it is the only way of ultimately calibrating the outputs of the assessments.

Silver eels are being assessed by fishing of index stations on the Corrib (2009 only), Erne, Shannon and Burrishoole catchments (Table 3.5), all of which have a long-term history of eel catch and data collection. Fishing and assessments using mark-recapture commenced on the Fane (Muckno) in 2011 and on the R. Barrow in 2014 and it is hoped in the future to include these as index locations in the future. Trials will also be carried out at other locations identified in the EMP using coghill nets, mark-recapture and technology options such as electronic counters or DIDSON technology. Figure 3.8 shows the locations of the silver sampling in 2009 - 2014.

The mark recapture experiments with yellow eel described below are a long-term study on the behaviour of silver eels. Feunteun *et al*. (2000) found that for silver eels tagged with Passive Integrated Transponders, 20% migrated that year, 5% stayed in the river, 1.5% recovered yellow eels characteristics, 9% stayed an extra year before migrating while 66% were not recaptured at all. It is expected that the M&R surveys will be continued in the selected catchments along with some additional catchments (Muckno and Waterville) over the coming years.

In 2009, the wetted area of the four index catchments (Burrishoole, Corrib, Shannon and Erne) accounted for 64% of the wetted area in Ireland and the Northern Irish portion of the IE_NorW (NWIRBD). Since 2010, the index catchments represent 45% of the wetted area.

Table 3-5: The locations where silver eel escapement will be assessed (extracted from the Irish EMPs).

Catchment	Priority	2009	2010	2011	2012	2013	2014	Method
Corrib	High	√		√				Coghill net / Mark-recapture
Erne	High	√	√	√	√	√	√	Coghill net / Mark-recapture
Shannon	High	√	√	√	√	√	√	Coghill net / Mark-recapture
Burrishoole	High	√	√	√	√	√	√	Trap
Mask	Medium		√					Coghill net / Mark-recapture
Muckno	Medium			√	√	√	√	Coghill net / Mark-recapture
Waterville	Medium			√			√	Fish Counter
Another/ Barrow	High					√	√	Coghill net / Mark-recapture

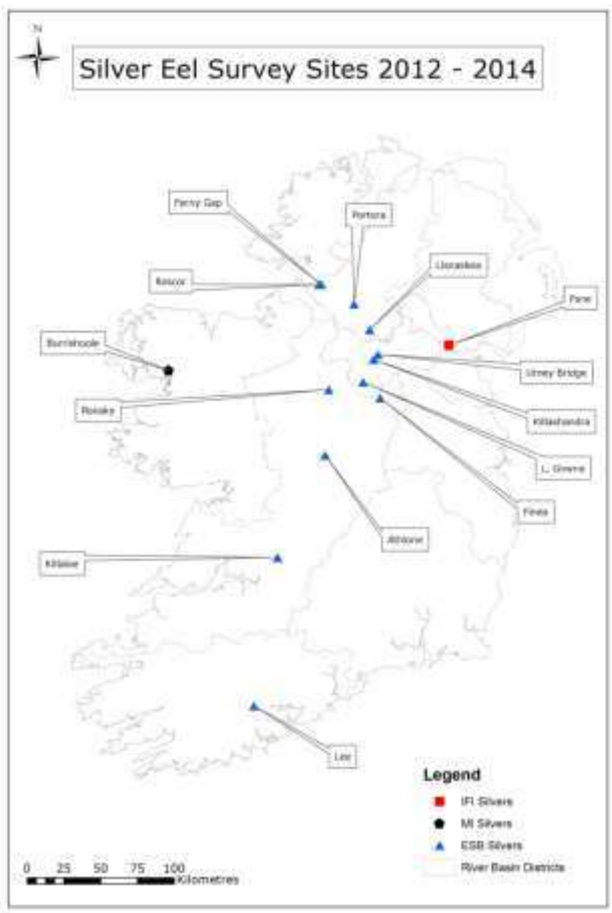


Figure 3-8: Locations of silver eel monitoring sites, 2009-2014.

3.3.2 Shannon

3.3.2.1 Shannon Introduction

Analysis of River Shannon silver eel migrations has been undertaken annually by NUIG in partnership with ESB since 1992 and considerable experience has been gained since the initial intensive studies in 1992-1994 (e.g. Cullen & McCarthy, 2000; 2003; McCarthy & Cullen, 2000; McCarthy *et al*. 1999; 2008). The focus changed in recent years, from fishery monitoring to eel conservation issues. This lead *inter alia* to the development of a Lower River Shannon silver eel trap and transport programme, in which ESB arranged for release of the entire Killaloe eel weir (Fig. 3.9) catch downstream of Parteen weir (Fig. 3.9). The ShIRBD Eel Management Plan proposed increased trap and transport targets for 2009-2012. Therefore, the work undertaken in 2012-2014 reflected the continuing need to provide accurate assessments of the population characteristics of the silver eel populations, especially in respect of the trap and transport fishing zones, and determination of the spawner biomass escapement from the lower River Shannon. Summaries of work in progress have been supplied to the SSCE over the past three years (Anon, 2012; McCarthy *et al.* 2013, 2014, 2015). ESB Fisheries Conservation Annual Reports have also provided regular up-dates on the Shannon eel stocks, for which ESB has statutory responsibilities.

The on-going River Shannon eel research programme is focused on: Monitoring the silver eel trap and transport programme; evaluation of potential alternative hydropower mitigation measures; eel population modelling and analyses of responses of silver eel populations to managed variation in discharge.

Figure 3-9: The Killaloe eel weir (A) and the Parteen regulating weir (B) on the lower River Shannon.

3.3.2.2 Shannon Annual Catch

The total catch in 2012 was 24,228kg. The Killaloe weir catch represented over half the overall catch (12,475kg). The fishing season at Killaloe extended from 19/10/2012 to 09/02/2013 and a total of 97 nights were fished at that location. Fishing at the other sites ended in late November (Finea and Rooskey) and late December (Athlone) (Fig. 3.10).

The 2013 fishing season for eels on the Shannon extended from 1st September to 7th December for the conservation sites in the upper Shannon (Fig. 3.10). In the case of the Killaloe eel weir, fishing began on 23rd October. A total of 84 nights were fished and the last fishing took place on 27th February 2013. A total of 22,561 kg was captured, 9,753 kg in the upper catchment sites and a further 12,808 kg at Killaloe.

The 2014 fishing season for eels on the River Shannon extended from 1st September to 8th December for the conservation sites in the upper Shannon. At Killaloe eel weir test fishing during September and October showed no migration was occurring in the low flow conditions. As discharge increased at the beginning of November the main silver eel migration started with the first catches at Killaloe occurring on 10th November 2014. A total of 73 nights were fished and the final fishing event took place on 26th January 2014. During the 2014 season 11,330 kg was captured at the upstream sites and 15,122 kg was captured at Killaloe.

The relative catch contribution from the upstream sites to the ESB silver eel trap and transport programme in 2012, 2013 and 2014 is summarised in Figures 3.15, 3.16 & 3.17.

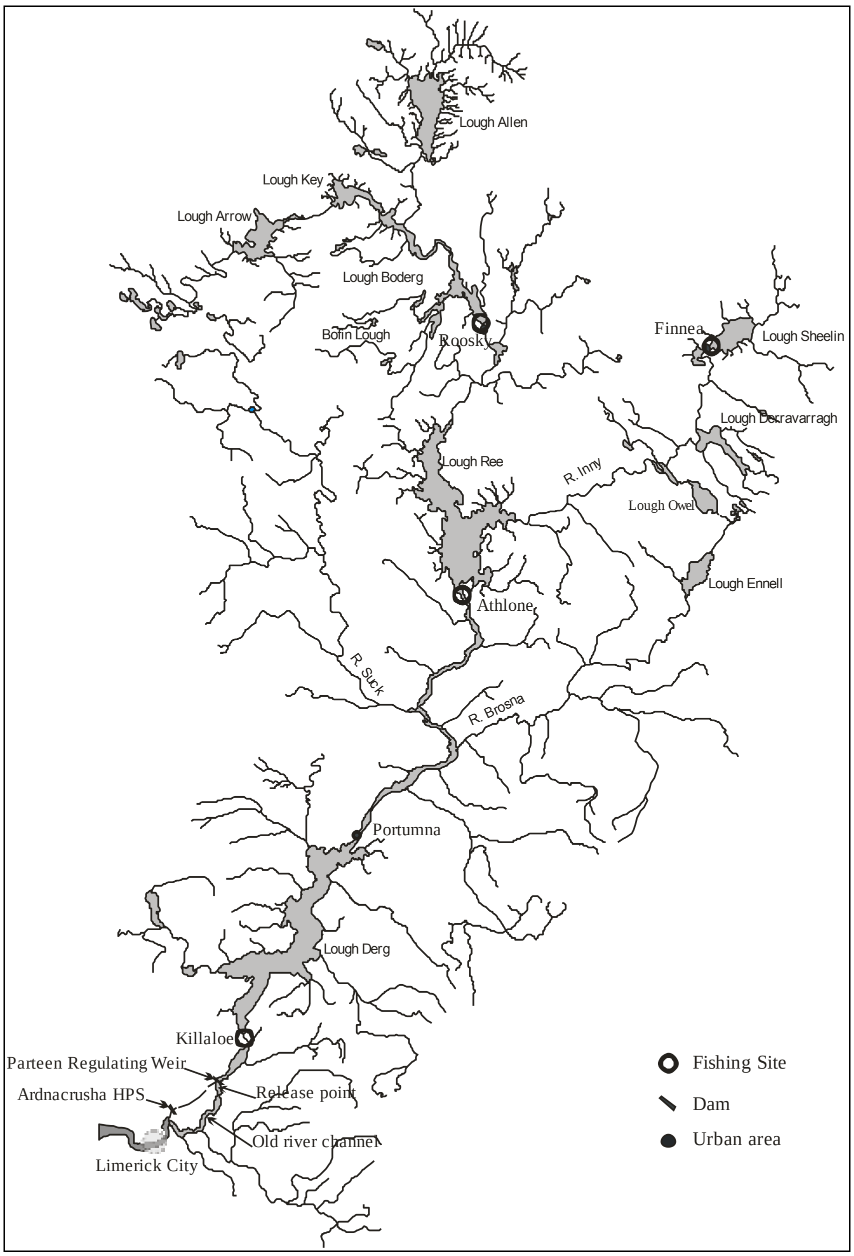


Figure 3-10: Map of River Shannon catchment.

3.3.2.3 Shannon Annual Hydropower Mortality and bypass

The determination of turbine passage mortality for silver eels passing through Ardnacrusha dam (Fig. 3.11) was determined by means of acoustic telemetry, using protocols described in NUIG/ESB reports to SSCE (McCarthy *et al*. 2010, 2011, 2012). Eels were tracked, following release in the headrace canal at Clonlara as they passed downstream, using an array of receivers deployed above and below the dam and mortality rates were determined on the basis of failures to detect tagged eels at the downstream sites. A total of 104 female eels, captured at Killaloe weir, were used and these were representative of the size range of eels typically passing downstream of Killaloe. Sample sizes varied (N=28 in 2008; N=16 in 2009; N= 40 in 2010; N=20 in 2011) and annual mortality rates varied from 16.6% to 25% for these small batches (Main Report Table 3.2). The detection or not of a single eel affects these rates, so the overall mean rate of 21.15% has been adopted. The overall sample size was determined by SSCE to have met the precision requirements specified in the IE_Shan Eel Management Plan and this has been adopted as a modelling parameter by NUIG. Some future refinements will be possible, when analyses of male mortality rates are incorporated into the telemetry model. Because of their relatively small size, male eels are more difficult to handle in such telemetry experiments. Initial results suggest silver eel male mortality rates are lower and this is in line with published observations elsewhere. However, provisional results for a 2011 male turbine passage experiment (N=30) when incorporated into the Ardnacrusha mortality rate for a representative Killaloe silver eel sex-ratio, only slightly reduces the mortality rate (to 20.78%). Therefore, use of this refined estimate would only change the calculations made for 2009-2012 very slightly, because males typically constitute less than 10% of the escapement biomass in the Shannon.

Figure 3-11: Ardnacrusha Dam on the Lower River Shannon.

To determine the proportion of the eel run using the old river channel as a bypass around the Ardnacrusha Hydropower Station, in 2006-2009, a series of batches of acoustically tagged eels were released immediately downstream of Killaloe (Fig. 3.12), during different levels of discharge and different levels of spillage at the Parteen regulating weir. During the experiments additional receivers were deployed upstream of the Killaloe release point, in the upper part of the headrace canal, in the old river channel below Parteen regulating weir and in the lower section of the old river channel. A total of 51 tagged eels were involved of which 39 were successfully tracked. The failure to detect some eels may have been due to initial tagging difficulties and selection of insufficiently mature eels in the initial experiments. However, the results showed that the route selection by eels was significantly influenced by the amount of spillage and a regression model has been developed that allows for prediction of route selection by eels migrating downstream from Killaloe. This is being used, together with analyses of daily Killaloe weir catches and hydrometric data to evaluate the extent to which the old river channel (bypass) contributes to safe silver eel passage to the estuary. This analysis has been completed for the 2008-2012 period and for four further years in the period 2000-2007. The results available at present indicate that 17.8% of eels passing downstream used the old channel route in recent years. A more comprehensive analysis will allow for revised estimates of historical silver eel escapement. The application of parameters such as Killaloe eel weir efficiency, percentage bypass selection, Ardnacrusha turbine mortality rates, together with results of analyses of the trap and transport monitoring research provide an increasingly robust set of protocols for estimation of River Shannon silver eel production and spawner biomass escapement.

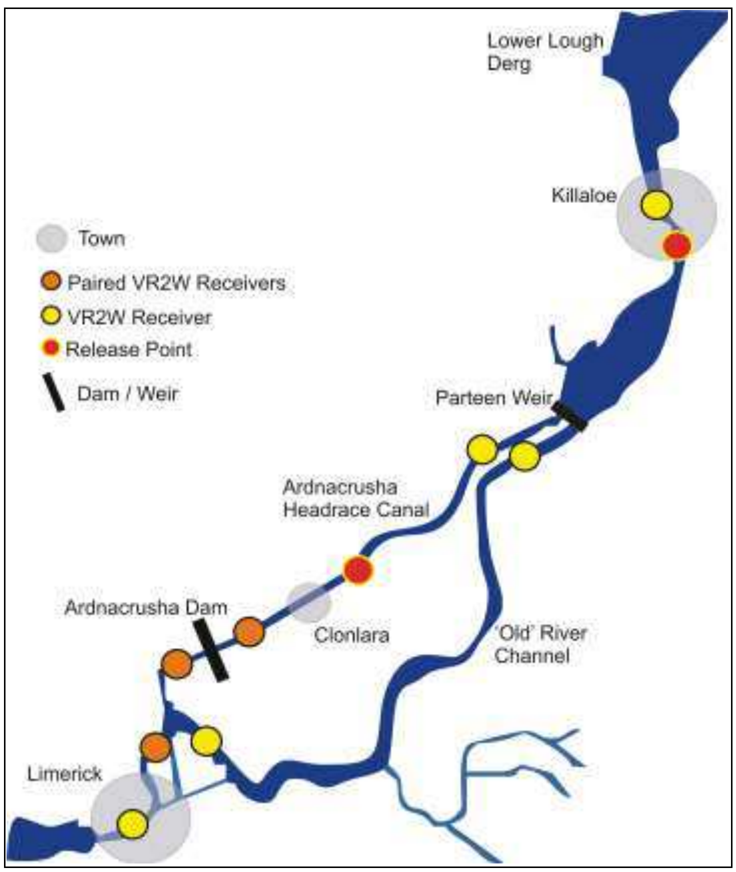


Figure 3-12: Locations of telemetry receivers and release point for acoustically tagged eels used for turbine passage studies in the Lower River Shannon 2008-2012. Not all receivers were deployed in all years.

3.3.2.4 Shannon Annual Silver Eel Production/Escapement

3.3.2.4.1 Historic

It was not possible to directly calculate the historic production from the Shannon as the impact of the hydroelectric power station constructed between 1925 and 1929 probably predated the fisheries data time series.

Using the model in the EMP, it was estimated that the historic production (Bo) for the Shannon was in the order of 189,709kg (Table 3.7). Records indicate that the silver eel catches in the 1920s were at least 60-70t.

3.3.2.4.2 Pre-EMP 2001-2007

Production and escapement for the period 2001-2007 were determined in a similar fashion to the historic production, also described in the Irish EMP, Chapter 5.2.3. Potential production (Bbest) was estimated to be on average 2.0kg/ha or 85,700kg. Escapement ($B_{2001\text{-}2007}$) was recalculated using the turbine mortality rates determined for Ardnacrusha for 2009-2011.

From 2001 to 2008 the ESB undertook a pilot programme of transporting a proportion of the silver eels captured in the Shannon silver eel fishery around the dams and releasing them for onward migration to the sea. These released eels amounted to 5% to 39% of the total silver eel catch on the Shannon and for the 2001 to 2007 period the average release was 2,700kg.

Escapement, including the 3,224kg (average 2001-2007) transported and released silver eels, was estimated to be on average 12,163kg (Table 3.7) using the more recent data of 17.8% as an average bypass and 21.1% turbine mortality (average 2009-2011).

3.3.2.4.3 Current 2009-2014

The current pattern of silver eel escapement has been well documented (McCarthy *et al.* 2010, 2011, 2012) for all ESB contracted fishing sites on the Shannon. Earlier peaks in migration occurred in the upper catchment sites, which typically exhibited clear lunar periodicity in catch levels, and eels in the upper catchment sites were typically larger than those recorded downstream at Killaloe (Fig. 3.13). The sex ratio varied along the river with catches at upper sites being comprised predominately, or exclusively, of female eels (Fig. 3.13). The appearance of males in the downstream sections may be as a result higher densities from stocking the lower catchment and/or selective fisheries altering the proportions of males and females in the run down through the catchment.

The production and escapement estimates for 2009 to 2011 were reported to the EU in 2012 (Anon, 2012) and are included in the tables (Table 3.7 and electronic Sheets for Ireland).

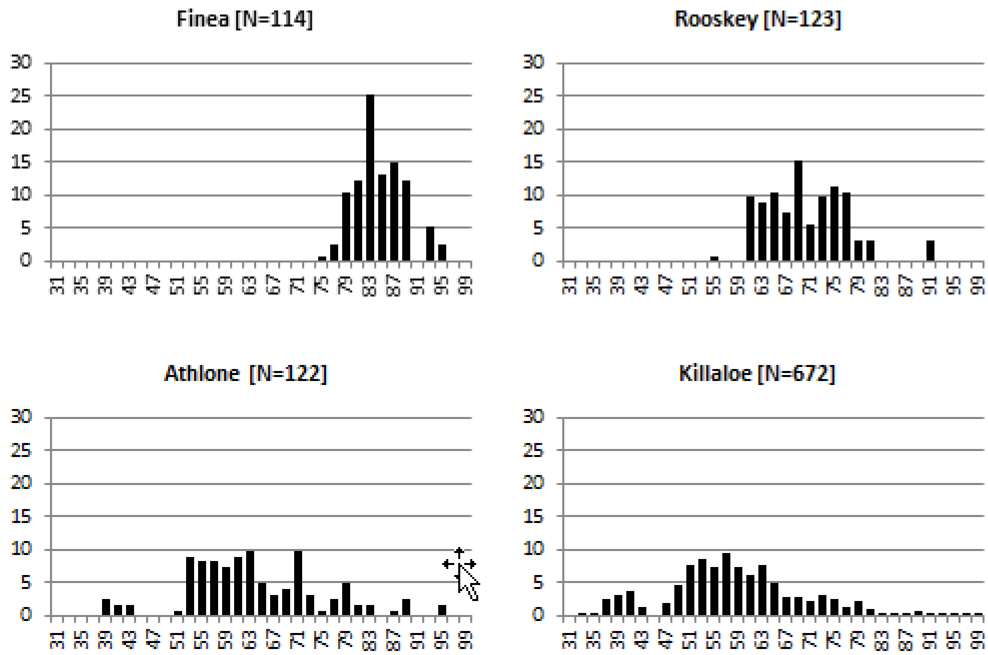


Figure 3-13: Length (cm) relative frequencies [%] of eels captured at River Shannon conservation fishing sites in the 2014 eel migration season.

The 2012 season results are presented in Figure 3.15. The silver eel production was estimated as 67,931kg, using Killaloe catch data and results of mark-recapture experiments. The eel weir capture efficiency, based on recaptures from 497 Floy- tagged eels (4 X batches) as 22.53%. Escapement was estimated to be 58,836kg (86.6% of production) and mortalities at Ardnacrusha were estimated to be 9,095kgt (13.4% of production). The trap and transport total (24.2t) represented 35.67% of silver eel production and exceeded the target (30%) by 3.8t. Following adoption of new analytical protocols for estimation of Shannon silver eel production by MacNamara and McCarthy (2013), it has been decided to also present the 2012 production/escapement results as part of the new time series. The production and escapement estimates obtained following the new protocols were 67,500kg and 58,500kg. Retrospective re-analysis of Shannon silver eel population dynamics has already been partially completed using the same approach.

The 2013 season results are presented in Figure 3.16. The silver eel production was estimated as 79,970 kg, using Killaloe catch data and results of mark-recapture experiments. The capture efficiency at Killaloe eel weir was very variable during the 2013 silver eel season, from the start of fishing (23rd October) until 2nd January 2014 the weir was using the standard number of nets as in previous years. During this period no eels were tagged, therefore the average weir efficiency from the previous three years was used in production calculations (22.47%). After that date a series of technical problem reduced the number of nets fishing. Between the 3rd January and 8th January the manual wattle nets were no longer fishable due to high flow conditions. During this period 300 eels, in two batches, were FLOY tagged giving a capture efficiency of 18% (54/300). From the 8th January until the close of the fishing season a number of the hydraulically operated nets were also unfishable due to a technical fault. A total of 299 eels were tagged and released during this period giving a capture efficiency of 12.4% (37/299). Had the weir been operating at its previous average capture efficiency for the entire silver eel season it is estimated that the total catch at Killaloe would have been 15,780 kg, which would have been 2,970 kg more than what was actually caught. Further refurbishment of the weir at Killaloe due to take place in 2014 may improve efficiency.

Escapement in 2013 was estimated to be 70,775 kg (86% of production) and mortalities at Ardnacrusha were estimated to be 9,195 kg (11.5% of production). The trap and transport total (22,561 kg) represented 28.2% of silver eel production. The three year rolling average for the 2011 (38.4%), 2012 (35.9%) and 2013 (28.2%) seasons was 33.8%. Therefore the target of 30% over a three year rolling average has been attained in the 2011-'13 period.

The 2014 season results are presented in Figure 3.17. The silver eel production was estimated as 70,725 kg, using Killaloe catch data and results of mark-recapture experiments. Prior to the commencement of the 2014 silver eel season major upgrading works were carried out on the fishing weir at Killaloe. All of the remaining manually lifted wattle nets were replaced with hydraulically operated nets (Fig. 3.14). In contrast to some previous fishing seasons, where weir efficiency was compromised by high river discharge, capture efficiency during the 2014 season remained constant through the fishing period and at a higher overall level. A total of 593 silver eels were tagged using FLOY tags during the 2014 fishing season. Of these 151 were recaptured giving a seasonal mean efficiency of 25.46%. This is an increase in efficiency over the recent (2009-2012) mean efficiency of 22.47%, when the weir fished with a combination of both hydraulically and manually lifted nets.

Escapement in 2014 was estimated to be 62,980 kg (89.05% of production) and mortalities at Ardnacrusha were estimated to be 6,950 kg (9.8% of production). The trap and transport total (26,438 kg) represented 37.4% of silver eel production. The three year rolling average for the 2012 (35.7%), 2013 (28.2%) and 2014 (37.4%) seasons was 33.8%. Therefore the target of 30% over a three year rolling average has been attained in the 2014 season.

The data for the River Shannon are presented on the modified ICES precautionary diagram using the EU target (40% SSB) as the reference point and a calculated mortality reference point based on the EU target (Alim 0.92) (Fig. 3.18 & 3.19). The reduction in mortality from both the fishery and the HPS is evident along with a corresponding increase in escapement. The Shannon R. remains below the EU target.

Figure 3-14: Killaloe weir on the Shannon River.

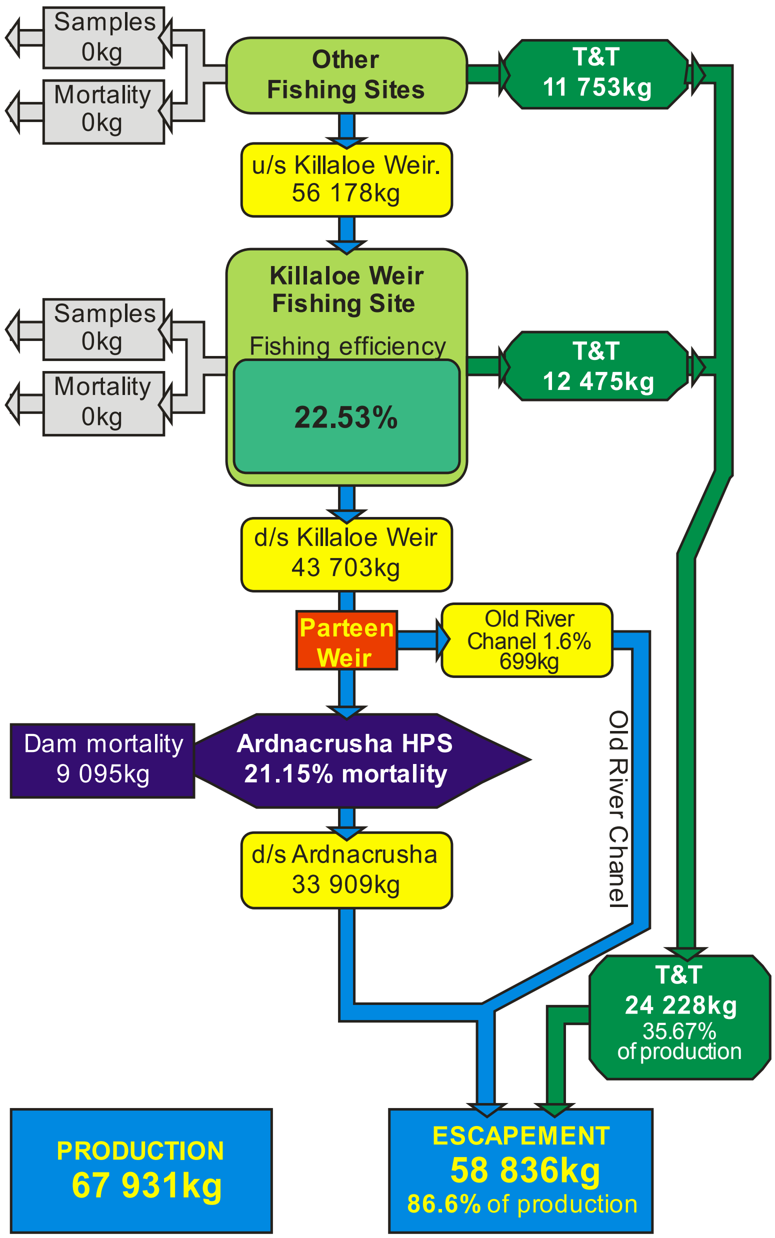


Figure 3-15: Summary silver eel biomass production and escapement estimate for River Shannon system 2012/2013.

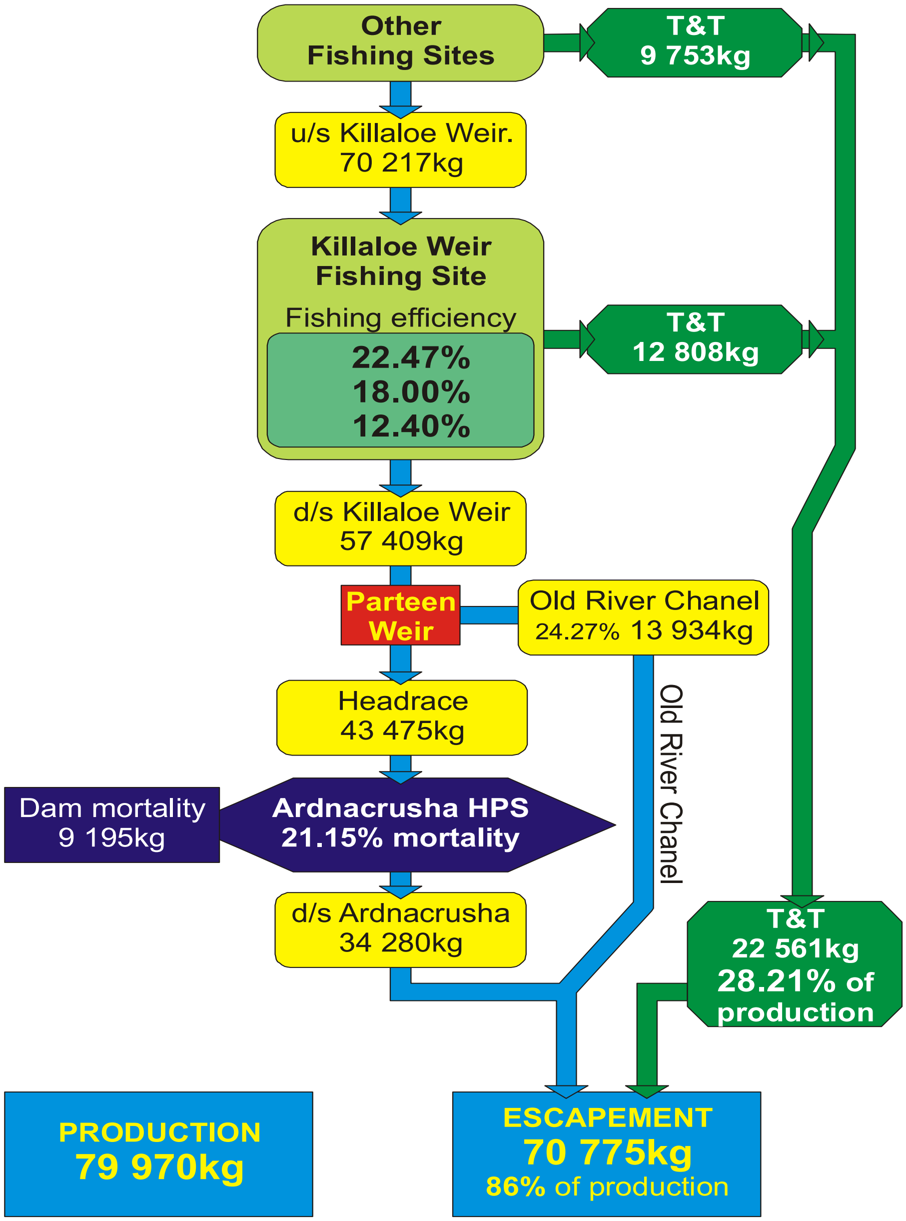


Figure 3-16: Summary silver eel biomass production and escapement estimate for River Shannon system 2013/2014.

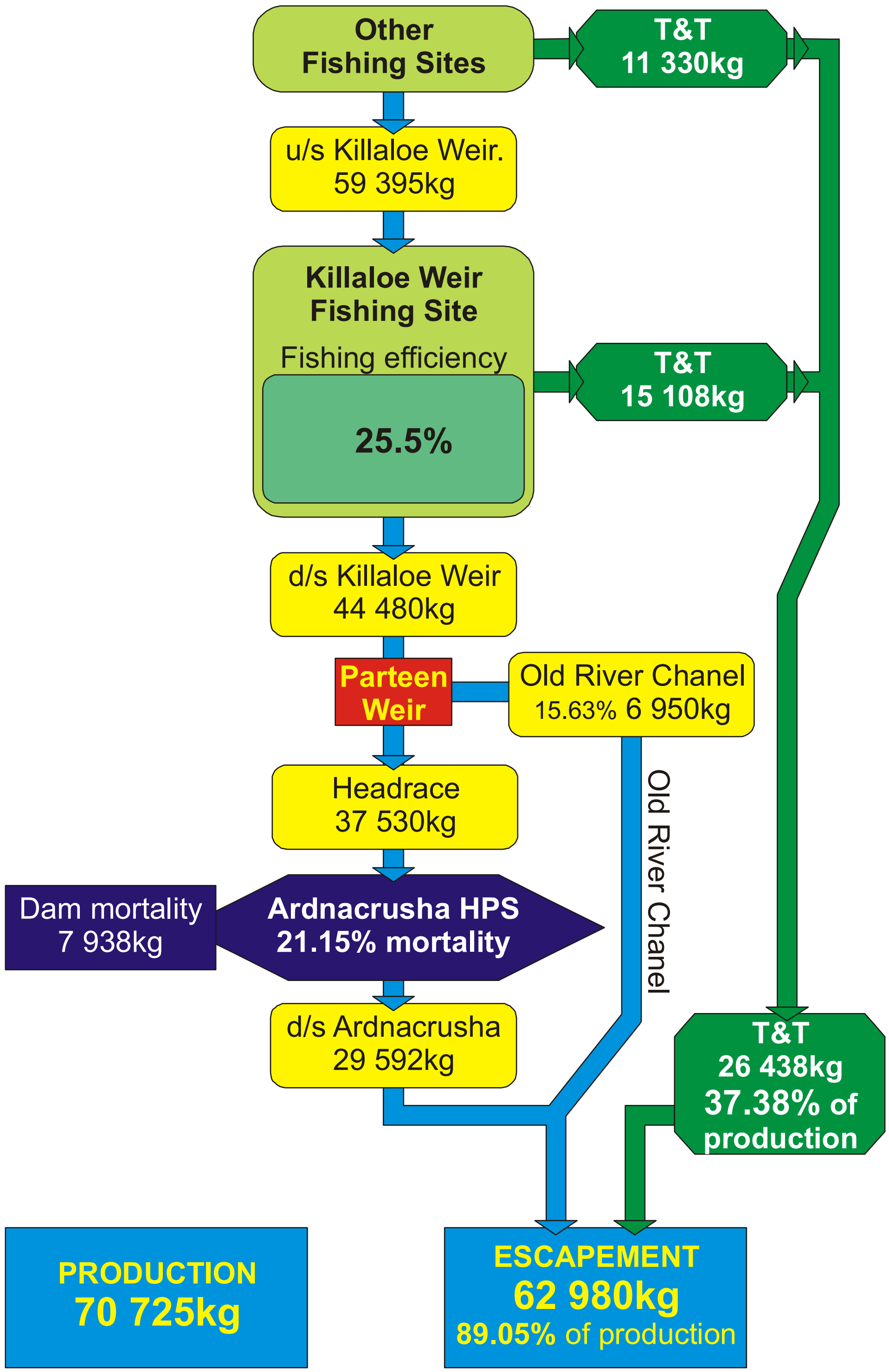


Figure 3-17: Summary silver eel biomass production and escapement estimate for River Shannon system 2014/2015.

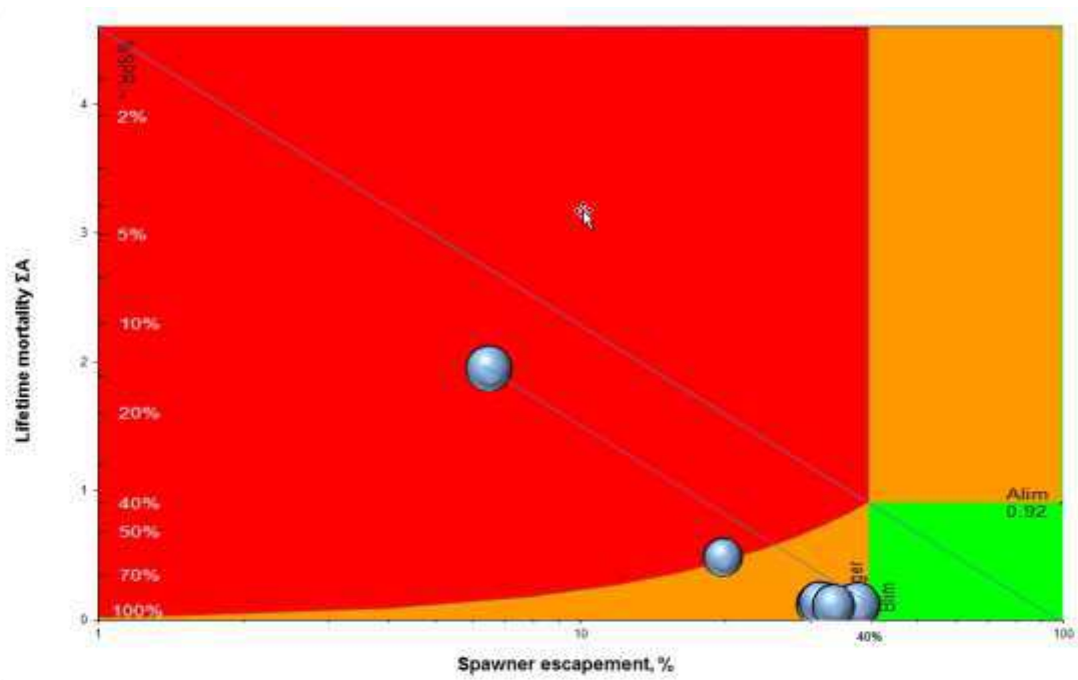


Figure 3-18: Status of the stock and the anthropogenic impacts, for the Shannon as presented in the Eel Management Plans for the average 2001-2007, in 2008 and for the current years, 2009-2014. For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

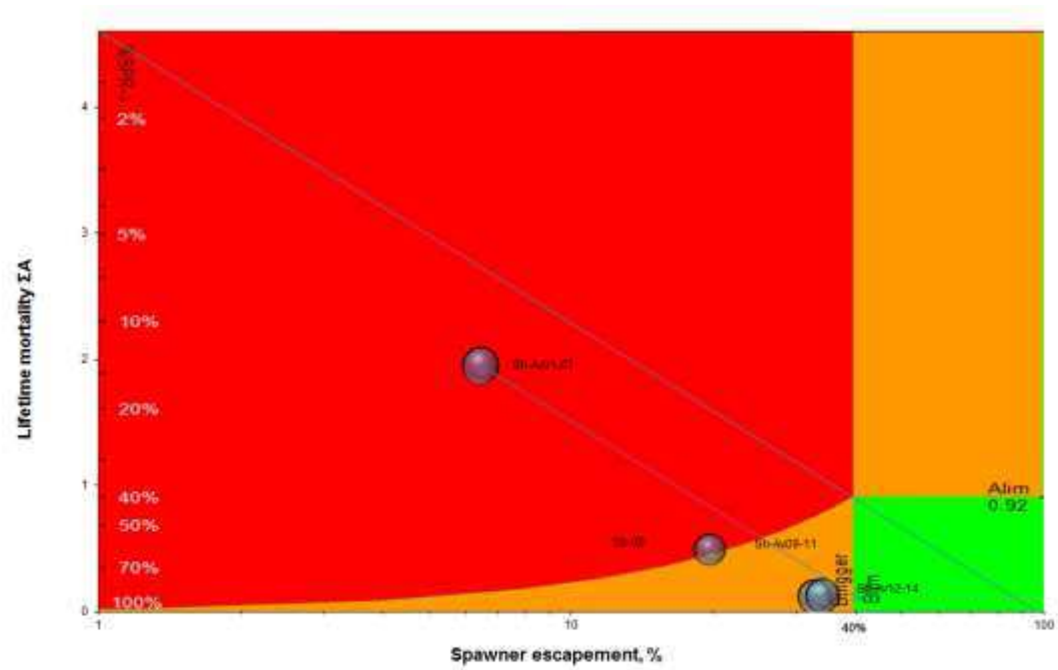


Figure 3-19: Status of the stock and the anthropogenic impacts, for the River Shannon as presented in the Eel Management Plans for the average 2001-2007, for 2008 and for the averages 2009-2011 and 2012-2014.

3.3.3 Erne Transboundary

3.3.3.1 Erne Introduction

The eel populations of the River Erne, with a long history of commercial exploitation, are of considerable importance in respect of the eel conservation objectives of the North-Western IRB Eel Management Plans. As indicated by previous reports, such as those of McCarthy *et al*. (1994) and Matthews *et al.* (2001), historical fishery records were very incomplete for the River Erne system and estimates of fishery yield have often been rather speculative. Previous eel research in the river basin has largely been focused on yellow eel populations. Consequently, the results presented below concerning downstream migrating silver eels are of particular value in assessment of the current spawner escapement and in provision of other data needed for eel management purposes.

The IE_NorW eel management plan specified targets for a silver eel trap and transport programme undertaken by ESB during 2009–2012, based on model predictions of the quantities of silver eels that were presumed to be produced in the extensive cross-border River Erne catchment area. The target set for 2009/2010 was 22.5t, with higher targets 33.75t and 39t phased in for the following two years to account for the development process of T&T in the Erne. These were based on the assumption that turbine mortality rates of 28.5% (ICES, 2003) applied to both the hydropower stations (Cliff HPS and Cathaleen's Fall HPS) operated by ESB in the lower section of the river (Fig. 3.20 & 3.21). Likewise, it was assumed that the commercial eel fishery would cease in 2009. The whole fishery on the Erne ceased in 2010.

The silver eel trap and transport target was modified on the Erne for the 2012-2014 period to allow for the transport of 50% of the annual silver eel production and a rolling target based on a 3-year basis allowing shortfalls in one year to be made up the following year. A consistent long-term shortfall should not be carried forward indefinitely.

Figure 3-20: River Erne hydroelectricity generating stations (A) Cliff HPS and (B) Cathaleen's Fall HPS.

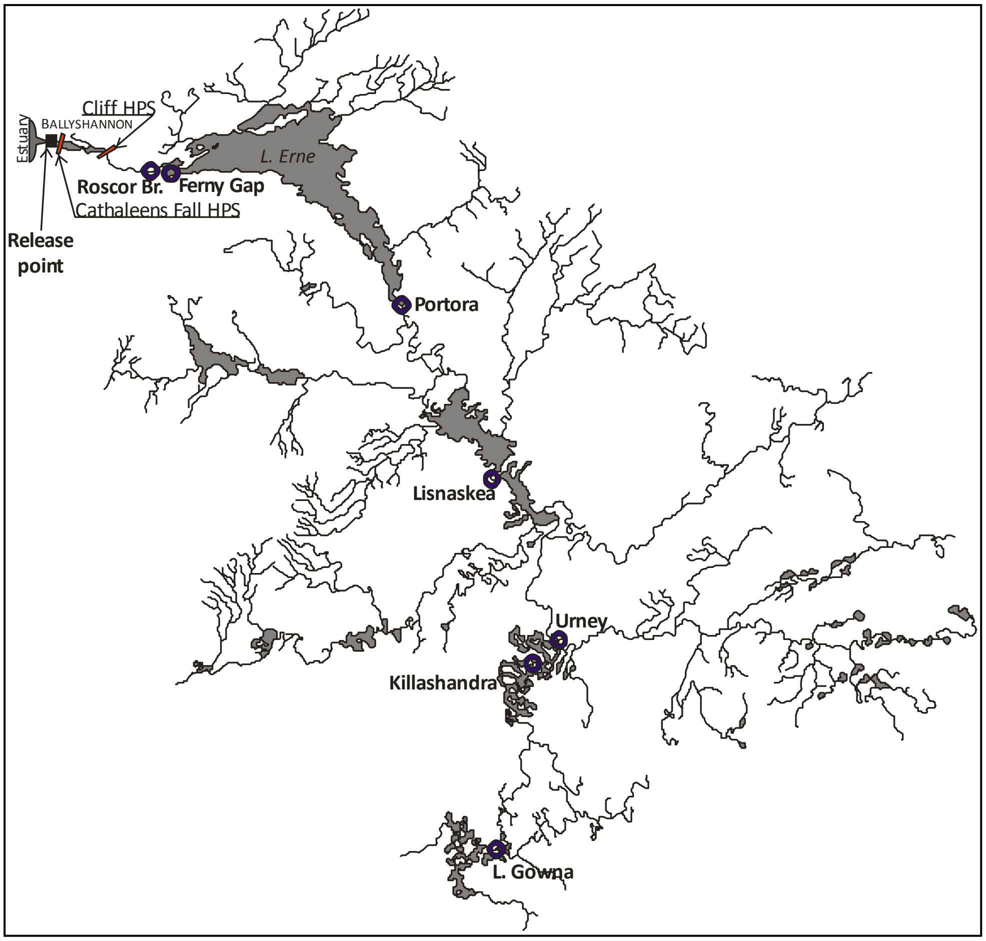


Figure 3-21: Conservation fishing sites in the River Erne system, monitored by NUIG, in 2009-2014 seasons with some small alterations in locations between years.

3.3.3.2 Erne Annual Catch

The analysis of downstream migrating silver eel population dynamics was complicated in 2009 by: Lack of reliable historical fishery data for the River Erne system; delayed fishery closure in part of the system; difficulties in establishing an effective monitoring site in the lower part of the system and development of research protocols. Following establishment in 2010 of an experimental fishing weir, which was scientifically monitored by NUIG, at Roscor Bridge significant progress became possible. Estimates of both silver eel production and escapement rates were possible in the 2010 and 2011 seasons and these have been reported previously (Anon, 2012a). In both the 2010 and 2011 season's estimation of eel mortalities associated with downstream passage at the two hydropower dams (Cliff HPS and Cathaleen's Fall HPS) was undertaken by means of acoustic telemetry. In 2012 it was possible to adapt protocols developed in 2009-2011 and to refine the methodology used for calculation of silver eel production in the River Erne system. The 2012 season was characterised by unusual weather and discharge patterns (Fig. 3.22). These were reflected in the eel migration patterns and in the catches obtained in the conservation fishing undertaken during the ESB trap and transport programme.

For the 2012 season, the fishing activities of contract crews (N = 7) at the authorized River Erne conservation fishing sites (Fi.g 3.21) were monitored by NUIG. Four sites (Urneys, Portora, Ferney Gap, Roscor Bridge) cumulatively contributed almost 88% of the total catches for 2012. The total catch amounted to 34,660kg.

The variation in Roscor Bridge experimental fishing weir daily catches is illustrated (Fig. 3.22) in relation to lunar cycles and variation in discharge. The fishing season at Roscor Bridge extended from 20th of September to 24th of February 2013 and a total of 126 nights were fished at that location. Fishing at the other sites ended at the end of November, with the exception of Urneys where scientific monitoring was continued till late December.

In **the 2013 Season**, the fishing season on the Erne started on 1st September and finished on 7th December 2014 (with the exceptions of Roscor Bridge and Urney). Four sites (Urney, Portora, Ferny Gap, Roscor Bridge) cumulatively contributed almost 72% of the total catches for 2013. The variation in Roscor Bridge experimental fishing weir daily catches is illustrated (Fig. 3.23) in relation to lunar cycles and variation in discharge. The fishing season at Roscor Bridge extended from 1st October 2013 to 7th March 2014 and a total of 142 nights were fished at that location. Fishing at the other sites ended at the beginning of December, with the exception of Urney where scientific monitoring was continued till mid February 2014.

The **2014 fishing season** on the Erne started on 17th August and finished on 2nd December 2014 (with the exceptions of the Roscor Bridge experimental weir). Four sites (Urney, Portora, Ferny Gap, Roscor Bridge) cumulatively contributed almost 75% of the total catches for 2014. The variation in Roscor Bridge experimental fishing weir daily catches is illustrated (Fig. 3.24) in relation to lunar cycles and variation in discharge. The fishing season at Roscor Bridge extended from 15th October 2014 to 28th January 2015 and a total of 98 nights were fished at that location. Fishing at the other sites ended at the beginning of December 2014.

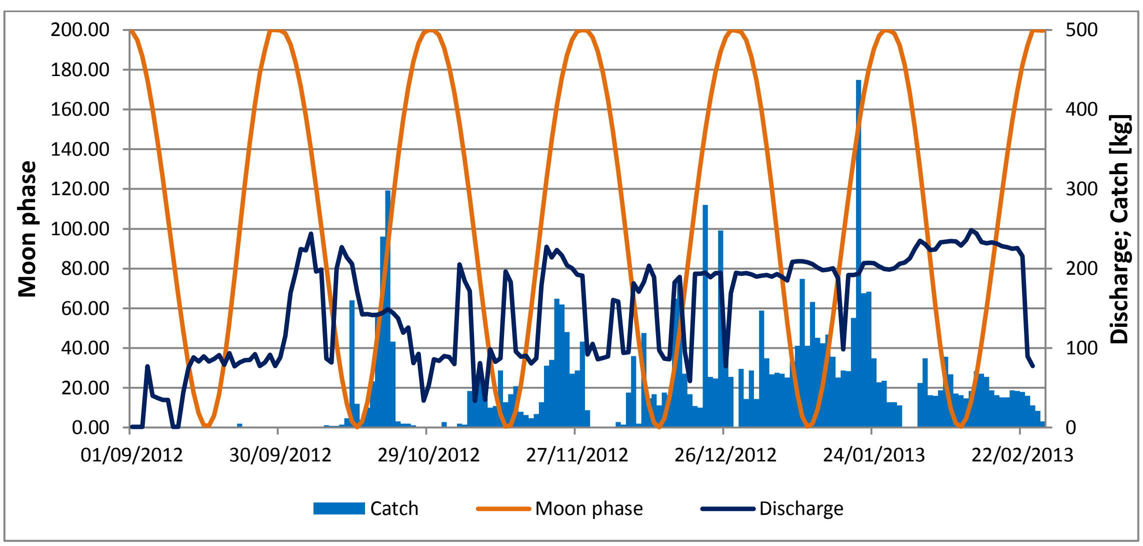


Figure 3-22: Variation in daily catches at the Roscor Bridge eel weir in relation to lunar cycle and discharge.

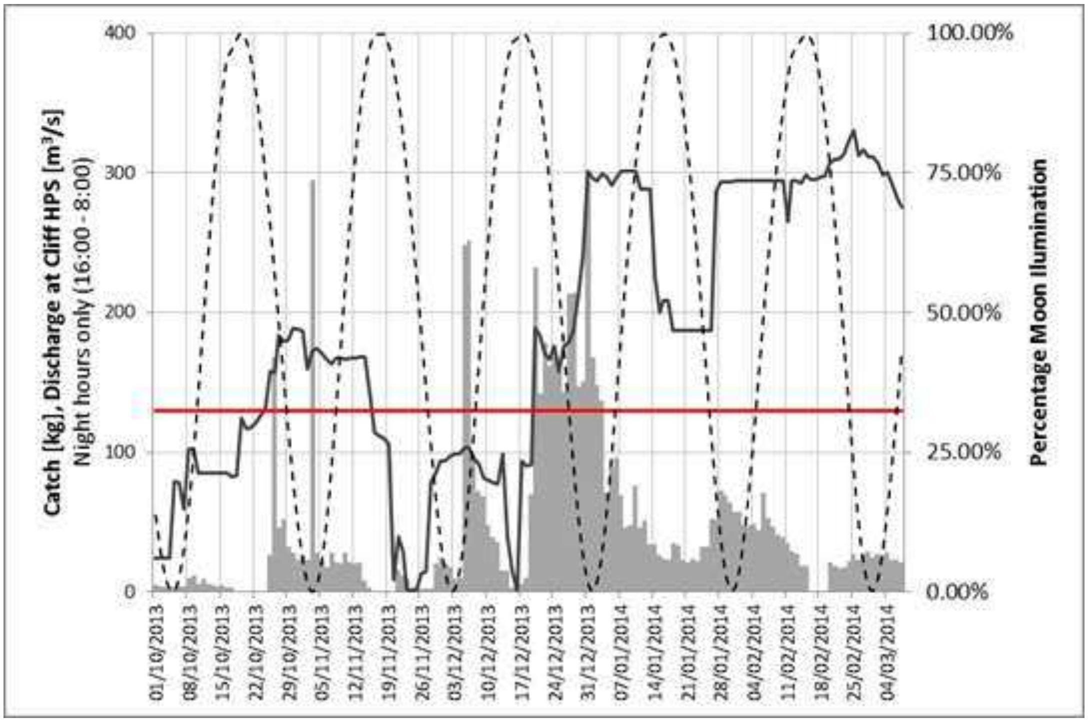


Figure 3-23: Variation in daily catches at the Roscor Bridge eel weir in relation to lunar cycle and discharge during the 2013 season. (The threshold discharge of 130 m3•s-1 delineating between use of high flow/low flow models used in population analyses is indicated by a red line).

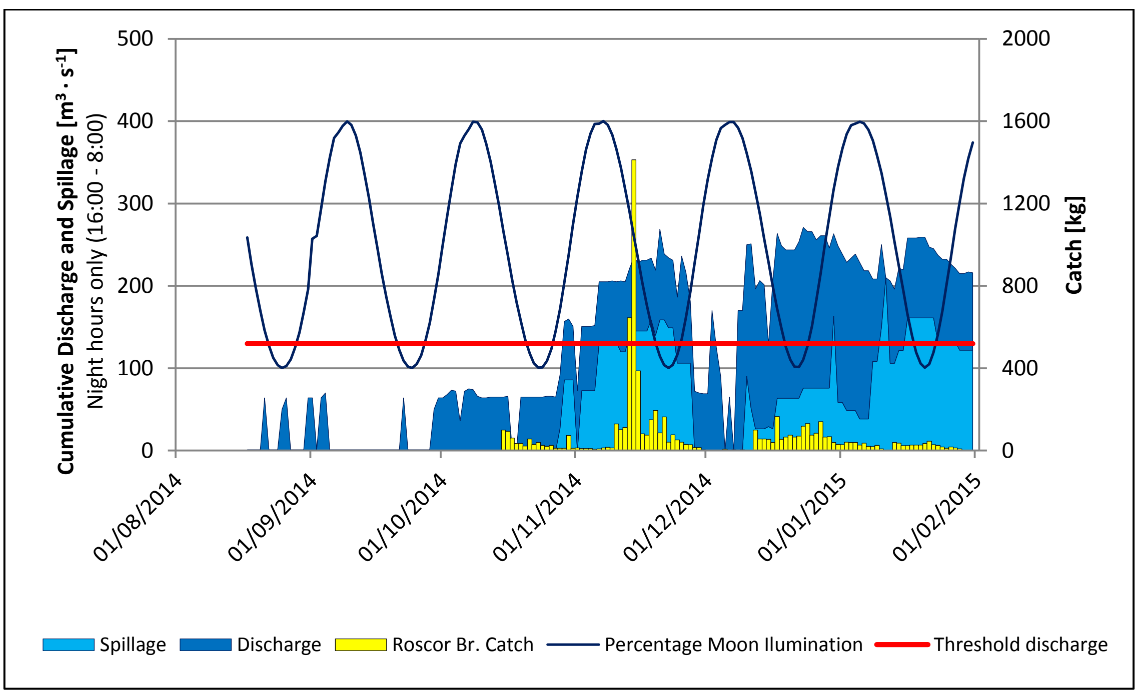


Figure 3-24: Variation in daily catches at the Roscor Bridge eel weir in relation to lunar cycle and discharge during 2014 season (the threshold discharge of 130m³·s⁻¹ used in population analyses is indicated by a red line).

3.3.3.3 Erne Annual Hydropower Mortality and bypass

Acoustic telemetry, using protocols described in Annual Reports (McCarthy *et al*. 2010, 2011, 2012) and, overall sample size considered appropriate in respect of SSCE precision estimation protocols, was used for assessment of the mortality rate experienced by downstream migrating silver eels passing from Belleek to the Ballyshannon estuary. Arrays of Vemco receivers were deployed annually (Fig. 3.25) for this purpose. The mortality rate recorded at Cliff HPS differed slightly from 7.7% to 6.9% to 8.5% during the three years of the study, but no particular significance is attached to this due to sample size limitations. However, the combined rate for tagged eels (N=101) was 7.9%. The relatively low mortality seems to have partly resulted from use of spillage opportunities, and favourable hydrological conditions that are typical of the Cliff HPS forebay.

In 2011 and 2012 a special double receiver experiment allowed for determination of the number of tagged eels passing on either side of it. This showed that the majority of acoustically tagged eels migrated on the northern side of the river channel and this would have brought them past the spillway. Further research on this route selection phenomenon is planned for 2012/2013. In the case of Cathaleen's Fall HPS, the initial year's telemetry was complicated by loss of an essential estuarine receiver during part of the experimental period. Though, a provisional estimate (22%) mortality rate was obtained, it was only based on a small sample size (N=9) and was not considered reliable, other than for provisional calculation of spawner biomass escapement. In 2010 and 2011 only one turbine was operational at Cathaleen's Fall HPS, thus the relatively low mortality rates recorded (7.7% in 2010/2011, N=26; 6.1% in 2011/2012, N=49) favoured spawner biomass escapement. However, in future years it's more likely that both the turbines will be operational Cathaleen's Fall HPS, and the equivalent of one turbine spillage that was present through most of the eel migration period in 2011-2012 will not occur. Therefore, on a provisional basis the combined mortality rate (13.3%) of the last two years are used in some calculations concerning past escapement rates. Experimental fishing below Cliff HPS, was undertaken on two occasions and samples of eels were retained for laboratory examination and for x-ray analysis. A relatively low level of injuries was recorded (6.45%; N=93), though some were extreme and would certainly result in death of the injured eels. Further experimental fishing is proposed for 2012/2013 to confirm these findings.

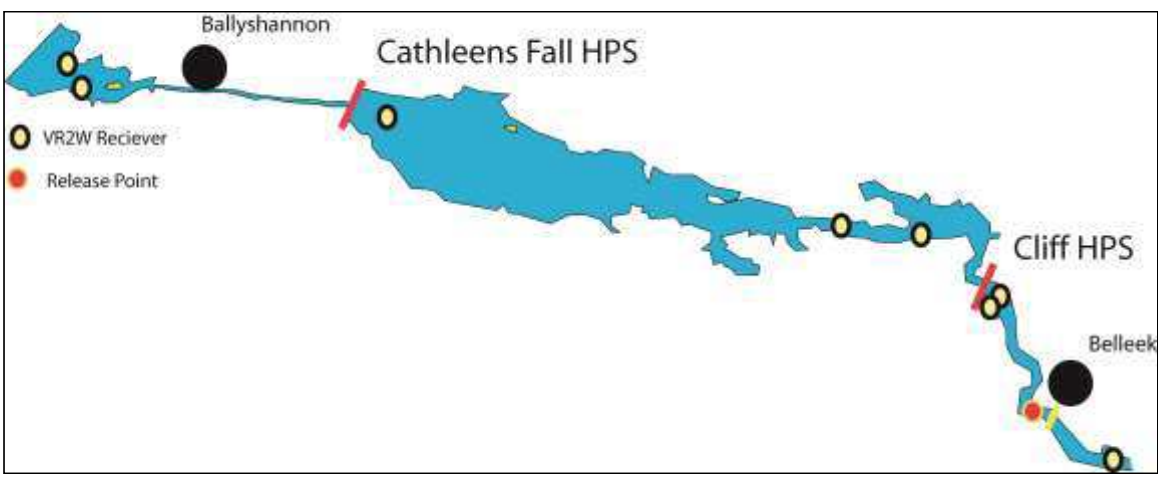


Figure 3-25: Location of telemetry receivers to track silver eels in the Lower River Erne area (2009-2012).

The 2012 silver eel migration season was characterized by an almost complete absence of spillage at Cliff dam. In contrast, at Cathaleen's Fall dam high spillage occurred throughout much of the migration season. Planned telemetry experiments, which were intended to provide estimates of eel mortality during periods in which the hydropower stations were on full load, had to be postponed to 2013. Because of the limited spillage, a pre-cautionary estimate of mortality (25%) at the Cliff HPS dam was used in the calculation of silver escapement in the 2012 season. Telemetry results from previous research were used for estimation of the hydropower passage mortality rate (8%) at the Cathaleen's Fall HPS dam.

The picture in 2013 was more complex. During the experimental period (20 Dec 2013 to 20 Feb 2014), Cliff HPS had no turbines operating with spillage at volumes equivalent to generation at the downstream Cathaleen's Fall HPS. 100% hydropower passage success occurred during this period. Outside of the experimental period, spillage occurred at Cliff HPS with turbines in operation, following the generation protocols from previous seasons (2009 – 2011). Therefore, the combined mortality (7.9%, 8/101) from these years was used in escapement calculations. When turbines were operating without spillage, the mortality estimate from the 2012 season (26.7%, 8/30) was used in calculations.

Initial analysis of discharge patterns at Cathaleen's Fall identified two basic generation protocols during period when telemetry studies were undertaken:

1. Two turbines operational with no spillage
2. Two turbines operational with spillage

The mortality rate at Cathaleen's Fall HPS during generation protocol 1 was calculated to be 27.3% (3/11). During generation protocol 2, the mortality rate was calculated to be 15.4% (4/26). For the remainder of the silver eel season, outside of the experimental period, a third generation protocol was also in operation. This was one turbine plus spillage. During the previous three migration seasons this was the generation protocol in operation. Therefore, the average mortality (7.7%, N=91) from this period (2010 – 2012) was used in the calculation of hydropower passage mortality on dates in which this generation protocol was being implemented. These estimates of mortality (3 generation protocols) were incorporated into the escapement calculations for the 2013 season.

During the 2014 silver eel season the patterns of generation and spillage at the River Erne hydropower stations were similar to those reported during the 2013 season. In the analyses of eel hydropower passage, varying mortality levels were incorporated, per calendar day, into the escapement model. These were based on dusk-dawn hydrometric data, power generation activity and results of previous years silver eel acoustic telemetry. Generation protocols and associated mortality rates have been described in previous reports. For the 2014 season different mortality rates were applied as follows: ***Cliff HPS*** (0%, only spillage); 7.9% (Generation plus spillage) and 26.7% (Only generation), ***Cathaleen's Fall HPS***: 0% (only spillage); 7.7% (spillage plus half generation load); 15.4% (spillage plus full generation load); 27.3% (only generation). Reduced overall generation levels occurred during the silver eel migration season, due to refurbishment of turbines. This resulted in relatively high spillage levels and reduced overall turbine passage mortality levels. This was estimated to have represented a cumulative 8.08% mortality of the total River Erne silver eel production or 24.2% of the migrating eel (not including the trapped and transported component) at the two dams during 2014.

3.3.3.4 Erne Annual Silver Eel Production/Escapement

3.3.3.4.1 Historic

A full description of how the historic production of the Erne catchment was determined is described in Chapter 5.2.1.2 of the Irish EMP. This was based on the time series of silver eel catch from which the escapement was determined (weir efficiency 18%) (Matthews *et al.* 2001). Added to the escapement were the yellow eel catch and other silver eel catches made in the catchment. Finally, the productivity estimates were raised by the level of unreporting and illegal fishing.

A reworking of the data identified a couple of minor errors in the calculation and the estimate of historic production (Bo) for the period 1955-1982 was changed from 4.5kg/ha to 4.1kg/ha., or 107,388kg (Table 3.7).

3.3.3.4.2 Pre-EMP 2001-2007

Production and escapement for the period 2001-2007 were determined using the extrapolation model in the EMP, Chapter 5.2.3. Potential production (Bbest) was estimated to be on average 3.28kg/ha or 85,140kg. Escapement ($B_{2001\text{-}2007}$) was recalculated using the turbine mortality rates determined for Cliff and Cathaleens Fall for 2009-2011. Escapement was estimated to be on average 32,542kg (Table 3.7) using 7.7% (Cliff HPS) and 6.9% (One turbine at Cathaleens Fall HPS) turbine mortality (average 2010-2011).

3.3.3.4.3 Current 2009-2014

The production and escapement estimates for 2009 to 2011 were reported to the EU in 2012 (Anon, 2012) and are included in the tables (Table 3.7 and electronic Sheets for Ireland).

The silver eel production and spawner biomass escapement, including both natural migration and assisted migration by means of the ESB trap and transport programme, was determined for the River Erne in 2010/2011 and 2011/2012 (McCarthy *et al.* 2010, 2011, 2012; Anon 2012). In 2010/2011 the silver eel production was estimated to have been 41,232kg or 1.57kg/ha. In the following year, 2011/2012, similar results were obtained and silver eel production was estimated to be 42,855kg or 1.63kg·ha. The corresponding estimates of spawner biomass escapement were 37,942kg or 1.45kg·ha in 2010/2011 and 40,011 or 1.54kg·ha, in 2011/2012.

The 2012 season Erne silver eel population study results are summarized in Figure 3.26. The silver eel production was estimated as 67,666kg and escapement was estimated to be 57,366kg (84.8% of production). The trap and transport total (34.7t) represented 51.3% of silver eel production and exceeded the target (50%) by 0.8t. The 2012 calculations were based on estimations of production at Roscor Bridge and use of alternative capture efficiency rates for discharges above and below a $130m^3.s^{-1}$ threshold. This threshold level differed slightly from the $150m^3.s^{-1}$ used in some earlier Roscor Bridge studies. This was done following examination of the variation in daily discharge in the 2012 season (Fig. 5.16) which was clearly bimodal. A series of 5 mark-recapture experiments (batches of 100 PIT-tagged eels) were undertaken at Roscor Bridge. Atypical delayed migration affected recapture pattern and tag detection at the site. Adjustments were made for recoveries of NUIG tags during IFI catch screening at the Ballyshannon release point in estimations of recapture rates (8% and 21% respectively) of 200 eels released during below-threshold discharge, and of 300 eels released during above-threshold discharge. The combined Cliff HPS and Cathaleen's Fall hydropower mortalities were estimated provisionally as 10.2 t (15.1% of production).

River Erne production in 2012 /2013 is estimated to have been over 50% higher than in the previous year. Several factors may have contributed to this:

- Favourable environmental conditions (e.g. rainfall, discharge, water temperatures and mild winter) increased silver eel runs in Irish rivers.
- A recruitment peak in 1990's, during EEEP programme, may be contributing to increased silver eel production.
- A time-lagged increase due to fishery closure and under-estimated fishing pressure may also be a factor.

- Fishing restrictions in December may have resulted in reduction of Ferny Gap barrier effect and allowed increased migration downstream from Lower Lough Erne.
- In-lake fishing and increased fishing intensity, especially in upper catchment, intercepted eels that would otherwise reach the sea next year.

The 2013 season Erne silver eel population study results are summarized in Figure 3.27 flow diagram. The silver eel production was estimated as 73,330 kg and escapement was estimated to be 64,285 kg (87.67% of production). The trap and transport total (39,319 kg) represented 53.62% of silver eel production and exceeded the target (50%) by 2,654 kg. The 2013 calculations were based on estimations of production at Roscor Bridge and the threshold discharge of 130 $m^3.s^{-1}$, described in the 2012 report, was used in the analyses. A series of 7 mark-recapture experiments (batches of 100 PIT-tagged eels) were undertaken at Roscor Bridge. Using protocols adopted in previous years, only PIT tags were used and batches (N=100) of marked fish were released at dusk at the established release point upstream. Five batches were released in high flow (>130 $m^3.s^{-1}$) and two in low flow (<130 $m^3.s^{-1}$). The efficiency of the Roscor Bridge index nets was estimated to have been 8% in low flow conditions and 16.6% in high flow conditions during this season. The results were used, together with index net catch and hydrometric data, to calculate the biomass of eels approaching Roscor Bridge.

The 2014 season Erne silver eel population study results are summarized in Figure 3.28. The silver eel production was estimated as 72,493 kg and escapement was estimated to be 66,525 kg (91.8% of production). The trap and transport total (48,126 kg) represented 66.4% of silver eel production and exceeded the target (50%) by 11,880 kg. The 2014 calculations were based on estimations of production at Roscor Bridge and the threshold discharge of 130 $m^3 \cdot s^{-1}$, described in the 2012 report, was used in the analyses. A series of 4 mark-recapture experiments (4 batches of FLOY-tagged eels, N=165) were undertaken at Roscor Bridge. Batches of marked fish were released at dusk at the established release point upstream. All four batches were released in high flow (>130 $m^3 \cdot s^{-1}$). The efficiency of the Roscor Bridge index nets was estimated to have been 25.5% in high flow conditions during this season. The low flow (<130 $m^3 \cdot s^{-1}$) weir efficiency experiment was not possible; therefore the 2013 estimate (8%) was used. The mark-recapture efficiency estimates were used, together with index net catch and hydrometric data, to calculate the biomass of eels approaching Roscor Bridge for each fishing date.

The increased capture efficiency recorded in high discharge in 2014 was due to improvements that the fishing crew made to the net system. Additional mark-recapture experiments are planned for 2015 to see if an increase in low discharge capture efficiency has also been achieved. If this is shown to have occurred, the 2014 calculations may have to be re-visited and some, relatively small, reductions in both silver eel production and escapement estimates may be appropriate.

The data for the River Erne are presented on the modified ICES precautionary diagram using the EU target (40% SSB) as the reference point and a calculated mortality reference point based on the EU target (A_{lim} 0.92) (Figs. 3.29 & 3.30). The reduction in mortality from both the fishery and the HPS is evident. The relatively low production in 2010 and 2011 can be seen flowed by an increase in 2012-2014 along with a corresponding increase in escapement. The Erne was achieving the EU target in 2012-2014.

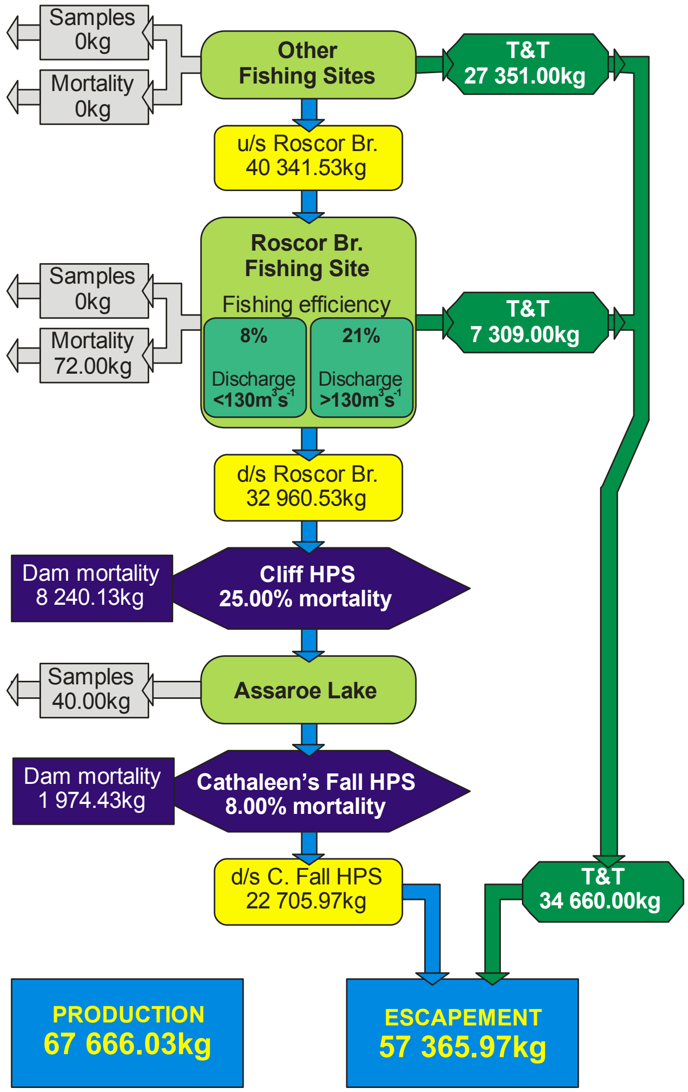


Figure 3-26: Summary silver eel biomass production and escapement estimate for River Erne system 2012/2013.

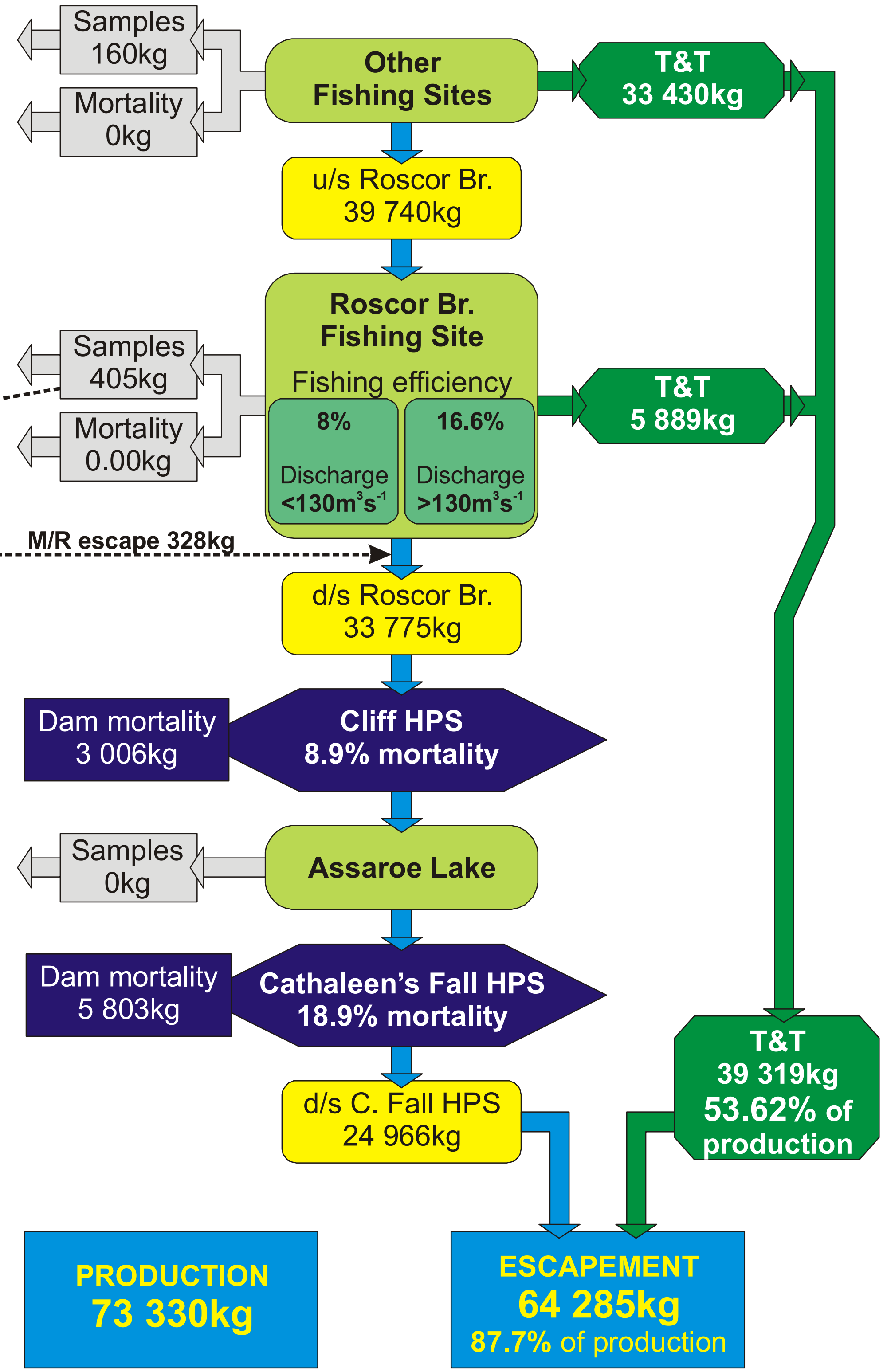


Figure 3-27: Summary silver eel biomass production and escapement estimate for River Erne system 2013/2014.

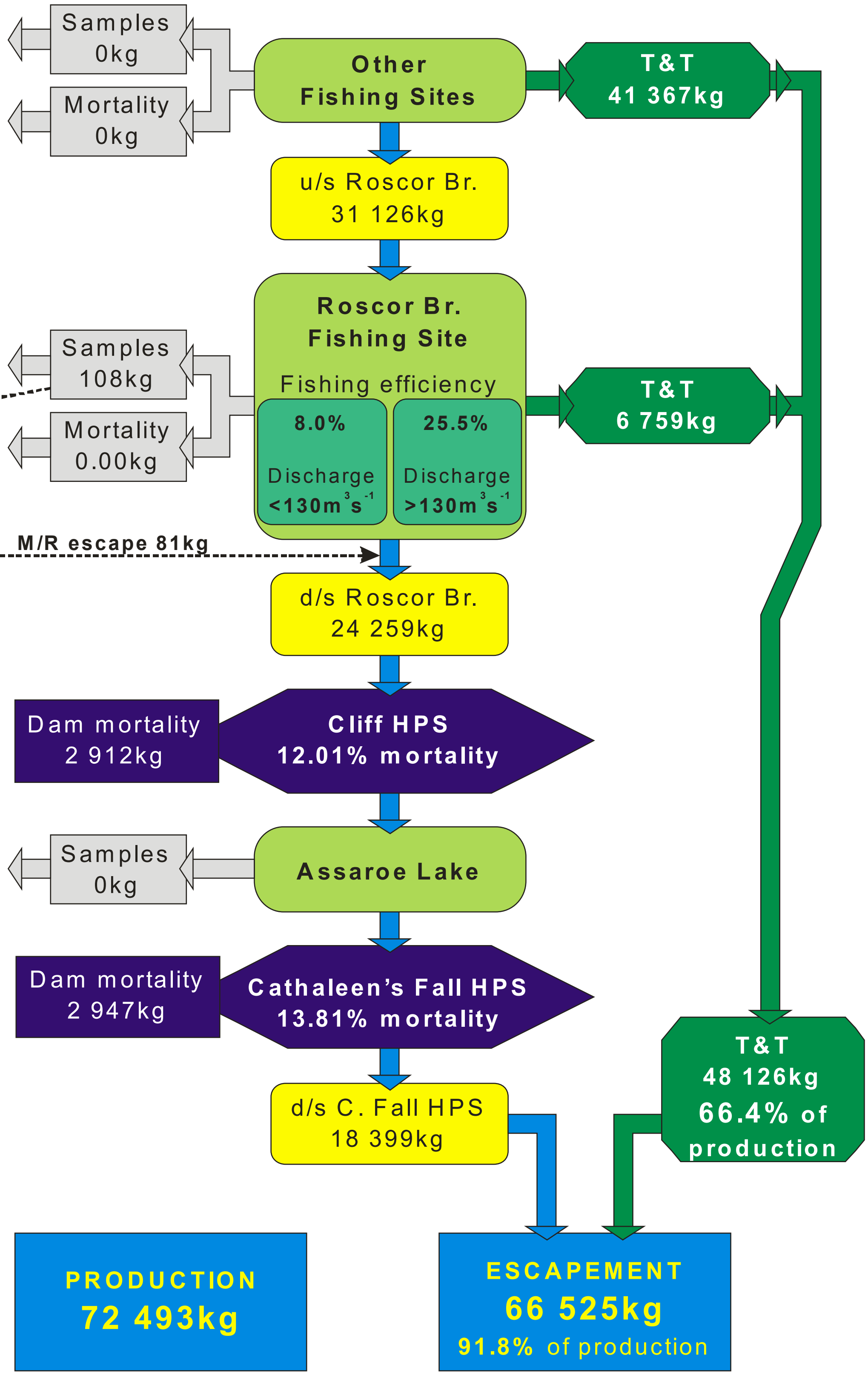


Figure 3-28: Summary silver eel biomass production and escapement estimate for River Erne system 2014/2015.

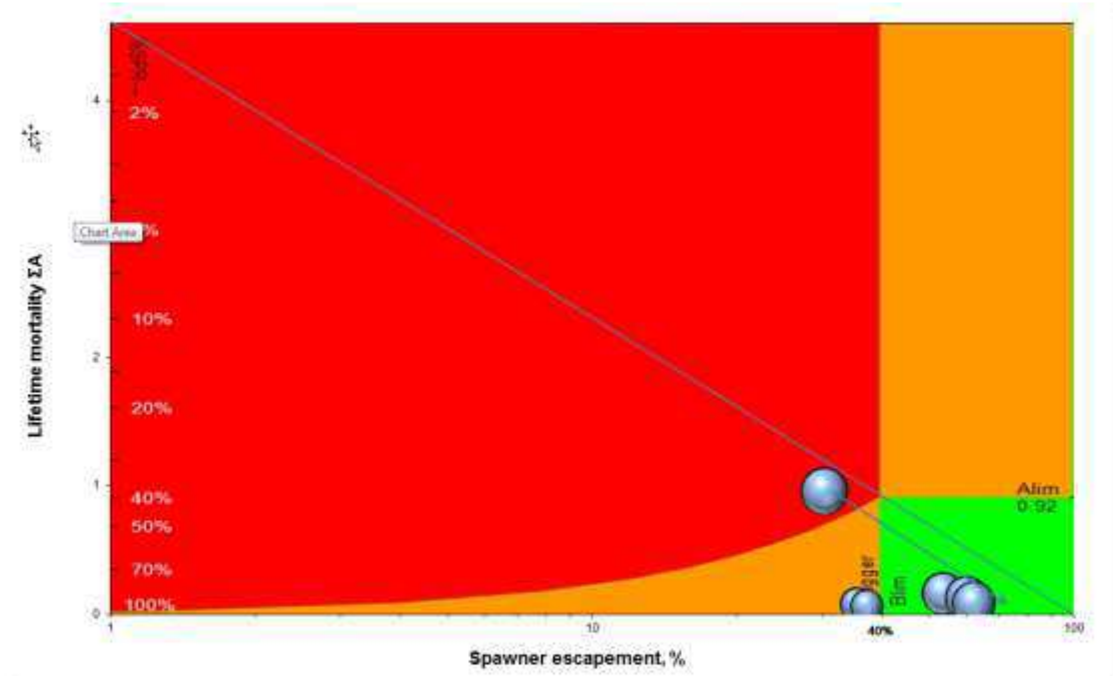


Figure 3-29: Status of the stock and the anthropogenic impacts, for the River Erne as presented in the Eel Management Plans in 2008 (average 2001-2007) and for the years 2010 to 2014. For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

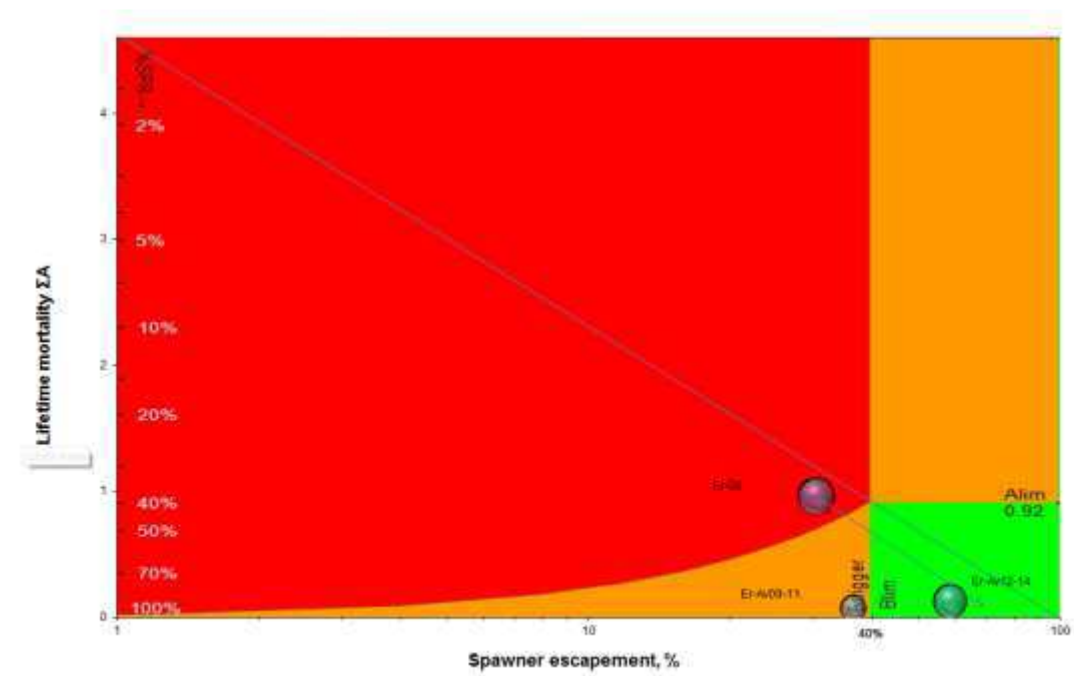


Figure 3-30: Status of the stock and the anthropogenic impacts, for the River Erne as presented in the Eel Management Plans for the average 2001-2007, and for the averages 2009-2011 and 2012-2014.

3.3.4 Burrishoole

3.3.4.1 Burrishoole Introduction

The only total silver eel escapement data available in Ireland is for the Burrishoole catchment in the Western RBD, a relatively small catchment (0.3% of the national wetted area), in the west of Ireland. The Burrishoole consists of rivers and lakes with relatively acid, oligotrophic, waters (Fig. 3.31). The catchment has never been commercially fished for yellow eels and there are no hydropower turbines.

The eels have been intensively studied since the mid-1950s; total silver eel escapement from freshwater was counted since 1970 (Poole *et al*., 1990; Poole, data unpublished); and an intensive baseline survey was undertaken in 1987-88 (Poole, 1994). The detailed nature of the Burrishoole data makes it suitable for model calibration and validation (Dekker *et al.* 2006).

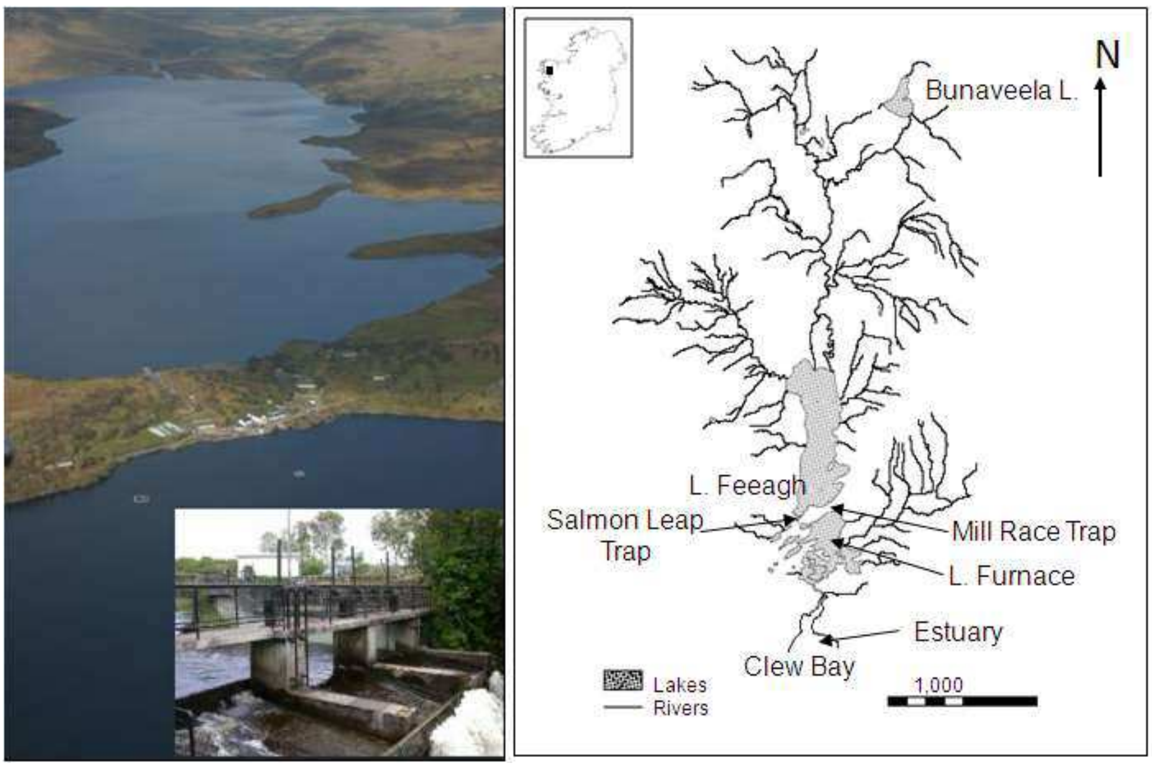


Figure 3-31: An aerial view of the Burrishoole catchment, looking north over the tidal Lough Furnace, in the foreground, and the freshwater Lough Feeagh: inset shows the silver eel downstream trap at the "Salmon Leap". A map of the Burrishoole catchment showing the locations of the silver eel traps at the lower end of the freshwater catchment.

3.3.4.2 Burrishoole Annual Catch

Operation of the downstream trapping in Burrishoole was continued for the period 2009 to 2014. The counts for the 2009 to 2011 period were reported previously (Anon, 2012).

In the 2012 season, the main run occurred in September, November and less so in October. Almost half of the run was complete by the end of September and the run dropped off after November with only sixteen eels recorded in December. Figure 3.32 shows the daily counts of silver eels. The total run amounted to 3335 eels. As in other years, the highest proportion of the total catch (78%) was made in the Salmon Leap trap.

In the 2013 season, the main run (68%) occurred in October. Figure 3.32 shows the daily counts of silver eels. The total run amounted to 3633 eels. As in other years, the highest proportion of the total catch (74.7%) was made in the Salmon Leap trap.

In the 2014 season, the main run (71%) occurred in October. Figure 3.32 shows the daily counts of silver eels. The total run amounted to 3117 eels, or a production of 580kg. As in other years, the highest proportion of the total catch (85%) was made in the Salmon Leap trap.

3.3.4.3 Burrishoole Annual Silver Eel Production/Escapement

The number of silver eels counted migrating downstream in Burrishoole is presented in Figure 3.33. Catches of silver eel between the years 1971 (when full escapement records began) and 1982 averaged 4,452, fell to 2,064 between 1983 and 1989 and increased again to above 3,000 in the '90s. There was an above average catch in 1995, possibly contributed to by the exceptionally warm summer. The numbers in the last three years (2009-2011) were 2879, 2136 and 1969 eels.

The average weight of the eels in the samples has been steadily increasing from 95 g in the early 1970s to 216 g in both the 1990s and the 2000s (Fig. 3.33). The annual count and average weight in 2010 and 2011 were both below the mean for the last decade.

The observed changes from a male dominated eel run (average 60% male 1971-75) to a much higher proportion of female eels in recent years (average 32% male 2001-2008) (Poole *et al*., 1990; Poole unpublished), along with an increase in mean size, particularly for female eels has meant that the biomass of silver eels being produced has been roughly maintained over the trapping time period. This may have been a density dependent response to falling recruitment and increased catchment productivity. The relatively low biomass and mean size observed in 2010 and 2011 is so far unexplained.

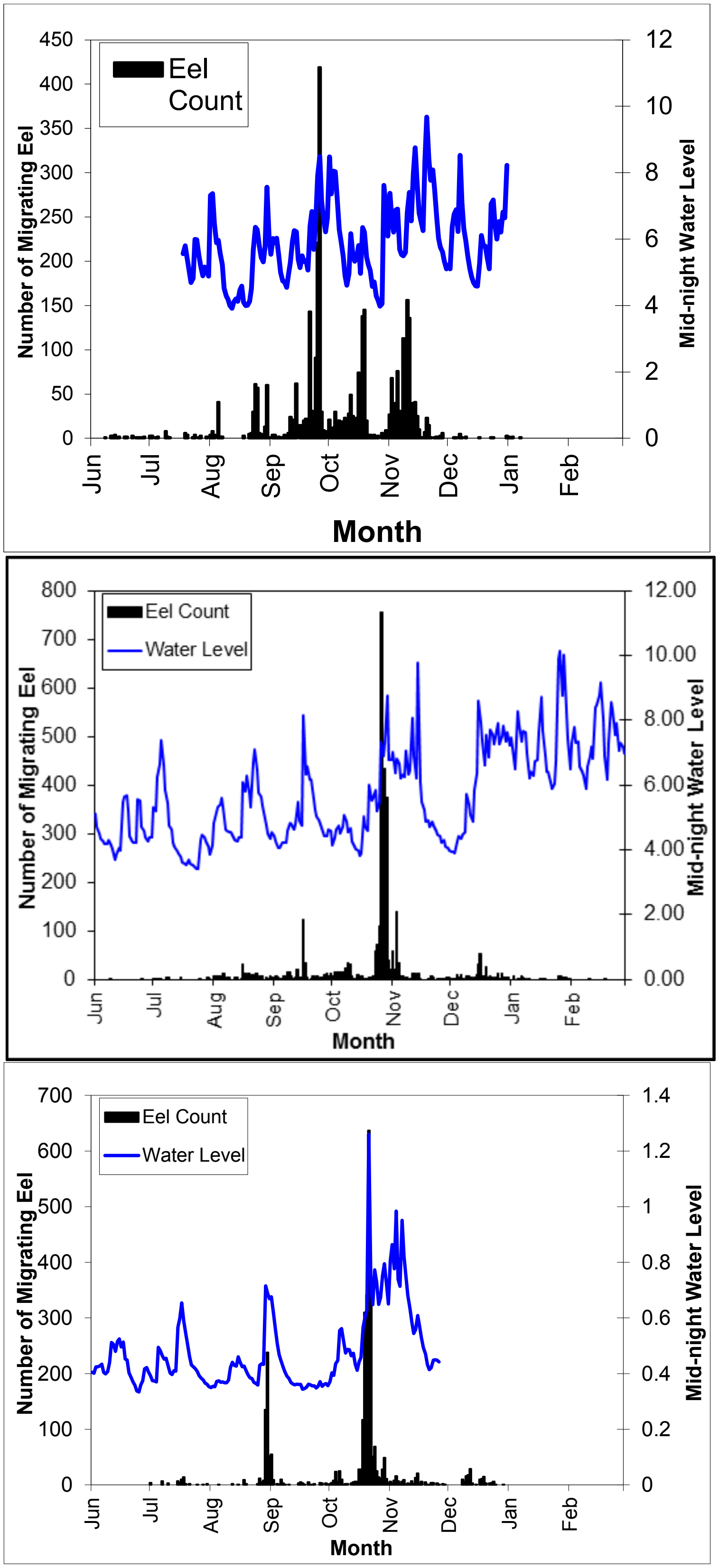


Figure 3-32: Daily counts of downstream migrating silver eel in the Burrishoole, 2012 (top) to 2014 (bottom).

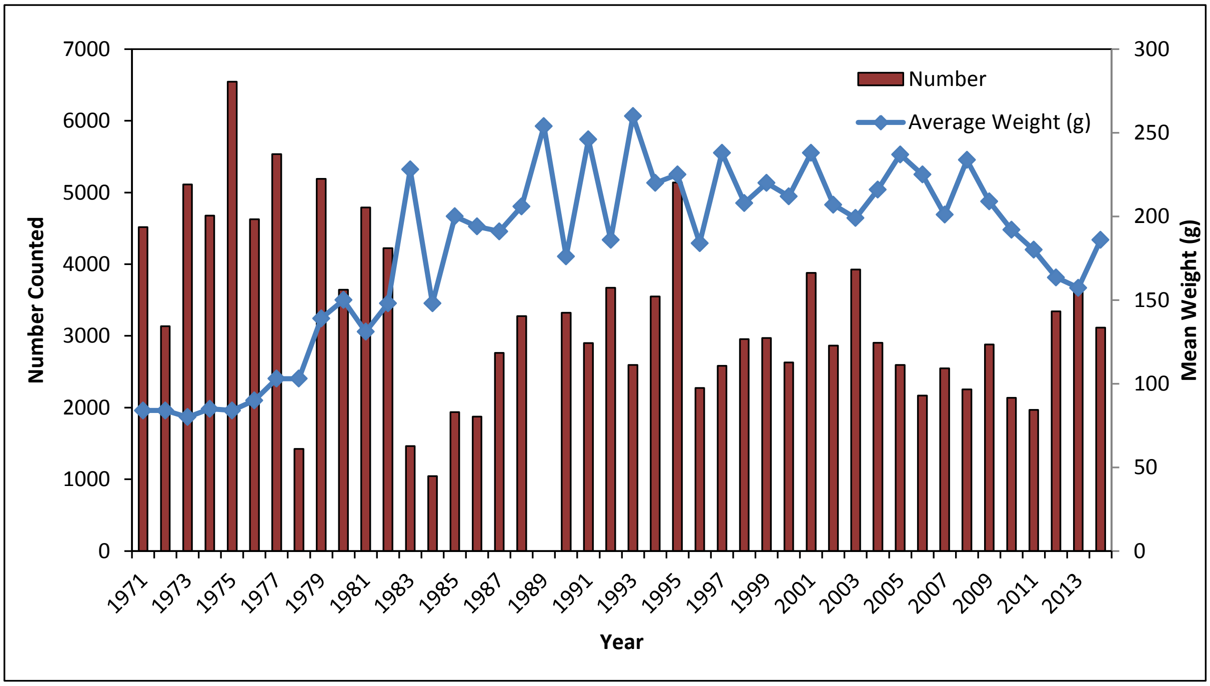


Figure 3-33: Annual number and mean weight (g) of silver eels trapped in the downstream traps.

3.3.4.4 Burrishoole Production and Escapement

Biomass production and escapement, calculated by multiplying numbers of silver eel by the average weight of the individuals, and production rate (biomass/wetted area of 474ha) are presented in Tables 3.7 and electronic Sheets for Ireland. There was no fishery in the Burrishoole over the period 1955-2011 and the trapping effort has not changed over the monitoring period.

Historic silver eel production (Bo) for 1971-1980 was 0.928kg/ha or 440kg.

Potential production (Bbest) for the period 2001-2007 was on average 1.37kg/ha or 649kg. Escapement ($B_{2001\text{-}2007}$) was the same as there was no anthropogenic mortality.

Production and escapement ($B_{2009\text{-}2011}$) for the 2009-2011 period was on average 0.96kg/ha or 455kg.

Production and escapement ($B_{2012\text{-}2014}$) for the 2012-2014 period increased to an average 1.19kg/ha or 566kg.

The data for Burrishoole are presented on the modified ICES precautionary diagram using the EU target (40% SSB) as the reference point and a calculated mortality reference point based on the EU target (Alim 0.92) (Fig. 3.24). The cluster of bubbles in the green area reflects the lack of anthropogenic mortality and high current escapement relative to historic levels in the Burrishoole.

Due largely to the change in sex ratio from a male dominated run to one with a high proportion of females, along with an increase in the average size of the female eels, the current production is higher than that observed during the historic baseline period (Bo). Therefore the 2008 bubble is off the graph at 148% and the 2012-2014 bubble is off the graph at 129%.

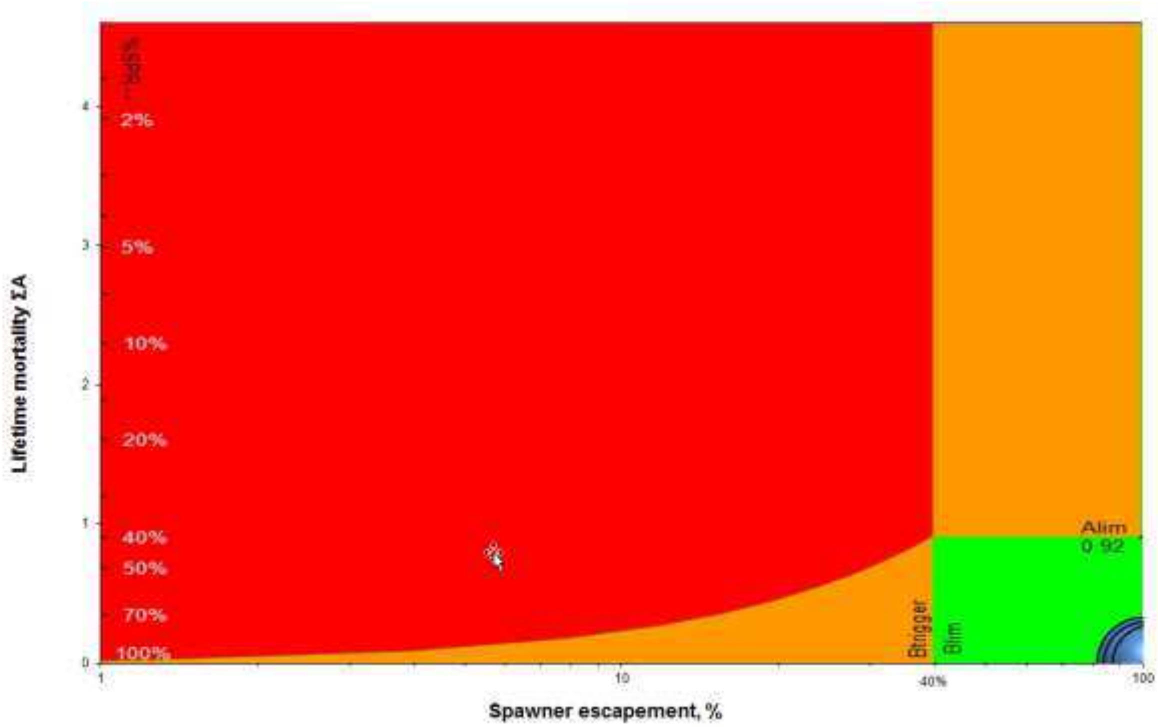


Figure 3-34: Status of the stock and the anthropogenic impacts, for the <u>Burrishoole</u> as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008, and for the average of 2009-2011 and 2012-2014. For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

3.3.5 Fane

3.3.5.1 Introduction

A research fishery was carried out on the Clarebane River on the outflow of Lough Muckno in 2011 (Fig. 3.35). The site was the location of a commercial silver eel fishery until 2008 and yellow eel were also previously commercially fished in the lake. The catchment is on the east coast of Ireland which will make it an important location for monitoring in the future.

3.3.5.2 Fane Annual Catch

There are no previous records of annual escapement.

In 2011, nine nights were fished during the October dark with a catch of 277 kg and four nights were fished in November with a catch of 13 kg. A total of 290 kg of silver eels was therefore caught for the 2011 season (Fig. 3.36).

Hydrometric data courtesy of the Office of Public Works suggest that the main migration run of silver eels may have occurred in the month of October starting in the first week of October during the full moon as indicated by the dramatic increase in the river water depth (Fig. 3.36). The contracted fishermen confirmed that recent weather patterns have resulted in one large flood early in the season which triggers the main migration run. Historically the water levels rose gradually over the course of the season with an increasing catch with rising flood waters.

A Mark Recapture survey was carried out in the River Fane, located approximately 0.5 km downstream from the Lough Muckno outflow (Figure 3.35). Passive Integrated Transponders (PIT) tags were used to mark the eels. Eels were released at two different locations. The first release site was located in the river upstream of Lough Muckno, approximately 5 km from the fishery. The second release site was located in the lake, approximately 2 km from the fishery. A third release site in the Clarebane River just upstream of the fishery site is proposed for the 2012 season. Table 3.6 gives the numbers tagged and recaptured each year. Full analysis, including the effect of delayed migration between years, has not been completed.

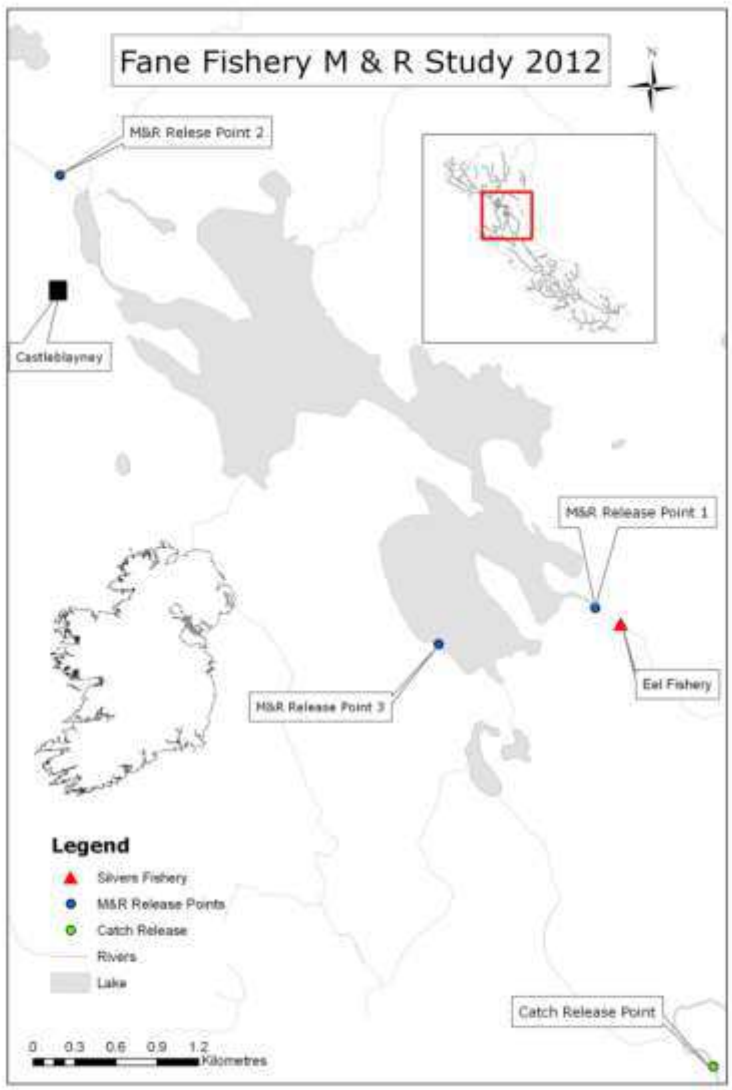


Figure 3-35: Locations of Fane catchment silver eel fishery and release points, 2012. Insets: Sampling area indicated by red box on Fane catchment and map of Ireland with Fane catchment (shaded) and Neagh-Bann River Basin District (outlined).

Table 3-6: Mark Recapture preliminary results 2011 – 2014.

Location	Year	Tagged	Recaptured within Yr	within Yr MR %	Total Recapture	Overall MR %
u/s fishery	2012	470	34	8%	92	20%
River	2011	173	47	29%	57	33%
River	2012	286	26	10%	52	18%
Lake	2011	160	23	15%	34	21%
Lake	2012	119	8	8%	28	24%
Mouth River	2013	303	61	22%	91	30%
Mouth River	2014	272	80	29%		
Average MR % all locations				18%		24%
Average MR% Mouth River				26%		30%

In 2012, five nights were fished during the August darkness with a catch of 55 kg, 3 nights were fished in September and 73 kg were caught. Nine nights were fished during the October darkness with a catch of 227 kg, and 4 nights were fished in November with a catch of 32.5 kg. The December darkness was not fished due to low water levels. A total catch of 448 kg was caught for the 2012 season compared with 290 kg in 2011.

Hydrometric data courtesy of the Office of Public Works was collected for the Clarebane River. The 2011 silver eel fishing season was characterised by low water levels for August and September followed by a flood event in early October which raised the water level dramatically (Fig. 3.37). The 2012 season had higher water levels with an increase in late September.

In 2013, low water levels in August and September prevented the site from fishing (Fig. 3.38). Three nights were fished in October with a catch of 28kgs following a rise in the water levels. A flood event occurred before the November new moon phase so the nets were set and continued to fish through the flood and into the November dark. A catch of 1,123kgs was caught over 16 nights. The nets were not set in December as the River water levels dropped to below that required to float the nets. The water levels for the Clarebane River were very variable for the silver eel season (Fig. 3.38). The increase in silver eels caught in 2013 was almost 2 and half times that caught in 2012 season.

In 2014, the Fane silver eel fishery did not fish in August or September due to low water levels (Fig. 3.39). An increase in water levels resulted in 6 nights of fishing in October resulting in a catch of 190 kg. A flood in early November (outside the moon phase) resulted in a catch of 60 kg for 4 nights fishing. The second flood of the month occurred on the 12th November and the nets were set for 15 consecutive nights resulting in a catch of 547 kg. This catch is less than the catch recorded in 2013 but is higher than the catch of 2011 and 2012. The flood during the November dark was greater than the 2013 flood with higher water levels recorded however the catch was not as high.

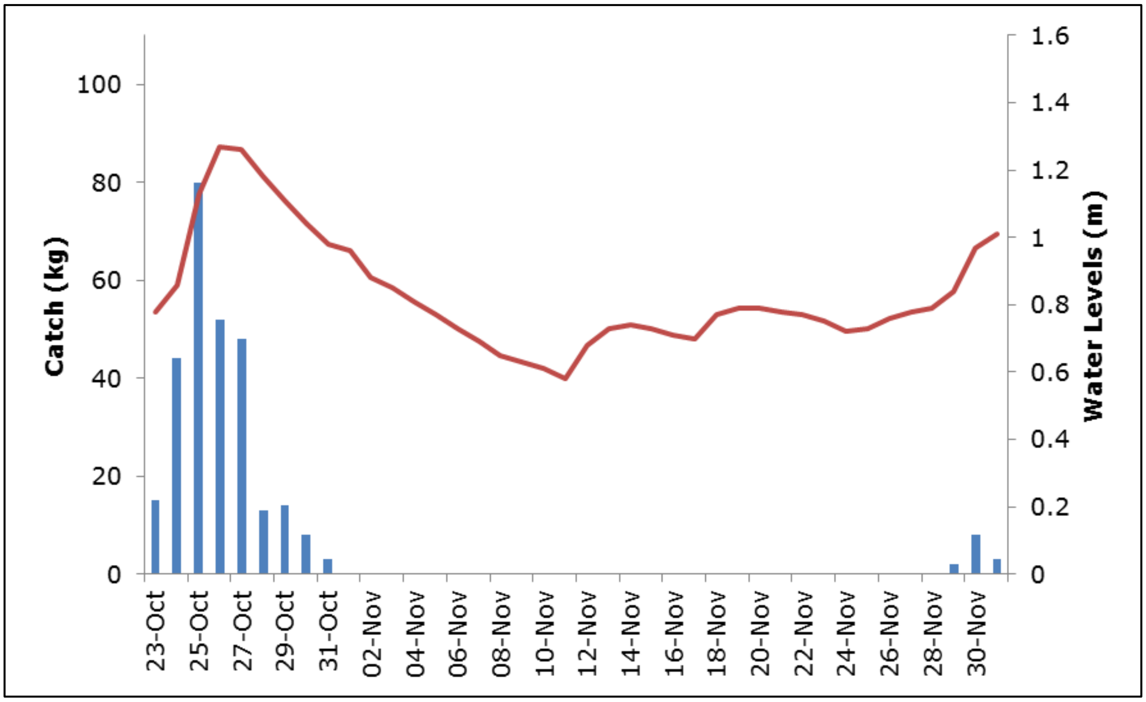


Figure 3-36: Silver eel catch and water depth for the silver eel season 2011 from the Fane catchment.

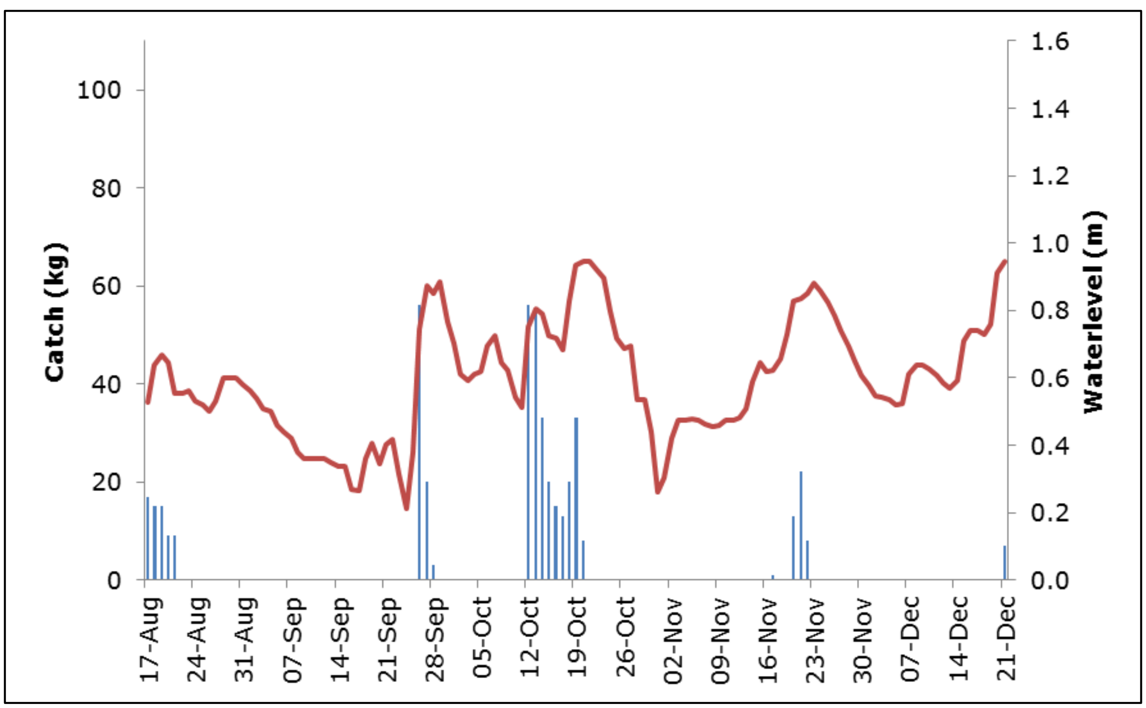


Figure 3-37: Silver eel catch and water depth for the silver eel season 2012 from the Fane catchment.

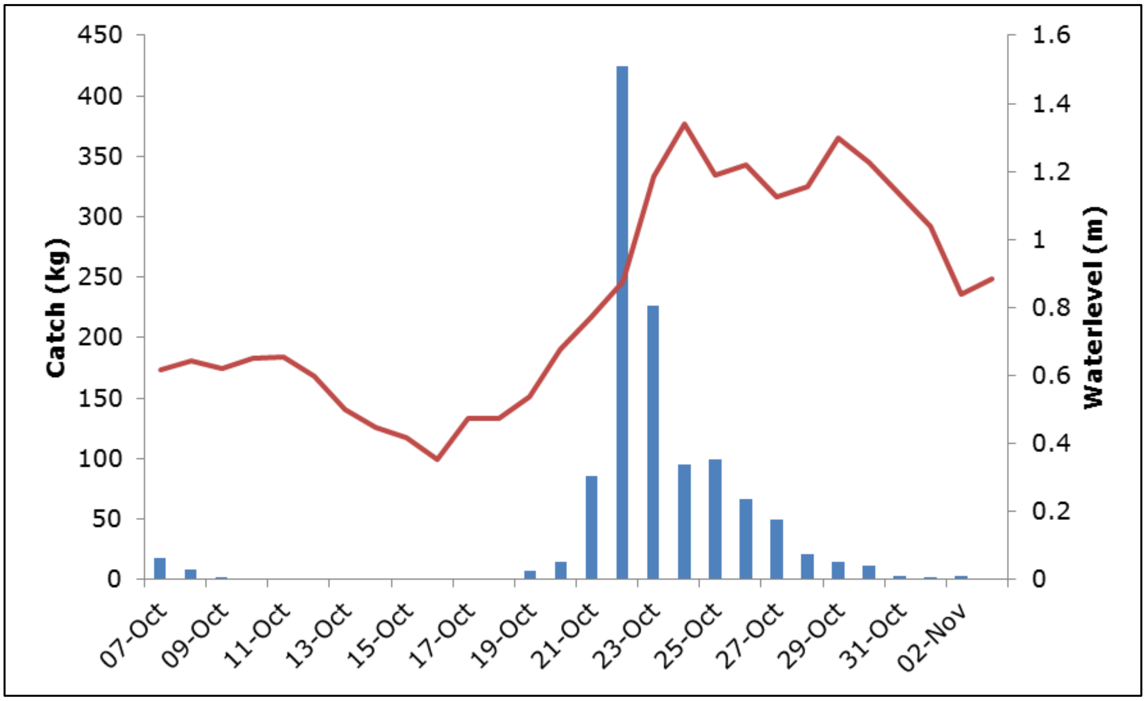


Figure 3-38: Silver eel catch and water depth for the silver eel season 2013 from the Fane catchment.

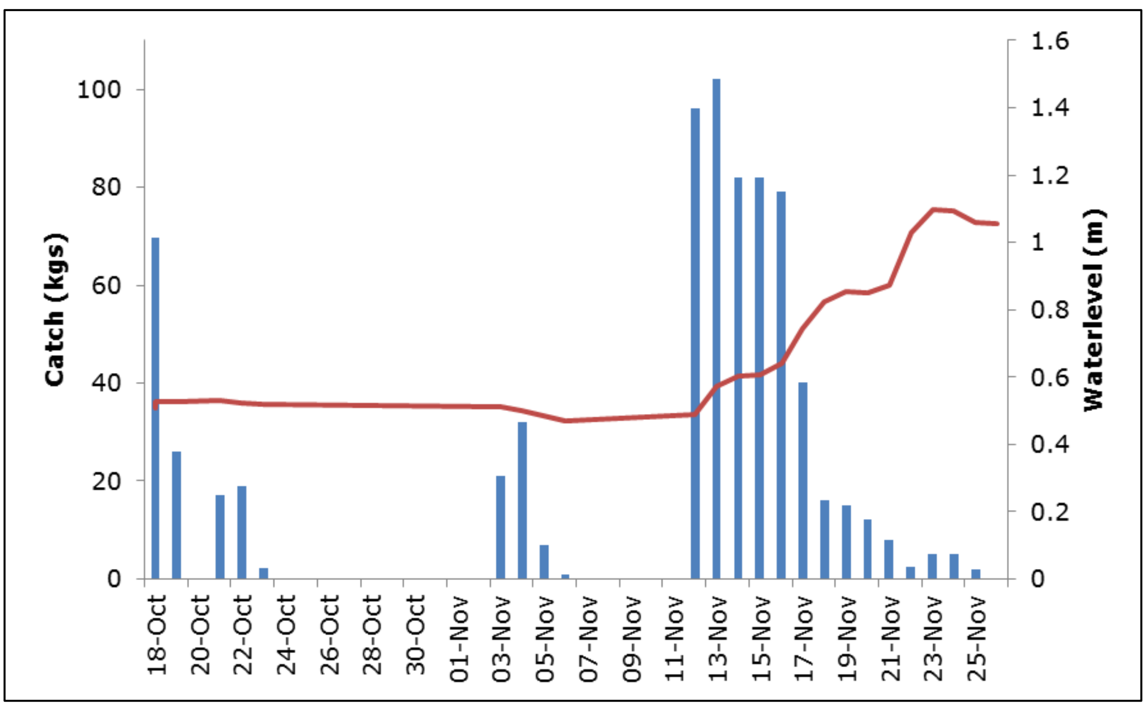


Figure 3-39: Silver eel catch and water depth for the silver eel season 2014 from the Fane catchment.

3.3.5.3 Fane Production and Escapement

3.3.5.4 Historic

The historic production of the Fane catchment was determined in described in Chapter 5.2.1.2 of the Irish EMP (2008). This was based on the extrapolation from the IMESE model in the EMP.

Using IMESE, it was estimated that the historic production (Bo) for the Fane catchment was in the order of 4.7kg/ha or 2,682kg.

3.3.5.5 Pre-EMP 2001-2007

Production and escapement for the period 2001-2007 were determined in a similar fashion to the historic production, also described in the Irish EMP, Chapter 5.2.3. Potential production (Bbest) was estimated to be on average 4.1kg/ha or 2318kg.

Records indicate that the reported silver eel catches 2002 & 2003 were 1,370kg and 1,050kg respectively and ranging from 287kg to almost 800kg in the following four years. Reported yellow eel catches averaged 3,000-4,000kg per annum.

3.3.5.6 Current 2009-2014

Given the preliminary nature of these estimates it is recommended that at least five years of multiple mark-recapture and fishing are undertaken before using Fane/Muckno as an index site.

3.3.6 R. Barrow

The Barrow catchment is a large riverine catchment located on the East coast of Ireland in the South Eastern River Basin District (IE_SouE). The IE_SouE is 60% calcareous bedrock which makes it a very productive habitat for eels. There has historically been a commercial fishery on the River Barrow and the presence of historical catch will aid in the assessment of the current silver eel escapement levels from the river. There is also historical research data on the River Barrow from the Fisheries Research Centre which is available to Inland Fisheries Ireland. The assessment of the silver eel stocks from a river dominated catchment will help highlight any difference in production and escapement of eels compared with catchments with large lake/lacustrine wetted areas. The Barrow will be the first riverine dominated silver eel index catchment assessed to date.

Four nets will be fished from lock gates of the canal section of the River Barrow at one location during the silver eel season (Figs. 3.40 & 3.41). The location fished is upstream of the town of Graiguenamanagh; approximately 5kms upstream from the tidal limit (estuary) in the River Barrow. This means that over 99% of the River Barrow freshwater is above the fishing site. Due to the size of the River Barrow it is currently not possible to fish the entire freshwater channel, however, through a mark recapture study it is hoped to assess the efficiency rate of the fishing site and estimate what proportion of the run is bypassing the nets.

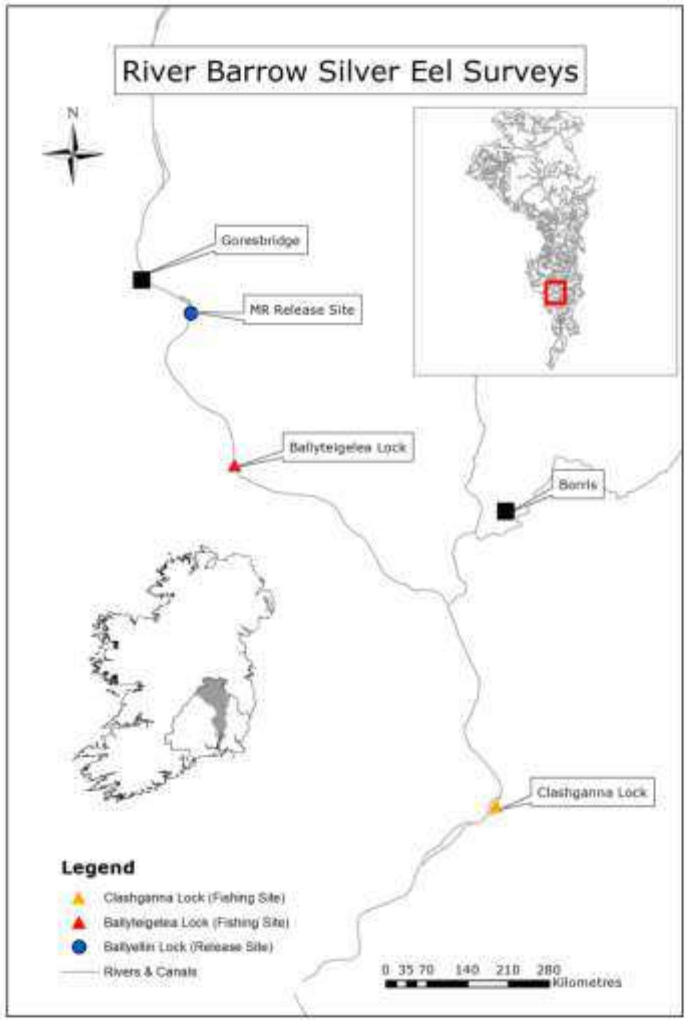


Figure 3-40: Map of fishing locations within the Barrow Catchment for 2014.

Figure 3-41: Location of research silver eel fishery on Barrow canal.

3.3.6.1 Barrow Eel catch

The new location was fished in 2014 as a pilot study to determine possible catch levels. The fishery was fished for 22 nights with a total catch of 174 kg. The location of the nets on the lock gates means the fishery is operated by fishing the flood waters as opposed to concentrating on the nights of the new moon.

It is proposed in 2015 to undertake new mark-recapture experiments, in combination with water level monitoring, to determine the proportion of eels using the canal compared to that using the main river channel. Over time it should be possible, by using batched releases for a number of years, to assess the escapement from the Barrow.

3.3.7 Waterville

There are a number of fish counters installed in Irish rivers around the country. While these counters are designed to count salmon it was proposed to investigate the potential of using these counters to assess the silver eel escapement. The Environment Agency in the UK undertook a similar investigation into using a resistivity counter to monitor silver eel escapement in 2010. It was decided to await the publication of this report before implementing a programme in Ireland, in order to learn from their experiences. The implementation of a similar programme in Ireland will be dependent on staff resources as the data analysis is time consuming as reported by NUIG who undertook a similar investigation using DIDSON technology.

The data from the Waterville counter has not been analysed for eel.

3.3.8 Baronscourt

As part of a PhD study on eels through IBIS (Integrated Aquatic Resource Management between Ireland, N Ireland and Scotland - funded through the EU INTERREG IVA Programme) the dynamics of eel within the Baronscourt Lakes, Co Tyrone in the Foyle catchment was examined. Field work took place during 2012 and 2013 and is currently being written up with an aim for completion by June 2015. The study involved extensive fyke netting and PIT tagging of yellow eels and also monitoring of silver eel migration. For further information please visit www.loughs-agency.org/ibis.

3.4 Summary on Index Catchments

The Shannon, Erne and Burrishoole all showed an increase in silver eel production (Bbest) in the 2012-2014 period compared to the previous three years (Table 3.7). Part of that increase could be attributed to the closure of the yellow eel fishery beginning to feed through to an increase in silver eel output, but as the unexploited Burrishoole also witnessed an increase it is also possible that it was a natural increase in production.

Silver eel production in the Shannon increased from 1.64kg/ha in 2009-2011 to 1.72kg/ha in 2012-2014 with a peak of 1.9kg/ha in 2013.

The Erne increased from 1.62kg/ha in 2009-2011 to 2.91kg/ha in 2012-2014 with a peak of 3.29kg/ha in 2014, an increase that was more or less expected due to previous recruitment patterns and the closure of the fisheries.

The Burrishoole increased from 0.96kg/ha in 2009-2011 to 1.19kg/ha in 2012-2014 with a peak of 1.22kg/ha in 2014.

The plots (Figs. 3.29, 3.30 & 3.34) and Table 3.7 (and the accompanying electronic tables) show the Erne and Burrishoole to be above 40% SSB, with a marked decrease in eel mortality in the Erne to a level well below Alim of 0.92.

The escapement biomass in both the Erne and the Shannon has increased, with the Erne going from 36.3% to 58.4% SSB and the Shannon going from 32.6% to 34.0% SSB.

There is an urgent need for the further development of additional silver eel index sites in the other EMUs.

Table 3-7: Historic production (Bo), current production (B_{best}), current escapement ($B_{current}$) and the current escapement as it related to Bbest - % EU Target - for the Shannon, Erne, Burrishoole and Corrib, and for historic production only for the Moy and Garavogue.

	Bo Prod	Production (Bbest)							Av 2009-2011	Av 2012-2014
	kg	2008	2009	2010	2011	2012	2013	2014		
Shannon	189,079	85,700	74,382	68,920	65,558	67,931	79,970	70,725	69,620	72,875
Erne	107,388	85,140		41,232	42,855	67,666	73,762	72,493	42,044	71,307
Burrishoole	440	649	602	410	354	546	571	580	455	566
Corrib	105,739	48,455	36,100							
Moy	46,435									
Garavogue	9,610									

	Bo Prod	Escapement (Bcurrent)							Av 2009-2011	Av 2012-2014
	kg	2008	2009	2010	2011	2012	2013	2014		
Shannon	189,079	12,163	66,788	60,170	57,885	58,836	70,775	62,980	61,614	64,197
Erne	107,388	32,542		37,942	40,011	57,366	64,285	66,525	38,977	62,725
Burrishoole	440	649	602	410	354	546	571	580	455	566
Corrib	105,739	13,371	36,100						36,100	
Moy	46,435									
Garavogue	9,610									

	Bo Prod	% Bcurrent/Bbest (EU Target)							Av 2009-2011	Av 2012-2014
	kg	2008	2009	2010	2011	2012	2013	2014		
Shannon	189,079	6.4	35.3	31.8	30.6	31.1	37.4	33.3	32.6	34.0
Erne	107,388	30.3		35.3	37.3	53.4	59.9	61.9	36.3	58.4
Burrishoole	440	147.5	136.8	93.2	80.6	124.1	129.9	131.8	103.5	128.6
Corrib	105,739	12.6	34.1							
Moy	46,435									
Garavogue	9,610									

4 Silver Eel Production and Escapement

4.1 Introduction

The EU Regulation (No. 1100/2007) sets a long-term objective which is the protection and sustainable use of the stock of European Eel. A target is set for the biomass of silver eel escaping from each eel management unit, at 40% of the pristine biomass. Pristine biomass is generally regarded as the biomass of silver eel without human impact and at recruitment levels before the sudden decline in the early 1980s.

Ireland used a system of extrapolating from index data rich catchments to data poor catchments for calculating estimates of pristine and current biomass as described in the Irish Eel Management Plan (Chapter 5) and the WGEEL report (ICES, 2009).

As set out in the EU template for the National Report 2012, the following definitions are adhered to:

B_0	The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock.
$B_{current}$	The amount of silver eel biomass that currently escapes to the sea to spawn.
B_{best}	The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock.
ΣF	The fishing mortality rate, summed over the age-groups in the stock, and the reduction effected.
ΣH	The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock, and the reduction effected.
R	The amount of glass eel used for restocking within the country.
ΣA	The sum of anthropogenic mortalities, i.e. $\Sigma A = \Sigma F + \Sigma H$.

4.2 Eel Management Plan Freshwater Biomass (Inland)

4.2.1 Introduction to IMESE

The estimation of pristine and current (2008 based on the average of 2001-2007) silver eel biomass being produced and escaping was described in the National Eel Plan (2008, Ch.5) and in ICES (2008, page 47). The calculation of pristine productivity for exploited catchments requires estimates of silver eel escapement along with historic silver and yellow eel catches, raised to account for unreported and also illegal catches. Historical catch records for silver eel fisheries were available for the five catchments of the

Corrib, Moy, Garavogue, Burrishoole and Erne. The efficiencies of the fisheries had been previously estimated for the Shannon, Corrib and Erne silver eel fisheries. Where fishery efficiency was not measured an approximately average value of 33% was used to calculate escapement. In addition to the catch at the recording station and escapement past the recording station the yellow eel and silver eel catches made upstream were included to estimate pristine productivity. In the absence of historic data for these latter parameters (yellow and silver eel catches upstream of the recording station) it was assumed that the yields were equal to those currently observed (2001-2007). A similar process was used to calculate the 2008 production, based on the average of 2001-2007, and escapement using data from four catchments, the Shannon, Corrib, Burrishoole and Lough Ennell (estimate based on depletion fishing surveys by NUIG).

For those catchments with hydropower at the lower end of the catchment (Shannon, Erne, Liffey and Lee), an estimate of the impact was derived by imposing a 28.5% mortality per turbine passage (WGEEL, 2002). Therefore, the probability of surviving passage through 'n' number of hydropower installations is $(0.715)^n$. In this report, we have recalculated these estimates using the newly available hydropower mortality data for the Erne and the Shannon. Other HP Stations remain at 28.5% default mortality in the analysis.

Silver eel production was then determined for the other catchments by using a habitat-based approach. The method involved determining the relationship between productivity and the geological characteristics of the catchment.

Growth rate of eel were available for 17 catchments (Moriarty 1988, WFD). The growth rates data were updated in 2014 with new validated data collected during the 2009-2012 surveys. These data were used in this report to reanalyse the 2008 and 2009-2011 extrapolations and to calculate the production in 2012-2014 and these are reported here.

The wetted area within each catchment was quantified using a geographical information system and classified according to the proportion of the catchment area comprising non-calcareous geology. For 17 catchments growth rate was found to be closely negatively related to the proportion of the catchments comprising non-calcareous geology. This allowed the estimation of silver eel production to be made on the basis of geology (natural productivity) and growth rate.

4.2.2 Historic Silver Eel Biomass (Bo)

Estimates of historic biomass were presented for each Eel Management Unit (EMU). During the course of 2009-2011 and the 2012 review, two errors were identified in the calculations, one in the Corrib historic escapement and one in the Erne historic escapement. This changed the estimated production in the Corrib from 3.38 kg/ha to 3.57 kg/ha and in the Erne from 4.50 kg/ha to 4.14 kg/ha. The corrected data for the two catchments are given in Table 3.7.

When the corrected data were inserted into the model for determining historic production for all the catchments, it made only a small difference in the overall silver eel production biomass estimate for each EMU and for the % escapement and this was reported in 2012 (Anon 2012).

It is not known how accurate the historic estimates of Bo are, as there was a lack of information on historical fishing catches and levels of undeclared catches. It is now appearing likely that these catches were underestimated and that Bo estimates are too low.

4.2.3 Current (2008) Silver Eel Biomass (Bbest, $B_{2001\text{-}2007}$) – pre-EMP

The production (B_{best}) and escapement ($B_{2001\text{-}2007}$) estimates presented in the EMPs are shown in Table 8.2 & 8.3. The escapement was determined by subtracting the fisheries catch, raised to account for illegal and unreported, and then the remaining silver eel production was subjected to hydropower mortality at 28.5% per hydropower station where these occurred. The escapements in 2008 were recalculated using the estimates of HPS mortality determined between 2009 & 2011, on the Shannon (21.1% & 17.8% bypass) and the Erne (cumulative 23%) and this was reported in 2012 (Anon, 2012).

4.2.4 Current (2009-2011) Silver Eel Biomass (Bbest, $B_{2009\text{-}2011}$)

The silver eel biomass produced and escaping during 2009 to 2011 in the monitored index catchments was fully described in Chapter 3 of this report and in Table 3.7.

These index data were then used to calibrate the IMESE model. The new growth data was used and the new estimates were quite close to those presented in the 2012 report. Figure 4.1 shows the relationship between the index data, the growth rate data and the geology (% non-calcareous).

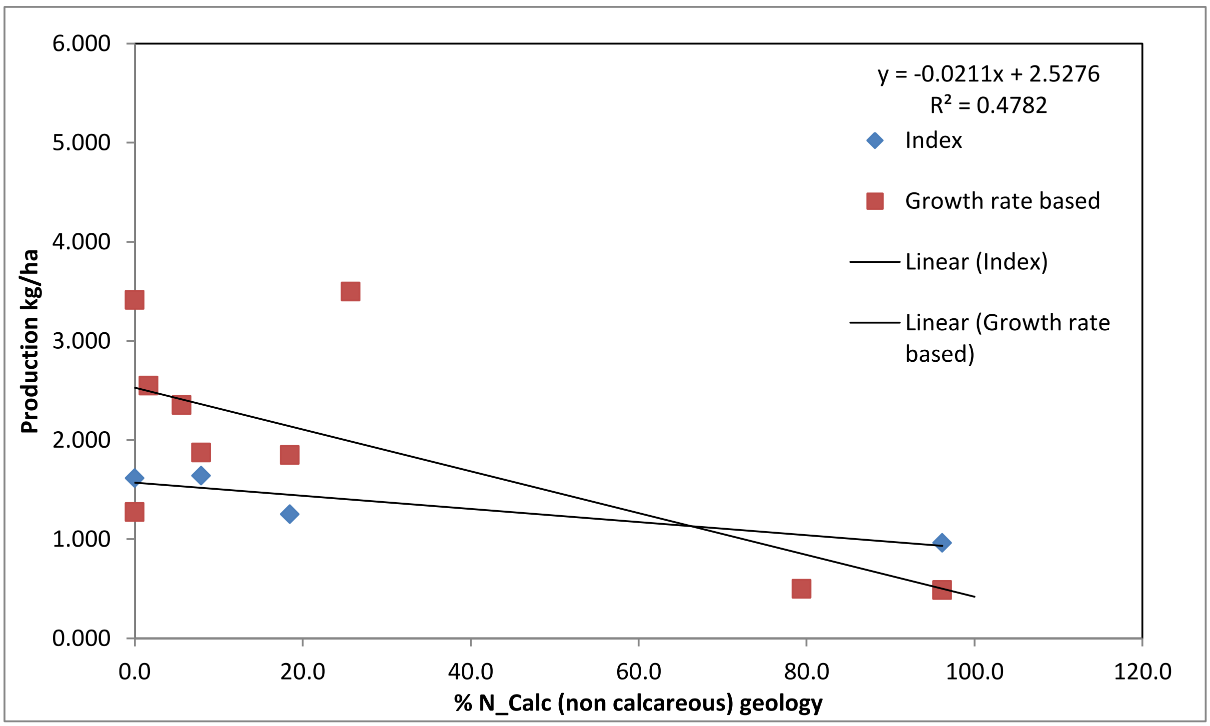


Figure 4-1: Average current (2009-2011) silver eel productivity based on new growth rates calibrated with direct silver eel counts and estimated silver eel production indices for the same period.

The estimates of historic (Bo), 2008 and current silver production and escapement are given in Table 4.6 as calculated using the IMESE and summated by individual catchments for each RBD and current escapement was then estimated taking into account the HPS mortalities. Where direct estimates of production were available for individual catchments, these were used instead of a modelled figure. It should be noted that the silver eel index locations were all on the west coast in 2009-2014. This may lead to inconsistencies when extrapolating to the East and south coast catchments. While a similar scenario existed for setting up the EMP, it is hoped to include at least one silver index on the east coast in the next three year period.

Current escapements are presented in Table 4.6 and expressed as a percentage of the historic production (Table 4.7), given for 2008 and for the 2009-2011 period as an average. The positive effect of the implemented management measures (fishery closure and silver eel trap and transport) can be seen by the total %SSB increasing from 25.6% (2008) to 36.7% (2009-2011).

The two EMUs where the impacts were severest with both fisheries and hydropower were the IE_Shan (ShIRBD) and IE_NorW (NWIRBD). In the IE_Shan the %SSB went from 10.7% to 34.5% (2009-2011) to 36.3% (2012-2014) and in the IE_NorW the %SSB went from 35.2% to 36.9% (2009-2011) to 57.4% (2012-2014), also reflecting the anticipated increase in output due to past recruitment history in the mid-1990s.

The IE_West also showed a considerable increase in SSB although this should be treated with some caution as the model may have over-estimated production from the very large area of the Corrib catchment.

4.2.5 Current (2012-2014) Silver Eel Biomass (Bbest, $B_{2012-2014}$)

The silver eel biomass produced and escaping from 2012 to 2014 in the monitored index catchments was fully described in Chapter 3 of this report and in Table 3.7.

These index data were then used to calibrate the IMESE model. The existing growth data was reused and it is hoped in the coming three year period to have new growth data to refresh the model. Figure 4.2 shows the relationship between the index data, the growth rate data and the geology (% non-calcareous).

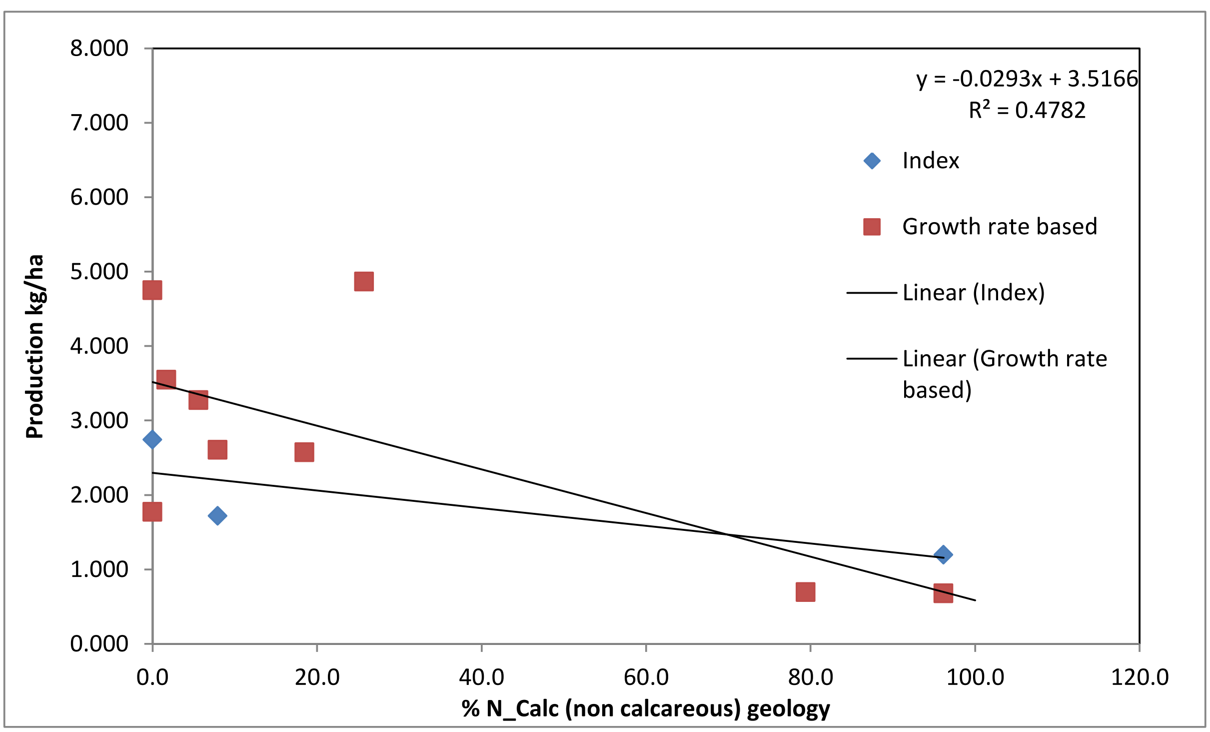


Figure 4-2: Average current (2012-2014) silver eel productivity based on new growth rates calibrated with direct silver eel counts and estimated silver eel production indices for the same period.

Current escapements are presented in Table 4.6 and expressed as a percentage of the historic production (Table 4.7), given for 2008, for the 2009-2011 and 2012-2014 periods as averages. The positive effect of the implemented management measures (fishery closure and silver eel trap and transport) can be further seen by the total %SSB increasing from 25.6% (2008) to 36.7% (2009-2011) to 54.5%; some 14.5% above the EU target confirming that Ireland is contributing significantly to the eel stock recovery.

4.3 Anthropogenic Mortality

The Eel Regulation sets a limit for the escapement of (maturing) silver eels, at 40% of the natural pristine escapement B_0 (that is: in the absence of any anthropogenic impacts and at historic recruitment). The EU Regulation thus sets a clear limit for the spawning stock biomass, B_{lim}, as a percentage of B_0. However, no explicit limit on anthropogenic impacts A_{lim} is specified. A value for A_{lim} of 0.92 has been proposed (ICES 2011a,b), i.e. the sum of all anthropogenic impacts over the entire continental life span should not exceed 0.92. Below B_{lim} ($B_{MSY\text{-}trigger}$), the mortality target should be reduced correspondingly (ICES 2011b).

The Eel Regulation specifies a limit reference point (40% of pristine biomass B_0) for the size of the spawning stock in terms of biomass. For long-lived species (such as the eel) with a low fecundity (unlike the eel), biological reference points are often formulated in terms of numbers, rather than biomass. For reference points based on biomass rather than on numbers, the relationship between relative spawner escapement (%SPR) and mortality (ΣA) is much more complex, but numerical simulation indicates that the relationship comes close to a reference point based on numbers (ICES 2011b).

Table 4.8 presents the mortality data calculated using biomass ($-\ln(B_{current}/B_{best})$). In Figures 4.7 & 4.8, the mortality data is calculated using biomass as follows:

F = - ln (what comes out / what goes in) or = $-\ln(B_{best}\text{-catch})/B_{best}$

H = idem, but B_{best} is not what goes into hydropower. (B_{best}-catch) is what goes in, and (B_{best}-catch-hydrokill) is what comes out, or $H = -\ln(B_{best}\text{-catch})\text{-hydrokill}/(B_{best}\text{-catch})$

The two EMUs where the impacts were severest with both fisheries and hydropower were the IE_Shan (ShIRBD) and IE_NorW (NWIRBD). In the IE_Shan the mortality (∑A) went from 1.48 to less than 0.2 and in the IE_NorW the mortality (∑A) went from 0.77 to less than 0.2.

Total mortality for Ireland (sum of fisheries, hydropower and other anthropogenic) has fallen from 0.83 in 2008 to less than 0.06 since 2009. This is considerably lower than the Alim of 0.92 and underlines Ireland's commitment to achieving the recovery in the fastest time possible.

4.4 Eel Management Plan Freshwater Biomass (Transitional Waters)

4.4.1 Introduction to transitional waters

There is a requirement to calculate the production of eels from the transitional (saline) water habitat as distinct from the freshwater habitat. One method is to apply the production value (kg/ha) for an inland catchment and extrapolate it to the respective transitional waters. However this method does not take into account the extreme change in habitat and potential productivity due to salinity and other habitat and ecological features.

In order to investigate an alternative method to that applying the freshwater production value 'blindly' to the transitional waters, it was decided to utilise the fyke net surveys undertaken as part of the Waterframework Directive monitoring and to come up with a classification of the different types of transitional waters in Ireland that reflected the CPUE from the fyke nets.

4.4.2 Methodology

A preliminary plot of fyke net CPUE in the transitional waters against silver eel biomass production (Bbest) for the inland upstream of the transitional water indicated a possible relationship worth investigating (Fig. 4.3). The relationship was non-linear and probably complex, if not spurious. On the basis that this possible relationship might prove a fruitful means of combining field data and habitat data to produce estimates of silver eel production it was decided to investigate by classifying the transitional waters under different categories.

The categories of transitional waters that were readily available and seemed intuitive were:

1. **Drying (drying, non-drying and partial drying).**

There are a number of transitional waters in Ireland that are stripped of suitable habitat when the tide is out (every 12 hrs) and therefore it is deceptive to think that the whole wetted area is available for production when it is only the area permanently inundated with water that is available for the eels to inhabit. All lagoons were considered non-drying.

2. **Coast (east, south, west)**

The distribution of glass eels and elvers to Ireland is influenced by the distribution of glass eels in the current in the ocean. The hot spots of elver recruitment are recorded by the extensive fisheries located in the Severn (UK) and the Bay of Biscay (France). This indicates that the plume of glass eels are passing Ireland by the west and south coast. Therefore we included coast in order to determine if the east coast is affected by the distance from the distribution plume. The Shannon, Southwest and Southeast RBD are classified as South coast, the Easter and NeaghBann RBD are classified as East coast, the Western and NorthWestern IRBD are classified as west coast.

3. **Exposure (sheltered, semi exposed)**

The area exposed to the coastal waters, which is the point of interaction between transitional waters and the coastal waters, was measured and each transitional water was classified as either sheltered or exposed. The sheltered waters had an opening <1.5km coast to coast. The exposed waters had an opening greater than 1.5km coast to coast. As the glass eels enter the transitional waters at this point did the size of the opening influence the attraction of eels into the catchment. Transitional waters nested inside a second transitional water was assigned based on the transitional water meeting the coastal water.

4. **Area (ratio of TW to RBD; 4 categories)**

The proportion of a transitional waters compared with the upstream freshwater habitat was classified in order to distinguish between the areas with small transitional waters but large freshwater habitat and those of high transitional waters and low freshwater.

5. **Category (lagoon, river)**

Fyke net data and historical fishery data suggests that lagoons are good locations for eels with high numbers present

6. **WFD Ecol classification (1-5 bad – high)**

In order to investigate whether the classification was representative of the cpue values recorded for eels in the transitional waters, all transitional waters were assigned a category for the six variables. A Principal Component Analysis was undertaken with the classification variables in order to investigate any correlation between the variables.

PCA of Transitional water (categorical data) – not ideal to do pca on categorical data but as it is an exploratory analysis it is allowed.

4.4.3 Results

The possible relationship between cpue and inland biomass is shown in Figure 4.3.

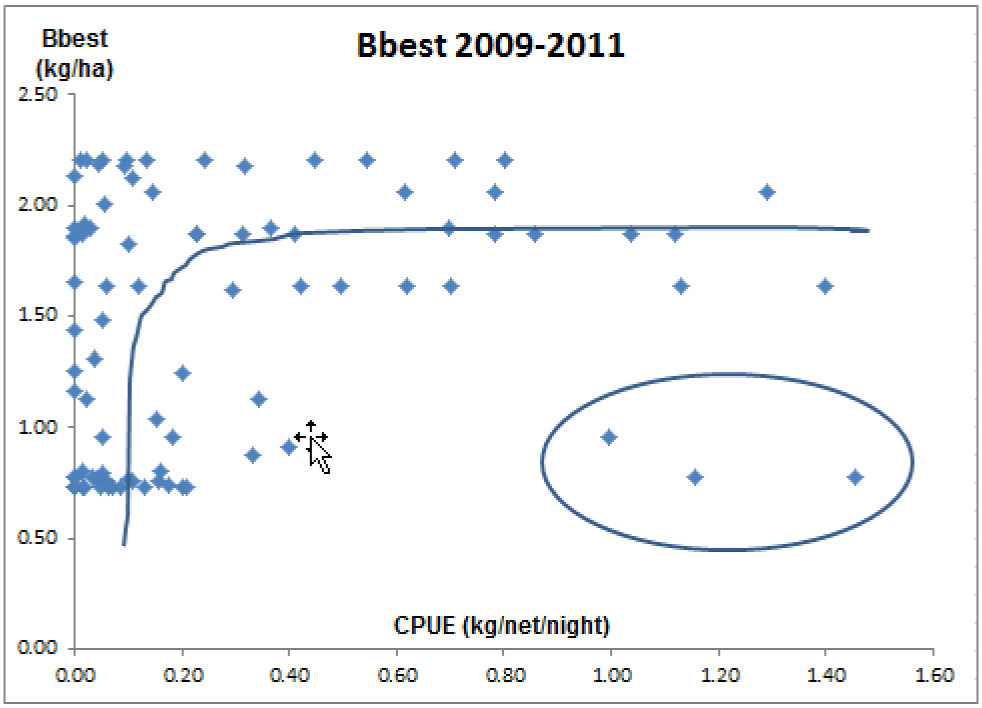


Figure 4-3: Plot of CPUE (wt) versus Bbest (2009-2011) for the corresponding inland catchment. Included are shown a possible relationship (line) and some outlying lagoons (encircled)

The PCA resulted in 2 groupings **drying** and **coast** on one axis; the remaining variables were clustered on the 2nd axis (Fig. 4.4).

A second PCA (Fig. 4.5) was carried out for the transitional waters surveyed using fyke nets over the last five years (2008-2012). For these surveys, cpue in numbers and cpue in weight are available along with the classification variables.

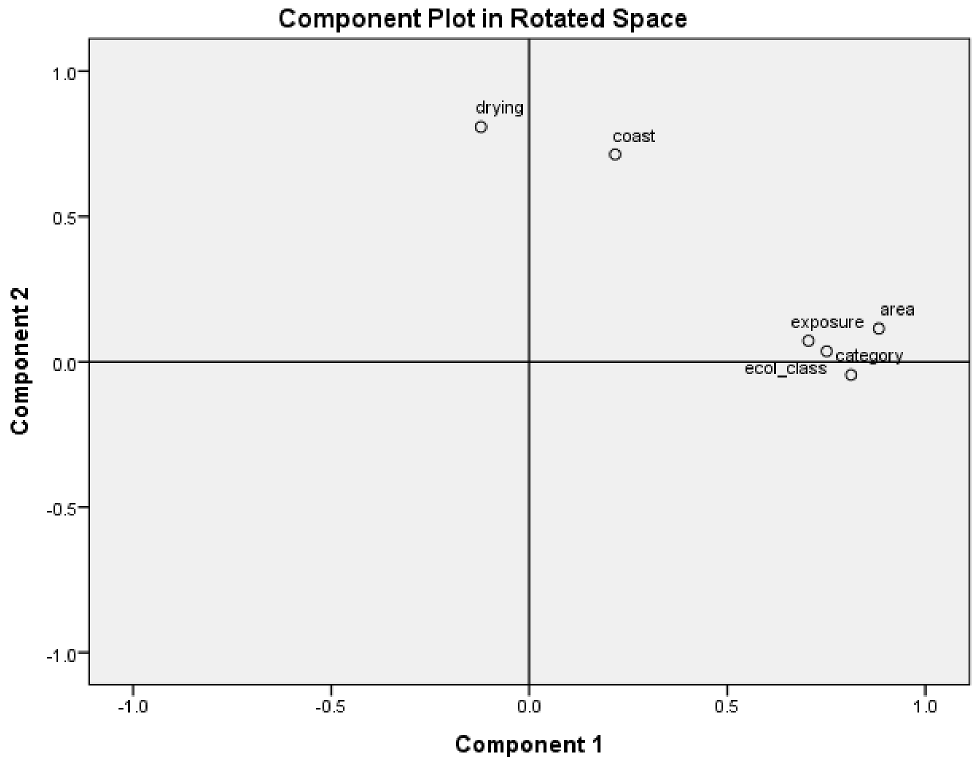


Figure 4-4: PCA plot for all transitional waters and environmental variables.

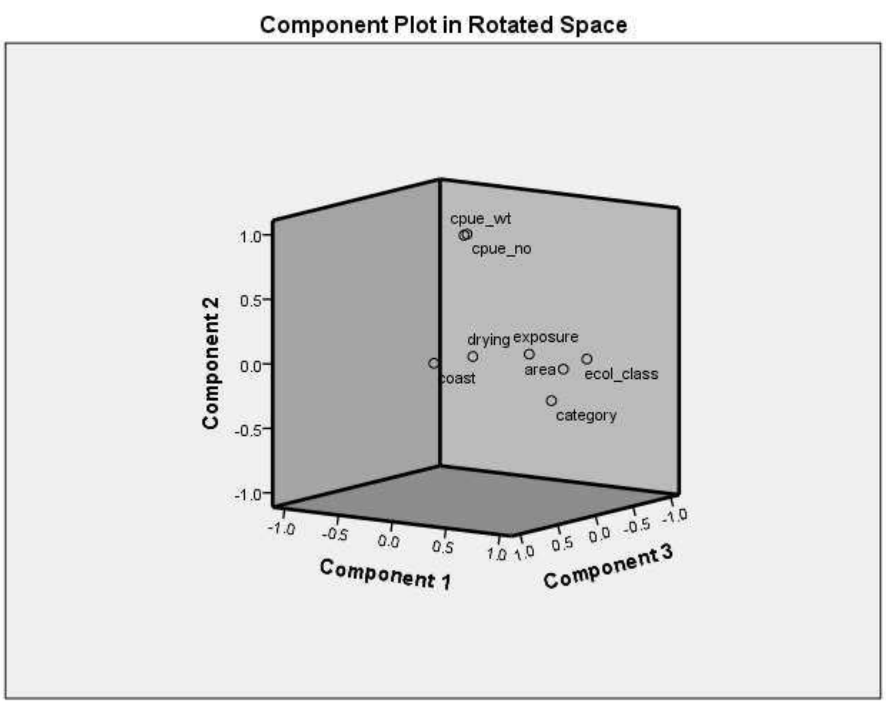


Figure 4-5: PCA plot for transitional waters with fyke nets surveys available.

To investigate the effect of the individual environmental variables on CPUE Numbers and CPUE Weight, a non-parametric analysis was carried out. The data is not normally distributed.

Table 4.1 contains the summary data for both cpue numbers and cpue weight for the different environmental variables. Following the non-parametric analysis only 2 variables had a significant relationship with both cpue nos and cpue wt (Table 4.2). These are Category (Lagoon or River) and Drying (Drying, non-drying and partial drying). The remaining variables were not significantly different.

A Mann Whitney test for the category (lagoon/river) was significantly different with a higher cpue numbers for lagoons compared with rivers (median lagoon cpue nos = 3; median River cpue nos = 1, $U = 553.5$, $p<0.05$, $r = .2$). A mann whitney test was also carried out on cpue weight and category (Lagoon/ river), again a significant difference was found between river and lagoon with lagoon recording a higher median cpue weight compared with river (median Lagoon cpue wt= .32 median River cpue wt = .1, $U = 545$, $p<0.05$, $r = .23$). The effect size for both cpue numbers and cpue weight is low but it does indicate a trend.

A Mann Whitney post hoc test was carried out for the Drying category following the significant Kruskal Wallis test ($p<0.01$). The drying transitional waters have a significantly different cpue numbers compared with the transitional waters that dry out (Median Drying cpue nos = 0.54, median non-drying cpue nos = 2.17, $U = 466$, $p< 0.01667$ bc, $r = .3$ medium effect size). There was also a significant difference between the non-drying transitional waters and the partial drying transitional waters (median non-drying cpue nos = 2.17, median partial drying cpue nos = 1, $U = 416$, $p<0.01667$bc, $r = .3$ medium effect size). There was no significant difference between the drying and partial drying transitional waters (median drying cpue nos = 0.54, median partial drying cpue nos = 1, $U = 345$, $p=.610$ ns). To conclude the drying and partial drying transitional waters had significantly lower cpue numbers compared with the non-drying transitional waters.

A Mann Whitney post hoc test was carried out for the drying category and cpue weight following the significant Kruskal Wallis test ($p<0.01$). The drying transitional waters had a significantly lower cpue weight compared with non-drying transitional waters (median drying cpue weight = 0.06, median non-drying cpue weight = 0.31, $U = 441$, $p<0.01667$ bc, $r = .4$ medium to large effect size). The partial drying transitional waters also had a significantly lower cpue weight compared with non drying transitional waters (median partial drying cpue wt = 0.09, mediam non-drying cpue weight = 0.31, $U = 398$, $p<0.01667$, $r = .3$ medium effect size). There was no significant difference between the drying and partial drying cpue weight ($p=.495$ ns).

A similar result was found for both environmental variables irrespective of whether cpue numbers or cpue weight was analysed. The effect size for the drying category indicated a stronger effect on the cpue compared with the category environmental variable.

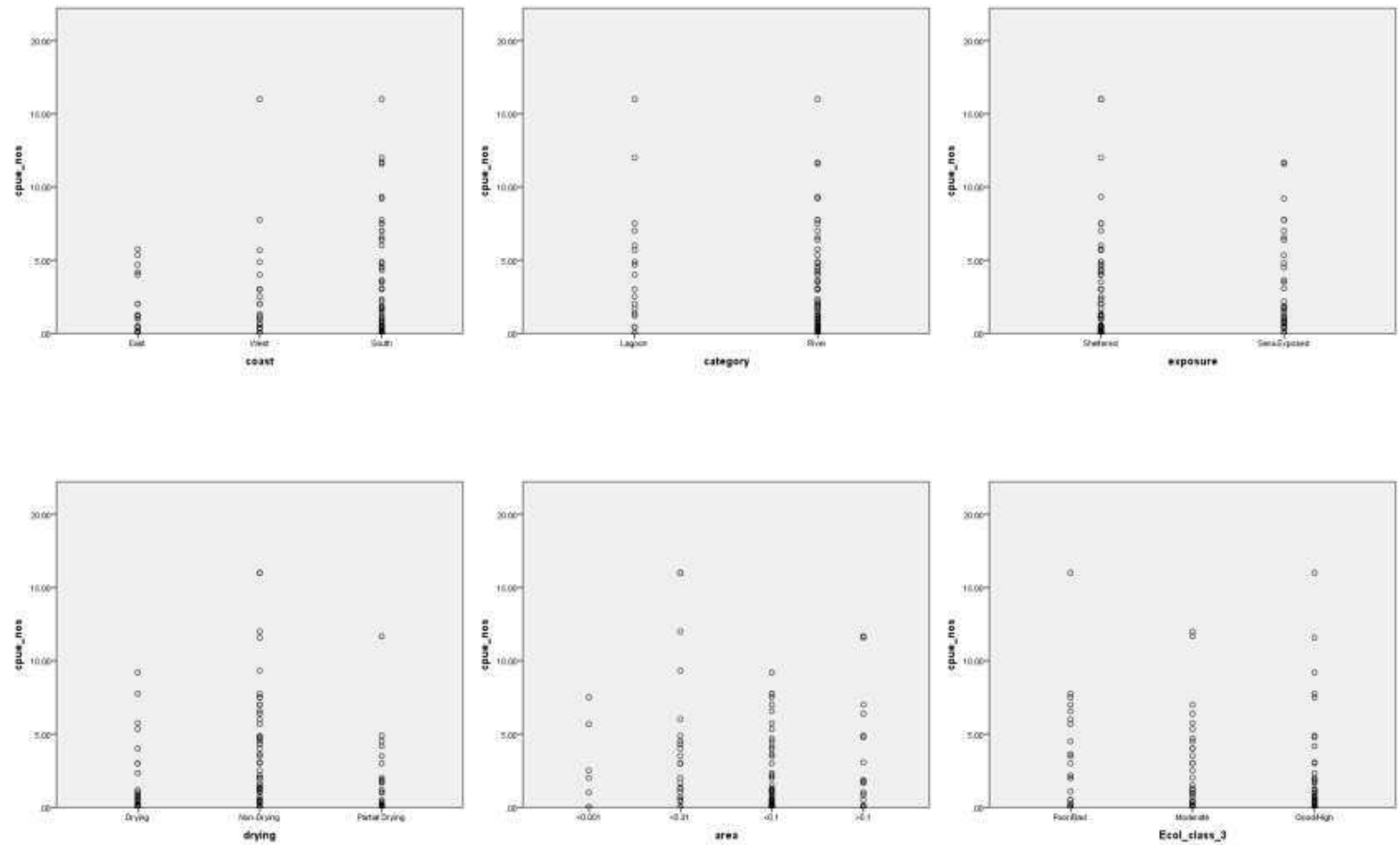


Figure 4-6: Scatter Plots of cpue and variables used in the PCA.

Following on from the results of the PCA and non-parametric tests (Table 4.3) it was decided to investigate the difference in median cpue numbers and cpue weights for 3 categories (Table 4.4).

- For Category River or Lagoon looking at the median the lagoons are twice the cpue of a river.
- For coast: East<West<South
- Drying:
    - partial drying is twice cpue of drying
    - non – drying is twice cpue of partial drying

4.4.4 Conclusion on Transitional Waters

- There appears to be a relationship between transitional water habitat classification and the CPUE of eels in fyke net surveys
- There is **no** apparent relationship between the transitional water habitat and freshwater potential production of silver eel (Bbest)
- Therefore, it was considered to unreliable at this point to attempt an extrapolation type estimate of silver eel production in transitional waters as the outcome could be quite misleading.

- Investigate further environmental variables that might explain the production of transitional waters (salinity, substrate (mud, algae, rocky – link to food source))
- Habitat use within transitional waters; are eels using all areas or do they require specific habitat e.g. for burrows?
- Investigate further the relationship between CPUE and density
- Investigate the silver eel potential production from transitional waters, separate from inland waters.

Table 4-1: Summary data for environment data

	CPUE Numbers			CPUE Weight		
category	**Lagoon**	**River**		**Lagoon**	**River**	
Mean	4.22	2.35		.47	.26	
Count	19	87		19	87	
Median	3.00	1.00		.32	.10	
Minimum	0.00	0.00		0.00	0.00	
Maximum	16.00	16.00		1.46	1.40	
exposure	**Sheltered**	**Exposed**		**Sheltered**	**Exposed**	
Mean	2.52	2.99		.27	.34	
Count	69	37		69	37	
Median	1.17	1.50		.10	.15	
Minimum	0.00	0.00		0.00	0.00	
Maximum	16.00	11.67		1.46	1.40	
Coast	**East**	**West**	**South**	**East**	**West**	**South**
Mean	1.85	2.28	3.13	.23	.23	.35
Count	19	27	60	19	27	60
Median	1.19	1.00	1.59	.10	.10	.16
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	5.75	16.00	16.00	.80	1.46	1.45
Drying	**Drying**	**Non Drying**	**Partial Drying**	**Drying**	**Non Drying**	**Partial Drying**
Mean	1.62	3.75	1.79	.16	.44	.17
Count	30	51	25	30	51	25
Median	.54	2.17	1.00	.06	.31	.09
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	9.21	16.00	11.67	1.40	1.46	1.12
Ecol_class_3	**Poor/Bad**	**Moderate**	**Good/High**	**Poor/Bad**	**Moderate**	**Good/High**
Mean	3.20	2.76	2.29	.38	.30	.23
Count	25	32	41	25	32	41
Median	2.00	1.38	1.00	.31	.13	.09
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	16.00	12.00	16.00	1.29	1.45	1.46

Table 4-2:

	CPUE Numbers				CPUE Weight			
area	**<0.001**	**<0.01**	**<0.1**	**>0.1**	**<0.001**	**<0.01**	**<0.1**	**>0.1**
Mean	2.67	3.78	2.01	3.17	.28	.39	.24	.35
Count	7	26	55	18	7	26	55	18
Median	2.00	2.50	1.00	1.71	.27	.27	.10	.13
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	7.50	16.00	9.21	11.67	.71	1.46	1.40	1.13

Table 4-3: Results for the Kruskal Wallis test for cpue nos and cpue wt

Kruskal Wallis test	CPUE NOS	CPUE wt
Coast	0.677 ns	.559 ns
category	0.05	0.02
Exposure	0.34 ns	.457 ns
Drying	<0.01	<0.01
Area	.495 ns	.690 ns
Ecol_Class_3	.531 ns	.327 ns

Table 4-4: Median cpue numbers and cpue weight assigned to different category of transitional waters

			CPUE Nos					CPUE Wt				
Category	**Coast**	**Drying**	**Average**	**Median**	**Min**	**Max**	**count**	**Average**	**Median**	**Min**	**Max**	**count**
	East	NonDrying	2.101	1.200	0.417	4.688	3	0.343	**0.133**	0.097	0.800	3
	South	NonDrying	5.764	6.500	0.417	12.000	6	0.549	0.377	0.021	1.448	6
Lagoon	**West**	NonDrying	3.937	2.750	0.000	16.000	10	0.452	0.322	0.000	1.455	10
		Drying	2.722	2.500	0.083	5.750	6	0.245	0.225	0.009	0.543	6
		NonDrying	1.125	1.125	0.000	2.000	6	0.214	0.096	0.000	0.699	6
	East	PartialDrying	1.459	0.793	0.083	4.167	4	0.123	0.080	0.014	0.317	4
		Drying	1.088	0.333	0.000	9.214	14	0.156	0.054	0.000	1.400	14
		NonDrying	4.288	3.563	0.000	16.000	24	0.510	0.513	0.000	1.292	24
	South	PartialDrying	2.178	1.333	0.000	11.667	16	0.208	0.103	0.000	1.120	16
		Drying	1.715	0.783	0.000	7.750	10	0.110	0.054	0.000	0.331	10
		NonDrying	0.526	0.526	0.385	0.667	2	0.044	0.044	0.036	0.052	2
River	**West**	PartialDrying	0.800	1.000	0.000	2.000	5	0.082	1.000	0.000	0.199	5

4.5 Eel Management Plan Freshwater Biomass (Coastal Waters)

The coastal waters of Ireland have not been assessed in 2012 or in 2015.

4.6 Biomass and Mortality Overview

No assessments were made of the stock indicators for transitional or coastal waters. Preliminary analysis indicated that it would be unwise to extrapolate directly from freshwater into the transitional zone.

In this report, the Irish eel stock in inland waters has been quantified and time trends presented. In this chapter, the state of the stock will be compared with the targets. The precautionary diagram introduced in Section 2.6 will be used, in a modified version. On the horizontal axis, the status of the stock is plotted (low versus high spawning stock biomass determining whether the stock is in good condition or not; logarithmic scale, percent of pristine biomass) and on the vertical axis the impact of fishing and hydropower generation (low versus high mortality determining whether the management regime is sustainable or not; mortality rates are logarithmic by definition). The diagrams below (Figs. 4.8 & 4.9) plot the most recent stock assessments (2009-2011 and 2012-2014), along with those presented in the EMP (2008).

The data for each EMU and for the total are presented on the modified ICES precautionary diagram, as developed by the WGEEL, using the EU management target (40% SSB) as the reference point and a calculated mortality reference point based on the EU management target (Alim 0.92) for 2008 and the averages for 2009-2011 and 2012-2014. The arrows in the diagrams indicate what effect the implementation of the management actions were expected to have.

It should be noted that while the diagrams indicate that all but the IE_Shan are above the target, due to the panmixia and shared nature of the eel stock and while the overall status of the stock is still outside safe biological bounds, it would probably be unwise for individual EMUs or countries to increase fishing mortality, at least until the stock is back within safe biological limits (Section 2.7).

The data are also presented in the projection plots (Figs. 4.11 & 4.12) that were first shown in the Irish national EMP Chapter 5.

In the IE_East, the IE_Shan, IE_West and IE_NorW, the mortality was clearly reduced as indicated by the downward direction of the bubbles and this led to increased escapement shown by right hand horizontal movement towards the 40% target. In some cases the bubbles did not respond as expected, by not moving as much to the right. This may due to some yellow eel still to feed through increasing the %SSB and moving the bubbles to the right in coming years. Or the negative impact of falling recruitment may now be leading to lower silver eel production, or there may be problems with some of the estimates as mentioned previously. Extrapolation to the east and south EMUs will need to be reviewed in the light of future additional data.

There is some anecdotal evidence to suggest higher than previously thought yellow eel exploitation. It is also possible that the historical production without anthropogenic mortality (Bo) may be too low. The estimates for undeclared or illegal catches included in the historical model were 40% of the declared catch but anecdotal information would suggest that this could have been as high as 200% or 300%. Fixing a value for Bo is fundamental to determining a realistic %SSB although this has always been a challenge.

In general, we have demonstrated the increase in biomass of silver eel escaping and the marked reduction in fishing and hydropower mortality. While further reduction in mortality is unlikely, it possible that additional biomass from the closure of the yellow eel fishery will continue to feed through in the coming years (circa 5 years). However, it is unclear how the collapse in recent recruitment will impact on silver eel biomass and whether density dependent effects (change from small males to higher proportions of larger females) will buffer the collapse in recruitment by temporarily increasing biomass of silver eels, even with falling numbers.

4.7 Timeframe to recovery

International scientific advice is to reduce the level of anthropogenic mortality to as close to zero as possible to achieve recovery of the stock. An 85% reduction of anthropogenic mortality was estimated to be required to prevent continued decline from the current extremely low level of recruitment without achieving any long-term recovery (Astrom & Dekker 2007). The lower the anthropogenic pressure the greater the likelihood of recovery and the quicker the recovery will occur (See Chapters 5.3.1 & 5.3.2 of the National EMP 2008).

The management actions implemented in the EMP resulted in no fishing mortality and markedly lower turbine mortality. According to the stock assessment of Astrom & Dekker (2007), this should result in recovery of recruitment within approximately 90 years and achievement of the EU escapement biomass target in a similar or shorter timeframe, assuming the average European anthropogenic mortality is reduced to a comparable level.

Even following the Member States reports to the EU in July 2012, it is not possible to reassess the timeframe to recovery. From the reported information, it appears that comparable actions were not implemented across Europe and therefore the timeframe set by Ireland may be longer.

Ireland has reduced its mortality rate to well below A_{lim} of 0.92 (the rate equivalent to the biomass EU 40% target). Therefore, Ireland is fulfilling its EMP commitment to recovering the stock in the fastest time possible.

The low recruitment levels of the recent past leads to a low adult yellow eel stock and consequently a low stock of silver eel returning to the ocean to spawn. Under these circumstances, it is unlikely that that the 40% target SSB can be sustained into the near future. Recruitment has now become the limiting factor for recovery in Ireland.

4.8 Eel Density Analysis

Eel Density Analysis (EDA) is a modelling framework that can be used to estimate eel populations in aquatic habitats. Survey data (primarily electrofishing operations) are used to build predictive models describing the presence/absence and the density of eel. These models are then applied to the entire network of aquatic habitat in the area of interest to estimate the total population size. The fluvial (riverine) population of yellow eel in Ireland was estimated (de Eyto, Briand, Poole, & O'Leary, in prep 2015) using the EDA (v2.0) model (Jouanin *et al.*, 2012).

A total fluvial population of 8,032,834 yellow eels and 200,821 silver eels (using a silvering rate of 2.5%) was estimated for **2011**. Eel presence and abundance decreased as the distance to the sea increased, and the percentage of calcareous geology in the catchments decreased. Stock indictors (Bo, Bbest and Bcurrent) were calculated from these yellow eel estimates to enable the display of precautionary diagrams for each EMU in Ireland. Lake production was also calculated for 2011, using empirical data from a small number of catchments. A precautionary diagram for this total production (fluvial and lacustrine habitat) was presented, and compared with previous estimates of stock indicators for Ireland.

It was encouraging to see that the stock indicators calculated using EDA and a proxy for lake productivity are quite similar to those previously calculated for Ireland (Table 4.5). The best example of this is for the Southeastern EMU, which has a very small proportion of lacustrine habitat (4%). The EDA fluvial estimate of *Bcurrent* for the Southeastern EMU is 6.4 tonnes for 2011, while the Irish model (Anon., 2012) predicted *Bcurrent* at 6.8. Both of these estimates exceed the biomass target (40%) set by the EU Regulation. These two statistical methods use very different data in their calculation, and the fact that they are very similar gives some confidence that production value for the Southeastern EMU is correct. Similarly, when we add in lake production, the estimates of *Bcurrent* for all EMU's are roughly similar, and, with one exception, give the same indication of whether the biomass target is being met (i.e. they are given the same colour coding in Table 4.5). The only exception is the Eastern EMU, where the Irish model estimate of Bcurrent is 9.4 tonnes, which is greater than 40% of the target, while the EDA model (flu + lake) gives an estimate of 6.5 tonnes, which is below the biomass target. In comparing the Irish model estimate with the EDA (flu + lake) estimate, we note that the raw data used to calculate lake production comes from the same source for the two models (i.e. total production from the Burrishoole, Shannon, Corrib and Erne catchments). However, the treatment of this data differs considerably between the two models, and again, this gives confidence that both estimates are in the correct range. This is a significant result as the estimation of eel production from EMU's is inherently difficult. The fact that we have two models giving roughly similar estimates strengthens the assessment of eel production from Ireland, and gives us complimentary methods with which to assess the success of future management actions. As EDA is run on current (or recent) surveys of yellow eel densities, any increase or decrease in recruitment in the coming decades should be captured by this model, allowing comparison with *B0* in the future.

The EDA model produced biomass estimates which were in line with those previously calculated using the Irish model, giving confidence that the two methods (IMESE & EDA) are successfully estimating total eel production for the country.

Table 4-5: Table 3.6: Stock indicators in Ireland, comparison with previous EU reporting (2012) and between 2015 fluvial (EDA) and 2015 fluvial + lake (EDA) estimates. Bcurrent is colour coded according to whether it is greater than (green) or less than (red) the biomass target (40% of Bo) set by the EU Regulation. ∑A is colour coded according to whether it is less than (green) or greater than (red) the mortality target equivalent to the biomass target (after (ICES, 2012). Note that the target for ∑A is lower than 0.92 if Bcurrent < 0.4B0.

	Source	Year	Biomass (t)			Mortality		
			$B_{current}$	B_{best}	B_0	ΣF	ΣH	ΣA
NorW								
	2012	2011	51.5	54.3	135.8	0	0.05	0.05
	2015 flu	2011	2.9	2.9	13.6	0	0.01	0.01
	2015 flu+lake	2011	42.4	58.0	135.8	0	0.31	0.31
West								
	2012	2011	68.7	68.7	189.2	0	0.00	0.00
	2015 flu	2011	5.5	5.5	13.2	0	0.00	0.00
	2015 flu+lake	2011	60.1	60.1	189.2	0	0.00	0.00
Shan								
	2012	2011	68.7	75.4	201.2	0	0.09	0.09
	2015 flu	2011	7.6	7.6	22.1	0	0.00	0.00
	2015 flu+lake	2011	72.6	79.1	201.2	0	0.09	0.09
SouW								
	2012	2011	11.3	11.6	24.5	0	0.03	0.03
	2015 flu	2011	4.5	4.5	7.1	0	0.01	0.01
	2015 flu+lake	2011	13.8	14.4	24.5	0	0.05	0.05
SouE								
	2012	2011	6.8	6.8	14.8	0	0.00	0.00
	2015 flu	2011	10.5	10.5	14.2	0	0.00	0.00
	2015 flu+lake	2011	10.7	10.7	14.8	0	0.00	0.00
East								
	2012	2011	9.4	9.6	20.5	0	0.01	0.01
	2015 flu	2011	1.9	1.9	6.4	0	0.00	0.00
	2015 flu+lake	2011	6.5	7.1	20.5	0	0.09	0.09

4.9 Summary of individual EMU targets

No assessments were made of the stock indicators for transitional or coastal waters. Preliminary analysis indicated that it would be unwise to extrapolate directly from freshwater into the transitional zone.

In Chapter 5.2.4.4 of the Irish Eel Management Plan, summary plots of the 2008 status of each EMU were presented, including projections for different management scenarios (no action, full fishery closure, full removal of hydropower mortality) and these were scaled according to the previous recruitment history (with no density dependence assumed) (See figures in Ch. 5.2.4.4 of the EMP 2008).

These plots have now been updated with the revised historic estimates of silver eel production and the new % SSB averages for 2009-2011 and 2012-2014 have been inserted. These are shown in Figures 4.11 & 4.12.

With the exception of the IE_Shan (ShIRBD) all other EMUs were above the EU target in 2012-2014. It is not expected that this can be sustained due to the history of recruitment, although density dependent changes to some of the stocks, such as sex ratio change to female and increase in eel size, are making it difficult to project further into the future. It should be noted, as mentioned in Sec 4.6, that three EMUs were assessed using the IMESE model with no local calibrating index.

In 2008, the total for all EMUs was projected into the future to peak at 36% before falling again due to lack of recruits; the average for 2009-2011 was 36.7%. This has now increased, however, to 54.5% average for 2012-2014 period. The 2012-2014 estimates here are also possibly unduly influenced by the Corrib catchment modelled estimate, as discussed earlier (Sec 4.6).

It was observed earlier that the current production had increased in all the index catchments in the 2012-2014 period. This was not the case in L. Neagh although production in L. Neagh is heavily influenced by past stocking history along with natural recruitment patterns and the current falling production in the Lough equates to a period of low juvenile inputs.

In Figure 4.10, each EMU is plotted using a separate colour. The size of the bubble indicates the relative production of that EMU. Three of the EMUs (IE_East, IE_SouE, IE_SouW) have relatively modest production compare to the other three, so care should be taken in interpreting the % target data presented in Table 4.7.

Table 4-6: Historic (Bo) and current silver eel production (Bbest) (kg) and escapement (Bcurrent) (kg) for 2008-2014 and average production and escapement for 2009-2011 and 2012-2014 calculated using the IMESE model and inserting actual catchment data where they exist.

EMU Code	EMU Name	Bo Prod	Production (Bbest)							Av 2009-2011	Av 2012-2014
		kg	2008	2009	2010	2011	2012	2013	2014		
IE_East	EEMU	20,517	16,768	14,755	10,865	9,928	13,936	15,079	14,756	10,484	14,592
IE_NorW	NWIRBD	135,732	102,502	57,295	52,447	52,956	82,099	89,376	87,747	52,883	86,286
IE_Shan	SHIRBD	201,401	95,979	83,464	75,608	71,669	76,507	89,250	80,151	76,073	81,855
IE_SouE	SERBD	14,836	11,229	9,877	7,271	6,645	9,333	10,098	9,878	7,018	9,774
IE_SouW	SWRBD	24,577	15,914	13,975	10,274	9,395	13,230	14,312	13,978	9,932	13,864
IE_West	WRBD	192,377	101,892	83,128	98,543	90,029	126,447	136,795	133,872	69,545	132,404
	Total	589,440	344,285	262,494	255,010	240,623	321,553	354,910	340,383	225,936	338,776
EMU Code	**EMU Name**	**Bo Prod**	**Escapement (Bcurrent)**							**Av 2009-2011**	**Av 2012-2014**
		kg	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**		
IE_East	EEMU	20,517	9,557	14,561	10,722	9,798	13,753	14,881	14,562	10,346	14,401
IE_NorW	NWIRBD	135,732	47,787	47,554	49,348	50,515	71,817	80,494	81,817	50,035	77,921
IE_Shan	SHIRBD	201,401	21,636	79,369	67,398	63,996	67,412	80,055	72,213	69,414	73,112
IE_SouE	SERBD	14,836	9,867	9,877	7,271	6,645	9,333	10,098	9,878	7,018	9,774
IE_SouW	SWRBD	24,577	15,379	13,576	10,067	9,389	12,910	14,189	13,807	9,767	13,659
IE_West	WRBD	192,377	46,546	83,128	98,543	90,029	126,447	136,795	133,872	69,545	132,405
	Total	589,440	150,771	248,064	243,350	230,372	301,673	336,512	326,149	216,126	321,272

Table 4-7: The % Bcurrent/Bbest (%EU target) for each EMU and for the total production, for 2008 to 2014 and for the average for 2009-2011 and 2012-2014. The data come from Table 4.6.

EMU Code	EMU Name	Bo Prod	%Bcurrent/Bbest (EU Target)							Av 2009-2011	Av 2012-2014
		kg	2008	2009	2010	2011	2012	2013	2014		
IE_East	EEMU	20517	46.6	71.0	52.3	47.8	67.0	72.5	71.0	50.4	70.2
IE_NorW	NWIRBD	135732	35.2	35.0	36.4	37.2	52.9	59.3	60.3	36.9	57.4
IE_Shan	SHIRBD	201401	10.7	39.4	33.5	31.8	33.5	39.7	35.9	34.5	36.3
IE_SouE	SERBD	14836	66.5	66.6	49.0	44.8	62.9	68.1	66.6	47.3	65.9
IE_SouW	SWRBD	24577	62.6	55.2	41.0	38.2	52.5	57.7	56.2	39.7	55.6
IE_West	WRBD	192377	24.2	43.2	51.2	46.8	65.7	71.1	69.6	36.2	68.8
	Total	589,440	25.6	42.1	41.3	39.1	51.2	57.1	55.3	36.7	54.5

Table 4-8: Annual fishing (∑F), other anthropogenic (∑H) and total mortality (∑A) rates for each Eel Management Unit and the total annual mortality rate for all EMUs.

Indicator	∑F	∑F	∑F	∑F	∑F	∑F	∑F	∑H	∑H	∑H	∑H	∑H	∑H	∑H	∑A	∑A	∑A	∑A	∑A	∑A	∑A
Unit	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate	rate
Year	pre-EMP	2009	2010	2011	2012	2013	2014	pre-EMP	2009	2010	2011	2012	2013	2014	pre-EMP	2009	2010	2011	2012	2013	2014
EMU_code																					
IE_East	0.539	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.013	0.013	0.013	0.013	0.013	0.013	0.559	0.013	0.013	0.013	0.013	0.013	0.013
IE_NorW	0.584	0.000	0.000	0.000	0.000	0.000	0.000	0.186	0.186	0.061	0.047	0.134	0.105	0.070	0.770	0.186	0.061	0.047	0.134	0.105	0.070
IE_Shan	1.240	0.000	0.000	0.000	0.000	0.000	0.000	0.242	0.050	0.115	0.113	0.127	0.109	0.104	1.482	0.050	0.115	0.113	0.127	0.109	0.104
IE_SouE	0.129	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.129	0.000	0.000	0.000	0.000	0.000	0.000
IE_SouW	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.048	0.029	0.020	0.001	0.024	0.009	0.012	0.054	0.029	0.020	0.001	0.024	0.009	0.012
IE_West	0.783	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.783	0.000	0.000	0.000	0.000	0.000	0.000
Total															0.83	0.06	0.05	0.04	0.06	0.05	0.04

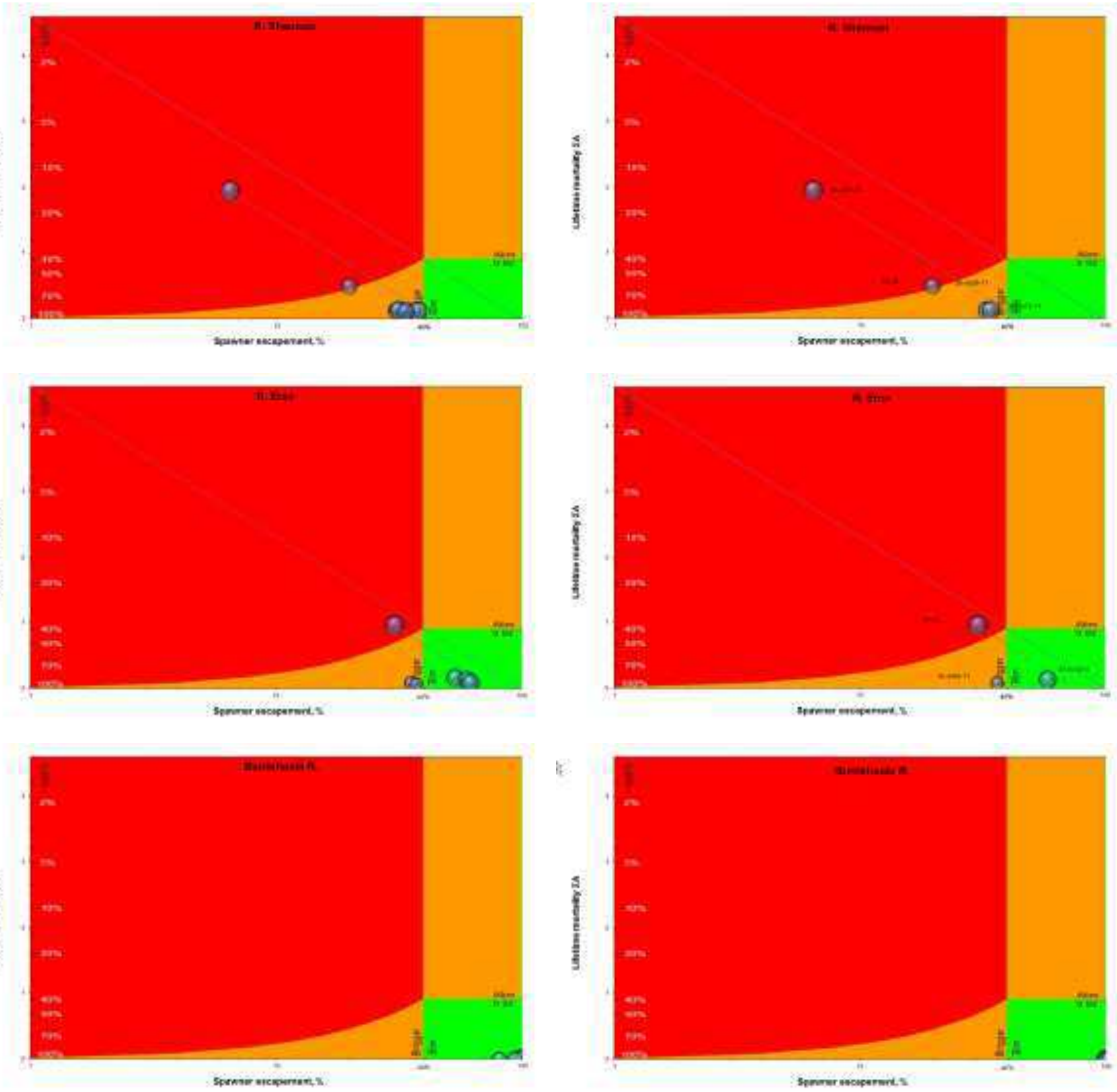


Figure 4-7: Status of the stock and the anthropogenic impacts, for the Rivers Shannon, Erne and Burrishoole as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008-2014 (left hand graphs), and for the average of 2001-2007, 2009-2011 and 2012-2014 (right hand graphs). For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

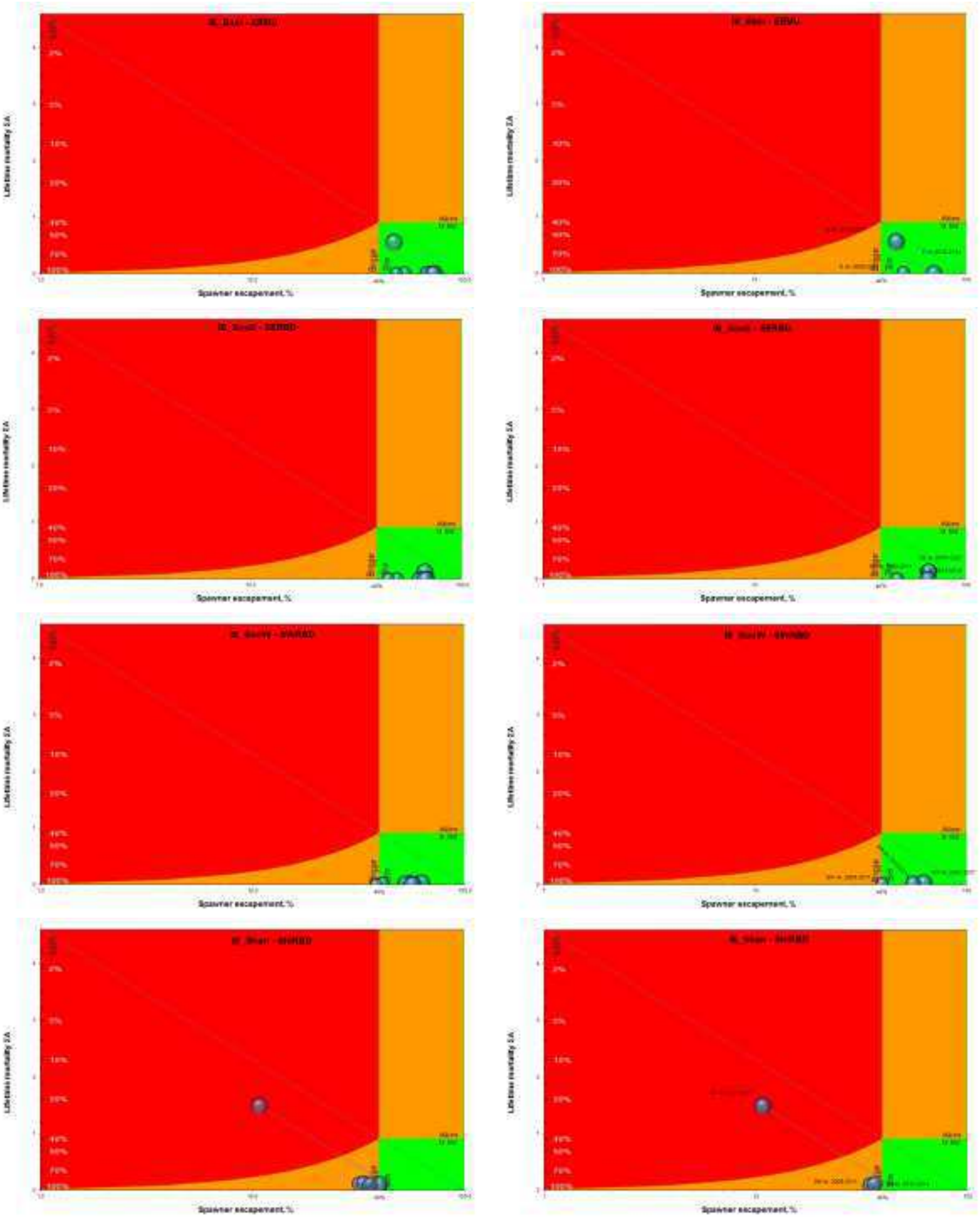


Figure 4-8: Status of the stock and the anthropogenic impacts, for the EMUs as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008-2014 (left hand graphs), and for the average of 2001-2007, 2009-2011 and 2012-2014 (right hand graphs). For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

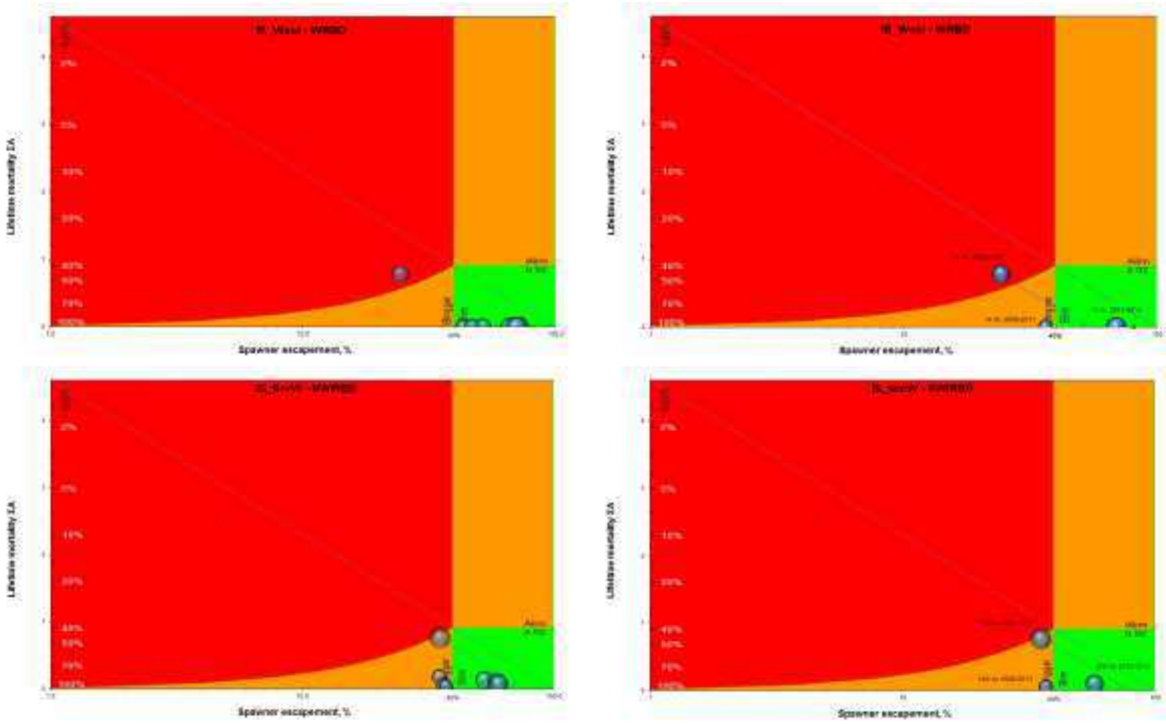
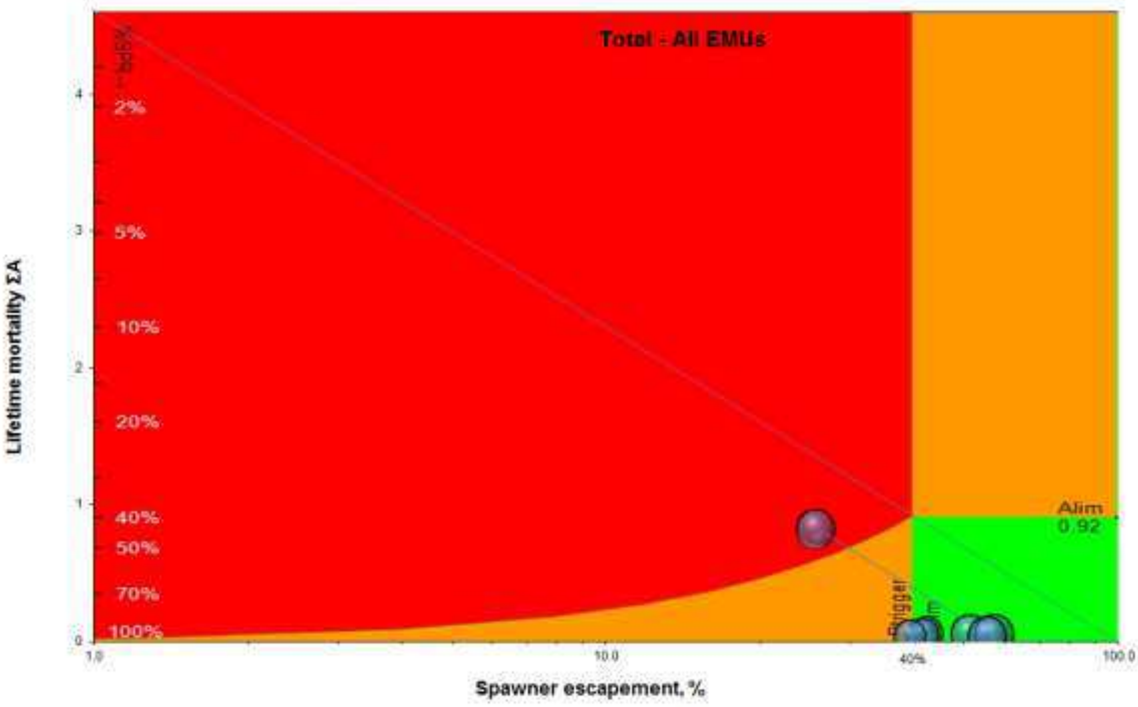


Figure 4.8 cont.: Status of the stock and the anthropogenic impacts, for the EMUs as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008-2014 (left hand graphs), and for the average of 2001-2007, 2009-2011 and 2012-2014 (right hand graphs). For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.



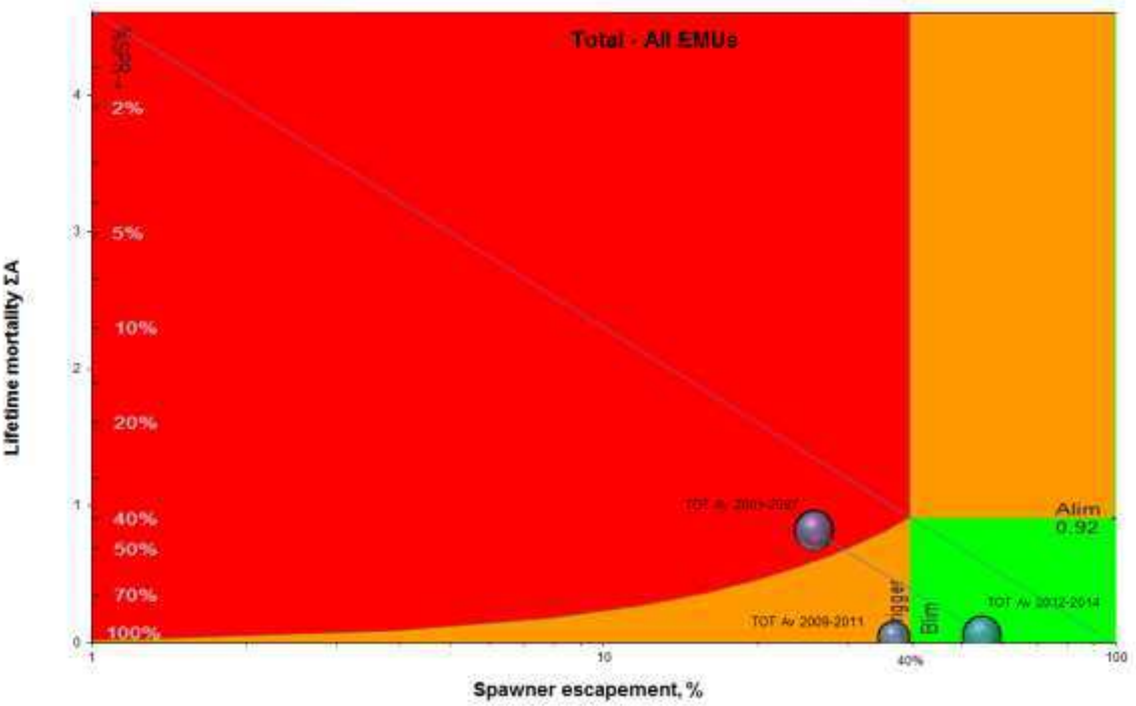


Figure 4-9: Status of the stock and the anthropogenic impacts, for the TOTAL EMUs as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008-2014 (top), and for the average of 2001-2007, 2009-2011 and 2012-2014 (bottom). For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

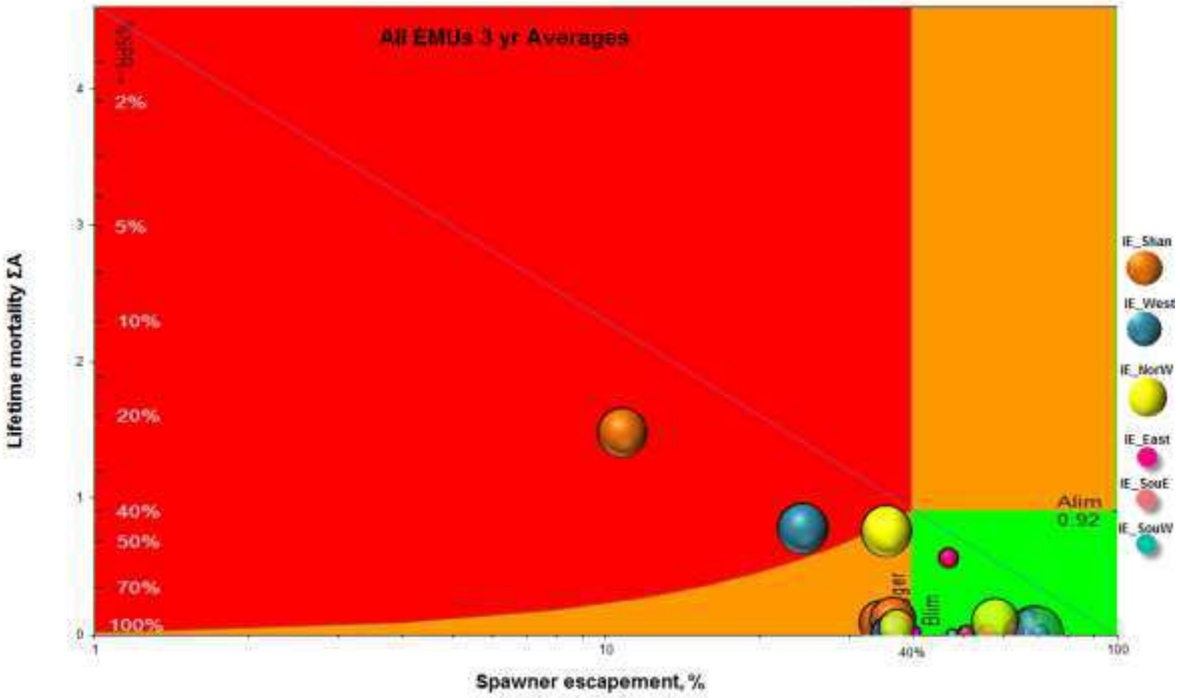


Figure 4-10: Status of the stock and the anthropogenic impacts, for the All EMUs for the average of 2001-2007, 2009-2011 and 2012-2014. For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

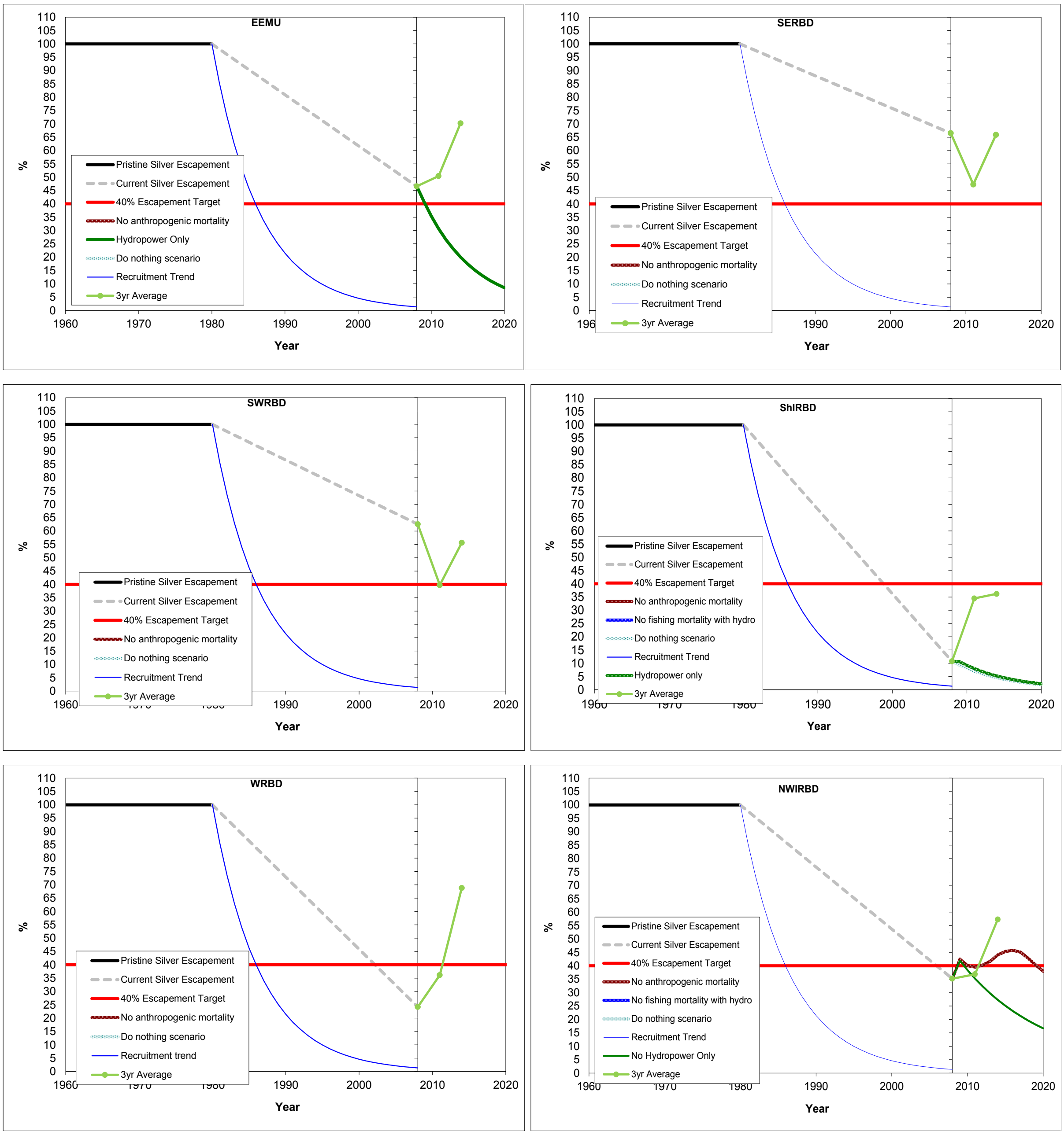


Figure 4-11: Plots for each Eel Management Unit of historic (100%) and current (2008) eel production and escapement related to the EU 40% target (red line). The recruitment trend is shown in plain blue. The effect of projected management scenarios are shown in dotted blue (fishery), dark green (hydropower) and total (brown) and the estimated points for the averages of 2009-2011 and 2012-2014 are shown as a light green line and dot plotted at 2011 and 2014 respectively.

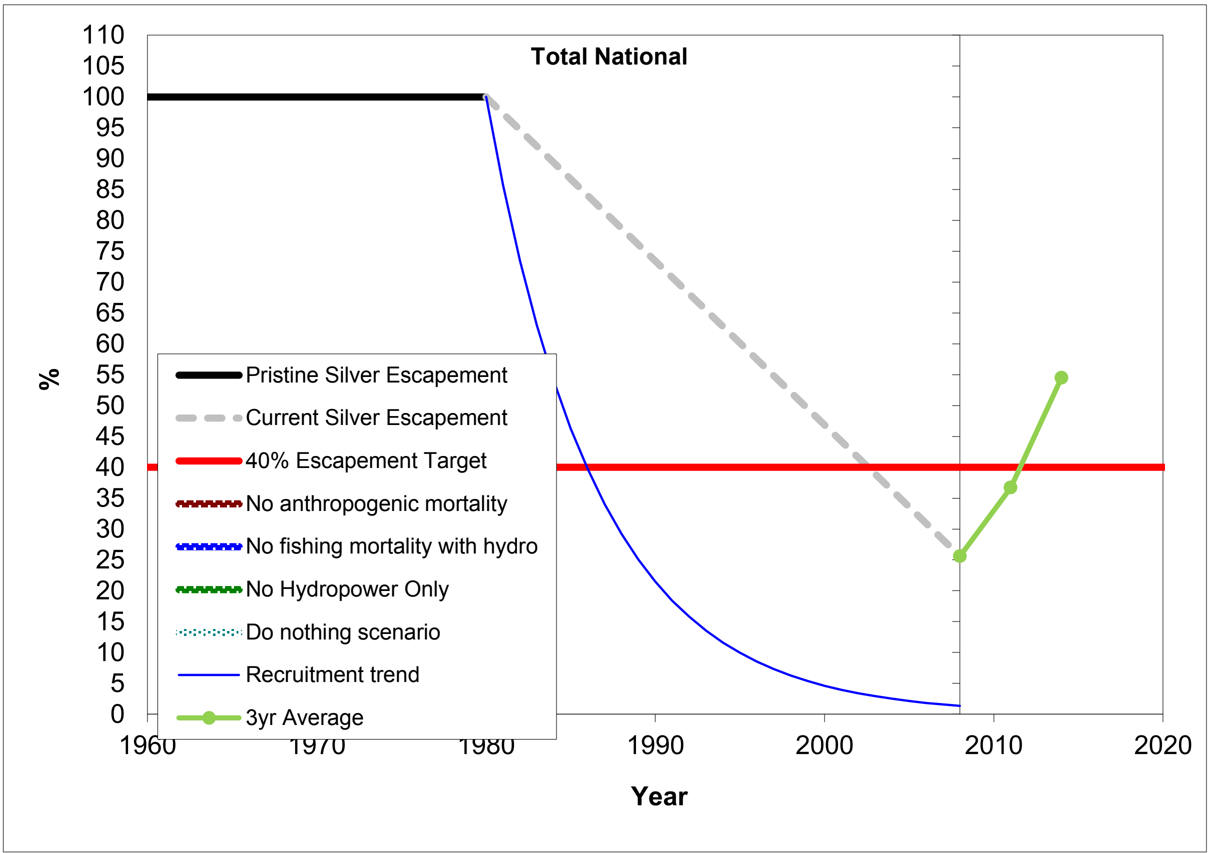


Figure 4-12: Plots for total of the Irish and transboundary Eel Management Units of historic (100%) and current (2008) eel production and escapement related to the EU 40% target (red line). The recruitment trend is shown in plain blue. The effect of projected management scenarios are shown in dotted blue (fishery), dark green (hydropower) and total (brown) and the estimated points for the averages of 2009-2011 and 2012-2014 are shown as a light green line and dot plotted at 2011 and 2014 respectively.

4.10 SWOT Analysis on the Assessment

Before using the above assessment in informing management decisions, it would be prudent to undertake a SWOT analysis:

Strengths

- Uses best available information
- Almost 50% of the inland wetted area is determined by direct assessment
- Extrapolation (IMESE) uses most recent information, eel growth and index silver eel production
- Mortality is determined by direct assessment
- Extrapolation (IMESE) provides a consistent means of estimating biomas and comparing between years
- 2009-2011 outputs have been supported by the independent EDA, using WFD field data

Weaknesses

- No silver eel index sites yet available for 3 EMUs
- The IE_West (WRBD) is dominated by catchments with large lakes with no index site
- The analysis is mostly calibrated by catchments where considerable yellow eel fisheries were extant in the past.
- Two of the three index sites are from highly regulated (HPS) catchments
- No quantitative yellow eel data available for lakes or transitional waters.
- No estimate of risk or uncertainty.

Opportunities

- Need to further develop index silver eel sites
- Need to apply EDA for 2012-2014 and 2015-2017 for inclusion in the 2018 report.
- Need to develop methodology for lake and transitional water assessments

Threats

- Further loss of silver eel index sites
- New silver eel indices fail to materialise
- Loss of WFD programme eel data
- Production v geology relationship breaks down completely, maybe due to density dependent changes in the eel stocks and other influences of recruitment.
- Irish recovery still reliant on EU-wide action
- Recovery of the European stock is dependent on concerted European action.

5 Overall Conclusions

Ireland has implemented a full monitoring programme as outlined in the EMP aimed at delivering the biomass, mortality and stock information required under EU Regulation (No. 1100/2007).

While **recruitment** remains low, improvements were noted in some catchments in 2013 and 2014. Increase to between 2.8% and 49.5% compared to pre-1995 averages were noted for the 2012-2014 period. In 2014, increases to between 3.2% and 47.1% of pre-1994 levels were observed and these compare favourably with the European data.

Yellow eel monitoring has shown a complex picture of eel stocks across Ireland, with some good stocks of eel along with some quite low stocks. The impact of low recruitment has been observed with lower numbers of small eels when compared to surveys in the 1960s and '70s. Some catchments are also seeing the disappearance of very large eels such as Burrishoole transitional lagoon (Furnace), possibly due to silvering rate overtaking growth rate. Some very good catches of yellow eel have been observed, such as in L. Muckno and Lower Lough Erne. Good catches of eel, including smaller eels, have also been recorded in transitional waters such as Waterford harbour and the Slaney.

Silver eel: The Shannon, Erne and Burrishoole all showed an increase in silver eel production (Bbest) in the 2012-2014 period compared to the previous three years (Table 4.6). Part of that increase could be attributed to the closure of the yellow eel fishery beginning to feed through to an increase in silver eel output, but as the unexploited Burrishoole also witnessed an increase it is also possible that it was a natural event.

Silver eel production in the Shannon increased from 1.64kg/ha in 2009-2011 to 1.72kg/ha in 2012-2014 with a peak of 1.9kg/ha in 2013. The Erne increased from 1.62kg/ha in 2009-2011 to 2.91kg/ha in 2012-2014 with a peak of 3.29kg/ha in 2014, an increase that was more or less expected due to previous recruitment patterns and the closure of the fisheries. The Burrishoole increased from 0.96kg/ha in 2009-2011 to 1.19kg/ha in 2012-2014 with a peak of 1.22kg/ha in 2014.

The Erne and Burrishoole were above the 40%SSB, with a marked decrease in eel mortality in the Erne to a level well below Alim of 0.92.

The escapement biomass in both the Erne and the Shannon has increased with the Erne going from 36.3% to 58.4% SSB and the Shannon going from 32.6% to 34.0% SSB.

There is an urgent need for the development of additional silver eel index sites in the other EMUs.

National Silver Eel Production, Escapement and Mortality: Current escapements expressed as a percentage of the historic production, given for 2008 and for the 2009-2011 period as an average. The positive effect of the implemented management measures (fishery closure and silver eel trap and transport) can be seen by the total %SSB increasing from 25.6% (2008) to 36.7% (2009-2011).

The two EMUs where the impacts were severest with both fisheries and hydropower were the IE_Shan (ShIRBD) and IE_NorW (NWIRBD). In the IE_Shan the %SSB went from 10.7% to 34.5% (2009-2011) to 36.3% (2012-2014) and in the IE_NorW the %SSB went from 35.2% to 36.9% (2009-2011) to 57.4% (2012-2014), also reflecting the anticipated increase in output due to past recruitment history in the mid-1990s.

The IE_West also showed a large increase in SSB although this should be treated with some caution as the model may have over-estimated production from the very large area of the Corrib catchment.

While Ireland has reduced its anthropogenic mortality to low levels, it is unlikely that the increase in biomass in the last three years can be sustained much into the future due to the legacy of poor recruitment. The international view is the stock is still below safe biological limits. A preliminary analysis of available data (post 2012 reporting) indicated that current (2012) silver eel escapement biomass was at approximately 6% of the historical 'pristine' state (ICES 2014).

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