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

IRELAND

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

May 2018

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 scientific monitoring programme is given in Annex 1. Tables 1.1-1.5 in this report 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 (2015 to 2017). Two runs of the IMESE model were carried out for the 2015-2017 period, the traditional one using the Shannon (IE_Shan), Erne (IE_NorW) and Burrishoole (IE_West) as tuning indices, and a new run with the addition of the Fane (IE_East). While the trends were similar, different levels of production (Bbest) were evident between the two runs. It was therefore decided to report on the mid-point between the two. Full details are given in the Stock Annex 2018 (Annex 1).

In general, Ireland has demonstrated an increase in biomass of silver eel escaping and a 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 is still possible that some additional biomass from the closure of the yellow eel fishery may continue to feed through in the coming years although as it is nine years since the closure this effect will be limited. 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 Spawning Stock Biomass (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.

Chapter 3 provides information regarding the additional items requested by the EU under Article 11 of the Regulation (Fishing fleet, Auction centres for first marketing of eel and recreational fishery). As all commercial eel fishing in Ireland is currently prohibited a Nil return applies in relation to eel fishing fleet details and first marketing of eel. Recreational fishing for eel and possession, purchase and sale of eel is also prohibited and any eels captured as bycatch when angling are required to be released.

Chapter 4 identifies proposed amendments to the Regulation (Council Regulation 1100/2007). These include: - Target and timeframe of the Regulation and whether or not the requirements are sufficiently defined, ambitious or time-bound to reverse the serious decline in European eel stocks; the requirement for improved standardisation and co-ordination of eel management returns from Member States; and the requirement for an EU traceability scheme to enable international movement of eels be cross-checked between donor and recipient countries.

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 third report is due by 30th June 2018.

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, now the Department of Agriculture, Environment and Rural Affairs (DAERA), 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, 2013-2018).

This management report should be read in conjunction with the SSCE Stock Annex (Annex 1) and the three annual SSCE Reports (Anon 2016, 2017, 2018).

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 DAERA (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.

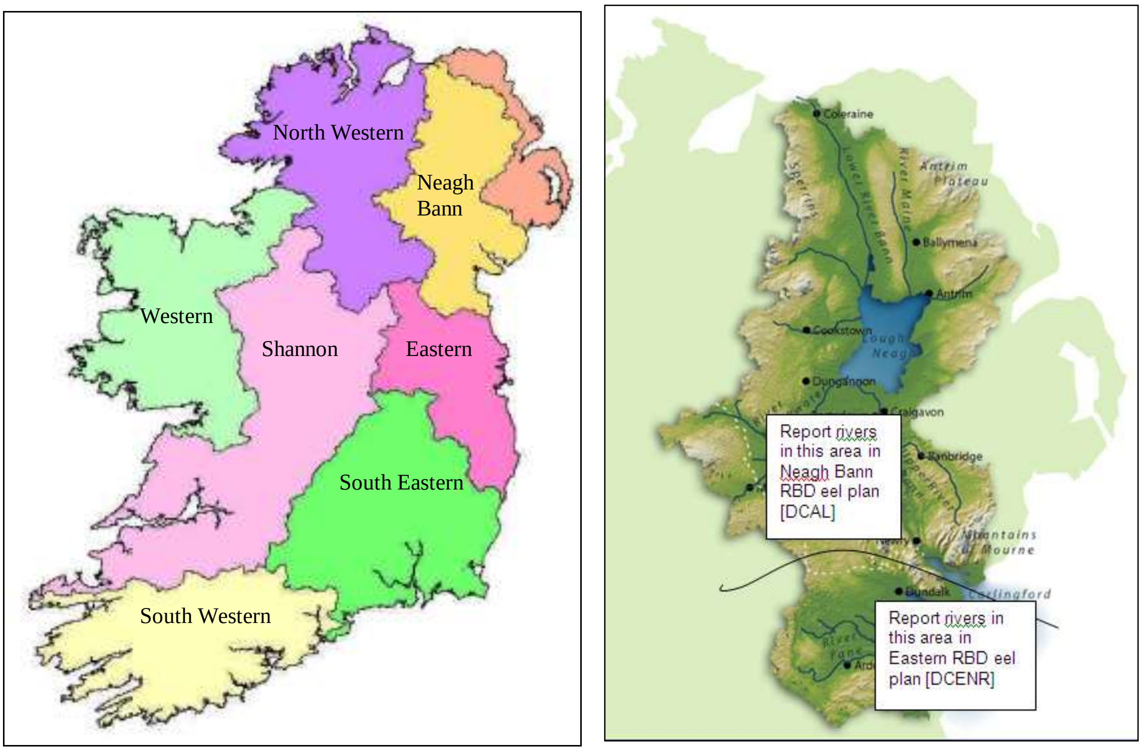


Figure 1-1: Map (left) showing the River Basin Districts and the map (right) showing the transboundary agreement between the Neagh/Bann RBD and the Eastern RBD.

1.4 Monitoring 2015-2017

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), the Boyne (IE_East) and the Barrow (IE_SouE). The Fane was included as an index site in this round (2015-2017) of reporting but the time series were too new and unverified for the Barrow and the Boyne to be included in the 2015-2017 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. This evaluation is fully described in the Stock Annex (Annex 1).

1.5 Status of the Irish Stocks 2015-2017

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

Between 2015 and 2017, recruitment was reasonable, with good catches in the Erne in 2015 and 2016, and in the Shannon, Feale and Maigue in 2016. However, in all stations there was a drop in 2017.

The average recruitment for the 2009-2011 period was at about 6% of historical and this increased to about 20% for the 2012-2014 period and 18% in the 2015-2017 period (largely due to large catches in the Erne in 2017) (Annex 1: Table 3.1; Fig. 3.1).

Recruitment of young yellow eels ("bootlace") recorded in Parteen on the Shannon was, in the 2000-2008, at 75% of its pre-1995 average. This fell to 17% from 2009-2014 and rose to 55% in the 2015-2017 period, due to a large recruitment in 2016 of 890kg (Annex 1: Table 3.1; Fig. 3.1).

In summary, recruitment has generally remained low over the 2009-2017 period, although considerable improvements were seen in the 2012 to 2014 years and also in 2016 in the Shannon and 2015 and 2016 in the Erne. There was a general drop in 2017 in most rivers.

1.5.2 Yellow Eel Monitoring

During the last three year cycle (2015-2017) of fieldwork seven lakes were repeatedly sampled for yellow eels; Lough Corrib Upper and Lower, Lough Conn, Cullin, Muckno, Ramor, Oughter, Ballynahinch, Inchiquin, Lough Feeagh and Bunaveela.

A multi-year year netting survey was carried out in the Waterford Harbour, Munster Blackwater Estuary and Lough Furnace to investigate the eel population of transitional waters. Locations are listed in Annex 1: Table 3.2 and Figure 3.2.

A semi quantitative electrofishing survey was undertaken in the Bride catchment of the Munster Blackwater and 5 subcatchments of the River Barrow in order to determine the extent of eel distribution in the rivers of our Index catchments.

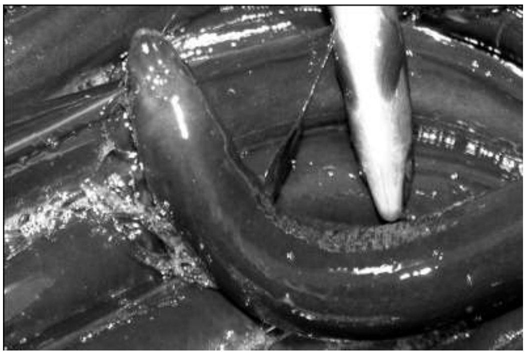
For the yellow eel surveys, the Corrib Upper survey had the largest catch per unit of effort for the two years (8.28 and 5.39). The smallest cpue recorded was Lough Bunaveela with 0.1-0.3 and Lough Furnace with a cpue of 0.3.

Lough Ramor in 2016 had the largest average length of 54.2 and Corrib upper had the largest average weight of yellow eels with 0.286kg. As expected the transitional waters had a lower average length and weight compared with the lake surveys with 35.7cm average length in the Munster Blackwater estuary and 38cm in Waterford. The surveys of the transitional waters in conjunction with the lake surveys highlight the importance of the estuaries as habitat for smaller eels.

Electrofishing data from 5 catchments fished between 2015 and 2017 have highlighted the importance of habitat in the distribution of eels within catchments. The absence and low density of eels within the rivers and streams have drawn attention to the error in assuming eels are everywhere and inhabit all wetted area. This will have knock on effects on attempts to model eel production and escapement from non-surveyed catchments. The importance of habitat and quantifying habitat needs to be addressed in the future.

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 the Boyne in 2017. The Fane was used as an index location in the 2015-2017 assessment and it is hoped in the future to include the Barrow and the Boyne as index locations in the future.



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 3.13). 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.

However, a different picture emerged in the last three years with a general reduction in production, especially in 2016 and 2017.

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. Production fell to 0.91 and 0.80 kg/ha in 2016 and 2017 respectively.

The Erne production 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 Erne production dropped a little in 2016 but rose again in 2017 from 2.4 to 2.7 kg/ha.

The Burrishoole production increased from 0.96kg/ha in 2009-2011 to 1.19kg/ha in 2012-2014 with a peak of 1.22kg/ha in 2014. However, a poor run occurred in 2015 with only 0.44 kg/ha being recorded and another poor run of relatively small eels was recorded in 2017 with 0.8 kg/ha production.

The Fane production over the period 2011 to 2017 ranged from 0.4 kg/ha (2016) to 6.5 kg/ha (2013).

The plots (Annex 1: Figs. 3.17, 3.30 & 3.34) and Annex 1: Table 3.13 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 (the mortality equivalent of the EU biomass target) of 0.92.

The escapement biomass in the Shannon increased 2012 and 2013, was 33% of B_o in 2014 and was considerably lower in 2016 and 2017 (17.4% and 16,5%).

The escapement biomass in the Erne also increased until 2015 (66.7%), and was lower, but still above the EU target in 2016 and 2017.

The escapement in Burrishoole fell considerably in the 2015-2017 period to 46% in 2015 and 89% in 2017.

The escapement in the Fane ranged from 139% in 2013 to 9.2% in 2016.

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

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 <u>currently</u> 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 <u>current</u> stock.
ΣF	The fishing mortality <u>rate</u>, summed over the age-groups in the stock, and the reduction effected.
ΣH	The anthropogenic mortality <u>rate</u> 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 - Freshwaters

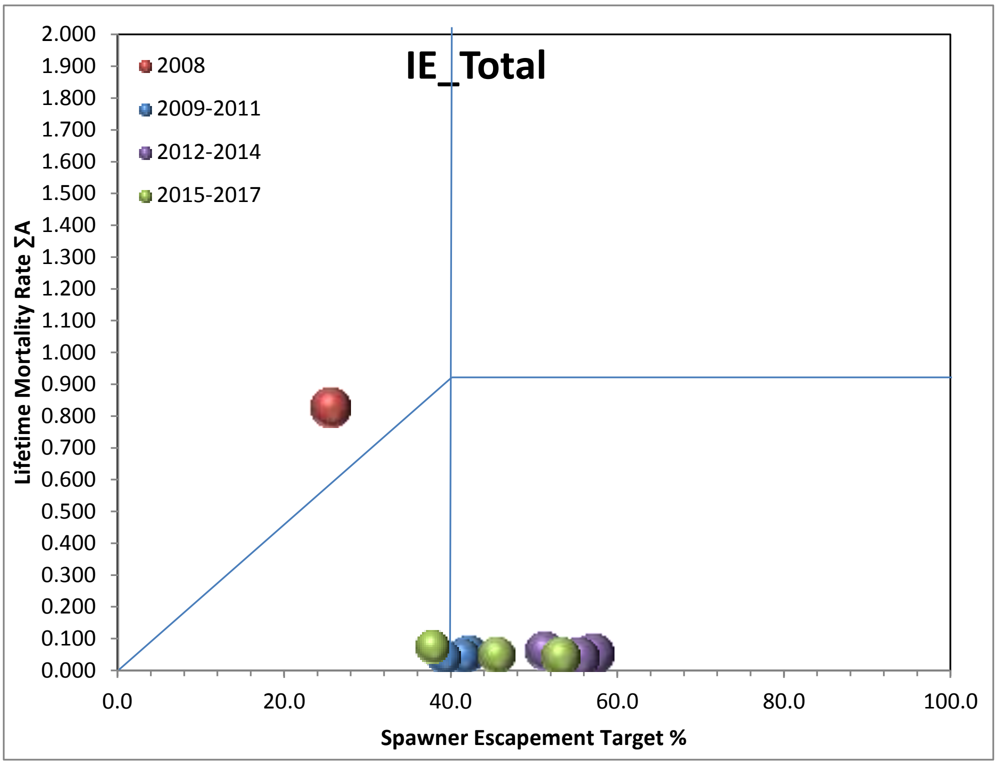
In this report, the Irish eel stock in inland waters has been quantified and time trends presented. In this chapter, the state of the stock will be compared with the targets. The precautionary diagram introduced in Annex 1: Section 2.6 will be used, in a modified version using the EU management target (40% SSB) as the reference point and a calculated mortality reference point based on the EU management target (Alim 0.92). 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, 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 diagram below (Figure 1.2) plots the most recent stock assessments for freshwaters (2009-2011, 2012-2014 and 2015-2017), along with those data presented in the EMP (2008).

For the assessment of the 2015 to 2017 period, the IMESE model was run as in the previous year's using the Shannon (2016-2017), the Erne (2015-2017) and the Burrishoole (2015-2017) as index catchments. The model was also run including a new Index catchment, the Fane, which is situated on the East coast (IE_East). This addresses a previously identified criticism that all the indexes were on the west coast. However, the inclusion of the Fane changes the model outputs. For consistency, outputs from IMESE are presented with, and without, the new index and the mid-point between the two values is reported for 2015-2017 (Tables 1.1 & 1.2). The trends of the two model outputs are similar, but it is not known whether the extrapolation to the data poor catchments should be made at the higher or lower level. Also the volatile nature of silver eel migrations due to floods (2015) and droughts (2016) has made the interpretation of IMESE difficult.

In the IE_East, the IE_Shan, IE_West and IE_NorW, mortality was clearly reduced in 2009 (Table 1.5) and as indicated by the downward direction of the bubbles (Annex 1: Figure 4.4) and this led to increased escapement up to 2014 as shown by right hand horizontal movement towards the 40% target. In some cases anticipated increases in spawner escapement did not always materialise. This may be due to some yellow eel still to feed through increasing the %SSB and moving the bubbles to the right in coming years. 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.

There is some anecdotal evidence to suggest that previous yellow eel exploitation may have been underestimated. It is possible that the historical production without anthropogenic mortality (Bo) may therefore be too low. The estimates for undeclared or illegal catches included in the historical model were set at 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 a marked reduction in fishing and hydropower mortality. While further reduction in mortality is unlikely, it is 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. Low production was noted in some catchments in the last three years, especially for the Shannon and Burrishoole.



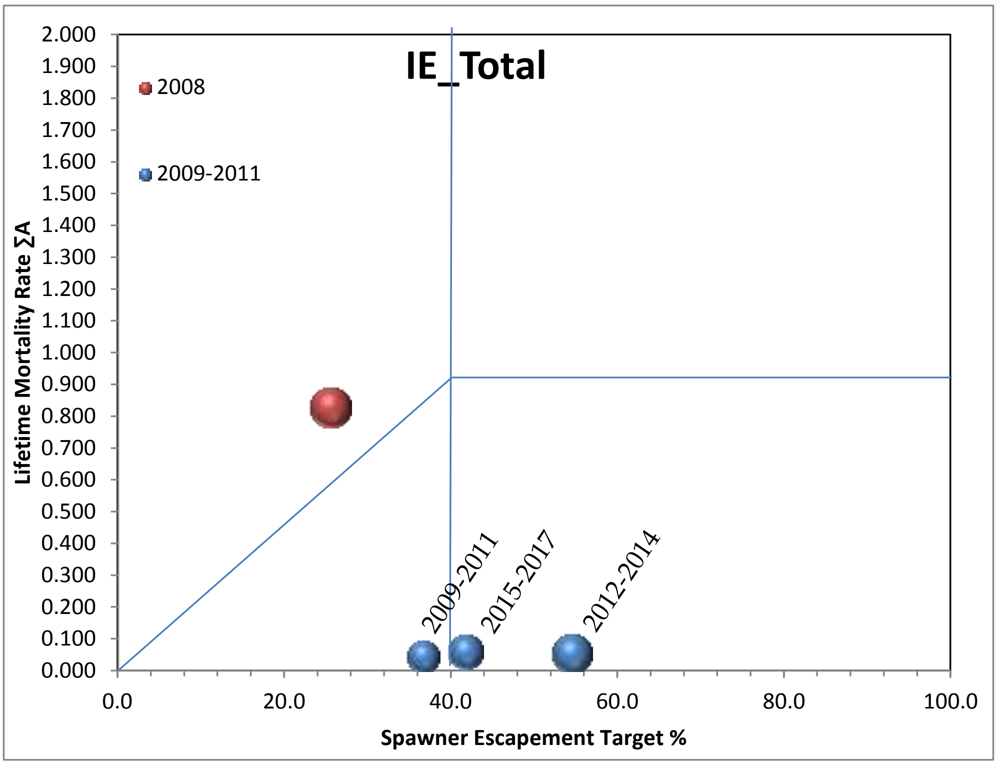


Figure 1-2: Status of the stock and the anthropogenic impacts, for the TOTAL of the EMUs as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008-2017 (top), and for the average of 2001-2007, 2009-2011, 2012-2014 and 2015-2017 (bottom). *These graphs represent the mid-point between the model outputs for 2015-2017.* **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.**

1.6.3 Biomass and Mortality Overview – Transitional waters

No assessments were made of the stock indicators for coastal waters. A preliminary assessment was made in 2018 of possible eel production from transitional waters, not previously reported on, using a combination of field CPUE data, physical characterisation of types of transitional waters and annual eel production rates from freshwater (See Annex 1: Ch.4.3).

Transitional Waters have not been directly assessed and it is not known what the rates of silver eel production are from the yellow eel stocks inhabiting these waters. For the 2018 EU Report, silver eel production from transitional waters has been estimated by categorising each transitional waterbody into one of two medium to high or one of four medium to low eel habitats, based on physical characteristics, and yellow eel CPUE from WFD and other eel fyke net surveys. These categories were then applied to the IMESE production rates (maximum and minimum) for each year and retrospectively for Bo. These estimates are given in the 2018 report (see 2015 stock Annex for the classification analysis and the 2018 Stock Annex for the estimated production) and these should be treated with caution.

Current production of silver eels in transitional waters was estimated at 159,812kg for 2008 and 126,952kg in 2017. Fishing mortality can't be accurately assessed as before the closure catches were reported along with the freshwater catch. Fishing mortality has been zero since 2009. Tables 1.3 & 1.4 give the Bo, Bbest and Bcurrent for the Transitional Waters. Current escapement was on average for 2015-2017 estimated at 50% of Bo.

The coastal waters of Ireland were not been assessed in 2012, 2015 or 2017. It is thought that eel production in coastal waters is low.

1.6.4 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} 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 1.5 presents the mortality data calculated using biomass ($-\ln(B_{current}/B_{best})$). In Figures 1.2, 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 the greatest 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 after the implementation of the EMPs.

Total mortality for Ireland (sum of fisheries, hydropower and other anthropogenic mortality) 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.

NOTE: In the past, fisheries landings were reported under the inland fisheries legislation and catches were not clearly separated for freshwaters and transitional waters. Ireland has reported Fishing Mortality and Hydropower Mortality rates based on its assessment of freshwaters and not including transitional waters.

1.6.5 Summary of individual RBD targets

No direct 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. Eel production was indirectly estimated using a combination of IMESE derived production rates, physical characteristics of transitional waters and fyke net CPUE catches of eels.

With the exception of the IE_Shan (ShIRBD) all other EMUs were above the EU target in 2015-2017. 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.

The Fane (IE_East) was included in the 2015-2017 analysis as a calibrating site. This is described in Annex 1: Chapters 3.3.5.3 and 4.2.5. In Annex 1: chapter 4, the original time series of Bbest production using only the Shannon, Erne and Burrishoole calibrating indices is presented along with the outcome of running the model including the Fane as a fourth index river. This addresses a previously identified criticism that all the indexes were on the west coast. However, the inclusion of the Fane changes the model outputs. For consistency, outputs from IMESE are presented with, and without, the new index and the mid-point between the two values is reported for 2015-2017. It is not known whether the inclusion of the new index site reflects the true situation as each catchment has its own eel stock characteristics and production levels. The trends are similar, and the volatile nature of silver eel migrations due to floods (2015) and droughts (2016) has also made the interpretation of IMESE difficult.

In the previous reports (Anon, 2012b, 2015), silver eel production from transitional waters was not estimated. In this report, silver eel production from transitional waters has been estimated for 2015-2017 by categorising each waterbody into one of two medium to high or one of four medium to low eel habitats, based on physical characteristics, and yellow eel CPUE from WFD and other eel fyke net surveys. These categories were then applied to the IMESE freshwater production rates (maximum and minimum) for each year and retrospectively for Bo. We report these estimates in the 2018 report and these should be treated with caution.

The total escapement relative to the pristine Bo for <u>all</u> EMUs for 2009-2011 was 36.7%. This increased to 54.5% average for 2012-2014 period but fell to 41.5% in 2015-2017. The Index Rivers also indicated a fall in escapement in all catchments, least so in the Erne.

Three of the EMUs (IE_East, IE_SouE, IE_SouW) have relatively modest production compared to the other three, so care should be taken in interpreting the % target data presented in Table 1.2. Escapement was relatively high in 2015 and 2017 and was lower in 2016. However, on average for the last three year period, production and escapement was lower in all EMUs than reported for the 2012-2014 period.

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.

Table 1-1: Pristine (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. Data for 2015-2017 are the mid-point values for the two model outputs. These data are extracted from the electronic tables.

EMU Code	Bo Prod	Production (Bbest)										Av 2009-2011	Av 2012-2014	Av 2015-2017
	kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
IE_East	20,517	16,768	14,755	10,865	9,928	13,936	15,079	14,756	13,903	9,265	13,984	10,484	14,592	11,715
IE_NorW	135,732	102,502	57,295	52,447	52,956	82,099	89,376	87,747	91,884	73,724	82,592	52,883	86,286	81,941
IE_Shan	201,401	95,979	83,464	75,608	71,669	76,507	89,250	80,151	78,969	45,048	42,348	76,073	81,855	43,526
IE_SouE	14,836	11,229	9,877	7,271	6,645	9,333	10,098	9,878	8,966	7,011	8,927	7,018	9,774	7,783
IE_SouW	24,577	15,914	13,975	10,274	9,395	13,230	14,312	13,978	12,692	9,951	12,629	9,932	13,864	11,032
IE_West	192,377	101,892	83,128	98,543	90,029	126,447	136,795	133,872	121,191	95,037	120,854	69,545	132,404	105,349
	589,440	344,285	262,494	255,010	240,623	321,553	354,910	340,382	327,605	240,036	281,334	225,936	338,776	261,346

EMU Code	Bo Prod	Escapement (Bcurrent)										Av 2009-2011	Av 2012-2014	Av 2015-2017
	kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
IE_East	20,517	9,557	14,561	10,722	9,798	13,753	14,881	14,562	13,728	9,127	13,809	10,346	14,401	11,559
IE_NorW	135,732	47,787	47,554	49,348	50,515	71,817	80,494	81,817	85,435	62,180	72,259	50,035	77,921	72,534
IE_Shan	201,401	21,636	79,369	67,398	63,996	67,412	80,055	72,213	71,224	39,360	39,400	69,414	73,112	38,066
IE_SouE	14,836	9,867	9,877	7,271	6,645	9,333	10,098	9,878	8,967	7,011	8,927	7,018	9,774	7,783
IE_SouW	24,577	15,379	13,576	10,067	9,389	12,910	14,189	13,807	12,505	9,659	12,451	9,767	13,659	10,835
IE_West	192,377	46,546	83,128	98,543	90,029	126,447	136,795	133,872	121,191	95,037	120,854	69,545	132,405	105,350
	589,440	150,771	248,064	243,350	230,372	301,673	336,512	326,149	313,049	222,373	267,699	216,126	321,272	246,126

Table 1-2: The freshwater % Bcurrent/Bo (%EU target) for each EMU and for the total production (calculated with and without the Fane) and the mid-point in the data, for 2015-2017 and average production and escapement for 2015-2017. The data come from Table 1.1. These data are extracted from the electronic tables.

EMU Code	EMU Name	Bo Prod	%Bcurrent/Bo (EU Target)										Av 2009-2011	Av 2012-2014	Av 2015-2017
		kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
IE_East	EEMU	20517	46.6	71.0	52.3	47.8	67.0	72.5	71.0	66.9	44.5	67.3	50.4	70.2	56.3
IE_NorW	NWIRBD	135732	35.2	35.0	36.4	37.2	52.9	59.3	60.3	62.9	45.8	53.2	36.9	57.4	53.4
IE_Shan	SHIRBD	201401	10.7	39.4	33.5	31.8	33.5	39.7	35.9	35.4	19.5	19.6	34.5	36.3	18.9
IE_SouE	SERBD	14836	66.5	66.6	49.0	44.8	62.9	68.1	66.6	60.4	47.3	60.2	47.3	65.9	52.5
IE_SouW	SWRBD	24577	62.6	55.2	41.0	38.2	52.5	57.7	56.2	50.9	39.3	50.7	39.7	55.6	44.1
IE_West	WRBD	192377	24.2	43.2	51.2	46.8	65.7	71.1	69.6	63.0	49.4	62.8	36.2	68.8	54.8
	Total	589,440	25.6	42.1	41.3	39.1	51.2	57.1	55.3	53.1	37.7	45.4	36.7	54.5	41.8

Table 1-3: Transitional Water historic (Bo) and current silver eel production (Bbest) (kg) and escapement (Bcurrent) (kg) for 2008-2017 calculated using the IMESE model mid-point outputs (maximum and minimum production rates).

EMU Code	EMU Name	Bo Prod kg	Production (Bbest)									
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
IE_East	EEMU	14,263	4,055	3,545	2,597	2,379	3,373	3,648	3,547	3,223	2,546	3,202
IE_NorW	NWIRBD	35,558	26,513	23,320	17,168	15,690	22,035	23,841	23,323	21,171	16,552	21,078
IE_Shan	SHIRBD	83,443	60,510	53,211	39,165	35,795	50,294	54,415	53,219	48,309	37,786	48,093
IE_SouE	SERBD	38,488	29,505	25,961	19,117	17,469	24,521	26,532	25,964	23,566	18,415	23,465
IE_SouW	SWRBD	41,594	16,506	14,469	10,621	9,719	13,726	14,847	14,474	13,146	10,339	13,072
IE_West	WRBD	38,105	22,723	19,964	14,683	13,424	18,889	20,436	19,968	18,128	14,202	18,042
	Total	251,450	159,812	140,471	103,352	94,475	132,838	143,718	140,495	127,542	99,840	126,952

EMU Code	EMU Name	Bo Prod kg	Escapement (Bcurrent)									
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
IE_East	EEMU	14,263		3,545	2,597	2,379	3,373	3,648	3,547	3,223	2,546	3,202
IE_NorW	NWIRBD	35,558		23,320	17,168	15,690	22,035	23,841	23,323	21,171	16,552	21,078
IE_Shan	SHIRBD	83,443		53,211	39,165	35,795	50,294	54,415	53,219	48,309	37,786	48,093
IE_SouE	SERBD	38,488		25,961	19,117	17,469	24,521	26,532	25,964	23,566	18,415	23,465
IE_SouW	SWRBD	41,594		14,469	10,621	9,719	13,726	14,847	14,474	13,146	10,339	13,072
IE_West	WRBD	38,105		19,964	14,683	13,424	18,889	20,436	19,968	18,128	14,202	18,042
	Total	251,450	-	140,471	103,352	94,475	132,838	143,718	140,495	127,542	99,840	126,952

Table 1-4: The transitional water % Bcurrent/Bo (%EU target) for each EMU and for the total production (calculated using the mid-point production 2015-2017), for 2009-2017. The data come from Table 1.3.

EMU Code	EMU Name	Bo Prod	%Bcurrent/Bo (EU Target)									
		kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
IE_East	EEMU	14,263	-	24.9	18.2	16.7	23.6	25.6	24.9	22.6	17.8	22.5
IE_NorW	NWIRBD	35,558	-	65.6	48.3	44.1	62.0	67.0	65.6	59.5	46.5	59.3
IE_Shan	SHIRBD	83,443	-	63.8	46.9	42.9	60.3	65.2	63.8	57.9	45.3	57.6
IE_SouE	SERBD	38,488	-	67.5	49.7	45.4	63.7	68.9	67.5	61.2	47.8	61.0
IE_SouW	SWRBD	41,594	-	34.8	25.5	23.4	33.0	35.7	34.8	31.6	24.9	31.4
IE_West	WRBD	38,105	-	52.4	38.5	35.2	49.6	53.6	52.4	47.6	37.3	47.3
	Total	251,450	-	55.9	41.1	37.6	52.8	57.2	55.9	50.7	39.7	50.5

Table 1-5: Annual fishing (kg & ∑F), other anthropogenic (kg & ∑H) and total mortality (kg & ∑A) rates for each Eel Management Unit and the total annual mortality rates for all EMUs. Bbest and Bcurrent 2015-2017 are based on the mid-point between the two modelled outputs for freshwater.

Year	EMU	F'water Bbest	F'water Bcurrent	Biomass F	Biomass H	Biomass Other	Biomass A	Rate F	Rate H	Rate Other	Rate A
2008	EEMU	16768	9590	6991	187	0	7178	0.539	0.019	0.000	0.559
2009	EEMU	14755	14561	0	194	0	194	0.000	0.013	0.000	0.013
2010	EEMU	10865	10722	0	143	0	143	0.000	0.013	0.000	0.013
2011	EEMU	9928	9798	0	131	0	131	0.000	0.013	0.000	0.013
2012	EEMU	13936	13753	0	183	0	183	0.000	0.013	0.000	0.013
2013	EEMU	15079	14881	0	198	0	198	0.000	0.013	0.000	0.013
2014	EEMU	14756	14562	0	194	0	194	0.000	0.013	0.000	0.013
2015	EEMU	13,903	13727	0	176	0	176	0.000	0.013	0.000	0.013
2016	EEMU	9,265	9127	0	138	0	138	0.000	0.015	0.000	0.015
2017	EEMU	13,984	13809	0	176	0	176	0.000	0.013	0.000	0.013
2008	NWIRBD	102502	47466	45349	9687	0	55036	0.584	0.186	0.000	0.770
2009	NWIRBD	57295	47554	0	9741	0	9741	0.000	0.186	0.000	0.186
2010	NWIRBD	52447	49348	0	3099	0	3099	0.000	0.061	0.000	0.061
2011	NWIRBD	52956	50514	0	2442	0	2442	0.000	0.047	0.000	0.047
2012	NWIRBD	82099	71817	0	10282	0	10282	0.000	0.134	0.000	0.134
2013	NWIRBD	89376	80494	0	8450	432	8882	0.000	0.099	0.005	0.105
2014	NWIRBD	87747	81817	0	5930	0	5930	0.000	0.070	0.000	0.070
2015	NWIRBD	91,884	85435	0	6449	0	6449	0.000	0.073	0.000	0.073
2016	NWIRBD	73,724	62179	0	11545	0	11545	0.000	0.170	0.000	0.170
2017	NWIRBD	82,592	72258	0	10334	0	10334	0.000	0.134	0.000	0.134
2008	ShIRBD	95979	21801	68209	5969	0	74178	1.240	0.242	0.000	1.482
2009	ShIRBD	83464	79369	0	4095	0	4095	0.000	0.050	0.000	0.050
2010	ShIRBD	75608	67398	0	8210	0	8210	0.000	0.115	0.000	0.115
2011	ShIRBD	71669	63996	0	7673	0	7673	0.000	0.113	0.000	0.113
2012	ShIRBD	76507	67412	0	9095	0	9095	0.000	0.127	0.000	0.127
2013	ShIRBD	89250	80055	0	9195	0	9195	0.000	0.109	0.000	0.109
2014	ShIRBD	80151	72213	0	7595	343	7938	0.000	0.100	0.005	0.104
2015	ShIRBD	78,969	71224	0	7745	0	7745	0.000	0.103	0.000	0.103
2016	ShIRBD	45,048	39360	0	5688	0	5688	0.000	0.135	0.000	0.135
2017	ShIRBD	42,348	39400	0	2948	0	2948	0.000	0.072	0.000	0.072
2008	SERBD	11229	9867	1362	0	0	1362	0.129	0.000	0.000	0.129
2009	SERBD	9877	9877	0	0	0	0	0.000	0.000	0.000	0.000
2010	SERBD	7271	7271	0	0	0	0	0.000	0.000	0.000	0.000
2011	SERBD	6645	6645	0	0	0	0	0.000	0.000	0.000	0.000
2012	SERBD	9333	9333	0	0	0	0	0.000	0.000	0.000	0.000
2013	SERBD	10098	10098	0	0	0	0	0.000	0.000	0.000	0.000
2014	SERBD	9878	9878	0	0	0	0	0.000	0.000	0.000	0.000
2015	SERBD	8,966	8966	0	0	0	0	0.000	0.000	0.000	0.000
2016	SERBD	7,011	7011	0	0	0	0	0.000	0.000	0.000	0.000

Table 1.5 continued:

Year	EMU	F'water Bbest	F'water Bcurrent	Biomass F	Biomass H	Biomass Other	Biomass A	Rate F	Rate H	Rate Other	Rate A
2017	SERBD	8,927	8927	0	0	0	0	0.000	0.000	0.000	0.000
2008	SWRBD	15914	15082	89	743	0	832	0.006	0.048	0.000	0.054
2009	SWRBD	13975	13576	0	399	0	399	0.000	0.029	0.000	0.029
2010	SWRBD	10274	10066	0	208	0	208	0.000	0.020	0.000	0.020
2011	SWRBD	9395	9389	0	6	0	6	0.000	0.001	0.000	0.001
2012	SWRBD	13230	12910	0	320	0	320	0.000	0.024	0.000	0.024
2013	SWRBD	14312	14189	0	123	0	123	0.000	0.009	0.000	0.009
2014	SWRBD	13978	13807	0	171	0	171	0.000	0.012	0.000	0.012
2015	SWRBD	12,692	12505	0	187	0	187	0.000	0.015	0.000	0.015
2016	SWRBD	9,951	9659	0	292	0	292	0.000	0.030	0.000	0.030
2017	SWRBD	12,629	12450	0	179	0	179	0.000	0.014	0.000	0.014
2008	WRBD	101892	46546	55346	0	0	55346	0.783	0.000	0.000	0.783
2009	WRBD	83128	83128	0	0	0	0	0.000	0.000	0.000	0.000
2010	WRBD	98543	98543	0	0	0	0	0.000	0.000	0.000	0.000
2011	WRBD	90029	90029	0	0	0	0	0.000	0.000	0.000	0.000
2012	WRBD	126447	126447	0	0	0	0	0.000	0.000	0.000	0.000
2013	WRBD	136795	136795	0	0	0	0	0.000	0.000	0.000	0.000
2014	WRBD	133872	133872	0	0	0	0	0.000	0.000	0.000	0.000
2015	WRBD	121,191	121191	0	0	0	0	0.000	0.000	0.000	0.000
2016	WRBD	95,037	95037	0	0	0	0	0.000	0.000	0.000	0.000
2017	WRBD	120,854	120854	0	0	0	0	0.000	0.000	0.000	0.000
2008	Total	344285	150353	177346	16586	0	193932	0.724	0.105	0.000	0.828
2009	Total	262494	248065	0	14429	0	14429	0.000	0.057	0.000	0.057
2010	Total	255010	243350	0	11660	0	11660	0.000	0.047	0.000	0.047
2011	Total	240623	230371	0	10252	0	10252	0.000	0.044	0.000	0.044
2012	Total	321553	301672	0	19880	0	19880	0.000	0.064	0.000	0.064
2013	Total	354911	336513	0	17966	432	18398	0.000	0.052	0.001	0.053
2014	Total	340382	326149	0	13890	343	14233	0.000	0.042	0.001	0.043
2015	Total	327605	313048	0	14557	0	14557	0.000	0.045	0.000	0.045
2016	Total	240036	222373	0	17663	0	17663	0.000	0.076	0.000	0.076
2017	Total	281334	267698	0	13636	0	13636	0.000	0.050	0.000	0.050

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 from 2009 to 2014. Preliminary analysis indicated that it would be unwise to extrapolate directly from freshwater into the transitional zone. In 2018, a modification of the extrapolation method, calibrated by field data from WFD fyke net surveys, was used to estimate silver eel production in transitional waters and this was applied retrospectively to all years.

While **recruitment** remains low, considerable improvements were seen in the 2012 to 2014 years and also in 2016 in the Shannon and 2015 and 2016 in the Erne. There was a general drop in 2017 in most rivers, a pattern common across Europe.

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 large eels, along with a drop in CPUE, 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 a decrease in silver eel production (Bbest) in the 2015-2017 period compared to the previous three years. Floods in 2015 and a drought in 2016 made interpretation of the results difficult.

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. Production fell to 0.91 and 0.80 kg/ha in 2016 and 2017 respectively.

The Erne production 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 Erne production dropped a little in 2016 but rose again in 2017 from 2.4 to 2.7 kg/ha.

The Burrishoole production increased from 0.96kg/ha in 2009-2011 to 1.19kg/ha in 2012-2014 with a peak of 1.22kg/ha in 2014. However, a poor run occurred in 2015 with only 0.44 kg/ha being recorded and another poor run of relatively small eels was recorded in 2017 with 0.8 kg/ha production.

The Fane production over the period 2011 to 2017 ranged from 0.4 kg/ha (2016) to 6.5 kg/ha (2013).

National Silver Eel Production, Escapement and Mortality: Current escapement is expressed as a percentage of the historical 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). With the exception of the IE_Shan (ShIRBD) all other EMUs were above the EU target in 2015-2017. It is anticipated that escapement may fall in future years in some or all of the EMUs 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.

The Fane (IE_East) was included in the 2015-2017 analysis as a calibrating site. This is described in Annex 1: Chapters 3.3.5.3 and 4.2.5. In Annex 1: chapter 4, the original time series of Bbest production using only the Shannon, Erne and Burrishoole calibrating indices is presented along with the outcome of running the model including the Fane as a fourth index river. This addresses a previously identified criticism that all the indexes were on the west coast. However, the inclusion of the Fane changes the model outputs. For consistency, outputs from IMESE are presented with, and without, the new index and the mid-point between the two values is reported for 2015-2017. It is not known whether the inclusion of the new index site reflects the true situation. The trends of the two model outputs are similar, but it is not known whether the extrapolation to the data poor catchments should be made at the higher or lower level. Also the volatile nature of silver eel migrations due to floods (2015) and droughts (2016) has made the interpretation of IMESE difficult.

The total escapement relative to the pristine Bo for all EMUs for 2009-2011 was 36.7%. This increased to 54.5% average for 2012-2014 period but fell to 41.5% in 2015-2017. The Index Rivers also indicated a fall in escapement in all catchments, least so in the Erne.

Three of the EMUs (IE_East, IE_SouE, IE_SouW) have relatively modest production compared to the other three, so care should be taken in interpreting the % target data presented in Table 1.2. Escapement was relatively high in 2015 and 2017 and was lower in 2016. However, on average for the last three year period, production and escapement was lower in all EMUs than reported for the 2012-2014 period.

Current production of silver eels in transitional waters was estimated at 159,812kg for 2008 and 126,952kg in 2017. Fishing mortality can't be accurately assessed before the closure as catches were reported along with the freshwater catch. Fishing mortality has been zero since 2009. Current escapement was on average for 2015-2017 estimated at 50% of Bo.

The coastal waters of Ireland were not been assessed in 2012, 2015 or 2017. It is thought that eel production in coastal waters is low.

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.

Bye-law 312 of 2012 was renewed in 2015 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. 319, 2015** prohibits fishing for eel, or possessing, purchasing or selling eel caught in a Fishery District in the State until 30 June 2018.

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 2017 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 2017. 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 (following closure of the commercial eel fishery) to 2014. Over the past three years (2015-2017) there has been evidence of modest levels of illegal activity particularly in the mid to lower River Shannon as confirmed by periodic detection and seizure of illegal fyke nets and long lines in these fisheries (Table 2.1). There have also been sporadic, but generally low, levels of incidences of illegal fishing for eel or seizures of eel fishing gear from the NWRBD (Upper R. Erne) and WRBD, with the remaining RBDs recording low or very low levels of illegal eel activity over the period.

Table 2-1: Summary of illegal eel fishing activity recorded and eel dealer movements encountered by IFI regions and Loughs Agency from 2012-2017.

	Year	ERBD	Loughs Agency	NWRBD	SHRBD	SERBD	SWRBD	WRBD
Est. level of Illegal fishing	**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	None	Low
	2015	Low	Low	None	Medium (Mid & Lwr Shannon)	None	None	None
	2016	Low	Low	None	Medium (Mid & Lwr Shannon)	None	None	Low
	2017	Low	Low	Low	Low	None	None	Low
Number of gear seizures	**2012**	3	0	1	5	0	0	1
	2013	0	0	4	6	0	0	2
	2014	0	2	3	12	0	0	0
	2015	0	0	0	19	0	0	0
	2016	(40 IFI survey fykes stolen- L. Ramor)	0	3	10	0	1	2
	2017	0	0	0	3	0	0	1
Gear types seized	**2012**	3 fykes	None	1 coghill	5 fykes	None	None	50 fykes (possibly lost)
	2013	None	None	12 fykes, 2 coghills	110 fykes, 800 m longlines	None	None	2 fykes
	2014	None	2 Angling rods	20 fykes	54 fykes, 2010 m longlines	None	None	1 fyke (probably lost)
	2015	None	None	None	68 fykes, 6 longlines, 1 coghill net	None	None	None
	2016	None	None	None	39 fykes, 22 longlines, 21 short lines	None	1 eel pot	8 fykes
	2017	None	None	13 fykes, 1 eel storage net & barrel	21 fykes	None	None	1 fyke
No. of dealer interceptions	**2012**	0	0	0	0	0	0	0
	2013	0	0	0	0	0	0	0
	2014	0	0	0	0	0	0	0
	2015	0	0	0	0	0	0	0
	2016	0	0	0	0	0	0	0
	2017	0	0	0	0	0	0	0

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 deeply ingested hooks) it is likely that a percentage of these 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.

The Department of Communications, Climate Action and Environment (DCCAE) tasked Inland Fisheries Ireland with setting up a network of scientific eel fisheries in collaboration with the former eel fishermen. A number of key locations were earmarked for surveys and a tender process was initiated with applications from interested parties. In 2016 and 2017 a series of yellow eel surveys were carried out in 5 locations (Upper and Lower Lough Corrib, Lough Conn, Lough Ramor and Lough Muckno) and 2 transitional waters (Waterford Harbour and Munster Blackwater). The programme also consists of an elver monitoring survey and a silver eel fishery on the River Boyne and a glass eel survey of the Shannon Estuary. The purpose of the scientific fisheries is to increase the data and knowledge of eel in Ireland ahead of the 2018 EU review of Ireland's National Eel Management Plan (EMP).

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, continued in the Shannon (IE_Shan), Erne (IE_NorW) and Lee (IE_SouW).

In both the Shannon and Erne catchments, anthropogenic mortality during 2015-2017 was kept as low as possible by closing the commercial eel fishery and transporting silver eels around the HPSs, and this is evident by examining the biomass data (see Table 1.1 & 1.5 and Annex 1).

In the EMP, the objective set by the National Working Group 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 DCCAE, DAERA and ESB, with the 30% of the production in the Shannon and 50% of the production in the Erne for 2015, 2016 & 2017 (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 – 2017 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 2017

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
2015	not defined	30
2016	not defined	30
2017	not defined	30

Erne: Trap and transport (50% of the annual escapement since 2012)

	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
2015	not defined	50
2016	not defined	50
2017	not defined	50

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
2015	0.5	not defined
2016	0.5	not defined
2017	0.5	not defined

The total amounts of silver eel trapped and transported in each of the three rivers from 2009 to 2017 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.

In the River 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.

Silver eel capture efficiency at Killaloe eel weir has been significantly improved by a major refurbishment of the fishery structures, including replacement of older manually operated net lifting equipment with new electrical lifting systems. Nets are now lifted individually, rapidly emptied and set again during nights on which multiple lifts are required. Weir maintenance and monitoring protocols have also been improved with a view to reducing eel numbers and biomass proceeding to the Ardnacrusha dam. Research has been undertaken on this topic by NUIG with a view to improving the capture efficiency at key sites on the River Shannon and this will be continued.

In the River 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 2012-2017 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 2012 to 2017.

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 takes place by fyke net in July or August with an annual catch target of 0.5 t.

Table 2-3: Total amounts (t) of silver eel trapped and transported in the Shannon, Erne and Lee, 2009-2017, and the success relative to the target set in the EMPs. (Note change of target on the Erne in 2012).

Catchment	Year	T&T Target	Amount Transported (kg)	Relation to target	Status	3 year Running Average
R. Shannon	2009	30% of run	23,730	31%	Achieved	31%
R. Shannon	2010	30% of run	27,768	40%	Achieved	36%
R. Shannon	2011	30% of run	25,680	39%	Achieved	37%
R. Shannon	2012	30% of run	24,228	36%	Achieved	38%
R. Shannon	2013	30% of run	22,561	28%	Not achieved	34%
R. Shannon	2014	30% of run	26,438	37%	Achieved	34%
R. Shannon	2015	30% of run	19,957	28%	Flood estimate	31%
R. Shannon	2016	30% of run	16,711	43%	Achieved	36%
R. Shannon	2017	30% of run	16,737	49%	Achieved	40%
R. Erne	2009	22t	9,383	43%	Not achieved	
R. Erne	2010	34t	19,334	57%	Not achieved	47%
R. Erne	2011	39t	25,405	65%	Not achieved	59%
R. Erne	2012	50% of run	34,660	51%	Achieved	51%
R. Erne	2013	50% of run	39,319	54%	Achieved	53%
R. Erne	2014	50% of run	48,126	66%	Achieved	57%[1]
R. Erne	2015	50% of run	43,706	56%	Achieved	59%
R. Erne	2016	50% of run	38,264	61%	Achieved	61%
R. Erne	2017	50% of run	43,470	63%	Achieved	60%
R. Lee	2009	0.5t	79	16%	Not achieved	16%
R. Lee	2010	0.5t	278	56%	Not achieved	36%
R. Lee	2011	0.5t	731	146%	Achieved	73%
R. Lee	2012	0.5t	230	46%	Not achieved	83%
R. Lee	2013	0.5t	824	165%	Achieved	119%
R. Lee	2014	0.5t	670	134%	Achieved	115%
R. Lee	2015	0.5t	527	105%	Achieved	135%
R. Lee	2016	0.5t	44	9%	Not achieved	83%
R. Lee	2017	0.5t	542	108%	Achieved	74%

[1] The rolling average was calculated excluding 11,000kg set aside for elver mortality mitigation.

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 2.4a and b). No further direct assessments of turbine mortality were undertaken from 2015-2017.

Shannon

An overall average mortality of 21.15 $\pm$ 8% has been used for silver eel arriving at Ardnacrusha HPS since 2012 (based on previous acoustic tracking studies of 104 tagged silver eel from 2009-2011). The estimated mortality of silver eels at Ardnacrusha power station was estimated to be 4,666kg in 2015/2016, 3,062 kg in 2016/2017 and 2,948kg in 2017/2018.

Erne

For the 2015 to 2017 seasons the silver eel turbine-related mortality rates that were applied to the Erne were as follows: Cliff HPS 0% (no flow or only spillage); 7.9% (Generation plus spillage) and 26.7% (Generation only, no spillage), Cathaleen's Fall HPS: 0% (no flow or only spillage); 7.7% (spillage plus half generation load); 15.4% spillage plus full generation load); 27.3% (generation only).

In 2015 reduced overall generation levels occurred during the silver eel migration season due to refurbishment of the turbines. This resulted in relatively high spillage levels and reduced overall turbine passage mortality levels. This was estimated to have represented a cumulative 8.1% mortality of the total River Erne silver eel production, or 27.2% of the migrating eel (not including the trapped and transported component) at the two dams during 2015. The estimated mortality for 2015/2016 season in the Erne system is 6,333kgs.

Estimated mortality at the dams was 11,494kg in 2016/'17 calculated using the cumulative mark/recapture method, or 8,204kg when calculated using four individual mark-recapture experiments (see chapter 5.4.2 for full explanation).

The estimated mortality at the dams was 10, 271kg in the 2017/2018 migration period. It was estimated that the cumulative mortality represented 14.9% mortality of the total River Erne silver eel production or 40.5% of the migrating eels reaching the dams during the season.

It should be noted that only an overall yearly mortality figure was presented by ESB/NUIG for each HP location with no breakdown of relative turbine mortality estimates for the different generating and spillage regimes at each HP station.

Table 2-4a Summary mortality data for acoustic telemetry on the R. Shannon (mortality and bypass)

	Year	Number 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	**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%
	2015	No direct assessment, 21.15% used in estimating escapement				56.5%
	2016	No direct assessment, 21.15% used in estimating escapement				8.5%
	2017	No direct assessment, 21.15% used in estimating escapement				19.9%

* Ardnacrusha HP station on the R. Shannon

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

		Number tagged eel	Mortality*	Number of tagged Eel	Mortality**	
		Cliff HPS		Cathaleen's Fall		
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****		
	2015		26.7%/7.9%/0% used***	0%/7.7%/15.4%/27.3% used****		
	2016		26.7%/7.9%/0% used***	0%/7.7%/15.4%/27.3% used****		
	2017		26.7%/7.9%/0% used***	0%/7.7%/15.4%/27.3% used****		

* Cliff HP station on the R. Erne

** Cathaleen's Fall HP station on the R. Er

*** Cliff HP station- Estimates applied with and without spillage, no direct assessment

**** Cathaleen's Fall HP station- Estimates applied with and without spillage, no direct assessment

2.3.3 Action 2c: Engineered Solutions

<u>Upstream migration</u>

Elver trapping facilities at both Cathaleen's Fall (R. Erne) and Ardnacrusha (R. Shannon) HP stations have been significantly upgraded by ESB following replacement of elver trap facilities and installation of elver bristle matting at both HP stations between 2014 and 2016 which has likely increased capture efficiency at both these long term recruitment index sites. New and increased flows of water have been added at the base of several traps to improve the attractiveness of the substrate ramp locations. New water aeration systems have also been added to all of the holding tanks which, together with greater frequency of checks and emptying of traps, has improved the survival and health of trapped elver and bootlace eel for upstream transport and stocking.

Figure 2-1: Upgraded elver trap facilities at Cathaleen's Fall HP station (R. Erne)

Figure 2-2: Upgraded elver trap facilities at Ardnacrusha HP station (R. Shannon)

Downstream migration

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.

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

2.3.4 Action 2d: Other Solutions

Silver eel deflection experiments were undertaken at Killaloe Weir on the River Shannon in 2015. No further information is available at this time.

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 2012-2017 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

Objective 7 of the National Eel Management Plan 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.

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

In recognition of the need for a national geo-referenced database of barriers of fish migration in rivers and streams IFI initiated a series of pilot studies in 2013 relating to barriers assessments. In 2017 IFI was tasked by the Department of Housing, Planning, Community and Local Government (DHPCLG), with accelerating this process as a management measure under the Water Framework Directive Second Cycle of actions and measures and to undertake a series of tasks at a national level.

These tasks include:

- Development of a barrier assessment tool consistent with current EU best practise
- Comprehensive programme of barrier survey and risk assessment in line with available resources
- Database storage of a national inventory of barriers for the purpose of interrogation and prioritising barriers for mitigation
- Prioritisation of structures for mitigation and a schedule of proposed works to be undertaken during the third cycle River basin Management Plan
- Production of guidance documents on structural mitigation options and permissions/surveys required for barrier mitigation

IFI established a National Barriers Programme to advance the above remit which will be progressed over the period 2018 – 2021.

Other programmes contributing to the Irish national database on barriers are:

- the IFI involvement in the EU H2020 AMBER project

www.fisheriesireland.ie/Fisheries-Research/the-amber-project.html

- The Eel Monitoring Programme is examining all structures within the Eel Index Catchments of the Fane and the Kells Blackwater.
- the University College Dublin study on the EPA-funded Reconnect project

http://www.ucd.ie/reconnect/

- the OPW-IFI study on riverine enhancement in drained rivers – the EREP study

https://www.opw.ie/en/media/Environmental%20River%20Enhancement%20Programme%20Annual%20Report%202015.pdf

- the IFI's Habitats Directive and Red Data Book Fish programme with a component examining the impact of large weirs on the migration of diadromous Annex II fish species

https://www.fisheriesireland.ie/extranet/fisheries-research-1/habitats/1440-habitats-directive-and-red-data-book-fish-species-summary-report-2016.html

During 2017 the IFI barriers investigations undertook and completed:

- Catchment-wide barrier survey on the Barrow catchment (> 300 barriers recorded)
- Catchment-wide survey on the lower Inny basin on the River Shannon catchment (35 barriers recorded)

In both studies the IFI's Level I survey protocol was used, with data collection on-site using the drop-down menus on ruggedized laptops. To date 1,873 structures have been assessed covering 94 catchments in all River Basin Districts (Table 2.5).

Table 2.5 Number of barriers assessments conducted by IFI between 2007 and 2017

River Basin District	Number of catchments assessed	Number of structures assessed
Eastern	9	322
South Eastern	13	897
South Western	13	78
Shannon	14	259
West	21	173
North Western	19	60
Neagh Bann	5	84
Total	**94**	**1873**

A number of additional, large structures were examined for fish passability in 2017 using the SNIFFER or WFD 111 protocol. This more detailed process is used by IFI as its Level II barrier assessment tool. It is used to assess large structures with more than one potential transversal section for migrating fish.

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.

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. These programmes, which were outlined in the EMP, were continued in 2015-2017. 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 DAERA. In recent years all assisted migration of elver and bootlace eel on the R. Erne has been released to Upper and Lower L. Erne in Northern Ireland.

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. 312, 2012 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. 319, 2015 which extends the provisions to 30 June 2018.

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 (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). There has been limited interest in development of small-scale hydropower facilities in Ireland since 2009.

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 Northern Ireland

Eel Fisheries legislation, fish passage, and water abstraction in Northern Ireland (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 work programme for the implementation of the Water Framework Directive (WFD). The objective of the Water Framework Directive (WFD) is 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 (www.wfdireland.ie). The first cycle of the WFD ran from 2009 – 2015, and the second cycle runs from 2016-2021 (www.catchments.ie).

National regulations for implementing the directive were put in place in 2003. A major monitoring programme began in December 2006 to inform the first cycle of the WFD. A detailed report on the results of the first cycle of WFD monitoring is not available to date (mid 2017). In the interim period, the Environmental Protection Agency (EPA) compile statistics on water quality in Ireland, the most recent of which covers the period 2010-2012 (Bradley *et al*., 2015). For that period, 53% of rivers, 43% of lakes, 45% of transitional waters, 93% of coastal waters and 99% of groundwater were satisfactory at good or high status. Rivers monitored, using the biological Q value scheme, were in high or good condition along 73% of the monitored river channels. This was up 4% from the last monitoring period (2007-2009), and includes an overall increase in high status sites. Serious pollution of rivers reduced to 17 km from 53 km since last reporting period. There was a 5% reduction (10 lakes) in the high or good status categories, and a corresponding increase in the moderate or worse status category compared to 2007-2009.

Before the publication of the interim reports, much of the monitoring data is available through the www.catchments.ie data portal, including the monitoring data for the period 2010-2015. The extended results for the period 2010-2015 are roughly similar to those reported for 2010-2012 (Bradley *et al*., 2015). Most rivers, lakes and coastal waters are classified as having good status, and most transitional waters are classified as moderate (Table 2.6, Fig. 4.4). The results from 2010-2015 are fairly similar to those recorded in 2007-2009, with 45% of surface waters being classified as having good ecological status (Table 2.6, Fig. 2.3).

The Irish EPA data (summarised above) refer to waterbodies within seven RBD's (Eastern, Neagh Bann, North Western, South Eastern, Shannon, South Western and Western). The Neagh Bann, Shannon and North Western RBD's are transboundary with Northern Ireland. Only a very small portion of the Shannon RBD is in Northern Ireland, while the Neagh Bann RBD is not included in the Irish Eel Management reports. Therefore, the implementation of the WFD in the Northern Irish portion of the North Western RBD is also of interest in this report, as it is the major international RBD which is considered in this eel management report. The status classification for 2015 for surface waters in NWiRBD shows that 46% are at good or better status. This can be broken down to 46% of rivers, 25% of lakes, and 33% of transitional and coastal water bodies (by numbers) at good or better (NIEA 2015).

Table 2.6: Trend in Surface Water quality over the first cycle of the WFD monitoring program. **Data accessed from https://www.catchments.ie/data (April 2017).**

Period	High	Good	Moderate	Poor	Bad
2007-2009	13%	44%	27%	14%	1%
2010-2012	14%	44%	26%	15%	1%
2010-2015	11%	45%	27%	17%	1%

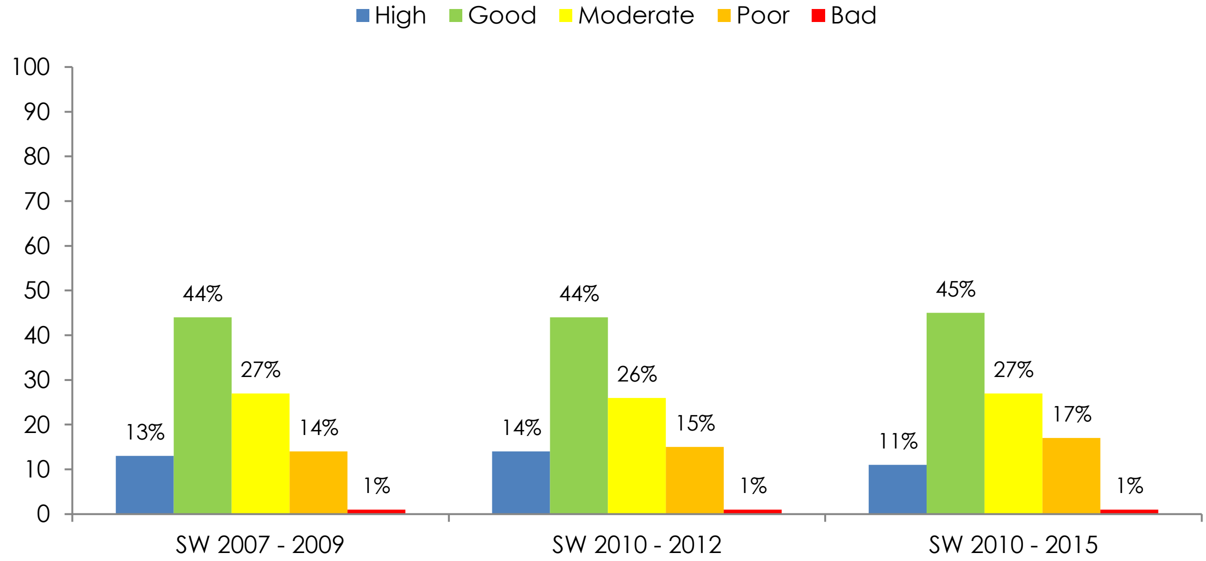


Figure 2.3: Trend in surface water quality over the first cycle of the WFD monitoring program. Data accessed from https://www.catchments.ie/data (January 2018).

2.5.2 WFD monitoring – fish.

Inland Fisheries Ireland (IFI) is responsible 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. Summary reports are available for all sites surveyed (www.wfdfish.ie). The most recent of these summary reports is the report for 2016 (Kelly et al. 2017). In 2016, a comprehensive fish surveillance monitoring programme was conducted, with 197 river sites, 19 lakes and 11 transitional waters successfully surveyed throughout the country. Eel are ubiquitous across all sites, and were found in 94% of lakes surveyed, 35% of river sites and 87.5% of transitional water sites.

Table 2.7: Interim assessment of Irish waterbodies according to fish metrics 2007-2014 as part of the WFD monitoring program carried out by Inland Fisheries Ireland (Kelly et al. 2014)

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	IFI	34
		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		
2014	**Fish only**	**Rivers**		10	46	25	18	1	IFI	22
		Lakes		11	35	33	12	8		
		Transitional		13	19	49	15	5		

Table 2.8: Interim assessment of Irish waterbodies 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	**Full suite**	**Rivers**	1564	13	39	28	19	1	EPA	
		Lakes	222	9	38	41	9	<1		
		Transitional	121	16	30	51	3			
2010-2012	**Full suite**	**Rivers**	2278	14	46	25	15	0	EPA	75
		Lakes	225	10	35	33	14	9		
		Transitional	80	5	26	52	17	0		
2010 - 2015	**Full suite**	**Rivers**	2345	10	46	25	18	0	EPA	172
		Lakes	225	11	35	33	12	8		
		Transitional	80	13	19	49	15	5		

2.5.3 Fish kills

A total of 23 fish kills were recorded by Inland Fisheries Ireland (IFI) in 2015, 31 in 2016 and 17 in 2017. Whilst none of these fish kills refer specifically to eel and the impact on eel has not been quantified, 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.

Year	Number of fish kills recorded
2007	22
2008	34
2009	16
2010	34
2011	31
2012	10
2013	52
2014	22
2015	23
2016	31
2017	17

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.

Anguillicola crassus

The swimbladder parasite, *Anguillicola crassus*, was first detected in Ireland in the Waterford Harbour in 1997 (McCarthy *et al*., 1999) and later in the Erne System (Evans and Matthews, 1999). The introduction of the parasite into the Republic of Ireland was most likely through the eel trade. Transport of live eels and potentially contaminated water was commonplace into and out of commercial eel fisheries areas. Since that time, the parasite has spread prolifically across the country and currently infestations are to be found in at least 75% of the wetted area of the Republic of Ireland (Becerra-Jurado *et al*., 2014), with only small coastal catchments and a few areas in the north west and south west of the country remaining parasite-free. On average, across yellow and silver eel populations sampled, percentage prevalence of the parasite is between 60-80% with mean infection intensities of between 4-6 worms per eel. Infection of a system begins with low prevalence and intensity values which quickly expand. Within just a few years, values increase to those reminiscent of a system infected for several years. Prevalence and intensity can often fluctuate for many years afterwards until the infestation becomes established, after which time, the percentage prevalence and intensity of infection will often remain quite stable. In 2011, Lough Ballynahinch and Lough Inchiquin both showed very low prevalence of the parasite (13% and 1%, respectively). These were noted as some of the lowest prevalence values gained to date. However, on resampling both lakes in 2015, the prevalence had increased to higher levels (86% and 13%, respectively). This indicates that the parasite is continuing to spread within catchments.

Since 2013, two swimbladder tissue health indices have been applied to the retained samples of eels in order to monitor the potentially increasing degree of damage due to infection - The Swimbladder Degenerative Index (SDI), (Lefebvre *et al*., 2002) and the Length-Ratio Index (LRI), (Palstra *et al*., 2007). Despite the high rates of prevalence and intensity recorded during surveys, these indices have reported, on average, slight to moderate damage in swimbladder tissue of eels captured in the Republic of Ireland. The reasonably low degree of swimbladder damage may be a result of 1) the high dependency of *A. crassus* on specific temperature ranges to complete its entire life cycle and 2) the ability of eels to regenerate tissue damage in times of low parasite infection rates. These elements are currently the focus of an on-going research study by the IFI's Eel Monitoring Programme.

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 temporary 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.

In early 2018 the CITES Secretariat in Geneva circulated a questionnaire to all parties of the CITES convention. This questionnaire was in relation to the trade in eel and to ensure Ireland was compliant with the listing of *Anguilla anguilla* on the CITES Appendix II. Ireland has responded to the questionnaire in an EU coordinated response dated the 18th March 2018. It was outlined in the report the difficulties of detecting legal and illegal trade in eels:

The absence of a Europe wide traceability scheme to ensure the adequate documentation and certification of all eel products (fresh live eels or processed products) makes it very difficult to identify legally traded eels from other European countries from illegally caught eels from Ireland or elsewhere. Also the trade code for eel do not separate the different life stages which is required both in the reporting of eel catches and in the trade statistics.

2.6.3 Silver Eel Trap and truck programmes

Significant resources were committed by the ESB in establishing and developing extensive trap and transport programmes on the Shannon, Erne and Lee river systems for downstream transport of silver eel around hydroelectric facilities for release to sea. Although a silver eel trap and transport 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 locations fished and increasing fishing efficiency as fishermen gained experience in fishing new capture sites. This resulted in a successive increase in the quantities of silver eels trapped and transported annually 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 2011-2017 period.

Considerable ESB, IFI and (in the case of the Erne transboundary fishery) DAERA 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 transport targets, were reviewed by the SSCE in light of work completed during 2009-2011. As a result the target for trap and transport 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 (50%).

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, although there is evidence of increased illegal fishing recorded particularly in the mid-lower Shannon over 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 the age of the structure and 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.

Following on from concerns from the SSCE that all silver eel index sites are located on the west coast of Ireland, IFI set up a research silver eel fishery in the Fane catchment. The site was a former commercial fishing location and has been fished annually from 2011 to present. It is located on the outflow of lake with good yellow eel population. The inclusion of this site gives a silver eel index site within the Eastern River Basin District/Neagh Bann District.

In 2014 a second east coast silver eel fishery was set up in the South East River Basin District. The fishery is located on the downstream freshwater section of the River Barrow. 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. 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 lacustrine wetted areas. The Barrow is the first riverine dominated silver eel index catchment assessed to date.

2.6.6 Monitoring

Transitional waters

While monitoring and surveys were carried out on transitional waters since the implementation of the eel regulation, 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. For this reporting cycle a preliminary assessment was carried out to apply a production value and a silver eel escapement to the transitional waters wetted area in each Eel Management Unit. This work will be continued and refined over the next few years.

Significant progress has been made however over the 2015-2017 period in terms of stock assessment (densities, size and age structure) through multi-year fyke net surveys conducted at Waterford Harbour (including the Suir and Barrow estuaries), Munster Blackwater 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).

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. In recent years the distribution of trapped elver and bootlace on the Erne has been exclusively stocked out to the Northern Ireland portion of the catchment.

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 Fishing Fleet, Auction centres and Recreational Fishery

3.2 A list of all fishing vessels flying your flag authorised to fish for eel in EU waters notwithstanding the overall length of the vessel

None.

3.3 A list of all fishing vessels, commercial entities or fishermen, authorised to fish for eels in eel river basins which constitute natural eel habitats according to Article 2(1) of the Eel regulation

None.

3.4 A list of all auction centres or other bodies or persons authorised by your Member State to undertake the first marketing of eel

None.

3.5 An estimate of the number of recreational fishermen and their catches of eels

Ireland has no recreational fishery for eel. Fishing, possession, purchase and sale of eel is prohibited. Capture of eel is limited to those eels occasionally taken as bycatch by rod anglers who are obliged by law to return any eel caught.

Coarse anglers using bait are the most likely category of rod and line anglers to encounter eels as accidental bycatch. The difficulty of disgorging deeply swallowed hooks from eel means captured eels are very often returned with the hook still attached thus impacting subsequent eel survival rates. A recent socio-economic study of recreational angling in Ireland commissioned by IFI confirmed 406,000 recreational anglers to have participated in angling in Ireland in 2012. Of 252,000 domestic anglers, 19 % (47,880) participated in coarse angling. No data exists on the quantities of eel caught on rod and line as bycatch, but it is likely to be extremely low.

4 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?

4.1 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 and 2015 reporting and evaluation processes 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.

4.2 Reporting and Evaluation

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 six year cycle to facilitate evaluation of the effectiveness of Eel Management Plans submitted. The provision of electronic tables in 2018 was welcome.

The second review of the Eel Management plans was submitted by June 2015, however these reports have apparently not yet been evaluated by the Commission. The only evaluation of Member States reports took place in 2013 which means the time frame between evaluating reports will be at least 6 years. Timely feedback is required to confirm all EU Member states are fully implementing Eel Managements Plans as submitted.

4.3 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 to satisfy the EU Regulation. Limited trade data made available to the group by the Central Statistics Office (CSO) for the period 2015 to 2017 were difficult to interpret and insufficient to deduce 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. This should also cover trans-shipment of eels through third party states.

5 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 eel less than 12cm.

6 References

Anon. (2007). Guidelines on the planning, design, construction and operation of small-scale hydroelectric schemes and fisheries. Department of the Communications, Energy and Natural Resources publication. 52pp.

Anon. (2012a). Report on the status of the eel stock in Ireland 2009-2011. Report of the Standing Scientific Committee for eel to Inland Fisheries Ireland and the Department of the Communications, Energy and Natural Resources. 204 pp.

Anon. (2012b). Report to the European Commission in line with Article 9 of the Eel Regulation 1100/2007: Implementation of Ireland's Eel Management Plans. DCENR. 105pp.

Anon. (2009-2018). Activity Report of the Standing Scientific Committee for Eel, 2012. DCENR.

Beccera-Jurado, G., Cruikshanks, R., O'Leary, C., Kelly, F., Poole, R. & Gargan, P. (2014). Distribution, prevalence and intensity of *Anguillicola crassus* (Nematoda) infection in *Anguilla anguilla* in the Republic of Ireland. *Journal of Fish Biology* **84;** 1046-1062.

Bradley, C., Byrne, C., Craig, M., Free, G., Gallagher, T., Kennedy, B., Little, R., Lucey, J., Mannix, A., McCreesh, P., McDermott, G., McGarrigle, M., Ní Longphuirt, S., O'Boyle, S., Plant, C., Tierney, D., Trodd, W., Webster, P., Wilkes, R. and Wynne, C. (2015). Water Quality in Ireland 2010-2012. 170 pp. Environmental Protection Agency, Wexford.

Evans, D. W. and Matthews, M. A. (1999), *Anguillicola crassus* (Nematoda, Dracunculoidea); first documented record of this swimbladder parasite of eels in Ireland. Journal of Fish Biology, 55: 665-668. doi:10.1111/j.1095-8649.1999.tb00707.x

ICES (2009). The report of the 2008 Session of the Joint EIFAC/ICES Working Group on Eels. Leuven, Sept. 2008; ICES CM 2009/ACOM;15

ICES (2011a). Report of the Study Group on International Post-Evaluation on Eels SGIPEE. 24-27 <ay 2011, London. ICES CM 2011/SSGEF: 13. 39pp.

ICES (2011b). Report of the 2011 session of the Joint EIFAAC/ICES Working Group on Eels. Lisbon, Portugal, from 5 to 9 September 2011. EIFAAC Occasional Paper. No. 48. ICES CM 2011/ACOM:18. Rome, FAO/Copenhagen, ICES. 2011. 246p. (Online).

Kelly, F.L., Connor, L., Matson, R., Feeney, R., Morrissey, E., Coyne, J. and Rocks, K. (2014). Sampling Fish for the Water Framework Directive - Summary Report 2013. Inland Fisheries Ireland, Citywest Business Campus, Dublin 24, Ireland.

Kelly, F.L., Connor, L., Coyne, J., Morrissey, E., Corcoran ,W., Cierpial, D., Delanty, K., McLoone, P., Matson, R., Gordon,P., O'Briain, R., Rocks, K., O'Reilly, S., Kelly K., Puttharee, D., McWeeney, D., Robson, S. and Buckley, S. (2017) Fish Stock Survey of Ardderry Lough, September 2016. National Research Survey Programme, Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24.

Knights, B. & White, E.M. (1998). Enhancing immigration and recruitment of eels; the use of passes and associated trapping systems. Fish. Mgmt. and Ecol., 5:459-471.

Lasne, E. and Laffaille, P. (2008). Analysis of distribution patterns of yellow European eels in the Loire catchment using logistic models based on presence-absence of different size-classes. Ecol. Freshwater Fish: 17:30-37.

Lefebvre, F., Contournet, P and Crivelli, A.J. (2002). The health state of the eel swimbladder as a measure of parasite pressure. *Parasitology* 124, 457-463

McCarthy, T. K., Cullen, P. & O'Connor, W. (1999). The biology and management of River Shannon eel populations. *Fisheries Bulletin* (Dublin) 17, 9–20.

McGarrigle, M., J. Lucey, and M. Ó Cinnéide. (2011). Water Quality in Ireland 2007-2009. Environmental Protection Agency, Wexford. 138 pp.

NIEA (2015). North Western River Basin Management Plan Summary. 75pp. NIEA, Lisburn, Northern Ireland.

Palstra, A.P., Heppener, D.F.M., Van Ginneken, V.J.T., Székely, C. & Van den Thillart, G.E.E.J.M. (2007). Swimming performance of silver eels is severely impaired by the swimbladder parasite Anguillicola crassus. *Journal of Experimental Marine Biology and Ecology* 352, 244–256.

Solomon, D.J. and Beach, M.H. (2004). Fish pass design for eel and elver (*Anguilla anguilla*). R & D Technical Report W2-070/TR1. Environment Agency, Bristol, 92 pp.

Source Material also used in the 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 for the Assessment of the Eel Stock in Ireland

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

2015-2017.

Contents

3 Introduction

3.2 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 in June 2015.

The third report is due by the 30th June 2018. 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 Agriculture, Environment and Rural Affairs 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 2015-2017 and provides the information on biomass and mortality for 2008-2017. Annual data for 2009 to 2017 are presented in the accompanying electronic tables.

3.3 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
DAERA	Dept. of Agriculture, Environment and Rural Affairs, N. Ireland.
DCCAE	Dept. of Communications, Climate Action and Energy
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, N. Ireland.
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
SSB	Spawning Stock Biomass
SSCE	Standing Scientific Committee for Eel (now the Technical Expert Group on 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".*

4 Eel Management Plan Monitoring Objectives

4.2 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).

4.3 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.

4.4 A general stock-recruitment relation

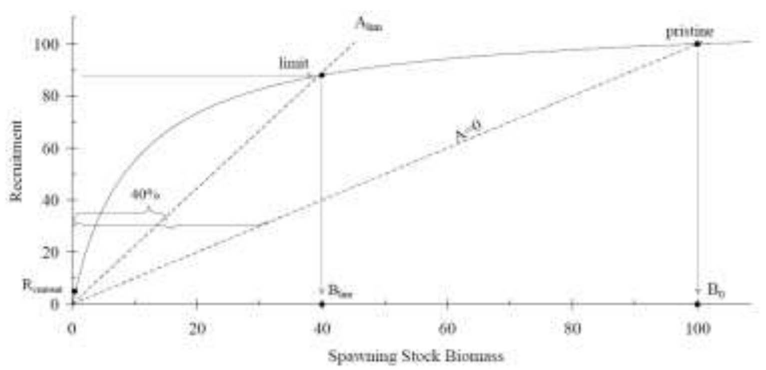


Figure 4-1: Hypothetical Stock-Recruitment relationship. The drawn line indicates what recruitment is produced at what spawning stock size; the dashed lines indicate what spawning stock can be derived from a given recruitment, at no fishery (A=0) or at maximal, just sustainable fishery (Alim). Both Recruits 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.

4.5 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.

4.6 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.

4.7 The Precautionary Diagram

For the international advice on fish stock management, ICES 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).

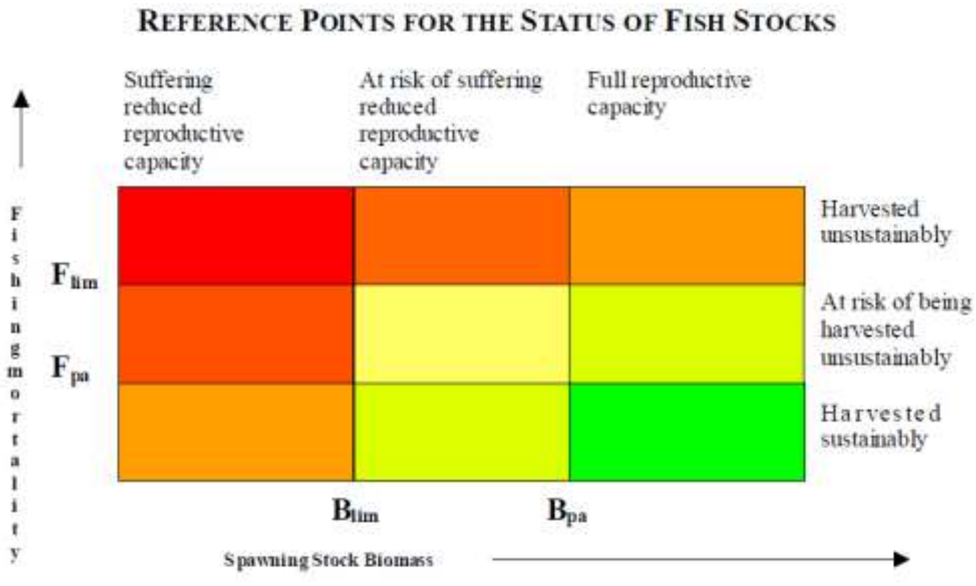
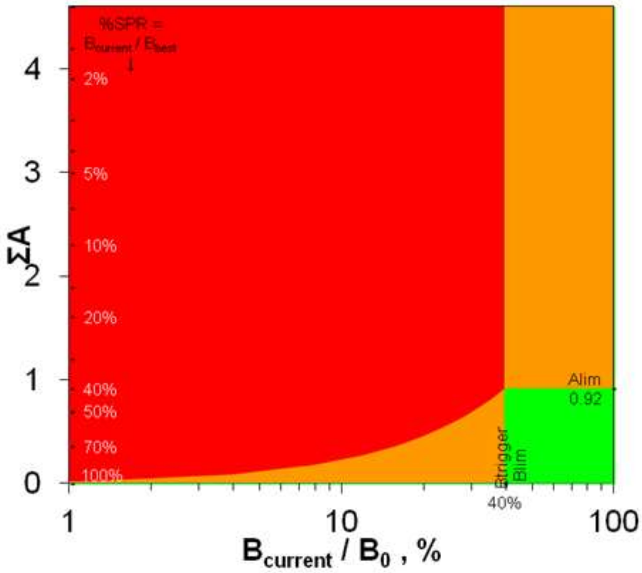


Figure 4-2: This "precautionary diagram" is used to summarise the state of the stock (horizontal) and the anthropogenic impacts (vertical).

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.

4.8 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).

[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.

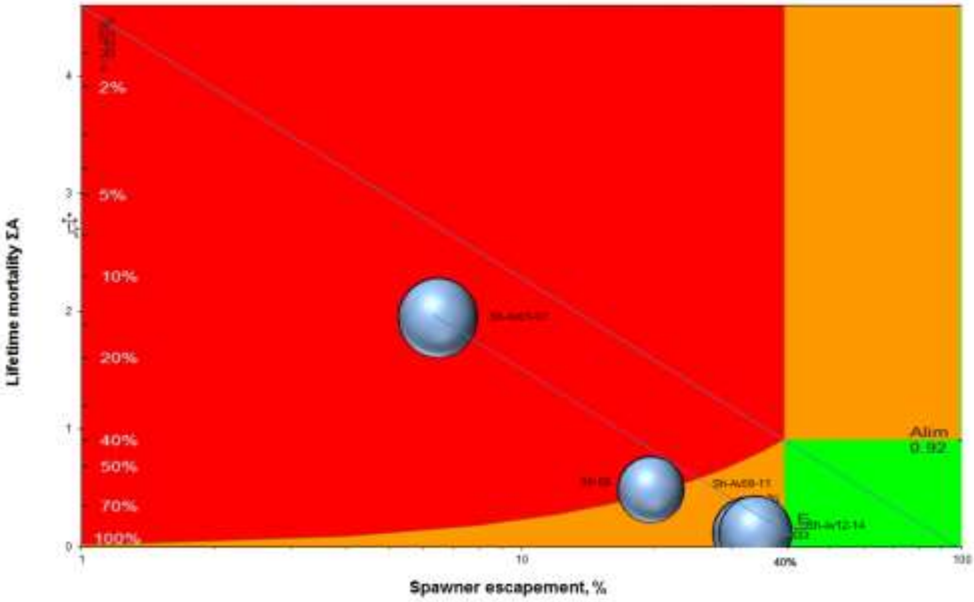


Figure 4-3: Precautionary diagram for the Shannon silver eel biomass (2001-2014). The downward movement of the bubble indicates lower mortality and to the right indicates increasing spawning stock biomass. The arrow indicates what effect the implementation of the EMP was expected to have.

4.9 Introduction to 2015-2017 Assessment

The assessment of the status of the Irish eel stocks for the 2015 to 2017 period broadly follows the procedures described in the Eel Management Plan and in the Stock Status reports in 2012 and 2015 (Anon, 2012, 2015b).

4.9.1 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.

4.9.2 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, 2015a, 2016, 2017 2018).

4.9.3 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).

4.10 Ireland's Eel Management Plan

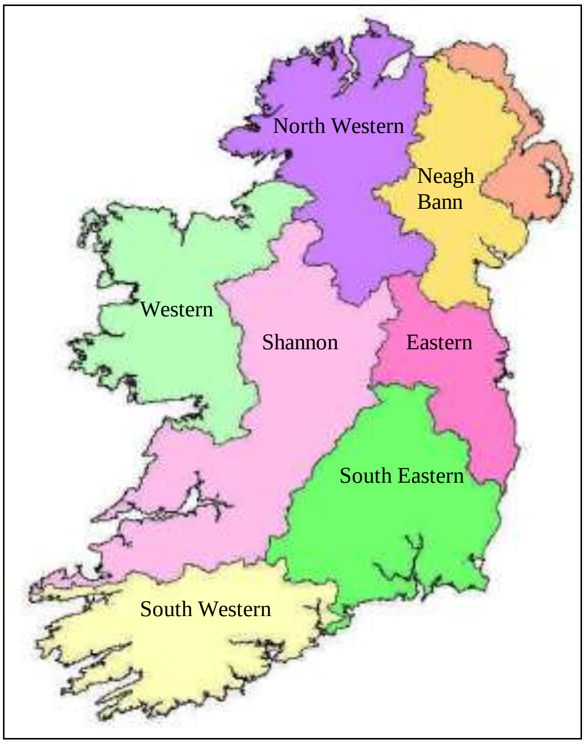
The EC Regulation (Council Regulation 1100/2007) for the recovery of the eel stock required Ireland to establish eel management plans for implementation in 2009. Under the EC Regulation, Ireland should monitor the eel stock, evaluate current silver eel escapement and post-evaluate implemented management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



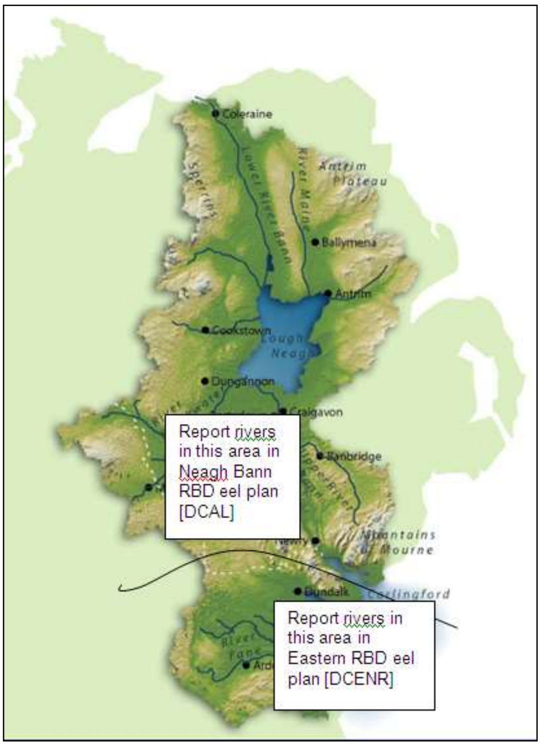


Figure 4-4: Map (left) showing the River Basin Districts and the map (right) showing the transboundary agreement between the Neagh/Bann RBD and the Eastern RBD.

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	EEMU	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

4.11 Monitoring 2015-2017

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). Since 2011, additional index sites were 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.

The Fane (IE_East) was included in the 2015-2017 analysis as a calibrating site. This is described in Chapters 3.3.5.3 (Table 3.9) and 4.2.5. In chapter 4, the original time series of Bbest production using only the Shannon, Erne and Burrishoole calibrating indices is presented along with the outcome of running the model including the Fane as a fourth index river. This addresses a previously identified criticism that all the indexes were on the west coast. However, the inclusion of the Fane changes the model outputs. For consistency, outputs from IMESE are presented with, and without, the new index and the mid-point between the two values is reported for 2015-2017. The trends of the two model outputs are similar, but it is not known whether the extrapolation to the datapoor catchments should be made at the higher or lower level. Also the volatile nature of silver eel migrations due to floods (2015) and droughts (2016) has made the interpretation of IMESE difficult.

In the previous reports (2012, 2015), silver eel production from transitional waters was not estimated. In this report, silver eel production from transitional waters has been estimated for 2015-2017 by categorising each waterbody into one of two med-high or one of four medium to low eel habitat, based on physical characteristics, and yellow eel CPUE from WFD and other eel fyke net surveys. These categories were then applied to the IMESE freshwater production rates (maximum and minimum) for each year and retrospectively for Bo. We report these estimates in the 2018 report and these should be treated with caution.

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). No new assessments of hydropower mortality rates were carried out during 2015-2017 and the rates previously determined were used in the current assessments.

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.

5 Status of the Irish Stocks 2015-2017

The following sections present a synthesis from the annual status reports (Anon, 2013, 2014, 2015a, 2016, 2017 & 2018) 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.

5.2 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 2000-2008 period, the glass eel catch in the Shannon was at 6.7% of the pre-1995 average and in 2009-2011 it was 1.6%. The Feale, Inagh and the Erne showed 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 Erne performed relatively well at 33% of the historic levels.

Between 2015 and 2017, recruitment was reasonable, with good catches in the Erne in 2015 and 2016, and in the Shannon, Feale and Maigue in 2016. However, in all stations there was a considerable drop in 2017. This was reflected in many stations around Europe, although the Bann remained similar to 2016.

The average recruitment for the 2009-2011 period was at about 6% of historic and this increased to about 20% for the 2012-2014 period and 18% in the 2015-2017 period (largely due to large catches in the Erne in 2017) (Table 3.1; Fig. 3.1). This compares to 7%, 13% and 12% respectively for “Elsewhere” Europe (Elsewhere = non-North Sea Europe).

Recruitment of young yellow eels (“bootlace”) recorded in Parteen on the Shannon was, in the 2000-2008, at 75% of its pre-1995 average. This fell to 17% from 2009-2014 and rose to 55% in the 2015-2017 period, due to a very large recruitment in 2016 of 890kg (Table 3.1; Fig. 3.1).

In summary, recruitment has generally remained low over the 2009-2017 period, although considerable improvements were seen in the 2012 to 2014 years and also in 2016 in the Shannon and 2015 and 2016 in the Erne. There was a general drop in 2017 in most rivers, a pattern common across Europe.

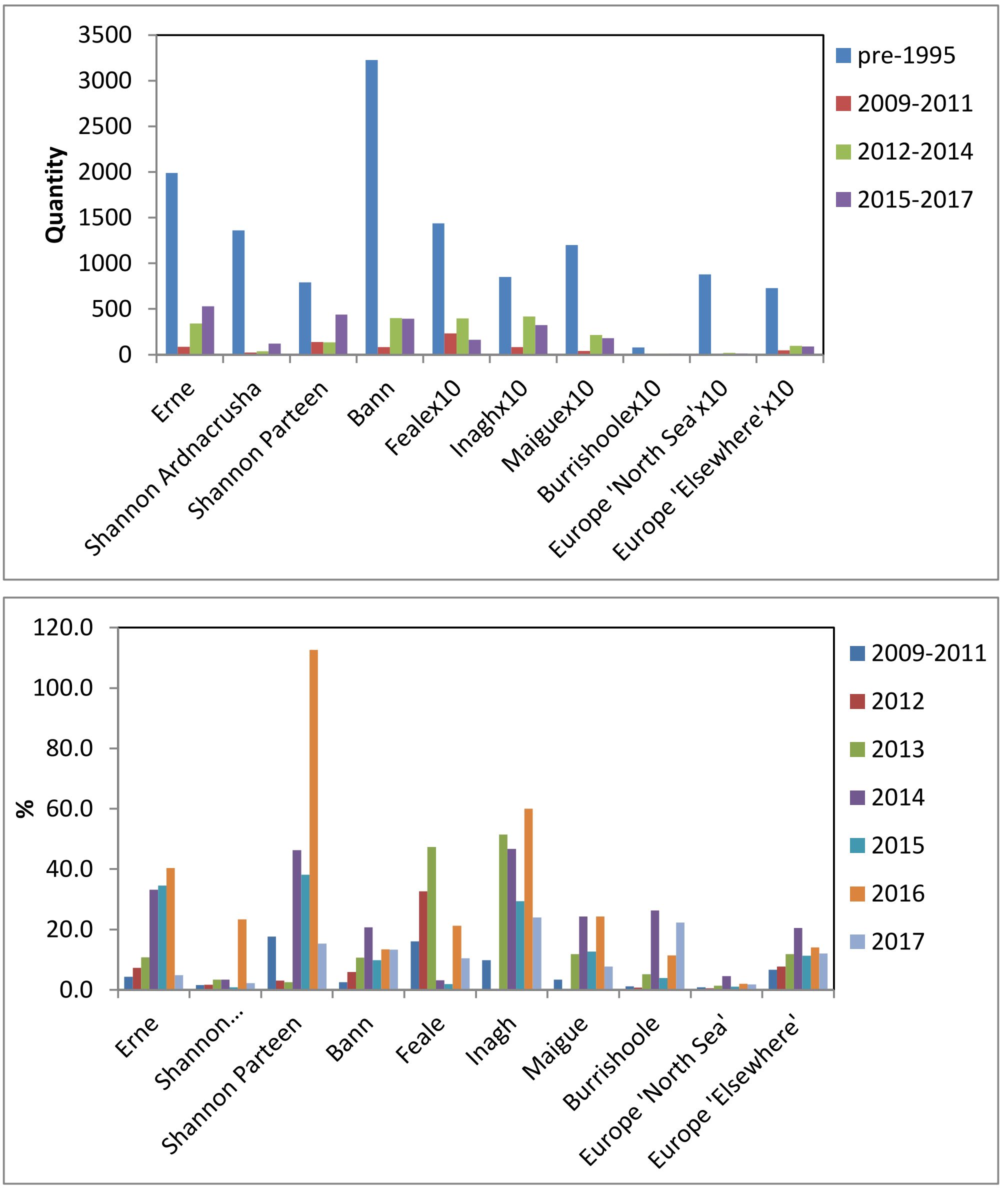


Figure 5-1: Top Graph: Average recruitment for time series in Ireland (kg) and in Europe (Average GLM) for the pre-1995 period and for 2009-2011, 2012-2014 and 2012-2014. Note some series are x10 for visibility on the graph. Bottom graph: Annual recruitment expressed as a %, scaled against the average recorded before 1995 or 2005 (Feale, Inagh, Maigue).

Table 5-1: Recruitment time series data for 2009-’11, 2012-’14 and 2015-’17, and for individual years 2012-2017, comparing with historical data. R. Bann & Europe data shown for comparison.

Year	Location	Average Weight (kg)	% compared to historic level	2012%	2013%	2014%	2015%	2016%	2017%
pre-1995	Erne	1989							
2009-2011	Erne	86	4.3						
2012-2014	Erne	340	17.1						
2015-2017	Erne	528	26.6	7.3	10.8	33.2	34.5	40.4	4.8
pre-1995	Shannon Ardnacrusha	1362							
2009-2011	Shannon Ardnacrusha	22	1.6						
2012-2014	Shannon Ardnacrusha	38	2.8						
2015-2017	Shannon Ardnacrusha	119	8.7	1.7	3.4	3.4	0.8	23.3	2.2
pre-1995	Shannon Parteen	790							
2009-2011	Shannon Parteen	139	17.6						
2012-2014	Shannon Parteen	136	17.3						
2015-2017	Shannon Parteen	437	55.3	3.0	2.6	46.2	38.1	112.6	15.3
pre-1995	Bann (N. Ireland)	3224							
2009-2011	Bann (N. Ireland)	81	2.5						
2012-2014	Bann (N. Ireland)	400	12.4						
2015-2017	Bann (N. Ireland)	393	12.2	5.9	10.7	20.7	9.8	13.4	13.3
pre-2004	Feale	144							
2009-2011	Feale	23	16.1						
2012-2014	Feale	40	27.7						
2015-2017	Feale	16	11.2	32.6	47.3	3.2	1.9	21.2	10.5
pre-2000	Inagh	85							
2009-2011	Inagh	8	9.8						
2012-2014	Inagh	42	49.1						
2015-2017	Inagh	32	37.8		51.5	46.7	29.4	60.0	24.0
pre-2000	Maigue	120							
2009-2011	Maigue	4	3.4						
2012-2014	Maigue	22	18.0						
2015-2017	Maigue	18	14.9		11.8	24.3*	12.7	24.3	7.7
pre-2000	Burrishoole	8							
2009-2011	Burrishoole	0.1	1.2						
2012-2014	Burrishoole	1	10.7						
2015-2017	Burrishoole	1	12.5	0.7	5.2	26.3	3.9	11.4	22.3
pre-1995	Europe 'North Sea' **	88							
2009-2011	Europe 'North Sea' **	1	0.8						
2012-2014	Europe 'North Sea' **	2	2.1						
2015-2017	Europe 'North Sea' **	1	1.4	0.5	1.4	4.5	1.0	2.0	1.8
pre-1995	Europe 'Elsewhere' **	73							
2009-2011	Europe 'Elsewhere' **	5	6.6						
2012-2014	Europe 'Elsewhere' **	10	13.4						
2015-2017	Europe 'Elsewhere' **	9.03	12.4	7.7	11.8	20.5	11.3	14	12

**The Europe data are GLM averages *partial effort

5.3 Yellow Eel Monitoring

5.3.1 Introduction

During the last three year cycle (2015-2017) of fieldwork seven lakes were repeatedly sampled for yellow eels; Lough Corrib Upper and Lower, Lough Conn, Cullin, Muckno, Ramor, Oughter, Ballynahinch, Inchiquin, Lough Feeagh and Bunaveela.

A multi-year netting survey was carried out in the Waterford Harbour, Munster Blackwater Estuary and Lough Furnace to investigate the eel population of transitional waters. Locations are listed in Table 3.2 and Figure 3.2.

A semi quantitative electrofishing survey was undertaken in the Bride catchment of the Munster Blackwater and 5 sub-catchments of the River Barrow in order to determine the extent of eel distribution in the rivers of our Index catchments.

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. All fieldwork carried out during the 3 year cycle was to fulfil these objectives.

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 Muckno, 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.

5.3.2 Yellow Eel Catches

Details of the fishing effort, catches and sizes of eel are presented in Table 3.3 for the period 2015 to 2017.

For the yellow eel surveys, the Corrib Upper survey had the largest catch per unit of effort for the two years (8.28 and 5.39). The smallest cpue recorded was Lough Bunaveela with 0.1-0.3 and Lough Furnace with a cpue of 0.3.

Lough Ramor in 2016 had the largest average length of 54.2 and Corrib upper had the largest average weight of yellow eels with 0.286kg. As expected the transitional waters had a lower average length and weight compared with the lake surveys with 35.7cm average length in the Munster Blackwater estuary and 38cm in Waterford. The surveys of the transitional waters in conjunction with the lake surveys highlight the importance of the estuaries as habitat for the smaller eels.

Electrofishing data from 5 catchments fished between 2015 and 2017 have highlighted the importance of habitat in the distribution of eels within catchments. The absence and low density of eels within the rivers and streams have drawn attention to the error in assuming eels are everywhere and inhabit all wetted area. This will have knock on effects on attempts to model eel production and escapement from non-surveyed catchments. The importance of habitat and quantifying habitat needs to be addressed in the future.

In the transboundary area (Lower Lough Erne), AFBI have carried out surveys in 2011 and 2014. The main findings of the previous surveys were the increases noted in CPUE from 2011 to 2014, reflecting the closure of the commercial yellow eel fishery. In July 2016, the survey areas for LLE were divided into 4 zones (moving downstream and westward in the Lough fished by one crew. The 2016 Lower Lough Erne eel survey (consisting of 1 crew over 120 net nights) caught a total of 1981 eels. In comparison, the 2014 survey (using the same crew over 150 net nights) caught 2546 eels.

In terms of the number of eels caught per night the CPUE for the 2 mid regions of the survey were similar to 2014. However, when taken as a mean across the 4 zones fished, CPUE has dropped marginally from 2014 to 2016 from 17.0 to 16.5 respectively. Whilst CPUE of the catches was similar to those recorded in 2014 the length frequency distributions were different with eels from 2016 skewed towards longer, older fish. This difference in length frequency distributed was also associated with a reduction in the number of eels <400mm in length, repeated across all sites surveyed. The number of eels caught from this size class was on average approximately half of that seen in 2014. These findings would be consistent with known (poor) recruitment history to the Erne over the preceding 8-10 years (verified by ageing of 2016 samples which showed eels, 400mm length to be less than 10 years old) and echo the modelling based scenarios of future output from the Erne from these year classes.

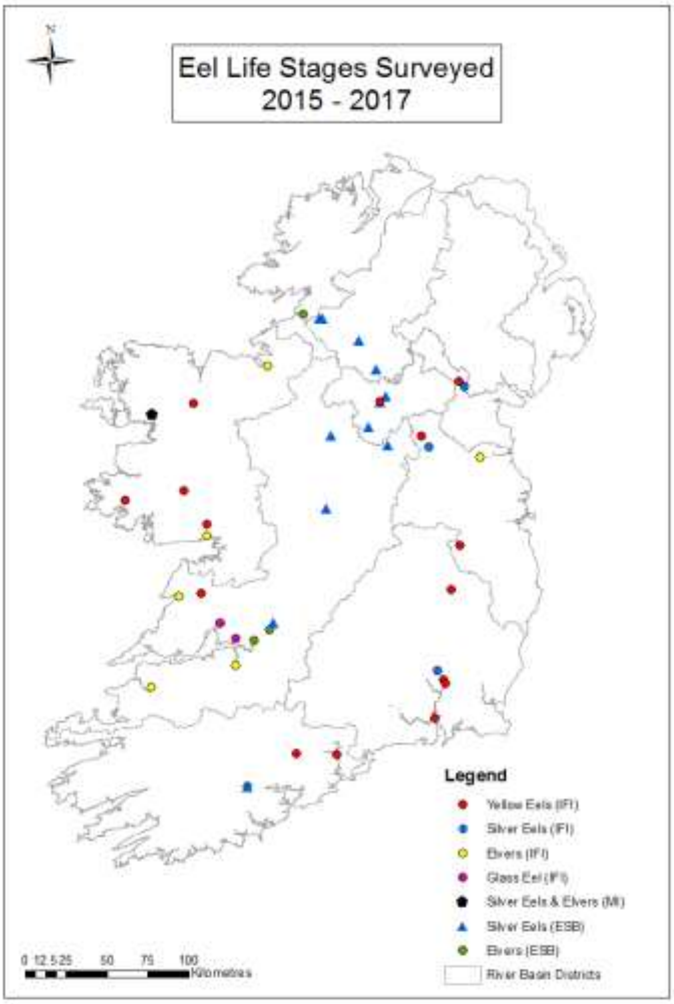


Figure 5-2: Locations of yellow eel surveys, 2015-2017.

Table 5-2 Yellow eel survey locations for 2015-2017 and the monitoring objectives in the EMP.

RBD	Location	Water body	Life stage	1	2	2.1	3	4	5	6	7	8	2015	2016	2017
SHIRBD	ESB Shannon	Catchment	Silver	√	√		√		√	√			√	√	√
NWIRBD	ESB Erne	Catchment	Silver	√	√		√		√	√			√	√	√
WRBD	Burrishoole	Catchment	Silver	√	√				√	√			√	√	√
SERBD	Barrow	River	Silver	√	√		√			√			√	√	√
ERBD/NBRBD	Fane	River	Silver	√	√		√			√			√	√	√
ERBD	Boyne	River	Silver	√	√		√			√				√	√
SHIRBD	Maigue	River	Elver	√						√			√	√	√
SHIRBD	Feale	River	Elver	√						√			√	√	√
SHIRBD	Inagh	River	Elver	√						√			√	√	√
ERBD	Liffey	River	Elver	√						√			√	√	√
WRBD	Ballysadare	River	Elver	√						√			√	√	√
WRBD	Corrib	River	Elver	√						√			√	√	√
SHIRBD	Shannon	Catchment	Yellow	√			√	√	√	√			√	√	
NWIRBD	Erne	Catchment	Yellow	√		√	√		√	√	√	√	√	√†#	
SHIRBD	Inchiquin	Lake	Yellow	√					√	√	√	√	√		
WRBD	Ballynahinch	Lake	Yellow	√		√			√	√	√	√	√		
SWRBD	Blackwater	Catchment	Yellow	√			√		√	√	√	√	√	√	√
ERBD/ NBRBD	Broadmeadow	T. water	Yellow	√					√	√	√			√ #	
WRBD	Corrib	Catchment	Yellow	√		√	√	√	√	√	√	√		√	√
WRBD	Moy	Lake	Yellow	√		√			√	√	√	√		√	√
SERBD	Barrow	Catchment	Yellow	√			√		√	√	√			√	√
ERBD/ NBRBD	Fane	Catchment	Yellow	√			√	√		√	√			√	√
ERBD	Boyne	Lake	Yellow	√		√			√	√	√	√		√	√
Ireland	WFD Parasite Free Lakes	Lakes	Yellow	√				√		√	√	√	√	√	√
Ireland	WFD Alkaline lakes	Lakes	Yellow	√				√		√	√	√	√	√	√

RBD	Location	Water body	Life stage	1	2	2.1	3	4	5	6	7	8	2015	2016	2017
Ireland	WFD Rivers	Rivers	Yellow	√				√		√	√		√	√	√
Ireland	WFD Transitional	T. water	Yellow	√				√		√	√	√	√	√	√
WRBD	Lough Feeagh	Lake	Yellow	√			√		√	√		√	√	√	√
WRBD	Lough Furnace	T. water	Yellow	√			√		√	√		√	√	√	√

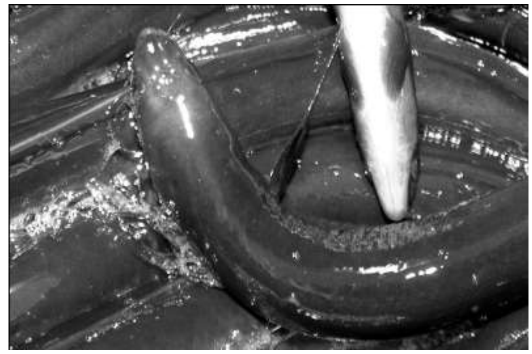
Table 5-3: Catch details of the yellow eel surveys in the national EMP Survey, 2015-2017.

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)
Ballynahinch	2015	123	240	0.513	14	38.7	30.0	74.4	0.117	0.048	1.042
Barrow -fyke	2017	27	20	1.350	5	44.1	33.9	63.5	0.167	0.054	0.497
Conn	2016	957	320	2.991	88	46.3	31.0	82.6	0.179	0.053	1.069
Conn	2017	866	320	2.706	119	46.9	30.6	93.7	0.192	0.052	1.139
Corrib Lwr	2016	576	320	1.800	104	49.0	28.9	73.2	0.209	0.050	0.629
Corrib Lwr	2017	508	320	1.588	82	49.1	32.4	70.3	0.216	0.054	0.584
Corrib Upr	2016	2387	288	8.288	179	52.4	33.4	77.4	0.268	0.060	0.933
Corrib Upr	2017	2159	400	5.398	393	53.4	30.7	83.2	0.286	0.050	1.104
Cullin	2017	146	80	1.825	26	46.0	31.0	66.0	0.181	0.048	0.577
Inchiquin	2015	479	240	1.996	81	51.2	33.3	78.3	0.237	0.043	1.013
Muckno	2016	2613	360	7.258	456	47.8	27.2	83.8	0.217	0.026	1.076
Muckno	2017	703	200	3.515	149	47.7	26.5	88.1	0.214	0.026	1.673
Oughter	2015	388	240	1.617	103	52.8	31.3	79.4	0.266	0.043	1.036
Ramor	2016	401	120	3.342	110	54.2	34.3	84.2	0.279	0.058	1.320
Ramor	2017	940	200	4.700	243	53.1	27.5	83.8	0.258	0.051	1.188
Lower Lough Erne	2016	1981	120	16.5	40.1	47.8	29.1	68.3	0.202	0.055	0.610
Munster Blackwater Estuary - fykes	2017	197	63	3.130	17	35.3	22.4	60.4	0.084	0.017	0.451
Munster Blackwater Estuary - pots	2016	521	625	1.320	100	43.4	13.3	88.4	0.223	0.004	1.448
Munster Blackwater Estuary - pots	2017	343	345	0.830	31	35.7	15.3	79.7	0.090	0.008	0.668
Munster Blackwater Freshwater	2017	698	90	7.760	129	43.3	25.6	86.6	0.183	0.029	1.442
Waterford Estuary - fykes	2016	1017	75	13.560	118	39.9	23.7	70.2	0.131	0.020	0.650
Waterford Estuary - fykes	2017	378	75	5.040	50	40.6	23.0	66.5	0.132	0.017	0.578
Waterford Estuary - pots	2016	5971	160	37.319	526	40.5	18.7	73.5	0.152	0.009	0.908
Waterford Estuary - pots	2017	6285	180	34.917	277	38.0	15.5	76.0	0.117	0.007	0.857

Table 5-4 cont.:

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)
Bunaveela L.	2015	3	30	0.10	0.890	52.6	46.4	64.1	0.296	-	-
Bunaveela L.	2016	10	30	0.33	1.13	39.6	34.8	44.6	0.113	0.074	0.162
Bunaveela L.	2017	8	30	0.27	1.62	48.1	40.4	59.5	0.203	0.105	0.355
L. Feeagh	2015	73	60	1.22	9.570	40.7	30.3	67.5	0.131	0.055	0.640
L. Feeagh	2016	87	60	1.45	14.52	42.6	28.5	79.4	0.169	0.040	1200
L. Feeagh	2017	40	60	0.67	6.130	43.4	31.3	59.9	0.153	0.055	0.200
L. Furnace Upper	2015	74	60	1.23	9.370	40.6	27.4	68.6	0.127	0.035	0.660
L. Furnace Upper	2016	69	100	0.69	7.50	39.7	28.7	61.6	0.123	0.035	0.460
L. Furnace Upper	2017	9	60	0.45	1.01	40.7	33.1	52.9	0.112	0.055	0.200
Lwr Furnace	2015	61	20	3.05	13.040	47.2	29.3	84.3	0.217	0.035	1.130
Lwr Furnace	2016	5	20	0.25	0.41	37.0	34.8	39.9	0.081	0.070	0.100
Lwr Furnace	2017	9	20	0.15	1.83	46.4	33.9	71.1	0.203	0.050	0.615

5.4 Silver Eel Monitoring



5.4.1 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 3.4; Fig. 3.3), 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 is included in the analysis for 2015-2017, and on the R. Barrow in 2014 and will be included in the analysis once 5 years of data have been collected and a whole catchment production estimation has been undertaken. 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.

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 some 45% of the wetted area.

In 2015, a massive flood event disrupted the silver eel stock assessment on the R. Shannon resulting in the loss of that index catchment in 2015. Drought conditions in 2016 also caused problems making coghill net fishing difficult, especially on the Fane (Muckno) site.

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

Catchment	2009	2010	2011	2012	2013	2014	2015	2016	2017	Method
Corrib	√		√							Coghill net / Mark-recapture
Erne	√	√	√	√	√	√	√	√	√	Coghill net / Mark-recapture
Shannon	√	√	√	√	√	√	√	√	√	Coghill net / Mark-recapture
Burrishoole	√	√	√	√	√	√	√	√	√	Permanent Trap
Mask		√								Coghill net / Mark-recapture
Fane/Muckno			√	√	√	√	√	√	√	Coghill net / Mark-recapture
Barrow					√	√	√	√	√	Coghill net / Mark-recapture
Boyne									√	V-wing Fyke

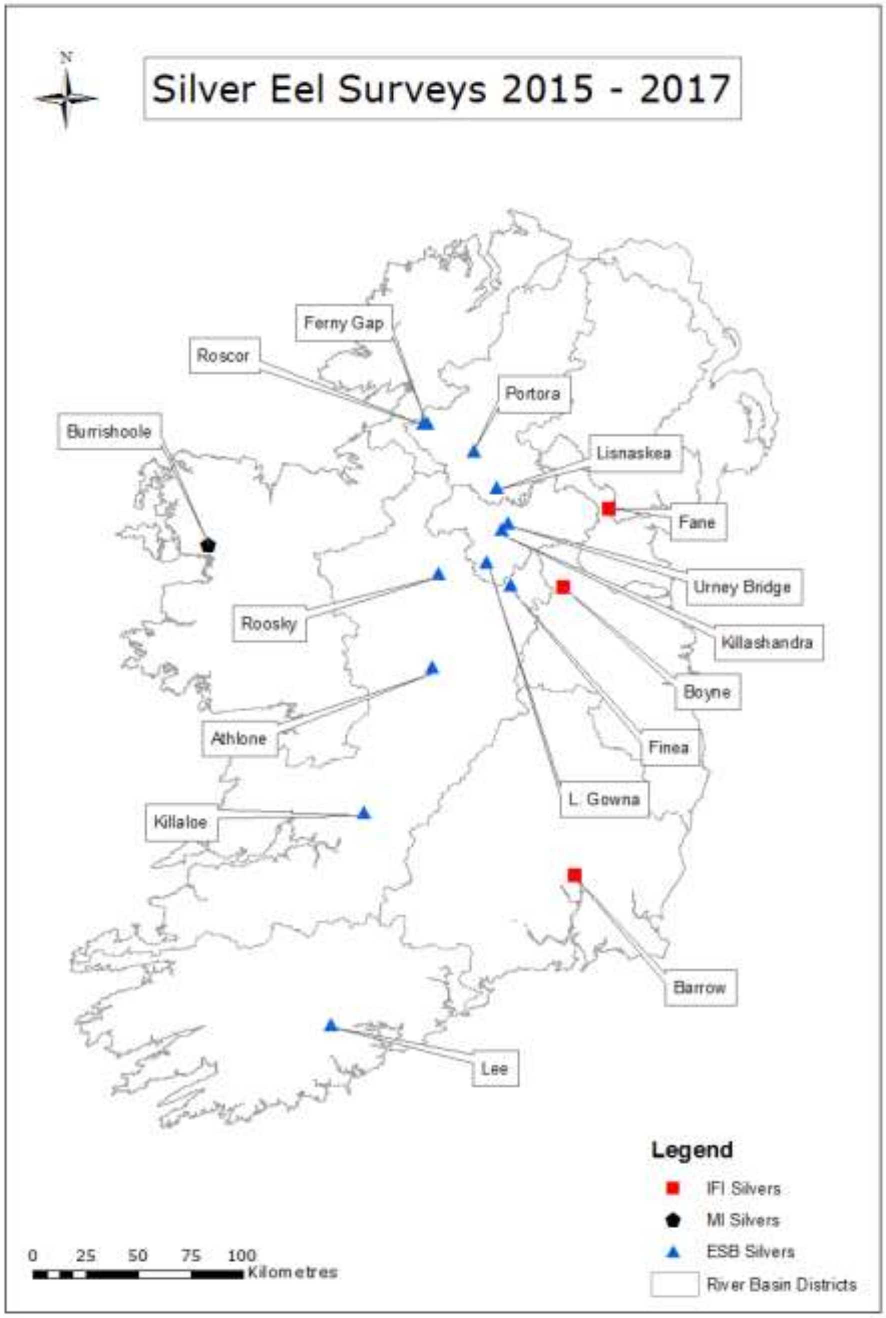


Figure 5-3: Locations of silver eel monitoring sites, 2009-2017.

5.4.2 Shannon

5.4.2.1 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. 3.4) catch downstream of Parteen weir (Fig. 3.4). 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 (MacNamara *et al*., 2013). Summaries of work in progress have been supplied to the SSCE over the past three years (Anon, 2012; McCarthy *et al.* 2013-2018). 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.

A major refurbishment of the Killaloe eel fishing weir was undertaken in 2014.

A major flood in 2015 resulted in the inability to fish the main part of the season (Dec/Jan) making it impossible to produce a stock assessment of eel production in that year (see below).

Figure 5-4: The Killaloe eel weir (A) and the Parteen regulating weir (B) on the lower River Shannon.

5.4.2.2 Shannon Annual Catch

The **2015 fishing season** for eels on the River Shannon extended from 29th of August to 14th of December for the conservation fishing sites in the upper Shannon (Fig. 3.5). At Killaloe test fishing at the eel weir 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 8th of November in 2015. Due to flooding and high discharge the ESB were required to close the Killaloe eel weir from 10th of December to 19th of January. A total of 49 nights were fished and the final fishing event took place on 10th of February.

During the 2015 season, a total catch of 20,228kg was made; 11,679 kg at the upstream sites and 8,549 kg at Killaloe. The pattern of downstream migration at Killaloe, apart from the fishery closure period, was reflected in the daily catches recorded at the eel fishing weir. These data are graphically presented, in relation to variation in discharge and to the lunar cycle, in Fig. 3.6. Most (8,323kg) of the catch at Killaloe was obtained prior to the closure period and only a small quantity (226kg) was caught in the final period.

The **2016 fishing season** for eels on the River Shannon began on 19th September 2016 and the fishing crews finished up on 11th February 2017 and Killaloe finished fishing on the 28th March. During the 2016/2017 silver eel migration season the discharge patterns were very atypical, with very low rainfall and river levels, and this was associated with unusual patterns of hydroelectricity generation. Night-time generation was regularly curtailed and spillage levels at Parteen regulating weir were minimal.

During the 2016 season, a total catch of 17,134kg was made; 10,797 kg at the upstream sites and 6,337 kg at Killaloe. The pattern of downstream migration at Killaloe in this season was reflected in the daily catches recorded at the eel fishing weir. This data is graphically presented, in relation to variation in discharge and to the lunar cycle, in Figure 3.7. Most of the catch (5,482 kg) at Killaloe was obtained during the higher discharge conditions in 33 fishing events. The remaining 913 kg was caught in lower discharge conditions during 56 fishing events.

The variation in seasonal catches during the last three seasons was a reflection of the range of weather conditions, that resulted in either very high (2015/16) or very low (2016/17) discharge conditions (Fig. 3.7)

The **2017 fishing season** for eels on the River Shannon commenced on the 1st September 2017 and was completed on the 13th February 2018 (Fig. 3.8). The Athlone crews fished from 01/09/17 to 15/12/17. Fishing at Killaloe, a nationally important silver eel monitoring index site, extended from 25/09/17 to 13/02/17. All catches, except for some used in mark-recapture studies at Killaloe, contributed to the silver eel trap and transport (T & T) programme. As is usual, the Killaloe weir (62%) was the most important silver eel source, followed by the Jolly Mariner crew (30%) and the least productive Athlone Yacht Club crew (8%). The total quantity captured, transported and released below Parteen weir was 16.737t.

The relative catch contribution from the upstream sites to the ESB silver eel trap and transport programme in 2015, 2016 and 2017 is summarised in Figures 3.13, 3.14 & 3.15.

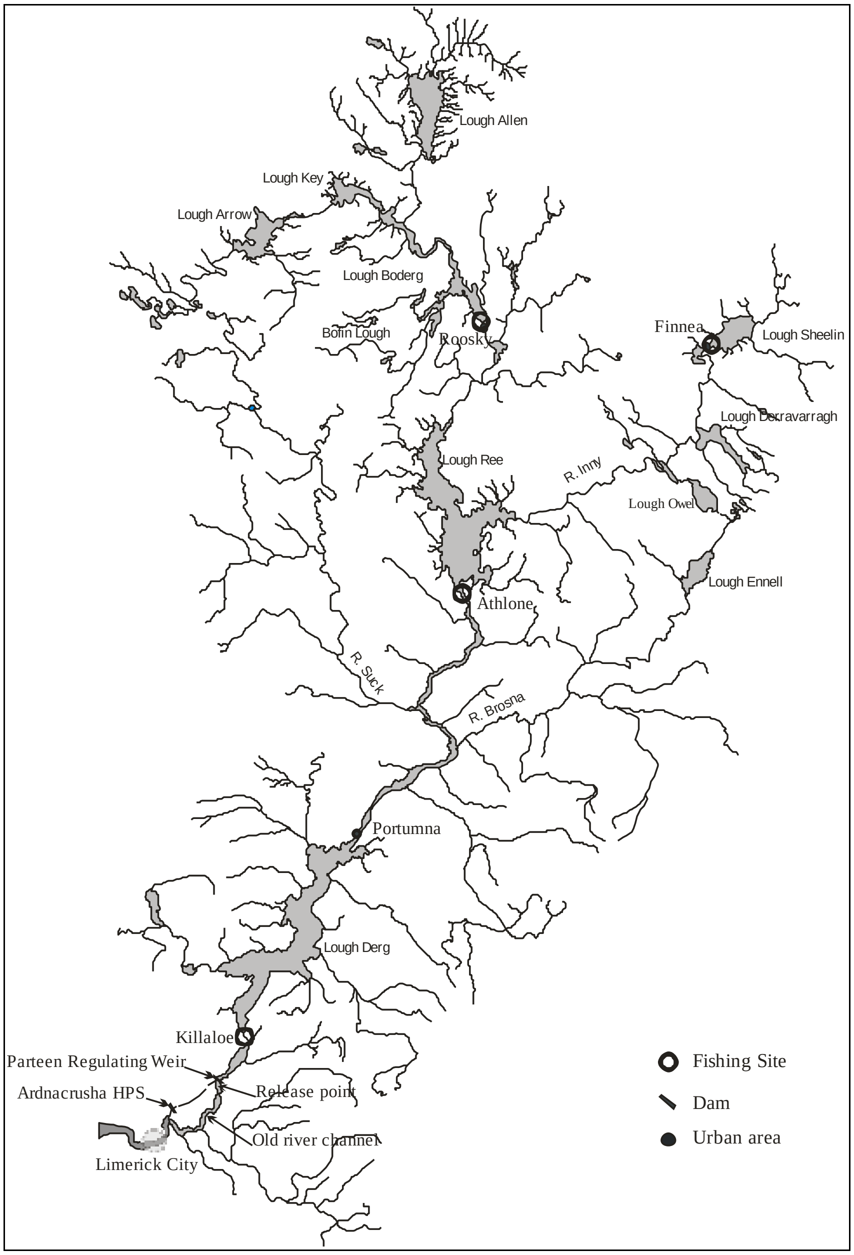


Figure 5-5: Map of River Shannon catchment.

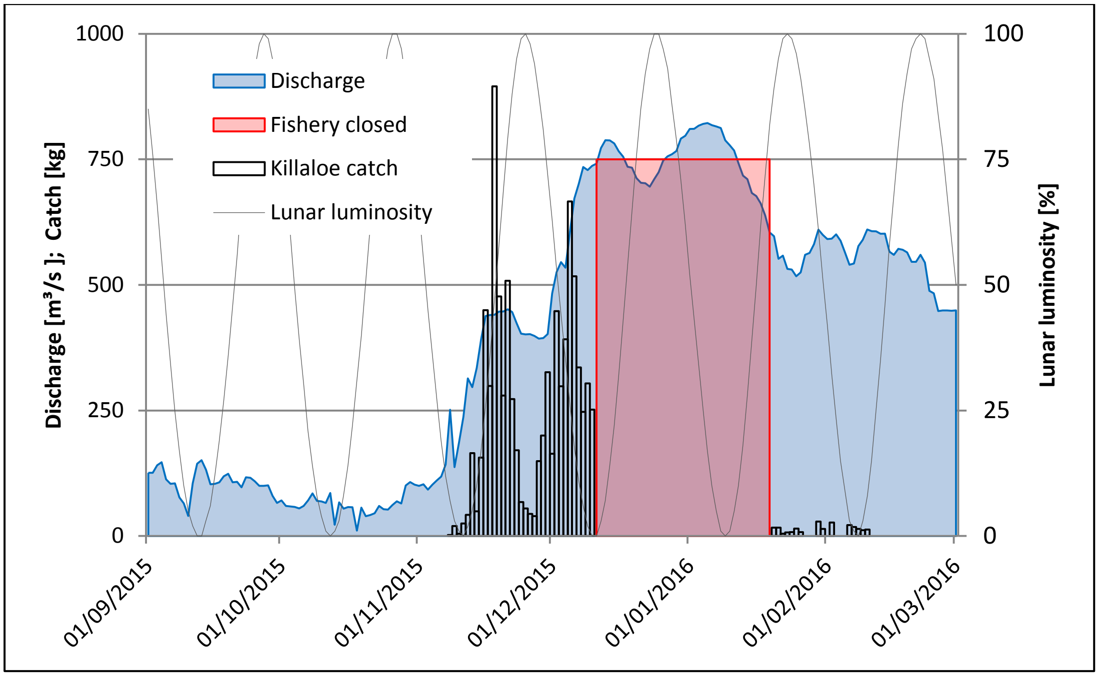


Figure 5-6: Killaloe weir eel catch (kg), discharge ($m^3 \cdot s^{-1}$) at pattern and lunar cycles during 2015 season.

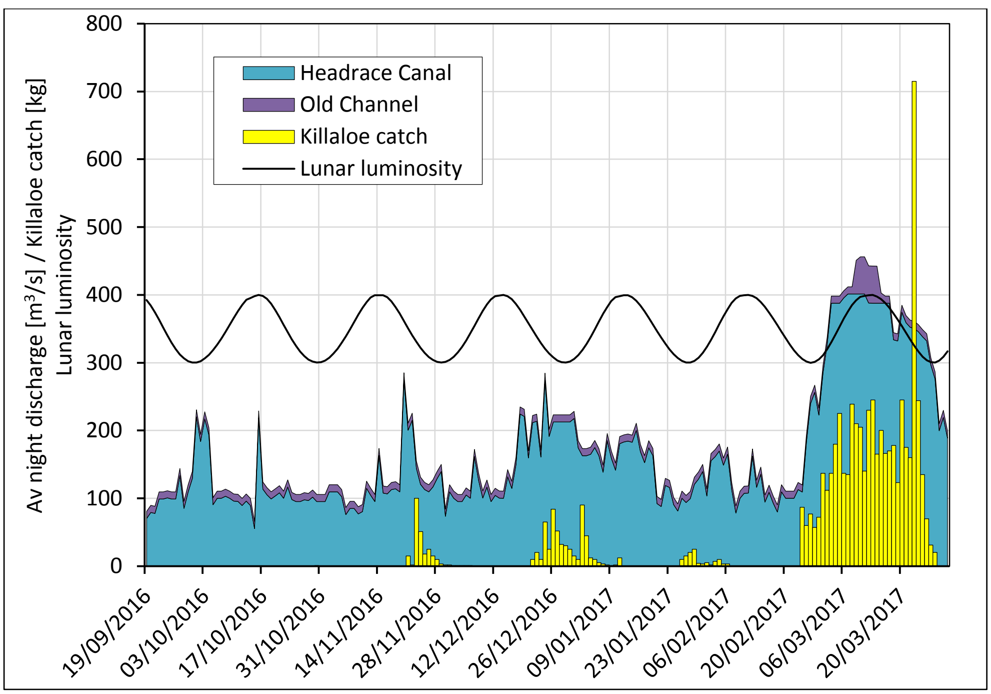


Figure 5-7: Killaloe weir eel catch, discharge pattern and lunar cycles during 2016/17 season.

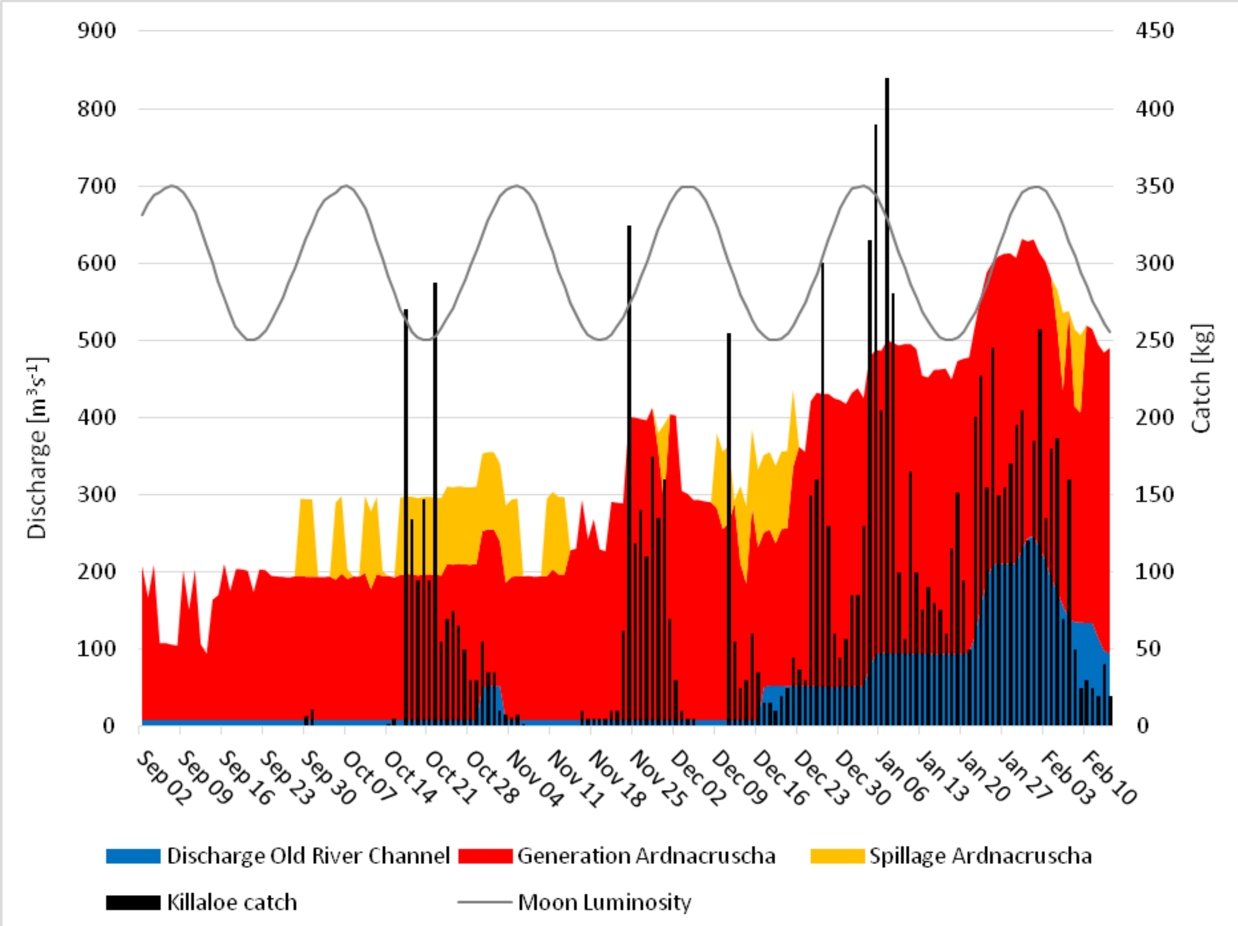


Figure 5-8: The seasonal variation in daily catches at the Killaloe eel weir during the 2017/2018 fishing season together with variation in discharge via Ardnacrusha (generation and spillage quantities) and as spillage to the Old River Shannon channel.

5.4.2.3 Shannon Annual Hydropower Mortality and bypass

The determination of turbine passage mortality for silver eels passing through Ardnacrusha dam (Fig. 3.9) was determined by means of acoustic telemetry, using protocols described in NUIG/ESB reports to SSCE (McCarthy *et al*. 2010, 2011, 2012-2018). 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 EU 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 5-9: 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, 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.

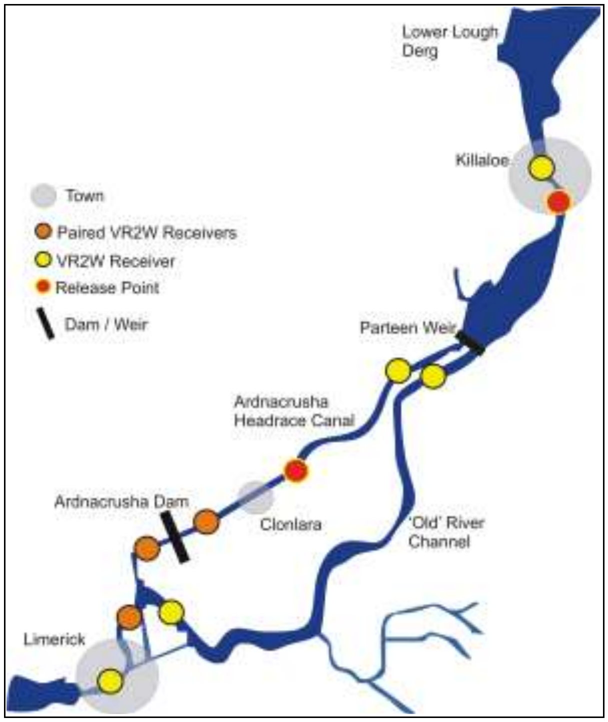


Figure 5-10: Locations of telemetry receivers and release point for acoustically tagged eels used for turbine passage studies in the Lower River Shannon 2008-2012. Not all receivers were deployed in all years.

The unusually high discharge conditions in the River Shannon during the **2015/16 period** of silver eel migration presented problems in estimation of spawner production and escapement. Attempts were made, using DIDSON surveys at Clonlara, to correct for missing data during the period when fishing could not be undertaken at Killaloe eel weir. However, due to equipment failure associated with local power outages, this was not technically possible.

In the **2016/17** season the estimated silver eel mortality at the Ardnacrusha dam was 3,062kg (21.15% HPS passage rate). The discharge conditions were exceptionally low, with very low flow in the old River Shannon channel. The estimates of both silver eel production and escapement were much lower than normal and the peak period of migration was later than has been recorded in recent decades.

Taking into account some interrupted fishing days, more appropriate production and escapement estimates were calculated which would infer an estimated silver eel mortality of 3,897kg at Ardnacrusha.

In the **2017/18** season, a steady increase to exceptionally high discharge conditions in the River Shannon during the period of silver eel migration influenced the seasonal pattern and route selection behaviour. An unusual feature of the regulated discharge was the extent of spillage at the Ardnacrusha dam, approximately equal to the quantity used by a single turbine, and the outage of one of the four turbines during the entire eel migration. High discharge (often >400m^3s^{-1}resulted in increasing spillage at Parteen weir as the season progressed. Since the proportion of the migrating eels passing via the Ardnacrusha that used the dam spillway was not known it was decided to adopt a precautionary approach and assume that all of them passed the dam via turbines. A mortality rate, used in previous years when no spillage took place at the hydropower dam, of 21.15% was applied. In the 2017/18 season the estimated silver eel mortality at the Ardnacrusha dam was 2.948t or 8.6% of production

5.4.2.4 Shannon Annual Silver Eel Production/Escapement

5.4.2.4.1 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 3.13). Records indicate that the silver eel catches in the 1920s were at least 60-70t.

5.4.2.4.2 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 ($B_{2001-2007}$) 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 3.13) using the more recent data of 17.8% as an average bypass and 21.1% turbine mortality (average 2009-2011).

5.4.2.4.3 Current 2009-2017

The current pattern of silver eel escapement has been well documented (McCarthy *et al.* 2010, 2011, 2012; MacNamara *et al.*, 2013) 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. 3.11 & 3.12). The sex ratio varied along the river with catches at upper sites being comprised predominately, or exclusively, of female eels (Fig. 3.12). 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, 2012a) and for 2012 to 2014 were reported to the EU in 2015 (Anon, 2015b) and are included in table (Table 3.13).

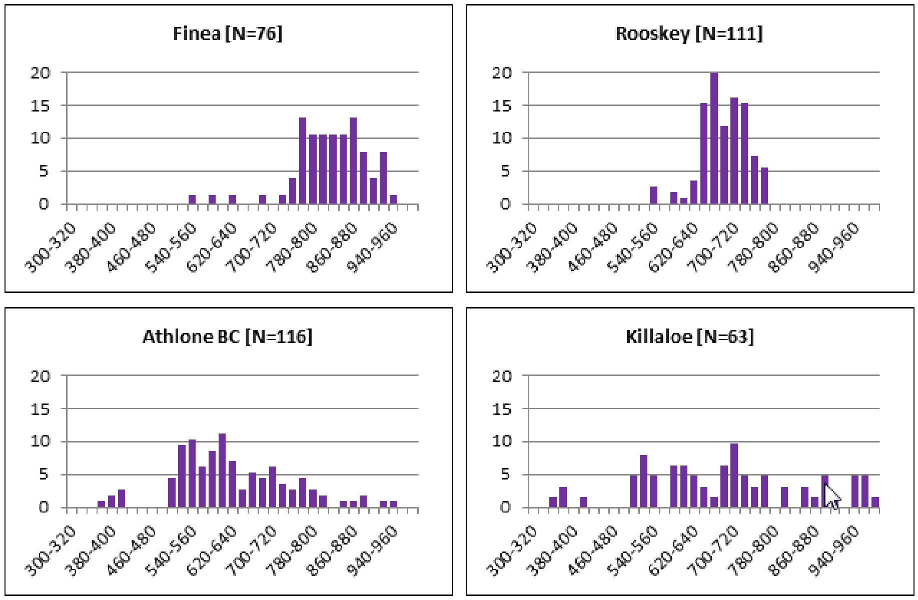


Figure 5-11: Length relative frequencies [%] of eels captured at River Shannon conservation fishing sites in the 2015 eel migration season.

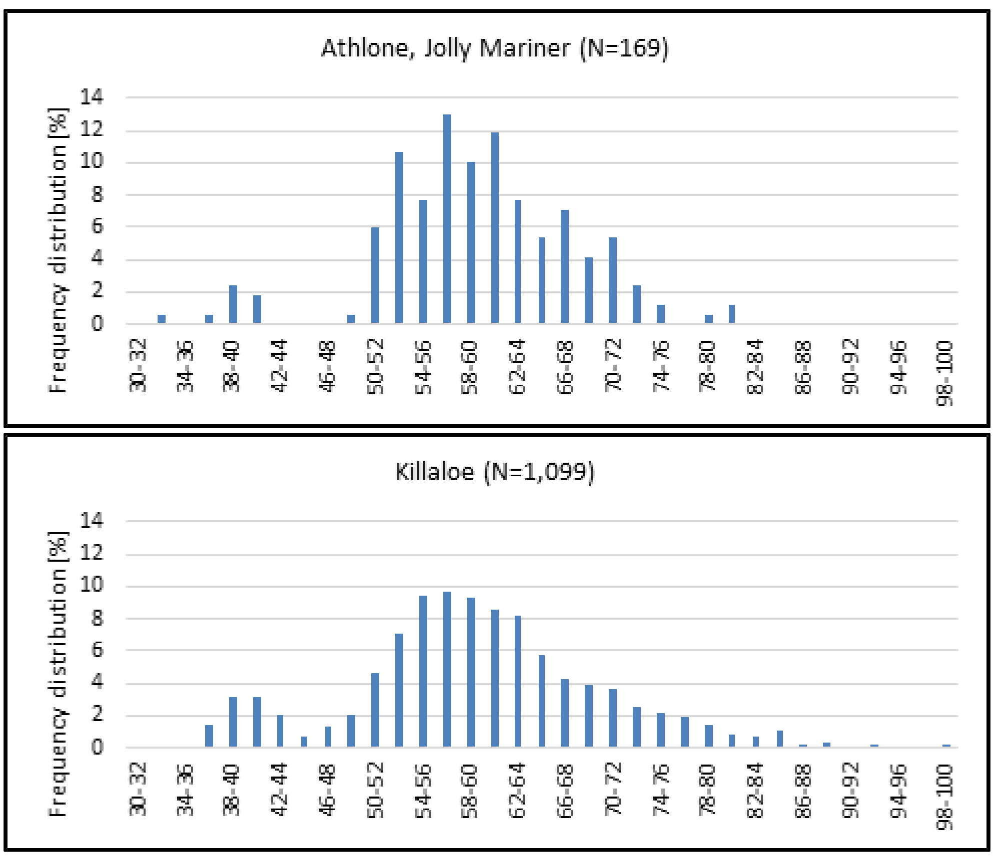


Figure 5-12: Relative size frequency distribution of eels sampled by NUIG, at Athlone and Killaloe in 2016/17 season.

The 2015 season results are presented in Figure 3.13. The problems presented by the extreme flooding and extended period of fishery closure in the 2015 silver eel migration season for more than 40 nights were addressed on the following basis. It was considered best to assume that the annual production, which has not varied greatly in recent years, could be represented by the 2014 estimate (70,725kg). Likewise, it was decided to use the previous year estimate of eel weir capture efficiency (25.5%) and the usual (21.15%) index of hydropower mortality for eels passing through Ardnacrusha HPS.

The Shannon was NOT used as an index station in 2015.

The 2016 season results are presented in Figure 3.14. The River Shannon discharge pattern during the 2016/17 fishing season was much lower than in previous years (Fig. 3.7). Low rain fall levels, general mild weather and low discharge conditions seem to have reduced silver eel migration at the Killaloe fishing site. NUIG carried out a series of six mark/recapture experiments and a total of 633 tagged eels were released up-stream of the nets to establish Killaloe weir fishing efficiency. In Table 3.5 a summary of the individual mark/recapture experiments results are presented. The overall percentage recapture rate was 28.80%.

Use of the standard protocol, adopted by NUIG, where one cumulative seasonal fishing efficiency value (28.8%) is assumed for all fishing events, resulted in a production estimate of 32,603 kg, an escapement estimate of 29,479 kg and total T&T contribution as a percentage of production of 51.26% (Fig. 3.14). This is less than 50% of the mean value estimated for the previous six years (71,405 kg; 2009-2014), in which the discharge patterns were higher and more constant at night throughout the season.

Because of the periodically interrupted Killaloe weir fishing during the 2016/2017 season, it was feared that some eels may have migrated downstream undetected. Therefore, by interpolating estimates of (missed fishing night potential catches) an estimated extra Killaloe weir of 1,730 kg catch was included in alternative production and escapement calculations. This resulted in estimates of production, escapement and T&T contribution as follows: Production 38,608 kg, escapement 32,920 kg and T&T contribution is 43.28%. Though this non-standard methodology is not intended to replace the scientific analysis presented in Figure 3.14, the results may be more appropriate for management purposes (e.g. discussions on T & T targets).

Table 5-6: Results of 2016/17 season mark/recapture experiments.

Date	Release [N=]	Recapture [N=]	Efficiency [%]	Discharge conditions
31/01/2017	152	12	7.89	Half night generation
24/02/2017	80	21	26.25	Interrupted generation
27/02/2017	100	35	35	Interrupted generation
02/03/2017	100	32	32	Constant generation
07/03/2017	100	39	39	Constant generation
13/03/2017	101	33	32.67	Constant generation
Total	633	172	28.8	

The 2017 season results are presented in Figure 3.15. The estimation of production involved records of daily catches at Killaloe weir which were used with results of floy-tagging / mark-recapture experiments. These data are used to estimate quantities of eels approaching the weir and those not caught which proceed downstream. In the 2017/2018 season a series of five tagging experiments were undertaken which involved release of 653 tagged eels and an overall recapture rate of 38.8%. This figure was used for eel weir efficiency in calculation of silver eel production, which was estimated to have been 34.139t. This low production level, which was comparable to the previous year, suggests that a collapse of the Shannon eel stock may be occurring though further years of monitoring would be needed to confirm such a trend. The reduced production level has implications for the T&T conservation work. In the 2017/2018 season the T&T represented 49% of production and was well above the EMP target of 30%. The higher than previously recorded efficiency recorded at Killaloe confirms the importance of this monitoring and eel conservation facility.

Contrary to expectations earlier in the season when spillage at Ardnacrusha was initially occurring, route selection to the old river channel represented almost 20% of the eels going downstream from Killaloe (Fig. 3.15). Dam mortalities were estimated at 2,948t. This is a precautionary overestimate as some eels would have taken advantage of the Ardnacrusha spillway route though we are not able to state definitively what quantities may have been involved. Ardnacrusha spillage occurred mostly in early season or when eel numbers were not at their peak. So its impact, whether positive due to spillway migration, or negative, due to reduction in Parteen spillage and in diversion of eels to the old river channel, may not have been as adverse as it might have been under different discharge regimes. Escapement, estimated as 31,191t, was 91.4% of production.

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. 3.16 & 3.17). The reduction in mortality from both the fishery and the HPS is evident along with an initial corresponding increase in escapement. The Shannon R. remains below the EU target. Falling production in 2016 and 2017 is a concern.

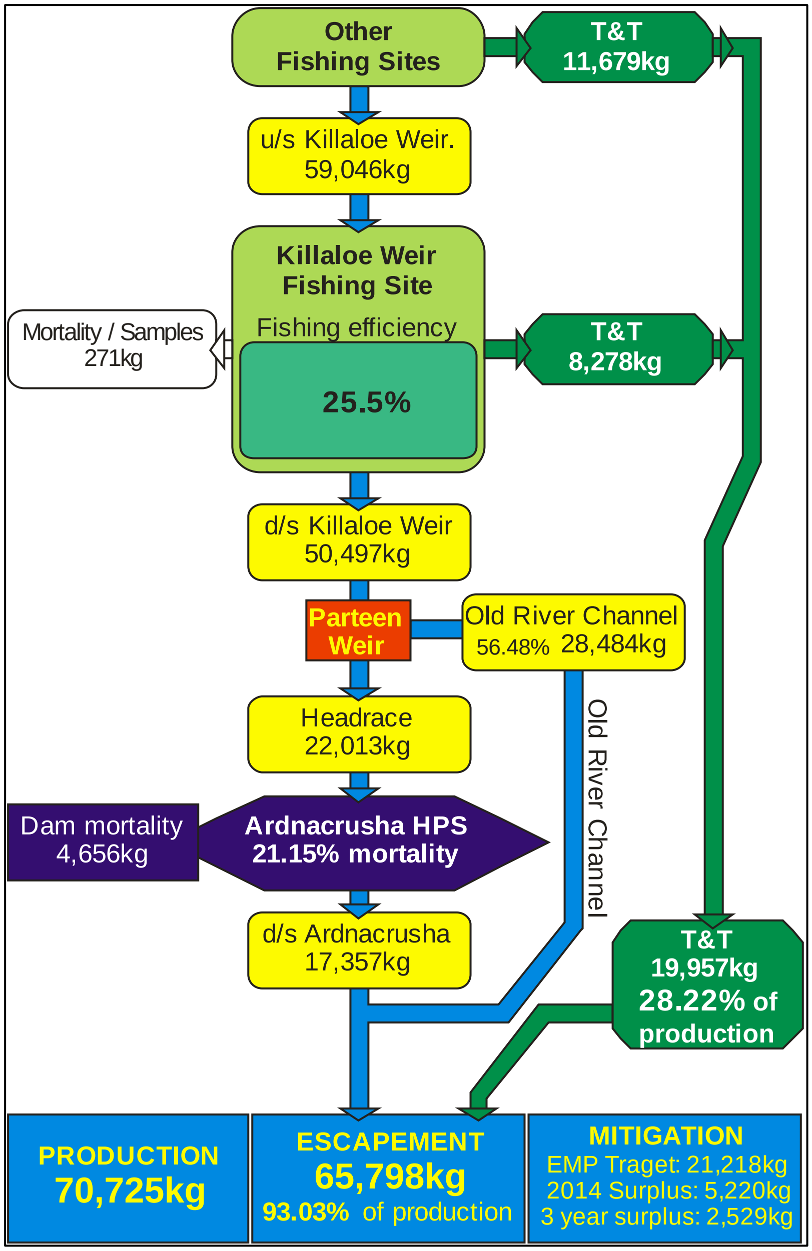


Figure 5-13: Summary silver eel biomass production and escapement estimate for River Shannon system 2015/2016.

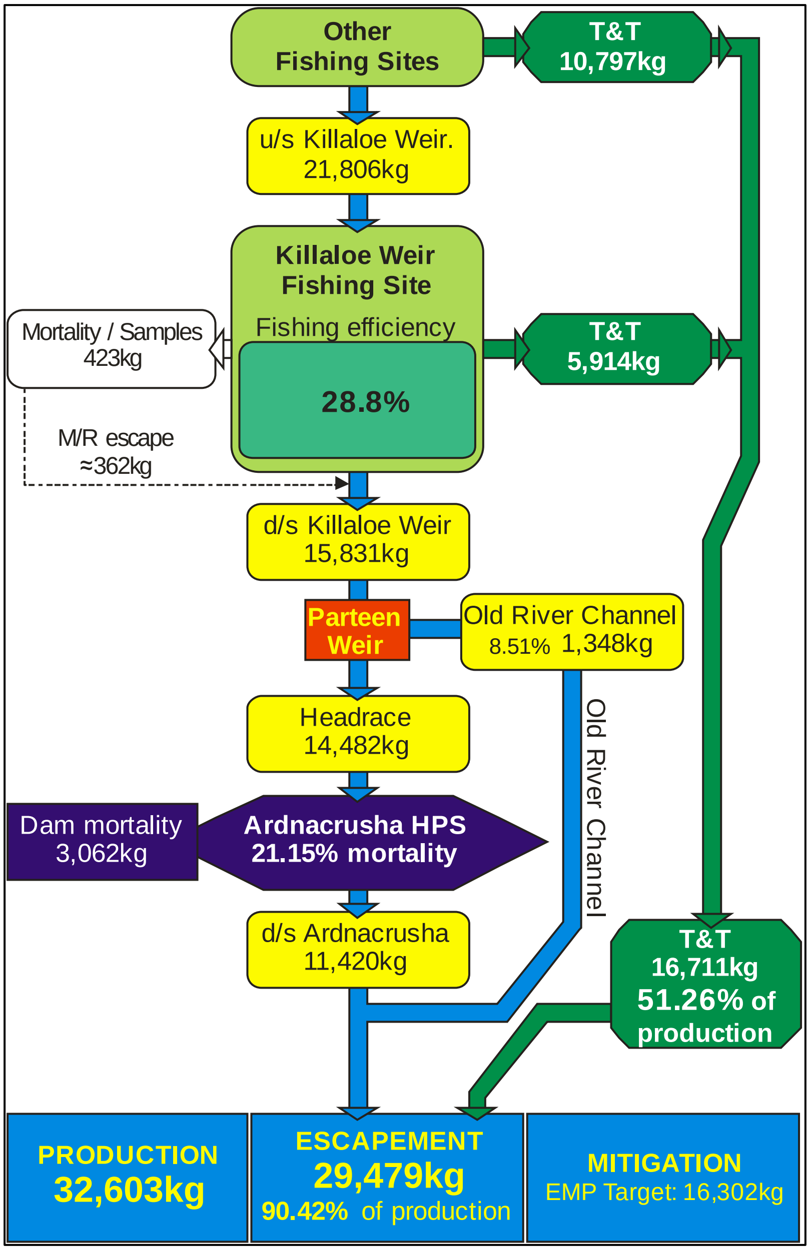


Figure 5-14: Summary silver eel biomass production and escapement estimate for River Shannon system 2016/2017.

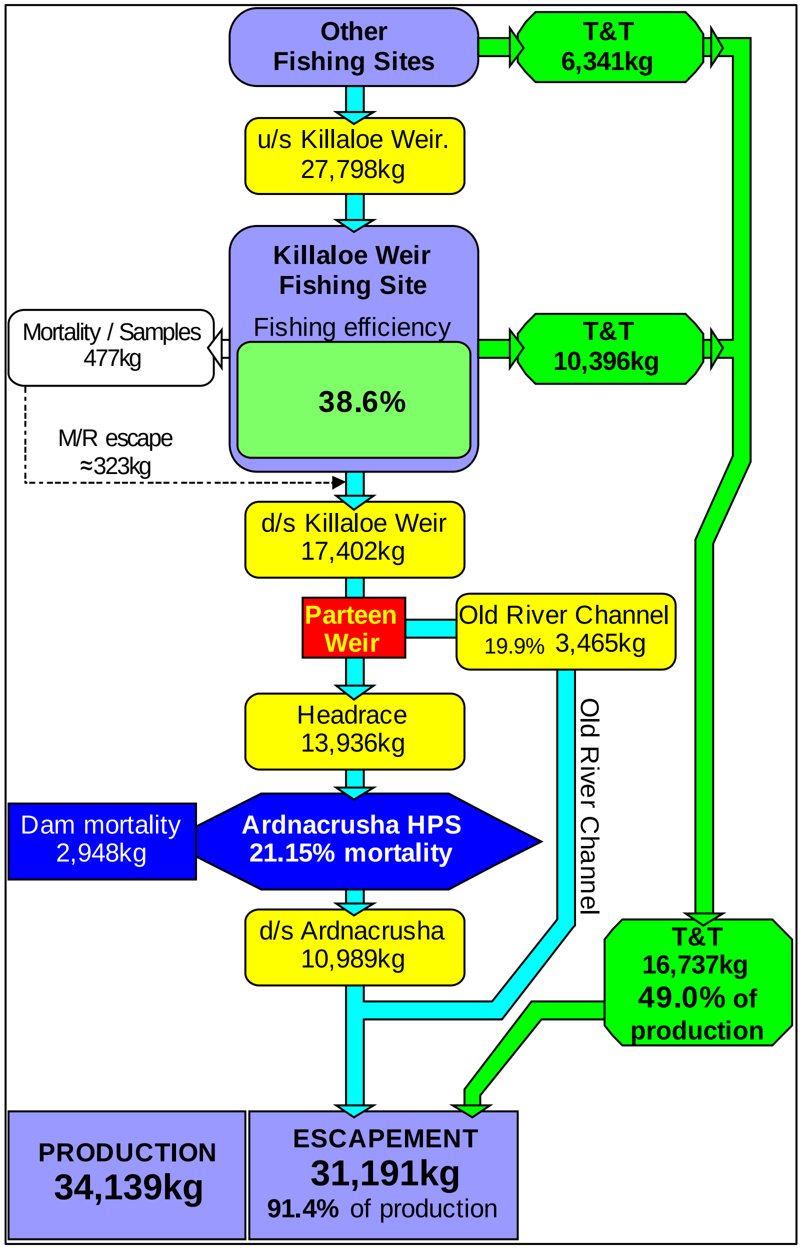


Figure 5-15: Summary silver eel biomass production and escapement estimate for River Shannon system 2017/2018.

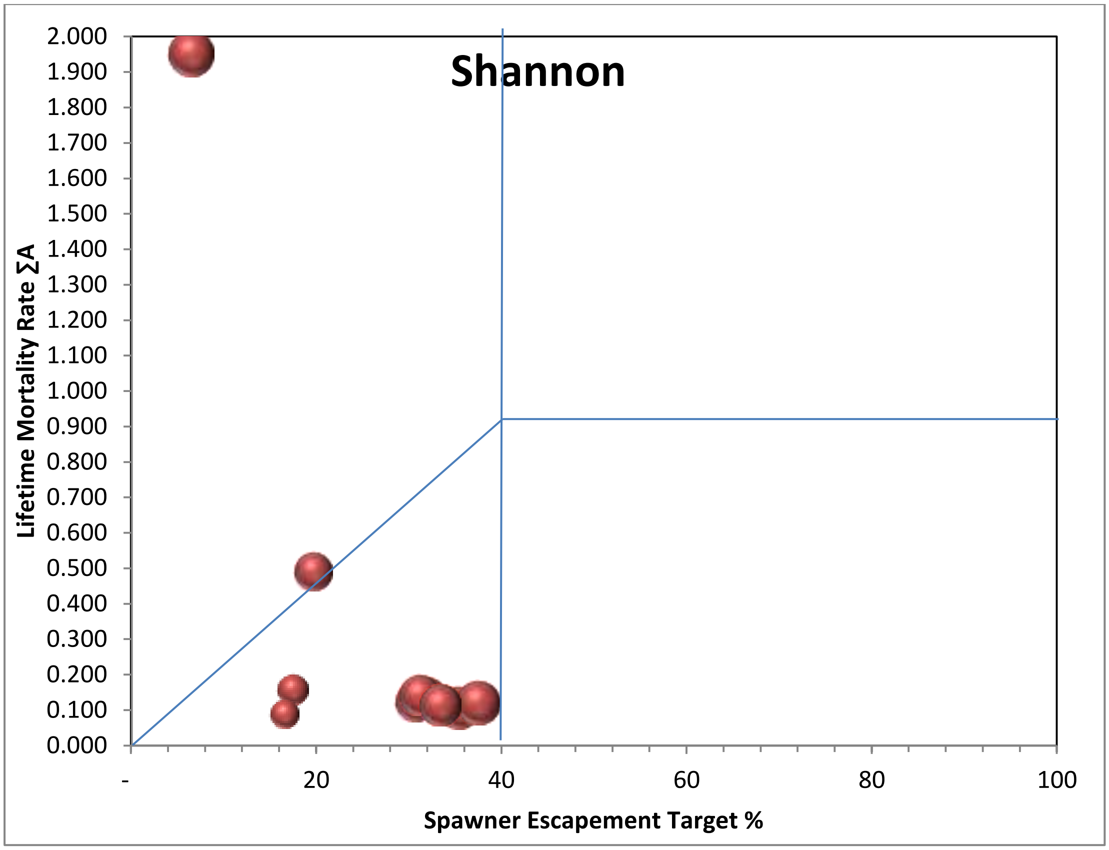


Figure 5-16: Status of the stock and the anthropogenic impacts, for the <u>Shannon</u> as presented in the Eel Management Plans for the average 2001-2007, in 2008 and for the current years, 2009-2017. For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement 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.

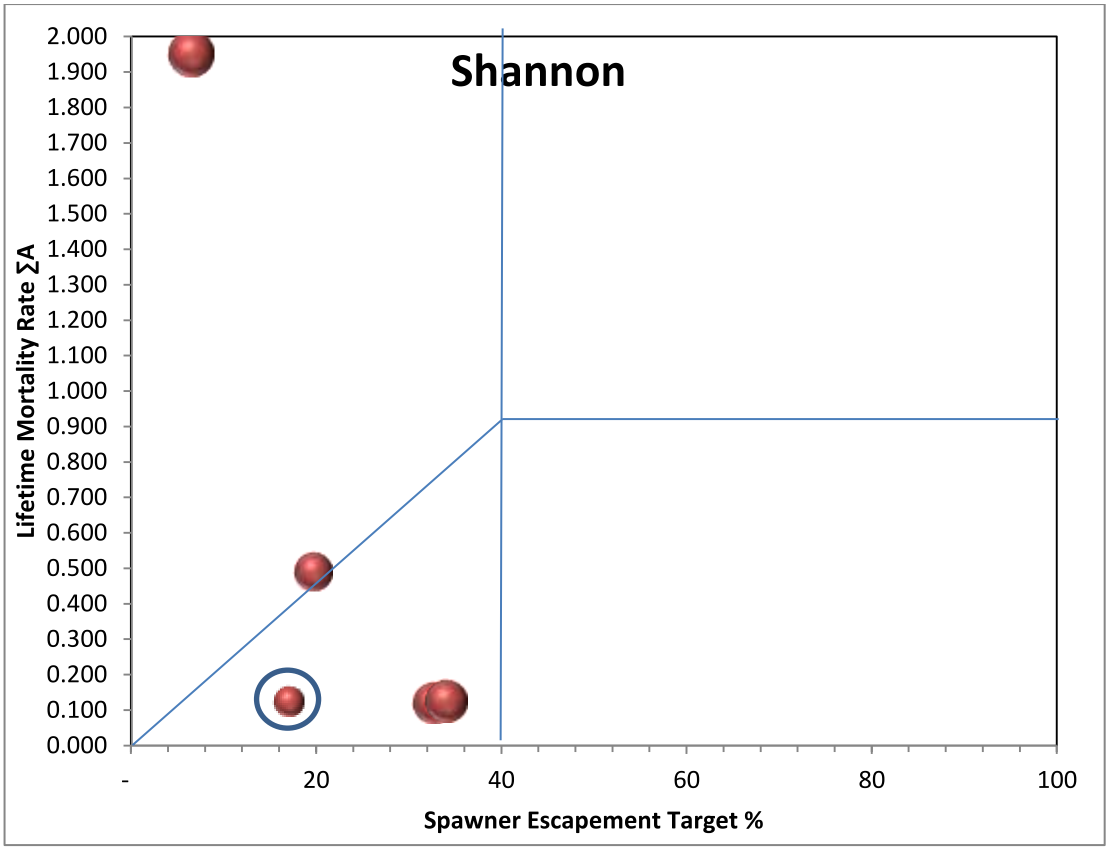


Figure 5-17: Status of the stock and the anthropogenic impacts, for the River Shannon as presented in the Eel Management Plans for the average 2001-2007, for 2008 and for the averages 2009-2011, 2012-2014 and 2015-2017 (circled).

5.4.3 Erne Transboundary

5.4.3.1 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 to be 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. 3.18 & 3.19). 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.

This system of transporting 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 was carried forward into the 2015-2017 reporting period.

Figure 5-18: River Erne hydroelectricity generating stations (A) Cliff HPS and (B) Cathaleen's Fall HPS.

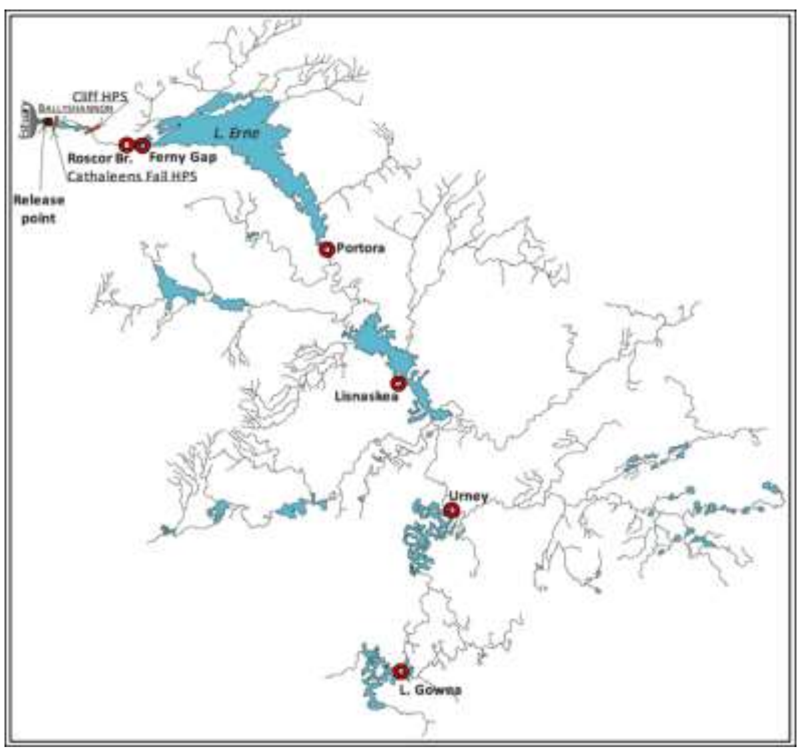


Figure 5-19: Conservation fishing sites in the River Erne system, monitored by NUIG, in 2009-2017 seasons with some small alterations in locations between years.

5.4.3.2 Erne Annual Catch

The analysis of downstream migrating silver eel population dynamics was complicated in 2009 by; a 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 and through into the 2015-2017 period, 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.

For the 2015 season, the fishing activities of River Erne contract crews at the seven authorized fishing sites (Fig. 5.3.9) were all monitored by NUIG in 2015, though additional scientific studies were undertaken at Roscor Bridge and Urney. The fishing season on the Erne started on 29th August and finished on 15th December 2015 (with the exceptions of the Roscor Bridge and Urney experimental weir). The percentage contributions to the trap and transport programme in 2015 from each of the fishing sites are indicated in Figures 3.26, 3.27 & 3.28. Four sites (Urney, Portora, Ferny Gap and Killashandra) cumulatively contributed 78.75% of the total catches for 2015. The total catch amounted to 54,706kg.

The variation in Roscor Bridge experimental fishing weir daily catches is illustrated (Fig. 3.20 in relation to lunar cycles and variation in discharge. The fishing season at Roscor Bridge extended from 6th October 2015 to 13th January 2016 and a total of 67 nights were fished at that location. Fishing at the other sites ended at the beginning of December 2015.

NOTE: In addition to the EMP 50% T&T target (39,017kg), additional mitigation measures for potential future losses of silver eel production that might result from a 112.5kg elver loss at Ballyshannon in 2014 were addressed by ESB in the 2015 season. Thus, ESB purchased 8,450kg of silver eels from the L. Neagh Eel Fishermen's Cooperative Society Ltd which were then released to the lower River Bann and allowed to migrate freely to sea. These eels are not included in the current River Erne analysis. However, the mitigation agreement also required ESB to increase T&T activities so that, prior to 2018, an additional 11,000kg of River Erne would be trapped and released (i.e. in addition to the annual 50% targets). The 2015 T&T programme, which involved additional fishing effort and increased efficiency of capture at several sites, resulted in a surplus of 15,689kg. Thus the normal (50%) 2015 target and the additional mitigation targets (8,450kg River Bann release and 11,000kg extra River Erne release) were all fully achieved. In addition, a small surplus 4,689kg was achieved which can contribute to the ongoing 3-year rolling average calculation protocol used to monitor the annual 50% T&T mitigation actions on the river system.

For the 2016 season, six conservation fishing crews were operating on the River Erne system. The fishing period extended from 19th September 2016 until 10th January 2017, with the exception of two sites: Urney and Roscor Bridge which continued fishing until 8th February. The total catch contributed to the T&T programme was 38,264 kg. The proportions of the catch obtained by each fishing crew are presented in Figure 3.27. The variation in the Roscor Bridge experimental fishing weir daily catches is illustrated (Fig.

3.21) in relation to lunar cycles and variation in discharge. The fishing season at Roscor Bridge extended from 29th September 2016 to 8th February 2017, with a total of 85 nights being fished. The cumulative discharge level (Fig. 3.21) observed during the fishing season was much lower (50%) than in previous seasons, which significantly influenced catch levels and seasonal catch distribution.

For the 2017 season, the conservation fishing on the River Erne was undertaken at six sites. The fishing sites included ones located in the upper, middle and lower sections of the river catchment area. The fishing season began on 01/09/17 and extended to 06/12/17. However, on scientific advice ESB extended authorization for fishing at the two lowermost sites (Ferny Gap and Roscor Bridge) until 20/12/17. The total catches from the 6 fishing sites contributed to the ESB T&T conservation action in the season was 39,916kg plus 3,553kg caught at Roscor.

The eel population structure at Ferny Gap (Fig. 3.19) has been shown in previous years to vary between nets and between months. In the 2017/2018 a sample (n= 105) was examined from the navigation nets and the results are presented as a size frequency distribution in Figure 3.23. The eels were mainly females (92.38%), which varied from 454mm to 1015mm. The mean female size was 737.67mm.

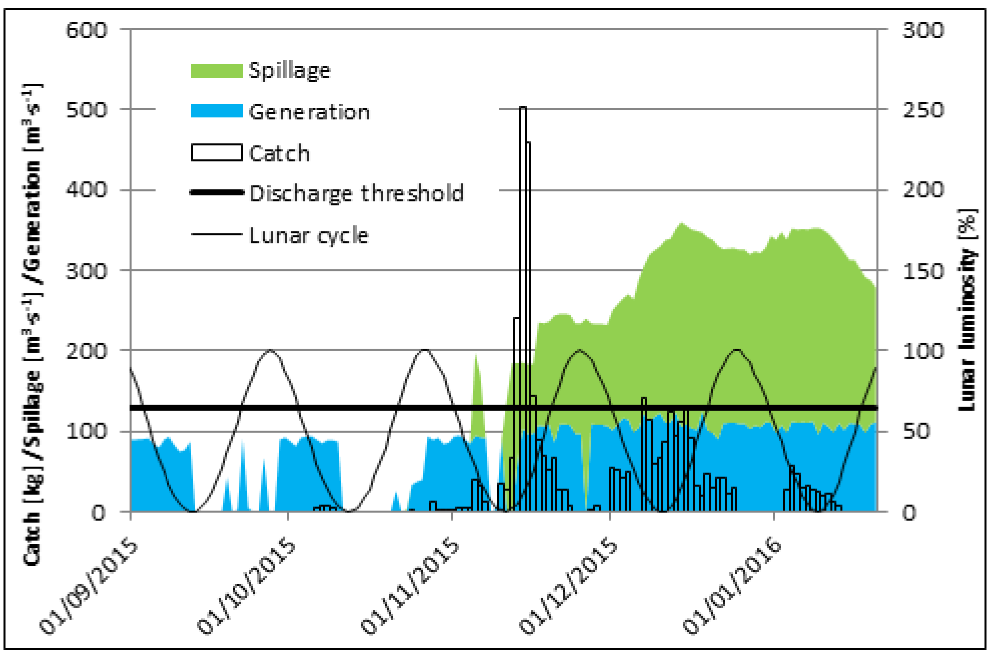


Figure 5-20: Variation in daily catches at the Roscor Bridge eel weir in relation to lunar cycle and discharge during 2015 season (the threshold discharge of 130 $m^3 \cdot s^{-1}$ used in population analyses is indicated by a black line). Lunar luminosity.

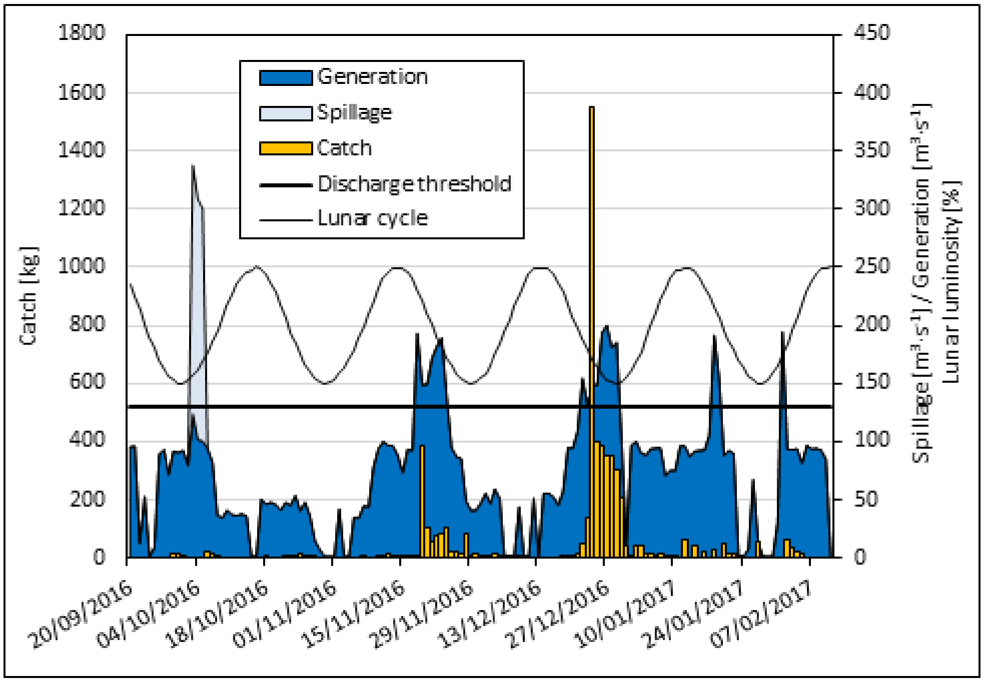


Figure 5-21: Variation in daily catches at the Roscor Bridge eel weir, in relation to lunar cycle and discharge during the 2016/17 season (the threshold discharge of 130 m^{3s-1} used in population analyses is indicated by a black line).

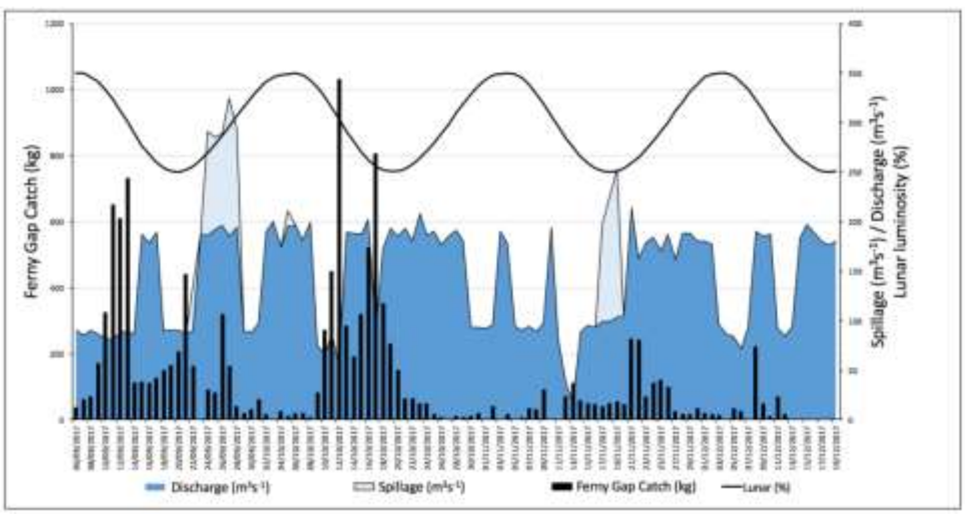


Figure 5-22: Variation in daily catches at the Ferny Gap fishing site, in relation to lunar cycle and discharge during the 2017/2018 season (the threshold discharge of 130 m^3s^{-1} used in population analyses is indicated by a black line).

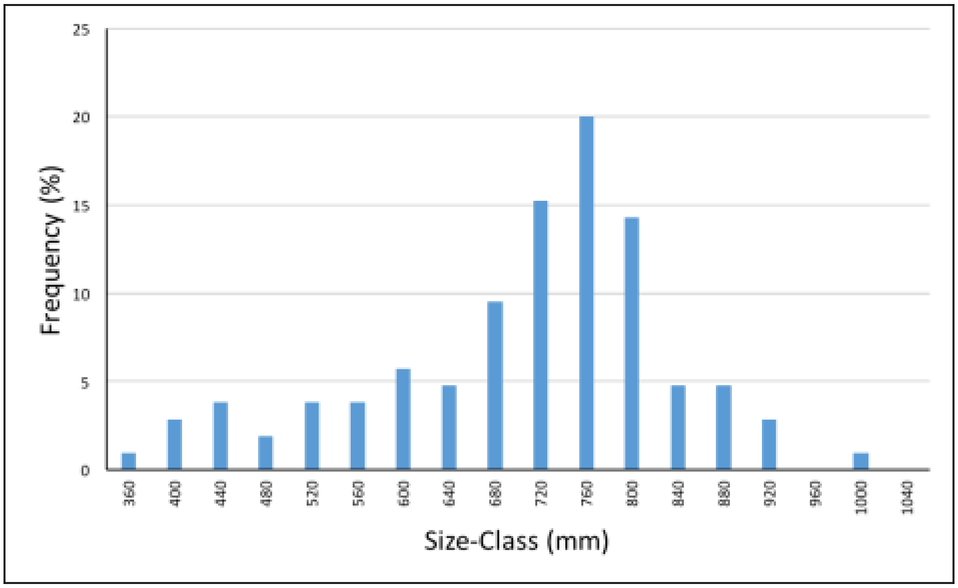


Figure 5-23: Relative size–frequency distribution of eels from Ferny Gap fishing site 14/12/17 (N=105).

5.4.3.3 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. 3.24) 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.

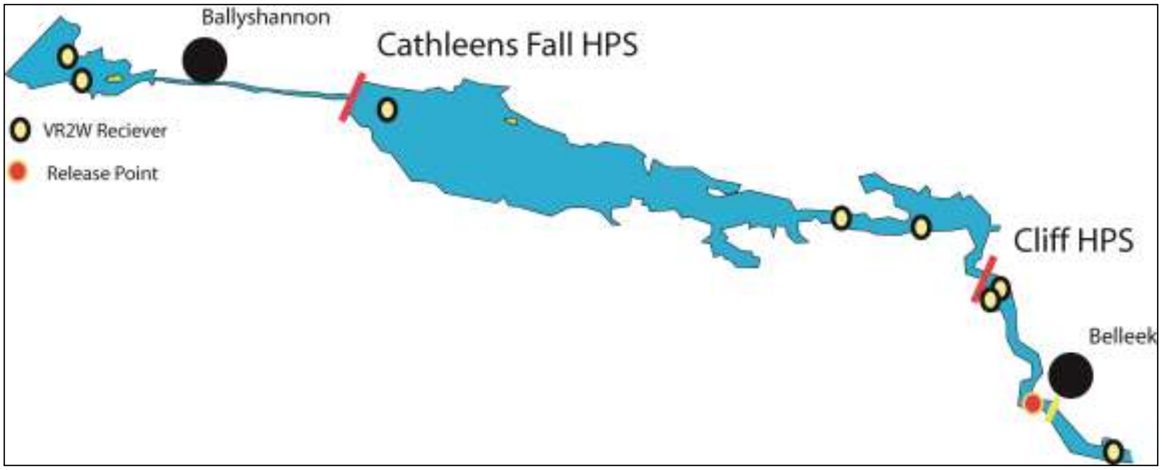


Figure 5-24: Location of telemetry receivers to track silver eels in the Lower River Erne area (2009-2012).

During the 2015 silver eel season the patterns of generation and spillage at the River Erne hydropower stations were unusual, because of high rainfall and discharge. 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 2015 season mortality rates were applied as follows: ***Cliff HPS*** 0% (no flow or only spillage); 7.9% (Generation plus spillage) and 26.7% (Only generation), ***Cathaleen's Fall HPS***: 0% (no flow or 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 8.1% mortality of the total River Erne silver eel production, or 27.2% of the migrating eel (not including the trapped and transported component) at the two dams during 2015.

During the 2016/17 silver eel migration season the discharge in the lower River Erne was exceptionally low. This impacted directly on the pattern of silver eel migration, causing seasonal delays, and indirectly via the pattern of hydropower generation at the two dams. Nocturnal electricity generation was frequently interrupted due to low water levels, as well as an increasing reliance on wind generation for electricity supply to the national grid. Spillage levels were very low for the entire 2016/17 season. For the 2016/17 season mortality rates applies as follows: ***Cliff HPS*** 0% (no flow or only spillage); 7.9% (Generation plus spillage) and 26.7% (Only generation), ***Cathaleen's Fall HPS***: 0% (no flow or only spillage); 7.7% (spillage plus half generation load); 15.4% spillage plus full generation load); 27.3% (only generation). It was estimated that the cumulative mortality represented 18.3% mortality of the total River Erne silver eel production or 46.7% of the migrating eels reaching the dams during the season. Estimated mortality at the dams was 11,494kg in 2016/'17 calculated using the cumulative mark/recapture method, or 8,204kg when calculated using four individual mark-recapture experiments.

During the 2017/18 silver eel migration season the discharge in the lower River Erne was more typical than in the previous year and nocturnal electricity generation was not generally interrupted due to low water levels. Spillage levels were very low for the entire 2016/17 season.

For the 2017/2018 season mortality rates that were applied were as follows: ***Cliff HPS*** 0% (no flow or only spillage); 7.9% (Generation plus spillage) and 26.7% (Only generation), ***Cathaleen's Fall HPS***: 0% (no flow or only spillage); 7.7% (spillage plus half generation load); 15.4% spillage plus full generation load); 27.3% (only generation).

It was estimated that the cumulative mortality represented 14.9% mortality of the total River Erne silver eel production or 40.5% of the migrating eels reaching the dams during the season. The estimated mortality at the dams was 10,271kg in the 2017/201migration period.

5.4.3.4 Erne Annual Silver Eel Production/Escapement

5.4.3.4.1 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 3.13).

5.4.3.4.2 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 ($B_{2001-2007}$) 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 3.13) using 7.7% (Cliff HPS) and 6.9% (One turbine at Cathaleens Fall HPS) turbine mortality (average 2010-2011).

5.4.3.4.3 Current 2009-2017

The production and escapement estimates for 2009 to 2011 were reported to the EU in 2012 (Anon, 2012a; 2015b) and are included in table (Table 3.13).

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 The silver eel production was estimated as 67,666kg and escapement was estimated to be 57,366kg (84.8% of production).

The 2013 season 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 2014 season 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 2015 season River Erne results are summarized in Figure 3.26. The silver eel production was estimated by NUIG as 78,034 kg and escapement was estimated to be 71,650 kg (91.8% of production). The trap and transport total (54,706 kg) represented 70.1% of silver eel production and exceeded the target (50%) by 15,689 kg. The 2015 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 7 mark-recapture experiments (7 batches of pit-tagged eels, N=700) were undertaken at Roscor Bridge. Batches of marked fish were released at dusk at the established release point upstream. All seven batches were released in high flow (>130 $m^3 \cdot s^{-1}$). The mean efficiency of the Roscor Bridge index nets was therefore estimated to have been 16.3% in high flow conditions during this season. The low flow (<130 $m^3 \cdot s^{-1}$) weir efficiency experiment was not possible due to persistent high discharge in this season; 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. Using catch data for this site and for the upstream sites, the silver eel production for the River Erne was calculated (Fig. 5). In the 2015 season the production was estimated to have been 78,034 kg.

The lower than expected capture efficiency (16.3%) observed at Roscor Bridge during the 2015 season seems to be due in part to the extreme rainfall which resulted in extensive river flooding and above average lake levels. It is also thought that the intensification of fishing at the Ferny Gap site, which contributed 39% (21,300kg) of the total T&T for the season, may have impacted on Roscor Bridge fishing because of increased quantities of floating debris. However, the low 2015 catch level (Fig. 3.20) at Roscor Bridge also reflected the overall impact of increased upstream fishing pressure.

The T&T annual target (50% of silver eel production) for the River Erne was exceeded in the 2015 season (Fig. 3.26). The quantity (54,706kg) transported for safe release at Ballyshannon represented 70.1% of the estimated silver eel production (78,034kg) for the river system for the season. In addition to the EMP 50% T&T target (39,017kg), additional mitigation measures for potential future losses of silver eel production that might result from a 112.5kg elver loss at Ballyshannon in 2014 were addressed by ESB in the 2015 season. Thus, ESB purchased 8,450kg of silver eels from the L. Neagh Eel Fishermen's Cooperative Society Ltd which were then released to the lower River Bann and allowed to migrate freely to sea. These eels are not included in the current River Erne analysis. However, the mitigation agreement also required ESB to increase T&T activities so that, prior to 2018, an additional 11,000kg of River Erne would be trapped and released (i.e. in addition to the annual 50% targets). The 2015 T&T programme, which involved additional fishing effort and increased efficiency of capture at several sites, resulted in a surplus of 15,689kg. Thus the normal (50%) 2015 target and the additional mitigation targets (8,450kg River Bann release and 11,000kg extra River Erne release) were all fully achieved. In addition, a small surplus 4,689kg was achieved which can contribute to the ongoing 3-year rolling average calculation protocol used to monitor the annual 50% T&T mitigation actions on the river system. The total estimated hydropower mortalities (6,333kg) represented 8.1 % of silver eel production and the escapement to sea (71,650kg) was estimated to have been 91.8% of production (Fig. 3.26).

The 2016 season River Erne results are summarized in Figure 3.27. The silver eel production was estimated at 62,871 kg, and escapement was estimated to be 51,377 kg (81.7% of production). The trap and transport programme catch of 38,264 kg represents 60.9% of silver eel production (exceeding the 50% of target by 6,829 kg).

The 2016/17 season calculations are based on the production estimations at Roscor Bridge, as in NUIG protocol described in the 2012 report. Four mark/recapture experiments were conducted by NUIG researchers, two in high (>130 m3/s) and two in low (<130 m^3/s) discharge conditions, indicating fishing weir efficiency to be 23.17% and 13.85% respectively. Use of these limited mark/recapture experimental results would estimate production to have been 55,827 kg (T&T 68.5%; Escapement 47,623kg).

However, because the Roscor Bridge weir fishing techniques and equipment used has remained consistent, it was decided that use of cumulative mark/recapture results obtained at this site since the 2010 season (Table 3.6) would enable a more robust analysis to be undertaken. These cumulative fishing efficiency estimates were used to estimate the production results presented in Figure 5.16. The cumulative mark/recapture fishing efficiency estimates were used, together with index nets catch and hydrometric data, to calculate the biomass of eels approaching Roscor Bridge for each fishing date. Overall HPS (both dams) mortality rate for the season was 20% higher than in previous years. This was a result of minimal water spillage throughout the fishing season.

Table 5-7: Cumulative Roscor Bridge mark/recapture results obtained in seven subsequent fishing seasons, from 2010/11 to 2016/17.

Low Flow Conditions [< 130 $m^3 \cdot s^{-1}$]		High Flow Conditions [> 130 $m^3 \cdot s^{-1}$]	
No. of M/R experiments	6	No. of M/R experiments	27
No. of fish tagged	526	No. of fish tagged	2720
No. of recaptures	53	No. of recaptures	495
Fishing efficiency	**9.78%**	Fishing efficiency	**18.43%**

The 2017 season River Erne results are summarized in Figure 3.28. Quantification of eel spawner biomass escapement and production has previously relied on Lower R Erne catch data estimates of fishing site efficiency. Fishing at Roscor Bridge was delayed in the early part of the 2017 eel season and the crew declined to facilitate scientific monitoring and tagging at the site. In the absence of catch data, one option for assessment of compliance with EMP targets is a method based on modeling. The Roscor Bridge difficulties lead to development of a model, using catch data from a nearby (Fig. 3.25) extensive fishing site (Ferny Gap) and environmental variables to predict daily catches at Roscor Bridge. The type of model chosen was a Generalized Additive Model (GAM) which can incorporate non-linear relationships and offer an objective way to predict eel abundance or biomass. GAMs require no a priori information on the functional relationship between the response variable (Roscor Bridge catch) and the explanatory variables. Data from 2011 to 2017 was included in the model, with two-thirds of the data used to fit the model while the remaining one-third was used to evaluate the accuracy of model predictions. Final fitted model performance was evaluated by predicting Roscor Bridge catch at each of the data points in the test data set, given the catch at the Ferney Gap and the environmental factors at that point. Predicted catch and observed catch values were highly correlated (Pearson's $r = 0.88$, $p<0.001$), and 91% of observed daily catches fell within the range of predicted catch (± 95% C.I.). Based on this result it was decided to use the River Erne GAM to predict catch for the entire season 2017/2018 at Roscor Bridge. The model was used to make daily predictions of catch and when summed for the entire season this amounted to 4,248kg. The incomplete season catch recorded at Roscor Bridge in the 2017/2018 season was 3,553kg, all of which was included in the T&T releases. The River Erne GAM predicted a cumulative catch of 3,687kg for this incomplete fishing period.

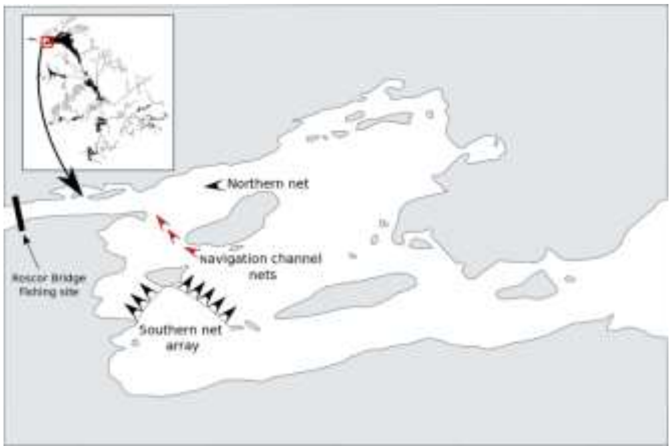


Figure 5-25: Map of the Ferny Gap with location of net arrays marked.

Daily GAM predicted catches were used, together with information gained in previous years on Roscor Bridge fishing efficiency (low discharge efficiency = 9.78% and high discharge efficiency = 18.43%) to calculate the biomass of eels migrating to the fishing site and downstream to the dams. The threshold discharge of $130 m^3 s^{-1}$ was used in distinguishing between high and low discharge levels at Roscor Bridge. Silver eel production (68,810kg) was estimated by combining the estimated biomass approaching Roscor Bridge (28.894t) with the upstream T&T (39,916kg). The cumulative full season biomass approaching the dams was 25,341kg. Hydropower mortalities, assigned on a nightly basis, were estimated using results of telemetry undertaken in previous years (detailed in previous Country Reports). The combined mortalities estimated for the two dams was 10,271kg in the 2017/2018 season. The total T&T biomass was 43,469kg, which was 63.2% of production. Spawner escapement biomass was estimated to have been 58,539kg, which was 85.1% of production. The summary details for the River Erne 2017/'18 are presented in Figure 3.28.

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 and 2015-2017.

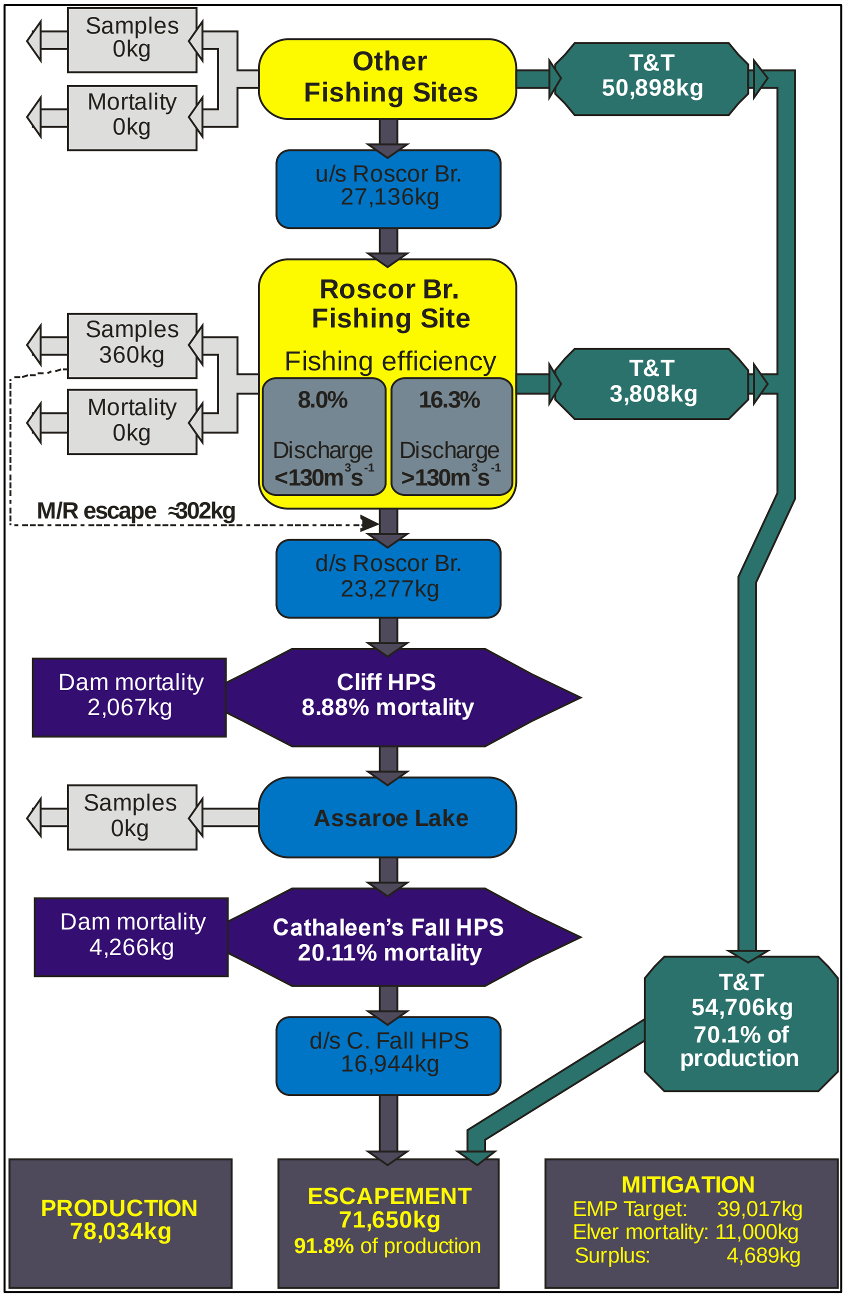


Figure 5-26: Summary silver eel biomass production and escapement estimate for River Erne system 2015/2016.

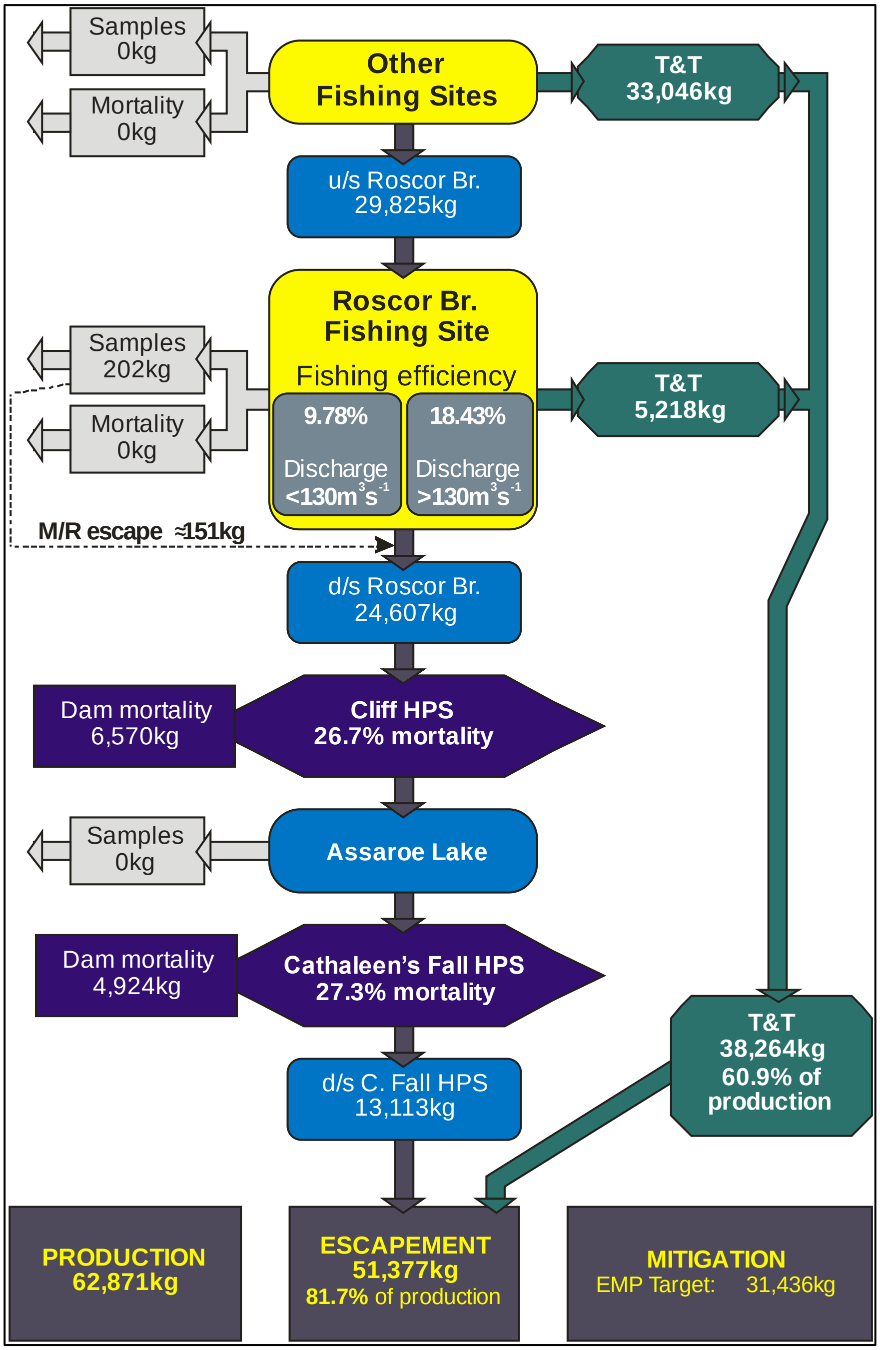


Figure 5-27: Summary silver eel biomass production and escapement estimate for River Erne system 2016/2017.

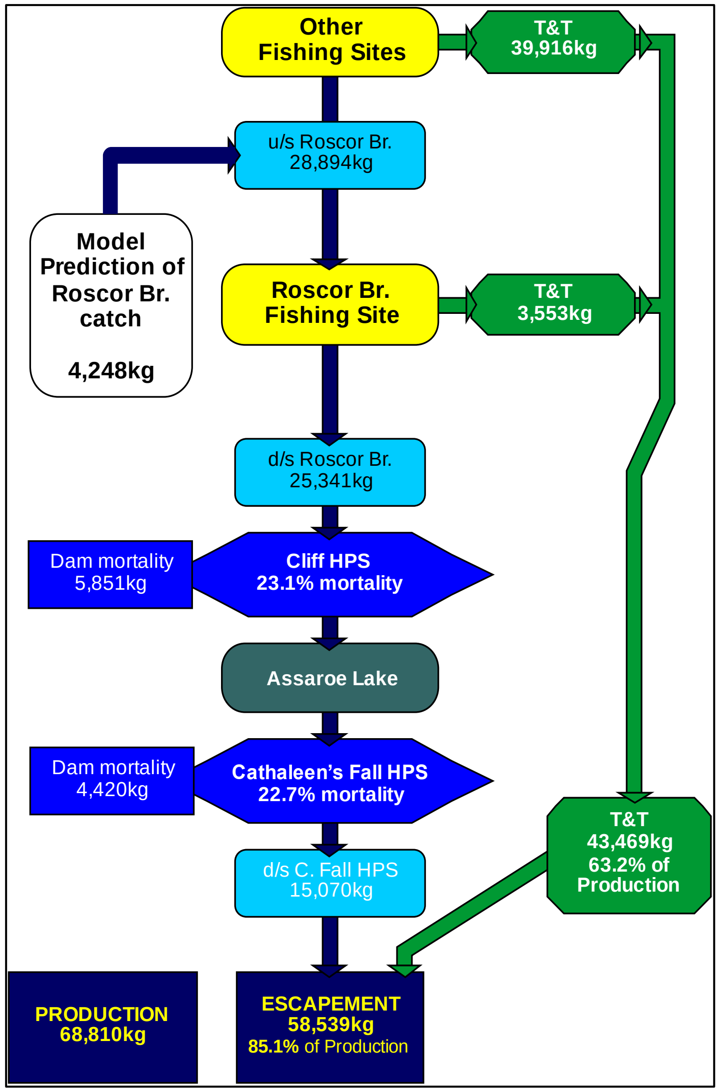


Figure 5-28: Summary silver eel biomass production and escapement estimate for River Erne system 2017/2018.

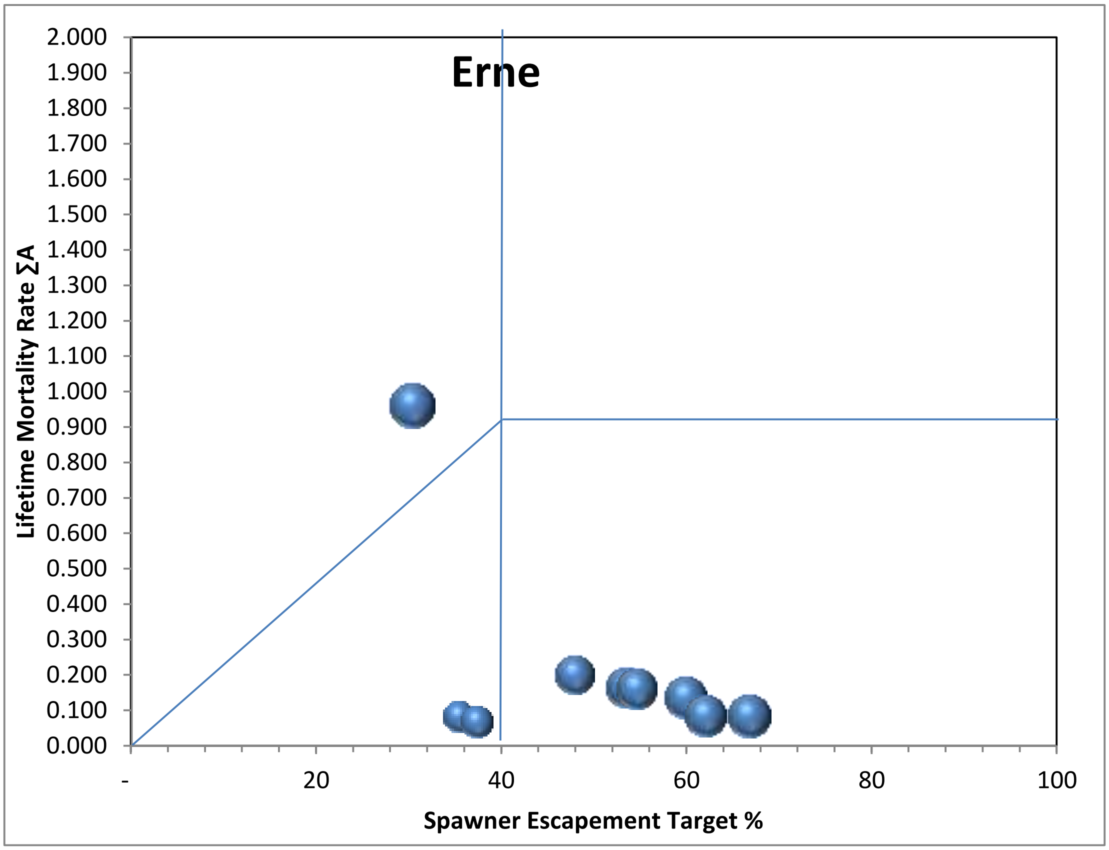


Figure 5-29: Status of the stock and the anthropogenic impacts, for the River Erne as presented in the Eel Management Plans in 2008 (average 2001-2007) and for the years 2010 to 2017. For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement given the recent 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.

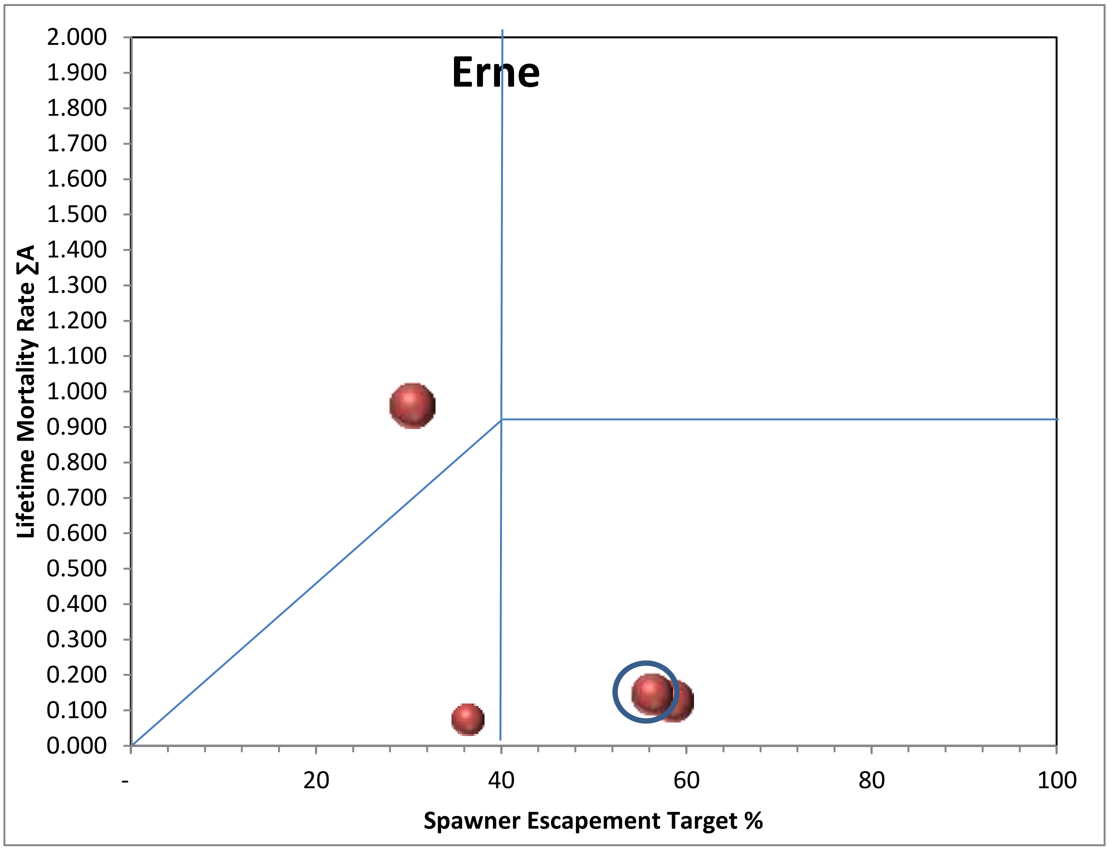


Figure 5-30: Status of the stock and the anthropogenic impacts, for the River Erne as presented in the Eel Management Plans for the average 2001-2007, and for the averages 2010-2011, 2012-2014 and 2015-2017 (circled).

5.4.4 Burrishoole

5.4.4.1 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; Sandlund *et al*. 2017; Poole *et al*. 2018); 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).

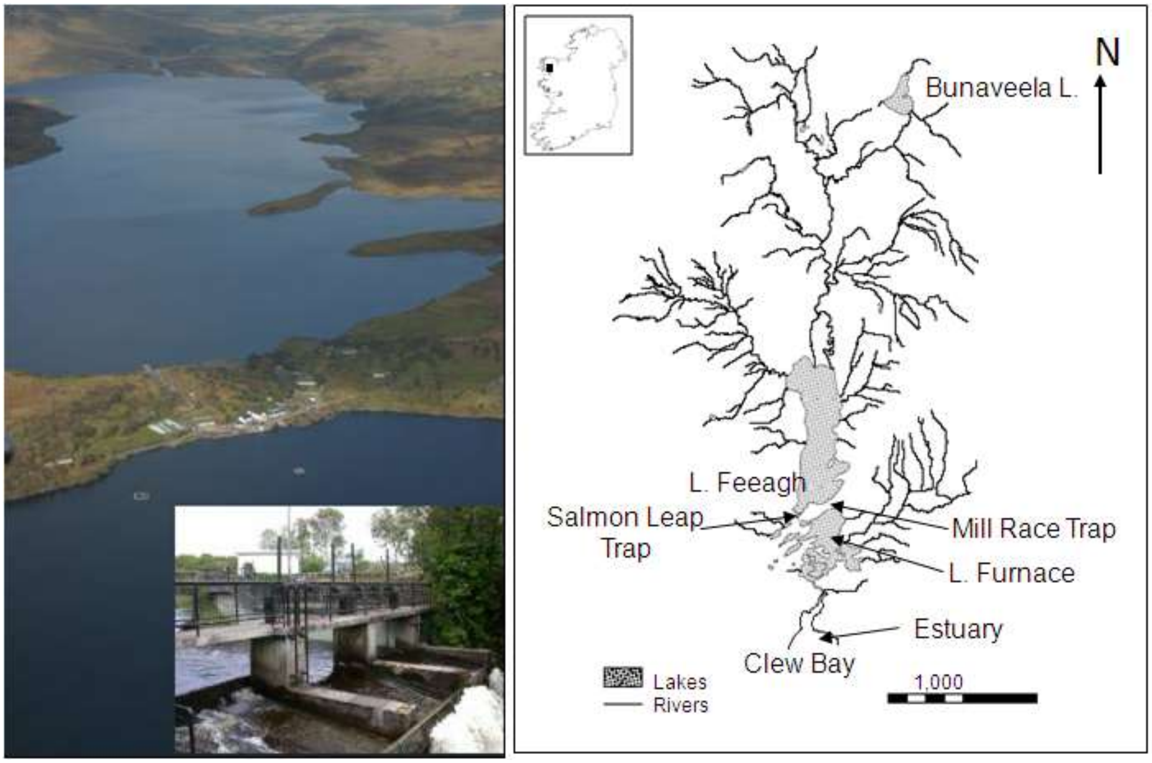


Figure 5-31: An aerial view of the Burrishoole catchment, looking north over the tidal Lough Furnace, in the foreground, and the freshwater Lough Feeagh: inset shows the silver eel downstream trap at the "Salmon Leap". A map of the Burrishoole catchment showing the locations of the silver eel traps at the lower end of the freshwater catchment.

5.4.4.2 Burrishoole Annual Catch

Operation of the downstream trapping in Burrishoole was continued for the period 2015 to 2017. The counts for the 2009 to 2014 period were reported previously (Anon, 2012a, 2015b).

In the 2015 season, the timing of the run was different to the general pattern, with 31% migrating in October and 32% migrating in November. Figure 3.32 shows the daily counts of silver eels with the water level. The total run amounted to 1073 eels. The highest proportion of the total catch (79%) was made in the Salmon Leap trap.

In the 2016 season, the timing of the run was different to the general observed pattern. The silver eel season was characterised by the lack of any major floods or storm events. The eels migrated on small floods and flow rates were easy to manage. The highest floods of the year were in February and March 2017 once the main migration was over. Figure 3.32 shows the daily counts of silver eels. The total run amounted to 2728 eels, more than double that recorded in 2015. The highest proportion of the total catch (80%) was made in the Salmon Leap trap.

In the 2017 season, the total run amounted to 2208 eels, lower than recorded in 2016. The silver eel season in 2017 was characterised by the lack of any major floods or storm events (Fig. 3.32). The eels migrated on small floods and flow rates were easy to manage. In 2017, the timing of the run was 15% migrating in August, 31% in September and 40% in October. 90% of the run was completed by the end of October.

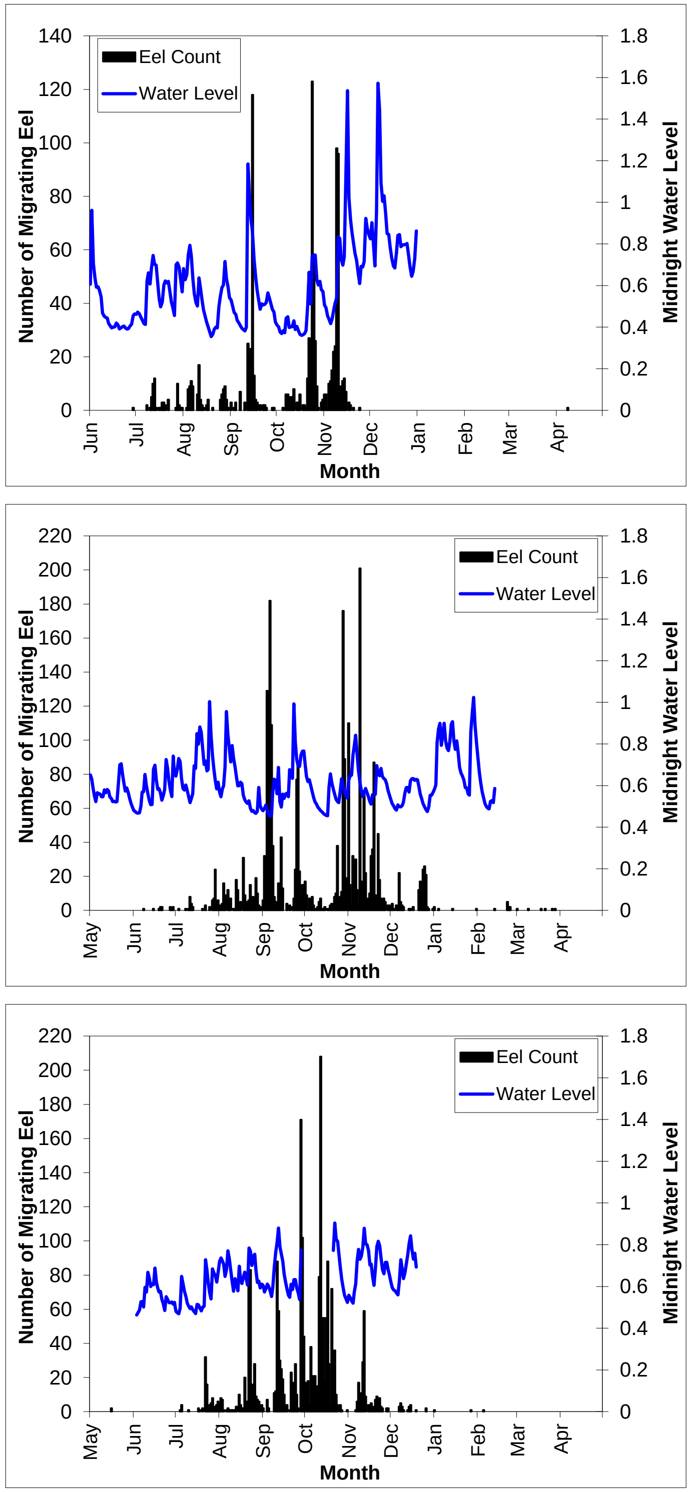


Figure 5-32: Daily counts of downstream migrating silver eel in the Burrishoole, 2015 (top) to 2017 (bottom).

5.4.4.3 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 (Poole *et al*. 2018). There was an above average catch in 1995, possibly contributed to by the exceptionally warm summer. The numbers in the last three years (2015-2017) were 1074, 2728 and 2208 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 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 1994; Poole *et al*. 2018), 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.

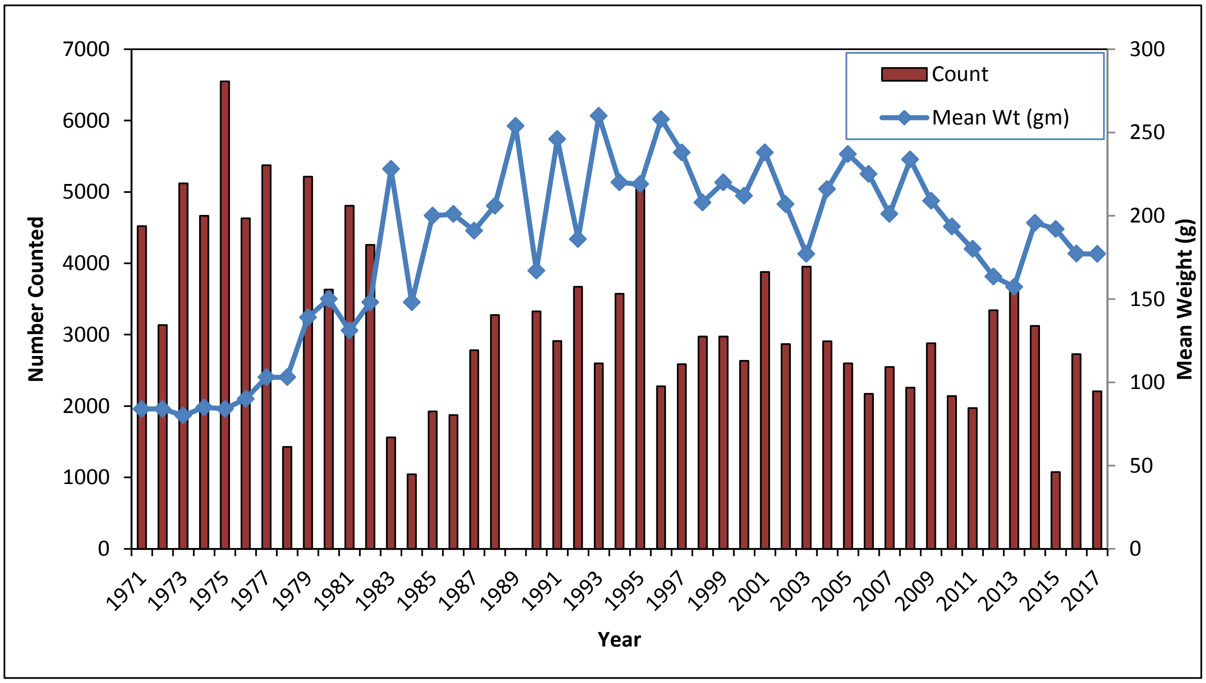


Figure 5-33: Annual number and mean weight (g) of silver eels trapped in the downstream traps.

5.4.4.4 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 Table 3.13. 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 ($B_{2001-2007}$) was the same as there was no anthropogenic mortality.

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

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

Production and escapement ($B_{2015-2017}$) for the 2015-2017 period fell to an average of 0.76kg/ha or 360kg.

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. 3.34). 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) leading to targets above 100%. The 2015-2017 escapement is the first to be recorded in Burrishoole below 100%.

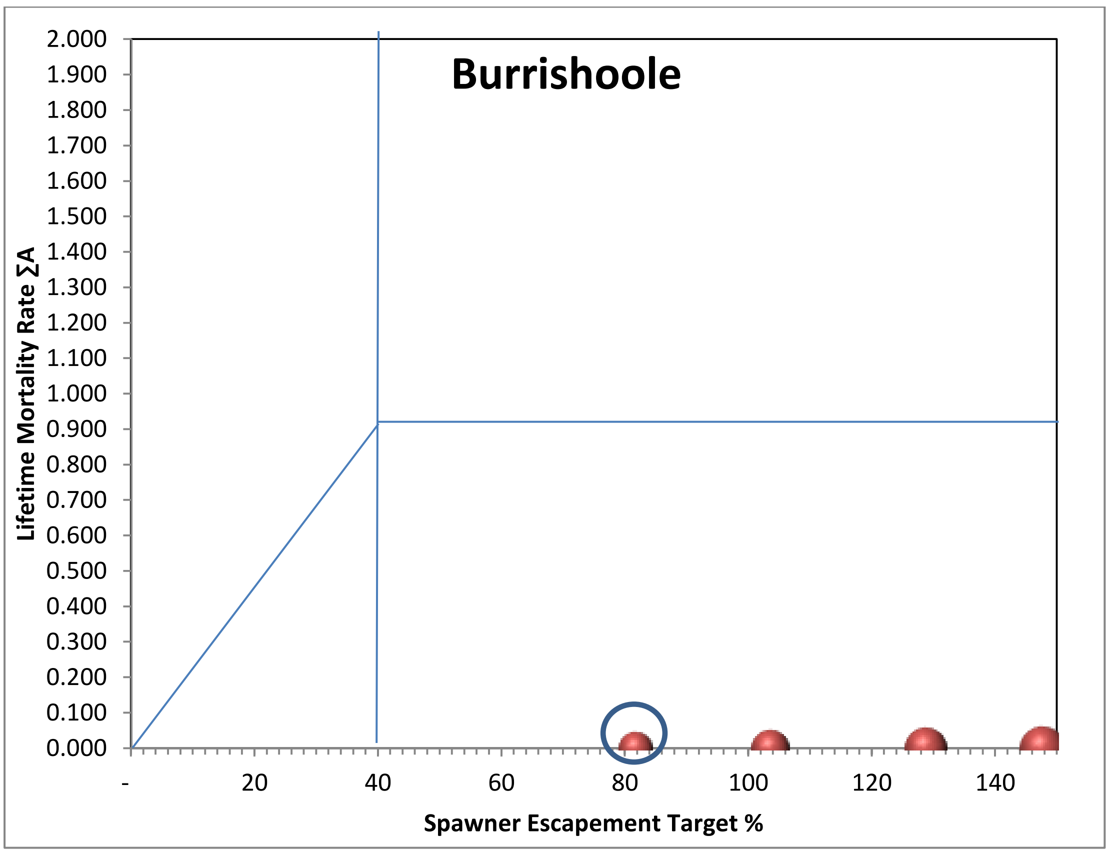


Figure 5-34: Status of the stock and the anthropogenic impacts, for the <u>Burrishoole</u> as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008, and for the average of 2009-2011, 2012-2014 and 2015-2017 (circled). For each, the size of the bubble is proportional to B_{best}, 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.

5.4.5 Fane

5.4.5.1 Introduction

The Fane is a relatively small catchment with the silver eel fishery located in the upper reaches of the system approximately 28km from the coast. The Fane has a riverine wetted area of 84 Ha and a lacustrine wetted area of 553ha. A research silver eel fishery was carried out on the Clarebane River on the outflow of Lough Muckno in the Fane catchment from 2011 to the present (Fig. 3.35). The site was the location of a commercial fishery until 2008.

5.4.5.2 Fane Annual Catch

The 2011 to 2014 catches for the Fane were reported previously (Anon, 2012, 2015) and in Table 3.7.

The Fane silver eel fishery is dependent on water levels in the river in order for the nets to be set. As the fishing site is located downstream of Lough Muckno and a water abstraction site there is a delay due to the lake absorbing rainfall before a rise in river water levels is observed in the Clarebane River. Table 3.7 shows the catches of silver eels (in kgs) and the numbers of nights fished from 2011 to 2017.

In 2015, water levels were low in September and October, but increased through November. Figure 3.36 depicts the water flow (and moon phases) for the Fane Fishery in 2015. Eight nights were fished in November with a total catch of 452kg. The nets were set for a further 15 nights in December with a lower catch of 147kg.

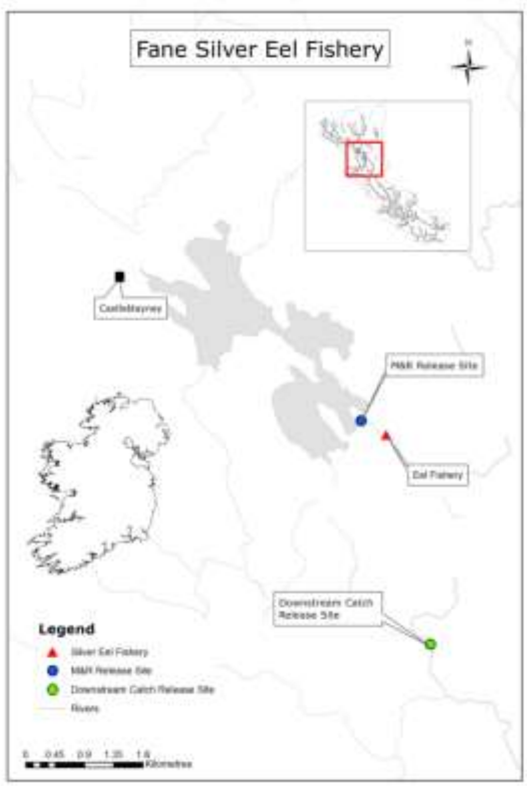


Figure 5-35: Locations of Fane catchment silver eel fishery and release points, 2012-2017. Insets: Sampling area indicated by red box on Fane catchment and map of Ireland with Fane catchment (shaded) and Neagh-Bann River Basin District (outlined).

In 2016, silver eel catches at the Fane Fishery were low due to unfavourable conditions for fishing. The heavy rainfall required to flood the site and float the coghill nets for fishing was absent during the autumn and winter months (Fig. 3.37). This may be attributable to the strong El Niño affect during the sampling season of 2015 which continued into 2016. The result was a comparatively warm and dry autumn, which would be uncharacteristic of weather in Ireland at that time of year.

In total, only 7 nights were fished in December during the 2016 season, with a total catch of approximately 80 kg. No mark-recapture study was carried out for the 2016 silver eel season.

In 2017, silver eel catches at the Fane Fishery were varied with a total catch of 770kgs and 20 nights fished. The catches, numbers of nights fished and numbers of eels captured in 2017 are presented in Table 3.7. In 2017, increasing rainfall levels on a first quarter moon (Fig. 3.38), early in the silver eel season led to large catches in September. Forty percent of total catch was captured over 2 nights (28th and 29th September). The catches then tapered off for the rest of the season coinciding with water levels that never rose above 1m for the season. In total 20 nights were fished across September, October and December respectively. No fishing was carried out in November due to very low water levels and no eels were caught in the December fishing.

A series of Mark recapture studies were undertaken at the site to determine the efficiency of the fishery (Table 3.8). Each year a number of eels tagged at the fishery and released upstream, when conditions are right this study can be repeated two and three times when the silver eels are migrating. Since 2012 eels have been released in the river upstream of the fishery. Due to the dry conditions for 2016 no MR studies were undertaken and the pattern of the silver eel run in 2017 resulted in only 1 eel being recaptured.

Table 5-8: The annual silver eel catch for the Fane 2011-2017

Year	days fished	Catch (kgs)	No eels
2011	13	268	1433
2012	21	448	1965
2013	19	1151	3097
2014	25	797	2542
2015	23	730	1810
2016	9	76	206
2017	20	770	2376

Table 5-9: Annual results for mark-recapture estimates of fishery efficiency.

Year	No. tagged	Recaptured	Recaptured within Year	Overall Recapture Rate %	Within Year recapture rate %
2012	469	94	36	20	8
2013	273	92	60	34	22
2014	320	93	87	29	27
2015	252	103	101	41	40
2017	124	1	1		
	Average rate			**30.91**	

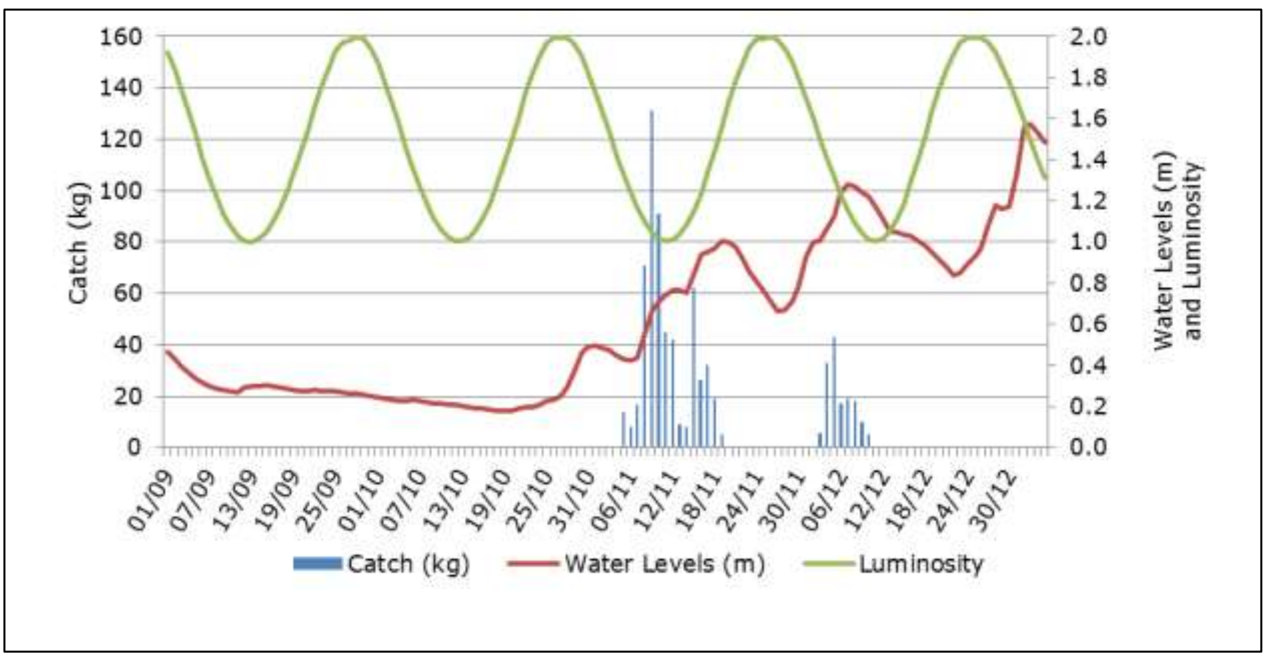


Figure 5-36: Water levels (m), Luminosity and Catch (kg) for the Fane fishery 2015 silver eel season.

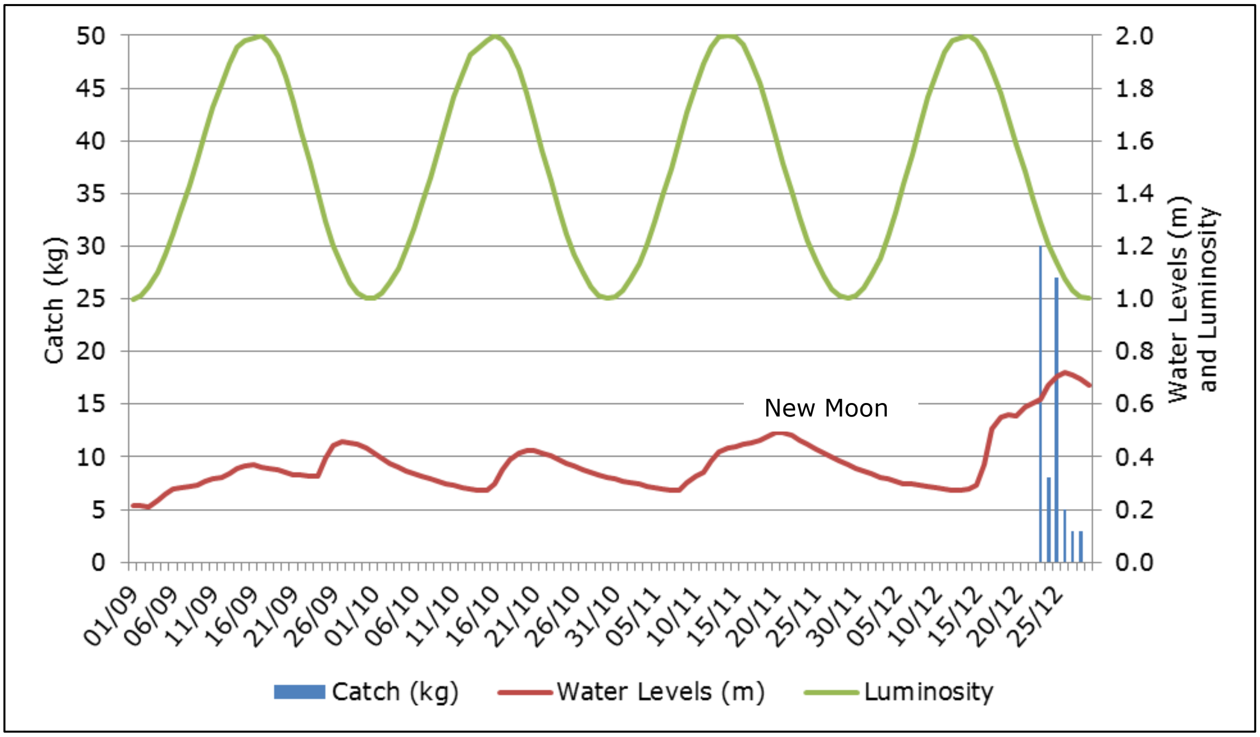


Figure 5-37: Water levels (m), Luminosity and Catch (kg) for the Fane fishery 2016 silver eel season.

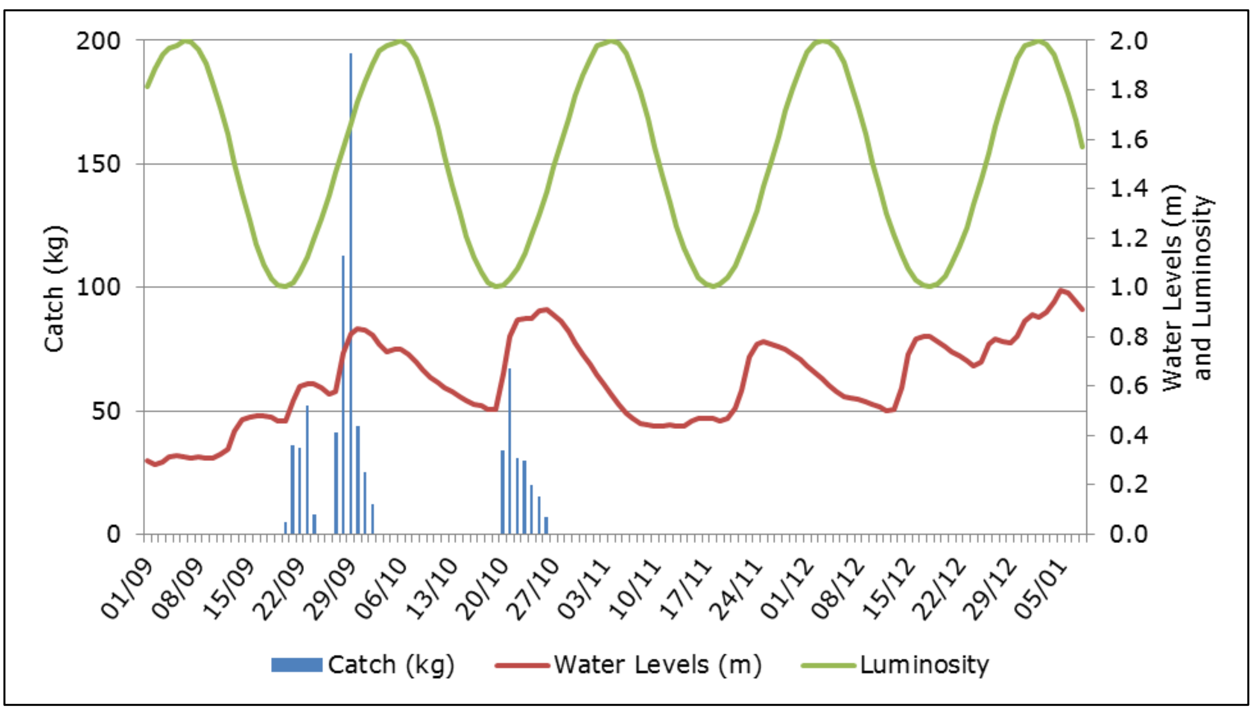


Figure 5-38: Water levels (m), Luminosity and Catch (kg) for the Fane fishery 2017 silver eel season.

5.4.5.3 Fane Production and Escapement

5.4.5.4 Historic

The historic production of the Fane catchment was determined as 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.

5.4.5.5 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.

5.4.5.6 Current 2009-2017

Table 3.9 presents the annual catch of silver eels in weight and numbers and the production in weight, numbers and per unit area. The average recapture efficiency estimate for the Clarebane Fishery on the Fane was determined by mark-recapture to be 30.9% (Table 3.8) and this was applied to each annual catch to estimate the actual escapement.

The Fane data were then used as a fourth index station in the IMESE model for estimating silver eel production in catchments where no data exists – See Chapter 4 of this report (Table 3.13).

Table 5-10: Annual catch and estimated production for the Fane Silver Eel Fishery, 2011-2017.

Year	days fished	Catch (kgs)	measured av wt (kg)	No of eels in catch	Production (kgs)	Production (nos)	Wetted Area (total)	Production kgs/ha
2011	13	268	0.187	1435	868	4643	574	1.513
2012	21	448	0.251	1785	1450	5776	574	2.523
2013	19	1151	0.289	3983	3725	12889	574	6.489
2014	25	797	0.292	2730	2580	8835	574	4.494
2015	23	730	0.369	1978	2362	6402	574	4.116
2016	9	76		217	246	703	574	0.428
2017	20	770	0.331	2326	2492	7528	574	4.341

5.4.6 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) (Fig. 3.39). 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.

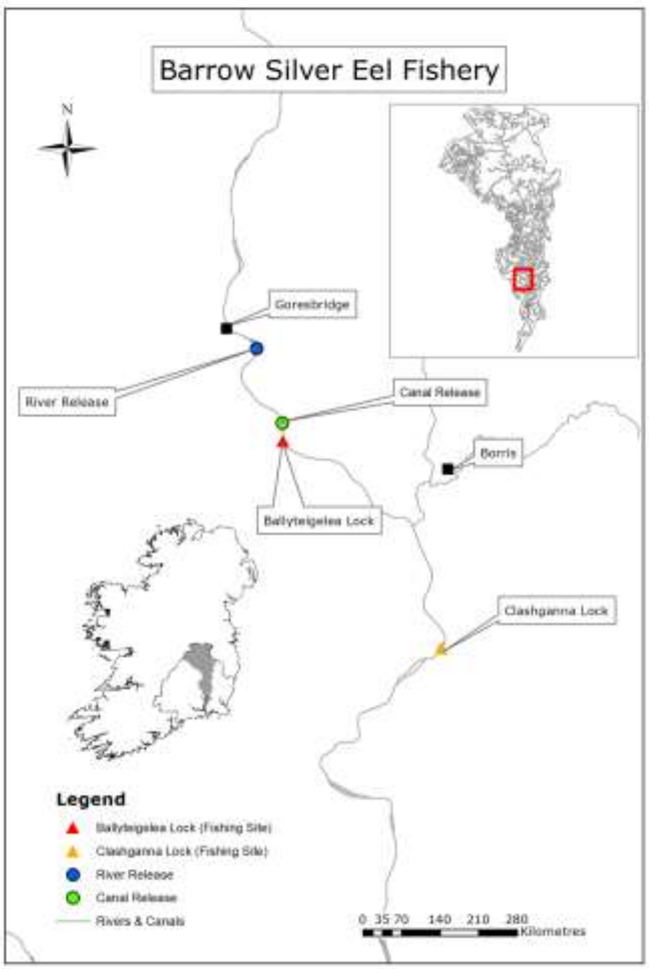


Figure 5-39: Map and picture of fishing locations within the Barrow Catchment.

5.4.6.1 Barrow Eel catch 2014-2017

In 2014, the Barrow was fished 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.

In 2015, silver eel catches at the Barrow Fishery were initially low due to unfavourable conditions for fishing. The water level in the river was very low during September and early October with insufficient water to float the nets for fishing. This may be attributable to the strong El Niño affect during the sampling season for 2015 which resulted in a comparatively warm and dry autumn. However, by November heavy rains began and flooding was seen throughout November and December. The first fishings for silver eels on the Barrow were attempted in August but but no catch was recorded. Six nights were fished in October with a total catch of 146 eels (17.42kg). The peak of the silver eel catch was recorded in November with 584 eels (91.32kg) captured in 13 nights (Table 3.10). The flooding on the Barrow near Graiguenamanagh became so intense that silver eel fishing was postponed in mid-December as conditions no longer supported fishing from the Ballyteiglea Lock. This effectively ended the silver eel fishing season for 2015 on the Barrow. Figure 3.40 depicts the water flow (and moon phases) for the Barrow Fishery in 2015.

Morphometric measurements were taken on 730 eels in 2015. The average length was 41.8 cm (range 31.5 – 77.4 cm), the average weight was 0.149 kg (range from 0.050 to 0.873 kg). The population structure for 2015 is in line with what was caught in 2014 (Fig. 3.43).

55 eels were retained for further analysis in the laboratory. Of these 65% were male, with 35% being female. The sex ratio in 2014 was 61% male.

In 2016, The Barrow location was fished for a total of 25 nights across September, October, November and December. Weather conditions led to only minor and infrequent flooding events during which silver eels could be captured and monitored (Fig. 3.41). The total number of measured eels processed was 845, with a total measured catch weight of 132.9 kg (175.5 kg including batch weights) (Tables 3.10).

In 2017, increasing rainfall levels on the first quarter (Fig.3.42 moon phase graph), early in the silver eel season led to large catches over 2 nights September (155kgs & 57% of the overall catch). In total 24 nights were fished with a total weight of 273kgs and morphometric measurements were taken on 351 eels. Catches then tapered off for the rest of the season coinciding with decreasing water levels (Fig. 3.42, water levels graphs).

Morphometric measurements were taken on 351 eels in 2017. The processed eels had an average length was 45.5 cm (ranging from 26.2 to 81.8 cm). The average weight per eel was 0.203 kg (ranging from 0.0250 to 1.078 kg). The length frequency for the processed eels is shown in Figure 3.43. During the silver eel season at the Barrow fishery, a total of 83 were retained in order to assess biological quality and were dissected in the laboratory. Of these, 67% were female and 33% were male (Fig. 3.43).

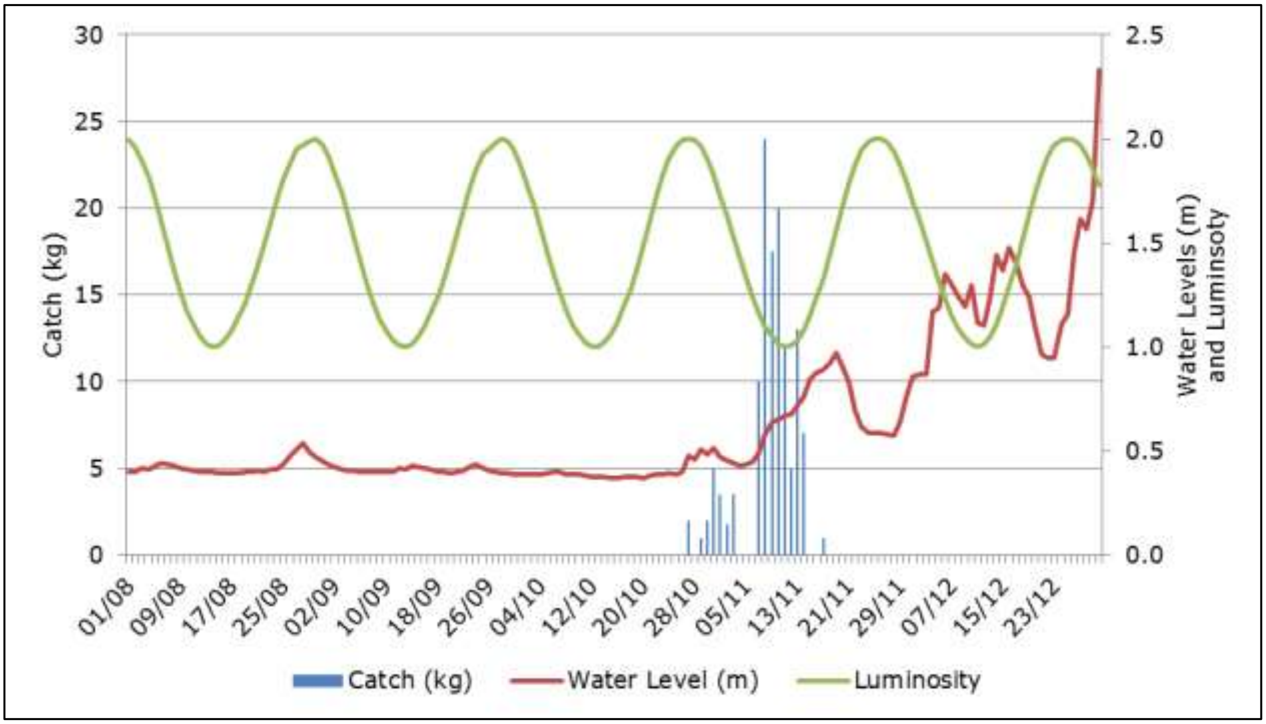


Figure 5-40: Water levels (m), Luminosity and Catch (kg) for the Barrow fishery 2015 silver eel season.

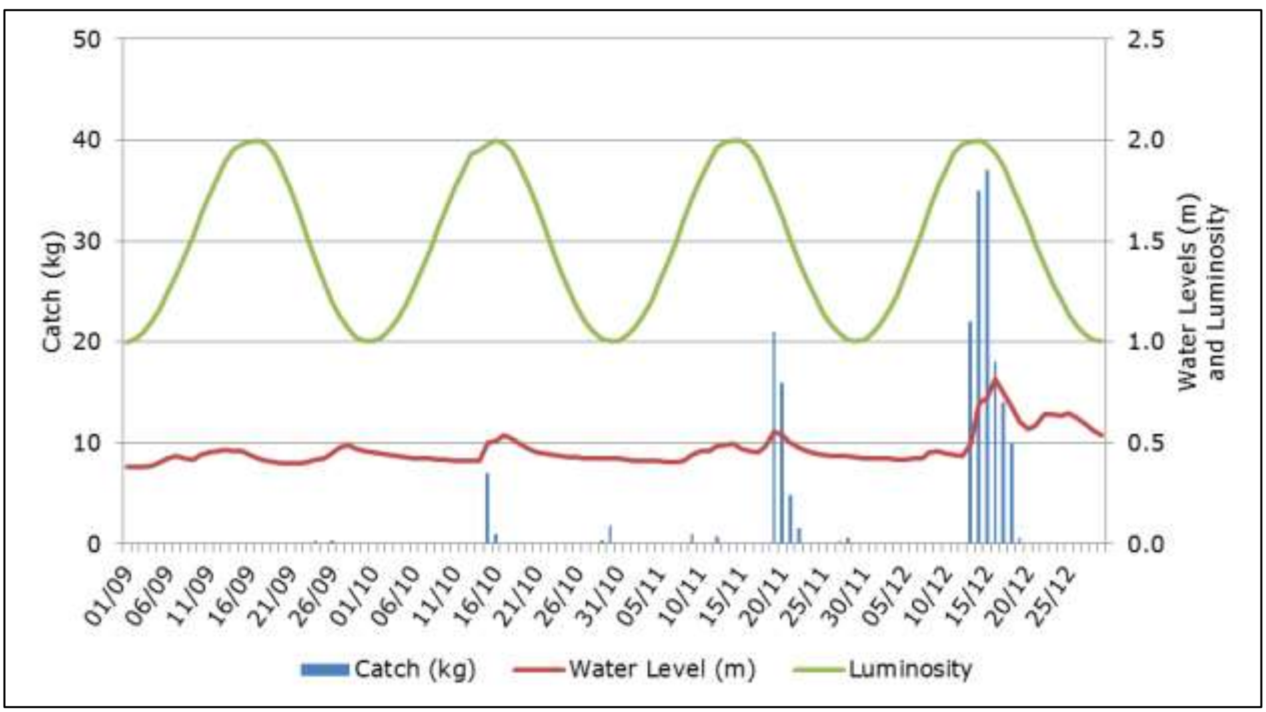


Figure 5-41: Water levels (m), Luminosity and Catch (kg) for the Barrow fishery 2016 silver eel season.

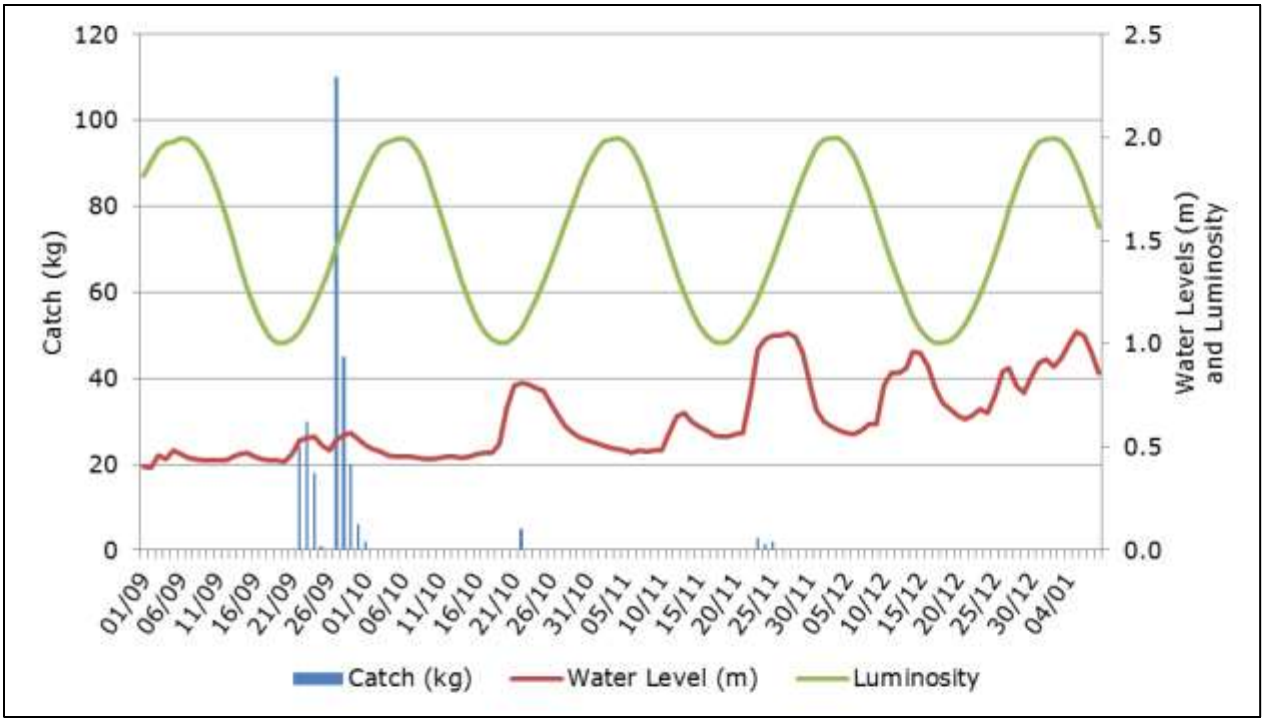


Figure 5-42: Water levels (m), Luminosity and Catch (kg) for the Barrow fishery 2017 silver eel season.

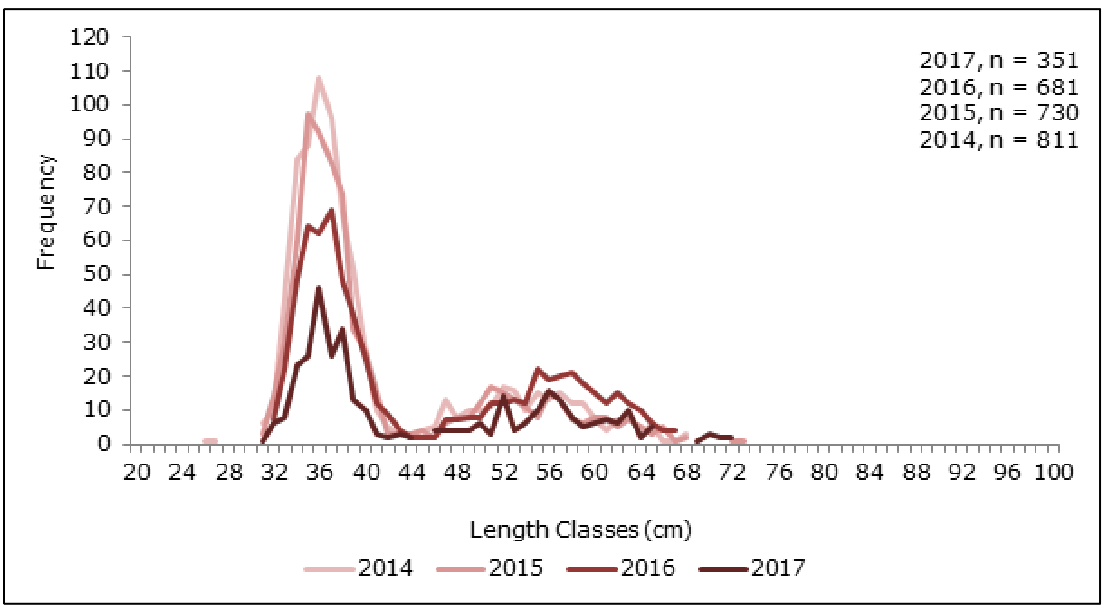


Figure 5-43: Length frequency for silver eels caught on Barrow catchment, 2014 – 2017

Table 5-11: Silver eel catch record for Barrow, 2014 – 2017

Year	No. Days Fished	Catch (kg)	No of Eels
2014	22	174	1,223
2015	20	128	687
2016	25	193	880
2017	24	273	1,388

5.4.6.2 Mark Recapture

In 2015, in order to determine the efficiency of the fishing site 50 eels were released into the canal 150m upstream of the fishing site. Twenty one eels were recaptured giving a recapture rate of 42% (Table 3.12). Due to the environmental conditions of low flows in September, October followed by severe flood conditions in December only one mark recapture survey was undertaken in 2015. The aim will be to repeat this MR survey over the next few years.

In 2015, a second mark-recapture experiment was run to determine how many eels are recaptured in the fishing site and how many avoid the canal and migrate down the river channel 227 eels were tagged and released 2kms upstream into the barrow river and 50 were tagged and released into the Ballyteiglea Lock. The eels were released over 3 occasions. The first tagging session reported a high recapture rate of 52% with the majority of eels recaptured 3-10 days after release. The second and third sessions saw a marked decrease in recapture rates with 3% and 2% respectively. The weather conditions for the 2nd and 3rd sessions saw higher flood conditions, affecting the recapture rate.

The weir upstream of the fishing lock holds back the water keeping the flow and depth in the canal resulting in good catches of eel at the lock gates. However, as the season progresses and the water level rises the spillover into the main channel increases and the catch at the lock decreases. This event is visible in the MR study undertaken in 2015, with a high recapture rate for the October session of 52% with a dramatic decrease in the November session.

In 2016, 48 eels were released into the canal 150m upstream of the fishing site. Twenty one eels were recaptured giving a recapture rate of 43.75% (Table 3.12). Due to the environmental conditions of low flows over the sampling season (Fig. 3.41) only one mark recapture survey was undertaken in 2016. The tagging session reported a high recapture rate with the majority of eels recaptured 2 days after release.

In 2017, like in 2016, due to the unusual silver eel migration pattern only 1 MR session was undertaken. 51 eels were tagged giving a recapture of 8 (16%).

Table 5-12: Mark Recapture Preliminary Results for Barrow Fishery, 2015 – 2017

Location	Year	Month	No. Tagged	No. Recaptured	% Recapture	Average rate
Ballyellin Lock	2014	October	202	7	3	11
Ballyellin Lock	2015	October	60	16	27	
Ballyellin Lock	2015	November	167	4	2	
Ballyteiglea Lock	2015	November	50	21	42	34
Ballyteiglea Lock	2016	November	48	21	44	
Ballyteiglea Lock	2017	September	51	8	16	

5.4.6.3 Barrow Production and Escapement

Production and escapement has not yet been directly calculated for the whole Barrow catchment. Once five years of data has been collected the Barrow can be included as another index site in the extrapolations to data-poor catchments.

5.4.7 Boyne

The Boyne catchment is a large catchment located on the east coast of Ireland in the Eastern River Basin District (EEMU). There has historically been a commercial fishery on the River Boyne and the presence of historical catch will aid in the assessment of the current silver eel escapement levels from the river. The fishing site selected on the Boyne was located at Floods Bridge on the main channel of the Kells Blackwater River (Fig. 3.44). The location fished is 5 km downstream of Lough Ramor and upstream of the town of Kells; approximately 50 km upstream from the tidal limit (estuary) in the River Boyne. A large river fyke net was fished during the 2017 silver eel season.

5.4.7.1 Silver Eel Catch

The Boyne silver eel catch was low in 2017 with a total of 91kgs. Catches in the winged fyke net were limited despite fishing carried out during increased flow conditions and around the new moon. High rainfall levels on the first quarter (Fig. 3.45), early in the silver eel season led to the largest catches in September (115 eels captured). A further 20 eels were caught in October and just 8 in November. No eels were captured in December but a further 14 were caught in January 2018. In total, 157 eels were captured and measured during the silver eel season. The catches then tapered off for the rest of the season coinciding with decreasing water levels (Fig. 3.45). In total 22 nights were fished.

Morphometric measurements were taken on 157 eels in 2017 / 2018 season. The processed eels had an average length was 64.5 cm (ranging from 31.4 to 93.0 cm). The average weight per eel was 0.526 kg (ranging from 0.062 to 1.424 kg). The length frequency for the processed eels is shown in Figure 3.46. During the silver eel season, a total of 61 were retained in order to assess biological quality and were dissected. Of these, 54 (89%) were female (Figure 3.46).

Figure 5-44: Map of silver eel fishing location within the Boyne Catchment, 2017 (Insets: Ireland with Boyne catchment (shaded) and Eastern River Basin District (outlined) and details of Boyne Catchment).

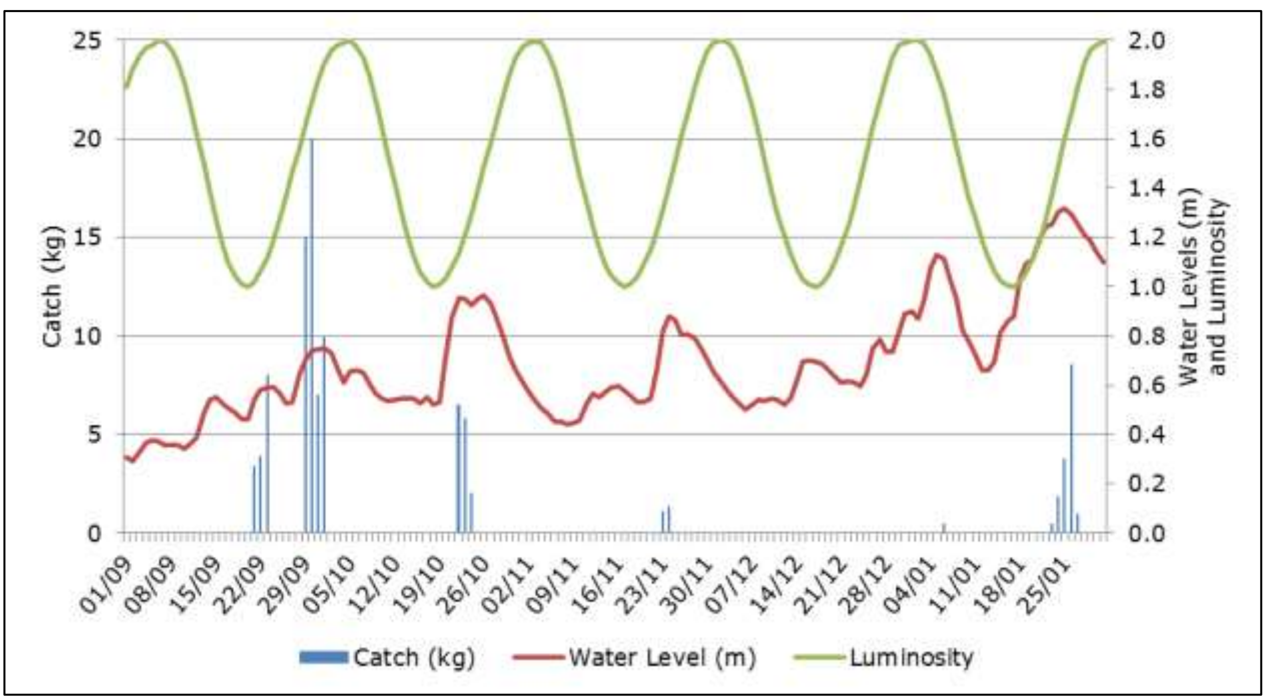


Figure 5-45: Water levels (m), Luminosity and Catch (kg) for the Boyne fishery 2017 silver eel season.

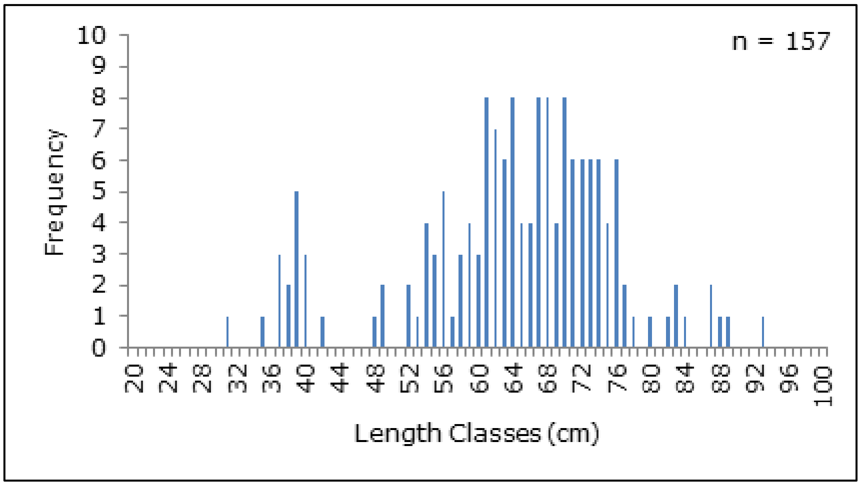


Figure 5-46: Length frequency of silver eels captured at the Boyne fishery, 2017.

5.5 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 3.13). 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.

However, a different picture emerged in the last three years with a general reduction in production, especially in 2016 and 2017.

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. Production fell to 0.91 and 0.80 kg/ha in 2016 and 2017 respectively.

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 Erne production dropped a little in 2016 but rose again in 2017 from 2.4 to 2.7 kg/ha.

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. However, a poor run occurred in 2015 with only 0.44 kg/ha being recorded and another poor run of relatively small eels was recorded in 2017 with 0.8 kg/ha production.

The plots (Figs. 3.29, 3.30 & 3.34) and Table 3.13 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 the Shannon increased 2012 and 2013, was 33% of Bo in 2014 and was considerably lower in 2016 and 2017 (17.4% and 16.5%) (Figs. 3.16 & 3.7; Table 3.13).

The escapement biomass in the Erne also increased until 2015 (66.7%), and was lower, but still above the EU target in 2016 and 2017.

The escapement in Burrishoole fell considerably in the 2015-2017 period to 46% in 2015 and 89% in 2017.

The escapement in the Fane ranged from 139% in 2013 to 9.2% in 2016.

Table 5-13: Historic production (Bo), current production (B_{best}), current escapement ($B_{current}$) and the current escapement as it related to Bo - % EU Target - for the Shannon, Erne, Burrishoole, Fane and Corrib, and for historic production only for the Moy and Garavogue. 2015 Shannon values in red are estimates.

	Bo Prod	Production (Bbest)										Av 2009-2011	Av 2012-2014	Av 2015-2017
	kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
Shannon	189,079	85,700	74,382	68,920	65,558	67,931	79,970	70,725	70,725	38,608	34,139	69,620	72,875	36,374
Erne	107,388	85,140		41,232	42,855	67,666	73,762	72,493	78,034	62,871	68,810	42,044	71,307	69,905
Burrishoole	440	649	602	410	354	546	571	580	206	480	391	455	566	359
Fane	2,682				868	1450	3725	2580	2362	246	2492		2,585	1700
Corrib	105,739	48,455	36,100											
Moy	46,435													
Garavogue	9,610													

	Bo Prod	Escapement (Bcurrent)										Av 2009-2011	Av 2012-2014	Av 2015-2017
	kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
Shannon	189,079	12,163	66,788	60,170	57,885	58,836	70,775	62,980	62,980	32,920	31,191	61,614	64,197	32,056
Erne	107,388	32,542		37,942	40,011	57,366	64,285	66,525	71,650	51,377	58,539	38,977	62,725	60,522
Burrishoole	440	649	602	410	354	546	571	580	206	480	391	455	566	359
Fane	2,682				868	1450	3725	2580	2362	246	2492		2,585	1,700
Corrib	105,739	13,371	36,100											
Moy	46,435													
Garavogue	9,610													

Table 5-13 cont.: Historic production (Bo), current production (B_{best}), current escapement ($B_{current}$) and the current escapement as it related to Bo - % EU Target - for the Shannon, Erne, Burrishoole, Fane and Corrib, and for historic production only for the Moy and Garavogue. 2015 Shannon values in red are estimates.

	Bo Prod	%Bcurrent/Bo (EU Target)										Av 2009-2011	Av 2012-2014	Av 2015-2017
	kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
Shannon	189,079	6.4	35.3	31.8	30.6	31.1	37.4	33.3	33.3	17.4	16.5	32.6	34.0	22
Erne	107,388	30.3		35.3	37.3	53.4	59.9	61.9	66.7	47.8	54.5	36.3	58.4	56
Burrishoole	440	147.5	136.8	93.2	80.6	124.1	129.9	131.8	46.8	109.1	88.9	103.5	128.6	82
Fane	2,682				32.4	54.1	138.9	96.2	88.1	9.2	92.9	-	96.4	63.4
Corrib	105,739	12.6	34.1											
Moy	46,435													
Garavogue	9,610													

6 Silver Eel Production and Escapement

6.2 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. $\Sigma A = \Sigma F + \Sigma H$.

6.3 Eel Management Plan Freshwater Biomass (Inland)

6.3.1 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 (2009, 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 (ICES, 2003). 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 2015-2017 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.

6.3.2 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 3.13.

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 2012a) (Table 4.4).

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 were set too low.

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

The production (B_{best}) and escapement ($B_{2001-2007}$) estimates presented in the EMPs are shown in Tables 4.4 & 4.5. 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, 2012a).

6.3.4 Current (2009-2014) Silver Eel Biomass (Bbest, $B_{2009-2014}$)

The silver eel biomass produced and escaping during 2009 to 2014 in the monitored index catchments was fully described in Chapter 3 of this report and in Table 3.13.

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 (See Stock Annex 2015b). 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.

6.3.5 Current (2015-2017) Silver Eel Biomass (Bbest, $B_{2015-2017}$) - Freshwaters

The silver eel biomass produced (Bbest) and escaping (Bcurrent) during 2015 to 2017 in the monitored index catchments were fully described in Chapter 3 of this report and in Table 3.13.

For the assessment of the 2015 to 2017 period, the IMESE model was run as in the previous years using the Shannon (2016-2017), the Erne (2015-2017) and the Burrishoole as reported in Chapter 3 as index catchments. The model was also run including a new Index catchment, the Fane, which is situated on the East coast (IE_East). This addresses a previously identified criticism that all the indexes were on the west coast. However, the inclusion of the Fane changes the model outputs. For consistency, outputs from IMESE are presented with, and without, the new index and the mid-point between the two values is reported for 2015-2017. The trends of the two model outputs are similar, but it is not known whether the extrapolation to the datapoor catchments should be made at the higher or lower level. Also the volatile nature of silver eel migrations due to floods (2015) and droughts (2016) has made the interpretation of IMESE difficult.

The Biomass indicators (Bo, Bbest, Bcurrent) for each EMU as calculated using the original index catchments (without the Fane) are presented in Table 4.4 and the level of escapement relative to Bo is presented in Table 4.5. The data for 2015-2017 are presented in Table 4.6 and 4.7, with and without the Fane as an east coast index. The Fane is a relatively small highly productive (eutrophic) catchment with 0% siliceous geology and therefore, in the growth rate/geology regression, the relatively small catchment has considerable influence over the relationship at the left end of the regression where a considerable proportion of the eel production occurs (~70%).

It was with this in mind, the TEGE decided to show both datasets in the Stock Annex (Table 4.6 & 4.7) and to report the mind-point between the two estimates to the EU in the data reporting templates.

Current escapements are presented in Table 4.4 and expressed as a percentage of the historic production (Table 4.5), given for 2008, for the 2009-2011, 2012-2014 and 2015-2017 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. However, in 2015-2017 using the original model, this has dropped to 37.7%. Including the Fane gives a figure of 45.8% and the mid-point is 41.8% (Table 4.7).

Of particular note (see also Chapter on the Index Rivers), the production in the IE_Shan fell in 2016 and 2017 to less than 20% of Bo. The production in the EAST, SouE, SouW and West all fell back to similar rates observed in the 2009-2011 period, the exception being the IE_NorW where current production was maintained at over 50% of Bo.

6.4 Eel Management Plan Escapement Biomass (Transitional Waters)

6.4.1 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 freshwater 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 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 for the different types of transitional waters in Ireland that reflected the CPUE from the fyke nets.

6.4.2 Methodology

From 2008 to 2017 149 fyke net surveys within transitional waters around Ireland were available. These surveys were undertaken by Inland Fisheries Ireland's Water Framework Directive and Eel Monitoring Programme and the Marine Institute's long term monitoring in Lough Furnace. These surveys were distributed around the country.

The aim of the analysis was to investigate if there was a link between number of eels and catch per unit of effort and the physical characteristics of the transitional waters. These physical characteristics do not change with time and are available for all transitional waters around the country. There are a lot of environmental variables that are important to classify a waterbody but they require monitoring and therefore were not included in this analysis as they were not widely available. The physical characteristics investigated are as follows:

1. **Drying (drying (0), non-drying(1) and partial drying(2)).**

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(1), south(3), west(2))**

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 may be 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 Eastern and NeaghBann RBD are classified as East coast, the Western and NorthWestern IRBD are classified as west coast.

3. **Coast (east (1), west(2))**

A variation of the 3 category coast mentioned above, a 2 category option was included to distinguish between east and west, splitting the country down the middle. The South west RBD was classified as west and the South east RBD was classified as east coast.

4. **Exposure (sheltered (0), semi exposed(1))**

The area exposed to the coastal waters, which is the point of interaction between transitional waters and the coastal waters, was measured and every transitional water in Ireland was classified as either sheltered or semi exposed. The sheltered waters had an opening <1.5km coast to coast. The semi 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 located at the coast water boundary.

5. **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 large transitional waters and low freshwater wetted area.

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

Fyke net data and historical fishery data suggests that lagoons are good locations for eels with high numbers recorded. Therefore we distinguished between a lagoon and a riverine estuary. A lagoon was also classified as sheltered under a separate category.

6.4.3 Analysis

Data exploration was carried out using the guidelines from Zuur *et al*. (2009) This involved 1) checking for Outliers in the response variable and all variables, 2) checking for collinearity among the variables, 3) checking the relationship between the response variable and variables, 4) assessing spatial and temporal dependency, 5) Interactions between variables, 6) checking for zero inflation, and 7) checking the sample size for all categorical covariates.

A negative binomial distribution was used due to the large variance in the data. Year was included as a random factor; count of eels was the dependent variable with effort included as an offset. A negative binomial mixed model analysis was carried out on 19 models with different combinations of the variables listed above (Table 4.1). Model selection was carried out using the Information Theoretic approach. Models were compared using the AIC and the weighted AIC (Table 1). There were 7 models with an AIC within 2 units of the lowest model. The simplest model with the lowest aic was Model 15 with variables exposure and drying.

The simpler model was used as the basis for categorising all transitional waters around Ireland and using the model to estimate a count of eels. This resulted in 6 categories of increasing number of eels/cpue (Table 4.2). This model suggested that there was a difference in catch of eels between sheltered and semi exposed estuaries and also between drying, non-drying and partial drying estuaries. The modelled CPUE of eels per transitional waters were then classified as either a low or high production for eels. There were 4 combinations of drying and exposure that were assigned a low production value for eels and 2 combinations that were assigned a high production value for eels.

From the Freshwater eel production model IMESE, a high kg/ha value and low kg/ha value per year was then assigned to each transitional water from 2008 to present, using the mid-point values for the 2015-2017 years as follows:

Year	High kg/ha	Low kg/ha
Bo	4.676	1.846
2008	4.042	0.672
2009	3.557	0.587
2010	2.620	0.430
2011	2.394	0.394
2012	3.359	0.559
2013	3.634	0.604
2014	3.558	0.588
2015	3.230	0.534
2016	2.522	0.422
2017	3.215	0.530

	High kg/ha	Low kg/ha
Av 09-11	2.528	0.418
Av 12-14	3.517	0.587
Av 15-17	2.801	0.466

Table 6-1: Binomial mixed model analysis carried out on 19 models and associated AIC values.

Model	Model - Year Random Effect, Effort offset	df	AIC	AIC min	AIC weighted
Mneg1.13	coast3+Category+exp+Dry	9	1162.933		0.207
Mneg1.15	exp+Dry	6	1163.41	0.477	0.163
Mneg1.6	coast3 + exp + Dry	8	1164.204	1.271	0.11
Mneg1.12	Category+exp+Dry	7	1164.393	1.46	0.1
Mneg1.4	coast2+ coast3+exp+Dry	9	1164.433	1.5	0.098
Mneg1.3	coast2+ coast3+Category+exp+Dry	10	1164.528	1.595	0.093
Mneg1.14	Dry*exp	8	1164.899	1.966	0.077
Mneg1.5	coast2+exp+Dry	7	1165.402	2.469	0.06
Mneg1.11	coast2+Category+exp+Dry	8	1166.075	3.142	0.043
Mneg1.2	coast2+ coast3+Category+exp+Dry+Area	13	1166.277	3.344	0.039
Mneg1	coast2+ coast3+Category+exp*Dry+Area	15	1169.31	6.377	0.009
Mneg1.8	coast3 + Dry	7	1172.397	9.464	0.002
Mneg1.7	coast2 + Dry	6	1175.581	12.648	0
Mneg1.18	Dry	5	1178.107	15.174	0
Mneg1.10	coast3 + exp	6	1184.5	21.567	0
Mneg1.17	coast3	5	1185.983	23.05	0
Mneg1.19	exp	4	1188.642	25.709	0
Mneg1.9	coast2 + exp	5	1188.962	26.029	0
Mneg1.16	coast2	4	1193.347	30.414	0

Table 6-2: Six categories of Transitional Waters with modelled CPUE

	exposure	drying	ExpDry	Modelled value	Cateogry
sheltered and drying	0	0	0_0	0.283087	low
semi exposed and drying	1	0	1_0	0.69677	low
sheltered and partial drying	0	2	0_2	0.781922	low
sheltered and non drying	0	1	0_1	1.41199	low
semi exposed and partial drying	1	2	1_2	2.011137	high
semi exposed and non drying	1	1	1_1	3.475367	high

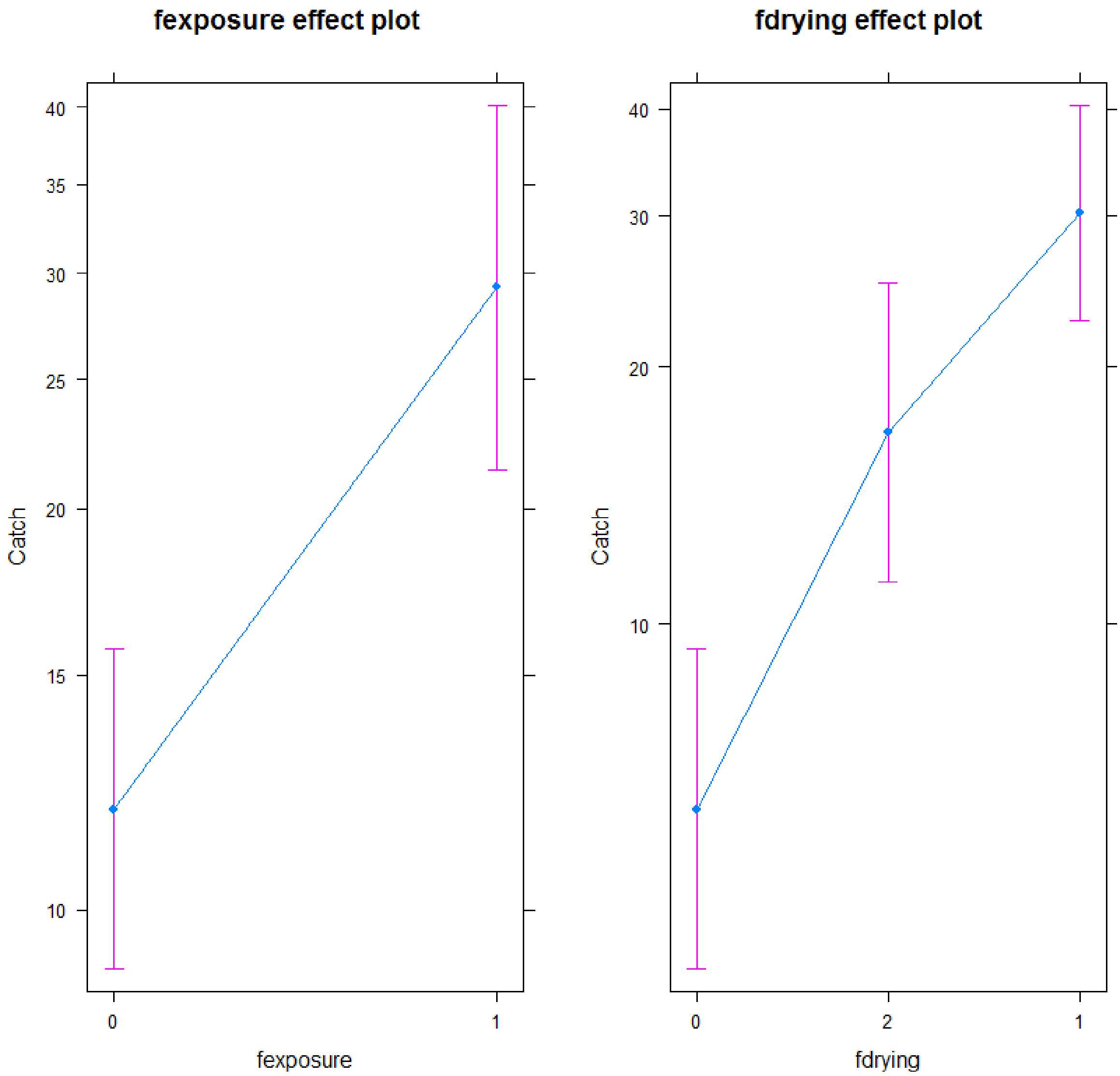


Figure 6-1: Plot of effect of exposure (0 = sheltered, 1 = semi exposed) and drying (0 = drying, 2 = partial drying, 3 = non drying) on eel catches.

Table 6-3: Strengths and weakness table for transitional water analysis.

	Weaknesses	**Strengths**
1	Doesn't take into account competition with conger eels Estuaries like Corrib Estuary and Westport bay which surveys found hard to catch eels but model would predict high numbers based on physical characteristics	Enable us to add cpue to unsurveyed estuaries, based on physical characteristics
2	Survey data cover a 10 year period, changes to population due to reduced recruitment is likely during this time however as Tws are the first port of call for glass eel/elvers and evidence suggests that in certain catchments eels are reducing the distribution around a catchment it is felt that the numbers will remain high in catchments with good tw habitat, however in poor habitat would eels move upstream entirely	Combination of wfd, Eels, MI studies
3	WFD surveys take place in September - October not during the summer when yellow eels are the most active, therefore need to take the numbers as a minimum value Can check this issue with the telemetry studies in Barrow and Mblackwater -rate of movement thru time	77 estuaries surveyed of the 194 available in the Republic ~ 40% of estuaries surveyed
4	No estuaries in Northern Ireland included	35 estuaries surveyed 1, 26 surveyed 2, 10 surveyed 3, 6 surveyed more than 3 times
5	Doesn't take into account seasonal movement of eels from freshwater to estuarine to avail of food	Freshwater model uses all wetted area despite evidence that some small subcatchments no longer have eels, the same holds for Twaters all wetted area used in calculation
6	Doesn't take into account silver eel migration - yellow eels present in months May - September could have left by the time the WFD survey is carried out, or silvers are present but not foraging, same survey within the same year - population numbers will have changed	As the High value is not that high compared with some of the catches recorded in estuaries this should balance out with any low estuaries that could be 0
7	WFD surveys could be 1 night - if this is a bad night or a good night this can influence the model	Jimmy King Twater surveys 2006 - 2008 available for confirmation as blind data set, not applied as yet
8	Calculating Bbest for the estuary not Bcurrent, eel production under current recruitment levels but with no anthropogenic mortality/ influence ie water quality, habitat destruction/removal, habitat disturbance (such other fishing methods, dredging, mussel farms etc) , water abstraction etc	Year used as a random effect

6.4.4 Current (2015-2017) Silver Eel Biomass (Bbest, $B_{2015\text{-}2017}$) – Transitional waters

Transitional Waters have not been directly assessed and it is not known what the rates of silver eel production are from the yellow eel stocks inhabiting these waters. For the 2018 EU Report, silver eel production from transitional waters has been estimated by categorising each waterbody into one of two med-high or one of four medium to low eel habitats, based on physical characteristics, and yellow eel CPUE from WFD and other eel fyke net surveys. These categories were then applied to the IMESE production rates (maximum and minimum) for each year and retrospectively for Bo. We report these estimates in the 2018 report (see 2015 stock Annex for the classification analysis and the 2018 Stock Annex for the estimated production) and these should be treated with caution as preliminary results.

Current production of silver eels was estimated at 159,812kg for 2008 and 126,952kg in 2017. Fishing mortality can't be accurately assessed before the fishery closure as catches were reported along with the freshwater catch. Fishing mortality has been zero since 2009. Tables 4.8 and 4.9 give the Bo, Bbest and Bcurrent for the Transitional Waters. Current escapement was on average for 2015-2017 estimated at 50% of Bo.

6.5 Eel Management Plan Escapement Biomass (Coastal Waters)

The coastal waters of Ireland were not been assessed in 2012, 2015 or 2017. It is thought that eel production in coastal waters is low and there was never a commercial or recreational eel fishery in coastal waters.

6.6 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 4.10 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.

NOTE: In the past, fisheries landings were reported under the inland fisheries legislation and catches were not clearly separated for freshwaters and transitional waters. Ireland has reported Fishing Mortality and Hydropower Mortality rates based on its assessment of freshwaters and not including transitional waters.

6.7 Biomass and Mortality Overview

No assessments were made of the stock indicators for coastal waters. A preliminary assessment was made in 2018 of possible eel production from transitional waters using a combination of field CPUE data, physical characterisation of types of transitional waters and annual eel production rates from freshwater (See Section 4.3).

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 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). 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. 4.4 & 4.5) plot the most recent stock assessments (2009-2011, 2012-2014 and 2015-2017), along with those data presented in the EMP (2008). The original index time series are presented along with the mid-point version for the EU Report.

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 up to 2014 as shown by right hand horizontal movement towards the 40% target. In some cases anticipated increases in spawner escapement did not always materialise. This may be 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.

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 an increase in biomass of silver eel escaping and a marked reduction in fishing and hydropower mortality. While further reduction in mortality is unlikely, it is 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. Low production was noted in some catchment in the last three years, especially the Shannon and Burrishoole.

6.8 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.

6.9 Summary of individual EMU targets

No direct 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. Eel production was indirectly estimated using a combination of IMESE derived production rates, physical characteristics of transitional waters and fyke net CPUE catches of eels.

With the exception of the IE_Shan (ShIRBD) all other EMUs were above the EU target in 2015-2017. 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.

The Fane (IE_East) was included in the 2015-2017 analysis as a calibrating site. This is described in Chapters 3.3.5.3 and 4.2.5. In chapter 4, the original time series of Bbest production using only the Shannon, Erne and Burrishoole calibrating indices is presented along with the outcome of running the model including the Fane as a fourth index river. This addresses a previously identified criticism that all the indexes were on the west coast. However, the inclusion of the Fane changes the model outputs. For consistency, outputs from IMESE are presented with, and without, the new index and the mid-point between the two values is reported for 2015-2017. The trends of the two model outputs are similar, but it is not known whether the extrapolation to the data-poor catchments should be made at the higher or lower level. Also the volatile nature of silver eel migrations due to floods (2015) and droughts (2016) has made the interpretation of IMESE difficult.

In the previous reports (2012, 2015), silver eel production from transitional waters was not estimated. In this report, silver eel production from transitional waters has been estimated for 2015-2017by categorising each waterbody into one of two med-high or one of four medium to low eel habitat, based on physical characteristics, and yellow eel CPUE from WFD and other eel fyke net surveys. These categories were then applied to the IMESE freshwater production rates (maximum and minimum) for each year and retrospectively for Bo. We report these estimates in the 2018 report and these should be treated with caution as the results are preliminary.

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 increased to 54.5% average for 2012-2014 period but fell to 37.7% in 2015-2017 (or 41.5% mid-point estimate).

The stock status plots for each Index River are given in Figure 4.3 and these indicate a fall in escapement in all catchments, least so in the Erne.

In Figure 4.4, each EMU is plotted separately. The size of the bubble indicates the relative production of that EMU. Three of the EMUs (IE_East, IE_SouE, IE_SouW) have low wetted areas (See Figure 3.4 of the National Eel Management Plan) and relatively modest production compare to the other three, so care should be taken in interpreting the % target data presented in Table 4.6. Escapement was relatively high in 2015 and 2017 and was lower in 2016. However, on average for the last three year period, production and escapement was lower in all EMUs than reported for the 2012-2014 period, even when using the higher values determined with the Fane as an index, or when using the mid-point value as reported to the EU in the e-tables.

Table 6-4: Freshwater historic (Bo) and current annual silver eel production (Bbest) (kg) and escapement (Bcurrent) (kg) for 2008-2017 and average production and escapement for the 2009-2011, 2012-2014 and 2015-2017 reporting periods, calculated using the IMESE model (without the Fane) and inserting actual catchment data where they exist.

EMU Code	EMU Name	Bo Prod kg	Production (Bbest)										Av 2009-2011	Av 2012-2014	Av 2015-2017
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
IE_East	EEMU	20,517	16,768	14,755	10,865	9,928	13,936	15,079	14,756	10376	10117	11228	10,484	14,592	10,142
IE_NorW	NWIRBD	135,732	102,502	57,295	52,447	52,956	82,099	89,376	87,747	87657	74743	79292	52,883	86,286	80,043
IE_Shan	SHIRBD	201,401	95,979	83,464	75,608	71,669	76,507	89,250	80,151	76449*	45657	40379	76,073	81,855	42,404
IE_SouE	SERBD	14,836	11,229	9,877	7,271	6,645	9,333	10,098	9,878	6227	7673	6787	7,018	9,774	6,560
IE_SouW	SWRBD	24,577	15,914	13,975	10,274	9,395	13,230	14,312	13,978	8820	10883	9606	9,932	13,864	9,292
IE_West	WRBD	192,377	101,892	83,128	98,543	90,029	126,447	136,795	133,872	84216	103972	91964	69,545	132,404	88,863
	Total	589,440	344,285	262,494	255,010	240,623	321,553	354,910	340,382	273,744	253,046	239,255	225,936	338,776	237,303

EMU Code	EMU Name	Bo Prod kg	Escapement (Bcurrent)										Av 2009-2011	Av 2012-2014	Av 2015-2017
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
IE_East	EEMU	20,517	9,557	14,561	10,722	9,798	13,753	14,881	14,562	10,254	9,966	11,095	10,346	14,401	10,007
IE_NorW	NWIRBD	135,732	47,787	47,554	49,348	50,515	71,817	80,494	81,817	81,228	63,193	68,972	50,035	77,921	70,613
IE_Shan	SHIRBD	201,401	21,636	79,369	67,398	63,996	67,412	80,055	72,213	68,704*	39,969	37,431	69,414	73,112	36,944
IE_SouE	SERBD	14,836	9,867	9,877	7,271	6,645	9,333	10,098	9,878	6,227	7,673	6,787	7,018	9,774	6,560
IE_SouW	SWRBD	24,577	15,379	13,576	10,067	9,389	12,910	14,189	13,807	8,752	10,563	9,520	9,767	13,659	9,149
IE_West	WRBD	192,377	46,546	83,128	98,543	90,029	126,447	136,795	133,872	84,216	103,972	91,964	69,545	132,405	88,863
	Total	589,440	150,771	248,064	243,350	230,372	301,673	336,512	326,149	259,381	235,336	225,769	216,126	321,272	222,136

* = Shannon River Index estimated due to flooding.

Table 6-5: The freshwater % Bcurrent/Bo (%EU target) for each EMU and for the total production (calculated without the Fane), for 2008 to 2017 and for the average for the 2009-2011, 2012-2014 and 2015-2017 reporting periods. The data come from Table 4.4.

EMU Code	EMU Name	Bo Prod kg	%Bcurrent/Bo (EU Target)										Av 2009-2011	Av 2012-2014	Av 2015-2017
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
IE_East	EEMU	20517	46.6	71.0	52.3	47.8	67.0	72.5	71.0	50.0	48.6	54.1	50.4	70.2	48.8
IE_NorW	NWIRBD	135732	35.2	35.0	36.4	37.2	52.9	59.3	60.3	59.8	46.6	50.8	36.9	57.4	52.0
IE_Shan	SHIRBD	201401	10.7	39.4	33.5	31.8	33.5	39.7	35.9	34.1	19.8	18.6	34.5	36.3	18.3
IE_SouE	SERBD	14836	66.5	66.6	49.0	44.8	62.9	68.1	66.6	42.0	51.7	45.7	47.3	65.9	44.2
IE_SouW	SWRBD	24577	62.6	55.2	41.0	38.2	52.5	57.7	56.2	35.6	43.0	38.7	39.7	55.6	37.2
IE_West	WRBD	192377	24.2	43.2	51.2	46.8	65.7	71.1	69.6	43.8	54.0	47.8	36.2	68.8	46.2
	Total	589,440	25.6	42.1	41.3	39.1	51.2	57.1	55.3	44.0	39.9	38.3	36.7	54.5	37.7

Table 6-6: Freshwater historic (Bo) and current silver eel production (Bbest) (kg) and escapement (Bcurrent) (kg) for 2015-2017 and average production and escapement for 2015-2017, calculated using the IMESE model (without and without the Fane) and the mid-point in the data. * = Shannon River Index estimated due to flooding.

EMU Code	EMU Name	Bo Prod	Production (Bbest)									Av 2015-2017	Av 2015-2017	Av 2015-2017
			ex Fane	ex Fane	ex Fane	inc Fane	inc Fane	inc Fane	midpt	midpt	midpt	ex Fane	inc Fane	midpt
		kg	2015	2016	2017	2015	2016	2017	2015	2016	2017			
IE_East	EEMU	20,517	10,376	10,117	11,228	17,431	8,412	16,740	13,903	9,265	13,984	10,142	13,287	11,715
IE_NorW	NWIRBD	135,732	87,657	74,743	79,292	96,110	72,706	85,893	91,884	73,724	82,592	80,043	83,838	81,941
IE_Shan	SHIRBD	201,401	76,449*	45,657	40,379	81,489	44,439	44,317	78,969	45,048	42,348	42,404	44,648	43,526
IE_SouE	SERBD	14,836	6,227	7,673	6,787	11,706	6,349	11,067	8,966	7,011	8,927	6,560	9,006	7,783
IE_SouW	SWRBD	24,577	8,820	10,883	9,606	16,564	9,018	15,652	12,692	9,951	12,629	9,292	12,773	11,032
IE_West	WRBD	192,377	84,216	103,972	91,964	158,166	86,102	149,744	121,191	95,037	120,854	88,863	121,836	105,349
	Total	589,440	273,744	253,046	239,255	381,465	227,026	323,414	327,605	240,036	281,334	237,303	285,388	261,346

EMU Code	EMU Name	Bo Prod	Escapement (Bcurrent)									Av 2015-2017	Av 2015-2017	Av 2015-2017
			ex Fane	ex Fane	ex Fane	inc Fane	inc Fane	inc Fane	midpt	midpt	midpt	ex Fane	inc Fane	midpt
		kg	2015	2016	2017	2015	2016	2017	2015	2016	2017			
IE_East	EEMU	20,517	10,254	9,966	11,095	17,201	8,287	16,522	13,728	9,127	13,809	10,007	13,110	11,559
IE_NorW	NWIRBD	135,732	81,228	63,193	68,972	89,642	61,166	75,546	85,435	62,180	72,259	70,613	74,455	72,534
IE_Shan	SHIRBD	201,401	68,704*	39,969	37,431	73,744	38,751	41,369	71,224	39,360	39,400	36,944	39,188	38,066
IE_SouE	SERBD	14,836	6,227	7,673	6,787	11,706	6,349	11,067	8,967	7,011	8,927	6,560	9,006	7,783
IE_SouW	SWRBD	24,577	8,752	10,563	9,520	16,258	8,755	15,381	12,505	9,659	12,451	9,149	12,521	10,835
IE_West	WRBD	192,377	84,216	103,972	91,964	158,166	86,102	149,744	121,191	95,037	120,854	88,863	121,836	105,350
	Total	589,440	259,381	235,336	225,769	366,717	209,410	309,629	313,049	222,373	267,699	222,136	270,116	246,126

Table 6-7: The freshwater % Bcurrent/Bo (%EU target) for each EMU and for the total production (calculated with and without the Fane) and the mid-point in the data, for 2015-2017 and average production and escapement for 2015-2017. The data come from Table 4.6.

EMU Code	EMU Name	Bo Prod	%Bcurrent/Bo (EU Target)									Av 2015-2017	Av 2015-2017	Av 2015-2017
			ex Fane	ex Fane	ex Fane	inc Fane	inc Fane	inc Fane	midpt	midpt	midpt	ex Fane	inc Fane	midpt
		kg	2015	2016	2017	2015	2016	2017	2015	2016	2017			
IE_East	EEMU	20,517	50.0	48.6	54.1	83.8	40.4	80.5	66.9	44.5	67.3	48.8	63.9	56.3
IE_NorW	NWIRBD	135,732	59.8	46.6	50.8	66.0	45.1	55.7	62.9	45.8	53.2	52.0	54.9	53.4
IE_Shan	SHIRBD	201,401	34.1	19.8	18.6	36.6	19.2	20.5	35.4	19.5	19.6	18.3	19.5	18.9
IE_SouE	SERBD	14,836	42.0	51.7	45.7	78.9	42.8	74.6	60.4	47.3	60.2	44.2	60.7	52.5
IE_SouW	SWRBD	24,577	35.6	43.0	38.7	66.2	35.6	62.6	50.9	39.3	50.7	37.2	50.9	44.1
IE_West	WRBD	192,377	43.8	54.0	47.8	82.2	44.8	77.8	63.0	49.4	62.8	46.2	63.3	54.8
	Total	589,440	44.0	39.9	38.3	62.2	35.5	52.5	53.1	37.7	45.4	37.7	45.8	41.8

Table 6-8: Transitional Water historic (Bo) and current silver eel production (Bbest) (kg) and escapement (Bcurrent) (kg) for 2008-2017 calculated using the IMESE model mid-point outputs (maximum and minimum production rates).

EMU Code	EMU Name	Bo Prod kg	Production (Bbest)									
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
IE_East	EEMU	14,263	4,055	3,545	2,597	2,379	3,373	3,648	3,547	3,223	2,546	3,202
IE_NorW	NWIRBD	35,558	26,513	23,320	17,168	15,690	22,035	23,841	23,323	21,171	16,552	21,078
IE_Shan	SHIRBD	83,443	60,510	53,211	39,165	35,795	50,294	54,415	53,219	48,309	37,786	48,093
IE_SouE	SERBD	38,488	29,505	25,961	19,117	17,469	24,521	26,532	25,964	23,566	18,415	23,465
IE_SouW	SWRBD	41,594	16,506	14,469	10,621	9,719	13,726	14,847	14,474	13,146	10,339	13,072
IE_West	WRBD	38,105	22,723	19,964	14,683	13,424	18,889	20,436	19,968	18,128	14,202	18,042
	Total	251,450	159,812	140,471	103,352	94,475	132,838	143,718	140,495	127,542	99,840	126,952

EMU Code	EMU Name	Bo Prod kg	Escapement (Bcurrent)									
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
IE_East	EEMU	14,263		3,545	2,597	2,379	3,373	3,648	3,547	3,223	2,546	3,202
IE_NorW	NWIRBD	35,558		23,320	17,168	15,690	22,035	23,841	23,323	21,171	16,552	21,078
IE_Shan	SHIRBD	83,443		53,211	39,165	35,795	50,294	54,415	53,219	48,309	37,786	48,093
IE_SouE	SERBD	38,488		25,961	19,117	17,469	24,521	26,532	25,964	23,566	18,415	23,465
IE_SouW	SWRBD	41,594		14,469	10,621	9,719	13,726	14,847	14,474	13,146	10,339	13,072
IE_West	WRBD	38,105		19,964	14,683	13,424	18,889	20,436	19,968	18,128	14,202	18,042
	Total	251,450	-	140,471	103,352	94,475	132,838	143,718	140,495	127,542	99,840	126,952

Table 6-9: The transitional water % Bcurrent/Bo (%EU target) for each EMU and for the total production (calculated using the mid-point production 2015-2017), for 2009-2017. The data come from Table 4.8.

EMU Code	EMU Name	Bo Prod	%Bcurrent/Bo (EU Target)									
		kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
IE_East	**EEMU**	14,263	-	24.9	18.2	16.7	23.6	25.6	24.9	22.6	17.8	22.5
IE_NorW	**NWIRBD**	35,558	-	65.6	48.3	44.1	62.0	67.0	65.6	59.5	46.5	59.3
IE_Shan	**SHIRBD**	83,443	-	63.8	46.9	42.9	60.3	65.2	63.8	57.9	45.3	57.6
IE_SouE	**SERBD**	38,488	-	67.5	49.7	45.4	63.7	68.9	67.5	61.2	47.8	61.0
IE_SouW	**SWRBD**	41,594	-	34.8	25.5	23.4	33.0	35.7	34.8	31.6	24.9	31.4
IE_West	**WRBD**	38,105	-	52.4	38.5	35.2	49.6	53.6	52.4	47.6	37.3	47.3
	Total	251,450	-	55.9	41.1	37.6	52.8	57.2	55.9	50.7	39.7	50.5

Table 6-10: Annual fishing (kg & ∑F), other anthropogenic (kg & ∑H) and total mortality (kg & ∑A) rates for each Eel Management Unit and the total annual mortality rates for all EMUs. Bbest and Bcurrent 2015-2017 are based on the mid-point between the two modelled outputs for freshwater.

Year	EMU	F'water Bbest	F'water Bcurrent	Biomass F	Biomass H	Biomass Other	Biomass A	Rate F	Rate H	Rate Other	Rate A
2008	EEMU	16768	9590	6991	187	0	7178	0.539	0.019	0.000	0.559
2009	EEMU	14755	14561	0	194	0	194	0.000	0.013	0.000	0.013
2010	EEMU	10865	10722	0	143	0	143	0.000	0.013	0.000	0.013
2011	EEMU	9928	9798	0	131	0	131	0.000	0.013	0.000	0.013
2012	EEMU	13936	13753	0	183	0	183	0.000	0.013	0.000	0.013
2013	EEMU	15079	14881	0	198	0	198	0.000	0.013	0.000	0.013
2014	EEMU	14756	14562	0	194	0	194	0.000	0.013	0.000	0.013
2015	EEMU	13,903	13727	0	176	0	176	0.000	0.013	0.000	0.013
2016	EEMU	9,265	9127	0	138	0	138	0.000	0.015	0.000	0.015
2017	EEMU	13,984	13809	0	176	0	176	0.000	0.013	0.000	0.013
2008	NWIRBD	102502	47466	45349	9687	0	55036	0.584	0.186	0.000	0.770
2009	NWIRBD	57295	47554	0	9741	0	9741	0.000	0.186	0.000	0.186
2010	NWIRBD	52447	49348	0	3099	0	3099	0.000	0.061	0.000	0.061
2011	NWIRBD	52956	50514	0	2442	0	2442	0.000	0.047	0.000	0.047
2012	NWIRBD	82099	71817	0	10282	0	10282	0.000	0.134	0.000	0.134
2013	NWIRBD	89376	80494	0	8450	432	8882	0.000	0.099	0.005	0.105
2014	NWIRBD	87747	81817	0	5930	0	5930	0.000	0.070	0.000	0.070
2015	NWIRBD	91,884	85435	0	6449	0	6449	0.000	0.073	0.000	0.073
2016	NWIRBD	73,724	62179	0	11545	0	11545	0.000	0.170	0.000	0.170
2017	NWIRBD	82,592	72258	0	10334	0	10334	0.000	0.134	0.000	0.134
2008	ShIRBD	95979	21801	68209	5969	0	74178	1.240	0.242	0.000	1.482
2009	ShIRBD	83464	79369	0	4095	0	4095	0.000	0.050	0.000	0.050
2010	ShIRBD	75608	67398	0	8210	0	8210	0.000	0.115	0.000	0.115
2011	ShIRBD	71669	63996	0	7673	0	7673	0.000	0.113	0.000	0.113
2012	ShIRBD	76507	67412	0	9095	0	9095	0.000	0.127	0.000	0.127
2013	ShIRBD	89250	80055	0	9195	0	9195	0.000	0.109	0.000	0.109
2014	ShIRBD	80151	72213	0	7595	343	7938	0.000	0.100	0.005	0.104
2015	ShIRBD	78,969	71224	0	7745	0	7745	0.000	0.103	0.000	0.103
2016	ShIRBD	45,048	39360	0	5688	0	5688	0.000	0.135	0.000	0.135
2017	ShIRBD	42,348	39400	0	2948	0	2948	0.000	0.072	0.000	0.072
2008	SERBD	11229	9867	1362	0	0	1362	0.129	0.000	0.000	0.129
2009	SERBD	9877	9877	0	0	0	0	0.000	0.000	0.000	0.000
2010	SERBD	7271	7271	0	0	0	0	0.000	0.000	0.000	0.000
2011	SERBD	6645	6645	0	0	0	0	0.000	0.000	0.000	0.000
2012	SERBD	9333	9333	0	0	0	0	0.000	0.000	0.000	0.000
2013	SERBD	10098	10098	0	0	0	0	0.000	0.000	0.000	0.000
2014	SERBD	9878	9878	0	0	0	0	0.000	0.000	0.000	0.000
2015	SERBD	8,966	8966	0	0	0	0	0.000	0.000	0.000	0.000
2016	SERBD	7,011	7011	0	0	0	0	0.000	0.000	0.000	0.000

Year	EMU	F'water Bbest	F'water Bcurrent	Biomass F	Biomass H	Biomass Other	Biomass A	Rate F	Rate H	Rate Other	Rate A
2017	SERBD	8,927	8927	0	0	0	0	0.000	0.000	0.000	0.000
2008	SWRBD	15914	15082	89	743	0	832	0.006	0.048	0.000	0.054
2009	SWRBD	13975	13576	0	399	0	399	0.000	0.029	0.000	0.029
2010	SWRBD	10274	10066	0	208	0	208	0.000	0.020	0.000	0.020
2011	SWRBD	9395	9389	0	6	0	6	0.000	0.001	0.000	0.001
2012	SWRBD	13230	12910	0	320	0	320	0.000	0.024	0.000	0.024
2013	SWRBD	14312	14189	0	123	0	123	0.000	0.009	0.000	0.009
2014	SWRBD	13978	13807	0	171	0	171	0.000	0.012	0.000	0.012
2015	SWRBD	12,692	12505	0	187	0	187	0.000	0.015	0.000	0.015
2016	SWRBD	9,951	9659	0	292	0	292	0.000	0.030	0.000	0.030
2017	SWRBD	12,629	12450	0	179	0	179	0.000	0.014	0.000	0.014
2008	WRBD	101892	46546	55346	0	0	55346	0.783	0.000	0.000	0.783
2009	WRBD	83128	83128	0	0	0	0	0.000	0.000	0.000	0.000
2010	WRBD	98543	98543	0	0	0	0	0.000	0.000	0.000	0.000
2011	WRBD	90029	90029	0	0	0	0	0.000	0.000	0.000	0.000
2012	WRBD	126447	126447	0	0	0	0	0.000	0.000	0.000	0.000
2013	WRBD	136795	136795	0	0	0	0	0.000	0.000	0.000	0.000
2014	WRBD	133872	133872	0	0	0	0	0.000	0.000	0.000	0.000
2015	WRBD	121,191	121191	0	0	0	0	0.000	0.000	0.000	0.000
2016	WRBD	95,037	95037	0	0	0	0	0.000	0.000	0.000	0.000
2017	WRBD	120,854	120854	0	0	0	0	0.000	0.000	0.000	0.000
2008	Total	344285	150353	177346	16586	0	193932	0.724	0.105	0.000	0.828
2009	Total	262494	248065	0	14429	0	14429	0.000	0.057	0.000	0.057
2010	Total	255010	243350	0	11660	0	11660	0.000	0.047	0.000	0.047
2011	Total	240623	230371	0	10252	0	10252	0.000	0.044	0.000	0.044
2012	Total	321553	301672	0	19880	0	19880	0.000	0.064	0.000	0.064
2013	Total	354911	336513	0	17966	432	18398	0.000	0.052	0.001	0.053
2014	Total	340382	326149	0	13890	343	14233	0.000	0.042	0.001	0.043
2015	Total	327605	313048	0	14557	0	14557	0.000	0.045	0.000	0.045
2016	Total	240036	222373	0	17663	0	17663	0.000	0.076	0.000	0.076
2017	Total	281334	267698	0	13636	0	13636	0.000	0.050	0.000	0.050

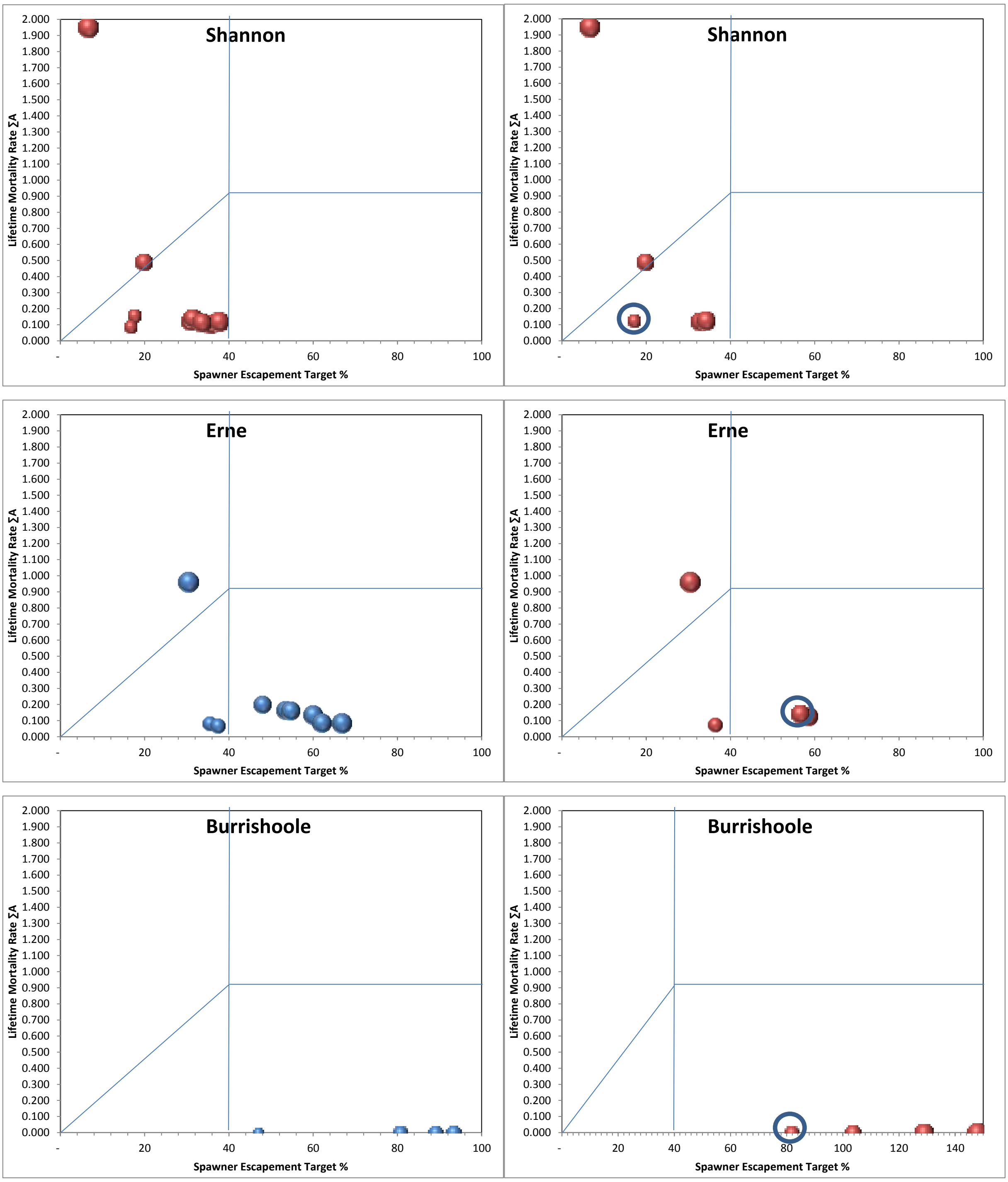


Figure 6-2: Status of the stock and the anthropogenic impacts, for the Rivers Shannon, Erne, Burrishoole and Fane as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008-2014 (left hand graphs), and for the 3-year averages (right hand graphs; 2015-2017 is circled). For each, the 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.

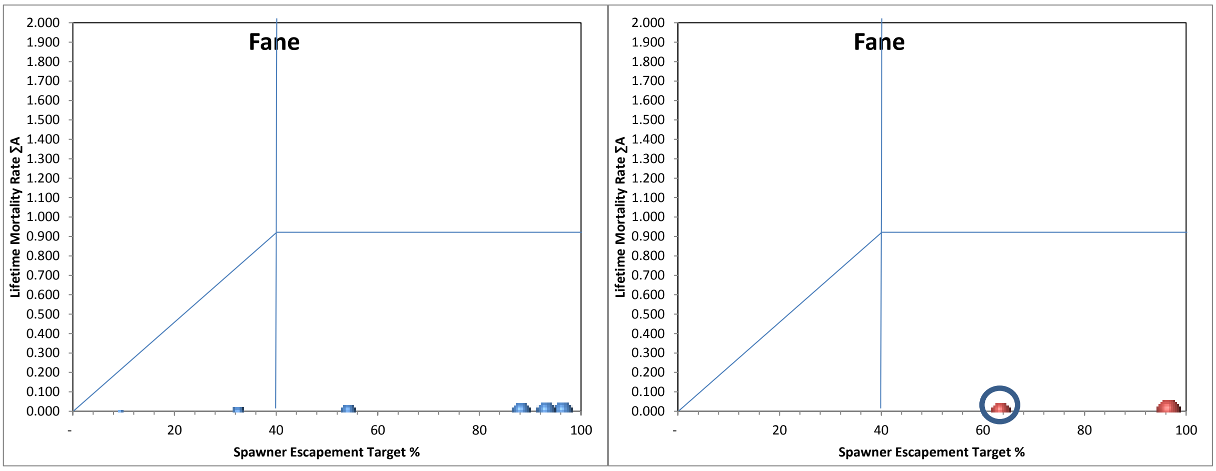


Figure 6-3 continued: Status of the stock and the anthropogenic impacts, for the Rivers <u>Shannon, Erne</u>, <u>Burrishoole and Fane</u> as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008-2014 (left hand graphs), and for the 3-year averages (right hand graphs; 2015-2017 is circled). 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.

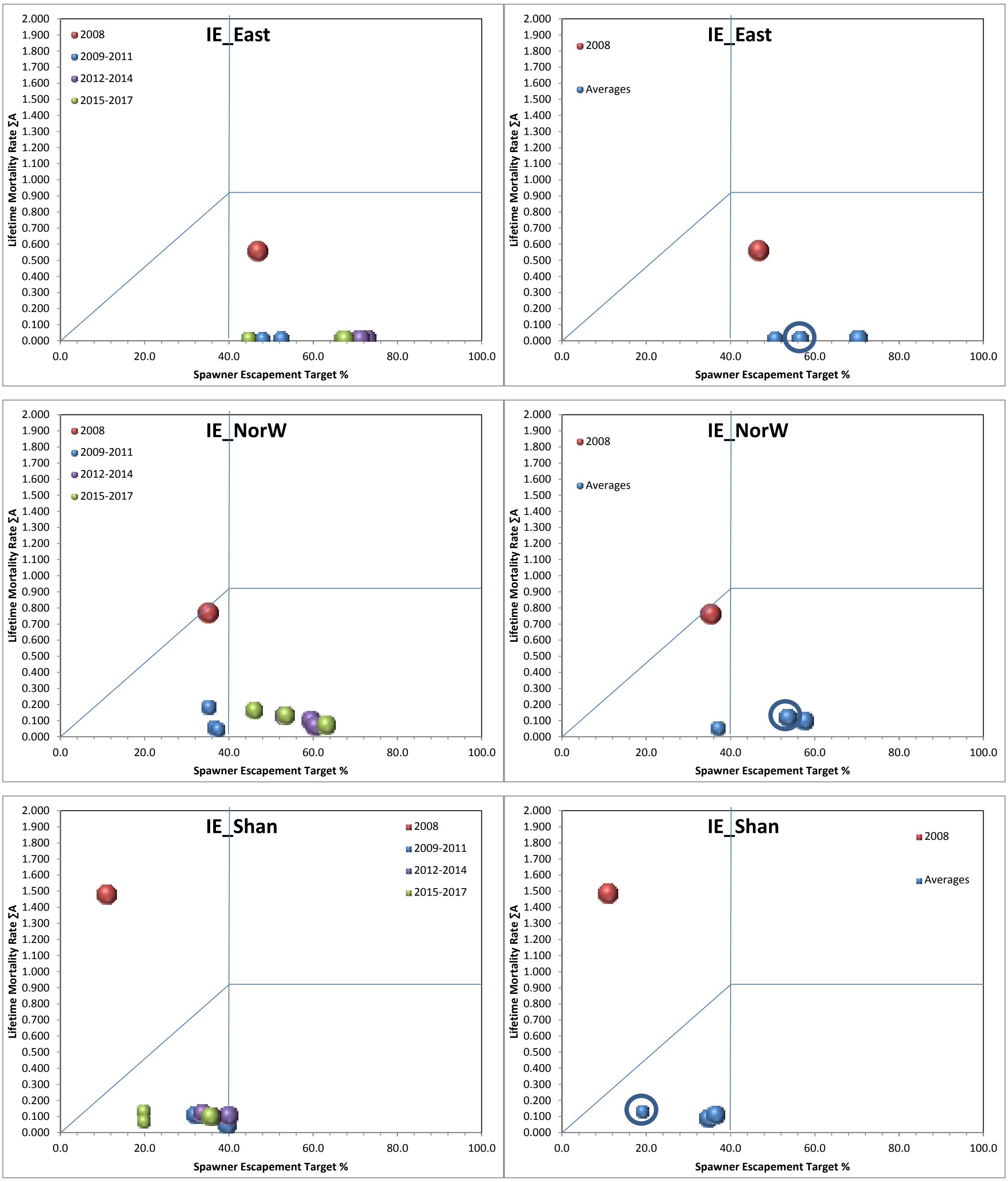


Figure 6-4: Status of the stock and the anthropogenic impacts, for the <u>EMUs</u> as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008-20117 (left hand graphs), and for the average of 2001-2007, 2009-2011, 2012-2014 and 2015-2017(right hand graphs; 2015-2017 is circled). ***These graphs represent the mid-point between the model outputs for 2015-2017.*** **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.**

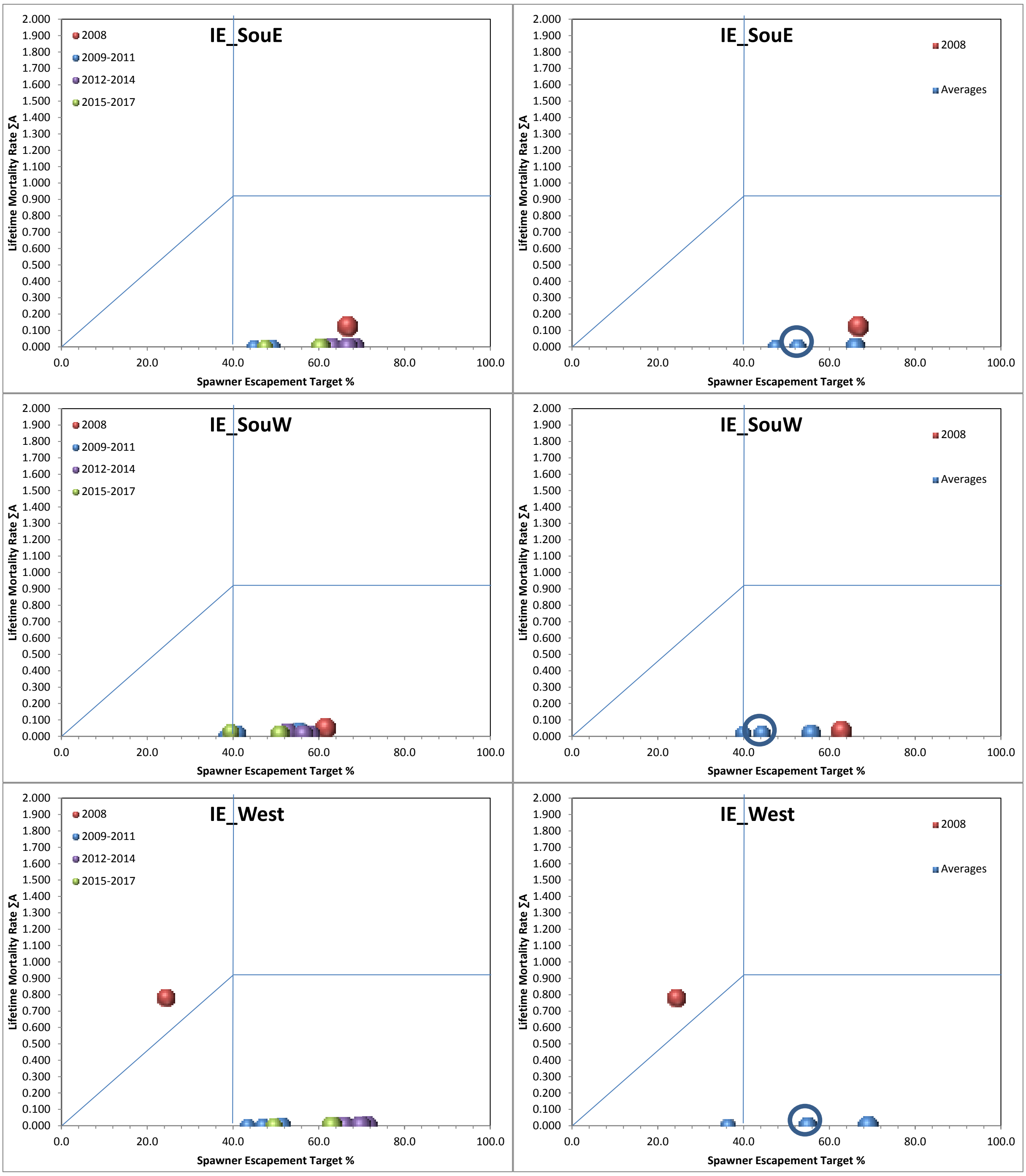
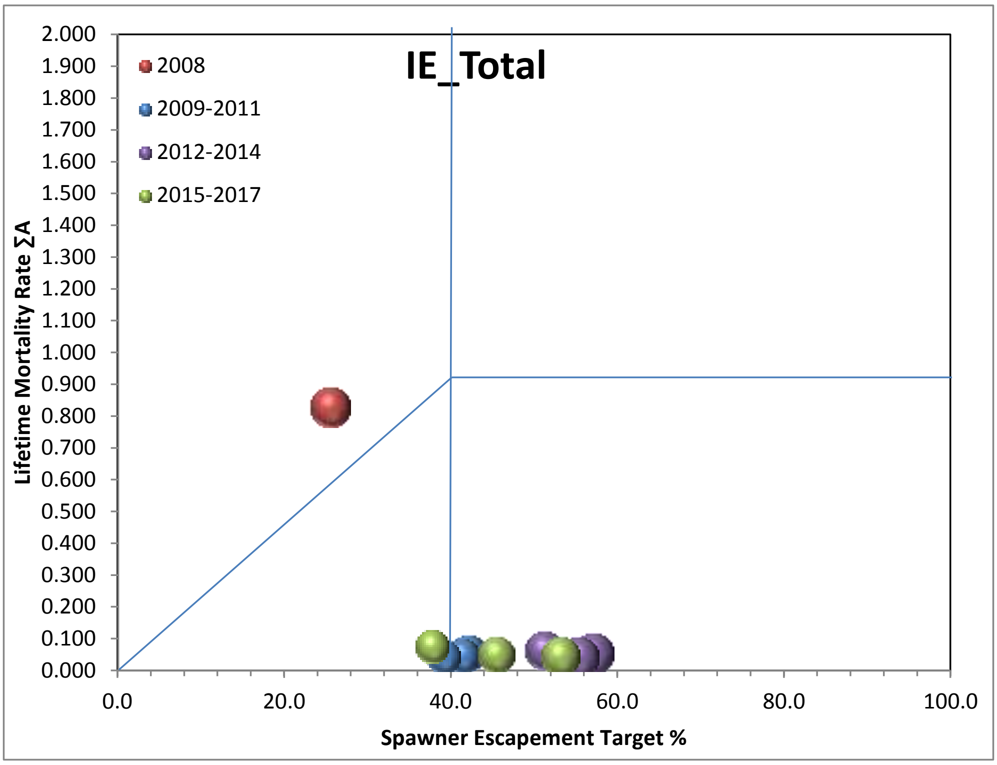


Figure 6-4 cont.: Status of the stock and the anthropogenic impacts, for the EMUs as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008-20117 (left hand graphs), and for the average of 2001-2007, 2009-2011, 2012-2014 and 2015-2017(right hand graphs; 2015-2017 is circled). ***These graphs represent the mid-point between the model outputs for 2015-2017.*** **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.**



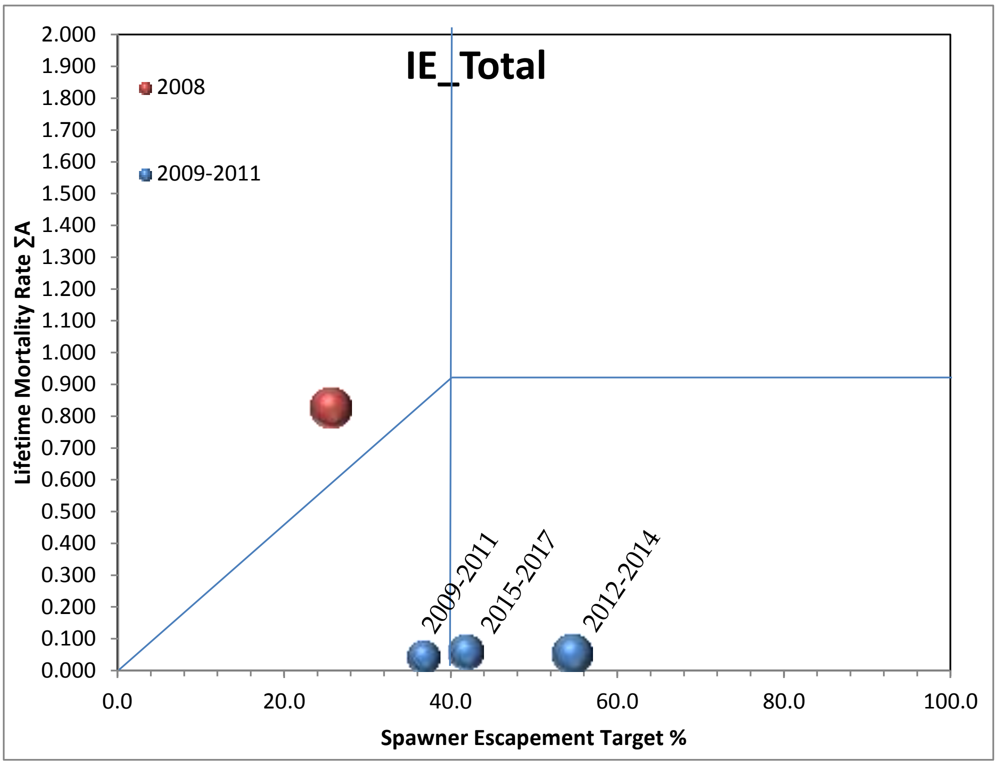


Figure 6-5: Status of the stock and the anthropogenic impacts, for the TOTAL of the EMUs as presented in the Eel Management Plans in 2008 (average 2001-2007), for 2008-2017 (top), and for the average of 2001-2007, 2009-2011, 2012-2014 and 2015-2017 (bottom). *These graphs represent the mid-point between the model outputs for 2015-2017.* **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.**

6.10 SWOT Analysis on the Assessment

Before using the above assessment in informing management decisions, it would be prudent to take account of the SWOT analysis below:

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
- HPS mortality is determined by direct assessment in the Shannon (2006-2011) and Erne (2009-2012).
- Extrapolation (IMESE) provides a consistent means of estimating biomass and comparing between years
- 2009-2011 outputs have been supported by the independent EDA model (deEyto et al. 2015), using WFD field data

Weaknesses

- No silver eel index sites yet available for 2 EMUs
- Two of the four index sites are from highly regulated (HPS) catchments
- HPS mortality estiamtes carried out in 2010 and 2011 when only one turbine installed.
- The IMESE regression is reliant on one low productivity index catchment and there is no weighting applied to index catchments (i.e. the Fane carried the same weight as the Shannon or Erne)
- The IE_West (WRBD) is dominated by catchments with large lakes with no index site
- No quantitative yellow eel density 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, or other yellow eel model, for 2012-2014 and 2015-2017.
- 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.

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).

While **recruitment** remains low, improvements were noted in some catchments between 2013 and 2016. 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. There was a general drop in recruitment during the 2015-2017 period, even though good numbers of elvers and young yellow eels (bootlace) were recorded in some locations such as Parteen and Inagh in 2016, elvers in the Erne in 2016 and bootlace in Burrishoole in 2017.

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 a number of small sub-catchments of the River Barrow with no eels present. Some catchments are also seeing the disappearance of 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, Lough Ramor and Lower Lough Erne. Good catches of eel, including smaller eels, have also been recorded in transitional waters such as Waterford harbour and the Munster Blackwater.

Silver eel: The Shannon, Erne and Burrishoole all showed a decrease in silver eel production (Bbest) in the 2015-2017 period compared to the previous three years (Table 4.6).

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. Production fell to 0.91 and 0.80 kg/ha in 2016 and 2017 respectively. The escapement biomass in the Shannon increased 2012 and 2013, was 33% of Bo in 2014 and was considerably lower in 2016 and 2017 (17.4% and 16,5%).

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 Erne production dropped a little in 2016 but rose again in 2017 from 2.4 to 2.7 kg/ha. The escapement biomass in the Erne also increased until 2015 (66.7%), and was lower, but still above the EU target in 2016 and 2017.

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. However, a poor run occurred in 2015 with only 0.44 kg/ha being recorded and another poor run of relatively small eels was recorded in 2017 with 0.8 kg/ha production. The escapement in Burrishoole fell considerably in the 2015-2017 period to 46% in 2015 and 89% in 2017.

The escapement in the Fane ranged from 139% in 2013 to 9.2% in 2016.

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

National Silver Eel Production, Escapement and Mortality: Current escapements expressed as a percentage of the historic production. 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). This increased to 54.5% average for 2012-2014 period but fell to 37.7% in 2015-2017 (or 41.5% mid-point estimate).

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) to 18.9% (2015-2017).

In the IE_NorW the %SSB went from 35.2% to 36.9% (2009-2011) to 57.4% (2012-2014) and 53.4% (2015-2017), also reflecting the anticipated increase in output due to past recruitment history in the Erne in the mid-1990s.

The total escapement from freshwater relative to the historic Bo was 25.6% in 2008, it increased to 36.7% in 2009-2011, further to 54.5% in 2012-2014 but fell again to 38.7% in 2015-2017 (without Fane) or 41.5% as the mid-point between the two model outputs.

A preliminary assessment of production from transitional waters was made, indicating a possible production ranging from a Bo of 251,450kg to a minimum of 99,840 kg in 2016. This production as estimated to be approximately 40% of the freshwater production in the 2015-2017 period and was on average 47% of Bo.

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.

8 References

Anon. (2012a). Report on the status of the eel stock in Ireland 2009-2011. Report of the Standing Scientific Committee for eel to Inland Fisheries Ireland and the Department of the Communications, Energy and Natural Resources. 204 pp.

Anon. (2012b). Report to the European Commission in lijne with Article 9 of the Eel Regulation 1100/2007: Implementation of Ireland's Eel Management Plans. DCENR. 105pp.

Anon. (2013). Activity Report of the Standing Scientific Committee for Eel, 2012. DCENR, 124pp.

Anon. (2014). Activity Report of the Standing Scientific Committee for Eel, 2013. DCENR, 137pp.

Anon. (2015a). Activity Report of the Standing Scientific Committee for Eel, 2014. DCENR, 140pp.

Anon. (2015b). Report on the status of the eel stock in Ireland 2012-2014. Report of the Standing Scientific Committee for eel to Inland Fisheries Ireland and the Department of the Communications, Energy and Natural Resources. 95 pp.

Anon. (2015c). Report to the European Commission in lijne with Article 9 of the Eel Regulation 1100/2007: Implementation of Ireland's Eel Management Plans. DCENR. 42pp.

Anon. (2016). Activity Report of the Standing Scientific Committee for Eel, 2015. DCENR, 173pp.

Anon. (2017). Activity Report of the Standing Scientific Committee for Eel, 2016. DCENR, 176pp.

Anon. (2018). Activity Report of the Standing Scientific Committee for Eel, 2017. DCENR, 171pp.

Åström, M. & Dekker, W. (2007). When will the eel recover? A full life-cycle model. – ICES *Journal of Marine Science*, **64;** 1–8.

Compass Informatics (2011). Compilation of habitat-base catchment information and historical eel data in support of eel management plans 'EEL-PLAN'. Marine Research Sub-Programme, NDP 2007-'13 Series, Marine Institute, Galway. 31pp.

Cullen P. & McCarthy, T.K. (2000). The effects of artificial light on the distribution of catches of silver eel, *Anguilla anguilla* L. across the Killaloe eel weir in the lower River Shannon. *Biology and the Environment*, **100**; 165-169.

Cullen P. & McCarthy, T.K. (2003). Hydrometric and meteorological factors affecting the seaward migration of silver eels (*Anguilla anguilla* L.) in the lower River Shannon. *Environmental Biology of Fishes*, **67**; 349357.

Dekker, W., Wickström, H. & Andersson, J. (2011). Status of the eel stock in Sweden in 2011. Aqua Reports 2011: 2. Swedish University of Agricultural Sciences. 66pp.

Dekker W., Pawson M., Walker A., Rosell R., Evans D., Briand C., Castelnaud G., Lambert P., Beaulaton L., Åström M., Wickström H., Poole R., McCarthy T.K., Blaszkowski M., de Leo G. and Bevacqua D. (2006). Report of FP6-project FP6-022488, Restoration of the European eel population; pilot studies for a scientific framework in support of sustainable management: SLIME. 19 pp. + CD.

de Eyto, E., Briand, C., Poole, R. & O'Leary, C. (2015). Application of EDA (v 2.0) to Ireland; Prediction of silver eel *Anguilla Anguilla* escapement, Report 2015 (in prep); Marine Institute, 74pp.

ICES, (2003). Report of the EIFAC/ICES Working Group on Eels, 2-6 September 2002, Nantes, France. ICES CM 2003/ACFM;06.

ICES, (2009). The report of the 2008 Session of the Joint EIFAC/ICES Working Group on Eels. Leuven, Sept. 2008; *ICES CM 2009/ACOM;15*

ICES, (2010). The report of the 2010 Session of the Joint EIFAC/ICES Working Group on Eels, September 2010; *ICES CM 2010/ACOM:18*. (Online).

ICES (2011a). Report of the Study Group on International Post-Evaluation on Eels SGIPEE. 24-27 <ay 2011, London. ICES CM 2011/SSGEF: 13. 39pp.

ICES, (2011b). Report of the 2011 session of the Joint EIFAAC/ICES Working Group on Eels. Lisbon, Portugal, from 5 to 9 September 2011. EIFAAC Occasional Paper. No. 48. ICES CM 2011/ACOM:18. Rome, FAO/Copenhagen, ICES. 2011. 246p. (Online).

ICES (2012). Report of the 2012 session of the Joint EIFAAC/ICES Working Group on Eels. Copenhagen, Denmark, from 3 to 9 September 2011. ICES CM 2012/ACOM:18. Copenhagen, ICES. 2012. 828p.

MacNamara, R. & McCarthy, T.K. (2013). Silver eel (*Anguilla anguilla*) population dynamics and production in the River Shannon, Ireland, *Ecology of Freshwater Fish* **23** (2), 181-192.

McCarthy, T. K. & Cullen, P. (2000). The River Shannon silver eel fisheries: Variations in commercial and experimental catch levels. *Dana* **12**, 67-76.

McCarthy, T. K., Cullen, P. & O'Conner, W. (1999). The biology and management of River Shannon eel populations. *Fisheries Bulletin (Dublin)* **17**, 9-20.

McCarthy, T. K., Frankiewicz, P., Cullen, P., Blaszkowski, M., O'Connor, W. & Doherty, D. (2008). Long-term effects of hydropower installations and associated river regulation on River Shannon eel populations: mitigation and management *Hydrobiologia* **609**, 109-124.

McCarthy, T.K., MacNamara, R., Nowak, D., Grennan, J., Egan, F. Conneely, B & Bateman, A. (2010). Silver eel escapement from the Rivers Lee, Shannon and Erne. A summary report for 2009/2010. NUIG/ESB Internal Report.

McCarthy, T.K., MacNamara, R., Nowak, D., Grennan, J., Egan, F. Conneely, B & Bateman, A. (2011). Silver eel research and trap and transport monitoring 2010/2011; an interim analysis for the 2nd review of the Irish Eel Management Plan. A summary report for 2010/2011. NUIG/ESB Internal Report.

McCarthy, T.K., MacNamara, R., Nowak, D., Grennan, J., Egan, F. Conneely, B & Bateman, A. (2012). Silver eel research and trap and transport monitoring 2011/2012; an interim analysis for the 3rd review of the Irish Eel Management Plan. A summary report for 2011/2012. NUIG/ESB Internal Report.

McCarthy, T.K., Nowak, D., Grennan, J., Bateman, A., Conneely, B. & MacNamara, R. (2014). Spawner escapement of European eel (*Anguilla anguilla*) from the River Erne, Ireland. Ecology of Freshwater Fish **23** (1), 21-32.

McCarthy T.K., O'Farrell M., McGovern P. & Duke A. (1994). Elver Management Programme; *Feasibility Study Report, Forbairt, Dublin*, 90pp.

McGinnity, P., de Eyto, E., Gilbey, J., Gargan, P., Roche, W., Stafford, T., McGarrigle, M., O'Maoileidigh, N. & Mills, P. (2011). A predictive model for estimating river habitat area using GIS-derived catchment and river variables. Fisheries Management & Ecology, 2011 – doi: 10.1111/j.1365-2400.2011.00820.

Matthews, M., Evans, D., Rosell, R. Moriarty, C. & Marsh, I. (2001). Erne Eel Enhancement Programme. EU Programme for Peace & Reconciliation Project No. EU 15. *Northern Regional Fisheries Board, Donegal*; 348pp.

Moriarty, C. (1988). The Eel in Ireland. *The Went Memorial Lecture, Occasional paper in Irish Science & Technology,* **4**; 9pp.

Palm, S., Dannewitz, J., Prestegaard, T. & Wickstrom, H. (2009). Panmixia in European eel revisited: no genetic difference between maturing adults from southern and northern Europe. *Heredity*, 103, 82–89.

Poole, W.R. (1994). A population study of the European Eel (*Anguilla anguilla* (L.)) in the Burrishoole System, Ireland, with special reference to growth and movement. *PhD Thesis, Dublin University*; 416pp.

Poole, W.R., Reynolds, J.D.R. & Moriarty, C. (1990). Observations on the silver eel migrations of the Burrishoole river system, Ireland. 1959 to 1988. *Int. Revue Ges Hydrobiol*. **75** (6); 807-815.

Poole W. R., Diserud, O.H., Thorstad, E.B., Durif, C., Doland, C., Sandlund, O.T., Bergesen, K., Rogan, G., Kelly, S. & Vollesatd, L.A. (2018). Long-term variation in numbers and biomass of silver eels being produced in two European river systems. *ICES Journal of Marine Science*, (2018), doi:10.1093/icesjms/fsy053.

Sandlund, O.T., Diserud, O. H., Poole, R., Bergersen, K., Dillane, M., Rogan, G., Durif,C., Thorstad, E. B., and Vøllestad, L. A. 2017. Timing and pattern of annual silver eel migration in two European watersheds are determined by similar cues. *Ecology and Evolution*, DOI:10.1002/ece3.3099; 11pp.

Zuur, A., Leno, E.N., Walker, N., Saveliev, A.A. & Smith, G.M. (2009). Mixed Effects Models and Extensions in Ecology with R. Springer-Verlag New York; XXII, 574pp.

Source Material also used in the Stock Annex 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 2: Eel Management Plan- electronic data tables for Ireland