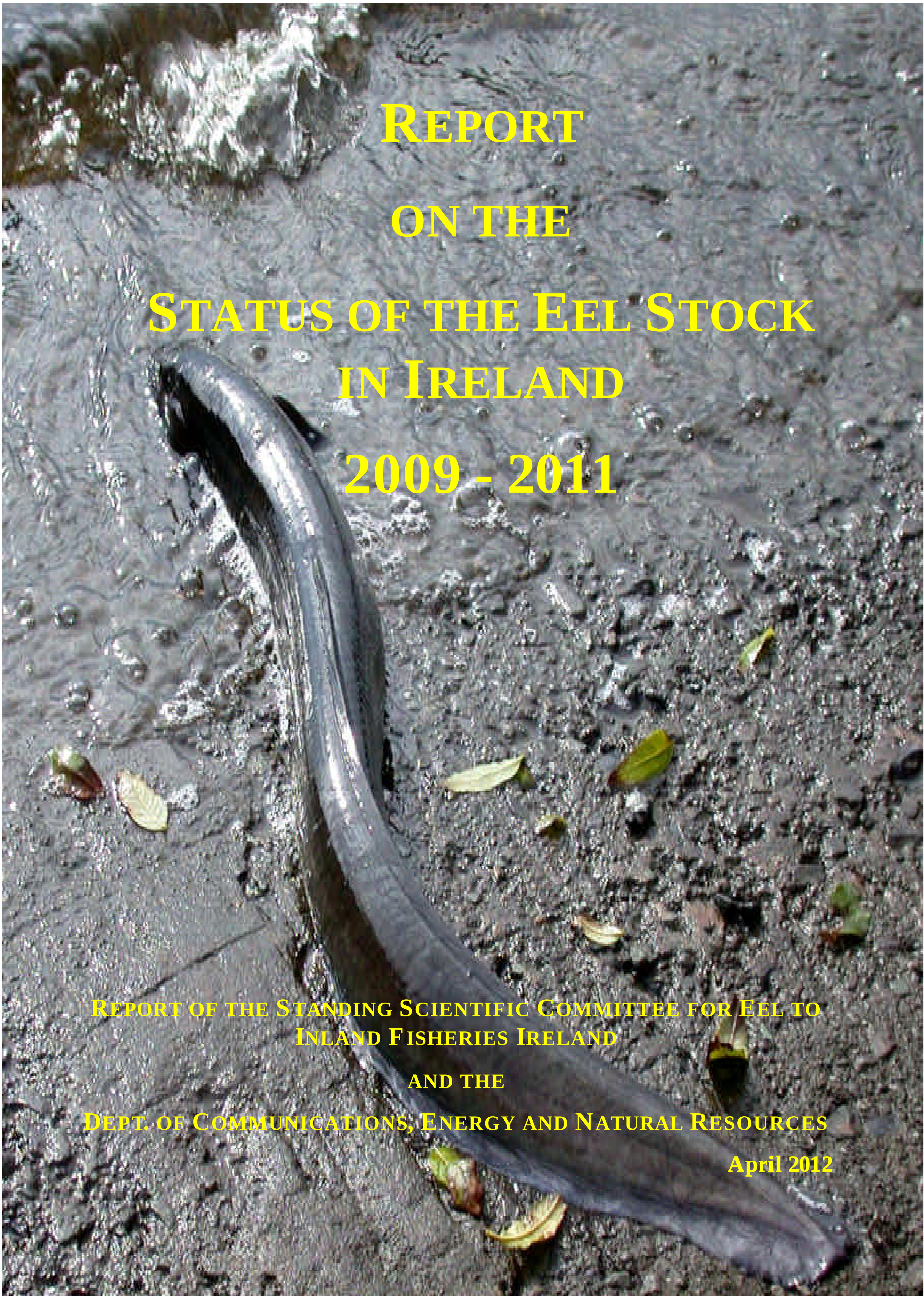

REPORT ON THE STATUS OF THE EEL STOCK IN IRELAND 2009 - 2011

REPORT OF THE STANDING SCIENTIFIC COMMITTEE FOR EEL TO INLAND FISHERIES IRELAND

AND THE

DEPT. OF COMMUNICATIONS, ENERGY AND NATURAL RESOURCES

April 2012

REPORT

ON THE

STATUS OF THE EEL STOCK IN IRELAND

2009 – 2011

A report providing information on:

- the National Eel Monitoring Programme under EU Regulation (Council regulation 1100/2007)
- Status of the eel stock in Ireland, recruitment, yellow eel and silver eel
- The level of Anthropogenic mortality pressure on the stock
- The scientific requirements for the obligatory 2012 post-evaluation of the Eel Management Plan (2008), the data and methods.
- International scientific advice with respect to eel
- National scientific advice 2012.
- The monitoring programme for 2012-2015 under the Regulation required for the obligatory 2015 post-evaluation reporting process.

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The data presented and analysed in this report has been drawn from various sources including annual IFI Eel Monitoring Programme Annual Reports (O'Leary *et al*. 2009-2011), annual reports to the ESB and the SSCE by NUIG on Silver Eel Research and trap and transport monitoring (McCarthy *et al*. 2009-2011), Marine Institute annual stock assessments for the Burrishoole (2009-2011) and the annual Country Report to the joint EIFAAC/ICES Working Group on Eel. More complete presentation and analysis of these data are available from the sources of these reports.

SSCE REPORT: 2009 - 2011

Executive summary and advice

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.

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 is due by 30th June 2012.

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

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 available in a full SSCE report. This document serves as an executive summary and also distils the information down into the most current scientific advice on the status of the eel stock following the first three years of the implementation of the Irish Eel management Plan (2009-2011). All data referred here has been assessed and referenced in the SSCE Report (2009-2011) and can be sourced through that document (Anon 2012).

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).

International Eel Stock and the EU Regulation

Extracted from ICES Advice

The eel stock continues to decline in the period 2009 to 2011. In 2011, glass eel recruitment has fallen to 5% of their 1960-1979 level in the Atlantic region and less than 1% in the North Sea area, and showed no sign of recovery. Recruitment of young yellow eel has been declining continuously since the 1950s. Stock indicators in the national eel management plans submitted in 2008 indicated that anthropogenic mortality was above the limit implied by EC Regulation No. 1100/2007 (EC, 2007).

Abundance of all stages of eel (glass eel, yellow eel, and silver eel) is at an historical minimum. The stock is in a critical state. In 2007, European eel, *A. anguilla*, was included in CITES Appendix II that deals with species not necessarily threatened with extinction, but trade of which must be controlled to avoid utilization incompatible with the survival of the species (see http://www.cites.org/eng/disc/how.shtml), implemented in March 2009. Eel was also listed (2008) as critically endangered in the IUCN Red List.

A management framework for eel was established in 2007 through an EC Regulation (EC No. 1100/2007; EC, 2007). The objective of this Regulation is the protection, recovery, and sustainable use of the stock. To achieve the objective, Member States have developed eel management plans (EMPs) for their river basin districts, designed to reduce anthropogenic mortalities and increase silver eel biomass. The objective of the national eel management plans is to provide, with high probability, a long-term 40% escapement to the sea of the biomass of silver eel, relative to the best estimate of the theoretical escapement in pristine conditions (i.e. if the stock had been completely free of anthropogenic influences).

As eel is a long-lived species and anthropogenic mortalities occur over all of its continental lifespan, the effect of management measures on silver eel production and escapement and on their subsequent recruits (glass eel coming back to the coast) is expected to take several years to be detected (ICES, 2009). When these management measures eventually feed through to silver eel escapement and glass eel recruitment, the natural variability of these migrations, local site effects, and sampling variation may prevent the detection of such changes for at least several more years, even a decade or more (ICES, 2011a, 2011b). Therefore, the recovery process and the detection of possible changes due to management actions will be a slow process. The reporting by Member States to the EC in 2012 is a first step, and, in the short term changes in anthropogenic mortality and local variations in the stock will have to be used to quantify the effect of management measures.

Over the period 2009-2011, there is no change in the scientific perception of the stock status: it remains critical and urgent action is needed. ICES reiterated its previous advice that all anthropogenic mortality (e.g. recreational and commercial fishing, hydropower, pollution) affecting production and escapement of eels should be reduced to as close to zero as possible until there is clear evidence that both recruitment and the adult stock are increasing. Urgent actions are needed to prevent further depletion of the stock.

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. 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
- ensure upstream migration of juvenile eel at barriers
- improvement of water quality

The Irish Eel Management Plan (EMP) also outlined a national 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.

Monitoring 2009-2011

As outlined in Chapter 7 of the 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 key index sites such as the Corrib, Burrishoole and Fane and in conjunction with the silver eel trap and transport programmes on the Shannon and Erne. 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 incorporated into the previous estimates of escapement used in the 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. The data collected will be incorporated into a report to the EU by 30th June 2012.

During the three year programme, some minor corrections were made to the eel database and the pristine silver eel production estimates used in the EMP. The outcome of these was small, and along with the new HPS mortality data, the National escapement (%SSB) of 24% changed to 24.3% and made little difference to the overall picture described in the EMP.

Status of the Irish Stocks 2009-2011

A full assessment of the eel stocks is presented by the SSCE in its Report 2009-2011. This 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.

Recruitment

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

Recruitment has been declining at many Irish monitoring sites since the mid 1980s. In the 2000-2011 period, the glass eel catch in the Shannon was at 2% of the pre-1980 average and in 2009-2011 it was <1%. The Feale, Inagh and the Erne show a slower rate of decline but in the 2009-2011 period these have also declined to low levels. For comparison, catches of glass eel in the Bann (NI) for the last five years were at about 3% of the pre-1980 level. While there is some local variation in abundance between sites and between years, often due to seasonal variations in water levels, recruitment remained low during the 2009 to 2011 period both in Ireland and across Europe.

Yellow Eel

Over the course of the last 3 years an extensive yellow eel fyke net survey was carried out in key Irish lakes. This programme addressed a number of the monitoring objectives in the EMP, such as creating a baseline data set for monitoring changes to the yellow eel population over time, comparison with historical surveys and inter-calibration with Water Framework Directive surveys. In the Corrib, Shannon, Erne and Burrishoole catchments, yellow eels (>30cm) were tagged with passive integrated transponders (TROVAN PIT tags). Silver eel catches from these catchments were scanned in order to detect the maturing tagged yellow eels. A number of transitional waters and lagoons were surveyed by the EMP, namely the Suir, Barrow/Nore and

Slaney transitional waters and the South Sloblands (a brackish lagoon). The aim of these surveys was to investigate the importance of transitional waters to the Irish eel population. Where data were available, the current surveys were compared with previous surveys in the 1970s, '80s and '90s.

The general picture from the comparisons made between previous and current surveys is one of similar CPUEs but with a shift to larger eels. This shift to larger average size is a combination of relatively low numbers of small eels (e.g. in L. Conn, Inchiquin, and Corrib), indicative of poor recruitment, and shifting sex ratios to a higher proportion of larger females (e.g. in Corrib, Shannon and Burrishoole). The surveys of the Erne catchment still show relatively good numbers of eel compared to previous surveys, but in some cases there was evidence of previous commercial exploitation with large size classes absent in the current survey (i.e. L. Oughter, Up, L. Erne). The stocks of yellow eel in the Erne may be a reflection of the good recruitment of the 1990s and early 2000s still resident within the catchment.

Surveys of the transitional waters showed differences between each water and between the transitional waters and the lakes. The transitional waters contained significantly smaller eels that the lakes. The highest CPUEs were recorded in the transitional waters of the Barrow/Nore and Suir. The Slaney and South Sloblands had comparatively lower CPUEs. Low mark-recapture rates indicated probable high levels of movement within these waters and made population estimation difficult. Due to the difficulties in obtaining density estimates for eels in large water bodies and the migratory habits of eels moving upstream into the rivers and/or leaving the transitional water as silver eel, it is still not possible to estimate silver eel escapement/production for transitional waters.

Silver Eel

Quantitative estimates of silver eel escapement are required to establish and monitor changes in escapement relative to the EU 40% SSB target. 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 yellow eel and modelled assessments. Silver eels were assessed during 2009-2011/'12 by fishing index stations on the Corrib (2009 only), Erne, Shannon, Burrishoole and Fane catchments (part of 2011), all of which, with the exception of the Fane, have a long-term history of eel catch and data collection. The index catchments have a combined wetted area of almost 98,000ha or 64% of the total wetted area (inc. the N. Ireland part of the NWIRBD).

In the Shannon Catchment (ShIRBD), historical (pristine) silver eel production was estimated to be in the order of 189t, falling to an average production of 86t for the 2001-2007 period, or an escapement of 12t (6.4% of pristine), after exploitation and using 17.8% as an average bypass at Parteen and 21.1% turbine mortality (average 2009-2011). Following the cessation of the fishery in 2009 and implementation of the trap and transport programme, escapement increased to 66.8t, 60.2t and 57.9t in 2009, 2010 & 2011 respectively, or an average of 61.6t (32.6% of pristine).

In the Erne (NWIRBD), historical silver eel production was estimated to be in the order of 107.5t, falling to an average of 85t for the 2001-2007 period, or an escapement of 32.5t (30.3% of pristine), after exploitation and using 22.9% turbine mortality (average 2009-2011 for both Cliff & Cathaleens Fall). Following the cessation of the fishery in Ireland in 2009 and N. Ireland in 2010 and implementation of the trap and transport programme, estimated escapement increased to 37.9t and 39.9t in 2010 and 2011, or an average of 38.9t (36.2% of pristine). Given the relatively high level of recruitment in the mid 1990s to the early 2000s in the Erne system (~235 recruits/ha yielding 1.6 kg/ha silver eel), comparisons with other river systems (e.g. Shannon ~64 recruits/ha yielding 1.7 kg/ha silver eel), and the relatively high yellow eel stocks in much of the Erne system compared to previous surveys, the estimates of current silver eel production in the Erne were lower than expected. This may be due to unexplained differences in productivity and recruitment, higher than previously thought commercial yellow eel catch, an under-estimate of current production or a combination of these factors. The SSCE advises that further work is required to clarify the lower than expected production estimate.

In the Corrib (WRBD), historical silver eel production was estimated to be historically in the order of 103t, falling to an average of 48.5t for the 2001-2007 period, or an escapement of 13.4t or 13% of pristine. Following the cessation of the fishery in Ireland in 2009, escapement increased to 36.1t in 2009 (35% of pristine). No estimates were available for 2010 or 2011 due to structural problems at the Galway Fishery.

In the Burrishoole (WRBD), historical silver eel production was estimated to be in the order of 0.5t, increasing to an average of 0.7t for the 2001-2007 period, or 140% of pristine. The yellow eel stock in Burrishoole has never been commercially exploited and the stock has shown evidence of sex ratio changes from a male dominated silver eel run to a higher proportion of larger females. The number of eels has decreased while the biomass increased until about 2005. Similar observations of increasing average size/female sex ratio have been made on the Corrib and the Shannon. Production and escapement in Burrishoole for the 2009-2011 period were 0.6t, 0.4t and 0.4t with an average of 0.5t (103% of pristine) and 2010 and 2011 were the lowest observed since 1986..

A preliminary assessment of the Fane in Dundalk (Eastern EMU) in October/November indicated a potential production in 2011 of approximately 2t. The migration appeared to be dominated by male silver eel. Further surveys will conducted at this important site as it is currently the only east coast site with potential to be an index for silver eel production.

National Production and Escapement (EU target)

The objective of the EMPs is to provide, with high probability, a long-term 40% escapement to the sea of the biomass of silver eel, relative to the best estimate of the theoretical escapement in pristine conditions (i.e. if the stock had been completely free of anthropogenic influences). In the Irish Eel Management Plan (2008), estimates of pristine silver eel production and current (2001-2007) silver eel escapement were determined for the freshwater catchments and plotted for each RBD and for the total national situation (including the Loughs Agency and DCAL areas in the EEMU and NWIRBD) (see Figures 1 & 2). Also shown on these plots is the 40% of pristine escapement target line marked in red. The estimated effect of complete fishery closure (yellow & silver eel and illegal/unreported) and/or removal of all hydropower mortality is also shown along with the “do nothing scenario”. The impact of these management options is trended to take account of the legacy of the previous 18 years of decreasing recruitment trends. Only the SERBD and the SWRBD were meeting their escapement target in 2008 and this situation was unlikely to be sustainable even within the short-term future due to the legacy of poor and declining recruitment in the last 18 years.

After 2009-2011, the indications are that the management measures implemented in the EMP have increased silver eel escapement from freshwater to a national average of 37% of pristine, improved from 24% in 2008. The EEMU, SERBD and SWRBD are estimated to be at 45+%, above the EU 40% target, and the ShIRBD, WRBD and NWIRBD are at 34%, 36% and 38% respectively (Figures 1 & 2). Silver eel production fell by 33% from the 2008 estimate to the average 2009-2011 estimate

In the report, the state of the stock is compared with the targets. A modified precautionary diagram is used to present the status of each RBD/EMU separately and for the total Irish stock. 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). Figures 3 & 4 plot the most recent stock assessment, presented in the SSCE report (2009-2011) and the assessment already presented in the Eel Management Plan (2008).

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). For each part of the stock (and for the whole of Ireland), the status of the stock is represented by a bubble. The positions of the bubbles indicate the status of the stock in 2008 (average 2001-2007) and for 2009-2011 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 were expected to have.

In the EEMU, the ShIRBD, WRBD and NWIRBD, the mortality was clearly reduced, as indicated by the downward direction of the bubbles, and this led to increased escapement shown by right hand horizontal movement towards the 40% target (Figure 3). In some cases the bubbles did not respond as expected, by not moving as much to the right. This may due to some yellow eel still to feed through increasing the %SSB and moving the bubbles to the right in coming years. Or the negative impact of falling recruitment may now be leading to lower silver eel production, or there may be problems with some of the estimates as mentioned previously. Extrapolation to the east and south RBDs may need to be reviewed in the light of future additional data and for the NWIRBD diagram, either the 2008 bubble is too far to the right, due to an over-estimate of 2008 escapement, or the 2009-2011 bubble is too far to the left due to an under-estimate of the current escapement or a combination of both. There is evidence to suggest higher than previously thought yellow eel exploitation, especially in the Erne, which would increase mortality and reduce escapement of the 2008 bubble in the NWIRBD diagram.

In general, we have demonstrated the increase in biomass of silver eel escaping and the reduction in mortality caused by fishing and hydropower. While further reduction in mortality is unlikely, it possible that additional biomass will feed through in the coming years from the closure of the yellow eel fishery.

However, it is unclear how the collapse in recent recruitment will impact on silver eel biomass and whether density dependent effects (change from small males to higher proportions of larger females) will buffer the collapse in recruitment by temporarily increasing biomass of silver eels, even with falling numbers.

The projected indications, given past recruitment patterns, yellow eel surveys and the closure of the yellow eel fishery, are that production of silver eels will remain at current levels, or may even increase until circa 2018, after which it is anticipated that a marked reduction will take place. Recruitment in the Erne, in particular, was relatively high between 1994 and 2001 and it is anticipated that this will have a positive effect on silver eel production in the coming 5-6 years. Some RBDs (e.g. SERBD & SWRBD) may already be showing the impact of declining recruitment (Figure 3).

It is therefore unlikely that the EU target and recovery of recruitment to historic levels will be achieved within the projected 90 years outlined in the Irish EMP. While management measures (i.e. cessation of fishing, trap and transport around hydropower stations) implemented in Ireland have led to considerable improvements in silver eel escapement, equivalent EU-wide actions have not, to the best of our knowledge, taken place. Further improvement in silver eel production is contingent on increased recruitment of juveniles to Irish waters. Conclusion of the EU 2012 reporting and evaluation process will provide the opportunity to evaluate whether the initial implementation of the Regulation is likely to lead to an improvement in recruitment.

Other Observations

Parasites

In Chapter 3.4.2.3 of the National EMP report (2008), it was indicated that approximately 73% of the wetted area was infected by *Anguillicoloides*. In the interest of maintaining good eel quality, it was hoped that the further spread of the parasite might be avoided.

The eels captured in the EMP and WFD surveys are checked for the presence of *A. crassus.* Prevalence and intensity rates varied from east to west, but the northwest and southwest of the country show little to no infection by *A. crassus*. A number of catchments, such as the Munster Blackwater, the Laune and the Fergus, have shown low infection rates and patchy distribution which indicates recent introductions and continued spread. Further monitoring and management will be necessary to maintain the parasite free status of catchments in these areas. It should be noted that any transfer of water or fish, not only eels, can act as a vector for the spread of *A. crassus*. Therefore, any movements of fish or water between catchments should be undertaken with caution. This includes stocking programmes from hatcheries, transfers of coarse fish between waterbodies and bilge water in boats.

Silver Eel Trap and Transport targets

In 2008, it was not possible to define a timeframe to achieve the EU biomass target (40% of pristine SSB) with the proposed management actions (cessation of fishery, trap and transport), so an alternative target of timeframe to achieve full recovery of recruitment (assumed to be at, or above, 40% SSB) was defined. With the management actions for 2009-2011, all EMUs, and Ireland as a whole, was expected to contribute to a recovery of recruitment at the 100 year timeframe or less. It was imperative that equivalent EU-wide action was taken at this level so as not to diminish the impact of Ireland's contribution. It was estimated that a recovery could only take place if anthropogenic mortality was reduced by more than 85% of the level in 2008.

In both the Shannon and Erne catchments, anthropogenic mortality during 2009-2011 was reduced to as low as possible, by closing the fishery and transporting silver eels around the HPSs, and this is evident by examining the biomass data (Figure 5). The downward movement of the 2009-2011 bubbles indicates the reduced anthropogenic mortality and the left to right movement indicates the increase in silver eel biomass escaping. Neither catchment is achieving its EU target of 40%.

In the EMP, the objective set by the national WG on Eel was to aim to recover the stock in the shortest time practicable. Trap and Transport amounts of silver eel were set by agreement between DCENR, DCAL and ESB, with the 30% of the production in the Shannon and three fixed annual catch quota in the Erne for 2009, 2010 & 2011. Taken into account in setting these quotas were the estimated eel productions, recent past recruitment history, practicable feasibility and infrastructure/experience on each catchment.

Along with the cessation of the fishery, the trap and transport targets were input to the EMP model for assessing the timeframe to achieve a recovery and all EMUs were expected to contribute to a recovery in 100 years or less. This was safely below the 300+ year breakpoint, or 85% reduction in mortality (see Chapter 5.3.1 of the EMP Report 2008).

For the 2012-2015 period, it is proposed that the trap and transport amount should remain unchanged at 30% of the silver eel production on the Shannon and 500kg on the Lee.

Given the unexplained possible anomaly in silver eel production in the Erne discussed above and the need for additional Hydropower Station mortality estimates within the next three years under full generation regimes, the SSCE recommends that the Erne T&T programme could move to being based on a proportion of the estimated annual production (as on the Shannon). This should be safely above the level required to contribute to the recovery of the stock (breakpoint minimum T&T level of 43% of production), and preferably 60% (as achieved in 2011), of the annual production. This will ensure that the anthropogenic mortality reduction needed to achieve a recovery is kept safely below the 15% threshold (Figure 6). The Shannon should continue with the 30% threshold set out in the EMP. The SSCE will review the T&T rate for the Erne in the light of the outcome of the EU 2012 review and the revised HPS mortality estimates under full generation capacity.

Table 1 shows the estimated reduction (%) in mortality rate in the Shannon and the Erne in 2009-2011, a 92-94% reduction in the Erne and 94% reduction in the Shannon. Shown in Figure 6 is the reduction that would be achieved by different proportions of the silver eel production transported on the Erne. The further above 85% reduction the more assured we are of contributing to a recovery and the quicker it will occur. It is recommended that a reasonable minimum target for the Erne in the next three years would be 50% of the production (or 87.3% reduction in mortality). This will ensure compliance with the Irish EMP and Ireland's contribution to the recovery of the eel stock. The cumulative 23% HPS mortality in the Erne is an estimate which will need to be revised under full generation regimes.

Due to the difficulty in obtaining real time data on the size of the run of silver eel, especially in the Erne, and in the event that the T&T target does not achieve the required % of the annual production, any deficit should be brought forward to the following year as an additional amount to be transported that year.

Should alternative mitigation measures from trap and transport, such as engineered solutions, be developed, they can also be included in this process and resulting escapement recognised in the determination of anthropogenic mortality and Irelands contribution to the stock.

Monitoring Programme 2012-2015

Under the Eel Management Plan, Ireland is committed to monitoring the outcome and effectiveness of the management measures; a three year programme was outlined in the EMP. This has now been updated for 2012-2015, based on the experience of the first three years, and is presented in the SSCE report.

Conclusion

The overall European eel stock is outside safe biological limits, recruitment has declined to an all-time low and the stock continues to decline to a critical state. Management actions implemented in Ireland have markedly increased silver eel escapement. Production fell by 33%, compared to the 2008 estimate, although this production is expected to be maintained, or maybe to increase, until circa 2018. Thereafter, it is anticipated that there will be a considerable decline in silver eel production, as indicated by recruitment history, yellow eel stock indicators and modelled projections for index stocks. Some RBDs (i.e. SERBD & SWRBD) are already showing indications of reduced silver eel production. Continuation of the management actions implemented under the Eel Management Plans will ensure Ireland's continued compliance with the Regulation and a national contribution towards the recovery of the stock.

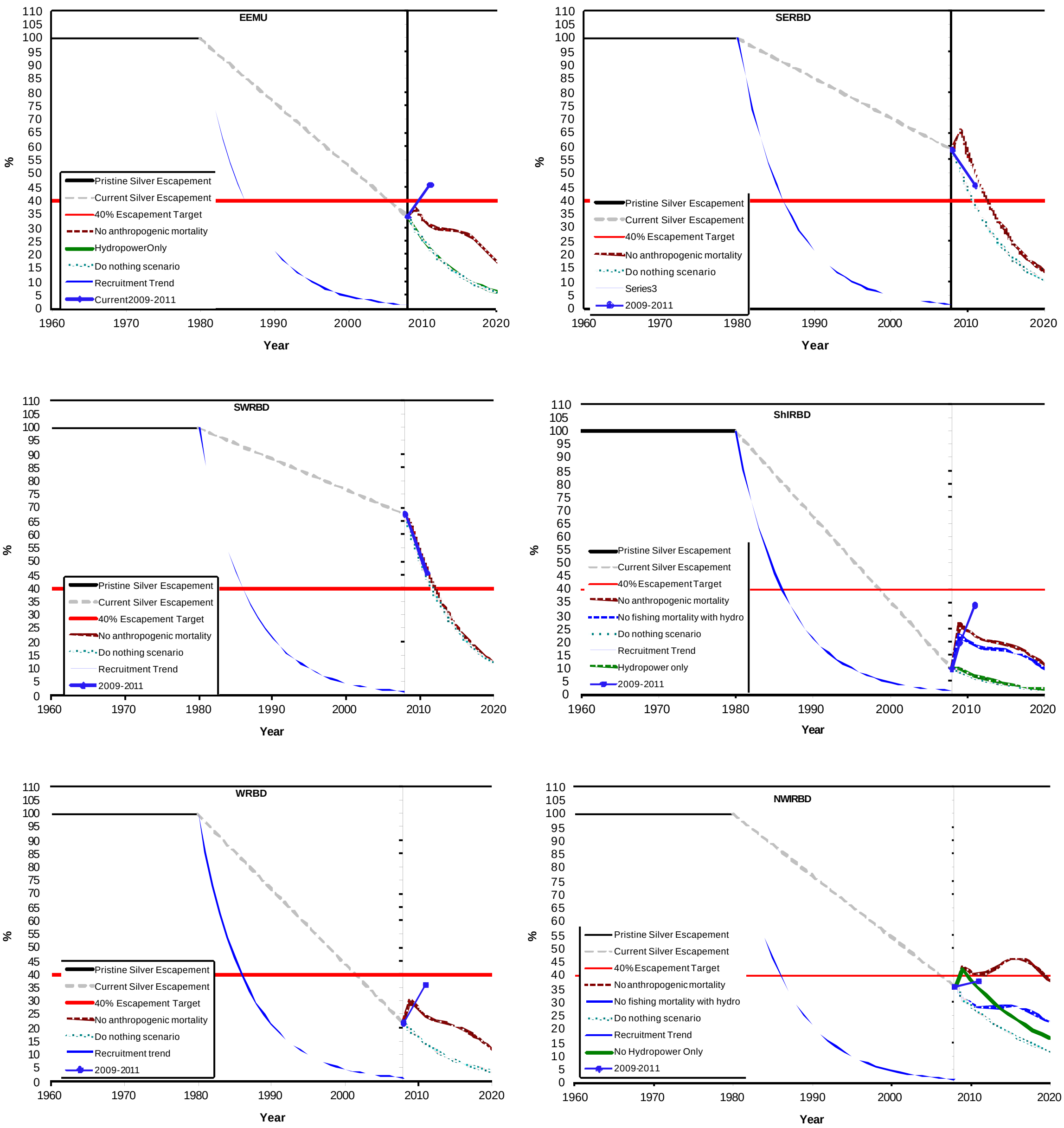

Figure 1: Plots for each Eel Management Unit of historic (100%) and current (2008) eel production and escapement related to the EU 40% target (red line). The recruitment trend is shown in plain blue. The effect of projected management scenarios are shown in dotted blue (fishery), green (hydropower) and total (yellow) and the first observed point for the average of 2009-2011 is shown as a blue line and dot plotted at 2011.

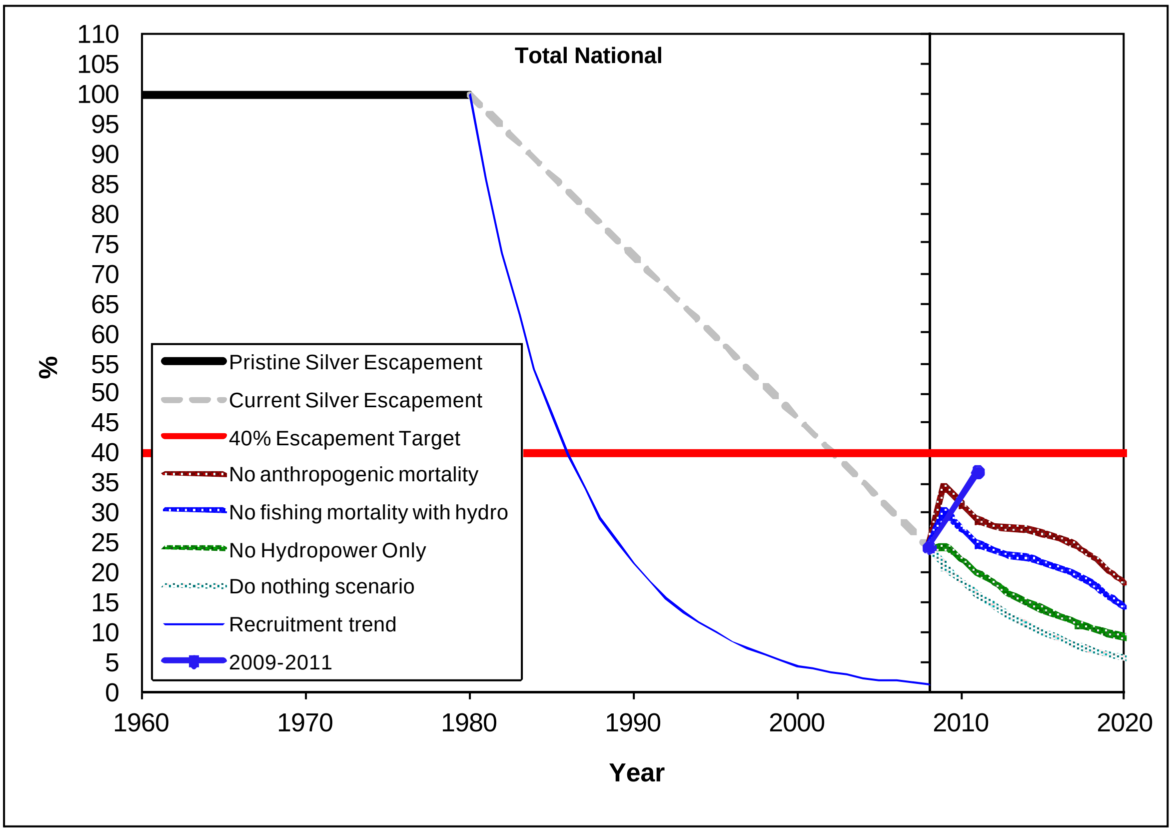

Figure 2: Plot for the total of the Eel Management Units of historic (100%) and current (2008) eel production and escapement related to the EU 40% target (red line). The recruitment trend is shown in plain blue. The effect of projected management scenarios are shown in dotted blue (fishery), green (hydropower) and total (yellow) and the first observed point for the average of 2009-2011 is shown as a blue line and dot plotted at 2011.

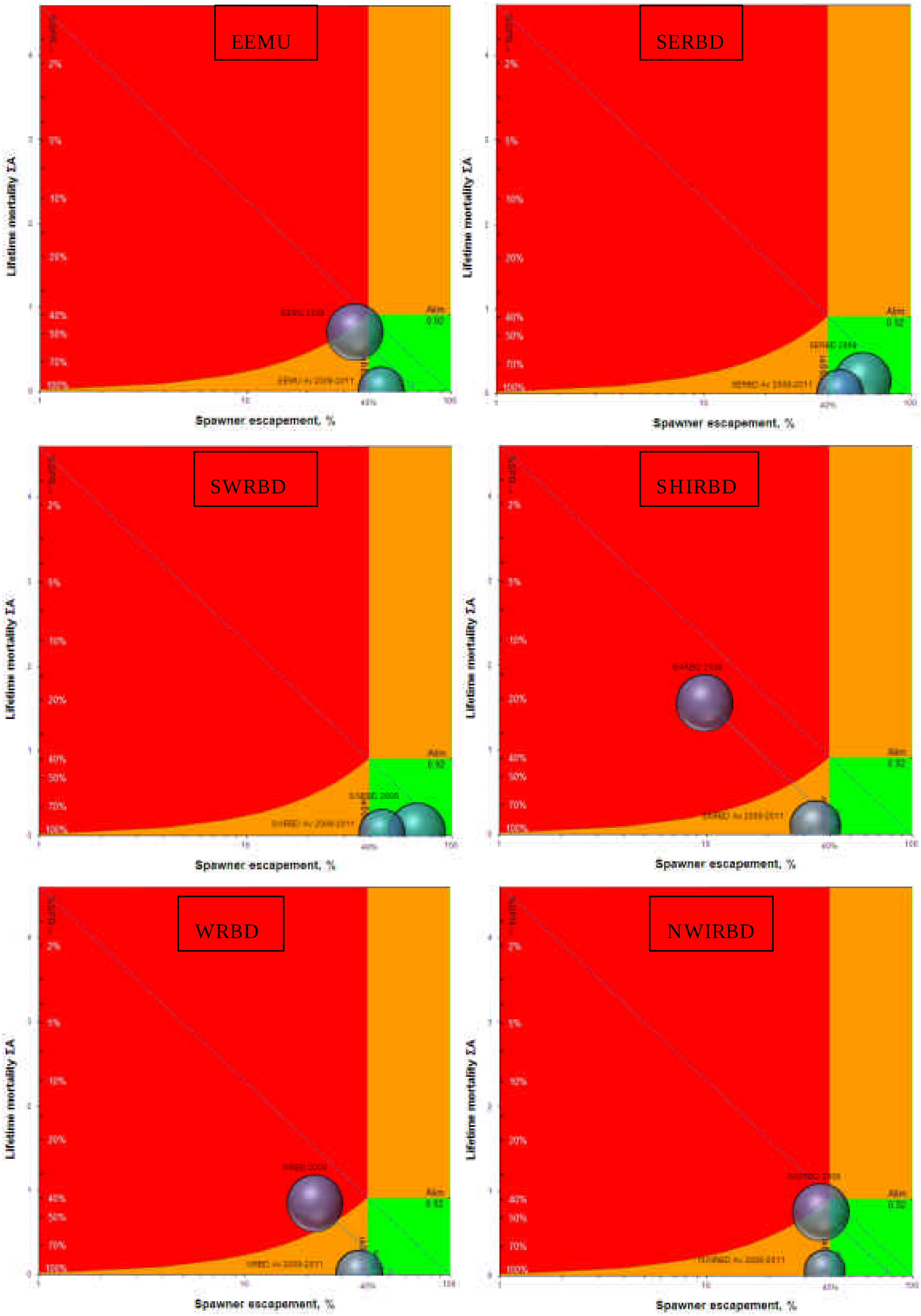

Figure 3: Status of the stock and the anthropogenic impacts, for each EMU in 2008 (average 2001-2007) and for the 2009-2011 period. For each, the size of the bubble is proportional to B_{best}, the best achievable escapement given recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the stock status related to pristine conditions while the vertical axis represents anthropogenic mortality.

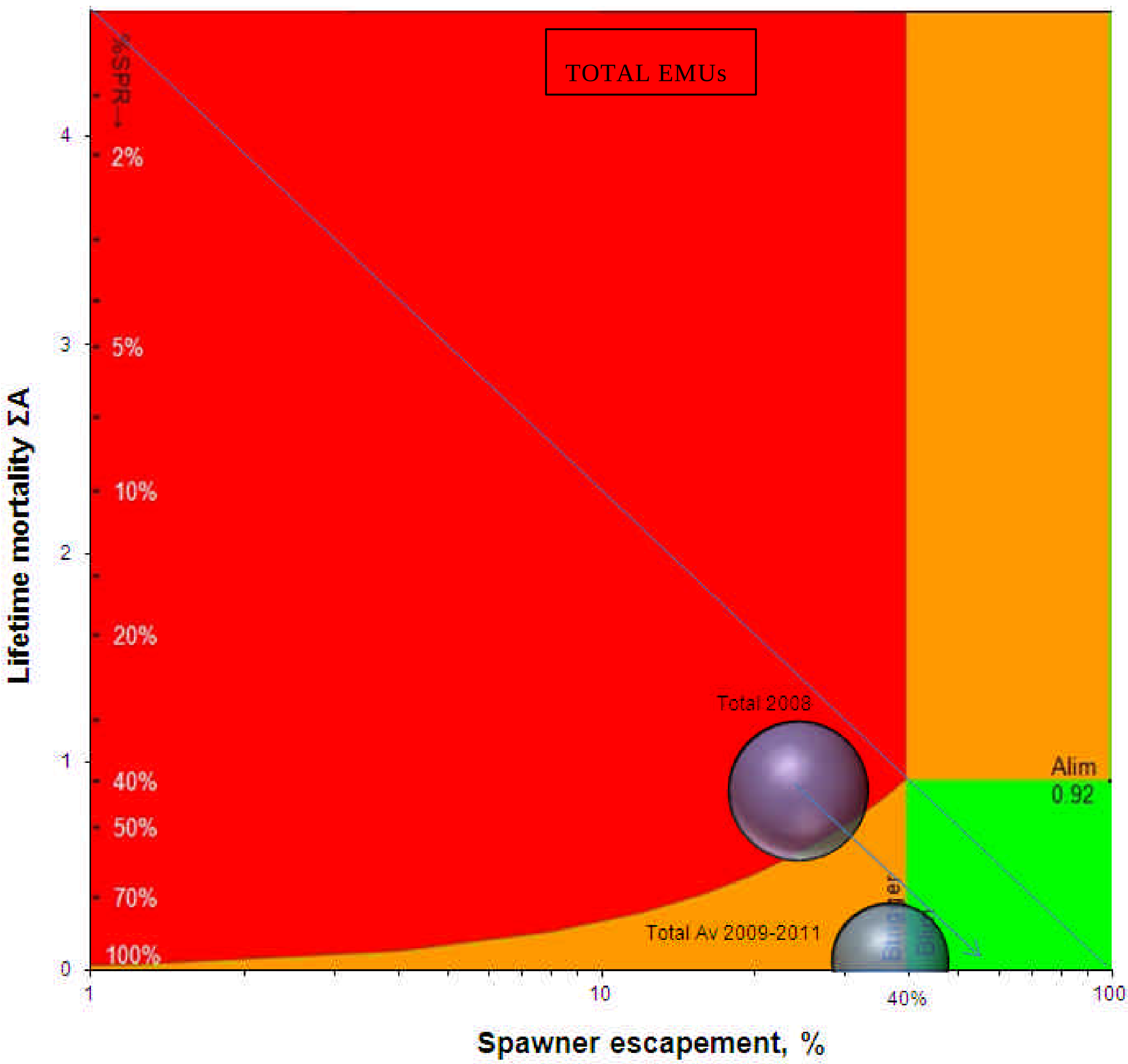

Figure 4: Status of the stock and the anthropogenic impacts, for total EMUs in 2008 (average 2001-2007) and for the 2009-2011 period. For each, the size of the bubble is proportional to B_{best}, the best achievable escapement given recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the stock status related to pristine conditions while the vertical axis represents anthropogenic mortality.

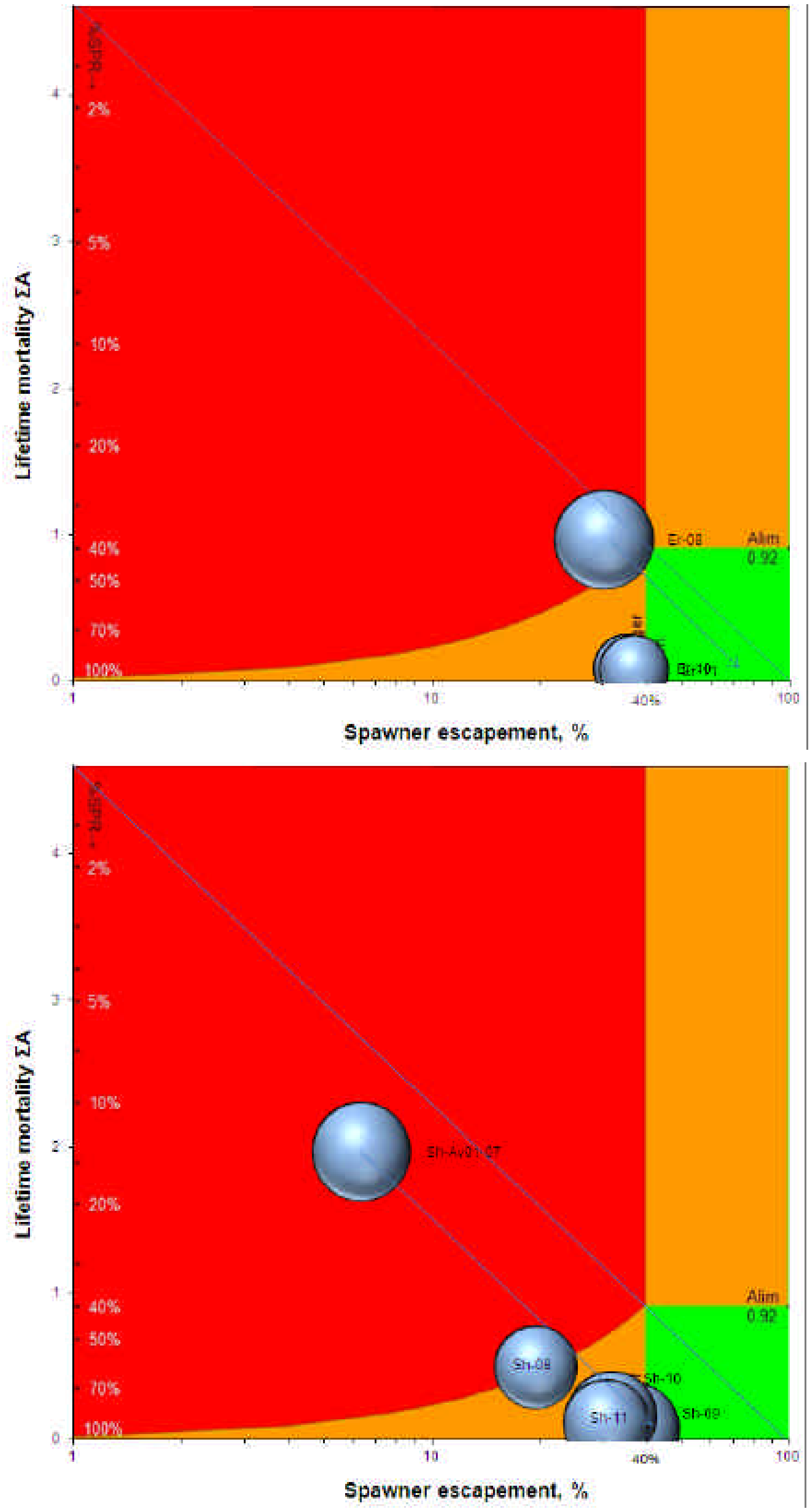

Figure 5: Precautionary diagrams for the Erne (top) and the Shannon (bottom) silver eel biomass. The downward movement of the bubble indicates lower mortality and to the right indicates increasing spawning stock biomass. The arrows indicate what effect the implementation of the EMP was expected to have.

Table 1: Levels of anthropogenic mortality (ΣA) for each year on the Erne and Shannon and the % reduction in mortality compared to 2008 (85% is the breakpoint to halt the decline).

Period	Erne		Shannon	
	ΣA	**% Reduction in ΣA**	**ΣA**	**% Reduction in ΣA**
2008	0.96	-	1.95	-
2009	-	-	0.13	94.0
2010	0.08	91.7	0.11	94.4
2011	0.06	93.8	0.11	94.3
Av 2009-2011	0.07	92.9	0.12	94.0

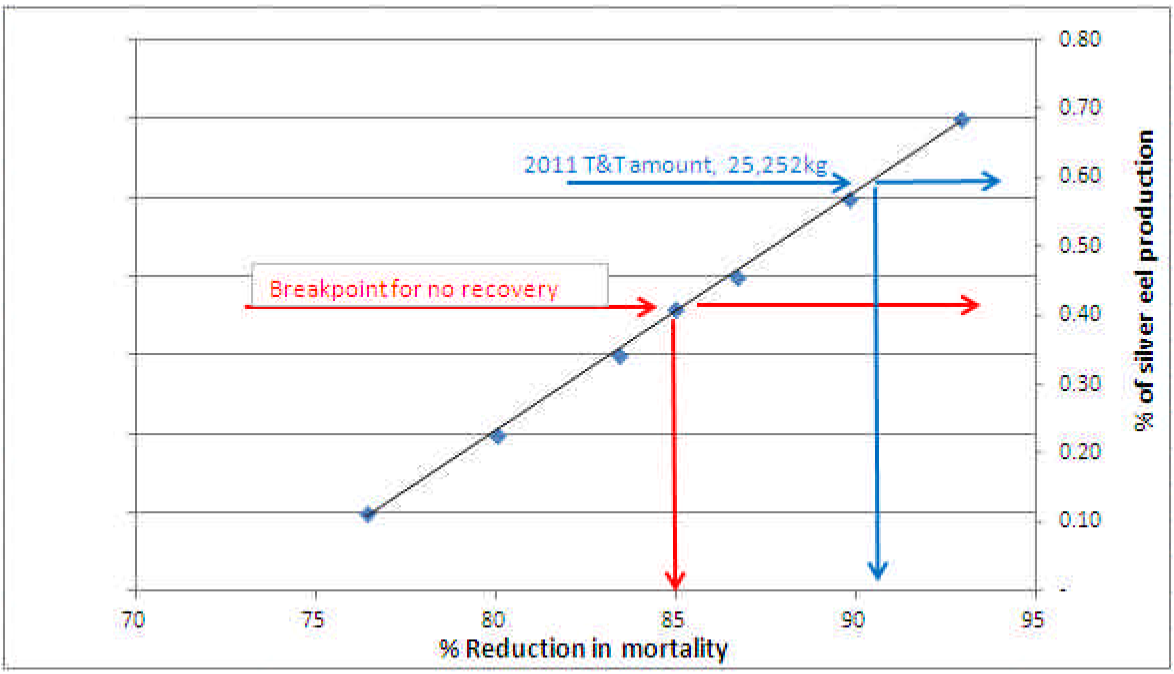

Figure 6: The relationship between % reduction in mortality and the proportion of the annual silver eel production required to be trapped and transported around Hydropower Stations in order to keep the mortality below the required limit (i.e. less than 15% of that before the EMP required to achieve a recovery).

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

Table of Contents

1 Introduction

1.1 EU Regulation

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

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

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

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

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

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

This report provides an assessment of the status of the Irish eel stocks 2009-2011, provides the information on biomass and mortality required for the 2012 Report to the EU and also provides scientific advice for the review of the fishing byelaws and for resetting the silver eel trap and transport targets for 2012-2014.

1.2 Glossary

Leptocephalus larva.	Ocean pelagic. Deep-bodied, strongly compressed, transparent 'willow-leaf' shape
Glass eel	Small eel, less than one year post metamorphosis. Continental shelf waters to lower reaches of rivers. Body form as in adult, largely transparent but with localised pigment. Term also used to define the zero age class recruitment cohorts.
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: to length 10cm.
Bootlace eel, snig	Small growing, sedentary or upstream migrating eel. Coastal and freshwater. Fully pigmented eel, yellow or brown colour: length 9 to 25 cm.
Yellow (brown) eel	Large growing, sedentary eel. Coastal and freshwater. Fully pigmented eel, yellow or brown colour: length greater than 20cm. Eyes small, body soft.
Silver (bronze) eel	Migrating, non-feeding eel. Freshwater to oceanic. Silver or bronze colour: length rarely less than 25 cm. Eyes large, body firm, lateral line prominent.

Acronyms in the Report

ACOM (ICES)	Advisory Committee on Fishery Management
AFBINI	Agri-food and Biosciences Institute, Northern Ireland
DARD	Dept. of Agriculture and Rural Development
DCAL	Dept. of Culture, Arts and Leisure
DCENR	Dept. of Communications, Energy and Natural Resources
EEEP	Erne Eel Enhancement Programme
EIFAAC	European Inland Fisheries & Aquaculture Advisory Commission
ESB	Electricity Supply Board
FAO	Food and Agriculture Organisation
FCB (NI)	Fisheries Conservancy Board
FCILC	Foyle & Carlingford Irish Lights Commission
HPS	Hydropower Station
ICES	International Council for Exploration of the Seas
IFI	Inland Fisheries Ireland
IMESE	**I**rish **M**odel for **E**stimating **S**ilver Eel **E**scapement
LNFCS	Lough Neagh Fishermen's Co-operative Society Ltd
MI	Marine Institute
MS	Marine Scotland
NUIG	National University of Ireland
SSB	Spawning Stock Biomass
SSCE	Standing Scientific Committee for Eel

Definition

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

1.3 Introduction to Stock Status and Management Targets

In chapters 7, 8 & 9 of this report and in the Executive summary / advice 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).

1.3.1 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.

1.3.2 A general stock-recruitment relation

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. 1.1).

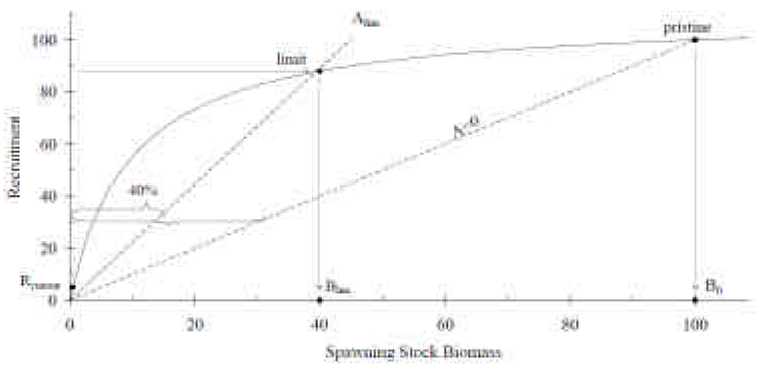


Figure 1-1: Hypothetical Stock-Recruitment relationship. The drawn line indicates what recruitment is produced at what spawning stock size; the dashed lines indicate what spawning stock can be derived from a given recruitment, at no fishery (A=0) or at maximal, just sustainable fishery (Alim). Both Recruits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

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 few youngsters. 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.

1.3.3 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%, halfway the safety margin. In this report, the 40% limit of the EU Regulation will be shown (Figure 1.1) 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 recruitment of glass eel from the ocean is at 1-10% of the historical level. 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.

1.3.4 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 (B_0). 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.

1.3.5 The Precautionary Diagram

For the international advice on fish stock management, ICES (2004) applies a traffic light colouring scheme, signalling the status of the stock and the impact of exploitation. The information on the stock status and the reference points are presented in a so-called Precautionary Diagram (Fig. 1.2), 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).

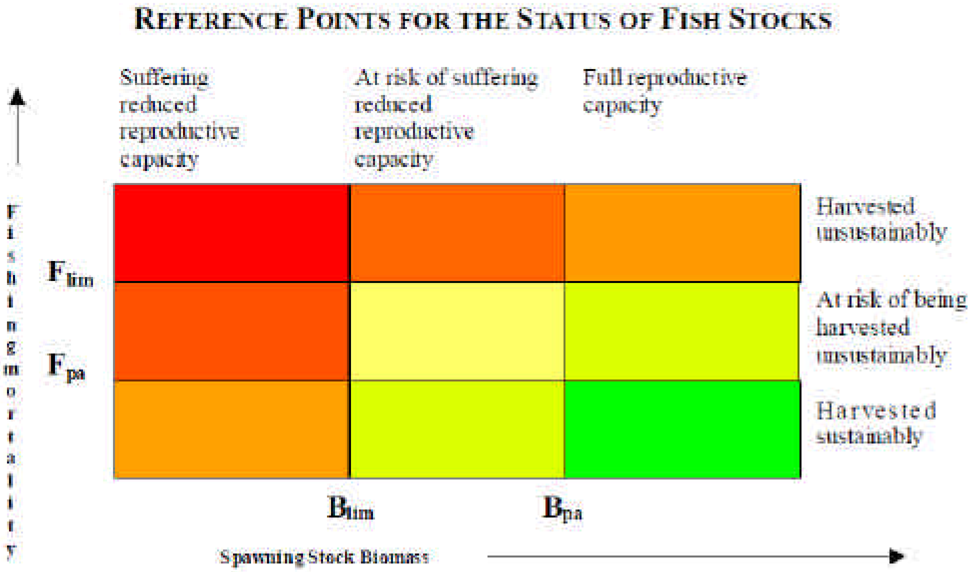
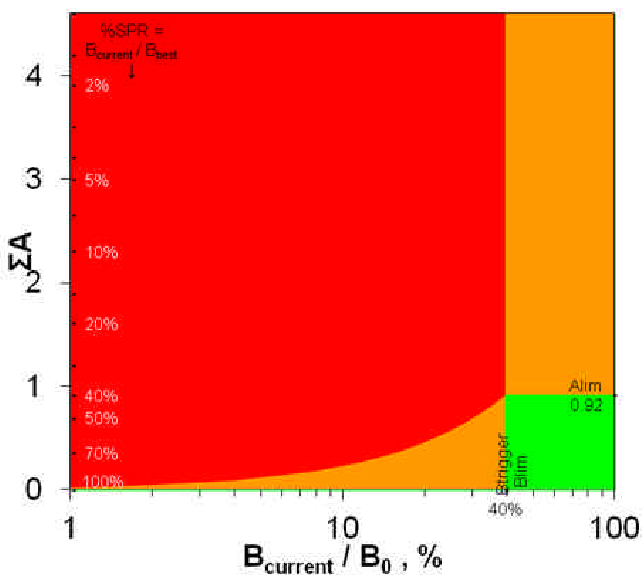


Figure 1-2: This "precautionary diagram" is used to summarise the state of the stock (horizontal) and the anthropogenic impacts (vertical)

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 1.3.

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.

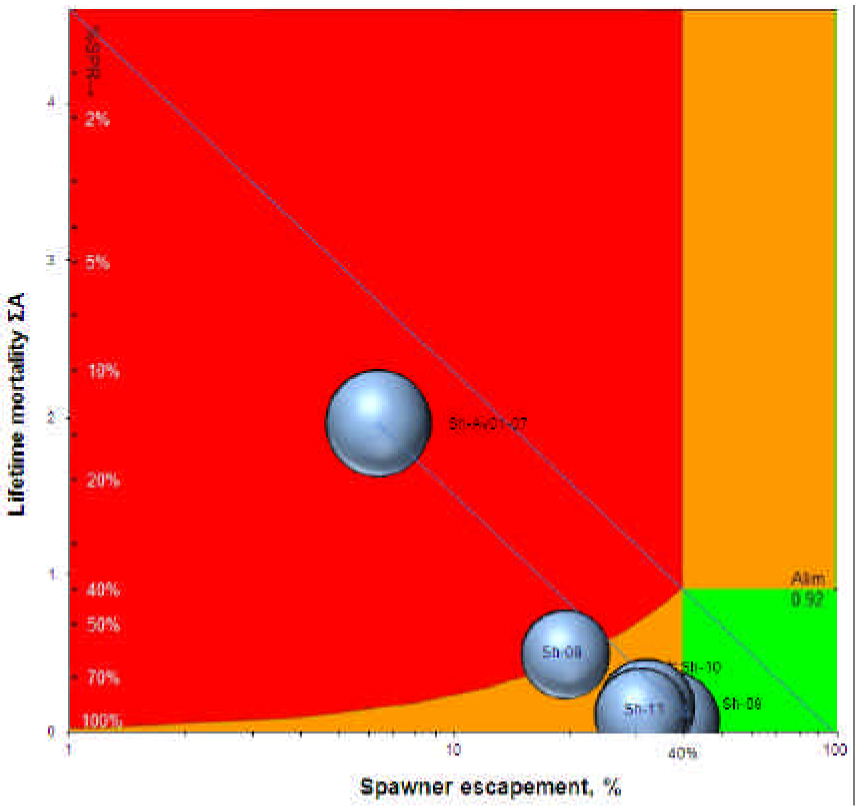


Figure 1-3: Precautionary diagram for the Shannon silver eel biomass. The downward movement of the bubble indicates lower mortality and to the right indicates increasing spawning stock biomass. The arrows indicate what effect the implementation of the EMP was expected to have.

[1] The orange 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.

2 Management Actions - progress 2009-2011

2.1 EU Regulation

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

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

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

2.2 Scientific Eel Group/SSCE

The Irish Eel Management Plan outlines a national programme for sampling catch and surveys of local eel stocks. Appropriate scientific assessment and monitoring by the Fisheries Boards and the Marine Institute will monitor the implementation of the plans. In the Irish plan, provision was made for the establishment of a Scientific Eel Group (SEG) which was established by the Department of Energy, Communications and Natural Resources in March 2009.

The SEG was nominated by the Dept. of Communications, Energy and Natural Resources and appointed by the Minister and comprises scientific advisers drawn from the Marine Institute (MI), Central Fisheries Board (CFB), The Loughs Agency, the Electricity Supply Board and the Agriculture, Food and Biosciences Institute for Northern Ireland (AFBINI). 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. Although the scientists are drawn from these agencies, the advice from the SEG is independent of the parent agencies.

In 2010, the SEG was reconstituted as a Standing Scientific Committee for Eel (SSCE) under the Inland Fisheries Ireland legislation, Section 7.5 (a) of the 2010 Inland Fisheries Act. The purpose of the committee is to provide independent scientific advice to guide IFI in making the management and policy decisions required to ensure the conservation and sustainable exploitation of the Ireland's eel stocks. All scientific advice provided by SSCE will be considered as independent advice by IFI.

2.3 Reduction of Fishery – Management Action #1

2.3.1 Introduction

The first Management Action set out in the Irish Eel Management Plan (2008) was to have zero fishing mortality and reduce illegal capture and trade to as near zero as possible with a view to contributing to 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. The option of re-opening the eel fishery will be considered in 2012, following a review of the data collated as a result of scientific sampling provided for in the National Eel Management Plan and international scientific advice.

- 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. Since EU Commission ratification of the Ireland/UK NWIRBD transboundary plan, in the UK submitted plans, in March 2010, the fishery in the NI portion of the Erne was closed from April 2010 and remained closed in 2011.

2.3.2 Action 1a: Closure of fishery

All management regions confirmed a closure of the eel fishery for the 2009, 2010 and 2011 seasons 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 2011. There was also no commercial fishery in the Northern part of the NWIRBD in 2010 and 2011 (Table 8.4).

There were no data available on export trade or the level of illegal fishery. This was thought to be relatively low.

2.3.3 Action 1b: Recreational Fishery

The legislation prohibits the possession of eel caught in Ireland and this extends to cover recreational angling. There was no legal recreational catch and rod angling for eel, even as by-catch during angling for other species, was on a catch and release basis (Table 8.4).

2.3.4 Action 1c: Diversification of the Fishery

No information available to the SSCE.

Some commercial fishermen were employed on a contract basis for conservation silver eel trap and transport and also on some surveys of yellow and silver eel.

2.4 Mitigation of Hydropower – Management Action #2

Develop best practice document on the safe passage of eels through hydro-electric power stations and other barriers including water abstraction points.

2.4.1 Action 2a: Trap & Transport

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

Shannon: Trap and transport 30% of the annual escapement

	catch target (t)	% of expected silver eel run	Proportion of EU H achieved – fishery closed	Approx. timeframe to recovery (y)
2009	not defined	30	0.045	95
2010	not defined	30	0.045	95
2011	not defined	30	0.045	95

Erne: Trap and transport the following*

	catch target (t)	% of expected silver eel run	Proportion of EU H achieved – fishery closed	Approx. timeframe to recovery (y)
2009	22	36	0.092	200
2010	34	54	0.075	140
2011	39	63	0.05	100

***Erne Fishery not closed in N. Ireland in 2009*

Lee: Trap and transport 500kg of the annual escapement

	catch target (t)	% of expected silver eel run	Proportion of EU H achieved – fishery closed	Approx. timeframe to recovery (y)
2009	0.5	34	0.007	80
2010	0.5	34	0.007	80
2011	0.5	34	0.007	80

The total amounts of silver eel trapped and transported in each of the three rivers in 2009, 2010 and 2011 are presented in Table 2.1. The separate detail sheets of the amounts transported from each site on each date are presented as an annex to this report (Annex 1). The target was achieved in the R. Shannon is all three years. The target was not achieved in the Erne and was achieved in one of the three years in the Lee. The experienced gained in operating such a scheme

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

In the R. Erne, the target 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. Both the experience and level of fishing effort increased on the Erne between 2009 and 2011 and this led to improved catches of eels for transport. Possible reasons for the target not being achieved are discussed later in the report (Section 7.3.3.3).

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. The fishing in 2009 was hampered by unusually high floods and in 2010 by very low water levels. A different approach was employed in 2011 with fishing taking place by fyke net in July where a catch of 731 kg was taken and transported. Analysis of the silvering characteristics indicated that it was reasonable to assume that at least 68% (500kg) of the transported eels were silver.

Table 2-1: Total amounts (t) of silver eel trapped and transported in the Shannon, Erne and Lee, 2009-2011, and the success relative to the target set in the EMPs.

Catchment	Year	Target	Amount Transported (t)	Relation to target	Status
R. Shannon	2009	30% of run	23.730	32-35%	Achieved
R. Shannon	2010	30% of run	27.768	40%	Achieved
R. Shannon	2011	30% of run	25.680	39%	Achieved
R. Erne	2009	22t	9.383	43%	Not achieved
R. Erne	2010	34t	19.334	57%	Not achieved
R. Erne	2011	39t	25.252	65%	Not achieved
R. Lee	2009	0.5t	0.079	16%	Not achieved
R. Lee	2010	0.5t	0.278	56%	Not achieved
R. Lee	2011	0.5t	0.731	146%	Achieved
Total	2009		33.192		
Total	2010		47.380		
Total	2011		51.663		

2.4.2 Action 2b: Quantify turbine mortality

Monitoring migrating silver eel, using acoustic tag telemetry, to determine migration routes and mortality at the hydropower stations has taken place on the Shannon between 2006 and 2011 and on the Erne in 2010 and 2011 (Table 2.2).

Shannon: Summarising the annual data gives mortality ranges of 16.6% to 25% and an overall average mortality of 21.15 $\pm$ 8% for 104 tagged eel arriving at Ardnacrusha HPS.

In the Eel Management Plan, a figure of 30% was used to account for the amount of eel potentially using the bypass route down the old river channel and around Ardnacrusha HPS. For 2009 – 2011, the actual amount of eels estimated to bypass were used in determining the escapement (59%, 4.4% & 12.5% respectively). A general figure for eels estimated to use the bypass in recent years is 17.8% (Section 7.2.2).

Erne: Summarising the data from 2009 to 2011 (see Section 3.2) gives mortality ranges for Cliff HPS of between 6.9% and 8.5% and an average of 7.8% $\pm$ 5% and mortality for Cathaleens Fall of 22% (9 tags) in 2009. In 2010 and 2011, one turbine was removed for renovation and therefore the mortalities were lower at 6.1% and 7.7%. It is likely that these will at least double when both turbines are operational and this should be assessed in the next three years.

Currently there is no solid information about the proportions of eel that migrate via spillways compared to via the turbine passages. There may be selective migration towards the spillways, especially at Cliff, and this may be indicative of safe passage and help to explain the low HPS mortality levels observed on the Erne. The HPS mortality and bypass needs additional work on the Erne to clarify.

Table 2-2: Summary mortality data for acoustic telemetry on the Shannon and Erne.

	Year	Number of tagged eel	Mortality *	Number of tagged Eel	Mortality **	
Shannon	2006					
	2007					
Average	2008-2011	104	21.15			
			Cliff		Cathaleens Fall	
Erne	2009	13	7.7	9	22*	*Low no. of tags
	2010	29	6.9	26	7.7	one turbine
	2011	60	8.5	49	6.1	one turbine
Average			7.8		16.5	estimate for two turbines.

* Ardnacrusha on the Shannon; Cliff on the Erne

** Cathaleens Fall on the Erne

2.4.3 Action 2c: Engineered Solutions

This has not been evaluated by the SSCE for the 2009-2011 period.

2.4.4 Action 2d: Other Solutions

2.4.4.1 Migromat®

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

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

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

2.4.4.2 Deflection Technology and bypasses

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

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

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

2.4.5 Action 2e: New turbine installations

No information for the SSCE to evaluate.

2.5 Ensure Upstream Migration at Barriers – Management Action #3

2.5.1 Action 3a: Existing barriers (including small weirs etc.)

Eels in common with other fish species may be severely impacted by barriers or obstructions leading to fragmentation of habitat and disrupting upstream migration. These can have a significant impact in reducing the productive capacity of a catchment. To investigate the impact of barriers on various fish species IFI (CFB) initiated a barrier impact assessment case study in 2007 on the Nore catchment using field data collected by the Southern Regional Fisheries Board. In this study 508 structures were identified, photographed and measurements were taken. This study initially concentrated on salmon but in 2010 the technique was modified into a multispecies assessment (Ryan *et al* 2010). In particular the identified structures were evaluated for eel pass ability. A total of 55 barriers were classified as impassable with a total of 5.5% of the Nore wetted area removed for eels. A further 34 barriers were classified as 'High Risk', representing a potential 18% of the wetted area. By taking into account the presence of impassable and high risk barriers on the Nore catchment it changes the current eel escapement estimate (2008) from 2,695kg to 2,097kg thereby reducing the % escapement from 70% to 54%. To further these investigations IFI established a National Barrier Group in 2011; this group is building on the earlier work in developing a standardised assessment of barriers nationally and is currently preparing a survey sheet and methodology. The long term aim is to develop a national database of barriers for rating fish passability which in turn will provide information to target mitigation measures at the most significant obstructions.

As part of these ongoing studies and work programmes the Eel Monitoring Programme in IFI undertook a desk study to identify potential obstacles within a catchment using geographical databases (OSI Discovery and 6inch maps), aerial photographs (courtesy of Dr. Martin O'Grady, IFI) and satellite images (Google Earth). The objective of this study was to remotely locate potential obstacles to elver migration. The top 20 eel productive catchments (based on their historic potential) were identified and the first 20kms of river channel from the high water mark were examined. A report containing detailed information is available for these obstacles and will be included in the IFI Eel Monitoring annual report. Details include the source of information, coordinates, maps, and the type of structure (e.g. weir, ford etc.). A total of 125 potential obstacles were found (Table 2.3). Most potential obstacles were found on the Shannon, Boyne, Barrow and Liffey catchments. These structures will need to be evaluated in the field using the multispecies barrier assessment form (Table 2.4).

Table 2-3: Ranking of the top twenty catchments based on historic eel production potential.

District	Name	RBD	EMU	Prod kgs	Number of potential obstacles
Limerick	Shannon (River)	SHIRBD	SHIRBD	188,849	30
Ballyshannon	Erne (Roi NI)	NWIRBD	NWIRBD	108,185	2
Galway	Corrib (River)	WRBD	WRBD	103,062	2
Ballina	Moy (River)	WRBD	WRBD	45,962	1
Drogheda	Boyne (River)	ERBD	EEMU	10,940	17
Ballyshannon	Drowes (River)	NWIRBD	NWIRBD	10,566	5
Kerry	Laune (River)	SWRBD	SWRBD	10,544	4
Dublin	Liffey (River)	ERBD	EEMU	10,153	12
Sligo	Garvogue (River)	WRBD	WRBD	9,610	5
Sligo	Ballysadare (River)	WRBD	WRBD	7,768	2
Waterford	Suir (River)	SERBD	SERBD	4,842	3
Loughs Agency	Foyle (RoI NI)	NWIRBD	NWIRBD	4,893	2
Bangor	Owenmore (River)	WRBD	WRBD	4,167	2
Waterford	Nore (River)	SERBD	SERBD	3,862	0
Waterford	Barrow (River)	SERBD	SERBD	3,689	24
Lismore	Blackwater (River)	SWRBD	SWRBD	3,614	1
Limerick	Fergus (River)	SHIRBD	SHIRBD	3,386	5
Cork	Lee (River)	SWRBD	SWRBD	3,174	3
Connemara	Ballynahinch (River)	WRBD	WRBD	2,951	2
Kerry	Currane (River)	SWRBD	SWRBD	1,449	3

In N Ireland the N Ireland Environment Agency WFD hydro-morphology group have been trialling the new Scottish and N Ireland Forum for Environmental Research (SNIFFER) assessment tool in ongoing surveys 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 have taken a different approach: rather than walk the rivers and assess all barriers they are trialling a quick assessment of setting fyke nets in the most upstream lakes. Length / frequency and age data of eels are collected. If eels are present with a "conventional" LF- and age profile then the river system is deemed passable to that point. So far, this technique has worked well. If there were no eel, 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. It is intended to continue with this in 2012.

In the cross-border Foyle and Carlingford area, the Loughs Agency area has undertaken a prioritisation assessment of 78 barriers using a version of the SNIFFER assessment tool. In addition under an EU INTERREG IVA project a PhD student is currently investigating barriers and salmon migration on the River Mourne and it is planned do similar work on eels and the potential for impact of barriers between now and 2015.

2.5.2 Action 3b: New potential barriers

For Ireland, the approach being taken is described in Sections 3.5.2 & 3.5.3 of the Irish Eel Management Plan and in Section 2.5.4.1 of this report.

For N. Ireland see Section 2.4.4.2 of this report.

2.5.3 Action 3c: Assisted migration and stocking

Assisted upstream migration takes place at the ESB Hydropower Stations on the Shannon (Ardnarcusha, Parteen), Erne (Cathaleens Fall), Liffey and Lee. 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, elvers and bootlace eel are transported upstream from the fixed elver traps. These programmes outlined in the EMP were continued in 2009-2011. The catches shown in Figs. 3.2 & 3.7 were transported upstream. On the Erne, the distribution of elvers throughout the catchment is by cross-border agreement between the ESB, IFI and DCAL.

Surplus recruits were not identified in the 2009-2011 period to facilitate a stocking programme and it is not envisaged to purchase foreign glass eel during the next three years. Should this take place, notice should be taken of the guidelines in ICES (2008) and the risk assessment/benefit analysis as proposed in ICES (2011) should be undertaken.

Table 2-4: Example of the multispecies barrier assessment form for field surveys.

River System						**River Basin District:**				**EPA_Code:**		**Sheet /**
River Tributary Name from 1:50000 OS on site:						**Location of GPS Reference (on site):**						
River Tributary Name (from GIS 6" at HQ)						**Location: GIS Ref (at HQ):**						
Townlands (GIS at HQ):						**Antecedent Conditions**		1	2	3	4	5
Nature of Obstruction: Bridge Apron **BA**; Weir **W**; Rock/Bedrock **R/B**; Culvert **C**; Ford **F**; Hydro Scheme **HS**; Bridge no apron **BNA**; Natural **N**; Sluice **S**; Other **O**;												
BA:	W:	RB:	C:	F:	HS:	BNA:	N:	S:	O:			
Material Type: Mass Concrete **MC**; Masonry **M**; Rock/Bedrock **R/B**; Ford Material **FM**; Timber **T**; Natural Bed Material **NBM**; Corrugated steel **CST**; Smooth steel **SST**; Other **O**												
MC:	M:	R/B:	FM:	T:	NBM:	CST:	SST:	O:				
River Conditions During Survey		Drought	Low Flow	Mod Flow	Spate	Flood Flow	**Depth high water mark d/s structure:**					
River Channel Width (metres) just d/s of Obstruction:			**Depth d/s structure (centre):**		**River Channel Width (metres) just u/s of Obstruction:**			**Depth u/s obstacle (centre):**		**Total width of Obstacle (metres):**		
Max Height of Obstruction substrate (m):				**Max Height of obstruction from water level (m):**					**Length of structure (culvert, ford; m):**			
Centre Height of Obstruction substrate (m):				**Centre Height of obstruction from water level (m):**								
(2) Profile (slope)		Vertical:	Steep:	Modest:	Gentle:	**Length of Slope :**			**Water Flow Through obstacle**			
									Low	Mod.	Fast	Rapid
No of Vertical Steps				**Height of steps**				**No of Horizontal lengths**				
Pipe/ Culvert Barrier (Specific)		**Pipe Position in regards to Water**			**(4) Edge Effect (easier passage along the barrier):**		**(5) Existance of alternative pathway**		Distance from structure	**Roughness of structure**		
		Below	Level With	Above						Smooth	Rough	Very Rough
					Y:	**N:**	**Y:**	**N:**				
Is Fish pass provided		Yes:	No:	Denil:	Pool:	Other:	**Target species**		**Position of fish pass to channel**			
Can fish readily pass		Not at all:		At low Flow:		At Moderate flow:		At High flow:		**% water thru fish pass:**		
Is Water diverted through HeadRace		Yes	No	**Is Water diverted through Tail Race**		Yes	No	**Pool/ Resting area d/s**	Max Depth:	Length:	Distance from structure:	
If water diverted, are screens present			**Risk of passage to fish species**	**Fish / Risk**		**No**	**Low**	**Moderate**	**High**	**Impassable**	**Plunge pool at structure:**	
Headrace	Yes	No		Salmonid								
Tailrace	Yes	No		Eel							**Structure:**	
Interbar Space (cm):				Lamprey							Maintained	Abandoned
Position to channel:				Other (Specify):								
Any other relevant Details:												
Photographs No's		d/s		u/s		Profile		Others:				
Surveyed By:								**Date:**				

2.5.4 Legislation relating to fisheries, fish passage and abstraction

2.5.4.1 Ireland

Conservation, management and development of Ireland's inland fisheries resource (including eel) is the responsibility of Inland Fisheries Ireland which was established on 1st July 2010, following the amalgamation of the Central and Regional Fisheries Boards as provided for under the Inland Fisheries Act (No. 10 of 2010).

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

- Bye-Law No 858, 2009 prohibits the issue of eel fishing licences in any Fishery District.
- Bye-law No C.S. 303, 2009 prohibits fishing for eel, or possessing or selling eel caught in a river in the State.

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

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

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

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

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

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

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

2.5.4.2 N. Ireland

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

The river basin eel management plans drawn up under the EU eel regulation were incorporated into Northern Ireland law with the enactment of the Eel Fishing Regulations (Northern Ireland) 2010. (*Statutory Rules of Northern Ireland 2010 no 166).* Under these regulations, which came into operation on 1st June 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 NI, 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.

2.6 Improve water quality – Management Action #4

2.6.1 Action 4a: Compliance with the Water Framework Directive

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

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

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

2.6.2 WFD monitoring – fish.

Inland Fisheries Ireland (previously the Central and Regional Fisheries Boards) has been assigned the responsibility by the EPA for delivering the fish monitoring element of the WFD in Ireland. Eel are included in the WFD (fish) monitoring of rivers, lakes and transitional waters. While this data will be included in the assessment of the second cycle of WFD reporting in 2015, interim reports are available (www.wfdfish.ie). The most relevant of these interim reports include the summary reports for 2007-2009 (Kelly *et al.* 2010), and the summary report for 2010 (Kelly *et al.* 2011). The determination of ecological quality of fish in rivers is under development, but is based on the Fisheries Classification Scheme 2, or "FCS2". These metrics are currently being intercalibrated across Europe. The determination of ecological quality of fish in lakes is based on the metrics outlined in FIL2 (Kelly *et al.* 2008, 2012). The ecological determination of ecological quality of fish in transitional waters is based on the Transitional Fish Classification Index or "TFCI". The tool uses the Index of Biotic Integrity (IBI) approach broadly based on that developed both for South African waters and the UK, with a total of ten metrics used in the index calculation (Harrison and Whitfield 2004; Coates *et al.* 2007). A summary of the results of the fish monitoring from 2007-2009 and 2010 and shown in Table 2.5.

Eel are fairly ubiquitous across Ireland and were found in nearly all the sites sampled for the WFD between 2008 and 2010. In 2008, eel were recorded in 31 out of 32 lakes, 63 out of 83 river sites and 32 out of 42 transitional water bodies sampled. In 2009, eel were recorded in 23 out of 23 lakes, 43 out of 52 river sites and 22 out of 23 transitional waters. In 2010, eel were recorded in 22 out of 25 lakes 33 out of 43 river sites and 22 out of 25 transitional waters. Overall, in the three years, eel were recorded in 84% of sites sampled.

In the international NWRBD, (not included in the summary above), thirty river waterbodies were classified for fish in between 2007-2010. Fourteen sites had Eel present. Surveys were carried out using WFD Fully quantitative electrofishing methods on shallow wadeable sites and a multi-method approach on deeper sites. Classification was based on professional judgement. Four lakes were surveyed in the NWRBD in 2010 by IFI in collaboration with AFBI on three of the sites. Eels were present at all four sites.

Table 2-5: Interim assessment of Irish waterbodies according to fish metrics, measure in 2007-2009 and 2010 as part of the WFD monitoring program carried out by Inland Fisheries Ireland (Kelly et al. 2010; Kelly et al. 2011).

Period		No. of sites surveyed	% High	% Good	% Moderate	% Poor	% Bad
2007-2009	Rivers	134	7.5	49.3	40.3	2.2	0.7
	Lakes	70	14.0	30.0	49.0	6.0	1.0
	Transitional water	72	1.4	51.4	31.9	12.5	2.8
2010	Rivers[1]	43	9.0	39.0	42.0	0.0	0.0
	Lakes[1]	25	24.0	32.0	4.0	4.0	
	Transitional water	25	0.0	52.0	36.0	8.0	4.0

[1]Not all the sites surveyed in 2010 have yet been assigned an ecological quality status.

2.6.3 Fish kills

The number of fish kills collated by the EPA between 2007 and 2009 was 72 (McGarrigle *et al.* 2011). This compares with 122 in 2004-2006 and 147 in 2001-2003. The lowest number of annual fish kills (16) was reported for 2009 while 22 and 34 respectively were documented in 2007 and 2008. The CFB/IFI record a total of 38 fish kills in 2010 (CFB 2010; IFI 2010). While none of these fish kills refer specifically to eel, it is likely that where conditions result in a kill of any fish species, there is likely to be detrimental impacts on all species in the waterbody. The data suggest that fish kills are becoming less common in the last decade.

2.6.4 Toxins

In recent years WGEEL has discussed the risks of reduced biological quality of silver eels. The reduction of the fitness of potential spawners, as a consequence of specific contaminants and diseases, and the mobilization of high loads of repro-toxic chemicals during migration, might be key factors that decrease the probability of successful migration and normal reproduction. An increasing amount of evidence has been presented indicating that eel quality might be an important issue in understanding the reasons for the decline of the species (ICES 2010). WGEEL reports (2007-2011) contain an overview and summary of a variety of reports and data on eel quality, which can be accessed through the ICES website.

High levels of contamination in eel are reported from Belgium, France, The Netherlands and Germany (ICES 2011). In some cases, levels were so high that immediate actions had to be taken and fisheries were closed as a human health measure. The occurrence of persistent chlorinated and brominated organic contaminants in the eel in Irish waters has recently been investigated (McHugh *et al.* 2010). Samples were taken from five Irish catchments (River Suir, Lough Conn, River Corrib, River Farne and Burrishoole) in October and November 2005 and confirmatory sampling also took place in Burrishoole in July 2007. The analysis looked at levels of dioxins, furans, polychlorinated biphenyls (PCBs), brominated flame retardants (BFRs) and chlorinated pesticides in eel muscle tissue. Elevated dioxins (especially octa-chlorinated dioxin (OCDD)) were found in eels from the Burrishoole catchment. The authors propose that this would strongly suggest point source influences at this location. Samples are currently being analysed to follow up on this. With the exception of higher substituted dioxins in three samples from the Burrishoole catchment, persistent organic pollutant (POP) levels in general were low in eels from Irish waters compared to those in other countries. Data from Santilo *et al.* (2005) confirm that bioaccumaulation of toxins in Irish eel is not significant.

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 fame 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.

2.6.5 Prevalence of *Anguillicoloides crassus*

Anguillicoloides crassus was first recorded in 1997. By 2009, it was estimated that at least 70% of Ireland's wetted area contained *A. crassus* (Irish Eel Management Plan, 2009) and it is predicted to continue to spread. IFI are examining the extent of *A. crassus* distribution using the eel monitoring programme together with the Water Framework Directive surveys (see Chapter 6.4).

2.6.6 EU EELIAD

The EU Eeliad project is a research initiative funded under the EU's 7th framework programme, and involving twelve European research institutes. The aim is to investigate the ecology and biology of European eels during their marine migrations, and how these relate to eel condition and population of origin. Work is ongoing in this project. WP4 (eel quality) is the work that is of most relevance in terms of water quality and resulting eel quality, and the deliverables include:

- Assessment of quality and variability of eels in different rivers
- Evaluation of biological and ecological characteristics of eels that contribute to production, escapement and migration success
- New molecular tools for determining the level of infection/pollutant load of eels

A number of migrating silver eels were tagged in Ireland with both Pop up Satellite Archival Tag (PSATs) and Implantable G5 drifter tags (IDTs) in 2008, 2009 and 2010. Large silver eels were selected from different parts of the country taking into account catchment of origin regarding the known presence or absence of the swim bladder parasite *Anguillicoloides crassus*. The selected location for the tagging and release of large silver eels was Galway. Experts in tagging techniques were involved in the operation. Regarding the collection of biological data an extensive European sampling programme was put in place. This ongoing work includes the analyses of contaminants, parasites, viruses, hormone levels, diet and eel otoliths. A total of 50 samples have been collected by IFI staff in Ireland and are being processed by different European research institutes. This information will be of great importance in the national management of this species.

3 Recruitment

(refers to Ch. 7.3 of the National EMP Report, 2008)

Nomenclature: ***Glass eel*** are the young unpigmented eel, recruiting from the sea into continental waters and ***elvers*** are young pigmenting eel recruiting in their first year, actively migrating into freshwater. For conformity with ICES and to avoid confusion, both of these stages are referred to as glass eel in this report.

Recruiting eel older than one year ('***bootlace***' eel) are referred to as young yellow eel in this report.

3.1 Introduction

Recruitment of glass eel to Ireland will depend on European wide management action 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 stock assessment. This information is also required to project the recovery in Irish eel stocks. Maintenance of long-term recruitment time series is therefore of utmost importance.

Long-term recruitment monitoring by ESB of 0+ age glass eel has taken place on the Shannon at Ardnacrusha and the Erne at Cathaleens Fall, and of >0+ age young yellow eel recruits at Parteen on the Shannon and the Lee at Inniscarra station (since August 2008). Additional monitoring has taken place at five sites since the 1990s, and six new sites were surveyed in 2010 and 2011 by IFI. Figure 3.1 shows the catchments monitored.

3.2 Glass eel

3.2.1 Introduction

Previously there was no authorised commercial or recreational catch of juvenile eel in Ireland as fishing in Ireland for juvenile eel was prohibited by law (1959 Fisheries Act, Sec. 173) and this remains the current situation. Fishing for juvenile eel is also prohibited under the conservation bye-laws.

3.2.2 Time Series

3.2.2.1 Shannon & Erne

There is no authorised commercial catch of juvenile eel in Ireland, but some fishing was authorised in the past under Sec. 18 of the Fisheries Act for enhancement of the fisheries. Catches are also made at impassable barriers and these are transported upstream (reported in the relevant Regional Eel Management Plans). Monitoring of glass eel migrating at Ardnacrusha (Shannon) and Cathaleens Fall (Erne) is undertaken by the ESB (Figure 3.2).

Full trapping of glass eel on the Erne commenced in 1980. Some discrepancies in the time series came to light in 2009. The Erne dataset has now been checked and the presented data have been agreed by DCAL and AFBINI, the ESB, IFI and MI. Any discrepancies were not major and the data trend and pattern has not changed.

Glass eel recruitment in the Shannon dropped after 1983 and with the exception of the mid 1990s has remained low since. Recruitment in the Erne fluctuated with high recruitment recorded between 1980-1982, 1987-1990 and 1992-1995. Recruitment into the Erne declined in the late 1990s and has been low since 2005. There was no improvement in recruitment in either the Shannon or the Erne between 2009 & 2011.

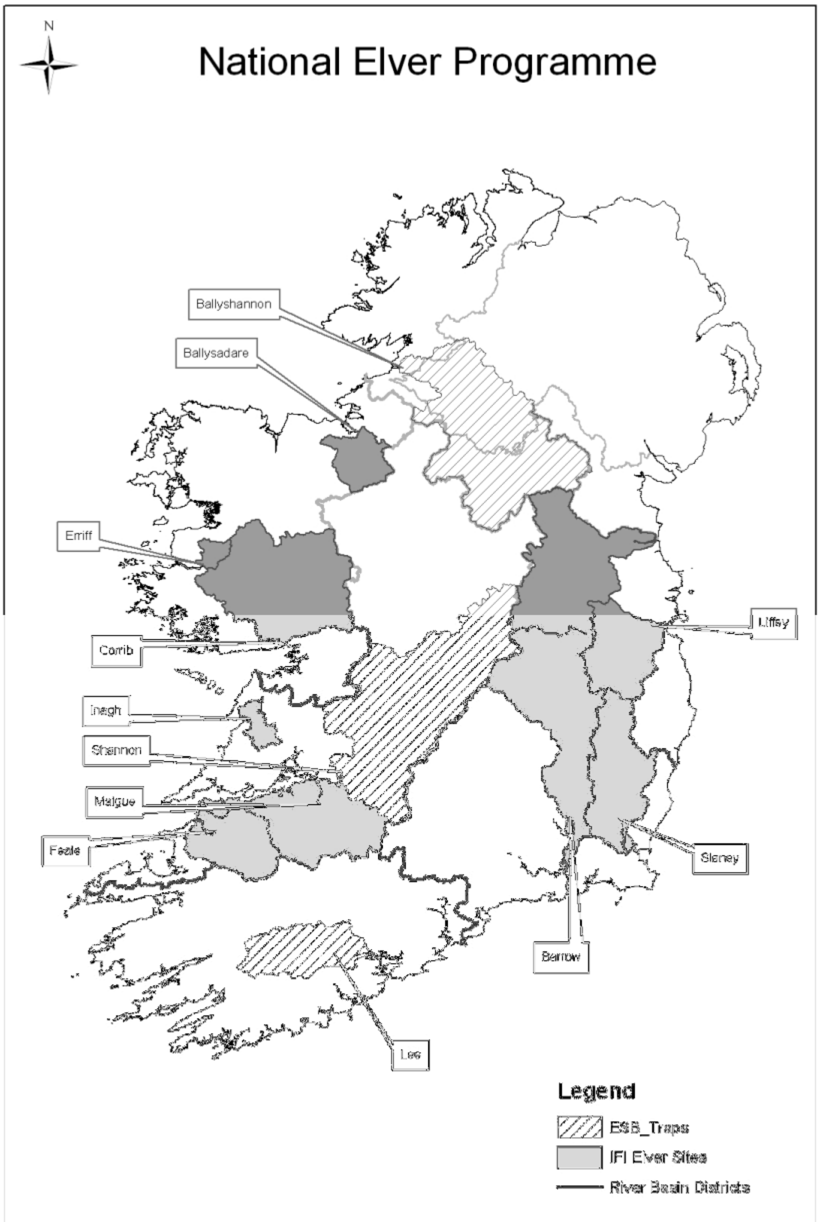
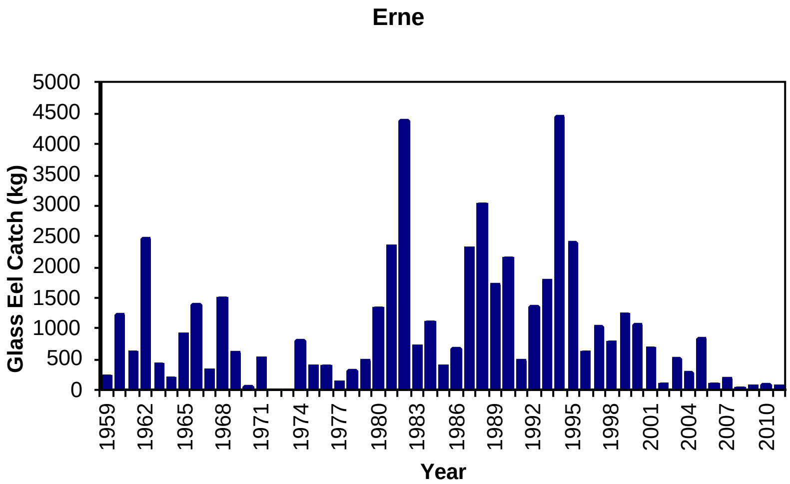


Figure 3-1: Catchments monitored for recruitment 2009-2011.

3.2.2.2 Other Stations

A number of additional trapping stations were fished with fixed traps in the Shannon Region; the Feale, the Maigue and the Inagh. The Maigue and Inagh were not fished in 2009 (Table 3.1). The numbers of glass eels and yellow eels in the Feale have decreased since 2009. Glass eel numbers in the Maigue increased from 3kgs in 2010 to 5 kgs in 2011. The Inagh also recorded an increase in glass eel catch, increasing from 1.5 kgs in 2010 to 8kgs in 2011. Recruitment compared to historical levels, remains low at all these stations.



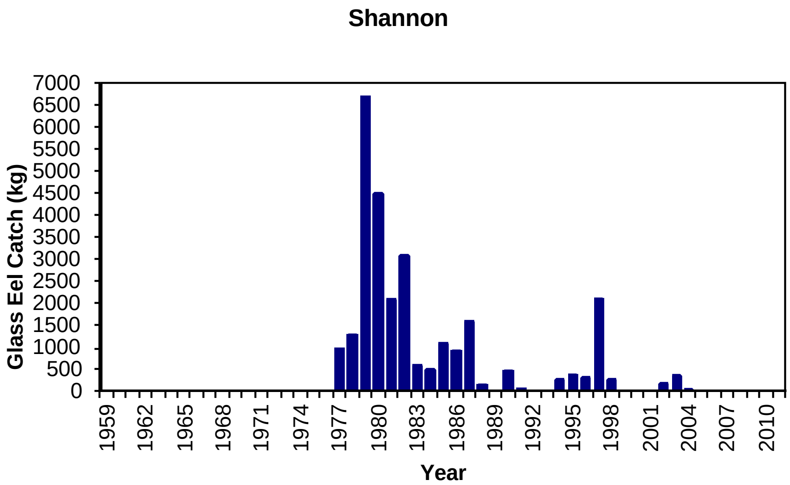


Figure 3-2: Annual glass eel catches (kg) in the traps at Ardnacrusha (Shannon) and Cathaleens Fall (Erne) – data from ESB. Note: Full trapping took place on the Erne from 1980 onwards.

Table 3-1: Glass eel catches (kg), 1985 to 2011 (blanks = not fished).

Year	Erne	Erne Estuary	Moy Estuary	Shannon Ardnacrusha	R Feale	R Maigue	Inagh R	Sh. Estuary Glass Eels
1985	394			1093	503			
1986	684			948				
1987	2322			1610				
1988	3033			145				
1989	1718			27				
1990	2152			467				
1991	482			90				
1992	1371			32				
1993	1785			24				
1994	4450			287	70	14		
1995	2400			398	0	194		
1996	618			332	0	34	140	
1997	1038			2120	407	467	188	616
1998	782	46		275	81	8	11	484
1999	1245	441		18	135	0	0	416
2000	1062	188		39	174	0	120	43
2001	699		13	27	58	2	18	1
2002	113		21	178	116	5		37
2003	525		36	378	36	72	111	147
2004	290		0	58	0	0	24	1
2005	838		14	41	0	1	0	41
2006	118		0	42	1	0	4	3
2007	189		0	45	0	0	39	12
2008	39		0	7	0	0	82.5	2
2009	88		1	8	42			
2010	97		7	50	20	3	1.312	3
2011	74		0	7	5	5	8	

3.2.3 National Survey Sites 2009-2011

The EIFAAC/ICES Working Group on Eel (WGEEL) report 2011 suggests that in the best situation, the detection of changes in the recruitment trend due to management actions will take four years to be visible. The WGEEL highlighted the need for a structured recruitment monitoring programme. The national programme needs to be a long term programme with a running time of at least a decade. Due to the difficulties in standardised sampling for glass eels in estuaries efforts have been focussed on the elvers entering freshwater. Understanding the recruitment of elvers to riverine/freshwater stock is critical to evaluate the dynamics underlying our eel stocks. Naismith and Knights (1988) suggest that the majority of elvers do not leave brackish water or if they do they only penetrate a short distance upstream, often moving close to the river bank. For these reasons, we have concentrated our activities at the high water mark.

Site location is often difficult as the traps need to be safely mounted to be secure from spate floods and vandalism, noted in locating a suitable sampling location in the Slaney and Barrow rivers.

The sites selected are located around the Irish coast (Fig. 3.1). Monitoring has been taking place on the Feale and the Maigue since 1994 and in the Inagh since 1996 by the Shannon Regional Fishery Boards and now by Inland Fisheries Ireland Limerick (Table 3.1). Fixed ramp style traps are used at these locations (Fig. 3.3). It is proposed to continue monitoring these sites due to the importance of these long-term data series. In the Eel Management Plan, it was proposed to extend the sampling locations around Ireland to incorporate a comprehensive monitoring programme. The additional locations are the Ballysadare, Corrib and Erriff on the West coast, and the Liffey, Barrow and Boyne on the East coast. The Boyne was chosen instead of the Slaney due to the lack of a suitable location on the Slaney.

Figure 3-3: Fixed ramp trap on the Inagh River

3.2.3.1 Corrib:

In 2010 and 2011, pipe style traps were placed in to the River Corrib at the downstream face of the Galway weir (Fig. 3.4). The traps are located on the left and right hand banks. In 2010, 30 kgs of glass eels were trapped (95,000 individuals) and 7 kgs of young yellow eels were also trapped in 2010 (equivalent to 728 individuals).

In 2011, there was a drop in the number of glass eels trapped with 4 kgs (12,000 individuals) trapped mainly during June and July. The amount of young yellow eels trapped increased to 24 kgs (equivalent to 3,200 individuals).

Figure 3-4: Pipe traps set in the fish pass at Galway weir on the Corrib

3.2.3.2 Erriff:

The Erriff was historically a good source of glass eel. Surveys were carried out on the river in 1974, 1975, 1979 (Moriarty, 1975, 1976, 1980) and it proposed using the Erriff as a source of glass eel for relocation stocking to other rivers to support commercial fisheries. In the early 1990s, the WRFB captured glass eel at the Erriff for sale to Aqua Arklow Ltd. and for stocking into Lough Corrib. In 1997, 32 kgs of glass eel were caught from April 6th – May 5th 1997.

In 2010 and 2011 pipe traps were set in the Erriff. No significant numbers were caught. The locations where glass eel were historically visible (under stones near the estuary and ascending the Aasleigh Falls) were checked during the sampling period but few were observed.

3.2.3.3 Ballysadare:

A site on the river was fished downstream of the falls in Ballysadare in 1979 (Moriarty, 1980) and again by Aqua Arklow in 1997.

In 2010 and 2011, the local IFI staff surveyed the river using pipe traps to locate an adequate location for a permanent ramp trap. In 2010 no visible glass eel run was found. In 2011 a significant run was observed using the fish pass at the Ballysadare Falls in July 2011. The run contained both glass eel and young yellow eels (Fig. 3.5). It is proposed to set up a ramp trap similar to the Shannon traps on this river for 2012.

Figure 3-5: Glass eel and young yellow at Ballysadare July 2011

3.2.3.4 Liffey:

In 2010 a ramp trap was installed on the right hand bank of the Islandbridge weir on the River Liffey. Very low numbers were caught in 2010.

In 2011 in addition to the ramp trap, a number of pipe traps and substrate traps were also used to determine if more eels were bypassing the ramp trap or using the other bank. It is the opinion of the IFI that the trap needs to be moved closer to the weir with an increase in flow of water down the ramp. If it's possible a second ramp trap should be installed on the left hand bank of the river.

3.2.3.5 Barrow:

In 2010 and 2011 the Barrow at the weir at St Mullins was sampled for glass eel using pipe traps. Very low numbers were recorded.

3.2.4 Northern Ireland & Lough Neagh

While the SSCE area of responsibility covers only the Republic of Ireland and the trans-boundary Erne and Foyle Catchments, it is useful for completeness to consider recruitment to the Bann and other catchments on Northern Ireland coasts. This information for Northern Ireland is provided by AFBI.

3.2.4.1 River Bann

The Lough Neagh Fishermens' Co-operative Society collect glass eel at the tidal limit of the Bann Estuary at the Cutts in Coleraine, where upstream migration is partially impeded by water level control sluices and a weir. The traps at this site have been operated with transport of glass eel to Lough Neagh with one break since 1936. More recently, some active fishing for glass eel also takes place downstream of the Cutts sluices gates, using circular framed drag nets with an area of 0.94 m^2. The total catch per night is recorded, but not catches per individual net. Since 1965 this trapping effort has provide a time-series index of natural recruitment (Fig. 3.6). Prior to 1983 mean annual recruitment was 3700 kg. Following the low point in recruitment seen Europe-wide in 1983, numbers recovered somewhat but since 2000 have declined further with the three most recent years being the lowest on record. Current catches over the past 5 years are on average 3% of pre-1980 levels. The 2011 recruitment to the river Bann reached an all time low with only 16 kg (approx 48,000 eels) captured and transported upstream.

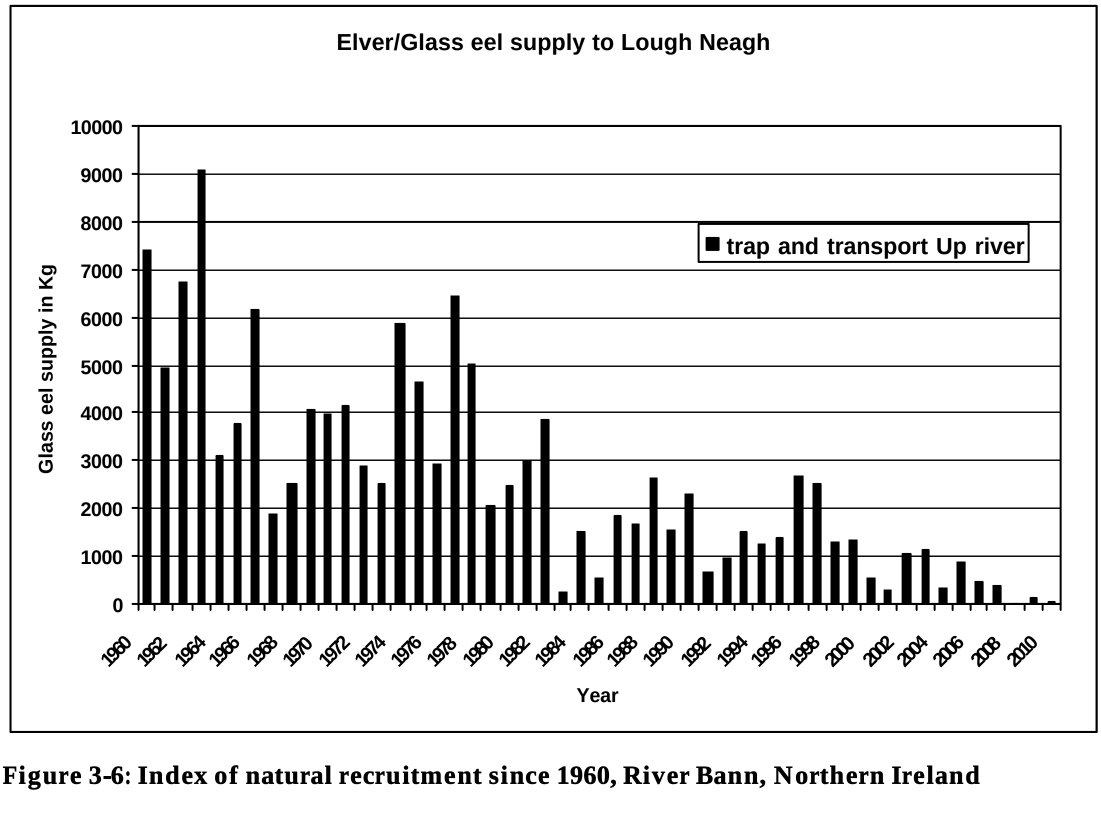


Figure 3-6: Index of natural recruitment since 1960, River Bann, Northern Ireland

3.2.4.2 Other Sites in N. Ireland

In addition to the annual glass eel and elver index on the River Bann, since 2004 investigations have been undertaken in the NI Eastern RBD. Sites investigated include Carlingford Lough/Newry Canal in South County Down, Quoile barrage and Shrigley River in Strangford Lough. These investigations have provided insight into the timing of arrival and recruitment strength of glass eel on the Irish Sea Coast. When resources permit, glass eel are sampled twice a month from their arrival in February/March through to April. A sample of 50 juveniles is removed for morphometric analysis, calculation of number per kilo and length frequency analysis.

Glass eel arrival is noted at other sites within this EMU but not intensely monitored, for example, at the tidal limit of the River Lagan, at Stranmillis, Belfast.

This work demonstrates that glass eels are still arriving annually (to 2009/10) to Northern Irelands' East coast, from Belfast southward. Some sites, particularly Carlingford Lough at the mouth of Newry Canal, had locally significant quantities of glass eel arriving. There could be merit in fitting permanent structures or traps for counting glass eel where tidal head sluices or sites with a fall exist (e.g. Lagan or Newry Canal) for use in annual monitoring and to avoid hazardous night sampling.

3.3 Young Yellow Eel Recruitment

There is no commercial or recreational catch of young yellow eel in Ireland as fishing for juvenile eel was prohibited by law (1959 Fisheries Act, Sec. 173) and this remains the current situation. Fishing for juvenile eel is also prohibited under the conservation bye-laws.

Monitoring of juvenile yellow eel migrating at Parteen Dam (Shannon) and Inniscarra on the R. Lee takes place using a fixed brush trap. The data for Parteen is presented in Figure 3.7. In 2009 and 2010, due to maintenance work by ESB at the Parteen regulating weir the discharge patterns were less favourable than in 2008. This partly accounted for the poor catches recorded in the latter two years at Parteen.

In 2010, less than one kg was recorded in the Inniscarra trap on the Lee and in 2011, 48kg were recorded.

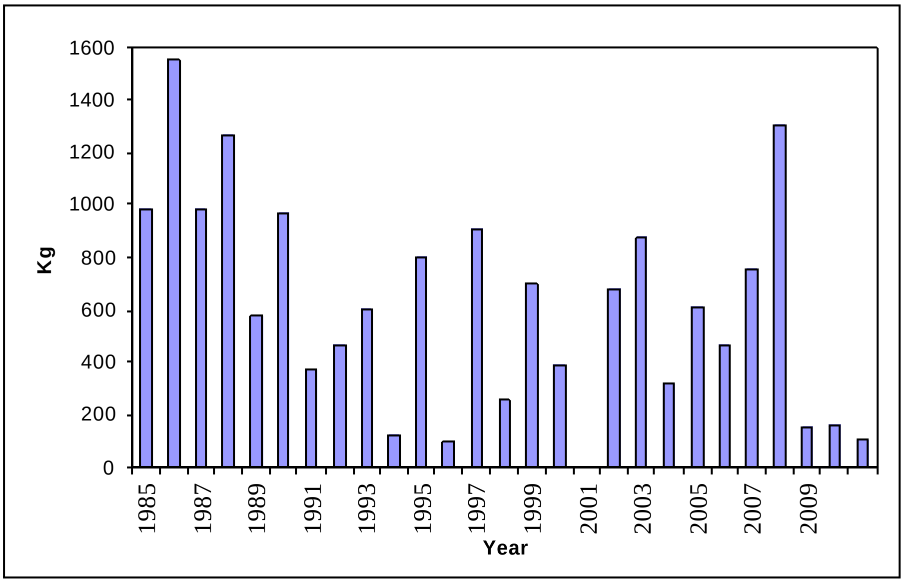


Figure 3-7: Juvenile yellow eel catches (kg) at Parteen Weir, 1985 to 2011.

3.4 Advice on Recruitment

Recruitment has been declining at many Irish monitoring sites since the mid 1980s (Table 3.2). Recruitment in the 2000-2011 period in the Shannon was at 2% of the pre-1980 average and in 2009-2011 it was <1%. The Feale, the Inagh and the Erne show a slower rate of decline but in the 2009-2011 period these have also declined to relatively low levels. For comparison, glass eel recruitment in the Bann (NI) in 2009-2011 was <2% of the pre-1980 level. Glass eel are still being observed in coastal and estuarine areas but numbers in 2010 were low.

In Europe (ICES 2011), recruitment in the last five years has been particularly low with an index average of less than 1% in the continental North Sea and less than 5% elsewhere in Europe compared to the mean for 1960–1979 levels. Young yellow eel recruitment series also remain low at around 10% of their mean for the 1960–1979 levels.

In summary, recruitment has been declining in many rivers since the mid 1980s, particularly in the most recent years. While there is some local variation in abundance between sites and between years, often due to seasonal variations in water levels, recruitment remains low (2009-2011) and has not shown any signs of recovery, either in Ireland or in Europe.

Table 3-2: Mean weight (kg) of glass eel catches in index rivers for the period's pre 1979, pre 1995, 2000-2011 and 2009-2011. Also presented are the percent changes of the 2000-2011 and 2009-2011 periods against the historic periods.

River	kg pre 1980	kg pre 1995	kg 2000-2011	kg 2009-2011	% 2000-2011 of pre'80	% 2000-2011 of pre'95	% 2009-2011 of pre'80	% 2009-2011 of pre'95
Erne	690*	1252	344	86	50	28	13	7
Shannon	3000	1312	69	11	2	5	<1	1
Feale		171	38	22		22		13
Maigue		120	8	4		7		3
Inagh		85	41	5		48		6
Bann, NI	3700			81			2	

* partial trap on Erne before 1980.

4 Yellow Eel Assessment 2009-2011

(refers to Ch. 7.2.2, 7.2.3 & 7.2.4 of the National EMP Report, 2008)

4.1 Introduction

Monitoring yellow eel stocks is important for understanding of the current status of local stocks and for informing models of escapement, in particular where direct silver eel estimates are difficult to achieve. Such monitoring also provides a means of evaluating the impact of changing recruitment and post-management changes on the stock and forecasting the effects of these changes on silver eel escapement. The monitoring strategy aims to determine, at a local scale, an estimate of relative stock density, the characteristics of the stock such as size, age and sex profiles, and the proportion of each length class that migrate as silvers each year. Furthermore, individuals from this sample will be used to determine levels of contaminants and parasites to assess spawner quality. Two classes of survey methodologies were employed; eel specific surveys and multi-species surveys, mainly involving standardised fyke netting and electro-fishing.

Fyke net surveys, carried out between 1960 and 2008 by State Fisheries Scientists will provide a useful bench mark against which to assess the changes in stock after the closure of the fishery. The yellow eel monitoring strategy relied largely on the use of standard fyke nets. Relative density was established based on catch per unit (scientific-survey) effort.

Under the Irish Eel Management Plan a detailed monitoring programme was outlined for the three year period. This monitoring programme aimed to meet a number of objectives as set out in Chapter 7.2.3 of the Irish EMP.

2.1 Estimate silver eel escapement using indirect assessment from yellow eel stocks

3. Monitor the impact of fishery closure on yellow eel stock structure

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

Over the course of the 3 year programme an extensive amount of information was gathered on the yellow eel in Ireland (Catch per unit of effort, length, weight, morphometric data, age, growth and parasite prevalence etc.). This information will be used as a baseline data set to track changes in the population structure of eels in Ireland over the coming years as a result of the closure of the fishery and the endangered status of the stock (Objective 3 and 6). An inter calibration study was conducted between the Eel Monitoring Programme and Water Framework Directive lake programme (Objective 4). The intensive survey work carried out incorporated repeat surveys allowing for the comparison with historical records from the 1960's, 1970's, 1980's and 1990's (Objective 5). New technology was employed in monitoring the maturation rate of yellow eels to silvers. Yellow eels were implanted with Passive Integrated Transponders (PIT tags) in order to carry out Mark Recapture studies and for the estimation of the maturation rate of yellow eels to silver eels (Objective 2.1).

A number of changes were made, to the schedule as set out in the EMP, over the three year period, dictated by availability of resources and weather conditions. In order to survey the lakes comprehensively, Lough Derg and Lough Ree were both divided into two lakes (upper and lower,

Table 4-1). Due to the presence of the silver eel trap at Burrishoole and the long-term data series available, Lough Feeagh and Lough Bunaveela were sampled every year as opposed to the one year outlined in the schedule. As a result of the extra additions and time constraints, four lakes were omitted from the schedule, Lough Allen, Lough Arrow, Lough Mask and Dromore Lough. Ballysadare was removed from the schedule as recent IFI surveys of the area resulted in very low eel catches. Waterford estuary was surveyed a second time in place of Ballysadare. The South Sloblands were surveyed in place of Lady's Island Lake due to the availability of historical data.

The sampling locations surveyed over the three year period are presented in Figure 4-1.

Table 4-1: Locations of eels specific surveys; planned and executed 2009 – 2011 (v surveyed, v! added to list, † not surveyed.

Water body	2009	2010	2011
Burrishoole	v	v	v
Lower Derg*	v		v
Upper Derg		v	
Upper Corrib		v	
Lower Corrib	v		
L. Cullen	v		
L. Conn	v		
Upper L. Erne		v	
L. Ree (Upr & Lwr)		v	
L. Oughter			v
L. Ramor			v
L. Inchiquin			v
Ballynahinch			v
L. Arrow		†	
L. Allen			†
L. Mask			†
Dromore L			†
Waterford Estuary	v		v
Slaney Estuary		v	
South Sloblands		v	
Ladys Island Lake			†
Ballysadare Estuary	†		

4.2 Methods

The yellow eel fyke net surveys consisted of setting 10 chains of 5 fyke nets for 6 nights, resulting in an effort of 300 net nights in each lake. The lakes were surveyed over at least two time periods to account for variation in time. Five or six lakes were intensively sampled each year.

In the fyke net surveys two life stages were encountered: the yellow stage and the silver migratory stage. Stage determination is based on skin colour: an eel that displays a silver belly well separated from a black dorsal region by the lateral line is considered at the 'silver stage'. However eels are found with intermediate features so additional measurements are recorded (ICES, 2009).

- Eye measurements: horizontal and vertical right eye is measured (not just the iris but the whole visible eye, mm).
- Pectoral fin measurements (corresponds to the tip of the fin to the greatest possible length (mm).
- Total body length (cm),
- Wet body weight (kg)
- State of lateral line (presence of black corpuscles)
- Presence of metallic colouration (i.e. bronze)
- Dorso-ventral colour differentiation

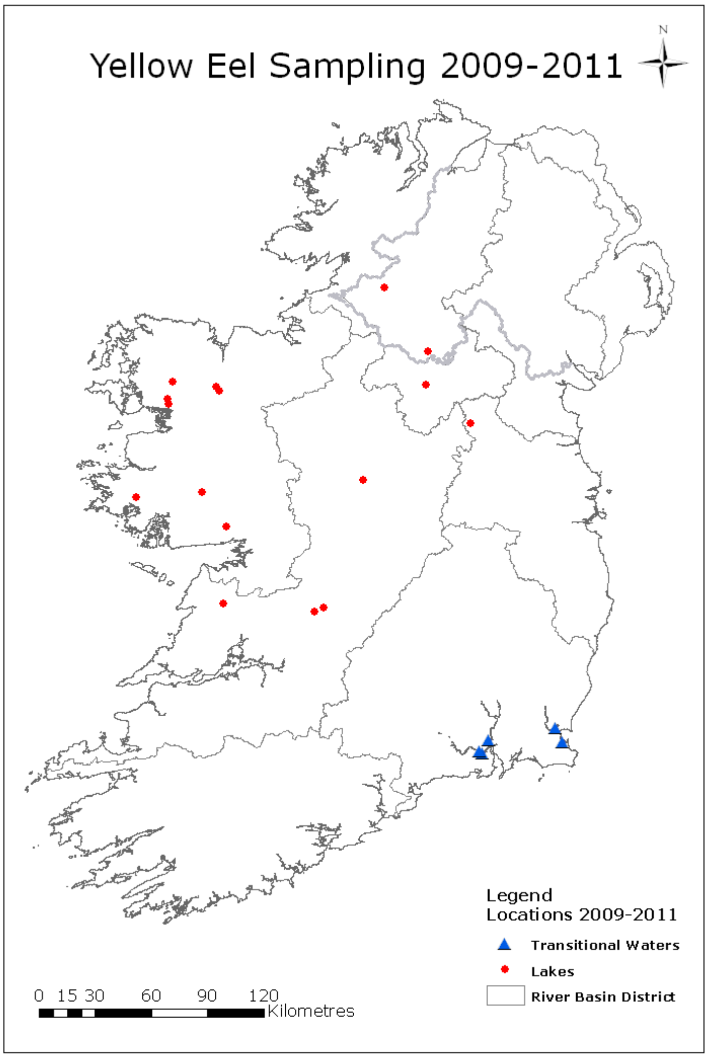


Figure 4-1: Locations of yellow eel surveys carried out between 2009 & 2011.

For each night's fishing, as many live samples as possible were measured for weight, length, and INDICANG style morphological features associated with silvering. At each location approximately 100 eels were sacrificed for further analysis in the laboratory. Total length (to nearest cm), weight (to nearest g) and silvering characteristics were determined on site. In the laboratory, otoliths were removed for age evaluation (cracking and burning - Christensen 1964, Hu & Todd 1981, Moriarty 1983, Graynoth 1999, Poole & Reynolds 1996), gonads for sex determination (macroscopically), swimbladders for evaluation of nematode parasite, *Anguillicoloides crassus* (Kuwahara, Niimi & Hagaki, 1974) and stomachs for diet composition.

A second objective of the yellow eel study was to carry out an indirect estimation of silver eel escapement. For lakes with a research silver eel fishery or Trap and Transport operation within the system, all yellow eels >30cm captured in the fyke nets were tagged using Trovan Passive Integrated Transponders (PIT). 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.

4.3 Yellow Eel Survey Results 2009-2011

During the three year programme, 13,194 yellow eels were captured over 5,308 net*nights. Summary catch information is available in Table 4-2. A full presentation of the results is given in the following Sections.

The highest lake CPUEs were recorded in the three zones of Lower Lough Erne (Table 4-2). This probably reflects the relatively high recruitment in the mid-1990s through into the early 2000s.

Lough Derg recorded the highest catch per unit of effort for a lake with a CPUE of 3.89. L. Derg has been closed to yellow eel fishing for a number of years as a conservation measure and most of the elvers from Ardnacrusha and Parteen are stocked into L. Derg. Both of these measures may have contributed to the relatively good CPUEs.

Lough Oughter recorded the lowest CPUE. There was a problem with weed growth obstructing the fykes but it is not know whether this resulted in the low CPUE. It is proposed to resurvey Lough Oughter in the following three year programme.

A relatively low CPUE was also recorded in Upper and Lower Lough Corrib.

Bunaveela Lough is a small lake at the top of the Burrishoole catchment. It is now showing signs of poor recruitment into the lough and has consistently recorded low CPUE for the last few years.

For the transitional waters, both the Barrow and Suir surveys caught good numbers of eels but the Slaney estuary recorded low numbers.

For the transboundary Erne, Lower Lough Erne was surveyed in July 2011 by commissioned fishermen. Good numbers of eel were captured in the Narrows zone and the larger eels in the Western zone. Numbers compared favourably with the surveys in the EEEP (1999). There was some evidence of a recovery in length classes.

IFI (2012) reported a significant reduction in CPUE with increasing depth ($p<0.05$), especially below 15m but no significant difference in CPUE with increasing distance from the shore. The change in CPUE with depth will need to be taken into account when comparing with WFD and other studies.

The first 3 year eel monitoring programme has concentrated on the distribution of yellow eels in lakes as they are a dominate component of Ireland's wetted area comprising more that 85%.

Many European countries that are modelling eel population do not take into account lake habitat due to the difficulty involved in relating CPUE data to density and abundance. It is recommended that further research into estimating density of eels in lakes is carried out to support the national management plan.

Table 4-2: Summary details from the yellow eel surveys 2009 – 2011.

Lake	Year	No. Eels	Nets Nights*	CPUE No./ net night	Total Weight (kg)	CPUE Wt/ net night	No. sampled	Mean Length (cm)	Min. Length (cm)	Max. Length (cm)	Mean Weight (kg)	Min. Weight (kg)	Max. Weight (kg)
Lower Lough Derg	2009	669	300	2.23	117.158	0.391	670	44.06	25.00	85.00	0.175	0.030	1.867
Upper Lough Derg	2010	771	255	3.01	110.063	0.432	758	46.0	28.1	81.2	0.179	0.045	1.316
Meelick Bay(L.Derg)	2011	856	220	3.89	204.1513	0.928	847	43.1	28.7	67.0	0.156602	0.039	0.592
Lower Lough Corrib	2009	314	300	1.05	56.700	0.189	327	45.97	27.00	71.00	0.173	0.042	0.742
Upper Lough Corrib	2010	471	300	1.57	98.733	0.329	445	50.1	31.50	87.5	0.222	0.046	1.372
Lough Feeagh	2009	517	295	1.75	53.538	0.181	332	42.16	20.80	79.80	0.161	0.009	1.340
Lough Feeagh	2010	496	300	1.65	73.165	0.244	478	42.5	26.6	89.1	0.154	0.026	1.656
Lough Feeagh	2011	73	60	1.22	13.18	0.220	76	43.22	29.0	86.2	0.173	0.039	1.590
Lough Bunaveela	2009	29	75	0.39	4.710	0.063	29	44.72	30.50	58.50	0.162	0.044	0.393
Lough Bunaveela	2010	11	50	0.22	-	-	5	47.9	36.2	58.3	-	-	-
Lough Bunaveela	2011	2	30	0.07	0.44	0.015	2	47.5	38.4	56.6	0.22	0.095	0.345
Lough Furnace	2011	52	90	0.58	8.44	0.094	53	42.2	19.4	86.1	0.159	0.03	1.35
Lough Ramor	2011	1067	300	3.56	240.588	0.802	1042	47.9	26.4	84.1	0.365834	0.030	1.150
Lough Cullin	2009	377	215	1.75	64.247	0.299	321	44.72	28.70	82.30	0.200	0.041	0.960
Lough Conn	2009	595	250	2.38	97.686	0.391	510	46.41	31.00	81.00	0.192	0.044	1.200
Lower Lough Ree	2010	505	300	1.68	90.020	0.300	500	46.4	28.2	84.5	0.184	0.028	1.503

Lake	Year	No. Eels	Nets Nights*	CPUE No./ net night	Total Weight (kg)	CPUE Wt/ net night	No. sampled	Mean Length (cm)	Min. Length (cm)	Max. Length (cm)	Mean Weight (kg)	Min. Weight (kg)	Max. Weight (kg)
Upper Lough Ree	2010	345	270	1.27	68.516	0.254	342	47.7	29.6	69.8	0.200	0.034	0.707
Lough Inchiquin	2011	548	250	2.19	150.548	0.602	543	52.5	31.7	77.8	0.2773	0.0450	1.110
Lough Ballynahinch	2011	434	300	1.45	64.243	0.214	434	41.7	28.0	90.5	0.1480	0.0420	1.760
Upper L. Erne	2010	493	300	1.64	106.246	0.354	491	49	28.90	78.7	0.221	0.035	0.950
Lwr L. Erne West	2011	616	100	6.16	117.04	1.10	60	44.7	26.3	81.3	0.190	0.05	1.10
Lwr L. Erne Broad	2011	528	100	5.28	84.48	1.01	70	42.5	27.2	70.2	0.160	0.05	0.78
Lwr L.Erne Narrows	2011	1659	100	16.59	265.44	3.03	70	42.2	26.4	77.4	0.160	0.05	0.61
Lough Oughter	2011	296	300	0.99	65.898	0.220	284	50.4	30.7	78.5	0.233681	0.0425	0.641
Barrow T. Waters	2009	1,410	215	6.56	-	-	100	42.5	22.50	65.00	0.197	0.021	0.980
Barrow T. Waters	2011	155	20	7.75	15.670	0.784	162	36.13	20.40	69.20	0.097	0.013	0.633
Suir T. Waters	2009	1,888	163	11.58	-	-	1,281	37.7	21.5	79.00	-	-	-
Suir T. Waters	2011	574	90	6.38	70.450	0.783	572	38.7	22.10	74.30	0.123	0.018	0.665
Slaney T. Waters	2010	350	210	1.67	-	-	346	33.9	22.70	57.90	-	-	-
South Sloblands	2010	24	30	0.80	4.140	0.138	24	43.9	29.8	64.20	0.172	0.0455	0.441

4.4 Transitional Waters

4.4.1 Waterford Harbour 2009 (Suir & Barrow)

4.4.1.1 Survey

It is well known that considerable stocks of eels exist in some, but not all, transitional waters. Transitional waters have supported commercial eel fisheries, particularly on the east and south east coast of Ireland. To date, there has been no suitable methodology available for determining the stock size in a large water body, including an estuary or tidal lagoon. It is also not possible to quantify the biomass of silver eel being produced in the transitional waters.

In order to determine the population density within an important eel habitat, a spatially explicit mark recapture experiment was carried out in the Waterford Harbour in July 2009 (Efford 2004, Hightower & Nesnow 2006, Morrison & Secor, 2003, 2004). This method consisted of 2-4 grids of 15-20 fyke net, with each fyke net spaced 50m apart. Fyke nets were set in grids along the right and left bank of the transitional water, avoiding the main shipping channel (Fig. 4-2). Nets were not set on consecutive nights as the anaesthetic suppresses appetite and therefore tagged eels are unlikely to forage directly after release, thereby impacting on their capture and recapture rate. The fyke nets were not baited to avoid attracting eels into the study area (Morrison & Secor 2004). All eels >30 cm were tagged with passive integrated transponders (TROVAN PIT tags).

On the Suir, two locations were selected, one upstream of the bridge in Waterford city and one downstream. The upstream site was only fished for one night (02nd July 2009). The downstream site was fished for 4 nights spread out over 7 nights (02nd, 06th, 08th & 13th July 2009). One site on the Barrow estuary was fished for 5 nights spread out over 9 nights (02nd, 06th, 08th, 13th, 15th July 2009) with an additional 2 sites (upstream and downstream of the main site) on the last night. One hundred eels were sacrificed on the last day of the survey in the Barrow transitional waters. Total length (to nearest cm), weight (to nearest g) and silvering characteristics were determined on site.

In total, 1,888 eels were captured in the fyke net survey in the Suir transitional waters with a catch per unit effort of 11.58 (Table 4-3). A large catch of 483 eels were captured in the upstream site (upstream of Waterford bridge) after one nights fishing and 712 eels were tagged in the downstream site (downstream of Waterford bridge). No eels from the upstream site were recaptured in the downstream site during the study period. Within site 2 (downstream of Bridge), 30 eels were recaptured over the time period giving a recapture rate of 4%. No tagged eels were recaptured more than twice in this survey (Table 4.4).

Hightower and Nesnow (2006) suggested that a 3 day mark recapture survey is sufficient to get an indication of the density of the population. To test this theory a traditional fyke net survey (5 nets in a chain) was carried out in July 2011. The nets were set off the main channel around Waterford Castle Island approximately 1 kilometre downstream from the 2009 survey. Six chains of nets were set for 3 nights and a total of 574 eels were captured giving a CPUE of 6.38. No tagged eels from the 2009 survey were recorded but 2 eels were recaptured within the survey period.

In the Barrow transitional waters 1,410 eels were captured with a catch per unit effort of 6.56 in 2009 (Table 4.3). 849 eels were tagged and 52 eels were recaptured giving a recapture rate of 6% (Table 4.5). No tagged eels were recaptured more than 3 times in the trapping session. In 2011 traditional fyke net chains were set in the Barrow main channel for one night in the same location as the 2009 survey. A total of 155 eels were caught giving a CPUE of 7.75. One eel tagged in 2009 was recaptured in 2011.

Moriarty (1986) concluded that recapture rates of 5.5 – 18.5% could be expected if a population was non-migratory, rates below 2% indicating a very mobile population. I n the Suir, tagged eels were caught at most twice and in the Barrow only 3 eels were caught three times. This low recapture rate could be due to trap shyness, because the home range of the species in question is greater than the trapping area or because the population is highly mobile.

Table 4-3: Suir and Barrow transitional water fyke net survey 2009 and 2011.

T_Water	Year	Location	No. Eels	No. Nets	CPUE
Suir	2009	Main Channel	1,888	163	11.58
	2010	Island	574	90	6.38
Barrow	2009	Main Channel	1,410	215	6.56
	2011	Main Channel	155	20	7.75

Table 4-4: Mark-recapture data from the Suir Survey 2009.

Occasion i	1	2	3	4
Caught at time i	345	80	136	181
1st caught at time i	345	73	132	162
Caught exactly i times	682	30	0	0
Marked animals at i+1	345	418	550	712

Table 4-5: Mark-recapture data from Barrow Survey 2009

Occasion i	1	2	3	4	5
Caught at time i	97	335	240	266	18
1st caught at time i	97	331	228	243	2
Caught exactly i times	849	49	3	0	0
Marked animals at i+1	97	428	656	899	901

4.4.1.2 Population Estimation

Population density is a key ecological variable and it has recently been shown how captures on an array of traps over several closely spaced time intervals may be modelled to provide estimates of population density (Borchers and Efford 2008; Efford *et al.* 2009). A maximum likelihood spatially explicit capture recapture (ML- SECR) experiment was carried out in the Barrow and Suir estuary in 2009. The Density programme 4.4 (Efford 2009) estimates the density of animal populations from capture – recapture data collected using an array of detectors (traps). Detectors are live capture traps with animals uniquely marked with PIT tags. Three models are used (Half- Normal, Hazard and Negative Exponential) and the model with the lowest Akaike Information Criterion (AIC) value is the density value reported.

Thibault *et al.* (2007) found that tagged eels in the St Jean watershed had a home range of between 100 m to 1 km. Morrison & Secor (2003) found an average distance travelled by eels in their study to be approximately 588 m with a maximum distance travelled at 4.5 km. In this analysis, boundary zones of 100 m, 500 m and 1,000 m to cover the variation in home range size were assessed.

For the Suir estuary, the half normal model had the lowest AIC value for both tests (Table 4.6). If a boundary of 100 m is used, the model predicts a density of 58 eels/ha (46 -69 eels/ha) and increasing the boundary to 1,000 m results in the density decreasing to 9 eels/ha (7- 11 eels/ha). Therefore, a conservative estimate of eel density in **the Suir estuary is between 9 – 58 eels/ha**.

For the Barrow estuary, the hazard model had the lowest AIC value for all tests (Table 4.7). For the 100 m boundary analysis, the model predicts a population of 49 eels/ha (42 – 56 eels/ha). When the boundary zone is increased to 1,000 m, the density decreases to 8 eels/ha (7 – 10 eels/ha). Taking a conservative estimate, the density of eels in the **Barrow estuary is estimated to be between 7-49 eels/ha**.

The density values reported here are representative of the gear dependent proportion of the population as fyke nets are size selective. In this study it was decided to tag eels that were >30cm. These density values are similar to recent density values reported in the literature. Morrison & Secor (2004) found a density of 9.5 eels/ha (1 – 30 eels/ha) for the Hudson River Estuary USA. Hightower & Nesnow (2006) reported a value of 4 – 13.8 eels/ha in the White Oak River Estuary, USA. These values are less than those reported by other studies (Table 4.8). Telemetry studies will give a clearer indication of the movement habits of eels in estuaries close to the river channel.

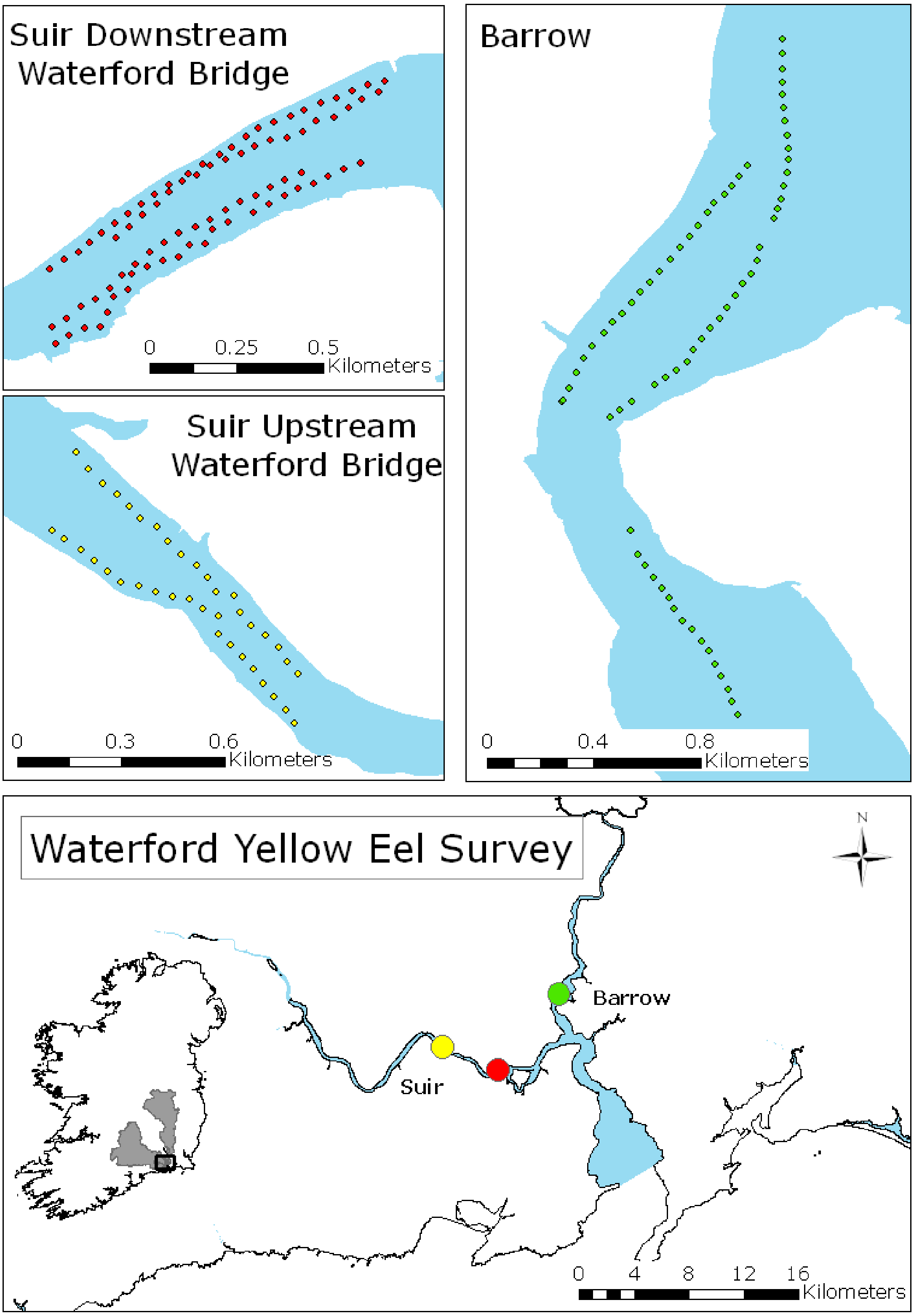


Figure 4-2: Location of surveys sites in Waterford Harbour, Suir and Barrow 2009.

Table 4-6: Comparison of models for density and spatial detection of eels in the River Suir.

Boundary zone	Distribution Type	AIC	AICc	Density ha	SE	G0	SE	Sigma	SE
100m	Half Normal	3291.39	3291.42	57.67	11.613	0.0004	0.0001	791.73	245.37
	Hazard*	3297.24	3297.30	57.09	11.504	0.0003	0.0001	33173.13	na
	Neg Exponential	3291.06	3291.10	57.93	11.704	0.0005	0.0002	985.37	641.15
1,000m	Half Normal	3293.74	3293.78	8.66	1.840	0.0005	0.0002	1212.73	578.76
	Hazard*	3297.24	3297.30	8.07	1.583	0.0003	0.0001	30041.54	na
	Neg Exponential	3294.26	3294.30	8.52	1.742	0.0006	0.0005	1673.46	5401.94
500m	Half Normal	3292.20	3292.23	19.98	4.036	0.0005	0.0002	855.23	329.42
	Hazard*	3297.24	3297.30	18.97	3.766	0.0003	0.0007	25517.64	n/a
	Neg Exponential	3292.89	3292.93	19.93	3.961	0.0006	0.0004	1076.08	1239.82

Table 4-7: Comparison of models for density and spatial detection of eels in the River Barrow.

Boundary Zone	Distribution Type	AIC	AICc	Density ha	SE	G0	SE	Sigma	SE
100m	Half Normal	3068.87	3068.90	48.06	6.677	0.0017	0.0003	313.52	24.73
	Hazard*	3063.54	3063.58	48.83	6.960	0.0015	0.0003	355.91	59.06
	Neg Exponential	3070.86	3070.89	48.15	6.844	0.0032	0.0007	233.21	32.94
1,000m	Half Normal	3122.68	3122.71	9.35	2.068	0.0011	0.0002	782.73	159.37
	Hazard*	3108.42	3108.46	8.44	1.161	0.0007	0.0001	1458.42	11.96
	Neg Exponential	3125.61	3125.64	10.01	36.884	0.0021	0.0042	592.21	16458.06
500m	Half Normal	3101.22	3101.24	19.64	3.111	0.0013	0.0002	511.52	60.12
	Hazard*	3083.26	3083.31	19.48	2.705	0.0008	0.0001	885.15	8.30
	Neg Exponential	3107.49	3107.52	19.63	3.568	0.0023	0.0007	413.28	110.56

Table 4-8: Density estimates for *Anguilla rostrata* from the literature.

Location	System	Fishing Method	Density eels/ha	Min eels/ha	Max eels/ha	Min length	Max length	Ref
Hudson River, NY, USA	Estuary	Pots	9.5	1	30	28	67	Morrison & Secor 2004
White Oak River Estuary, N. Carolina, USA	Estuary	Pots		4	13.8			Hightower & Nesnow 2006
Georgia Tidal Creek	Estuary	Pots		182	232	20	80	Bozeman *et al.* 1985
Massachusetts tidal creek	Estuary	Traps	875			15	63	Ford & Mercer 1986
Maine	River	e/fishing		800	2200	>10		Oliveira and McCleave 2000
Rhode Is.	River	e/fishing		450	3230	16	74	Oliveira 1997
Vermont Lake	Lake	e/fishing		232	636	-	-	La Bar & Facey 1983

4.4.2 Wexford Harbour 2010 (Slaney)

4.4.2.1 Survey

In July 2010, a spatially explicit mark recapture experiment was undertaken downstream of the Ferrycarraig bridge and upstream of Wexford town (Fig. 4.3). This location was chosen due to the size of the trapping area required for the MR survey. The commercial eel fishermen usually fished further upstream (above Killurin) due to the abundance of crabs in the estuary. Finding adequate depth to set nets proved difficult for this site. Two chains of fyke net were set; each chain consisted of 15 fyke nets with each net spaced 50m apart.

A similar sampling method to that used in the Slaney estuary was employed in the Waterford estuary in 2009. However, due to the low recapture rate recorded, the methodology was modified for the 2010 Slaney survey. In 2009, nets were not set on consecutive nights as the anaesthetic suppresses appetite and the tagged eels are not expected to be recaptured. However, for the Slaney estuary survey, it was felt that to capture the whole population (untagged eels) the area needs to be fished on consecutive nights. Fyke nets were not baited to avoid attracting eels into the study area.

Two chains of 15 nets were set for 7 nights (13th July to 23rd July, excluding weekends) with a trapping area of 17 ha. A total of 350 eels were captured in 210 net*nights giving a catch per unit of effort of 1.67. All eels >30cm were tagged with passive integrated transponders (PITs) and released.

In total, 240 eels of the 350 caught were tagged. A very low recapture rate was recorded for the Slaney Estuary (1%, Table 4.9). Two eels were recaptured (one twice and one three times). The recaptured eels travelled less than 400m. No eels were taken back to the laboratory for further analysis due to the low numbers caught. Due to the low recapture rate, the Slaney data was not analysed using the Density programme as it requires a minimum of 20 recaptures (Efford *et al.* 2009).

Home range is dependent on the size of the eel, diurnal and nocturnal activities but also on the habitat itself (Thibault *et al.* 2007). Studies show that the home range of eels is very dependent on the habitat available with home ranges for A. *rostrata* ranging from 325+/-64 ha in a tidal estuary in Maine to 0.5 to 2.0 ha in an estuary of the Calumet River (Parker 1995, Dutil *et al.* 1988). Ford and Mercer 1986 found that 93% of eels travelled less than 100m in a tidal marsh giving a mean home range of 209m^3. A telemetry study of either the Slaney or Waterford Estuary would indicate whether these eels are utilising an area within their home range or are undertaking a migratory or seasonal journey.

The eels captured by fyke nets ranged in length from 22.7 cm to 57.9 cm with an average length of 33.9 cm (Fig. 4.4). A similar distribution of relatively small eels was observed in the commercial fishery in 2008 (Fig. 4.5).

Table 4-9: Mark Recapture data from the Slaney Estuary.

Occasion *i*	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Caught at times *i*	83	47	18	6	23	25	41
First caught at times *i*	83	46	18	6	22	25	40
Caught exactly *i* times	238	1	1	0	0	0	0
Marked animals at *i* +1	83	129	147	153	175	200	240

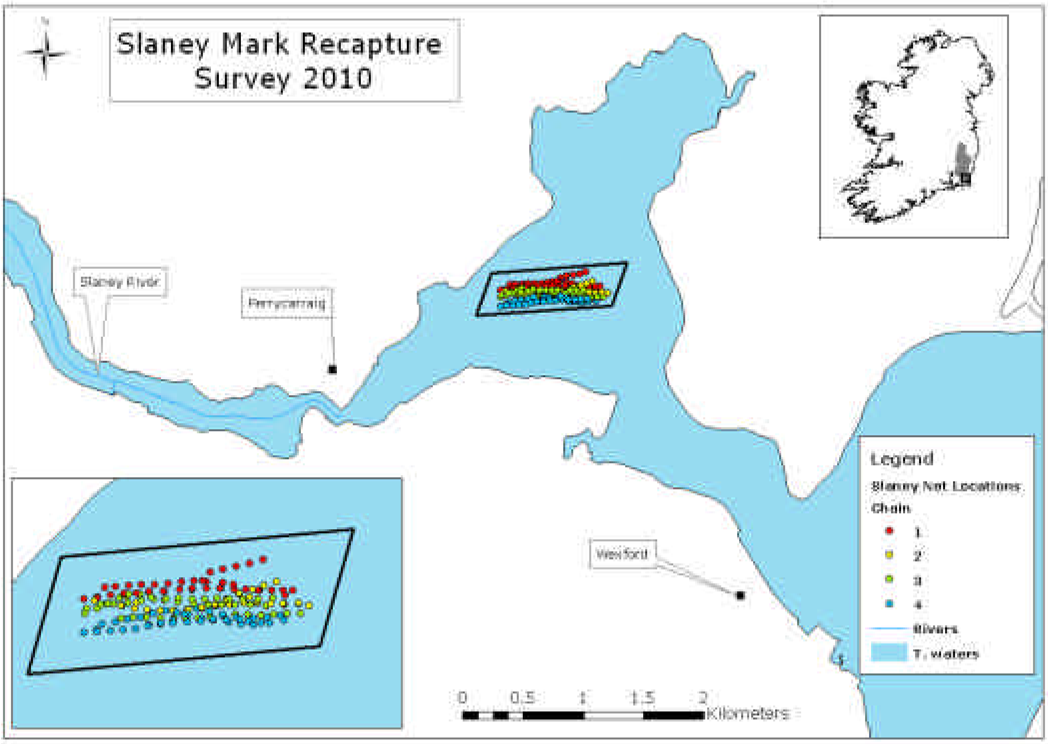


Figure 4-3: Locations for the Slaney Transitional Waters survey 2010.

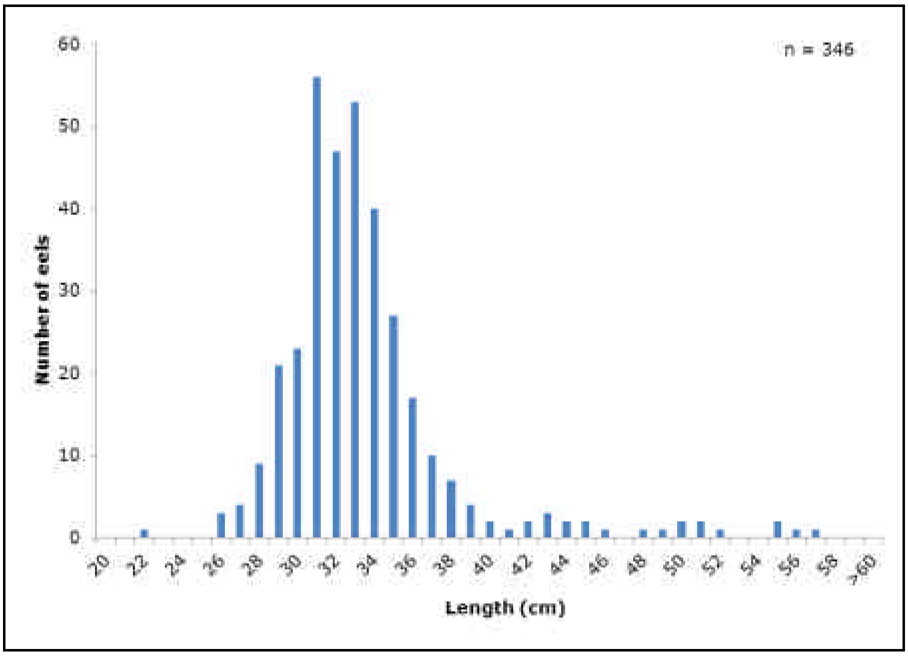


Figure 4-4: Length frequency of yellow eels captured in the Slaney Estuary, 2010.

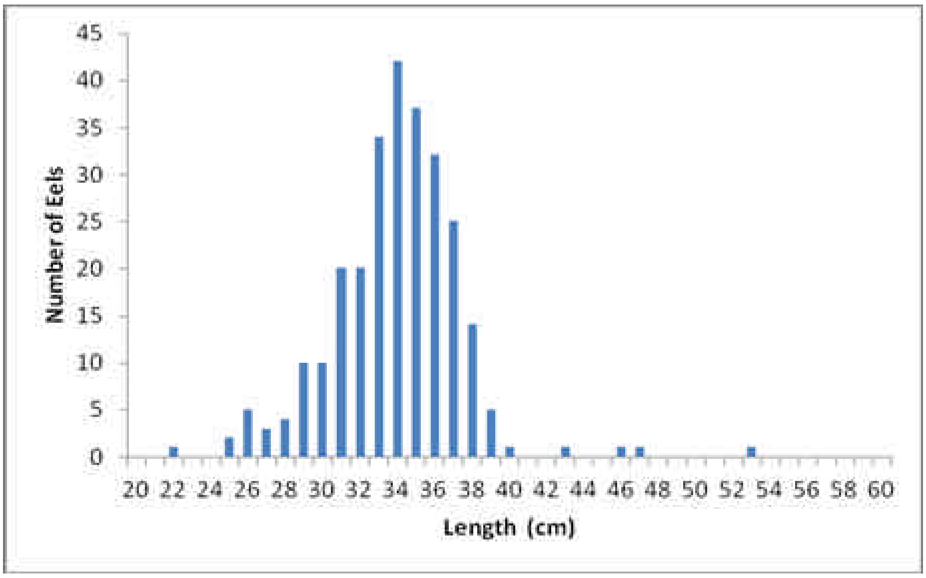


Figure 4-5: Length frequency of yellow eels captured in the commercial fishery in the Slaney Estuary, 2008.

4.5 Comparison between lakes and transitional waters

There was a significant difference in the length of eels from transitional waters and lakes (Mann Whitney test, $p<0.001$, Fig. 4.6) using the data from the 2009 -2011 surveys. The average length of an eel in the lakes is 45.8 cm compared to only 38.6 cm for eels in transitional waters, with a medium effect size (r=0.3).

There was also a significant difference in the weight of eels found in transitional waters and lakes (Mann Whitney test, $p<0.001$, Fig. 4.7). The average weight of an eel in the lake is 0.194 kg compared with 0.127 kg in the transitional waters. A medium effect size was calculated for this analysis (r=0.3). The average condition factor for eels in the lakes is 0.178 were not significantly different compared with an average condition factor of 0.180 for the transitional water eels.

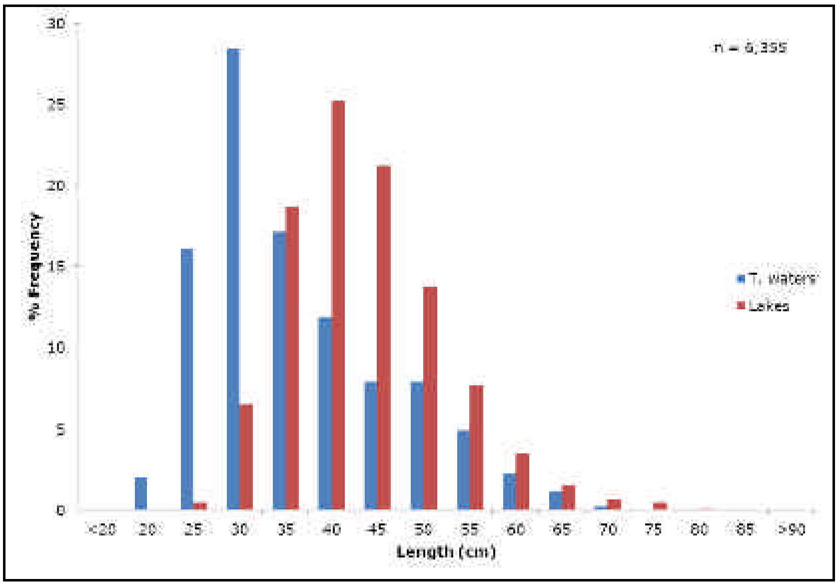


Figure 4-6: Length frequency of yellow eels from transitional waters and lakes.

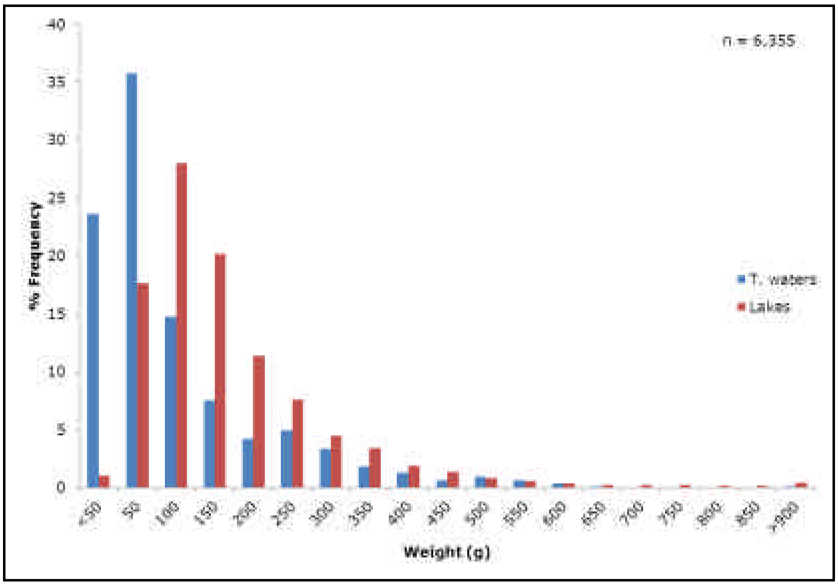


Figure 4-7: Weight frequency of yellow eels from transitional waters and lakes.

5 Comparison of historic and current (2009-2011) yellow eel stocks

(refers to Ch. 7.2.3 of the National EMP Report, 2008)

5.1 Introduction

Extensive survey work was carried out on eels throughout Ireland from 1968 until the late 1990's by the Fisheries Research Centre (FRC). These surveys covered all water body types (rivers, lakes and transitional waters) and valuable time series were created. The raw data sheets were available to the Marine Institute and Inland Fisheries Ireland and a large section of this historical data was collated into a national eel database under the NDP 'Eel Plan' Project, (Compass Informatics, 2011).

Objective 5 of the National Eel Management Plan (Chapter 7.2.3) is to compare current and historic yellow eel stocks and the FRC datasets will be used in this comparison.

The Fisheries Research Centre used Dutch fyke nets which were generally set in chains of 10 nets. The same nets were used under the Eel Monitoring Programme; however chains of 5 fyke nets were set rather than 10. In one instance, in a repeat survey carried out in Meelick Bay, Lough Derg in 2011, chains of 10 fyke nets were set to compare with the extensive survey carried out by the FRC from 1981 – 1994, also using 10 nets. A variation in CPUE over time could be a factor of the use of different crews to set and haul the nets.

Summary data for the current surveys are presented in Table 4.2.

5.2 Moy Catchment

5.2.1 Lough Conn

Lough Conn in the Moy catchment was surveyed under the eel monitoring programme in 2009. This lake had previously been surveyed in 1972 and again in 1988 (Moriarty 1973; Fig. 5.1). Historical and current length (cm) and weight (g) were available. Due to the non normal distribution of biological data a non-parametric test was used to examine the length and weight between the 3 years of data.

5.2.1.1 CPUE

The historical CPUE data is not broken down into effort per net, therefore a worked up average is used for each night. As we have nightly catch data, but not net data, preliminary statistics were performed on this data set. There was no significant difference in CPUE between 1972, 1988 and 2009 (p=0.098, Table 5.1) although the 1988 figure was substantially higher and the 2009 figure was lower than the previous two surveys. The previous surveys had a relatively low effort and the catch on one night in 1988 was remarkable.=

5.2.1.2 Length & weight

A Kruskal Wallis test showed that there was a significant difference in length between the years 1972, 1988 and 2009. A post hoc Mann Whitney test showed a significant difference for 2 analyses, between 1972 and 2009 and between 1988 and 2009 (bonferroni correction, p<0.0017; Table 5.2). The median and mean length of eels caught in 2009 was greater than those in 1972 or 1988. The weight analysis was only carried out on the 1972 and 2009 data with the 2009 eels being significantly heavier (Fig. 5.3).

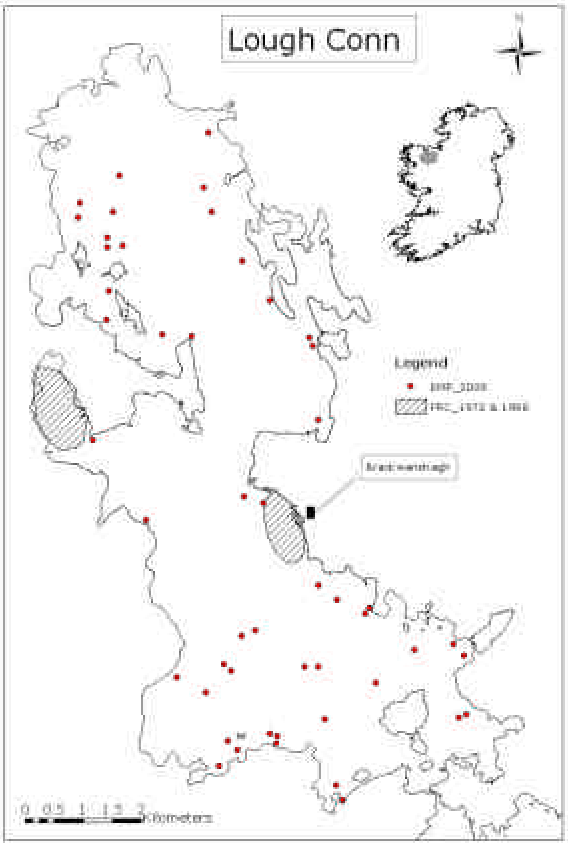


Figure 5-1: Location of FRC survey sites in 1972, 1988 and IFI sites in 2009 in L. Conn.

Table 5-1: Surveys of Lough Conn in 1972 and 1988 and in 2009.

Group	Date	Year	No. Eels	Net*Nights	CPUE
FRC	Aug/1972	1972	46	13	3.54
	Aug/1972	1972	38	13	2.92
		1972	**Average**		**3.23**
	Aug/1988	1988	124	12	10.33
	Aug/1988	1988	71	12	5.92
	Aug/1988	1988	41	12	3.42
		1988	**Average**		**6.56**
EMP	Jun/2009	2009	66	50	1.32
	Aug/2009	2009	152	50	3.04
	Aug/2009	2009	103	50	2.06
	Aug/2009	2009	175	50	3.50
	Aug/2009	2009	104	50	2.08
		2009	**Average**		**2.40**

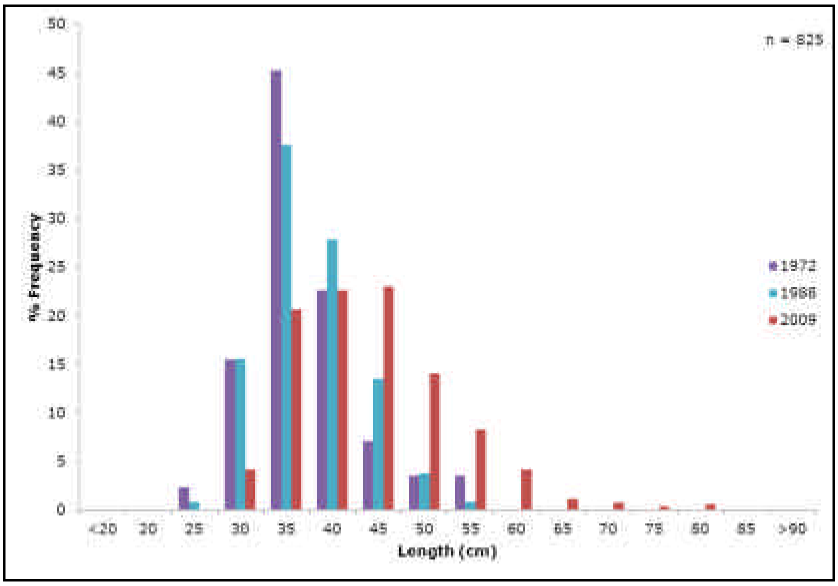


Figure 5-2: Length frequency of yellow eels from 1972, 1988 and 2009 in Lough Conn.

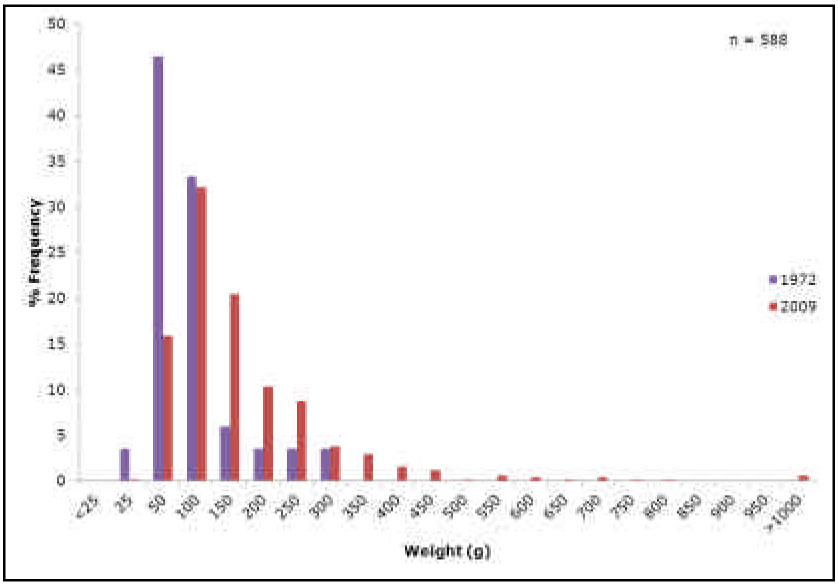


Figure 5-3: Weight frequency of yellow eels caught in Lough Conn (FRC_1972 and EMP_2009).

5.3 Corrib catchment

5.3.1 Lower Lough Corrib

Lower Lough Corrib was surveyed in 1969, 1985, 1989, 1990 and 2009 (Moriarty, 1972, 1992; Fig. 5.4). Length and weight data were only available for 1969 and 2009. Due to the non normal distribution of biological data non parametric statistics were used.

5.3.1.1 CPUE

For the historical data, only worked up CPUE's are available, these values are from netting surveys spread out over the season. There can be a lot of variation in the catch of eels per chain and per night, as this variation is not available, no statistics was performed on this data set. The summary CPUE data are presented in Table 5.2, the value found for 2009 is lower than previous surveys.

5.3.1.2 Length & Weight

Length data was the only parameter available for the four time periods (Fig. 5.5). A significant difference in length was detected by the test (p<0.001; Table 5.2), with the eels caught in 2009 having a greater median length than the eels captured in 1969 (Fig. 5.6). The fyke net surveys carried out in 1969 captured more eels in the 30-40cm size class which were not present in the 2009 surveys. Moriarty's report in 2001 stated that 'medium sized and large eels were more plentiful in 1990 than in 1967 while small specimens were fewer'. The 2009 survey concurs with this statement. It must be taken into account that while the fyke nets target the larger eels generally missing the <30cm eels, these eels were caught in the fyke nets used in 1969 and in fykes set in transitional waters. This is probably indicative of the low recruitment in recent years. A significant difference in weight was found (p<0.001; Table 5.2). The median weight in 2009 was higher than the median weight in 1969 (Fig. 5.7).

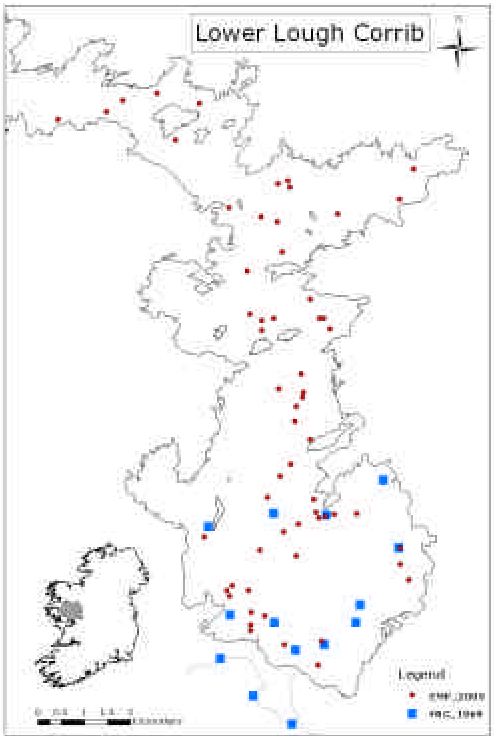


Figure 5-4: Net locations for surveys carried out in Lower L. Corrib 1969 and 2009.

Table 5-2: Surveys of Lower Lough Corrib in 1969 and 1990 and in 2009.

Group	Year	No eels	No nets	CPUE	Av. Lt	Av. Wt
FRC	1969	458	288	1.59	44.0	183
	1985	93	58	1.60		
	1989	152	82	1.85		
	1990	1,172	615	1.90		
EMP	2009	300	314	1.05	46.0	172

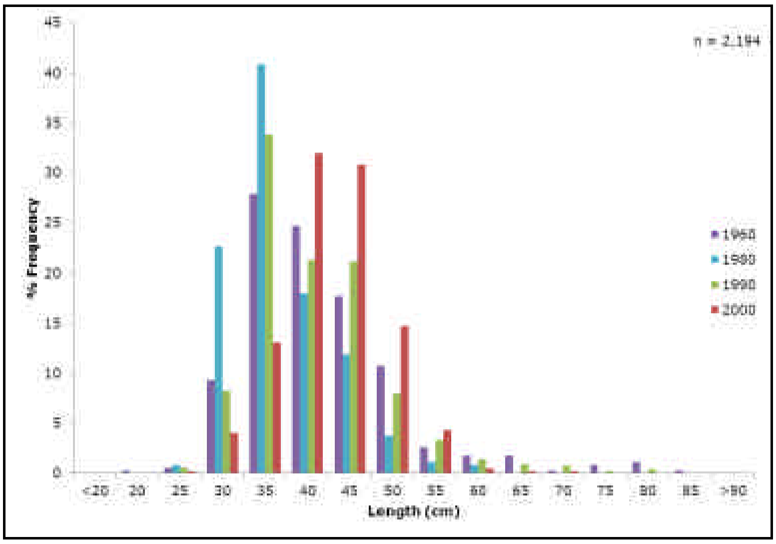


Figure 5-5: Length frequency for Lower Lough Corrib, grouped by decade.

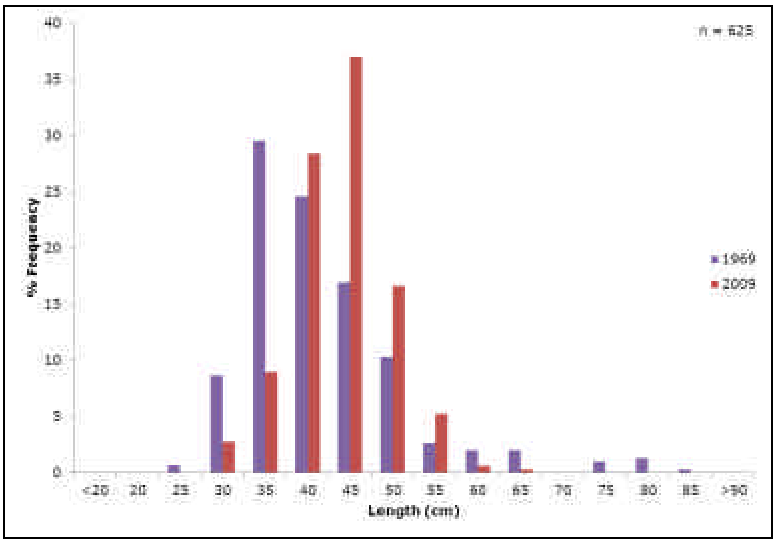


Figure 5-6: Length frequency for Lower Lough Corrib, 1969 and 2009.

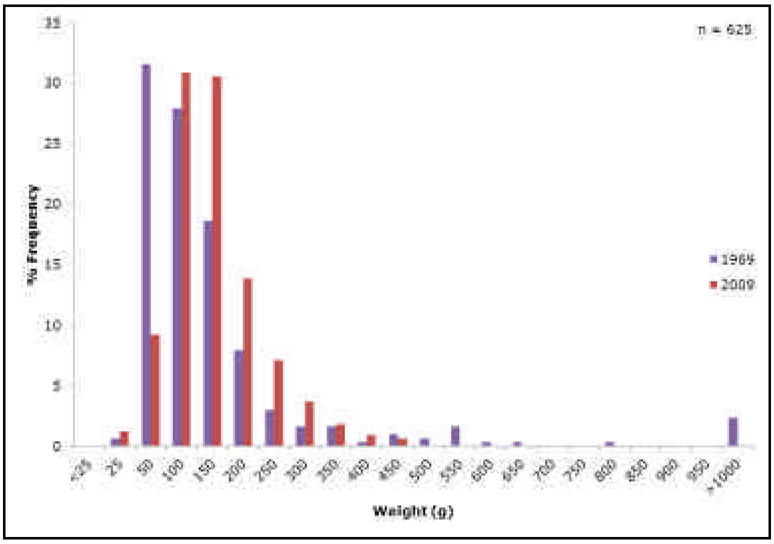


Figure 5-7: Weight frequency for Lower Lough Corrib, 1969 and 2009.

5.3.2 Upper Lough Corrib

Upper Lough Corrib was surveyed by the Fisheries Research Centre in 1967, 1968, 1990 and by the Eel Monitoring Programme in 2010 (Fig. 5.8). CPUE, length and weight is available for 1967, 68 and 2010; only length data is available for the 1990 surveys (Table 5.3).

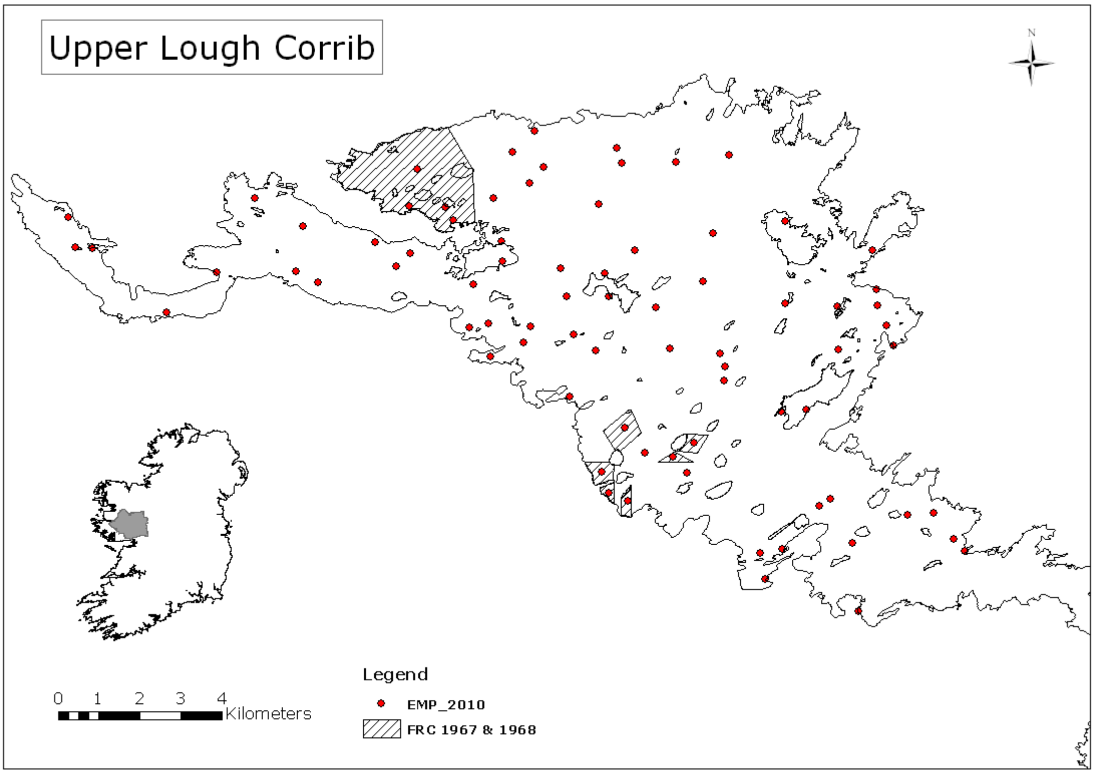


Figure 5-8: Locations of fyke nets in Upper Lough Corrib.

Table 5-3: Catch per unit of effort for the Fisheries Research Centre and Eel Monitoring Programme Surveys.

Group	Year	Av. CPUE	Mdn CPUE	Min CPUE	Max CPUE	Av. Lt	Av. Wt
FRC	1967	1.447	1.00	0	8.33		
	1968	1.077	0.667	0.20	5.50		
	1960's	1.373	0.833	0	8.33	43.2	180
EMP	2010	1.570	1.40	0	6.0	50.1	223

5.3.2.1 CPUE

There was a significant difference in CPUE between the two surveys in the late sixties and the 2010 survey (p<0.05). The average CPUE for Upper Lough Corrib was greater in 2010 than in the 1967 and 1968 surveys.

5.3.2.2 Length & Weight

There was a significant difference in length between the 1960s and 2010 (p<0.001, Table 5.3, Fig. 5.9). The 2010 surveys had a higher average length to the eels captured in the '60's.

The 2010 surveys also had a significantly higher average weight to the eels captured in the '60's (p<0.001, Table 5.3, Fig. 5.10).

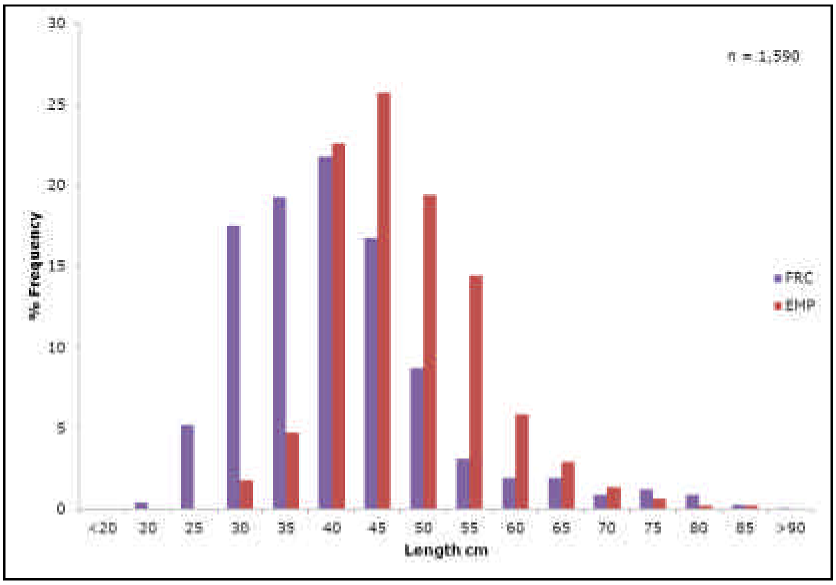


Figure 5-9: Length frequency of eels from the 1960's and 2010 surveys for Upper Lough Corrib.

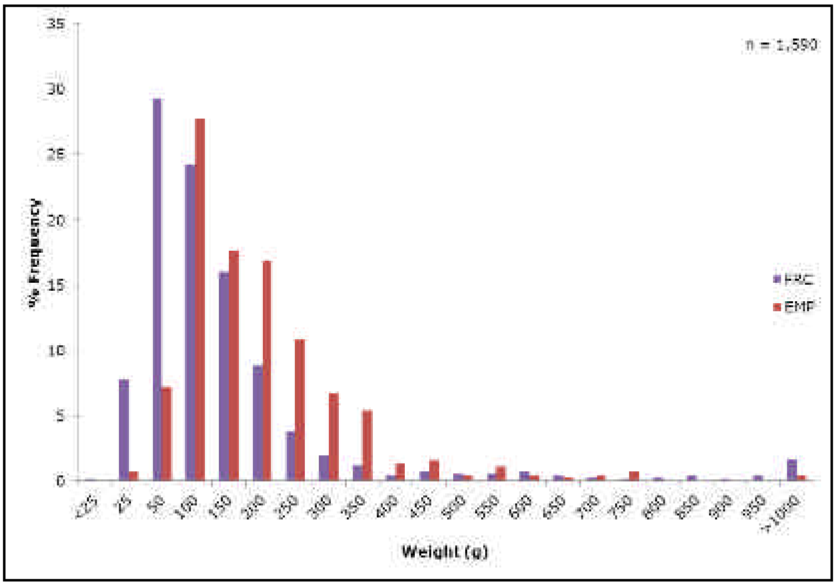


Figure 5-10: Weight frequency for eels from the 1960's and 2010 survey for Upper Lough Corrib.

5.4 Fergus Catchment

5.4.1 Lough Inchiquin

Lough Inchiquin in Co. Clare was surveyed between July 11th and August 9th 1968 and in June and August 2011.

5.4.1.1 CPUE

A similar catch per unit of effort was found for the worked up values for the lakes in the two time periods (Table 5.4). Detailed nightly catch records were not available for the 1968 data; therefore no statistics was carried out on the CPUE.

5.4.1.2 Length

Length data was available for 1968 and 2011. A mann whitney test showed a significant difference in length between the two time periods with a higher average length of eels caught in 2011 compared with 1968 (Table 5.4).

Table 5-4: Catch per unit of effort and average length for Lough Inchiquin.

Group	Year	No. Net*Nights	No. Eels	CPUE	Av. Lt
FRC	1968	72	164	2.28	43.3
EMP	2011	250	548	2.19	52.5

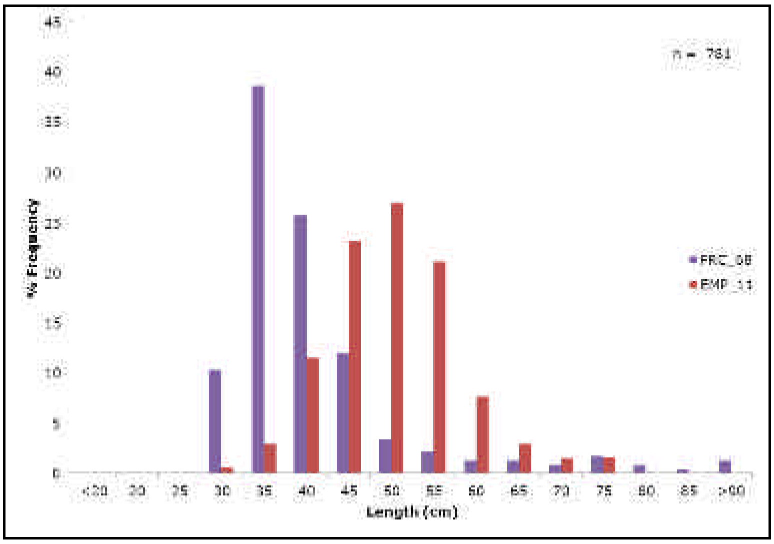


Figure 5-11: Length frequency of eels from the 1980's and 2010 surveys for Lough Inchiquin.

5.5 Shannon Catchment

5.5.1 Lough Ree

Lough Ree was surveyed in 1969, 1982, 1983, 1986 and in 2010 (Fig. 5.12).

5.5.1.1 CPUE

Raw CPUE data were available for 1986 and 2010 surveys (Table 5.5). No statistics were carried out on the data as only 1 night was fished in 1969 and 2 nights were fished in 1986. Moriarty (1987) reports the highest catch recorded for fyke nets in Lough Ree at Lanesborough where 466 eels were caught in one chain of nets. This is represented by the high CPUE for Lough Ree for 1986. Similar large catches were recorded in a survey by NUIG in the 1990's (McCarthy per comm). It is possible that this clustering of eels could be due to local enrichment or a behavioural response to migration or presence of a food source.

5.5.1.2 Length

Length data were available for 1982, 1983 and 2010. A non parametric Mann whitney test was carried out. There was no significant difference in the length of eels from the 1980's and in 2010 (Table 5.5, Fig. 5.13). The sample size for the 1980's was smaller than in 2010.

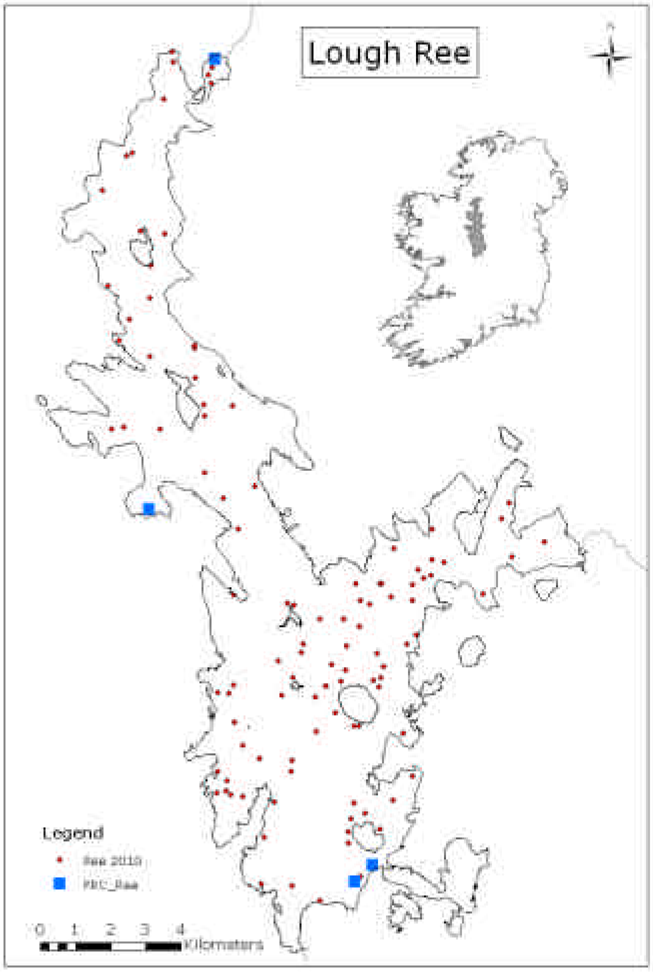


Figure 5-12: Locations of surveys on Lough Ree.

Table 5-5: Catch per unit of effort and average length for Lough Ree.

Group	Year	No. Net*Nights	No. Eels	CPUE	Av. Lt
FRC	1969	24	16	1.5	
FRC	1986	20	475	23.75	48.9
EMP	2010	570	850	1.49	46.9
WFD	2010	36	114	3.17	

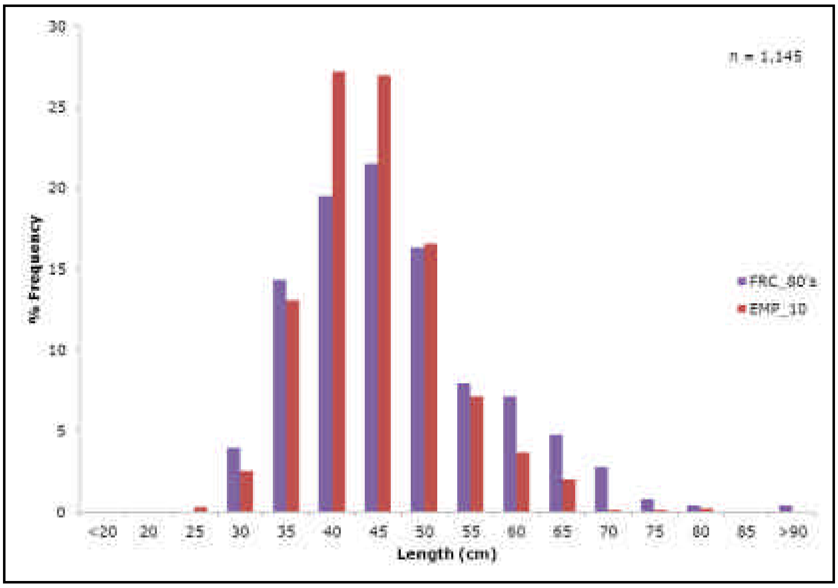


Figure 5-13: Length frequency of eels from the 1980's and 2010 surveys for Lough Ree.

5.5.2 Lough Derg

Meelick Bay in Lough Derg was intensively surveyed from 1981 – 1992 using chains of 10 fyke nets (Fig. 5.14; Moriarty 1996). Lough Derg was surveyed in 2009 and 2010 using chains of 5 fyke nets and Meelick Bay was surveyed in 2011 using chains of 10 fyke nets. Catch per unit of effort is available for these years 1981-1988, 2009 – 2011 (Table 5.6). Only FRC surveys carried out between June and September were used in the analysis to compare with the survey period of EMP.

5.5.2.1 CPUE

There was no significant difference in CPUE between the years (Kruskal Wallis, p=0.440). It should be noted that the two years of the EMP surveys used chains of 5 instead of chains of 10. When the individual net CPUEs are analysed between the two groups (FRC and EMP) there was no significant difference (Mann Whitney p= 1.00, Table 5.6).

5.5.2.2 Length & Weight

To analyse length data, the data was pooled into 2 groups, the historic data and the current data. There was a significant difference in length of eels from 1980's and 2000's with the 2000's eel having a higher average length than the eels from 1980's, however the effect size is low (p< 0.001, r = 0.1; Table 5.6 and Fig. 5.15).

There was also a significant difference in weight between the decades with larger average eels in 2000s compared with 1980's (Table 5.6, Fig. 5.16).

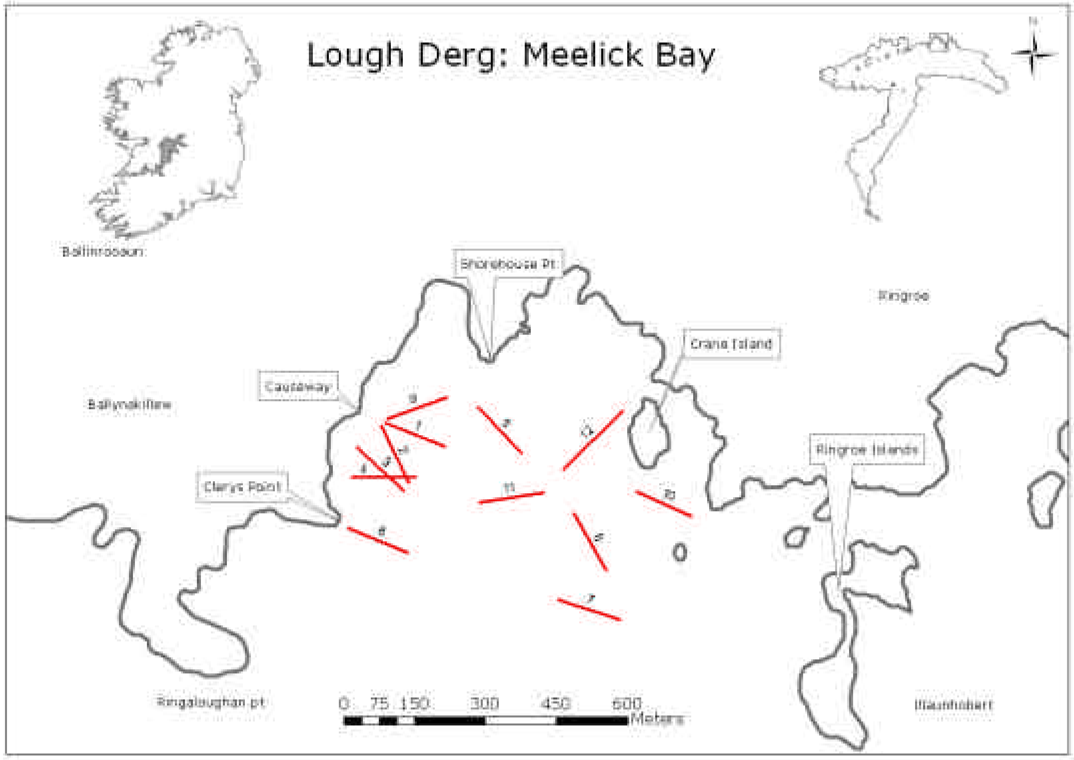


Figure 5-14: Locations of surveys sites for Meelick Bay, Lough Derg.

Table 5-6: Catch per unit of effort and average length and weight for Lough Derg.

Group	Year	Eels	net*nights	CPUE	Av. Lt	Av. Wt
FRC	1981	478	210	2.276	42.8	158
	1982	1039	300	3.463		
	1983	830	320	2.594		
	1984	1159	450	2.576		
	1985	1255	520	2.413		
	1986	927	380	2.439		
	1987	941	340	2.768		
	1988	744	280	2.657		
EMP	2009	669	290	2.307	44.2	167
	2010	771	255	3.024		
	2011	856	220	3.891		

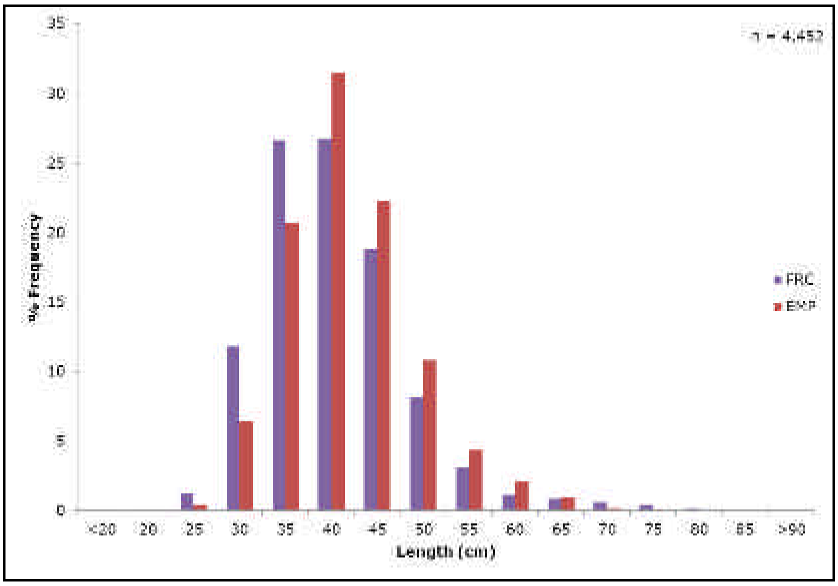


Figure 5-15: Length frequency of eels from Lough Derg.

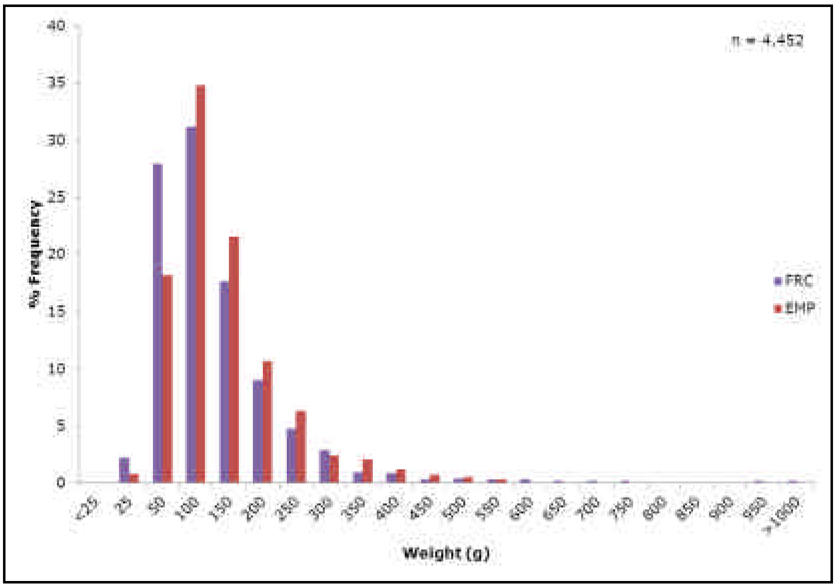


Figure 5-16: Frequency of weight from Lough Derg.

5.6 Wexford

5.6.1 South Sloblands

The South Sloblands in Wexford harbour were intensively surveyed in the 70's and high catches were recorded for this productive coastal lagoon habitat. The lake was surveyed in 1970, 1971, 1973, 1974 and 1975 collecting data on length, weight, sex and CPUE (Moriarty, various reports).

Chains of 10 fyke nets were set in the early surveys, whereas the current survey used chains of 5 fyke nets. In 2010 the South Sloblands was fished for one night using two chain lengths. Two chains were set with 10 nets and 2 chains were set with 5 nets. The location of nets was randomly assigned using the trap builder tool in Density 4.4 (Efford 2009), the number of nets per chain for the net location was assigned using a random number tables.

5.6.1.1 CPUE

In total 24 eels were caught in 30 net nights in 2010 giving a catch per unit of effort of 0.8 (Table 5.7). The CPUE from 2010 is low compared with the historical values recorded for the area. The South Sloblands were intensively commercially fished in 1971. In the following years a recovery of the stock was observed with the increase in CPUE from 1972 to 1975 (Table 5.7; Moriarty, 1976).

Due to the availability of historical data it is proposed to repeat this survey over the next 3 year monitoring programme.

Table 5-7: Catch details of the South Sloblands surveys

Year	Net Number	No. Eels	Net* Nights	CPUE
1970	Total	752	48	15.7
1972	Total	15	54	0.3
1973	Total	457	96	4.8
1974	Total	157	24	6.5
1975	Total	234	16	14.6
2010	1	9	10	0.9
2010	2	1	5	0.2
2010	4	1	5	0.2
2010	5	13	10	1.3
2010	**Total**	**24**	**30**	**0.8**

5.7 Transboundary Catchments

The Erne Eel Enhancement Programme was carried out from 1998 – 2000 covering the entire Erne catchment (Matthews *et al*., 2001). The aim of the programme was to maximise recruitment of glass eel and elver to the Erne; determine the current status of eel stocks and ascertain the potential for increased exploitation and to develop a cross-border management plan for the Erne eel fishery. Under this programme detailed records of the catches of yellow and silver eels were kept. An intensive stock assessment using fyke nets was carried out throughout the catchment.

Lower Lough Erne, Upper Lough Erne and Lough Oughter were surveyed under the Eel Monitoring Programme 2009-2011. The aim was to compare the current stock status with that reported in the Eel Enhancement Programme a decade earlier. Historical data is also available for Upper Lough Erne in 1972 and for L. Oughter in 1968. Of additional interest was the fact that during the mid to late 1990's recruitment to the Erne system was considerably higher than that observed in much of the rest of Europe, and based on ageing estimates carried out during the EEEP that recruitment should now be apparent in the yellow eel catches within the catchment.

5.7.1 Lower Lough Erne

In conjunction with the IFI surveys of other areas of the Erne system between 2009 and 2011, Lower Lough Erne was surveyed by AFBI in July 2011, with the same aims of comparing current stock status with that recorded in the Erne Eel Enhancement Programme (EEEP) of the late 1990's.

The survey was carried out using fyke nets and involved the employment of three ex-commercial eel fishermen who had fished the lough in the past. Each fisherman was provided with 20 fyke nets and asked to fish a specific region of the lough, the Western, Central/Broad lough & the Narrows to the east. The crews fished for five consecutive nights covering the areas marked in Figure 5.17 with the main aim to try and cover as many sampling points as those undertaken during the three years of the EEEP.

During the survey all captured eels were brought to three separate measuring stations each at least 15kms from where the eels had been caught. At each of the stations all eels were counted, weighed to the nearest 10g, measured to the nearest millimetre and released back to the lake from that point in an attempt to minimise the chance of repeat captures. In addition a random sample of 200 eels covering the breadth of size ranges captured were removed for further laboratory analysis to examine age, sex, *A. crassus* infection parameters, stomach content and fat analysis

5.7.1.1 CPUE

A total of 2803 yellow eels were caught over the five nights (300 net nights), the majority of which were captured in the Narrows zone, whilst the largest in terms of both mean and maximum length were caught in the western zone (Table 5.8).

The CPUE values in terms of weight (kg) of yellow eel caught per net per night are presented in Figure 5.18. The same metric from the three years of the EEEP is also given and in comparison with current findings CPUE on Lower Lough Erne has increased; doubling on both the western and broad lough zones, whilst being six times higher in the Narrows. Similar doubling of CPUE was also recorded in other parts of the Erne system (Upper Lough Erne) in 2011 (O'Leary *et al*., 2011).

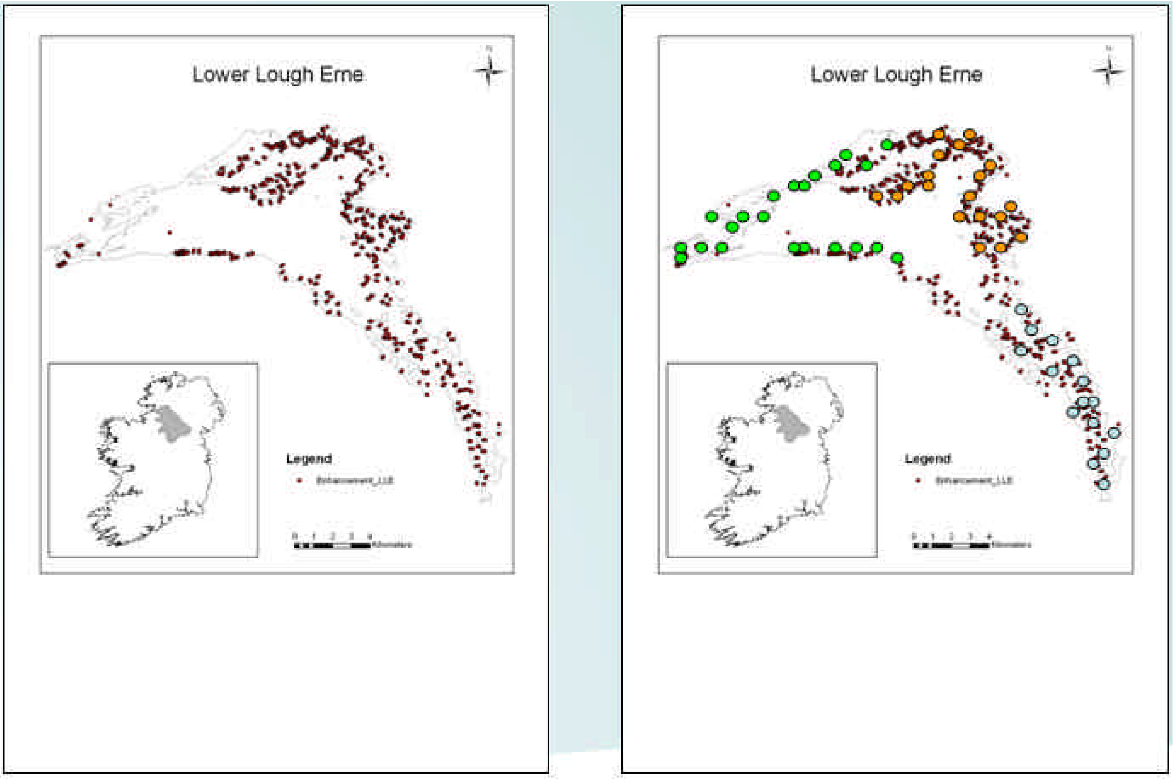


Figure 5-17: Lower Lough Erne fyke net sampling sites during the Erne Eel Enhancement Programme 1998-2000, and those undertaken in July 2011.

Table 5-8: Catch per unit of effort and average length and weight for Lower Lough Erne

Lower L. Erne	year	no. eels	net nights	CPUE no.	CPUE wt.	mean Lt cms	mean Wt g
zone 1 (west)	1998	7723	3074	2.66	0.37	42.8	149.9
	1999	3192	1420	2.24	0.61	43.1	129.4
	2000	9634	3320	2.9	0.53	42.4	104.7
	2011	577	100	5.77	1.1	44.7	190
zone 2 (Central/Broad)	1998	7723	3074	2.66	0.37	42.8	149.9
	1999	3429	1100	3.11	0.61	43.1	129.4
	2000	9634	3320	2.9	0.53	42.4	164.7
	2011	528	100	5.28	1.01	42.5	160
zone 3 (narrows)	1998	11032	3657	3.53	0.49	44.3	171.6
	1999	7425	2300	3.37	0.44	42.6	197.2
	2000	3110	1350	2.3	0.24	42.4	159
	2011	1587	100	15.87	3.03	42.2	160

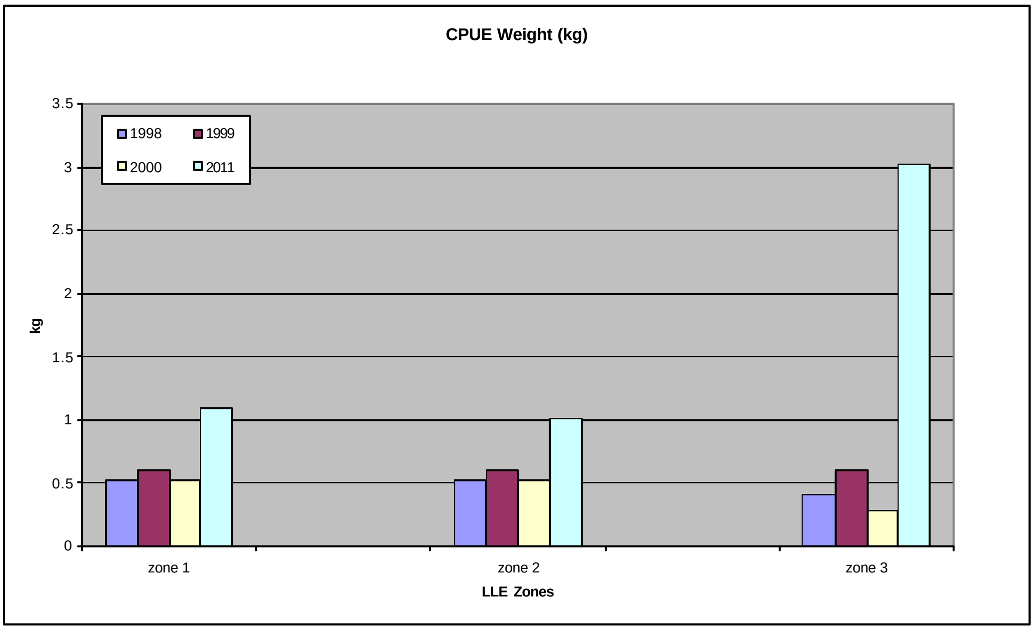


Figure 5-18: CPUE values (Weight kg) of yellow eels caught per net per night in LLE from 1998-2000 and 2011.

5.7.1.2 Length & Weight

The largest eels in terms of both mean and maximum length were caught in the western zone (Table 5.9). These data compare favourably with fyke net survey data produced during the EEEP (1999) in terms of mean length which recorded a mean length of 42.2cms (ranging from 38.5-42.6cm).

At that time it was considered that the absence of larger eels, and the maximum length of eel caught being 62.1cms was indicative of the presence and pressure of the commercial eel fishery on the Erne (Matthews *et al.* 2001).

The capture of larger yellow eels in the 2011 survey, combined with the length frequency distribution shown in Figure 5.19, would suggest that the closure of the commercial fishery in 2009/2010 has now led to an increased and more normally distributed eel population within Lower Lough Erne. There are clearly strong year classes to follow throughout Lower Lough Erne but in particular the Narrows, which has always been well known as an ideal habitat for eel.

Table 5-9: Catch composition of yellow eel captured over 5 nights fyke netting in the 3 zones of Lower Lough Erne using 20 nets per crew per night (300 net nights).

Area (zone)	number caught	mean length (SD)	min. length	max. length
West LLE (1)	616	44.7 (7.37)	26.3	81.3
Broad LLE (2)	528	42.5 (6.04)	27.2	70.2
Narrows (3)	1659	42.2 (5.71)	26.4	77.4
EEEP	597	42.6 (5.8)	27.1	62.1

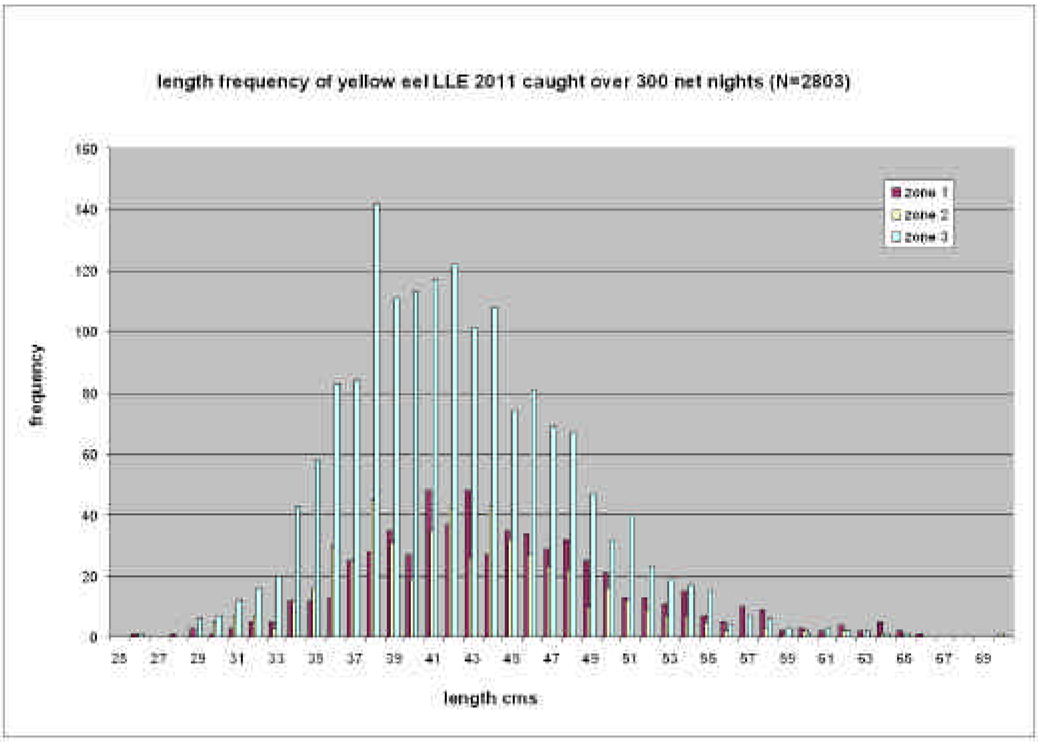


Figure 5-19: Length frequency histogram of yellow eels captured at the 3 zones of Lower Lough Erne.

5.7.1.3 Yellow Eel Age

Eels sampled from Lower Lough Erne ranged in age from 8-21 years old (Fig. 5.20). The mean age of the yellow eels was 13.3 years (mean length 46.9 cms), the same as that found from the ageing of 351 yellow eels during the EEEP (mean length 46.6cms). This age structure would suggest that eels of this age were recruited to the system during the late 1990's at a time of high recruitment to the Erne. From the graph the impact of the recent commercial yellow eel fishery can be seen in those eels aged 15-16 and upwards, whilst the effect of its closure can be seen in the strong year classes to come in eels aged 9-13.

5.7.1.4 Silver Eel Age

For comparative purposes, a small sample of 30 female silver eels were collected in 2011 and aged, ranging from 10-23 years, with a mean age 18.1 years (Fig. 5.21). Whilst a small sample, the mean age is comparable with that of the 38 female silvers aged in 1999, with a mean age of 18.3 years (ranging from 5-38 years, though inclusive of the wider Erne catchment such as Dromore and Annalee Rivers). Silver eels of this age would have entered the Erne in the mid 1990's during the period of high recruitment.

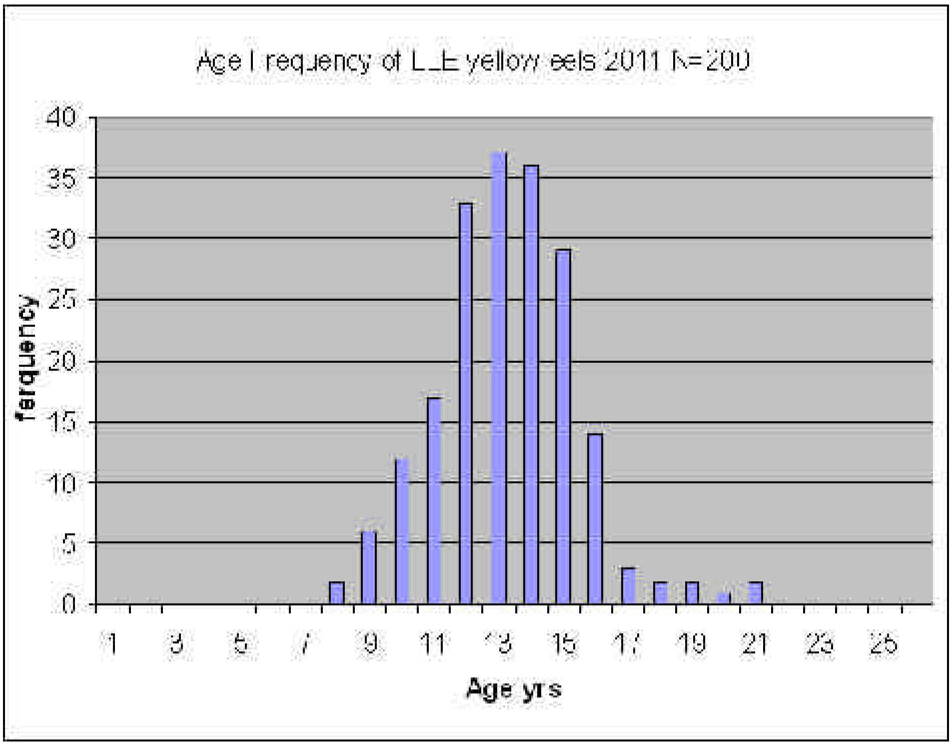


Figure 5-20: Age frequency histogram of Lower Lough Erne yellow eels 2011 (n= 200).

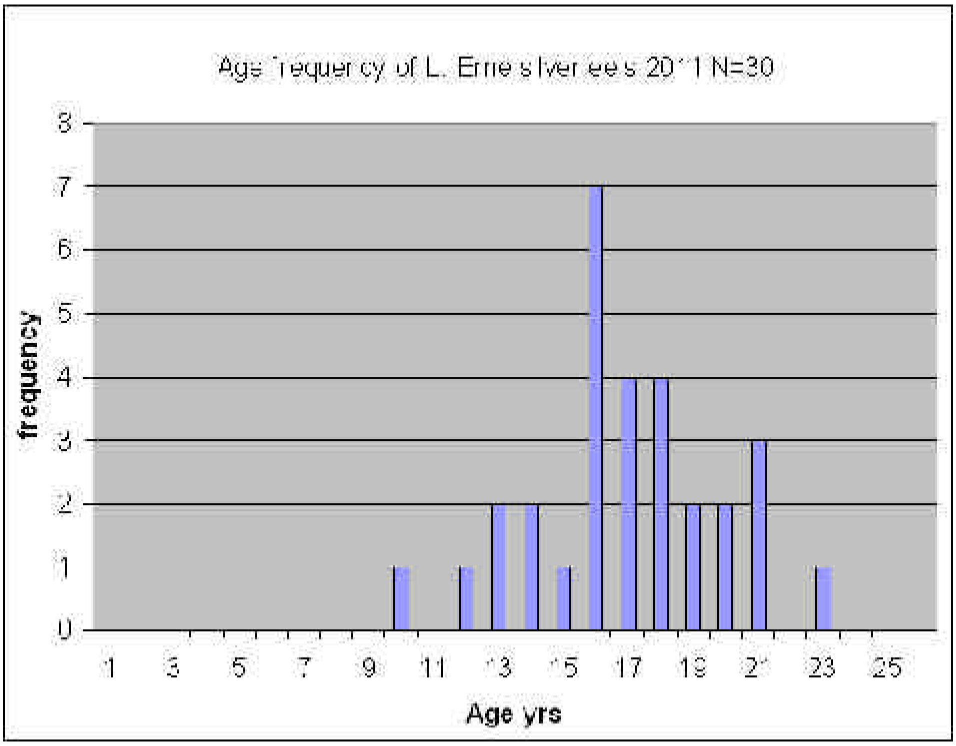


Figure 5-21: Age frequency histogram of Lough Erne silver eels 2011 (n = 30).

5.7.2 Upper Lough Erne

In June and August 2010, Upper Lough Erne was surveyed using fyke nets set with random net locations (Fig. 5.22). In July 2011, ex-commercial fishermen were also contracted to fish the Lough.

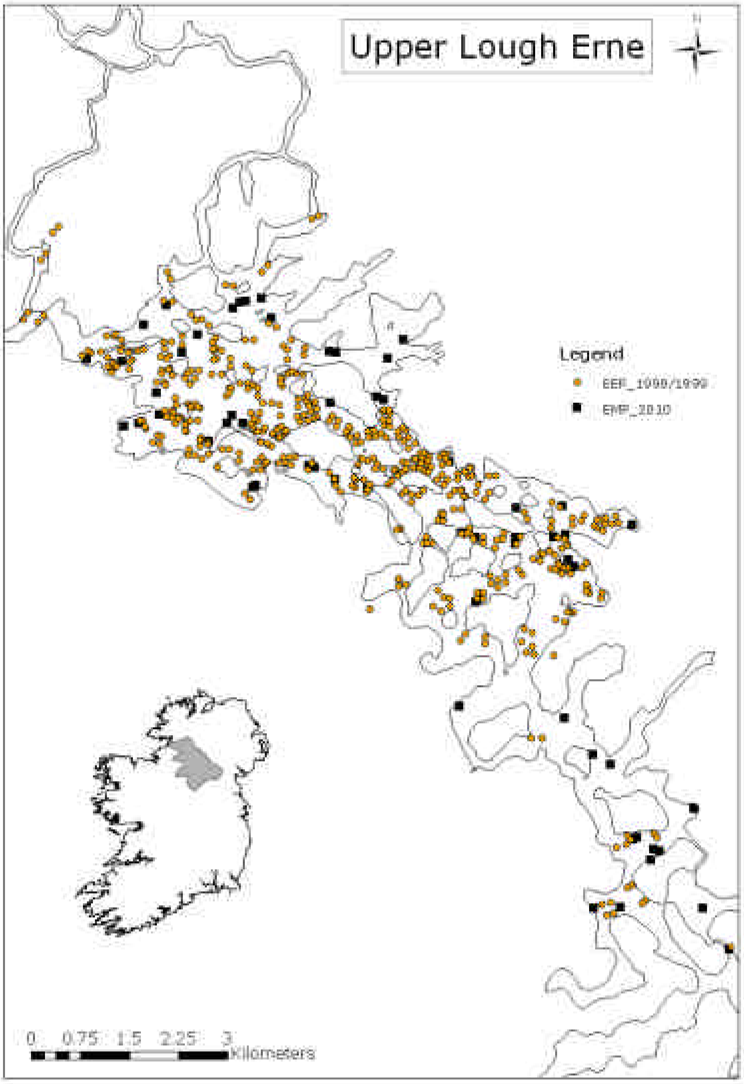


Figure 5-22: Locations of sampling for EEP and EMP programmes on Upper Lough Erne.

5.7.2.1 CPUE

Table 8-1 shows the summary CPUE values for the different surveys. There was significant difference in CPUE (Table 5.10, Kruskal –Wallis p <0.001). A post hoc Mann Whitney test showed a difference between the 2011 CPUE, which was higher than in 1998 – 2000 (U = 30, p <0.01225, Table 5.10). The 1998 – 2000 period had a higher CPUE than the 2010 survey (U = 499.5, p <0.01225). There was no significant difference in CPUE between 1972 and 2010 (U = 92, p = 0.436 ns). However it must be noted that during the summer 2010 the growth of the invasive weed Nuttall's Pond weed (*Elodiea nuttall*) caused some difficulty and could be responsible for the lower catch rates for this period.

5.7.2.2 Length & Weight

A non parametric Kruskal Wallis test showed a significant difference in length from the four time periods ($p<0.001$, Table 5.10; Fig. 5.23). A post hoc mann whitney test showed the median length of eels was greater for 2010 and 2011 compared with the 1998 – 2000 period ($p< 0.01225$). There was no difference between 2010 and 1972 and there was also no significant difference in length between 2010 and 2011.

A similar result was found for the weight of eels as for the lengths (Fig. 5.24) and weight.

Table 5-10: CPUE values, average length (cms) and average weight (g) for Upper Lough Erne

Group	No. Nights	No. Eels	Av CPUE	Mdn CPUE	Min CPUE	Max CPUE	Av. Lt cm	Av. Wt gm
FRC 1972	144	138	0.969	1.0	0.35	1.52	49.5	230
EEEP '98/99	3,745	14,527	4.065	3.68	0.40	10.10	44.2	204
EMP 2010	300	493	1.643	1.40	0	6.20	49.0	222
AFBI 2011	100	850	8.500	7.0	3.0	16.40	50.3	240

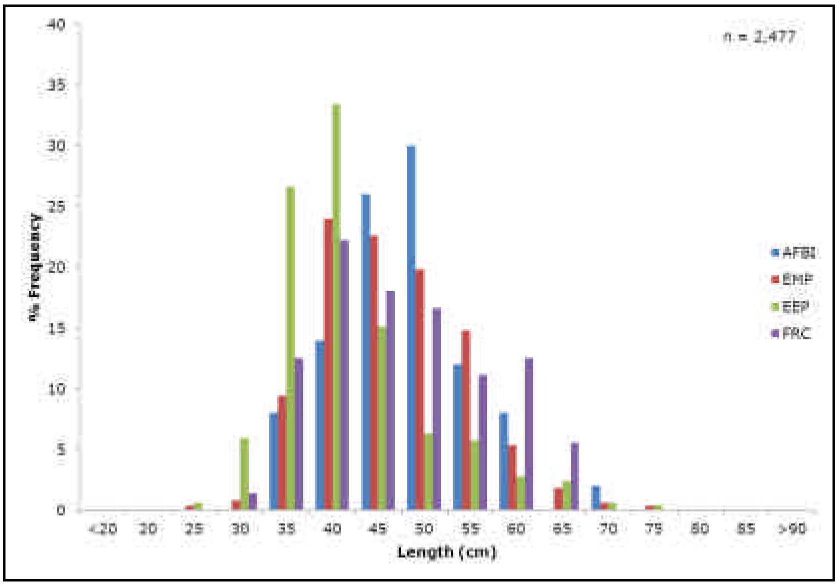


Figure 5-23: Length frequency for Upper Lough Erne.

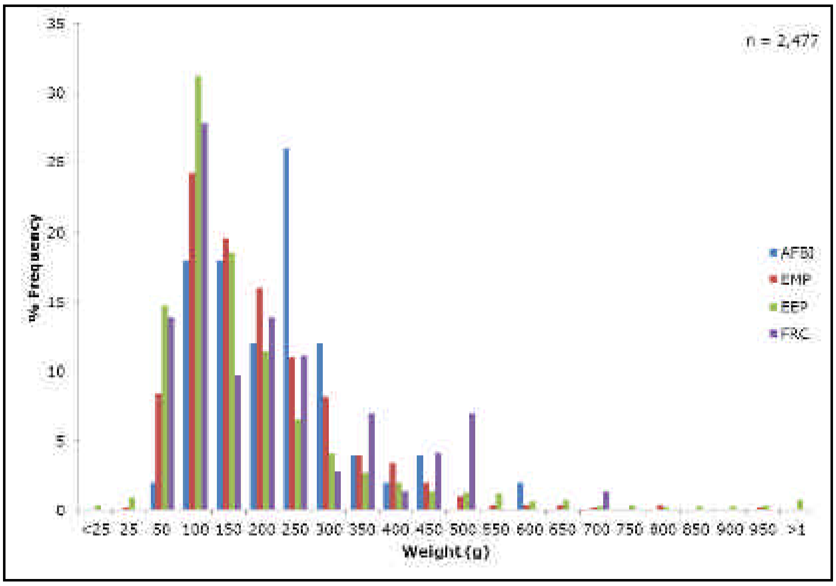


Figure 5-24: Weight frequency for Upper Lough Erne.

5.7.3 Lough Oughter

Lough Oughter was surveyed in 2011 (Fig. 5.25). This lake was also surveyed during the Eel Enhancement Programme 1998 – 2000 (Fig. 5.25) and in 1968. However only worked up data is available for 1968 and this was not included in the statistical analysis.

5.7.3.1 CPUE

There was a significant difference (Mann whitney, $p<0.05$) between CPUE values for 1998/99 and 2011, with the earlier survey having a larger CPUE than in 2011 (Table 5.11). The CPUE for 2011 was the lowest recorded for the 3 year programme. It is likely that the 2011 CPUE was affected by interference from dense weed growth in the lake.

5.7.3.2 Length & Weight

A Mann whitney test showed no significant difference between the two time periods (Table 5.11, Fig. 5.26). However the sample size for the 2011 is smaller than other analyses carried out (n = 282). The length distributions do, however, show evidence of over-fishing following the EEEP period with the loss of the larger size classes.

A significant difference in weight was detected for the 2 groups with the 1998/99 period having a greater median weight than the current study (Table 5.11, Fig. 5.27).

Table 5-11: CPUE values, average length (cms) and average weight (g) for L. Oughter.

Group	N	Av. CPUE	Mdn CPUE	Av. Lt	Av. Wt
1998/99	368	1.425	1.00	51.9	347
2011*	60	0.099	0.08	50.3	234

* Affected by dense weed growth interfering with the nets

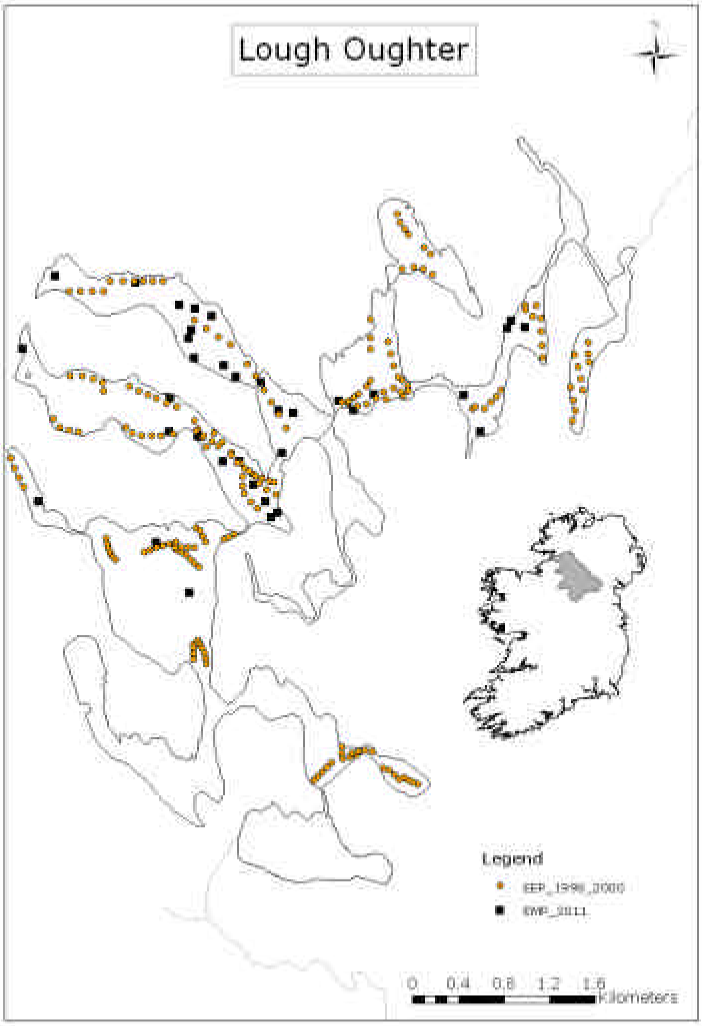


Figure 5-25: Location of surveys in 1998/99 and 2011 in Lough Oughter.

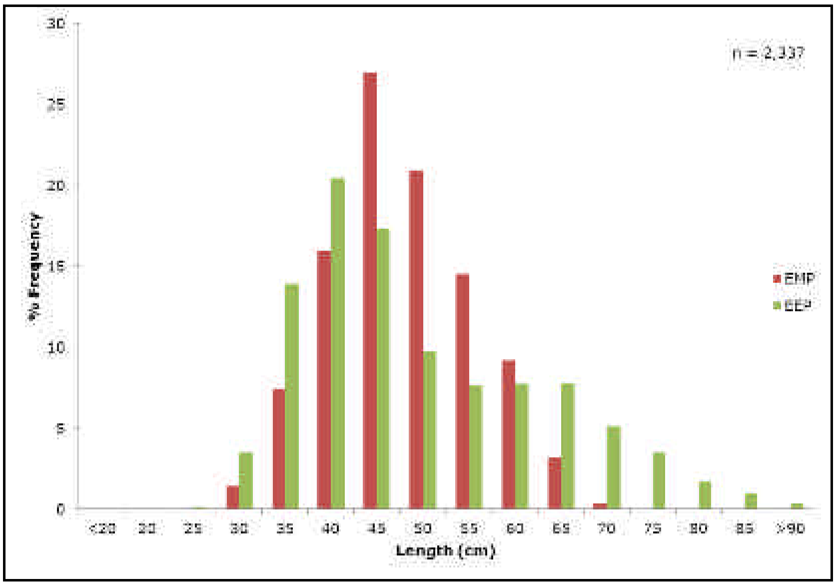


Figure 5-26: Length frequency for L. Oughter

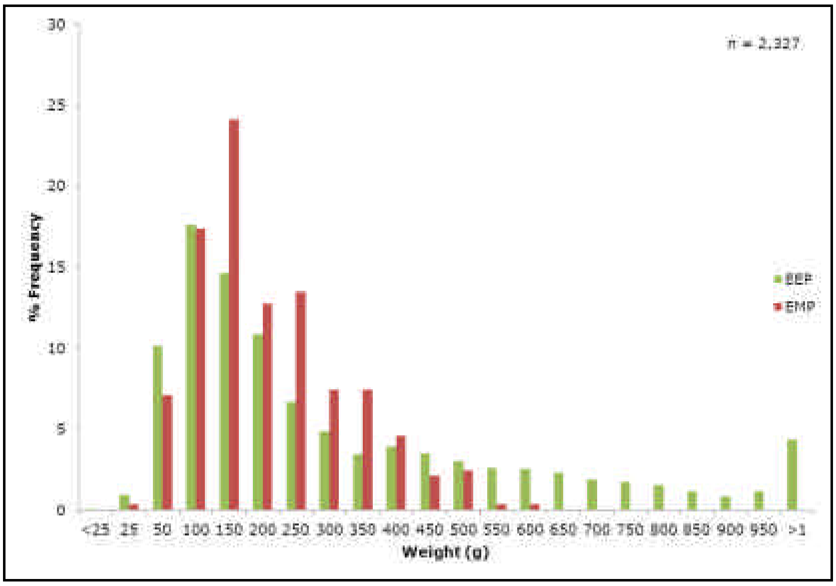


Figure 5-27: Weight frequency for L. Oughter

5.8 Historic and current length-weight condition of eel

The comparisons between the historical and current fyke net studies are showing a general increase in the length and weight of eels through time. To examine if there is a difference in the length-weight relationship (condition) between eels from the 1960's, 1980's and the current eels, regression analysis was carried out. An increase in condition is often observed when a population is in decline, the reduced numbers resulting in less competition for resources (De Lafontaine *et al.* 2009).

A least squares regression analysis was carried out on each time series in each lake (Table 5.12). To determine if there is a change in the relationship between lengths and weight over time a kruskal wallis test was carried out on the slope of the regressions lines. No significant difference was found between the gradient of the regression slope between the pre 1980's, post 1980's: pre 2000's and post 2000's data. Graphs highlighting the regression for each lake and group are presented (Fig. 5.28). It is clear from the regression plots that the general relationship between length and weight hasn't changed despite the appearance of *A. crassus* in Ireland in 1997 and the reduction in recruitment.

The parasite *A. crassus* was introduced to Ireland in 1997 and since then has been spreading around the country. Studies on the effects of the nematode on the growth and condition of eels has been a topic of discussion ever since. Kelly *et al.* 2000 reported that from the parameters examined in the laboratory, there is little evidence that chronic *A. crassus* infection adversely affects the physiological status of wild European eels at most times of the year and they assume that the eels can generally adapt to the chronic effects of parasitism. A number of other studies have found no effect of the parasite on body condition (Neto *et al.* 2010, Sjoberg *et al*. 2009). However the effect the parasite has on eels during their migration route to the Sargasso Sea and on their reproductive ability is still not known. The effect of infection on the annual growth of eels is being examined over the coming years within the eel monitoring programme.

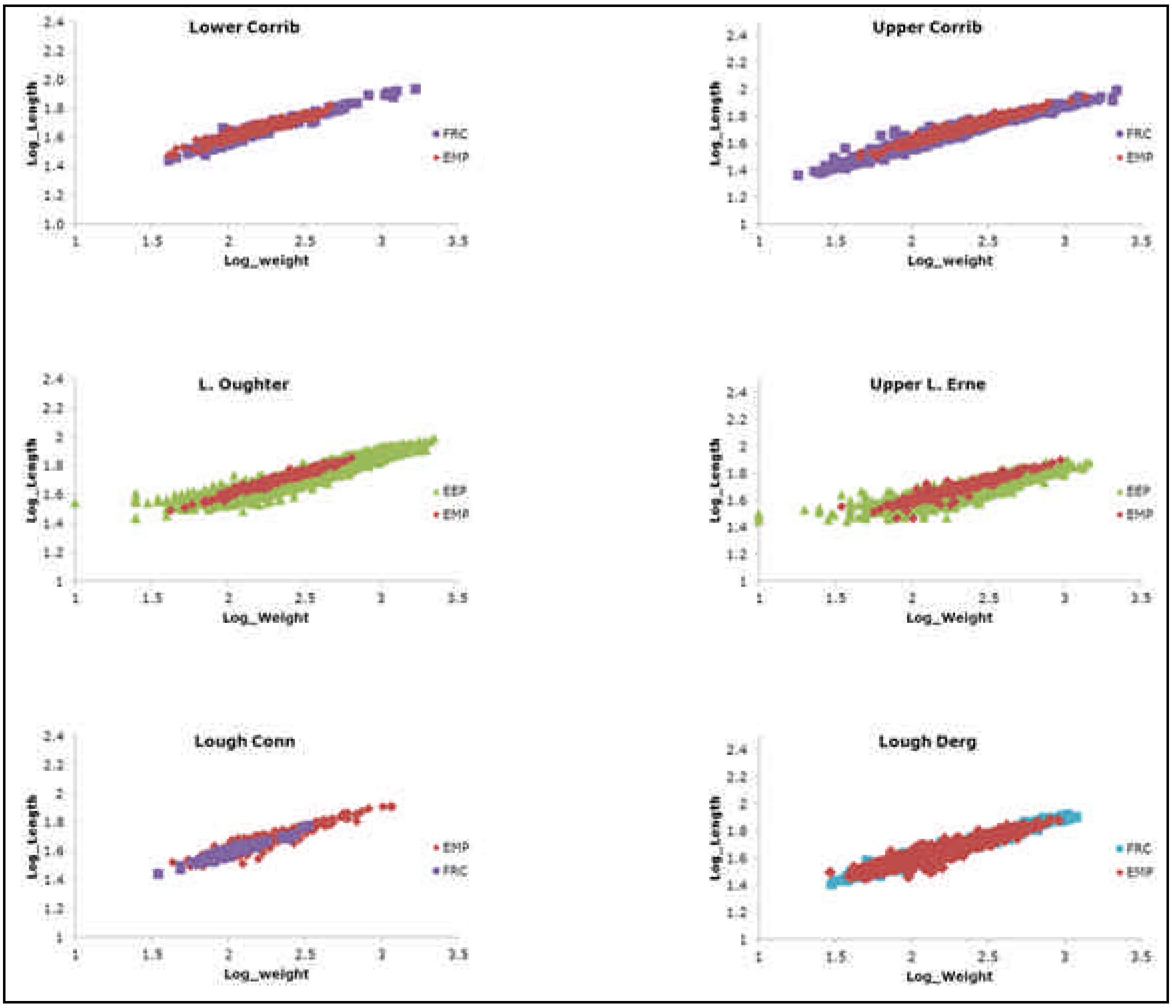


Figure 5-28: Length weight regressions plots for current and historical yellow eel data.

Table 5-12: Regression statistics for yellow eels.

Location	Group	r	r2	y intercept (bo), a	bo SE	gradient b1, b	b1 SE	Beta	p value (t)	n
Conn	FRC_77	0.971	0.943	1.907	0.009	0.321	0.009	0.971	0.001	84
Conn	EMP_09	0.955	0.912	1.909	0.004	0.315	0.004	0.955	0.001	504
Derg	FRC_1980's	0.98	0.961	0.959	0.003	0.313	0.001	0.98	0.001	2,327
Derg	EMP_00's	0.947	0.897	0.974	0.005	0.307	0.002	0.947	0.001	2,125
Lwr Corrib	FRC_69	0.974	0.949	1.897	0.004	0.309	0.004	0.974	0.001	301
Lwr Corrib	EMP_09	0.956	0.914	1.886	0.004	0.283	0.005	0.956	0.001	324
Oughter	EEP_98/99	0.979	0.959	1.905	0.003	0.305	0.004	0.979	0.001	282
Oughter	EMP_11	0.945	0.893	1.87	0.001	0.277	0.002	0.945	0.001	2,045
Upr Corrib	FRC_67/68	0.98	0.961	1.898	0.002	0.307	0.002	0.98	0.001	1,147
Upr Corrib	EMP_10	0.974	0.948	1.912	0.003	0.304	0.003	0.974	0.001	443
Upr L. Erne	FRC_72	0.972	0.946	1.9	0.006	0.297	0.009	0.972	0.001	72
Upr L. Erne	EEP_98/99	0.853	0.728	1.821	0.003	-	0.003	0.853	0.001	1,855
Upr L. Erne	EMP_10	0.957	0.917	1.898	0.003	0.3	0.004	0.957	0.001	500
Upr L. Erne	AFBI_11	0.961	0.924	1.889	0.008	0.29	0.012	0.961	0.001	50

5.9 Summary of Lake Surveys

L. Conn: The CPUEs were not significantly different, although the value in 2008 was double the other two surveys. There was an increase in the length and weight of eels over the 37 year period.

Corrib Catchment: CPUE was lower in 2009 in the lower Corrib, but higher in 2010 in the upper Corrib compared to the historical CPUEs. There was an increase in the length and weight of eels captured in the surveys of 2009 and 2010 when compared with the surveys from the 1960's. The absence of smaller eels in the fyke nets of 2009, also observed in 2001, is a concern. The absence of small eels in the catch could indicate the absence of this life stage within the water body due to low recruitment.

Inchiquin: The CPUE was similar between the two periods. The average size of eels was significantly larger in 2011.

Shannon Ree & Derg: There is a significant difference in length and weight of eels from the current surveys and from the surveys of the 1980's and 1960's; with an increase in the length of eels for Lough Derg but not in L. Ree. The current survey covered the whole of Lough Derg and Meelick Bay while the historic studies were concentrated in Meelick bay only. It is proposed to continue monitoring this bay over the coming years to allow a more accurate comparison with the historical Meelick Bay study. In 2001, commercial fishing in Lough Derg was restricted as a stock conservation measure with effort shifting to the upper catchment and therefore the eel population is Lough Derg has been protected for 8 years longer than the Lough Ree.

South Sloblands: The CPUE was lower in the 2010 survey than previously recorded, with exception of 1972 when the area had been intensively commercially fished.

Erne Catchment: Some of the highest CPUEs for lakes were found in the Erne catchment during the current surveys and in the 1998 /99 period for both Lough Oughter and Upper Lough Erne. There is evidence of a good stock of yellow eel in much of the Erne. The length for the 2000 data is higher than the 1998/99 for Upper Lough Erne. However for Lough Oughter the 1998/99 programme had the significantly higher weight but there was no significant difference between 1998/99 and 2010 for the length of eels. Both Upper Lough Erne and Lough Oughter were stocked with glass eel and elvers from 1993 to 2000 in order to develop the fishery in the Erne catchment. As a result of this stocking the low CPUE for the fyke nets in Lough Oughter was not expected. It is recommended to repeat these surveys over the coming years in order to carry out a more complete comparison with the 1998/99 period. It is possible that these lakes were intensively commercially fished which may have affected the stocks.

Length-weight Condition: There has been no apparent change in the length-weight condition of eels between the 1970s, 1980s and the current surveys.

5.9.1 Overall Summary

The historical data available for analysis spans a number of important time periods. The pre 1980's data is representative of the population of eels in Ireland before the recruitment collapsed after 1980. The data from the period 1980- present represents the period of change that is occurring as a result of this collapse. The average life span of male and female eels in Ireland is between 10 and 20+ years, or older, depending on the productivity of the catchment, and therefore the collapse in recruitment should be reflected in the data from the mid 1990's onwards. The eel population structure was also influenced by the effects of the commercial fishery (up to 2008).

The general picture from the comparisons made in this chapter is one of similar CPUE but an increasing size of eels in the later years (Fig. 5.29; Tables 5.13 & 5.14). The lack of small eels in the fyke net catches in the 2009-2011, with some exceptions (i.e. transitional waters), is an indication of poor recruitment. The increasing size is largely a function of low numbers of small eels, but may also be a reflection of reduced competition and improved growth as a result of the reduced population density. A short period of relatively good recruitment in many catchments in the mid-1990's to early '00's may have maintained the yellow eel stock giving to comparative CPUE's with previous studies, but the low recruitment in the last decade is now leading to lower densities of small yellow eel. From modelling exercises (Section 7.3.4) it seems likely that silver eel production will be at least maintained at least in some catchments, and may even increase for a short time, but this is anticipated to be short-lived and a serious decline in silver eel production is expected to follow.

For a more complete analysis, the catch and length frequency data should be coupled with growth analysis, age at length and age at weight analysis to give further information on the state of the eel stock. This information is being worked on at present and will be analysed and reported on at a later stage.

Table 5-13: Catch per unit of effort for historical and current surveys.

Location	Year	CPUE			
		Mean	Median	Min.	Max.
L. Conn	1972	3.23	3.23	2.92	3.54
	1988	6.56	5.92	3.42	10.33
	2009	2.4	2.08	1.32	3.5
Upper. L. Corrib	1960's	1.37	0.83	0	8.33
	2009	1.57	1.4	0	6
Lower. L. Corrib	1969	1.59	-	-	-
	1985	1.6	-	-	-
	1989	1.85	-	-	-
	1990	1.9	-	-	-
	2009	1.05	-	-	-
Lower L. Erne zone 1 (west)	1998	2.66	-	-	-
	1999	2.24	-	-	-
	2000	2.9	-	-	-
	2011	5.77	-	-	-
Lower L. Erne zone 2 (Central/Broad)	1998	2.66	-	-	-
	1999	3.11	-	-	-
	2000	2.9	-	-	-
	2011	5.28	-	-	-
Lower L. Erne zone 1 (narrows)	1998	3.53	-	-	-
	1999	3.37	-	-	-
	2000	2.3	-	-	-
	2011	15.87	-	-	-
Upper. L. Erne	1972	0.97	1	0.35	1.52
	1998/99	4.07	3.68	0.4	10.1
	2010	1.64	1.4	0	6.2
	2011	8.5	7	3	16.4
L. Oughter	1968	0.95	0.95	0.5	1.40
	1998/99	1.43	1	0	10
	2011	0.99	0.8	0	5.4
L. Derg	1980's	2.63	1.8	0	19.9
	2000's	2.85	2.2	0	13.1
L. Ree	1969	1.5	-	-	-
	1986	23.75	23.75	0.9	46.6
	2011	1.42	1	0	8.6
L. Inchiquin	1968	2.28	-	-	-
	2011	2.24	1.9	0	9.4

Table 5-14: Summary length and weight of yellow eels.

Location	Year	Count	Mean Length (cm)	Mdn Length (cm)	Min Length (cm)	Max Length (cm)	Mean Weight (kg)	Mdn Weight (kg)	Min Weight (kg)	Max Weight (Kg)
L. Conn	1972	84	39.6	38.2	27.5	59.5	117	100	35	334
	1988	237	39.6	39	29	56	-	-	-	-
	2009	504	46.5	45.2	31	81	191	153	44	1,200
Upr. L. Corrib	1960's	1,147	43.2	42	23	97.8	180	124	18	2,196
	1990's	1,390	49.9	48.7	19	85.6	-	-	-	-
	2009	443	50.1	48.9	31.5	87.5	223	190	46	1,372
Lwr. L. Corrib	1960's	344	43.88	42.4	22	86.5	180	130	40	1,680
	1980's	346	38.61	37	28	64	-	-	-	-
	1990's	909	43.1	41.5	29.2	83.5	-	-	-	-
	2000's	597	45.08	45	29	71	170	160	40	470
Lwr L. Erne west	1998	7723	42.8				150			
	1999	3192	43.1				129			
	2000	9634	42.4				105			
	2011	577	44.7				190			
Lwr L. Erne mid	1998	7723	42.8				150			
	1999	3429	43.1				129			
	2000	9634	42.4				165			
	2011	528	42.5				160			
Lwr L. Erne narrows	1998	11032	44.3				172			
	1999	7425	42.6				197			
	2000	3110	42.4				159			
	2011	1587	42.2				160			
Upr. L. Erne	1972	72	49.5	47.3	34.8	69.5	230	178	68	717
	1998/99	1,855	44.2	42.4	28.1	79.6	204	150	5	1,460
	2010	500	49	48.8	28.9	78.7	222	193	35	950
	2011	50	50.3	50.1	35.8	70.8	240	240	60	600
L. Oughter	1968	100	50.3	47.9	10.4	86.5	-	-	-	-
	1998/99	2,045	51.94	48.2	27.3	97.5	350	220	10	2240

Location	Year	Count	Mean Length (cm)	Mdn Length (cm)	Min Length (cm)	Max Length (cm)	Mean Weight (kg)	Mdn Weight (kg)	Min Weight (kg)	Max Weight (Kg)
	2011	282	50.3	49.6	30.7	70.9	230	200	40	640
L. Derg	1980's	2,327	42.8	41.8	25.6	83.5	158	128	30	1,200
	2000's	2125	44.2	43.5	28.1	76.1	167	144	30	915
L. Ree	1980's	251	49	47	31	94	-	-	-	-
	2010	894	46.9	46	28.2	84.5	191	158	28	1503
L. Inchiquin	1968	233	43.28	40.1	30.9	92.5				
	2011	548	52.51	52.5	31.7	77.8	277	253	45	1110

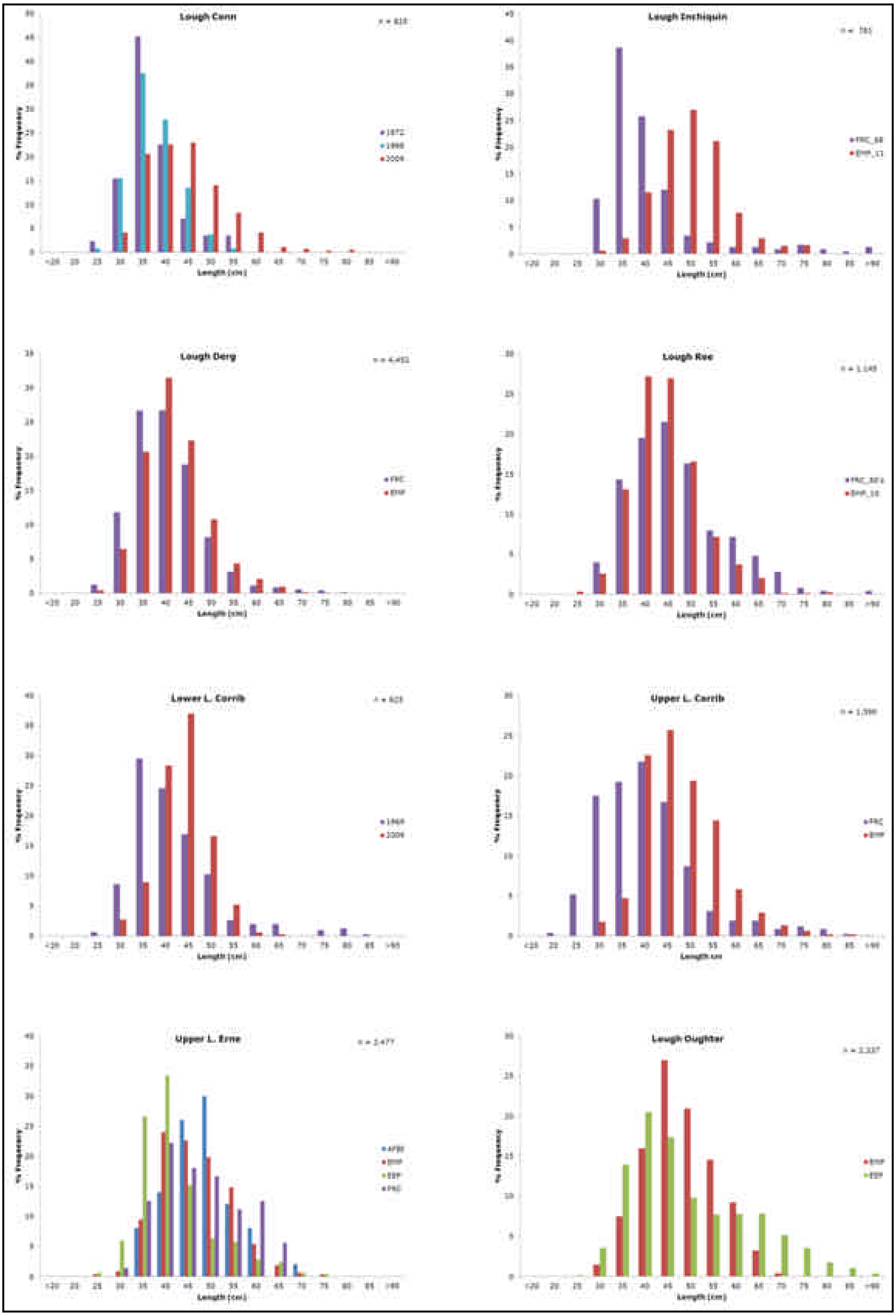


Figure 5-29: Length Frequencies for 8 lakes in the historical analysis.

6 Water Framework Directive sampling of yellow eel

(refers to Ch. 7.2.3 & 7.2.4 of the National EMP Report, 2008)

6.1 Introduction

In December 2000, the European Union introduced the Water Framework Directive (WFD) (2000/60/EC), as part of a standard approach for all countries to manage their water resources and to protect aquatic ecosystems. The fundamental objectives of the WFD are to protect and maintain the status of waters that are already of good or high quality, to prevent any further deterioration and to restore all waters that are impaired so that they achieve at least good status by 2015.

A key step in the WFD process is for EU Member States to assess the health of their surface waters through national monitoring programmes. Monitoring of all biological elements including fish is the main tool used to classify the status (high, good, moderate, poor and bad) of each water body. The responsibility for monitoring fish has been assigned to Inland Fisheries Ireland and AFBI in N. Ireland. A national fish stock surveillance monitoring programme has been initiated at specified locations in a 3-year rolling cycle (Kelly *et al.* 2012).

Under the Eel Management Plan, monitoring Objective 4 relates to an inter-calibration study between the Water Framework Directive Sampling and the Eel Monitoring Programme. This study was undertaken successfully in 2010 in Lough Ree and Upper Lough Erne. The WFD monitoring programme also addresses EMP Objectives 6 (eel stock status baseline), 7 (extent of upstream colonisation) & 8 (spread of *A. crassus*).

6.2 WFD Survey Methods

Lakes

Lakes are surveyed between June and September. Standard multi-mesh monofilament survey gill nets were used to sample the fish population. Surface floating nets, “Dutch” fyke nets and benthic braided single panel (62.5mm mesh knot to knot) gill nets were used to supplement the gill netting effort. Survey locations were randomly selected using a grid placed over the map of the lake and portable GPS instruments were used to mark the precise location of each net. All nets were set between 3 and 6pm, fished overnight and lifted between 10.00am and 12.00-midday in order to ensure that the activity peaks of each fish species was included.

Rivers

Electric fishing is the method of choice for WFD surveillance monitoring of fish in rivers to obtain a representative sample of the fish assemblage at each sampling site. The standard methodology includes fish sampling, hydrochemistry sampling, and a physical habitat survey. A macrophyte survey was also carried out at selected sites. Surveys were carried out between July and early October (to facilitate the capture of 0+ salmonids) when stream and river flows were moderate to low. Three fishings were carried out in a contained area. In small shallow channels (<0.5-0.7m in depth), a portable (bank based) landing net (anode) connected to a control box and portable generator (bank-based) or electric fishing backpack was used to sample in an upstream direction.

In larger deeper channels (>0.5-1.5m), fishing was carried out from flat-bottomed boat(s) in a downstream direction using a generator, control box and a pair of electrodes. All habitats, in wadeable and deeper sections, were sampled (i.e. riffle, glide, pool).

Transitional Waters

A multi-method approach is used for sampling the transitional waters. Beach seining using a 30m fine-mesh net is used to capture fish in littoral areas. Beam trawling is used for specified distances (100 – 200m) in open water areas adjacent to beach seining locations. Fyke nets were set overnight in selected areas adjacent to beach seining locations.

A total of 108 lakes were sampled from 2008-2011 (Table 6.1). In 2009, 2010 and 2011, all lakes surveyed recorded eels as present. No eels were caught in Lough Skeagh upper in 2008, but all other lakes surveyed had eels present in that year. Two hundred and forty-five river sites were sampled in total across 2008-2011. No eels were recorded at 20 sites in 2008, 11 sites in 2009, 10 sites in 2010 and 24 in 2011. Seventy-four transitional waters were sampled from 2008 to 2011. Eels were recorded at both of the sites sampled in 2011 and in all but 3 transitional waters in 2009 (no eels were captured in Inner Donegal Bay, Swilly Estuary and Lough an tSaile). In 2008, no eels were recorded in 11 transitional waters (Argideen, Maigue, Colligan, Harpers island (Lough Mahon), Lough Mahon, Ilen, Lee (Tralee), Lower Lee, Bridge Lough, Tullaghan Estuary, Westport estuary).

Table 6-1: Site numbers in the surveys carried out by the WFD team, 2008-2011. * Lough an Aibhinn and Camus Bay are considered as one transitional waterbody, therefore there were actually 22 sites sampled.

Water body	2008	2009	2010	2011
Lakes	32	24	22	30
Rivers	83	54	43	65
Transitional Waters	42	23*	25	2

6.3 Intercalibration between EMP Surveys and WFD Monitoring programme

Monitoring Objective 4

6.3.1 Introduction

Monitoring objective 4 of the National Management Plan refers to an inter-calibration study between the Eel Monitoring Programme (EMP) and the Water Framework Directive (WFD) fyke net sampling methodology. The WFD sampling programme covers a total of 78 national lakes surveyed between 2008 and 2010. The National eel survey uses intensive fyke net effort in chains of five fykes nets while the WFD employs a lower effort in chains of three nets. O'Neill *et al.* (2009) demonstrated no difference in precision in CPUE determined between chains of five and chains of ten nets, but chains of three nets were not tested. A power analysis of more than 3,800 5-net nights indicated a high effort required to achieve a modest precision of, for example, 10% coefficient of variation which equates to approximately 250 net nights; more net nights at low densities and less net nights at higher densities of eel.

The aim of this exercise is to test the broad-scale low effort surveys of the WFD against the intensive eel specific surveys of the national eel monitoring programme (EMP) in order to assess the possible application of the WFD surveys for determining eel stock structure and relative density.

6.3.2 Methodology

The fyke net surveys, carried out in the WFD monitoring programme, consist of setting Dutch fyke nets in chains of 3. The number of fyke net chains to be set in a lake is determined by the wetted area of the lake. The locations of the nets were randomly assigned to the shallow regions around the lake shore (2 depth zones 0-2.9 m, 3-5.9 m). Occasionally nets are moved closer to possible eel habitat such as near the mouth of a river. Nets are set perpendicular to the shore.

The EMP uses fyke nets of the same dimensions as in the WFD programme but the nets are set in chains of 5 as opposed to 3 in the WFD. A total effort of 300 net nights is carried out per lake, usually distributed into 2 sessions of 3 nights with 50 nets set per night. The location of each chain of nets was randomly allocated for each session using the trap builder task in Density 4.4 (Efford, 2009). The EMP survey sites include a greater range of depths than those covered by the WFD surveys.

In 2010, two lakes were sampled simultaneously by the WFD and EMP teams in order to compare the efficiency of the two methods. Upper Lough Erne and Lough Ree in the Shannon catchment (Lough Ree was surveyed as two lakes, upper and lower). In addition to the simultaneous sampling, four additional lakes were surveyed by the two teams but in different years, these included Lough Cullin, Upper and Lower Lough Corrib, Upper and Lower Lough Derg (due to the size of the lakes they were split into upper and lower).

6.3.3 Results

Details of the catch per night of effort are shown in Table 6.2. Due to the non-normal distribution of biological data, non parametric statistics was performed on the data. A Mann Whitney Test was used to analyse the CPUE of the lakes sampled by both teams (n = 8, CPUE). There was no significant difference in Catch per Unit of Effort for the EMP and WFD surveys in the same lakes (U = 40, p=0.442 ns, Fig. 6.1).

A Mann Whitney test was used to analyse the length and weight of eels sampled in the EMP and WFD surveys. There was no significant difference in the length of eels sampled (U=76,894, p=0.341 ns). There was also no significant difference in the weight of eels sampled (U = 78,257, p= 0.524 ns).

6.3.4 Conclusion

Harley *et al.* (2001) recommended that if using CPUE to estimate abundance, surveys must be carried out multiple times or that the survey represents a good coverage of the stocked area. O'Neill *et al.* (2009) indicated that a high level of effort is needed to achieve good precision in the CPUE estimates. Initial indications from this inter-calibration are that the size structure of the local eel populations and the CPUE of the two surveys are generally comparable and it is intended to investigate this further. However, a low net effort and small number of sites lends itself to a wide variation in catch and therefore the higher net effort will be required to identify relative changes in eel stock structures and densities with any precision.

Approximately 81 lakes were surveyed by the WFD team in the 3 year cycle (2008-2010) compared with 13 lakes by the Eel monitoring programme. The WFD national programme gives a good representation of the state of the eel stocks in selected Irish lakes and will be repeated in each location every 3 years. Further analysis after the second 3 year cycle will give a clearer indication of how to use the WFD data for stock analysis. If the EMP surveys are restricted to less than 15m depth, then the data between the two surveys should be interchangeable.

The effort intensive eel specific fyke net surveys for the EMP are required in order to set a robust benchmark for the assessment of future changes in the stocks with a reasonable chance of detecting changes (O'Neill *et al.* 2009). The intensive surveys have also resulted in a large dataset of morphological measurements. It is through these measurements that the maturation of the yellow eels into silvers will be assessed, a requirement for determining silver eel escapement. To determine the quality of eels in a lake such as age, growth and parasite prevalence, a large sample size is required. This requirement is not met under the WFD methodology with a maximum of 66 eels captured for a lake. Therefore, intensive fyke netting surveys, while time consuming, are required when assessment of the eel stock structure and detecting changes in same is the aim.

The use of fyke nets to assess the population of eels in a lake must take into account the gear dependent fraction of the catch. Fyke netting samples a length class >30cm (Naismith and Knights 1990). Both mesh size and length of leader of the fyke nets have been identified as introducing bias to the catch. Therefore the CPUE used in this analysis refers to the population of eels >30-40cm (Moriarty 1972). However, generally the mesh size and leader length are standardised between the different surveys and are similar to those used in historical Irish surveys making it easier to compare the different results. Further analysis of how to relate CPUE to population abundance is currently on-going through the EMP Mark Recapture surveys.

Table 6-2: Catch per unit of effort for selected lakes surveyed by WFD and EMP.

Lake	Group	Year	No. Eels	Net* Nights	CPUE
L. Cullin	EMP	2009	420	220	1.909
	WFD	2009	48	12	4.000
Lower L. Corrib	EMP	2009	420	300	1.400
	WFD	2008	8	15	0.533
Upper L. Corrib	EMP	2010	470	300	1.567
	WFD	2008	28	18	1.556
Lower L. Derg	EMP	2009	669	290	2.307
	WFD	2009	57	18	3.167
Upper L. Derg	EMP	2010	765	255	3.000
	WFD	2009	66	18	3.667
Lower L. Ree	EMP	2010	501	300	1.670
	WFD	2010	44	18	2.444
Upper L. Ree	EMP	2010	299	240	1.246
	WFD	2010	26	18	1.444
Upper L. Erne	EMP	2010	490	300	1.633
	WFD	2010	32	18	1.778

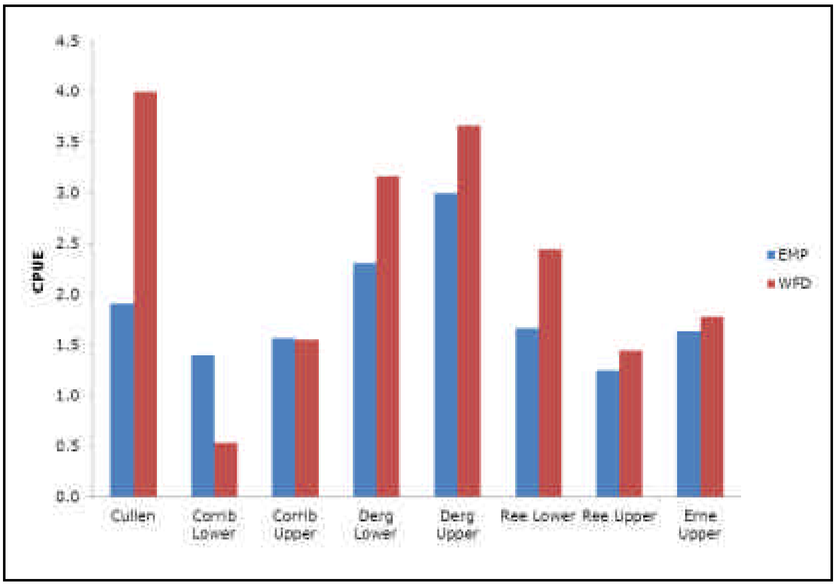


Figure 6-1: CPUE for lakes sampled by EMP and WFD

6.4 Status of *Anguillicoloides crassus*

Monitoring Objective 8

In Chapter 3.4.2.3 of the National Eel Management Plan report, it was indicated that approximately 73% of the wetted area was infected by *Anguillicoloides*. In the interest of maintaining good eel quality, it was hoped that the further spread of the parasite might be reduced.

The eels captured during both the EMP surveys and the WFD surveys are checked for the presence of *A. crassus*. The data are summarised in Figure 6.2. Prevalence and intensity rates vary from east to west, but the northwest and southwest of the country show little to no infection by *A. crassus*. A number of catchments, such as the Munster Blackwater, the Laune and the Fergus, have shown very low infection rates and patchy distribution which probably indicates recent introductions. Further monitoring and management will be necessary to maintain the parasite free status of catchments in these areas.

It should be noted that any transfer of water or fish, not only eels, can act as a vector for the spread of *A. crassus*. Therefore, any movements of fish or water between catchments should be undertaken with caution. This includes stocking programmes from hatcheries, transfers of coarse fish between waterbodies and bilge water in boats.

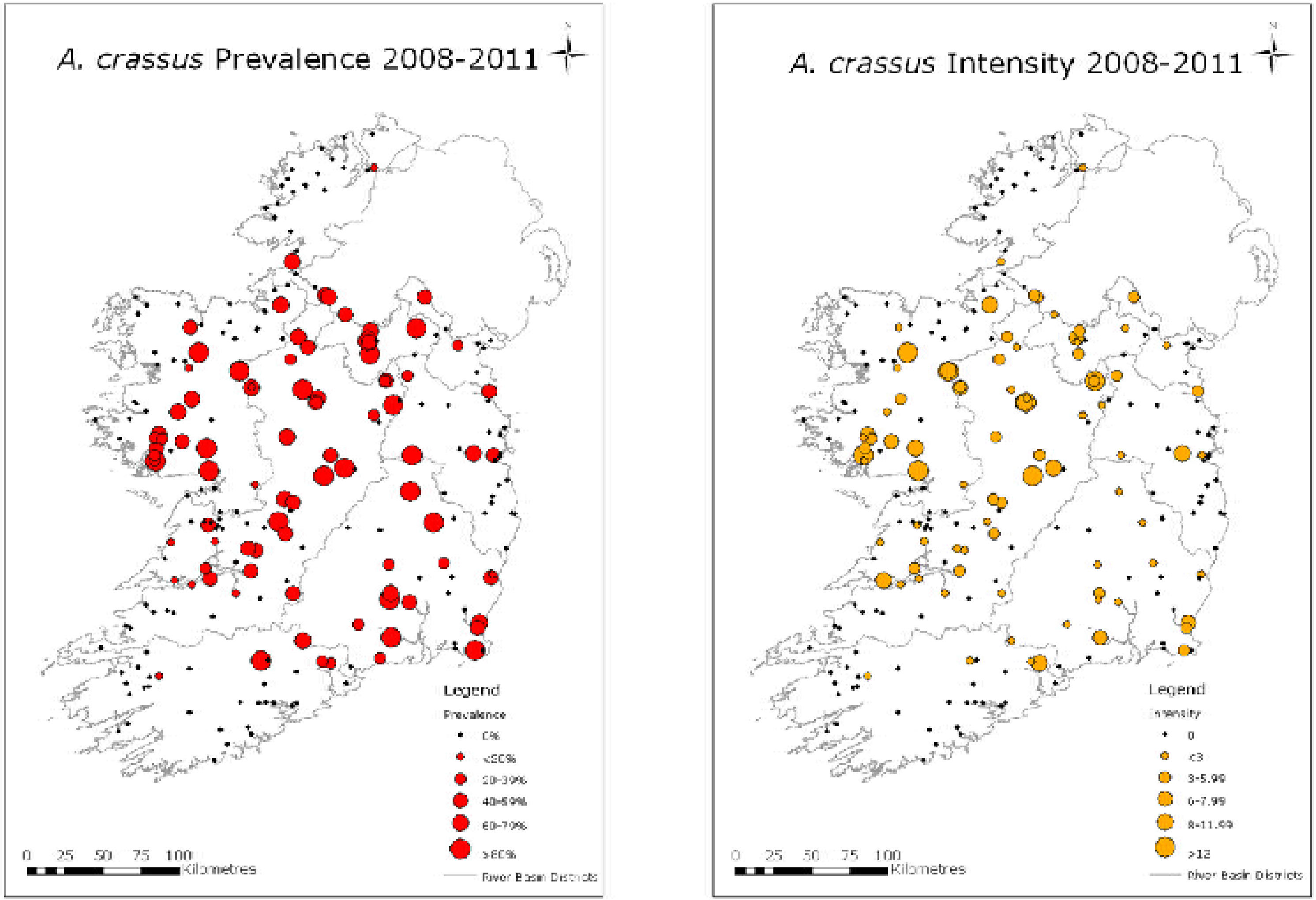
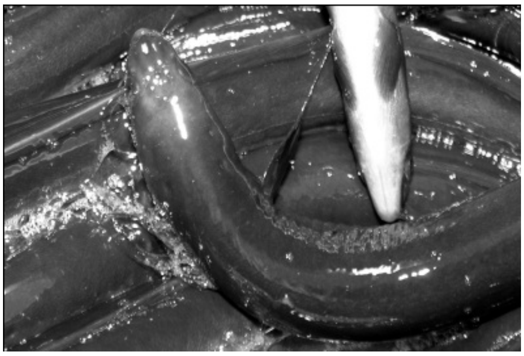


Figure 6-2: ***Anguillicoloides crassus*** **prevalence and mean intensity distribution in Ireland.**

7 Silver Eel Escapement, 2009-2011

(refers to Ch. 7.2.1 of the National EMP Report, 2008)

7.1 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 7.1), all of which have a long-term history of eel catch and data collection. 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. Subject to this evaluation, it is proposed to survey a series of additional index locations on a three year rolling basis (Table 7.1). Figure 7.1 shows the locations of the silver sampling in 2009 - 2011.

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

In 2009, the wetted area of the four index catchments (Burrishoole, Corrib, Shannon and Erne) accounts for 64% of the wetted area in Ireland and the Northern Irish portion of the NWIRBD. This dropped to 45% with the loss of the Corrib data in 2010/2011.

Table 7-1: The locations where silver eel escapement will be assessed (extracted from the Irish EMPs).

Catchment	Priority	2009	2010	2011	Method
Corrib	High	v		v	Coghill net / Mark-recpature
Erne	High	v	v	v	Coghill net / Mark-recapture
Shannon	High	v	v	v	Coghill net / Mark-recpature
Burrishoole	High	v	v	v	Trap
Mask	Medium		v		Coghill net / Mark-recpature
Muckno	Medium			v	Coghill net / Mark-recpature
Waterville	Medium			v	Fish Counter

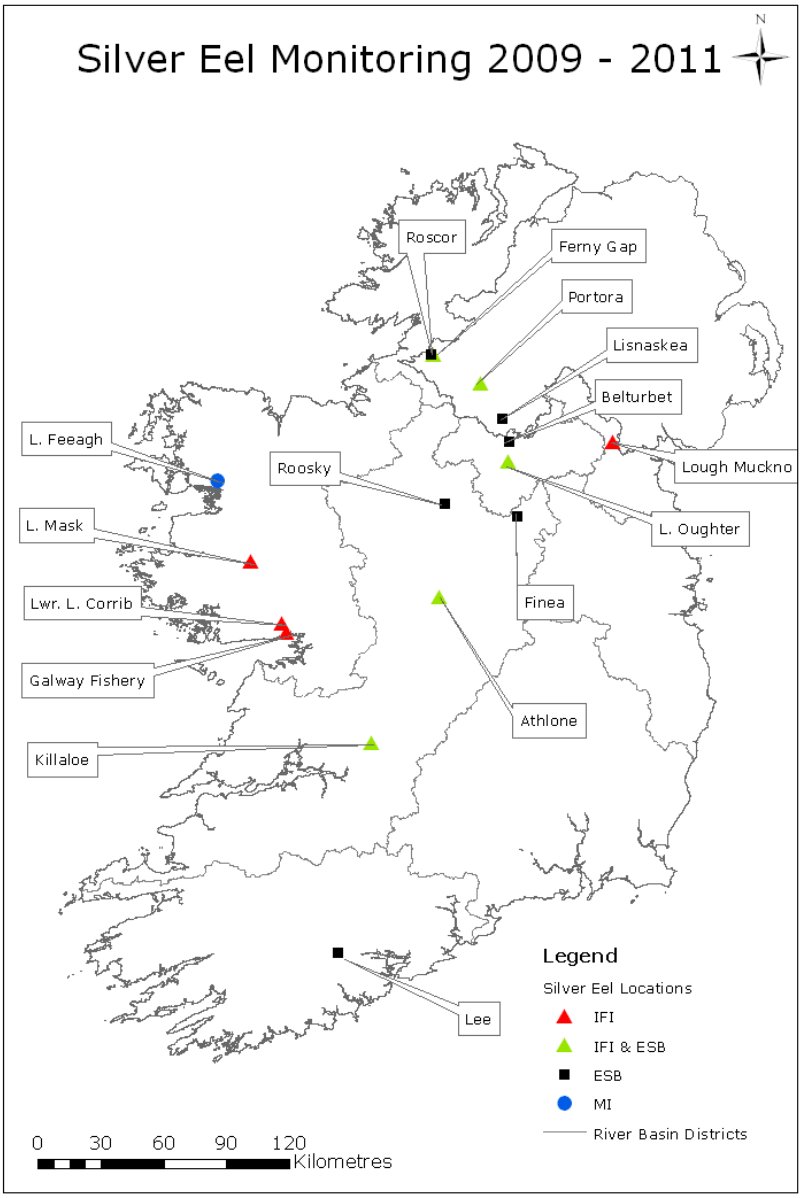


Figure 7-1: Locations of silver eel monitoring sites, 2009-2011.

7.2 Shannon

7.2.1 Introduction

Analysis of River Shannon silver eel migrations has been undertaken annually by NUIG 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. 7.2A) catch downstream of Parteen weir (Fig. 7.2B). The ShIRBD Eel Management Plan proposed increased trap and transport targets for

2009-2012. Therefore, the work undertaken in 2009-2012 reflected the 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. In addition to sub-sampling the silver eel catches made for the trap and transport programme in the upper Shannon catchment area, detailed monitoring of the daily catches at the Killaloe eel weir was undertaken. Spawner quality monitoring, which involved analyses of morphometric indices of silvering, body fat levels and parasite burdens was also undertaken in detail in 2009-2010. Summaries of work in progress have been supplied to the SSCE over the past three years (McCarthy *et al.* 2010, 2011, 2012). ESB Fisheries Conservation Annual Reports have also provided regular up-dates on the Shannon eel stocks, for which ESB has statutory responsibilities.

Figure 7-2: The Killaloe eel weir (A) and the Parteen regulating weir (B) on the lower River Shannon.

The on-going River Shannon eel research programme, undertaken by NUIG in partnership with ESB, is now 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. Established and novel methods for investigation of silver eel behaviour and population dynamics have been used in the 2009-2012 NUIG/ESB Shannon eel research programme and research/monitoring and "milestones", defined in the lead up to the ShIRBD Eel Management Plan, have now been successfully reached. Some future refinements in monitoring protocols may be possible, including increasing use of DIDSON™ technology, and these issues will be addressed in the next few years during research that is now being focused on investigation of alternative mitigation measures.

7.2.2 Shannon Annual Escapement

The pattern of silver eel escapement has been well documented (McCarthy *et al.* 2010, 2011, 2012) for all ESB contracted fishing sites on the Shannon. Earlier peaks in migration occurred in the upper catchment sites, which typically exhibited clear lunar periodicity in catch levels, and eels in the upper catchment sites were typically larger than those recorded downstream at Killaloe (Fig. 7.3). The sex ratio varied along the river with catches at upper sites being comprised predominately, or exclusively, of female eels (Fig. 7.3). 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.

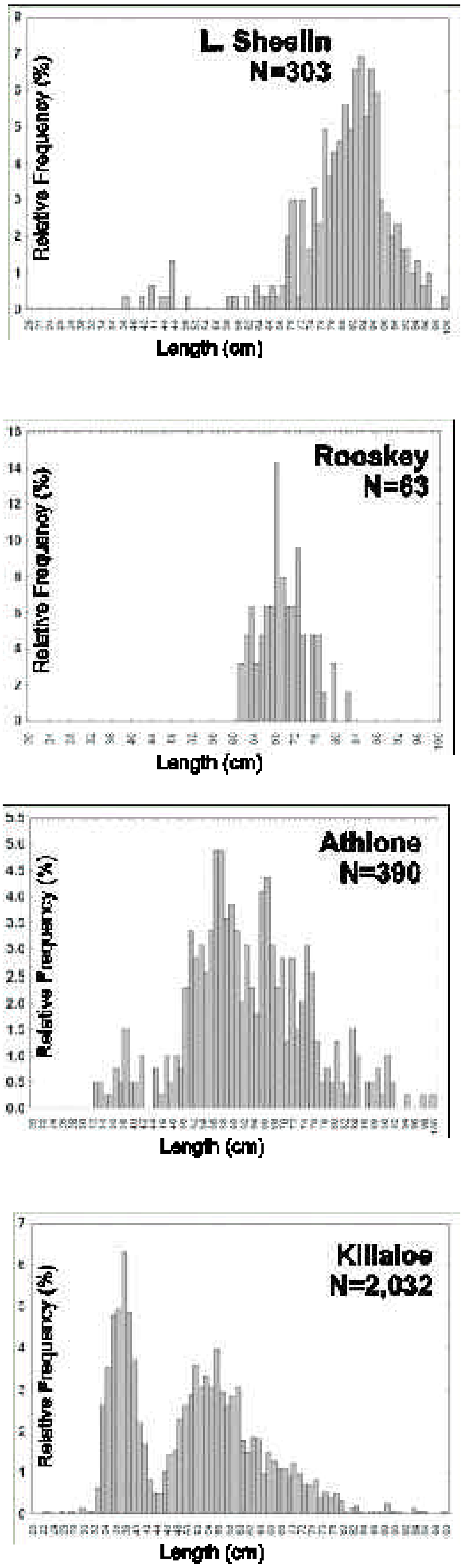


Figure 7-3: Length frequencies, mean weights and sex ratios of silver eels sampled at the four silver eel zones fished during the 2011/2012 silver eel trap and transport programme.

A detailed analysis of the environmental factors affecting silver eel migration in the catchment is in progress but evidence of the importance of variation in discharge was evident at all sites during 2009-2012. The effects of discharge were clearly evident in Killaloe especially in 2009/2010 but the underlying lunar periodicity was noted in some years e.g. 2011/2012 (Fig. 7.4).

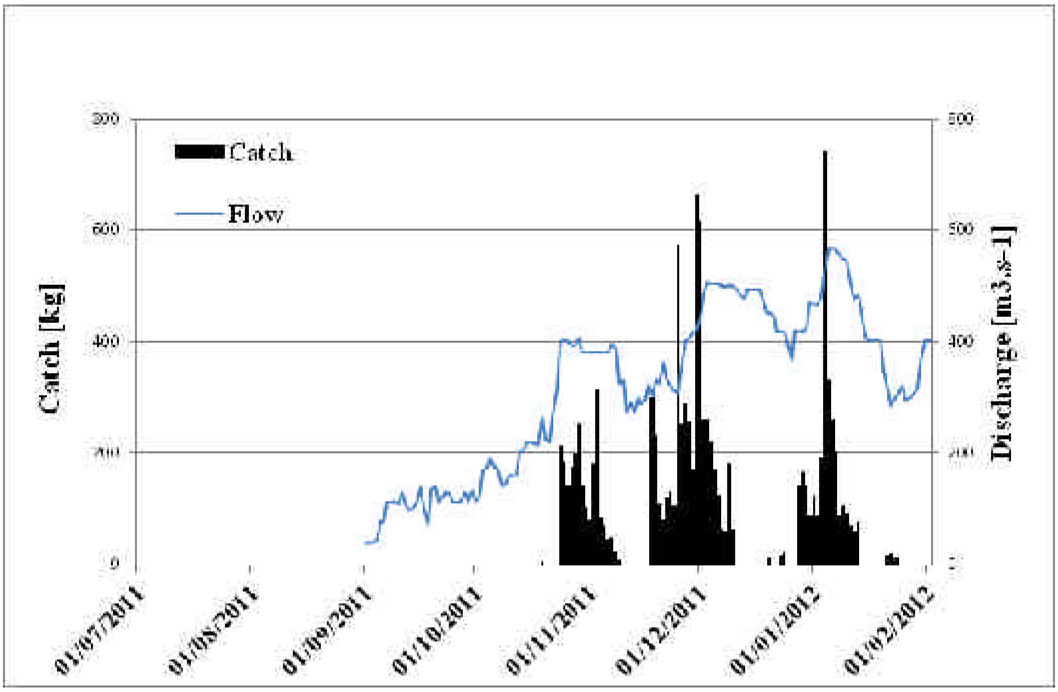


Figure 7-4: Daily silver eel catches at the Killaloe eel weir, in relation to discharge 2011/2012.

Killaloe eel weir efficiency was investigated by means of a series of mark/recapture experiments each year from 2008/2009 to 2011/2012, as part of the NUIG research at Killaloe eel weir. Initially both FLOY and PIT tags were used on an equal basis but since difficulties arose in 2010 in respect of PIT tag detection during IFI screening of catches at Parteen, less reliance was placed on PIT tag recovery data in subsequent years and in overall eel weir efficiency calculations. In NUIG tag screening at Killaloe in 2008, no significant differences were detected between recapture rates for the two types of tags. The overall 2008-2012 efficiency of the eel weir was estimated to be 23.3%, based on recapture rates of batches of tagged eels (N=2,202), and annual efficiency estimates varied from 20.8% to 25.0%. The mean annual silver eel escapement for 1998-2008 was estimated to be 46.08t using the results of the 2008-2012 eel weir study. A more detailed account of the efficiency experiments were presented in annual reports by NUIG/ESB (McCarthy *et al.* 2010, 2011, 2012).

The determination of turbine passage mortality for silver eels passing through Ardnacrusha dam (Fig. 7.5) was determined by means of acoustic telemetry, using protocols described in NUIG/ESB reports to SEG and SSCE (McCarthy *et al.* 2010, 2011, 2012). Eels were tracked, following release in the headrace canal at Clonlara as they passed downstream, using an array of receivers deployed above and below the dam and mortality rates were determined on the basis of failures to detect tagged eels at the downstream sites. A total of 104 female eels, captured at Killaloe weir, were used and these were representative of the size range of eels typically passing downstream of Killaloe. Sample sizes varied (N=28 in 2008; N=16 in 2009; N= 40 in 2010; N=20 in 2011) and annual mortality rates varied from 16.6% to 25% for these small batches. 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 ShIRBD 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.

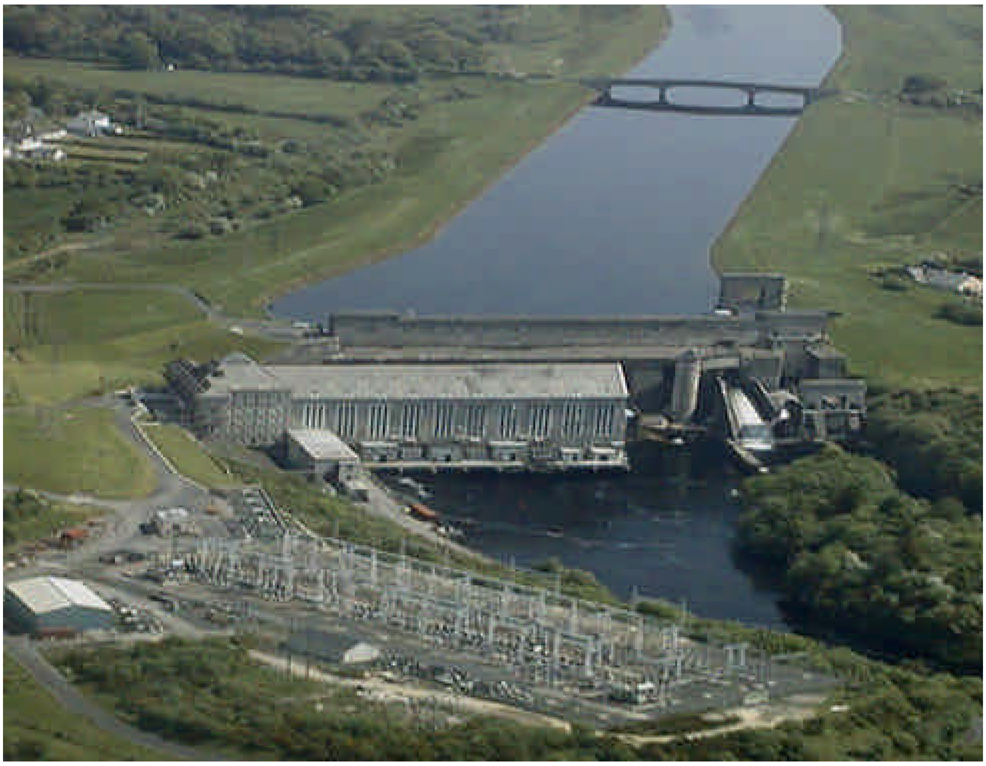


Figure 7-5: Ardnacrusha Dam on the Lower River Shannon.

In 2006-2009, a series of batches of acoustically tagged eels were released immediately downstream of Killaloe (Fig. 7.6), during different levels of discharge and different levels of spillage at the Parteen regulating weir (Fig. 7.2B). 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.

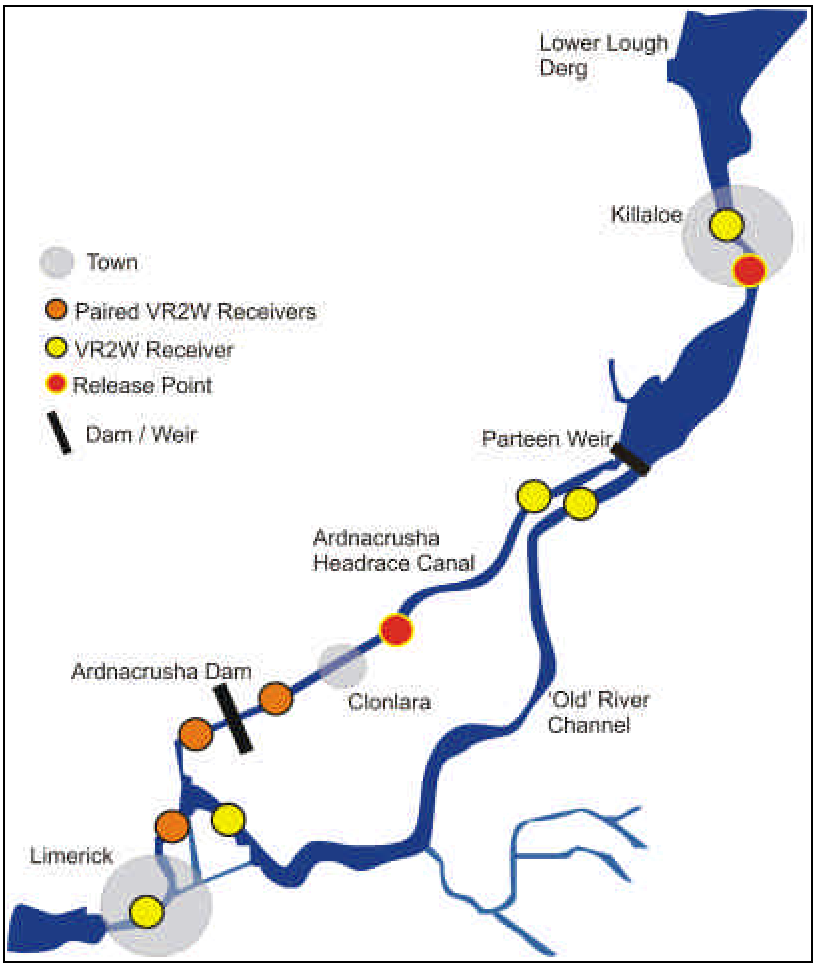


Figure 7-6: Locations of telemetry receivers and release point for acoustically tagged eels used for turbine passage studies in the Lower River Shannon 2008-2012. Not all receivers were deployed in all years.

7.2.3 Shannon Production and Escapement

7.2.3.1 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 188,849kg (Table 8.1). Records indicate that the silver eel catches in the 1920s were at least 60-70t.

7.2.3.2 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 8.1) using the more recent data of 17.8% as an average bypass and 21.1% turbine mortality (average 2009-2011).

7.2.3.3 Current 2009-2011

Production of silver eels in the River Shannon has varied historically, reflecting variation in recruitment and fishing pressure. Modelling of the variation has provided a basis for evaluation of the current levels. The variation from 2000 to 2008 partly reflected the increasing development of the ESB eel conservation protocols but positive effects of the ShIRBD eel management plan are evident in the detailed results of the 2008-2012 NUIG/ESB research programme. The silver eel production of 2008 was 60.958t.

In Figures 7.7, 7.8 & 7.9 the summary results of the NUIG/ESB research on River Shannon eel production and escapement for 2009-2012 are illustrated. These results differ slightly from those presented in annual reports (McCarthy *et al.* 2010, 2011, 2012) because of revised analyses using improved hydrometric data and cumulative estimates of turbine passage mortality (21.15%) have now been used. The results show that spawner biomass escapement increased significantly from 37.35t level recorded in 2008/2009 to 66.79t in 2009/2010 but that a subsequent decline occurred in the following two years, to 60.12t and then 57.88t. Current (2008–2011) productivity for the Shannon wetted area (42,466 ha) has been estimated to be 1.52–1.75 $kg \cdot ha^{-1}$.

The data for the Shannon Catchment are presented on the modified ICES precautionary diagram as developed by the WGEEL (2011) 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) (Fig. 7.10) and the average for 2009-2011 is presented on Fig. 7.11. The revised Bo and a recalculated 2008 figure using the turbine mortality estimates determined for Ardnacrusha between 2006 and 2011 (Table 2.2) were used in these diagrams.

The downward direction of the bubbles shows the reduction in mortality by closing the fishery and transporting silver eels around the HPS. There is a corresponding increase in silver eel biomass escaping which is shown by the movement to the right of the bubbles in Figures 7.10 & 7.11.

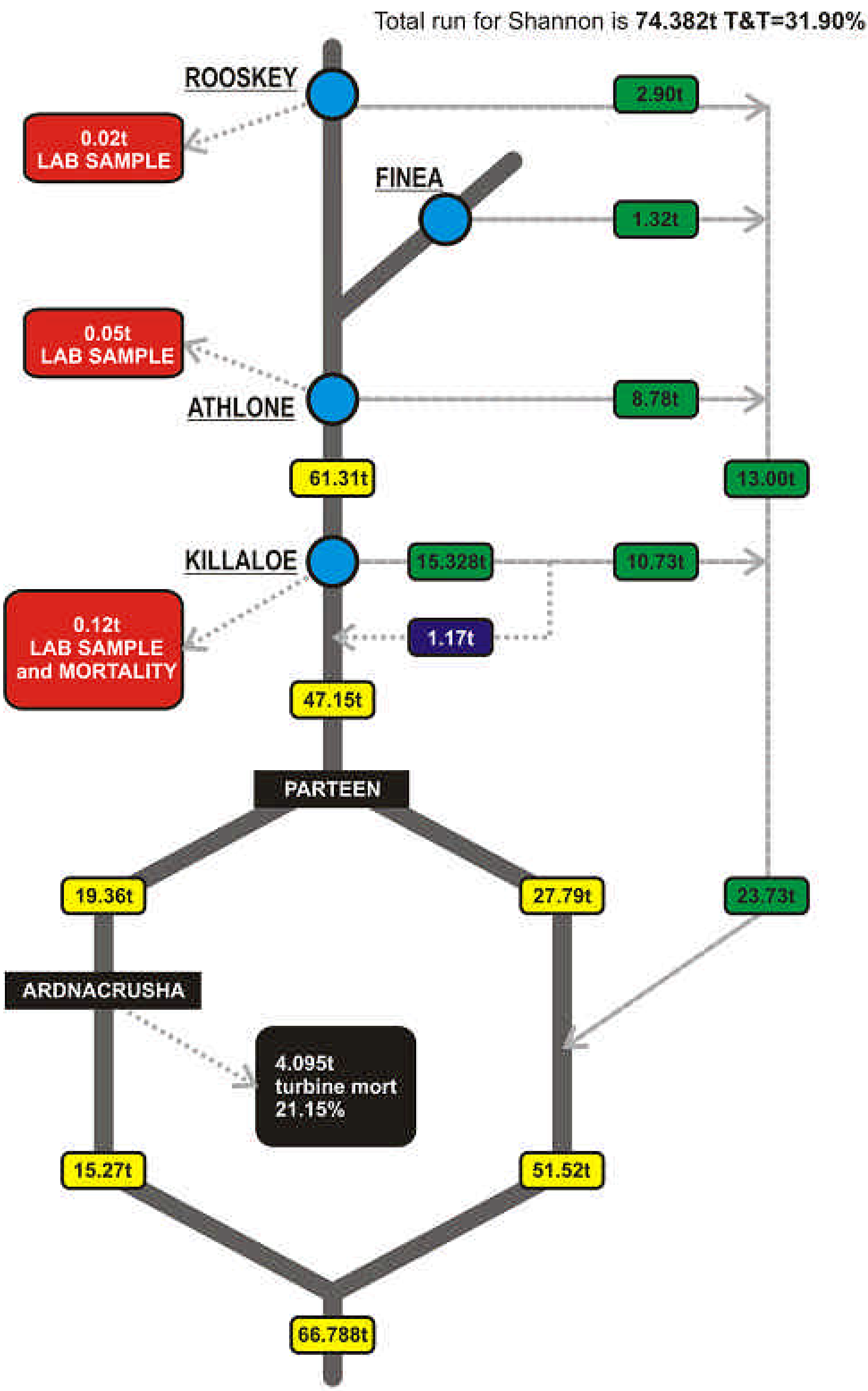


Figure 7-7: Silver eel trap and transport and spawner escapement from the River Shannon during the 2009/2010 silver eel migration season.

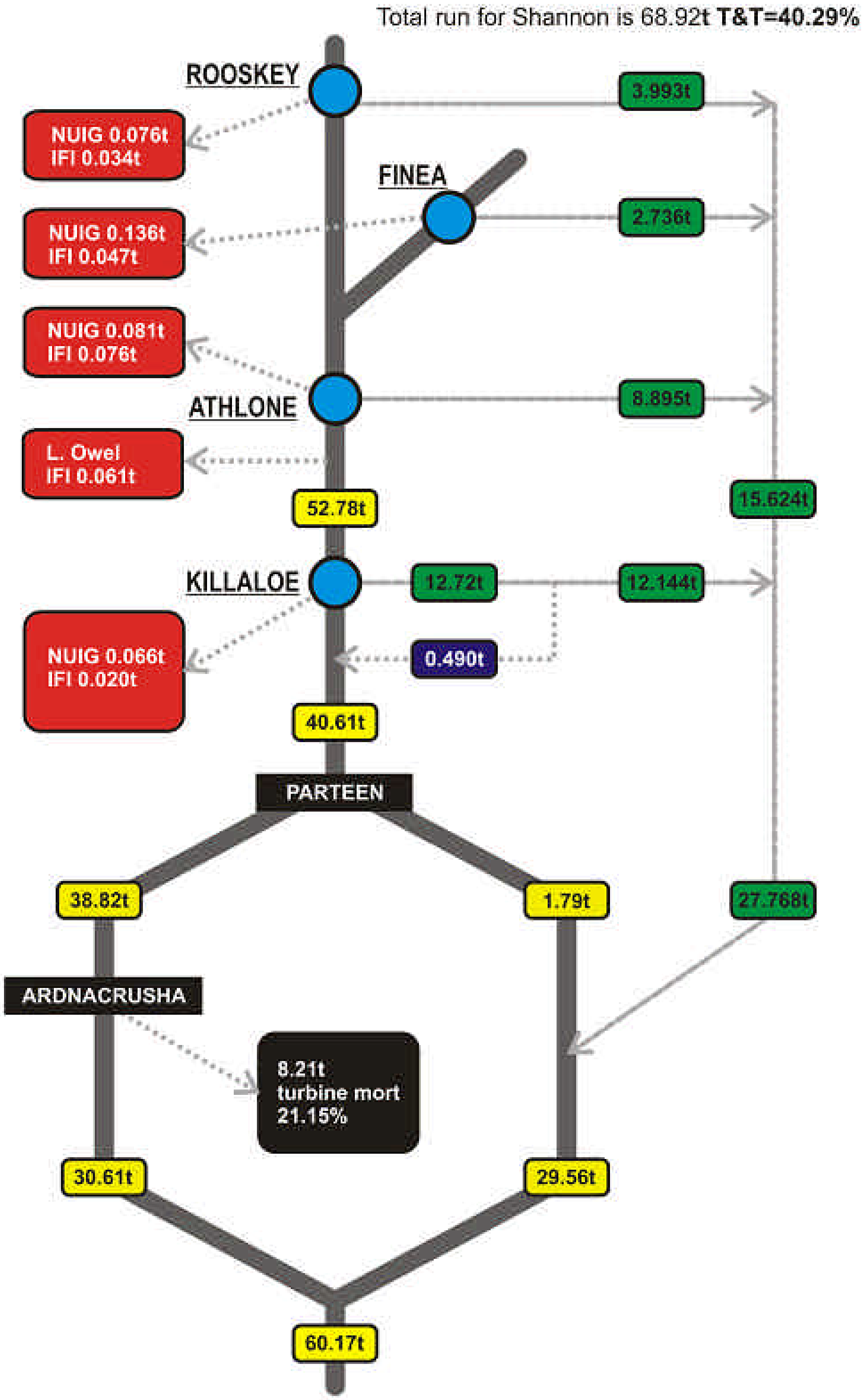


Figure 7-8: Summary spawner biomass escapement estimate for River Shannon system 2010/2011.

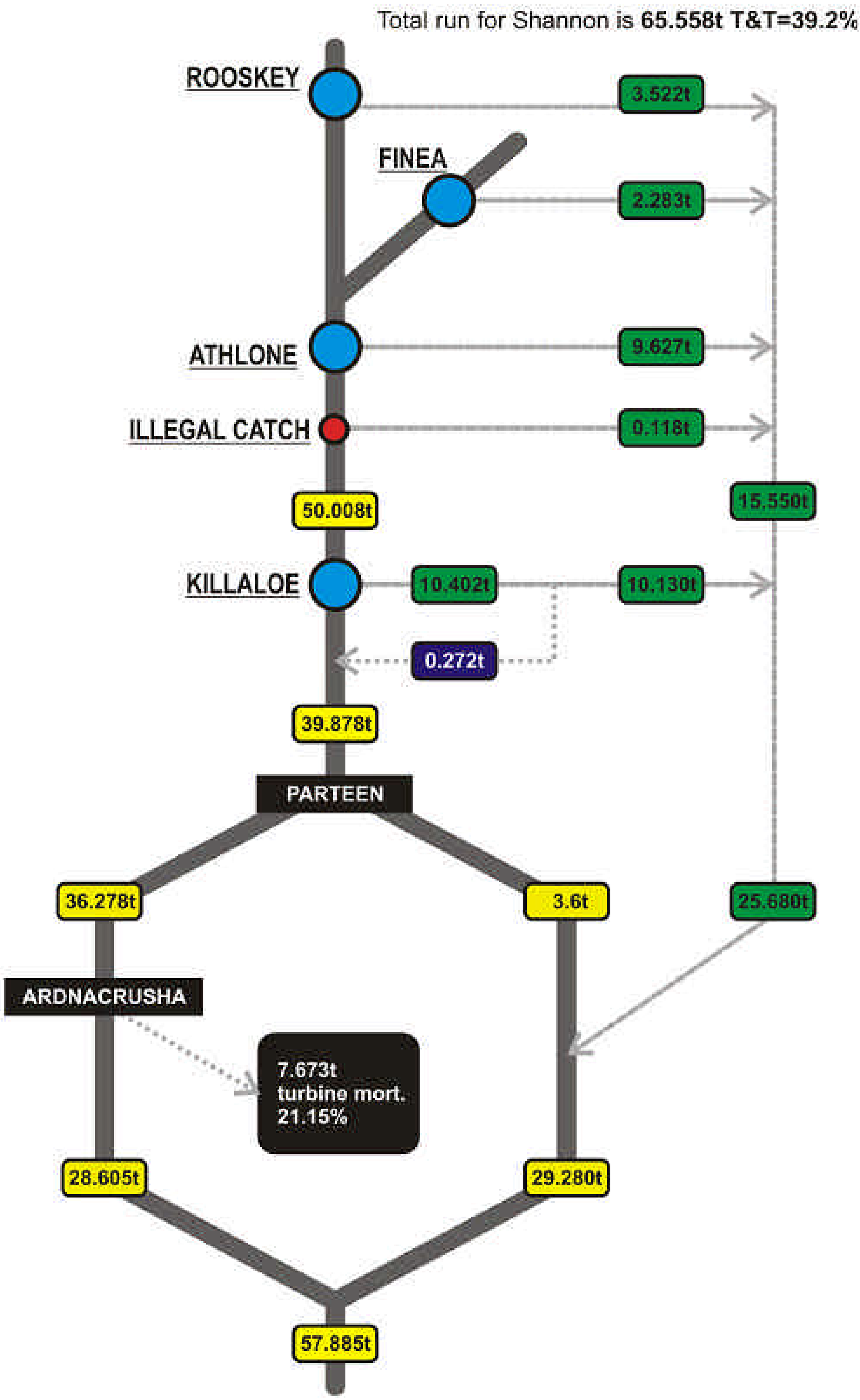


Figure 7-9: Summary spawner biomass escapement estimate for River Shannon system 2011/2012.

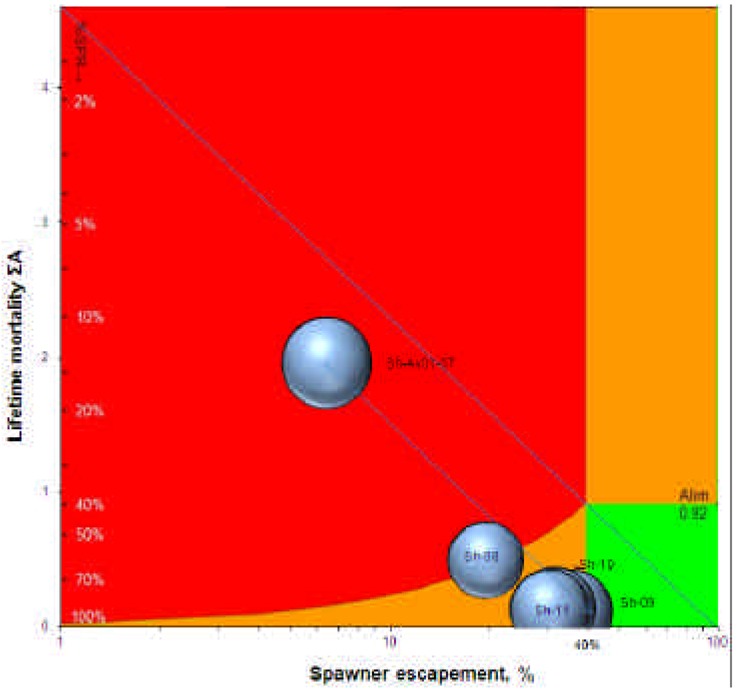


Figure 7-10: Status of the stock and the anthropogenic impacts, for the <u>Shannon</u> as presented in the Eel Management Plans for the average 2001-2007, in 2008 and for the current years, 2009-2011. For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement 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.

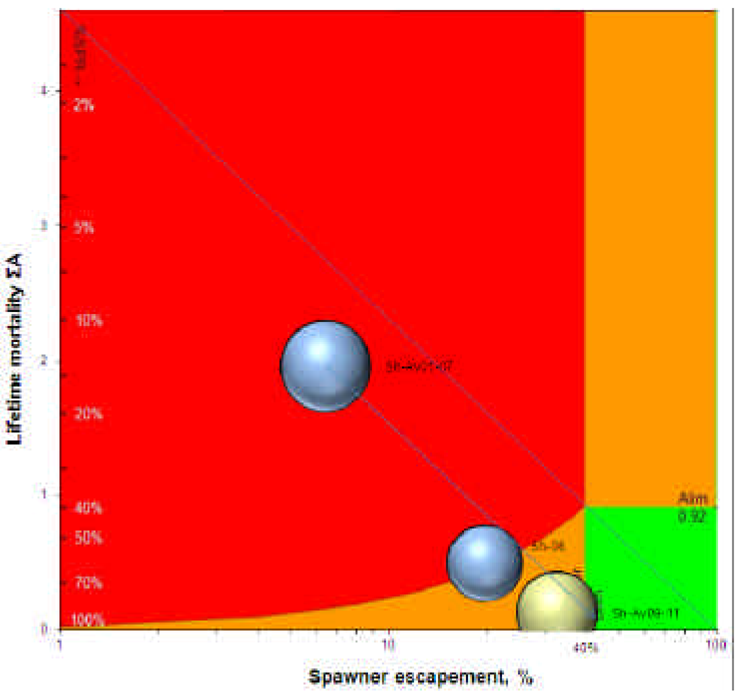


Figure 7-11: Status of the stock and the anthropogenic impacts, for the <u>Shannon</u> as presented in the Eel Management Plans for the average 2001-2007, for 2008 and for the average 2009-2011.

7.3 Erne

7.3.1 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 are 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 NWIRBD eel management plan specified targets for a silver eel trap and transport programme undertaken by ESB during 2009–2012, based on model predictions of the quantities of silver eels that were presumed to be produced in the extensive cross-border River Erne catchment area. The target set for 2009/2010 was 22.5t, with higher targets 33.75t and 39t phased in for the following two years to account for the development process of T&T in the Erne (See Section 2.4.1). These were based on the assumption that turbine mortality rates of 28.5% (ICES, 2002) applied to both the hydropower stations (Cliff HPS and Cathaleen's Fall HPS) operated by ESB in the lower section of the river (Fig. 7.12). Likewise, it was assumed that the commercial eel fishery would cease in 2009.

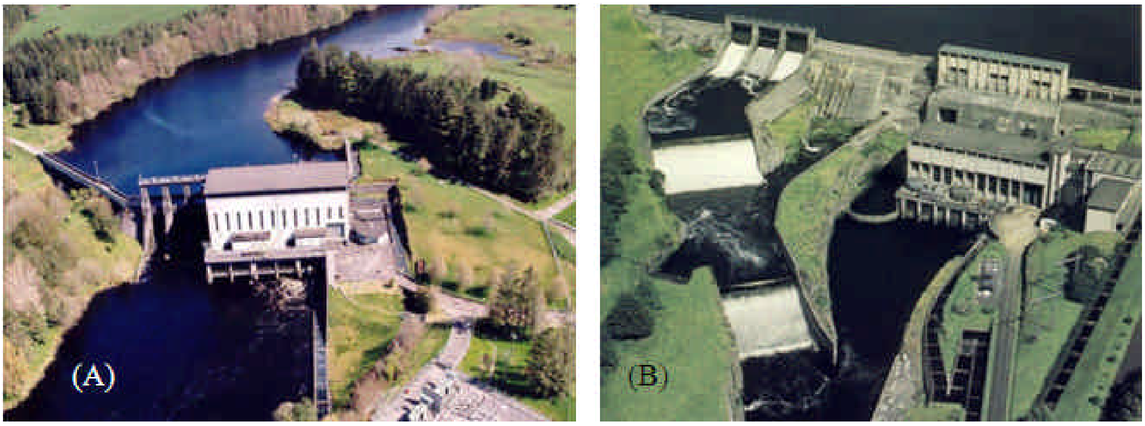


Figure 7-12: River Erne hydroelectricity generating stations (A) Cliff HPS and (B) Cathaleen's Fall HPS.

A survey of potential silver eel fishing sites was undertaken by NUIG in 2009, prior to the development of a trap and transport programme by ESB, and the site descriptions were used as a basis for site selection and for development of a catch monitoring programme. The sites (Fig. 7.13) used by ESB varied in minor respects over the 2009-2012 period, as did the scientific monitoring, and fishing intensity (increased site numbers, increased fishing nights, improved fishing protocols) in an attempt to capture the quantities of eels specified in annual EMP targets. However, for scientific monitoring the main focus in 2009-2012 was on the seaward migrating populations in the Lower Lough Erne to Ballyshannon estuary and on the potential adverse effects that might result from passage via the two ESB operated hydropower dams in that lower section of the River Erne catchment area. The descriptions of the current population structure of the spawner escapement involved, regular analyses at all ESB conservation fishing sites and use of these data in conjunction with ESB records of the quantities transported from each fishing site. Research on the variation in population structure and population dynamic of the naturally migrating eel populations were analysed by detailed catch analyses together with mark/recapture experiments, acoustic telemetry and use of DIDSON™ acoustic camera eel counts. The initial year, 2009/2010, was complicated by problems in gaining access to the selected experimental fishing site at Roscor Bridge. Therefore, reliable estimates of escapement were not possible.

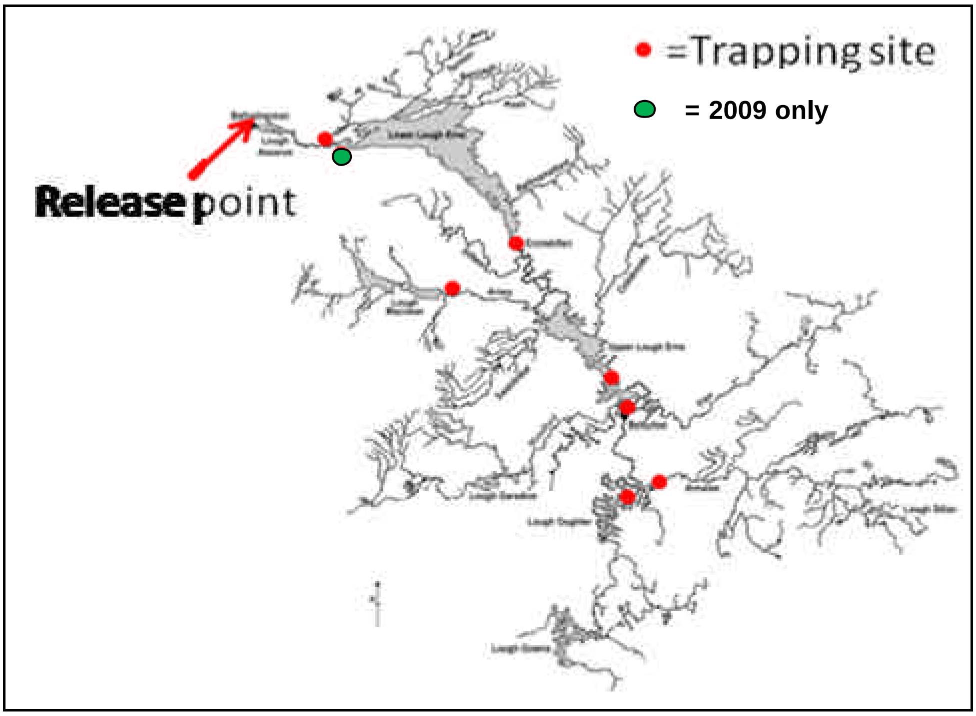


Figure 7-13: Conservation fishing sites in the River Erne system, monitored by NUIG, in 2009-2012. The green shows the site fished in 2009 and the red and green sites were fish in the 2010/11 and 2011/12 seasons with some small alterations in locations between years.

7.3.2 Erne Annual Escapement

The pattern of silver eel escapement, variations in size frequencies, sex ratio and other parameters have been documented for the 2009-2011 period during the trap and transport monitoring (Fig. 7.14). There was considerable variation along the river course, with relatively high numbers of males being recorded in some upstream sites, such as Killashandra in 2011/2012 (Fig. 7.14).

Current spawner biomass escapement, and silver eel population characteristics, were determined in the 2010/2011 and the 2011/2012 seasons by means of a detailed population study at Roscor Bridge experimental fishing location (Fig. 7.15A) and at Roscor Point 0.4km upstream (Fig. 7.15B). Independent analyses (mark-recapture experiments; DIDSON™ surveys) of the variation in silver eel population and of the total biomass migrating downstream gave similar results. Furthermore, though the monitoring of a nearby site in the Lower Lough Erne outlet area (Ferny Gap) was difficult, estimations (DIDSON™ surveys; catch records) of the population biomass leaving Lower Lough Erne also gave similar results.

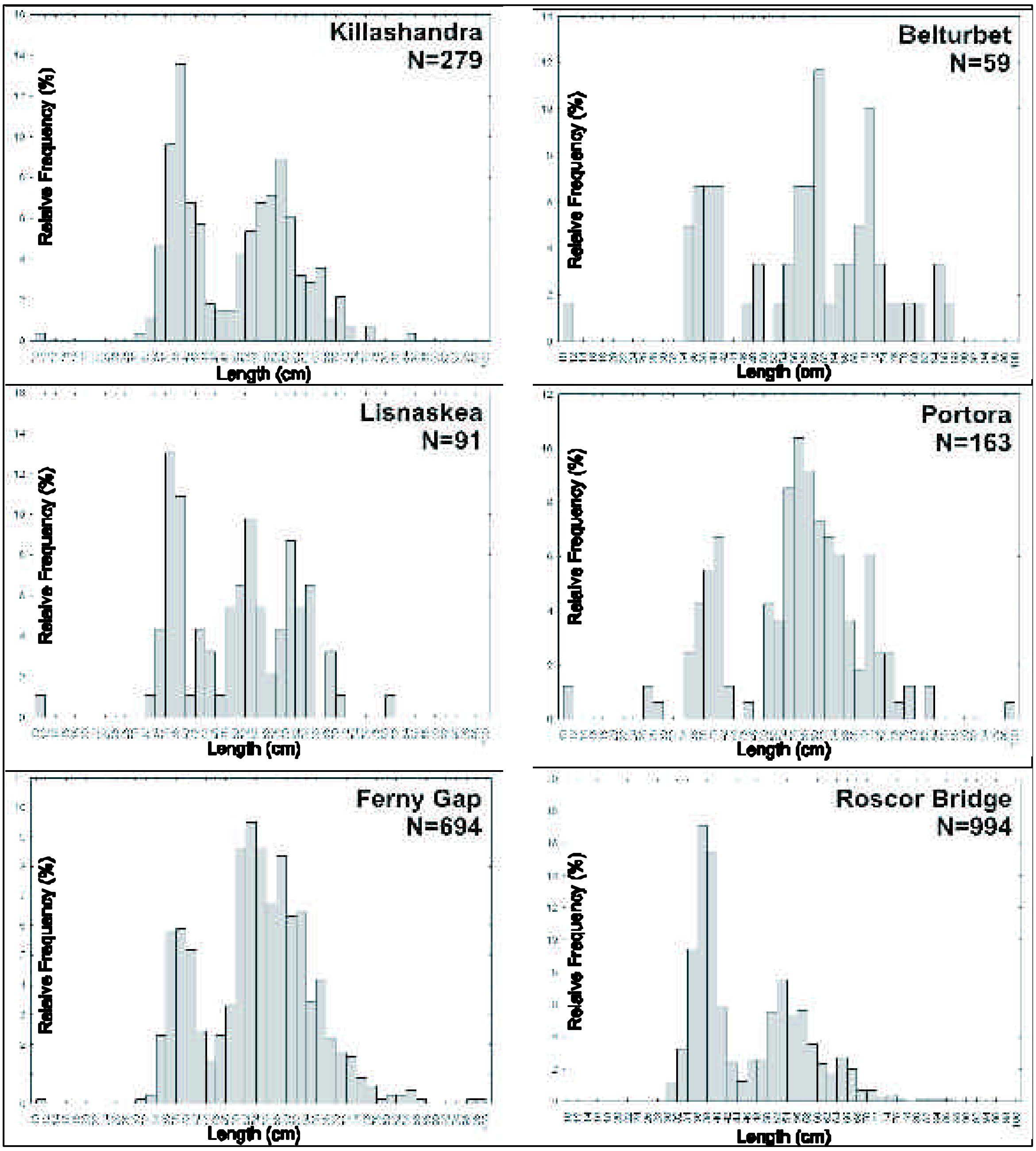


Figure 7-14: Size frequency distributions of silver eel, in 2011/2012.

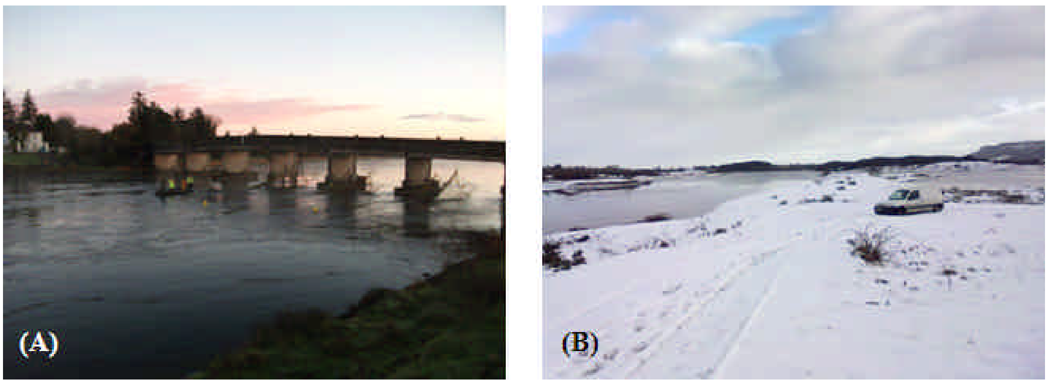


Figure 7-15: (A) Roscor Bridge experimental fishing weir, monitored by the NUIG, in 2010/2011 and 2011/2012, (B) Roscor Point, site used for Lower River Erne DIDSONÔ acoustic camera monitoring of silver eel population dynamics (2009-2012).

The seasonal pattern of silver eel migration varied between sites and between years with earlier catch levels being relatively higher in the upper catchment fishing sites. Effects of environmental factors, such as river discharge/lake level and lunar periodicity were evident at all sites. An example of catch data reflecting these factors is provided in Figure 7.16. Differences between years were also noted and, for example, whereas the catch patterns at the lower Erne sites in 2010/2011 more (76%) of the catch was made in a single lunar dark period in early November, the catch was more evenly distributed between the two main lunar dark fishing periods of the season in 2009/2010 and 2011/2012.

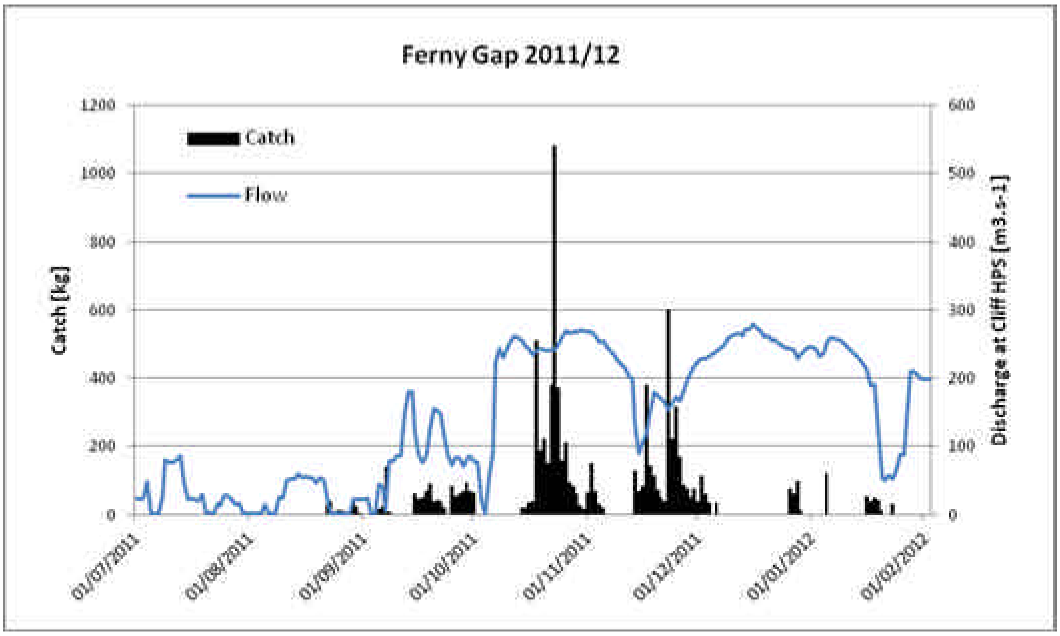


Figure 7-16: Seasonal variation in silver eel catch at the Lower Lough Erne (Ferny Gap) fishing site in relation to lake outlet discharge.

The determination of escapement with any degree of certainty from the River Erne has only been possible for two seasons (2010/2011 and 2011/2012), though attempts have been made to use historical time series of declared silver eel catches for the system. The data presented in the EMP suggests levels of eel catches in the Lower Erne, (N.I.) area may have been lower in the 1990's than at present although non-reporting of catch was a problem at the time. McCarthy *et al.* (2010) reported on records for one year (1999) in respect of the Lower River Erne silver eel fishery. The catch pattern at Roscor Bridge, with lunar cycle and discharge strongly affecting the seasonal pattern, was similar in 1999 to observations made in 2010-2012. It was not possible to accurately determine escapement to sea for 1999, by applying 2010-2012 mark/recapture efficiency to 1999 data for Roscor Bridge (Fig. 7.17) suggests that the escapement downstream of Belleek was then lower than current levels although the production was likely to have been comparable to current levels. Thus a significant improvement has occurred largely reflecting fishery closure and the development of the ESB Erne trap and transport programme.

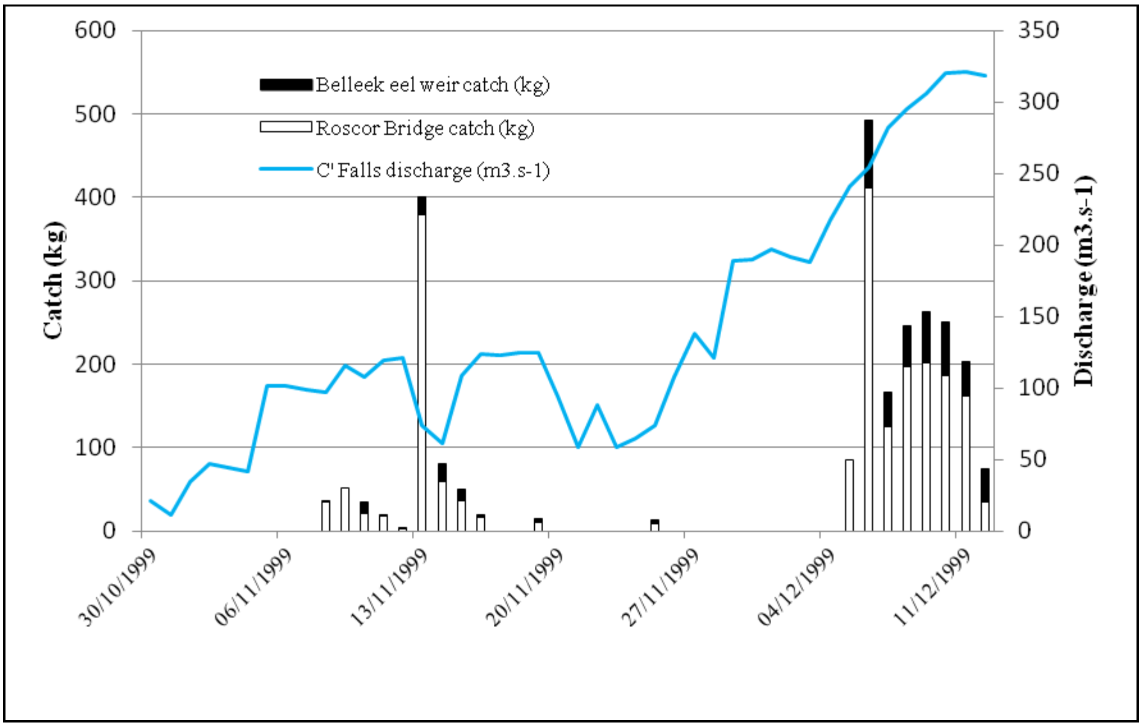


Figure 7-17: Roscor Bridge and Belleek weir silver eel catch records and Cathaleen's Fall discharge for the 1999/2000 fishing season.

Mark/Recapture experiments were undertaken at Roscor Bridge in 2010/2011. PIT tagged eels (N=395) were released in four batches during the fishing season, 400m upstream of the fishing site and a cumulative 17.8% recapture rate was recorded. It was intended to use FLOY tags as well. However, initial observations on FLOY tagged eels (N=200) resulted in difficulties in tag recovery with many tags observed becoming detached in the long coghill nets being used. For this reason, only PIT tags were used at this site in 2011/2012, when a total of 600 PIT tagged eels (3 x batches of 200) were used in fishing weir experiments. In that season a higher overall recapture rate of 20.2% was recorded, which reflected improvements to the fishing weir net deployment protocols.

During 2010/2011 an experimental fishery weir was operated at Roscor Bridge. NUIG directed the operation of the fishing weir and were present at all net settings and liftings and the entire catch was observed. Large numbers of eels (N=1,594) were individually measured. Additional morphometric parameters (length, weight, eye diameter, pectoral fin length, colour, cloacal aperture appearance) were recorded for representative samples and spawner quality was also investigated with respect to body fat levels and *Anguillicoloides crassus* burdens (see McCarthy *et al*. 2010, 2011, 2012). Eel size frequency data and monitored catch records were used, along with data from other sites, in estimation of silver eel production and escapement. In 2011/2012 the site was operated by a commercial crew but they were again closely monitored by NUIG and the site was fished even more efficiently (additional fishing effort, improved net attachment). Scientific protocols were similar to those adopted in 2010/2011.

The Lower Lough Erne outlet site (Ferny Gap) was monitored during 2010-2012. Preliminary observations in 2009/2010 suggested it was not possible to effectively undertake mark/recapture experimental analysis of the silver eel population at this site. The complex net array (Fig. 7.18), and the variation in number of nets fished, made it difficult to analyse the population dynamics but close monitoring at the site was considered important for interpretation of Roscor Bridge results. Differences in size selectivity of nets and of catch patterns, in relation to lake water level/outlet discharge rates were recorded for the Lower Lough Erne outlet site. If it is assumed that the fishing operations in the Lower Erne area were operated with efficiencies similar to those of 2009-2012 during 1999, then some indication of pre-EMP escapement from the River Erne is possible. Estimation of 1999 production levels is not possible, because of unreliable fishing data elsewhere in the system. For example, using the data (Fig. 7.17) presented by McCarthy *et al.* 2010, and 2010/2011 Roscor Bridge efficiency (17.8%) it is possible to calculate the escapement downstream from Belleek. Furthermore, if 2009-2012 mortality rates 7.9% (N=101) in respect of Cliff HPS and 2010-2012 mortality rates 13.3% (N=75) in respect of Cathaleen's Fall HPS are applied to the estimated downstream migratory population the spawner biomass escapement was 7,793kg or 0.297kg·ha. This extremely low escapement is presumed to reflect high fishing pressure and the absence of any trap and transport mitigation measure at that time. The status of the overall River Erne eel stock at the time may also have been a contributing factor.

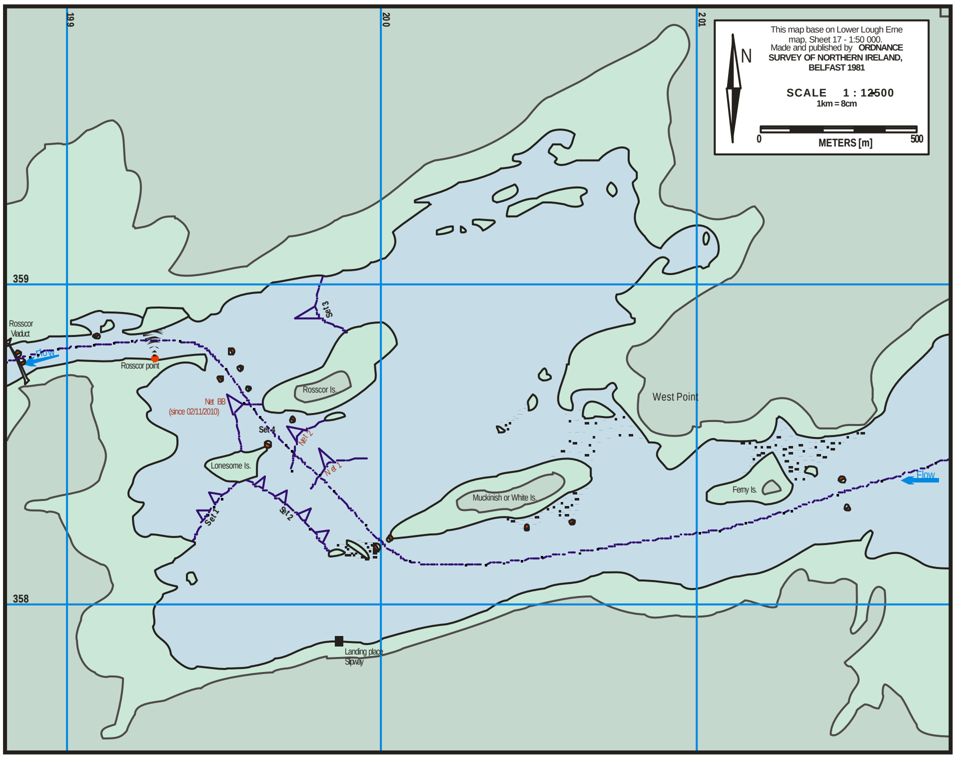


Figure 7-18: The Lower Lough Erne (Ferny Gap) fishing site, showing net locations (October 2010) and position relative to Roscor Point and the experimental fishing weir at Roscor Bridge.

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. 7.19) 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. Further telemetry, proposed for 2012/2013 will also be combined with use of other field survey techniques. 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.

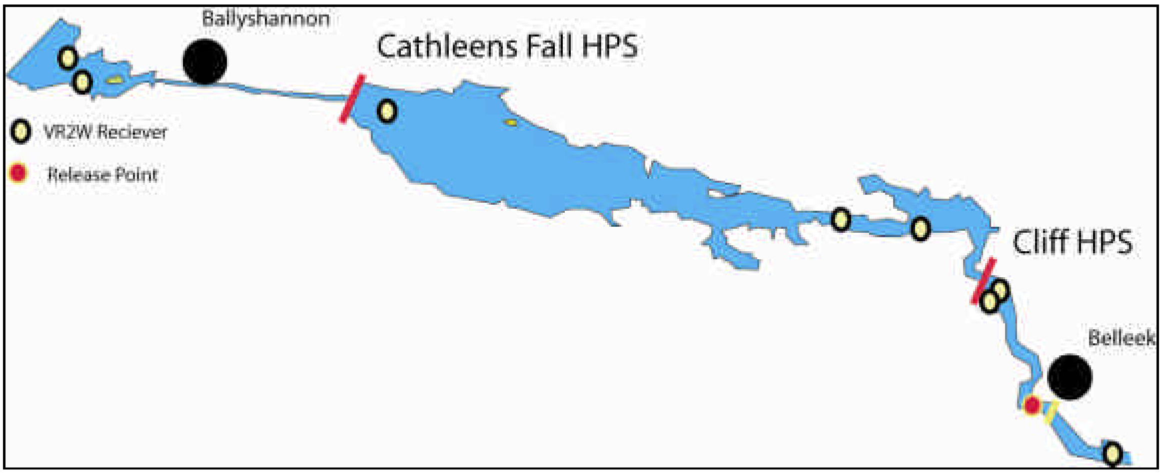


Figure 7-19: Location of telemetry receivers to track silver eels in the Lower River Erne area (2009-2012).

DIDSON™ camera observations (N=35) of silver eel migrations were undertaken at Roscor Point (Fig. 7.4B) on the lower river Erne in 2009-2012. Initially, in 2009/2010 limited use was made of the equipment, following difficulties in establishment of an experimental fishery at Roscor Bridge for that season. Protocols for fishery independent quantitative surveys were developed and these were successfully used in both the 2010/2011 and 2011/2012 silver eel migration seasons. The accuracy of the fishery independent surveys was confirmed by reference to catches at the experimental silver eel fishing site at Roscor Bridge (Fig. 7.15A). A highly significant correlation ($P<0.01$) (Fig. 7.20) was observed between the population estimates obtained using the DIDSON™ camera and the corresponding monitored catches at Roscor Bridge (N=21). The DIDSON™ survey technique was also used to investigate nocturnal activity patterns and to observe effects of changes in discharge patterns of silver eel migration. The DIDSON™ observations revealed that in low discharge conditions ($<150m^{3.s-1}$), small but collectively significant quantities of eels were migrating downstream and that during such conditions the fishing efficiency of the Roscor Bridge experimental weir was low (4.43%). However, it was possible to take account of these heretofore unobserved low level migrations in determination of silver eel production and spawner biomass escapement for the River Erne system. The DIDSON™ survey protocols have been detailed elsewhere (McCarthy *et al.* 2010, 2011, 2012). The DIDSON™ camera was deployed, from late afternoon to mid-morning, at right angles to the river channel at Roscor Point and during the 2009-2012 studies the DIDSON™ cone of observation involved on average 18.1% of the river cross sectional area being monitored.

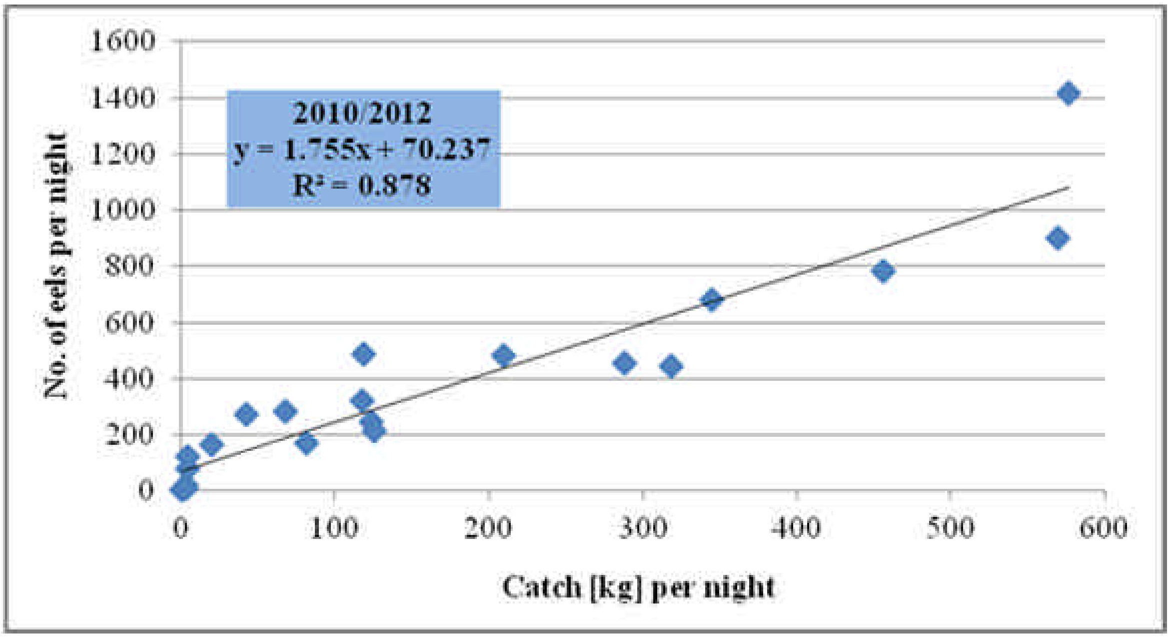


Figure 7-20: The relationship between DIDSONÔ survey of biomass estimates (N=21) of nightly silver eels migrating downstream from Roscor Point and the corresponding catches at Roscor Bridge (observed by NUIG) in 2010/11 and 2011/12 combined.

7.3.3 Erne Production and Escapement

7.3.3.1 Historic

A full description of how the historic production of the Erne catchment was determined in 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 107,474kg (Table 8.1).

7.3.3.2 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 8.1) using 7.7% (Cliff HPS) and 6.9% (One turbine at Cathaleens Fall HPS) turbine mortality (average 2010-2011).

7.3.3.3 Current 2009-2011

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; Figs. 7.21 & 7.22). In 2010/2011 the silver eel production was estimated to have been 41.23t or 1.57kg·ha. In the following year, 2011/2012, similar results were obtained and silver eel production was estimated to be 42.71t or 1.63kg·ha. The corresponding estimates of spawner biomass escapement were 37.94t or 1.45kg·ha in 2010/2011 and 39.86t or 1.52kg·ha, in 2011/2012.

In 2009/2010, direct observation of silver eel production and spawner biomass escapement was not possible, though provisional estimates were discussed (McCarthy *et al.* 2011). However, catch data were available for the Lower Lough Erne outlet site (Ferny Gap) for the full season and because in the successive two seasons a relatively constant ratio (0.44871 in 2010/2011; 0.4375 in 2011/2012; mean=0.4435) was observed between seasonal catches at that site and the spawner biomass estimated to have migrated downstream from Roscor Bridge (Figs. 7.21 & 7.22) to the hydropower regulated section of the river. Therefore, on the assumption that 2009/2010 migration patterns were similar to those in the two succeeding years; it was possible to estimate the spawner biomass escapement for 2009/2010. It was not possible to estimate silver eel production for 2009/2010 due to lack of reliable fishing records for the area upstream of the Ferny Gap site. Using the available information, and assuming that 7.9% mortality (mean value for 2009-2012) occurred at Cliff HPS and 13.3% (provisional estimate for 2010/2011 and 2011/2012) for Cathaleen's Fall HPS, it was calculated that escapement from the Erne was 26.20t or 1.00kg·ha, in 2009-2010. If a higher mortality rate (22%) is assumed to have occurred at Cathaleen's Fall HPS that season, then the corresponding calculations indicate a 25.12t, or 0.96kg·ha escapement.

Given the relatively high level of recruitment in the mid 1990s to the early 2000s in the Erne system (~235 recruits/ha yielding 1.6 kg/ha silver eel), comparisons with other river systems (e..g. Shannon ~64 recruits/ha yielding 1.7 kg/ha silver eel), and the relatively high yellow eel stocks in much of the Erne system, the estimates of current silver eel production in the Erne seem low. This may be due to unexplained differences in productivity and recruitment, higher than previously thought undeclared commercial yellow eel fishing, an under-estimate of current production (less likely given there are three independently derived estimates) or a combination of these factors. SSCE advises that further work is required to clarify this.

The data for the Erne Catchment are presented on the modified ICES precautionary diagram as developed by the WGEEL using the EU management target (40% SSB) as the reference point and a calculated mortality reference point based on the EU management target (Alim 0.92) (Fig. 7.23) and the average for 2009-2011 is presented on Figure 7.23. The revised Bo and a recalculated 2008 figure using the turbine mortality estimates determined between 2009 and 2011 (Table 2.2) were used in these diagrams.

The almost vertical direction of the bubbles was surprising and go towards supporting the notion that somewhere in the Erne data there is a discrepancy as mentioned above. It is quite likely to be related to the 2008 estimate of escapement (Average 2001-2007) given the paucity of reported catch data for the catchment. If the escapement below Beleek for 1999 (discussed earlier in this section) is inserted instead of the 2008 figure the plot looks very different (Fig. 7.24). A higher than previously thought rate of yellow eel exploitation in the catchment prior to its closure would have the effect of increasing the mortality rate and lowering the escapement as demonstrated in this example.

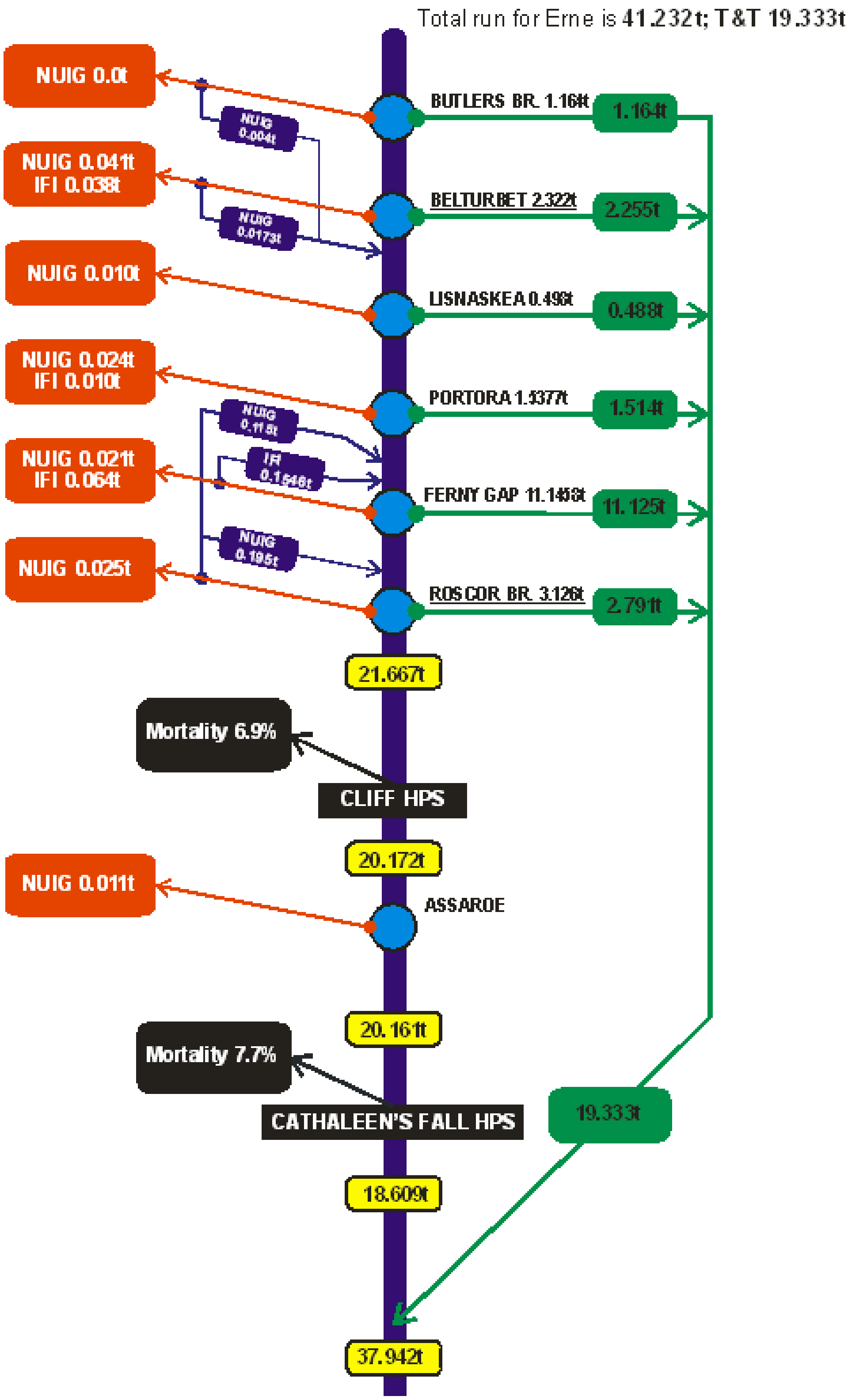


Figure 7-21: A summary of the NUIG analysis of 2010/2011 silver eel production, trap and transported eels and spawner biomass escapement on the River Erne.

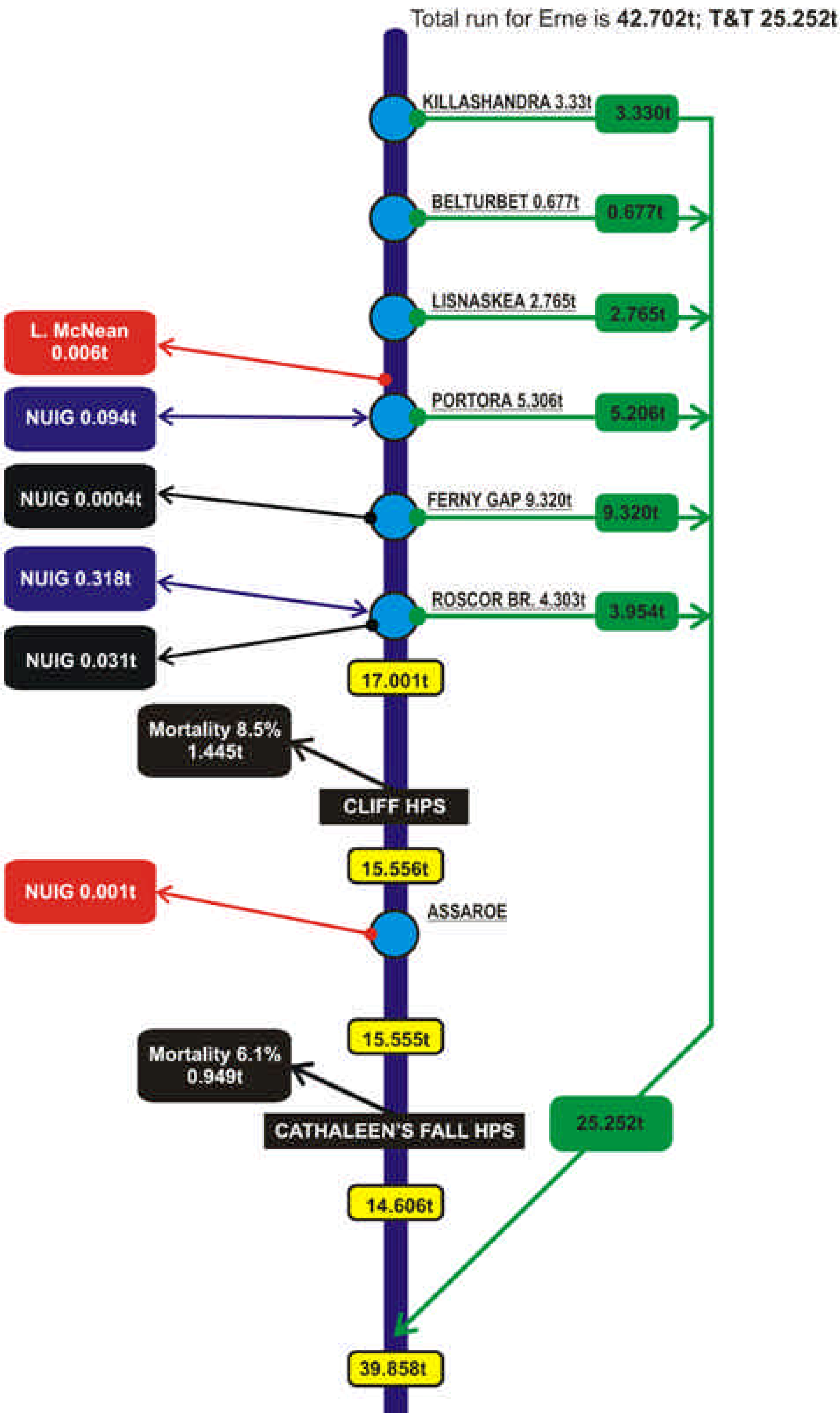


Figure 7-22: A summary of the NUIG analysis of 2011/2012 silver eel production, trap and transported eels and spawner biomass escapement on the River Erne.

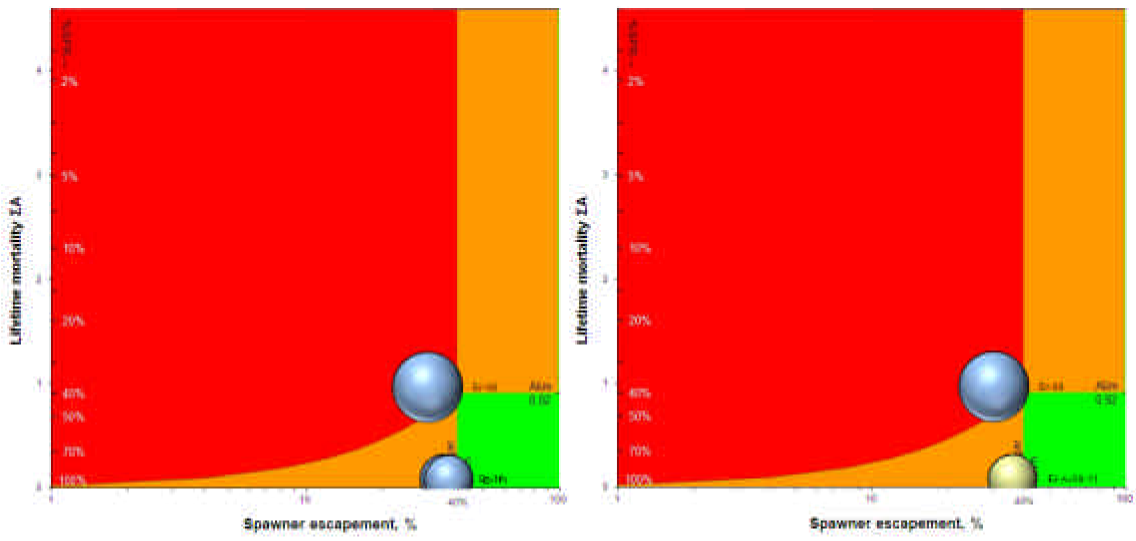


Figure 7-23: Status of the stock and the anthropogenic impacts, for the <u>Erne</u> as presented in the Eel Management Plans in 2008 (average 2001-2007) and for the 2010 and 2011 in the left plot and the average for 2010/2011 in the right plot. For each, the size of the bubble is proportional to B_{best}, 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.

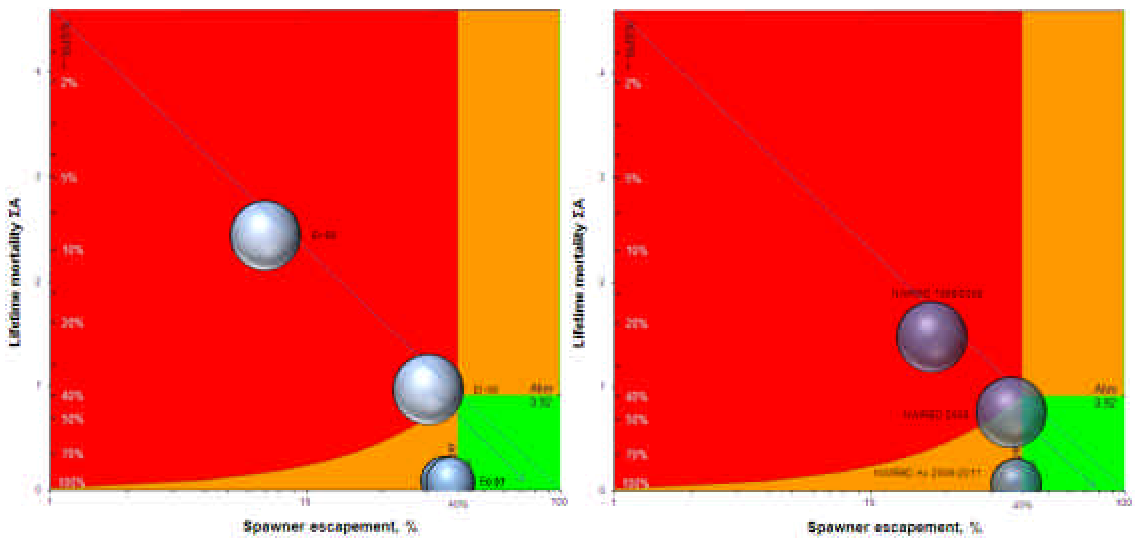


Figure 7-24: Stock status diagrams for the Erne (left) and the NWIRBD (right) with the 1999 escapement estimate inserted along with the EMP 2008 (average 2001-2007). The top bubble in each plot is higher up and further to the left compared to the 2008 data as shown in Figure 7.23 and Figure 8.3. This would indicate that there may have been higher fishing mortality and lower escapement than previously thought.

7.3.4 Future silver eel production in the Erne

7.3.4.1 Input – Output analysis (analysis 1)

Following commercial fishery closure on the Erne lakes and commencement of trap and transport fishery for silver eel, a predictive estimate of silver eel run is needed to inform planning of future T&T or other options for hydro-power mortality mitigation. An Excel spreadsheet predictive calculation tool has been built to address this need.

The starting point for the analysis is the time series of recruitment data. This calculates forward to outputs of male and female silver eel, which can then be used to generate tonnage output estimates. The key use of such a model is to test scenarios of changing variables. This can be done to "tune" the model to actual estimates. The output model in scenario 5 below, sets parameters which give the current production estimate and projects forwards to predict outcomes to 2018.

7.3.4.2 Input parameters

These are:

1. The recruitment time series in Kg of glass eel annually
2. Number of glass eel per Kg
3. The effective productive area of the system (Adjustable manually)
4. Density dependent individual lifetime survival relationship (based on that measured in Lough Neagh)
5. Density dependent sex determination (initially, a linear relationship from 5% female at 950 Glass eel per hectare to 5% male at 50 Glass eel per hectare. These extremes are based on Lough Neagh Historical time series data, and there is insufficient data in between to apply anything other than a linear relationship
6. Age related annual natural mortality profiled over the freshwater Lifespan (20 years)
7. Age related annual Fishing mortality profiled from 12 years (assumed equivalent to first reaching marketable size of 40 cm) to 20 years,
8. Cumulative age related emigration rates of silver eels. Males are assumed to emigrate from 8 years to 12 years, and females from 15 to 20 years. The profiles of migration used below are based on approximations to EEEP 1998 to 2000 and additional 2010-11 ages determined from samples of Erne Silver eels.
9. Weight of average male and female silver eel

7.3.4.3 Model Outputs

The Model Outputs with different combinations of Fishing and Natural Mortality assumptions are shown below. Five scenarios of output prediction are presented below, with different assumed mortality regimes. In these calculations, set parameters were:

1. Recruitment history: Known Erne Elver/Glass eel lift in Kg
2. 3000 glass eel per Kg
3. Effective production area of 20,000 Ha (this more than discounts the 2500 Ha of deep water >15m in Lower Lough Erne , and has the effect of increasing the density dependent mortality and male generation parameters)

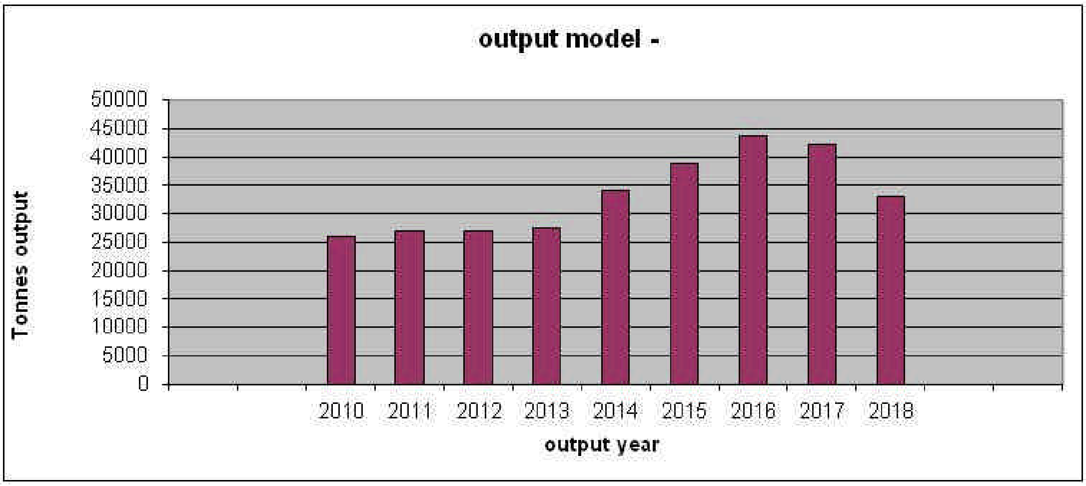
4. Density dependent individual survival as from Lough Neagh
5. Density dependent sex determination as above $Survival = 0.6211e^{-.0027*\text{density in kg/ha}}$
6. Natural mortality profile: High medium or Low: See table Below
7. Fishing mortality profile: High or Low: See table below
8. Age related emigration:

   Males from 8,9,10,11 and 12 years at 10, 25, 50, 75, and 100% cumulative respectively, Females from 15,16,17,18.19 and 20 years at 5,15,50,80,95 and 100 % cumulative respectively
9. Erne male silver eel average Wt 112 g, Female silver eel average Wt 400g (EEEP data)

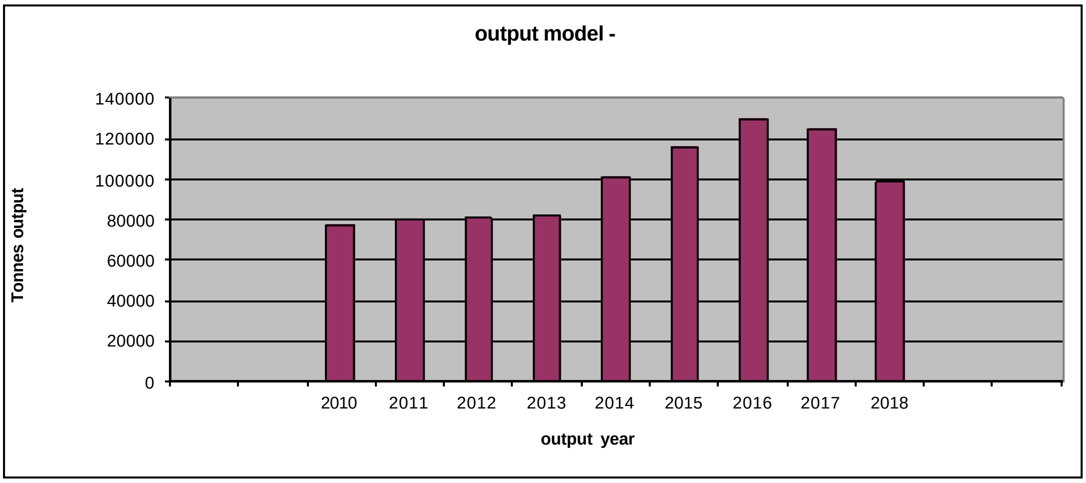
Table 1: Mortalities in annual % values

Year of life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
M - High	70	30	15	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
M - Med	50	30	15	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
M- Low	30	20	10	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
F - High	0	0	0	0	0	0	0	0	0	0	0	25	30	30	30	25	25	20	10	5
F - Low	0	0	0	0	0	0	0	0	0	0	0	5	15	20	20	20	15	10	7	5

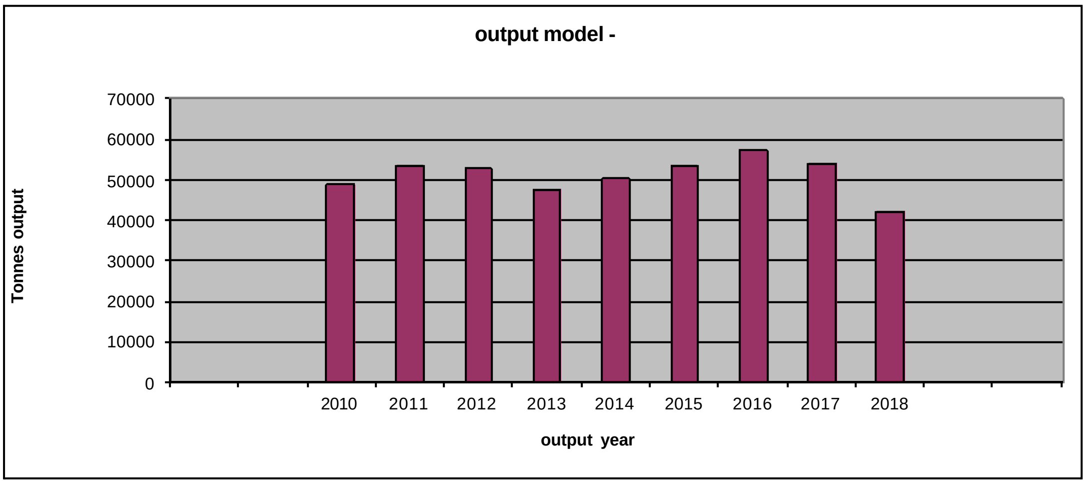
Example run 1: High F, High M



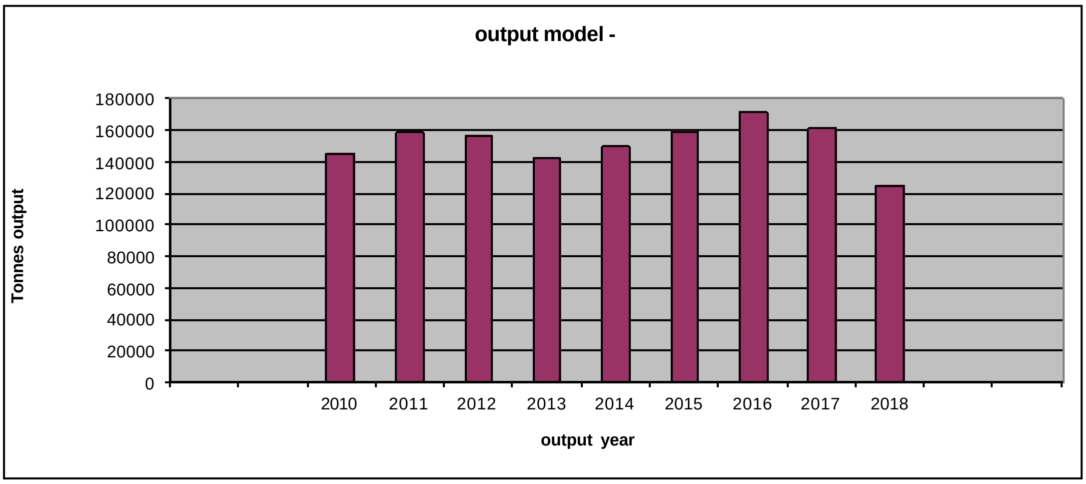
Example Run 2: High F, Low M



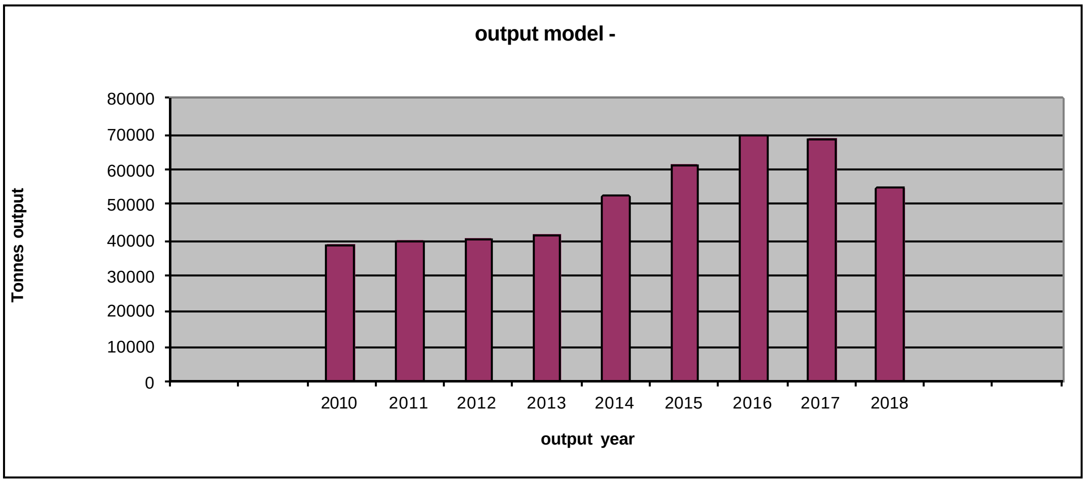
Example Run 3: Low F, High M



Example Run 4: Low F, Low M



Example Run 5: High F, Med M



7.3.4.4 Recruitment to silver-eel analysis (analysis 2)

A second analysis was carried out using the following inputs. This followed the sequence of using the recruitment converted to numbers, applying a sex ratio split and then for each sex applying natural mortality. Following that the numbers of eels were converted to biomass, summed for the two sexes and then the silver eel equivalents for the yellow eel catch were deducted leaving the silver escapement without turbine mortality.

7.3.4.5 Input parameters

0. The recruitment time series in Kg of glass eel and elver annually
1. Number of glass eel (av. wt 0.4gm) and elver (av. wt 0.25gm)
2. The effective productive area of the system (Adjustable manually) 25960ha
3. Density dependent lifetime survival relationship for each sex (based on Bevaqua et al 2010)

   And the following parameters: male, med. Density, growth 3.3, age 10.1, temp 11degC

   Female. Med. Density, growth 3.12, age 18.1, temp 11degC

   Proportion of males surviving to silver: 0.12023

   Proportion of females surviving to silver: 0.02743
4. Density dependent sex determination (initially, a linear relationship from 5% female at 950 Glass eel per hectare to 5% male at 50 Glass eel per hectare. These extremes are based on Lough Neagh Historical time series data, and there is insufficient data in between to apply anything other than a linear relationship
5. Age related annual natural mortality profiled over the freshwater Lifespan (10.1years male; 18.1 years female)
6. Age related annual fishing mortality profiled over an eight year period converted to silver eel equivalents on a wt for wt basis, Catch of 46790kg pre-2009 and 10000kg 2009/2010
7. Age related emigration rates of silver eels. Males are assumed to emigrate from 5 years to 16 years, and females from 9 to 26 years. The profiles of migration used below are based on approximations to EEEP 1998 to 2000.
8. Weight of average male (114g) and female (679.5g) silver eel
9. To allow the model to run forwards, recruitment was applied in future years on the basis of repeating the 2007-2011 data, every five years and assuming no recovery.

7.3.4.6 Output

The output from the analysis is presented in Figure 7.25. This is the amount of silver eel produced after the yellow eel fishery has been taken into account. Production of silvers was low in the late 1990s rising to a peak in the mid-2000s before falling back from 2008 to 2011. It is anticipated that silver eel production will rise again over the 2013 to 2018 period before falling due to the lack of recruitment. No effect of density dependence has been accounted for during the 2018 period onwards.

The analysis was particularly sensitive, in the calculation of natural mortality, to the selection of perceived density, and to the temperature. The values selected were the closest to the natural conditions over the period. Therefore the absolute values are less important at this stage but the trends remain the similar regardless of natural mortality parameters.

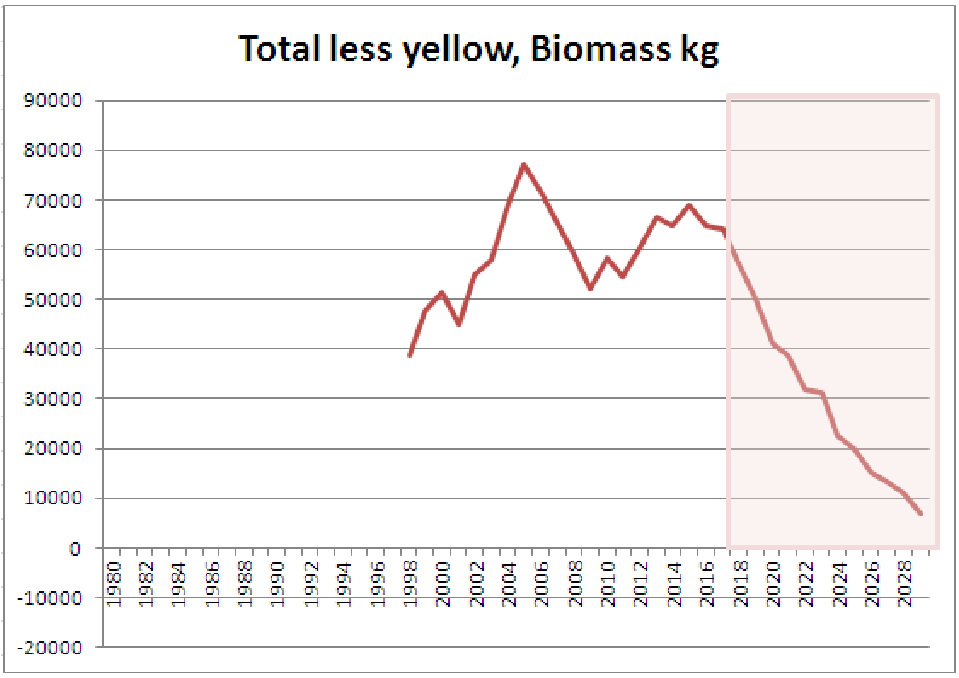


Figure 7-25: Analysis of recruitment input to silver eel escapement for the Erne, less the yellow eel catch. The shaded are is for production influenced by future recruitment assumed to be similar to the 2007-2011 period with no recovery.

7.3.4.7 Conclusions

The particular focus on the Analysis 1 scenarios to date is to try and explain what appears to be a lower than expected productivity from the Erne system, and the emerging possibility that fishing prior to 2010 may have had a much greater impact than previously assumed. To get the model to generate the apparently low level of current estimates of production, high fishing and/or natural mortality parameters have to be used. The outcomes depend critically on the assumed balance between natural and (historical) fishing mortality. Using High natural mortality parameters relative to fishing mortality parameters creates a relatively flat projection of outputs, but still at significant levels, to 2017. The use of high fishing mortality parameters with medium natural mortality tunes the model outputs to match current production estimates and has significant implications for what happens to the remainder of the cohorts of good recruitment in 1990 to 2001 As these are progressively free of fishing mortality, there is the likelihood of more of them contributing to silver than before. All runs with low natural mortality generate projected outputs higher that currently estimated.

In summary, all the model scenario results indicate that a major fall off in Erne silver eel runs is not to be expected until 2018. Furthermore, if one assumes that high undeclared fishing prior to 2010 is a significant contributor to unexpectedly low measured production, then it follows that silver eel runs should increase to 2017 (See analysis 1 - model scenario 5 above, which comes closest to current measures of production 2010 and 2011). This scenario, as a minimum scenario, should therefore be planned for in future silver eel mortality mitigation efforts. Analysis 2 also demonstrates an expected increase in silver eel production over the next 5-6 years followed by a severe drop-off.

7.4 Burrishoole

7.4.1 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. 7.26). The catchment has never been commercially fished for yellow eels and there are no hydropower turbines.

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

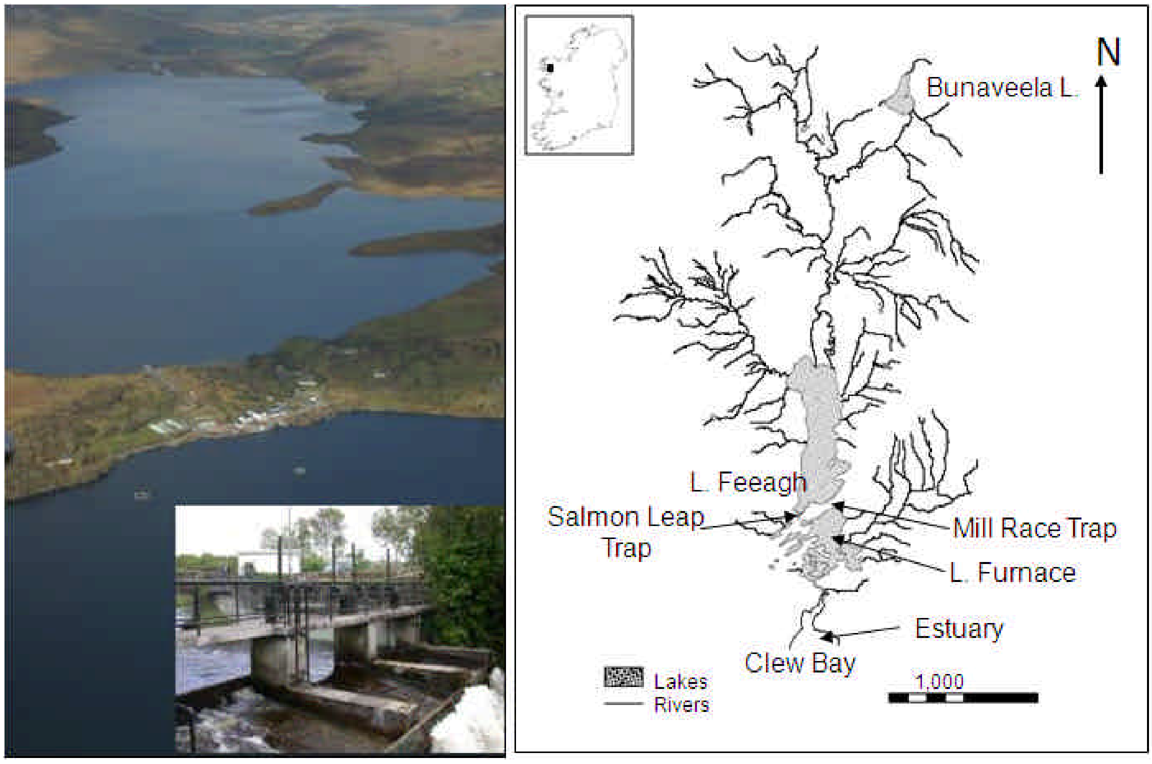


Figure 7-26: An aerial view of the Burrishoole catchment, looking north over the tidal Lough Furnace, in the foreground, and the freshwater Lough Feeagh: inset shows the silver eel downstream trap at the "Salmon Leap". A map of the Burrishoole catchment showing the locations of the silver eel traps at the lower end of the freshwater catchment.

7.4.2 Burrishoole 2009-2011

Trapping in Burrishoole was continued for the period 2009 to 2011. In 2009, the main run occurred in August, September and October (Fig. 7.27). The run dropped off in November and only six eels were recorded in December. The main runs of eels were closely related to increases in level. In 2010, the main run occurred in September, October and November (Fig. 7.27). The run dropped off in November and only four eels were recorded in December probably due to very low water temperatures. Few eels were recorded in January to March after water temperature increased. In 2011, the run occurred in September and October (Fig. 7.27). Half of the run was complete by the end of September and the run dropped off in November with only eleven eels recorded in December. The total run in 2011 amounted to 1969 eels, the lowest recorded in the last 25 years.

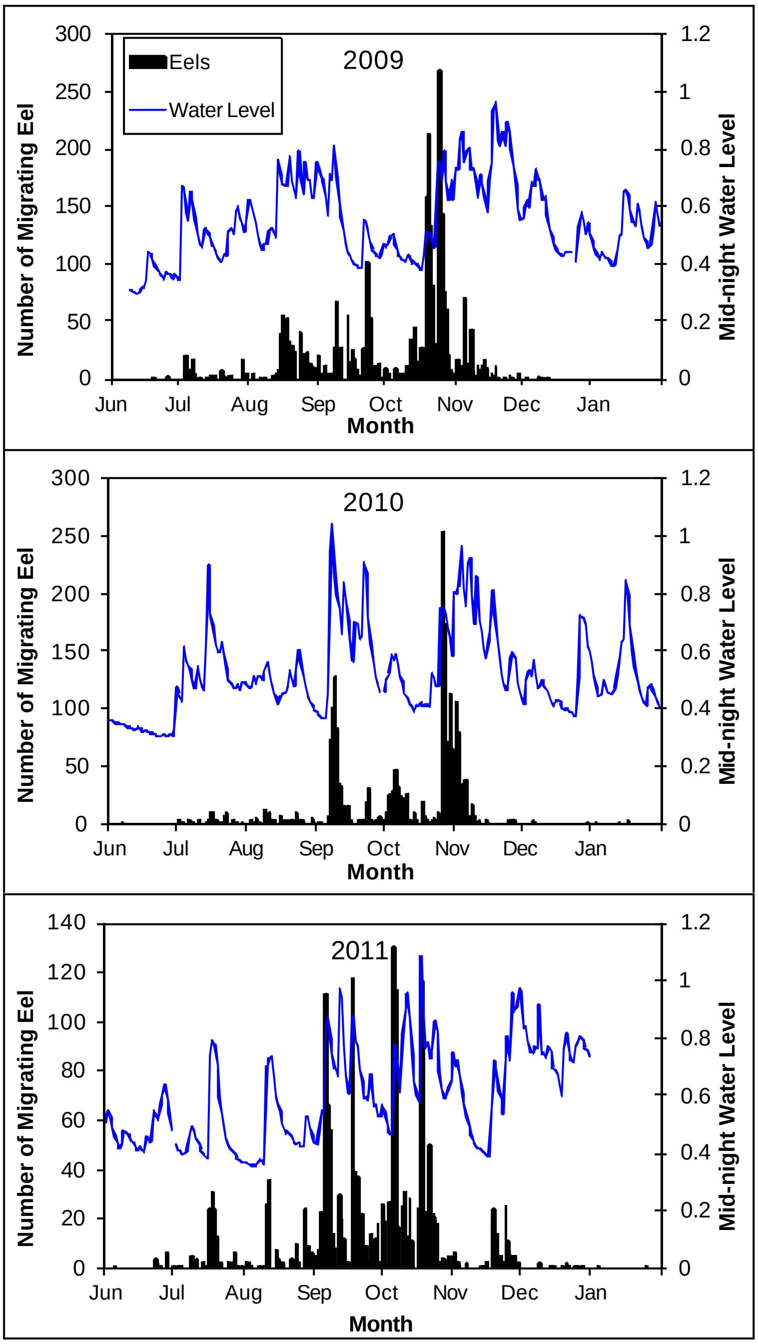


Figure 7-27: Daily counts on the Burrishoole of downstream migrating silver eel and mid-night water levels (m) for 2009 - 2011.

7.4.3 Burrishoole Annual Escapement

The number of silver eels counted migrating downstream in Burrishoole is presented in Figure 7.28. Catches of silver eel between the years 1971 (when full escapement records began) and 1982 averaged 4,452, fell to 2,064 between 1983 and 1989 and increased again to above 3,000 in the '90s.

There was an above average catch in 1995, possibly contributed to by the exceptionally warm summer. The numbers in the last three years (2009-2011) were 2879, 2136 and 1969 eels.

The average weight of the eels in the samples has been steadily increasing from 95 g in the early 1970s to 216 g in both the 1990s and the 2000s (Fig. 7.28). The annual count and average weight in 2010 and 2011 were both below the mean for the last decade.

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

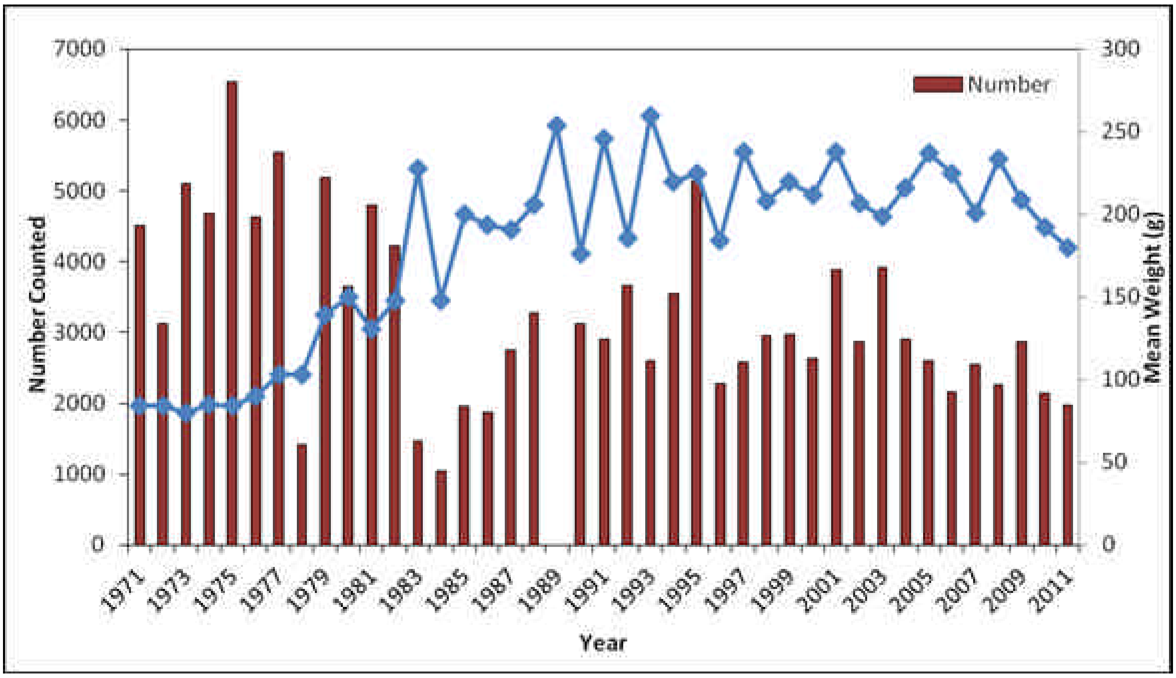


Figure 7-28: Annual number and mean weight (g) of silver eels trapped in the downstream traps.

7.4.4 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 8.1. There was no fishery in the Burrishoole over the period 1955-2011 and the effort has not changed over the monitoring period.

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

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

Current production and escapement ($B_{2009\text{-}2011}$) was on average 0.96kg/ha or 455kg.

The data for Burrishoole are presented on the modified ICES precautionary diagram as developed by the WGEEL using the EU target (40% SSB) as the reference point and a calculated mortality reference point based on the EU target (Alim 0.92) (Figure 7.29). 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.

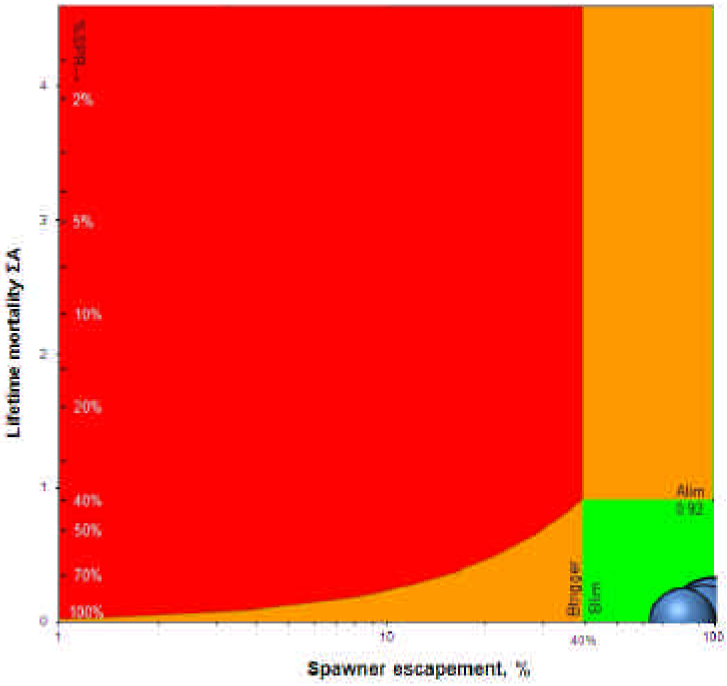


Figure 7-29: Status of the stock and the anthropogenic impacts, for the <u>Burrishoole</u> as presented in the Eel Management Plans in 2008 (average 2001-2007) and for the current three years. For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement given the 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.

7.5 Corrib

7.5.1 Introduction

The Corrib catchment is ranked as number 3 in the country in terms of eel productivity with an estimated eel historic "pristine" productivity of 102,968kg. It is a large system with a high proportion of wetted area tied up in productive lakes. The total wetted area is 28,869 ha split between 4 large lakes, Upper and Lower Lough Corrib (17,000 ha), Lough Mask (8,000 ha) and Lough Carra (1,500 ha).

The Galway Fishery at the seaward end of the Corrib Catchment in the Western RBD (Fig. 7.30) comprises a weir with 14 coghill nets. These are fished throughout the dark moon phases and may be lifted during periods of very high water. The Galway fishery was purchased by the state in 1978 and has been fished continually since then.

In 2009, the Irish commercial fishery was closed and the Galway Weir was fished as a research catch and release fishery for scientific purposes. Due to structural defects, the fishery was not fished in 2010 or 2011.

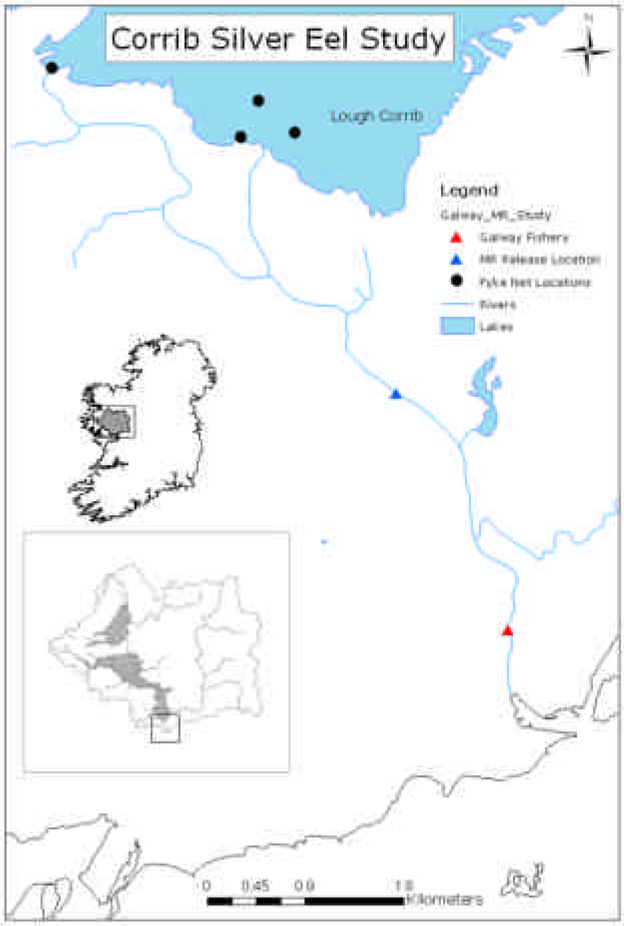


Figure 7-30: Map of the Corrib Catchment, Western RBD and the locations of the Galway Fishery and sampling locations.

7.5.2 Corrib Annual Escapement

The Galway Fishery silver eel weir was operated in 2009 as a scientific silver eel fishery by the Western Regional Fisheries Board and fished in a similar fashion to the previous commercial fishery although the catch was released downstream. Figure 7.31 presents the total annual catches since 1976. There was a maximum catch of 31,300kg recorded in 1982 and a minimum of 4,070kg in 1996.

A total catch of 12,650kg of silver eels were caught from the 17th October to the 18th November 2009 with an average weight per night between 0.026kgs and 0.039kgs (Fig. 7.32). This was the highest catch recorded for the Galway eel weir since 1990 when 12,600kg of silvers were caught (Fig. 7.31). The increase in catch in 2009 was probably contributed to by the cessation of yellow and silver eel fishing in the Corrib Catchment upstream of the Galway Fishery (reported average of 7,200kg for 2001-2007).

There appears to be a shift in the sex ratio of silver eels sampled from the Galway fishery from the late 1970's to present (Table 7.2). The proportion of male eels in the catch has declined (Fig. 7.33). It should be noted that the timing of samples can influence the results due to differential run timing between the sexes. As observed in the Burrishoole, this reduction in the proportion of males and increase in the mean size of females may a density dependent response to decreasing recruitment.

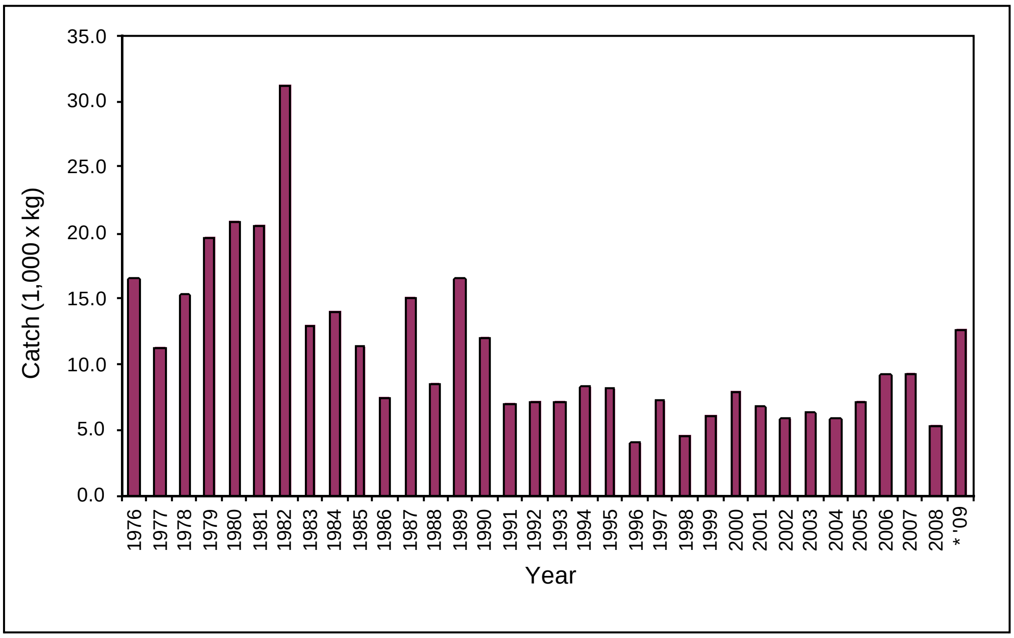


Figure 7-31: Annual commercial catch at the Galway Fishery 1976 – 2009. *Note: 2009 was a non-commercial fishery.

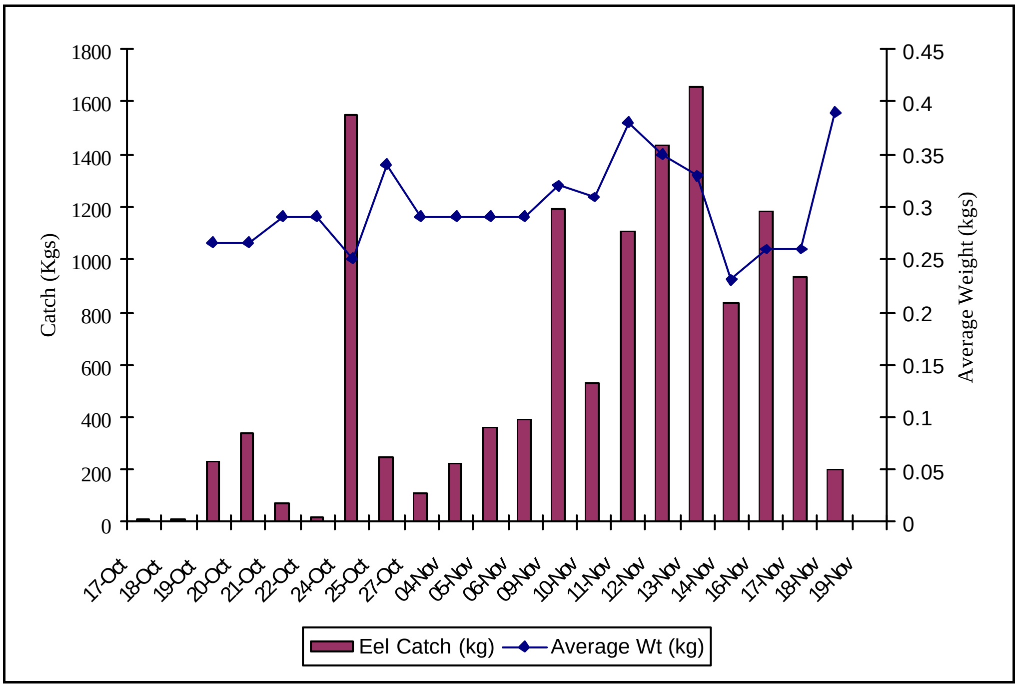


Figure 7-32: Galway fishery silver eel catch (kgs) and average weight per silver eel (kgs) in 2009.

Table 7-2: Historical silver eel sex ratios for Galway fishery.

Year	Sex ratio (% Male)	No. Female eels	Av Length Female eel	No. Male eels	Av. Length Male eels
2009	18	434	56.3	98	37.4
2006	17	25	52.6	5	36.7
2005	50	191	54.8	191	37.9
1989	40	60	53.1	39	36.8
1986	44	298	54.8	232	37.1
1985	50	102	55.1	103	37.7
1983	82	50	49.1	234	37.2
1982	95?	14	49.9	322	36.0
1981	78	53	50.3	188	36.0
1979	84	63	48.5	347	35.7
1978	79	24	48.4	91	36.6

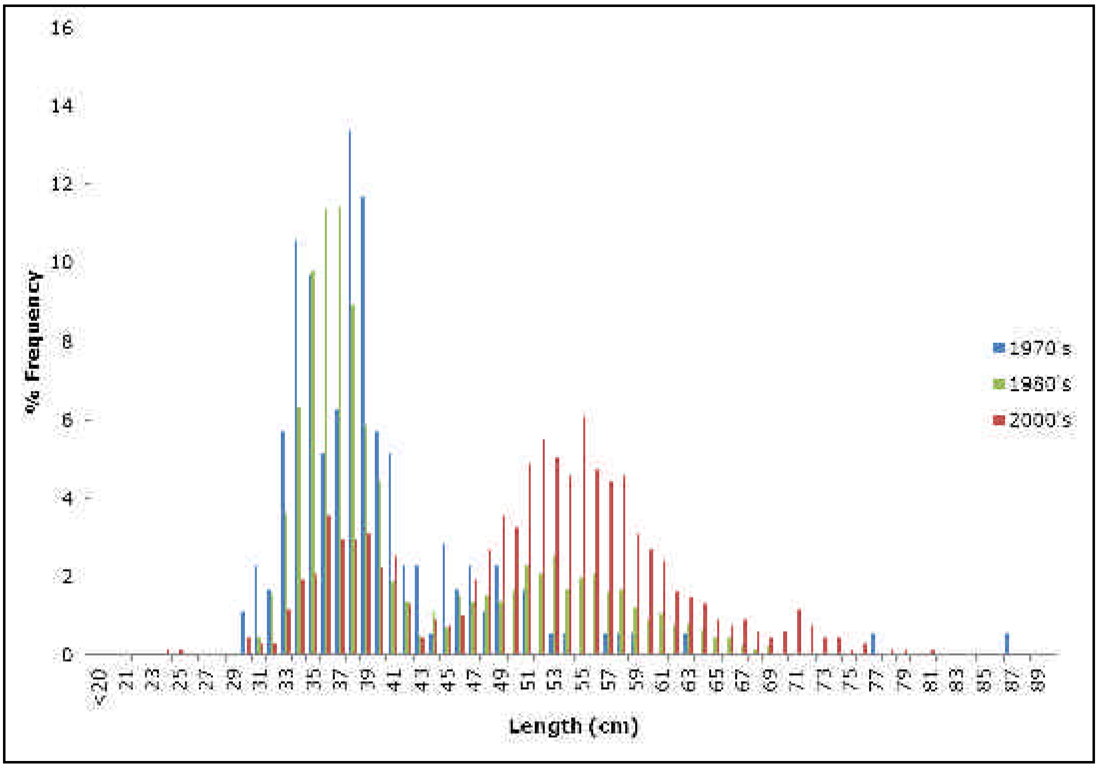


Figure 7-33: Length frequency (%) of historical silver eel data from Galway fishery.

7.5.3 Corrib Production and Escapement

7.5.3.1 Historic

A full description of how the historic production of the Corrib catchment was determined in described in Chapter 5.2.1.2 of the Irish EMP. This was based on the time series of silver eel catch (Fig. 7.31) from which the escapement was determined by mark-recapture (weir efficiency 35%). Added to the escapement were the yellow eel catch and other silver eel catches made in the catchment upstream of Galway. 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 1976-1982 was changed from 3.4kg/ha to 3.57kg/ha., or 103,062kg (Table 8.1).

7.5.3.2 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 1.7kg/ha or 48,455kg. Escapement ($B_{2001-2007}$) was estimated to be on average 13,371kg (Table 8.1).

7.5.3.3 Current 2009-2011

In 2009, to estimate the efficiency of the weir and the silver eel escapement, a Mark Recapture exercise was carried out at the Galway Fishery on two darks with 210 and 206 eels pit-tagged after capture at the eel weir and released approx 1km upstream of the fishery in the Corrib River in October and November respectively (Table 7.3).

The silver eel escapement was estimated by three different methods (Table 7.3). The most appropriate may be the third method.

1. The monthly recapture rate of tagged eels was applied to the nightly catch for the relevant month (36% for October and 34% for November).
2. The average of the two recapture rates was applied to each nightly catch (35%).
3. The average of the two recapture rates (35%) was applied to the total catch (12,650kg) for silver eel run.

Overall, the three methods give roughly the same estimate of 36,100kg or 1.3kg/ha of silver eels escaping from the Corrib catchment (Table 7.3) for 2009. The escapement (B_{2009}) was the same as the production (Bbest) as there were no commercial fisheries in 2009 (Table 8.1).

The data for the Corrib Catchment are presented on the modified ICES precautionary diagram as developed by the WGEEL using the EU management target (40% SSB) as the reference point and a calculated mortality reference point based on the EU management target (Alim 0.92) (Fig. 7.34). The bubble moved down and to the right reflecting the closure of the fishery and increased escapement.

Table 7-3: Silver eel Mark Recapture Surveys carried out in 2009 in the Galway Fishery.

	20/10/2009	11/11/2009
Tagged	210	206
Total Recaptured	79	70
Aug Dark	-	-
Sept Dark	-	-
Oct Dark	76	9
Nov Dark	-	61
Dec Dark	-	-
No. Sacrificed	53	58
Yellow Recaptures	3	0
% Recapture	36%	34%

Table 7-4: Estimated silver eel escapement for Corrib catchment.

	Mthly Recapture rate	Av recapture rate (35%)	Total Recapture 35%
Catch at weir (kg)	12,650	12,650	12,650
Escapement past weir (kg)	23,480	23,400	23,480
Total Silver produced (kg)	36,130	36,060	36,130
Numbers escaped	122,822	122,561	120,598

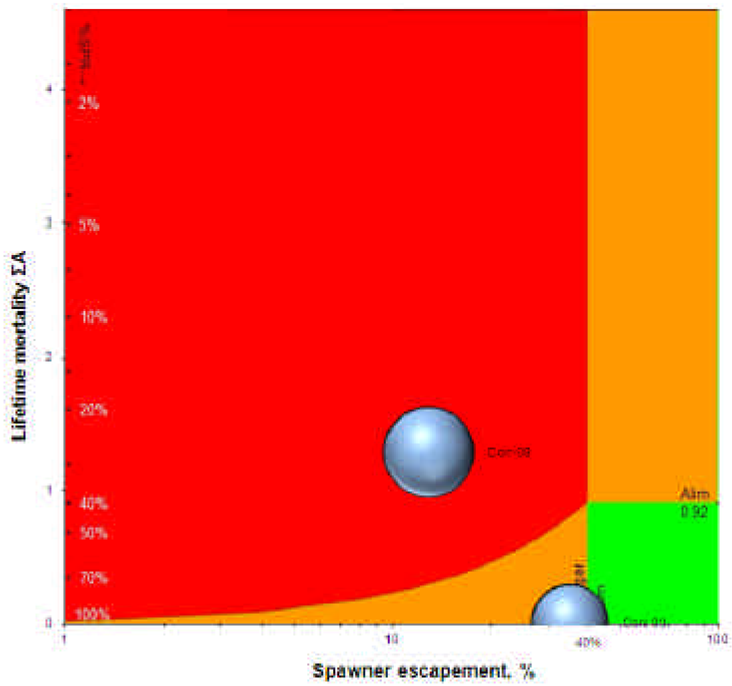


Figure 7-34: Status of the stock and the anthropogenic impacts, for the Corrib Catchment as presented in the Eel Management Plans in 2008 (average 2001-2007) and for the 2009. For each, the size of the bubble is proportional to B_{best}, the best achievable spawner escapement given the recent recruitment, 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.

7.6 Mask

7.6.1 Introduction

Lough Mask lies in the Corrib Catchment upstream of L. Corrib (Fig. 7.35). It is connected to Corrib via a series of complex channels and subterranean passages. Both yellow and silver eels have been commercially fished on Lough Mask but time series data of catch were not available to date.

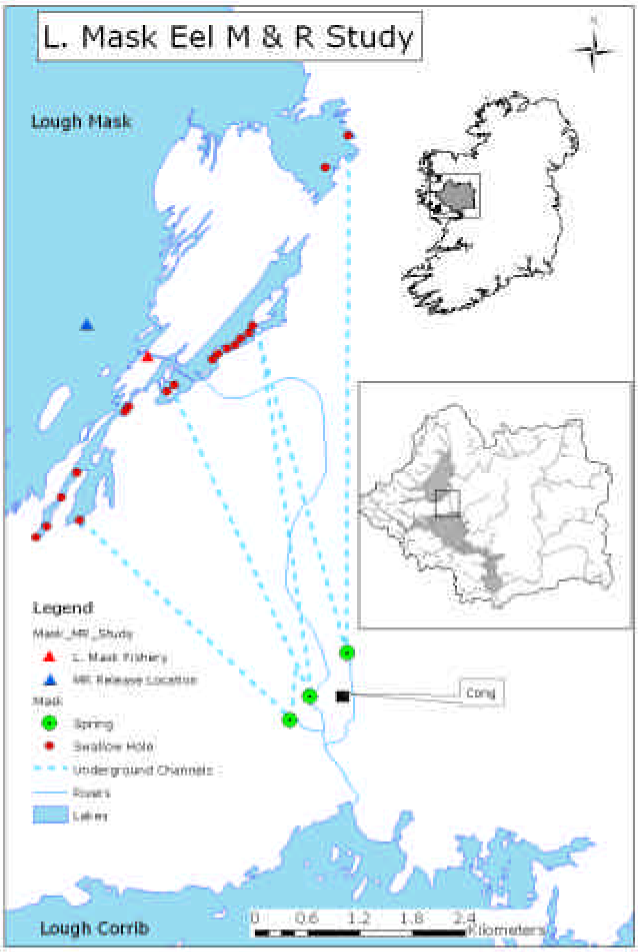


Figure 7-35: Diagram of Mark Recapture survey and rough depiction of underground channels from Lough Mask to Lough Corrib. Hydromorphology information courtesy of **http://www.gsi.ie/Programmes/Groundwater/Karst+Booklet/The+western+lowlands.htm.**

7.6.2 Mask Annual Escapement

As outlined in the management plan Lough Mask was scheduled to be surveyed in 2010. A contracted fisherman fished the outflow of L. Mask for 6-9 nights per dark for the months of October, November and December 2010. A total catch of 2.65 tonnes (Table 7.5) was collected.

Table 7-5: Catch details from L. Mask.

Month	Catch (kg)	Numbers Eels	Av. Weight (kg)
Oct	707	1,284	0.551
Nov	1,932	2,455	0.787
Dec	12	17	0.694
Total 2010	2,651	3,756	0.706

To estimate the efficiency of the weir and the silver eel escapement from Lough Mask, a mark recapture exercise was carried out in October and November 2010. A total of 367 eels (171 in October and 199 in November) were tagged and released 1 km upstream in Lough Mask (Table 7.6 and Fig. 7.35). The recapture rate was low in both months (2% and 0.5% respectively). A geological survey of the bedrock around L. Mask shows a number of swallow holes with underground channels returning to the surface around the town of Cong. It is possible that the low recapture rate was due to tagged eels using a different outflow channel, bypassing the Cong canal and the fishing site. A number of tagged eels may have postponed migration to later in the year or to 2011 as has been found in the Erne system. However, due to the low flow and frosty conditions in December catches were small and a third mark recapture survey could not be carried out. Due to the difficulties encountered at the L. Mask site, it is currently not possible to determine a total silver eel escapement for this lough.

Table 7-6: Silver Eel Mark Recapture Study carried out in 2010 in L. Mask.

Month	No Tagged	Recaptured	Efficiency %
Oct 2010	171	4	2
Nov 2010	199	1	0.5
Total	370	5	1.35

7.6.3 Mask Production and Escapement

7.6.3.1 Historic

No separate historic estimate was determined for Lough Mask. It was incorporated in the wider estimate for the Corrib Catchment.

7.6.3.2 Pre-EMP 2001-2007

No separate production or escapement estimates were determined for Lough Mask. These were incorporated in the wider estimates for the Corrib Catchment.

7.6.3.3 Current 2009-2011

As described in Section 7.6.2, it was not possible to estimate the current escapement from L. Mask.

7.7 Fane

7.7.1 Introduction

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

7.7.2 Fane Annual Escapement

There are no previous records of annual escapement.

Nine nights were fished during the October dark with a catch of 277 kg and four nights were fished in November with a catch of 13 kg. A total catch of 290 kg of silver eels were therefore caught for the 2011 season (Fig. 7.36).

Hydrometric data courtesy of the Office of Public Works suggest that the main migration run of silver eels may have occurred in the month of October starting in the first week of October during the full moon as indicated by the dramatic increase in the river water depth (Fig. 7.37). The contracted fishermen confirmed that recent weather patterns have resulted in one large flood early in the season which triggers the main migration run. Historically the water levels rose gradually over the course of the season with an increasing catch with rising flood waters.

It is proposed to carry out this research fishery in 2012. The effort will be concentrated around the new moon as well as targeting the first large flood of the season.

A Mark Recapture survey was carried out in the River Fane, located approximately 0.5 km downstream from the Lough Muckno outflow (Figure 15-14). Passive Integrated Transponders (PIT) tags were used to mark the eels. Eels were released at two different locations. The first release site was located in the river upstream of Lough Muckno, approximately 5 km from the fishery. The second release site was located in the lake, approximately 2 km from the fishery. Recapture rates were 31% and 15%, respectively (Table 7.7). A third release site in the Clarebane River just upstream of the fishery site is proposed for the 2012 season.

Applying the 31% recapture rate to the total catch (277kg) gives an escapement of 936kg and 15% gives an escapement of 1933kg.

The silver eels in the River Fane ranged in length from 30 cm to 92 cm and in weight from 0.044 kg to 1.709 kg (Table 7.8 and Fig. 7.38). There are two modes within the length frequency diagram, the first representing the male eels with the second representing the female eels. 70% of the Fane silver eels were male in 2011 and 73% were male in 2005. Such a male dominated run is often indicative of relatively high recruitment or density.

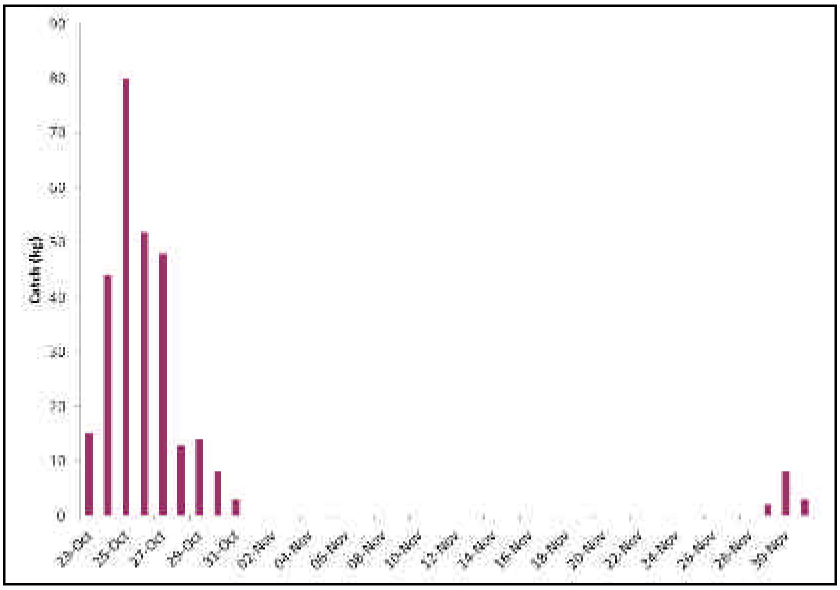


Figure 7-36: Silver eel catch from the Fane catchment 2011.

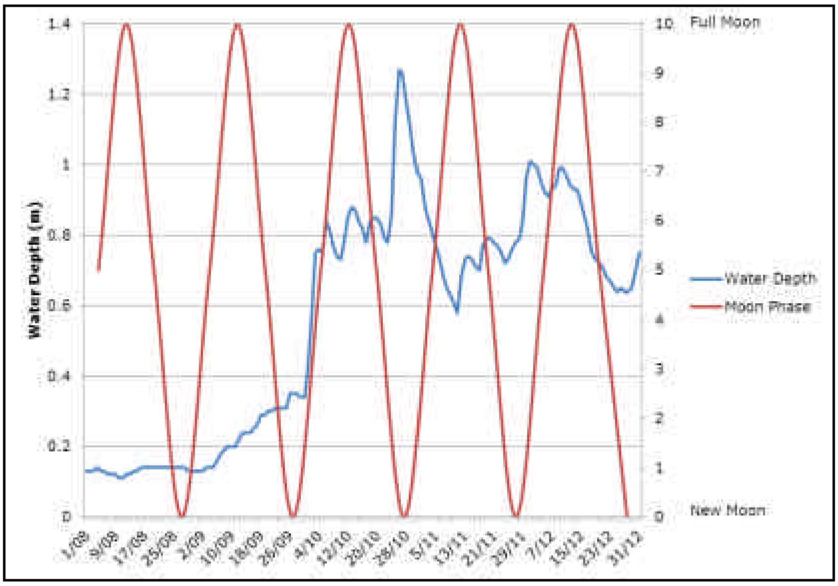


Figure 7-37: Water depth and moon cycle for the silver eel season 2011.

Table 7-7: Mark recapture data from the Fane catchment.

Release Location	Tagged Oct.	Oct.	Nov.	Total Recaptures	% Recapture Oct.	Recapture Total Oct.
River	150	39	8	47	26	31
Lake	150	18	5	23	12	15

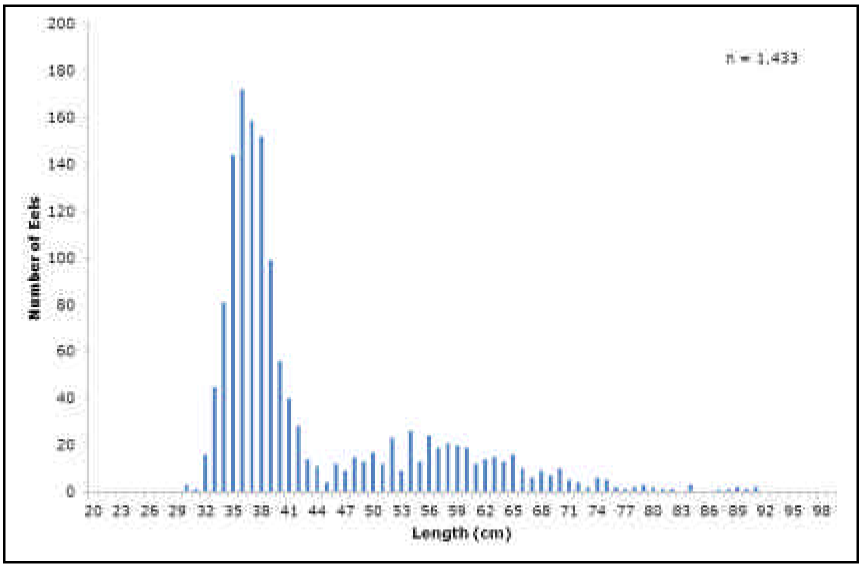


Figure 7-38: Length frequency of silver eels caught in fyke nets in the Fane river outflow of L. Muckno in 2011.

Table 7-8: Length and weight data for silver eels form the River Fane.

Location	**Month**	**No. Eels**	**Mean length (cm)**	**Min length (cm)**	**Max length (cm)**	**Mean weight (kg)**	**Min weight (kg)**	**Max weight (kg)**
Fane	2005	200	45.7	31.0	90.0	0.174	0.06	1.063
Muckno	Oct. '11	1377	43.9	30.4	91.7	0.188	0.044	1.709
	Nov. '11	56	42.7	33.4	66.0	0.162	0.066	0.551
	2011	**1433**	**43.8**	**30.4**	**91.7**	**0.187**	**0.044**	**1.709**

7.7.3 Fane Production and Escapement

7.7.3.1 Historic

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

Using the model in the EMP, it was estimated that the historic production (Bo) for the Fane catchment was in the order of 4.67kg/ha or 2,679kg.

7.7.3.2 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 3.28kg/ha or 1881kg.

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.

7.7.3.3 Current 2009-2011

Applying the 31% recapture rate to the total catch (277kg) gives an escapement estimate of 936kg and 15% gives an escapement estimate of 1933kg or 2.7 to 5.5kg/ha. (wetted area estimated at 350ha). Given that not the whole migration period was fished these can be considered as minimum estimates.

Given the preliminary nature of these estimates it is recommended that a further full season of multiple mar-recapture and fishing are undertaken before using Muckno as an index site.

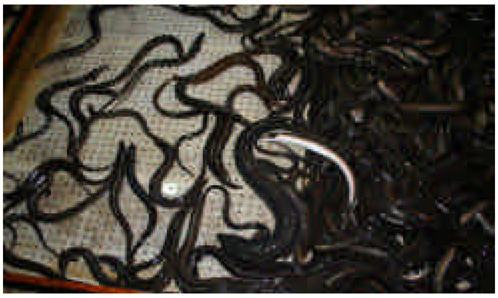
7.8 Waterville

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

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

8 Silver Eel Production and Escapement

8.1 Introduction



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

Ireland used a system of extrapolating from index data rich catchments to data poor catchments for calculating estimates of pristine and current biomass as described in the Irish Eel Management Plan (Chapter 5) and the WGEEL report (ICES, 2008).

Note: tidal and transitional waters were not included in the production and escapement analysis

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.
SF	The fishing mortality rate, summed over the age-groups in the stock, and the reduction effected.
SH	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.
SA	The sum of anthropogenic mortalities, i.e. SA = SF+ SH.

8.2 Eel Management Plan Biomass

8.2.1 Introduction

The estimation of pristine and current (2008 based on the average of 2001-2007) silver eel biomass being produced and escaping was fully described in the National Eel Plan (2008, Ch.5) and in ICES (2008, page 47). The calculation of pristine productivity for exploited catchments requires estimates of silver eel escapement along with historic silver and yellow eel catches, raised to account for unreported and also illegal catches. Historical catch records for silver eel fisheries were available for the five catchments of the Corrib, Moy, Garavogue, Burrishoole and Erne. The efficiencies of the fisheries had been previously estimated for the Shannon, Corrib and Erne silver eel fisheries. Where fishery efficiency was not measured an approximately average value of 33% was used to calculate escapement. In addition to the catch at the recording station and escapement past the recording station the yellow eel and silver eel catches made upstream were included to estimate pristine productivity. In the absence of historic data for these latter parameters (yellow and silver eel catches upstream of the recording station) it was assumed that the yields were equal to those currently observed (2001-2007). A similar process was used to calculate the 2008 production, based on the average of 2001-2007, and escapement using data from four catchments, the Shannon, Corrib, Burrishoole and Lough Ennell (estimate based on depletion fishing surveys by NUIG).

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

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 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.

Note: tidal and transitional waters were not included in the production and escapement analysis

8.2.2 Historic Silver Eel Biomass (Bo)

Estimates of historic biomass were presented for each Eel Management Unit (EMU). During the course of 2009-2011 and the review for this report 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 8.1.

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. Both datasets are presented in Table 8.2 and only the new historic biomass estimates will be used from this point forward.

8.2.3 Current (2008) Silver Eel Biomass (Bbest, $B_{2001-2007}$)

The production (B_{best}) and escapement ($B_{2001-2007}$) estimates presented in the EMPs are shown in Table 8.2 & 8.3. The escapement was determined by subtracting the fisheries catch, raised to account for illegal and unreported, and then the remaining silver eel production was subjected to hydropower mortality at 28.5% per hydropower station where these occurred.

The escapements in 2008 were recalculated using the estimates of HPS mortality determined between 2009 & 2011 (Table 2.2), on the Shannon (21% & 17.8% bypass) and the Erne (cumulative 23%) and both datasets are included in Table 8.2 & 8.3.

8.2.4 Current (2009-2011) Silver Eel Biomass (Bbest, $B_{2009-2011}$)

The silver eel biomass produced and escaping during 2009 to 2011 in the monitored index catchments was fully described in Chapter 7 of this report and in Table 8.1.

These index data were then used to calibrate the IMESE model. The existing growth data was reused and it is hoped in the coming three year period to have new growth data to refresh the model. Figure 8.1 shows the relationship between the index data, the growth rate data and the geology (% non-calcareous).

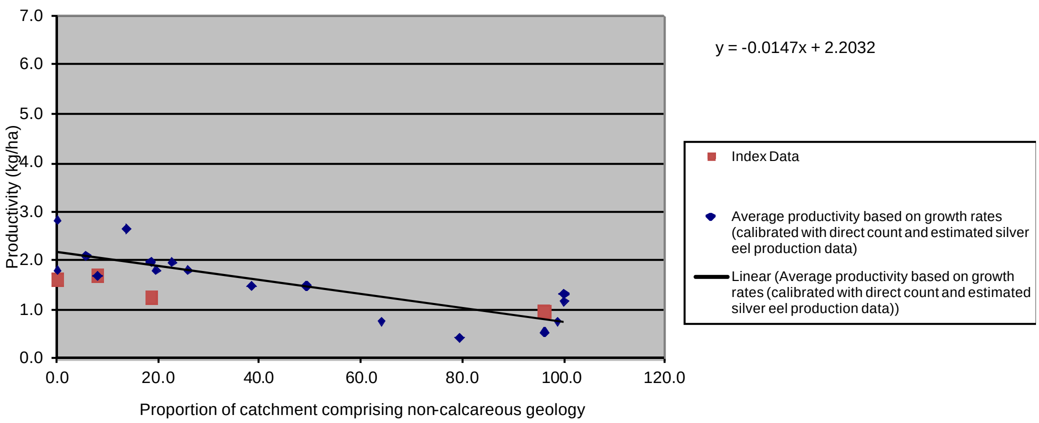


Figure 8-1: Average current (2009-2011) silver eel productivity based on growth rates calibrated with direct silver eel counts and estimated silver eel production indices for the same period

The estimates of historic (Bo), 2008 and current silver production and escapement are given in Table 8.3 as calculated using the IMESE and summated by individual catchments for each RBD and current escapement was then estimated taking into account the HPS mortalities.. Where direct estimates 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 2009-2011. This may lead to inconsistencies when extrapolating to the East and south coast catchments. While a similar scenario existed for setting up the EMP, it is hoped to include at least one silver index on the east coast in the next three year period.

Current escapements are presented in Table 8.3 expressed as a percentage of the historic production. These are 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 clearly seen by the %SSB increasing from 24.4% (2008) to 36.8% (2009-2011).

8.2.5 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 (SA) is much more complex, but numerical simulation indicates that the relationship comes close to a reference point based on numbers (ICES 2011b).

In the Irish EMP (2008), the silver eel production (B_{best}) and escapement ($B_{current}$) were converted from biomass to numbers in order to calculate mortality and a timeframe to recovery. Commercial catch weight frequency distributions for yellow and silver eels (n > 2300) were investigated for a number of catchments in 2008 (Corrib, Mask, Conn, Oughter, Erne, Waterford Estuary, Slaney Estuary, Shannon) (EMP 2008). These size frequencies were used to convert the catch weights within those catchments to numbers of eels. The data were pooled to provide a national average weight distribution which was used to calculate numbers from the catches in all other catchments. Because the model was now based on numbers rather than weight, natural mortality was imposed on the yellow eel catch in order to determine the number of potential silver eels removed by the fishery. The yellow eel catch was assigned a maturation rate distribution, on the basis that if it was released or not caught, would therefore mature as silver eels, on average, over the following 0-10 years range (Irish EMP Sec 5.2.4.3; Fig. 8.2). Natural survival was estimated at 86% per annum. This level of survival was derived from a lifetime estimate for the non-Biscay stock as a whole spread over the residence time of Irish eels (Dekker 2004).

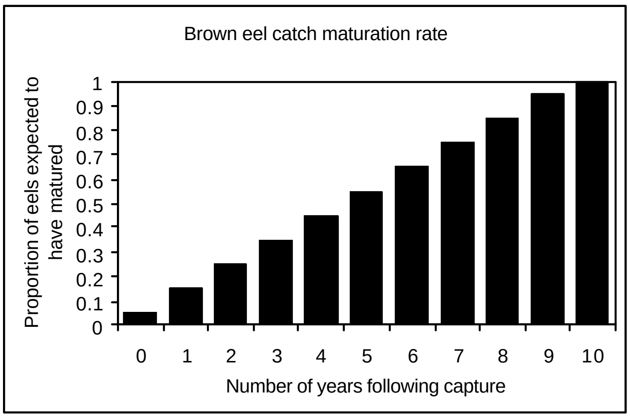


Figure 8-2: The approximated proportion of yellow eels expected to have matured to silver eel if the catch had not been killed.

Calculations of the instantaneous rates of fishing and turbine mortality were calculated based on silver eels alone, i.e. yellow eels caught by the fishery were converted to potential silver eels in order to quantify the pressure of the fishery on the stock.

$? = C_s + E + ?_b$

(?) potential silver eels, (C_s): silver eel catch, (E): escapement, ($?_b$): potential silver eels from yellow eel catch.

$?_b = ?_1^n (C_b).(P_n).(e^{-M})^n$

(C_b): yellow eel catch, (P_n): proportion of yellow eel catch maturing in (n) years, (M): natural mortality.

$F = -\ln((? \ - C_{s} - ?_{b}) / ?)$

$H = -\ln(((? \ - Cs - ? \ b)*?) / ? \ - (? \ - Cs - ? \ b))$

$A = F + H$

(A): anthropogenic mortality, (F): fishing mortality, (H): turbine mortality, (?): proportion of run surviving turbine

Table 8.4 presents the mortality data calculated using biomass ($-\ln(B_{current}/B_{best})$) and using numbers as described above. In Figures 8.3-8.4, the mortality data is calculated using biomass as follows:

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

Note that the mortality on yellow eel in the past has not been taken into account in the estimates of S *F* and S *A* for the 2009-2011 period due to lack of detailed catch data.

8.2.6 Biomass and Mortality Overview

In this report, the Irish eel stock has been quantified and time trends presented. In Chapter 1.3, the objectives and targets of the EU eel protection plan have been clarified. In this chapter, the state of the stock will be compared with the targets. This involves the comparison of the actual state of the stock to the state it is intended to have, comparing the observed mortalities to the targets set in the management plans. To this end, the precautionary diagram introduced in section 1.3.5 will be used, in a modified version. On the horizontal axis, the status of the stock is plotted (low versus high spawning stock biomass determining whether the stock is in good condition or not; logarithmic scale, percent of pristine biomass) and on the vertical axis the impact of fishing and hydropower generation (low versus high mortality determining whether the management regime is sustainable or not; mortality rates are logarithmic by definition). The diagrams below (Fig. 8.3 & 8.4) plot the most recent stock assessment (2009-2011), and those presented in the Eel Management Plan (2008).

The data for each EMU and for the total are presented on the modified ICES precautionary diagram, as developed by the WGEEL using the EU management target (40% SSB) as the reference point and a calculated mortality reference point based on the EU management target (Alim 0.92) for 2008 (Fig. 8.3) and the average for 2009-2011 is presented on Fig. 8.4. The revised Bo and a recalculated 2008 figure using the turbine mortality estimates determined for Ardnacrusha between 2006 and 2011 and for the Erne 2010 & 2011 were used in these diagrams (Table 2.2). The arrows in the diagrams indicate what effect the implementation of the management actions were expected to have.

In the EEMU, the ShIRBD, WRBD and NWIRBD, the mortality was clearly reduced as indicated by the downward direction of the bubbles and this led to increased escapement shown by right hand horizontal movement towards the 40% target. In some cases the bubbles did not respond as expected, by not moving as much to the right. This may due to some yellow eel still to feed through increasing the %SSB and moving the bubbles to the right in coming years. Or the negative impact of falling recruitment may now be leading to lower silver eel production, or there may be problems with some of the estimates as mentioned previously. Extrapolation to the east and south RBDs may need to be reviewed in the light of future additional data and for the NWIRBD diagram, either the 2008 bubble is too far to the right, due to an over-estimate of 2008 escapement, or the 2009-2011 bubble is too far to the left due to an under-estimate of the current escapement or a combination of both. As shown previously, there is some evidence to suggest higher than previously thought yellow eel exploitation, especially in the Erne, which would increase mortality and reduce escapement of the 2008 bubble in the NWIRBD (See sec 7.3.3.3 7 & Figs. 7.23 & 7.24).

In general, we have demonstrated the increase in biomass of silver eel escaping and the reduction in mortality caused by fishing and hydropower. While further reduction in mortality is unlikely, it possible that additional biomass will feed through in the coming years from the closure of the yellow eel fishery. 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.

8.2.7 Timeframe to recovery

International scientific advice is to reduce the level of anthropogenic mortality to as close to zero as possible to achieve recovery of the stock (ICES 2008). An 85% reduction of anthropogenic mortality is estimated to be required to prevent continued decline from the current extremely low level of recruitment without achieving any long-term recovery (Astrom and 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.

Until the Member States report to the EU in July 2012, it will not be possible to reassess the timeframe to recovery. From anecdotal information, it seems that comparable actions were not implemented across Europe and therefore the timeframe will probably be longer.

Current recruitment of glass eel from the ocean is at 1-13% of the historical level. This low recruitment 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 maintained. Recruitment has now become the limiting factor for recovery.

8.2.8 Summary of individual RBD targets

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

These plots have now been updated with the revised historic estimates of silver eel production and the new % SSB averages for 2009-2011 have been inserted. These are shown in Figures 8.5 & 8.6.

The SERBD and SWRBD remain above the EU target, but have shown considerable decreases in %SSB. The EEMU has increased to above the EU target. It should be noted, as mentioned in Sec 8.2.4, that these three EMUs were assessed using the IMESE model with no local calibrating index.

The SHIRBD, WRBD and NWIRBD all demonstrated increases in %SSB, more or less as projected.

The total for all the EMUs was projected to peak at 36% with a three year average of 33% and the estimated figure from the three year National Programme was 36%.

Table 8-1: Historic production (Bo), current production (B_{best}), current escapement, fisheries catch and estimates of turbine mortality for the Burrishoole, Corrib, Shannon and Erne. The top table presents the data as rates (kg/ha), the bottom table as total quantities (kg). ND = no data.

Catchment	Historic production (Bo) kg/ha	Best possible production (Bbest) kg/ha					Escapement (Bcurrent) kg/ha					Fishery Catch (kg/ha). *including unreported & illegal					Turbine Mortality (kg) ** 2001-2007 recalculated using '09-'11 estimates				
		2001-2007	2009	2010	2011	Average 2009-2011	2001-2007	2009	2010	2011	Average 2009-2011	2001-2007*	2009	2010	2011	Average 2009-2011	2001-2007**	2009	2010	2011	Average 2009-2011
Burrishoole	0.928	1.37	1.27	0.87	0.75	0.96	1.37	1.27	0.87	0.75	0.96	0	0	0	0	0					
Corrib	3.57	1.68	1.25	ND	ND	ND	0.46	1.25	ND	ND	ND	1.22	0	0	0	0					
Shannon	4.45	2.02	1.75	1.62	1.54	1.64	0.29	1.57	1.42	1.36	1.45	1.76	0	0	0	0					
Erne	4.14	3.28	ND	1.59	1.64	1.62	1.25	ND	1.46	1.52	1.49	1.70	ND	0	0	ND					

Catchment	Historic production (Bo) kg	Best possible production (Bbest) kg					Escapement (Bcurrent) kg					Fishery Catch (kg). *including unreported & illegal					Turbine Mortality (kg) ** 2001-2007 recalculated using '09-'11 estimates				
		2001-2007	2009	2010	2011	Average 2009-2011	2001-2007	2009	2010	2011	Average 2009-2011	2001-2007*	2009	2010	2011	Average 2009-2011	2001-2007**	2009	2010	2011	Average 2009-2011
Burrishoole	440	649	602	410	354	455	649	602	410	354	455	0	0	0	0	0	0	0	0	0	0
Corrib	103,062	48,455	36,100	ND	ND	ND	13,371	36,100	ND	ND	ND	35,084	0	0	0	0	0	0	0	0	0
Shannon	188,849	85,700	74,382	68,920	65,558	69,620	12,163	66,788	60,170	57,885	61,614	74,600	0	0	0	0	5,969	4,095	8,210	7,673	6,659
Erne	107474	85,140	ND	41,232	42,702	41,967	32,542	-	37,942	39,858	39,199	44,239	ND	0	0	ND	9,403	ND	3,047	2394	2,721

Table 8-2: Historic (Bo) and current (Bbest - 2008) silver eel production (t) and escapement (Bcurrent) (t) and the percent escapement of historic production calculated using the IMESE model and inserting actual catchment data where they exist. The data for historic production was reworked and the recalculated data are presented along with those as presented in the EMP (2008). The current 2008 escapements are presented as in the EMP, with 28.5% average turbine mortality*, and recalculated using the turbine mortalities determined during 2009-2011.**

The shaded columns are the definitive columns of biomass data with the most recent data.

	Historic Production (EMP) (kg)	Historic Production **Recalculated** (kg)	Current 2008 Production (kg)	Current 2008 Escapement (kg)	Current 2008 Escapement **Recalculated** (kg)	Current 2008 Escapement as % of Historic Production (EMP)	Current 2008 Escapement as % of Historic Production **Recalculated Bo**	Current 2008 Escapement as % of Historic Production **Recalculated Bo & ** **
EMU	Bo	Bo	Bbest	Bcurrent*	Bcurrent**	%	%	%
EEMU	21785	20490	14186	7008	7008	32.2	34.2	46.0
SERBD	15723	14813	10069	8707	8707	55.4	58.8	45.6
SWRBD	25925	24526	17390	16603	16603	64.0	67.7	67.7
ShIRBD	214048	201156	94231	19599	19,902	9.2	9.7	9.9
WRBD	170403	189167	96924	41578	41578	24.4	22.0	27.0
NWIRBD	146536	135760	103511	38014	48759	25.9	35.9	35.9
National	594420	585912	336311	131509	142847	22.1	22.4	24.3

* escapement calculated using 28.5% for hydropower and 30% Shannon bypass.

** escapement recalculated for 2001-2007 using current estimates of mortality for Hydropower in the Erne (23%) and Shannon (21.1% & 17.8% bypass)

Table 8-3: Historic (Bo), current (Bbest - 2008) and current (Bbest 2009-2011) silver eel production (kg) and escapement (Bcurrent) (kg) and the percent escapement of historic production. The escapements for 2008 are presented as in the EMP, with 28.5% average turbine mortality, and recalculated using the turbine mortalities determined during 2009-2011. Mortalities are calculated on biomass. The shaded columns are the definitive columns of biomass data with the most recent data.

	Bo Historic	Bbest 2008 Prod	2008 Escap at 28.5% HPS*	2008 Escap at new % HPS**	Bbest 2009-2011 Prod	Bcurrent 2009-2011 Escap	2008 EU%	New % HPS 2008 EU%**	2009-2011 EU %
EEMU	20,490	14,186	7,008	7,008	9,555	9,430	34.2	34.2	46.0
SERBD	14,813	10,069	8,707	8,707	6,754	6,754	58.8	58.8	45.6
SWRBD	24,526	17,390	16,603	16,603	11,637	11,282	67.7	67.7	46.0
ShIRBD	201,156	94,231	19,599	19,902	75,377	68,718	9.7	9.9	34.2
WRBD	189,167	96,924	41,578	41,578	68,650	68,850	22.0	22.0	36.3
NWIRBD	135,760	103,511	38,014	48,759	54,256	51,545	28.0	35.9	38.0
Total	**585,912**	**336,311**	**131,509**	**142,847**	**226,239**	**216,379**	**22.4**	**24.3**	**36.9**

* escapement calculated using 28.5% for hydropower and 30% Shannon bypass.

** escapement recalculated for 2001-2007 using current estimates of mortality for Hydropower in the Erne (23%) and Shannon (21.1% & 17.8% bypass)

Table 8-4: Mortality rate table of fishing mortality (SF), anthropogenic mortality outside the fishery (SH) and the sum of anthropogenic mortalities, (SA = SF + SH) using the most recent data updates. Mortality rates are calculated using biomass and also converting to numbers. Fishing mortality includes raising factors for illegal and unreported catches. *F* in 2009-2011 does not take into account yellow eel fishing mortality on the stock prior to 2009.

	biomass						numbers					
	SF* 2008	SH 2008	SA 2008	SF 2009-2011	SH 2009-2011	SA 2009-2011	SF* 2008	SH 2008	SA 2008	SF 2009-2011	SH 2009-2011	SA 2009-2011
EEMU	0.68	0.03	0.71	0.00	0.01	0.01	0.45	0.02	0.47	0.00	0.01	0.01
SERBD	0.15	0.00	0.15	0.00	0.00	0.00	0.15	0.00	0.15	0.00	0.00	0.00
SWRBD	0.01	0.04	0.05	0.00	0.03	0.03	0.01	0.03	0.04	0.00	0.02	0.02
ShIRBD	1.29	0.26	1.55	0.00	0.09	0.09	0.72	0.14	0.86	0.00	0.1	0.1
WRBD	0.85	0.00	0.85	0.00	0.00	0.00	0.62	0.00	0.62	0.00	0.00	0.00
NWIRBD	0.58	0.18	0.75	0.00	0.05	0.05	0.36	0.19	0.55	0.00	0.05	0.05
Total	0.75	0.11	0.86	0.00	0.04	0.04	0.49	0.10	0.59	0.00	0.04	0.04

SF The fishing mortality rate, summed over the age-groups in the stock, and the reduction effected.

SH The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock, and the reduction effected.

SA The sum of anthropogenic mortalities, i.e. SA = SF + SH

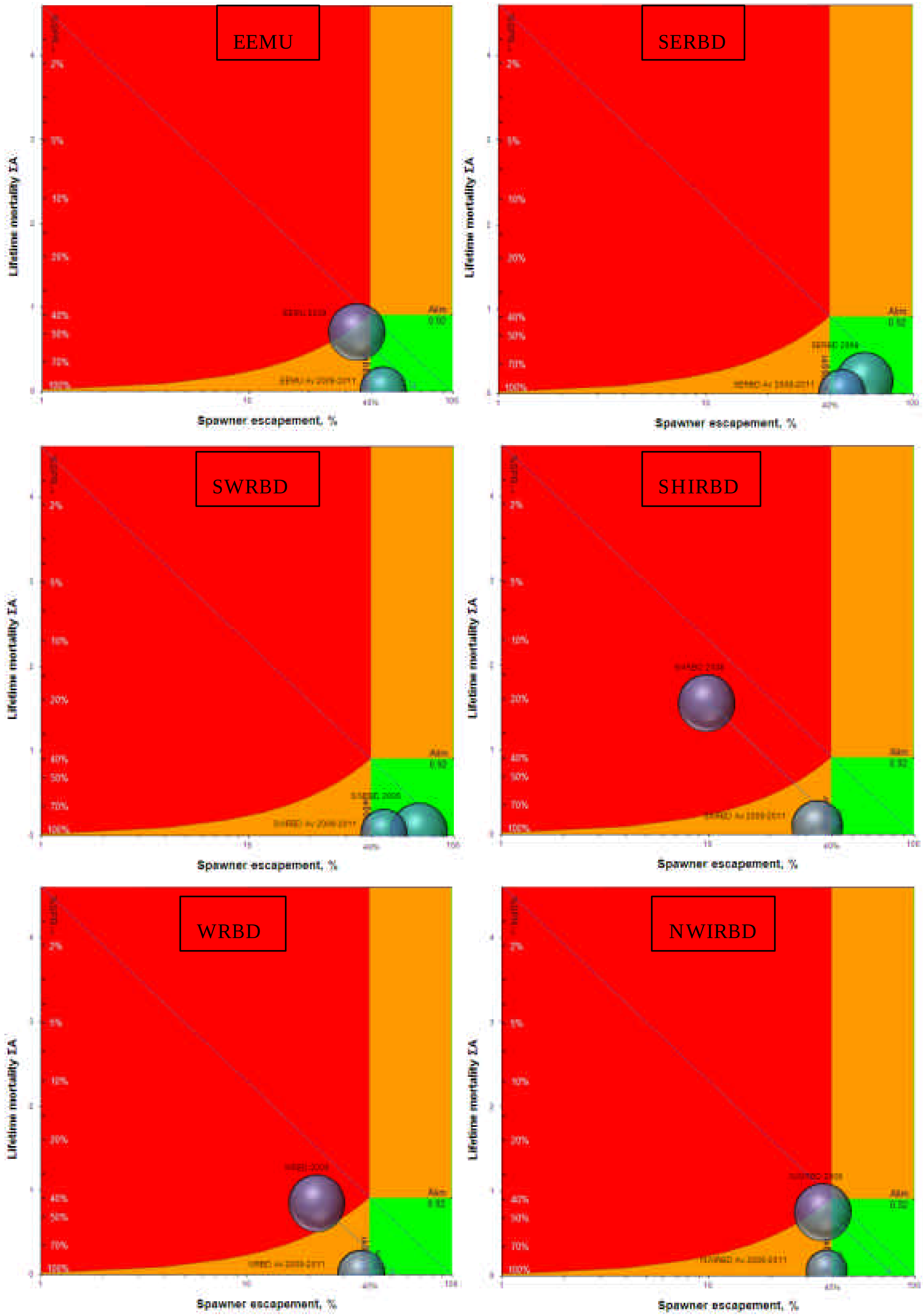


Figure 8-3: Status of the stock and the anthropogenic impacts, for each EMU in 2008 (average 2001-2007) and for the 2009-2011 period. For each, the size of the bubble is proportional to B_{best}, the best achievable escapement given recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the stock status related to pristine conditions while the vertical axis represents anthropogenic mortality.

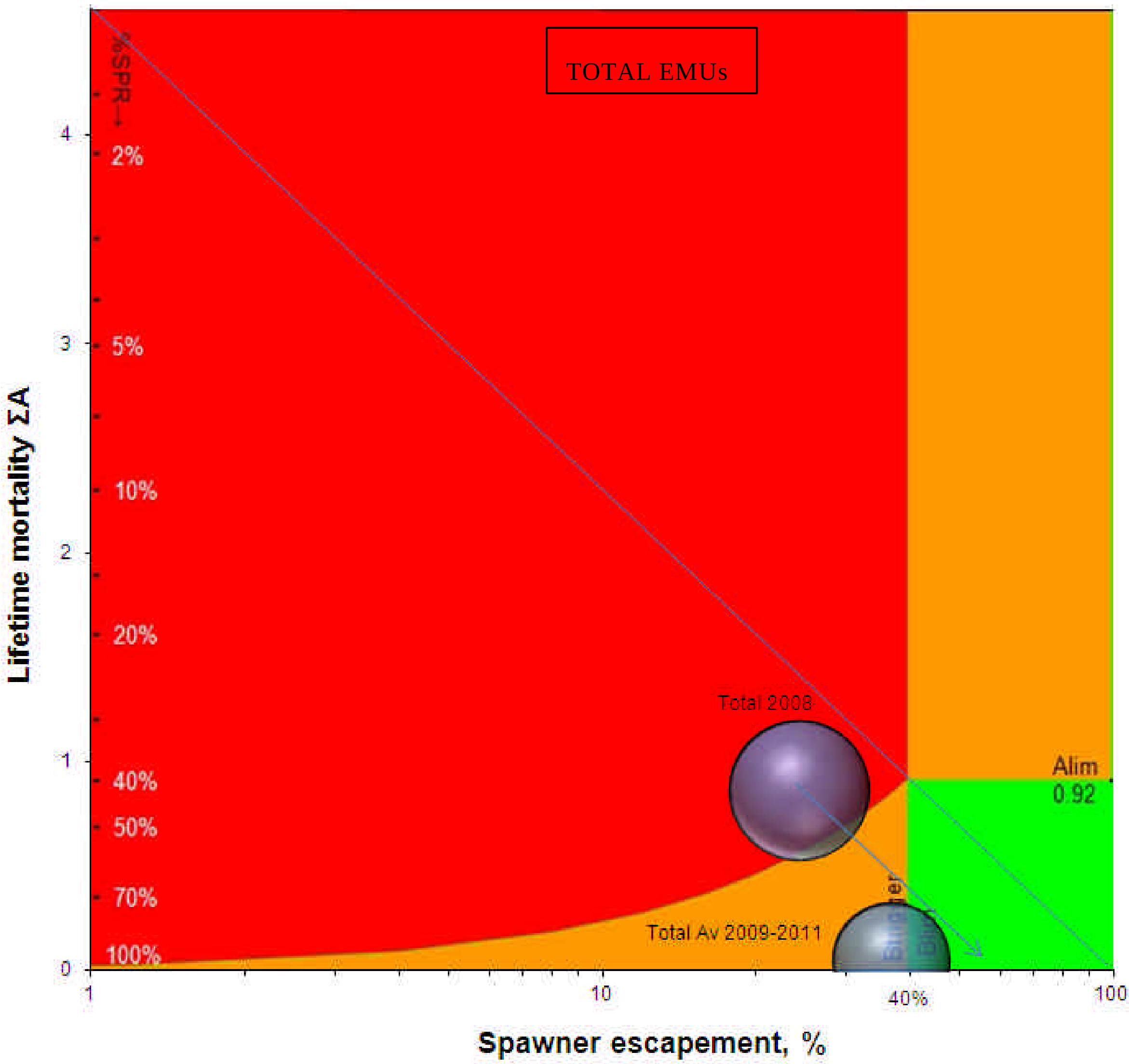


Figure 8-4: Status of the stock and the anthropogenic impacts, for total EMUs in 2008 (average 2001-2007) and for the 2009-2011 period. For each, the size of the bubble is proportional to B_{best}, the best achievable escapement given recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the stock status related to pristine conditions while the vertical axis represents anthropogenic mortality.

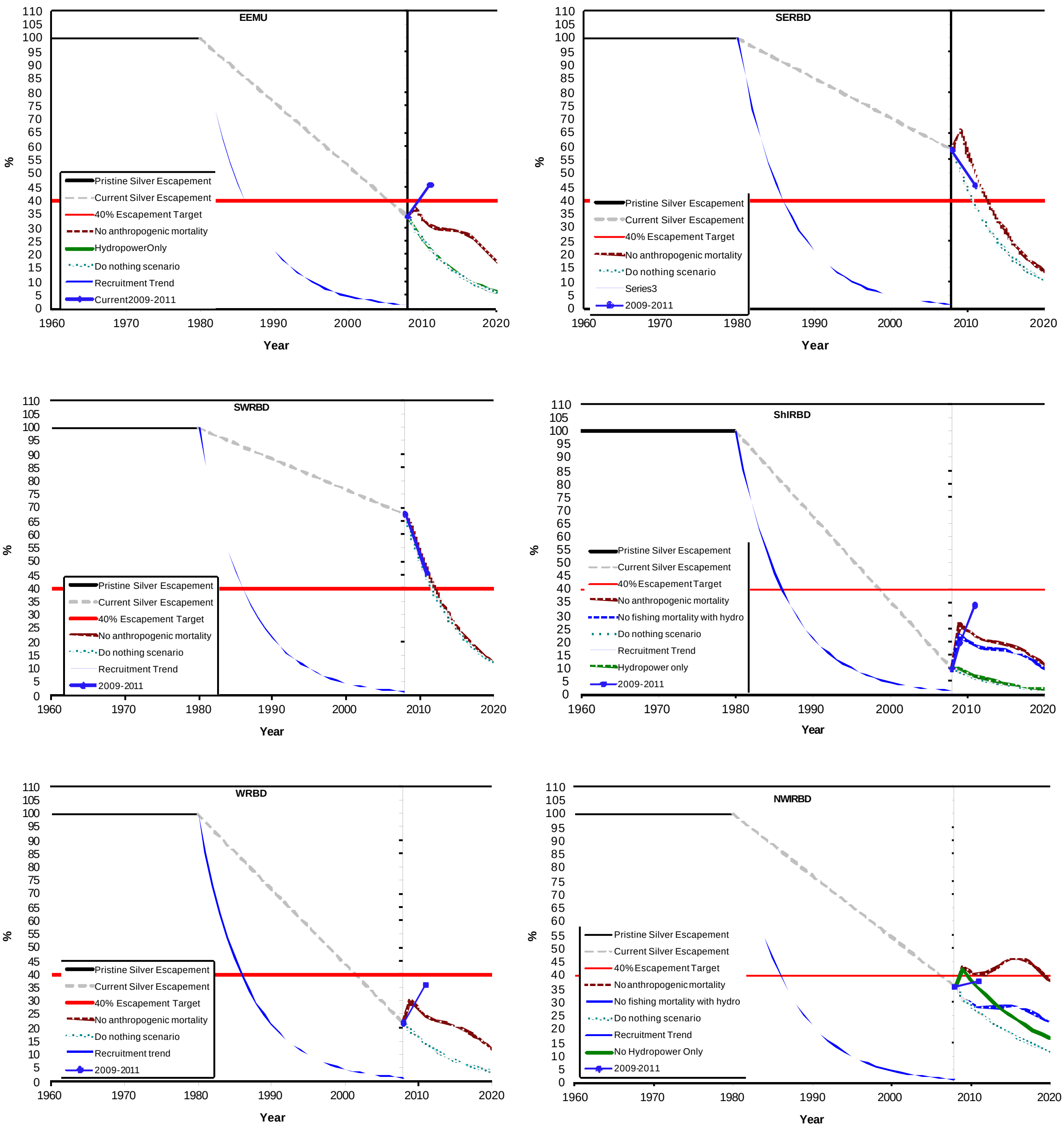


Figure 8-5: Plots for each Eel Management Unit of historic (100%) and current (2008) eel production and escapement related to the EU 40% target (red line). The recruitment trend is shown in plain blue. The effect of projected management scenarios are shown in dotted blue (fishery), green (hydropower) and total (yellow) and the first observed point for the average of 2009-2011 is shown as a blue line and dot plotted at 2011.

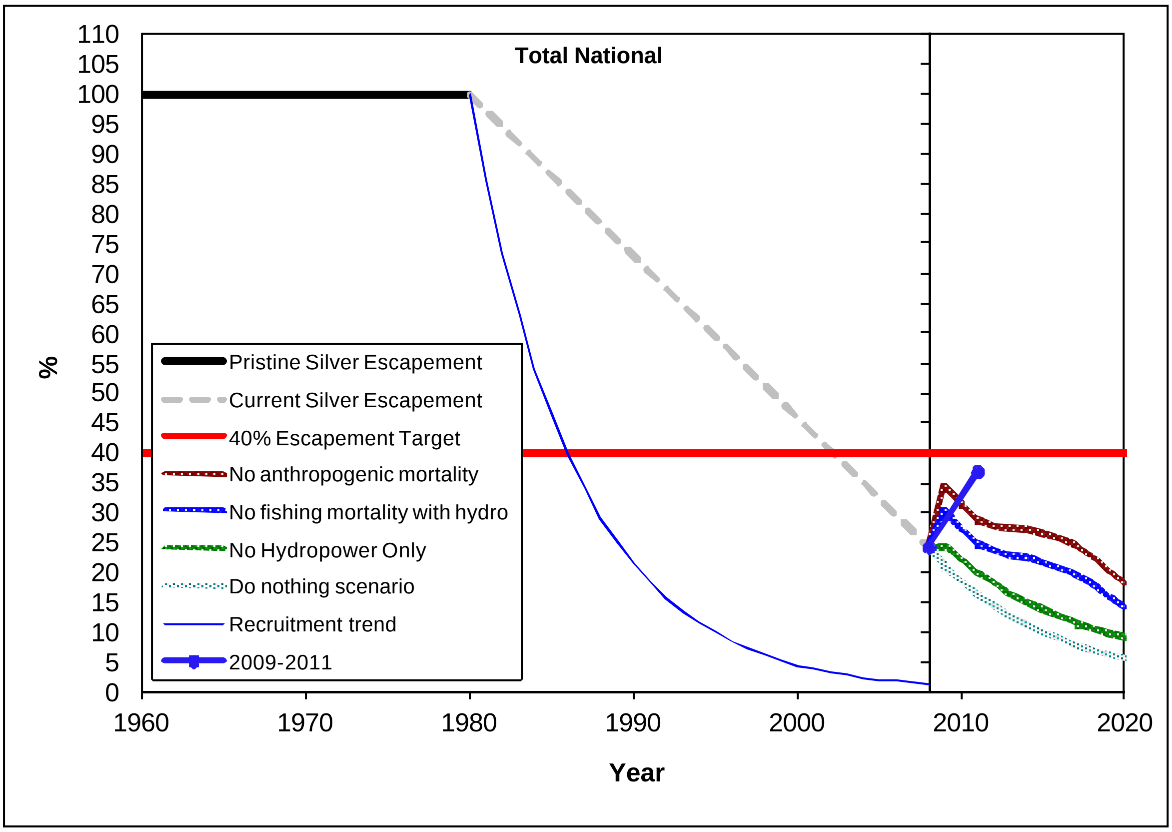


Figure 8-6: Plot for the total of the Eel Management Units of historic (100%) and current (2008) eel production and escapement related to the EU 40% target (red line). The recruitment trend is shown in plain blue. The effect of projected management scenarios are shown in dotted blue (fishery), green (hydropower) and total (yellow) and the first observed point for the average of 2009-2011 is shown as a blue line and dot plotted at 2011.

9 Silver Eel Trap and Transport 2012-2015

Silver eel trap and transport programmes, used to mitigate against Hydropower Station induced mortality, took place in the Lee (SWRBD), Shannon (ShIRBD) and Erne (NWIRBD). As discussed in Section 5.3 of the National EMP Report (2008), it was not possible to define a timeframe to achieve the EU biomass target (40% of pristine SSB) with the proposed management actions (cessation of fishery, trap and transport), so an alternative target of timeframe to full recovery of recruitment was defined. With the management actions for 2009-2011, all EMUs, and Ireland as a whole, was expected to contribute to a recovery of recruitment at the 100 year timeframe or less. It was imperative that equivalent EU-wide action was taken at this level so as not to diminish the impact of Ireland's contribution. It was estimated that a recovery could only take place if anthropogenic mortality was reduced to below 15% of the level in 2008.

In both the Shannon and Erne catchments, anthropogenic mortality during 2009-2011 was reduced to as low as possible, by closing the fishery and transporting silver eels around the HPSs, and this is evident by examining the biomass data (Figure 5). The downward movement of the 2009-2011 bubbles indicates the reduced anthropogenic mortality and the left to right movement indicates the increase in silver eel biomass escaping. Neither catchment is achieving its EU target of 40%.

In the EMP, the objective set by the national WG on Eel was to aim to recover the stock in the shortest time practicable. Trap and Transport amounts of silver eel were set by agreement between DCENR, DCAL and ESB, with the 30% of the production in the Shannon and three fixed annual catch quota in the Erne for 2009, 2010 & 2011. Taken into account in setting these quotas were the estimated eel productions, recent past recruitment history, practicable feasibility and infrastructure/experience on each catchment.

Along with the cessation of the fishery, the trap and transport targets were input to the EMP model for assessing the timeframe to achieve a recovery and all EMUs were expected to contribute to a recovery in 100 years or less. This was safely below the 300+ year breakpoint, or 85% reduction in mortality (see Chapter 5.3.1 of the EMP Report 2008).

For the 2012-2015 period, it is proposed that the trap and transport amount should remain unchanged at 30% of the silver eel production on the Shannon and 500kg on the Lee.

Given the unexplained possible anomaly in silver eel production in the Erne discussed above and the need for additional Hydropower Station mortality estimates within the next three years under full generation regimes, the SSCE recommends that the Erne T&T programme could move to being based on a proportion of the estimated annual production (as on the Shannon). This should be safely above the level required to contribute to the recovery of the stock (breakpoint minimum T&T level of 43% of production), and preferably 60% (as achieved in 2011), of the annual production. This will ensure that the anthropogenic mortality reduction needed to achieve a recovery is kept safely below the 15% threshold (Figure 6). The Shannon should continue with the 30% threshold set out in the EMP. The SSCE will review the T&T rate for the Erne in the light of the outcome of the EU 2012 review and the revised HPS mortality estimates under full generation capacity.

Table 1 shows the estimated reduction (%) in mortality rate in the Shannon and the Erne in 2009-2011, a 92-94% reduction in the Erne and 94% reduction in the Shannon. Shown in Figure 6 is the

reduction that would be achieved by different proportions of the silver eel production transported on the Erne. The further above 85% reduction the more assured we are of contributing to a recovery and the quicker it will occur. It is recommended that a reasonable minimum target for the Erne in the next three years would be 50% of the production (or 87.3% reduction in mortality). This will ensure compliance with the Irish EMP and Ireland's contribution to the recovery of the eel stock. The cumulative 23% HPS mortality in the Erne is an estimate which will need to be revised under full generation regimes.

Due to the difficulty in obtaining real time data on the size of the run of silver eel, especially in the Erne, and in the event that the T&T target does not achieve the required % of the annual production, any deficit should be brought forward to the following year as an additional amount to be transported that year.

Should alternative mitigation measures from trap and transport, such as engineered solutions, be developed, they can also be included in this process and resulting escapement recognised in the determination of anthropogenic mortality and Irelands contribution to the stock.

Table 9-1: Levels of anthropogenic mortality (ΣA) for each year on the Erne and Shannon and the % reduction in mortality compared to 2008 (85% is the breakpoint). Also shown are the estimated mortality rates for 50% T&T Erne and 30% T&T on the Shannon.

Period	Erne		Shannon	
	ΣA	% Reduction in ΣA	ΣA	% Reduction in ΣA
2008	0.96	-	1.95	-
2009	-	-	0.13	94.0
2010	0.08	91.7	0.11	94.4
2011	0.06	93.8	0.11	94.3
Av 2009-2011	0.07	92.9	0.12	94.0

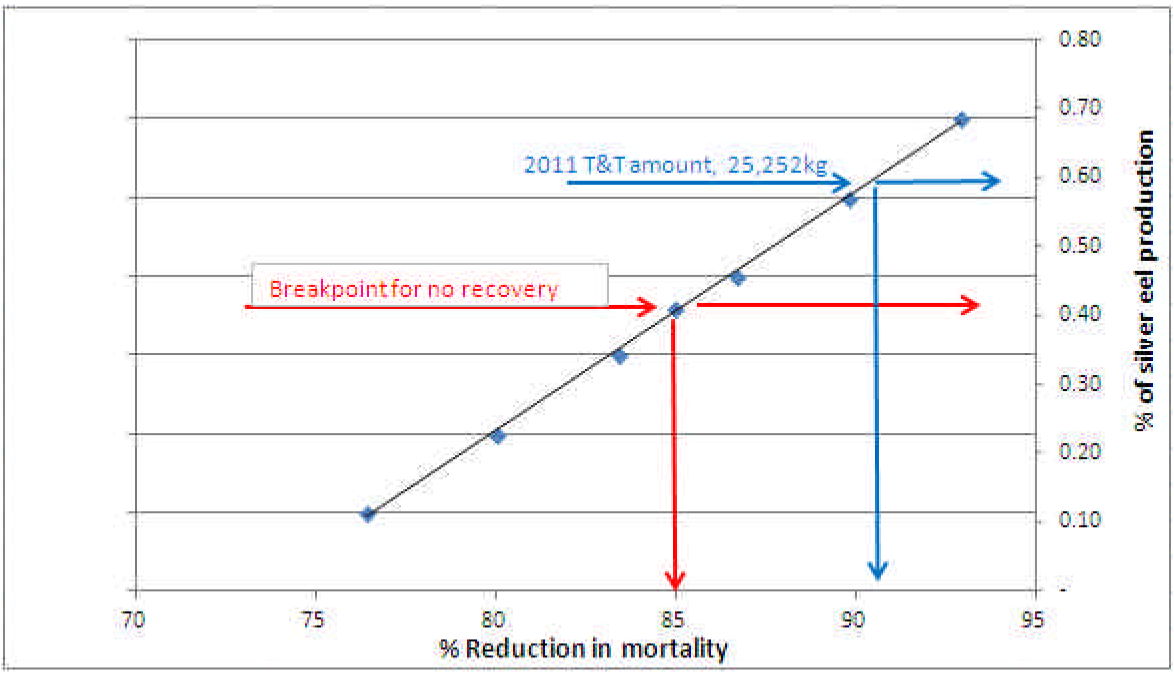


Figure 9-1: The relationship between % reduction in mortality and the proportion of the annual silver eel production required to be trapped and transported around Hydropower Stations in order to keep the mortality below the required limit (i.e. less than 15% of that before the EMP required to achieve a recovery).

10 International Advice from ICES

10.1 Introduction to ICES Advice

The International Council for Exploration of the Seas (ICES) is the prime source of scientific advice on the marine ecosystem to governments and international regulatory bodies that manage the North Atlantic Ocean and adjacent seas. The ICES Council has delegated its advisory authority to the Advisory Committee or ACOM. ACOM has established the mechanisms necessary to prepare and disseminate advice subject to a protocol satisfying the following criteria:

Objectivity an d integrity;

Openness and transparency;

Quality assurance and peer review;

Integrated advice – based on an ecosystem approach;

Efficiency and flexibility;

National consensus.

Therefore, ACOM is the sole competent body in ICES for scientific advice in support of the management of coastal and ocean resources and ecosystems. It designs strategies and processes for preparation of advice, manage advisory processes, and create and deliver advice, subject to direction from the Council. The content of scien tific advice is solely ACOM's responsibility not subject to modification by any other ICES entity. ACOM has one member from each member country under the direction of an independent chair appointed by the Council

ACOM works on the basis of scientific analysis prepared in the ICES expert groups and the advisory process include peer review of the analysis before it can be used as basis for the advice. In the case of eel, the relevant expert group is the Joint EIFAC/ICES Working Group on Eel.

10.2 ICES Advice on Eel - 2009

European eel (reproduced from the *ICES Advice 2009; Book 9*)

State of the stock

Abundance of the European eel stock (all stages glass eel, yellow eel and silver eel) is at a historical minimum and continues to decline (Figure 9.4.9.1). Recruitment is also at a historical low level and continues to decline. All glass eel recruitment series show clear and marked reductions since the early 1980s. For the different areas (Baltic, continental North Sea, continental Atlantic, British Isles, and Mediterranean), current recruitment is between 1 and 9% of that observed in the 1970s. Recruitment in 2008 and 2009 has been especially low.

Recruitment of continental North Sea yellow eel has been declining continuously since the 1950s. Recruitment of yellow eels in the Baltic is now less than 10% of that observed in the 1950s and 1970s (Figure 9.4.9.2).

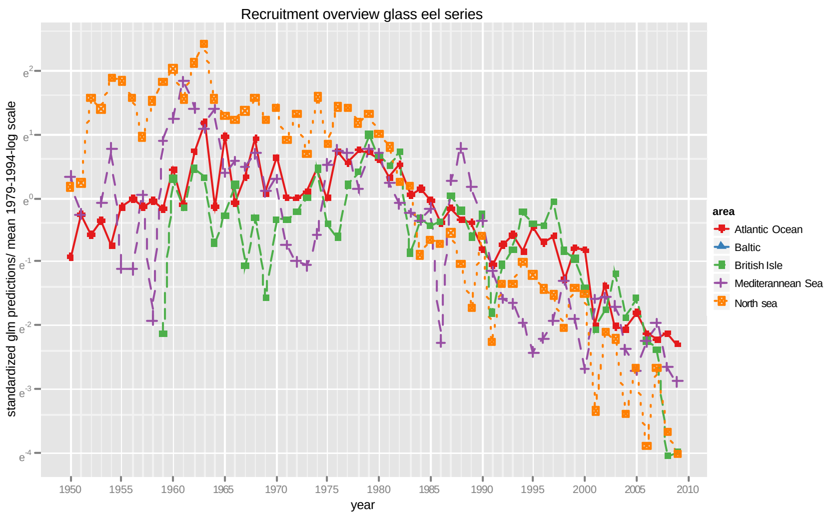


Figure 9.4.9.1 Recruitment index for glass eel per area in logarithmic scale. Each series is scaled to the mean of 1979–1994.

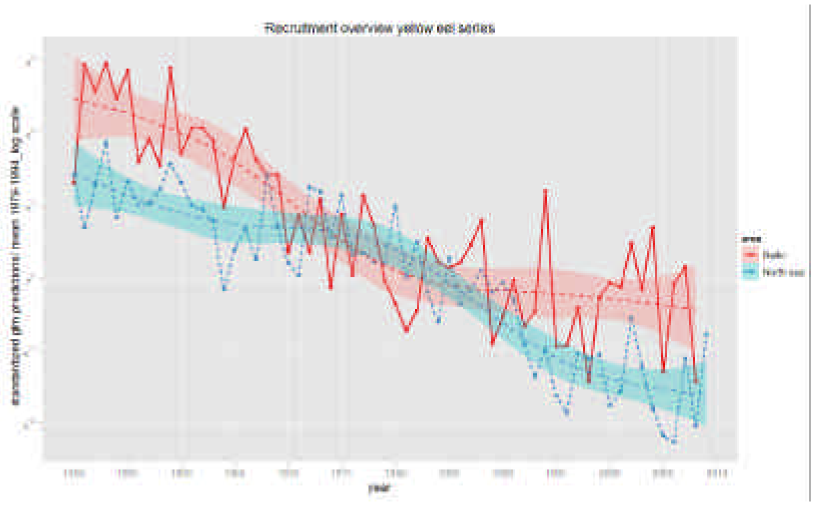


Figure 9.4.9.2 Recruitment index for yellow eel per area in logarithmic scale. Each series is scaled to the mean of 1979–1994.

Despite the marked stock decline, fishing effort and mortality continues to be high both on juvenile (glass eel) and older eels (yellow and silver eel) (FAO/ICES 2009).

Landings reported to FAO have declined to about 25% of the annual catches during the mid-1960s, although the reported landings values are known to be unreliable (see ICES, 2008, Figure 9.4.9.5). Decreased landings in combination with continuous high fishing mortality are a strong indication of reduced stock size.

Management objectives

EU adopted a management framework for the eel stock in 2007 via EU regulation (EU 1100/2007). The objective of the management framework is the protection and sustainable use of the stock. With the objective to rebuild the eel stock Norway decided in June 2009 to cut the eel quota by 80% in 2009 and to carry out an experimental fishing at a very low level in 2010.

Reference points

Precautionary reference points have not been agreed for eel. However, exploitation that leaves 30% of the virgin spawning stock biomass is generally considered to be a reasonable target for escapement. Due to the uncertainties in eel management and biology ICES proposed a limit reference point of 50% for the escapement of silver eels from the continent in comparison to pristine conditions (ICES, 2003). This is higher than the escapement level of at least 40% 'pristine' set by the EU Regulation.

Single-stock exploitation boundaries

Exploitation boundaries in relation to precautionary limits

The abundance of the European eel stock continues to decline at an alarming rate. A concerted effort by all European countries over the distribution area of eel is urgently needed to halt this decline. There are indications that recruitment may be impaired by the current low level of spawning stock size. All types of anthropogenic stresses (e.g., recreational and commercial fishing, barriers to passage, habitat alteration, pollution,) should be minimized to promote stock recovery until there is clear evidence that the stock is increasing. Due to the long life time of eel recovery will be a long-term process.

Given the continued declining abundance of glass eels, ICES reiterates its concern about glass eel stocking programs. The programs involve capture and translocation of eels from one river to another. While stocking programs may benefit specific rivers, these programs risk reducing the contribution that these glass eels could make to sustain the overall European eel stock, because of capture and translocation mortality and reduced survival in the river where eels are stocked. Fishing and use of glass eel for any purpose should be reconsidered, with intervention only taking place where there is an objective of increasing or protecting the glass eel's contribution to spawner production.

ICES reiterated its previous advice that **"all anthropogenic impacts on production and escapement of eels should be reduced to as close to zero as possible until stock recovery is achieved"**.

Management considerations

In the 1970s, recruitment of glass eels was still at average levels. This indicates that SSB was not limiting the production of recruits during this period.

The eel stock is scattered over a multitude of inland and coastal waters with divergent characteristics. Anthropogenic pressures, such as fishing, barriers to migration (including intakes and turbines), pollution, habitat loss, etc. vary between river basins. Therefore, management plans prepared under the auspices of the EU Regulation should address anthropogenic stresses that are locally important. Interim recovery levels, more stringent that those defined in the EU Regulation, should also be considered in the development of management plans. Candidates for interim recovery levels are discussed in FAO/ICES (2008).

The EU Regulation makes a portion of glass eel catches available for stocking, which may involve translocation of eels between river basins. It is unlikely that the 40% recovery objective of the EU Regulation can be met primarily through stocking, since the total catch of glass eels is well below that required. Moreover, the contribution the glass eels used for stocking make to the future spawning stock will be reduced if: (a) there is some capture and translocation mortality, (b) there are more anthropogenic stresses in the river system in which they are stocked than in the source river and (c) the stocked eels are not able to migrate to spawning grounds and contribute to the spawning portion of the stock. As noted above, ICES is concerned about the use of glass eels for stocking, and it does not endorse this aspect of the EU Regulation. However, recognizing that it is allowed under the Regulation, stocking should be limited to unpolluted waters with low pathogen burdens, and exhibiting minimal other anthropogenic impacts, including fishing. Procedures to prevent the introduction and spreading of parasites and diseases should be applied, in accord with European fish disease prevention policies. As stated in the ICES Advice 2008: "...large-scale stocking should not be allowed unless a scientific evaluation demonstrates that the potential escapement of silver eels will be enhanced."

It is important that monitoring of stock size and recruitment be continued and further enhanced so that future stock development can be measured and the efficacy of eel management plans can subsequently be quantified and evaluated. Arrangements must be made to make monitoring data accessible and compiled in a form for international analysis. Following the implementation of eel management plans in July 2009 (although some have been delayed), national reports from Member States on their implementation practices are expected in 2012. Following this, the first post-evaluation of the regulation is expected.

The escapement level of at least 40% 'pristine' set by the EU regulation is below ICES proposal for a limit reference point of 50% for the escapement of silver eels.

Ecosystem considerations

Habitat alteration, including barrier to eel passage and deterioration in water quality (contaminants, diseases and parasites) contribute to the anthropogenic stresses on eels and also affect their reproductive success.

Factors affecting the fisheries and the stock

Regulations and their effects

In 2007, eel was included in CITES Appendix II that deals with species not necessarily threatened with extinction, but in which trade must be controlled to avoid utilization incompatible with the survival of the species (see http://www.cites.org/eng/disc/how.shtml). The listing was implemented in March 2009.

The environment

Recent research has indicated that pollution, diseases, and parasites seriously impair the quality and reduce the fat content of individual silver eels, although the impact on the overall stock is unknown. On a pan-European scale, large differences in eel quality occur between areas. The quality of spawners also varies with biological characteristics such as fat content. None of these quality parameters are currently included in the assessment of stock status, or in setting management targets. However, these quality parameters have impacts on the condition and behaviour of individual eels and may impact their reproductive success. As well, from some regions, eels are contaminated to such an extent that they exceed either National or EU human consumption limits and consequently represent a threat to consumers.

Scientific basis

Data and methods

The advice is based on recruitment indices both from surveys and commercial data. Reported landings data are unreliable and incomplete, but show a decline. Most EU Member States now have quantitative estimates of pristine silver eel production.

Uncertainties

The varying degrees of uncertainty in the estimates of pristine silver eel production make evaluation of progress toward the 40% recovery level (called for in the EU Regulation) difficult. The lack of spatial and process information on the effect of decreasing spawner quality makes it challenging to quantify the impact on effective spawner biomass.

The implementation of the EU Regulation has the potential of improving data in the future. However, several long time-series may be jeopardised in the near future due to changes in the local eel fisheries under the Eel Management Plans (EMPs). Given the poor state of the stock and the high anthropogenic impacts, it is critically important that the existing time-series of recruitment be continued and supplemented. For all existing fisheries, effort and yield need to be monitored. Improved spatial coverage is needed to adequately characterize the quality of eels over the species area of distribution.

Current data collection programmes (EMPs, DCR, WFD, etc) need to be extended, co-ordinated, and integrated to support enhanced eel assessment and management.

Comparison with previous assessment and advice

The status of the stock is critical. The stock continues to decline. The advice remains that urgent actions are needed to avoid further depletion of the eel stock and to promote recovery.

Source of information

EC 2007. Council regulation (EC) N° 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel.

ICES 2003. Report of the ICES Advisory Committee on Fishery Management 2002. ICES Cooperative Research Report No. 255: 938–947.

ICES. 2008. Report to the ICES Advisory Committee, 2008. ICES Advice, 2008. Books 1–10. 1842 pp.

FAO/ICES 2009. Report of the EIFAC/ICES Working Group on Eels, Göteborg (Sweden), 7–12 September 2009.

10.3 ICES Advice on Eel - 2010

European eel (reproduced from the *ICES Advice 201; Book 9*) (November 2010; revised December 2010)

ICES reiterates its previous advice that all anthropogenic mortality (e.g. recreational and commercial fishing, barriers to passage, habitat alteration, pollution, etc.) affecting production and escapement of eels should be reduced to as close to zero as possible until there is clear evidence that the stock is increasing. A concerted effort by all European countries to conserve eel habitats is urgently needed.

Given the current record-low abundance of glass eels, ICES reiterates its concern that glass eel stocking programs are unlikely to contribute to the recovery of the European eel stock. This is because (a) there is no surplus anywhere of glass eel to be redistributed to other areas and (b) there is evidence that stocked/translocated eels experience impairment of their navigational abilities.

Stock status

Abundance of the European eel stock continues to decline at an alarming rate. There are indications that recruitment is impaired by the current low level of spawning stock size. Abundance of all stages of eel (glass eel, yellow eel and silver eel) remains at the historical minimum. Recruitment in 2006, 2008, 2009 and 2010 has been especially low (Figures 9.4.9.1 and 9.4.9.2). In 2009, the decrease was sharp, especially in the northern part of the distribution area, with a drop of around 50 60% for glass eel between 2008 and 2009.

All glass eel recruitment series show clear and marked decadal reductions since the early 1980s.

Over the last 5 years glass eel recruitment has averaged between 1% (continental North Sea) and 7% (continental Atlantic) of the 1960-1979 levels (Figures 9.4.9.3 and 9.4.9.4).

A difference in spatial pattern of recruitment is observed at most stations in the North Sea, where the decline is sharper than elsewhere. There is no current clear explanation for that observation, although the North Sea and Baltic Sea data are predominantly fisheries independent time series.

Recruitment of continental yellow eel has been declining continuously since the 1950s (Figure 9.4.9.5).

Management plans

A management framework for the eel stock was established in 2007 through an EU Regulation (EU 1100/2007). The objective of this Regulation is the protection, recovery and sustainable use of the stock. To achieve the objective, Member States have developed eel management plans for their river basin districts designed to reduce anthropogenic mortalities and increase silver eel biomass. The objective of the eel management plans is to allow in the long term, with high probability, an escapement to the sea of the biomass of silver eel of at least 40%, relative to the best estimate of the theoretical escapement in pristine conditions (i.e. if the stock had been completely free of anthropogenic influences). ICES has evaluated whether individual EMPs by country are in accordance with the Regulation, but ICES could not evaluate whether the overall performance of national management plans are in accordance with the EU Regulation. The reason why ICES could not evaluate the plan was that some important countries had not quantified their plans and that some plans were not accepted.

Biology

European eel spawn in the Sargasso Sea and die after spawning. The larvae are transported by the Gulf Stream to North Africa and Europe and the juvenile eel enter coastal areas and freshwater as glass eel. They quickly transform into yellow eel and stay in Europe for 5 15 years or more. Growth and age at maturity are linked to regional temperature (eels mature later at colder temperatures). Then they start maturing, become silver eel and migrate back to the Sargasso Sea.

Environmental influence on the stock

Habitat alteration, including barriers to eel passage and deterioration in water quality (contaminants, diseases and parasites) contribute to the anthropogenic stresses on eels and also affect their reproductive success. In some cases, an improvement in water quality has been observed in the 1980s and 1990s and it is anticipated that future improvements might be expected when the Water Framework and Marine Strategy Framework Directives are fully implemented. Due to bioaccumulation in eels, however, contamination in some areas remains a serious problem.

It is likely that there is a relationship between eel contaminant levels and spawning success. However, this could not be quantified.

The fisheries and other mortality causes

The fisheries target glass eel, yellow eel and silver eel. Both commercial and recreational fisheries are important. A large proportion of the catch is unreported. Many silver eel die in hydropower turbines when they migrate out of freshwater on their way to the Sargasso Sea. Cormorants consume a substantial amount of eel each year.

Effects of the fisheries on the ecosystem

The current eel fishery probably has no or minor influence on the marine ecosystems. However, the exploitation rate on eel may affect the riverine ecosystem through changes in species compositions. There is a limited knowledge on the magnitude of these effects.

Quality considerations

Total landings data have been found to be unreliable and it is hoped that the implementation of the DCF and eel Regulation/CITES traceability schemes will improve this situation. There was a great heterogeneity among the landings data with incomplete and inconsistent reporting by countries and changes in management practices were found to have also changed the reporting of non-commercial and recreational fisheries

Scientific basis

The advice on stock decline is based on recruitment indices both from surveys and commercial data. While the traceability element of the catch reporting has led to an improvement, particularly for glass eel, yellow and silver eel landings data remain unreliable, incomplete and need to be radically improved. Monitoring recruitment has been the main tool in the past for assessing the overall status of the eel stock. Monitoring recruitment is not an obligation in the WFD, DCF or Eel Regulation and this should be rectified.

Supporting information November, Revised December 2010

Reference points

Exploitation that leaves 30% of the virgin spawning stock biomass is generally considered to be a reasonable target for escapement. Due to the uncertainties in eel management and biology, ICES proposed a limit reference point of 50% for the escapement of silver eels from the continent in comparison to pristine conditions (ICES, 2003). This is higher than the escapement level of at least 40% pristine set by the EU Regulation for the escapement of silver eels.

Management plan(s)

The eel stock in Europe is assumed to constitute a single, panmictic stock, jointly exploited and impacted by all countries. Restoration of the stock thus requires that protective measures are taken in all countries (or at least, no single country can presently be excluded without potentially jeopardizing a recovery).

In the Baltic Sea area, major interactions between countries have been identified, questioning the nation-by-nation (river-by-river) approach to management of Eel for this region. Silver eels, emigrating from one country, are being fished on their route towards the outlet; and possibly, young eels on their way into the Baltic Sea might be affected by coastal management in the countries around the inlet. Effective management of eel in the Baltic Sea requires that protective efforts are coordinated between countries, and/or potentially integrated into a single Baltic Sea Eel Management Plan, preferably with the aim of reducing all anthropogenic mortality as much as possible.

In order to rebuild the stocks to sustainable levels, Norway closed all fisheries for eel from January 2010 and onwards, except for a research programme (with a 50 t quota) to monitor the development of the stock in Norwegian waters. A range of management actions have been included in the EC eel management plans ranging from complete fisheries closures and hydropower mitigations (i.e. Ireland) to almost no fisheries restrictions accompanied by restocking programmes (e.g. Germany).

Local fishery closures have also been applied in Belgium and France in order to protect human health from the impact of high contamination levels; such closures interact with the implementation of the eel Regulation.

Additional considerations

Management considerations

In the 1970s, recruitment of glass eels was at an historical maximum level, since records began. This suggests that SSB was not limiting the production of recruits during this period.

The EU-Regulation 1100/2007 includes stocking, amongst many other measures, as one management option to increase silver eel escapement from River Basin Districts. Because there are evidence of impairment of the navigational abilities of stocked/translocated eels, and since there is no surplus of glass eel production which can be redistributed in other areas, countries with EMPs elements based on stocking are urged to revise their EMP accordingly.

It is important that monitoring of stock size and recruitment be continued and further enhanced so that future stock development can be measured and the efficacy of eel management plans can subsequently be quantified and evaluated. Following the implementation of eel management plans in July 2009 (although some have been delayed), national reports from Member States on their implementation practices are expected in 2012. Arrangements must be put in place as a matter of urgency to make monitoring data accessible and compiled in a form for international analysis.

It is recommended that data collection and reporting be co-ordinated at the international level to ensure quality assurance, standardised reporting and inter-calibration between assessment methods be executed to standardise results.

The minimum data requirement for this evaluation on stock status is B_{post} (Biomass of the escapement in the assessment year), B_{best} (estimated biomass in the assessment year based on the recent recruitment and assuming no anthropogenic impacts) and B_0 (biomass of the escapement in the pristine state), or equivalent trios, e.g. B_{post}, A (sum of anthropogenic mortality) and B_0.

The escapement level of at least 40% pristine set by the EU regulation is below ICES proposal for a limit reference point of 50% for the escapement of silver eels.

Factors affecting the fisheries and the stock

Regulations and their effects

The EU Regulation to recover the eel stock is being implemented. In 2007, eel was included in CITES Appendix II that deals with species not necessarily threatened with extinction, but in which trade must be controlled to avoid utilization incompatible with the survival of the species (see http://www.cites.org/eng/disc/how.shtml). The listing was implemented in March 2009. Eel was listed in September 2008 as critically endangered in the IUCN Red List.

The environment

Recent research has indicated that pollution, diseases, and parasites may seriously impair the quality of individual silver eels, although the impact on the overall stock is unknown. On a pan-European scale, large differences in eel quality occur between areas and the quality of the eels leaving many systems is poor. New information indicates similar high levels of contamination to those which were reported previously in some countries (e.g. Belgium), at sites in other countries (e.g. France, The Netherlands, and Germany). In some cases, levels were so high that immediate actions had to be taken, and fisheries were closed as a human health protection measure.

For management purposes it is essential to understand the quality of eels present in European River Basin Districts (RBDs) in order to evaluate the reproductive potential of the silver eels leaving those systems and to compare eel quality between systems. However, there are many uncertainties and comparing the effects of different quality pressures might not be appropriate. Little is known about the eel s sensitivity towards parasites, diseases, and contaminants under field conditions with respect to reproduction, and information will be required on setting threshold values for various contaminants.

A possible approach to this developed by the ICES in 2010 is an Eel Quality Index (EQI) which uses threshold values in a quality rating as demonstrated in Figure 9.4.9.6. It should be noted that this approach is not based on ecotoxicological data from dose-effect studies, but from environmental concentrations in the field. Nevertheless, they may provide a practical tool for classifying the intensity of contaminants in eels. As an example, the EQI values have been calculated in eels on the basis of their Sum 7 PCBs using recent data from case studies in Scotland, France, the Netherlands and Belgium. It should be stated that in most of the cases (Scotland, France, and the Netherlands) sample sites may not be representative of the quality of eels across the whole country. Furthermore, the sampling strategy was not standardised (e.g. length classes) and this could give rise to additional variation in contaminant levels. Figure 9.4.9.6 is an illustration of a 'traffic light' system that could be applied in the future to classify eel quality, based on standardised sampling programmes.

Anguillicoloides parasite continues its spread over Europe and occurs now in all countries. Infection levels are less in brackish water systems. Overall, the levels tend to decrease slightly. The quality of spawners also varies with biological characteristics such as fat content.

None of these quality parameters are currently included in the assessment of stock status, or in setting management targets. However, these quality parameters have impacts on the condition and behaviour of individual eels and may impact their reproductive success.

Scientific basis

Data and methods

Most EU Member States now have quantitative estimates of pristine and current silver eel production, although the quality of these data has not yet been fully evaluated. Estimates of current anthropogenic mortality have only been made by some, but this information will be required for reporting under the Regulation in 2012.

Uncertainties in assessment and forecast

The varying degrees of uncertainty in the estimates of pristine silver eel production make evaluation of progress toward the 40% recovery level (called for in the EU Regulation) difficult. The lack of spatial and process information on the effect of reduced spawner quality makes it challenging to quantify its impact on effective spawner biomass.

Reduced spawner quality and climate and ocean affects probably influence spawning success and recruitment to the continent, but these processes are not yet well understood. Under the precautionary approach, the absence of full knowledge and control of these factors strengthen the need to reduce all anthropogenic impacts to as close to zero as possible.

The implementation of the EU Regulation has the potential of improving data in the future. However, several long time series have ceased or may be jeopardised in the near future due to changes in the local eel fisheries under the Eel Management Plans. Given the poor state of the stock and the high anthropogenic impacts, it is critically important that the existing fisheries-independent time series of recruitment be continued and supplemented. For all existing fisheries, effort and yield need to be monitored. Improved spatial coverage is needed to adequately characterize the quality of eels over the species area of distribution.

Current data collection programmes (EMPs, DCF, WFD, etc) need to be extended, co-ordinated, and integrated as a priority to support enhanced eel assessment and management. It is recommended that an international workshop be convened as a matter of urgency to achieve this.

Data collection, analysis and reporting needs to be co-ordinated at the international level and reporting of data should be standardised and quality assured. This integrated and internationally co-ordinated approach is particularly important in the Baltic Sea area where a joint management action is necessary. Procedures and assessments need to be in place and tested before 2012.

Comparison with previous assessment and catch options

There is no change in the perception of the stock: the status remains critical and shows no sign of recovery. The advice remains that urgent actions are needed to avoid further depletion of the stock.

Sources of information

EC. 2007. Council Regulation (EC) N° 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel.

ICES. 2003. Report of the ICES Advisory Committee on Fishery Management 2002. ICES Cooperative Research Report, 255: 938 947.

FAO/ICES. 2009. Report of the EIFAC/ICES Working Group on Eels, Goteborg (Sweden), 7-12 September 2010.

FAO/ICES. 2010. Report of the EIFAC/ICES Working Group on Eels, Hamburg (Germany), 9-14 September 2010.

ICES. 2010. Report of the Workshop on Baltic Eel, Stockholm (Sweden), 2-4 November 2010. ICES CM 2010/ACOM:59. *In prep.*

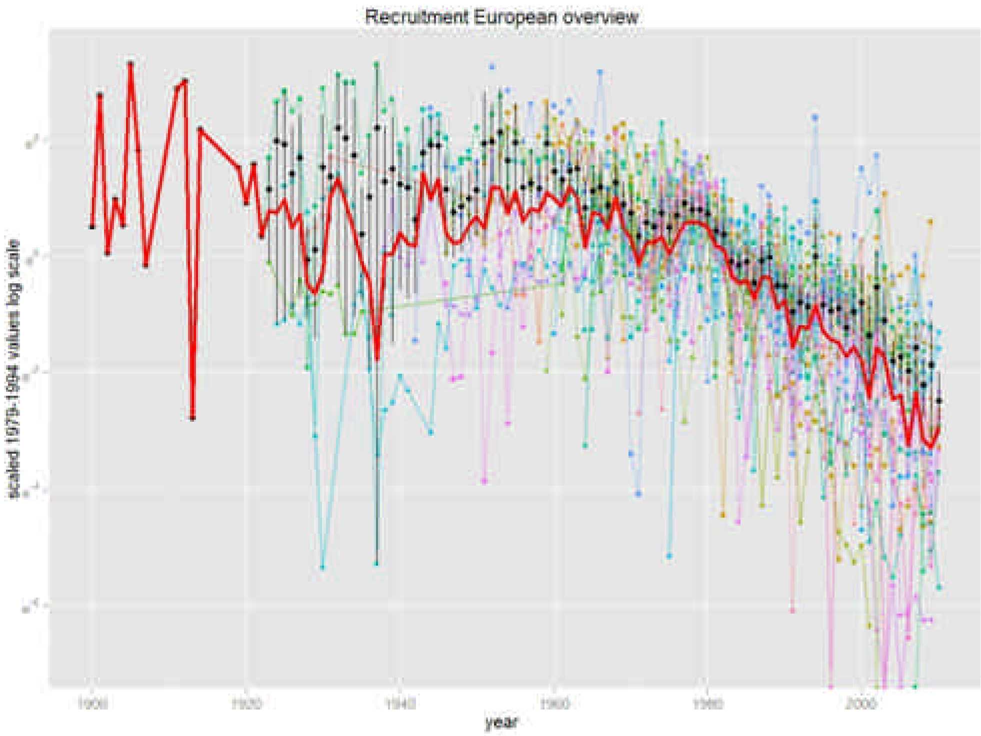


Figure 9.4.9.1 Time-series of monitoring glass eel and yellow eel recruitment in European rivers with data series > 35 years (26 rivers). Each series has been scaled to its 1979–1994 average. Note the <u>logarithmic scale</u> on the y-axis. The mean values and their bootstrap confidence interval (95%) are represented as black dots and bars. Note: for practical reasons, not all series are presented in this graph, whereas the following analysis is done on all series. Geometric means are presented in red.

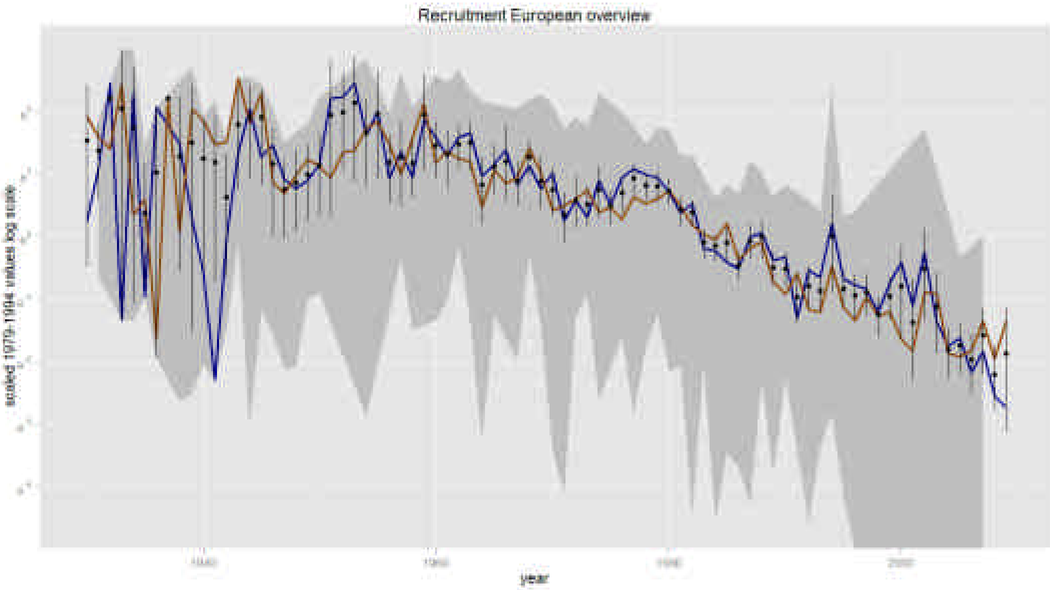


Figure 9.4.9.2 Time-series of monitoring glass eel and yellow eel recruitment in European rivers with data series > 35 years (24 rivers). Each series has been scaled to its 1979–1994 average. Note the <u>logarithmic scale</u> on the y-axis. The mean values and their bootstrap confidence interval (95%) are represented as black dots and bars. The brown line represents the mean value for yellow eel while the blue line represents the mean value of the glass eel series. The range of the series is indicated by grey shading.

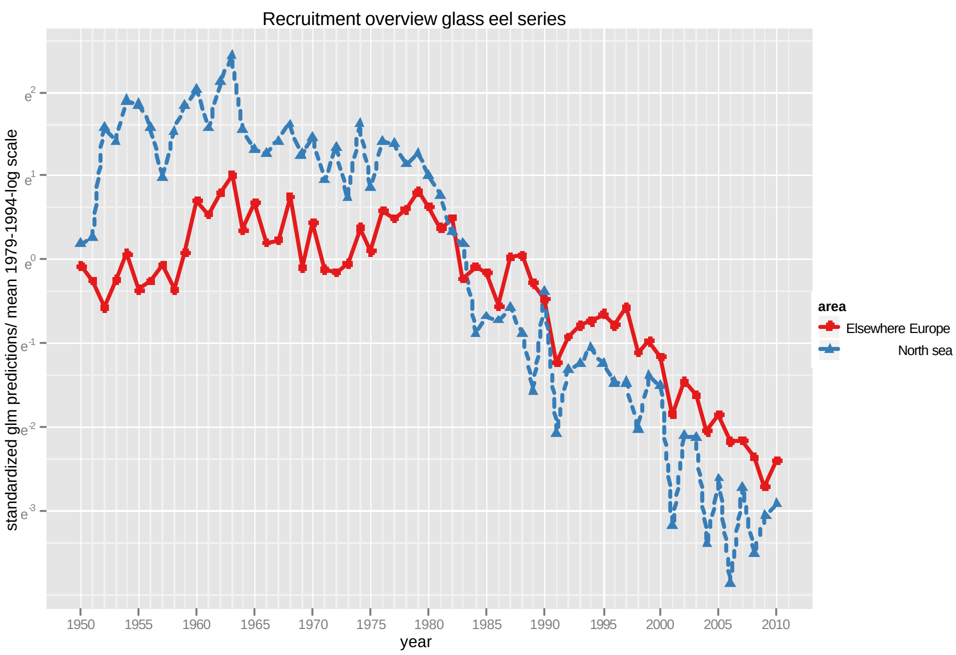


Figure 9.4.9.3 Mean of estimated (GLM) glass eel recruitment for each <u>area</u> in Europe. The GLM (recruit=area:year+site) was fitted to all glass eel series available and scaled to the 1960-1979 average. No series for glass eel are available in the Baltic Sea area. Note <u>logarithmic scale</u>.

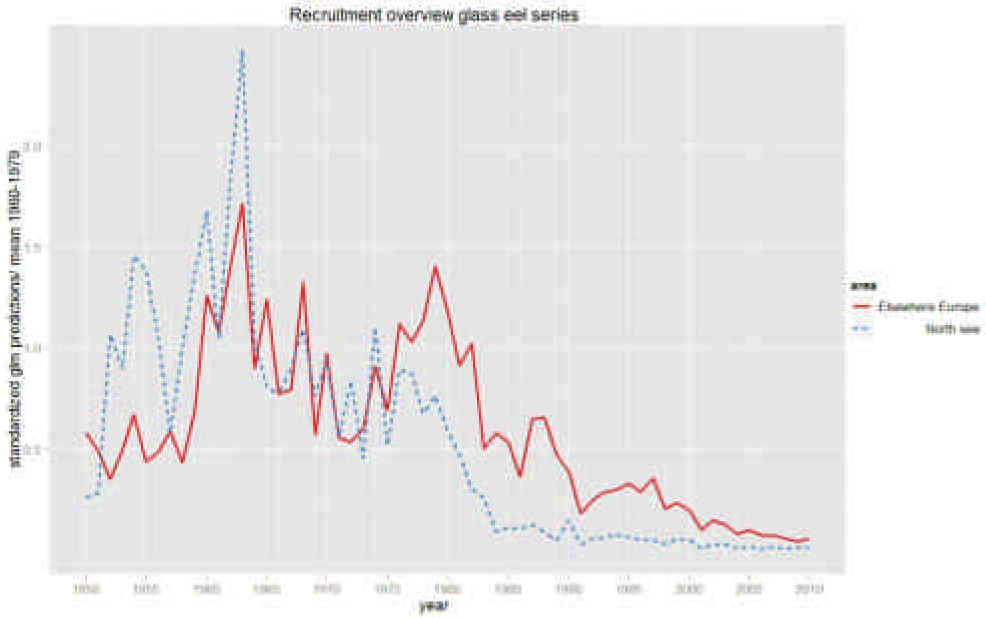


Figure 9.4.9.4 Mean of estimated (GLM) glass eel recruitment for each area in Europe. The GLM (recruit=area:year+site) was fitted to all glass eel series available and scaled to the 1960–1979 average. No series for glass eel are available in the Baltic Sea area. Note linear scale.

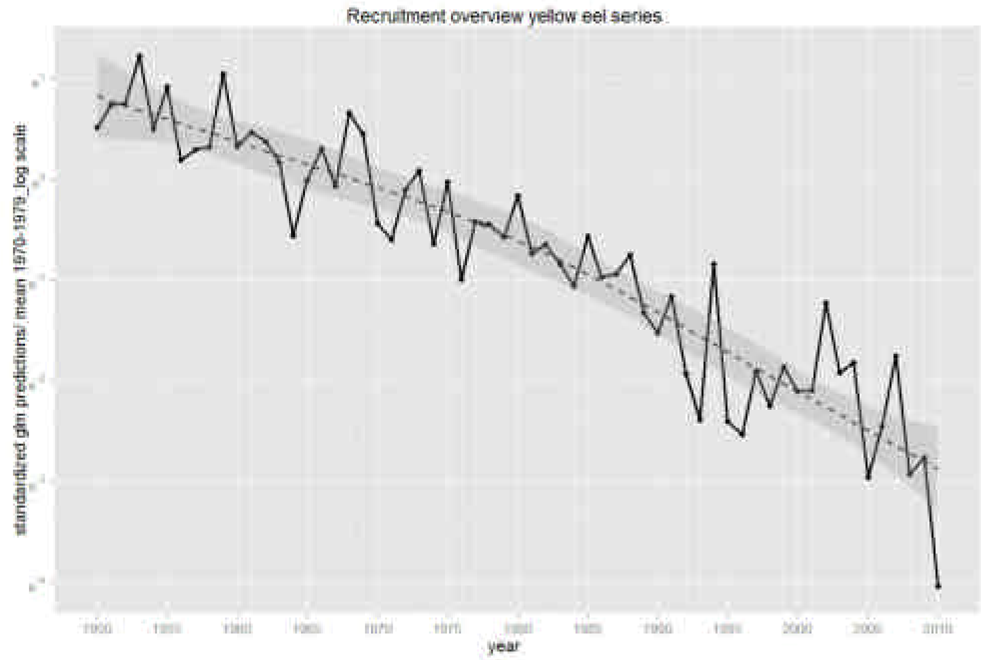


Figure 9.4.9.5 Mean of estimated (GLM) yellow eel recruitment and smoothed trends for Europe. The GLM (recruit=area:year) was fitted to all yellow eel series available and scaled to the 1960–1979 average. Note logarithmic scale. Band shows 95% point-wise confidence interval of the smoothed trend.

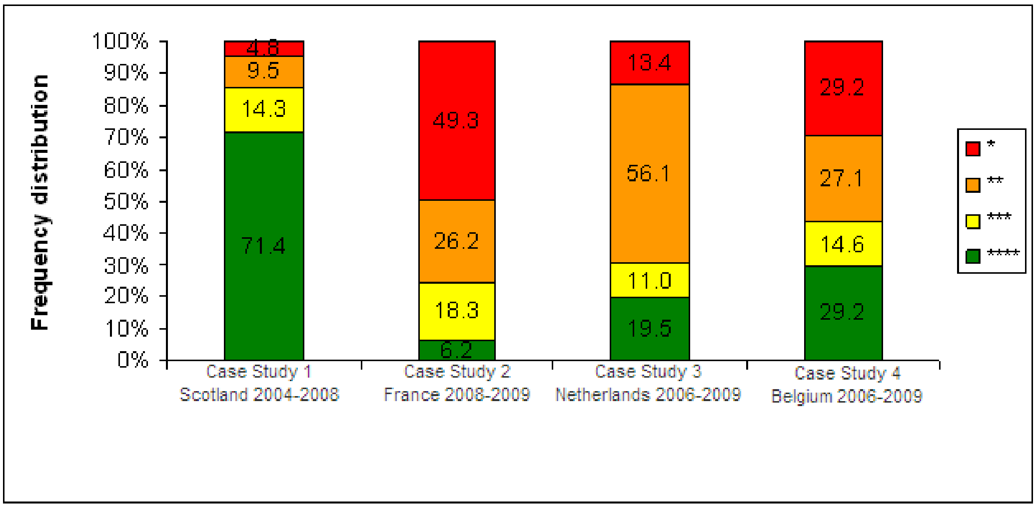


Figure 9.4.9.6 Demonstration Eel Quality Index (EQI) based on the ICES 7PCBs from recent data provided in the EEQD. Care should be taken when interpreting this as many of the samples were targeted at known pollution sites with non-uniform sampling strategies and may not be representative of wider scales. Four stars (green) represent unpolluted or low polluted eel. Eel with a slight to moderate pollution level are classified as three (yellow) or two (orange) star eel. The more polluted sites are assigned as 2 (polluted) or 1 (strongly polluted) star eel (red). This classification system is not based on ecotoxicological data from dose-effect studies, but from environmental concentrations in the field.

10.4 ICES Advice on Eel - 2011

European eel (reproduced from the *ICES Advice 2011; Book 9*)

Advice for 2012

The status of eel remains critical and urgent action is needed. ICES reiterates its previous advice that all anthropogenic mortality (e.g. recreational and commercial fishing, hydropower, pollution) affecting production and escapement of eels should be reduced to as close to zero as possible until there is clear evidence that both recruitment and the adult stock are increasing.

Given the current record-low abundance of glass eels, ICES reiterates its concern that glass eel stocking programmes are unlikely to contribute to the recovery of the European eel stock in a substantial manner. The overall burden of proof should be that stocking will generate net benefits, in terms of contributions to silver eel escapement and spawning potential. Prior to stocking, or for continuing existing stocking, a risk assessment should be conducted, taking into account fishing, holding, transport, post-stocking mortalities, and other factors such as disease and parasite transfers. To facilitate stock recovery all catches of glass eel should be used for stocking. Stocking should take place only where survival to the silver eel stage is expected to be high and escapement conditions are good. This means that stocking should not be used to continue fishing and stocking should only take place where all anthropogenic mortalities are low.

If suitable biomass and mortality data are reported by Member States in 2012 under the Council Regulation EC No. 1100/2007 (EC, 2007), ICES will use those to define and propose standard precautionary approach reference points.

Stock status

The eel stock continues to decline in 2011. The glass eel recruitment trend has fallen to 5% of the 1960–1979 average in the Atlantic region and to less than 1% in the North Sea area, showing no sign of recovery (Figures 9.4.9.1–3).

Recruitment of young yellow eel has been declining continuously since the 1950s (Figure 9.4.9.4). Stock indicators in the national eel management plans submitted in 2008 indicated that anthropogenic mortality was above the limit implied by EC Regulation No. 1100/2007 (EC, 2007). New data were not available, but it is anticipated that the 2012 reports to the EC will provide them.

Abundance of all stages of eel (glass eel, yellow eel, and silver eel) is at an historical minimum. The stock is in a critical state. In 2007, eel was included in CITES Appendix II that deals with species not necessarily threatened with extinction, but in which trade must be controlled to avoid utilization incompatible with the survival of the species (see http://www.cites.org/eng/disc/how.shtml). The listing was implemented in March 2009. Eel was listed in September 2008 as critically endangered in the IUCN Red List.

Management plans

A management framework for eel was established in 2007 through an EC Regulation (EC No. 1100/2007; EC, 2007). The objective of this regulation is the protection, recovery, and sustainable use of the stock. To achieve the objective, Member States have developed eel management plans for their river basin districts, designed to reduce anthropogenic mortalities and increase silver eel biomass.

The objective of the national eel management plans is to provide, with high probability, a long-term 40% escapement to the sea of the biomass of silver eel, relative to the best estimate of the theoretical escapement in pristine conditions (i.e. if the stock had been completely free of anthropogenic influences). ICES has evaluated the conformity of the national management plans with EC Regulation No. 1100/2007 (ICES Advice Reports 2009 and 2010, Technical Services), but it has not evaluated the consistency of the regulation itself with the precautionary approach. ICES will undertake such an evaluation based on the national reports due in 2012 in accordance with EC Regulation No. 1100/2007 (EC, 2007).
A coordinated approach to planning, data workshops, and stock assessment is needed to take full advantage of the 2012 scheduled reporting by Member States on monitoring, effectiveness, and outcome of the national eel management plans. The subsequent statistical and scientific assessment will include an opinion by STECF as envisaged by the EU. Independent access to the raw data, biomass, and mortality estimates (see supporting information) provided by the Member States will be required to undertake the statistical and scientific assessments of the reliability and accuracy of the estimates.

Biology

European eel life history is complex and atypical among aquatic species. The stock is genetically panmictic and data indicate random arrival of adults in the spawning area. The European eel spawns in the southwestern part of the Sargasso Sea. 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 and enter continental waters. The growth stage, known as yellow eel, may take place in marine, brackish, or freshwaters. This stage may last from 2 to 25 years (and could exceed 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. Silver eels then migrate to the Sargasso Sea where they spawn and die after spawning.

Environmental influence on the stock

Changes in environmental conditions at the spawning grounds and during the oceanic phase are likely to affect the stock but are not quantified.
Habitat alteration, including barriers to eel passage, deterioration in water quality, contaminants, non-native diseases and parasites contribute to the anthropogenic stresses and mortality on eels and also affect their reproductive success. It is anticipated that future improvements to the

environment might be expected when the Water Framework and Marine Strategy Framework Directives are fully implemented and that this will have a positive effect on the quality of silver eel, in terms of consumption value as well as for reproduction. Bioaccumulation of contaminants in eels, however, remains a serious problem in some areas.

It is likely that there is a negative relationship between eel contaminant levels (and *Anguillicoloides crassus* and diseases) and spawning success. However, this could not be quantified.

An increased awareness of contaminants in eel, in relation to consumption limits for food, is leading to fishery closures to protect consumers. These selective closures may lead to an increased proportion of low quality spawners in the escapement.

The fisheries and other mortality causes

Fisheries on all continental life stages take place throughout the distribution area. Impacts vary from almost nil to heavy overexploitation. The EC Eel Regulation delegates the assessment and management of the fisheries to the Member States, and fishing mortalities are expected to be quantified in the national reports delivered by Member States in 2012 (EC Regulation No. 1100/2007; EC, 2007).

Effects of the fisheries on the ecosystem

The current eel fishery probably has little influence on aquatic ecosystems, with the possible exception of local bycatch issues. However, the loss of eel, whether due to fisheries or other causes, as an important and frequently dominating species may have had a more profound effect. There is limited knowledge on the magnitude of these effects and assessment is needed at the species, habitat, and ecosystem level.

Quality considerations

Total landings and effort data have been found to be unreliable. There is a great heterogeneity among the landings data with incomplete and inconsistent reporting by countries. Changes in management practices have also changed the reporting of non-commercial and recreational fisheries.

Scientific basis

The assessment is based on surveys and commercial data. Monitoring recruitment has been the main tool in the recent past for assessing the overall status of the eel stock.

Assessment type	Index-based assessment.
Input data	Glass eel and yellow eel indices.
Discards and bycatch	Discards not included.
Indicators	None.
Other information	Landing statistics unreliable.
Working group report	WGEEL

9.4.9 Supporting information November 2011

ECOREGION Widely Distributed and Migratory Stocks

STOCK European eel advice

Reference points

Exploitation that leaves 30% of the virgin spawning-stock biomass is generally considered to be a reasonable target for escapement. Due to the uncertainties in eel management and biology, ICES proposed a limit reference point of 50% for the escapement of silver eels from the continent in comparison to pristine conditions (ICES, 2003). This is higher than the escapement of at least 40% "pristine" set by the EC Regulation for the escapement of silver eels. ICES has evaluated the conformity of country management plans with EC Regulation 1100/2007 (ICES Advice Reports 2009 and 2010, Technical Services), but it has not evaluated the consistency of the regulation itself with the precautionary approach. ICES will undertake such an evaluation based on country reports due in 2012 under EC Regulation 1100/2007.

Additional considerations

Management considerations

When stocking to maximize output from the limited supply of glass eel currently available, an estimation of the prospective net benefit to silver eel escapement, to the extent possible, should be made prior to translocation for stocking.

Where eel are translocated and stocked, a means should be put in place to evaluate their fate and their contribution to silver eel escapement. This might take the form of batch marking of eel to distinguish groups recoverable in later survey, or implementation of tracking studies of eel of specifically known origin.

Factors affecting the fisheries and the stock

Regulations and their effects

As eel is a long-lived species and anthropogenic mortalities occur over all of its continental lifespan, the effect of management measures on silver eel and on their subsequent recruits (glass eel coming back to the coast) is expected to take several years to be detected (ICES, 2009). When these management measures eventually feed through to silver eel escapement and glass eel recruitment, the natural variability of these migrations, local site effects, and sampling error may prevent the detection of such changes for at least several more years, even a decade or more (ICES, 2011a, 2011b). Therefore, the recovery process and the detection of possible changes due to management actions will be a slow process. The reporting by Member States to the EC in 2012 is a first step, and, in the short term changes in anthropogenic mortality and local variations in the stock will have to be used to quantify the effect of management measures.
The implementation of the eel management plans may imply progressive restrictions on local small-scale fisheries, and with the decline of the eel stock some of these fisheries could collapse. Poaching is widespread in some countries and might, in some places, continue despite legal closures of the fishery. There is a risk of an increase in illegal fishing as legal fisheries decline.

The environment

There is a need for standardization of eel quality assessments as different analytical methods and data reporting often make comparisons difficult.

There is an urgent research need to better quantify the effects of parasites, diseases, and contaminants on migration and reproduction success, and to further develop the Eel Quality Index. When the effects of stress factors can be quantified they should be included in eel stock assessments and management. Contamination by hazardous substances is so high that an effect on reproduction is likely to occur, but hard scientific evidence (dose/response studies) is not available.

EC Regulation No. 1881/2006 (EC, 2006), setting maximum concentrations of dioxins and dioxinlike PCBs in food, has lead to closures or restrictions of eel (or fish in general) fisheries. During the last years (2010–2011) fisheries restrictions/bans have been issued for an increasing number of water bodies.

The non-native invasive *Anguillicoloides crassus* parasite that infects the swimbladder of eel is now widespread in Europe and is continuing to spread within some countries (e.g. Scotland and Ireland). As *A. crassus* impacts on the health, energy reserves, and migratory behavior of the eel and is likely to hinder a recovery of the stock, this gives serious cause for concern.

Scientific basis

Data and methods

WGEEL (ICES, 2010a; Annex 5) recommended that Eel Management Plan reporting must provide the following biomass and anthropogenic mortality data:

- B_{post}, the biomass of the escapement in the assessment year;
- B_0, the biomass of the escapement in the pristine state. Alternatively, one could specify B_{lim}, the 40% limit of B_0, as set in the Eel Regulation;
- B_{best}, the estimated potential biomass in the assessment year, assuming no anthropogenic impacts (and without stocking) have occurred and from all potentially available habitats.
- ?A, the estimation of B_{best} will require an estimate of A (anthropogenic mortality (e.g. catch, turbines)) for density-independent cases, and a more complex analysis for density-dependent cases.

Most EU Member States now have quantitative estimates of B_0 and B_{post} silver eel production, although the reliability and accuracy of these data have not yet been fully evaluated. Estimates of current anthropogenic mortality have only been made by some Member States, but this information will be required for reporting by Member States under the Regulation in 2012.

Coordinated planning of data collection and assessment is urgently required to support the statistical and scientific assessment outlined in the EC Regulation (EC No.1100/2007) following reporting by Member States in 2012. Efforts to coordinate data collection and analysis have commenced in some regions with, for example, a series of Baltic workshops planned. A similar system is recommended for other regions, particularly the Mediterranean for which there is a lack of data.

Monitoring recruitment is not an obligation in the WFD, DCF, or Eel Regulation, and this should be rectified along with other recommended improvements to the data collection process under these directives.

Uncertainties in assessment and forecast

Statistical uncertainty, which could be considerable, was not taken into account in the preliminary model derived for the assessment of the effect of stocking.

Quantifying the impact of reduced quality on effective spawner biomass is not currently achievable.

Considerations regarding the quality of the advice

Total landings and effort data have been found to be unreliable. The implementation of the Data Collection Framework and Eel Regulation/CITES traceability schemes needs to be improved. There is a great heterogeneity among the landings data with incomplete and inconsistent reporting by countries. Changes in management practices have also changed the reporting of non-commercial and recreational fisheries.

ICES warns of a risk of data discontinuities (ICES 2009, 2010a, 2010b), particularly related to data from commercial fisheries, following implementation of EMPs (e.g. management measures affecting fishing effort, season, quota, size limits), and CITES restrictions. The loss since 2008 of four long-term recruitment series in France is such a consequence. The expected changes to the recruitment time-series due to the implementation of management measures, particularly the glass eel time-series, would reduce the data available for analysis by almost half. The provision of scientific advice on changes to the stock based on recruitment series will in the coming years become vulnerable and it is unlikely that statistical modelling will be able to correct for this. Losing recruitment series reduces the potential to detect a recovery.

The post-evaluation process for the EC Regulation (EC No. 1100/2007) following the reporting by Member States in 2012 requires urgent and careful planning. This includes the development and application of harmonized and accessible data and assessment procedures.

Comparison with previous assessment and advice

There is no change in the perception of the stock: the status remains critical and the stock shows no sign of recovery. The advice remains that urgent actions are needed to prevent further depletion of the stock.

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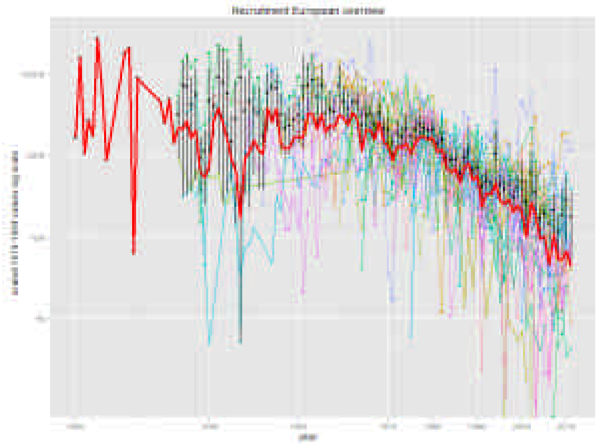

Figure 9.4.9.10-1 Time-series of monitoring glass eel and yellow eel recruitment in European rivers with data series > 35 years (26 rivers). Each series has been scaled to its 1979–1994 average. The mean values and their bootstrap confidence interval (95%) for glass eel and yellow eel combined are represented as black dots and bars. Geometric means for glass eel and yellow combined are presented in red. For practical reasons, not all series are presented in this graph. Note the logarithmic scale on the y-axis.

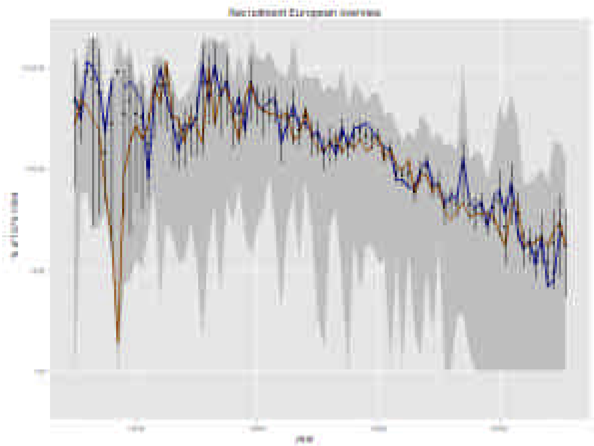

Figure 9.4.9.10-2 Time-series of monitoring glass eel and yellow eel recruitment in European rivers with data series > 35 years (26 rivers). Each line is the average of series scaled to their 1979–1994 average. For glass eel and yellow eel combined, the mean values and their bootstrap confidence interval (95%) are represented as black dots and bars. The brown line represents the mean value for yellow eel while the blue line represents the mean value of the glass eel series. The range of the series is indicated by a grey shade. Note the logarithmic scale on the y-axis.

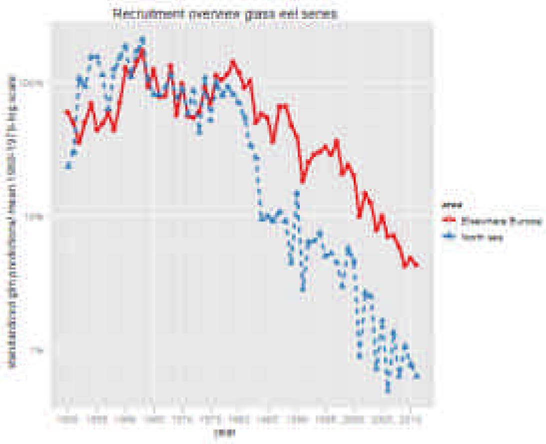

Figure 9.4.9.10-3 WGEEL recruitment index: mean of estimated (GLM) glass eel recruitment for the North Sea and elsewhere in Europe. The GLM (recruit=area:year+site) was fitted to all glass eel series available and scaled to the 1960–1979 average. No series for glass eel are available in the Baltic area. Note the logarithmic scale on the y-axis.

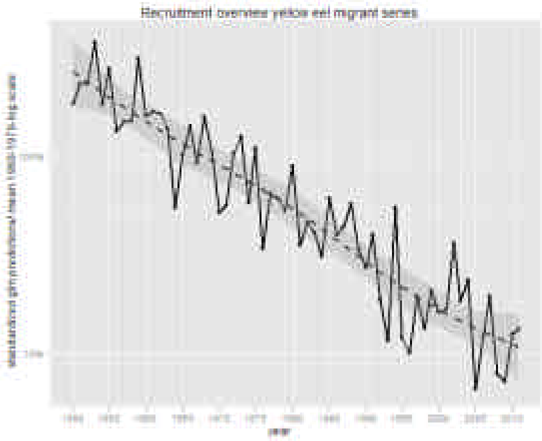

Figure 9.4.9.10-4 Mean of estimated (GLM) yellow eel recruitment and smoothed trends for Europe. The GLM (recruit=area:year) was fitted to all yellow eel series available and scaled to the 1960–1979 average. Note the logarithmic scale on the y-axis. Bands show 95% point-wise confidence interval of the smoothed trend.

10.5 Summary of International Advice 2009-2011

The eel stock continues to decline in the period 2009 to 2011. In 2011, glass eel recruitment has fallen to 5% of their 1960-1979 level in the Atlantic region and less than 1% in the North Sea area, and showed no sign of recovery. Recruitment of young yellow eel has been declining continuously since the 1950s. Stock indicators in the national eel management plans submitted in 2008 indicated that anthropogenic mortality was above the limit implied by EC Regulation No. 1100/2007 (EC, 2007).

Abundance of all stages of eel (glass eel, yellow eel, and silver eel) is at an historical minimum. The stock is in a critical state. In 2007, European eel, *A. anguilla*, was included in CITES Appendix II that deals with species not necessarily threatened with extinction, but trade of which must be controlled to avoid utilization incompatible with the survival of the species (see http://www.cites.org/eng/disc/how.shtml). The listing was implemented in March 2009. Eel was also listed in September 2008 as critically endangered in the IUCN Red List.

A management framework for eel was established in 2007 through an EC Regulation (EC No. 1100/2007; EC, 2007). The objective of this Regulation is the protection, recovery, and sustainable use of the stock. To achieve the objective, Member States have developed eel management plans (EMPs) for their river basin districts, designed to reduce anthropogenic mortalities and increase silver eel biomass. The objective of the national eel management plans is to provide, with high probability, a long-term 40% escapement to the sea of the biomass of silver eel, relative to the best estimate of the theoretical escapement in pristine conditions (i.e. if the stock had been completely free of anthropogenic influences).

As eel is a long-lived species and anthropogenic mortalities occur over all of its continental lifespan, the effect of management measures on silver eel production and escapement and on their subsequent recruits (glass eel coming back to the coast) is expected to take several years to be detected (ICES, 2009). When these management measures eventually feed through to silver eel escapement and glass eel recruitment, the natural variability of these migrations, local site effects, and sampling variation may prevent the detection of such changes for at least several more years, even a decade or more (ICES, 2011a, 2011b). Therefore, the recovery process and the detection of possible changes due to management actions will be a slow process. The reporting by Member States to the EC in 2012 is a first step, and, in the short term changes in anthropogenic mortality and local variations in the stock will have to be used to quantify the effect of management measures.

Over the period 2009-2011, there is no change in the scientific perception of the stock status: it remains critical and urgent action is needed. ICES reiterated its previous advice that all anthropogenic mortality (e.g. recreational and commercial fishing, hydropower, pollution) affecting production and escapement of eels should be reduced to as close to zero as possible until there is clear evidence that both recruitment and the adult stock are increasing. Urgent actions are needed to prevent further depletion of the stock.

11 Monitoring Programme: 2012 – 2015

The monitoring objectives from the National Eel Management Plan to be undertaken between 2012 and 2015 by the State Agencies and the ESB are:

1. Synthesise available information into a model based management advice tool
2. Estimate Silver Eel Escapement
    a. Direct estimates on index catchments (Burrishoole, Shannon, Erne, Corrib, Fane + 2 others)
    b. Estimate silver eel escapement indirectly using yellow eels
    c. Use modelling approaches to where applicable
3. Silver Eel Escapement on the Shannon and Erne to verify the trap and transport programme
4. Estimate HPS bypass and HPS mortalities, especially on the Erne under full generation regimes.
5. Monitor the impact of fishery closure on yellow eel stock structure; CPUE, age and growth studies
6. Inter-Calibration with Water Framework Sampling
7. Compare current and historic yellow eel stocks
8. Establish baseline data to track changes in eel stock over time
9. Evaluate impedance of upstream colonisation: migration and water quality effects.
10. Determine parasite prevalence and eel quality (prevalence of *Anguillicoides crassus*, (swimbladder parasite) and chemical contamination).

The following sections contain a list of proposed field work for the eel monitoring programme 2012 – 2015, including the national monitoring programme by IFI and index catchment research by ESB, NUIG and the MI. There is a large body of work outlined however the extent of what is achieved will be dependent of the availability of resources. Priority will be given to monitoring the recruitment of elvers to our rivers and silver eel escapement.

11.1 Elvers

Maintain and improve the national elver monitoring programme (Table 11.1)

Introduce a 2nd site on the East coast in 2013 e.g. Boyne

Investigate the addition of a small coastal catchment on the south coast (Kerry or Cork)

Table 11-1: Proposed elver monitoring locations for 2012-2015 programme

Location	Water body	Life stage	1	2	3	4	5	6	7	8	9	10
Ballysadare	River	Glass eel, elver, yellow	*							*	*	*
Corrib	River	Glass eel, elver, yellow	*							*	*	*
Feale	River	Glass eel, elver, yellow	*							*	*	*
Inagh	River	Glass eel, elver, yellow	*							*	*	*
Liffey	River	Glass eel, elver, yellow	*					*	*	*		
Maigue	River	Glass eel, elver, yellow	*					*	*	*		

11.2 Silver Eel Escapement

Table 11.2 contains the silver eel locations and the intended monitoring objectives that will be achieved.

Carry out a 2nd year survey in Fane Catchment

- Netting efficiency
- Estimate escapement from catchment
- Age/ growth/ parasite prevalence

It is intended to tender for a 2nd silver eel fishery for the years 2013 & 2014. The fishery should be located on the East coast preferably in the lower reaches of the river in a large catchment.

Silver eel production and escapement estimates will be required for the Erne and Shannon in order to judge the success and required level of silver eel trap and transport programmes. New estimates of HPS mortality will also be required, especially for the Erne under full generation regimes.

The SSCE recommends the inclusion of at least one additional non-regulated catchment into the silver direct assessment programme.

Table 11-2: Proposed silver eel monitoring locations for 2012-2015 programme.

Location	Group	Life stage	1	2	3	4	5	6	7	8	9	10
Shannon	ESB	Silver	*	*	*	*			*	*	*	*
Erne	ESB	Silver	*	*	*	*			*	*	*	*
Lee	ESB	Silver	*	*					*	*	*	*
Burrishoole	MI	Silver	*	*					*	*		*
Fane	IFI	Silver	*	*					*	*		*
An other	IFI	Silver	*	*					*	*		*

11.3 Yellow Eels

See Table 11.3 for breakdown of locations and intended monitoring objectives that will be achieved.

11.3.1 Repeat Historical Lake and River surveys

- Meelick Bay, Lough Derg
- Erne Rivers/lakes
- Barrow
- Blackwater (Munster)
- Burrishoole Lakes
- Burrishoole & N. Mayo Rivers

11.3.2 Lake Surveys

- Repeat Mark recapture study of Meelick Bay
- L. Muckno
- Erne lakes e.g. L. Oughter
- Survey 3 depth zones (remove >20m) compare with 1st 3 year programme
    - L. Ramor
    - L. Ree/ L. Derg
    - L. Feeagh

- Intensively fish some of the smaller lakes. A number of these lakes can be compared with WFD surveys. There is the potential to carry out a mark recapture for population estimate, using a smaller and confined wetted area might result in more accurate estimates
    - Fergus catchment (Inchiquin, L. George, L. Bunny, Dromore L., L. Fin, L. Gash)
    - Garavogue (L. Gill)
    - Ballysadare (L. Arrow)
    - Shannon (L. Key)
    - Lough Feeagh
    - Lough Bunaveela
    - Furnace (tidal)

11.3.3 River

- It is intended to focus more attention on the quality of eels in riverine habitats by using the data from the WFD river sites, EREP and the Coarse Fish Unit. This data includes:
    - Morphometric analysis
    - Otolith analysis – age and growth for various locations around the country comparing age with distance to sea.

- Historical data is available for a number of river locations. The data available include CPUE, length, weight etc. The locations include:
    - River Barrow
    - River Blackwater
    - River Nore
    - Burrishoole and N. Mayo Rivers

- Eel population in canals can be investigated in cooperation with the IFI Coarse Fish Unit (CFU). The dredging operations would enable a density value to be assigned to a stretch of canal. This could be coupled with a mark recapture study. The CFU and Waterways Ireland maintain the canals and undertake numerous operations in these waterways.

11.3.4 Transitional Waters

Investigate the importance of small coastal embayment's and lagoons to the national stock. This can be accomplished in collaboration with some of the WFD transitional water surveys by increase the number of fyke nets set or by adding additional days to the survey to reach the objectives of the Eel Monitoring Programme.

- Historical data is available for
    - Blackwater Estuary
    - Broadmeadow Estuary
    - South Sloblands
    - Lady's Island
    - Furnace

11.3.5 Habitat Use

Investigate the use of habitat (freshwater and transitional water) using acoustic telemetry studies. There are outstanding questions on the extent of the home range of eels as well as the seasonal migratory journey of eels between water bodies (from freshwater to transitional waters).

- Barrow catchment
- Meelick Bay, L. Derg
- Canals

11.4 Maturation

- Shannon (PIT tag yellow eels, monitor silver eel catch)
- Erne (PIT tag yellow eels monitor silver eel catch)
- Burrishoole (PIT tag yellow eels monitor silver eel catch)

Table 11-3 Proposed yellow eel monitoring locations for 2012 - 2015 programme

Location	Water body	Life stage	1	2	3	4	5	6	7	8	9	10
Meelick Bay, L. Derg	Lake	Yellow	*	*			*		*	*	*	*
Erne	Lake & River	Yellow	*	*			*	*	*	*	*	*
Barrow R.	River	Yellow	*	*			*	*	*	*	*	*
Blackwater	River	Yellow	*				*		*	*		*
Nore R.	River	Yellow	*				*		*	*		*
L. Ramor	Lake	Yellow	*				*			*		*
L. Ree	Lake	Yellow	*	*			*	*	*	*		*
L. Feeagh/Bunaveela	Lake	Yellow	*	*					*	*		*
L. Gill	Lake	Yellow	*				*	*	*	*		*
L. Inchiquin	Lake	Yellow	*						*	*		*
L. Key	Lake	Yellow	*	*			*		*	*		*
Dromore L. (Fergus)	Lake	Yellow	*				*	*	*	*		*
L. Bunny	Lake	Yellow	*				*	*	*	*		*
L. Arrow	Lake	Yellow	*				*	*	*	*		*
South Sloblands	Lagoon	Yellow	*				*		*	*		*
Lady's Island	Lagoon	Yellow	*				*		*	*		*
Lough Furnace	Brackish lagoon	Yellow	*	*					*	*		*
Blackwater Estuary	T. water	Yellow	*						*	*		*

11.5 Age & Growth Analysis

A large number of otoliths and age and growth determinations exist from last 3 years of Eel Monitoring Programme surveys, from the 4 years of WFD surveys and from 2008 commercial fisheries. The otoliths of these eels are available for growth and age analysis (EMP: n = 2,400 eels; WFD: n = 1,945 eels; 2008: n = 600). This analysis will benefit monitoring objective 10 referring to the quality of eels and is essentially for the modelling of potential silver eel output (objectives 1 & 5).

11.6 Eel Database

A large amount of current data has now been collected over the 1st 3 year programme. This data needs to be uploaded into the National Eel Database. Time and resources need to be allocated to allow for this and for the inclusion of the outstanding historical data that came to light after the 'Eel Plan' project finished. The collation of data into the database will benefit monitoring objectives 1, 5 and 8.

11.7 Stock Modelling

Under Monitoring Objective 1 in the EMP, it is recommended that further development of the models is progressed. Particular emphasis should be place on combining the habitat, potential production and local stock data in analyses such as the French EDA model, recruitment input/output models and reassessing Ireland's stock in the light of reported EU data.

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Annex 1: Dates and catches for the Silver Eel Trap and Transport Management Action.

The dates and total transported catch of the River Shannon trap and transport plan – 2009.

Week No.	Week Ending	Athlone 1	Athlone 2	Rooskey	Finea	Kilaloe Eel Weir	Total Week
1	05/09/09	0	Not Fishing	Not Fishing	Not Fishing	Not Fishing	0
2	12/09/09	283.5	Not Fishing	0	Not Fishing	Not Fishing	283.5
3	19/09/09	624	Not Fishing	189	Not Fishing	Not Fishing	813
4	26/09/09	0	Not Fishing	97	232.5	Not Fishing	329.5
5	03/10/09	164.5	0	Not Fishing	Not Fishing	Not Fishing	164.5
6	10/10/09	0	0	0	Not Fishing	0	0
7	17/10/09	240.5	78	Not Fishing	Not Fishing	0	318.5
8	24/10/09	1144.5	412	Not Fishing	118	0	1674.5
9	31/10/09	433	150	171	0	8	762
10	07/11/09	0	0	406	0	567	973
11	14/11/09	2658	0	1155	0	5550	9363
12	21/11/09	1317	188	543	441	3422	5911
13	28/11/09	309	0	339	532	992	2172
14	05/12/09	218	0	0	0	Not Fishing	218
15	12/12/09	0	0	0	0	Not Fishing	0
16	19/12/09	556	0	0	0	156	712
17	26/12/09	0	0	0	0	0	0
18	02/01/10	0	0	0	0	15	15
19	09/01/10	0	0	0	0	21	21
Total to Date (kgs)		**7948**	**828**	**2900**	**1323.5**	**10731**	**23730.5**

The dates and total transported catch of the River Shannon trap and transport plan – 2010.

Week No.	Week Ending	Athlone 1	Athlone 2	Rooskey	Finea	Kilaloe Eel Weir	Total Week
Catch Quota per Location		8 Tonnes	2 Tonnes	4 Tonnes	3 Tonnes	No Quota	
1	11/09/10	0	0	1496	910	0	2406
2	18/09/10	0	0	1238	1325	0	2563
3	25/09/10	1529	0	0	0	0	1529
4	02/10/10	396	0	0	0	0	396
5	09/10/10	1013	0	0	0	0	1013
6	16/10/10	258	184	203	382	0	1027
7	23/10/10	0	0	0	0	0	0
8	30/10/10	0	0	0	0	0	0
9	06/11/10	1468	366	500	0	2525	4859
10	13/11/10	1738	810	556	0	4650	7754
11	20/11/10	243	172	0	119	1445	1979
12	27/11/10	0	0	0	0	947	947
13	04/12/10	0	0	0	0	434	434
14	11/12/10	0	0	0	0	6	6
15	18/12/10	0	0	0	0	0	0
16	25/12/10	0	0	0	0	0	0
17	01/01/11	0	0	0	0	0	0
18	08/01/11	80	0	0	0	0	80
19	15/01/11	0	0	0	0	0	0
20	22/01/11	0	0	0	0	110	110
21	29/01/11	0	0	0	0	195	195
22	05/02/11	0	0	0	0	119	119
23	12/02/11	308	0	0	0	898	1206
24	19/02/11	75	0	0	0	646	721
25	26/02/11	0	0	0	0	169	169
26	05/03/11	229	0	0	0	0	229
27	12/03/11	0	0	0	0	0	0
28	19/03/11	26	0	0	0	0	26
29	26/03/11	0	0	0	0	0	0
30	02/04/11						0
Total to Date(kgs)		**7363**	**1532**	**3993**	**2736**	**12144**	**27768**

The dates and total transported catch of the River Shannon trap and transport plan – 2011.

Wk No.	Week Ending	Athlone 1	Athlone 2	Rooskey	Finea	Kilaloe Eel Weir	Others (see *)	Total Week
Catch Quota per Location		8 Tonnes	2 Tonnes	4 Tonnes	3 Tonnes	No Quota		
1	27/08/11	0	0	0	355	Not Fishing	0	355
2	03/09/11	0	0	0	0	Not Fishing	0	0
3	10/09/11	0	0	0	0	Not Fishing	0	0
4	17/09/11	0	0	316	0	Not Fishing	0	316
5	24/09/11	63	0	0	0	0	0	63
6	01/10/11	111	227	329	507	Not Fishing	0	1174
7	08/10/11	0	0	0	0	0	0	0
8	15/10/11	0	0	0	0	0	0	0
9	22/10/11	789	219	1026	0	0	0	2034
10	29/10/11	2412	549	1623	1136	797	0	6517
11	05/11/11	1445	397	0	0	1040	0	2882
12	12/11/11	458	0	228	285	325	118	1414
13	19/11/11	0	0	0	0	300	0	300
14	26/11/11	833	182	0	0	1287	0	2302
15	03/12/11	761	148	0	0	2701	0	3610
16	10/12/11	0	0	0	0	810	0	810
17	17/12/11	0	0	0	0	63	0	63
18	24/12/11	75	0	0	0	52	0	127
19	31/12/11	0	0	0	0	452	0	452
20	07/01/12	571	0	0	0	1860	0	2431
21	14/01/12	139	199	0	0	443	0	781
22	21/01/12	0	0	0	0	0	0	0
23	28/01/12	0	0	0	0	0	0	0
24	04/02/12	34	15	0	0	0	0	49
25	11/02/12							0
26	18/02/12							0
27	25/02/12							0
28	03/03/12							0
Total to date (kg)		**7691**	**1936**	**3522**	**2283**	**10130**	**118**	**25680**

* 118 kgs taken by IFI from illegal nets above Killaloe on 5/11/11 and released on 7/11/11

The dates and total transported catch of the River Erne trap and transport plan – 2009.

Week No.	Week Ending	Mid- Erne Catchment (Cleenish)	Lower Erne catchment (Ferny Gap)	Total for Week
1	05/09/2009	Not Fishing	Not Fishing	0
2	12/09/2009	Not Fishing	0	0
3	19/09/2009	Not Fishing	444	444
4	26/09/2009	Not Fishing	384	384
5	03/10/2009	Not Fishing	429	429
6	10/10/2009	Not Fishing	0	0
7	17/10/2009	Not Fishing	589	589
8	24/10/2009	Not Fishing	2035.5	2035.5
9	31/10/2009	Not Fishing	1136	1136
10	07/11/2009	0	0	0
11	14/11/2009	0	1858	1858
12	21/11/2009	0	685	685
13	28/11/2009	0	750	750
14	05/12/2009	0	662	662
15	12/12/2009	0	85	85
16	19/12/2009	20	305	325
17	26/12/2009	0	0	0
18	02/01/2010	0	0	0
Total to Date (Kgs)		**20**	**9362.5**	**9382.5**

The dates and total transported catch of the River Erne trap and transport plan – 2010.

Week No.	Week Ending	Lisnakea (Lady Craigavon br)	Ferny Gap	Portora Gates	Butlersbr. Belturbet	Butlersbr. Belturbet	Roscor	Total Week
1	14/08/2010	Not Fishing	Not Fishing	Not Fishing	0	0	Not Fishing	0
2	21/08/2010	Not Fishing	Not Fishing	Not Fishing	0	0	Not Fishing	0
3	28/08/2010	Not Fishing	Not Fishing	Not Fishing	150	150	Not Fishing	300
4	04/09/2010	Not Fishing	0	Not Fishing	0	0	Not Fishing	0
5	11/09/2010	0	703	0	688	225	Not Fishing	1616
6	18/09/2010	192	0	0	322	0	0	514
7	25/09/2010	0	0	0	0	0	0	0
8	02/10/2010	0	0	0	0	96	0	96
9	09/10/2010	0	677	0	0	0	0	677
10	16/10/2010	0	1588	0	0	0	0	1588
11	23/10/2010	0	0	0	0	0	0	0
12	30/10/2010	0	0	0	0	0	0	0
13	06/11/2010	0	4252	834	0	143	1295	6524
14	13/11/2010	0	3663	680	0	0	1422.5	5765.5
15	20/11/2010	296	176	0	0	1533	74	2079
16	27/11/2010	0	0	0	0	0	0	0
17	04/12/2010	0	0	0	0	0	0	0
18	11/12/2010	0	0	0	0	0	0	0
19	18/12/2010	0	66	0	0	0	0	66
20	25/12/2010	0	0	0	0	0	0	0
21	01/01/2011	0	0	0	0	0	0	0
22	08/01/2011	0	0	0	0	0	0	0
23	15/01/2011	0	0	0	0	0	0	0
24	22/01/2011	0	0	0	0	0	0	0
25	29/01/2011	0	0	0	0	0	0	0
26	05/02/2011	0	0	0	0	0	0	0
27	12/02/2011	0	0	0	0	0	0	0
28	19/02/2011	0	0	0	0	108	0	108
29	26/02/2011							0
30	05/03/2011							0
Total to Date(kgs)		**488**	**11125**	**1514**	**1160**	**2255**	**2791.5**	**19333.5**

The dates and total transported catch of the River Erne trap and transport plan – 2011.

Week No.	Week Ending	Lisnakea (Ldy Craigavon br)	Ferny Gap	Portora Gates	Killashandra	Belturbet	Roscor	Total Week
1	**03/09/2011**	0	0	0	0	0	0	0
2	**10/09/2011**	0	350	305	0	0	0	655
3	**17/09/2011**	0	0	0	0	0	0	0
4	**24/09/2011**	168	561	435	0	0	37	1201
5	**01/10/2011**	346	0	0	117	0	0	463
6	**08/10/2011**	0	644	479	0	0	0	1123
7	**15/10/2011**	459	0	526	0	0	73	1058
8	**22/10/2011**	0	1029	1468	515	0	457	3469
9	**29/10/2011**	998	2165	760	1991	0	1042	6956
10	**05/11/2011**	0	443	430	500	0	273	1646
11	**12/11/2011**	690	158	114	0	0	0	962
12	**19/11/2011**	0	0	0	68	0	268	336
13	**26/11/2011**	0	2046	214	0	0	341	2601
14	**03/12/2011**	104	854	0	139	441	509	2047
15	**10/12/2011**	0	471	475	0	236	193	1375
16	**17/12/2011**	0	0	0	0	0	182	182
17	**24/12/2011**	0	0	0	0	0	0	0
18	**31/12/2011**	0	0	0	0	0	249	249
19	**07/01/2012**	0	365	0	0	0	174	539
20	**14/01/2012**	0	0	0	0	0	0	0
21	**21/01/2012**	0	0	0	0	0	0	0
22	**28/01/2012**	0	234	0	0	0	88	322
23	**04/02/2012**	0	0	0	0	0	0	0
24	**11/02/2012**	0	0	0	0	0	68	68
25	**18/02/2012**							0
26	**25/02/2012**							0
27	**03/03/2012**							0
28	**10/03/2012**							0
29	**17/03/2012**							0
Total to Date(kgs)		**2765**	**9320**	**5206**	**3330**	**677**	**3954**	**25252**

The dates and total transported catch of the River Lee trap and transport plan – 2009.

Week No.	Week Ending	Inchageela	Total for Week
1	05/09/2009	Not Fishing	0
2	12/09/2009	Not Fishing	0
3	19/09/2009	Not Fishing	0
4	26/09/2009	Not Fishing	0
5	03/10/2009	Not Fishing	0
6	10/10/2009	Not Fishing	0
7	17/10/2009	15	15
8	24/10/2009	11	11
9	31/10/2009	30	30
10	07/11/2009	19	19
11	14/11/2009	0	0
12	21/11/2009	4	4
13	28/11/2009	Not Fishing	0
14	05/12/2009	Not Fishing	0
15	12/12/2009	0	0
16	19/12/2009	0	0
Total to Date(kgs)		**79**	**79**

The dates and total transported catch of the River Lee trap and transport plan – 2010.

Week No.	Week Ending	transported to Carrigadrohid Hatchery and sorted as Yellow/Silver	Location	Eel Released below Iniscarra Station
1	**14/08/2010**	0	Innis-slinna	
2	**21/08/2010**	52	Innis-slinna	
3	**28/08/2010**	43.5	Innis-slinna	
4	**04/09/2010**	57.5	Innis-slinna	
5	**11/09/2010**	27	Innis-slinna/ L Alua	
6	**18/09/2010**	69	Lough Alua	
7	**25/09/2010**	22	Lough Alua	185
8	**02/10/2010**	35	L Alua/ Macroom Br	
9	**09/10/2010**	26.5	Lee Reservoir	
10	**16/10/2010**	6	Lee Reservoir	93
11	**23/10/2010**			
Total to Date(kgs)		**338.5**		**278**

The dates and total transported catch of the River Lee trap and transport plan – 2011.

Week No.	Week Ending	Iniscarra Reservoir	Total for Week
1	**02/07/2011**	0	0
2	**09/07/2011**	163	163*
3	**16/07/2011**	159	159*
4	**23/07/2011**	0	0
5	**30/07/2011**	409	409*
6	**06/08/2011**		
7	**13/08/2011**		
8	**20/08/2011**		
9	**27/08/2011**		
10	**03/09/2011**		
11	**10/09/2011**		
31	**28/01/2012**		
Total to Date(kgs)		**731**	**731**

*Eels released below Iniscarra Dam on the 8, 11 & 29 July 2011.