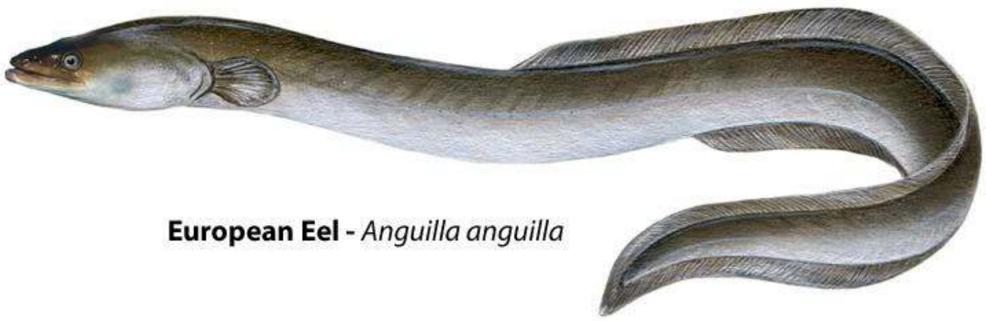

THE EUROPEAN EEL IN INISHOWEN

A DESKTOP RESEARCH REPORT

by

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Abstract

The European eel *Anguilla anguilla* is a fish of ecological importance - a mysterious creature that still to this day eludes scientific research in terms of the exact location within the Sargasso Sea that spawning occurs. The European eel is one of only 15 native species present in Irish freshwater systems and is perhaps the most familiar next to wild Atlantic Salmon, Sea Trout and native brown trout. The eel is listed as a critically endangered species by ICES (2006) and faces an extremely challenging existence in our world today. Yet there is so much more we need to understand about the European eel and its relationship with us in our waterways and in our communities.

The Inishowen Peninsula County Donegal extends far into the Atlantic Ocean to earn the title of the most northerly point on the island of Ireland at Malin Head. The European eel migrates along the remote and rugged coast of Inishowen to tidal freshwaters within the peninsula completing the same journey they have undertaken for decades. Making their migratory journey through freshwater systems have seen the eel a familiar resident in many rivers throughout Inishowen. A much misunderstood and misrepresented creature, the European eel has had many assumptions made about it as a species in our fresh waters, from claims such as eels prefer slightly polluted waters, to what they eat and how they migrate in our rivers.

Taking into account what is known about the eel crisis, we have sought to understand the species presence in Inishowen, to understand how the eel behaves in our fresh waters, what they eat, how they locate their prey and what are the habitat requirements that best support the European eel's sustainability within the waterways of Inishowen. In this report into the European eel species, we researched limited available data looking at trends in current eel levels based on recent ICES reports as well as documented fishery surveys carried out in locations within the peninsula area from fishery bodies such as the Loughs Agency and Inland Fisheries Ireland, from other relevant sources and personal communication with local anglers and fishermen.

Data was also researched from local records (riverfly monitoring) from ongoing surveying of river habitat within areas of Inishowen to establish the quality of habitat and food source availability. Information from water monitoring stations located in Inishowen were also viewed to understand the current Q score status of selected waterbodies outlined in this report. Citing (EPA) reports on water quality, photographic evidence of active monitoring sites within the Inishowen area were also supplied for the purposes of illustrating localised impacts within our freshwater bodies. Through this report we hope to achieve a better understanding of the European eel in our rivers in Inishowen, to help identify the issues, where we can help and to understand where we cause harm and to use this information to educate and inspire others in regards this elusive, fascinating, ancient creature the European eel.

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Introduction

The European eel is an amazing creature. A catadromous fish characterised by a snake-shaped body, it has continuous dorsal, anal and caudal fin atrophy, approximately 60-80cm in length, rarely reaching more than 1m, but at times they may reach lengths of up 1.5m. Found in the rivers of the North Atlantic, Baltic and Mediterranean Seas, the European eel has an amazing life-cycle, that consists of two-way migration across the Atlantic Ocean were eel eggs hatch in the depths of the Sargasso Sea in the western Atlantic. Small, transparent, leaf-like larvae called *leptocephali* drift with the oceanic currents through the Gulf Stream towards continental Europe, the duration of this larval migration has been estimated to take between 7-9 months and can take as long as 2 years.

Recent research has shown that leptocephali larvae feed on gelatinous zooplankton through the stages of their oceanic journey and when the larva reaches the continental slope, the first stage of metamorphosis takes place and the larval stage ends with a metamorphosis to glass eel. The glass eel gradually attains their familiar eel shape, but they are still lacking in pigmentation and are therefore transparent - hence the name, Glass eel. The species enter our rivers and estuaries migrating towards inland waters, where they begin to develop brown, yellow and dark green colours, the familiar characteristic features we associate with the European eel.

Juvenile eels are also partially termed as elvers in their early growth stage which last between 12-14 months before they enter the yellow eel stage which can last between 5 - 15 years, all part of their two-way migration. Eels inhabit rivers, streams, lakes, brackish and marine areas. Given the large range of habitats and the distribution of the species to these areas categorizes the European eel as both euryhaline and eurythermal, tolerating a wide range of salinities and temperatures. Eels live near the bottom substrates, in areas of sediment under stones, submerged roots, debris, and crevices where their diet consists of insects, invertebrates, larvae, crustaceans and fish. They feed heavily during the spring, summer and autumn months but in the winter their feeding habits change.

Eels in their natural habitat reduce or cease activity and become physically inactive (lethargic) during the winter and their feeding stops at temperatures below 8°C, at this point a state of physical or mental inactivity is displayed (torpor) (Sadler, 2006). Eels are known to bury themselves in muddy areas and sediments protecting themselves from predators and reducing energy consumption. where their growth during the continental stage varies depending upon geographical location and food availability. There is also a difference between males and females, males remain in the yellow stage until they are between approximately two to fifteen years old with a body length of 30-46 cm whereas females are between 4-20 years in the yellow eel stage with body lengths of 50-100 cm, commonly though in Ireland between 5-15 years. At this stage the yellow eel phase is over, and they undergo another stage of metamorphosis where they turn to silver eels and return to their spawning grounds in the Sargasso Sea where they spawn and then die.

(1) European Eel crisis

European eel stocks are considered 'outside the safe biological limits' (ICES, 2006). In 2007 the European Commission (EC) brought in a regulation to help recover eel stocks to a more sustainable level. The regulation stated that each European member state must implement a national eel management plan that includes measures to help successfully increase the numbers of adult (silver) eels leaving inland waters to cross the Atlantic to the Sargasso Sea to their spawning grounds.

Glass eel recruitment to continental waters has dramatically declined since the 1970s and has remained low showing increasing downward trends overall in European eel levels. In 2011 European eel stocks hit an all-time low and it has remained this way despite a slight increase in eel levels in 2014 but returned to declining trends post-2014.

Results in the 2019 report by ICES using a 46 time-series consisting of either glass eel or mixtures of glass eels and yellow eels, shows both glass and yellow eel recruitment strongly declined from 1980 to 2011. The latest glass eel recruitment in the "North Sea" index area, compared to that in 1960–1979, was 0.5% in 2020 (provisional) and 1.4% in 2019 (final). In the "Elsewhere Europe" index series it was 6.5% in 2020 (provisional) and 5.6% in 2019 (final), based on available data series. For the yellow eel data, recruitment for 2019 was 17% (final) of the 1960–1979 level. The 2020 data collection for yellow eel is ongoing. Statistical analyses of the time-series from 1980 to 2020 show that glass eel recruitment remains at a very low level' (ICES 2020).

Most up to date reports on the Glass eel recruitment shows that in 2020 the North Sea Index Series was 0.5% of the 1960-1979 stock estimates compared to 14% in 2019 of the 1960-1979 index. The North Sea Index Series in the Elsewhere (Europe) Index series showed results of 6.5% in 2020 compared to 5.6% in 2019 of the total estimations of stock evaluations based against the model used to estimate eel levels.

The model, which used an all-recruitment time-series available at European scale since 1960 gave accurate data and based upon that information it is clear that the European eel continues to decline. In some cases, uncertainty was associated with escapement data and fourteen remaining member states reported that escapement targets had not been met. However, Ireland has met its 40% escapement target but it has been cited by ICES (30 October 2020) that there are issues around cohesive data when it comes to an overall estimation in the European eel for each member state.

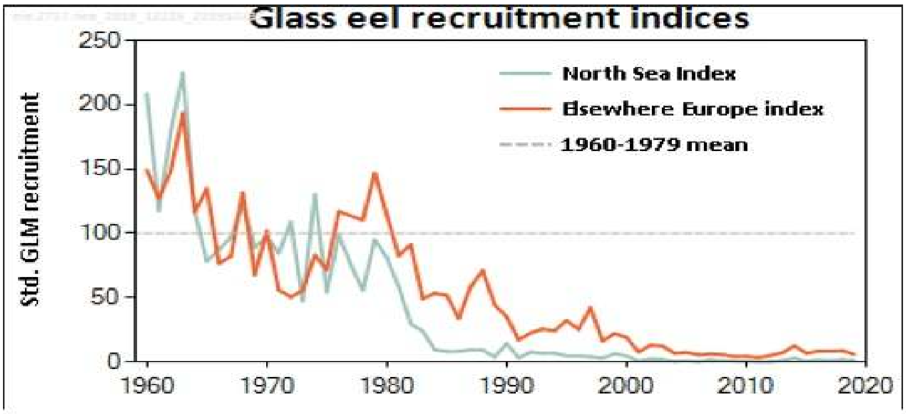

Figure 1.1: *ICES review of glass eel recruitment levels between 1960-1979 (ICES, 2020)*

(1.1) About the European Eel

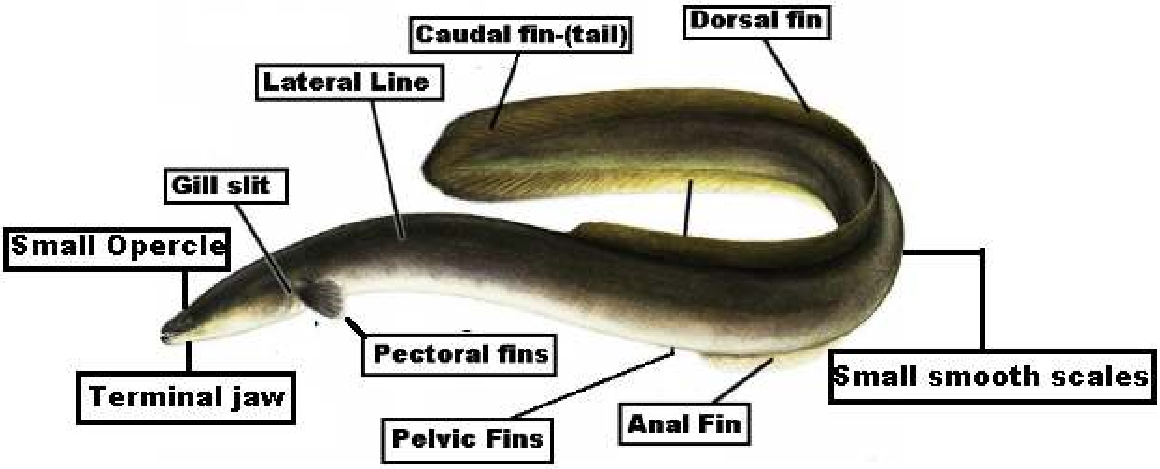

Figure 1.2: *Anatomy of European eel (Modified from https://kidskonnect.com/animals/eels/)*

Scientific Name	*Anguilla anguilla*
Common Name	European Eel
Status	Critically Endangered (IUCN 3.1)
Size	Up to 1m (average 60-80cm). Max length 1.5m Weight: 2-4kg. Max weight 6.6kg
Life span	Males – 5-15 years Females – 5-50 years
Distribution	Coastal areas of Europe and northern Africa, ranging from Murmansk near the North Cape of the Scandinavian Peninsula through the coastal areas of the Baltic Sea to the Atlantic coastal areas of Morocco. In the south it can be found in the coastal areas of the landmasses bordering the Mediterranean and the Black Sea. In addition to the continental shelves of Europe and Africa the species can also be found in the British Isles, Iceland, the islands in the Mediterranean Sea and the Azores and Canary Islands in the Atlantic Ocean. (CABI.org)
Migration	1st stage – larval leptocephali – across Atlantic Ocean 2nd stage – Into freshwater systems – become elvers Yellow eel stage – migrate up river system Silver Eel stage – final migration from freshwater to Sargasso Sea

Table 1.1: *Overview of European Eel* Anguilla Anguilla*. Various sources: Dekker* et al. *(1998), CABI.org, IUCN Red List*

Lifespan/Longevity
The lifespan of European eels is dependent on maturation time because once eels mature and spawn, they die. European eels can spawn as early as 7 years old. The maximum reported age of a European eel in the wild is 85 years (Dekker *et al.*, 1998).

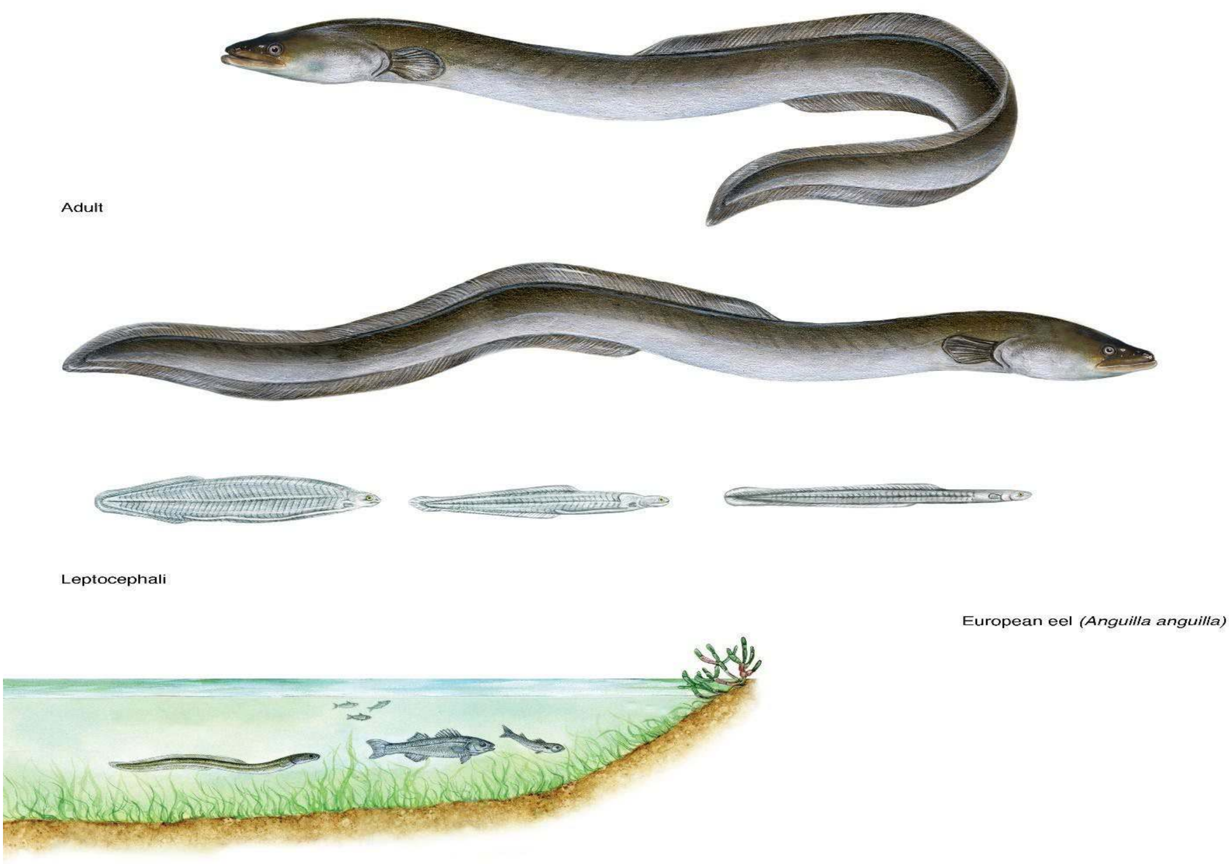

Figure 1.3: Life stages of the European Eel *Anguilla anguilla*
https://www.dreamstime.com/duranteillustrations_info - *Marina and Anna Luisa Durante*

(1.2) Where can we find eels in freshwater systems?

The European eel can be found in most freshwater aquatic systems in Inishowen. Entering our loughs and migrating to our coastal rivers, eels make their way through the river systems seeking out habitat to support the first stage of their migration. Eels have been in our river systems for decades, but we know very little about the right habitat conditions that are needed to support the species in our freshwaters. Recent studies by ecological consultants (RSK Consultants) into European eel habitat have allowed us to understand the habitat requirements needed to support eel stocks in our rivers.

Research carried out by RSK Consultants (Walker, 2020) established and produced evidence that different size eels displayed variances in terms of preferred habitat showing distribution of eels to freshwater is influenced by the distance from the tidal limits. Data harvested from these studies indicate that large eels are more dominant with increasing distance from the tidal reaches compared to elvers and small yellow eels in river systems. Velocity and depth have an influence on variations of eel densities within a freshwater system showing eels under 300-mm in full body length have a preference to mid to shallow water. Large-sized eels with body lengths more than 300 mm are said to not show any specific preference of water velocities and seem to prefer deeper areas of water in channel substrates or deep bodies of water. Smaller eels and elvers prefer shallower waters with areas of siltation and fine gravel.

(1.3) Understanding Eel habitat

Habitat plays an important part in the distribution of the eels throughout our river systems in Inishowen. Understanding this habitat helps us identify the locations in which eels may be present which is useful in terms of monitoring eels in our rivers. Elvers and very small eels hide in silty areas of rivers, often the marginal areas but also among structures such as submerged roots, woody debris and undercut riverbanks. Small eels are quite capable of manoeuvring through submerged roots systems where small spaces exist.

Larger eels favour areas among cobbles and boulders with a preferred solitary refuge only big enough for the eel itself. There is not thought to be a schooling instinct among eels within our freshwaters but more a convergence occasionally in areas as a result of upstream migration. When eels have completed their migratory journey inward in our rivers, they are solitary in behaviour. When we talk about habitat structures in our rivers which provide eels with sanctuary what does it mean? Habitat structures means physical structures such as submerged roots, natural debris, piers, undercut banks and channel substrates.

Examples of physical habitat structures used by eels of various sizes are shown below in two Buncrana rivers, Crana River and Mill River.

Figure 1.4: *The Mill River, Inishowen, Co. Donegal. Marked areas showing typical eel habitat structures.*

Figure 1.5: *The Crana River, Inishowen. Marked areas indicating typical habitat sites for European eels.*

(1.4) How do Eels feed?

The European eel is nocturnal and elusive, concealing itself in the substrate sediments or under a number of physical structures during the day, at night emerging from the darkness where they feed on a variety of food dependent upon their stage of growth. In the early stages of life, the species predominantly forages for insects, a key dietary requirement which consist of insect larva, macroinvertebrates, worms and molluscs. Eels also eat decaying flesh which they locate using their heightened sense of smell. As the eels become larger, they turn to predation, eating small fish and even their own species in addition to insects.

Eels reduce feeding in cold temperatures and may cease feeding altogether through the duration of an entire winter, remaining inactive in freshwater systems (Dr. Peter Walker, Principal Aquatic Consultant, RSK, pers. comm.). There are suggestions that eels feed somewhat like snakes, slowly digesting a meal until their stomachs are completely empty, before feeding again. Food availability is vital for the eels during their periods of feeding, building fat reserves to survive through the winter is vital to the species, and it also is one of the key factors relating to the silver eel migration stage. Eels need to have gained enough fat reserves to sustain their migratory return journey to the Sargasso Sea.

European eels are strong swimmers, and they have impressive climbing skills allowing them to navigate obstacles dependent upon height and vertical slope. In fact there are even reports of European eels leaving waters altogether entering fields, where the species feed on slugs and worms, this gives the species an added advantage over other aquatic species like trout. Occasionally eels may be seen hunting for food at night as they hunt by smell and vibration rather than sight.

Once the European eel reaches the adult yellow eel stage, they are not very particular when it comes to food, but it is within the early stages of metamorphosis to yellow and early yellow eel stage that dietary requirements are important for successful growth. Reduced availability of the right diet could lead to poorer fat and energy reserves and may negatively impact the eels ability to return to the continental shelf. If there is little availability of the dietary requirements to support the eels in their early growth stage the losses within freshwater and estuarine systems will be greater as a result in poor fat and energy reserves, the negative effects will be fewer eel's making it to the continental shelf.

(2) Distribution and Observations of European Eels in Inishowen

The distribution of the European eel within Inishowen was examined using data fisheries authorities data from 2008 to 2018 plus anecdotal records provided from 1978 to 2021. The two fisheries agencies operating in Inishowen (Inland Fisheries Ireland (formerly Northern Regional Fisheries Board) and the Loughs Agency) provided access to data listing the areas where eels have been detected.

Although recorded data of eel presence is not available for all waterbodies in Inishowen, the author was provided with a number of local accounts from anglers and other parties. In September 2008 the Northern Regional Fisheries Board (now Inland Fisheries Ireland) carried out electrofishing surveys for the presence of fish species in river bodies for the Water Framework Directive.

For the NRFB 2008 report (Kelly *et al.*, 2009) twelve waterbodies were surveyed with two areas being located within the peninsula of Inishowen - the Ballyhallan River in Clonmany and the Burnfoot River. The report indicated that of the twelve waterbodies surveyed, eels were present in 75% of the sites and that the Ballyhallan and Burnfoot rivers were found to have a higher eel abundance due to the proximity of these waterbodies to coastal outlets. However, it was noted that during the survey of the Burnfoot River the site location was in very poor condition with a strong smell of sewage present.

During the survey a number of eels were retained for further analysis, although the reasons for this were not provided in the report (Kelly *et al.*, 2009).

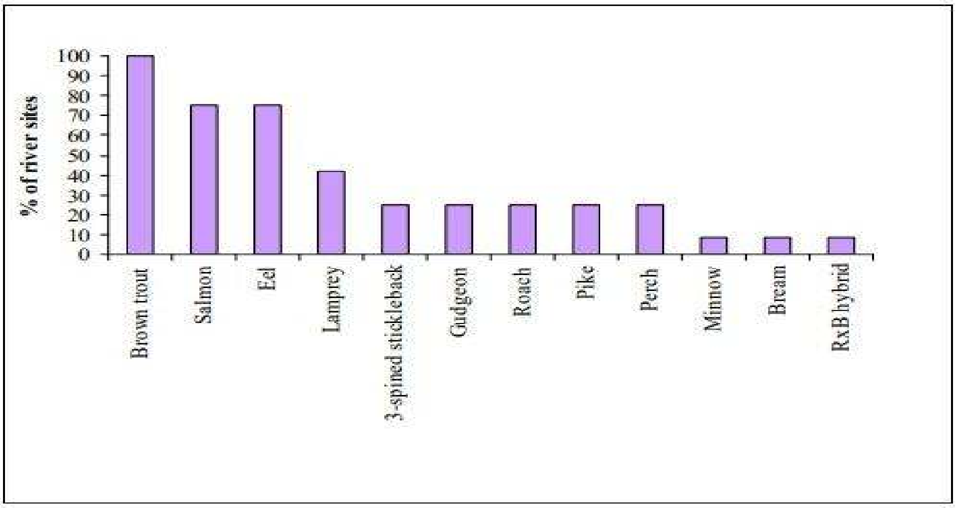

Figure 2.1: *A total of 12 fish species were recorded within the 12 river sites surveyed during the NRFB survey. Brown trout were the most widespread species and were also the only species to occur at all the sites surveyed. Salmon and eel occurred in 75% of the sites surveyed (Kelly,* et al.*, 2009).*

Catchment assessments were carried out by Loughs Agency between the years 2005 to 2018. However, data on eels is only available from 2010 to 2018 (Loughs Agency, pers. comm.). Sites on the Culdaff River and various tributaries, the Bredagh River and Portaleen River were sampled by the Loughs Agency using electrofishing methods. These sites were visited each year between 2010-2018, and European eels were found during all surveys at these designated sites. In addition, coastal and estuarine netting surveys on the Culdaff River shows eels were trapped between March and August in 2016.

Detections of the European eel (Glass eel) were also recorded on the lower area of the Mill River in Buncrana in May 2020 and April 2021 by voluntary river monitors within the locality. Using all of the data available a compiled list of areas where eels have been recorded has been listed along with coordinates for these locations to identify the exact sites where samples were taken (see Appendix I). This adds to the existing agency data and will help to monitor the presence of eels in our waterbodies in the Inishowen district in the future.

(2.1) Local accounts of the European Eel in Inishowen

There are many accounts of the abundance of eels in Inishowen in the past. These eyewitness accounts, although not submitted as scientific records, are important in understanding the significant decline of the species within the local area. The author made contact with local angling clubs and individuals who have first-hand experience with eels in our waterbodies and overall discussions indicate that the distribution of the species within the peninsula 30+ years ago were healthy compared to today's stock levels.

Accounts were given of the European eel's presence over 30 years ago on the Mill River in the townland of Buncrana, with larger species of the eel being found below the reservoir dam located upstream of Millfield Lodge House. Reports are given of 3-5 pound eels being caught in the upper Mill River area, and indeed, there have been reports of large silver eels found in the highest reaches of the Mill River (Tullydish area) in the Owenkillew tributary through the years.

Anecdotal reports from the lower area of the Owenkillew (Mill River) below the waterfall in the mid-1970s to the early 1980s, indicate elvers or young yellow eels could be seen in late evening until dark climbing the rock face wall of the waterfall negotiating their way to the upper pools in their hundreds (D. Lynch, pers. comm.). On the opposite side of Buncrana town, accounts from the Crana River suggests large eels were being caught by rod and line in the early 1980s with reported weights of 3-4 pounds (Kevin Moore, pers. comm.).

According to local historical accounts, Inch lake and its connected tributaries did have a large abundance of European eels over 20 years ago. The runs of eels, as they were referred to locally, were called silver eels and described as being 10-12 inches in length and found during the months of June and July. At the time these were described as an annoyance while angling for other species, as there were so many eels present it made angling difficult - an indication perhaps of healthy stock levels in that area.

Indeed, the connected waterbodies that flow into Inch lake located near the townland of Burnfoot on the south western edge of the Inishowen peninsula, have eels present throughout its water systems, with accounts been given of eels traveling through a culvert at an area known as Fanny Wylie's Bridge on the Skeoge River (UKGBNI1NW393901002) and located at the intersection of Beragh Hill Road and Lenamore Road. An account by angler Kevin Moore (pers. comm.) describes eels entering a culvert in this area and traveling quite a distance concealed in the dark as a result the expansion and development of lands along the border between Inishowen and Northern Ireland. The eels would exit the culvert system in an area known as Templemore on the outskirts of Derry, Northern Ireland.

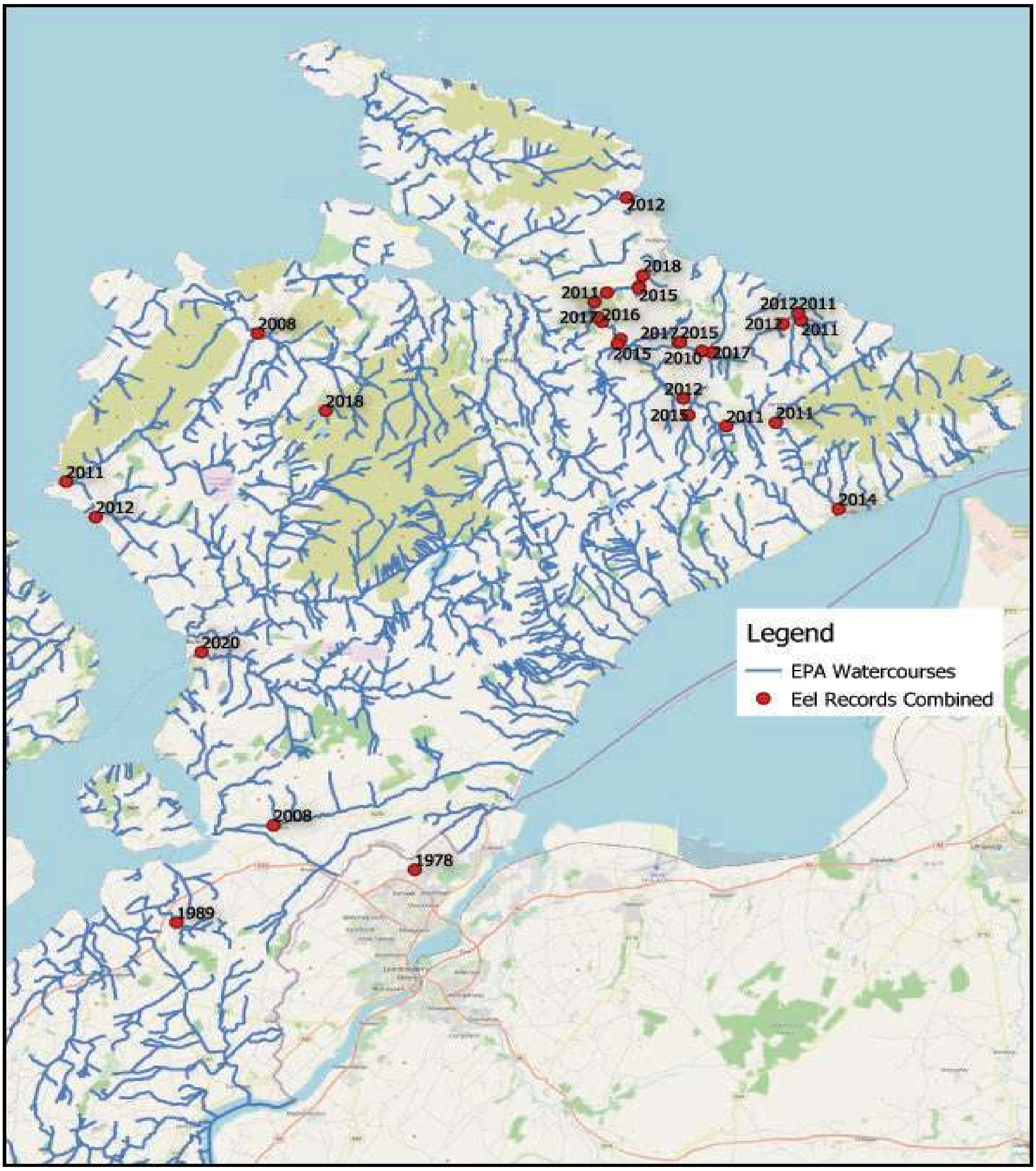

Figure 2.2: *Distribution of European eel in Inishowen using data collated from a combination of scientific eel records and reliable personal observations. (See Appendix I for datasheet).*

In the area around the Culdaff and Tremone Rivers local angler Mervyn Norris (pers. comm.) observed large numbers of eels on the river with 'every stone turned revealing an eel'. Accounts of eels at Drumlee Lough (Culdaff/Gleneely system) in the area indicate that eels were trapped at culverts using onion bags to provide a local meal once per week (Hutchinson family). He also recounts observing significant amounts of eels in pools on the Culdaff River behind the Richardson's Dance Hall where the eels fed on scraps left over from the dance dinner the night before.

Data collated from the fisheries authorities and various accounts are collated and tabulated in Appendix I of this report and mapped on Figure 2.2.

(3) Threats to European Eels

(3.1) A changing Inishowen

With the declining numbers in European eels, we consider how the local environmental conditions have changed. What is different within the peninsula of Inishowen now in terms of natural habitat and biodiversity compared to previous decades? The geographical landscape of Inishowen has vastly changed since the 1900s. With growing economic and transport infrastructure changes, consideration should be given to the impact these events have had upon the eel species. The population of Inishowen has increased, and with this increase has come a demand for amenities to meet the needs of this ever-growing population. Based on 2011 Census records show that the population in Inishowen increased within the peninsula (Dowds, 2011)**.**

A good example of the landscape changes that have occurred within the peninsula of Inishowen, is the large numbers of housing developments built. Vast amounts of land were acquired for the purpose of construction and with this development came the need for more water and sewage facilities. For example, in some areas of Inishowen the growth in housing development has seen older sewage and wastewater overflow tanks unable to deal with capacity of waste storage. The increase has seen areas like Westbrook pumping station in Buncrana overflowing into the Crana River directly (Maguire, 2017). These issues are not the only factor impacting the eel in our rivers in Inishowen but will have a negative impact affecting numbers of species within our rivers and the general biodiversity within our natural environment.

The European eel is a native species to our freshwater systems so it is important to understand the changes that have occurred within our rivers and what impacts they are having in the natural habitat. Water quality in our rivers is a deep concern. The pressures that species are faced with in their time spent in our waters has changed through the years. According to the EPA (http://epa.ie/irelandsenvironment/water/) summary findings on water quality, the status of our natural waterbodies has declined with only 53% of our rivers being of satisfactory status. We must consider the negative impacts of this to the biodiversity of our rivers and the impact to migratory species within them.

(3.2) Water Quality

Downward trends in water quality on a national level is an issue that has been ongoing for many years and Inishowen has seen many of its natural waterbodies decline in their ecological status. This has resulted in a negative impact for the European eel and other species in terms of food source availability. This can reduce the capacity for the eel to gain enough fat reserves, Eels build fat reserves during periods of feeding however they cease feeding in wintertime. Inadequate food sources and poor habitat will not support the sustainability of the eel within Inishowen. Reduced fat reserves may have a negative impact on the eel's ability to successfully complete their migration to the Sargasso Sea, a journey of approximately 6,900km (Viney, 2016).

(3.3) EPA Report 2013–2018

Information from the Environmental Protection Agency report (EPA, 2019) cited below provides an evaluation of the ecological health of Ireland's rivers, lakes, canals, groundwaters, estuaries and coastal waters against the standards and objectives set out in the EU Water Framework Directive and National River Basin Management Plan 2018-2021

The analysis is based on the assessment of biological and environmental data collected from 2,703 surface water bodies and from 514 groundwater bodies over the period 2013-2018.The report found that 52.8 % of surface water bodies assessed are in satisfactory ecological health being in either good or high ecological status. The remaining 47% of surface water bodies are in moderate, poor, or bad ecological status.

This compares with 55.4% at satisfactory status for the last assessment period of 2010 – 2015, a decrease of 2.6%. Coastal waters have the highest proportion of water bodies in good or high ecological status (80%), followed by rivers (53%), lakes (50.5%) and estuaries (38%). 92% of groundwater bodies were found to be in good chemical and quantitative status, accounting for 98% of the country by area. This is a 1% improvement in the number of water bodies in good chemical and quantitative status when compared with the previous assessment (2010-2015)

Nearly all of the negative trends are driven by changes in river water quality. The substantial increase in the number of river water bodies in poor status, which have increased by a third (or 110 water bodies) since 2007-2009 is evidence that river water quality is getting worse. Furthermore, some of the positive trends previously reported, such as the reduction in the number of seriously polluted (bad status) river water bodies, are now going in the wrong direction.

The number of seriously polluted waters had dropped dramatically from 91 in 1987-1990 to only six in the last assessment period, mainly driven by concerted action to address the causes of pollution in these areas. In this current assessment the number of bad status water bodies has increased to nine. While a relatively small increase numerically, this is disappointing from both an ecological and water management perspective.

(3.4) Loss of high-quality river sites

The deterioration in our highest biological quality river waters between the sampling periods 1987-1990 and 2016-2018 shows a significant decline in Q status between the periods (Table 3.1). In particular, the number of pristine or reference condition sites are now perilously low with just 22 rivers (EPA 2020) in this condition across the whole of Ireland. The Blue Dots Catchment Programme has been established under the current River Basin Management Plan specifically to improve the protection and restoration of these high ecological status water bodies (McConigley, 2019).

Status	Period 1987-1990	Period 2016-2018
Q5-Pristine rivers	13.4%	0.7%
Q5-Q4 good status rivers	18.1%	16.5%
No. of Remaining Q5 Sites	500	20

Table 3.1: *Data from EPA Water Quality in Ireland Report 2019*

(3.5) Transitional and coastal waters

Transitional waters have the poorest water quality with only 38% of water bodies being in good or better ecological status. These waters are under significant pressure from human activities. Impacts to the marine environment have seen phosphorus and nitrogen inputs increase by 31% and 16%, respectively, since 2014, indicating that these water bodies are seeing an increase in pressures from catchment-wide sources (EPA, website). According to Barry *et al.* (2015) transitional waters are highly productive growth habitat for eels and with the decline in the overall eel population density, recruiting eels may be more inclined to settle in estuaries and not migrate to freshwaters.

(3.6) Pressures on the aquatic environment

The deterioration in water quality, and in particular river water quality, seen since 2015 indicates an increase in pressures coming from human activities. Overall, 1,460 individual water bodies were identified in the River Basin Management Plan as being at risk of not achieving their water quality objectives due to the damage being caused by significant pressures. The main significant pressures impacting water quality in Ireland include agriculture, wastewater discharges, impacts to the physical habitat conditions including excess fine sediment (hydromorphology), and pressures from forestry activities.

Identified Pressures	Impact
Agriculture	53%
Urban and domestic wastewater	29%
Hydromorphological alterations	24%
Forestry	16%

Table 3.2: *Data from EPA Water Quality in Ireland Report 2019*

(3.7) Habitat Loss

Wooded riparian zones reduce instream temperatures, which is known to affect fish and invertebrate life. It is possible that the loss of riparian areas in Inishowen have had an effect on the distribution of fish species. As we have come to understand the significance of woody debris and root systems in regards habitat for the European eel, the effects of losses are likely to have a biological significance for the streams biotic community and the impact to the species may be significant (Bowler, et al, 2012).

A once familiar feature within grazed agriculture lands in Inishowen, riparian corridors are now in decline or patchy. These corridors have become degraded by flooding events or as a result of river bank erosion and have not been replanted. In some areas the riparian zones have been removed altogether to increase agricultural area. It is important to recognise that attitudes to this practice are changing locally with engagement of community-based groups and landowners on tree planting programmes which will help to restore these vital areas of habitat.

The August 2017 flooding event in the Inishowen peninsula saw large areas of the riparian corridors decimated and large areas of riverbanks ripped away as a result of the flooding. Many areas of Inishowen were affected by the event but the damage was most evident around the rivers. This was a 1 in 100 year event (meaning there is a 1% chance of a flood of this magnitude occurring each year).

Figure 3.1: *Example of the impact of the flood on 22 August 2017 and the large amount of woody debris that was ripped from the riparian corridors and accumulated at pinch points such as the Cockhill Bridge in Buncrana.*

(3.8) Disease-Virus impacts

Anguillid herpesvirus or AngHV-1 was first isolated from cultures taken from European eels (*Anguilla anguilla*) and Japanese eels (*Anguilla japonica*) in Japan in 1985 (Sano *et al*., 1990). Since the virus was first discovered it has spread throughout Asia and Europe, with the disease infecting both adult and juvenile eels. Anguillid herpesvirus is not thought to infect any other fish species. The impact of this virus is devastating to affected eels which appear lethargic, swimming near the surface of the water's edge displaying visual symptoms such as reddened fins and mottled conditioning of the skin (Hangalapura *et al*, 2007). The main damage caused by this virus is to the onset of severe necrosis resulting in cell death causing loss of normal gill structure. AngHV-1 is frequently active in warm waters between 10°C and 26°C with disease outbreaks reported during summer and early autumn months. Conditions such as poor water quality, high stock levels, barriers to migration and waters between 10°C to 26°C are triggers that exacerbate and promote the spread of Anguillid herpesviruses.

Conditions which promote the spread of AngHV-1

- Poor water quality
- High stock levels
- Barriers to migration
- Waters between 10°C and 26°C

Eel Virus European X (EVEX): The Eel Virus European X is a rhabdovirus that infects all species of eel in freshwater. Detected in 1977 from European eels imported to Japan from France, it has since spread throughout Europe as well as parts of Asia and Africa Environment

Agency). EVEX is considered one of the more important viruses of the European eel which has the potential to cause mortality and migration failure within the species. EVEX has been found in healthy eels and has also been associated with significant mortalities within the three species of freshwater eels. If the parasite is present the associated symptoms that eels will display are appearing lethargic, emaciation, skin lesions and haemorrhaging. Infected eels can die from severe haemorrhagic changes that appear across the skin and throughout the internal organs (Environment Agency, National Fisheries Laboratory factsheet).

Anguillicoloides crassus: *Anguillicoloides crassus* is a nematode native to eastern Asia where it is considered a widespread, non-pathogenic parasite of the swim bladder. First found in *Anguilla japonica* it was introduced to Germany with imported Japanese eels around 1980, where it transferred to the European eels *Anguilla anguilla*. The parasite has subsequently spread throughout Europe and Northern Africa spreading easily among eel populations after introduction to a waterbody. A parasitic nematode worm that lives in the swim bladder *Anguillicoloides* is considered to be one of the threats to the sustainability of populations of European eels (https://www.cabi.org/isc/datasheet/93709).

(4) Anthropogenic Impacts on the European eel

Cited by the ICES (2017), 50% of mortalities amongst the eel species are a result of anthropogenic issues. There are many sources of research available regarding anthropogenic issues that have led to the direct mortality of eel species but no records could be found for the Inishowen peninsula, most likely due to the lack of recorded data on the eel. Although this report looks at the European eel's occurrence within Inishowen, it is important to consider the impacts within County Donegal as we endeavour to understand the overall impacts upon the species. With a growing infrastructure the supply of electricity and the introduction of hydropower stations this has had a major impact upon the European eel species.

Cathaleen's Fall hydroelectric power station is a hydroelectric plant located on the River Erne at Ballyshannon in County Donegal, Ireland and today it is owned and operated by the ESB Group. The plans for the Erne power station were first conceived in the 1920s, but it was not until 1946 that the construction of two dams started at two locations on the river between Belleek and Ballyshannon. The construction design of the dams was reinforced concrete gravity dams, started in 1946 and completed in 1955. Notably the decline in eel populations globally can be traced back to the early 1960s, just five years after the creation of these structures which were not common in Ireland at this time.

The impacts from these structures are well documented, with one such incident occurring in 2014 where the ESB Group admitted responsibility for the killing of 300 thousand eels (Russell, 2014). The European Eel Consultancy expressed its dissatisfaction with ESB, suggesting that it should not be managing the eels migration programme based upon the event that occurred at the ESB hydroelectric station at Cathaleen Falls, Ballyshannon, County Donegal (O'Connor, 2014).

A female European silver eel is capable of laying between 2,000,000 to 10,000,000 eggs on a successful migration to the Sargasso Sea. However, the high mortalities in silver eels would no doubt impact on the number of returning glass eels. The consistent pressures upon the eel populations from such anthropogenic structures may be contributing to their decline despite

Ireland's attempts to adhere to the European guidelines regarding European eel management in our freshwaters.

(4.1) Anthropogenic Issues in Inishowen - Dams

Barriers to migration represent one factor affecting riverine fish populations in Ireland and within Inishowen. There is visible evidence of such anthropogenic structures present on our rivers with two large examples being located within the peninsula - the Eddie Fullerton Dam on the upper area of the Crana river catchment in the townland of the Illies, Inishowen and the Swan's Mill Dam located at Gransha in the townland of Buncrana. Both of these structures demonstrate how the continuity of a river system can be disrupted. The Fullerton Dam was highlighted in the Inland Fisheries Ireland review of fish stocks and associated habitat in the Crana River for 2019 citing hydromorphological issues as a result of the existence of the dam (Millane, *et al.,* 2019).

Figure 4.1: *Eddie Fullerton Dam, Illies, Inishowen, County Donegal*

Dams interfere with the free movement of fish and substrate in a river system and disrupt fish migration upstream, resulting in a loss of access to upstream habitats. These barriers pose serious problems within catchments including restrictions in river continuity which causes delays for migratory species and possible mortalities. Identifying such impacts within our waterbodies is important and should be considered a probable factor in the decline in European eels in our freshwater bodies.

(4.2) Anthropogenic issues on the Mill River, Inishowen

Swan's Mill on the banks of the Mill River supplied the first electricity to the town of Buncrana in 1905 continuing this supply up until 1954. Although the function of the Swan's Mill has long since ceased and its buildings assigned to history, many of its structures are still visible on the river system itself with one of the largest being the Swan's Mill Dam. This structure may now be impacting the river systems continuity.

Figure 4.2: *The Swan's Mill Dam on the Mill River in Buncrana, Inishowen.*

There is a fish pass located to the right-side face of the dam wall, in wintertime or prolonged periods of rain there is good hydrological availability but during drier months, the fish pass frequently dries up with little to no water availability in the spring and summer months. The probability of issues to upstream migration are highly likely. Local accounts once described the area where the dam is located as an area where large eels could be located. Monitoring and sampling of the Mill River in 2019-2020 through a riverfly monitoring scheme detected no eels in this area nor were there any local angling accounts of catches of the species in this location in recent years.

A waterfall in the lower area of the river has been physically modified by humans but local historical accounts state that European eels have been able to negotiate this area and have been found above the waterfall in the past. When we consider the information available together regarding the two illustrated sites within in this report in reference to anthropogenic impacts, it is clear there is an existing problem impacting both catchments

Figure 4.3: *The Mill River Dam Fish Pass, Inishowen, County Donegal*

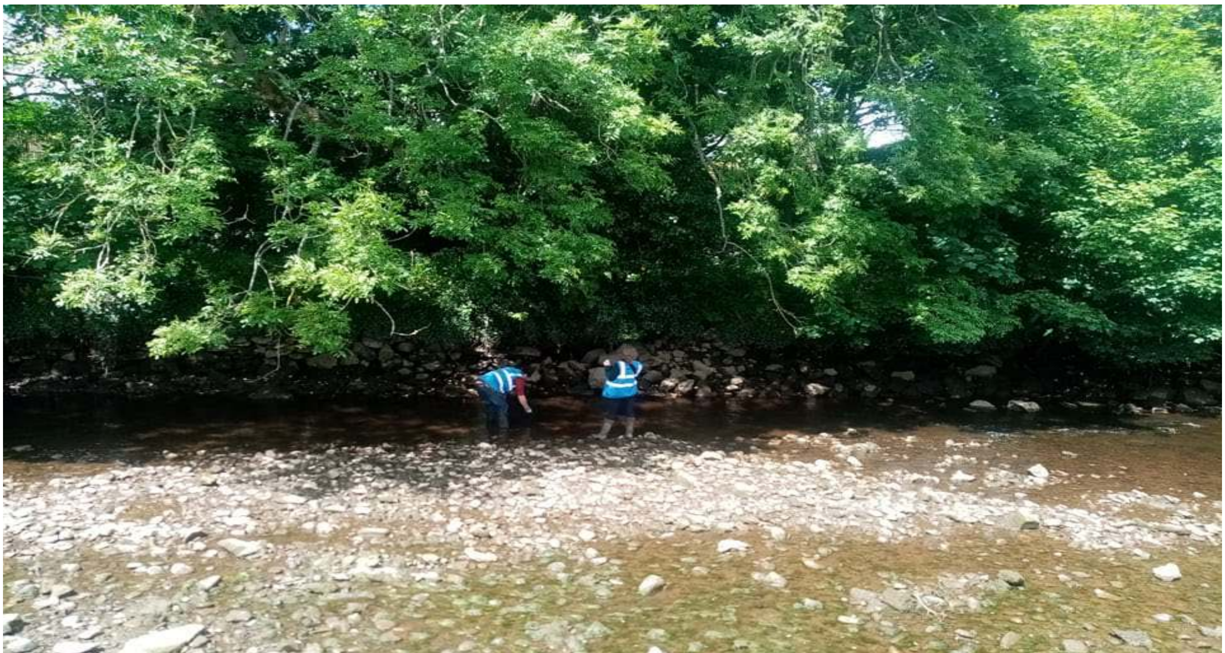

Figure 4.4: *Lower area Mill River (Scarvey), Inishowen during 2020 (note the very low water levels).*

(4.3) Q Scores on the Mill River, Inishowen

The EPA derived Q value status for both upper and lower sections of the Mill River are cited below. Q scores have declined in recent years in the lower section (area known locally as the Scarvey), although the upper sections of the Mill River (Owenkillew) are still good. Previously in 1991 sampling in the lower section yielded scores of Q4-5.

	Upper Mill	**Lower Mill**
Station Code	**RS39M020100**	**RS39M020300**
Station Name	Bridge W. of Tullydish Upper	D/s Old Rly Br S. of Buncrana
Station Type EDEN	RIVER_STATION	RIVER_STATION
River Waterbody Name	MILL (DONEGAL)_020	MILL (DONEGAL)_020
Entity Name	MILL (DONEGAL)	MILL (DONEGAL)
Entity Code	39M02	39M02
Year	2019	2019
Q Value Score	4-5	3
Q Value Status	High	Poor

Table 4.1: *The upper area of the Mill River-Owenkillew River Q Value status (data source EPA Map Portal)*

Consideration should be given to the declining ecological status of a waterbody in line with the declining numbers of European eels. Equating this against other identifiable pressures impacting upon a freshwater system will allow for a better understanding for the loss or rapid decline of eel stocks within our rivers.

(5) The Final Migration

Researching various studies of the European eel's migration to the Sargasso Sea, we highlight Ireland's contribution towards science-based studies of the species between 2006 and 2012. Researchers from Inland Fisheries Ireland took part in an EU funded research study (Righton, 2016) that has helped to uncover some of the deepest secrets regarding the oceanic journey and behaviour of the European eel. The international research team, led by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) in the UK, tagged and tracked more than 700 eels as they made their mass migration from Europe to the Sargasso Sea. As a result of the tracking system 200 tags were recovered, allowing the scientists to chart more than 5,000 kilometres of the migration route.

Ireland was one of four countries which released eels between 2006 and 2012 for tracking purposes allowing scientists to map the eel's migration routes from Europe to the Azores region, approximately half the distance to the area where they spawn in the Sargasso Sea. Forty-four eels were successfully tracked from Ireland with satellite tags which monitored eels further and longer than any previous studies with one of the tagged eels from Ireland registering a journey of 6,982 kilometres and 273 days at sea. The study has changed previous theories on the European eel which believed that eels made one large journey to the Sargasso Sea to breed once before they die (Righton, 2016).

The research showed the eel’s arrival to the Sargasso Sea is more staggered, a concerning finding when it comes to managing and conserving an endangered species. Other findings from this study showed some eels did choose the fastest route available migrating from Europe and spawning in early spring within six months of departure from fresh waters. Evidence however suggests that the majority of eels undertake their journey moving at a slower paced migration. This means the eel are at sea a year later than previously thought making the risks greater in terms of being exposed to greater losses from predation and other mortality events.

(5.1) How do eels know the navigational route to their spawning grounds?

At the larval stage eels are thought to imprint a magnetic map of their very first transoceanic journey of migration which is considered related to the silver eel's phase of their migratory travels back to the Sargasso Sea. Based upon the magnetic mapping in the species. Studies suggest that silver eels are sensitive to magnetic cues (Chang *et al*., 2020). Using this sensory ability silver eels orient in a direction that they have registered just before they are displaced. The advantage to possessing magnetic mapping abilities is more understandable in terms of the migration towards the spawning grounds for example. If their migration is impeded or blocked, or when environmental conditions become unfavourable, eels would be able to resume their movements along their old bearings when conditions become favourable again or when they pass the impediments.

A recent study by Chang *et al*. (2020) submitted theories relating to the directional spawning journey of the European eel. The study showed silver eels swam south westward within the Sargasso Sea and that European eels, whatever their release points be that Ireland, the Baltic Sea, the Bay of Biscay, or Mediterranean converge towards the Azores. From a point of distance this would not be the fastest route to the spawning grounds but it has been proposed there is significance behind this method of migration. It would seem the magnetic compass abilities of the European eel are vital in this stage of their journey but it is not just their magnetic directional abilities the eels rely on and there are other methods that the eels deploy which enables them to negotiate their journey

One hypothesis proposed in this study (Chang *et al*., 2020) is that the Azores serves as a converging point because of its location to the mid-Atlantic ridge. Once the eels reach this point research shows they turn southwest using the mid-Atlantic ridge as their guide. A change in the European eel's migration behaviour was also discovered showing the eels moving to epipelagic layers around 150-300m depth during their night travels and during daytime travel the eels would change to mesopelagic and bathypelagic depths of 1000-200m depths.

(5.2) Reasons for migratory behaviour

Behavioural patterns in migratory travel in this manner enabled the silver eels to detect and follow the Mid Atlantic Ridge and associated seamounts that reaches 2000m to 3500m of elevation above the seafloor that lies at depths of four thousand meters. The research also suggests that eels detect variations of chemical changes in seawater by using their highly sensitive olfactory abilities enabling them to detect odours or plumes from deep layers of water. A rise in sea levels around the Mid-Atlantic ridge and volcanic activity likely modifies the chemical composition and related odour of the water and therefore providing a directional guide for the eels to follow a theory proposed by Chang *et al*. (2020).

(5.3) Sargasso Sea is a North Atlantic Subtropical Mode Water

The Sargasso Sea is vertical in temperature distribution in which there is almost the same degree in the mode of water layers especially in spring and winter. The southern boundary at an approximation of 22–26°N. Theoretically the water mode boundary there could potentially serve as a destination of spawning (Chang *et al*., 2020). At the North-South Y axis, silver eels may reach the best thermic conditions which are between 22°C to 24°C for spawning to occur and once eels have reached favourable habitat conditions to spawn, they find their mates to breed. However random mating in the huge Sargasso Sea is unlikely as the male and female silver eels do not have a synchronized migration. Males start their migration from August to September, whereas females migrate between November and December.

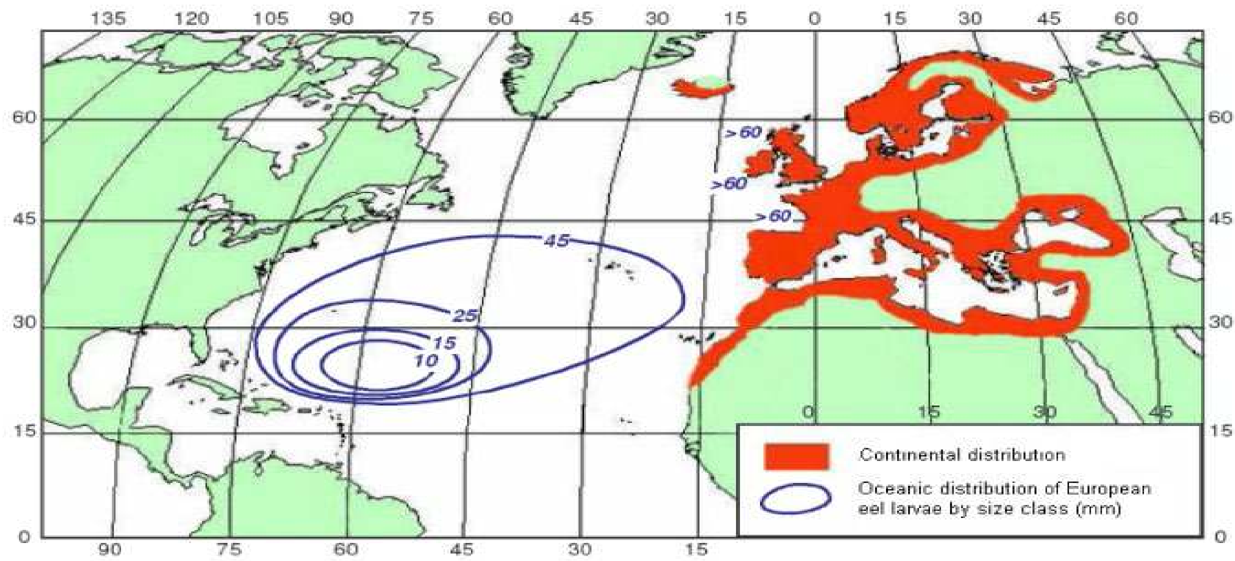

Figure 3: Distribution area for *A.anguilla*, adapted from Adam (1997).

Figure 5.1: *Distribution area for European Eel.*
(source: https://qsr2010.ospar.org/media/assessments/Species/P00479_european_eel.pdf)

(6) What is being done at a local level in Inishowen?

Since 2019 a trained, team of riverfly monitoring volunteers have carried out kick sampling surveys on many rivers in the Inishowen peninsula, with the data retained by the Inishowen Rivers Trust. The technique used is the standardised ARMI method (Angler's Riverfly Monitoring Initiative, UK Riverfly Partnership) which gives a biological indication of water quality but may also infer levels of abundance of macroinvertebrates in each location.

Location	Site	Taxa detected	Abundance	ARMI Score	Date
Mill River	Scarvey Buncrana Inishowen	Caddis Caseless Caddis Heptageniidae Baetidae Blue winged Olive Stonefly Gammarus	5 14 10 22 1 9 1	10	May 2020
Mill River	Tullydish Inishowen	Caddis Caseless Caddis Blue wing Olive Heptageniidae Baetidae Stonefly Gammarus	8 4 3 39 80 11 14	11	May 2020

Crana River	Tullyaravan Buncrana Inishowen	Caddis Caseless Caddis Blue wing Olive Baetidae StoneFly Gammarus	67 6 4 46 4 5	8	May 2020
Crana River Mid	Cockhill Buncrana Inishowen	Caddis Caseless Caddis Blue wing Olive Baetidae Stonefly Gammarus	28 8 11 26 2 1	9	May 2020
Crana River upper	Twin Bridges Illies Inishowen	Caddis Caseless Caddis Baetidae Gammarus	1 11 35 3	6	June 2020
Owenirk River	Hillside Desertegney Inishowen	Caddis Caseless Caddis Baetidae Gammarus Heptageniidae	4 9 21 7 5	6	June 2020

Table 6.1: *Example data from riverfly monitoring Inishowen, 2020. Records by Thomas Lawrence.*

There appears to be reasonably good abundance of the various taxa recorded in the rivers which would provide a good food source for the eel. Ongoing monitoring of the rivers will ultimately provide more robust data and aid in the development of hypotheses or conclusions.

Other species detections River fly Monitoring 2019-2020

In the process of Riverfly Monitoring a number of other species were observed and recorded, other than the key macroinvertebrates recorded for ARMI. Other species were noted but are not included in the assessment of invertebrate scoring method. Species detected included: Simulidae (Blackfly larva), Tipulidae (cranefly larva), Potamopyrgus (snail) and worms.

Figure 6.1: *Detection of a European Glass eel (elver) May 26th 2020 lower Mill River, (Scarvey area).*

(7) Discussion

Despite limited data in regards European eel presence within the freshwaters of Inishowen, we have been able to source some data that has given us a reasonable picture into the local distribution of the European eel. Taking into account information sourced from fishery reports and local accounts of the species, the eel is geographically well represented across the peninsula, although stock levels are not what they would have been pre-1960. Currently it is difficult to conclude what the status of the population is (if it is at risk or not) without further detailed study.

This desktop study identified European Eel presence in the following rivers and lakes in Inishowen:

- Aghaweel River
- Ballyboe River
- Bredagh River
- Crana River
- Clonmany - Ballyhallan River – Cloontagh River
- Culdaff- Gleneely River
- Drumlee Lough
- Lough Fad
- Lough Nastacken River
- Mill River
- Owenirk River
- Tremone River
- Sharagore River
- Skeoge River

Presently there are a number of pressures impacting upon the European eel species locally, downward trends in water quality are an identifiable key factor affecting over 40% of our freshwater systems nationally. Trending downward since 2004, waterbodies of previous good status have dropped to moderate and poor levels. This in turn has an impact in the ecological health of our rivers adding pressures upon already low numbers in fish stocks. Local anthropogenic and agricultural practices may be negatively impacting upon our rivers, issues regarding toxicity levels and human interference with the natural connectivity of streams in some areas of Inishowen have affected inward migratory journeys of the European eels. The loss of large areas of riparian corridors is impacting rivers resulting in natural areas of waterbodies previously shaded now exposed to solar rays. The impact in real terms is an increase in water temperature, a stress factor for fish stocks and trigger for the promotion of viruses amongst freshwater eels.

Anguilla anguilla, *Anguilla japonica* and *Anguilla rostrata* are all impacted by viruses specific to their species, detected since early and late 1970s. These viruses have greatly impacted the abundance of the Anguillidea species directly and currently this is an existing pressure which poses the risk of complete mortality within the freshwater eel species. This does not take into account illegal fishing activities outside of Irish jurisdictional control.

The landscape of Inishowen has changed greatly since 1960, in terms of modifications to our natural waterbodies, land drainage, housing developments and water abstraction. Examining historical maps (Geohive.ie) in the course of this research, it is clear there has been significant change to the natural freshwaters of Inishowen. Poor planning practices in relation to building regulations in the past have led to a number of significant changes which have negatively impacted upon our waterbodies and increased pressure on shrinking populations of our freshwater species.

Limited data was available in the process of this research report so, this in itself represents a problem for the eel species in our freshwaters. Failure to acquire and record adequate up to date information specifically in regards the European eel risks not being able to assess the impacts posed to the species within our waterbodies.

One of the most notable issues encountered in the research for this report was a lack of knowledge and understanding with regard to the freshwater eel. During consultations with various members of the community it became apparent that there is a lack of knowledge of the life cycle of the eel – a common misconception is that the eel is born in our rivers before migrating to the sea.

Lack of awareness around biodiversity can be an important factor in conservation management. Knowledge among anglers was good but with declining eel populations, the upcoming generations will have less opportunity to become engaged with this fascinating species. A positive element to this research is that there is an increasing number from the local community who are volunteering their time to monitor the local rivers of Inishowen. This is increasing our awareness of the health of our rivers and encouraging community groups to engage in positive solutions for our rivers. This can only be a positive benefit to the freshwater eel in the long term within the Inishowen Peninsula.

(8) Conclusions and Recommendations

Taking into account all aspects of the data reviewed, we conclude that there are a number of key drivers to the decline of the European eel. Virus impacts, anthropogenic issues and climate change all play a role in the rapid downward trends within the *Anguilla* species. In the rivers of Inishowen, fish passage impediments, loss of habitat and declining water quality are the localised impacts facing the eel. Although at a local level we cannot personally change the main issues affecting the European eel at sea, we can address the pressures impacting the species within our rivers by adopting best environmental practices that sustain biodiversity. Failure to do this adds further pressures to an already critically endangered species.

The European eel is present and distributed well throughout Inishowen but additional work needs to be done to monitor their welfare within our river catchments. Given that the species is categorised as critically endangered, management of the species within our rivers system, notwithstanding allocated areas under the EU eel management plan, seem inadequate in terms of assessing the overall welfare of the species. Ascertaining just the numbers of eels recruited through a few monitoring stations at specific dams does not give a true reflection of the situation or stock pressures within the water bodies of the Inishowen peninsula.

This report recommends a number of key actions to be taken in Inishowen to help manage and support eel populations as much as possible within the jurisdiction of our local freshwater systems. We recommend:

- Regular monitoring of eels within suitable water bodies identified in Inishowen, including estuaries
- Recording up to date information on species year on year building a robust dataset
- Engaging with the local community through workshops or events to promote and create awareness on the European eel

- Identifying pressures within rivers in the locality and using nature-based solutions to mitigate these impacts where possible
- Restoring riparian corridors
- Identifying anthropogenic impacts within the waterbodies of Inishowen and liaising with authorities locally and nationally to establish best practices to overcome these impacts to benefit the natural habitat and local community.

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Historical Maps – Accessed through http://geohive.ie/

APPENDIX I

Collated European Eel Data, Inishowen, County Donegal

Year	River	X co-ordinate	Y co-ordinate	No. caught	Data source
1978	Skeoge River	243736	421700	++	Kevin Moore (pers. obs.)
1980s	Drumlee Lough	55419	44044	++	Mervyn Norris (pers. obs.)
1980s	Tremone	59269	47044	++	Mervyn Norris (pers. obs.)
1989	Carrowen	233995	419179	++	Ross Buchanan (pers. obs.)
2008	Ballyhallan	237099	446319	1	North Regional Fisheries Board River Report 2008
2008	Burnfoot	237932	423694	1	North Regional Fisheries Board River Report 2008
2010	Culdaff	251110	446995	1	Loughs Agency
2010	Culdaff	252600	448550	1	Loughs Agency
2010	Culdaff	251765	445970	2	Loughs Agency
2010	Culdaff	251300	448330	1	Loughs Agency
2010	Crana	234285	432718	1	Loughs Agency
2011	Culdaff	251110	446995	1	Loughs Agency
2011	Culdaff	252600	448550	1	Loughs Agency
2011	Portaleen	252050	452700	1	Loughs Agency
2011	Culdaff	259104	447493	1	Loughs Agency
2011	Bredagh	258259	442454	1	Loughs Agency
2011	Culdaff	250800	447900	1	Loughs Agency
2011	Gleneely	254475	443515	1	Loughs Agency
2011	Tremone	259223	447161	1	Loughs Agency
2011	Lough Nastacken	258477	446981	1	Loughs Agency
2011	Owenirk	229329	439452	3	T. Lawrence (pers. obs)
2012	Culdaff	252600	448550	1	Loughs Agency
2012	Culdaff	251675	445970	10	Loughs Agency
2012	Gleneely	254475	443515	1	Loughs Agency
2012	Sharagore	230552	437837	1	T. Lawrence (pers. obs)
2014	Culdaff	251869	446209	1	Loughs Agency
2014	Culdaff	251300	448330	1	Loughs Agency
2014	Culdaff	251765	445970	1 large	Loughs Agency
2014	Culdaff	254685	442750	1	Loughs Agency
2014	Bredagh	260862	438513	1	Trish Murphy (pers. obs)
2015	Culdaff	251110	446995	2	Loughs Agency
2015	Culdaff	252600	448550	1	Loughs Agency
2015	Culdaff	251765	445970	2	Loughs Agency
2015	Culdaff	254300	446100	2	Loughs Agency
2016	Culdaff	251100	446995	1	Loughs Agency
2016	Culdaff	252600	448550	1	Loughs Agency
2017	Culdaff	252609	448623	1	Loughs Agency
2017	Culdaff	250938	447203	1 adult	Trish Murphy (pers. obs)
2018	Culdaff	252749	449136	1 elver	Trish Murphy (pers. obs)

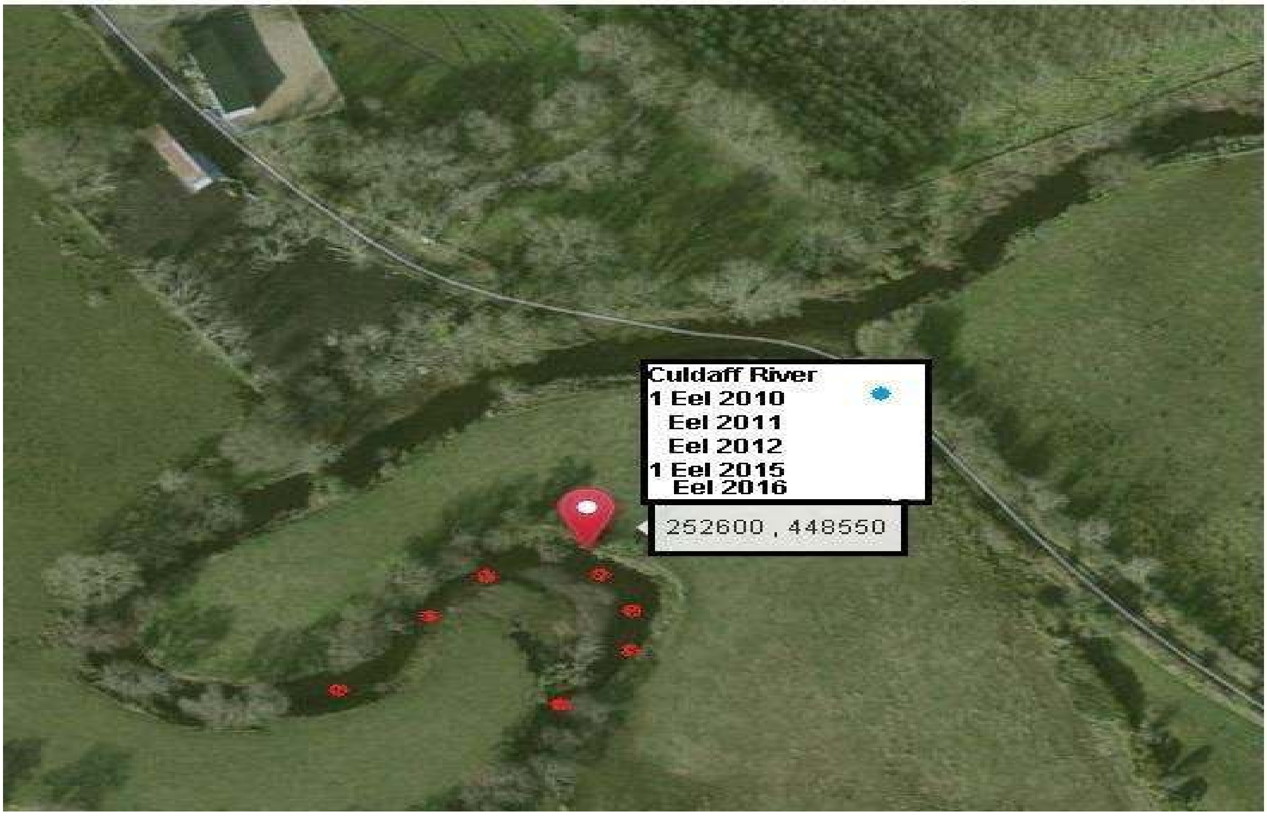
2018	Culdaff	251300	448330	1	Loughs Agency
2018	Lough Fad	239889	442798	1	Gerry Gallagher (pers. obs.)
2020	Mill	234919	431652	1 Glass Eel	T. Lawrence (pers. obs).
2021	Mill	234919	431652	1 Glass Eel	T. Lawrence (pers. obs).

Additional anecdotal accounts by local community of eel presence on rivers including: Aghaweel, Bredagh, Cloontagh, Mill

APPENDIX II

Aerial view of locations of Eel detected in Inishowen waterbodies

Data from Culdaff River, Inishowen County Donegal provided by Loughs Agency.



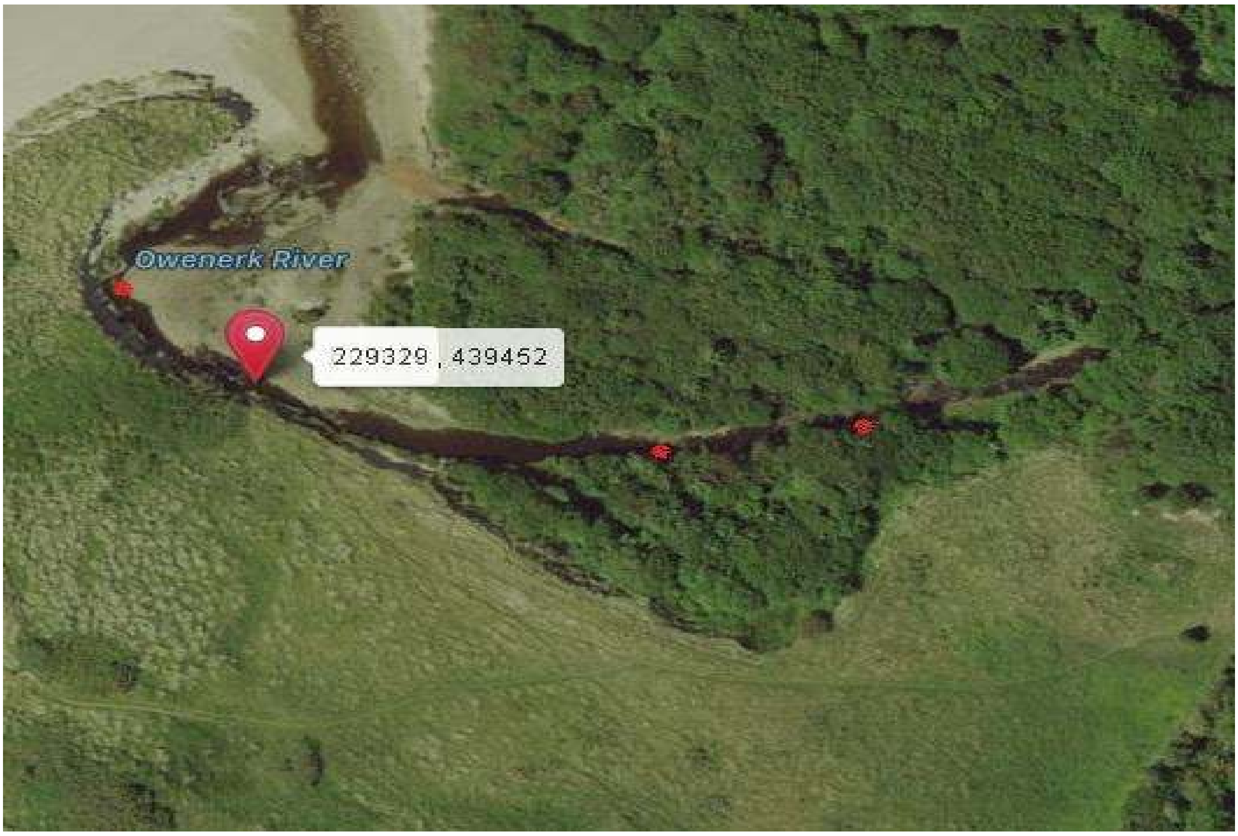

251765 , 445970
Culdaff River
2 Eel 2010
10 Eel 2012
Eel Lrg 2014
2 Eel 2015


Culdaff River
Eel 2014
Eel 2018
251300 , 448330


Culdaff River
Eel 2010
Eel 2014
Eel 2018
251300 , 448330


Crana River
Eel Lrg 2010
234285 , 432718

Data from Sharagore River-Owenirk River, Inishowen County Donegal (T. Lawrence.)



Data from Mill River, Inishowen, County Donegal provided by Thomas Lawrence

Data from Gleneely River (Culdaff), Inishowen, Co. Donegal provided by Loughs Agency