



**Newport Research Facility**

# **ANNUAL REPORT**

**NO. 64**

**Report for the year ended 31<sup>st</sup> December 2019**

**This report follows in sequence from the  
Annual Reports of the Salmon Research Agency of Ireland Inc.  
and the Salmon Research Trust of Ireland Inc.**

**Office and Laboratory:  
Farran Laboratory, Newport, Co. Mayo.**

**Telephone: (098) 42300**

**FAX: (098) 42340**

## Summary

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1. The Salmon Research Agency of Ireland merged with the Marine Institute on the 1<sup>st</sup> July 1999 into Aquaculture & Catchment Management Services and in 2010 the group merged with Fisheries Ecosystem Advisory Services. This report provides a continuation of the data records for the Burrishoole facilities.
2. The total rainfall recorded in Furnace in 2019 was 1754.7 mm. Rainfall in 2019 (1755mm) was slightly above the long-term average (1626mm), but not unusually so. Of note was the low amount of rain in June and July and high rainfall in August. Months of relatively high rainfall were March, August and December. Low rainfall was recorded in April, June and July.
3. The environmental programme was maintained in the catchment with the network of rain gauges, water level recorders and river and lake monitoring stations all in operation, apart from the Furnace AWQMS which was refitted in 2019, and was only operational from September on. The Feeagh AWQMS ceased operation in November 2019, and is currently being refitted. Regular downloads of remote equipment, as well as routine maintenance and replacement of broken equipment, were carried out at all sites. In the last two decades, the physical, chemical and meteorological data have been supplemented with biological datasets describing zooplankton and phytoplankton assemblages in Lough Feeagh and Lough Furnace, along with macroinvertebrate species occurrence and abundance from 16 index sites.
4. The total release of microtagged smolts of ranched Burrishoole grilse origin was 21,836 comprising of 3 tag codes. Fish were released into Lough Furnace on May 2<sup>nd</sup>. Two tag groups (12,485) were released in the morning and one group (9,351) in the evening. Mean weights of smolt groups released into L. Furnace ranged from 70 to 75 gm. Conditions at release were cool and overcast with light winds.
5. In addition to the core release groups an additional 7,838 smolts were released for an SFI experiment. They were released as three separate groups and were freeze branded (O, T, X, H) prior to release.
6. In 2007, the Irish Government introduced a cessation of drift netting for salmon at sea and this was continued in 2019.
7. A total of 443 wild grilse and no previously spawned grilse (psg) were recorded moving upstream through the permanent traps during the season. The number of spring fish recorded was 14. The total run of wild grilse, including the Furnace rod catch (0), was 443 + 0 previously spawned grilse as determined by floy tag returns.
8. No escaped farm fish were recorded in the upstream traps in 2019.
9. No pink salmon were recorded in 2019.
10. Returning adults were checked for net mark damage; The main migration occurred during July and net marks were recorded on 1.6% (n=254) of the wild fish and 5% (n=403) of the ranched in July.  
Overall the incidence of net marks for the season on wild fish was 0.9% (n=427) and on ranched 2.2% (n=1006).
11. The maximum spawning escapement was estimated to be 483 wild and 59 reared fish.

12. A total of 5,863 wild salmon smolts were recorded in the downstream trap in 2019. The wild return of 2018 smolts as wild grilse in 2019 was 7.1%, a slight improvement on 2018. The ova to smolt survival at 0.54 - 0.48%.
13. Wild kelt survival was 47.4% and the tagged kelt return in 2019 as previously spawned grilse later in the year was 0.0%.
14. The percentage return for reared grilse was 3.3%.
15. A total of 18 wild sea trout and a further 75 non-silvered trout migrated upstream through the traps in 2019. Of the silvered trout, 4 were adults and 14 (82%) were finnock.
16. The 2019 sea trout smolt run amounted to 243 smolts.
17. The percentage of trout smolts returning as finnock in the same year has historically ranged from 11.4% to 32.4%. In 1989 it collapsed to a minimum of 1.5%. There has been a saw-tooth pattern of finnock return in the 1990's between 4 & 10%, rising to 16.7% in 1999. Finnacle return in 2019 was 6.4%.
18. Silver eel trapping continued with the total run amounting to 2227 eels. In 2019, the timing of the run was 20% migrating in August, 18% in September and 25% in October. Almost 70% of the run was completed by the end of October.
19. A total of 32 salmon were caught in the Rod Fishery in 2019. The catch consisted of 14 wild fish and 18 reared salmon. No wild fish were killed. A total of 6 sea trout were caught on Lough Furnace and 2 sea trout on Lough Feeagh. Regulations remained in place whereby all rod caught sea trout were returned alive.
20. 2019 marked the completion of 29 years of catchment electrofishing surveys for juvenile salmonids and eel and beach seine surveys of the lakes for juvenile salmonids.
21. Eel fyke net surveys of Bunaveela, Feeagh and Furnace were undertaken in 2019.
22. *Anguillicola crassus*, the non-native swim bladder parasite of eel, was recorded in the saline waters of Lough Furnace for the first time in 2011 and each year since. Infection intensity increased year on year but fell in 2016. This is the first known introduction of an aquatic invasive species into Burrishoole. In 2016, 28 silver eels were checked and 10 were found to be infected with adult worms (35.7%) at an intensity of 2.0% - this was the first recorded incidence of *A. crassus* from above the traps in freshwater in Burrishoole. In 2019, the prevalence was 83.3 in Feeagh yellow eel, 50.0% in Furnace yellow eel and 88.4% in silver eel. There are initial indications that the parasite has spread to Bunaveela.
23. Staff in Newport were authors on 18 peer-review publications and were involved with six reports in 2019, including five ICES group reports.

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## 1 Introduction

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This report represents a continuation of the scientific aspects of the Annual Reports published by the Salmon Research Agency of Ireland, now integrated into the Fisheries Ecosystem Advisory Services Group (FEAS) of the Marine Institute. The data presented creates a unique record of fish rearing and wild fish census data for the past 49 years. This data is an essential component in the local, regional and national management of salmon, sea trout and eel and is becoming ever more valuable in the light of increasing pressures on natural stocks, such as exploitation, habitat degradation and global climate change scenarios. The fish monitoring facilities in Newport, along with the reared and ranched salmon stocks held in Burrishoole, are also essential for supporting projects such as development of novel enhancement techniques, alternative stocks and ranching and evaluation of interactions between farmed, ranched and wild strains. An expanding programme in the Burrishoole system is including ecological and genetics research into eel, sticklebacks and stock dynamics of juvenile salmonids and eels.



The Seven Arch Bridge, Burrishoole Estuary.

## 2 Environmental Data

### 2.1 Mill Race Data

#### 2.1.1 Rainfall

Daily meteorological data were collected during 2019 at the manual Met Station in Furnace. The monthly rainfall figures for 2016, 2017, 2018 and 2019 are given in Table 2.1, along with the annual totals for the years 1977 to 2019. Rainfall in 2019 (1755mm) was slightly above the long-term average (1626mm), but not unusually so. Of note was the low amount of rain in June and July and high rainfall in August.

Months of relatively high rainfall were March, August and December. Low rainfall was recorded in April, June and July. The total rainfall was 1754.7mm. Daily rainfall amounts are shown in Figure 2.1.

**Table 2-1: Monthly rainfall totals (mm) for the Furnace Station in 2016, 2017, 2018 and 2019 and the annual totals for 1977 to 2019.**

Month	2016	2017	2018	2019	Year	Total	Year	Total
January	186.2	87.7	262.7	139.1	1977	1579.7	2000	1833.2
February	214.1	157.7	155.0	107.9	1978	1592.2	2001	1298.7
March	139.5	225.8	87.3	231.2	1979	1653.3	2002	1715.9
April	96.5	25.3	86.2	92.6	1980	1792.1	2003	1353.2
May	49.4	63.1	63.7	110.5	1981	1646.8	2004	1641.3
June	102.4	98.8	61.4	74.2	1982	1609.6	2005	1608.2
July	100.7	181.7	55.4	77.5	1983	1495.9	2006	1550.7
August	132.0	186.3	174.9	243.6	1984	1556.6	2007	1576.8
September	196.1	146.8	142.2	166.3	1985	1584.1	2008	1805.0
October	41.3	169.6	131.2	152.0	1986	1886.9	2009	1793.9
November	160.0	207.0	150.2	142.5	1987	1373.6	2010	1311.6
December	96.3	181.3	189.1	217.3	1988	1715.2	2011	1826.9
					1989	1583.9	2012	1676.4
Total	1514.5	1731.0	1559.2	1754.7	1990	1805.9	2013	1391.8
					1991	1549.6	2014	1723.1
					1992	1771.1	2015	2011.8
					1993	1473.4	2016	1514.5
					1994	1757.1	2017	1731.0
					1995	1382.5	2018	1559.2
					1996	1286.6	2019	1754.7
					1997	1351.6		
					1998	1830.9		
					1999	1949.1		

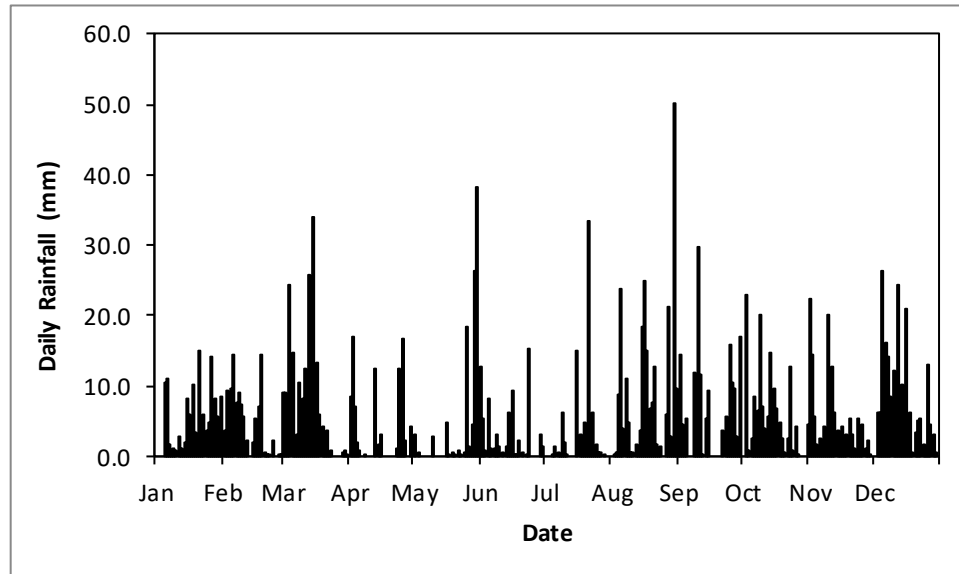


Figure 2-1: Daily rainfall amounts (mm) recorded in the Mill Race manual weather station in 2019.

### 2.1.2 Water Level and Temperature

**Water Level:** There is a long term continuous measurement of water level on the Millrace, measured until 2003 with a paper chart recorder, and since then with an OTT Orphimedes water level recorder. Water level for 2019 is presented here. Water levels are recorded every 15 minutes and are presented in Figure 2.2 recorded at 00:00 hrs.

The plot in Figure 2.2 shows a period of relatively low water from April to mid-June and again, following a flood, from mid-June to the end of July. Upstream fish migration was impaired in May, June and July.

**Water Temperature:** There is a long term continuous measurement of water temperature on the Millrace, measured until 2005 with a paper chart recorder. In 2004, a TidbiT temperature logger was installed along with the chart recorder and this records water temperature every 30 minutes. In 2009, this was upgraded to an OTT Orpheus mini sensor and logger. The temperature logger data are presented in Figure 2.3, recorded at midnight. The water temperature data are available at <http://data.marine.ie/geonetwork/srv/eng/catalog.search#/metadata/ie.marine.data:dataset.2796>

In 2019, water temperatures (recorded at midnight) fell to a minimum of 5.9°C in February (low temperatures from 2<sup>nd</sup> Feb to 12<sup>th</sup> Feb). Temperature rose to a peak of 14.4°C in May and further to 18.2°C on the 15<sup>th</sup> July. Temperature then fell gradually from the 8<sup>th</sup> August until the end of the year with a relatively mild autumn and winter.

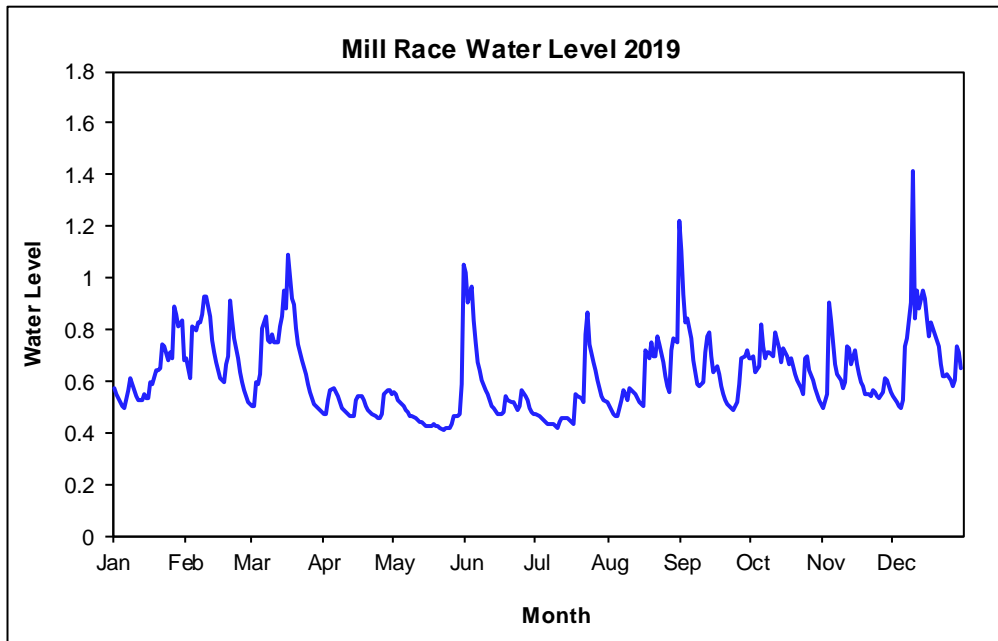


Figure 2-2: Water levels recorded at mid-night for the Mill Race using an OTT Orphimedes automatic water level recorder, 2019.

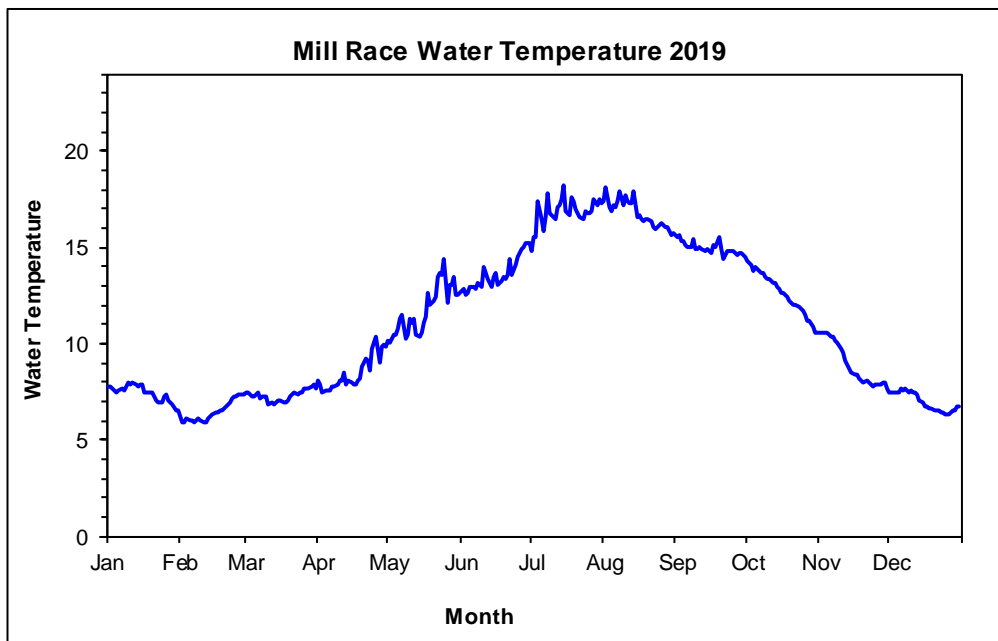


Figure 2-3: Water temperatures (°C) recorded, by OTT Orpheus mini sensor and logger, at mid-night for the Mill Race, 2019.

## 2.2 Catchment Programme

### 2.2.1 Background

Over the last thirty years, the Marine Institute has developed a monitoring programme in the Burrishoole catchment, with the aim of ensuring a long term ecological record against which changes in fish biology can be assessed. At the centre of the monitoring program are a series of automatic monitoring stations which measure key aquatic parameters at high frequency. These automatic stations include two lake stations (AWQMS), which have various meteorological instruments included with a suite of underwater temperature and water chemistry sensors, and four river stations, (ARMS), which are equipped with sensors for measuring water temperature, water level, pH, conductivity, dissolved oxygen, and turbidity. The automatic monitoring stations are also equipped with telemetry systems for relaying high-resolution data back to the laboratory. The data from the lake and river stations are complemented by spot samples analysed for water colour, turbidity, Total Phosphorus, Total Nitrogen and ethanol extracted chlorophyll *a*. In addition, the Institute maintains temperature loggers, water level recorders and data-logging rain gauges in the Burrishoole, Owengarve and Owenduff catchments. These instruments allow high-resolution patterns of rainfall to be linked with stream flow. An important feature of the monitoring network is the ability to collect simultaneous data from river, lake, and climatic instruments.

The physical, chemical and meteorological data have been supplemented with biological datasets describing zooplankton and phytoplankton assemblages in Lough Feeagh (since 2003) and Lough Furnace (since 2009), along with macroinvertebrate species occurrence and abundance from 16 index sites (since 2003).

### 2.2.2 The 2019 Programme

The maintenance and development of long term physical, chemical and biological datasets characterising the freshwater component of the Burrishoole catchment continued in 2019. Regular downloads of remote equipment, as well as routine maintenance and replacement of broken equipment, were carried out at all sites.

### 2.2.3 The Black River

The main river flowing into Lough Feeagh is the Black River, also known as the Shramore River. A water level recorder is situated approximately 500m above the lake. Figure 2.4 shows the average daily water level for 2019 and Figure 2.5 shows the average monthly water levels from 2002 to 2019.

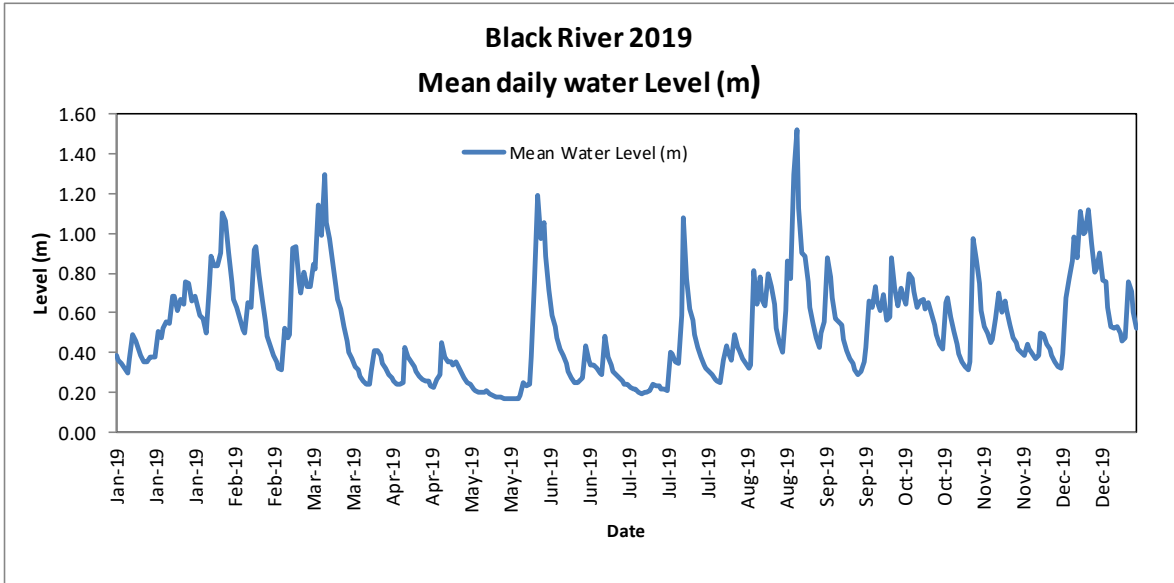


Figure 2-4: Mean daily water level for the Black River, 2019.

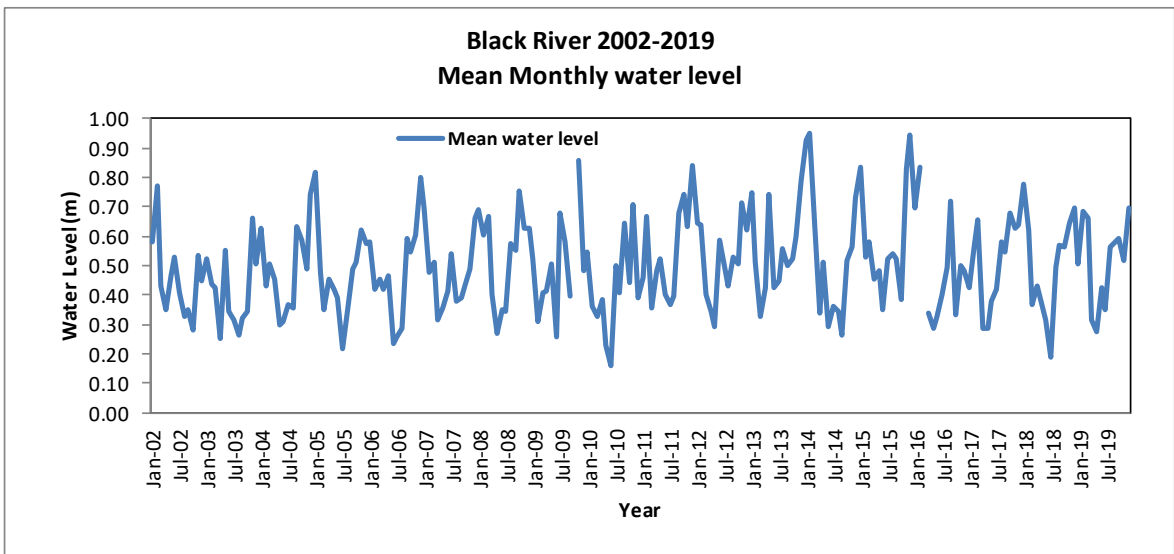
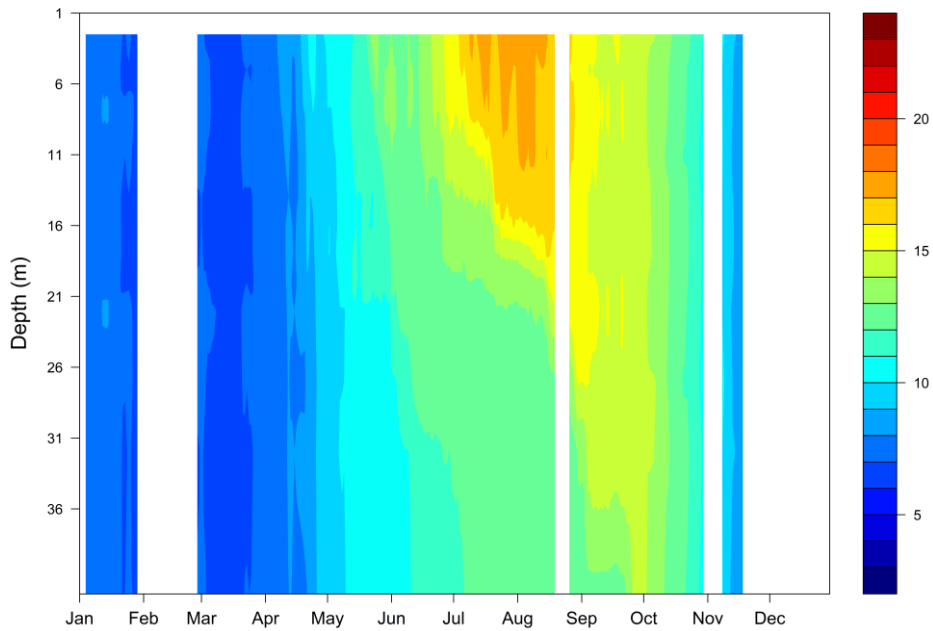


Figure 2-5: Monthly mean water levels for the Black River, 2002-2019.

**2.2.4 Lough Feeagh**

Lough Feeagh is situated in the Burrishoole catchment in the west of Ireland close to the Atlantic coast and is therefore strongly affected by the temperate oceanic climate that predominates in the region. The water is soft and highly coloured (2018 mean of 72 mg<sup>l</sup><sup>-1</sup> PtCo, n = 11), and is oligotrophic, with Chlorophyll *a* ranging between 0.4 and 2.3 µg l<sup>-1</sup> (2018, n=15). Mean annual Total Phosphorous is 6.8µg l<sup>-1</sup> (2018, n = 21) and Total Nitrogen is 0.41mg<sup>l</sup><sup>-1</sup> (2018, n = 21). The Lough Feeagh Automatic Water Quality Monitoring System (AWQMS) measures various parameters using a Hydrolab Datasonde 5, two Chelsea Scientific Minitrackas and a Seapoint fluorometer (pH, dissolved oxygen, temperature and conductivity, turbidity, Chl and CDOM fluorescence). There is also a thermistor chain and various weather instruments continually monitoring variables such as barometric pressure, wind speed and wind direction.

The Lough Feeagh AWQMS operated well in 2019, until November. At this time, the circuit board controlling the logging equipment failed, after almost twenty years of operation. The temperature profile indicates a period of stratification between June and October (Fig. 2.6). Maximum summer temperatures reached 18 °C. (Fig. 2.6). Temperatures were a little cooler than those recorded in the summer of 2018 (Fig. 2.7), but it seems that the hypolimnion of the lake warmed to a greater degree than previously seem. The PRT at the bottom (42 m) recorded a maximum temperature of 14.2 °C in 2019. The lake stratified relatively late in the summer, after an initial brief period of warming in June. (Fig. 2.8). The peak stratification was noticeably later than other years, and broke down rapidly in early September.



**Figure 2-6: Temperature profile for L. Feeagh measured using PRT sensors on the AWQMS for 2019. The white areas denote missing data.**

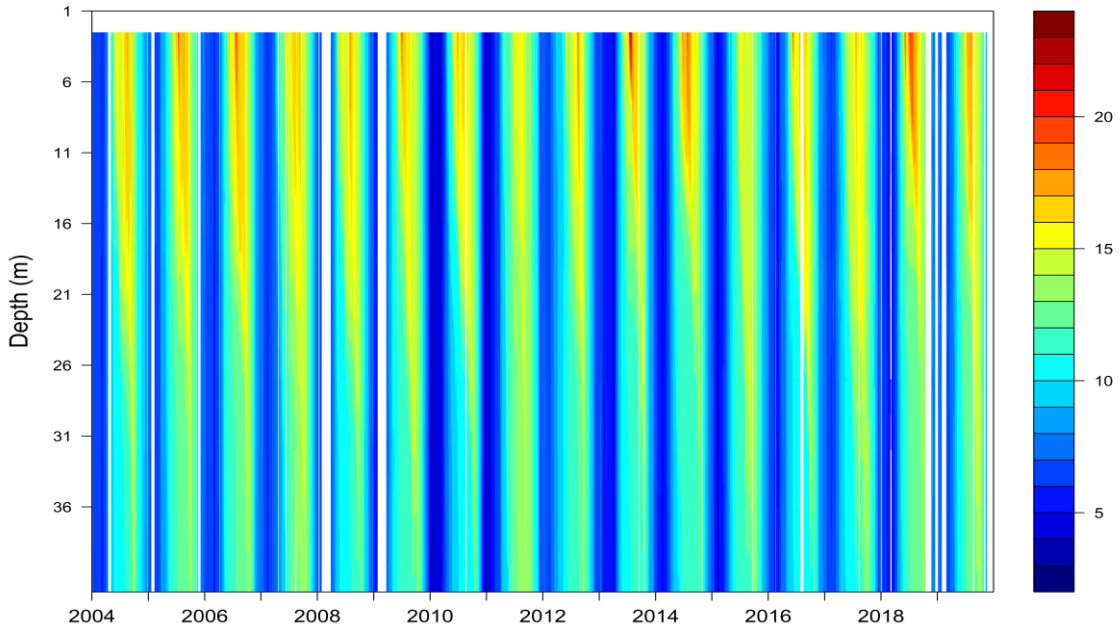


Figure 2-7: Temperature profiles for L. Feagh measured using PRT sensors on the AWQMS for 2004-2019. The white areas denote missing data.

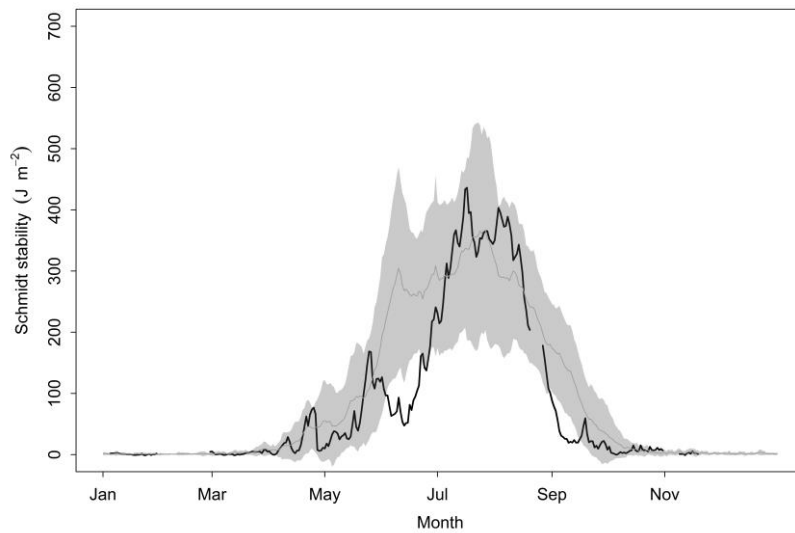


Figure 2-8: Schmidt stability of the water column on Lough Feagh. The black line indicates the daily measured values for 2019. The grey line indicates the average daily values for the period 2004-2018  $\pm$  the standard deviation (shaded grey area).

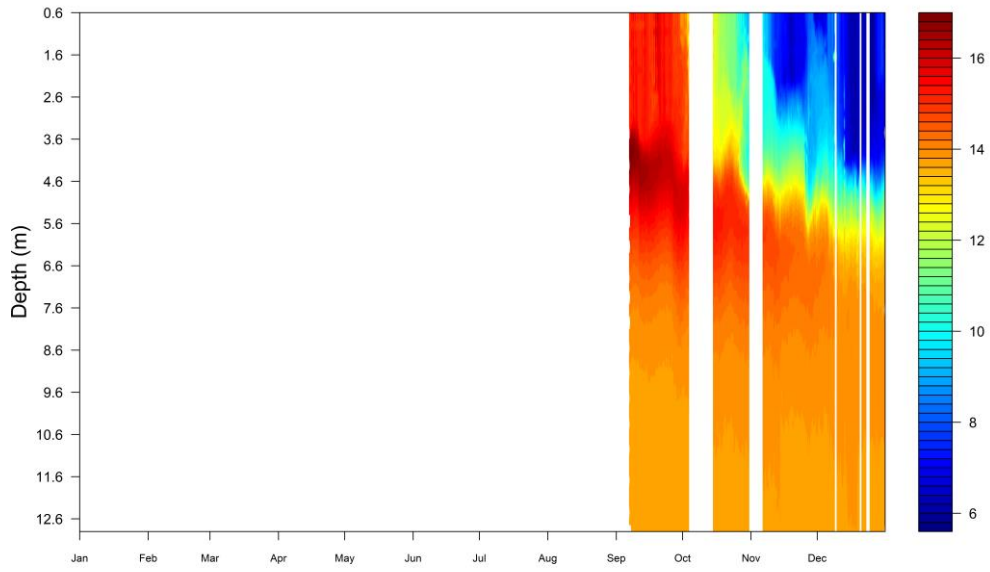
### 2.2.5 Lough Furnace

Lough Furnace is situated in the lower end of the Burrishoole catchment. Lough Furnace, (2km from north to south at its widest point, covering an area of 170ha, max depth is 21m with an average depth of 7m) is a cryptodepression tidal lagoon lake. Sea water enters the lake during spring tides but the freshwater exchange ensures relatively low salinities at the surface throughout the year. The lough is thermally stratified throughout the year with spring and autumn inversions and accompanying halo- and oxyclines. Surface Chlorophyll *a* ranged between 0.36 and 6.37 $\mu\text{g l}^{-1}$  (Mean annual = 1.74  $\mu\text{g l}^{-1}$ , n=12). Mean annual Total Phosphorous of surface waters was 7.3  $\mu\text{g l}^{-1}$  (2018, n=18) and Total Nitrogen is 0.436 $\text{mg l}^{-1}$  (2018, n=18). Monitoring of L. Furnace commenced in the early 1970s and automatic daily monitoring commenced in May 2008. This AWQMS (Fig. 2.9) has a Datasonde DX5 attached to a profiling winch, enabling temperature, conductivity, dissolved oxygen (% and mg/l), salinity, chlorophyll fluorescence and pH profiles of the lake to be taken. The winch profiles the lake 4 times a day (6am, noon, 6pm and midnight), taking four hours to run a profile and is parked for two hours. There is also a nephelometer and fluorometer positioned one meter below the water column. All parameters are measured every two minutes. A weather station is also fully functional on the AWQMS measuring wind direction, wind speed, radiation, relative humidity and barometric pressure.

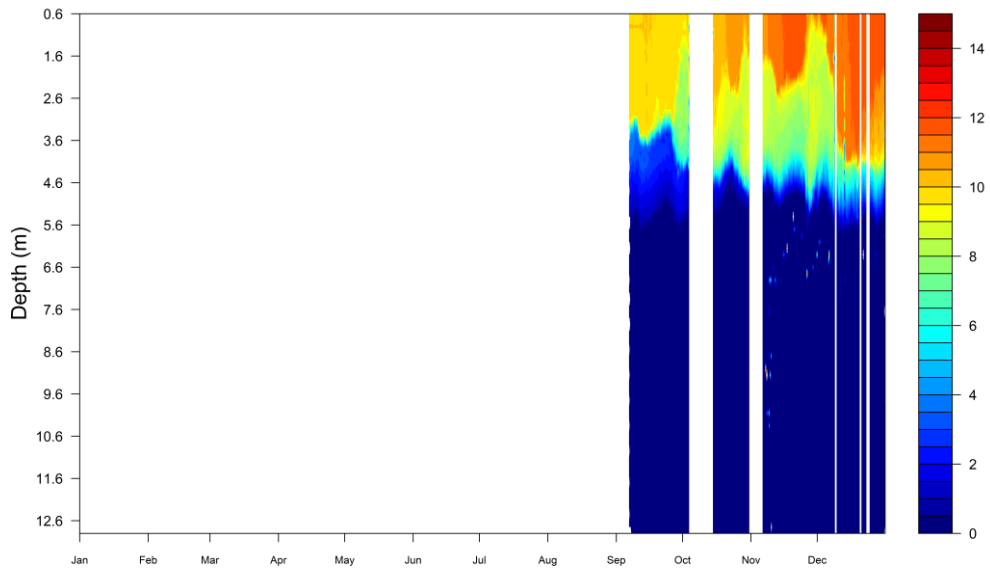
The AWQMS was not working for much of 2019, following faults with the winch in late 2018. We therefore only have data from September 2019 on. At this stage, the surface waters had warmed over the summer (Fig. 2.10), and then began to cool at the surface after October. As expected, the hypolimnion was hypoxic below 6 metres, for the portion of the year for which we have data (Fig. 2.11), The epilimnion became very shallow at the end of November, with saline water extending almost to the surface (Fig. 2.12). No discernible chl fluorescence was measured by the sonde in 2019. As the winch was only working for part of the year, the data from the string of HOBO temperature tidbits are also presented here to get a complete picture of stratification in 2019 (Fig. 2.13). Here, a consistent thermocline is apparent at ~6 metres throughout the year, with colder water in the epilimnion until May, and again after October. There was no indication of deep water renewal in June 2019, as was recorded in 2010, 2013, 2014, 2017 and 2018 (Fig. 2.14).



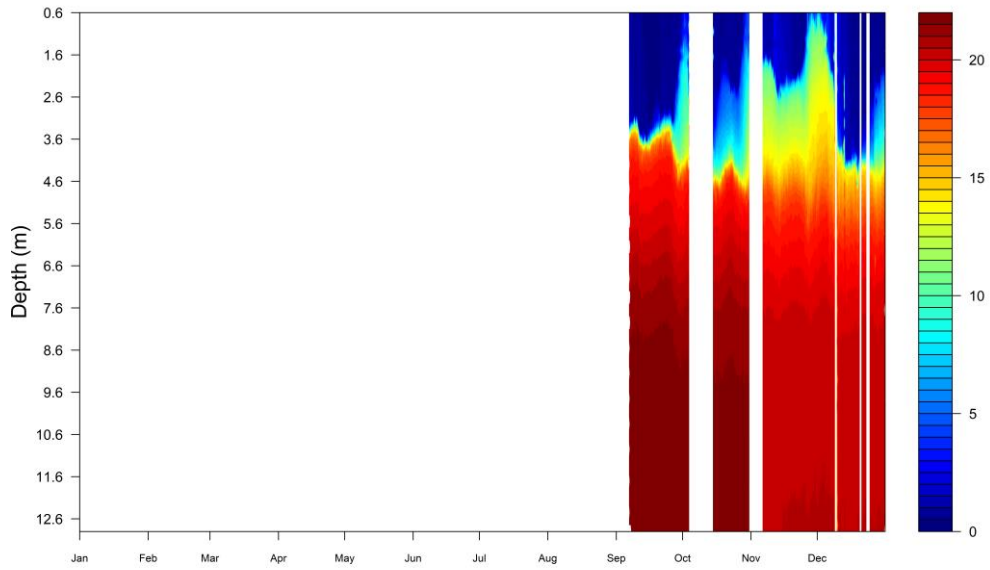
Figure 2-9: The Automatic Water Quality Monitoring Station (AWQMS) on L. Furnace (left) and the meteorological instruments attached (right).



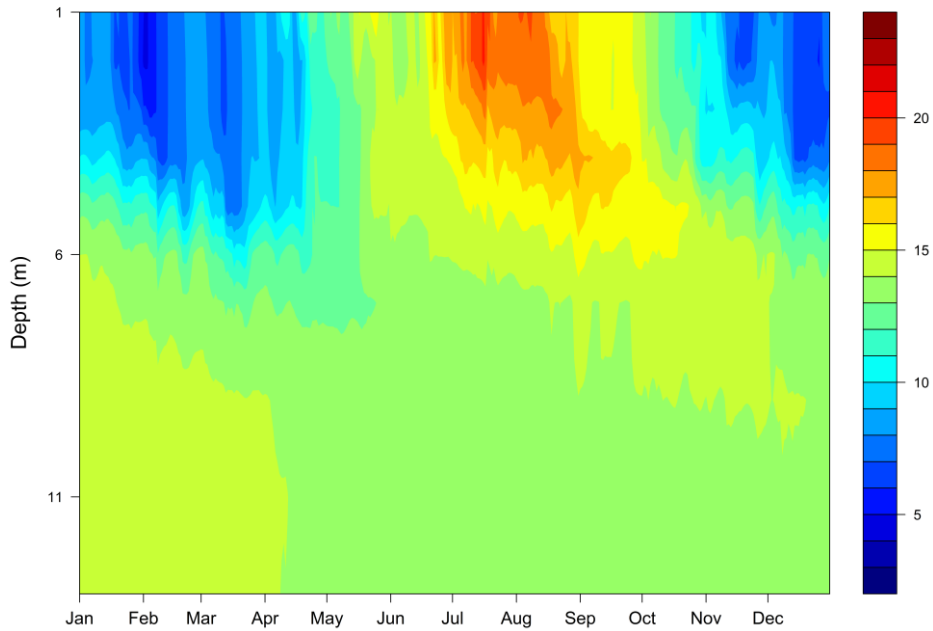
**Figure 2-10: Daily average water temperatures (°C) measured every metre at the deepest point in Lough Furnace in 2019. White indicates missing data.**



**Figure 2-11: Daily average dissolved oxygen (mg/l) measured every metre at the deepest point in Lough Furnace in 2019. White indicates missing data.**



**Figure 2-12: Daily average salinity (ppt) measured every metre at the deepest point in Lough Furnace in 2019. White indicates missing data.**



**Figure 2-13: Daily average water temperatures (°C) measured every metre at the deepest point in Lough Furnace in 2019. White indicates missing data. Data collected using Hobo tidbits.**

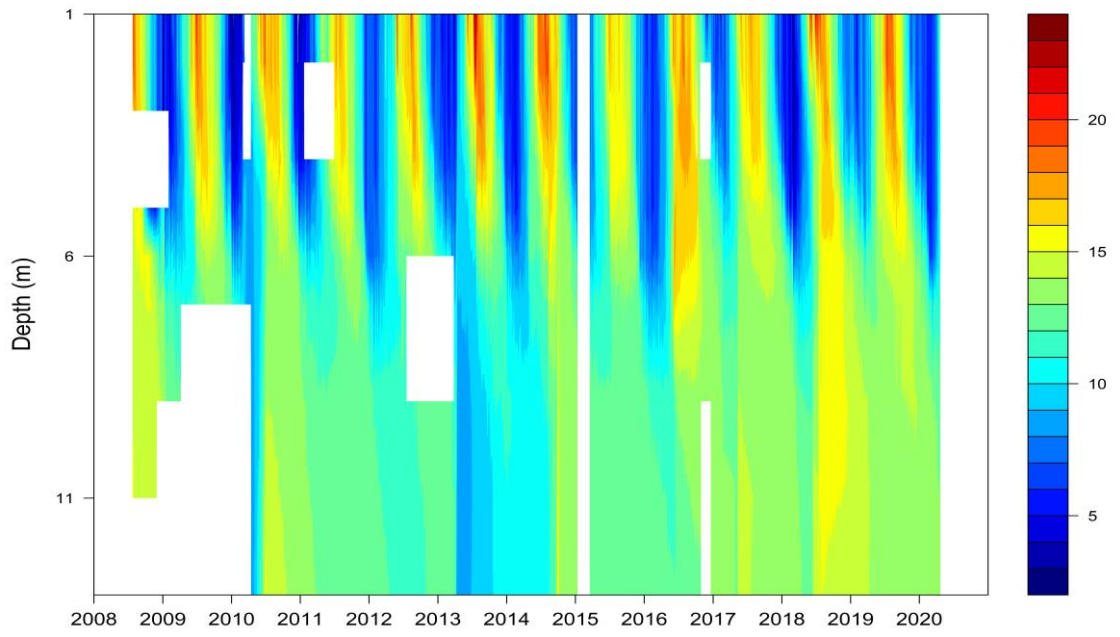


Figure 2-14: Daily average water temperature, Lough Furnace 2008-2019.

## 3 Salmonid Rearing

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### 3.1 Salmon Stocks 2018

#### 3.1.1 Ranching

The total release in 2019 of microtagged smolts of ranched Burrishoole grilse origin was 21,836 comprising 3 tag codes. Fish were released into Lough Furnace on May 2<sup>nd</sup>. Two tag groups (12,485) were released in the morning and one group (9,351) in the evening. Mean weights of smolt groups released into L. Furnace ranged from 70 to 75gm. Conditions at release were cool and overcast with light winds.

In addition to the core release groups an additional 7,838 smolts were released for an SFI experiment (see Section 3.4).

Tag code details are shown in Table 5.1.

### 3.2 Salmon Stocks 2019

An estimated 45,000 Burrishoole ranch eyed ova from five stripping dates were retained for ongrowing. Water temperatures ranged from 7.0°C at the commencement of first feeding in late March to 9.6°C on 29<sup>th</sup> April when the last group commenced first feeding. Growth and survival were good with an overall survival of 87% from first feeding to grading in September. Ranch salmon were mixed after grading in September to produce core medium and large grade release groups. Stock remaining in December 2019 was 22,737.

### 3.3 Salmon Stocks 2020 (Grilse ova laid down in 2019/'20)

An estimated 58.7% of all returns (609/1036), 58.2% (585/1004) of Burrishoole ranch grilse returns and 85.7% (12/14) of Burrishoole 2SW returns were processed between May and August. There were 12 ranched fish processed in the same period where the microtag was not detected. In addition, a further 5 ranched fish were processed from September onwards where no microtag was detected and 1 ranched fish which was identified from its microtag as a Delphi grilse.

Broodstock collection commenced on 16<sup>th</sup> August 2019 and salmon were transferred from the traps directly to the broodstock holding pond. Broodstock collection continued into December and in total 420 ranch adults (210 females, 210 males) were held during the stripping period (December 2019 – January 2020). A total 177 females and 179 males were stripped (total 356). Remaining surplus fish were culled on 9<sup>th</sup> January 2020.

In December, average water temperature was 6.5°C, ranging 5.6°C to 7.3°C. Salmon were examined over a six-week period (4<sup>th</sup> December to January 7<sup>th</sup> 2020), to recover ripe females for egg production.

An estimated 505,000 green ova were produced by 173 females. The average fecundity value was 2,922 ova per grilse female (n=84). A proportion of each family, from confirmed Burrishoole stock, was retained in the hatchery from each of the five stripping dates, totalling 52,256 eyed ova from 173 females and 176 males. Ova quality and survival was good. Broodstock condition was good throughout the holding period. Thirty ranch salmon broodstock were sampled in January 2020 and subsequently certified by the Marine Institute Fish Health Unit as disease free.

### 3.4 Experimental Salmon Stocks 2017–2019

The Institute are collaborators with UCC in a research programme funded by Science Foundation Ireland (SFI), 'Wild farmed interactions in a changing world: formulation of a predictive methodology to inform environmental best practice to secure long-term sustainability of global wild and farm fish populations'. The overall purpose of the work packages is to support studies designed to understand the genetic mechanisms (genetic architecture) underpinning the expression of critical life history traits in the wild associated with the fitness of the progeny of wild and farm salmon and the progeny of resident and anadromous brown trout. Experimental populations were produced in 2016/17 for a work package examining the relative performance of the juvenile progeny of Atlantic salmon from farm and wild genetic backgrounds, undertaken in the experimental controlled section of the Shrarevagh River and also under hatchery conditions.

A second experimental population was established in the 2017/18 brood season for the SFI research programme. Wild Burrishoole and farmed salmon of Fanad origin were used to produce pure bred and hybrid families. All broodstock used for egg production were certified disease free by the Marine Institute Fish Health Unit. Unfed fry and PIT tagged parr were released into the Shrarevagh River, above the trap, as detailed in Annual Report 2017/2018. A subset of the remaining fish from each of the progeny groups were ongrown to smolt stage and transferred to the MI marine site in May 2019.

Three groups of smolts, two reciprocal crosses (n=5,234) and one pure Fanad group (n=2,604) were fin clipped, freeze branded (O, T, X, H), coded wire tagged and released to Lough Furnace on May 1<sup>st</sup> 2019 (see also Table 5.1).

### 3.5 Aquaculture Research Salmon Stocks 2019–2020

The Institute are collaborating on two aquaculture research programmes that utilise the Newport research and fish rearing facilities. Further information on these programmes is outlined in sections 10.13 and 10.14.

In January 2019, ova were sourced from two hatcheries that produce salmon for the commercial aquaculture sector. 30,030 ova were sourced from StofnFiskur, Iceland, along with 40,000 ova from Mowi Ireland, Co. Donegal. All ova were derived from broodstock certified as disease free. These ova were on-grown at the flow-through fish rearing facility in Newport.

In September 2019, 3,031 Mowi parr were transferred to the NUIG research station in Carna, Co. Galway for use in the HYDROfish feed trial. In November 2019 8,962 S0 smolts were transferred to the Institute's marine site at Lehanagh Pool, Co. Galway for on-growing. Stock remaining in December 2019 was 40,093 comprising of 25,912 of Mowi Ireland origin and 14,181 of StofnFiskur origin.

## 4 Salmon Census Programme

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The salmon census and stock assessment programme was continued in 2019 with a full upstream and downstream census of migrating wild salmon. The data provides a valuable index of salmon survivals (freshwater and marine) and stock dynamics for the freshwater components of the stock.

### 4.1 Wild Salmon and Grilse

#### 4.1.1 Wild Salmon & Grilse

A total of **443** wild grilse were recorded moving upstream through the permanent traps during the season, no previously spawned grilse (from floy tag or pit tag returns) were recorded, (Table 4.1 and 4.2).

The total number of spring fish recorded for the year in the upstream traps was **14**.

The total wild grilse return to fresh water was **443** and **0** previously spawned grilse.

Water levels were generally low during the first half of July but heavy rain around the 17<sup>th</sup> July resulted in sufficient water for fish to run. On the following day, July 18, a total of 91 wild grilse and 169 reared grilse were recorded in the upstream traps. Heavy rain occurred again on Sunday 21<sup>st</sup> August resulting in flood conditions at the traps. Despite the high water levels few fish were recorded in the Mill Race trap. Weather in early sept was mixed with periods of rainfall and on Sept 10<sup>th</sup> an additional 30mm of rain was recorded

Three significant storm events were recorded in the winter period. Storm Lorenzo (October 3-4). Wind increased during the afternoon of Thursday Oct. 3 and started to increase from 6pm with the windiest period occurring from midnight to 7am on Friday 4<sup>th</sup>. With rain during the night and the wind, this resulted in lots of leaves which blocked screens at the traps. SLDT did not overflow but a blockage at the MRDT resulted in an overflow on the 4<sup>th</sup>. Both upstream traps were fine.

A rain and wind event occurred on the 9-10 November but there were no overflows at the traps. A further event occurred on the 8<sup>th</sup> December, where the Mill Race fish fence became blocked and overtopped. This allowed some ranched grilse to move upstream and downstream unrecorded.

#### 4.1.2 Fish in MRUT from pool 2019

As in recent years, ranched grilse have been recorded in the MRUT during October, November and December. A total of 239 RG was recorded in the MRUT in 2019 during this period compared to 8 for the same period in the SLUT.

The greater number of fish recorded in the MRUT is likely a result of reared fish homing to the water intakes and holding up in the pools on the Mill Race. This is not a new phenomenon and generally fish would move upstream from the pools during October and November. However, it is worth noting that despite high water levels during this period the majority of fish moved later in December. A total of 201 ranch fish were recorded in Dec 2019 compared to 11 in 2018. The number of wild fish was also higher at 25 compared to 2 the previous year. Generally, it would be expected that wild fish would be already on the spawning grounds at this stage, genetic samples were taken from these investigate if there is anything of note with these fish. The wild fish consisted of both males and females with slightly more males. All these fish were released upstream. Also note that although wild fish were recorded in the downstream traps during November and December the majority of these fish were floy tagged in the downstream trap and released downstream. The wild fish recorded in the upstream traps during December did not have floy tags therefore were not fish that had been previously released downstream during November and December.

#### 4.1.3 Farm Escapees

There were no farm escapes recorded in 2019.

#### 4.1.4 Pink Salmon

There were no Pink Salmon (*Oncorhynchus gorbuscha*) recorded in 2019.

**Table 4-1: Monthly wild grilse totals for the Salmon Leap and Mill Race traps, 2019.**

	Mill Race	Salmon Leap	Total	%
May	0	0	0	0
June	0	79	79	17.8
July	18	247	265	59.8
August	0	49	49	11.1
September	1	18	19	4.3
October	1	3	4	0.9
November	2	0	2	0.5
December	25	0	25	5.6
	47	396	443	100

**Table 4-2: Monthly proportions (%) of the wild grilse run timing 2008-2019.**

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
May	0.0	0.0	0.0	0.2	0.1	0.7	0.4	0.0	0.9	0.6	0.3	0.0
June	9.1	4.6	0.9	16.8	29.8	13.2	11.8	1.9	37.7	40.8	12.6	17.8
July	17.9	78.7	75.8	43.4	57.1	45.0	61.6	86.6	29.1	43.7	5.4	59.8
August	62.6	15.5	15.5	29.8	10.1	26.6	19.2	6.1	9.2	12.7	76.3	11.1
September	7.3	0.9	6.7	8.4	2.4	10.3	0.7	2.5	6.6	0.6	3.2	4.3
October	2.9	0.2	1.0	0.6	0.4	2.6	4.8	0.8	12.5	0.9	0.6	0.9
November	0.2	0.2	0.1	0.8	0.0	1.6	1.1	2.0	3.8	0.8	0.9	0.5
December	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.2	0.0	0.6	5.6

**Table 4-3: Wild salmon, grilse and previously spawned grilse (PSGs identified from floy tag recoveries) totals in the upstream traps, 1970-2019; 5 year means and annual data from 2000. \* years where the grilse count was raised to account for loss in the traps.**

Year	Total Salmon	Total Grilse	Previously Spawned Grilse
1970-'74	14	1145	
1975-'79	36	703	
1980-'84	35	449	
1985-'89	22	492	
1990-'94	16	421	
1995-'99	12	509	
2000-'04	12	542	
2005-'09	22	642	16
2010-'14	27	572	11
2000	6	568	
2001	6	368	
2002	2	648	
2003	18	544	
2004	28	580	
2005	9	532	
2006*	31	530	
2007*	12	1049	
2008	23	548	21
2009	37	549	10
2010	17	686	17
2011	50	523	7
2012	18	671	6
2013	23	710	15
2014	26	271	8
2015	11	635	4
2016	16	530	2
2017	9	529	3
2018	19	317	1
2019	14	443	0

## 4.2 Net marked fish in upstream traps

In 2007, the Irish Government introduced a cessation on drift netting in Irish coastal waters. The overall incidence of net marks recorded since the cessation in 2007 remains low.

The upstream migration of salmon during 2019 commenced in June, however no net marks were recorded on either wild or ranched salmon in that month. The main migration occurred during July and net marks were recorded on 1.6% of the wild fish and 5% of the ranched in July.

Overall the incidence of net marks for the season on wild fish was 0.9% and on ranched 2.2%.

**Table 4-4: Percentage occurrence of net marks on wild and reared salmon, 2019.**

	Wild Grilse %	n for wild/month	Reared Grilse %	n for reared/month
May	0	0	0	0
June	0	75	0	61
July	1.6	254	5.0	403
August	0	49	1.0	202
September	0	19	0	86
October	0	5	0	23
November	0	2	0	27
December	0	23	0	204
Total	0.94	427	2.19	1006

### 4.3 Wild Spawning Stock

The spawning stock (escapement) represents the number of fish available for spawning. It is calculated by subtracting rod caught fish and downstream-displaced fish as well as losses due to poaching, disease and predation, which have been estimated at 5% for wild fish and 10% for reared fish not displaced downstream.

In both 2006 & 2007, an additional number of fish, reared and wild, escaped upstream undetected (see previous reports). It is likely that the wild grilse count for those years were minimum figures and this was taken into account for all calculations based on the 2006 & 2007 spawning escapements.

In 2018, it was noted that more reared grilse were recorded in the downstream traps in the autumn than in the upstream traps in the summer. Many of these fish in the DS traps had no floy tag or tag scar. It is likely that these fish ascended around the Mill Race fish fence in high floods in September and, most likely, in October. It is unlikely that many wild fish ran undetected as their behaviour is different to that of the ranched fish. The reared fish tend to hangout in the Mill Race pool below the fish fence as part of their homing behaviour. The reared fish figures have been amended to account for this. A new fish fence was installed in 2019 along the walkways of the Mill Race pool to try to minimise this problem.

In 2019 a total of 117 ranched fish were released upstream and by December 2019 117 were recorded in the downstream traps. However, an additional 22 ranched fish were recorded in the downstream traps during 2020. It is likely that some ranched fish escaped upstream unrecorded when the fish fence was over-topped in December. (see section 4.1.1).



**4.3.1 Spawning escapement and stock**

The total spawning stock in 2019 consisted of 424 wild fish and an estimated 59 reared fish (Table 4.5). The reared component was derived from 117 reared fish tagged and released upstream and an additional estimate of 59 fish to account for an unintentional escapement around the Mill Race fish fence.

Table 4.6 gives the annual total spawning escapement, the wild escapement and the reared fish component. The spawning escapement of wild fish in 2007 was the highest observed over the last two decades. Particularly poor wild escapement was recorded in the 1990s, in 2001, 2014 and 2018.

**4.3.2 Wild salmon broodstock stripped December 2019**

No wild fish were taken for broodstock from the catchment in 2019.

Ten adult ranched fish were released with radio transmitters for a spawning behavior study in the Shrarevagh River, above the fish trap. Some or all of these may have spawned naturally.

**Table 4-5: Spawning stock of salmon and grilse, 2019.**

	<b>Wild grilse (1SW) &amp; previously spawned grilse</b>	<b>Wild Salmon (2SW)</b>	<b>Ranched fish released upstream</b>
<b>Counted in trap</b>	443	14	=117 + 59*
<b>Rod Feeagh</b>	0	0	0
<b>Culled</b>	0	0	0
<b>Broodstock UT</b>	0	0	0
<b>Broodstock DT</b>	0	0	115
<b>Broodstock Upper Catchment</b>	0	0	0
<b>Estimated morts.</b>	22	1	0
<b>Displacement</b>	10	0	2
<b>Spawning stock</b>	<b>411</b>	<b>13</b>	<b>59**</b>

\* = the difference between the upstream count and the downstream displacement, plus the additional estimated spawning fish (see \*\*)

\*\* = 22 kelts plus the estimated mortality from spawning (62% average from 2016 and 2017)

**4.4 Survival from Ova to Grilse**

The relevant brood year for the 2019 grilse was 2015 with ova hatched in 2016 and smolt migration in 2018 (Table 4.7).

As in previous years, it has been assumed for the purpose of estimating survival that ranched grilse spawned naturally. Specific data are not currently available on differential survival rates of wild and ranched stocks spawned in the wild, although new genetic data may facilitate this analysis in the future. All relevant calculations are based on parameters set out in the Ann. Rep. No. 19, 1974.

**Table 4-6: Spawning escapement, 1970-2019.**

	<b>Maximum spawning escapement</b>	<b>Wild fish component</b>	<b>Reared fish component</b>
1970-'74	1126	986	140
1975-'79	725	683	42
1980-'84	474	430	44
1985-'89	662	428	232
1990-'94	603	348	254
1995-'99	519	428	95
2000-'04	516	494	21
2005-'09	624	587	38
2010-'14	571	544	27
2005	503	472	31
2006	552	520	32
2007	1038	958	80
2008	512	495	17
2009	517	489	28
2010	652	617	38
2011	548	512	36
2012	668	640	28
2013	702	691	11
2014	284	260	24
2015	601	583	18*
2016	539	492	47
2017	530	478	52
2018	340	289	51*
2019	483	424	59*

\* estimated, see table 4.5.

**Table 4-7: Survivals from ova to smolt and smolt to grilse.**

Spawning escapement in 2015	601
No. of females*	300 -331
Ova deposition	1,202,000 -1,360,213
No. of smolts in traps 2018	6475
No. of smolts released	6227
Survival ova to smolt	0.54 - 0.48
No. returning grilse 2019	443
Survival smolt to grilse	7.11
Survival to grilse per grilse female	1.47 - 1.34

\* two estimates of the % females in the run using 50% and 55%

#### 4.5 Ova to Smolt and Smolt to Grilse Survival

The survival of ova to smolt recorded in 2019 was 0.54-0.48 from a spawning escapement of 601 adults in 2015 (Table 4.7).

The percentage return of grilse in 2019 from the 2018 smolt output was 7.1%, which was higher than 2018 at 6.5 and similar to 2017 at 7.4%.

The survival to grilse per grilse female was 1.47 - 1.34 (Tables 4.7- 4.8).

**Table 4-8: Percent survivals for ova to smolt and grilse per female grilse spawner; comparative data for 5-year averages from 1970-1989 and values for the individual brood years from 1990 onwards.**

<b>Brood year-class</b>	<b>% survival rates ova to smolt</b>	<b>survival rates to grilse per grilse female spawner</b>
1970-'74	0.48 - 0.62	1.4 - 1.7
1975-'79	0.63 - 0.73	1.5 - 1.7
1980-'84	0.61 - 0.69	1.7 - 1.9
1985-'89	0.44 - 0.45	1.4 - 1.5
1990	0.47 - 0.54	1.8 - 2.0
1991	0.47 - 0.53	1.8 - 2.0
1992	0.48 - 0.54	1.3 - 1.5
1993	0.39 - 0.45	1.5 - 1.6
1994	0.36 - 0.41	1.3 - 1.4
1995	0.83 - 0.93	1.9 - 2.1
1996	0.53 - 0.61	1.8 - 1.9
1997	0.52 - 0.59	1.4 - 1.5
1998	0.58 - 0.60	2.4 - 2.6
1999	0.79 - 0.70	1.8 - 2.0
2000	0.56 - 0.64	1.9 - 2.1
2001	1.30 - 1.10	2.9 - 2.6
2002	0.56 - 0.64	1.7 - 1.9
2003	0.68 - 0.76	3.7 - 4.1
2004	0.53 - 0.60	1.8 - 2.0
2005	0.69 - 0.61	2.0 - 2.2
2006	0.75 - 0.67	2.4 - 2.6
2007	0.34 - 0.30	0.9 - 1.0
2008	0.65 - 0.57	2.4 - 2.6
2009	0.75 - 0.66	2.7 - 2.5
2010	0.49 - 0.43	0.8 - 0.9
2011	0.66 - 0.74	2.3 - 2.1
2012	0.53 - 0.47	1.6 - 1.4
2013	0.52 - 0.46	1.5 - 1.4
2014	0.89 - 0.78	2.2 - 2.0
2015	0.54 - 0.48	1.5 - 1.3

## 4.6 Salmon Smolts

### 4.6.1 Wild Salmon Smolts

The main smolt run occurred during equally in April and May (44% in each month) and, due to a drought, 10% occurred in June (Table 4.9). The total for 2019 was 5,863 (Table 4.10). The number of smolts counted decreased from 7,362 in 2016 to 5,029 in 2017 but showed an increase in 2018 to 6,475.

Water conditions at the downstream traps during April 2019 were ideal for downstream migration with sufficient water flow for migration, smolts migrated in relatively small shoals and generally less than 200 fish were recorded during daily sampling sessions (Fig. 4.1). The small numbers of smolts per session also helped to reduce stress levels on fish during sampling for pit tags.

During the first week of May water levels continues to drop and the temperature remained below normal for the time of year. By May 20th water levels at the Salmon Leap were very low and as a result the main downstream migration was through the MRDT. The first significant rainfall occurred on the 24/25 May. This resulted in a sufficient flow at the SLDT to enable smolts to enter the trap, however, despite the increase in water flow there was no major increase in smolt numbers at either downstream trap.

**Table 4-9 : Number and proportion of wild salmon smolts counted monthly in 2019.**

Month	Salmon Leap Down Trap	Mill Race Down Trap	Total	%
March	2	0	2	0.0
April	2569	48	2617	44.6
May	2335	252	2587	44.1
June	176	425	601	10.3
July	1	54	55	0.9
August	0	0	0	0.0
September	0	1	1	0.0
<b>TOTAL</b>	<b>5083</b>	<b>780</b>	<b>5863</b>	<b>100</b>

**Table 4-10: Annual numbers of wild salmon smolts recorded in the downstream traps and the number released after sampling and mortalities have been removed.**

Year	1990- '94	1995- '99	2000- '04	2005- '09	2010- '14	2015- '19	2013	2014	2015	2016	2017	2018	2019
<b>Smolts Counted</b>	5618	7052	7490	7351	7195	6353	6357	8150	7034	7362	5029	6475	5863
<b>Smolts Released</b>		6967	7340	7138	6966	6136	5960	7957	6832	7170	4918	6227	5535

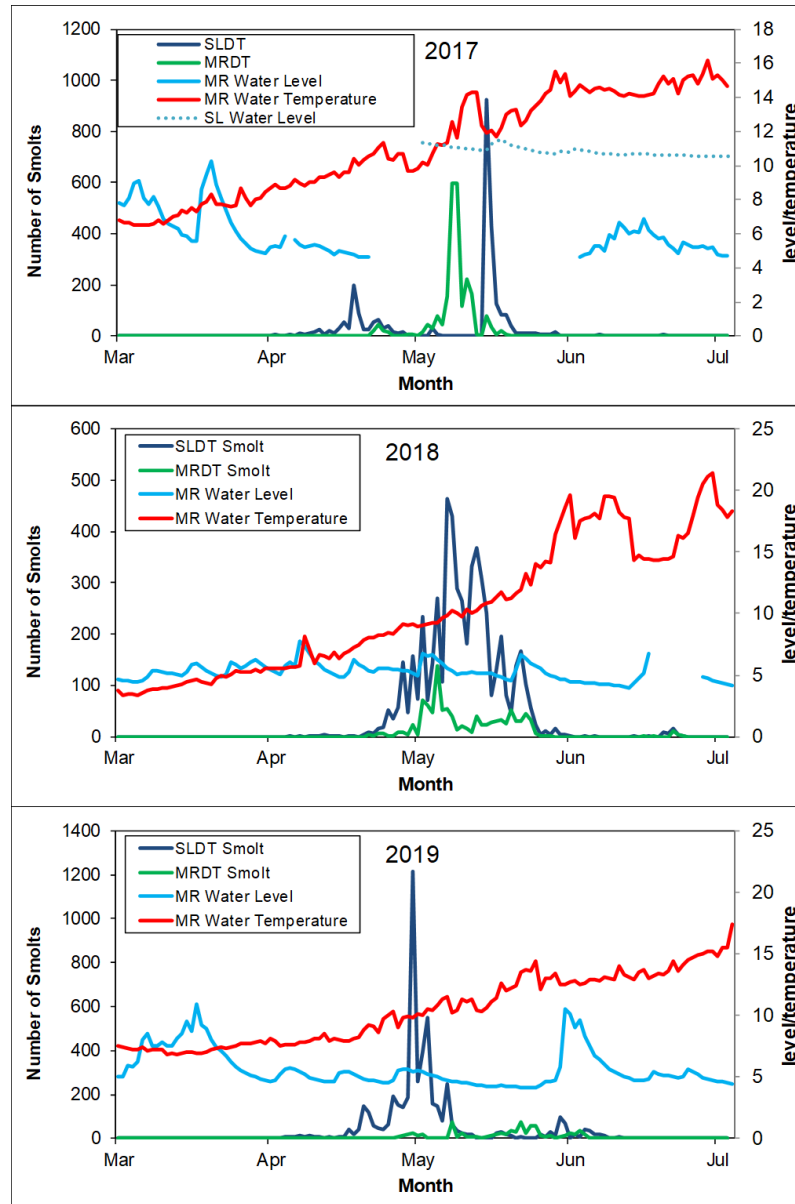


Figure 4-1: Timing of the 2017, 2018 and 2019 wild salmon smolt runs in the Salmon Leap and Mill Race traps with daily midnight MR water level (m x 10) and midnight temperature (°C). In 2017, the Salmon Leap water level has been inserted to cover the gap in the MR data.

**4.6.2 PIT Tag Recaptures**

In 2018, 230 wild salmon smolts with PIT tags were recorded in the downstream traps between January and August, of which 224 were released downstream. These fish were previously tagged as parr in the catchment as part of a Cullen Fellowship project. No wild salmon parr with PITs were recorded in the rest of the year.

Of the 224 wild smolts released with tags in 2018, seven were recovered as wild grilse in 2019, a recovery rate of 3.1%.

In 2019, 40 wild salmon smolts (or putative wild with origin unconfirmed) were recorded with PIT tags in the downstream traps, 35 were sampled and five were released on downstream.

### 4.6.3 Ranched Salmon Smolts

There were no ranch smolts released directly into the catchment above the traps in 2019.

In 2018, 30 PIT tagged salmon smolts of reared origin, released from the Rough River Trap, were recorded in the main downstream traps, of which 22 were released downstream. One was recovered in 2019 as grilse, a recovery rate of 4.5%.

In 2019, 71 PIT tagged experimental smolts from the Rough River were recovered in the downstream traps, of which nine were released on downstream making a total release of 14 smolts (5 wild & 9 RSS) with adipose fins and PIT tags.

## 4.7 Wild Salmon Kelts

### 4.7.1 Census

Kelts migrate downstream after spawning. A total of 137 wild salmon kelts were recorded in the downstream traps between December 2018 and May 2019 (Table 4.11).

Survival of wild fish to kelt was 47.4% and over 97.5% of these were recorded as being in good condition (Table 4.12).

**Table 4-11: Numbers of wild salmon kelts counted in 2019.**

Month	SLDT	MRDT	Total
December '18	3	1	4
January '19	13	1	14
February	57	4	61
March	50	2	52
April	6	0	6
May	0	0	0
June	0	0	0
	<b>129</b>	<b>8</b>	<b>137</b>

### 4.7.2 Tagging of wild kelts

Following the cessation of drift netting during 2007 and the corresponding increase in the wild spawning stock at Burrishoole, annual tagging of the wild kelts recommenced during 2008.

A total of 124 floy tagged kelts were released from the downstream traps in spring 2019. 69 of these also had PIT tags inserted.

Subsequently during the summer of 2019, 0 previously spawned grilse were recorded. The percentage recovery of PSGs decreased from 1.6% in 2017 to 0.6% in 2018 and 0% in 2019 (Table 4.12).

**Table 4-12: Comparison of annual salmon kelt runs. A = % healthy kelts in kelt run, B = % males in kelt run, C = % lightly marked, D = % survival from wild spawning escapement, E = % recapture of previously spawned grilse in first year.**

Year	Kelt Quality Grade				
	A	B	C	D	E
1975-79	75	18	14	30	8.1
1980-84	82	18	6.7	48.7	9.7
1985-89	88	21	5.1	43.2	8.4
1990-94	92	31	4.8	61.4	6.6
1995	74	28	18.3	59.9	2.3
1996	88.1	27	10.1	53.1	4.0
1997	93.7	33.5	6.3	58.9	*
1998	94.3	30.8	5.7	67.6	*
1999	90.6	38.5	4.5	76	*
2000	92.5	44.5	5.5	62.1	*
2001	97	38.5	2.8	72.5	*
2002	91.3	40.9	7.8	49.6	*
2003	95.5	37	3.5	42.3	*
2004	89.9	36.3	9	53.2	*
2005	83.3	35.5	15.3	57.6	*
2006	82.2	36.1	16	54.4	*
2007	95	37.3	4.1	**	*
2008	93.2	26.9	6.8	**	5.6
2009	96.1	20.8	3.3	43.8	4.9
2010	98.1	13.5	1.3	34.2	10.1
2011	95.9	22.7	0.5	35.5	4.1
2012	96.7	20.8	2.8	54.7	3.6
2013	95.1	29.6	4.6	53.9	4.5
2014	91.3	40.7	6.7	51.4	2.4
2015	88.6	27.8	9.8	61.2	2.7
2016	93.8	18.8	6.3	26.6***	1.4
2017	96.1	20	3.4	42.1	1.6
2018	92.9	28.6	7.1	37.2	0.6
2019	97.5	32.3	2.5	47.4	0

\* no kelt tagging; \*\* see section 4.7 (2007 report)

\*\*\* Data compromised by Storm Desmond (see 2016 Report)

## 5 Reared Salmon Census Programme

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A programme of rearing and releasing tagged salmon has been carried out in Burrishoole since the early 1960s. The stock was based originally on donor wild salmon from the Burrishoole system and the stock has been closed since using returning tagged fish as broodstock. Additional experimental groups are sometimes released and these are freeze branded and differentially tagged so as to distinguish them from the core ranched stock and avoid including them in the ranched broodstock. The ranched stock facilitates data collection and comparison with the wild stock without putting undue stress or mortality on the wild stock – in this report the components of the ranched stock are known as reared grilse (1SW) and reared 2SW salmon.

### 5.1 Coastal Returns

Details of coastal returns of Burrishoole fish are available in the Marine Institute 'National Report for Ireland - The 2019 Salmon Season' report.

### 5.2 Return rate of reared and wild grilse

A total of 1,133 nose-cores were recovered from reared fish returning to Burrishoole in 2019 consisting of 13 different microtag codes. Of these fish, 17 were identified as multi sea winter fish and 1,125 as one sea winter (grilse) and 17 had no tags.

The overall percentage return for reared grilse returning in 2019 was 3.3% which was significantly lower than the average of 5.6% recorded in 2018.

The percentage return of wild grilse in 2019 from the 2018 smolt output was 7.1%, an increase from 6.5% the previous year.

### 5.3 Recapture of Reared 2SW Fish

The total number of microtagged 2SW reared fish recorded returning to Burrishoole during 2019 was 14, comprising of 6 core release groups. The longest fish was 76.5 cm and the heaviest 5.2 kg.

### 5.4 Smolt Releases 2019

A total of 21,836 core ranched smolts were released from Burrishoole during 2019. They consisted of three individual microtag coded groups. Two of the groups were released into Lough Furnace, as a morning release and one group was released into Lough Furnace as an evening release.

In addition to the core release groups an additional 7,838 smolts were released for an SFI experiment. They were released as three separate groups and were freeze branded (O, T, X, H) prior to release. These wild/farm hybrid (F1) smolts were released in May 2015. Fish were cold branded to be easily identifiable upon their return as adults to the main traps. The objective is to collect gametes from the returned adults and produce second-generation hybrids (F2 and backcrosses). Second-generation hybrids are extremely valuable to examine potential post-zygotic disturbances in early developmental processes, as the breakdown of co-adapted sets of alleles following recombination of parental chromosomes is expected to lead to severe defects.

For additional information on the rearing, see section 3.1.1.

**Table 5-1: Details of microtag codes and smolt release groups 2019.**

Group ID	Tag Code	Mean Weight	Mean Length	No. Released	Date released	Comment
Core	47/08/28	72.2	18.6	9,343	02/05/2019	Core ranched
Core	47/08/29	72.7	18.7	9,351	02/05/2019	Core ranched
Core	47/06/83	72.5	17.5	3,142	02/05/2019	Core ranched
Experimental	47/06/84	83.7	19.5	1,255	01/05/2019	SFI Reciprocal cross: X Brand
Experimental	47/06/88	88.0	19.6	3,979	01/05/2019	SFI Reciprocal cross: H Brand
Experimental	47/06/89	113.7	21.5	2,604	01/05/2019	SFI Pure Fanad: O & T Brand

## 5.5 Reared kelts

Reared fish often move downstream throughout the late summer and autumn and these are collected for broodstock. A general cut-off date of the 1<sup>st</sup> December is used to separate these pre-spawned migrants and post-spawned kelts. However, some of the fish migrating downstream in December might not actually have spawned and might end up in the broodstock.

In 2017, 108 were released upstream during the summer. By the end of November 2017 a total of 53 ranched fish were recaptured in the downstream traps and transferred to the broodstock pond. In 2018, an additional 20 fish were recaptured in the downstream traps. Therefore, the total recapture from the 108 released upstream was 73 fish (67.6%).

In 2018, 143 were released upstream during the summer. However, it was noted that the number of ranched fish displaced downstream prior to the spawning season (179) was greater than the number of fish released upstream (143). In 2019, an additional 15 fish were recaptured in the downstream traps (See Chapter 4.3 for additional information).

In 2019, 117 were released upstream during the summer. By the end of 2019 a total of 117 ranched fish, 115 recorded as ranched grilse and 2 recorded as ranched kelts were recorded. However, an additional 22 ranched salmon were recorded as kelts in 2020.

## 6 Wild Sea Trout Census Programme

### 6.1 Upstream Movements: Timing and Numbers.

A total of 18 wild silvered sea trout and a further 75 non-silvered trout migrated upstream through the traps in 2019. Of the silvered trout, 4 were adults and 14 (82%) were finnock. The numbers are compared with other years in Table 6.1. Of the total run of migratory (silvered and unsilvered) trout (93), 80% were unsilvered. For the purposes of this report, the unsilvered trout are not included with the sea trout. Table 6.1 shows that the numbers of sea trout have not recovered in the Burrishoole system and have shown a ten-fold drop since the 1970s.

The timing of the sea trout run in 2019, and in previous years, expressed in monthly percentages, is given in Table 6.2. The highest proportion of sea trout, both finnock and adults, moved upstream in July (44.4%) and August (38.9%). The unsilvered trout moved upstream from April through to December, with the highest proportion in July, August, and October.

**Table 6-1: Annual runs of sea trout recorded in the traps.**

Year	Mill Race	Salmon Leap	Total	Amended Total
1970-74	1365	762	2127	
1975-79	829	1775	2604	
1980-84	458	780	1238	1719 *
1985-89	386	590	978	
1990-94	134	72	206	
1995-99	86	91	177	
2000-04	32	64	97	
2005-09	21	44	65	
2005	5	10	15	
2006	16	22	38	
2007	35	59	94	
2008	4	36	40	
2009	45	93	138	
2010	10	62	72	
2011	15	53	68	
2012	19	120	139	
2013	20	50	70	
2014	16	126	142	
2015	31	28	59	
2016	8	73	81	
2017	1	9	10	
2018	5	16	21	
2019	2	16	18	

\* See Table 34, Ann. Rep. XXX (1985); p. 43.

**Table 6-2: Timing of the Burrishoole (a) silvered sea trout run and (b) unsilvered trout run (in monthly percentages). (n = no. of trout).**

*(a) Silvered Trout*

	1970- '79	1980- '84	1985- '89	1990- '94	1995- '99	2000- '04 (483)	2005- '09 (325)	2010- '14 (491)	2015 (59)	2016 (81)	2017 (10)	2018 (21)	2019 (18)
May	-	0.2	0.5	0.1	3.1	2.0	1.3	3.2	0.0	6.2	0.0	0.0	0.0
June	13.1	24.6	9.4	8.4	8.6	16.7	9.0	6.1	6.3	21.0	20.0	9.5	16.7
July	54.4	44.9	62.2	55.0	42.4	37.5	32.5	54.0	75.0	58.0	60.0	4.8	44.4
Aug	15.8	10.3	18.4	16.5	19.3	26.4	38.1	22.3	18.8	12.3	10.0	76.2	38.9
Sept	7.6	14.8	3.7	8.5	9.8	5.7	13.6	7.8	0.0	1.2	10.0	4.8	0.0
Oct	6.4	3.5	4.1	7.9	12.2	10.2	4.7	4.9	0.0	1.2	0.0	4.8	0.0
Nov	2.4	1.5	1.5	2.9	4.3	1.5	0.7	1.6	0.0	0.0	0.0	0.0	0.0
Dec	0.3	0.2	0.2	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*(b) Unsilvered Trout*

	2005- '09 (408)	2010 (104)	2011 (87)	2012 (47)	2013 (101)	2014 (91)	2015 (79)	2016 (95)	2017 (53)	2018 (64)	2019 (75)
April	1.4	0.0	3.4	0	1.0	3.3	1.3	0	0.0	4.7	1.3
May	7.2	1.0	5.7	0	3.9	9.9	3.8	29.79	0.0	6.3	10.7
June	12.4	0.0	3.4	21.7	6.9	12.1	2.5	25.53	11.3	17.2	10.7
July	18.3	44.2	12.6	17.4	9.9	30.8	34.2	14.89	37.7	3.1	21.3
Aug	20.5	16.3	14.9	13.0	34.7	4.4	20.3	12.77	9.4	26.6	14.7
Sept	9.6	17.3	11.5	13.0	9.9	3.3	7.6	9.574	15.1	14.1	9.3
Oct	15.7	7.7	11.5	19.6	24.8	25.3	12.7	2.128	11.3	18.8	20.0
Nov	10.2	11.5	36.8	6.5	5.0	6.6	13.9	4.255	7.5	4.7	6.7
Dec	4.8	1.9	0.0	8.7	5.0	4.4	3.8	1.064	7.5	4.7	5.3

## 6.2 Tag Recaptures in Upstream Migration

In total, 10 trout were detected with PIT tags in 2019. Of these, 5 were identified as brown trout, one as a silvered finnock (from a 1+ autumn trout tagged in 2017) and 4 were detected on the main antenna in the Denil fish ladder but were not subsequently detected in the upstream trap. The fate of these 4 is unknown as they were not picked up on the handheld detectors in the upstream trap.

TSU genetics samples were collected from 87 trout, not including one previously collected for the recaptured fish.

## 6.3 Spawning Escapement

With the continuation of the catch and release bye-law into the 2019 fishing season, no sea trout were reported killed by anglers on L. Feeagh in 2019. Using the upstream fish counts through the traps, the total maximum spawning escapement of migratory trout to the L. Feeagh catchment was 93, of which 75 were non-silvered sea trout.

**Table 6-3: Annual spawning escapement of sea trout into freshwater, 1970-2019.**

	1970	1980	1985	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
	'79	'84	'89	'94	'99	'04	'09	'14					
Max.													
Escap.	2090	1146	906	231	289	156	146	184	138	176	63	85	93
Revised	1622												

#### 6.4 Downstream Movements, Sea Trout Smolts

The 2019 smolt run amounted to 243 smolts, of which 219 were released downstream (Table 6.4). Few smolts were recorded from January to March. The main migration occurred in May (67.1%), was delayed by relatively low water temperature in March and April and was strongly regulated by both water level and water temperature (Fig. 6.1). The 2019 smolt count was the lowest smolt count since 2010 (Table 6.5).

A total of 231 wild trout smolts were measured in 2019. Length measurements were taken to facilitate an estimated age breakdown of the smolt run. The estimated statistics for the 2019 smolts were a mean length of 19.3 cm and a range from 10.1 cm to 26.3 cm and the length frequency is presented in Figure 6.2 compared with that of 2017 and 2018. This gave an estimated age of 88.3% 2-year-old and 11.7% 3-year-olds.

#### 6.5 Tagging and Recaptures in Spring Downstream Migration

In 2019, no wild sea trout smolts were PIT tagged in the downstream traps. 49 trout that had been previously tagged in the catchment were recorded and/or sampled in the downstream traps in 2019. Eight of these were fish originating from the ERC project in the Rough River.

18 were recorded as Brown trout (5 were parr in the spring, 1 was a finnock kelt and 12 were parr in the autumn).

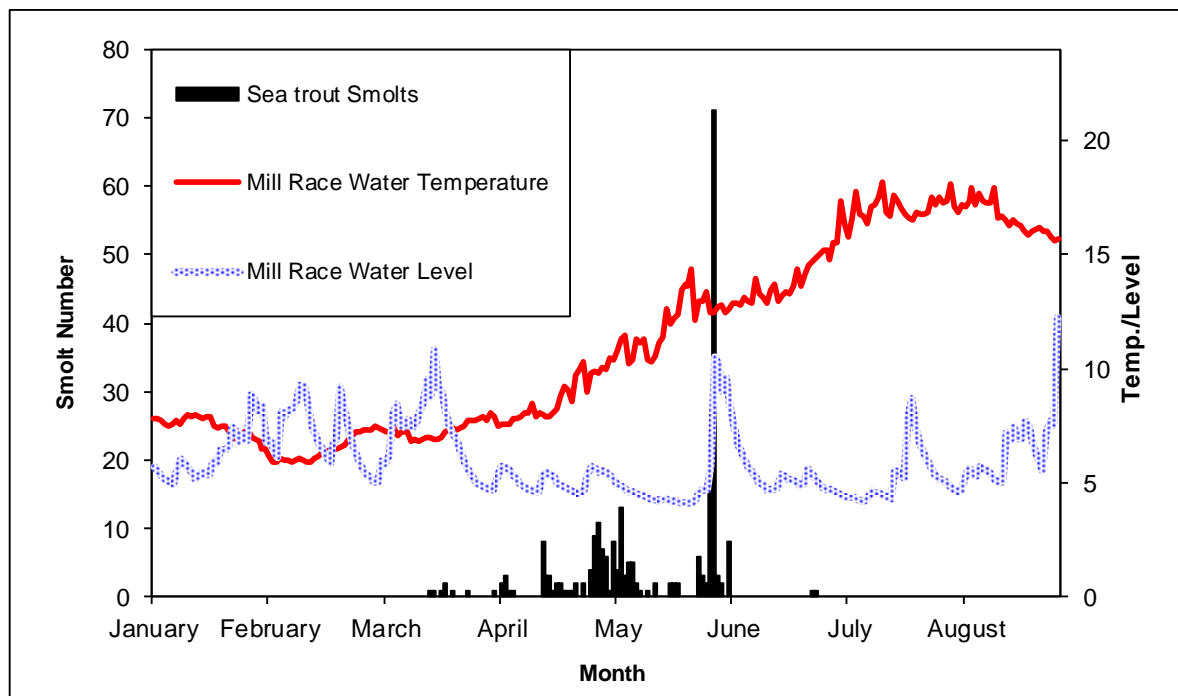
21 were recorded as wild sea trout smolts

10 were recorded on the main antenna but not located in the trap, 9 of these were likely smolts and one was a parr.

TSU genetics samples were collected from 819 trout moving downstream in 2019. Of these, 221 were wild sea trout smolts, 165 were brown trout in the first half of the year and 422 were brown trout in the second half of the year.

**Table 6-4: Monthly numbers of Burrishoole sea trout smolts recorded through the traps.**

Month	Salmon Leap	Mill Race	Total	%
January	0	0	0	0.0
February	0	0	0	0.0
March	5	2	7	2.9
April	55	3	58	23.9
May	137	26	163	67.1
June	11	4	15	6.2
July	0	0	0	0.0
Total	208	35	243	
Number Released Downstream			219	



**Figure 6-1: Timing of the 2019 wild sea trout smolt migration with daily midnight water level (m x 10) and midnight temperature (°C - OTT).**

**Table 6-5: Annual sea trout smolt numbers in Burrishoole for 1970 to 2019.**

	1970-79	1980-84	1985-89	1990-94	1995-99	2000-04	2005-09	2010-'14	2015	2016	2017	2018	2019
Number of Smolt	4176	4038	4119	1531	1361	816	609	475	426	356	291	362	243
Number sacrificed				144	35	24	6	10	3	2	0	0	24

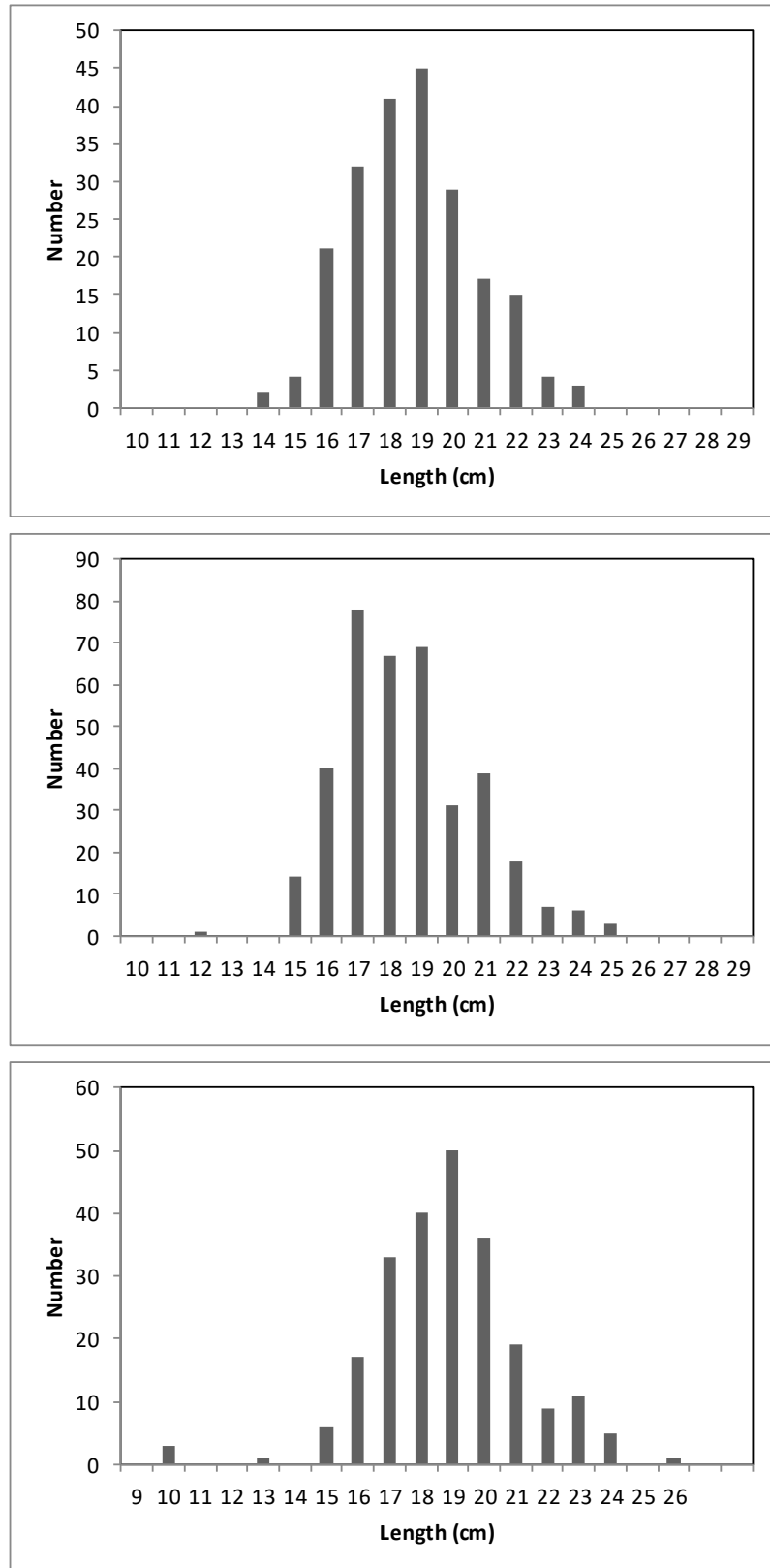


Figure 6-2: Length distributions for smolts in the Burrishoole system, top graph 2017 (n=213), middle graph 2018 (n=373) and bottom graph and 2019 (n=231). Note also change of x-axis scale from the 2018 report.

### 6.6 Autumn Migrating Smolts

These are juvenile trout (*Salmo trutta* L.) which generally move downstream through the traps from August to December. It is not clear whether these are true sea trout or part of the resident trout stock being displaced downstream. It is known through mark-recapture studies that a proportion of the 1+ autumn trout do return the following year as silvered finnock. These runs of trout would appear to becoming more prolonged with substantial numbers of un-silvered 0+ and 1+ trout continuing to migrate downstream in the early months of the year.

A total of 640 juvenile trout entered the downstream traps between July 2019 and May 2020 (Table 6.6). The percentage of 0+ trout that migrated over the period was 35.5% (Table 6.7).

### 6.7 Tagging and Recaptures in Autumn Downstream Migration

In 2019 autumn trout were not PIT tagged in the downstream traps.

TSU genetics samples were collected in 2019 (up to end of May 2020), see Section 6.5).

**Table 6-6: Numbers of migrating autumn juvenile trout in 2019, to the end of May 2020.**

Month	0+		1+		Total	
	Salmon Leap	Mill Race	Salmon Leap	Mill Race	Salmon Leap	Mill Race
July	3	0	8	2	11	2
August	16	3	12	5	28	8
September	45	1	108	12	153	13
October	40	4	97	5	137	9
November	34	6	42	2	76	8
December	30	0	38	6	68	6
January '20	18	0	47	1	65	1
February '20	8	3	8	1	16	4
March '20	10	0	8	0	18	0
April '20	4	1	8	0	12	1
May '20	0	1	2	1	2	2
Total	208	19	378	35	586	54
Overall Total	227		413		640	

**Table 6-7: Percentage of 0+ juvenile trout (<10cm) in the trapped autumn migrating trout.**

Year	% 0+	Year	% 0+
1982	50.0	2001	56.3
1983	N/A	2002	32.8
1984	55.8	2003	48.9
1985	30.3	2004	35.5
1986	16.1	2005	37.3
1987	35.3	2006	51.2
1988	60.9	2007	27.9
1989	37.2	2008	28.2
1990	35.2	2009	25.0
1991	26.0	2010	34.9
1992	38.2	2011	37.6
1993	27.6	2012	47.3
1994	16.8	2013	36.1
1995	25.3	2014	36.6
1996	34.0	2015	27.2
1997	18.7	2016	46.4
1998	33.5	2017	37.0
1999	42.0	2018	31.2
2000	47.8	2019	35.5

## 6.8 Total Recruitment

The 0+ autumn trout will not be large enough to become sea trout smolts in the following spring. The remainder, predominantly 1+ year olds, could contribute to the overall recruitment of sea-run trout the following year. The exact proportion of 1+ autumn trout that become smolts in any given year is not known. It is only since 1982 that the proportion of 0+ trout amongst the autumn migration has been estimated. Thus the figures for total recruitment up to this time are over-estimated (Table 6.8).

From 1982, total recruitment was calculated by adding the number of sea trout smolts produced in any one year to the total of 1+ autumn trout the previous year (Table 6.9). The assumption is made that all the 1+ autumn trout will become sea trout smolts and that no 0+ trout from the two years previous will be recruited as smolts. The fate of 1+ unsilvered juveniles migrating down in January to May is unknown but seems unlikely these will contribute to the 2+ spring smolt migration.

**Table 6-8: Estimates of total migrant trout recruitment up to 1981.**

Year	Smolt Total	Autumn trout (preceding year)	Total Recruitment
1970-74	4450	2870	6746
1975-79	4314	3186	7489
1980	2337	2351	4688
1981	6710	2631	9341

**Table 6-9: Estimates of total migrant trout recruitment from 1982 to date.**

Year	Smolt Total	1+ Autumn trout (preceding year)	Total Recruitment
1982-84	3714	1203	4917
1985-89	3706	1063	4778
1990-94	1788	399	2187
1995-99	1361	498	1860
2000-04	816	578	1377
2005-09	610	449	1059
2010	213	267	480
2011	620	501	1121
2012	632	493	1125
2013	485	536	1021
2014	427	351	778
2015	426	481	907
2016	356	334	690
2017	291	365	656
2018	362	436	798
2019	243	636	879

## 6.9 Marine Survival

An estimate of sea trout survival to first return to freshwater can be more accurately calculated by the use of trap census data rather than rod catch returns of tagged or marked fish. Small numbers of stray fish are captured in other systems and it is not known whether these fish would have returned to their natal systems to spawn. Finnock are known to wander between river systems and are therefore not as reliable for assessing survival.

The pattern of marine survival found is similar whether the number of smolts is used or the combined total recruitment of smolts and autumn 1+ trout. The percentage of smolts that return as finnock (0+ sea age) in the same year historically ranged from 11.4% to 32.4% (Fig. 6.3). In 1988 it fell below the previous recorded minimum to 8.5% and in 1989 to a minimum of 1.5%. There has been a saw-tooth pattern of finnock return in the 1990's rising to 16.7% in 1999, 18.1% in 2009 and 17.5% in 2010 – the highest return rates since 1986. These increases were not, however, always sustained in subsequent years and there was a collapse in 2005 down to 1.5%. This was associated with the heaviest infestations of sea lice observed in the Burrishoole area since 1992. The return of smolt as finnock in 2011 was 5.8%, 13.8% in 2012, 11.0% in 2013 and 29.5% in 2014 – the highest recorded level since the mid-1970s. The return in 2019 was 6.4%.

The total survival of smolts to their first return to freshwater as finnock in the same year and one year old sea trout in the following year (always an over-estimate as a proportion of finnock re-entering freshwater in year 1 return as sea trout in year 2 (Mills *et al*, 1990)) also showed a drop in survival from 1987 to 1989 (Fig. 6.4).

Historically, the total survival to first return ranged from 19% to 66%. This collapsed to 1.8% in 1989 but rose to 12.1% in 1990. However, little further improvement was recorded in 1991 (12.8%). Marine survival fell to the second lowest level in 1992 but returned to 13.2% for the 1993 year class of smolts. There was a further increase in 1994 to 17.0% but a drop in 1995 to 8.4%. There were marginal improvements again in 1996 (12.8%) and 1997 (13.1%), a drop to 8.3% in the 1998 year class and a

marked improvement in the 1999 year class where marine survival was 20%, the highest recorded in 12 years and back within the pre-collapse historical range. Total survival increased for the 2009 cohort to the highest recorded level since 1988 of 23% and to 23.2% for the 2010 cohort. For the 2011 cohort of smolts, it was 10.2% and for the 2012 cohort it was 17.1%. In 2013 it was 14.4% and rose to 33.0% in 2014 but following the fall in finnock return in 2015 the total return in 2016 fell to half that of the previous year. The total return of 2018 smolts in 2019 was 6.4%.

NOTE: The data used in Chapter 6.6 have been updated in 2014 following a comprehensive data quality control project. None of the changes were significant and the main changes were in 2011 and 2012 following a reclassification of trout considered to be silvered and unsilvered.

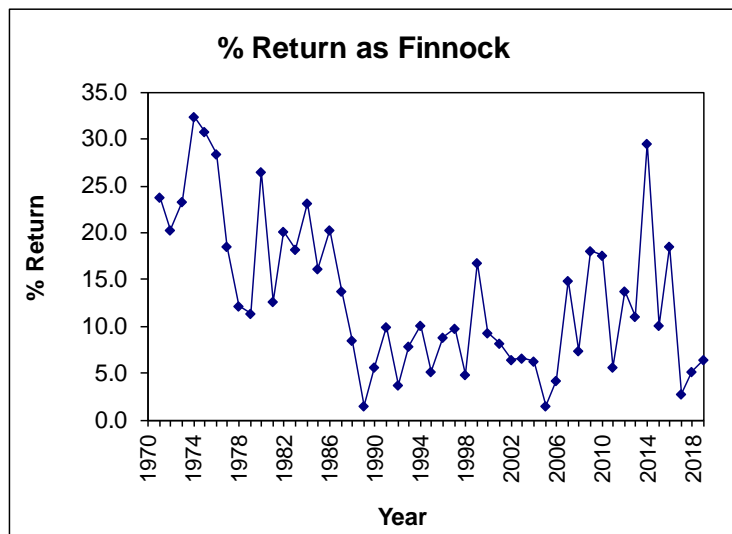


Figure 6-3: Annual percentage return of smolts returning as finnock to the Burrishoole system.

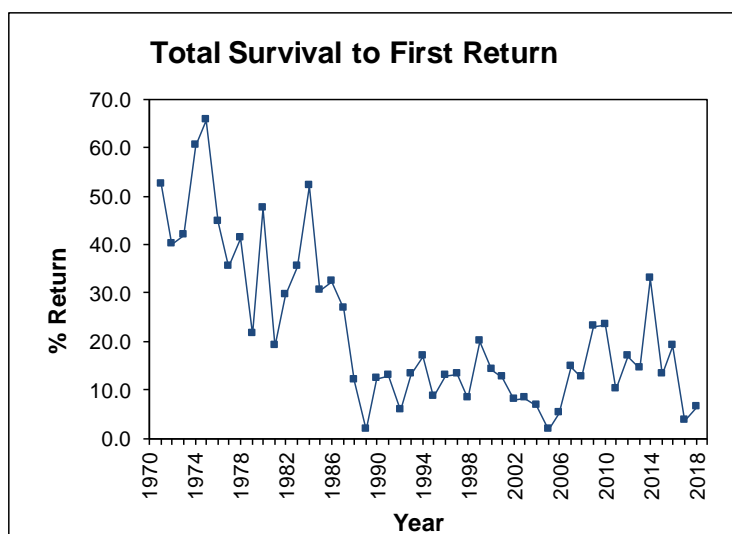


Figure 6-4: Annual marine survival of smolts to first return (as finnock and 1+ sea trout) to the Burrishoole system.

### 6.10 Sea Trout Kelts

Table 6.10 gives the numbers of sea trout and brown trout kelts, both spawned and immature, counted downstream in the winter of 2017 and spring of 2018.

The freshwater survival of kelts is given in Table 6.11. In some years, the number of kelts migrating downstream has exceeded the number of upstream migrants. This occurred in the early '80s when the screen allowed finnock to escape. This was rectified. More recently, the difficulty in separating small finnock and large smolts has led once again to a discrepancy as shown in Table 6.11. In addition to the size overlap, trout counted upstream as unsilvered migrants may be counted downstream as silvered kelts, and immature autumn downstream migrants may be misidentified as brown trout kelts, both causing additional difficulties in making survival estimates.

Since 1987, only one survival rate has been given for all sizes as it has been shown that a proportion (at least 33%) of the sea trout population may over-winter in freshwater. These fish do not spawn and continue to grow. There is also the additional complication of larger smolts and reduced sea growth mentioned above. Thus the comparisons of the proportion of fish in different year classes between the upstream migrants of one year and the downstream migrants of the next are invalidated.

In 2018/19, overall sea trout kelt survival was 47.6% and for finnock only (small sea trout) it was 36.8%. These survivals were relatively low compared to previous years. However, there was once again an unusually high unsilvered (BT) count downstream so some of these may account for additional sea trout. The total downstream count of sea trout and BT was 160, from an upstream count in 2018 of 64 fish. Of these 160, 34 were in June 2019 which was unusual, and of those 27 were less than 20cm, so were likely not kelts. It is not known what effect the unusual spring and summer conditions of 2017, 2018 and 2019 had on smolting, silvering and survival rates.

**Table 6-10: Timing and numbers of sea trout kelts for the 2018/2019 season.**

Month	Large ST	Small ST	BT	Total ST	Total Trout
October '18	0	0	12	0	12
November	0	0	18	0	18
December	0	0	30	0	30
January '19	1	0	10	1	11
February	0	2	18	2	20
March	1	1	31	2	33
April	0	2	3	2	5
May	1	2	4	3	7
June	0	0	34	0	34
<b>Total</b>	<b>3</b>	<b>7</b>	<b>160</b>	<b>10</b>	<b>170</b>

**Table 6-11: Annual survival rate to sea trout kelt, as % of the upstream escapement of the previous year.**

Year	Larger (> 30.0 cm)	Small (< 30.0 cm)	Year	Larger (> 30.0 cm)	Small (< 30.0 cm)
1976	79	66	1998	140.10%	" *
1977	63	45	1999	110.40%	" *
1978	50	66	2000	70.10%	"
1979	33	107*	2001	82.00%	" *
1980	50	82	2002	129.60%	" *
1981	44	345*	2003	66.10%	"
1982	53	203*	2004	120.50%	"*
1983	63	177*	2005	142.20%	"*
1984	74	210*	2006	110.50%	"
1985	70	98	2007	228.90%	"**
1986	66	72	2008	98.90%	"**
1987	58.70%	(combined)	2009	107.50%	"*
1988	65.50%	"	2010	59.40%	"
1989	68.70%	"	2011	88.90%	"*
1990	79.00%	" *	2012	117.65%	"*
1991	98.70%	" *	2013	161.33%	"*
1992	89.50%	" *	2014	87.14%	"
1993	96.70%	" *	2015	92.81%	"
1994	104.60%	" *	2016	115.30%	"*
1995	96.20%	" *	2017	48.20%	"
1996	127.70%	" *	2018	30.00%	"
1997	97.00%	" *	2019	47.60%	"

\* Years when the number of finnock kelts counted downstream exceeded the number counted upstream during the previous season.

## 7 Silver Eel Census Programme

### 7.1 Numbers

The total run amounted to 2227 eels. As in other years, the highest proportion of the total catch (83%) was made in the Salmon Leap trap.

There were three large flood events in the silver eel season in 2019, one in early June, one in early September and one in December (Figure 7.1).

In 2019, the timing of the run was 20% migrating in August, 18% in September and 25% in October (Table 7.1). 28% migrated in November mainly due to a peak in the first week of the month. Almost 70% of the run was completed by the end of October with the remainder in November. Figure 7.1 shows the daily counts of silver eels.

**Table 7-1: Timing and numbers of the 2019/'20 silver eel run.**

	Salmon Leap	Mill Race	Total	%
May	0	0	0	0.0
June	6	4	10	0.4
July	60	31	91	4.1
August	368	66	434	19.5
September	310	97	407	18.3
October	454	90	544	24.4
November	558	61	619	27.8
December	90	23	113	5.1
Jan. 2020	3	0	3	0.1
February	2	1	3	0.1
March	1	1	2	0.1
April	0	1	1	0.0
<b>Total</b>	<b>1852</b>	<b>375</b>	<b>2227</b>	

### 7.2 Size

Sampling of individual eels (n = 637) gave an average length of 43.3 cm (range: 30.4 – 92.1cm) and an average weight of 170g (Table 7.2) and the proportion of male eels was 42.1%. The length frequency is presented in Figure 7.2 along with those for 2017 and 2018 for comparison. The lack of eels above 46/47cm (now 44/46cm) was once again notable.

Counts of silver eel between the years 1971 (when records began) and 1982 averaged 4,400, fell to 2,200 between 1983 and 1989 and increased again to above 3,000 in the '90s (Fig. 7.3). There was an above average count in 1995, possibly contributed to by the exceptionally warm summer. The count in 2001 of 3875 eels was the second highest recorded since 1982. The average weight of the eels in the samples increased from 95 g in the early 1970s to 216 g in both the 1990s and the 2000s (Fig. 7.3). This has dropped again to an average of about 175g in the last three years.

In 2012, the majority of the eel run was sampled (n=3317; 99.5%). The run increased from 1969 in 2011 to 3335 in 2012 and the average weight decreased from 180 to 163.5g. The sex ratio changed from 24% to 45% over the past five years. Male eels have remained the same length over the past 15 years (36cm) whereas the females have changed from 53cm (1997-2005) to 50cm (2008-2012). The silver eel biometric data have been published in Poole et al. (2018).

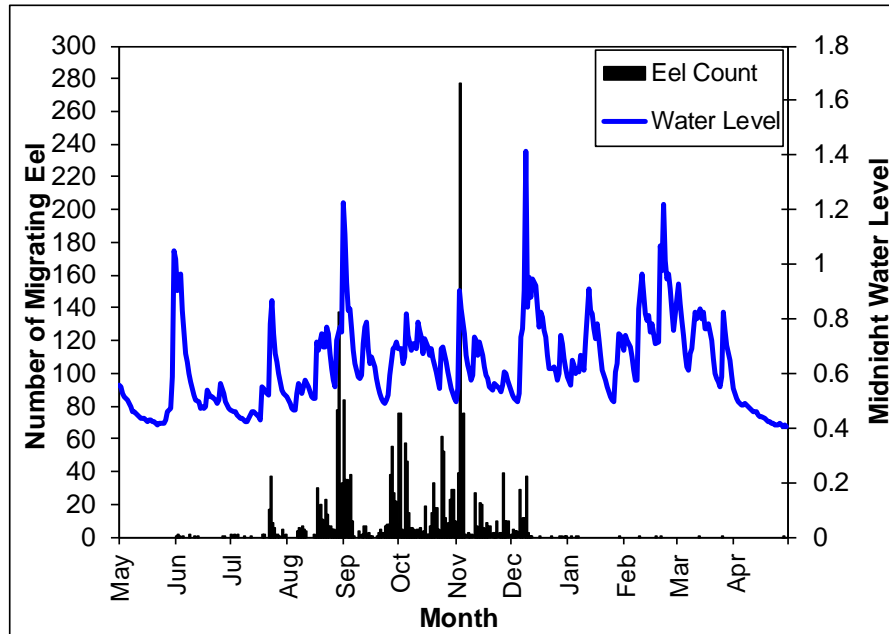


Figure 7-1: Daily counts of downstream migrating silver eel and mid-night water levels (m), May 2019 to April 2020.

Table 7-2: Comparative data for the silver eel runs since 1971.

Years	Number Sampled	Mean. Weight (gm)
1971 - '75	4465	84
1976 - '80	4023	115
1981 - '85	2678	171
1986 - '90	11658	196
1991 - '95	3441	227
1996 - '00	3958	212
2001 - '05	3201	215
2006	493	225
2007	571	201
2008	796	234
2009	220	209
2010	982	192
2011	1835	180
2012	3315	163
2013	1301	157
2014	650	196
2015	366	192
2016	554	177
2017	481	177
2018	573	178
2019	637	170

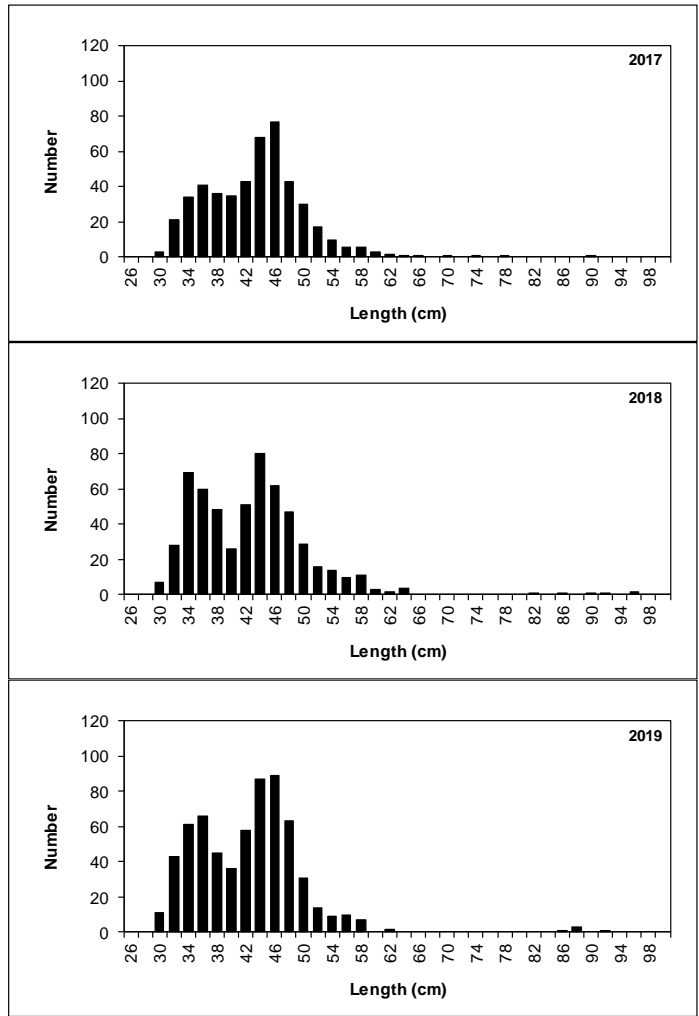


Figure 7-2: Length frequency of sub-samples of silver eels trapped in the downstream traps, 2017 (n=481), 2018 (573) and 2019 (637).

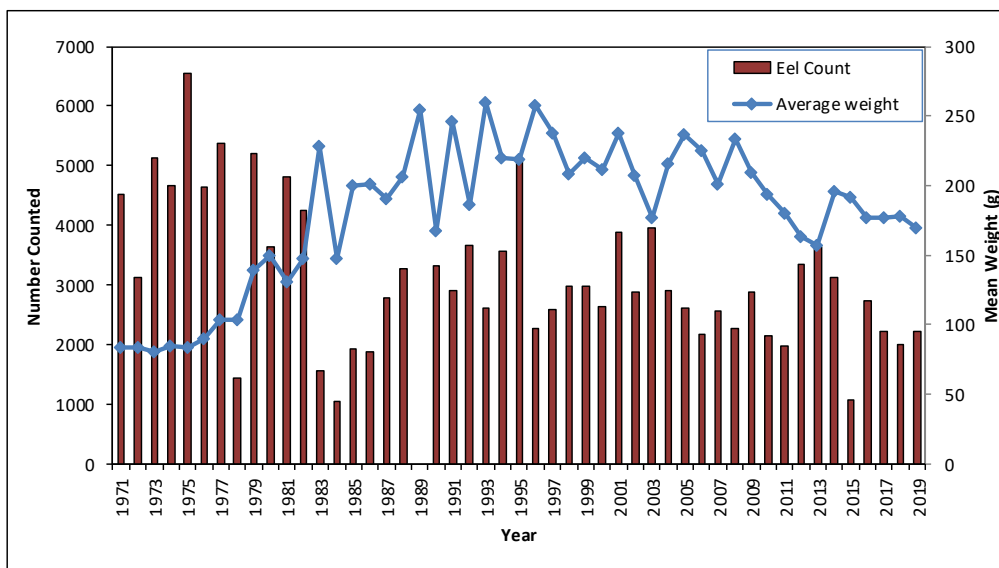


Figure 7-3: Annual number and mean weight (g) of silver eels trapped in the downstream traps.

## 8 Fishery Report – Catch Data

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The Burrishoole Fishery is a valuable part of the overall stock census programme and is run as an integral part of the monitoring programme. As part of the conservation of the Burrishoole wild stock, changes to the active season and to the parts of the catchment being fished have caused differences, or gaps, in the data being collected. Lough Feeagh, which had been closed to angling since 1997 for conservation reasons was opened to angling for the month of September in 2008, on a catch and release basis for wild fish. In 2009 - 2013 Lough Feeagh was open for angling on a catch and release basis from August to the end of September and in 2014 for one week only from 24<sup>th</sup> August due to low stock. During 2017 Lough Furnace was open from June 14<sup>th</sup> to September 30<sup>th</sup>. Lough Feeagh was closed under a conservation byelaw. During 2018 Lough Furnace was open from June 15<sup>th</sup> to September 30<sup>th</sup>. Lough Feeagh opened on the 3<sup>rd</sup> September. The fishery was operated on a 7-day week and on a catch and release basis for both wild salmon and sea trout.

During 2019 Lough Furnace was open from June 15<sup>th</sup> to September 30<sup>th</sup>. Lough Feeagh opened from the end of August for one boat. The fishery was operated on a catch and release basis for both wild salmon and sea trout.

### 8.1 Numbers and Average weight of Rod Catch

The Lough Furnace rod catch in 2019 consisted of 3 wild fish and 17 reared fish. All wild caught fish were returned alive. The first reared fish was caught on June 5<sup>th</sup> and the first wild fish on 20<sup>th</sup> July. The L. Feeagh rod catch consisted of 11 wild fish and 1 reared fish. All wild fish were returned alive.

The average weight of reared fish was 1.6kg (n = 17) and the heaviest fish was 2.2. No lengths or weights are available for wild fish due to catch & release being in place.

A total of 35 sea trout were caught on Lough Furnace. Regulations remained in place whereby all rod caught sea trout were returned alive. A total of 538 brown trout were caught on Lough Feeagh.

### 8.2 Timing of Catch and Rod Effort

The main feature of the 2019 angling season was the relatively low angling effort throughout the angling season. The low effort in June resulted in the rod catch of two ranched salmon and no wild salmon. Although there was a significant increase in rod effort in July the first wild salmon was not caught until 20<sup>th</sup> July. The total wild catch for July was three and the total reared catch was 11.

Rod effort decreased again during August, four ranched salmon were caught but no wild salmon. The total rod effort on Lough Furnace during September was only 3 hours and no ranched or wild salmon were caught

The Fishery opened on the 15<sup>th</sup> of June on Lough Furnace. Angling conditions were mixed for the remainder of June and rod effort was low. Poor angling conditions continued in July. By August the majority of salmon had moved upstream from Lough Furnace and as a consequence rod effort on Lough Furnace was low for the remainder of the season.

Angling on Lough Feeagh commenced at the end of August for catch and release only and angling was permitted to the end of September. The first salmon was caught on the 9<sup>th</sup> of September. The angling effort was low in September, one regular angler fished it for 15 days resulting in a rod catch of 9 wild salmon, 1 ranched salmon and over 400 brown trout. The total rod catch for Feeagh was 11 wild salmon 1 ranched salmon, 2 sea trout and 538 brown trout, all the fish that were caught were in excellent condition.

**Table 8-1: Wild and reared salmon rod catch and rod effort (hours) for the 2019 season for L. Furnace and L. Feeagh.**

<b>Furnace</b>			
	Salmon Catch		Effort in hours
	Wild	Reared	
May	0	0	0
June	0	2	91
July	3	11	564
August	0	4	230
September	0	0	3
<b>Total</b>	<b>3</b>	<b>17</b>	<b>888</b>
= 111 rod days			
<b>Feeagh</b>			
	Salmon Catch		Effort in hours
	Wild	Reared	
May	0	0	0
June	0	0	0
July	0	0	0
August	0	0	26
September	11	1	162
<b>Total</b>	<b>11</b>	<b>1</b>	<b>188</b>
= 23.5 rod days			

### 8.3 Exploitation Rates of Rod Fishery

Rod exploitation rates for Lough Furnace and Lough Feeagh from 2011 to 2019 are shown in Table 8.2. From 1997 onwards Lough Feeagh was closed to angling. Exploitation rates are only available for Lough Furnace since 1997. The cessation of angling on Lough Feeagh was due to the continuing low stock level of wild fish. Following the cessation of drift netting in 2007 and the increased return of wild fish it was decided to re-open Lough Feeagh in 2008 to angling for the month of September only on a catch and release basis for both wild and ranched fish. Since 2008, and in future years, the running of a fishery on L. Feeagh was reviewed each year and was dependent on sufficient wild stock being present. In 2017 Lough Feeagh was closed to angling as the stock was below the limit permitted for Catch & Release.

No sea trout angling was permitted on L. Feeagh between 1997 and 2008 and since 2008 up to 2016 the fishery has been open on a limited basis. In 2017 sea trout angling was not permitted.

Anglers fishing on Lough Furnace were requested to return wild salmon alive to the water. Injured or damaged wild fish were permitted to be retained however no fish were retained in 2019. The fishery was open in both Furnace and Feeagh in 2019 on a strictly catch and release basis for both salmon and trout.

Rod exploitation rates for Lough Furnace and Lough Feeagh from 2011 to 2019 are shown in Table 8.2.

**Table 8-2: Rod fishing exploitation rates (2011-2019).** <sup>1</sup> based on total catch; <sup>2</sup> based on catch killed.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
<b>WILD SALMON</b>										
<b>Lough Feeagh</b>										
"Available" fish by end of fishing season	691	516	683	694	145	632	461	*	310	412
Total rod catch	8	13	28	16	0	19	12		7	11
Rod catch retained	0	0	0	0	0	0	0		0	0
Angling success % <sup>1</sup>	1.15	2.5	4.10	2.31	0.00	3	2.6		2.3	2.7
Exploitation rate % <sup>2</sup>	0	0	0	0	0	0	0		0	0
<b>WILD SALMON</b>										
<b>Loughs Feeagh &amp; Furnace</b>										
Total stock of wild fish	703	571	686	734	305	650	548	541	330	457
+ 10% addition for										
L. Furnace population	773	628	755	807	336	715	602	595	363	503
Total catch of wild fish	26	36	50	35	8	28	17	12	17	14
Rod catch retained	0	0	0	1	0	0	0	0	0	0
Max. angling success %	3.7	6.3	7.3	4.8	2.6	3.9	3.1	2.2	5.2	3.1
Min. exploitation rate	0	0	0	0.1	0	0	0	0	0	0
Max. exploitation rate	0	0	0	0.1	0	0	0	0	0	0
<b>REARED SALMON</b>										
<b>Lough Feeagh</b>										
"Available" fish by end of fishing season	130	125	128	105	117	101	109	*	143	117
Total rod catch	1	1	3	1	0	2	3		2	1
Rod catch retained	0	0	0	0	0	0	0		0	0
Angling success % <sup>1</sup>	0.8	0.8	1.5	1.0	0.0	2	1.5		1.4	0.9
Exploitation rate % <sup>2</sup>	0	0	0	0	0	0	0		0	0
<b>Loughs Feeagh &amp; Furnace</b>										
Total stock	940	1293	2392	1301	1205	1931**	1245	1212	2019	934
Total rod catch	79	86	78	71	40	25	47	57	34	17
Exploitation rate %	8.4	6.7	3.3	5.5	3.3	1.3	3.8	3.3	1.7	1.8
<b>WILD SEA TROUT</b>										
<b>Lough Feeagh</b>										
"Available" fish by end of fishing season	71	58	129	60	140	58	80	*	20	18
Rod catch	1	1	5	12	19	30	28		0	2
Exploitation rate %	0	0	0	0	0	0	0		0	0
Angling Success %	1.4	1.7	3.9	20.0	13.6	51.7	35.0		0.0	11.1

\* Fishery closed on Feeagh; \*\* due to the flooding issue in November & December, this figure is based on the total return of reared fish processed for tags

## 8.4 Angling Success

Table 8.3 presents the Catch per unit effort (CPUE) which is the number of fish caught per rod day, and the Effort per unit catch (EUPC) which is the number of rod days it takes to catch a fish.

**Table 8-3: Catch per unit effort (CPUE) and effort per unit catch (EPUC) for the Burrishoole Fishery based on an eight hour fishing day. Salmon includes both wild and reared.**

Year	Lough Furnace				Lough Feeagh			
	Salmon		Sea Trout		Salmon		Sea Trout	
	CPUE	EPUC	CPUE	EPUC	CPUE	EPUC	CPUE	EPUC
'80-'84	0.13	9.92	0.85	1.35	0.23	4.47	0.63	2.10
'85-'89	0.24	4.89	0.46	5.09	0.24	4.57	0.29	70.30
'90-'95	0.20	6.10	0.17	16.80	0.20	5.40	0.10	14.00
'96	0.22	4.40	0.10	10.50	0.83	1.20	0.30	2.90
'97	0.17	6.00	0.10	9.60	*	*	*	*
'98	0.44	2.30	0.08	13.20	*	*	*	*
'99	0.09	10.80	0.05	20.80	*	*	*	*
'00	0.30	3.31	0.06	16.50	*	*	*	*
'01	0.15	6.70	0.12	8.40	*	*	*	*
'02	0.12	8.30	0.07	15.30	*	*	*	*
'03	0.13	7.60	0.06	17.70	*	*	*	*
'04	0.22	4.60	0.16	6.30	*	*	*	*
'05	0.26	3.80	0.08	13.00	*	*	*	*
'06	0.44	2.30	0.04	23.50	*	*	*	*
'07	0.49	2.10	0.14	6.90	*	*	*	*
'08	0.35	2.89	0.05	21.60	0.46	2.18	0.07	13.80
'09	0.18	5.66	0.24	4.09	0.21	4.75	0.42	2.38
'10	0.60	1.66	0.14	7.27	0.82	1.22	0.09	11.00
'11	0.68	1.47	0.35	2.8	1.06	0.95	0.08	13.10
'12	0.96	1.04	0.10	10.10	1.10	0.91	0.18	56.62
'13	0.66	1.51	0.22	4.5	0.60	1.70	0.42	2.40
'14	0.32	3.17	0.35	2.9	0.00	0.00	0.18	5.60
'15	0.23	4.31	0.17	5.75	0.40	2.50	0.56	1.77
'16	0.31	3.18	0.13	7.41	0.38	2.6	0.72	1.4
'17	0.39	2.57	0.03	29.5	*	*	*	*
'18	0.41	2.44	0.06	17.08	0.29	3.4	0	0
'19	0.18	5.55	0.32	3.17	0.51	2	0.09	11.75

## 9 Catchment Stock Assessment

### 9.1 Introduction

The Burrishoole catchment, upstream of the main fish traps, has been monitored since 1990 with surveys of the salmonid and eel stocks taking place in the rivers and the main lakes. Electrofishing, with 3-fishing depletions, is used for salmonids and eels in the streams, fine mesh beach seines are used for salmonids in the lakes and summer fyke nets are used for eels in the lakes. Eel surveys are also undertaken in the tidal waters below the traps.

### 9.2 Electrofishing Surveys

2019 marked the completion of 29 years of electrofishing surveys in the Burrishoole and Owengarve catchments. Densities of eels and juvenile salmonids were calculated using three pass removal sampling.

As in 2017 and 2018, poor weather conditions in 2019 again hampered our efforts at a catchment wide survey, but we managed to get 22 sites fished in total. Sites were fished between the 14th August and the 23rd September 2019. A total of 1063 fish were caught and measured over the 21 sites. The 22 sites comprised 2341 m<sup>2</sup>



of representative habitat. Summary data are presented in Figures 10.1-10.6, and these show the distribution of fish densities around the catchment for eel (Fig. 9.1), 0+ salmon (Fig. 9.2), 1+ salmon (Fig. 9.3), 0+ trout (Fig. 9.4), 1+ trout (Fig. 9.5) and 2+ trout (Fig. 9.6).

The average eel density was 0.03 fish/m<sup>2</sup>, with eels recorded in 12 sites out of 22.

Average density of 0+ salmon was 0.17 fish/m<sup>2</sup>, with catches recorded in 12 sites. 1+ salmon were also recorded in 10 sites, with an average density of 0.07 fish/m<sup>2</sup>.

Average densities of 0+, 1+ and 2+ trout were 0.22, 0.06 and 0.02 fish/m<sup>2</sup> respectively. 0+ and 1+ trout were recorded in all 22 sites, while 2+ trout occurred in 14 sites.

Average densities of 0+ trout were similar to those recorded in previous years. (Fig. 9.7), as were the densities of 0+ and 1+ salmon. The density of eel was higher than previous years. We did not fish the Rough River sites 1-5, which has quite a large impact on numbers, as densities of salmon and trout would be high, and eel would be low in these sites generally.

### 9.3 Beach Seine Surveys

Beach seine surveys were not conducted in 2019 due to high lake levels.

## 9.4 Fyke Net Surveys

### 9.4.1 Survey Data

Fyke net surveys of yellow eels have been conducted in the 1970s and 1980s as parts of previous studies. The Burrishoole lakes Feeagh and Bunaveela have been incorporated into the National Eel Survey in 2009-2019. Fyke net surveys of the tidal Lough Furnace and 'Back of the House' have been more sporadic or at a lower effort.



Yellow-eel stock monitoring is integral to gaining an understanding of the current status of local stocks and for informing models of escapement. Such monitoring also provides a means of evaluating post-management changes 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 stock's length, age and sex profiles, and the proportion of each length class that migrate as silvers each year.

Fyke net surveys carried out between 1960 and 2008 provide a useful bench mark against which to assess the changes in stock. The yellow eel monitoring strategy will rely on the use of standard fyke nets. Relative density will be established based on catch per unit effort.

Bunaveela Lough is located in the upper reaches of the catchment. It has a surface area of 42ha and a maximum depth of 23m. Bunaveela L. was fished in the traditional style (sets of 10 nets perpendicular to the shore) in 2019 (25-26 June 2018), with chains of 10 nets fished at six sites. In total 27 eels were caught with a catch per unit of effort of 0.45 eels/net/night (Table 9.2). The average length was 44.3cm and ranged in length from 33.3cm to 62.56cm. Twenty four eels were PIT tagged and three recaptures were made of previously tagged fish.

Lough Feeagh has a surface area of 395ha and an average depth of 14.5m (with several areas >35m in depth). L. Feeagh was fished in the traditional style (sets of 10 nets perpendicular to the shore) in 2019 (2-3 July 2018), with chains of 10 nets fished at six sites for one night each. In total, 52 eels were caught with a catch per unit effort (CPUE) of 0.87 eels/net/night (Table 9.2). The average length of eels was 41.7cm and ranged in length from 30.8cm to 63.2cm, with a total weight of 7.07 kg caught in the two nights. Most of the catch (38) was PIT tagged and three previously tagged eels were recorded. Twelve eels were sacrificed in this survey. Ten of the 12 (83.3%) of the eels contained *A. crassus* with an infection intensity of 6.9 continuing the rising trend in infection rates in the Burrishoole yellow eel stock.

Lough Furnace, the tidal lough, has a surface area of 125ha north of Nixon's Island and 16ha between Nixon's Island and the mouth of the estuarine river (Lower Lough Furnace). The main lough has a maximum depth of 21.5m. Furnace is heavily stratified with significant areas of deoxygenated water in the main basin. L. Furnace was fished in the traditional style (sets of 10 nets perpendicular to the shore) in 2019 (8-9 July), with chains of 10 nets fished at six sites in one night each. Three chains of nets were fished at the Back of the House (24 July), which is a shallow tidal area between the lough and the estuarine river.



In L. Furnace, 23 eels were caught with a catch per unit effort (CPUE) of 0.38 eels/net/night (Table 9.2). The average length was 37.5cm ranging from 30.7cm to 64.5cm. A total weight of 2.24kg was caught.

In the Lower Lough Furnace, 43 eels were caught with a catch per unit effort (CPUE) of 1.4 eels/net/night (Table 9.2). The eels average length was 45.6cm ranging in length from 29.8cm to 66.3cm, with a total weight of 8.11kg caught. Eight eels were PIT tagged and released and two previously tagged eels were recorded

Twelve eels were sacrificed in this survey from Lough Furnace. Six of the 12 (50.0%) of the eels contained *A. crassus* with an infection intensity of 3.8. *A. crassus* has been established in the lough since about 2011.

No eels were sacrificed in this survey from Lower Lough Furnace. All but one of the forty-five eels were PIT tagged and released.

**Table 9-1: Catch details of the standard yellow eel survey in 2019. \*Net (pair of traps).**

Lake	Dates	No. Eels	Net* Nights	CPUE	Total weight (kg)	Mean length (cm)	Mean weight (Kg)
<b>Bunaveela</b>	25-26/06/2019	27	60	0.45	4.24	44.3 (33.3-62.5)	0.157
<b>Feeagh</b>	2-3/07/2019	52	60	0.87	7.07	41.7 (30.8-63.2)	0.136
<b>Furnace</b>	8-9/07/2019	23	60	0.38	2.24	37.5 (30.7-64.5)	0.102
<b>Lwr Furnace BOH</b>	24/07/2019	45	30	1.50	8.11	45.6 29.8-66.3)	0.18

#### 9.4.2 Quantitative Eel Survey

The quantitative survey was not fished in 2019.

#### 9.4.3 *Anguillicola crassus*

*Anguillicola crassus* is an indigenous parasitic nematode of the Japanese eel *Anguilla japonica* in Asia. *A. crassus* does not cause serious pathological damage in its natural host. However, infections in European eel are potentially more serious and can cause damage to the swimbladder with associated bacterial damage, red and swollen anus, as well as, in most severe cases, the collapse of the swimbladder lumen.

*A. crassus* was introduced into Europe in the early 1980s and it has since spread widely and has successfully colonized most European countries. It was first recorded in Ireland (Waterford Harbour) in 1997. Later records came from the Erne catchment in 1998 and it is now present in approximately 74% of the wetted area of Ireland. The most likely infective route to Ireland was the commercial eel trade although localised spread can be through natural eel movements and paratenic hosts.

The Burrishoole catchment remained free of the parasite until recently. In the fyke net survey in 2012, samples of yellow eels captured in L. Furnace (saline) and at the Back of the House (tidal lough below L. Furnace) were found to be infected with *A. crassus*. Samples of yellow eels from L. Feeagh were negative and a comprehensive sample of silver eels from the traps was also negative indicating that in 2012 the infection seemed to be confined to the tidal lough. This was somewhat surprising as a number of environmental factors have been shown to influence *A. crassus* infections. High salinity has been shown as having a negative impact in the egg hatching and larvae survival of the parasite although the effects of water salinity remain unclear as various surveys have shown no differences in infection levels in waters with different salinity values.

Examination of previous samples would indicate that the parasite was likely to have been introduced into L. Furnace in 2010 or early 2011 (Table 9.3).

The infection intensity in L. Furnace eels continued to rise in 2014 and it was also detected in yellow eels in the Mill Race channel in 2014. The prevalence in 2017 remained at 67% although the intensity increased to 20.7.

The first detection in freshwater was made in 2016 with 10 silver eels (36%) migrating out of the catchment containing the parasite (Table 9.3).

In 2017, the infection had increased to 67% in Lough Feeagh and 65% in the out-migrating silver eels, which had an intensity of 7.2.

In 2018, the infection in freshwater was similar to that in 2017. In saline water, the prevalence was lower in Furnace and a high prevalence was observed in a sample of 6 eels taken from the Back of the House. One eel in the estuary was also infected.

In 2019, the infection rates continued to rise in freshwater with prevalences of 88.4 (silver eels) and 83.3 (Feeagh Yellow). Tests using faecal washes indicated that the parasite has spread to Bunaveela in the headwaters of the catchment where 8 out of 25 (32%) tested positive (Michele de Noia, pers com).

## 9.5 Long-term biological monitoring in the Burrishoole catchment

Macroinvertebrate surveys of 14 index sites were conducted in 2019. 1585 individuals from 42 samples were counted and identified, and are recorded in the Catchment Macroinvertebrate Access database for future analysis. Zooplankton and phytoplankton surveys of Feeagh and Furnace were continued in 2019, with monthly samples being collected using standard methods, and preserved for future enumeration and identification.

**Table 9-2: Location and sample details for eels in Burrishoole examined for the presence of *Anguillicola crassus*.**

Year	Location	No. of eels checked	Stage	No. Infected	Prevalence	Intensity
<b>Freshwater</b>						
2009	Traps	50	Silver	0	0	0
2010	Yellow R.	5	Yellow	0	0	0
2010	Black Lakes	3	Yellow	0	0	0
2010	Glenamong R.	3	Yellow	0	0	0
2010	Feeagh	2	Yellow	0	0	0
2010	Traps	17	Silver	0	0	0
2011	Traps	50	Silver	0	0	0
2011	Feeagh	30	Yellow	0	0	0
2012	Feeagh	4	Yellow	0	0	0
2012	Traps	168	Silver	0	0	0
2013	Traps	106	Silver	0	0	0
2014	Traps	94	Silver	0	0	0
2014	Mill Race Lwr	7	Yellow	4	57.1	2.3
2014	Mill Race Uppr	11	Yellow	2	18.2	1.0
2015	Traps	10	Silver	0	0.0	0.0
2016	Traps	28	Silver	10	35.7	2.0
2017	Feeagh	6	Yellow	4	66.7	2.5
2017	Traps	26	Silver	17	65.4	7.2
2018	Feeagh	6	Yellow	4	66.7	4.0
2018	Traps	53	Silver	36	67.9	7.0
2019	Traps	43	Silver	38	88.4	14.2
2019	Feeagh	12	Yellow	10	83.3	6.9
<b>Saline Water</b>						
2008	Furnace	60	Yellow	0	0	0
2009	Fu Nixons	47	Silver	0	0	0
2010	Furnace	10	Yellow	0	0	0
2010	Fu Nixons	50	Silver	0	0	0
2011	Furnace	4	Yellow	2	50.0	1.0
2012	BOH	6	Yellow	6	100.0	2.0
2012	Furnace	10	Yellow	7	70.0	4.4
2013	Furnace	6	Yellow	6	100.0	13.5
2014	Furnace	9	Yellow	5	55.6	17.6
2016	Furnace	12	Yellow	8	66.7	2.7
2017	Furnace	6	Yellow	4	66.7	20.7
2018	Furnace	6	Yellow	1	16.7	13.0
2018	BOH	6	Yellow	5	83.3	7.6
2018	Estuary	5	Yellow	1	20.0	5.0
2019	Furnace	12	Yellow	6	50.0	3.8

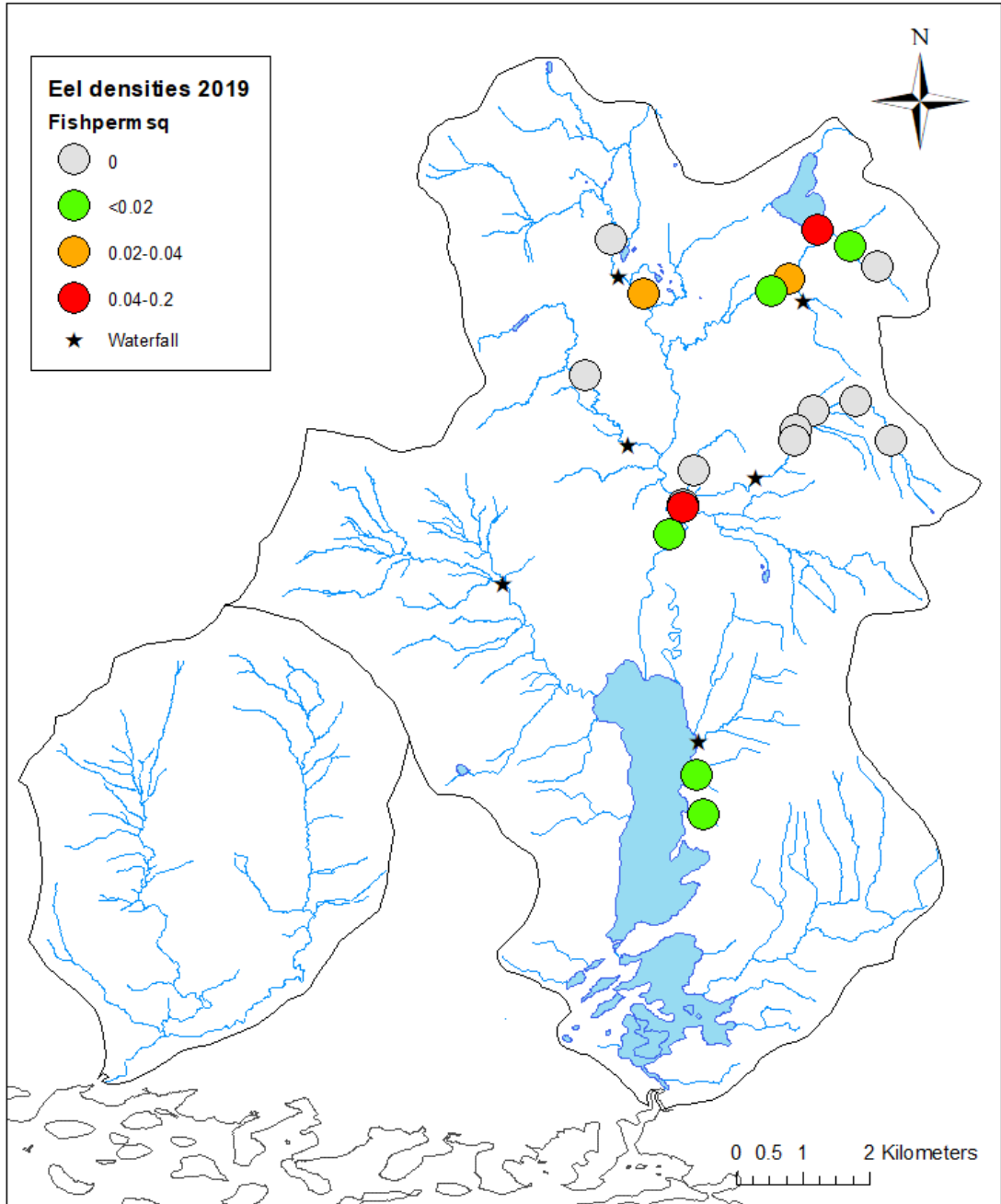


Figure 9-1: Densities of eel calculated from the 2019 electrofishing survey of the Burrishoole catchment.

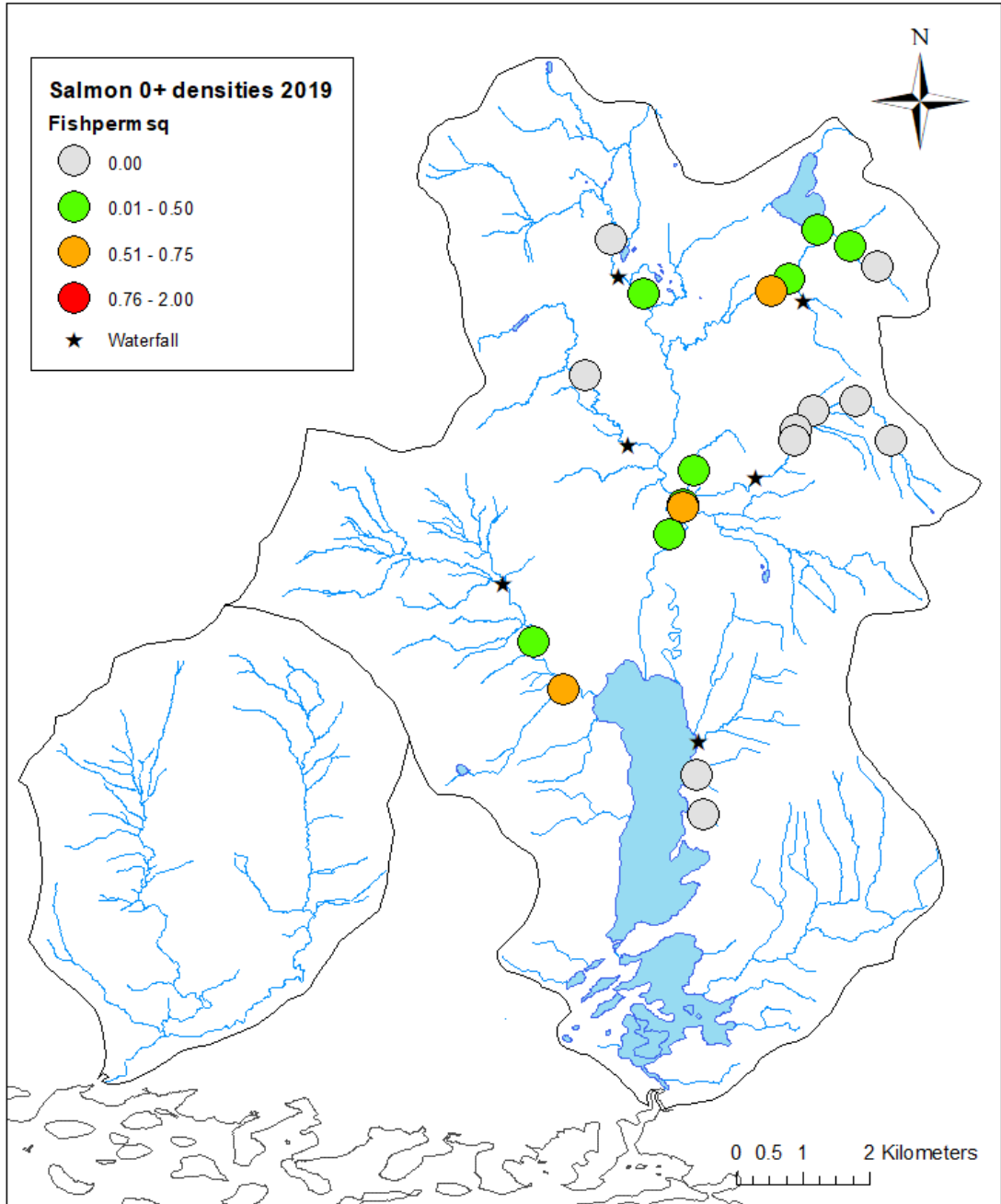


Figure 9-2: Densities of 0+ salmon calculated from the 2019 electrofishing survey of the Burrishoole catchment.

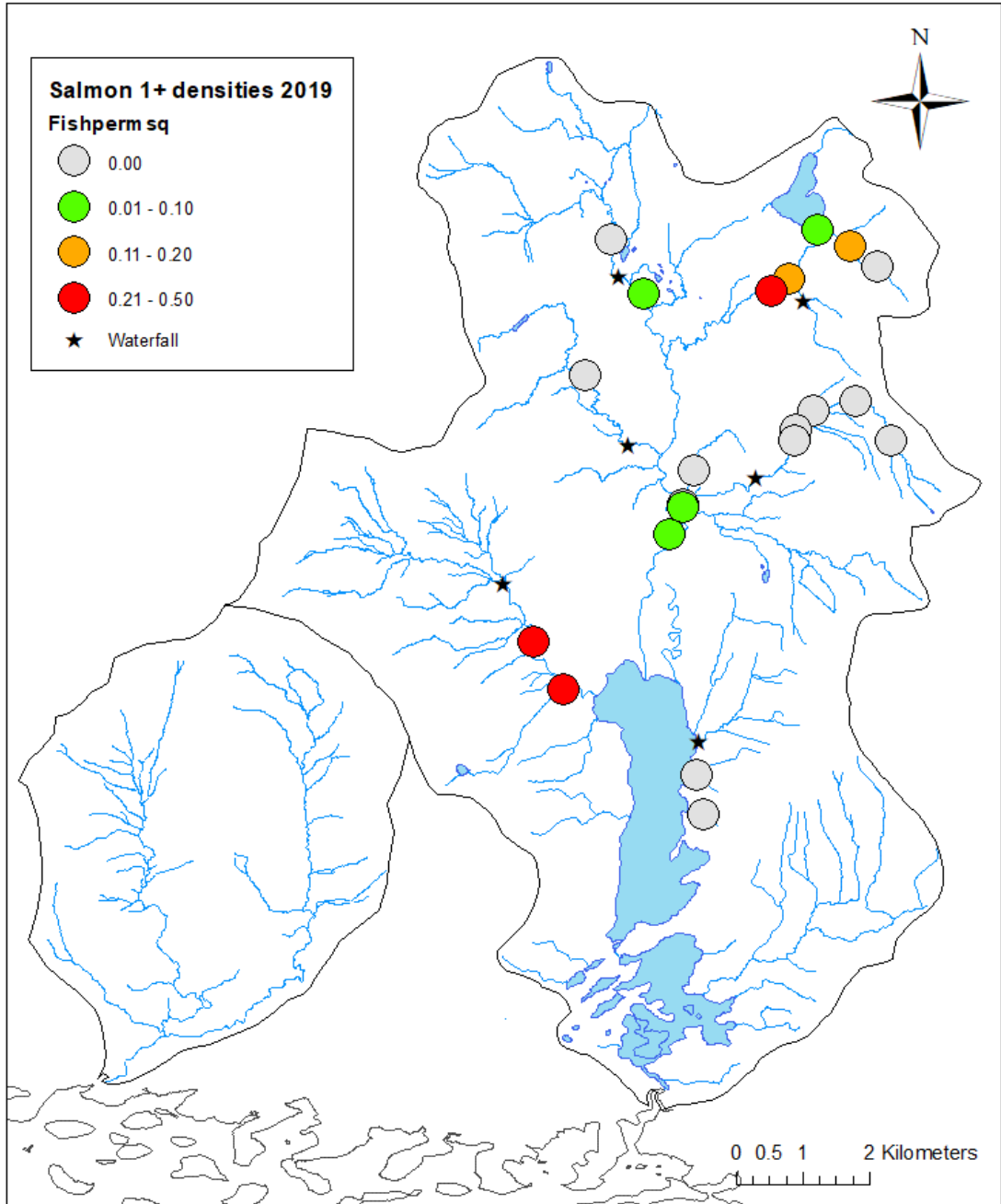


Figure 9-3: Densities of 1+ salmon calculated from the 2019 electrofishing survey of the Burrishoole catchment.

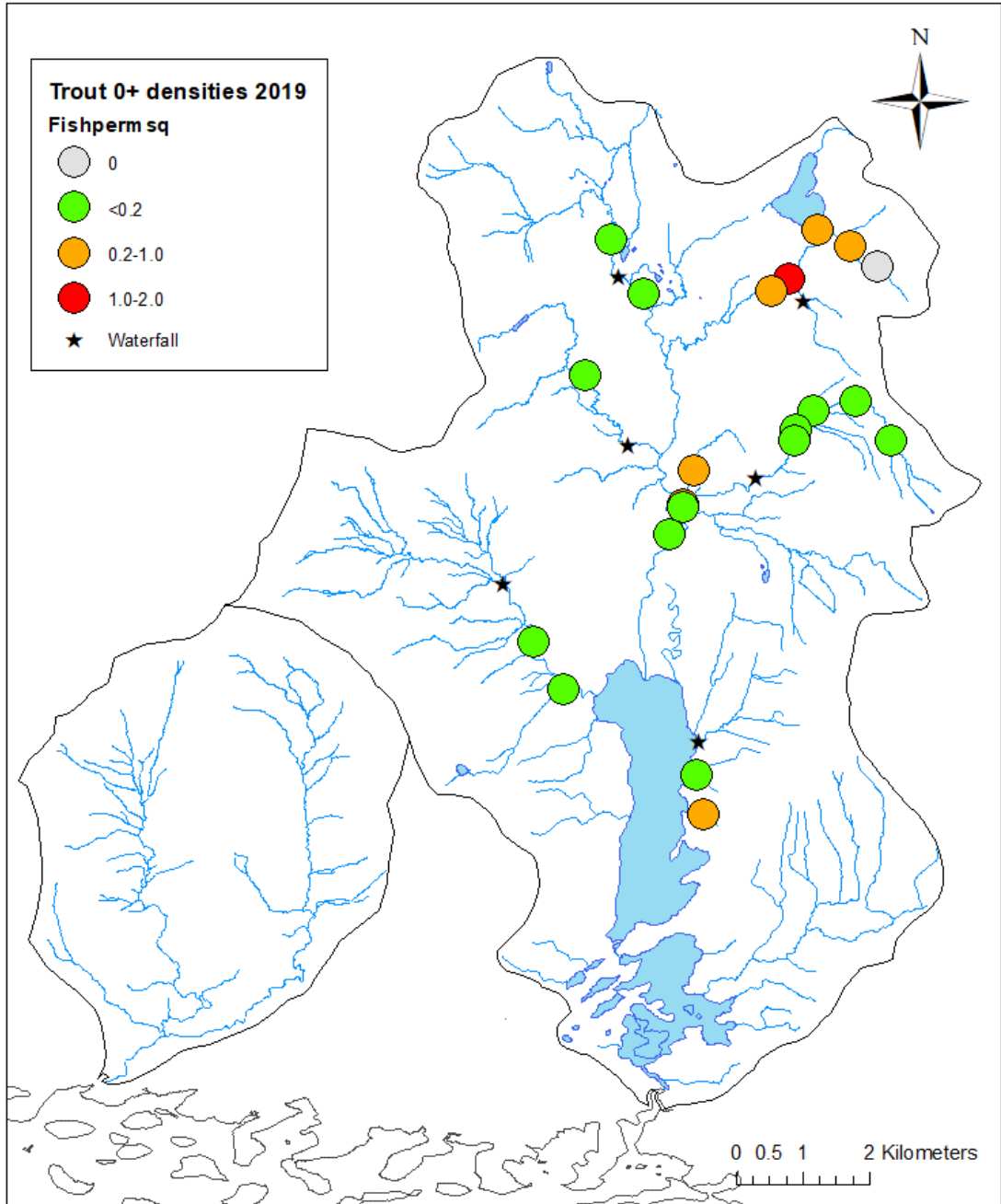


Figure 9-4: Densities of 0+ trout calculated from the 2019 electrofishing survey of the Burrishoole catchment.

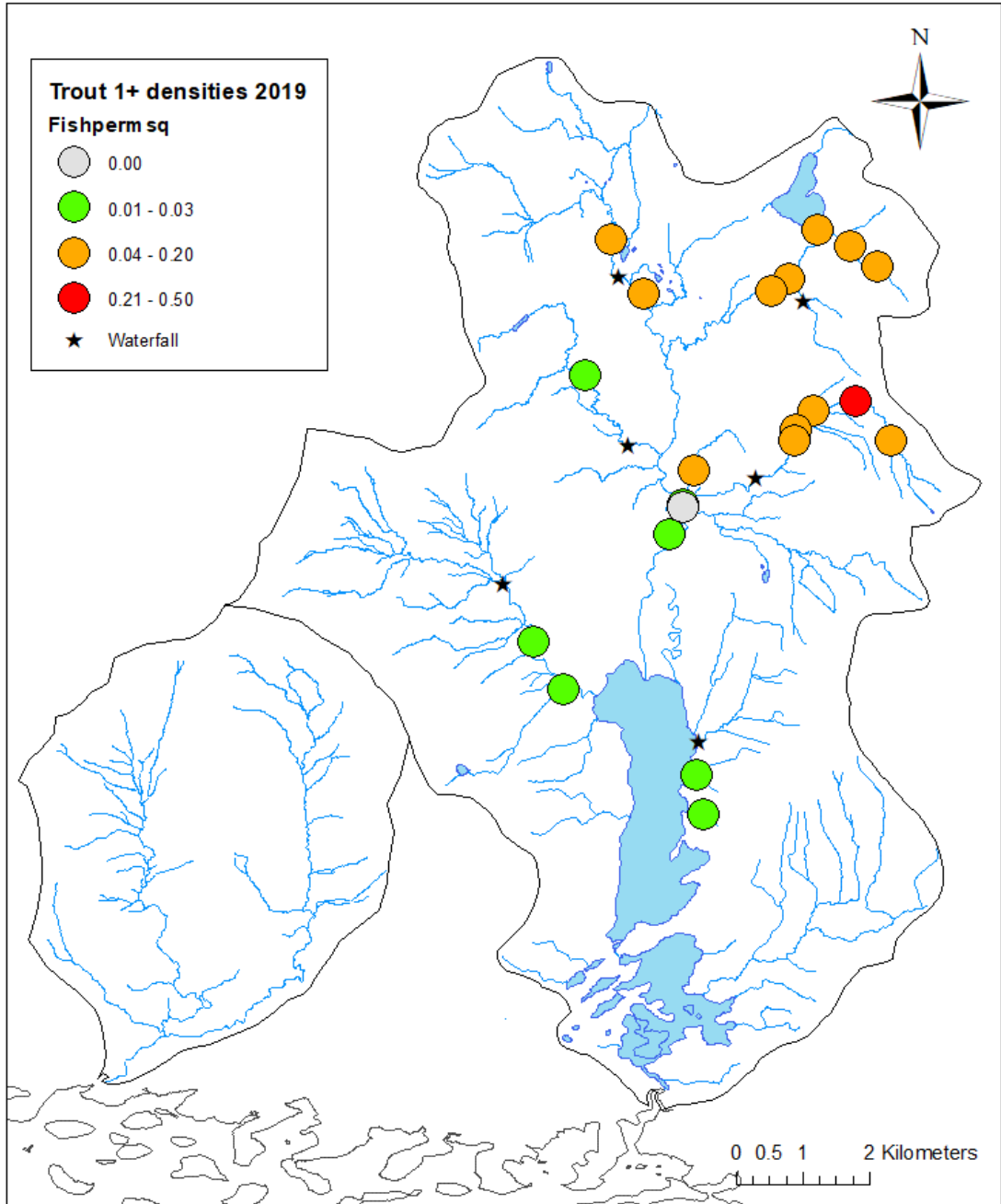


Figure 9-5: Densities of 1+ trout calculated from the 2019 electrofishing survey of the Burrishoole catchment.

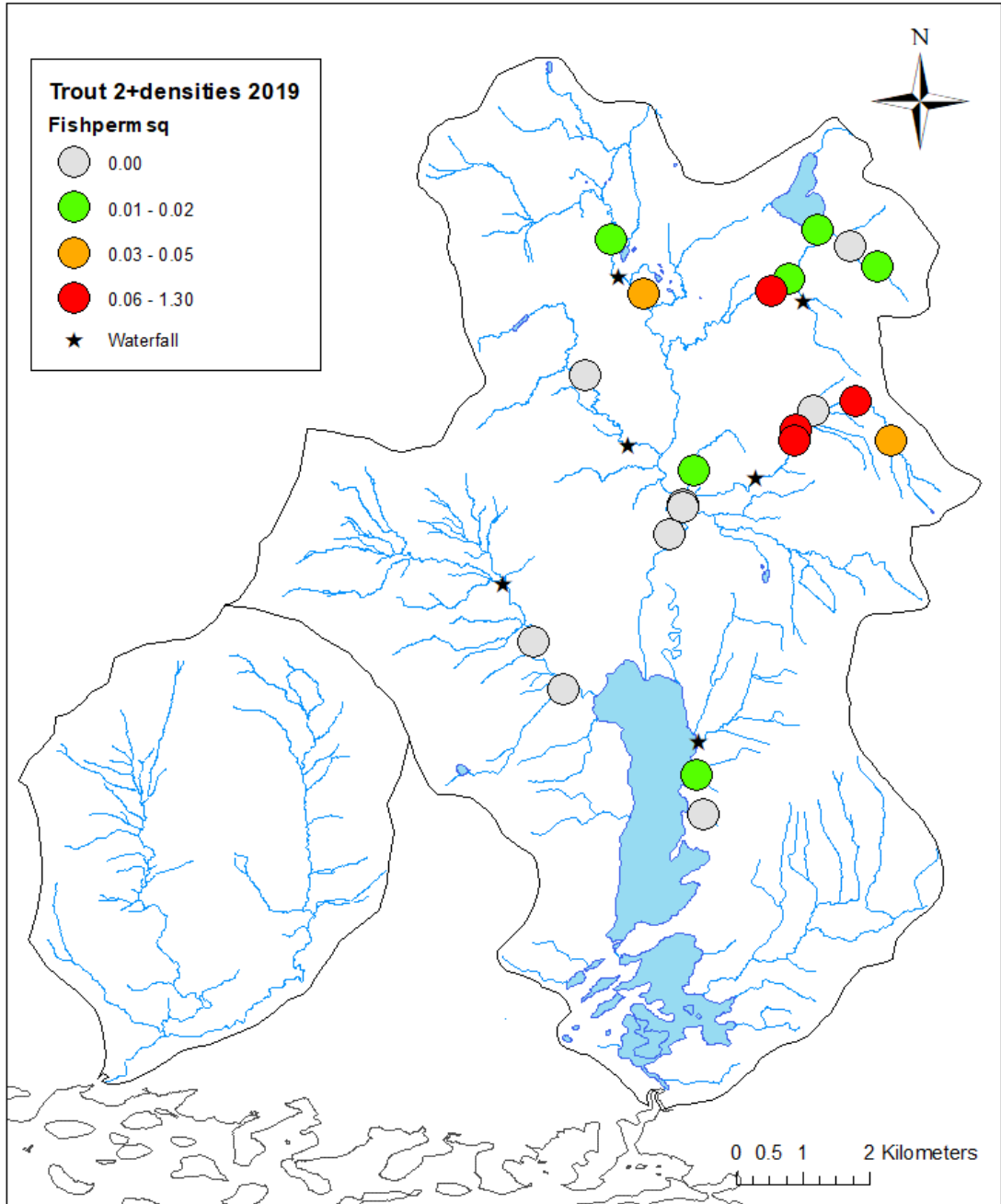


Figure 9-6: Densities of 2+ trout calculated from the 2019 electrofishing survey of the Burrishoole catchment.

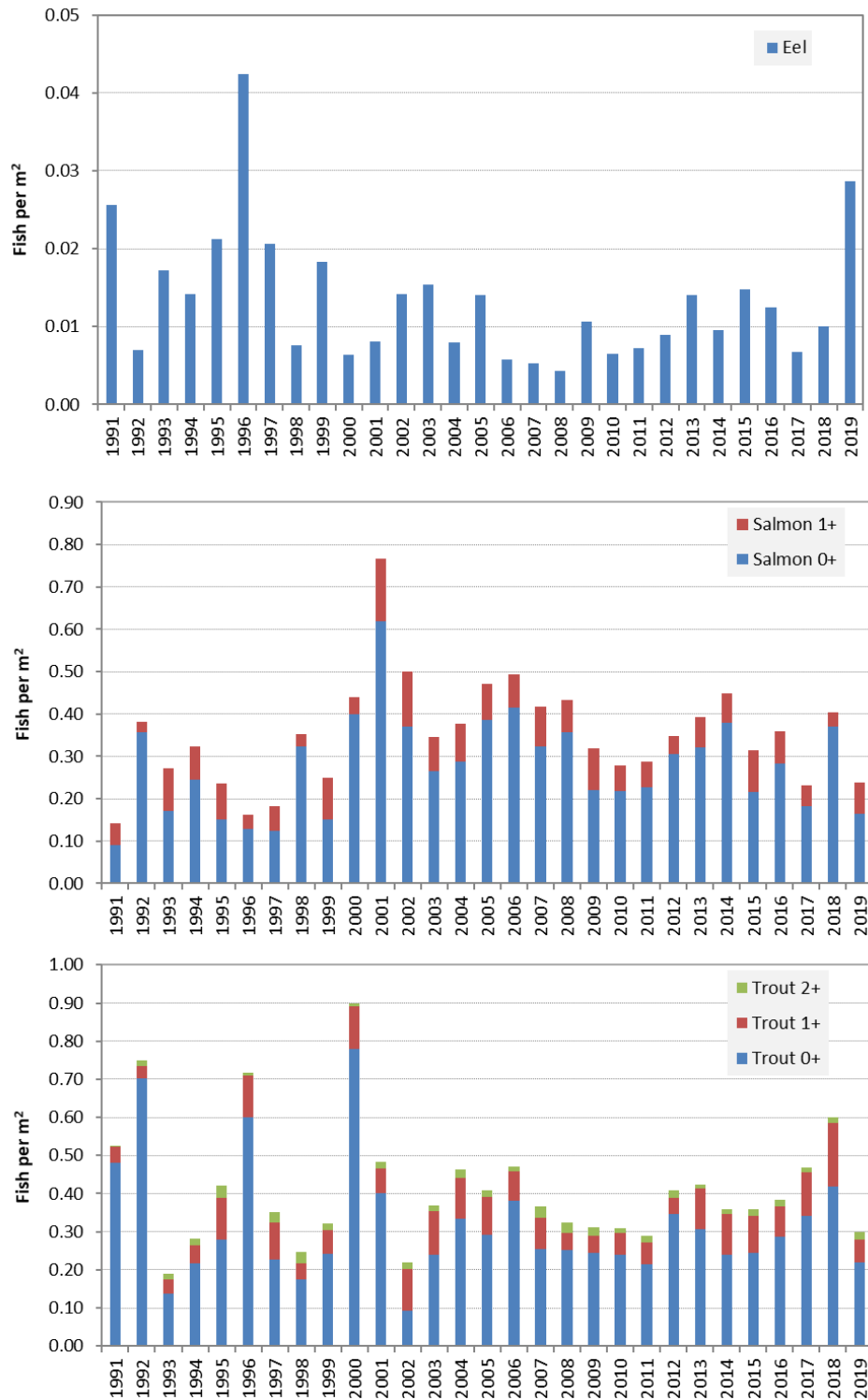


Figure 9-7: Average densities of eel, salmon and trout (fish per m<sup>2</sup>) calculated from electrofishing surveys of the Burrishoole and Owengarve catchments, 1991-2019. Note that the values for 0+salmon and trout do not include densities from the Rough river, sites 1-5 as these were stocked heavily for experimental purposes in some years.

## 10 Collaborative Research Programme

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### 10.1 GLEON

In 2007, the Burrishoole catchment became a member of the Global Lake Ecological Observatory Network (GLEON: <http://www.gleon.org>), an association of limnologists, information technology experts and engineers whose goal is to establish a persistent network of lake ecology observatories (<http://www.gleon.org>). Work with GLEON working groups continued in 2019. There was a large Irish contingent at the GLEON 21 meeting in Canada, representing the many diverse collaborative projects we are involved in. Data from the Burrishoole catchment are being used in several GLEON working groups, including those focussed on signal processing of high frequency lake data, the role of catchment processes and dynamics on lake metabolism and the role of lakes in the global carbon cycle. Elvira de Eyto served her fourth year on the steering committee. During 2019, we carried out field work for a GLEON project, Day-Night Zoop, focussed on the diel migration of zooplankton in lakes across the world.

### 10.2 Cullen PhD Fellowships

In 2015, a call was put out for four PhD fellowships to be awarded for projects based in Burrishoole. Sean Kelly commenced his project in October 2015, and three others started in 2016.

The projects are as follows:

Brian Doyle (E. Jennings, DKIT): Resolving the Organic Carbon Budget of a salmonid humic lake.

Sean Kelly (M. White, NUIG): To investigate the dual influence of marine water and freshwater on the hydrography and related ecology of a coastal lagoon, Lough Furnace, Co. Mayo.

Aisling Doogan (D. Brophy, GMIT): Investigation of the causes of early migration mortality in salmon and sea trout from the Burrishoole National Index River using acoustic telemetry in freshwater and coastal areas.

Ross Finlay (T. Reed, UCC): Investigation of the early migration of salmon and brown trout from the Burrishoole National Index River using PIT tag technology in freshwater and brackish areas

By the end of 2019, Sean Kelly had successfully submitted and defended his thesis, while Brian, Aisling and Ross are in the final stages on writing up.

### 10.3 PROGNOSES

In 2016, we commenced the PROGNOSES project, which was financed under the ERA-NET Cofund WaterWorks2014 Call. This ERA-NET was an integral part of the 2015 Joint Activities developed by the Water Challenges for a Changing World Joint Programme Initiative (Water JPI). Irish funding to the two partners (Marine institute and Dundalk IT) came from the EPA. In PROGNOSES, the aim was to develop an integrated approach that links high frequency (HF) lake monitoring data to dynamic water quality models to forecast short-term changes in nuisance algal blooms and higher levels of dissolved organic carbon (DOC). This potentially provides a greater window of opportunity over which to make water quality management decisions, and will increase the value of HF monitoring data, ensuring that their potential to guide water quality management is fully realised. The project consortium included expertise from European sites that have been involved in the forefront of HF monitoring systems since the late 1990s, expertise in modelling algal blooms and DOC levels, and expertise in assessing societal benefits from changes in water management. Lough Feagh was used as a DOC case study. Tadhg Moore continued his PhD with the project team,

registered in DkIT under the supervision of Eleanor Jennings (DkIT) and Elvira de Eyto (MI), and made significant progress in 2019. The final annual PROGNOS meeting was held in Sweden in August 2019, and the project is now finished. Peer reviewed papers are in progress.

#### 10.4 WATExR

In 2017, work began on the WATExR project, which is part of ERA4CS, an ERA-NET initiated by JPI Climate, and funded by MINECO (ES), FORMAS (SE), DLR (DE), EPA (IE), IFD (DK), RNC (NO) with co-funding by the European Union (Grant 690462). It will run from 2017 to 2020. The aim of the project is to integrate state-of-the-art climate seasonal prediction and water quality simulation in a QGIS-based advanced solution to ensure efficient decision making and adaptation of water resources management to an increased frequency of climate extreme events. The project started in September 2017, with a kick-off meeting in ICRA Girona. The MIs role is to conduct the modelling work for the Burrishoole catchment, primarily focussing on using seasonal forecasts to predict fish phenology. Andrew French started as a post-doctoral researcher on this project in February 2018 and made significant progress on collating and modelling fish phenology data from Burrishoole. The annual meeting was held in Furnace in November 2019. More information can be found here: <https://watexr.eu/>

#### 10.5 MANTEL

The Marine Institute is a partner in the MANTEL project which is a Marie Sklodowska-Curie Action. MSCAs provide funding for research-focussed organisations, such as universities, research centres and companies, to host foreign researchers and to create strategic partnerships with leading institutions world-wide. Innovative Training Networks (ITNs) are one area which are funded through MSCAs. In addition to organisations from different EU or associated countries, the participation of additional organisations from anywhere in the world, including from the non-academic sector, is encouraged. This is the role of the Marine Institute, as MANTEL is training a cohort of 12 PhD students, many of whom are using data collected in Burrishoole. MANTEL kicked off in 2017, and recruited throughout the year. Most of the students were in place by the end of 2017. In 2019, an extensive fieldwork campaign in Burrishoole was carried out with one of the students, Truls Hansson, to characterise methane concentrations across the aquatic habitats of the catchment. Alex Hoke was recruited to take over from Ewan Goeffrey on project 4 (microbial community responses in Burrishoole) <https://www.mantel-itn.org/mantel-project-4>. More information can be found here <https://www.mantel-itn.org/>.

#### 10.6 Other catchment

During 2019, the catchment team continued collecting samples for inclusion in the GNIR (Global Network of Isotopes in Rivers - [http://www-naweb.iaea.org/naweb/ih/IHS\\_resources\\_gnir.html](http://www-naweb.iaea.org/naweb/ih/IHS_resources_gnir.html)). GNIR is a global environmental observation programme dedicated to the compilation of isotopic assays of water, nutrients and particulate and dissolved constituents in global river systems. GNIR serves as an essential world-wide repository for riverine isotope data, and facilitates public dissemination of contributed riverine isotopic data through a cost-free user-friendly web portal. GNIR is a complimentary programme to the IAEA (International Atomic Energy Agency) well-established Global Network of Isotopes in Precipitation. Monthly samples are taken from the Black and Mill Race rivers, and dispatched to the IAEA facility in Vienna for analysis.

We also took samples for the FunAqua project, the objective of which is to ascertain the drivers of global aquatic fungal diversity and determine the breadth of the niche of aquatic fungi locally and globally and in relation to soil and leaves

<http://pk.emu.ie/en/structure/hydrobiologyandfishery/research/projects/international-projects/funaqua/>

Of particular note is the inclusion of data from Lough Feeagh (Mill Race surface water temperatures) in an annual publication "The State of the Climate in (year)" which is produced every year by the *Bulletin of the American Meteorological Society*. We started contributing data to this publication in 2016, (for the 2015 period), and have now contributed to the State of the Climate report for 2015, 2016, 2017, 2018 and 2019.

### 10.7 DkIT Landscape PhD students

Two students were recruited under the internal funding umbrella of DkIT, and the supervision of Prof. Eleanor Jennings, Dr Valerie McCarthy and Dr Iestyn Woolway. Emma Drohan commenced a study of littoral carbon processing in September 2019, and her first chapter will focus on a resurvey of littoral macroinvertebrates from Lough Feeagh. During the summer of 2019, we resurveyed the entire littoral region of the lake, following the protocol in the 1971 annual report, and the new data will be compared to that collected by Partridge and Foy (1971 annual report) and May (1994 Annual report). Sofia La Fuente Pillco commenced work modelling evaporation from inland surface waters.

### 10.8 BEYOND2020

BEYOND 2020 (Burrishoole Ecosystem Observatory Network 2020) is funded under the Marine Research Programme by the Irish Government. It is a multi-institute research cluster that is working with the Marine Institute Newport Catchment Facilities to build on the existing biological and sensor monitoring programme in the Burrishoole catchment in County Mayo by using next generation science and technology to inform ecosystem response to environmental change. The team, from six Irish and UK institutes, aim to maximise and enhance the current capabilities by undertaking new analysis on lake physics and aquatic ecosystem metabolism, modelling environmental variables in the recent past and into the near future, developing Burrishoole as a testbed for new chemical and biological sensors, undertaking new aerial observations using drone technology to inform on marine-freshwater links, and harnessing next generation 'omic science, to understand, predict and communicate the role and response of aquatic ecosystems in a changing global environment. In addition, the cluster will train a set of five postgraduate and four post-doctoral researchers in cutting-edge technologies, thus building capacity and ensuring the place of the Burrishoole Ecosystem Observatory Network at the forefront of national, regional and global network science in the coming decades. The project commenced in 2017 and work is ongoing. More information can be found here: <https://www.dkit.ie/beyond-2020>. The PIs are E. Jennings (DkIT) & P. McGinnity (UCC).

### 10.9 Unlocking the Archive

This project is a collaboration with the Marine Institute, funded under the Marine Research Programme by the Irish Government. An aim of the project is to consolidate national collections of scales, otoliths, associated images and data into a single biochronology repository, thus maximising the use of the archive by researchers. Time series of scale/otolith growth and chemical composition will be analysed within the project to investigate how migratory fish respond to environmental change. The PI on the project is Deirdre Brophy, GMIT.

### 10.10 Alternative life histories (ALH): linking genes to phenotypes to demography

The Institute are collaborating with University College Cork (Dr Tom Reed), who were awarded funding for five years (2014-2019) by the European Research Council (ERC) to achieve an understanding of how genetic, environmental and physiological factors interactively shape ALH tactics in Brown Trout and how this in turn affects population demography. Project partners are the Marine Institute, Inland Fisheries Ireland and University College Cork (project lead).

Understanding how and why individuals develop strikingly different life histories is a major goal in evolutionary biology. It is also a prerequisite for conserving important biodiversity within species and predicting the impacts of environmental change on populations. The aim of the study is to examine a key threshold phenotypic trait (alternative migratory tactics) in a series of large scale laboratory and field experiments, integrating several previously independent perspectives from evolutionary ecology, ecophysiology and genomics, to produce a downstream predictive model. The chosen study species, the brown trout *Salmo trutta*, has an extensive history of genetic and experimental work and exhibits 'partial migration': individuals either migrate to sea ('sea trout') or remain in freshwater their whole lives. Recent advances in molecular parentage assignment, quantitative genetics and genomics (next generation sequencing and bioinformatics) will allow unprecedented insight into how alternative life history phenotypes are moulded by the interaction between genes and environment. To provide additional mechanistic understanding of these processes, the balance between metabolic requirements during growth and available extrinsic resources will be investigated as the major physiological driver of migratory behaviour. Together these results will be used to develop a predictive model to explore the consequences of rapid environmental change, accounting for the effects of genetics and environment on phenotype and on population demographics. In addition to their value for conservation and management of an iconic and key species in European freshwaters and coastal seas, these results will generate novel insight into the evolution of migratory behaviour generally, providing a text book example of how alternative life histories are shaped and maintained in wild populations.

This (2019) was to be the penultimate year of the ERC grant, the original end date being 30 April 2020. However, a no-cost extension of one year was successfully granted, so the new end date is 30 April 2021. The project consists of four main spokes: (1) a tank-based experiments in UCC, (2) a field-based common garden experiment in the Burrishoole catchment, (3) a genome scan study involving five different rivers along the west coast of Ireland, and (4) *in silico* modelling. The tank experiment reached its conclusion in summer 2018 and was a huge success in the end, having fuelled an entire PhD (that of Ms. Louise Archer) and several other papers that are in progress. We published a paper in *Frontiers in Ecology and Evolution* (in a special issue on "Flexibility in the Migration Strategies of Animals") on how migration decisions in brown trout emerge as a complex interplay between intrinsic and extrinsic factors (Archer et al. 2019: <https://tinyurl.com/yd65rar8>). A second paper from this lab experiment, again driven by Louise Archer, which explored interactions between food and temperature in driving flexible migration decisions in brown trout, was accepted in 2019 in the journal *Global Change Biology*, and was published in early 2020: Archer et al. 2020: <https://tinyurl.com/yajzykza>. Louise also successfully defended her PhD in October 2019, with Prof. Neil Metcalfe from the University of Glasgow being her external examiner. We have since submitted a third paper, on metabolism aspects, to the journal *Conservation Physiology* (Archer et al. *In Review*), and Louise is currently working on converting her final PhD data chapter in a manuscript for submission to the journal *Functional Ecology*.

For the field-based common garden experiment, we have established and introduced into the Srahrevagh River experimental populations consisting of the progeny of crosses from various genetic backgrounds. The goal here is to gain insights into genetic factors underpinning migration decisions, in particular facultative anadromy. In addition to annual electro-fishing, there has been the continuous monitoring, sampling and PIT tagging of the experimental populations at the

Srahrevagh River trap. In 2019 we sampled a limited number of (age 2+) smolts at the sea-entry traps belonging to our experimental cohort, and our hope is to obtain a larger sample (of age 3+ smolts) in 2019.

For the genome scan project, samples taken from our five different rivers (from below and above impassable waterfalls in each river) were sent off for outsourced whole-genome sequencing, and in 2019 we received high quality sequence data from this company. Analysis of these data has since been ongoing, with the expectation that two or more papers will result. Additionally, samples from our lab experiment for sent off for RNA sequencing in order to explore various questions related to gene expression and its regulation; again, two or more manuscripts are expected to result from this.

Finally, in 2019 we produced an individual-based eco-genetic model to explore a range of questions related to facultative anadromy in brown trout. This first paper is looking out the role of sexual conflict over migration decisions and the impacts of ectoparasites (sea lice) on life histories and population dynamics. We hope to submit this paper in late 2020.

## 10.11 SFI-DEL Investigators Programme

### **SFI-DEL Investigators Programme 2015 15/IA/3028 (2016-2021)**

*Wild farmed interactions in a changing world: formulation of a predictive methodology to inform environmental best practice to secure long-term sustainability of global wild and farm fish populations.*

This is a multidisciplinary study partnering the Marine Institute with University College Cork (joint project lead), Queen's University Belfast (joint project lead) and University of Glasgow funded by Science Foundation Ireland and the Department of Education and Learning for Northern Ireland which has commenced in 2016 to exploit novel analytical advances in population genomics (e.g. NGS; high density SNP arrays; gene expression; epigenetics) and quantitative genetics (e.g. animal model) to understand the complex effects of wild-farm hybridisation on the dynamics of quantitative traits and fitness in wild populations. The study aims to produce a working eco-genetic model for predicting the adaptive capacity of hybridised populations to respond to environmental change. The model can be directly applied to inform the sustainable management and/or restoration of wild populations in addition to the improvement of aquaculture strains. In addition we propose to test here several novel ideas: e.g. (1) the use of archives and pedigrees in common-garden and longitudinal studies to examine gene x environment interactions; (2) SNPs as biomarkers, which are linked to metabolism; (3) the first occurrence of the establishment of a Norwegian farm escape population in the wild outside Norway, which will enable the study of divergent selection in the farm fish in the wild relative to their farm progenitors; (4) surveys of gut and skin microbiomes and the application of assays for comprehensive screening of micro-parasites in Atlantic salmon.

This (2019) was the third year of the SFI-DEL project. We have arrived at a number of key milestones. There has been the development a diagnostic SNP panel of 200 genetic markers for the discrimination of multi-generational farm x wild hybrids identified from an array of 150,000 candidate markers. We have established and introduced into the Srahrevagh River experimental populations consisting of the progeny of wild, farmed and ranch origin parents, including their hybrid progeny, in 2017, 2018 and 2019 respectively. In addition to annual electro-fishing, there has been the continuous monitoring, sampling and PIT tagging of the experimental populations at the Srahrevagh River trap. We have set up a state-of-the-art PIT tag array network in the Srahrevagh River consisting of 18 antennae to study fish behaviour and movement. We have collected season specific phenotypic information for several thousand individuals, in respect of for example, energy status, metabolic potential, stream use behaviours, feeding behaviours, brain morphology, brain chemistry, microbiome community composition, body morphology, size, sex, age, parasite load. If

it moves, we measure it. We have also built a genetically based pedigree of all the returning adult salmon potentially spawning in the Burrishoole river system since 2011. Extensive sampling of the Tullaghobegley river in Co. Donegal and the Screebe river in Co. Galway to assess levels of introgression of farm genes into the local wild population has also been undertaken.

### 10.12 BBSRC-SFI Responsive Mode

#### **BBSRC-SFI Responsive Mode proposal Jes-1674874 (2016-2020)**

##### ***A microbial basis for Atlantic salmon energetics***

This multidisciplinary project which commenced in 2016 brings together world class UK and Irish fish biologists, population geneticists, microbiologists, bio-informaticians, engineers and major industry partners (Marine Institute, University College Cork – joint project lead, Marine Harvest and the University of Glasgow – joint project lead) to determine for the first time the role of salmon gut microbiota in defining host energetics, so paving the way for more sustainable salmon farming. Atlantic salmon (*Salmo salar*) are anadromous salmonids of major commercial, cultural and recreational importance in the UK, Ireland and worldwide. Metabolism, feed conversion efficiency and growth lie at the core of salmonid aquaculture productivity and its ecological impact and sustainability. The role of gut microbiota in driving energy metabolism in vertebrates is increasingly clear, opening up new avenues to fine-tune salmon metabolism and growth.

The BBSRC-SFI project focusses in detail on the microbiological aspects of the farm x wild experimental populations established as part of the SFI-DEL project. In 2019 we have been attempting to do this specifically in respect of responses of salmon gut microbiome community structure observed under natural, freshwater hatchery and sea farm conditions. Access to the sea farm experimental facility at Lehanagh Pool has been a massive addition to the project. We have now put two test populations through the facility. In addition, an artificial simulated laboratory based bioreactor system has been developed by our partners at the University of Glasgow (<https://www.llewellynlab.com/salmosim>) that simulates microbial communities present in three major gut compartments of salmon: stomach, pyloric caecum, and mid-intestine. We have been characterising microbiomes these various environments using high-end sequencing methods. Good progress has also been made on biochemical marker identification, testing of bead based artificial mucosal splant energetically divergent microbiota to a population of control fish with the objective of manipulating their energetic profile.

### 10.13 SALMSON – European Maritime and Fisheries Fund Knowledge Gateway

#### **Programme**

A new state-of-the-art freshwater RAS (Recirculating Aquaculture System) at the Marine Institute's Newport Research Facility has been developed and is being utilised as part of a major research project to address the needs of Ireland's aquaculture sector. The four-year research project, SALMSON smolt, is investigating the potential of RAS technology to produce larger Atlantic salmon pre-smolts. The aim is to produce smolts that are more robust and also reduce the grow-out time at sea to one year. The SALMSON Project is funded under the European Maritime and Fisheries Fund Knowledge Gateway Programme and is administered by Bord Iascaigh Mhara (BIM).

The Marine Institute RAS in Newport, consists of eight 5.5m<sup>3</sup> tanks with a capacity of 44,000 litres and it is capable of producing up to 12,000 Atlantic salmon pre-smolts at a time. By linking up with the Lehanagh Pool Marine Research Site at Beirtreach Buí Bay, Co Galway, the SALMSON project

will follow the performance of the smolts after they are transferred to sea and will be compared with smolts grown in conventional flow-through tanks. One of the key objectives of the project is to ensure that this type of production is compatible with organic certification standards, as Atlantic salmon in Ireland are exclusively produced to organic certification standards.

#### **10.14 HYDRO-fish**

The Marine Institute is collaborating with NUI Galway, Bio-Marine Ingredients Ireland and Teagasc on the HYDRO-fish project funded by the Disruptive Technologies Innovation Fund through the Department of Business, Enterprise and Innovation. The HYDRO-fish research project is designed to produce tangible products for the aquaculture industry in order to disrupt the current farming practises. It will serve by producing a high-quality bioactive product based on applying novel and refined biotechnological solutions to the aquaculture sector, notably the Irish salmon industry. It will address the need for ensuring the sustainable development of the industry in meeting the requirement for natural feed ingredients to mitigate the dependency on both fishmeal and plant ingredients in commercial fish diets.

Commercial salmon diets are largely based on such materials. Additionally, there is a need for alternatives to the use of antibiotics to avoid the development of antimicrobial resistance in aquatic pathogens. Salmon are still subject to various diseases both infectious and production related with many stressors and challenges to face. The HYDRO-fish plan will be for a major disruptive input in the form of fish protein hydrolysates using these as both a partial substitute for the primary diet ingredients as well as developing their potential as functional additives to promote enhanced gastrointestinal integrity, boost the immune system of salmon and strengthen the gut/mucosal and integument interface of fish to improve resistance to bacterial, fungal and ectoparasitic pathogens. The fish protein hydrolysate is based on the fisheries catch of pelagic fish bycatch where the waste by products are processed into a fish hydrolysate. A selection of such fish species is envisaged to guarantee fluidity of supply. The project will offer a low risk, innovative and enterprising strategy to maximise the value of fish protein hydrolysate products in the aquaculture market where they would be of much higher value. They are currently exploited for human consumption and compliant with very high standards. The programme will develop an optimised range of bespoke fish hydrolysates developed to meet the needs for the growing Irish (>€100 million trade 2016) and global (>€121 billion trade in 2016) aquaculture sector with particular focus on Atlantic salmon.

## 11 Publications

### 11.1 Peer-review 2019

- Archer, L., Hutton, S., Harman, L., McCormick, S., O'Grady, M., Kerry, J., Poole, R., Gargan, P., McGinnity, P., Reed, T. (2019). Food and temperature stressors have opposing effects in determining flexible migration decisions in brown trout. *Global Change Biology*.
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- Carrea L., Woolway R.I., Merchant C., Dokulil M.T., de Eyto E., DeGasperi C.L., et al. (2019). Lake surface temperature [in "State of the Climate in 2018"]. *Bulletin of the American Meteorological Society* **100**, 13–14
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- de Eyto, E., Kelly, S., Ryder, E., Dillane, M., Archer, L., O'Cathain, D., Daly, S., Lyons, K., Obrador, B., Brentrup, J., Naumoski, A., Poole, R., Lucey, F., Jennings, E., High frequency monitoring reveals fine scale spatial and temporal dynamics of the deep chlorophyll maximum of a stratified coastal lagoon. *Estuarine, Coastal and Shelf Science* (2019), doi: <https://doi.org/10.1016/j.ecss.2018.12.010>.
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- Masó, G., Kaufmann, L., Clavero, H., & Fitze, P. S. (2019). Age-dependent effects of moderate differences in environmental predictability forecasted by climate change, experimental evidence from a short-lived lizard (*Zootoca vivipara*). *Scientific reports*, 9(1), 1-10.
- Muhlfeld, C.C., Dauwalter, D.C., D'Angelo, V.S., Ferguson, A.F., Giersch, J.J., Impson, N.D., Koizumi, I., Kovach, R.P., McGinnity, P., Schöffmann, J., Vollesatad, L.A. and Epifanio. (2019). Global status of trout and char; conservation challenges in the 21st Century. In *Diversity and Status of Trouts & Chars Worldwide*, American Fisheries Society ISBN 978-1-934874-54-7.
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- evolutionary potential for sea-age at maturity, but not size within age-classes. *Canadian Journal of Fisheries & Aquatic Science*; 10.1139/cjfb-2018-0123.
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## 11.2 Reports – 2019

- ICES. 2019. Report of the Working Group on Science to Support Conservation, Restoration and Management of Diadromous Species (WGDIAD), 10 September 2019, Gothenburg, Sweden. *ICES Fisheries Resources Committee*: 21 pp.
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- TEGE. 2019. Activity report of the Technical Expert Group on Eel, 2018. Report to DCENR & IFI; 132pp.