National Salmonid Index Catchment Erriff Annual Report

IFI/2025/1-4746

Iascach Intíre Éireann
Inland Fisheries Ireland

fisheriesireland.ie

National Salmonid Index Catchment Erriff
Annual Report 2023

CITATION: Kelly, S., Wightman, G., Kelly F.L., Ó'Briain R., Roche, W. & Millane, M. (2025). National Salmonid Index Catchment Erriff, Annual Report 2023. Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24. 63 pp.

DOCUMENT CONTROL SHEET

Name of Document:	National Salmonid Index Catchment Erriff Annual Report 2023				
Author (s):	Seán Kelly, Glen Wightman, Fiona Kelly, Rossa Ó'Briain, William Roche, Michael Millane				
Authorised Officer:	Michael Millane				
Description of Content:	This document reports on research activities undertaken in the National Salmonid Index Catchment River Erriff in 2023.				
Approved by:	Cathal Gallagher				
Date of Approval:	24/01/2025				
Assigned review period:	n/a				
Date of next review:	n/a				
This document comprises	TOC	Text	List of tables	List of Figures	No. Appendices
	YES	YES	NO	NO	1

Version Control Table

Version No.	Status	Authors(s)	Reviewed by	Approved by	Date of issue
1.0	Issued	Seán Kelly	Glen Wightman, Fiona Kelly, Rossa Ó'Briain, William Roche, Michael Millane	Michael Millane	22/01/2025
2.0	Issued	Seán Kelly, Glen Wightman, Fiona Kelly, Rossa Ó'Briain, William Roche, Michael Millane	Cathal Gallagher	Cathal Gallagher	24/01/2025

Table of Contents

1 Scope

This document reports on research activities undertaken in the National Salmonid Index Catchment (NSIC) River Erriff during 2023. The document recounts the data recorded in the NSIC for this year and sets it in the context of the long-term annual data time series collected as part of the core NSIC Erriff research programme. Summaries of specific research activities conducted in the relevant reporting year are also provided. More detailed and comprehensive information on methods used and outputs from specific areas of interest can be found in associated literature as this is made available. The research undertaken aims to address knowledge gaps on migratory salmonids to better inform fisheries management in Ireland as well as to inform national and international scientific advice provision and the reporting obligations of IFI.

2 Introduction

The River Erriff system (Co. Mayo) has been designated by Inland Fisheries Ireland (IFI) as the National Salmonid Index Catchment (NSIC). A dedicated research station with fish counting and trapping facilities is located at Aasleagh Falls by the mouth of this prestigious Atlantic salmon and sea trout fishery which flows into Killary Harbour fjord on the western Irish Atlantic coast. The research facility is managed by IFI and supports a wide range of scientific research and monitoring activities principally on the resident salmonid populations and their migratory component as undertaken by the state agency and its national and international partners.

This work aims to contribute to developments in the scientific understanding of the biology, marine and freshwater ecology, life histories and population dynamics of Atlantic salmon and sea trout, and the effects of environmental and anthropogenic factors on their continued sustainability. In this regard, as an “index catchment” for salmonids, the Erriff acts as a representative model system to better inform the conservation and management of salmon and sea trout stocks throughout Ireland and further afield, meeting national and international obligations through the focused research activities described herein.

Such obligations notably include providing scientific information on Atlantic salmon stock status for national assessments (for the Technical Expert Group on Salmon, North-South Standing Scientific Committee for Inland Fisheries, IFI, Department of Environment, Climate and Communications and Habitats Directive reporting) and international assessments (for the International Council for the Exploration of the Sea, the EU and North Atlantic Salmon Conservation Organisation). As such, the research activities aim to support EC Habitats Directive conservation objectives which are “to restore the favourable conservation condition of Atlantic Salmon” in Irish SACs.

3 Site description

3.1 Study area

The NSIC Erriff comprises the Erriff Catchment and Killary Harbour fjord area, with research activities further extending out into the adjacent marine zone. The catchment comprises the Erriff River, a number of its tributaries such as the Black, Owenmore and Derrycraff rivers and three primary lakes, Loughs Tawnyard, Lugacolliwee and Glenawough, encompassing a total catchment area of 169.9 km^2. The primary research infrastructure in the NSIC comprises fixed fish trapping facilities and a laboratory facility at Aasleagh Falls (for monitoring of upstream migrating adult salmon and sea trout) and at Tawnyard Lough outflow (for monitoring downstream migrating juvenile salmon and sea trout smolts and kelts). Additional research resources include deployment of rotary screw traps during the main smolt run, annual catchment-wide juvenile salmonid electrofishing surveys, acoustic telemetry arrays to support studies of salmon and trout migration behaviour and a climate/environmental monitoring programme of stream and lake environments (Figure 1). The river discharges into the Atlantic Ocean *via* Killary Harbour at Aasleagh Falls located at the innermost point of the fjord. The Harbour is 14 km long extending from the townland of Aasleagh to the outer end of Inishbearna Island and has a maximum depth of 45 m. A commercial enterprise, Rosroe Salmon Farm, operates at two sites in Killary and surrounding waters, namely west of the pier in the village of Rosroe and on the eastern shore of Inishdeighil island outside the mouth of the Harbour. Extensive cultivated mussel farms also extend the length of the Killary along its south shore (Figure 1). The majority of the Erriff catchment is within the Mweelrea/Sheeffry/Erriff Complex Special Area of Conservation (SAC). Killary Harbour is also bordered by the Twelve Bens Garraun Complex and Maumturk Mountains SACs on its southern side.

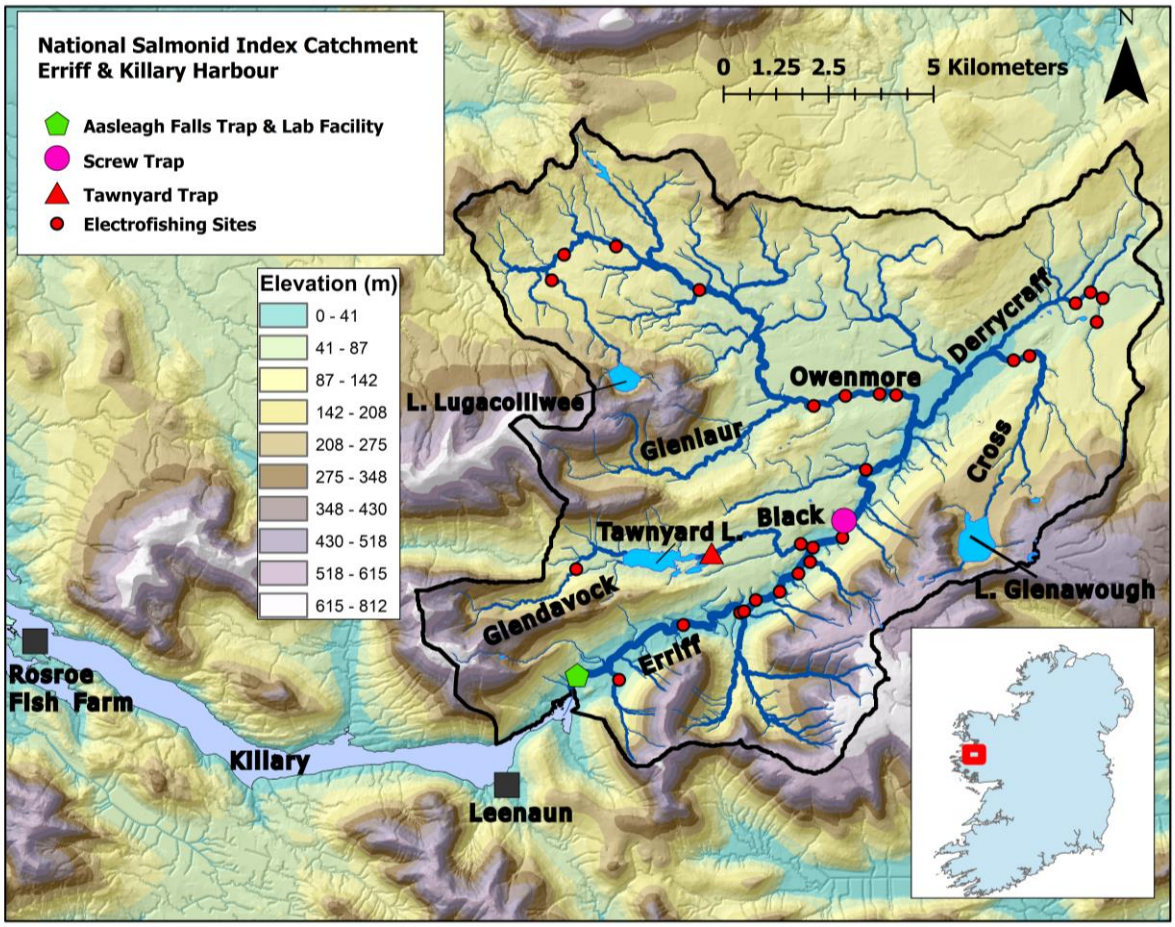


Figure 1 National Salmonid Index Catchment (Erriff Catchment and Killary Fjord) showing fixed trapping infrastructure and principal tributaries, lakes and estuarine zone.

3.2 Resident and migratory fish species

Erriff fish stocks principally comprise Atlantic salmon, sea trout and brown trout. Eels, minnow and stickleback are also present. The salmon conservation limit for this river system is 1385 and the Erriff salmon stock is predominately made up of one-sea-winter grilse. Annual sea trout returns are principally comprised of finnock (i.e. return in the same year as smolt migration), more notably so since the wider collapse of sea trout stocks in the west of Ireland in the early 1990s which has been associated with commercial salmon farming (e.g. Gargan et al. 2016). The Tawnyard sub-catchment is the focal point of long-term studies on Erriff sea trout stocks. Brown trout are present throughout the catchment, notably more abundant in the smaller order streams and lakes, although specific stock information is not available, nor is there specific stock information available for eels.

Salmon ranching for scientific purposes (i.e. studies on the effects of sea lice on marine survival) were undertaken in the Erriff from 2003 with smolts released annually until 2019 when this work ceased. However, ranching solely for angling purposes commenced in 2021 (see Section 3.3.). Ranching strays from the nearby Bundorragha River are also intercepted annually in the lowermost reaches of the Erriff in the upstream fish trap and by anglers at

Aasleagh Falls and typically removed to prevent further upriver migration. Farmed salmon and Pacific pink salmon have on occasion been intercepted attempting to enter the river and removed in the same manner.

3.3 Fisheries

Game angling is an important activity in the Erriff main channel and at Aasleagh Falls with salmon the primary species targeted. A catch and release policy has been implemented in recent years by local agreement with all wild salmon caught released and a ranched salmon provided *in lieu*. A tightly regulated and licensed commercial draft-net fishery for salmon operates in Killary Harbour each summer. Both angling and commercial fishing activity is managed locally by IFI and subject to catch quotas which are informed by annual scientific stock assessments undertaken by the Technical Expert Group on Salmon and published in national regulations.

3.4 Research infrastructure

A detailed overview of the preexisting operational fisheries research infrastructure was provided in Kelly et al. 2023. Plates 1 to 3 briefly recap this. No further fisheries research infrastructure was installed or developed during 2023.

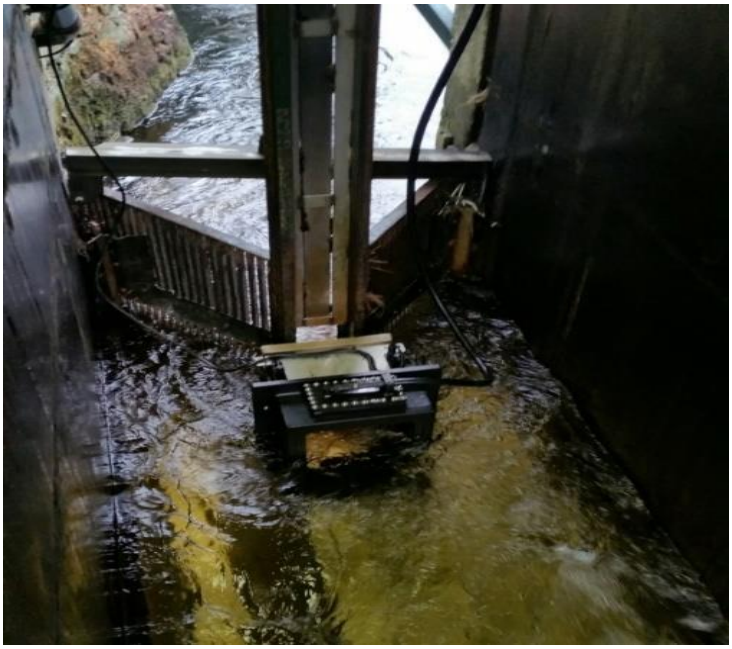


Plate 1 Erriff upstream adult fish trap with VAKI Riverwatcher counter and Biomark antenna (dark rectangular unit). Fish migrating upstream past Aasleagh Falls (tidal limit) enter through the trap door and are manually identified as sea trout or salmon (grilse or multi-sea winter) and ranched salmon are intercepted and removed. Detections of PIT tagged fish are registered and typically tagged fish are sampled for length, weight and scale sampled and released (see Section 4.2.1).

Plate 2 Wolf-trap located along the outflow from Tawnyard Lough captures downstream migrating smolts and kelts. In 2023, this trap was operated daily from March through mid-June. All fish entering the trap were visually classified as salmon or sea trout (kelt or smolt) and a subsample were measured and PIT or acoustically tagged (section 4.2.2 & 4.2.3)

Plate 3 Rotary screw trap for capturing smolts in operation on the main river channel at Erriff Bridge. This trap was deployed during April-May in 2023 primarily for the purposes of capturing emigrating salmon and sea trout smolts for PIT and DST tagging (section 4.2.3)

4 Research objectives and activities

4.1 Background

The principle guiding objective informing the research undertaken in the NSIC Erriff is:

> *to assess current status and address key knowledge gaps to better understand the biology, ecology and stock dynamics of migratory salmonids and the associated influences of environmental and anthropogenic pressures and threats to their continued sustainability to better inform their wider protection, fisheries management and conservation in Ireland and further afield*.

Dedicated research on migratory salmonids (i.e. Atlantic salmon and sea trout) has been undertaken in the NSIC Erriff since the early 1980s. This has primarily focused on monitoring the annual stock status of returning adults and out-migrating smolts and kelts, as well as quantifying the impacts of sea-lice associated with salmon aquaculture on wild stocks. Since 2007, catchment-wide juvenile fry production has been assessed annually. This annual programme of work has enabled the collation of valuable long-term time series which are used to monitor stock trends; identify, quantify and better understand threats and pressures; comply with Ireland's reporting obligations; and provide necessary data to develop and populate national and international stock assessment models which are used to inform fisheries management. The latter includes the provision of data to establish conservation limits and set catch quotas to protect against the over-exploitation of salmon stocks and better ensure their long-term sustainability.

In addition, the unique setting of both downstream and upstream traps facilitate annual sub-sampling of wild juvenile and adult salmon and sea trout populations to record pertinent biological information such as length and weight and to retrieve scale samples for further analyses (Plate 4). Such information can provide insight into freshwater and marine growth rates, which can ultimately affect marine survival and fecundity.

Plate 4 Recording length of a sea trout kelt, undertaking its second emigration from Tawnyard Lough to the marine environment. The NSIC Erriff infrastructure and biological sampling programme offers unprecedented insights into the ecology of wild anadromous trout.

Reporting obligations for IFI include:

- Provision of adult returns, biological data and catch information to the Technical Expert Group on Salmon for the annual national stock assessment. Biological information is used to determine necessary inputs to the stock assessment model.
- Provision of catch and biological information on salmon to the European Union Multi-Annual Programme (EU DCMAP) pending its commencement.
- Article 17 reporting of stock status under EC Habitats Directive.
- Provision of fisheries and biological data on salmon to the International Council for the Exploration of the Sea (ICES) and the North Atlantic Salmon Conservation Organisation (NASCO). Biological information is primarily used to determine necessary inputs to the ICES stock assessment model.
- Provision of sea trout smolt and kelt output and adult returns to determine marine survival and other biological data.

More recent research (since the mid-2010s) has focused on quantifying the survival of migratory stocks during their freshwater and the marine life stages and identifying the key contributory pressures (such as impacts from salmon aquaculture) and migration bottlenecks (such as predation hot-spots and migration barriers) that may unduly supress stocks. This is principally conducted through tagging / telemetry studies.

The NSIC Erriff has also provided a valuable dedicated resource to undertake disease surveillance (notably of sea lice infestation, red vent syndrome, red skin disease and other parasites), and invasive species surveillance (for farmed escapees and Pacific Pink salmon) annually throughout the seasons. Furthermore, the NSIC Erriff has recently been developed as key index site in Ireland for an IFI project to monitor and assess the impacts of climate change on fish and their surrounding environment through the establishment of a catchment-wide environmental sensor network. Research in the NSIC Erriff is often undertaken in collaboration with international partners which contribute to the research objectives.

4.2 Research methodologies in 2023

This section describes the core long-term research activities undertaken at the NSIC Erriff in 2023, including the general methodology utilised, as well as any novel research activities that occurred.

4.2.1 Adult salmonid stock monitoring programme

Returning wild adult Atlantic salmon and sea trout are monitored at the fixed trapping infrastructure at Aasleagh Falls for enumeration, biological sampling and disease surveillance purposes. Total counts for stock assessment purposes, measurements of lengths, weights and scale sampling and surveillance for disease (red skin disease (RSD), red vent syndrome (RVS), sea lice infestation and invasive species monitoring (Pacific pink salmon and escaped farmed salmon) are conducted here. Upstream migrating fish are visually classified as wild one-sea winter grilse, multi-sea winter salmon or sea trout and total numbers recorded daily. A subsample of adult fish (approximately 100 sea trout and 100 salmon, inclusive of PIT tagged fish (section 4.2.2)) are briefly removed from the trap, anaesthetised and sampled in the lab facility adjacent to the trap. Lengths and weights of sampled fish are recorded and typically a scale sample is taken. Observations related to predation or net marks are noted. Sea lice infestation rates are documented for the subsampled adult sea trout run by visually counting and recording numbers of both chalimus juvenile and pre-adult/adult lice present (Appendix 1). In 2023, the revised classification system developed in association with the Environment Agency UK, Marine Scotland and Natural Resources Wales to align reporting between Ireland and Britain regarding assessment of the prevalence and severity of red skin disease (RSD) in salmon (RSD Severity Field Guide, 2022, Appendix 2) was used. In addition, the classification system used by the Environment Agency UK and Marine Scotland was adopted to assess the severity of RVS in salmon (RVS Severity Field Guide, 2011, Appendix 3).

4.2.2 Juvenile and post-spawner salmonid stock monitoring programme

Out-migrating Atlantic salmon and sea trout smolt and kelt monitoring occurs at the fixed trapping infrastructure at Tawnyard during the annual smolt/kelt run (March to June). A

complete count of all out-migrating fish is possible using the Wolfe-type trap. This enables year-to-year estimates of smolt output at this key tributary, particularly for sea trout. Each fish entering the trap is visually classified as a salmon or sea trout and enumerated. A subsample form the basis of the various tagging programmes carried out in the NSIC (section 4.2.3). In addition, the majority of sea trout kelts entering the Tawnyard trap are measured for lengths to continue the long-term monitoring programme of sea trout age-classes, which has been in place since 1985.

4.2.3 Tagging programmes

Owing to the ability to capture wild salmonids on their downstream and upstream migrations passively, tagging programmes represent a core element of the NSIC research activities. A medium-to-long term component of NSIC tagging activities comprises the mark-recapture PIT tagging programme of Atlantic salmon and sea trout. Annually, out-migrating smolts are tagged at the fixed trapping facility at Tawnyard, a primary tributary of the Erriff, and at a temporarily deployed rotary screw trap on the main Erriff channel. 500-1000 salmon and sea trout smolts are captured, anaesthetised, measured and tagged with a unique PIT tag each year. Subsequent salmonid returns to the Aasleagh upstream trap are monitored for the presence of PIT tags, both through an automated Biomark PIT tag antenna located at the entranceway to the trap and through the use of a handheld Biomark PIT tag scanner. Efforts are made to retrieve PIT tagged fish to include as part of the core biological sampling programme (section 4.2.1), which in turn can provide information on marine return rates, time period spent at sea and marine growth rates. Additional tagging programmes which arise year-to-year include acoustic tagging of sea trout smolts and deployment of acoustic receivers throughout the Erriff River and Killary Harbour, in an effort to inform on sea trout migratory movement and behaviour, especially in the context of aquaculture interactions. In recent years, a subsample of Atlantic salmon smolts have been tagged with data storage tags (DSTs) (Plate 5) as part of the EU NASCO-coordinated SMOLTrack project (https://smoltrack.eu/). DSTs record at set intervals the ambient water temperatures experienced by tagged fish, which could ultimately inform on marine migration routes. DST-tagged salmon also received a PIT tag, which would allow their subsequent detection and recapture at the Aasleagh trap upon return.

4.2.4 Catchment-wide juvenile salmonid electrofishing survey

Catchment-wide electrofishing is carried out for the purposes of stock assessment of juvenile salmonids (fry and parr) at sampling locations throughout the Erriff catchment during late summer (August-September) (Figure 1). Weather-dependent, survey sites are kept consistent year-to-year and the methodology involves timed (5-minute) electrofishing in riffle habitat to provide a semi-quantitative estimate of juvenile salmonid abundance at each location. Each

captured fish undergoes fork length measurements to nearest mm and is visually classified as salmon or trout.

4.2.5 Climate change research programme

In collaboration with IFI's Climate Change Mitigation Research Programme (CCMRP) a catchment-wide array of thirty-five stream and river water temperature data loggers are maintained and turned-over annually (Figure 2). Data loggers record water temperature at 30-minute intervals and were strategically placed at locations throughout the catchment to enable comprehensive coverage of all stream and river types, in order to characterise the response of the Erriff watershed to climate variations throughout the year, a critical element of salmonid ecology during their freshwater phase. A fully-automated meteorological station is present at the Aasleagh Falls trap. In addition, a thermistor array, dissolved oxygen sensors, water level gauges and a shoreline meteorological station are deployed year-round in Lough Tawnyard (Plate 6) to enable limnological appraisals of this lake system, which is a critical habitat element of the migratory and resident trout populations of this sub-catchment.

4.2.6 River Erriff hydromorphological condition assessment study

A catchment-wide characterisation of river hydromorphology condition was performed during 2023 (funded through the Salmon and Sea Trout Rehabilitation, Conservation and Protection Fund award SCF-22-0896). The objective of the research study was to classify the current state of physical river habitat throughout the catchment and identify hydromorphological features and pressures that may require management intervention to mitigate against adverse hydrological and climatological conditions (e.g. heatwaves, droughts, floods), ultimately to meet the ecological objective of having at least "Good" status in line with the Water Framework Directive and Habitats Directive. Furthermore, it was envisaged that this study would provide a frame of reference more generally for salmonid habitat in similar river systems nationally.

Plate 5 Pit tag and DST tag inserted into sea trout smolt captured at Tawnyard downstream trap.

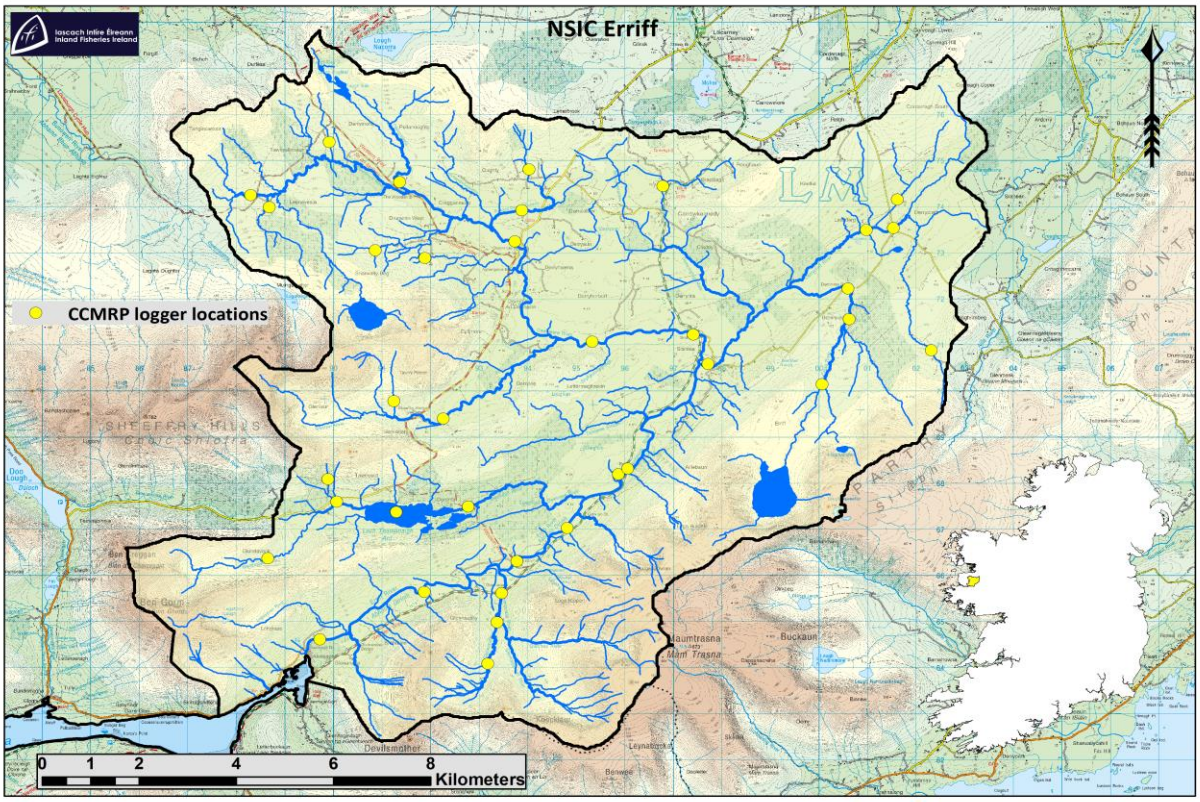


Figure 2 Catchment-wide water temperature monitoring network in NSIC Erriff for IFI's Climate Change Mitigation Research Programme (location of data loggers and thermistor array in Tawnyard Lough).

Plate 7 Tawnyard Lough, December 2023.

5 Results

5.1 Atlantic salmon adult returns

In 2023, the total number of adult wild salmon counted and released upstream through the Aasleagh fish trap was 1,358. Commencing in 2023, counts of adult upstream migrating salmon were partitioned between one-sea winter grilse and multi-sea winter components, primarily through expert-judgement of research staff operating the trap. These visual classifications were underpinned by findings of length-frequency modal analysis of Erriff adult salmon, which implied that fish with a length greater than 69 cm are most likely multi-sea winter salmon (Kelly et al. 2023). Furthermore, scale reading of sampled fish was used to corroborate visual categorisation of sea-age class based on size criteria alone. Of the 1,358 wild adult salmon counted through the trap in 2023, 88 fish were classified as multi-sea winter and 1,270 as grilse (Figure 3). 508 ranched salmon also returned to the Aasleagh trap, where they were intercepted and removed from further upstream migration. In addition to fish counted through the trap, 66 adult wild salmon were caught below Aasleagh falls by anglers and released above the falls, thereby bypassing the trap counts, which brings the total estimated adult salmon returns for 2023 to 1,424, just exceeding the conservation limit for this river system (Figure 4). Returns of salmon in 2023 were marginally up on 2022 (1,364 fish) but are considerably lower than the annual average recorded in the preceding 5-year period 2018-2022 (2,305 fish) and compared to the full available timeseries (1986-2023) appeared to be a relatively poor return year (Figure 4; Table 1).

Observations of the timing of adult returns and upstream migration showed an initial small run of multi-sea winter “spring fish” between April and May (Figure 5). However, larger multi-sea winter salmon continued to return sporadically throughout the entire summer period, with small numbers returning in autumn through to winter. The grilse run commenced in earnest in mid-to-late June, with largest numbers returning through July and August (Figure 5; Table 2). Notably, later returns of grilse, albeit in smaller total abundances compared to peak July and August runs, continued to occur from September through to December.

5.2 Sea trout adult returns

Returns of sea trout in 2023 counted through the Aasleagh trap was 803 (Figure 3; Table 1). This represents a substantial decline from numbers recorded for 2022 (1,958 fish) and is also lower compared to mean annual figures for the preceding 5-year mean (2018-2022) of 1,407 fish (Figure 4). Whilst representing a marginal improvement over particularly poor returns of sea trout since 1998, the sea trout returns in 2023 were generally below average.

The majority of upstream migrating sea trout occurred earlier in the summer period during June and early August, the bulk of which comprised by finnock (Figure 5). Smaller numbers of returns continued to occur sporadically from August through to the autumn/winter months.

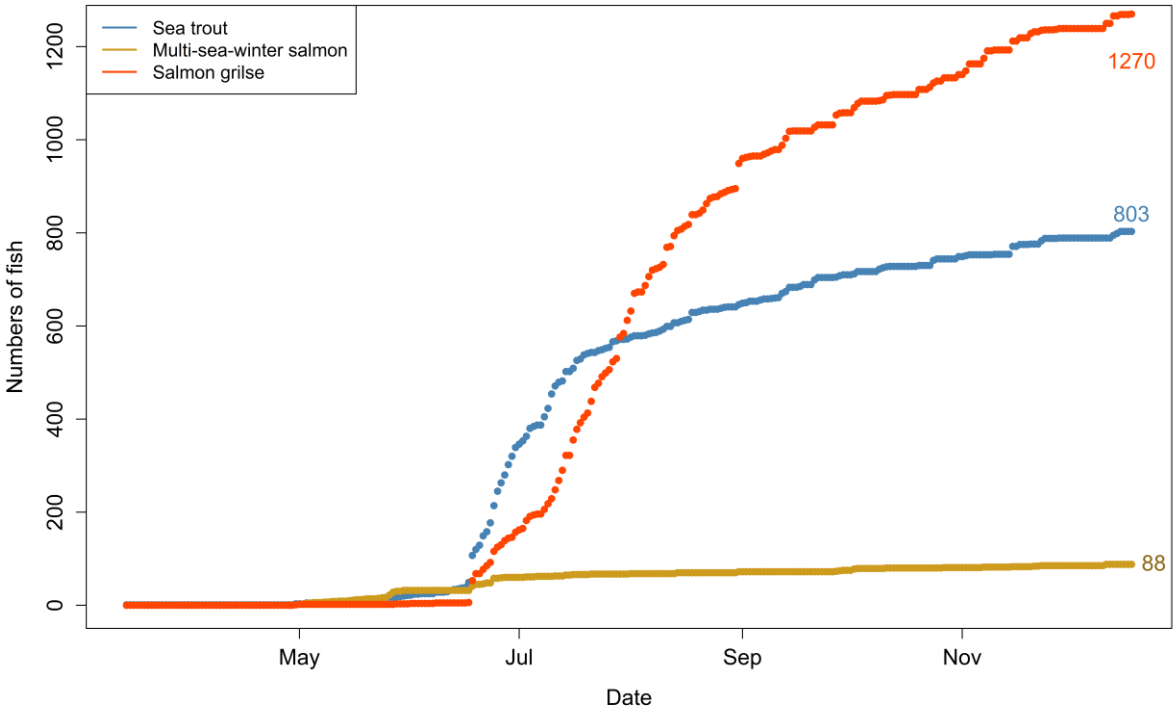


Figure 3 Cumulative returns of wild Atlantic salmon grilse (orange), multi-sea winter (yellow) and sea trout (blue) to the River Erriff upstream Aasleagh trap over the 2023 season.

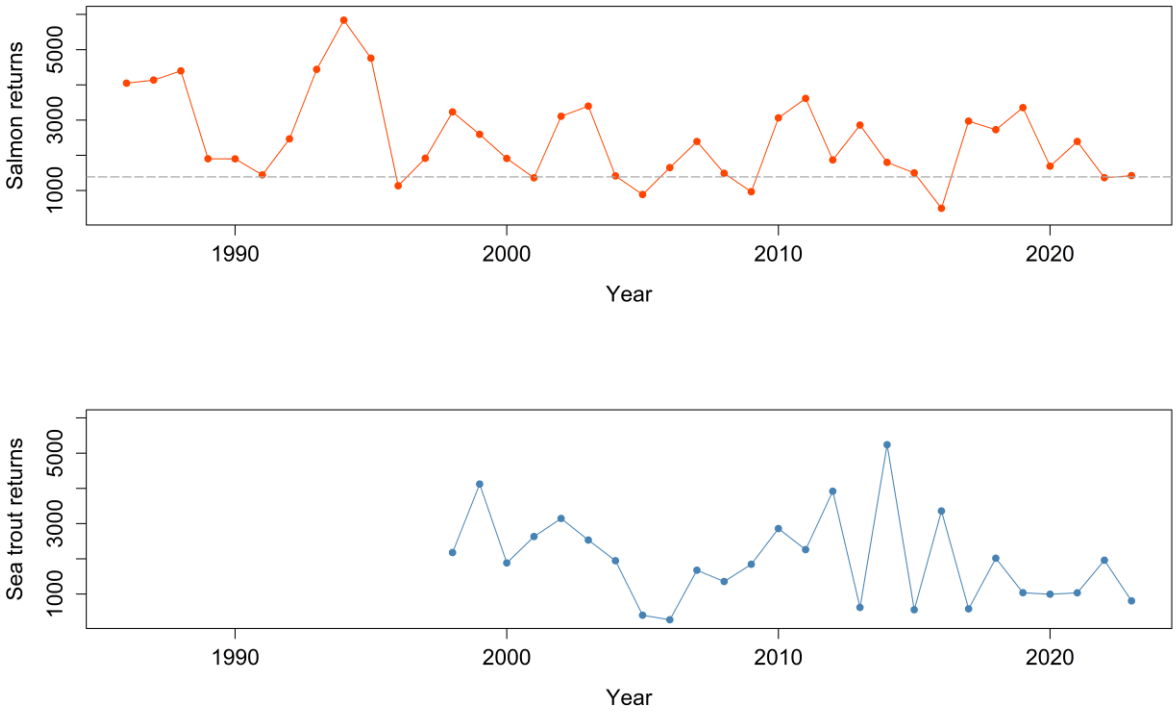


Figure 4 Annual total returns of wild Atlantic salmon (top panel) and sea trout (bottom panel) to the upstream Aasleagh trap. Dashed line in upper panel represents the river-specific conservation limit for Erriff Atlantic salmon.

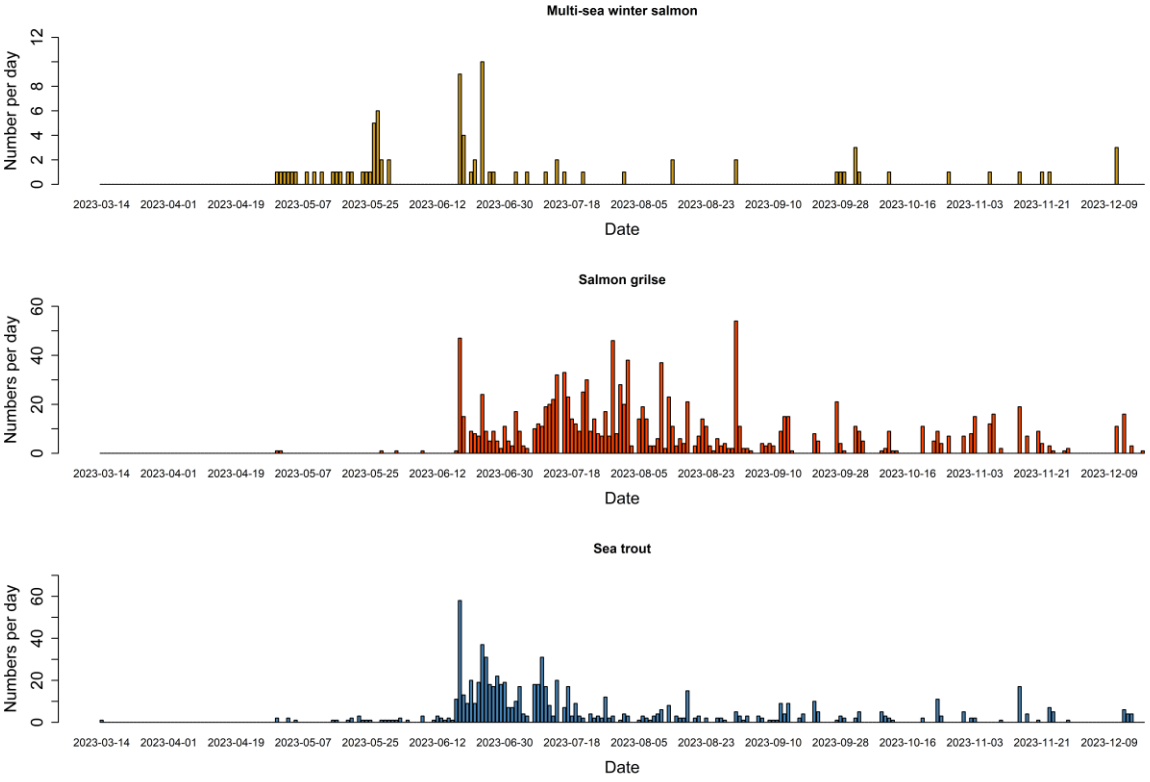


Figure 5 Daily counts of multi-sea winter salmon (top panel), salmon grilse (middle panel) and sea trout (bottom panel) through the upstream Aasleagh trap over the course of 2023.

5.3 Out-migrating smolts and kelts

In 2023, 932 wild salmon and 1,002 sea trout smolts and 197 sea trout kelts and zero salmon kelts were recorded at the Tawnyard trap, during its operation from 1st March until 14th June (**Error! Reference source not found.** and **Error! Reference source not found.**). The salmon smolt run occurred steadily throughout the month of April and had mostly finished by May (Figure 7). In contrast, smaller runs of sea trout smolts emigrated sporadically during March and April, with the bulk of the sea trout smolt run occurring over a four-day period in early May (Figure 7). The sea trout kelt run initiated earlier than either smolt run in mid-March and continued sporadically up until early May (Figure 7).

Since 2020, the annual output of sea trout smolts has shown successive decreases and the periodic relatively large runs recorded prior to 2009 have not been observed since that time (Figure 8). A marginal upward trend is apparent in salmon smolt runs since the time series low of 2013, although the annual output of salmon smolts in 2023 represented a decrease from 2022 (1,312). The sea trout kelt run is variable year-to-year but in general kelt numbers in the last 5-year period (2023 inclusive) have not reached timeseries highs recorded in the timeseries during the late 1990s, early 2000s and early-mid 2010s (Figure 8).

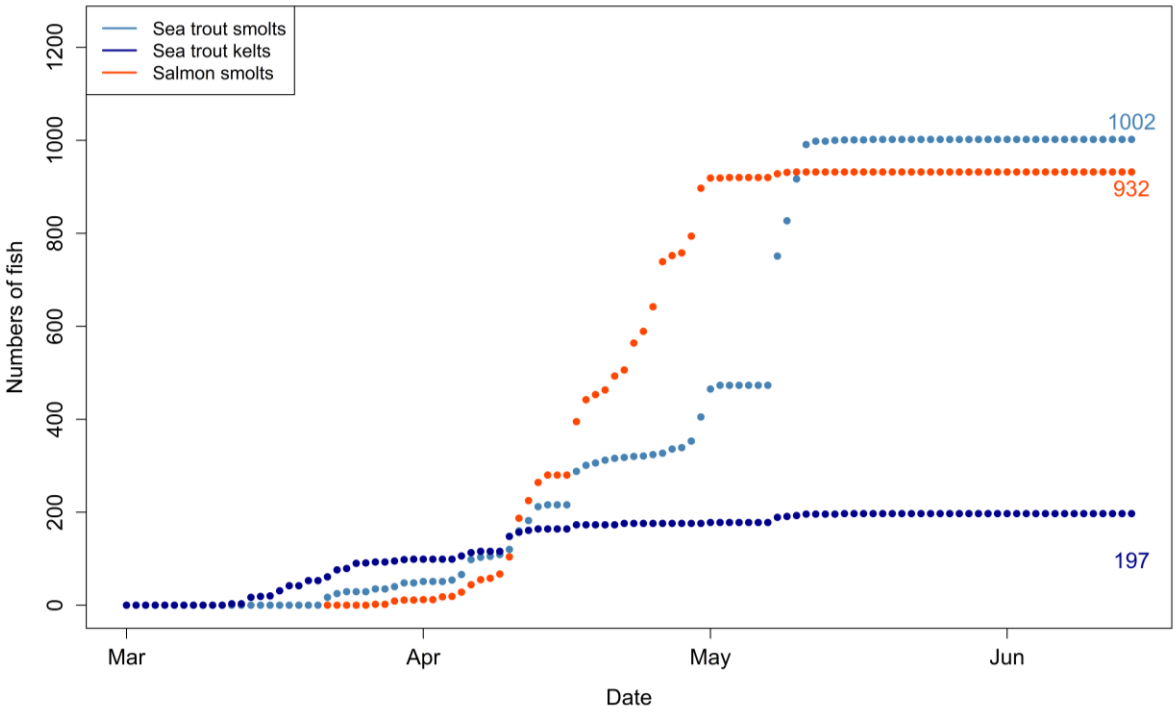


Figure 6 Cumulative outputs of wild Atlantic salmon smolts (orange), sea trout smolts (light blue) and sea trout kelts (dark blue) from the Tawnyard trap over the 2023 season.

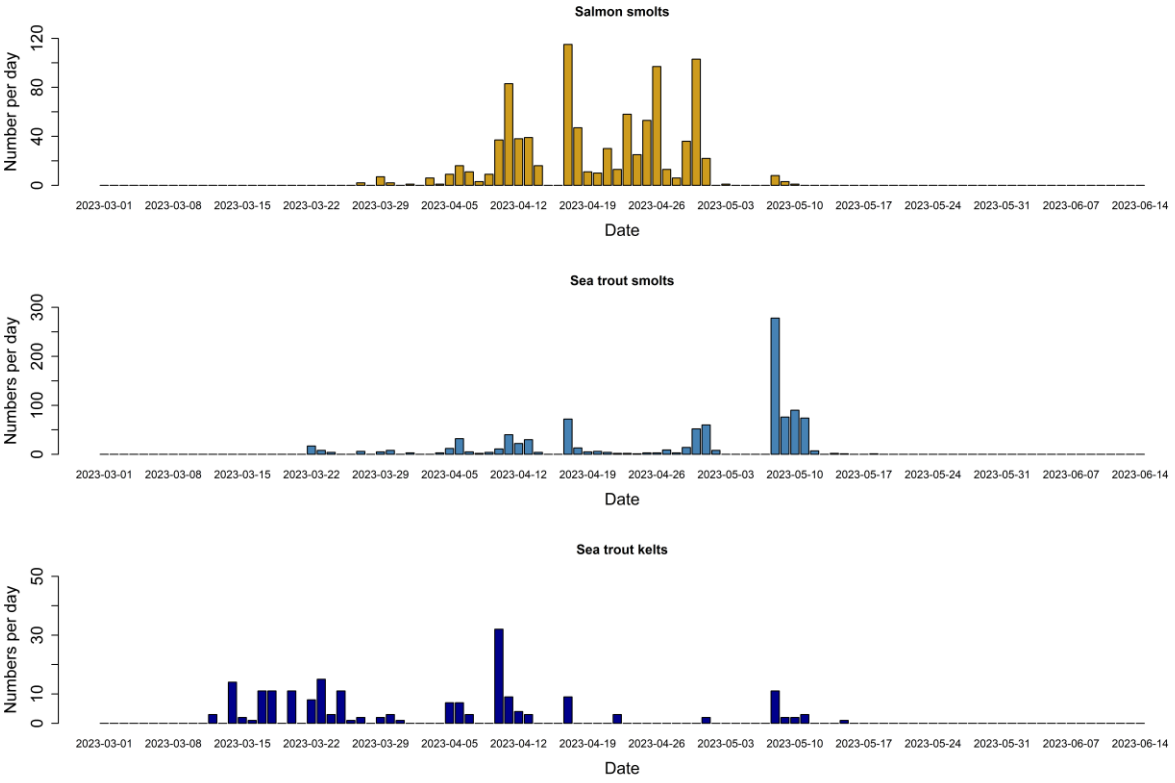


Figure 7 Daily counts of Atlantic salmon smolts (top panel), sea trout smolts (middle panel) and sea trout kelts (bottom panel) through the downstream Tawnyard trap during 2023.

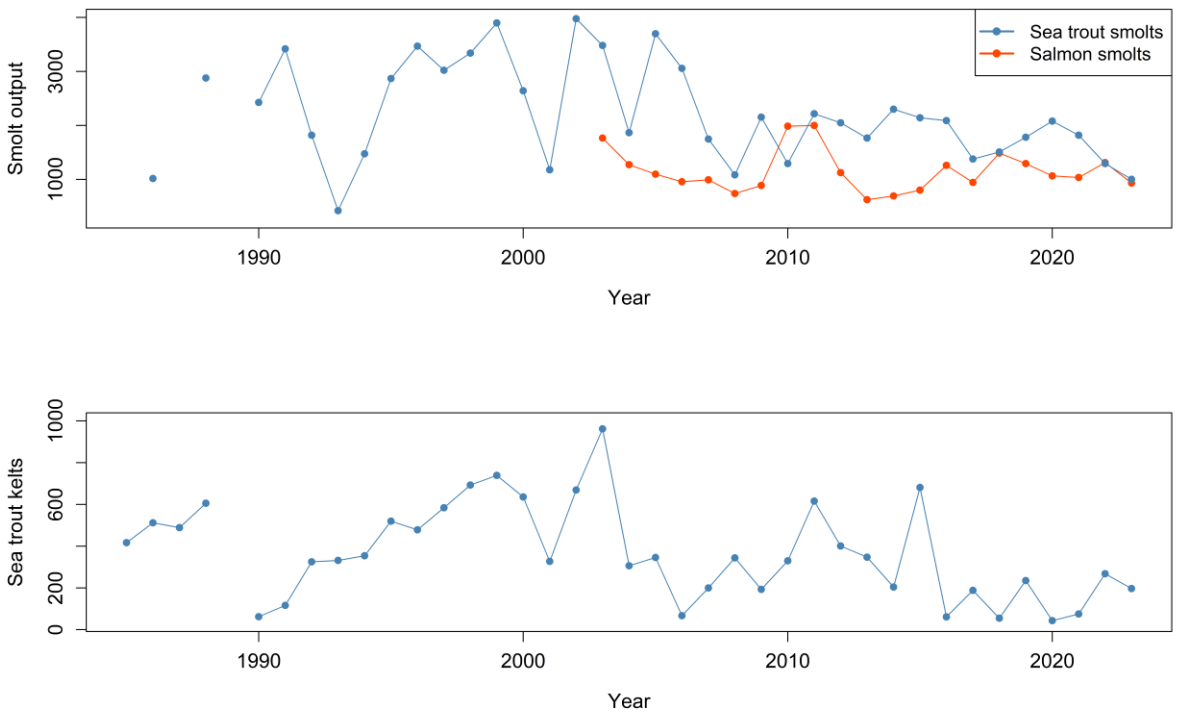


Figure 8 Annual total downstream counts of wild Atlantic salmon smolts (orange, top panel), sea trout smolts (blue, top panel) and sea trout kelts (bottom panel) from the Tawnyard trap.

5.4 Salmonid biological data

106 wild adult salmon were sampled for lengths and weights during the adult return run in 2023 (Table 3), with nine of these fish classified as multi-sea winter and 97 classed as grilse. The overall mean length and weight of sampled multi-sea winter fish was 72.48 cm and 3.86 kg respectively, smaller compared to multi-sea winter fish sampled in 2022 (mean length 74.8 cm, mean weight 4.56 kg (n=21)). Grilse sampled during 2023 had a mean length of 55.6 cm and a mean weight of 1.84 kg, slightly larger than grilse sampled in 2022 (mean length 53.9 cm, mean weight 1.74 kg) (**Error! Reference source not found.**). The mean condition index [$log_{10}(Weight(kg)/Length(m)^3$] of sampled adult salmon returns in 2023 was 1.01, similar to values for 2021 and 2022.

The lengths of adult wild salmon sampled in 2023 were added to sampled fish for 2021 and 2022 (n=272 fish) in order to assess the overall length-frequency histogram for Erriff salmon stocks and further refine size-based estimates of the difference between one-sea winter grilse and multi-sea winter age-classes (Figure 9). Statistical testing for the number of population modes present (following Silverman, 1981) revealed one size mode centred around 56.3 cm (i.e. median size for one-sea winter fish) and one centred around 73.2 cm (i.e. median size for multi-sea winter fish). An estimated anti-mode implied that a size cut-off of 69.2 cm effectively

partitions between multi-sea and one-sea winter fish for the River Erriff (further refined from the value of 68.7 cm determined from 2021 and 2022 samples alone (Kelly et al. 2023)). Some overlap between size classes occurs in the range 66 – 69 cm and these potentially represent small multi-sea winter fish, large one-sea winter grilse, or perhaps most likely, previously spawned grilse (Figure 9). Of sampled fish in the period 2021-2023, 32.5% of those fish above the 69.2 cm threshold (and thus classified as multi-sea winter salmon) returned during spring months (prior to June 1st). That is to say that the majority (over two-thirds) of multi-sea winter salmon of the Erriff population sampled during 2021-2023 were not true "spring fish", as larger multi-sea winter salmon returned to the river environment throughout the summer period, into autumn months. As changes in body size and proportions of multi- and one-sea-winter fish impact overall spawning fecundity estimates, and different sea-age classes may be subject to different environmental pressures, this is an active area of research currently underway in the Erriff system which may help to inform effective conservation management in other Irish salmon rivers over the coming years.

120 adult sea trout migrating upstream through the Aasleagh trap underwent biological sampling during their main river ascent period in 2023. The average length of sea trout returning to the Erriff river in 2023 was 28.6 cm, with a mean weight of 0.29 kg (compared to 29.0 cm and 0.31 kg in 2022 (n=154)) (**Error! Reference source not found.**).

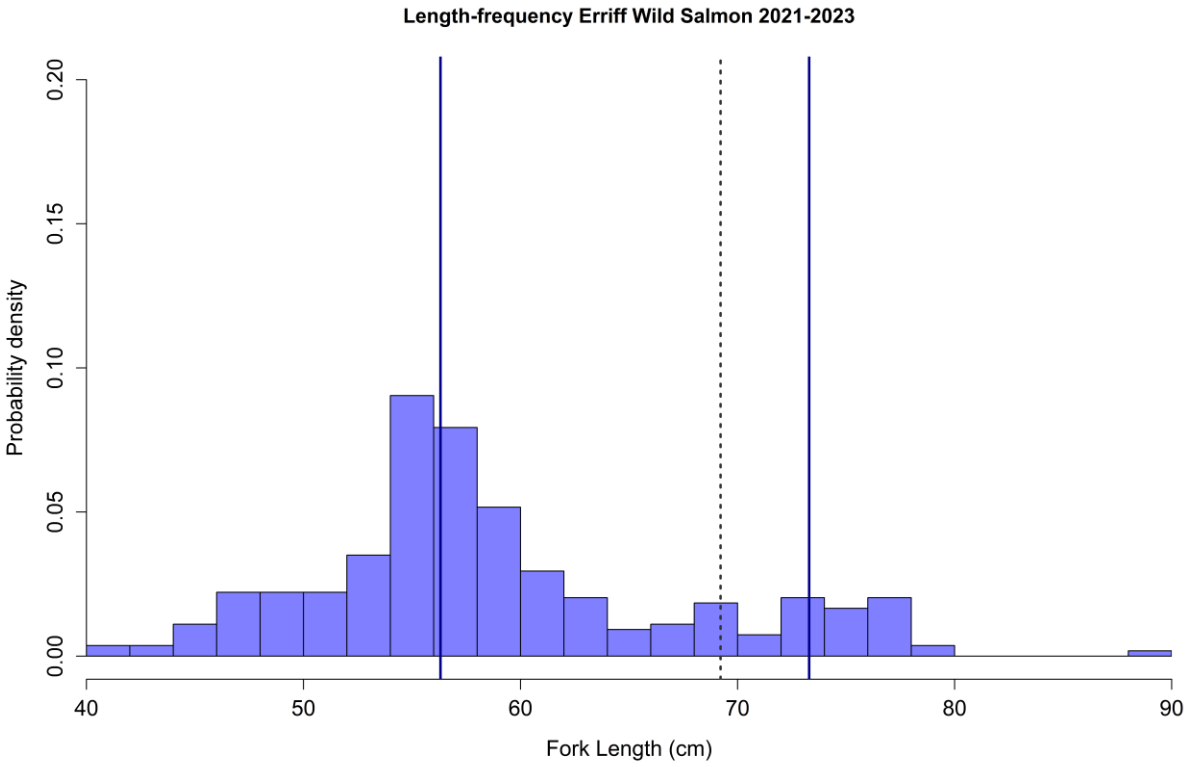


Figure 2 Length-frequency of fork length (cm) for returning wild adult salmon sampled during 2021, 2022 and 2023 (n=272). Solid vertical lines indicate estimated size modes for median grilse (56.3 cm) and multi-sea winter (73.2 cm) lengths. Dashed vertical line denotes anti-node (69.2 cm).

Analysis of length-frequency distribution of salmon smolts sampled in 2023 (n=1,050) revealed a mean length of 12.2 cm. Partitioning sampled salmon smolts between the Tawnyard trap and the Erriff main channel screw trap revealed that smolts emigrating from the lake were on average 1.36 cm (~11%) larger compared to smolts captured in the main river channel trap (Figure). Average length of seaward migrating sea trout smolts sampled from the Tawnyard trap in 2023 (n=564) was 19.89 cm. Only 37 sea trout were sampled from the main Erriff channel screw trap, with considerably fewer numbers of trout smolts caught in this location compared to salmon smolts. The average length of sea trout smolts captured at the Erriff main channel was 17.55 cm.

Sea trout kelts sampled during the river descent through the Tawnyard trap in 2023 (n=111) had an average length of 28.88 cm, ranging from a minimum of 21.6 to a maximum of 42.7 cm (Figure). The length-frequency distribution of sea trout kelts in 2023 was not unimodal, highlighting the contribution of various different sea trout age classes to the overall kelt run. The majority of sampled kelts had a population size mode centred around 26.8 cm, consistent with the majority of upstream sea trout returns as finnock in 2022. A second smaller population mode was centred around 36.5 cm representing either 1SW maiden fish returning in 2022 or potentially veteran migrants who had undergone multiple upriver migrations. The larger population size cohort was virtually absent from the 2022 sea trout kelt run (Kelly et al. 2023). The relative proportions of these size classes and how they have changed over time was originally characterised in Gargan et al. 2016, which highlighted the decline of the larger size class following introduction of salmon aquaculture in Killary and the general Connemara/Ballinakill region during the late 1980s. Furthermore, a number of “kelts” overlapped in size with the 2023 sea trout smolt population. Several sea trout < 25 cm in length (traditionally the cut-off point distinguishing between smolts and kelts) were confirmed as not being true first time smolt migrants through the detection of preexisting PIT tags (i.e. these fish had been tagged as first time smolts during 2022). The size distribution of downstream migrating sea trout highlights the complex demographics of the Tawnyard sea trout population. The ongoing mark-recapture PIT tag programme in conjunction with scale reading will be utilised to further elucidate the various life-history strategies of Tawnyard sea trout in future, particularly in relation to variation in environmental conditions (e.g. marine aquaculture impacts, freshwater and marine conditions).

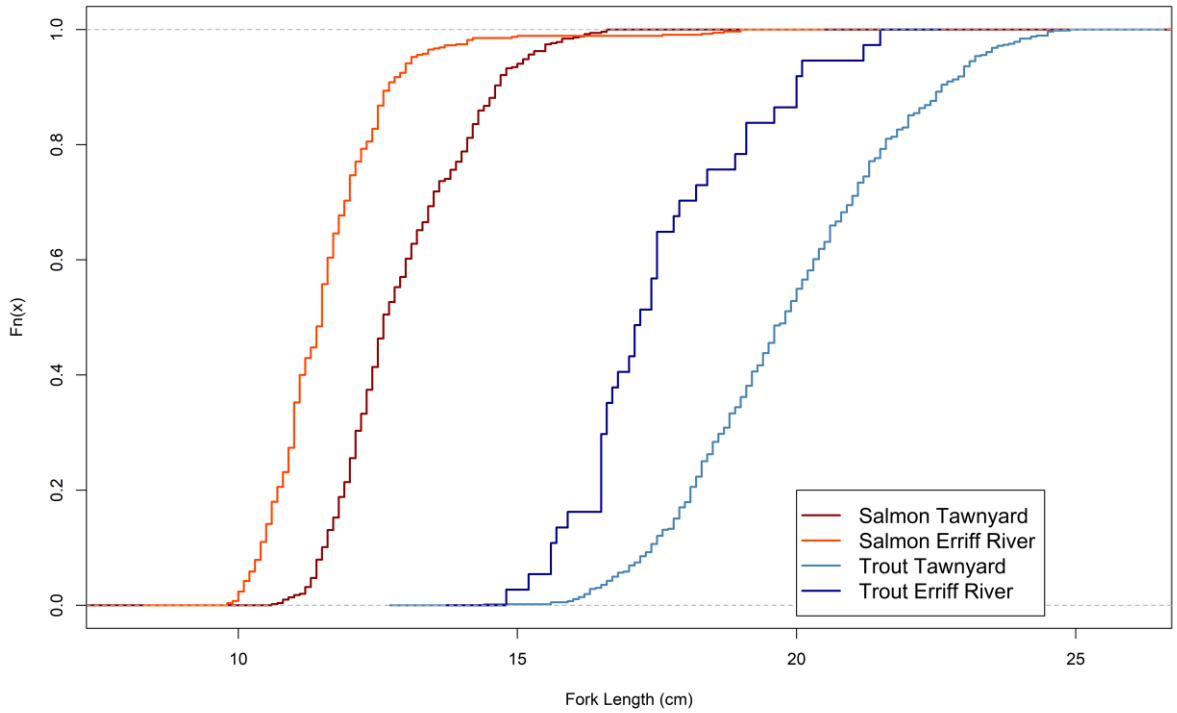


Figure 10 Empirical cumulative distribution function of fork length (cm) of Atlantic salmon and sea trout smolts sampled during 2023 smolt run.

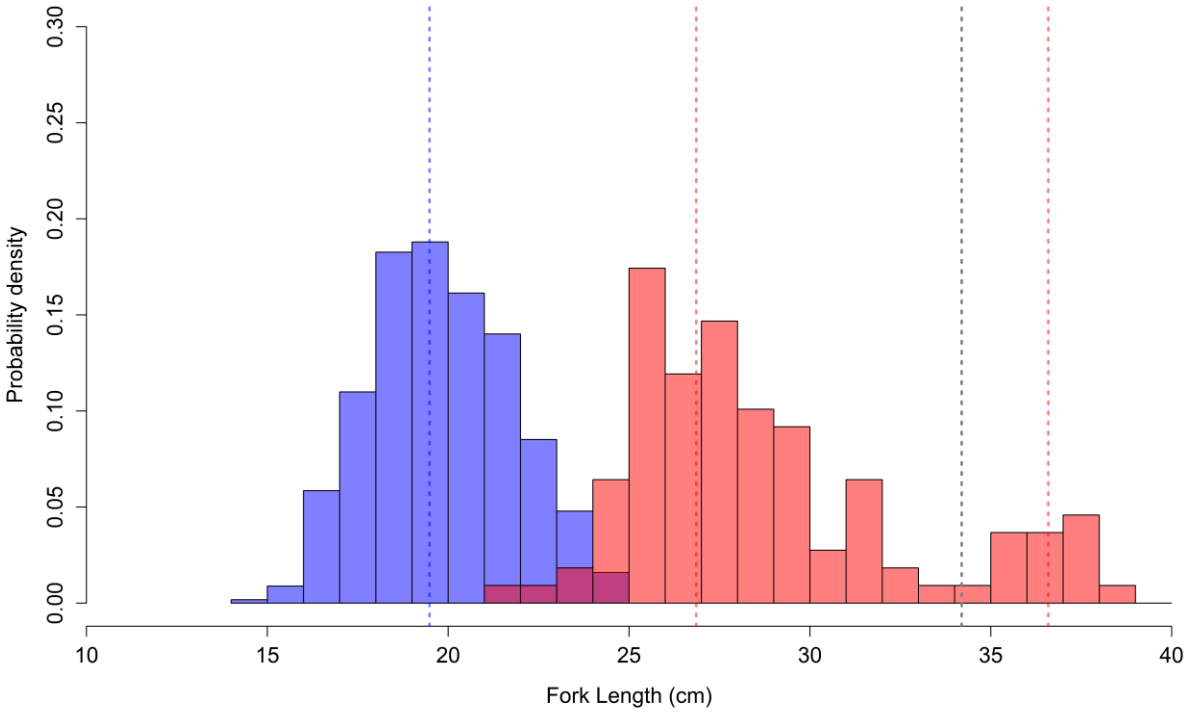


Figure 11 Probability histogram of fork length (cm) for sea trout smolts (blue) and sea trout kelts (red) sampled in the Tawnyard trap during 2023. Vertical dashed lines denote the mean length for smolts and kelts. (Note a small amount of overlap between fish recorded as smolts (visual categorisation) and kelts (recapture of a pit-tagged smolt) (22 – 25 cm length category). This could imply that a number of smolts tagged previously return to freshwater without significant marine growth (I.e. maturation) and thus may not contribute significantly to the overall spawning escapement.)

5.5 Predation marks and net marks on wild adult returns

Monitoring of predation marks and net marks on wild salmonid returns is undertaken by examining adult salmon and sea trout intercepted for routine sampling in the Aasleagh upstream trap as they entered the river on their upstream migration. The prevalence of obvious predation marks recorded on sampled fish in 2023 was 7%, considerably higher than the typical range observed since 2020 of 1.1% to 2.9%. The prevalence of net marked fish sampled in 2023 was 2.6%, a reduction on the figure of 7% for 2022 and an increase compared to 1.5% in 2021 and 0% in 2020. Prevalence of predation marks and net marks separated by salmon and sea trout for 2023 relative to preceding years is summarised in Table 4.

5.6 Catches

In 2023, the total rod catch of adult salmon was 258 fish with 202 of these wild (Table 5). The total number of ranched fish caught was 55 (all retained). The vast majority (~68%) of rod catch was at Beat 9 (the lowermost beat on the river), which experiences considerably more angling pressure compared to any other beat. The total commercial harvest in the mixed-stock fishery in Killary in 2023 was 237 salmon (Table 6). An estimated 82% of the commercial fishery catch is comprised of Erriff fish (195 in 2023) and utilising the ratio of wild to ranched fish returning through the Aasleagh trap in 2023 (61% wild fish), 119 fish retained in the commercial fishery in 2023 were estimated to be wild Erriff salmon.

5.7 Juvenile salmon abundance

Mean salmon fry abundance in the River Erriff catchment from catchment-wide electrofishing surveys in 2023 was 19.6 fry per 5-minute site fished. This represented a substantial decline from timeseries' highs in 2020, 2021 and 2022 (Figure 12; Table 7). Whilst higher compared to the timeseries' low in 2017 and remaining above the threshold mean value of 17 salmon fry used to inform overall stock status in Irish rivers more widely, the 2023 mean fry abundance in the Erriff was generally lower compared to most years surveyed since 2007. Site-specific results of the CWEF survey in 2023 are presented in

Figure 13.

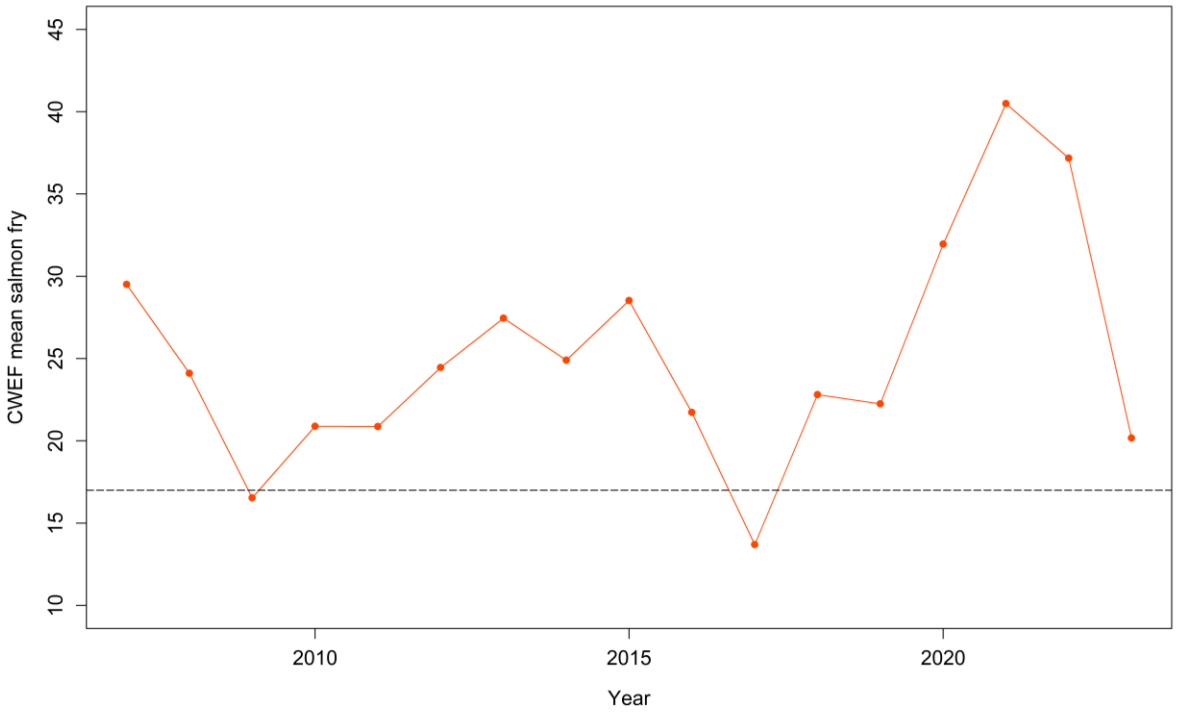


Figure 12 Results of mean salmon fry abundance in the River Erriff catchment from catchment-wide electrofishing surveys since 2007.

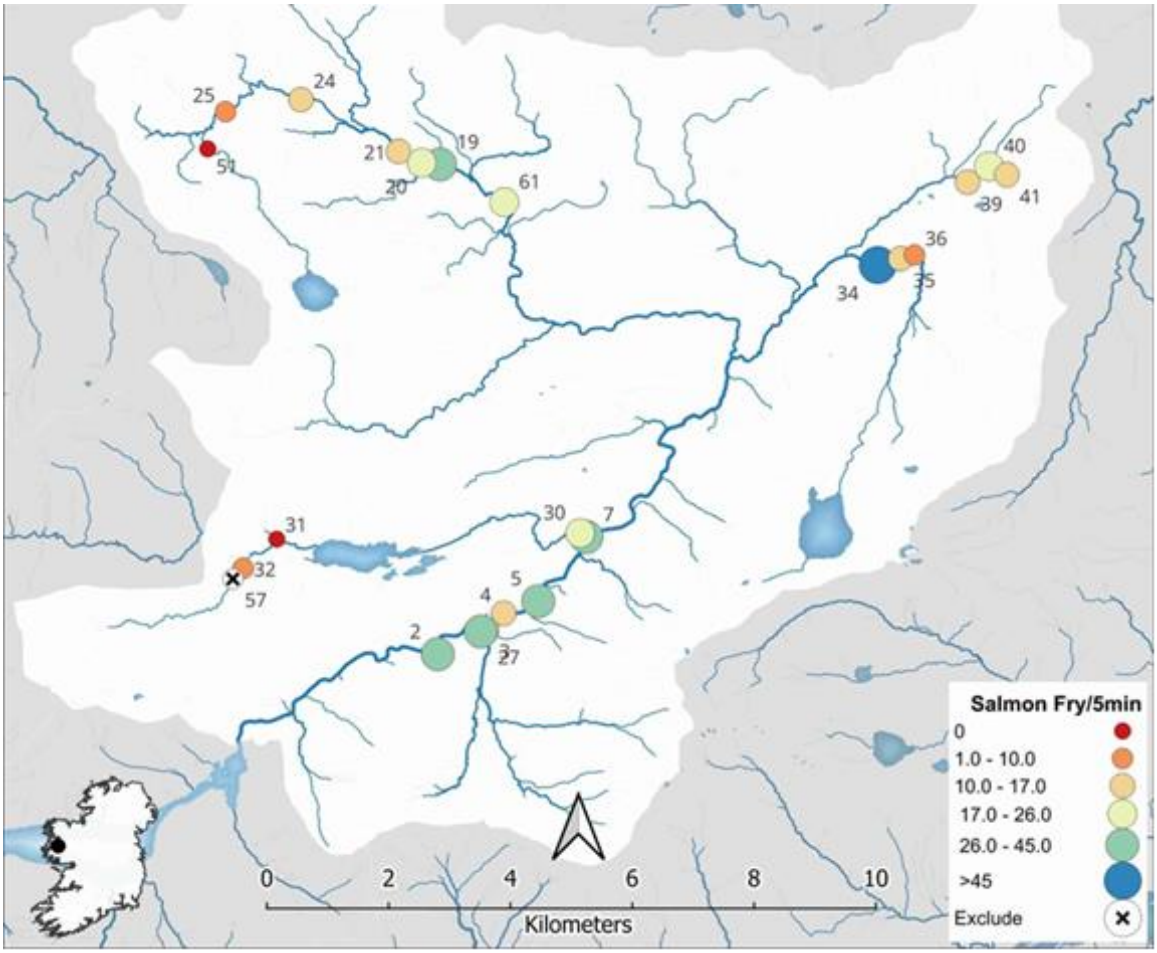


Figure 13 Site-specific results of mean salmon fry abundance in the River Erriff catchment from catchment-wide electrofishing surveys in 202**3**.

5.8 Telemetry and tagging studies

A range of telemetry and tagging studies have been undertaken in the NSIC Erriff in recent years to assess survival and monitor migration of both salmon and sea trout through the freshwater, estuary and marine environment and better understand the factors that influence these.

5.8.1 PIT tagging

In 2023, a total of 966 salmon and 551 sea trout smolts, respectively, were PIT tagged (Table 8). This comprised 505 and 457 salmon smolts at Tawnyard trap and at the screw trap in the main channel, respectively, and 514 and 37 sea trout smolts at Tawnyard trap and at the screw trap in the main channel, respectively (Table 9).

From the cohort tagged in 2022, a total of 23 PIT tagged adult salmon returned to the Erriff during 2023 representing a provisional marine survival of 1.9% for 1-sea winter (grilse) returns. Any multi-sea-winter fish which will return in 2023 will have to be considered when finalising this estimate. Additionally, three two-sea-winter salmon returned in 2023 from the smolt cohort tagged in 2021. For salmon PIT tagged in 2017, 2018, 2019, 2020 and 2021 marine survival was 2%, 3.8%, 3.2%, 1.5% and 1.7% respectively (Table 10).

From the sea trout smolt cohort tagged in 2022, a total of 14 PIT tagged adult sea trout returned to the Erriff during 2023. These returns represented a combination of one-sea-winter maidens as well as zero-sea-winter finnock that returned to the river during 2022 and descended again during the 2023 smolt run period. The precise proportion of each cohort representing the 14 adult sea trout returns is subject to further analyses using a combination of scale reading and mark-recapture data from the Aasleagh and Tawnyard traps. Any multi-sea-winter fish and repeat spawners which will return in future years will have to be considered when finalising these results. Of the 601 sea trout smolts PIT tagged during the 2023 smolt run, 31 fish returned during 2023 (i.e. zero-sea-winter finnock), representing a return rate of 5.1%. Again, there is the potential for further returns of this tagged cohort in future years. Two sea trout smolts tagged during 2021 returned to the Erriff River during 2023 and one individual returned during June that had been previously tagged as a smolt in May 2018. This fish measured 35.6 cm and had not been encountered migrating through either the Aasleagh upstream trap nor the Tawnyard downstream trap as a kelt, implying that it may have returned to a river system other than the Erriff during the intervening period between first tagging event and subsequent recapture. A more comprehensive picture of sea trout marine survival trends and migratory dynamics will become available through assessment of a longer-term time series of mark-recapture data (2019-2025).

5.8.2 Acoustic tagging

Prior to the acoustic tagging of sea trout smolts, 21 acoustic receivers were deployed across the River Erriff, Killary Harbour, and Ballinakill Bay to monitor the movements of tagged individuals (Figure 14). A total of 20 sea trout smolts were acoustic tagged between April 19 and May 8, 2023. The mean length and weight of the tagged smolts were 20.3 cm and 83.8 g, respectively.

Survival rates were calculated based on the number of tagged fish that successfully returned to the River Erriff after their marine migration. These rates represent minimum estimates, as some individuals may remain at sea for extended periods, exceeding the battery life of the acoustic tags (174 days).

Three sea trout smolts successfully returned to the River Erriff, corresponding to a survival rate of 15%. During their migration, 95% of the smolts survived to Killary Harbour, with one mortality occurring during freshwater migration. An additional 5% were lost during migration through Killary Harbour to the open sea. The largest losses (55%) occurred at sea. Four smolts (20%) were lost in Killary Harbour following their seaward migration.

Premature return behaviour was observed in five smolts (25%), which were detected in the Bundorragha River. Sixteen smolts (80%) were detected by acoustic receivers south of Killary Harbour, migrating towards Ballinakill Bay, with two individuals (10%) detected near a salmon farm located within Ballinakill Bay.

An overview of acoustic tagging activities on the River Erriff for 2014-2023 is shown in Table 11.

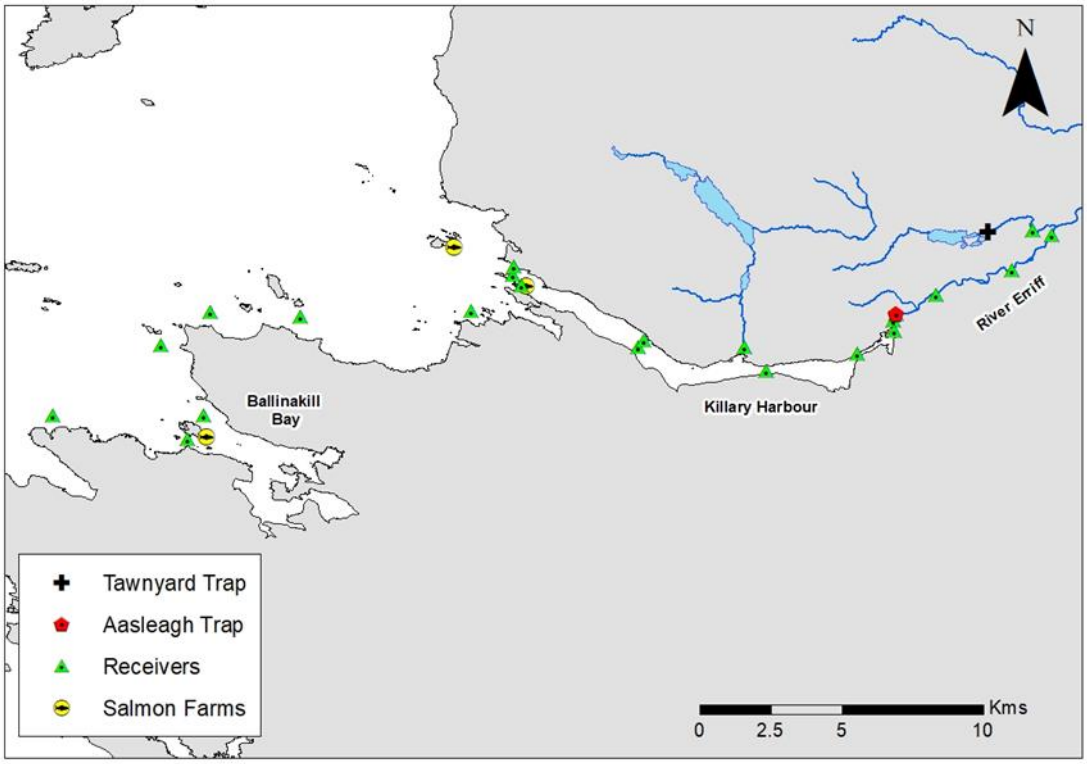


Figure 14 Location of acoustic receivers in Ballinakill Bay, Killary Harbour and the Erriff catchment.

5.8.3 Sea trout temperature project

The Sea Trout Temperature (ST Temp) project aims to document the range of temperatures experienced by migrating sea trout (*Salmo trutta*) smolts during their riverine and marine migrations. This research seeks to enhance understanding of temperature-related factors that may influence marine survival. Rising temperatures have been identified as a potential contributor to the decline of migratory salmonid populations at both local and oceanic scales, with climate change representing a significant long-term threat to these species.

Tagging commenced on the River Erriff on May 8 and concluded on May 9, 2023, utilizing the Tawnyard Wolf trap (Figure 3). Fifty smolts were successfully tagged with NanoT tags, which record temperature at 5-minute intervals for a duration of 151 days. The tagged fish ranged from 17.5 to 24.6 cm in fork length (mean 20.7 cm) and 55.0 to 143.0 g in weight (mean 90.0 g). Each fish was also fitted with a Passive Integrated Transponder (PIT) tag to enable identification upon return for tag recovery.

One tagged fish was observed returning on July 4, 2023, but escaped from the trap. Video footage confirmed the fish bypassing the trap through a gap in the bars, which was subsequently repaired. However, no other tagged fish returned, and thus no NanoT tags were recovered in 2023.

5.8.4 SmolTrack III (Eval-Smolt)

The Eval-Smolt study concluded in 2022, but one salmon smolt from the Truck-6 group returned in 2023. This smolt was originally tagged on April 6, 2022, at the Tawnyard trap, measuring 14.3 cm in length and weighing 31 g at the time of tagging. Upon its return to the trap on July 29, 2023, the fish had grown to 56.1 cm in length and 1.8 kg in weight. This event provided a proof-of-concept for the Ocean-Temp project.

5.8.5 SmolTrack IV (Ocean-Temp)

The Ocean-Temp project aims to record the temperature ranges experienced by Atlantic salmon from the smolt stage to adult return throughout their oceanic migration. Outgoing smolts were equipped with miniature Data Storage Tags (DSTs) to capture temperature data across freshwater, transitional, and marine environments. The tags record temperature every 30 minutes for the first year and hourly thereafter, continuing until mid-September 2024. PIT tags were also applied to facilitate identification upon fish return.

In 2023, 84 wild salmon smolts were tagged at the rotary screw trap at Erriff Bridge between April 14 and May 5. The tagged fish ranged from 12.5 to 15.0 cm in fork length (mean 13.0 cm) and 18.5 to 34.0g in weight (mean 22.0 g). These fish are expected to return in 2024. Similarly, 100 smolts were tagged in 2021 and 2022 using the same methodology; however, no returns were recorded in 2023.

An overview of DST tagging activities on the River Erriff for 2014-2023 is shown in Table 11.

5.9 Invasive and introduced fish species

No Pacific pink salmon were recorded migrating upstream through the Aasleagh trap in 2023. No farmed salmon were intercepted in the Aasleagh upstream trap in 2023.

5.10 Disease

5.10.1 Sea lice

Monitoring of sea lice loads on wild sea trout returns is undertaken as part of the routine sampling of sea trout intercepted in the Aasleagh upstream trap as they enter the river on their upstream migration (Appendix 1). Of the sampled upriver migrating sea trout returning from the marine environment in 2023, 107 underwent full sea lice counts. 57.0% of fish showed some presence of sea lice (lower compared to the value of 83.2% in 2022 sampled fish (n=125)). Sea lice load was calculated for each sampled fish as number of lice per gram of

body mass (n g^{-1}) and an assessment of the severity of individual lice infestation rates performed using the established salmon lice risk index (so-called 'traffic-light system' as used in Norway (Taranger *et al*. 2015)). <1% of sampled adults were in the high-risk category (100% probability of lice-related mortality), 3.7% in the medium-risk category (50% probability of lice-related mortality) and 5.6% in the low-risk category (20% probability of lice-related mortality). These categories were then used to assess lice-related increased mortality risk at the whole-population level (Taranger *et al*. 2015; Gargan *et al*. 2016). Results show that 10.2% of fish had lice infestation rates > 0.1 n g^{-1}, denoting that lice levels impacting the 2023 Erriff sea trout cohort had an intermediate probability of increasing population-level mortality risk. However this figure represents a decline compared to the 2022 and 2021 Erriff sampled sea trout cohorts, of which 25.6% and 25.2% of fish had lice infestation rates > 0.1 n g^{-1} respectively, and it was likely that sea lice infestation represented a greater population-level mortality risk during those years.

Over 60% of the historical surveys carried out in Killary Harbour and in the estuarine zone of the primary river inflows to Killary, including the Erriff, indicated high mortality risk levels during the 1990s, 2000s and 2010s (Gargan *et al*. 2016). Given that the sea lice sampling reported here is carried out on individual fish that have spent variable amounts of time back in freshwater (and thus would be anticipated to have lost a proportion of their lice load), the population-level risk reported here should be considered an absolute minimum, and lice-induced mortality risk is likely higher in the adjacent coastal habitat utilised by Erriff sea trout, and by extension, out-migrating salmon smolts. It should be further noted that sea lice counts are carried out only on those fish that have survived and successfully return to freshwater and is not fully representative of sea trout lice infestation rates at sea as it omits any sea lice counts from fish that do not survive the marine migration phase.

5.10.2 Red skin disease

Anecdotal observations suggest that mild RSD-like signs have been observed in Irish salmon for many decades. However, there has been no specific focus in this regard until 2019 when more obviously diseased fish were encountered in some Irish rivers. Routine surveillance for RSD in the NSIC Erriff commenced in 2020 when ranched salmon were examined to assess prevalence and severity of this emerging phenomenon. Since 2021, surveillance for RSD has been undertaken by examining wild adult salmon intercepted for routine sampling in the Aasleagh upstream trap as they entered the river on their upstream migration. Assessment of severity of disease is classified according to the scheme used in the RSD Severity Field Guide, 2022 (Appendix 2). In 2023, six of the 106 wild Erriff adult salmon examined had signs of RSD, with 100% of these cases classed as mild in severity. This represents a prevalence rate of

5.6% in the total numbers of wild salmon examined, a notable decrease compared to the prevalence of 34% in 2022 and more comparable to the 4.5% recorded in 2021 (Table 12).

It should be noted that although the majority of recorded cases of RSD in Ireland are observed in one-sea-winter grilse, this is not the case elsewhere in Europe (notably Scandinavia) where RSD is principally observed in multi-sea-winter salmon stocks. This may be a consequence of the Irish stock being pre-dominantly one-sea-winter.

5.10.3 Red vent syndrome

Routine surveillance for RVS in the NSIC Erriff commenced in 2020 when ranched salmon were examined to assess prevalence and severity of this disease. A standardised classification method to record RVS has been introduced to align with the mild-moderate-severe severity scale used in Britain by the Environment Agency and Marine Scotland.(RVS Severity Field Guide, 2011; Appendix 3). Since 2021, surveillance for RVS has been undertaken by examining wild adult salmon intercepted for routine sampling in the Aasleagh upstream trap as they entered the river on their upstream migration. In 2023, 15 of the 106 wild Erriff adult salmon examined had signs of RVS, of which 87% were classed as mild and 13% as moderate in severity (Table 13). This represents a prevalence rate of 14.1% in the total numbers which is marginally higher than the 12.8% prevalence recorded in 2022 but lower compared to 2021 (19.3%).

5.11 Climate and Environmental Research Programme

River water temperatures and water levels on the main channel of the Erriff River as recorded by the Office of Public Works' hydrometric station located just below Aasleagh Falls varied largely across 2023 (Figure 15 & 16). Water temperatures ranged from a low of 2.3 °C during March to a high of 24°C during June. In general, during the early part of the year water temperatures remained below 10 °C and gradually rose from April onwards. From late May a period of considerable warm and dry weather predominated for several weeks and saw June water temperatures in excess of 20 °C recorded, substantially higher than climatological norms for this month in the period 2007-2023. In combination with extremely low water levels these meteorological conditions resulted in the closure of the Erriff recreational fishery for several weeks. However, following June, the water temperatures decreased and were slightly below summer averages and July and August were characterised by several heavy rainfall events that lead to high flow events and generally elevated water levels for the remainder of the summer. A heat spell in September saw the return of high water temperatures, which exceeded 20 °C at times, and low water levels which were considerably lower than climatological norms

since 2007. River water temperatures steadily decreased into winter months although values in December were notably higher compared to previous years. Though water levels throughout autumn and winter were characterised by frequent high water flood events, the overall spate-type hydrology of the Erriff was evident throughout the year with rapid transitions between high flood events and low water conditions.

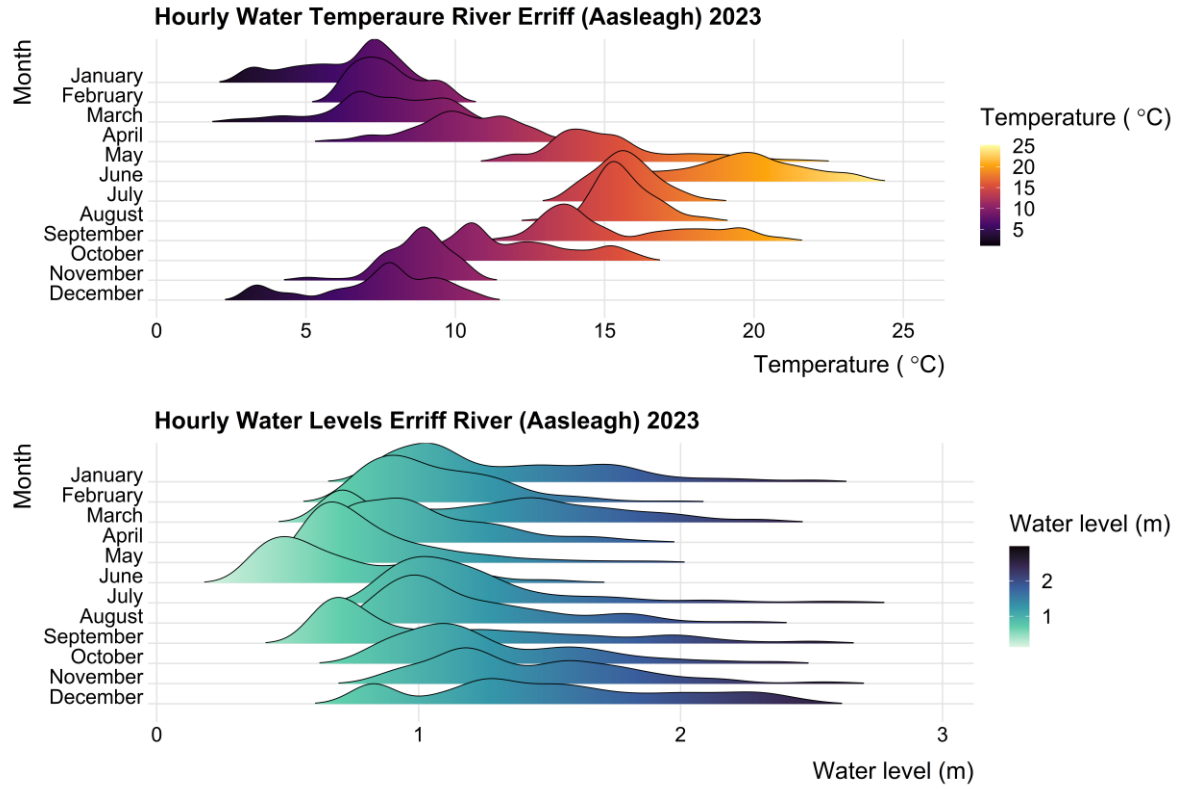


Figure 15 Distribution of river water temperatures (top panel) and river water levels (bottom panel) by month on the River Erriff main channel during 2023 (using data recorded by the hydrometric gauging station below Aasleagh Falls maintained by the Office of Public Works).

Monitoring of climatic and limnological variables continued in 2023 through the IFI Climate Change Mitigation Research Programme (CCMRP) (. Barry et al., 2023). Thirty-five water temperature loggers and a fully-automated meteorological station installed during summer 2019 continue to record the thermal dynamics of fishery habitat throughout the Erriff river system every 30-minutes. Analysis of the water temperature data recorded during the first 5-years of logger deployments is currently underway, which will allow detailed assessment of the thermal response of salmonid habitat to climatic conditions. This will include the delineation of thermally vulnerable and resilient habitat-types based on the relationship between water temperatures and other key variables such as meteorological conditions, groundwater influences and landscape factors (e.g. riparian shading). In addition, limnological monitoring of Tawnyard Lough was continued in 2023 through downloading and redeployment of a full water column thermistor array and dissolved oxygen loggers at strategic locations through the water column to inform on oxythermal conditions. A shoreline meteorological station was also

maintained, providing local information on wind conditions and solar radiation, which drive physical conditions in the lake and will eventually be utilised to inform on potential linkages between climatic conditions and the lake's resident and anadromous trout populations.

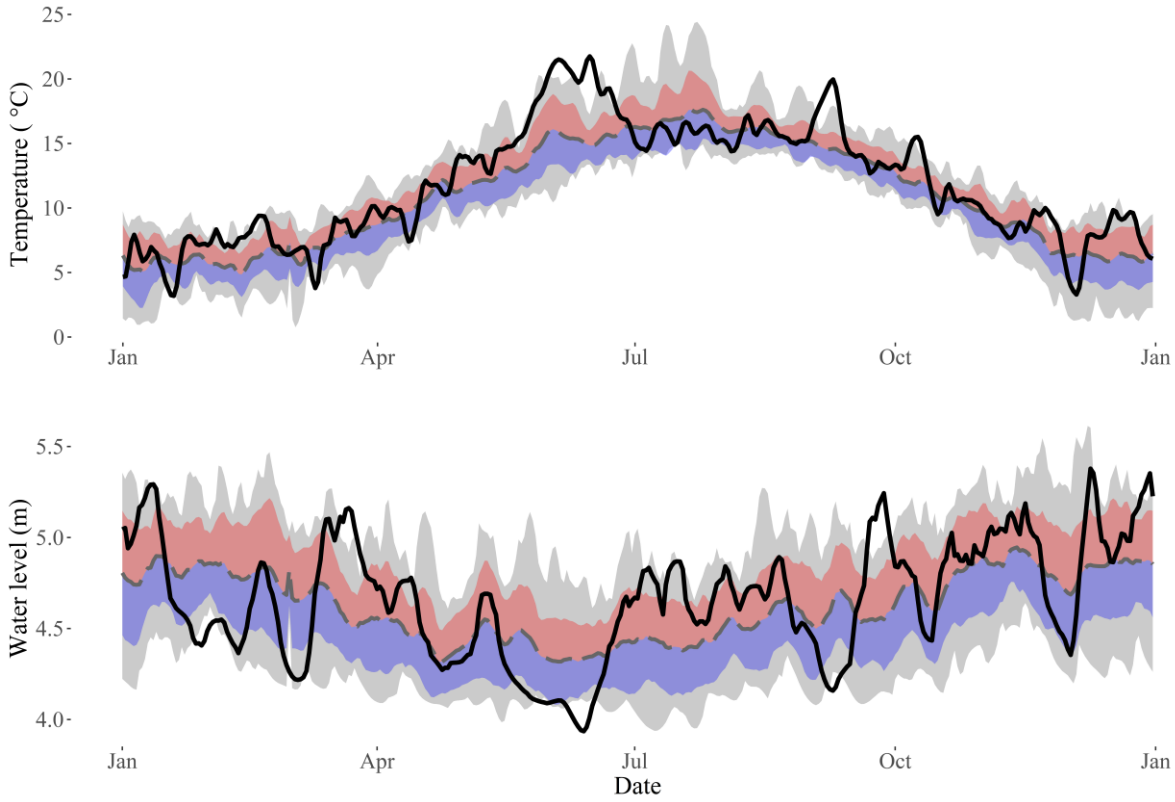


Figure 16 Comparison of river water temperatures (top) and water levels (bottom) on the River Erriff main channel in 2023 (thick solid black line) with climatological conditions during the period 2007-2022. Dashed grey line is climatological mean, red and blue shaded areas denote standard deviation around the climatological mean and grey shaded areas indicate historical maxima and minima. Temperatures were filtered using a 3-day moving average and water levels using a 7-day moving average to improve plot interpretation. (Data was obtained from the hydrometric gauging station below Aasleagh Falls maintained by the Office of Public Works)

5.12 River Erriff Hydromorphological Condition Assessment Study

A comprehensive assessment of the River Erriff was undertaken to characterise its current hydromorphological condition and the degree of human modification, as per CEN Guidance standard on determining the degree of modification of river hydromorphology (EN 15843). This was achieved through combination of desk-based delineation of all river reaches in the catchment and their associated watershed properties (Figure 17). Elements of the desktop study were ground-truthed in the field using the River Hydromorphological Assessment Technique (RHAT). The resulting synthesis highlighted the location, type and severity of modifications and provided information relevant to river management (e.g. the design of river rehabilitation or restoration efforts, improving biodiversity, flood management, resilience to the effects of climate change). While the Erriff catchment retains many natural elements and generally scored relatively well according to the RHAT surveys (Figure 18), the assessment

revealed widespread hydromorphological alterations to the flow and temperature regime, riparian and bank vegetation, and sediment delivery and transport.

Pressures associated with land use change, absence or simplification of functional riparian and bank vegetation (Figure 19), and artificial bank reinforcement (Plate 8) are present throughout the catchment. Alterations to these hydromorphological components, which specifically increase vulnerability to thermal and hydrological stressors, are likely to negatively impact stream ecology in the short-medium term. These impacts are liable to be further exacerbated by climate change-induced impacts without appropriate management interventions at a meaningful scale.

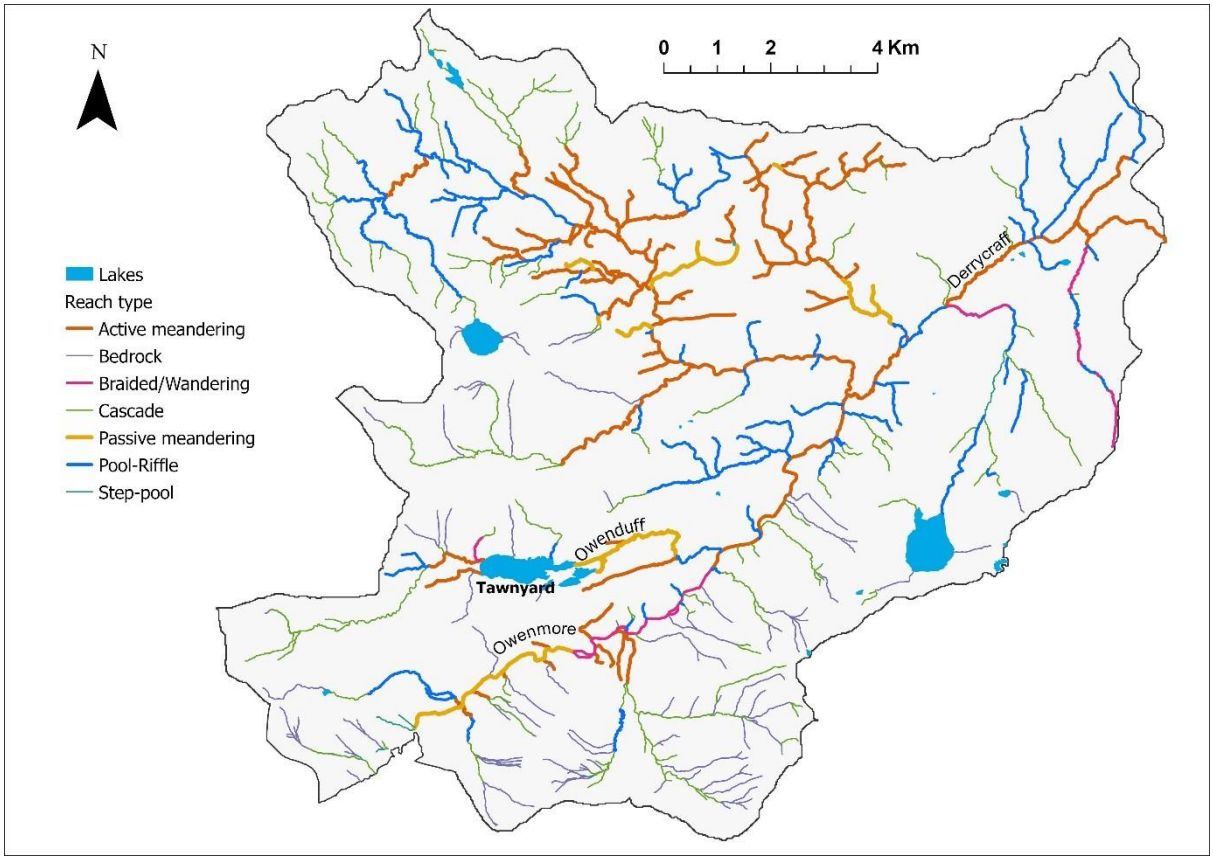


Figure 17 River Erriff hydromorphological types.

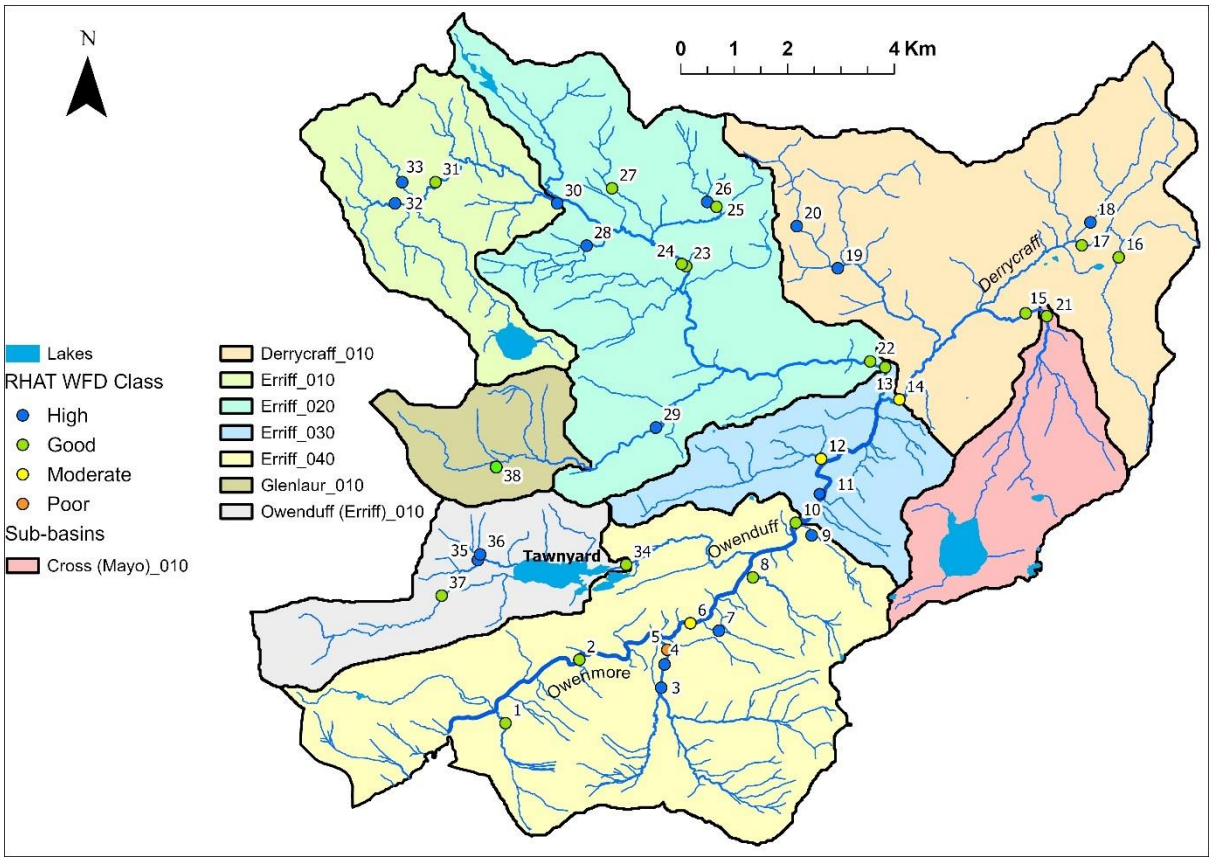


Figure 18 River Hydromorphological Assessment Technique (RHAT) survey locations and assigned WFD hydromorphological condition class for sites assessed in the Erriff catchment.

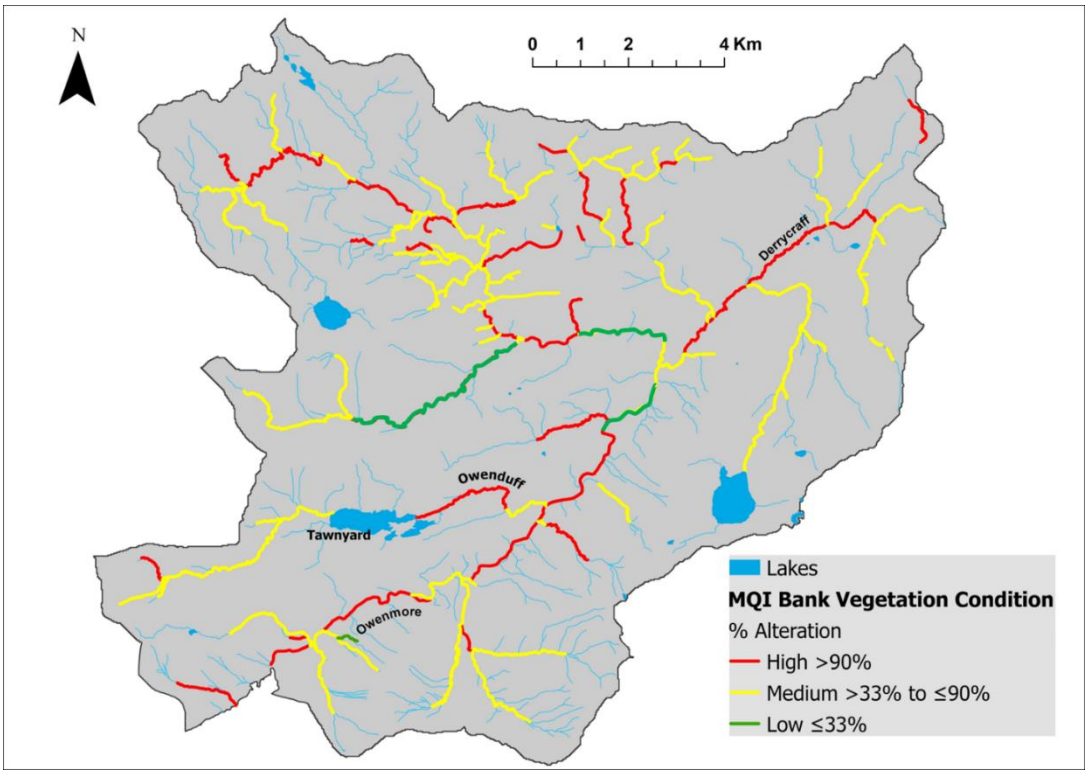


Figure 19 The extent of alterations to bank vegetation within 3m of the wet channel. High (red line) indicates extensive alteration and Low (green line) indicates relatively natural bank vegetation.

Plate 8 Examples of reach alterations in sub-basin Erriff_040, including bank reinforcement, artificial instream structures and absence or low levels of functional bank and riparian vegetation

In response, a restoration strategy that aims to support long-term provision of habitat and to promote system resilience to climate change impacts was outlined. This restoration strategy focuses on renaturalising flow, sediment delivery, and riparian vegetation processes as these are most impacted by human activities and critical to habitat provision. The strategy also considers likely changes in the catchment due to climate change i.e. higher temperatures and more frequent severe drought and flood events, and the restoration measures are intended to buffer related impacts on stream biota. Specific types of measures recommended for implementation include:

- Creation of riparian broadleaf buffer zones to improve productivity and mediate observed high stream temperatures
- Creation of wetland habitat at suitable locations
- Addition of large woody habitat to improve instream habitat and provide cool/deep water refugia for salmonids
- Installation of leaky ‘dams’ in upland tributaries to help attenuate flood peak flows
- Removal of hard bank reinforcements to allow natural sediment recruitment and space for the river to adjust to changing environmental conditions

6 References

Barry, J., Coyne, J., Kelly S., and Kelly, F.L. (2023). Climate Change Mitigation Research Programme, Annual Report 2022. National Research Survey Programme, Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24.

Gargan, P, Shephard, S and Macintyre, C. (2017). Assessment of the increased mortality risk and population regulating effect of sea lice (*Lepeophtheirus salmonis*) from marine salmon farms on wild sea trout in Ireland and Scotland. In: Sea Trout: Science & Management. Proceedings of the 2nd International Sea Trout Symposium (pp. 507–522)

Kelly, S., Wightman, G., Gargan, P., Kelly F.L., Roche, W. & Millane, M. (2024). National Salmonid Index Catchment Erriff, Annual Report 2022. Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24.

RSD Severity Field Guide (2022). Red Skin Disease in wild Atlantic salmon – a severity field guide. Version 1. February 2022. Published online. Environment Agency, Inland Fisheries Ireland, Marine Scotland and Natural Resources Wales, 3 pp. https://tinyurl.com/mr2zhyzs

RVS Severity Field Guide (2011). Red Vent Syndrome in wild Atlantic salmon – a severity field guide.. Published online. Environment Agency and Marine Scotland, 2 pp. https://tinyurl.com/5y7h63fr

Silverman, B.W. (1981). Using Kernel Density Estimates to Investigate Multimodality. *Journal of the Royal Statistical Society: Series B (Methodological)* 43, 97–99. https://doi.org/10.1111/j.2517-6161.1981.tb01155.x

Taranger, G.L., Karlsen, Ø., Bannister, R.J., Glover, K.A., Husa, V., Karlsbakk, E., Kvamme, B.O., Boxaspen, K.K., Bjørn, P.A., Finstad, B., Madhun, A.S., Craig Morton, H. and Svåsand, T. (2015). Risk assessment of the environmental impact of Norwegian Atlantic salmon farming. *ICES Journal of Marine Science* 72: 997−1021.

Thorstad, E.B., Todd, C.D., Uglem, I., Bjørn, P.A., Gargan, P.G., Vollset, K.W., Halttunen, E., Kålås, S., Berg, M. and Finstad, B. (2015). Effects of salmon lice *Lepeophtheirus salmonis* on wild sea trout *Salmo trutta* - a literature review. *Aquaculture Environment Interactions* 7, 91–113

7 Appendices

7.1 Appendix 1 Sea lice screening of adult sea trout returns

Monitoring of sea lice loads on wild sea trout returns is undertaken as part of the routine sampling of sea trout intercepted in the Aasleagh upstream trap as they enter the river on their upstream migration. The fish are anaesthetised and held partially submerged in water during lice counts to reduce stress. Numbers of sea lice observed are recorded as juvenile chalimus or pre-adult / adult life stages (Figure 3 and Figure 4).

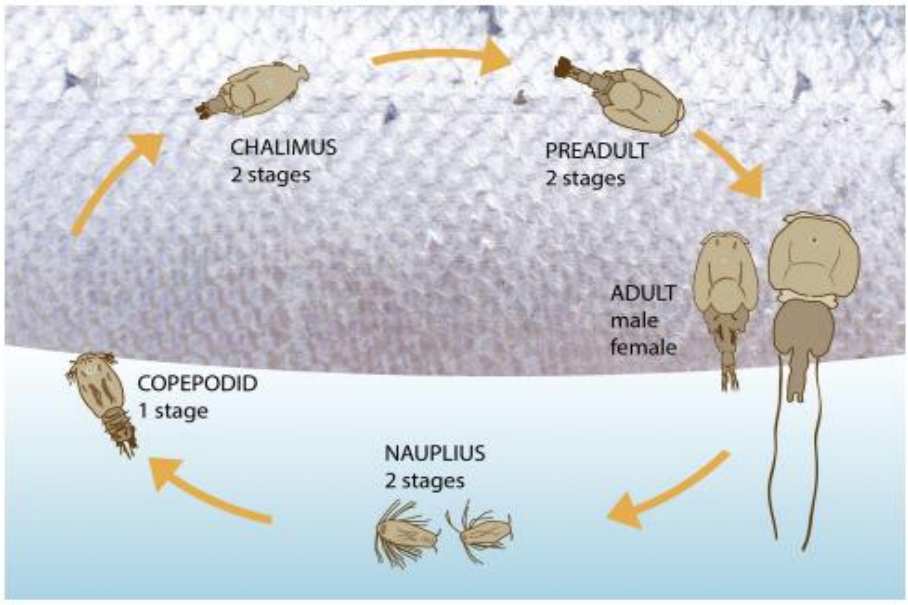


Figure 3 Life cycle of *Lepeophtheirus salmonis* showing the attached chalimus, pre-adult and adult stages which are routinely screened for as part of the NSIC annual sea trout biological sampling programme (figure from Thorstad *et al*. (2015)).

Figure 4 Counting sea lice on returning wild sea trout in the NSIC Erriff.

7.2 Appendix 2 RSD severity field guide

Environment Agency | Cyfoeth Naturiol Cymru Natural Resources Wales | marinescotland science | Iascach Intíre Éireann Inland Fisheries Ireland

Red Skin Disease in wild Atlantic salmon – a severity field guide

Red Skin Disease (RSD) is a term given to an emerging disease of wild Atlantic salmon characterised by haemorrhaging along the underside of the body, and occasionally the lower flanks. Milder symptoms of ventral haemorrhaging have been recorded in some populations of salmon for decades, but the severity and prevalence appear to have increased markedly in the last few years.

The most consistent characteristic of the condition appears to be distinct and pronounced ventral haemorrhaging in fresh run Atlantic salmon. This haemorrhaging is described as petechial or pinpoint, expressed as rounded reddened spots on the skin.

The cause and impact of RSD are currently unknown and detailed histopathological descriptions are still being established. Until then, the following field guide has been produced to standardise clinical reporting of RSD-like lesions to support ongoing monitoring of this condition across salmon rivers. It also serves to distinguish this emerging condition from other, frequently observed skin lesions in migratory salmonids.

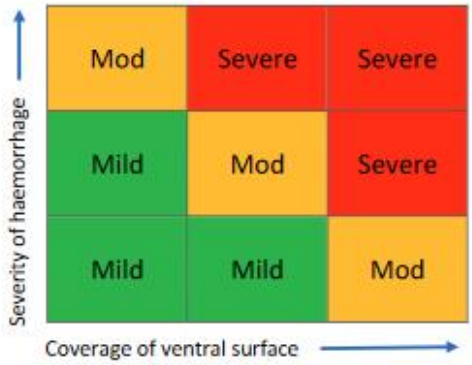
This index is not intended as a definitive diagnostic guide, but simply to standardise reporting of RSD. This document may evolve as our understanding of RSD develops and will be updated accordingly alongside a more detailed case description.

The images in this guide show the ventral surface of salmon exhibiting varying severities of ventral haemorrhaging associated with RSD, along with descriptions to assist the assessment of individual fish.

To distinguish RSD-like lesions from other skin conditions, there is a page at the end of this guide showing a range of images of wild Atlantic salmon with common symptoms and infections - none of which are considered to be consistent with RSD. Whilst secondary infections may be a typical progression of RSD-like lesions, these growths often mask underlying characteristics and hinder a reliable assessment of this condition.

Severity and characteristics of RSD

Based on observations from rivers across the UK and Ireland, it appears that RSD-like lesions can vary widely both in the extent and severity of ventral reddening. As such, the categorisation of mild, moderate, and severe lesions is based on the coverage of ventral regions of affected fish and the severity of haemorrhage/inflammation. The contribution of these two factors to the assignment of RSD severity is demonstrated in the diagram below.



Severity of haemorrhage: refers to the colour of lesions and extent of disruption to the skin, ranging from subtle pale marks with little or no skin disruption, through to deep red, aggressive lesions with notable disruption to skin surface including scale displacement.

Coverage of ventral surface: refers to the extent of the ventral surface covered by haemorrhagic/inflammatory lesions. Ranging from discrete, localised marks to extensive rash-like lesions covering most if not all of the ventral surface, and even extending on to the lateral surfaces of the fish.

Version 1. February 2022

Normal ventral surface

Clean, white ventral surface with no evidence of haemorrhaging or significant skin lesions. N.B. Some minor blemishes or imperfections in wild migratory fish are common and normal and may arise from multiple causes.

Mild RSD-like lesions

Ventral haemorrhage typically focal or diffuse, with minimal disruption to the skin. Lesions are relatively pale, discrete and typically cover less than 50% of the ventral surface.

Moderate RSD-like lesions

Coverage and severity of lesions variable with patches of more significant reddening including raised or more disrupted regions of the skin. Coverage may be extensive and variable, with either mild severity of lesions covering a large proportion of the fish, or focal regions consisting of more pronounced red marks.

Severe RSD-like lesions

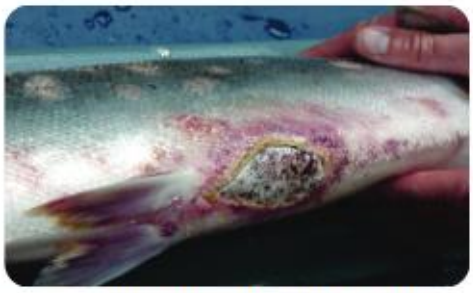
Pronounced and extensive petechial or rash-like haemorrhage covering large proportions of the ventral surface, occasionally extending onto the flanks of the fish. Evidence of skin disruption including raised areas of scale displacement with marked petechiae, extending into larger patches, usually raised and deep red in colour.

Symptoms associated with other skin conditions of wild salmon

Red Vent Syndrome, involving localised swelling and reddening of the vent.

Lice damage, with typical fine, petechia often localised posterior to the fin bases.

Abrasion, with associated scale displacement.



Severe bacterial infection with ulceration and inflammation.

Saprolegnia infection with typical rounded, cotton wool-like growths.

Mixed secondary infections involving bacteria and Saprolegnia.

Contact details

England: To report fish mortalities or fish in distress please contact the **Environment Agency** incident hotline on 0800 80 70 60. For further information on RSD please contact our National Fisheries Laboratory on 02084 745244 or email fish.health@environment-agency.gov.uk

Wales: contact the **Natural Resources Wales** hotline on 0300 065 3000, or visit the website: Natural Resources Wales / Report an incident. For further information, contact fisheries.wales@cyfoethnaturiolcymru.gov.uk

Ireland: contact **Inland Fisheries Ireland**. Tel: 0818 34 74 24, or email salmonhealth@fisheriesireland.ie

Scotland: contact the Fish Health Inspectorate at **Marine Scotland**. Telephone 0131 244 3498, or email ms.fishhealth@gov.scot

For further information on this document, please contact fish.health@environment-agency.gov.uk

Version 1. February 2022

7.3 Appendix 3 RVS severity field guide

marinescotland science | The Scottish Government | Environment Agency

Red Vent Syndrome in wild Atlantic salmon – A severity field guide

Background

Wild Atlantic salmon returning with inflamed, swollen and bleeding vents have been seen in rivers throughout the UK since 2006. This condition has been called Red Vent Syndrome (RVS). This index has been developed to standardise the recording of RVS within Britain, allowing consistent reporting and monitoring. It replaces all earlier field guides. The following images show the normal vents of salmon and vents with varying degrees of RVS. Descriptions are provided to help clarify the different stages of RVS. Please use this guide when recording RVS and report these cases to the contact details below.

Contact us: For more information about RVS or to report affected fish please contact

- In England and Wales contact the Fisheries Technical Services at the **Environment Agency**. Telephone 02084 745244, or email fish.health@environment-agency.gov.uk
- In Scotland contact the Fish Health Inspectorate at **Marine Scotland**. Telephone 01224 876544 and ask for the Duty inspector, or alternatively email MS.fishhealth@scotland.gsi.gov.uk

Vent condition

The vents of salmon can differ in appearance for natural reasons. For example, just prior to spawning the vent may become pinker and protrude slightly, but should appear clean. Some salmon may also have abrasions in the vent area or some sea lice damage as seen in the right hand image below (circled). This should not be recorded as RVS, which involves more pronounced reddening and swelling. The severity of RVS varies. Some evidence suggests that the condition of the vent can improve the longer the salmon are in fresh water. Consequently, please include date of capture, the river and location when reporting RVS cases.

Normal

Normal: Small, pink coloured vent with no evidence of swelling, lesions or haemorrhaging.

Mild RVS

Mild: Slight or no swelling. Reddening around the vent and/or a few red spots (petechial haemorrhage). No evidence of skin erosion, dead skin (necrosis) or scale loss.

Moderate RVS

Moderate: Pronounced reddening around the vent with marked swelling. Some bleeding (haemorrhage), skin erosion and scale loss may be evident.

Severe RVS

Severe: Severe swelling and/or open lesions with bleeding and/or prolapsed tissue from the vent. Eroded or dead skin (necrosis) evident around the vent. Secondary infections may also be present.

Inland Fisheries Ireland
3044 Lake Drive,
Citywest Business Campus,
Dublin 24,
Ireland.
D24 CK66

www.fisheriesireland.ie
info@fisheriesireland.ie

+353 1 8842 600