National Barriers Programme Annual Report

2022

IFI/2023/1-4643

An Roinn Tithíochta,
Rialtais Áitiúil agus Oidhreachta
Department of Housing,
Local Government and Heritage

NATIONAL BARRIERS PROGRAMME

Iascach Intíre Éireann
Inland Fisheries Ireland

National Barriers Programme Annual Report 2022

IFI Report Number: IFI/2023/1-4643

Project Personnel
Members of the National Barriers Programme Team 2022 included:
Brian Coghlan MSc (Res)
Róisín Donovan MSc
Sarah Keane
Dr. Ciara O'Leary
Abi O'Connell

Bursary Student
Michael Paris

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Executive Summary

The National Barrier Programme (NBP) has created a national database of potential barriers to fish passage (73,076) encompassing structures which can impact on both fish passage and hydromorphology. Since 2019, the programme has streamlined barrier evaluation through the development, roll out, and optimisation of an android-based barrier assessment App (I-BAST), integrated with an online database. This advance has contributed to the rapid assessment (as of Spring 2023) of 30,214 structures and identification of 7,429 barriers to fish passage.

By completing 233 large barrier assessments on major rivers, including the Shannon, Munster Blackwater, Boyne, Liffey and Suir, the NBP has delivered reports documenting fish passage issues. These reports are critical to the barrier mitigation process. They highlight the requirement to the planning authorities for fish passage enhancement and represent a primary step in the current barrier mitigation programmes being undertaken, or supported, by Inland Fisheries Ireland.

The recent EU Commission Biodiversity Strategy 2030 has underlined the critical importance of river network connectivity. This calls for greater efforts to restore freshwater ecosystems and the natural functions of rivers and sets a minimum target of 25,000 km of European rivers to be free flowing again by 2030, through removal of obsolete barriers and restoring floodplains and wetlands. The NBP is actively contributing to Ireland reaching its EU Biodiversity Strategy goals though the mitigation of barriers to fish passage identified through local knowledge and high-level prioritisation.

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Introduction

Inland Fisheries Ireland (IFI), the state agency responsible for the protection, management, and conservation of Ireland's inland fisheries and sea angling resources. Ireland has over 74,000 kilometres of rivers and streams and 128,000 hectares of lakes, all of which fall under the jurisdiction of IFI.

The EU Water Framework Directive (WFD) views water quality in an all-round sense of ecological quality and uses several elements to assess 'water quality' in each water body. These elements include the fish and invertebrate community and how these communities may differ from natural conditions. Another important quality element in the WFD is that of 'hydromorphology'. This term incorporates the quantity of water (hydrology) and the quality of the physical habitat (morphology and ecology). Another component of hydromorphology is that of 'continuity' i.e., the flow of water (fluvial geomorphology) is undisturbed by obstructions or barriers, allowing both fish and other wildlife to pass both upstream and downstream and allowing normal downstream transport of sediment.

Migratory species such as Atlantic salmon, sea trout, sea lamprey, river lamprey, twaite and allis shad, and European eel all make long migratory journeys to reproduce. However, a range of other fish, such as pike, brown trout, and bream, live entirely in fresh water but also make extended feeding or spawning migrations within this habitat. Any restrictions to fish migrations may have negative consequences for their reproductive and feeding capacity and could lead to decline in population. Fish movements and migrations can be affected by different man-made structures in rivers. These structures may include bridge floors, culverts, sluices, dams and weirs. Fish require freedom of movement to feed, grow, find shelter, and reproduce effectively. Barriers can have negative impacts on reproduction and somatic growth by creating physical, hydrological, and behavioural restrictions to these natural migrations.

To facilitate fish passage at artificial barriers, a range of applied techniques have been developed (e.g. barrier removal, bypass channel, fish ladders, lifts). However, historically attention was focussed on relatively few species, driven primarily by their economic, recreational, and cultural importance. As a result, the majority of fish passage research and mitigation measures have concentrated on upstream migrating adult salmonids. Despite this bias, current WFD/Habitats Directive legislation has led to advanced progress in the development of fish passage and screening criteria for multiple species throughout their life-histories including other threatened, but weak swimming species such as European eel and lamprey species.

Typical run-of-the-river weirs affect river continuity for biota and sediment, but one important effect is the reduction of flow velocity, which directly changes sediment composition, bed structure and water residence times. Benthic invertebrates are highly sensitive to impact by those alterations, but fish are also significantly affected (e.g. by a reduction in habitats, migration barriers or changes to thermal regimes) and macrophyte communities are severely impacted as reductions in flow velocity causes changes in abundance and occurrence of species with different growth forms.

The impact of hydromorphology as a key pressure under the Water Framework and Habitat Directives has led to added impetus to address such issues in the current 2nd cycle of WFD and to plan for implementation of mitigation measures into the 3rd cycle. The Department of Housing, Local

Government, and Heritage invited IFI to undertake a series of investigations in regard to barrier issues and to develop plans and protocols in preparation for WFD cycle 3 implementation.

Key Activities and Outputs

This programme aims to deliver an inventory of barriers structures on Irish rivers supported by applied studies that will inform best practice approaches to barrier mitigation. This will make a significant contribution to the programme of measures included in the 3rd cycle of the river basin management plan (2021-2025) and provide critical information for the 4th cycle of the river basin management plans.

1. Further integration and evolution of barrier assessment tools into the streamlined approach that has been developed in the National Barrier Programme.

Duplicate Barrier Points

The NBP team are consistently looking to update the technology we use to have the most efficient tools in place to survey and assess the potential barriers across Ireland. This year an additional selection to 'barrier' options was included in the IFI Barrier Assessment and Screening Tool (I-BAST). This was the' duplicate' option, to identify where there were two points for the one structure being assessed. This update to the survey allows for the NBP to identify these 'duplicate' points both in the field and in the database respectively.

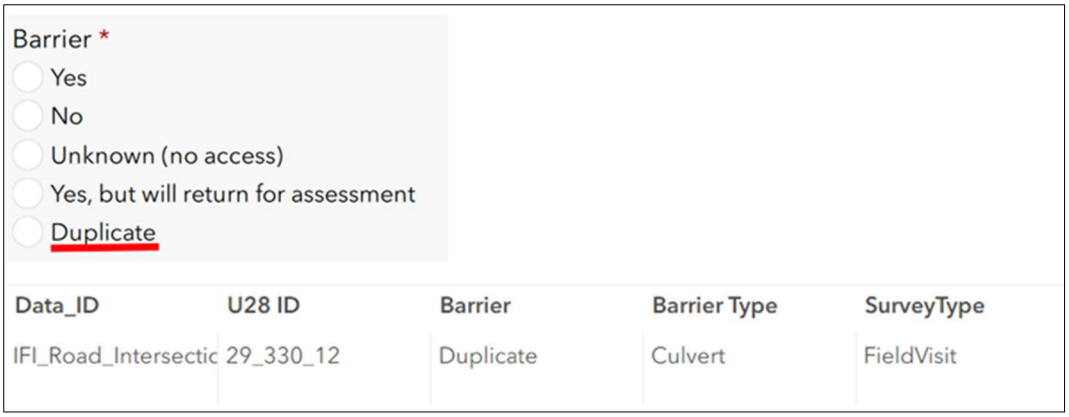

Figure 1. AGOL and Survey123 interface with Duplicate button integrated.

In 2022, 116 'Duplicate' points were assessed in the 14 sub-catchments completed by the NBP team (Figure 1). These points were removed from the geodatabase to give an accurate representation of the barriers impacting fish passage of instream structures within the Republic of Ireland.

SNIFFER Integration to ESRI geodatabase

SNIFFER (Scotland and Northern Ireland Forum for Environmental Research) created a Passability or barrier assessment approach. The NBP team presently employs this technique, known as the WFD 111 method, to inspect structures when some kind of remedial work is planned, such as partial or complete removal, modified fish passage structures, etc. The structure is examined using the WFD111 barrier assessment approach, which also counts the number of potential passageways that various fish species could take. The NBP team have on-going development to integrate this assessment- tool (level III) into a Esri geo-database format. This development has started in 2022 and will aim to be fully integrated by end of 2023.

Redd Count Surveys

To estimate salmonid and Lamprey *Sp.* spawning population size and provide substantial spatial and temporal coverage in monitoring activities, a comprehensive survey is currently being developed. In order to get this information from both research professionals and operational staff, the NBP will assist in creating and tailoring a survey for both. This data collection application will dovetail with the Annacotty Fish Passage Project and the survey will be used to collect Lamprey spawning location and abundance data to show benefits of the Annacotty Weir mitigation Process.

Migrate existing SNIFFER data to ESRI geodatabase format. (Approx. 230ish Surveys)

The NBP team has completed 233 SNIFFER surveys thus far. The national geodatabase has been updated with these sites' data and points.

2. A comprehensive programme of barrier surveys, risk assessments, applied research of barrier impacts/mitigation effectiveness and reporting in line with available resources.

I-BAST

A level I assessment tool was developed by the NBP team to identify and appraise instream barriers to Irish river connectivity. The IFI Barrier Assessment and Screening Tool (I-BAST) is a standardised method of recording the dimensions, distribution, and degree of impact to fish passage of instream structures such as bridges, culverts, fords, and weirs.

In 2022, 4,168 potential barriers were assessed in 76 WFD sub-catchments and seven River Basin Districts (Figure 2). Of the 76 sub-catchments, 14 (containing 1,764 potential barriers) were completed by the NBP team (Figure 3).

To date, January 2023, the IFI Operations in conjunction with the NBP team have assessed ≥75% of potential barriers in 144 WFD sub-catchments, ranging across seven River Basin Districts (Figure 3). Of the 583 WFD sub-catchments in the Republic of Ireland, 514 (88%) have at least a portion of the barriers within their borders assessed. More than 25% barrier assessment coverage exists in 216 sub-catchments. Of these, 113 are >90% completed and 59 are >50% completed.

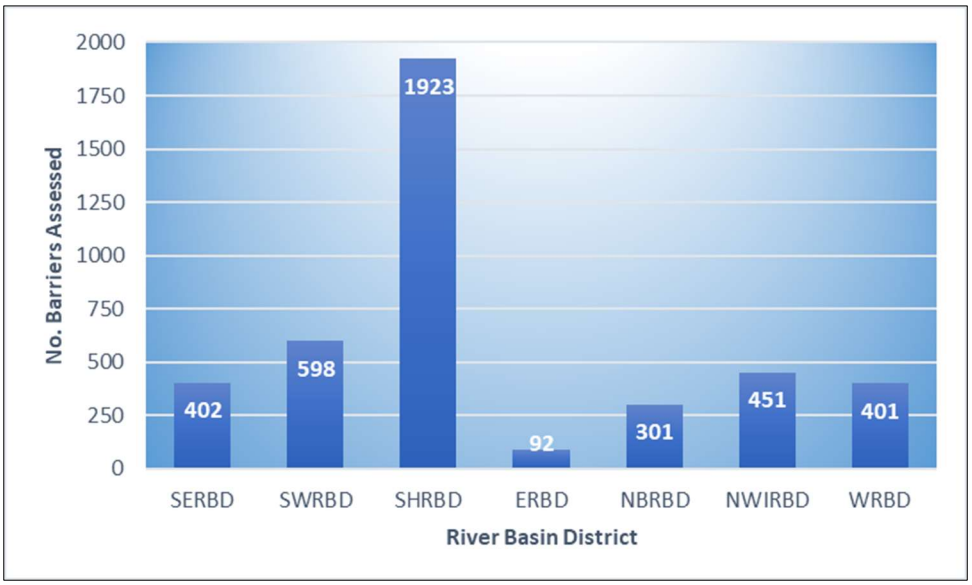

Figure 2. Number of I-BAST barrier assessments completed in 2022 by River Basin District.

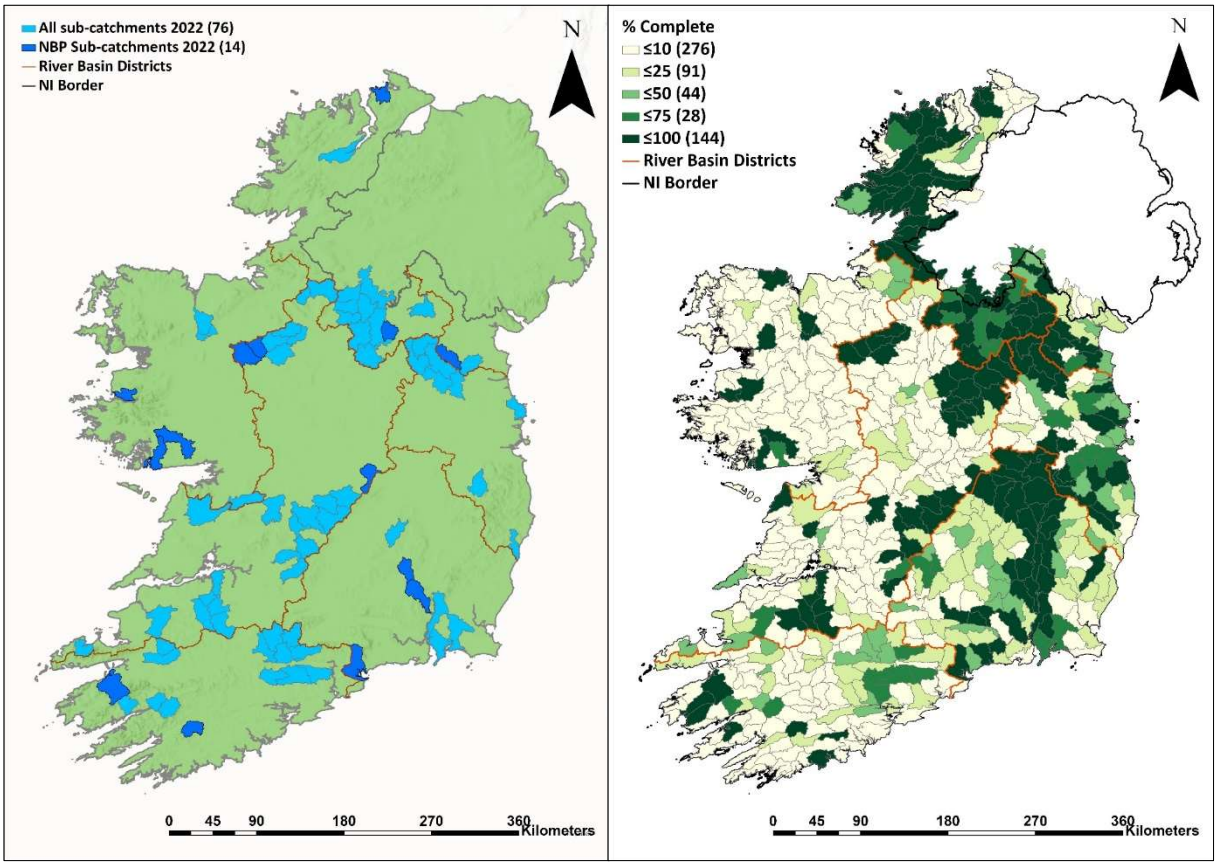

Figure 3. Left: WFD sub-catchments surveyed with the I-BAST application by the NBP team (dark blue) and IFI Operations (light blue) in 2022. Right: Percentage of potential barriers assessed within each WFD sub-catchment as of 12/01/2023.

SNIFFER Surveys

A more advanced assessment tool (level II) is employed at structures where there is potential for barrier mitigation. The Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) protocol considers additional parameters, such as velocity, and offers a detailed appraisal of fish passage.

In 2022, 35 SNIFFER surveys were conducted on instream structures by the NBP team (Figure 4). Survey sites were spread across five River Basin Districts and 25 different rivers, primarily on stretches with an order greater than 4. Some of the rivers included were the Maigue in the SHRBD, the Awbeg, Maine, and Owvane in the SWRBD, the Aughrim and Ballyduff in the ERBD, the Robe, Corrib, and Bunowen in the WRBD, and the Eany, and Donagh in the NWIRBD. The structures assessed in 2022 were either weirs (33) or Culverts/ bridges (2).

The 2022 SNIFFER survey programme included 18 IFI fish counters, constructed to count salmonids for stock management purposes. These structures may present a barrier to poor swimming fish species in low flow conditions. 6 IFI fish counters are outstanding for assessment, these will be assessed in 2023 and a report delivered outlining findings.

To date, 233 SNIFFER surveys have been conducted in seven River Basin Districts (Figure 4). A small portion of these surveys were repeat assessments, such as at Annacotty Weir, Limerick.

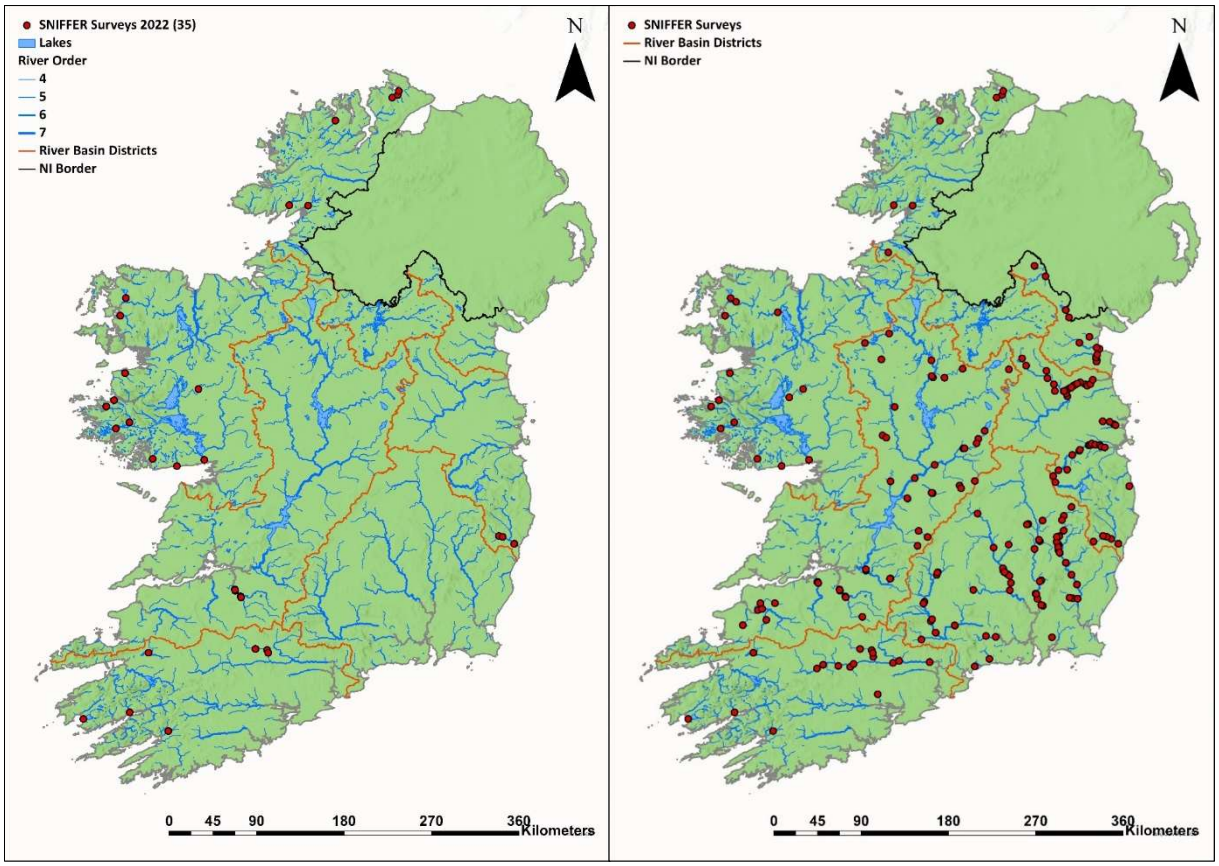

Figure 4. Left: The locations of the 35 SNIFFER surveys conducted in 2022. Right: All 233 SNIFFER surveys conducted to date.

Training

A comprehensive training programme was devised by the NBP comprising of a classroom-based session and a practical field session where the barrier survey form was introduced, explained, demonstrated, and practiced. This one-day course explores the issues involved in identifying potential barriers to fish passage and thereafter the practical details of applying the survey form on a mobile device in a field setting.

In 2022, training was delivered to the IFI Research Officer responsible for the National Salmonid Index Catchment in Ireland (the Erriff), the Cavan Office of the NWRBD, and the Tralee office of the SWRBD. In Total, 14 IFI staff were trained in the use of the I-BAST barrier assessment tool in 2022. In the lifetime of the NBP, 107 IFI Operations and Research staff have been trained in the use of I-BAST tool.

In 2020, the NBP shared the supporting Survey123 forms of the I-BAST assessment with the Lough's Agency of Northern Ireland. With consultation, it was modified to suit their administrative needs while retaining the barrier assessment forms, retaining cross border inter-calibration. In October and November 2022, the NBP delivered the standard I-Bast training course to 34 loughs agency staff over 3 days.

Figure 5. I-BAST barrier assessment training delivered to the Loughs Agency, November 2022.

3. Further develop a national, regional and catchment-based prioritisation matrix to identify structures for mitigation and provide documentation for funding proposals for mitigation works.

Prioritisation Matrix

Barriers associated with human infrastructure have a widespread impact in freshwater ecosystems worldwide, disrupting connectivity along river networks and key processes. Spatial optimisation methods can help inform decisions on what barriers to remove to maximise gain in connectivity under limited budgets. However, current optimisation approaches rely on programming skills that are not easily accessible, which restricts the use of these methods. To promote the use of optimization tools, straightforward and open-access platforms are needed to support holistic basin-scale connectivity restoration.

There are dozens of prioritization methods in use. These can be broadly grouped into six main types depending on whether they are reactive or proactive, whether they are typically applied at local or larger spatial scales, and whether they employ an informal or a formal approach. These include, in increasing order of complexity:

1. Opportunistic response
2. Use of local knowledge and expert opinion
3. Scoring and ranking
4. Geographic information system (GIS) scenario analysis
5. Graph theory
6. Mathematical optimization.

As noted by Garcia de Leaniz and O'Hanley (2021), mathematical optimization sets the gold standard for effective and robust barrier mitigation planning. But to be implemented, it needs to factor in the constraints imposed by uncertainties and opportunities. Therefore, a hybrid approach encompassing uncertainty, natural barriers, future-proofing, and opportunities provided by local knowledge is likely to be the best overall approach.

Open access platforms identified for prioritisation.

- **Fipex+Dci V10.4**: Bridging Network Analysis and GIS for River Connectivity Assessment
  - Oldford, G., Cote, D., Wiersma, Y.F., Kehler, D.G. and Riefesel, G.R., Fipex+ Dci V10. 4: Bridging Network Analysis and GIS for River Connectivity Assessment. Available at SSRN 4159582.

- **Marxan** - A freely accessible spatial prioritisation tool commonly used in conservation planning assessments, for prioritising barrier removal projects at the catchment scale.
  - Hermoso, V., Clavero, M. and Filipe, A.F., 2021. An accessible optimisation method for barrier removal planning in stream networks. *Science of the Total Environment*, 752, p.141943.

- **River Network Toolkit (RivTool)** - Supported by the project Dammed Fish, new add-ons are being developed to expand the ability of this software. RivConnect, a plugin to enable the calculation of fragmentation metrics and river connectivity indexes. RivOpt, an optimization tool to support decision making for barrier connectivity enhancement, accounting for conflicting ecological and socioeconomic goals.

- Duarte, G., Segurado, P., Ferreira, M.T. and Branco, P., 2022. The Future of RivTool. In Biology and Life Sciences Forum (Vol. 13, No. 1, p. 100). Multidisciplinary Digital Publishing Institute.

The National Barrier Programme has undertaken preliminary investigation into the above prioritisation tools. Each has significant benefits and negatives. Fipex+Dci V10.4 is an ESRI ArcMap based too which is user friendly and integrates with available software, however this iteration does not fully meet the needs of the barrier programme as its capacity to iterate prioritisation calculations is significantly time consuming. Promised further iterations of this software may fix this issue. Marxan, while a commonly used tool in conservation planning would require significant learning and data processing. While freely available this approach has not been widely used by the scientific community. The River Network Toolkit (RivTool) is in development by the Europe-wide research project Dammed Fish. This will be a free application and while the software to run the prioritisation add-ons is available the timeline for deliver is unclear.

In line with investigating an automated prioritisation approach the NBP is currently extending its scoring and ranking prioritisation exercise to the remaining Technical Expert Group on Salmon (TEGOS) catchments. Expanding the exercise from the initial 40 largest catchments to the remaining 100. Further ranking catchment parameters will also be investigated to streamline and maximise outputs. This task also requires further population of the national barrier database.

Assessments and Reports to Stakeholders

In 2022, 6 SNIFFER reports on individual structures were issued to assist in planning permission or at the request of IFI Operations. Three reports based on I-BAST assessments were also delivered. Additionally, SNIFFER catchment reports, detailing the assessments of multiple structures within a river system, were issued for the River Liffey, River Brosna, and Owendalulleegh River. The River Boyne is an outstanding SNIFFER catchment report requested by IFI Operations (surveys done and writeup is being prepared).

<u>Reports produced in 2022.</u>

SNIFFER:

- Castlebellingham Weir, River Glyde, Co. Louth.
- Blackcastle Weir, River Boyne, Co Meath.
- Gearagh Bridge, Owvane River, County Cork.
- Carondonagh Town Bridge, Donagh River, County Donegal.
- Glenart Fish Pond Weir, Ballyduff Stream, County Wicklow.
- Maine Fish Counter, River Maine, County Kerry.
- Owendalulleegh River Catchment Report.
- River Liffey Catchment Report.
- River Boyne Catchment Report.

I-BAST:

- Nore_SC_060 Priority sites, Owenbeg River, County Kilkenny and County Laois.
- Deansgrange River - Barriers to fish passage and habitat mitigation through flood relief.
- Owenerk Bridge, Owenerk River. Co. Donegal.

4. Provide a data led research and monitoring programme to evaluate the impact of barriers and the effectiveness of management approaches.

Low Head Barrier Temperature Study – River Boyne

A temperature study was devised by the NBP to quantify the impacts of thermal disruption by low head artificial instream structures. Instream structures have the potential to create not just physical barriers, but also thermal environments inhospitable to native fish populations. Temperature is an important ecological variable that impacts the reproduction, feeding, growth, and migration of aquatic biota. Thermal thresholds exist for native species that have the potential to be exceeded in barrier-impacted river reaches. The ramifications of barriers for thermal regimes in Irish rivers are currently poorly understood, despite the prevalence of instream structures. The results of this study will help to inform effective barrier mitigation and are especially relevant for mitigation designs in the context of climate change.

Figure 6. Left: Dunmoe Weir. Right: Stackallen Weir.

In July 2022, temperature loggers were placed at Stackallen Weir and Dunmoe Weir on the River Boyne. At both structures, loggers were installed upstream, in the impoundment, and immediately downstream of the weir to assess water temperature variability surrounding the barriers (Figure 7). A control site on the Boyne, without the influence of barriers, was chosen at Bellinter, Co. Meath. In total, 16 loggers were deployed. On the 7th September, the loggers were collected and the data analysed. A baseline dataset was created, in addition to data collection methodologies.

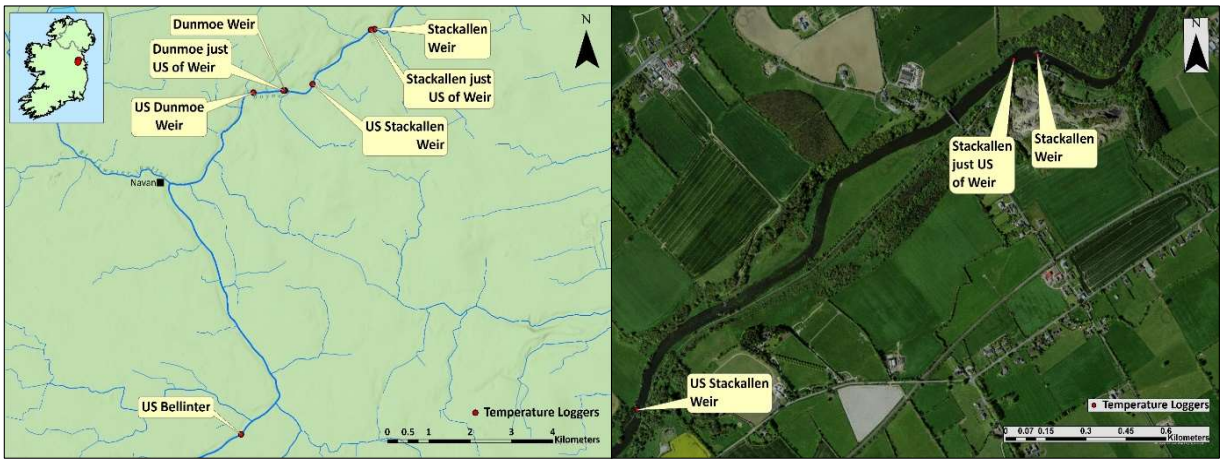

Figure 7. Left: The locations of temperature loggers on the River Boyne. Right: The locations of loggers at Stackallen Weir.

The deployment of probes on the River Boyne coincided with potentially the hottest day recorded in Ireland in 2022. A temperature of 33°C was documented at the Phoenix Park on Monday 18th of July 2022 (Met Eireann). This coincides with the significant heating event displayed in Figure 8. However, the water temperature peaked on the 19th of July (22.6 to 23.2°C) rather than on the 18th of July.

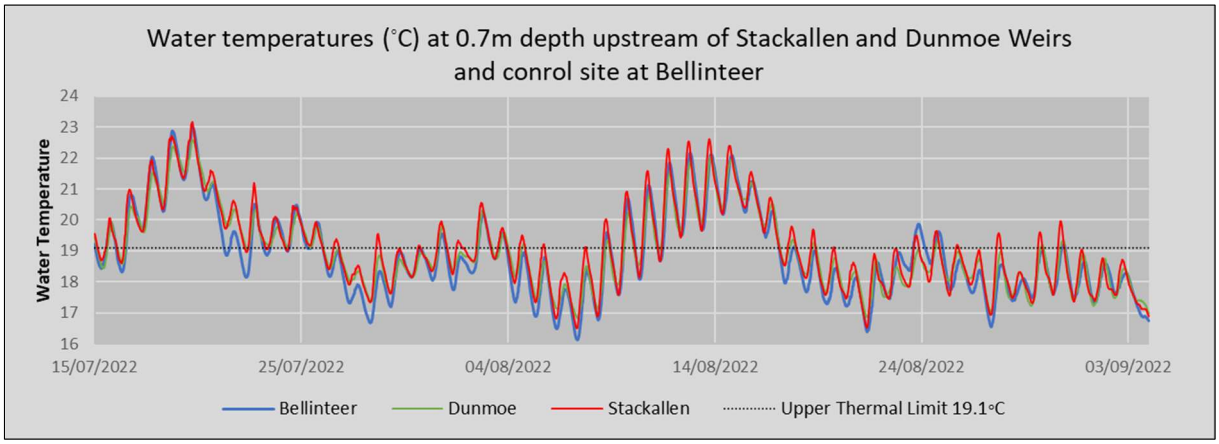

Figure 8. Graph showing the water temperature 0.7m below the water's surface in the impounded sections upstream of Stackallen Weir, Dunmoe Weir, and at the control site of Bellinter, between the 15th of July and the 3rd of September, 2022. The 19.1 °C demarcation corresponds to the upper thermal limit for trout.

The two high temperature events in Figure 8 (18th July/13th August) show how a large main stem river such as the Boyne responds to a "heat wave". In both periods, the water temperature exceeded 19.1 °C, the temperature at which trout no longer grow. In a comparison of the impounded water temperatures upstream of the Stackallen and Dunmoe weirs, and the control site at Bellinter during the sampling period, water temperatures exceeded 19.1 °C for 36% of the time at Bellinter but 40% and 44% at Dunmoe and Stackallen respectively. High water temperature maximums were recorded at all sites during the sampling period. However, water temperatures appeared to cool faster at the control site compared to the sections impounded by man-made weirs (Figure 9).

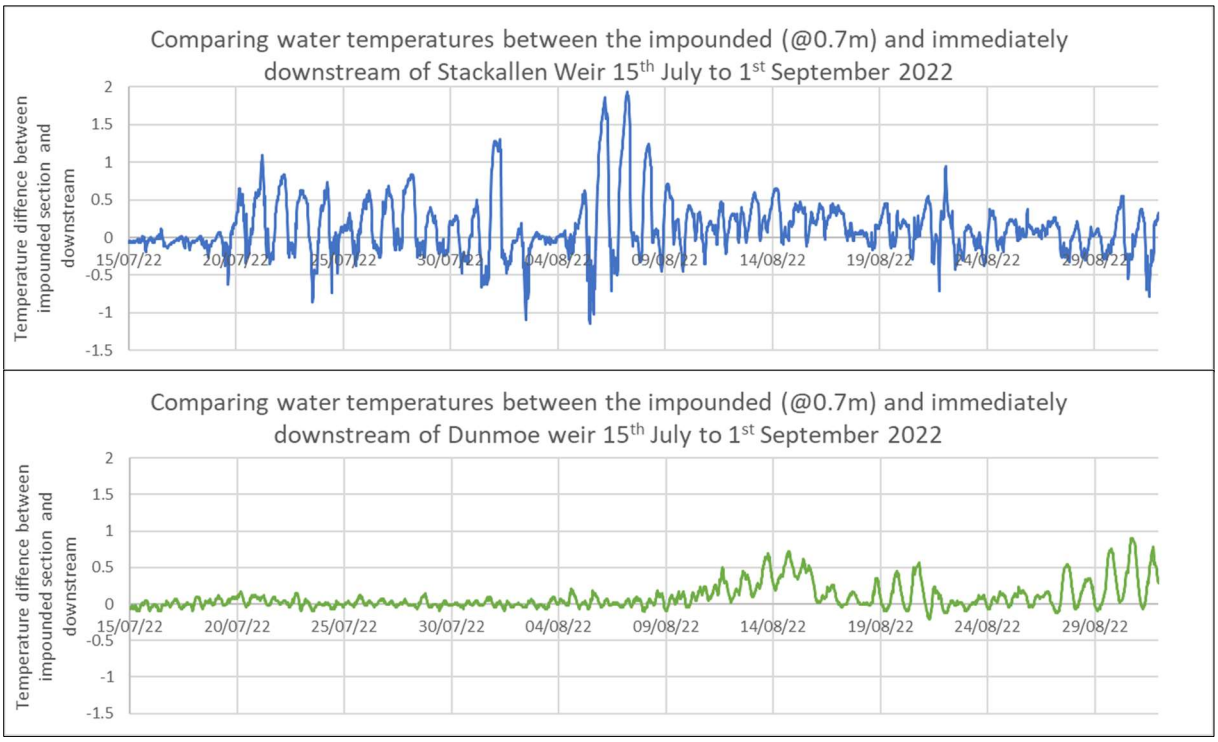

Figure 9. Graphs showing the difference between impounded sections (0.7m depth) and downstream water temperatures for Stackallen and Dunmoe weirs during the logger deployment period in 2022.

Comparing temperatures in the impounded areas (0.7 m below surface) versus immediately downstream, positive temperature values mean temperature in the impounded sections are higher. The two weirs demonstrate different temperature dynamics, with pronounced diel variations at times but not following same temporal pattern (Figure 9).

Diurnal variations in temperature can be seen in both the air temperature and differences in upstream/ downstream water temperatures (Figure 10) at Stackallen Weir during summer heating events. Difference in upstream/downstream water temperatures of up to 1.5°C were recorded during the extended sampling period. The impounded section upstream of the weir retains heat during cooler nights (air temp dropping to ~10 degrees). The impoundment acting as a "heat store" as it retains heat during these nights with up to 1.2°C difference compared to immediately downstream. However, during the day (when air temperature is hotter) the water is (slightly) warmer downstream of the weir. From this initial investigation Stackallen's biggest modification of thermal habitat is in maintaining warm temperatures during cooler nights, when otherwise a cool respite may have been provided to fish, invertebrates etc.

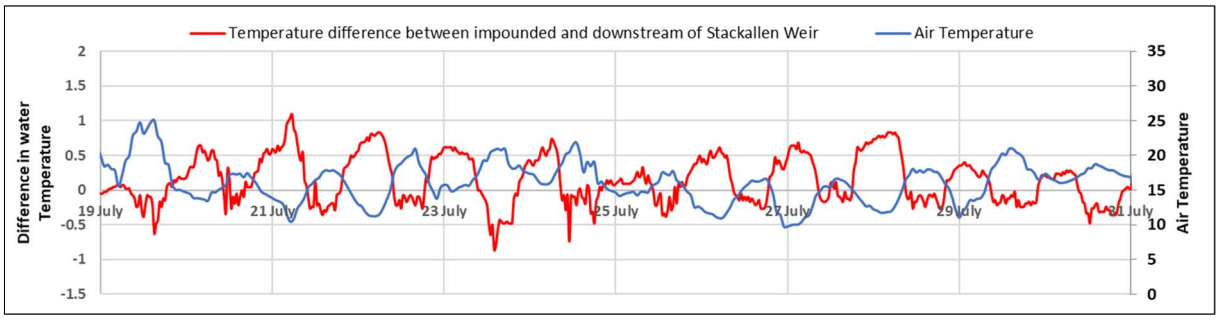

Figure 10. Graphs showing air temperature and the difference between impounded and downstream water temperatures for Stackallen between 19th to 31st of July 2022.

Cumulative impact of barriers on River Boyne (2023) – Seán Kelly, Office of Public Works Climate Resilience Project (OPWCRP)

Inland Fisheries Ireland (IFI) and Office of Public Works (OPW) initiated a collaborative research programme tasked with understanding the implications of climate change for Ireland's fish species and their freshwater habitats in arterially drained catchments. A key element of the project is to use temperature data to identify streams and rivers that remain relatively cool during warm periods, 'climate refugia", and to similarly identify streams and rivers that reach excessively warm temperatures. This could aid with site specific conservation planning and allow resourceful targeting of climate mitigation measures for cold-water fish.

A stream temperature scenario map for the Boyne (Figure 11), was developed from 46 temperature sensors recording during the heatwave that occurred in July 2021. The difference in mean and maximum water temperatures observed between different rivers across the catchment was over 10°C in some in stances. Maps of thermal habitat ('scenario maps') allow us to visualise these differences and clearly distinguish between cool streamer fugia (that remained below 14°C) and river hotspots (with water temperatures exceeding 20°C) (Figure 11).

The warmest sites indicated in red were the outflows from Lough Ramor and Lough Leane/Adeel and the Boyne downstream of Navan (Figure 11). Lake discharges are affecting the temperature regime of both the Deel and Kells blackwater rivers, similarly the multiple impounding weir structures downstream of Navan may be impacting on the natural thermal regime of the River Boyne. These weirs are impounding flows, increasing water residence times, and altering river habitat, creating small "lakes" behind each structure. Each structure is potentially creating a "river hotspot" and with little downstream distance between each structure, the river may not have the distance to cool to a more natural temperature regime between these structures.

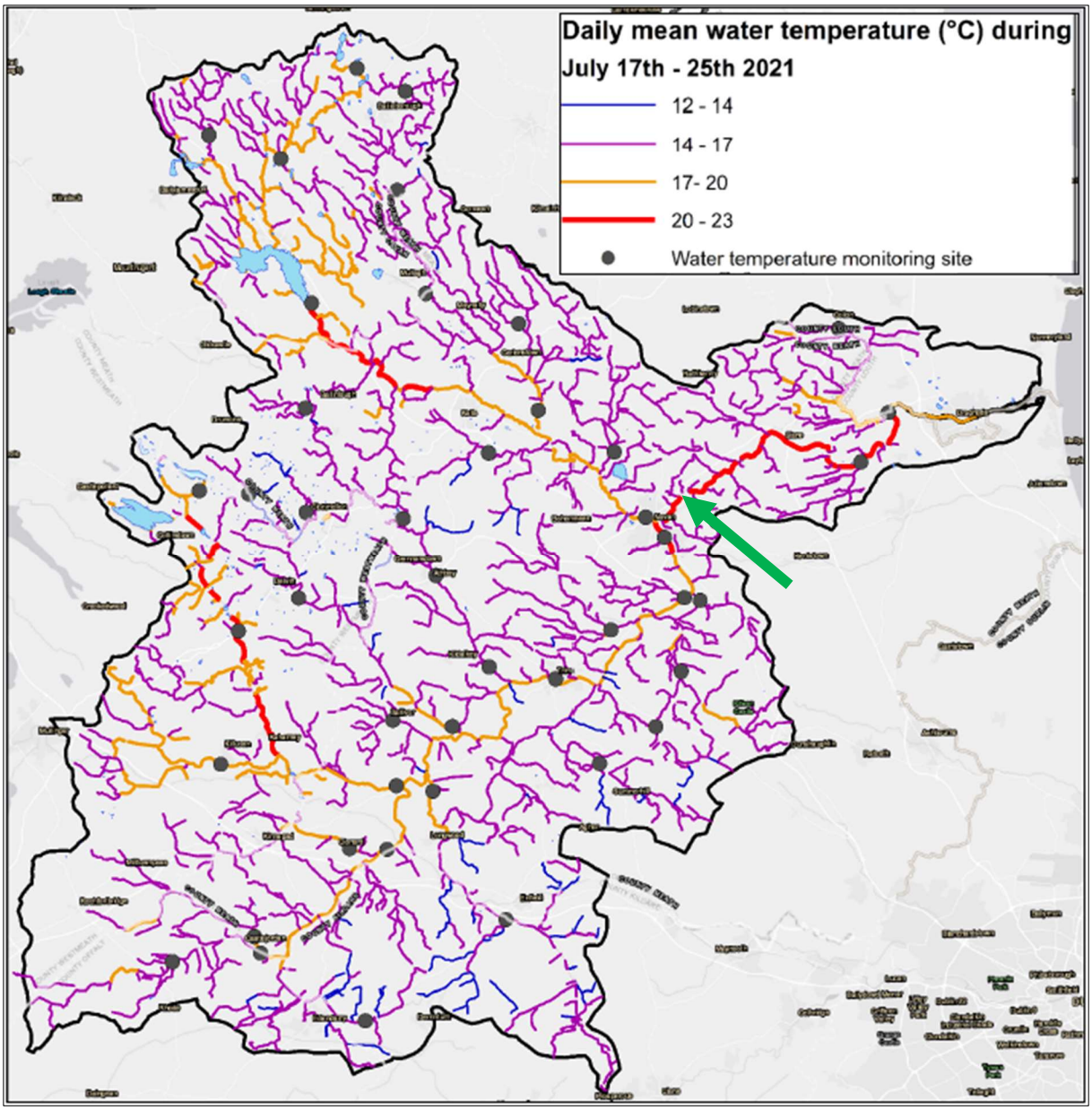

Figure 11. Modelled river temperatures developed from temperature observations (grey circles) across the Boyne, showing average daily water temperatures during July 2021 heatwave (arrow – location of Dunmoe and Stackallen weirs).

East Coast Reservoir Study - Environmental flows

In Ireland, little is known about ecological (flow and thermal ecology) and hydromorphological impact of flow regulation associated with major barrier structures such as hydro-electric schemes and reservoirs, despite their presence in large waterbodies such as the Erne, Liffey, Lee, and Shannon catchments among others. To help address this knowledge gap, Inland Fisheries Ireland (IFI) has commenced a pilot study that takes in the Dodder, Liffey, and Vartry reservoirs and other free-flowing rivers (Dargle, Slaney, Avoca) within the Dublin/Wicklow mountains for reference. These catchments all support annex listed species listed under the Habitat Directive, including Atlantic salmon and Sea trout species that are considered particularly vulnerable to altered flow and thermal disruption. This study involves collecting Water Level/Temperature Data, using remote loggers that generate high resolution temporal data. In addition, discharge related data is collected at sampling locations

downstream of the reservoirs using an Acoustic Doppler Current Profiler (ADCP). This this will be used in conjunction with the water level data to generate discharge curves and investigate the relationship between water temperature and discharge management in the context of environmental flows.

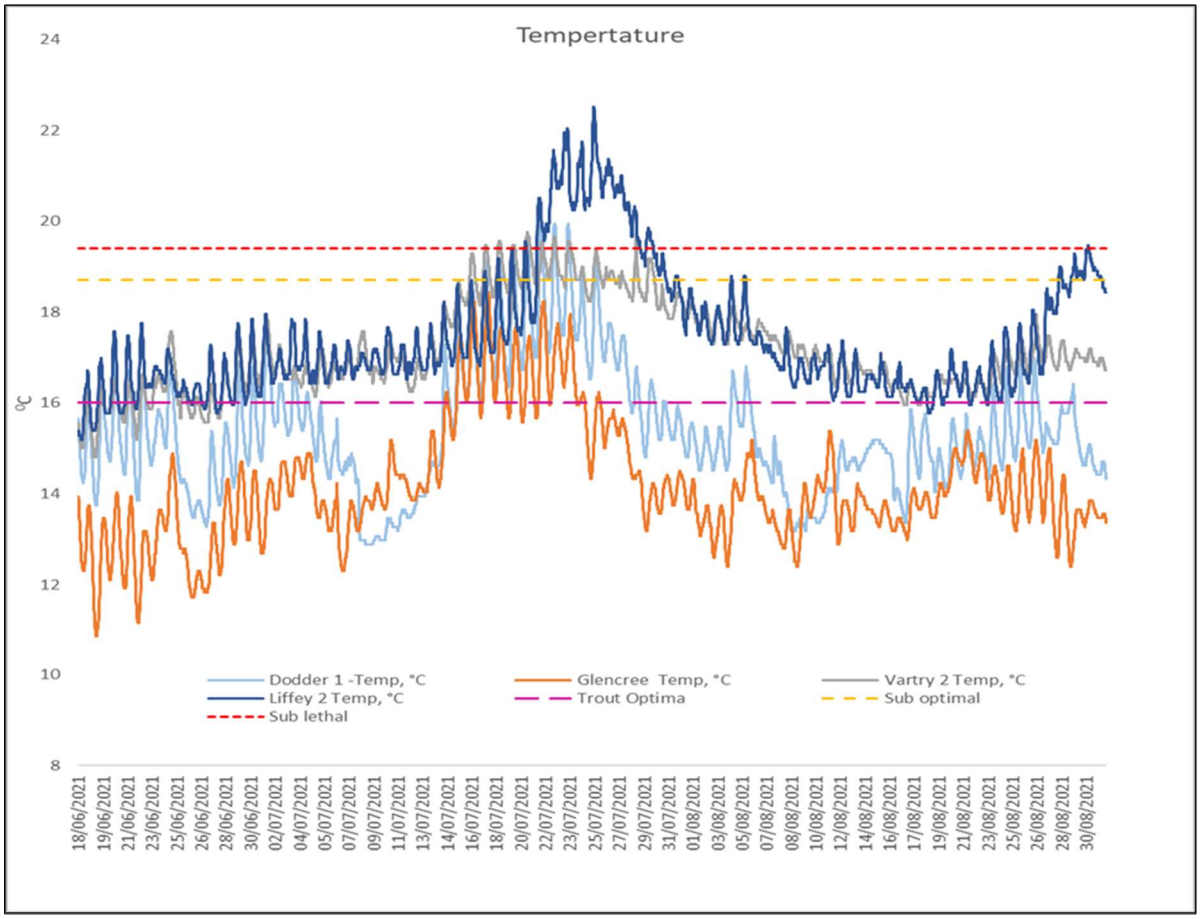

Figure 12. Water temperature data from the dammed/regulated rivers (Dodder, Vartry, Liffey) and a free-flowing river (Glencree) from mid-June to August, 2021. Optimal thermal habitat conditions for brown/sea trout (<16 0C), sub-optimal (16-18.70C and sub lethal (>19.40C) are also shown as horizontal threshold lines.

Results show that all rivers experienced temperatures above the optimum for trout in July 2021 during a heatwave/drought event (Figure 12). However, the free flowing Glencree experienced this for a much shorter period relative to the dammed rivers. Notably, the Liffey and Vartry rivers experienced temperatures above the optimum for trout for most/all the summer period, including temperatures that exceeded the sub lethal thresholds.

Pre and Post Barrier Removal Assessment (liaising with IFI Annacotty fish passage project)

The NBP team aim to consider and quantify the status of fish passage and hydromorphological processes both pre- and post- mitigation works. By creating a baseline dataset prior to works, the success of any mitigation measures implemented can be accurately assessed. The assessment process can also help to inform future mitigation efforts.

Pre barrier removal assessments included:

- SNIFFER assessments, conducted in 2015 and 2021 by the NBP team.

- Lamprey redd surveys from 2012 to 2022, compiled from Mulkear Life data (2012 to 2014) and surveys conducted by the Habitats Directive team at IFI (2015 onwards). An animated map was created displaying the changes in lamprey abundances in the catchment over an 11 year period.
- A re-analysis of the raw data collated as part of the Mulkear Life project, with a focus on Annacotty Weir, involving the following:
    - The **passage success** of tagged sea lamprey at Annacotty Weir in its pre-mitigation state was analysed.
    - The **length /weight** distribution of lamprey attempting to traverse the weir was graphed.
    - The **delay** imposed by the structure on sea lamprey successful in passage was calculated (mean= 29.5 days).
    - The **changes to migratory behaviour** displayed by tagged sea lamprey when confronted with Annacotty Weir were assessed and categorised (Figure 13).
    - **Animated maps** were created to exhibit the influence of the weir on the use of catchment by sea lamprey (Figure 14.).
    - **Densities** of lamprey live spawners, carcasses, and redds per stretch of river surveyed from 2012 to 2014 were calculated, compared, and mapped.
    - The **lamprey abundance and distribution** from 2012 to 2014 was mapped (Figure 15).

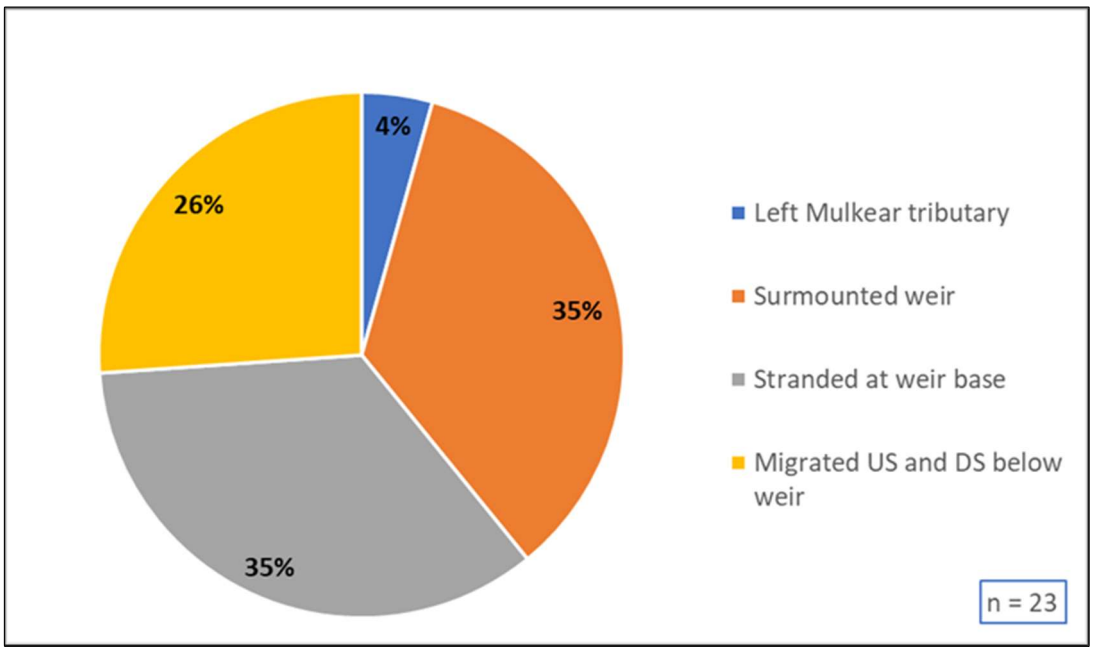

Figure 13. Migratory reactions of tagged sea lamprey (n=23) to the presence of Annacotty Weir.

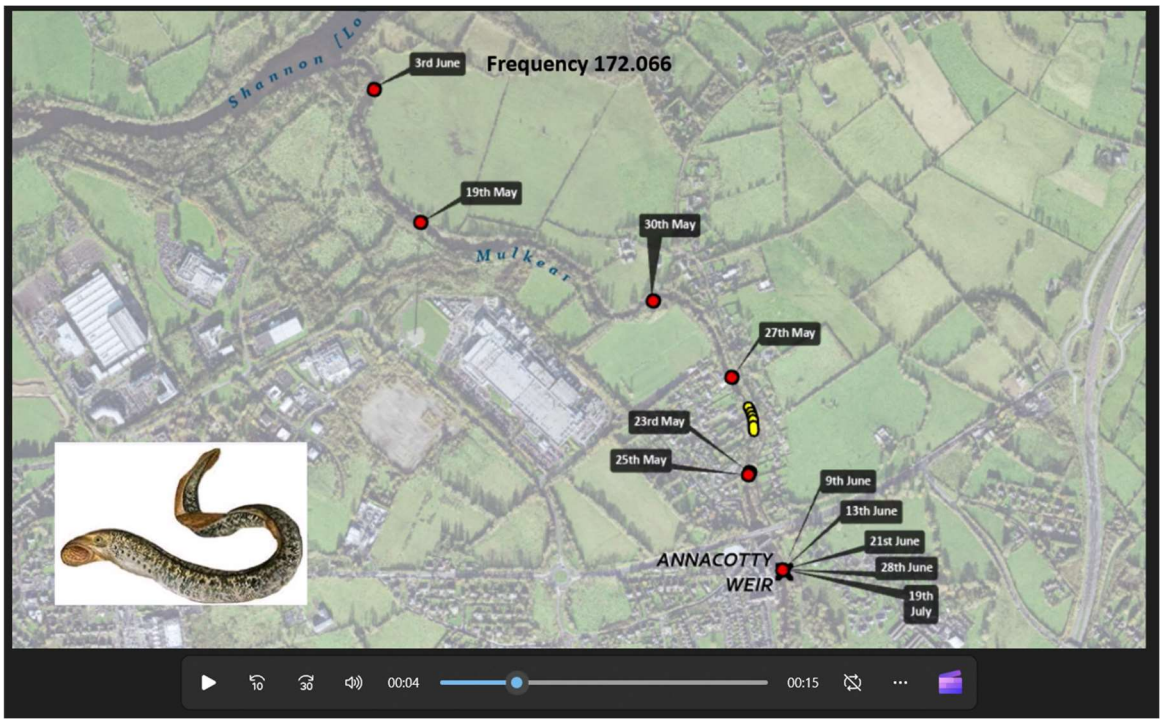

Figure 14. Screenshot of animated map displaying the movements of a tagged sea lamprey on the Mulkear River in 2011.

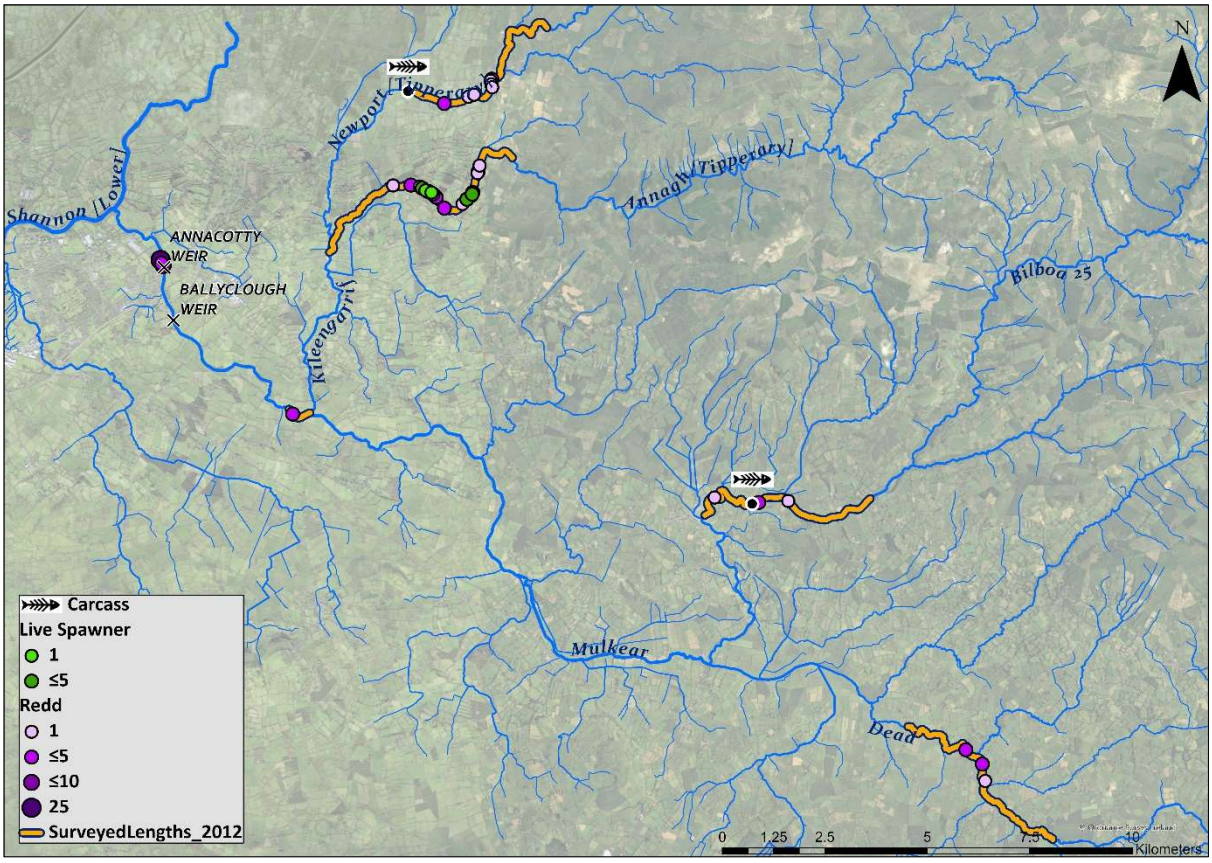

Figure 15. The distribution and abundance of lamprey live spawners, redds, and carcasses in 2012. The lengths surveyed are highlighted in orange.

5. Coordinate with local authorities, State Agencies, TII and Rail Network on supporting barrier assessment with data or incorporating barrier assessments into their maintenance cycles

The National Inventory of Architectural Heritage (NIAH)

To identify potential barriers from the National Inventory of Architectural Heritage (NIAH) website, a thorough desk study was conducted. The NIAH is dedicated to identifying and recording architectural landmarks in Ireland. The goal of this desk study was to establish whether the structure would act as a barrier to fish passage by looking at over 2,632 points with a number of image attachments. As a scholarship student who was a part of the NBP team, Michael Paris completed this work. In total, 1,919 points were determined not a barrier to fish migration, 184 were identified as yes potential barriers and 529 were unidentifiable from the images provided by the NIAH website. This study resulted in the creation of a baseline dataset (Figure 16) and a thorough report. This approach can result in a considerable cost saving, representing 75 days of onsite field assessment.

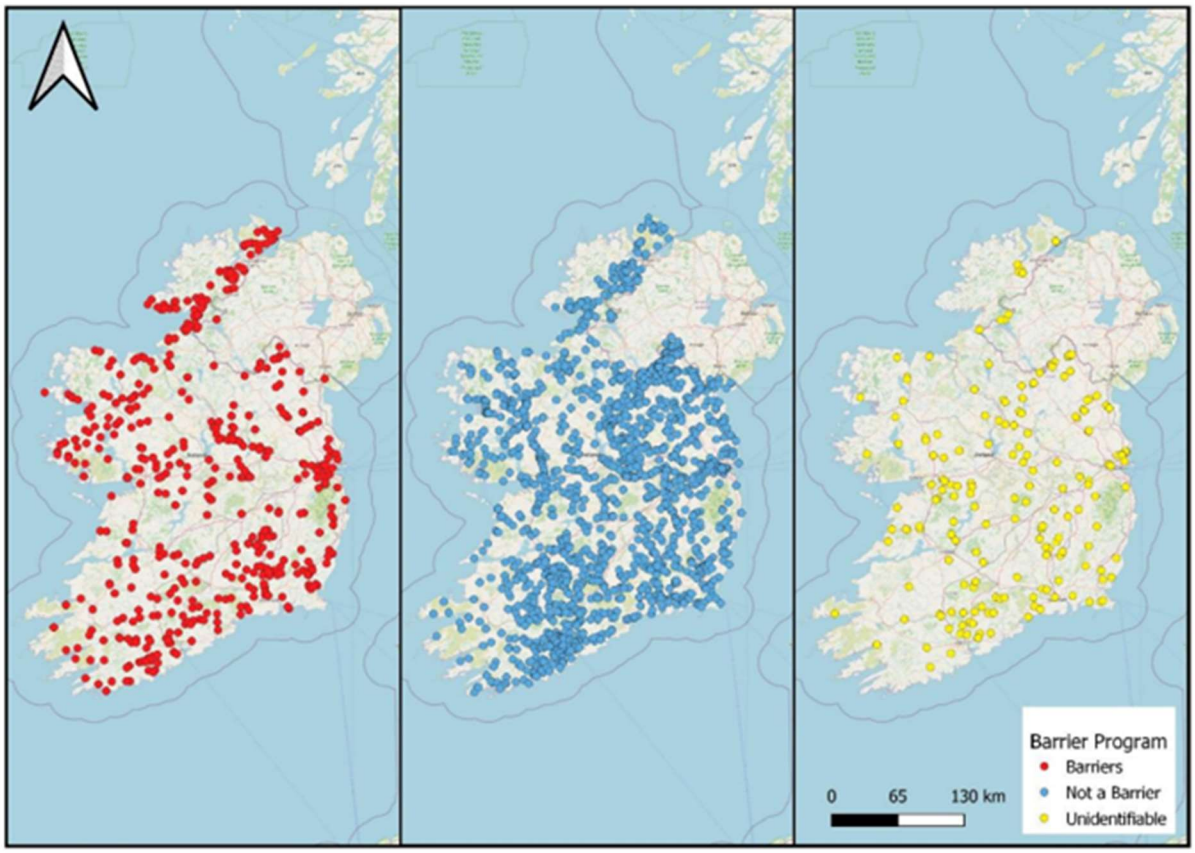

Figure 16. Breakdown of the Barriers points from the NIAH website (n =2632).

Office of Public Works (OPW) Drainage Division – Bridge Inspection Reports

The NBP engaged the OPW drainage division to modify their standardised bridge inspection form. The proposed form modification is designed to capture the presence of a fish passage issue at an inspected structure. Simplified guidelines were produced to identify structures which would impact on the species least capable of passing manmade barriers (e.g. *lamprey Sp.*). A simple question being asked; Does this structure interfere with fish movement or migration? YES/NO. A training video has been produced, explaining the rational of the question with minimal thresholds which when exceeded would mean fish passage would is affected. This video would be accessible through a simple internet address given on the form, for onsite reference.

Office of Public Works (OPW) Flood Relief Division - OPW Barrier Mitigation Opportunities in the Shannon flood relief areas

Meetings were held between IFI SHRBD, NBP and the OPW Flood Relief Division to discuss OPW barrier mitigation opportunities in the Shannon flood relief areas. The OPW Flood Relief Division supplied GIS Polygon Layers outlining the scheme areas and AFA (Areas for Further Assessment) where "Barrier Mitigation" would be a possible/considered during flood relief works. This GIS information was compiled against the NBP National Geodatabase, this identified 35 "priority" structures which could be pushed forward for assessment/mitigation/maintenance works.

The list of 35 priority structures for mitigation/ management for the OPW in the Shannon River Basin District comprised of:

- Culverts and weirs of varying sizes
- Fish passage option repairs/ maintenance on OPW Weirs
- All structures listed are in or very close to the OPW GIS Polygon Layers
- These structures are known problems, there are probably many more which have yet to be identified / Surveyed.
- Waterways Ireland main stem Shannon River structures are listed.

This list of structures represents a great opportunity for OPW to mitigate barriers to fish migration within their flood relief work areas and particularly in flood relief schemes.

6. Dissemination– Raising awareness/ Data portal.

Annacotty fish passage project

The NBP is an internal project partner in the Annacotty fish passage project. This fish passage improvement programme encourages pro-active engagement from stakeholders across the community including key state agencies, special interest groups, voluntary, public and private sectors. The ultimate goal of this project is to improve fish passage at Annacotty Weir on the River Mulkear for species such as Atlantic salmon, sea lamprey, river lamprey, eels and trout, helping them migrate both up and downstream.

The NBP has provided documentation and technical guidance to aid in application for and securing funding through the Salmon and Sea Trout Rehabilitation, Conservation and Protection Fund.

A public information meeting was held on August 23rd, 2022, in Limerick to raise awareness of the Annacotty Fish Passage Project and to highlight potential solutions to the fish passage problems at the weir. Almost 60 people turned out for the meeting at the Castletroy Park Hotel, which was organised by Inland Fisheries Ireland. Attendees included members of the public, representatives from community groups, local angling clubs, Annacotty residents, government departments, state agencies and environmental organisations.

At the meeting, Brian Coghlan, a Research Officer with the National Barriers Programme, gave a presentation about how the weir acts as an artificial 'barrier' to certain fish species and the resulting problems for their life cycle.

Online and in Person Dissemination events

Presentations on barriers to fish migration were delivered to:

- The EPA Water Conference 2022 – Title: "Assessing physical barriers to fish migration"
- World Fish Migration Day 2022 – Title: "Barriers to Fish Migration Ireland"
- Internally to IFI Research, December 2022 – Title: "I-Bast Barrier Identification"
- European Inland Fisheries and Aquaculture Advisory Commission (EIFAAC) International Symposium –2022 "Inland Fisheries and Aquaculture - Advances in Technology, Stock Assessment and Citizen Science in an Era of Climate Change", Killarney, Co. Kerry, Ireland." Title: "Asymmetric impact of climate change on salmonid migration in a fragmented riverscape". Discussing how climate change may affect the downstream migration of juvenile Atlantic salmon in a heavily fragment river.

Data portal - Interactive web application for data investigation

The NBP team produced a dataset in 2022 that was made available on IFI's Open Data Portal. Only the information on the structures that the NBP team has assessed is included in the dataset. This has more than 30,163 records of surveyed barriers (Figure 17). The availability of this data on the open data site enables both public and external users to learn more about the river structures affecting fish passage in Ireland's rivers. As further possible barriers are assessed by the NBP team, this dataset will be updated on a monthly basis.

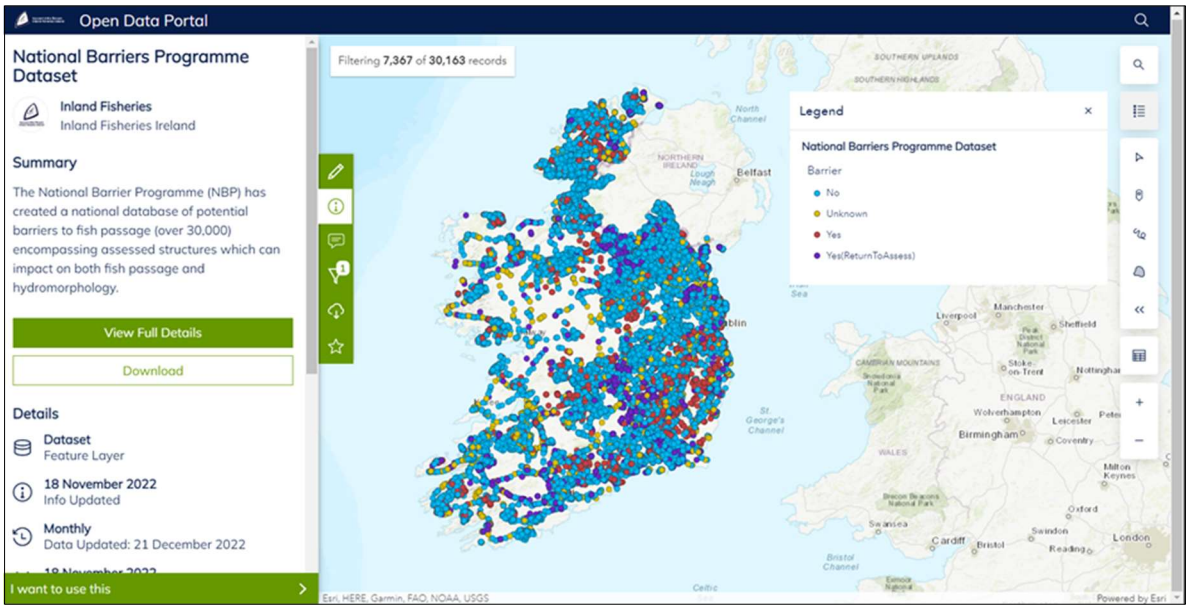

Figure 17. IFI's Open Data Portal Displaying the National Barriers Programme Dataset which has been surveyed.

References

Garcia de Leaniz, C. and O'Hanley, J., 2021. Best practices for selecting barriers within European catchments.

Inland Fisheries Ireland
3044 Lake Drive,
Citywest Business Campus,
Dublin 24,
Ireland.
D24 Y265

www.fisheriesireland.ie
info@fisheriesireland.ie

+353 1 8842 600