SAMARCH 2022
INTERNATIONAL FORUM

ORGANISED BY: Bretagne Grands Migrateurs

IN PARTNERSHIP WITH: Seinormigr

SALMON AND SEA TROUT:
SCIENTIFIC TOOLS FOR THEIR PROTECTION

17 AND 18 MAY 2022 – PLÉNEUF VAL ANDRÉ (FR – 22)

PARTICIPANT'S FILE

IMPROVING MANAGEMENT IN ESTUARIES AND THE SEA

interreg France (Channel) England SAMARCH
Côtes d'Armor le Département
Région Bretagne
Fédération Nationale Pêche

EDITORIAL

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Dear participants, speakers and friends,

I am delighted to welcome you to the **SAMARCH forum in Brittany** on the Pléneuf Val André site. Over the course of two days, scientists, managers, technicians and fishermen will discuss the preservation and safeguarding of migratory salmonids in estuarine and coastal areas. It is essential today to better understand the functional role of these areas to try to slow down or even reverse the decline of these populations in the North Atlantic.

Thanks to the extensive efforts made in freshwater by fishermen and their associations, State services, local authorities and their financial partners, we are fortunate enough to observe the gradual return of migratory fish to coastal rivers, as shown by the scientific monitoring conducted in both Normandy and Brittany. Unfortunately, the marine indicators are much more worrying. This is the challenge for the SAMARCH programme, of which this symposium is a part before the programme ends in June 2023.

Bretagne Grands Migrateurs is proud to be contributing to this major programme, which I am sure will provide scientific answers and improve the management of our large migratory species. I hope you all enjoy an excellent forum, filled with informative and constructive discussion.

Jean-Yves MOËLO, president of BRETAGNE GRANDS MIGRATEURS

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Programme

Tuesday, 17 May

9.30 am: **Welcome coffee**

10 am: **Welcome speech**

Jean-Yves MOËLO, president of Bretagne Grands Migrateurs

Delphine ALEXANDRE, vice-president of health, water and biodiversity of the Brittany region

Nathalie NOWAK, councillor for the environment of the Côtes d'Armor department

10.30–10.50 am: **Report on the objectives and content of the SAMARCH programme (Dylan ROBERTS, GWCT)**

10.50 am–12.10 pm: **Introduction – Current knowledge and knowledge gaps in the marine phase of migratory salmonids**

10.50–11.15 am: Finally getting to grips with the complex life of Atlantic salmon at sea (Ken WHELAN, Atlantic Salmon Trust -Ireland-)

11.15–11.40 am: Modelling population dynamics and stock assessment of salmon in the North Atlantic basin (Etienne RIVOT, Institut Agro)

11.40 am–12.05 pm: The distribution of diadromous fish at sea and the role of Marine Protected Areas (MPAs) (Sophie ELLIOTT, Institut Agro / GWCT)

12.05–12.25 pm: Discussion with the audience

12.30–2.00 pm: **Lunch**

2.00 pm: **SESSION 1: Presentation of scientific work from the SAMARCH programme on improving knowledge of migratory salmonids in estuaries and at sea**

2.00–2.30 pm: WPT1 – The survival of smolts during their downstream migration: influence of biotic and abiotic parameters (Céline ARTERO, GWCT)

2.30–3.00 pm: WPT2 – Sea trout in the Channel: what can we learn from genetic analysis? (Sophie LAUNEY, INRAE & Jamie STEVENS, University of Exeter)

3.00–3.30 pm: Discussion with the audience

3.30–3.50 pm: **Coffee break**

3.50–4.20 pm: WPT3 – Tracing the life of salmon at sea by analysing their scales (Marie NEVOUX, INRAE)

4.20–4.45 pm: Comparative analysis of the population dynamics and diet of the great cormorant (*Phalacrocorax carbo*) in the Arques (76) and Léguer (22) river basins (Yann FEVRIER, GEOCA and Alexandre CARPENTIER, MNHN)

4.45–5.15 pm: Discussion with the audience

5.15 pm: **Closing of the day**

Programme

Wednesday, 18 May

9 am: **Welcome speech:** Isabelle GRYTTEN, head of the Natural Heritage department / Biodiversity, Geology and Landscape division of DREAL Bretagne

9.15 am: **SESSION 2: What planning and management tools are used for migratory salmonids?**

9.15–9.40 am: Comparison of salmonid management and policy developments in France and the UK (Laurent BEAULATON, OFB and Lawrence Talks, EA)

9.40–10.05 am: The National Plan for Diadromous Migrators and its links to other existing tools for the preservation of these species (Marine PORTENEUVE, OFB-INRAE)

10.05–10.30 am: Regulating fishing for migratory salmonids in estuaries and at sea in Brittany and Normandy (Elise CARNET, DREAL Bretagne and Gwenaël ROBINEAU, OFB)

10.30–10.50 am: Discussion with the audience

10.50–11.10 am: **Coffee break**

11.10 am: **SESSION 3: Feedback and examples of measures taken to preserve migratory salmonids in freshwater**

11.10–11.30 am: From data collection to data development (Laëtitia LE GURUN, BGM)

11.30–11.50 am: Managing recreational fishing for migratory salmonids in Brittany: regulations, reporting catches and new management strategy for salmon fishing (Marie-Andrée ARAGO, OFB)

11.50 am–12.10 pm: RENOSAUM: moving towards new recreational salmon fishing regulations in Brittany (Etienne PRÉVOST, INRAE)

12.10–12.30 pm: Major pathological risks for migratory salmon: from UDN (a myth?) to reality (*Gyrodactylus salaris*) (Patrick GIRARD and Armand LAUTRAITE, Santé Poissons Sauvages association)

12.30–12.50 pm: Discussion with the audience

12.50–2.30 pm: **Lunch**

2.30–4.45 pm: **SESSION 4: Round table – Feedback and examples of measures taken to preserve migratory salmonids in estuaries and at sea**

- **What is the added value of Marine Protected Areas (MPAs) for the management of migratory salmonids?**

(Gwenola DE ROTON, OFB & Pauline BLANCHARD, OFB)

- **How do you factor in the restoration of ecological continuity in coastal areas? What are the difficulties involved?**

(Christophe MAUGENDRE OFB & Pierre LEGENDRE, Morlaix Communauté)

- **What are the potential impacts of offshore wind farms on salmonids?**

(Anthony ACOU, OFB & Lydie COUTURIER, France Énergies Marines)

- **How do you better manage migratory salmonid fisheries at sea and in estuaries?**

Reporting catches and bycatch (Guillaume LE PRIELLEC, CRPMEM),

Risk analysis of bycatch (Vincent TOISON, OFB)

A tool to raise awareness among recreational fishermen: Nav&Co (Marie LE BARON, OFB)

4.45 pm: **Summary and conclusion of the forum: Jean-Paul DORON, 1st vice-president of FNPF and member of the SEINORMIGR board of directors**

5.00 pm: **Closing of the Forum**

BRETAGNE GRANDS MIGRATEURS AND SEINORMIGR,

two associations that contribute to the restoration and management of migratory fish in the rivers of Brittany and Normandy

Bretagne Grands Migrateurs (BGM) is an association created in 1995 (when it was initially called "Ouest Grands Migrateurs"). On its registration, a "migratory fish" section was first included in the 1994 to 1999 State-Region Plan Contract. The parties to this contract are the four French Departmental Federations for Fishing and the Protection of the Aquatic Environment in Brittany.

The purpose of the association is to help restore and manage migratory fish populations in Brittany's rivers and their environment. BGM is responsible for coordinating the regional programme for the preservation and restoration of migratory fish and for running the Migratory Fish Observatory set up in 2011.

Find out more at: www.observatoire-poissons-migrateurs-bretagne.fr

Seine-Normandie Migrateurs is one of the eight major migratory fish associations in France, focusing on the Seine basin and Normandy.

Approved for environmental protection, the association works to safeguard and protect migratory fish in the Seine-Normandy basin. Its responsibilities include improving knowledge of migratory species, their management and the restoration of their migration routes, as well as providing recognised scientific expertise.

Find out more at: www.seinormigr.fr

The rivers of Brittany and Normandy provide favourable aquatic environments for diadromous migratory fish such as Atlantic salmon, sea trout, sea lamprey, shad and eels. However, these fragile populations have to cope with a number of pressures such as pollution, the degredation of spawning grounds, physical barriers and poaching among other things. The preservation and restoration of these species, which indicate that rivers are in good ecological condition, represent a major challenge to ecology, heritage and economics!

SAMARCH: WHAT IS IT?

SAMARCH is a seven-year project supported by the EU Interreg France (Channel) England Programme

The SAMARCH (SAlmonid MAnagement Round the Channel) programme is funded by the Interreg "France (Channel) England Programme" for a period of seven years from 2017 to 2023. It aims to improve the management of salmon and sea trout populations in the Channel.

The SAMARCH project has a €9 million budget, 69% of which is financed by the Interreg "France (Channel) England" Programme, representing a contribution of €6.2 million.

By working with a consortium of 10 partners involved in scientific research and management, SAMARCH aims to create new knowledge on the biology and ecology of salmonids and to transfer this knowledge to improve regulations in France and the UK for the management of salmonids in estuaries and coastal areas. The ultimate aim is to help increase salmon and sea trout populations. To this end, research activities will focus on studying the behaviour of salmonid populations in estuaries and coastal areas to identify the main sources of mortality. This will involve:

* Analysing DNA to map key sea trout habitats in the Channel
* Studying the movements and mortality of smolts in estuaries
* Providing new information on long-term changes in salmon growth rates from the analysis of historical scale collections
* Enhancing understanding of the difference in life history between male and female salmon, which is essential to better manage populations.

Find out more at: www.samarch.org

Key findings of the SAMARCH programme

Salmonid populations have declined drastically in the last four decades. Multiple freshwater factors such habitat loss or alteration have been associated with this trend, but the recent decrease of marine return rates of Atlantic salmon suggest that salmonid populations are also significantly impacted during the marine phase. Reasons for this low marine return rate are yet to be fully understood, leading researchers, like those in the SAMARCH project to focus on the marine phase of the salmonids life cycle.

WP T1 – Tracking salmonid use of and mortality rates in transitional, coastal and marine waters

Author: Celine ARTERO, Game & Wildlife Conservation Trust

Work Package Leads: Celine ARTERO, Game & Wildlife Conservation Trust – Rasmus LAURIDSEN, Game & Wildlife Conservation Trust – Elodie RÉVEILLAC, La Rochelle Université

The main objective in the WP-T1 is to follow two species of salmonid: Atlantic salmon (*Salmo salar*, hereafter salmon) and anadromous brown trout (*Salmo trutta*, hereafter sea trout) during their migration to sea from freshwater to the marine environment via transitional waters (estuarine environment). It is important to dissociate the different environments that salmonids span during their migration to: (1) describe their migration route, behaviour in each environment and; (2) identify, the factors potentially impacting their survival during the migration.

WP-T1 is divided into 2 sub projects: the smolt tracking project and the kelt tracking project.

Smolt tracking project

The smolt tracking project tracked both salmon and sea trout smolts during their first migration to sea in fresh, transitional, and coastal waters. To do so, during the spring of 2018 and 2019, 835 wild salmon and trout smolts were acoustically tagged using 180 kHz Innovasea V5 tags (5mm diameter, 0.77g weight in air) in four catchments: the rivers Frome, Tamar, Bresle and Scorff. These acoustic tags transmit unique coded ultrasonic signals (containing an identification number, ID) recognised by submerged acoustic receivers deployed along their migration path.

This methodology enables the study of the spatio-temporal use of transitional and coastal waters by emigrating salmonid juveniles and their survival through these environments.

Key findings of the smolt tracking project:

* Salmon smolts migrated significantly faster than trout smolts.
* Trout smolts stayed on average 2 days longer in the estuaries than salmon smolts.
* Salmon smolts migrated through the estuary with constant or increasing speed from freshwater to coastal environment, taking the shortest route whereas, trout smolts slowed as they transitioned through the estuaries on their way to sea.
* Both salmon and trout smolts reduced their migration speed in the area around the salinity limit in all study sites.
* Smolt loss was gradual along the estuaries and no specific areas accounted for pronounced increases in detection loss.
* Trout smolts displayed a higher survival rate during their estuarine migration than salmon smolts.

Kelt tracking project

The kelt tracking project only focused on sea trout kelts, as most salmon do not survive after their first reproduction. Kelts are much bigger than smolts, providing the opportunity to use larger tags which have an extended battery life and/or have memory space to record environmental parameters. Tags with a recording capacity, called data storage tags (DST) do not require recording stations to be deployed on the fish migration path, and therefore extend the spatial coverage possibilities. Thanks to DSTs, it is possible to collect migration data not only in estuarine and coastal waters but also in the marine environment. However, DSTs do not transmit data therefore it is necessary to recover the tag to retrieve the data.

During the winters of 2018/2019, 2019/2020 and 2020/2021 a total of 314 sea trout kelts were tagged with both a 180 kHz Innovasea V9 tags acoustic tag, and a Cefas Technology Limited G5 data storage tag, in the Frome, Tamar and Bresle rivers, to follow their post spawning estuary and marine migration.

Key findings of the kelt tracking project:

* 24% of the deployed sea trout tags have been recovered.
* 67% of the recovered tags were found by beach walkers highlighting the great participation of the public in our research project.
* Tags were found in every country with a coastline in the English Channel or southern North Sea.
* The tagged sea trout exhibited a strong diving behaviour reaching depths of up to 80 m. However, the pattern of this diving behaviour appeared to vary between study rivers and by time of day.
* Of the recovered tags 27% of the sea trout had been predated at sea.

Analysis of the DST data is ongoing, but will provide information on the at sea migration route of sea trout. Preliminary findings have shown that sea trout from France migrate to the UK coast and vice versa, and that individuals from both France and the UK share similar marine feeding habitat. This information underpins the need for international management of sea trout at sea.

WPT2 Developing novel genetic tools for managing migratory fish in Coastal and Transitional Waters (TCW)

Authors: Jamie STEVENS and Andrew KING, University of Exeter & Sophie LAUNEY and Mathieu VANHOVE, INRAE Rennes

Work Package Leads: Jamie STEVENS, University of Exeter & Sophie LAUNEY, INRAE Rennes

Objectives of the work package

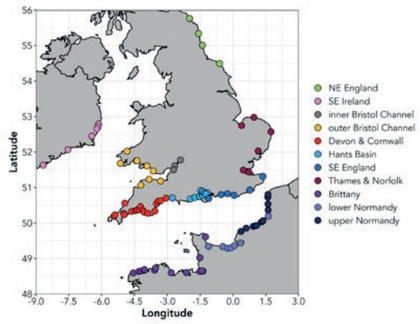
In order to effectively manage trout populations, accurate information on life history and migration patterns is needed. For many rivers, we now have a good idea of the population size, location of spawning areas and potential threats (i.e. habitat and water quality, location of barriers to fish movement etc.). In-river trout populations can then be managed considering this information. However, while sea trout spend a significant proportion of their life at sea, for such an iconic fish, relatively little is known about the marine phase of their life cycle. Tracking (WPT1) is an excellent tool for following small numbers of fish, and previous studies have suggested that many sea trout stay close to their natal river, while a minority can move considerable distances. But these methods do not yield sufficient information for population-level studies. However, every fish carries its own natural unique genetic 'tag' or profile, which can be analysed and used to study the movements of sea trout in TCW.

The University of Exeter (UExe) and INRAE collaborated to build a genetic database incorporating DNA profiles of trout populations (sampled as juveniles) and associated metadata from potential source rivers of sea trout from the FCE area. This database will enable scientists and managers: (1) to determine the river of origin of adult sea trout sampled in the FCE area; (2) to understand how far sea trout travel from their natal river; (3) to identify the marine landscape («seascape») parameters that impact the movement of sea trout between rivers. Ultimately, INRAE and UExe will map the marine areas that are used preferentially by adult sea trout in TCWs. This will be used to advise managers and stakeholders regarding the impact of new coastal and offshore development projects, and/or the designation of marine protected areas.

Main activities and results – what has been achieved and what is still going on

Genetic database

Samples were collected from brown trout parr from both UK and French rivers flowing into the English Channel/Manche, as well as from northeast England, the Bristol Channel and southeast Ireland (Figure 1).



Map showing the location of the 103 UK, Irish and French rivers sampled for the SAMARCH genetic baseline. Symbol colour indicates to which of 11 distinct genetic groups each river belongs.

FIGURE 1.

Map showing the location of the 103 UK, Irish and French rivers sampled for the SAMARCH genetic baseline. Symbol colour indicates to which of 11 distinct genetic groups each river belongs.

The current genetic baseline comprises nearly 3000 trout sampled from 103 UK, Irish and French rivers which have been genotyped at a suite of 94 genetic markers. The final database will cover 190 markers. Initial findings indicate significant genetic structuring across the region, with the identification of 11 genetic groups (Figure 1).

Assignment of sea-caught sea trout to their river of origin

As part of the SAMARCH project, UExe has been undertaking a programme of at-sea sampling, utilising local nets men at four locations around southern England (Appledore, Cawsand Bay, Kimmeridge Bay and Rye Harbour). In addition, sea trout have been obtained from commercial fisheries along the East Anglian coast and the Rhine/Meuse estuary as well as from sea trout caught in estuarine areas of the Taw/Torridge, Tamar and Sussex Ouse rivers.

Preliminary results suggest that each of our marine sampling locations represent mixed stocks of sea trout. For instance, as might be expected, the majority of fish sampled from Kimmeridge Bay assign to Hampshire Basin rivers (Figure 2). However, fish from Devon, Cornwall and southeast England were also sampled at-sea in the waters of Kimmeridge Bay. There is also a suggestion that French sea trout (from lower Normandy rivers) are present along the Dorset coast. Interestingly, several fish from northeast English rivers were caught at Kimmeridge, representing a migration distance in excess of 800 km from their natal rivers.

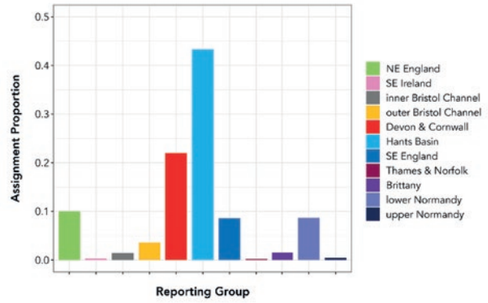


FIGURE 2.

Stock composition of sea trout sampled from Kimmeridge Bay, Dorset showing the proportion of fish assigned to each of 11 distinct genetic groups (known as reporting regions).

Identifying habitat features and areas important for sea trout in the Channel area

We aim to link genetic distances between populations and environmental variables from the marine environment. The studied variables go from hydrographic to anthropic features (temperature, currents, depth, substrate, chemicals, fishing pressure...). Each environmental variable will be associated to a cost distance (positive or negative depending on whether the variable facilitate or restrict sea trout movements in the sea). In a first step, theoretical work has allowed the development of a new method, based on machine-learning processes, that is able to handle multiple environmental predictors. It generates resistance maps, showing the most likely routes used by individuals between populations, and identifying the environmental parameters that will have an influence on these routes. The second step, applying this method to the sea trout data, is still on-going.

WPT3 – Salmon Stock Assessment: Data and modelling

Authors: Etienne RIVOT (Institut Agro), Marie NEVOUX (INRAE), Jamie STEVENS (University of Exeter), Andrew KING (University of Exeter) and Stephen GREGORY (formerly Game & Wildlife Conservation Trust, now CEFAS)

Work Package Leads: Marie NEVOUX (INRAE), Stephen GREGORY (formerly Game & Wildlife Conservation Trust, now CEFAS) and Etienne RIVOT (Institut Agro)

Introduction

Understanding the demographic and ecological mechanisms shaping the response of populations to multiple stressors is a prerequisite for scientific expertise on the population status and their sound science-based management. This is particularly critical in the context of rapidly changing ecosystems under climate change. This is even more challenging for salmonids that share their life cycle between a freshwater breeding habitat and the marine environment, and that interact with multiple single and/or synergistic factors at different points in time and space during their life cycle. Accumulated evidence suggests that key life history traits of salmonids (e.g. survival, growth, age or size at maturation) have changed in response to recent environmental changes; however, the precise magnitude of those changes, its variability among population and even between sexes, and the mechanisms that underline this variability remain largely unknown. As a consequence of those data and knowledge gaps, population dynamic models used for stock assessment (Stock Assessment Models, SAMs) and to derive biological management reference points (e.g., Conservation Limits) most often rely on inaccurate values of vital rates and do not consider the influence of environmental changes. Those strong assumptions could lead to inappropriate management decisions based on biased population productivity estimates.

In SAMARCH we provide new data and knowledge on the variability of life history traits of salmon and sea trout that bring new insights on the response of salmonids populations to environmental changes. This work will enhance stock assessment models for adaptive management plans to mitigate the effect of environmental change on salmonid stocks in England, France and at an international level. Previous work in SAMARCH has shown that "bigger is better" among salmon smolts migrating from SAMARCH rivers, that early summer growth at sea is a critical time for salmon sex-specific life-history choices, and that national salmon SAMs could derive more accurate assessments using new information on sex ratios and that international salmon SAMs can and should use a more contemporary life-cycle approach to stock assessment. This update highlights work that builds on these earlier findings.

Data Analysis

The project capitalized and complemented biometric data and scale samples from seaward-migrating smolts and returning adults from five wild Atlantic salmon and four sea trout populations of southern England (Frome, Tamar) and northern France (Scorff, Oir, Bresle), collected over 49 years (1969-2017). SAMARCH provided the financial support to carry on running long-term monitoring programs over the last five years on all five rivers. For each of the five rivers, the abundance of seaward-migrating smolts and upstream returning adults was estimated. Fish traps were operated to count fish and collect scale samples from seaward-migrating smolts and returning adult. An unprecedented effort of scale reading was made to analyse growth variation during the freshwater and the marine phase among individuals, population, and over time. In order to analyse variations in sex ratio, and compare growth trajectories and maturation patterns within and between males and females, we assessed the genetic sex of each individual using DNA extracted from scales. Individual measurements of length and fecundity available on a large sample of females were also collated. Within SAMARCH, we developed a new information system to catalogue available biological samples and store the diversity of individual-based information from our different study sites within a unique framework. This database met international standards and ensured that the data is easily searchable and usable to answer key research and management questions, at the scale of the FMI zone, and beyond.

Based on this extensive database, we assessed the long-term trends in the sex ratio at different salmonid life stages (smolts and adults) and fecundity of adults in the SAMARCH rivers, and investigated the factors contributing to these changes (e.g. body size, age). Results highlight that the sex ratio of returning fish was relatively stable for each sea age class over time, but that the average fecundity declined by 15% between 1985 and 2018, mostly driven by a decline in the mean body length and weight of returning multi sea-winter females. This suggests that SAMs might systematically overestimate eggs deposition, particularly in recent years, which could lead to overstate compliance

with conservation limits. The novel data on sex ratio and fecundity will be incorporated in new SAMs to reduce their possible bias. This will encourage managers to derive more realistic conservation limits that recognize the changing ratio of females and the changes in mean body size within each sea age class.

River Tamar Study

A study on the River Tamar, UK, investigated the effect of updated sex ratio data on the conservation compliance for the river. Utilising archive scales samples and a highly accurate genetic sex test, the sex ratio within the one- and two-sea winter adults was assessed over six years (2015-2020). For one-sea winter salmon, the genetically determined proportion of females was remarkably close to the default value historically used to calculate egg deposition for the Tamar. However, it was clear that the proportion of females in the two-sea winter age class was being significantly under-estimated. To determine the influence of changing sex ratios on calculated annual egg deposition rates, values were recalculated using the default historic and new genetically determined sex ratios. Application of annually derived genetically determined sex ratios had a generally positive effect on egg deposition estimates: egg deposition estimates increased by an average of > 6% compared to historic default values. Only for a single year (2016) did use of the annual sex ratio data result in a reduction in the deposition estimate. This study highlights the need to collect accurate, up-to-date data to inform and update salmon stock assessments. The genetically determined average proportion of females for each sea age class will be used to assess future conservation limit compliance for the Tamar.

Results

Analysis of salmon growth from scales reveal exciting new results on the response of populations to environmental changes. In particular, results reveal a strong decline of growth of salmon at sea after year 2005 common to all five populations. This decline is particularly marked during the first month of the marine life after the smolt sea-ward migration (first summer at sea). This declining growth at sea likely reveals recent environmental changes at sea, characterised by a rise in temperature and a decline in abundance and energetic quality of available salmon prey.

Further analyses of the demographic mechanisms revealed the critical influence of growth on salmon life history traits with a special interest on marine survival and maturation rate. Different results obtained on the Frome and on the Scorff revealed that body length at smolt migration may positively influence survival of post-smolt during the first months at sea. This builds on previous SAMARCH work that supports the "bigger-is-better" paradigm based on the hypothesis of size-selective mortality during ocean migration. Early results of another SAMARCH study show that the support for the "bigger is better" paradigm is a general phenomenon and not limited to the Frome and Scorff, but can be generalised to rivers from France to Norway. It is generally assumed that the migration of smolts through the estuary and coastal waters is a very critical phase of the life cycle, with extremely high mortality risk. Nevertheless, our analysis was not able to detect the effect of any additional environmental and anthropic pressure encountered by migrating smolts. This has important management implications as it exemplifies that, in addition to maximising the smolt number, maximising the length of the migrating smolt may also be an important leverage to maximise returns. We also show that growth during the first summer at sea partly controls the maturation age, with fish with a higher growth during the first summer at sea having a higher probability to mature after only one year spent at sea. This dependence of the maturation decision to growth at sea also highly depends upon the sex of fish, with females that need a higher growth at sea to mature than males. This result again has important management implications as growth at sea is ultimately susceptible to control the proportion of the different sea-age classes and sex-ratios in the returns, and hence the average fecundity of returning fish.

Modelling

To transfer those new data and knowledge to advance population dynamics and stock assessment models, we developed integrated stage- and sex-structured population models that articulate key demographic processes controlling survival at sea and maturation decision for males and females separately. Those models seek to better capture the effect of environmental changes at sea on salmon population dynamics and stock productivity by accounting for differences in life histories between males and females and the influence of changes in growth at sea on marine survival and maturation age. A novel pilot model was developed based on data available from the survey of the Scorff population (the Scorff is one of the ICES index rivers). It integrates the size selective mortality of post-smolt at sea, and the influence of growth at sea on the maturation rate through an effect that depends on sex. Results demonstrate that temporal variations of post-smolt survival mostly contribute to temporal variations of both the return rate and the reproductive potential as measured by the average number of eggs spawned for one female migrating smolt. Although weaker, the contribution of the maturation rate is non-negligible in explaining the variability in the return rate especially of highly fecund 2SW females, thus highlighting that the dynamics and productivity of salmon population not only depends upon survival at sea but also on the maturation rate. By linking the growth of fish to return rate, sex and age structure of returns, and ultimately the reproductive potential, our model improves our ecological knowledge of the past influence of environmental conditions on population dynamics and productivity and could also be used to predict the effect of future environmental changes and to provide indicators for management decision making. A second model was also developed to capture patterns of change in salmon stock productivity and life history traits at the scale of the North Atlantic Ocean, and will be transferred to ICES WGNAS to improve forecasting of abundance of fish returning into different stock units, under different scenarios of environmental and management changes.

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Work Package T4 – Stakeholder engagement, policy delivery and training

Authors: Dylan ROBERTS (Game & Wildlife Conservation Trust), Genoveva ESTEBAN (Bournemouth University)
Work Package Leads:
Training – Genoveva ESTEBAN (Bournemouth University), Ivan BERNEZ (Institut Agro)
Stakeholders and Policy – Dylan ROBERTS (Game & Wildlife Conservation Trust), Janina GRAY (Salmon & Trout Conservation), Laurent BEAULATON (OFB), Gaëlle GERMIS (Bretagne Grands Migrateurs), Lawrence TALKS (Environment Agency), Maxime POTIER (Seine Normandie Migrateurs) and Jérémie CORRE (Normandie Grands Migrateurs – until 2019)

Partners Involved

* L'Institut national d'enseignement supérieur pour l'agriculture, l'alimentation et l'environnement (Institut Agro)
* Bretagne Grands Migrateurs
* Office Français de la Biodiversité
* Seine Normandie Migrateurs
* Game & Wildlife Conservation Trust
* Bournemouth University
* Environment Agency
* Salmon and Trout Conservation

Work Package Aims

This work package aims to engage with the relevant stakeholders from various sectors throughout the project to disseminate the projects aims, progress the findings, and effectively work with the regulators to deliver policy recommendations based on current best practice and the projects research results on both sides of the France/England Channel.

Stakeholders, include those in the:

* Angling and recreational fisheries management and regulatory sectors
* Inshore commercial fishing and regulatory sectors
* Harbour, estuary, and inshore coastal management sectors
* Marine spatial planning to include the renewable energy sector
* Awareness raising of the declines of salmon and sea trout across their range

The project also aims to provide opportunities for undergraduate, MSc and PhD students to gain experience in salmon and sea trout conservation work and research, and fisheries and marine management.

Stakeholder Engagement

To raise awareness of the projects work to the above sectors the project has produced a digital communications strategy to include web site (www.samarch.org) Blog (www.samarch/blog) and a number of project videos. In addition, it has hosted a number of large events including:

* SAMARCH project launch in Southampton in January 2018
* A conference for key stakeholders and policy makers in the marine fisheries and management sectors at Mont St Michel Brittany in May 2018
* A workshop on the marine tracking of salmonids in Southampton in November 2019
* The International Forum in Brittany in May 2022
* The project will host a workshop on marine management interactions with salmon and sea trout in November 2022
* The project will host a final closing conference in March 2023

Policy Delivery

We are now in the final year of the project and the main focus is to develop policy recommendations to be considered by the regulatory bodies, based on current best practice and the projects research findings. To develop these recommendations the project has a dedicated Policy Group, which will release the recommendations later this year, along with the research results from the project. To facilitate the inclusion of SAMARCH's results in local policy, we organised a special meeting with French administrations in June 2021.

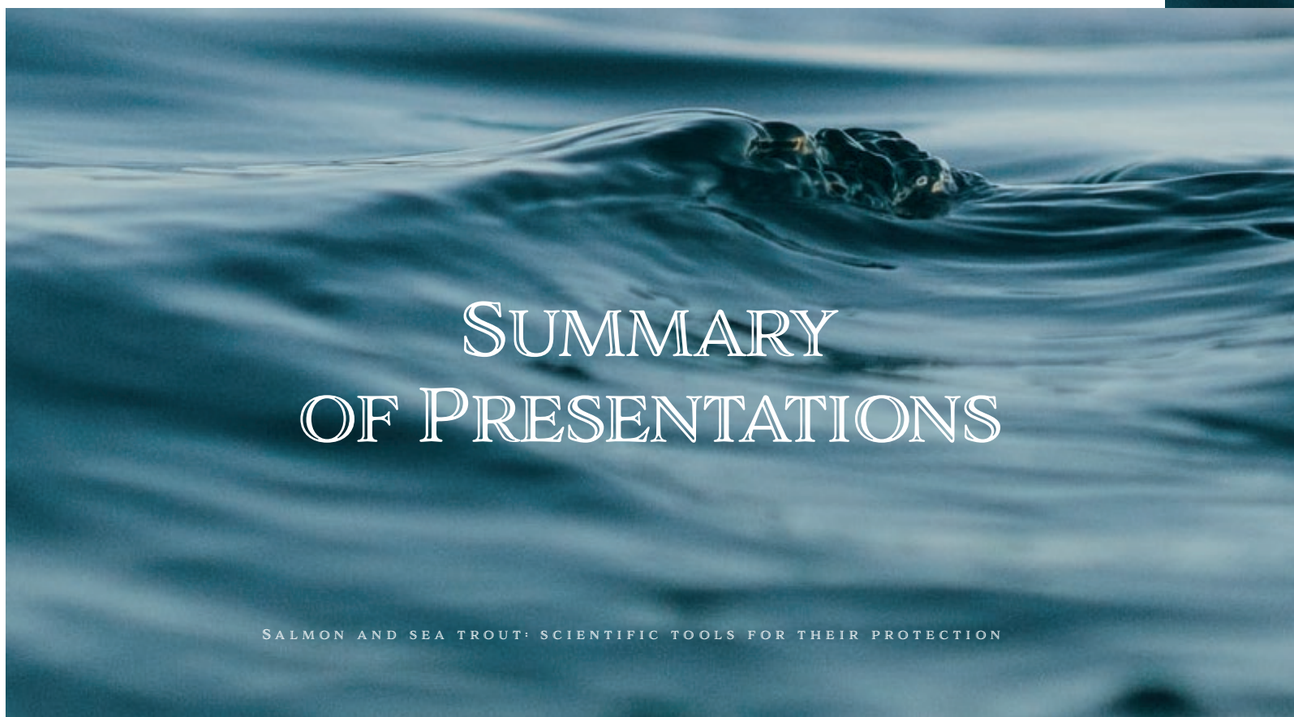
To facilitate the development of Best Practice the project has:

* Reviewed and compared the fishery management tools used to protect salmon and sea trout in England and France.
* Produced a report taking stock of the regulation of salmon and sea trout fishing in Brittany and western Normandy.
* Submitted evidence on changes in salmon growth, marine survival and sex ratios for salmon stocks assessment models.

Training

The project has thus far provided practical training opportunities for over 60 undergraduates, 20 MSc and two PhD students. They have gained experience from working with the project partners in a variety of areas, from tracking salmon smolts using acoustic telemetry technology, salmon stock assessment research and data management, to communications and organising and speaking at public events (interaction with over 4,000 school children and general public.

A full list of PhD, MSc, and undergraduate dissertations projects undertaken by students supported by the project will be available on the SAMARCH website.



Tuesday, 17 May

Report on the objectives and content of the Salmonid Management Round the Channel (SAMARCH) programme, 2017 to 2023

AUTHOR: DYLAN ROBERTS,

SAMARCH project manager, Game and Wildlife Conservation Trust GWCT

The **SA**lmonid **MA**nagement **R**ound the **CH**annel project 2017 – 2023 (SAMARCH) has aimed to provide new transferable scientific evidence to inform the protection and management of salmon and sea trout in the estuaries and coastal waters of both the French and English sides of the Channel to reduce some of the anthropogenic pressures on these fish. The project has focused on three key areas:

* The bycatch of salmon and sea trout in commercial inshore fisheries.
* Challenges to salmonids caused by estuarine and inshore coastal activity and developments.
* Strengthening salmon stock assessment models.

The project has utilised the research facilities on the salmon index rivers in the Channel area, the rivers Tamar and Frome in the South of England and the Scorff, Bresle and Oir in Northern France. During the next two days you will hear the key findings of the projects work and we look forward to discussing how this new information can be used to inform policy.

SAMARCH is part funded (69%) through the European Union Interreg Channel VA programme and involves 10 partners, five from the UK and five from France who are a blend of government, non-government and research organisations.

UK Partners	French Partners
Lead Partner: Game and Wildlife Conservation Trust	Institut national de recherche pour l'agriculture,
University of Exeter	l'alimentation et l'environnement
University of Bournemouth	L'Institut national d'enseignement supérieur pour
Environment Agency	l'agriculture, l'alimentation et l'environnement
Salmon and Trout Conservation	(l'Institut Agro)
	Bretagne Grands Migrateurs
	Office Français De La Biodiversité
	Seine-Normandie Migrateurs

Dr Celine ARTERO, lead researcher of the projects sea trout and salmon tracking programme at the fish trap at Gunnislake on the River Tamar, England. The project has tagged 315 sea trout kelts in three rivers to estimate their locations and swimming depths at sea © D. Roberts

Tuesday, 17 May
Introduction session:

Current knowledge and knowledge gaps in the marine phase of migratory salmonids

Finally getting to grips with the complex lives of Atlantic Salmon at sea

AUTHOR: KEN WHELAN,

Research Director, Atlantic Salmon Trust

Over the past 15 years significant strides have been made in gaining an understanding of the complex lives of Atlantic salmon at sea. From the initial ground-breaking results of the SALSEA programme (2008 to 2011), through the scientific outcomes currently emanating from the Norwegian SeaSalar programme, this presentation will summarise the progress that has made to date. It will also outline work currently underway to assess the migration pathways of salmon in the North East Atlantic and some of the factors affecting the early lives of salmon at sea. Finally, the talk will summarise the major areas where detailed knowledge is still lacking and how we might tackle these in the years to come.

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Tuesday, 17 May
Introduction session:

Current knowledge and knowledge gaps in the marine phase of migratory salmonids

Modelling population dynamics and stock assessment of salmon in the North Atlantic basin

AUTHOR: ETIENNE RIVOT

Institut Agro, UMR DECO Dynamique et Durabilité des Écosystèmes, Institut Agro, INRAE, Ifremer, Rennes

CONTRIBUTORS: **Etienne RIVOT, Rémi PATIN, Maxime OLMOS, Pierre-Yves HERNVANN, Marie NEVOUX, Stephen GREGORY, Cécile TRÉHIN, Etienne PRÉVOST**

Most populations of Atlantic salmon in the North Atlantic (NA) basin have experienced a sharp decline in numbers over the past 50 years. The causes are multifactorial. However, variations in the availability of trophic resources during the early marine phase, in response to changes in the marine ecosystem, have been identified as factors which greatly influence the growth and survival of salmon at sea.

It is important to understand the mechanisms inherent in populations' response to multiple pressure factors to: improve scientific expertise on the status of populations; anticipate their evolution under various management scenarios or environmental changes; and propose suitable management measures. Nevertheless, this remains a challenge for this migratory species which interacts with multiple factors at different life stages, in different environments and at different connected spatial scales. The difficulty is compounded by the dispersion of population monitoring data across multiple jurisdictions in the NA basin.

To better understand of the mechanisms underlying salmon population dynamics and the scientific bases of the assessment models used by the ICES Working Group on North Atlantic Salmon (ICES WGNAS), we have developed a life history model for all salmon populations in the NA basin. The dynamics of all 25 European and North American stock units taken into account by WGNAS are jointly analysed in a single model. Developed within a Bayesian framework, the model has assimilated the available data sets to estimate changes in marine survival and age at maturation since 1971. It quantifies the correlated variation of key life history traits between different populations which share habitats during part of their marine migration. The results show that a significant proportion of the variability is attributable to temperature fluctuations and primary productivity variations along the migration routes. To complement this model and to ensure effective transfer to stock assessment and management, we have developed a database and web interface which improves the transparency of the data used and the robustness of the data processing chain to stock assessment outputs.

This new modelling framework represents a major step towards gaining a better understanding of the ecology of salmon at sea and the mechanisms controlling population dynamics in the NA basin. It improves the explanatory and predictive capacity of the assessment model used by WGNAS, while encouraging more effective use of existing data. Furthermore it is easy to develop to incorporate new knowledge and data.

Tuesday, 17 May
Introduction session:

Current knowledge and knowledge gaps in the marine phase of migratory salmonids

The distribution of diadromous fish at sea and the role of Marine Protected Areas (MPAs)

AUTHOR: SOPHIE A. M. ELLIOTT [1, 4, 7]

CONTRIBUTORS: **Sophie A. M. ELLIOTT[1,4,7], Laurent BEAULATON[1,5], Anthony ACOU[1,2], Elodie RÉVEILLAC[3], Etienne RIVOT[1,4]**

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2) UMS OFB-CNRS-MNHN PatriNat, Station marine du Museum National d'Histoire Naturelle, 35800 Dinard, France
3) Littoral, Environnement et Sociétés (LIENSs), UMR 7266, La Rochelle Université-CNRS, 17000 La Rochelle, France
4) DECOD (Ecosystem Dynamics and Sustainability), Institut Agro, Ifremer, INRAE, Rennes, France
6) OFB, DRAS, 35042 Rennes, France
7) Game and Wildlife Conservation Trust, Salmon & Trout Research Centre, East Stoke, Wareham.

Declines in diadromous fish occurred due to anthropogenic pressures during the late twentieth century. Many diadromous fish which were commercially important, are now protected. In the past 25 years there has been a rise in Marine Protected Areas (MPAs), some of which are supposed to protect threatened diadromous fish (e.g. salmon, shad, lamprey). Yet, little is known about diadromous fish marine life history phases, and no observation-based distribution model exists for this group of species.

We collated a database of 168 904 hauls from fisheries observer bycatch data and scientific fisheries surveys, from across north-eastern Atlantic waters. We developed statistical models to estimate the distribution of diadromous fish at sea (three species of shad, two salmonids, two lampreys, the European eel, the thinlip mullet, smelt and the European flounder), while considering imperfect detection from gear types. We then developed a combined modelling approach to most accurately predict 'core' and 'unsuitable' areas of diadromous fish at sea distribution. The latter was to ensure the potential to adequately protect these species within MPAs whilst minimising impacts on sea-users.

All eleven species present (2003-2019) distribution were modelled within north-eastern Atlantic waters using a Bayesian hierarchical model. All species were observed within shallow coastal areas. Gear types with a higher probability of bycatch for each species were identified (e.g. demersal mobile trawls). 'Core' and 'unsuitable' areas of distribution were modelled with high accuracy (positive prediction rate >0.74 and negative prediction rate of >0.89). More than 60% of diadromous fish core areas were within the MPAs, yet less than 50% of MPAs which the species were present within protected these rare and data-limited species.

Given the coastal distribution of these species, they are exposed to higher anthropogenic pressures resulting from both terrestrial and marine environments. For MPAs to be effective accurate SDM is essential. By modelling accurate 'core' and 'unsuitable' areas, priority areas for protection within MPAs can be identified with specific management measures, minimising impacts on sea users.

Note: Some of this work is in revision within the Journal of Biological Conservation

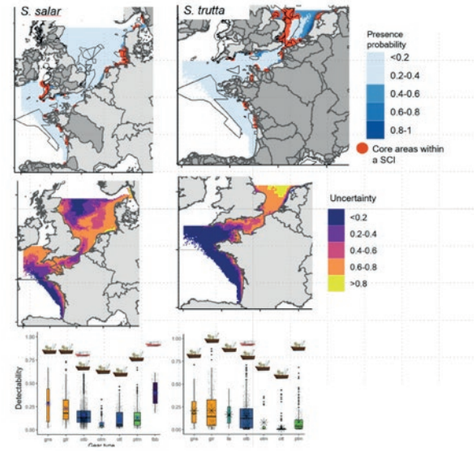


Figure 1: Hierarchical Species distribution model probability of presence

Tuesday, 17 May
Session 1:

Presentation of scientific work from the SAMARCH programme on improving knowledge of migratory salmonids in estuaries and at sea

WPT1 – The survival of smolts during their downstream migration: influence of biotic and abiotic parameters

AUTHOR: CÉLINE ARTERO,
Lead Researcher of the SAMARCH WPT1 Tracking programme – GWCT

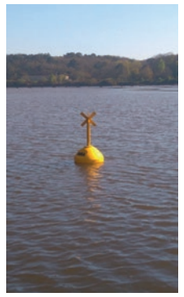
An acoustic telemetry study was carried out in spring 2018 and again in 2019 on two juvenile salmonid species (smolts), Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta*), to quantify and explore the biotic and abiotic parameters influencing their survival when migrating down estuaries. To this end, V5-type acoustic tags (5 mm wide and 0.77 g, InnovaSea) were inserted into the abdominal cavity of the smolts. These acoustic tags emit a coded acoustic signal, containing an identification number, which is recognised and recorded by acoustic receivers previously deployed along their migratory routes at four study sites: the Tamar and the Frome, rivers located in the south of England, and the Bresle and the Scorff, two French rivers located in Somme and southern Brittany. Both species were monitored in parallel at all sites except the River Scorff where only salmon were represented.

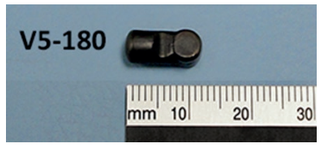
The survival of smolts when migrating down estuaries was estimated from acoustic sensing using a hidden Markov capture-recapture model in which environmental parameters of the four study sites (dissolved oxygen level, salinity, temperature, flow rate, river type, and distance) as well as the characteristics of the tagged specimens (species, size, sex, age, condition, migration speed, and date of entering the estuary) were recorded. Various model structures were tested in order to study the spatio-temporal variability of smolt survival in estuaries.

The model incorporating both temporal and spatial variability in smolt survival was the most frugal. However, incorporating annual variability only slightly improved the performance of the model, highlighting variation in smolt survival along the estuary but little between years.

The results show that the type of species is the main variable which influences smolt survival rates. Indeed, during their downstream migration in estuaries, young trout displayed better survival rates than young salmon, regardless of the study site. Except for the River Frome, survival rates were very similar between study sites (on average 95% for trout and 89% for salmon).

In general, estuarine crossings resulted in losses of between 5% and 24% for the four smolt populations studied, highlighting the challenges that estuarine habitats present to smolt progression.





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Tuesday, 17 May
Session 1:

Presentation of scientific work from the SAMARCH programme on improving knowledge of migratory salmonids in estuaries and at sea

WPT2 – Sea trout in the Channel – what can we learn from genetic analysis?

AUTHORS: SOPHIE LAUNEY & MATHIEU VANHOVE, **INRAE**
JAMIE STEVENS **S & R .A. King, University of Exeter**

To effectively manage trout populations, accurate information on life history and migration patterns is needed. Reliable information is now available for management of in-river populations. However, some trout spend a significant proportion of their life at sea (as sea trout) but relatively little is known about this phase of their life cycle. Tracking studies indicate that many sea trout stay close to their natal river, with some moving longer distances. However, such methods are typically restricted to studies on a single catchment (or a small number of rivers). Conversely, every fish carries its own unique genetic 'tag', which can be analysed and used to study the origins and movements of sea trout in coastal waters (TCW).

A genetic database incorporating DNA profiles of trout populations (and associated metadata) from potential source rivers of sea trout from the FCE area has been built by UExe and INRAE. In-river sampling has been undertaken by OFB, BGM and NGM/SEINORMIGR in France (as well as local anglers associations), and by GWCT and the Environment Agency in the UK. The baseline comprises genotypes from ~3000 trout sampled from 103 UK, Irish and French rivers and genotyped with 94 genetic markers. Initial findings indicate significant structuring across the region, with the identification of 11 distinct genetic groups.

This database will be used by scientists and managers:

- to determine the river of origin of adult sea trout sampled at sea in the FCE area and to understand how far sea trout travel from their natal river.

As part of the SAMARCH project, GWCT has undertaken at-sea sampling, using local netsmen at four southern English locations; sea trout have also been obtained from two southern North Sea commercial fisheries, as well as other estuarine areas in UK and France. Preliminary results suggest that each of our marine samples represent mixed stocks of sea trout. At most locations, the majority of sea trout seem to originate from a geographically close river, but a not insubstantial minority of individuals have been found more than 800km from their natal river.

- to identify the marine landscape («seascape») parameters that impact the movement of sea trout between rivers.

We aim to link genetic distances between populations and environmental variables from the marine environment (from hydrographic to anthropogenic features). In a first step, we have developed a new method, based on machine-learning processes, that is able to handle multiple environmental predictors. This generates resistance maps, showing the most likely routes used by individuals between populations, and identifying the environmental parameters that will have an influence on these routes. Application of this method to the sea trout data, is on-going.

Ultimately, INRAE and UExe will map the marine areas that are used preferentially by adult sea trout in TCWs. This will be used to advise managers and stakeholders regarding the impact of new coastal and offshore development projects, and/or the designation of marine protected areas.

Note: Some of this work is in revision within the Journal of Biological Conservation

Sampling of juvenile trout (© S. Launey)

Tuesday, 17 May
session 1:

Presentation of scientific work from the SAMARCH programme on improving knowledge of migratory salmonids in estuaries and at sea

WPT3 –Tracing the life of salmon at sea by analysing their scales

AUTHOR: MARIE NEVOUX

Research Fellow – UMR DECOD (Ecosystem Dynamics and Sustainability) – INRAE, Institut Agro, Ifremer, Rennes, France

CONTRIBUTORS: **Frédéric MARCHAND, Ludivine LAMIREAU, Julien TREMBLAY, Jean-Pierre DESTOUCHES, Nicolas JEANNOT, Quentin JOSSET, William BEAUMONT, Luke SCOTT, Robert HILLMAN, Sophie LAUNEY, Anne-Laure BESNARD, Lisa MESLIER, Pierre-Yves BOISSON, Agnès STARK, Jamie STEVENS, Andy KING, Nadine HERRARD, Benjamin BAGOT, Etienne RIVOT, Cécile TRÉHIN, Valentin SANTANBIEN, Rémi PATIN, Quentin QUEIROS, Stephen GREGORY, Olivia SIMMONS**

The life cycle of salmon takes place between rivers and the sea. However, most knowledge relates to their life in rivers, and there is very little information and direct observations on the life of salmon at sea. Nonetheless, the long-term monitoring conducted at counting stations during migration, as well as information on catches made by fishermen, can provide us with clues about the marine life of these fish. A detailed analysis of these clues will help us better understand how salmon respond to changes in their marine environment. Salmon scales are calcified structures which grow with the fish and consequently record growth over the course of a lifetime. The analysis of alternating periods of high and low growth is traditionally used to determine the age of fish. A more in-depth analysis of the microstructures of these scales provides a more detailed description of the different past growing seasons. In the SAMARCH project, we were able to mobilise the required resources to collect, analyse, catalogue and integrate knowledge about the sea life of salmon to inform management approaches. This project was carried out in a joint and concerted manner in five rivers in Southern England and Northern France and offers an original multi-population approach. For instance, we showed that most growth at sea takes place during the first summer after smolt migration. This is also the period when growth has been the most variable over the last 30 years, with a rapid and persistent decline since 2005 experienced by all five of the salmon study populations. This decline in growth coincides with a decrease in the size of the salmon on returning to the river. We also demonstrated that growth during this first summer partly determines age at maturation, and therefore age on returning to the river. High-growth salmon are more likely to return as grilse after a winter at sea, whereas weaker-growth salmon will mainly return as spring salmon after two winters at sea. The genetic sexing of the salmon sampled on the five rivers, however, provides a new and contrasting view of the marine phase. While the growth of females and males at sea is similar, females appear to need to reach a larger size than males to initiate maturation and return to the river. As such, any decrease in marine growth would be likely to produce more spring salmon. By integrating demographic processes from the marine phase of the life cycle into a model, we investigated the relative impact of the observed changes on the number and age of salmon returning to the river. Our results show that growth reduction directly impacts fecundity but has so far contributed little to the observed variation in returns. We nevertheless found these variations to be mainly dependent on variations in the survival of salmon at sea.

Scale and juvenile salmon (© M. Nevoux)

Tuesday, 17 May
session 1:

Presentation of scientific work from the SAMARCH programme on improving knowledge of migratory salmonids in estuaries and at sea

Comparative analysis of the population dynamics and diet of the great cormorant (Phalacrocorax carbo) in the Arques (76) and Léguer (22) river basins

AUTHORS: ALEXANDRE CARPENTIER, **MNHN – University of Rennes 1,** and YANN FEVRIER, **GEOCA**

CONTRIBUTORS: **Marie Caroline HUSSET, MNHN – Maxime POTIER, Alice LEMONNIER & Floriane LUTZ, Seinormigr - Johanna THEYS, BGM – Gaëlle GERMIS, BGM**

As part of the Interreg SAMARCH project, a study designed to estimate the impact of predation by the great cormorant, during an annual cycle, on the populations of migratory salmonids in the Léguer (22) and Arques (76) basins was launched from January 2021 to March 2022. The main objectives of this study, which was conducted in partnership with a consortium of partners pooling their skills, were: i) to **analyse the population dynamics** of great cormorants on both sites, by monitoring the spatial and temporal distribution of the species and ii) to **describe the diet of cormorants, focusing on salmonids**, by analysing the contents of droppings and biochemically analysing muscular and feather tissues collected from birds from shooting regulations or in the field. Surveys were conducted monthly, with increased monitoring (weekly) when smolts were presumed to be migrating downstream. The initial results of the study tend to show contrasting population dynamics and predation behaviour, which differ according to various parameters such as the level of anthropisation of the basin, the naturalness of the estuary and abiotic parameters (seasonality and tides etc.). Nearly 370 pellets were collected and are currently being analysed. They should provide a relatively accurate picture of the level of predation pressure exerted on salmonids in relation to the presence of birds, in terms of the number and frequency of salmonids consumed, the size of individuals, and the birds' feeding habits (temporality and origin of prey in general: marine, estuarine, freshwater or mixed etc.)

Atlantic salmon otoliths (© A. Carpentier)

Great cormorants (Phalacrocorax carbo sinensis sub-species) (© Y. Février, GEOCA)

Wednesday, 18 May session 2:

WPT4 -Management of salmonids in France and England and evolution of policies

AUTHORS: LAURENT BEAULATON,
OFB – R&D hub OFB-INRA-Agrocampus Ouest-UPPA for the Management of Diadromous Fish in their Environment, Rennes & LAWRENCE TALKS**, Environment Agency**

In this talk we will present a comprehensive overview of the management of salmonids in France and England.

In France, salmonids benefit from a dedicated management regime alongside other diadromous species in brackish and freshwater, thanks to nine (three in SAMARCH area) diadromous fish management committees (COmité de GEstion des POissons MIgrateurs aka CO.GÉ.PO.MI). These committees, which include government representatives and representative stakeholders, can adopt any appropriate management measure regarding professional and recreational fisheries. For example, in Britany, Seine-Normandy and Artois-Picardie, fishing quotas have been settled for recreational fisheries of salmon. They also establish the conservation status of diadromous species in their area and propose the adoption of management measures regarding other anthropogenic impacts (like ecological continuity disruption) to appropriate stakeholder or planning committees. In French marine waters there is no dedicated management for salmonids.

Salmonids also benefit from general conservation management and spatial planning. Those particularly relevant for them are the EU Habitats Directive, EU Water Framework Directive and EU Marine Strategy Framework Directive and all French regulations derived from these directives. For example, salmonids are taken into account in the designation of protected areas such as Special Areas of Conservation or French Marine National Parks. Diadromous species, including salmonids, are also the subject of one of the objectives of the Marine Strategic Planning Document (Document Stratégique de Façade aka DSF).

In England, the Environment Agency's aim is to restore the abundance, diversity and resilience of salmonid stocks by maximising the production of healthy wild smolts in freshwater and reducing mortality at sea (we operate to six miles offshore). To do this we work with Government, its agencies and partner organisations. We establish the conservation status of salmonid populations across 42 principal salmon rivers and 44 principal sea trout rivers and this is used to inform and drive the implementation of management measures. These include five key priorities: further reducing exploitation by nets and rods; removing barriers to migration and enhancing habitat; safeguarding sufficient flows; maximising spawning success by improving water quality; and improving marine survival. Detailed actions are set out in the England and Wales North Atlantic Salmon Conservation Organisation (NASCO) Implementation Plan 2019-2024 and progress is reported in England and Wales NASCO Annual Progress Reports. Significant management actions include closing all salmon netting in 2019 and rod anglers achieving 94% catch and release in 2021. Despite these measures, however, the status of England's salmon populations remains critical with increasingly stressful environmental conditions in fresh, transitional and marine waters impacting on salmonids because of climate change, diffuse pollution, habitat quality and barriers to migration, in particular.

The results of the SAMARCH project will be used to improve the protection of salmonids at sea. For example:

* **Fish tracking.** By defining the migration routes and behaviour of salmonids in estuaries and coastal waters it will enable a review and potentially a strengthening of the current management measures to reduce the risks to salmonids at sea from pressures such as marine fisheries bycatch, marine renewables and dredging.
* **Genetic Tool Development.** The evidence from the tracking of sea trout kelts and the genetic work will be used to identify the important areas for sea trout at sea and be used to inform marine spatial planning.
* **Salmonid Stock Assessment Models.** By improving the way that the status of salmon and sea trout populations are assessed it will enhance and strengthen evaluations of conservation status, which are then used to drive investment to enhance salmonid populations.




© L. Talks

Wednesday, 18 May session 2:

What planning and management tools are used for migratory salmonids?

The National Plan for Diadromous Migrators and its links with other existing tools for the preservation of these species

AUTHOR: MARINE PORTENEUVE,
Research Engineer, National Plan for Diadromous Migrators – INRAE U3E Experimental Aquatic Ecology and Ecotoxicology – MIAME hub, OFB Research hub, INRAE, Institut Agro UPPA for the Management of Diadromous Fish in their Environment

The Ministry of Ecological Transition and the Ministry of Agriculture and Food have tasked the French Office for Biodiversity with the development of a national plan for diadromous migrants (PNMA), in line with Action H4 of the French salmon action plan. Furthermore, the European Union has co-financed this project as part of the International Year of the Salmon.

The species being studied are the diadromous fish and macro-crustaceans present in mainland France and the overseas departments and regions. Mainland France has 12 species of diadromous migratory fish, some of which are already subject to management measures at international, national, seaboard or catchment area level, but not all of which have the same protection status.

Launched in 2020, the joint creation process with stakeholders resulted in the approval of the draft plan in late 2021. The PNMA has a multi-species approach, whose value is highlighted in Action 42 of the biodiversity plan. It provides a global vision of the status and management practices of all these species. It also aims to complement existing management measures (PLAGEPOMI, SDAGE and DSF etc.) by supporting them with operational measures at national level. They are divided into six areas: land-sea link; fisheries; habitats and ecological continuity; hatcheries and restocking; monitoring – evaluation – prospects; and communication – awareness-raising – training.

The plan is scheduled to run for 10 years. The aim is to produce a concrete, operational and costed plan, in line with the national biodiversity strategy (SNB) 2021 to 2031. Following the mid-term review of the PNMA, it will be possible to make proposals for the drafting of the new PLAGEPOMI, SDAGE and strategic facade documents (DSF). The year 2022 will be used to implement some of the measures selected in an operational manner, to estimate the costs of implementation and to identify the financial partners.

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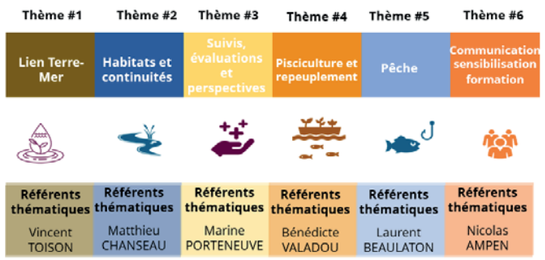

The main topics of the National Plan for Diadromous Migrators

Wednesday, 18 May session 2:

What planning and management tools are used for migratory salmonids?

Regulating fishing for migratory salmonids in estuaries and at sea in Brittany and Normandy

AUTHORS: ELISE CARNET, **Head of Biodiversity, protected species – Natural Heritage department / Biodiversity, Geology and Landscape division – DREAL Bretagne** & GWENAËL ROBINEAU, **Technical SupportTechnician – Police department – Technical Support hub – Normandy Regional Directorate – OFB**

In estuaries, fishing regulations are subject to both the river and sea domain. Upstream of the saltwater demarcation line, fishing is regulated by the Environmental Code (which regulates fishing in the river domain). Between the saltwater demarcation line and transverse limit of the sea, fishing is subject to the regulations for fishing in the sea domain. The sea authorities are therefore responsible for the part of the estuary downstream of the saltwater demarcation line.

Sea fishing for migratory fish and estuary fishing in Brittany is defined by order R53-2020-03-03-03 , 3 March 2020 of, the prefect of the region of Brittany. This order regulates the general and specific provisions applicable to professional and recreational fishing, specifying in particular authorised fishing periods, regulated fishing areas, fishing gear and techniques.

Some coastal rivers do not have a transverse limit of the sea or saltwater demarcation line or they are inaccurate, leading to problems with enforcement and policing fishing. Other inaccuracies in the order governing sea and estuary fishing in Brittany have been reported at COGEPOMI meetings on Brittany's rivers, which led to a detailed review of the decree from 2021 to 2022, the aim being to have a new order applicable from 2023.

To identify the issues at stake in the review of the order, various consultations were held with bodies for leisure fishing in rivers, and professional and recreational fishermen in sea environments and estuaries. At the same time, a survey and mapping of the applicable regulations highlighted the gaps and inconsistencies in terms of zoning. These elements helped simplify and change the way migratory fish are taken into account in the regulations for the sea and estuaries.

Wednesday, 18 May session 3:

Feedback and examples of measures taken to preserve migratory salmonids in freshwater

From data collection to data development

AUTHOR: LAËTITIA LE GURUN,
Project Manager – Bretagne Grands Migrateurs
CONTRIBUTOR: **Maxime POTIER, SEINORMIGR**

From the field to management, data migrates! Studies and monitoring networks for migratory fish generate a large amount and variety of data, regarding on populations and their habitats. For the knowledge acquired to contribute to management decisions, it is essential to communicate and explain this information to those involved in water and aquatic environments.

In Brittany and Seine-Normandy, several regular data acquisition systems are deployed to improve knowledge, and monitor the situation of migratory salmonid stocks:

* Monitoring of salmon and sea trout runs at counting stations to assess the number of anadromous fish
* Monitoring of the reproduction of migratory salmonids to evaluate their stock of spawners and highlight colonisation fronts
* Monitoring of the index of abundance of juvenile salmon by electric fishing to estimate annual recruitment
* Monitoring of reported catches of migratory salmonids to assess fishing catches
* Monitoring of index rivers (the Bresle, Oir and Scorff) to better understand the state and dynamics of salmon and sea trout populations.

For the past ten years, the Migratory Fish Observatory in Brittany and the Seine-Normandy basin dashboards, run respectively by Bretagne Grands Migrateurs (BGM) and Seine-Normandie Migrateurs (SEINORMIGR), have been working to centralise, develop and disseminate information to the network of stakeholders involved in migratory fish management and to the public. They are based, among other things, on key indicators for monitoring the state of populations, making it possible to set alert levels and assess the impacts of management. As tools which improve knowledge, they also fulfil the objective of assisting public policy decision-making (identification of hydroelectric facilities which most affect salmon, definition of salmon catch quotas, and salmon conservation limits etc.).

Salmon of the year / Sea trout © P. Rigalleau

Wednesday, 18 May
session 3:

Feedback and examples of measures taken to preserve migratory salmonids in freshwater

Managing recreational fishing for migratory salmonids in Brittany: regulations, reporting catches and new management strategy for salmon fishing

AUTHOR: MARIE-ANDRÉE ARAGO

Head of the Police department at the OFB's Brittany Directorate

Fishing for migratory fish in France is governed by Articles R 436-44 to R 436-68 of the Environment Code. These articles defined in the decree of 16 February 1994, are known as the diadromous decree. This decree sets up migratory fish management plans and migratory fish management committees, and determines the fishing methods to be used for migratory fish. These articles define the periods when salmonid fishing is prohibited, the minimum sizes of fish that can be caught, and salmon marking and catch reporting requirements.

In France, fishing for migratory salmonids is permitted in 13 departments in four regions (Hauts-de- France, Normandy, Brittany and Nouvelle-Aquitaine).

In Brittany, the first migratory fish management plan was drafted and approved in 1994. The measures concerning salmon aimed to make the exploitation of this resource more balanced by making the composition of catches closer to that of stocks, specifically via measures to extend the autumn fishing season to the lower parts of rivers.

At present, salmon fishing in Brittany is governed by a regional decree. This decree sets the total allowable catches (TACs) for the various Breton rivers, establishes an individual quota of six salmon, including two spring salmon, and reiterates the marking and reporting requirements. The annual departmental orders take up the recommendations of COGEPOMI and provide details on fishing methods and certain specific bans.

Since 1996, a method of managing fishing catches based on TACs has been in place for each basin. The aim is to leave the right amount of spawners at the end of the fishing season for the resulting egg deposition to maximise the potential number of catches in subsequent years.

The calculation of TACs is based on a simple model of the quantitative dynamics of salmon stocks. The parameters involved in the method, which was established by Prévost and Porcher in 1996, include the size of the production system, the carrying capacity and the productivity of the basin.

From 2000 onwards, given the greater fishing pressure on spring salmon, a specific spring salmon TAC needed to be enforced.

As knowledge was acquired, the TAC values for the various rivers were recalculated during the PLAGEPOMI revisions.

Even though this innovative method in 1996 made it possible to preserve salmon populations, limitations and misunderstandings have arisen:

* The notion of a conservation limit is vague
* The very high grilse TACs are very rarely reached, calling into question the TAC method
* Whatever the state of the salmon population, a TAC can always be defined. The fishery should be closed if the salmon population is in trouble.

In 2017, COGEPOMI started to consider how to change the salmon management system. The RENOSAUM study (an acronym for "renovation of salmon management" in French) set about defining conservation limits for each river, developing all the data produced in Brittany, and revisiting the exploitation regulation system, focusing on making it straightforward, robust and understandable for stakeholders.

The RENOSAUM study was finalised and presented at a public meeting in March 2022. After considering the opinions of the fisheries authorities, a new decree defining the terms of salmon management will be issued for five years from 2023.

Wednesday, 18 May
session 3:

Feedback and examples of measures taken to preserve migratory salmonids in freshwater

RENOSAUM: moving towards new recreational salmon fishing regulations in Brittany

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OFB, INRAE and UPPA, in collaboration with the association Bretagne Grands Migrateurs (BGM), have decided to collaborate through the RENOSAUM project to revisit the regulations on salmon exploitation by angling in the rivers of Brittany. Carried out over a period of six years (2016 to 2022), RENOSAUM was the first project of its kind in France (and probably beyond) which facilitates the decision-making process for managing salmon populations: both in terms of the scope of the work carried out, the amount of data used, its regards for international recommendations (NASCO in particular), and the ongoing dialogue between scientists and those involved in the management of salmon populations which has governed its progress.

RENOSAUM now provides new knowledge for the 18 main salmon rivers in Brittany about: (i) the abundance of juvenile recruitment in the year and the return of adults; (ii) the exploitation of salmon in Brittany by angling; (iii) the mechanisms of generation renewal within the 18 populations studied.

This new knowledge covers the period 1987 to 2020 and served as a basis for: (i) establishing new conservation limits for each of the populations studied, which were themselves based on an updated operational definition of conservation; (ii) a comparative analysis of a very large set of exploitation regulation scenarios (~200).

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New methods and tools were also developed during the project, mainly in the field of modelling, which are now available to update and extend the work already done in the future.

A comparative analysis of angling regulation scenarios in Breton rivers is the key outcome of the project. Its main findings can be summarised as follows: (i) for four rivers, none of the scenarios (i.e. even the absence of catches) respect conservation restrictions, due to lack of compliance with the first criterion used (i.e. controlling the risk of low recruitment); (ii) for the 14 other rivers being studied, the current conditions of exploitation intensity and population renewal do not require the exploitation of grilses to be restricted beyond the current fishing dates including an autumn extension; (iii) depending on the river, the exploitation of spring salmon should be restricted to a greater or lesser extent, primarily to satisfy the second conservation criterion (i.e. grilse balance vs. spring salmon catch); (iv) depending whether stability of catches is deemed a relevant criterion from an exploitation perspective, the most effective scenarios are based solely on TAC regulations or may include a check by fishing dates, which are more restrictive than those currently in force for spring salmon.

Wednesday, 18 May session 3:

Feedback and examples of measures taken to preserve migratory salmonids in freshwater

Major pathological risks for migratory salmon: from UDN (a myth?) to reality (*Gyrodactylus salaris*)

AUTHORS: PATRICK GIRARD AND ARMAND LAUTRAITE,
Santé Poissons Sauvages association

While many diseases affect wild Atlantic salmon, two deserve to be mentioned in particular because of the threat they pose to wild Atlantic salmon in Brittany: "UDN" and salmon fluke or *Gyrodactylus salaris*.

UDN – or ulcerative dermal necrosis – mainly affects Atlantic salmon spawners which complete their anadromous migration to breed. Identified in 1877 (the disease was first classified in Great Britain, including Scotland and Ireland), UDN is a recurrent problem that has been observed on and off for several decades in many coastal rivers of Brittany.

The disease is first characterised by the appearance of small grey areas of roughened skin initially only located on areas without scales (the head, opercula and fins). These skin lesions then develop into ulcers and necroses, quickly followed by a mycotic infection, most often caused by an oomycete of the genus *Saprolegnia*. The appearance of the lesions is usually preceded and accompanied by behavioural disturbances: the fish swim frantically, jump out of the water, and finally come to a standstill.

A cold-water disease (at 6–10°C) which is thought to occur only in freshwater, UDN has never been observed in fish farms. The cause(s) of these morbid episodes remain largely unexplained. While the epidemiology of UDN resembles that of an infectious disease, no infectious agents (viruses or bacteria) or parasites have been identified or demonstrated in the first instance.

In response to the concerns of amateur fishermen, BGM asked the Association Santé Poissons Sauvages (ASPS) to develop a study protocol to determine the aetiology of this disease and its contributing factors. A hypothesis of purely environmental origin will be studied.

Salmon fluke or *Gyrodactylus salaris* is so far unknown in France. This microscopic ectoparasite which lives on Atlantic salmon is mainly found in freshwater, although it can temporarily survive in brackish water. Rainbow trout can also harbour this parasite inconspicuously. This has been the case in Italy in a fish farm at least since the early 2000s.

Originating from the Baltic Sea catchment area, *Gyrodactylus salaris* is virtually harmless to its natural host, the Atlantic salmon of the Baltic stock (co-adaptation). Conversely, the accidental introduction of *Gyrodactylus salaris* in Norway in 1975 into wild populations of salmon from the East Atlantic stock (resistent to the parasite), was extremely fatal: 90 to 99% of parr died in the contaminated rivers within a few years.

As early as 1980, the Norwegian authorities tried to eradicate *Gyrodactylus salaris* with drastic measures by introducing biodegradable fish poisoning (rotenone) into the infected catchments and then restocking them with healthy fish. Despite doing this for forty years, the parasite remains in places and attempts are now being made to treat wild fish by killing the parasite with solutions containing aluminium or zinc.

An epidemiological survey (conducted from 1998 to 2000) showed that this parasite was almost certainly absent from the river basins hosting salmon in France (including the rivers of the Armorican Massif), which happened to indicate the confusion in a 1996 publication between *Gyrodactylus salaris* and *Gyrodactylus teuchis* (a species discovered during the survey) which erroneously concluded that the former was present in French waters.

The true distribution of *Gyrodactylus salaris* in continental Europe has yet to be confirmed and it could be introduced through the movement of live salmonids or their fertilised eggs at any time. However, no specific measures to protect Atlantic salmon populations from the introduction of this dangerous parasite have been put in place in France since these results, which date back more than two decades.

UDN-like ulcerative lesions on the head of a salmon

Generalised saprolegniosis on salmon from the River Leff

As early as 1996, EU regulations introduced a series of zoo-sanitary barriers to prevent the introduction of the parasite into UK waters.

Implementing regulatory measures on the movement of live salmonids means attempts can be made to protect wild Atlantic salmon populations from the introduction and catastrophic effects of *Gyrodactylus salaris*. To do so, the true status of our waters in relation to this parasite must first be scientifically established.

Wednesday, 18 May session 4:

Round table – Feedback and examples of measures taken to preserve migratory salmonids in estuaries and at sea

What is the added value of Marine Protected Areas for the management of migratory salmonids?

GWENOLA DE ROTON, **Natural Heritage Project Manager: marine habitats and functionalities – Contact for the eastern Baie de Seine – Channel and North Sea Facade Delegation – OFB**

PAULINE BLANCHARD, **Project Manager for marine birds – Natura 2000 sites in North Brittany – Atlantic Facade Delegation, OFB**

How do you factor in the restoration of ecological continuity in coastal areas? What are the difficulties involved?

CHRISTOPHE MAUGENDRE, **Technical Support Engineer – Normandy Directorate, OFB**

PIERRE LEGENDRE, **Head of the Sea and Coast Department – Morlaix Communauté**

What are the potential impacts of offshore wind farms on salmonids?

ANTHONY ACOU, **DCSMM Scientific co-Manager of coastal fish and cephalopods, rare and/or diadromous species – OFB, OFB-CNRS-MNHN PatriNat department, MNHN marine station, Dinard – R&D hub OFB-INRA-Agrocampus Ouest-UPPA for the Management of Diadromous Fish in their Environment, Rennes**

LYDIE COUTURIER, **Research Fellow in marine ecosystems and EMT – France Énergies Marines**

With the contribution of: ANTONIN GIMARD, **Project Manager of "Industrial Uses, Sea Developments and Management of the Marine Environment" – Natura 2000 contact – Seine-Maritime coastline / Pays de Caux – Normandy Directorate – Channel and North Sea Facade – OFB**

How do you better manage migratory salmonid fisheries at sea and in estuaries?

REPORTING CATCHES AND BYCATCH – GUILLAUME LE PRIELLEC, **Administrative Secretary for fishing licences and authorisations, diadromous species and Télécapêche – CRPMEM**

RISK ANALYSIS OF BYCATCH – VINCENT TOISON, **Marine Biodiversity Officer – OFB Brest**

A TOOL TO RAISE AWARENESS AMONG RECREATIONAL FISHERS: NAV&CO – MARIE LE BARON, **Project Manager – OFB Brest**

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