



ETN Symposium 2026 – Book of abstracts

A big thanks to our sponsors for providing student travel and free merch!



Oral presentations

SESSION 1 – LITTLE DO WE KNOW: TRACKING UNKNOWN AND OVERLOOKED SPECIES

The international movement and migration behaviour of twaite shad (*Alosa fallax*) from the Schelde Estuary, Belgium – an ETN example

Pieterjan Verhelst, Arc'hantael Labrière, Jan Breine, David Casals, Lydie Couturier, Peter Davies, Jena Edwards, Fred Fourie, Alice Hall, Hanna Jaspaert, Martial Laurans, Damiano Oldoni, Alex Plaster, Melanie Meijer zu Schlochtern, Emma Sheehan, Thomas Stamp, Ine Pauwels, Hendrik Volken Winter, Mathieu Woillez & Jan Reubens

Many diadromous species perform large-scale migrations, are of commercial interest and faced dramatic declines over the past decades. Therefore they are frequently subject of telemetry studies. However, these studies mainly focus on just a dozen species, such as Anguillid eels and salmonids. One group of species that is only limitedly investigated via telemetry, are the anadromous shads or river herrings of the *Alosa* genus. Like salmon and eel, shads are migratory species of (regional) commercial interest that are currently at record-low levels, resulting in some species being taken up by legal frameworks. The reason for the limited number of tracking studies is likely explained by their high vulnerability to handling and stress, making them delicate fish to tag. In this study, we tagged 194 twaite shads (*Alosa fallax*) via surgical implantation. We tracked them during their spawning migrations into the Schelde Estuary (Belgium) and were able to follow their movement behaviour and habitat use during the foraging stage in the marine environment. The results indicate that shads start their upstream migration earlier when the average spring water temperature is higher. By bringing data together from various acoustic receiver networks via ETN, we managed to elucidate the seasonal movement patterns and habitat use of the tagged shads during the marine foraging stage. While many shads remained closely to the mouth of the estuary where they spawned, a part migrated north to the Dutch coast during the end of summer and autumn, while another part moved southward to The Channel in winter.

Impact of shipping locks on the spawning migration of the river lamprey (*Lampetra fluviatilis*) in the Upper Scheldt River

Wannes Perdaen, Hanna Jaspaert, Pieterjan Verhelst, David Buysse & Jan M. Baetens

Advances in tracking technologies, such as acoustic telemetry, have made it possible to gain new ecological insights by monitoring individual movements in unprecedented detail. Yet, some species have only been studied to a limited extent with this technique, such as the European river lamprey (*Lampetra fluviatilis*). As an anadromous species with a complex life cycle spanning both marine and freshwater environments, it relies heavily on river connectivity for successful reproduction. Despite its ecological and cultural importance, the species has experienced significant declines. One of the main causes is habitat fragmentation by water regulating structures, such as weirs and shipping locks. Understanding the factors that influence and impede its migration, is therefore crucial to inform conservation strategies. In this project river lampreys were tagged during their upstream spawning migration in the river Scheldt. By combining ecological knowledge with insights from acoustic telemetry, we strive to identify key drivers of migration success in this heavily fragmented river and will try to locate the spawning grounds. The study area focusses on a 43 km reach of the upper Scheldt River, including four shipping lock complexes that potentially affect fish migration. Since these barriers are only partially equipped with fishways, their specific influence on migration success is assessed. Moreover, both physiological characteristics of the individuals, such as sex and size, and environmental triggers, such as discharge and temperature, are investigated.

Giants in the making: tracking the long-term movements of juvenile *Mola mola*

David Abecasis, Miguel Gandra, Sebastian Kraft, Lucas Martinez-Ramirez, J. Jiménez Rincón, Ricardo. F. Sánchez Leal & Cesar Vilas

The ocean sunfish (*Mola mola*), one of the largest bony fish, is a vulnerable and iconic species whose spatial ecology, particularly during early life stages, remains poorly understood. In this study, we used acoustic telemetry to track the movements of juvenile sunfish (<50 cm TL) captured at a tuna trap in southern Portugal, where large numbers of small sunfish are caught each spring. Eighteen juveniles were internally tagged with long-term (>7 years) acoustic transmitters. Initial results revealed that several individuals migrated toward the Mediterranean, with two fish reaching the Strait of Gibraltar (~300 km from the tagging site) within a month. The fastest individual reached the Strait of Gibraltar in just 12 days, covering a minimum average distance of 24 km per day. While most detections occurred near the shoreline, some individuals were detected in areas where the water depth exceeded 800 m, including two fish that migrated between opposite sides of the Mediterranean (Tarifa–Ceuta). Detection patterns indicated that these tagged juveniles were not schooling together, despite multiple individuals being detected at the same locations. This study represents the longest monitoring period of *M. mola* juveniles to date, with detections of one individual spanning over 200 days. Given the extensive monitoring infrastructure and the lifespan of the transmitters, future detections are anticipated, offering deeper insights into the movement patterns of the early life stages of this enigmatic species.

The return of the North Sea Houting in the River Overijsselse Vecht

Jan Kamman, Robert Weijman, Remko Verspui & Willie van Emmerik

North Sea Houting (*Coregonus oxyrinchus*) was extinct in the Netherlands. From 1996 to 2006 a reintroduction program was carried out in the river Rhine. Reintroduction efforts were stopped, when a large part of houtings caught in Lake IJsselmeer turned out to originate from natural reproduction. Since then, the number of houtings observed in the Netherlands has continued to increase. In 2018, during research in the river Overijsselse Vecht (Swimway Vecht), more than 150 houtings were unexpectedly caught during their spawning migration. To follow their annual migration, we tagged a total of 61 houtings in 2019 and 2020 with an acoustic transmitter (Innovasea V13). A telemetry network of 57 hydrophones was installed, ranging from the upper reaches of the river, past the mouth including lake Ketelmeer. These hydrophones were located below and above each weir in the river and in the largest tributary waters. Several houtings migrated annually towards the Vecht during their spawning period, which occurred in December. In the following years, several houtings were detected at the first weir, but none of them managed to pass through the fish passage. In December 2023 the river Vecht had extremely high levels of discharge. This record discharge coincided with the spawning migration of the houting. All three houting detected at the first weir passed. Conclusions are that North Sea houting is homing to spawn in the Overijsselse Vecht and that at normal discharge the river is still largely inaccessible for the species, only at extreme discharge are the weirs passable.

Rays Against the Machine: Elasmobranch movements challenge marine management

David Casals, Kim Aarestrup, Dries Bonte, Lydie Couturier, Lotte Dahlmo, Peter Goethals, Gustav Hellström, Petter Lundberg, Lotte Pohl, Jan Reubens, Erwin Winter & Kim Birnie-Gauvin

Sharks, skates, and rays are ecologically significant yet severely data-deficient members of North Sea biodiversity. Despite their importance as predators, their movement ecology remains poorly characterized across the region, and conservation assessments frequently diverge between national jurisdictions for the same species. This fragmented, country-by-country governance sits in tension with the biology of animals that routinely cross political boundaries, making direct empirical evidence of elasmobranch space use at ecologically meaningful scales an urgent priority. We present acoustic telemetry data from the NorTrack project, which deployed and coordinated receiver infrastructure across the Northeast Atlantic through the European Tracking Network (ETN). Drawing on this transnational array spanning the North Sea, Kattegat, Skagerrak and adjacent waters, we tracked multiple elasmobranch species to characterize movement patterns, identify spatiotemporal detection hotspots, and evaluate how habitat use overlaps with national management boundaries and offshore infrastructure. Our findings document extensive individual movements, with animals detected across multiple receiver arrays in different national waters within single seasons, confirming the transboundary nature of elasmobranch habitat use. Detection hotspots display strong spatiotemporal structure, pointing to aggregation areas not currently reflected in management frameworks. A notable proportion of tracked individuals were also detected within or near offshore wind farm footprints, raising questions about cumulative exposure to anthropogenic stressors across life history stages. These results challenge both the placement of existing management boundaries and whether meaningful protection extends across the full range of habitats these species depend on.

SESSION 2 – TRACKING RAYS AND SKATES ACROSS EUROPEAN WATERS

Partitioned yet connected: spatial organisation of estuarine elasmobranchs revealed by integrated telemetry and BRUVs

Kenn Papadopoulos, Iñigo Expósito Ochoa & David Villegas-Ríos

Many diadromous species perform large-scale migrations, are of commercial interest and faced dramatic declines over the past decades. Therefore they are frequently subject of telemetry studies. However, these studies mainly focus on just a dozen species, such as Anguillid eels and salmonids. One group of species that is only limitedly investigated via telemetry, are the anadromous shads or river herrings of the *Alosa* genus. Like salmon and eel, shads are migratory species of (regional) commercial interest that are currently at record-low levels, resulting in some species being taken up by legal frameworks. The reason for the limited number of tracking studies is likely explained by their high vulnerability to handling and stress, making them delicate fish to tag. In this study, we tagged 194 twaite shads (*Alosa fallax*) via surgical implantation. We tracked them during their spawning migrations into the Schelde Estuary (Belgium) and were able to follow their movement behaviour and habitat use during the foraging stage in the marine environment. The results indicate that shads start their upstream migration earlier when the average spring water temperature is higher. By bringing data together from various acoustic receiver networks via ETN, we managed to elucidate the seasonal movement patterns and habitat use of the tagged shads during the marine foraging stage. While many shads remained closely to the mouth of the estuary where they spawned, a part migrated north to the Dutch coast during the end of summer and autumn, while another part moved southward to The Channel in winter.

Acoustic positioning reveals conspecific interactions and social dynamics in aggregating thornback rays (*Raja clavata*)

Jena E. Edwards, Lotte Svengård Dahlmo, Knut Wiik Vollset & Robert J. Lennox

In elasmobranchs, conspecific aggregations commonly reflect needs such as foraging, mating, or refuge from predators or unfavorable conditions. Meanwhile, dynamic social relationships can form (fusion) and dissolve (fission) within these groups as the costs and benefits of interactions shift. Importantly, such aggregations may also heighten the vulnerability of wild individuals or populations to threats including habitat degradation, environmental shifts, and human interactions. Detecting social structure in marine species - particularly non-surfacing elasmobranchs - remains a challenge, but advances in aquatic tracking are improving our ability to detect and characterise animal interactions. In particular, high-resolution acoustic positioning systems provide opportunities to examine how environmental conditions and social behaviours shape individual and group-level space use within aggregation sites. Veajorden is a deep-water fjord in southern Norway where mixed aggregations of thornback rays (*Raja clavata*) persist year-round. While relatively abundant throughout the Northeast Atlantic, the species is listed as Near Threatened by the IUCN Red List, underscoring the need for continued monitoring. Using fine-scale positioning data from 24 adult rays, combined with approaches such as Generalised Additive Models and Social Network Analysis, we investigate the timing and frequency of ray interactions and assess whether environmental (bathymetry, temperature) or biological (sex, size) factors influence group formation and structure. This information will provide a better understanding of the drivers and consequences of conspecific interactions in a spatially constrained aggregation site, offering valuable insight into the behavioural ecology of a species of conservation concern.

Filling the gaps of the spatial ecology of four species of Myliobatiformes in the northwestern Mediterranean

Ángela Palomino, Skye Brown, Miquel Sacanell, Eneko Aspillaga, Joan Lluís Riera, Nicolas Lucchini, Gilles Saragoni, Philippe Lenfant & Bernat Hereu

Knowledge of the spatial ecology of two species from the family Myliobatidae (*Myliobatis aquila* and *Aetomylaeus bovinus*) and two from the family Dasyatidae (*Dasyatis pastinaca* and *Pteroplatytrygon violacea*) in the northwestern Mediterranean remains limited and is based primarily on fishing records and occasional sampling. Some of these species have experienced significant population declines in recent decades. This is particularly concerning for species with slow life cycles, low fecundity, and high susceptibility to bycatch, as these characteristics increase their vulnerability to fishing pressure and other anthropogenic impacts. For this study, acoustic telemetry is being used to characterize individual movements, spatial fidelity, and habitat connectivity for the four species along the northwestern Mediterranean coast. The study area includes a network of ecologically important Marine Protected Areas, making it ideal for evaluating functional connectivity. Preliminary results reveal distinct spatial behavioral patterns among species, with marked differences in movement reflecting species-specific ecology and habitat preferences. This information will provide a solid basis for identifying distribution areas, critical habitats, and temporal or reproductive patterns for these species, thereby improving the effectiveness of Marine Protected Areas and fisheries management measures, contributing to their long-term conservation under increasing anthropogenic pressure and climate change.

Acoustic Tracking of Endangered Coastal Sharks and Rays Across a Network of MPAs in the Balearic Islands

Jordi Abad-Platas, Eneko Aspillaga & Josep Alós

Marine Protected Areas (MPAs) are critical for the conservation of elasmobranchs (sharks and rays), offering refuges where these species can reproduce, feed, and grow with reduced anthropogenic pressures. Recent advancements in acoustic telemetry technology have facilitated the collection of long-term data on the movement patterns of marine species, providing a robust framework for evaluating the effectiveness of MPAs in conserving biodiversity, sustaining ecological functions, and supporting resource productivity in surrounding ecosystems. Here, we present the work carried out to investigate the role of MPAs in preserving the biodiversity of endangered elasmobranchs in the Balearic Islands. We successfully tagged and began tracking over 150 individuals from four taxonomic orders—Rajiformes, Myliobatiformes, Torpediniformes, and Carcharhiniformes—using long-term acoustic transmitters (~10 years). Individuals were captured and tagged in collaboration with local fishers, with subsequent monitoring carried out by the Balearic Tracking Network over the following decade. The primary objective was to advance our understanding of how MPAs contribute to maintaining the biodiversity and ecological roles of coastal elasmobranchs, mostly batoids, a taxonomic group of high conservation concern. Our study showed that the spiny butterfly ray (*Gymnura altavela*), eagle ray (*Myliobatis aquila*), and the common smooth-hound (*Mustelus mustelus*) displayed high mobility across the study area. These movements revealed functional connectivity between MPAs, underscoring their role as ecological networks rather than isolated sites. The insights already generated from this project are helping to inform future conservation strategies and are expected to further enhance the management of MPAs for long-term ecological sustainability.

Acoustic telemetry as an innovative tool to investigate fish behaviour and habitat use around offshore wind farm structures

Lydie Couturier, **Riwan Leroux**, Coline Guiquello, Bastien Taormina, Mathieu Woillez, Jerome Bourjea, Philippe Lenfant, Jan Reubens, Hugo Hervé, Olivier Blanpain, Emilien Lasne, Anthony Acou & Karine Herrah

The rapid expansion of offshore wind farms (OWF) in Europe is transforming coastal marine habitats. These anthropogenic structures can modify fish space use and habitat connectivity in contrasting ways. While foundations and scour protections may function as artificial reefs that promote residency and site fidelity, operational pressures such as underwater noise may disrupt movements, migration routes, or habitat selection. Given the ecological roles and socioeconomic value of coastal fish communities, assessing these effects requires long-term, multi-scale monitoring. Acoustic telemetry provides a powerful framework for addressing these questions. Within French OWFs, projects such as FISHOWF+ and MMERMAID deploy acoustic arrays in and around OWF structures and are integrated into broader regional networks of the European Tracking Network. Together, these regional networks track more than 800 individuals across 23 species, providing essential information on broadscale connectivity. Within this multi scale framework, the fine scale acoustic positioning arrays deployed by FISHOWF+ and MMERMAID at OWF structures offer complementary, high-resolution insights into local behavioural processes. Here, we present two case studies investigating fish movements around distinct OWF structures. We examined the reef effect and associated behavioural patterns, such as residency, site fidelity, transient use, and species-specific habitat occupation. Preliminary findings reveal contrasted patterns among species, providing insights into the role of OWF habitats in shaping movement ecology. Additionally, the deployment of multilateral acoustic positioning arrays provides the first fine scale movement trajectories near these structures, offering perspectives on the spatial behaviour of resident individuals. This work contributes to improving ecological understanding of OWF impacts and supports the development of evidence-based monitoring strategies for future offshore renewable energy developments.

SESSION 3 – NOVEL METHODS, TECHNIQUES AND INTEROPERABILITY IN ACOUSTIC TELEMTRY

Novel methods for fine-scaled positioning: Population Monte Carlo and extended Kalman filtered time-of-arrival positioning

James Campbell, Petter Lundberg, Rachel Mawer, Jelger Elings, Samuel Shry, Ine Pauwels & Franz Hölker

Two novel models for fine-scaled positioning will be presented (i) population Monte Carlo time-of-arrival (PMC-TOA), and (ii) extended Kalman time-of-arrival (EK-TOA). PMC-TOA is a robust method shown to give good positions even in the presence of reflected transmissions, while EK-TOA provides a closed form solution for extremely fast processing of large time-of-arrival datasets. Additionally, a simple method will be shown for reporting absolute measures of positioning error which can be applied to any positioning model. Combined with YAPS, the suite of positioning methods makeup a versatile processing toolbox for fine-scale positioning.

Accelerometer transmitters reveal biological rhythms and activity of marine species in Norwegian fjords

Robert J. Lennox, Saron Berhe, Lars-Martin Myhre, Cecilie I. Nilsen, Lotte S. Dahlmo & Knut W. Vollset

Accelerometers have been widely applied now to evaluate elasmobranchs in the wild including recovery from capture events, sociality, and fine-scale behaviour classification. However, accelerometer loggers are challenging because they must be recovered from animals and the battery life can be limited, obviating observations throughout the full year. Accelerometer transmitters integrated into acoustic tags offer a solution for accessing long-term data about activity patterns of animals as long as the animals remain within an area covered by acoustic receivers. Using acoustic accelerometer transmitters in the Osterfjord system of western Norway, we investigated the full-year biological rhythms of seven different species. Using a novel generalised additive model parameterisation, we identified interactions between season and diel period to reveal activity peaks for both species across an entire year. Results yield exciting insights into the ecology of aquatic species using remote tracking tools, and offer a promising template for future research to investigate biological rhythms that reveal eco-evolutionary dynamics of species that are otherwise challenging to observe in the wild.

Building a globally compatible observatory for animal movement - data exchange between the European Tracking Network and the Ocean Tracking Network

Angela Dini, Claudia Meneses, Stijn Vermaere & Jon Pye

The Ocean Tracking Network (OTN) and European Tracking Network (ETN) have been long-standing data partners, collaborating on data publication formats for the Ocean Biodiversity Information System (OBIS) and supporting global acoustic telemetry research. In February 2026, for the first time, detections and tags were cross-matched between the two networks in a successful pilot: animals tagged by any OTN node have been matched to detections in ETN arrays, and vice versa. This breakthrough was enabled through the alignment of OTN and ETN's data policies to clarify and balance the sharing obligations of receiver and tag-owners, and was facilitated by many years of collaborative problem-solving by staff of both networks. The ability to act as a compatible OTN node allows ETN researchers with OTN equipment loans to report data to only one network while meeting obligations across both systems. Though there remains capacity for streamlining and automation of this data sharing mechanism between OTN and ETN, this marks a major milestone for the networks and acoustic telemetry researchers whose animals may enter or leave European waters, connecting with any of the regional, national or global telemetry networks. Future avenues for collaboration will include the expansion of supported tag types and harmonization of network-built data products provided to OBIS and to the European Digital Twin of the Ocean (EDITO), strengthening interoperability and maximizing the research value of acoustic telemetry data.

Optimizing acoustic telemetry arrays using a simple probabilistic tool

Jordan Matley, Christopher Monk, Thomas Clarke, Jacob Brownscombe, Joshua Dennis & Natalie Klinard

Strategically deploying acoustic telemetry receiver arrays is vital for tracking the movements of aquatic animals. Nevertheless, there is a lack of tools that provide the capacity to evaluate how well arrays perform in their study area, as well as ways to optimise receiver configurations so they best meet study goals. Optimising detectability across receivers — relative to the diverse study objectives that often exist — should be a major priority in acoustic telemetry research. Here, we introduce a simple probabilistic approach to plan and evaluate the detection performances of acoustic telemetry arrays, specifically with the goal to optimise receiver locations depending on the needs of the study. Using a case study, we show how optimal receiver configurations vary based on study parameters and highlight how strategic receiver deployments across different habitats can improve detection capacity for telemetry studies. Thus, this work can contribute to better research planning and study design across the European telemetry community and marine, estuarine, and freshwater environments.

More than detections: A novel Time of Arrival-based approach to infer activity from simple telemetry setups

Eneko Aspillaga, Josep Alós, Ignacio A. Catalán, Vicenç Moltó, Jordi Abad-Platas, Bernat Morro & David Villegas-Ríos

Quantifying activity patterns from acoustic telemetry typically requires either sensor-equipped transmitters or dense receiver arrays for positioning, increasing both logistical complexity and cost. Here, we present a novel method to infer animal activity from single-receiver acoustic telemetry setups by exploiting the Time of Arrival (TOA) of acoustic transmissions. Our approach estimates the relative distance between a tagged individual and a fixed receiver from TOA data and uses temporal variation in these estimates to derive movement metrics such as step lengths, which can subsequently be used to classify behavioural states and quantify activity patterns. In this presentation, we will explain the method in detail, from TOA extraction to behavioural inference, and showcase its application across diverse telemetry datasets and ecological contexts. Through practical examples, we will illustrate the range of ecological questions that can be addressed with this approach, and discuss its principal advantages, assumptions, and limitations. By extracting behavioural information from minimal telemetry infrastructure, this method expands the analytical potential of existing acoustic telemetry datasets and provides a cost-efficient alternative for activity inference in aquatic telemetry studies. These results challenge both the placement of existing management boundaries and whether meaningful protection extends across the full range of habitats these species depend on.

Improving acoustic telemetry positioning in coastal systems: insights from the Kaltoa framework

Tanguy Moreau, Mathieu Woillez, Martial Laurans & Lydie Couturier

Global changes are driving rapid and intense modifications of ecosystems, at rates and magnitudes that research may not anticipate. These population fluctuations raise significant conservation challenges, whether species of concern are declining or increasing in biomass. Such dynamics and consequences for ecosystems, call for individual-level studies to inform the underlying ecological processes governing monitored populations. Fine-scale acoustic tracking provides critical data for understanding the movements of species of interest. However, applying these methods requires error-free reconstruction of tracked individuals' positions within a receiver array subject to clock drift, acoustic multipath, and variable environmental conditions — particularly in coastal and estuarine environments. Within the framework of environmental studies conducted between 2024 and 2026 on behaviours of European lobsters (*Homarus gammarus*) and spider crabs (*Maja brachydactyla*) in the English Channel, we investigated whether the Kaltoa framework can improve the accuracy and robustness of individual trajectory reconstruction in complex coastal environments. Kaltoa (Kalman-filtered time-of-arrival positioning) is a package under development that enables the temporal synchronisation of receiver arrays and the modelling of individual positions detected within such networks. Applying this framework allowed us to improve the temporal synchronisation of a 32-receiver array under degraded acoustic conditions, and to model fine-scale predatory interactions of spider crabs on mussels at small resolution. This work demonstrates that Kaltoa framework constitutes a robust tool for high-resolution reconstruction of movements. It opens new perspectives for the study of ecological processes at fine scales, thereby strengthening our capacity to adapt to global changes and address their environmental and socio-economic implications.

SESSION 4 – REGIONAL-SCALE, RARE AND PILOT ACOUSTIC TRACKING IN APPLIED RESEARCH

The Lost Sharks - tracking spiny dogfish in Norwegian fjords subjected to deoxygenation

Lotte S. Dahlmo, Gaute Velle, Yngve Landro, Eirik S. Normann, Cecilie I. Nilsen, Keno Ferter, Otte Bjelland, Claudia Junge, Anders F. Opdal & Knut Wiik Vollset

Spiny dogfish (*Squalus acanthias*) in the North Atlantic are well known for extensive migrations, yet several studies point towards highly resident individuals or ecotypes with little migratory behaviour. Following overfishing in the mid-to-late 1900s, the Northeast Atlantic population is recovering, but whether local resident ecotypes survived or were fished to extinction remains an open question. Fjords are particularly susceptible to deoxygenation due to restricted water exchange, and declining oxygen levels are projected to intensify under climate change. To investigate this, we acoustically tagged more than 90 spiny dogfish in deoxygenated fjords outside Bergen, Norway, between November 2021 and March 2023, using tags with two-to-five year battery lifetimes and integrated depth sensors. While some individuals migrated out of the fjord, many remained for several years, supporting the hypothesis of a recovering resident ecotype. Males and females used the fjords differently, highlighting the importance of accounting for sex-related differences in management. Both sexes performed diel vertical migrations, though the largest females ceased this behaviour during summer. Most individuals showed similar oxygen selection probabilities, suggesting habitat use is not substantially constrained by current oxygen levels. Three females were detected on receiver networks approximately 200 km south of our array, potentially indicating reproduction-related migrations given that all three exceeded the 50% maturity length. These findings support the existence of a coastal fjord ecotype of spiny dogfish. Effective management and stock assessments must account for divergent movement strategies among ecotypes, as local fishing pressure and intensifying deoxygenation can have disproportionate and compounding impacts on spatially restricted populations.

Route choice of brown trout smolts passing a hydropower facility

Henrik Bakftoft, Karl-Øystein Gjelland, Finn Økland, Jon Museth, Ana Silva, Halvor Kjæråsen & Torbjørn Forseth (presented by **Lene K. Sortland**)

Hydropower is a key source of renewable energy but can severely disrupt river connectivity for migrating fish. To pass hydropower facilities, downstream migrating fish must often select among multiple passage routes, including spillways, turbines, bypass systems, or surface outlets. While certain routes are safer, they may be less attractive to fish. Migrating fish generally follow the main flow, which at hydropower facilities is diverted into turbine intakes, where the risk of injury and mortality is typically higher. This study investigated the behaviour and route choice of downstream migrating brown trout smolts (*Salmo trutta*) during passage of a large run-of-the-river hydropower plant in the River Gudbrandsdalslågen in southeastern Norway using high-resolution 2D and 3D telemetry. In 2017, 117 hatchery-reared brown trout smolts (F1, originating from the same river) were internally tagged with acoustic transmitters and released upstream of the hydropower plant, and their downstream passage was monitored using a dense array of acoustic receivers. To cover different discharge conditions, smolts were released in four batches between May and June. Of the 117 tagged smolts, 51 had sufficient data to estimate passage route. Preliminary analysis indicated that most smolts (33 out of 51) selected the turbine intake over other routes (ice gate, fishway, and spillways), regardless of discharge conditions. Given that turbine passage often entails increased risks of direct and indirect injury or mortality, these findings indicate that mitigation measures are needed to prevent smolt entry into turbine intakes.

Females dive towards dispersed leks during spawning season in Atlantic cod (*Gadus morhua*) in western Norway

Arjen A. W. van der Kamp, Jon Egil Skjæraasen, Lise Doksaeter Sivle, Kate McQueen, Esben M. Olsen, Ørjan Karlsen & Anders F. Opdal

In a lek mating system, males aggregate at display sites that females visit only for the purpose of fertilization. Although empirical studies consider the Atlantic cod (*Gadus morhua*) as a lekking species, fundamental uncertainties exist about the extent to which males are aggregating and how females approach these putative male aggregations. Within a spawning ground in western Norway, 161 individual mature Atlantic cod (86 males; 75 females) were tracked with acoustic tags fitted with acceleration and depth sensors for six consecutive years by an acoustic receiver array of 30 receivers. Using Brownian bridge movement models, we found that males seem to form and likely defend their own territory during the spawning period with little overlap between individual males. Moreover, female fish seem to aim a deep dive from shallower waters to approach male territories. Our findings suggests that male-male interactions occur, while females approach male territories using deep dives during day and night to spawn. These findings provide a new layer for our understanding of the mating behaviour of the iconic Atlantic cod.

Tracking silver European eel *Anguilla anguilla* emigration and inshore movements using acoustic receivers at the regional scale

Sibusisiwe Moyo, Tea Bašić, Rosalind Wright, Tom Major, Jonas Palder, Simone Cittadino, Will Beaumont, Bill Beaumont, Dylan Roberts, Andy Moore, Mark Ives, Peter Davies, Alice Hall, Thomas Stamp, Emma Sheehan & J. Robert Britton

Tracking silver European eel *Anguilla anguilla* riverine emigration and subsequent marine movements can generate novel insights into how individuals move through highly modified river channels and then the marine environment. This tracking can be challenging, given the difficulties of receiver deployment across multiple habitats and across relatively large spatial areas. Here, we applied acoustic biotelemetry (transmitters with pressure sensors) to track silver eel emigration out of two chalk-streams, River Frome (including Poole Harbour) (n = 50) and the River Test (n = 25) in southern England before tracking their emigration through the English Channel. The eels were tracked on over 100 receivers deployed by multiple organisations that covered a linear distance of over 125 km. Silver eels from both rivers emigrated through their lower river reaches relatively successfully, with most Frome eels also successfully moving through the transitional waters of through Poole Harbour (approximately 35 km²) before reaching the open sea. Although a small proportion of eels did not move immediately once into the marine environment, the majority were detected moving in a westerly direction (towards the Atlantic Ocean), with their final detections suggesting the majority of eels were moving relatively close to the coastline at depths between 5 and 50 m. Individuals were generally detected on marine receivers for approximately 20 days but for up to 95 days. These results show the value of being able to track silver eels across relatively large distances and on receivers deployed by multiple organisations.

Quantifying spatiotemporal overlap between Arctic charr and pink salmon in Isfjorden, Svalbard

Jack Colman, Saron Berhe, Guttorm Christensen, Tormod Haraldstad, Knut Wiik Vollset, Robert J. Lennox, Oddmund Isaksen, Thomas Strand, Thrond Haugen & Louise Chavarie.

Climate change is facilitating the northward expansion of pink salmon into Arctic waters, creating the potential for competitive interactions with native Arctic charr in Svalbard. Using acoustic telemetry, we quantified residency and spatiotemporal overlap of both species across Isfjorden from 2022-2025. A total of 138 Arctic charr and 14 pink salmon were monitored. Pink salmon exhibited higher residence indices than Arctic charr during periods of co-occurrence. Significant negative co-occurrence associations at both daily and hourly scales were found, suggesting avoidance behavior between the two species. Furthermore, Arctic charr displayed diel activity times which seemed to be disrupted by the presence of pink salmon, with bimodal activity peaks occurring before and after a single pink salmon peak. Arctic charr residency and departure phenology differed between even and odd years, with odd-year fish (i.e., high pink salmon abundance) departing significantly later. Additionally, increased pink salmon abundance appeared to disrupt the size-dependent migration patterns of Arctic charr observed in even years, homogenizing the departure day of odd-year fish. These findings suggest that pink salmon presence may influence Arctic charr space use and migratory behavior, which is valuable insight given the importance of marine foraging to the anadromous charr populations in Svalbard. As pink salmon abundance is likely to increase with continued warming, competitive pressure on Arctic charr in Svalbard may intensify, with potential consequences for their marine foraging success.

Long-distance movements and divergent spatial strategies in co-occurring sea snakes revealed by acoustic telemetry in a trawled seascape

Shannon Coppersmith, Kate Sanders & Vinay Udyawer

For vulnerable species interacting with anthropogenic activities, understanding movement patterns is critical for conservation. Sea snakes are frequently caught as bycatch in trawl fisheries, yet their spatial ecology remains poorly understood due to challenges in collecting data across large spatial and temporal scales. We deployed an extensive acoustic telemetry array in Exmouth Gulf, a remote and ecologically important region in Western Australia where commercial trawling presents logistical constraints for telemetry studies. We used this system to investigate the movements, space use and depth preferences of three co-occurring sea snake species (*Aipysurus laevis*, *Hydrophis major* and *Hydrophis stokesii*) over a two-year period. All species exhibited substantial long-distance movements (>70 km), with dispersal distances far exceeding previous estimates for sea snakes. Despite this shared dispersal capacity, we found contrasting patterns in residency and space use between species and sexes. Female *A. laevis* were highly resident and associated with shallow reefs, while males exhibited greater mobility and larger activity spaces. *H. stokesii* showed the highest dispersal rates, frequently moving between reefs and shoals, while *H. major* appeared to use deeper habitats that were underrepresented in our receiver coverage. Depth use was relatively consistent across diel periods, with variation between sexes and species likely reflecting habitat preferences and behavioural strategies. These findings challenge the prevailing assumption that most sea snakes are highly philopatric and demonstrate how multi-year telemetry data collected in a logistically constrained system can reveal species- and sex-specific movement strategies, with important implications for assessing vulnerability to fisheries and informing spatial management.

SESSION 5 – FROM DATA TO DIGITAL TWINS: PIPELINES, CENTRALISATION AND MORE

Access ETN data with the improved etn R package

Pieter Huybrechts, Sanne Govaert & Peter Desmet

For several years the etn R package has been one of the foremost ways to access acoustic telemetry data from the European Tracking Network (ETN) database. The package allows easy access to data (acoustic detections, sensor data) as well as metadata (animals, tags, deployments, receivers, projects) in a way that can be automated via scripts and reproduced as part of a larger workflow. Through the package, you can retrieve open data and data under moratorium to which you have access. Over the last year, we've made major changes to the package. The most important new feature is that you can now access ETN data from your own personal computer, rather than from a server or computer with database access. We've also implemented a method to get sensor data from archival tags and citation information for projects. We're also providing better support for data publication, by making it easier to export entire animal projects to Frictionless Data Packages and transforming these to Darwin Core Archives. The latter can be published as interoperable biodiversity data to the Global Biodiversity Information Facility (GBIF) or the Ocean Biodiversity Information Facility (OBIS). This presentation will give an overview and general demonstration of the new features and a brief look at future developments.

Predictive modelling of marine animal movement

Ahmad Catur Widyatmoko, Erwin Winter, Leo Nagelkerke & Jan Jaap Poos

Predictive modelling of marine animal movement is increasingly seen as a building block for Digital Twins of the Ocean (DTO), translating observations into forecasts. In the North Sea, acoustic telemetry provides valuable detections, but limited receiver coverage can make tracks patchy. Data Storage Tags (DSTs) offer a complementary source of reconstructed trajectories for developing and testing forecasting methods. We present methodological lessons from forecasting movements of North Sea skates using 35 DST deployments lasting 30–400 days per individual. Positions were reconstructed using a geolocation framework integrating temperature, bathymetry, and tidal constraints, then regularised into continuous tracks. Forecasting datasets were created with sliding windows, using seven days of movement history to predict multi-day trajectories. We compared deep sequence-to-sequence models, mixture-of-experts LSTMs, posterior-grid LSTMs, and movement-process baselines, including correlated random walk and hidden-state step-turn models. Three findings emerged. First, target formulation was critical: direct coordinate-based formulations were less stable, while velocity or displacement-based models anchored to the last known position were more reliable. Second, movement structure mattered: models incorporating directional persistence, behavioural states, or step-turn dynamics produced more realistic trajectories than models predicting spatial location alone. Third, errors were behaviour-dependent: resident or low-excursion movements were predicted relatively well, whereas rare migratory or high-excursion episodes remained difficult and were often underestimated. Movement-process models, particularly vector-autoregressive step-turn and switching correlated random walk models, were highly competitive with neural models. These results suggest that hybrid approaches combining neural prediction with mechanistic movement priors may offer robust and interpretable forecasts for DTO applications in marine animal movement.

SESSION 6 – FROM INSIGHTS TO IMPACT: HOW TELEMETRY RESULTS FIND THEIR WAY INTO POLICY

Telemetry in action, from research to decision making - WePass 2 project restoring connectivity at Iron Gate I & II

Marija Smederevac-Lalić, Finn Økland, Henrik Baktoft, Karl Gjelland, Gorčin Cvijanović, Dušan Nikolić, Stefan Hont, Marian Iani, Marian Paraschiv, Nevena Cvijanović, Miodrag Milovanović, Marq Redeker, Julia Gatzweiler, Jörn Gessner & Eva Thorstad

Restoring fish migration in the Danube River is essential for achieving key European and international policy goals, including the Danube River Basin Management Plan, the Water Framework Directive, and the Biodiversity Strategy for 2030. River continuity is a top priority for ecological restoration. The Danube is the most international river basin in Europe, flowing through 10 and spanning 19 countries. It hosts over 100 fish species, including critically endangered sturgeons. Many species depend on long-distance migrations between freshwater and marine environments, with movements of several hundred to over 2,500 km. However, the river is fragmented by 1,030 barriers related to hydropower, flood protection, and water supply. The Iron Gate dams are the most critical bottleneck, limiting longitudinal connectivity. Telemetry studies under the WePass 2 project have been crucial for understanding fish movement and barrier impacts. Tagging and tracking included key migratory species such as sterlet (*Acipenser ruthenus*), asp (*Leuciscus aspius*), barbel (*Barbus barbus*), nase (*Chondrostoma nasus*), and vimba bream (*Vimba vimba*). These studies identified migration routes, habitat use, and fish aggregation sites downstream of dams, confirming that fish cannot pass the Iron Gate dams. Combined telemetry and hydraulic analyses show that restoring fish migration at the Iron Gate dams is technically feasible. Key migration pathways and aggregation zones have been identified, enabling the development of technical solutions for upstream and downstream passage. These findings provide a strong scientific basis for improving river connectivity and supporting large-scale ecological restoration across the Danube River Basin.

Acoustic tracking reveals the deterrent effect of strobe lights on silver eel (*Anguilla anguilla*) near hydropower infrastructure

Ine Pauwels, Sarah Broos, David Buysse & Johan Coeck

Stroboscope light deterrence systems have been installed at hydropower stations with varying success. Efficiency depends on species-specific responses and system characteristics such as color and flash frequency. This study evaluated the efficiency of a strobe light system (1 Hz frequency) in deterring downstream migrating silver eels (*Anguilla anguilla*) from a hydropower plant intake channel. The study was conducted in a highly regulated shipping canal where thirty eels had no alternative route downstream except through large shipping locks located directly behind the strobe lights. Eel movement was monitored for four months using a positioning system of 180 kHz acoustic receivers. Of the 31 recorded approaches to the strobe lights, eels were deterred in 30 instances (one approach was inconclusive). While not all eels approached the lights, several did so multiple times. Crucially, no eels passed through the hydropower plant during the study period. This contrasts with a previous study at a similar site without strobe lights, where approximately 12% of eels entered the intake. We conclude that the strobe light system effectively deterred downstream migrating silver eels and prevented intake entrainment. These results highlight the potential of stroboscope lights as a mitigation tool for eels. However, further research is required to assess long-term habituation. And we emphasize that site-specific characteristics and consistent system maintenance remain vital for successful implementation.

How an acoustic tracking trial has changed fish protection measures at Hinkley Point C Nuclear power station

David Clarke, Rachel Mawer, Novella Franconi, Carina Rees, Georgina Blow, Toby Linley-Adams, Amelia Jones, Oliver Duke, Jessica Rodger, Charles Crundwell, Randolph Velterop, Jonas Palder, Robert Britton, Oliver Brown, Ida Neilsen, Ben Kibel, Pete Kibel, Harry Thatcher & Jonathan D. Bolland

The construction of 4 cooling water intakes 3km offshore from the new Hinkley Point C nuclear power plant, drawing 132 m³ s⁻¹, has raised concerns for local fish populations in the Bristol Channel. UK distribution of twaite shad (*Alosa fallax*) is limited to four spawning rivers which all drain into the Bristol Channel, and shad from all populations use the Hinkley Point area during their marine phase. Although required by consent conditions, the developer, EDF, previously dismissed the use of Acoustic Fish Deterrence (AFD) for mitigation, citing feasibility, cost and safety issues. We describe the initial development of a novel battery powered high frequency AFD targeted at shad, our approach to securing EDF support for trials, and a full-scale controlled field trial around the abstraction heads. The field trial tested 36 directional high-frequency acoustic deterrent devices (AFD's), purpose built by FISHTEK Marine Ltd (AFD output 170kHz, 190 dB at 1µPa), deployed in mid-June around two intakes, with the other two intake heads treated as controls. A fine scale array (96 receivers) was deployed to examine detailed behaviour around the intake heads, before and after the AFDs were deployed. 56 shad (tagged in the rivers Tywi, Usk, Wye and Severn) were detected in the fine-scale array, with the positioning of 149 distinct fish tracks within the array. The AFD's were highly successful in deterring shad, and as a result EDF has committed to operational deployment of the high frequency AFD as well as further development of a low frequency prototype.

OPEN TRACKING SESSION

Marine migrations and trophic niche use of Arctic charr (*Salvelinus alpinus*) in SW Greenland fjords with contrasting influx from glacial runoff

Jan G. Davidsen, Sindre H. Eldøy, Adam T. Piper, Fred Whoriskey, Mikkel E.L Friis, Jan Reubens, Eva B. Thorstad, Tihomir Stefanov, Hannah Gaber, Robert L. Lennox, Aslak D. Sjørnsen, Jakob Brodersen & Michael Power

The facultatively migratory Arctic charr often undertakes annual marine feeding migrations. Climate-driven environmental changes such as increased glacial runoff can alter selective pressures shaping migration behaviour. To assess environment-related influences on migratory patterns and trophic niche use, we combined acoustic telemetry with otolith and stable isotope analyses to study two southwestern Greenland charr populations in fjords (Igaliku and Ikersuaq) differing in glacial runoff. Anadromous charr in Igaliku had a mean maximum travel of 21 km from their home river, while those in the more glacially influenced Ikersuaq remained near shore with shorter movements (mean 9km). Despite similar marine feeding durations (mean 48 vs 54 days) Ikersuaq fish exhibited lower marine feeding intensity. Arctic charr in Igaliku Fjord experienced warmer (mean 8.0°C) conditions than those in Ikersuaq Fjord (5.7°C), with estuaries (Igaliku 8.5°C; Ikersuaq 7.2°C) consistently warmer than marine areas in both systems. Findings suggest that where Arctic charr feeding and habitat use are constrained by high glacial runoff they may shift to more open waters altering diet and life-history strategies.

Atlantic bluefin tuna recovery from catch-and-release events

Marie Pedaccini, David Righton, Serena Wright, Freja Azzopardi, Henrik Baktoft, Kim Aarestrup & Kim Birnie-Gauvin

Catch-and-release is a practice commonly associated with recreational fishing. In this context, it refers to catching a fish and then releasing it back into the water, rather than keeping it for consumption. Scientists working with telemetry methods often rely on this practice to be able to tag fish. However, fishing-related stressors (hooking, handling, exhaustive physical exercise, air exposure) can impact the physiology of the fish, generate physical injuries, alter behaviour, and reduce fitness or even cause death after release. Little study about the post-release recovery of Atlantic bluefin tuna (ABFT) has been done and none in Denmark. During this work, packages with acceleration, depth and temperature loggers were mounted on 18 ABFT and swimming behaviour metrics (tailbeat frequency (TBF) overall body acceleration (VeDBA) and percentage of time gliding) were calculated to estimate a “recovery” time, defined as the duration required for the individual to return to baseline swimming behaviour. We found that ABFT were 1.7 times more active (based on VeDBA), with 1.2 times greater TBF values within the first hour post-release than the following 24 hours, stabilizing at lower levels within ~ 4–6 hours. Additionally, a closer analysis on descents showed that individuals initially performed more active descents, but after 1.5–2 days (for those with sufficient data), their behaviour stabilized, with most descents classified as “low-effort” (i.e., $\geq 30\%$ of time spent gliding). Further analyses are currently ongoing to evaluate the potential effects of fishing, handling and environmental stressors on post-release recovery behaviour.

Chronotypes in a wild Atlantic cod population: ecological consequences revealed through long-term acoustic telemetry

Martina Martorell-Barceló, Albert Fernández-Chacón, Inge van der Knaap, David Villegas-Ríos, Marte Sodeland & Esben M. Olsen

Chronotypes, defined as consistent among-individual differences in behaviours linked to circadian rhythms, are increasingly recognised as important drivers of ecological and evolutionary processes. Because chronotypes arise from internal biological rhythms interacting with environmental conditions, they should ideally be studied under natural conditions. In fish, however, this topic remains poorly explored. Acoustic telemetry offers a valuable opportunity to quantify chronotypes in free-ranging individuals over long time periods. Here, we present a large-scale acoustic telemetry study on Atlantic cod from Tvedestrand, southern Norway. Nearly 400 individuals tagged with acoustic transmitters equipped with depth sensors were monitored between 2011 and 2020. As cod do not show the clear burial behaviour previously used to estimate chronotypes in other fish species, this study also develops a general protocol to infer chronotypes from depth time-series data. Using this framework, we investigate population-level chronotype variation, seasonal changes, and links between chronotypes and the spawning period. We also assess whether reproductive behaviour influences chronotype expression, or whether chronotype influences reproductive timing and behaviour. In addition, multi-event models are applied to test which chronotypes show higher overall survival and which are more vulnerable to fishing mortality or natural predation. Finally, dispersal tendencies are estimated to identify whether some chronotypes are more likely to disperse, and comparisons are made among size classes, sexes, and ecotypes. Although analyses are ongoing, this study will provide one of the first comprehensive assessments of chronotypes in a wild fish population and their consequences for reproduction, survival, and movement ecology in Atlantic cod.

Tracking fish in Swiss rivers

Jelger Elings, Luis Habersetzer, Sara Sueess & Jakob Brodersen

Movement and migration are a crucial part of a fish's life cycle. In order to reach the different habitats required for the different parts of its life cycle, a fish is dependent on river connectivity. Over the last centuries this connectivity has been heavily diminished through the construction of riverine infrastructure. In Switzerland, the development of hydropower has led to an incredibly impounded river system. While many native species rely on long-range movements, these are very hampered by the presence of the many hydropower facilities in the Swiss rivers. To analyze how fish movements are shaped in such an anthropogenic environment, a large-scale acoustic telemetry network has been installed in the Swiss Rhine-Aare riversystem. Within the scope of this project, almost 750 individuals have been tagged across all larger fish species present in this river system. Ranging from rheophilic (e.g. barbel) to limnophilic (e.g. tench), and from threatened (trout, nase, and grayling) to common (e.g. catfish and chub). It is seen that all species largely restrict their movement to 'between-barrier' movements. 'Across-barrier' movements are very sparse. Congruently, ground speed heavily declines when barriers are present. Whether this points to a reluctance to pass, searching behaviour, or other explanations remains an open question. However, clear downstream migration events (e.g. as seen in silver eel) show ground speeds across barriers similar to when no barrier is present, pointing to the fish's capability of navigating migration barriers. Again, whether this navigation goes through the turbines, over the weirs, or through fishways remains unresolved.

Poster presentations

SESSION 1 – LITTLE DO WE KNOW: TRACKING UNKNOWN AND OVERLOOKED SPECIES

Daily nocturnal homing reveals goal-directed navigation in a wild teleost

Milan Říha, Ruben Rabaneda-Bueno, Ivan Jarić, **Marie Prchalová**, Petr Blabolil, Marek Šmejkal, Tomáš Jůza, Michal Tušer, Jan Kubečka & Jiří Peterka

Understanding how free-ranging animals navigate large, low-visibility environments remains an important challenge in movement ecology. Using high-resolution acoustic telemetry, we investigated the movement behaviour of adult pikeperch (*Sander lucioperca*) in a large freshwater reservoir. Individuals repeatedly left a stable resting place to forage across extensive areas and reliably homed back even after multi-kilometre nocturnal excursions lasting several hours. Return trajectories were initiated in complete darkness and were strongly oriented toward the refuge from the onset of movement. Bearings during the initial phase of return showed low deviation from the direct direction to the goal, and trajectories were characterized by stable swimming speeds and low tortuosity. Final approach distances were small relative to excursion scale, and returns were achieved without extended search behaviour. Together, these patterns demonstrate consistent and repeatable daily homing under low-visibility conditions and are consistent with goal-directed navigation toward a fixed spatial target.

Multi-species acoustic telemetry reveals spatial ecology in a large deep Norwegian lake

J. G. Davidsen, Mikkel E. L. Friis, Jon Museth, Elizabeth S. Barron, Mats Ingulstad, Øyvind Ødegård, Terje A. Eikemo, Geir Johnsen, Asgeir J. Sørensen, Rune Strand, Siri G. Carson, Eirik S. Sivertsen & Jørn Wroldsen

Mission Mjøsa is a large interdisciplinary research programme aimed at enabling sustainable value creation and safeguarding ecosystem services in Norway's largest lake, Lake Mjøsa (365 km²). As part of the programme's Water research track, we have established one of the most extensive freshwater acoustic telemetry infrastructures in Norway, consisting of ~90 receivers covering the lake's main basins and key habitats. We are currently tracking nine fish species using acoustic transmitters equipped with depth, acceleration, and temperature sensors: *Salmo trutta*, *Perca fluviatilis*, *Leuciscus idus*, *Coregonus lavaretus*, *Thymallus thymallus*, *Abramis brama*, *Esox lucius*, *Coregonus albula*, and *Osmerus eperlanus*. This system enables high-resolution monitoring of habitat use, diel and seasonal movement patterns, and species-specific responses to environmental gradients. In this presentation, we will (i) describe the telemetry infrastructure and tagging strategy, (ii) present initial insights into spatial ecology and habitat partitioning among species, and (iii) discuss how these data will contribute to a digital twin of Lake Mjøsa and support knowledge-based freshwater management at regional and national scales.

Movement ecology of Great Hammerhead Sharks (*Sphyrna mokarran*): Structure and drivers of behaviour across body size revealed by acoustic telemetry

Pina K. Hentschel, Christopher T. Monk, Félicie Dhellemmes, Natalie V. Klinard & Matthew Smukall

Conservation and management require knowledge of species' spatial behaviour, which may be highly variable among individuals and within individuals over ontogeny. For difficult to observe species, such as highly mobile marine predators, uncovering structured movement patterns and the mechanisms driving such patterns can be especially valuable for predicting future spatial behaviour and making decisions under scenarios with little information. Our aim was to investigate the presence of structured movement patterns and the environmental drivers of movement of the great hammerhead shark (*Sphyrna mokarran*) in the western North Atlantic, considering a wide range of body sizes. Thirty-three sharks tagged in the Florida Keys were monitored from 2022 to 2025 using acoustic telemetry, leveraging the ocean tracking network. Sharks were detected throughout the Florida coastline, in the Gulf, Key and Atlantic, and north up to the South Carolina coast. A suite of behaviours (max. distance, activity space size, residency, temporal variability, habitat preference) was summarised from the detection data on a seasonal and weekly basis, and combined with environmental parameters (sea-surface temperature, sea-surface salinity, chlorophyll-a concentration, meridional and zonal current, moon phase) collected from NOAA ERDDAP. Cluster analysis revealed sharks separated into two movement strategies: a resident-like strategy with higher site fidelity and smaller spatial extent, and a wide-ranging transient strategy characterized by larger movements. Individuals showed consistency in their clustering across seasons. Generalized mixed effects models revealed that weekly distance travelled and activity space size increased with increasing SST and body size. The results indicate that great hammerhead sharks in this region do not appear to behave as a uniform migratory population and movement is not uniform across body size, or across variables associated with temperature. Overall, our work suggests that conservation measures based solely on population-average behaviour may overlook key components of space use.

Acoustic telemetry to reveal main channel – tributary movements of rheophilic fish in the heavily modified river Meuse (the Netherlands)

Luc Visser, Leo Nagelkerke, Erwin Winter & Tom Buijse

Large sections of the river Meuse in the Netherlands lack a natural water flow regime due to weirs. Human modifications have had a severe impact on the fish communities, particularly for rheophilic fish. As part of the Water Framework Directive, a wide range of rehabilitation measures have been implemented since 1990, including fishways, removal of artificial bank protection and reconnecting tributaries to the main channel. The efficacy of these measures, however, is insufficiently evaluated, and the movement of rheophilic fish remains poorly understood, hampering effective population recovery. Therefore, the objective of this study is to increase understanding of the spatio-temporal movements of rheophilic fish, both along the main channel, and between free-flowing tributaries and the impounded main channel. We tagged 25 individuals of adult barbel (*Barbus barbus*), chub (*Squalius cephalus*), nase (*Chondrostoma nasus*) and ide (*Leuciscus idus*) with 2LP9 Thelma Biotel (R64K) transmitters between February and May 2026. Our acoustic telemetry network, consisting of 28 Innovasea receivers, covered upstream and downstream of the four weirs and the confluences of major tributaries. Individuals will be followed for two years. We expect that collected detections will reveal which tributaries and areas in the main channel play an important role for rheophilic fishes during spawning, foraging, and overwintering, thereby guiding conservation efforts.

Carp migration in Markermeer

Roland van Aalderen & Willem Romeijn (presented by **Martijn Klaver**)

The common carp (*Cyprinus carpio*) is a popular fish for anglers in the Netherlands. In several waters carp is stocked to enhance local populations. Agreements have been reached between Dutch water authorities and angling organizations regarding the numbers of carp to be stocked; these have been set out in a guideline. A specific question in this case was how many of the stocked carp would migrate to the Zuidelijke Randmeren. In 2019 the province of Flevoland was planning to carry out recovery measures for the reed swamps in the Oostvaardersplassen. To prevent fish mortality, it was proposed that the carp be transferred to the adjacent Lake Markermeer. In order to obtain permission from the Markermeer water authority, it was necessary to understand the migration patterns of the transferred carp. For this research 70 carp were caught from the Oostvaardersplassen, tagged with V13 Vemco tags and released into the Markermeer. A network of 20 receivers was deployed around Lake Markermeer. The results showed that 25 of the 70 tagged carp had left Lake Markermeer, but 10 of these carp also returned to Lake Markermeer. The remaining 15 carp (21%) migrated to the Zuidelijke Randmeren. The results were satisfactory for the water authority. As part of the restoration work at the Oostvaardersplassen, a total of 115,000 kg of carp were transferred to the Markermeer. These results challenge both the placement of existing management boundaries and whether meaningful protection extends across the full range of habitats these species depend on.

Connectivity and habitat use of coastal predators in the northwestern Mediterranean Sea: Insights from a collaborative acoustic telemetry network

Skye Brown, Angela Palomino, Miquel Sacanell, Eneko Aspillaga, Nicolas Lucchini, Jérôme Bourgea, Philippe Lenfant & Bernat Hereu

Marine protected areas (MPAs) are spatially fixed management tools, whereas many ecologically and commercially important fish are highly mobile and likely to utilize broad spatial areas. Understanding how mobile species use diverse habitats and undertake seasonal or long-distance movements is essential for effective conservation and fisheries management. Here, we present preliminary results from an acoustic telemetry study of three coastal predators in the northwestern Mediterranean Sea: greater amberjack (*Seriola dumerili*), leerfish (*Lichia amia*), and bluefish (*Pomatomus saltatrix*). Using detections from a multi-institutional and transboundary receiver network spanning Catalonia (Spain) and the Gulf of Lion (France), we quantified spatial occupancy, general and seasonal residency patterns, and movements among protected areas, ports, and open coastal zones. Early analyses reveal marked interspecific and interindividual variability in residency and displacement scales. Some individuals exhibited residency in specific coastal zones, whereas others undertook broader movements linking multiple management jurisdictions, habitat types and zones. Several individuals of *Seriola dumerili* and *Lichia amia* were repeatedly detected in ports, highlighting the potential ecological role of anthropogenic or modified habitats. Our results indicate that movement patterns of coastal predators extend beyond individual protected areas, emphasizing the importance of considering broader coastal connectivity in Mediterranean MPA management. Telemetry data provide a valuable basis for improving ecological understanding of these highly mobile species and for informing network design, cross-border coordination, and conservation planning.

Movement and trophic ecology of sharks and rays using the Dutch North Sea (MONS)

Katinka Bleeker, Guido Leurs & **Erwin Winter**

Sharks and rays are ecologically important species in the wider North Sea ecosystem, and although several species historically occurred throughout the Dutch Continental Shelf (DCS), major knowledge gaps remain regarding their movement ecology, habitat use and ecological roles. Addressing these knowledge gaps, as required under the North Sea Agreement, provides a basis for more effective management of the wider North Sea ecosystem. The MONS Shark and Ray Research program (2025-2028) addresses two major knowledge gaps: the movement ecology and habitat use of sharks and rays, and the trophic ecology and ecological role of sharks and rays. To study the movement ecology and habitat use of sharks and rays we combine telemetry (acoustic, data-storage, and pop-up archival tags) and fisheries-independent surveys to: determine long-distance movements between the DCS and adjacent waters, fine-scale movements in coastal areas, estuaries and offshore wind farms, and determine the function of specific areas as (seasonal) nursery or feeding areas for different life stages. To address knowledge gaps in the trophic ecology of sharks and rays, we use a combination of techniques (stable isotope analysis, diet metabarcoding and stomach content analysis) to determine how trophic niches, food web positions, and diet change across species and life stages. We integrate this information with the movement ecology and the ecomorphological traits of these species to determine to what extent diet drives movement and habitat use. By resolving these interconnected knowledge gaps, this research program provides ecological insights needed for evidence-based management of a rapidly changing North Sea.

Migration patterns of invasive blue crab *Callinectes sapidus* at the Guadalquivir estuary

César Vilas, Óscar Mansilla, Gustavo Souza, Juan Jimenez, Ricardo F. Sanchez-Leal, David Abecasis & Enrique Gonzalez Ortégón

The invasive blue crab (*Callinectes sapidus*) has established a growing population in the Guadalquivir estuary, raising ecological and management concerns. This study applies acoustic telemetry to investigate the species' movement patterns and habitat use within the estuarine system. A network of five acoustic receivers (Innovasea VR2Tx, 69 kHz) was deployed along the Guadalquivir fishing reserve, complemented by additional receivers along the Andalusian Atlantic coast to detect broader-scale movements. A total of 69 crabs were tagged with acoustic transmitters (Innovasea V9-2x). Tagging campaigns were conducted during 2024 and 2025 at multiple locations along the estuary. Biometric data (size, weight, sex, and maturity) were recorded prior to release. Movement data from more than 50 detected individuals were analyzed individually and by sex. Results reveal clear sex-specific migration patterns. Most tagged females consistently moved downstream toward the estuary mouth and coastal waters, with some individuals covering distances exceeding 50 km and even reaching the inner Bay of Cádiz. In contrast, males exhibited more variable behavior, frequently migrating upstream toward lower-salinity zones and displaying cyclical movements between upper and lower estuarine areas. These findings highlight significant spatial dynamics and sexual segregation in movement behavior, suggesting differing ecological roles and dispersal strategies. The study demonstrates the effectiveness of acoustic telemetry for tracking invasive marine species and provides essential information for future monitoring and management of blue crab populations in the Guadalquivir estuary and adjacent coastal areas.

SESSION 2 – TRACKING RAYS AND SKATES ACROSS EUROPEAN WATERS

Residency and transboundary movements of the Critically Endangered flapper skate (*Dipturus intermedius*)

Ella Wallhagen, Edward Lavender & James Thorburn

Evaluating the effectiveness of management measures for mobile aquatic species requires an understanding of how individuals move. Passive acoustic telemetry is a powerful approach for studying such species, but deploying receiver arrays over large areas can be challenging. These limitations are particularly relevant for understudied elasmobranchs such as the Critically Endangered flapper skate (*Dipturus intermedius*). In Scotland, the Loch Sunart to the Sound of Jura Marine Protected Area (MPA) was designated to protect this species, yet residency patterns and connectivity beyond its boundaries remain poorly understood. To address this gap, a multi-project acoustic receiver array spanning 637 locations across western Scotland, Northern Ireland, and the Republic of Ireland (August 2018–December 2022) was used to investigate skate movements. Overall, 73 of 74 tagged flapper skate were detected. The MPA was identified as an important area of use across all seasons and life-history groups, with 65 individuals detected for durations ranging from 1–726 days (median = 113 days). Residency was most pronounced among mature females. In addition, 11 individuals (nine females, predominantly mature) moved between the MPA and the receiver-covered regions in Northern Ireland, providing direct evidence of cross-border connectivity. A single mature female also moved between Northern Ireland and northern Scotland, indicating additional connectivity beyond the MPA. These findings demonstrate the importance of spatial management alongside wider fisheries management measures for flapper skate conservation. Coordinated efforts across projects and national boundaries are therefore essential for the effective management of mobile marine species.

Network-Based Insights into Movement, Connectivity, and Protected Area Use in three Demersal Elasmobranchs in NW Spain

Alina Hillinger, Emma Deboës, David Jacoby, Jaime Otero Villar & Alexandre Alonso-Fernández

Understanding how mobile marine predators use space and connect habitats is critical for effective spatial management. We investigated movement extent, habitat use and functional connectivity of three demersal elasmobranchs, *Scyliorhinus canicula*, *Raja undulata*, and *Raja clavata*, along the Galician coast (NW Spain) including the national park “Illas Atlánticas de Galicia”. Based on acoustic telemetry data from an array spanning the Rías Baixas (~100m depth range, ~100km coastline) we applied GAMMs to model the probability of presence in key habitats and network analysis to quantify inshore-offshore movements and connectivity among protected and non-protected areas. GAMMs revealed strong, species-habitat-specific seasonal patterns. Both, *R. undulata* and *R. clavata* showed higher presence in open waters during winter. Within the national park archipelagos (Cíes, Ons, Sálvora), presence in Cíes was higher in summer (particularly for *R. undulata*), whereas Ons and Sálvora showed opposing trends. In the Ría de Vigo, skates were largely absent during summer but present from autumn through spring, while *S. canicula* showed a marked summer peak. Network analysis indicated clear interspecific differences in movement and connectivity. *R. undulata* showed broad coastal connectivity but remained bathymetrically constrained, linking shallow coastal and inshore habitats and connecting multiple archipelagos of the national park, consistent with stepping-stone use. *S. canicula* exhibited directed movements connecting deep and shallow habitats, including periodic use of the “Rías”. *R. clavata* exhibited more restricted movements with rare inshore incursions. Ongoing analyses assess seasonal and sex-specific network features and the extent to which existing protected areas encompass key habitats and movement pathways.

Modelling movement trajectories to infer behavioural states in the undulate skate, *Raja undulata*

Camila Vidal, David-Ríos Villegas & Eneko Aspillaga

The causes and consequences of fish movement behaviour are critical yet understudied aspects of aquatic species' movement ecology. We investigated behavioural states and movement patterns of the undulate skate (*Raja undulata*) in Galicia, NW Spain. Acoustic telemetry data from 176 tagged individuals were collected over a four-year period. Movement trajectories were calculated using a movement model and analysed with Hidden Markov Models (HMMs) to infer latent behavioural states and evaluate their ecological drivers. HMMs identified two distinct states, interpreted as resting and active behaviour. State transitions were influenced by diel period and habitat type, with individuals showing a higher probability of being active at night and over sandy substrates. Additional analyses are exploring variation in activity budgets among individuals to assess potential differences in behavioural strategies within the population. This knowledge can be used to protect important habitats for the species, such as the transition habitat between sandy habitat and rocky reefs, to design and implement marine protected areas, and to establish fisheries regulations, such as regulating fishing at night when undulate skates are more active.

Tracking skate in the Bristol Channel: a multi-year study

Rachel Mawer, Georgie Blow, Oliver Duke, Novella Franconi, Amelia Jones, Toby Linley-Adams, Carina Rees, Randolph Velterop & David Clarke

Several commercially-important skate species – the thornback, spotted, small-eyed and blonde rays – inhabit the Bristol Channel, UK. Situated across English and Welsh waters, the Bristol Channel is subject to cross-jurisdictional management and substantial anthropogenic impacts, such as commercial fishing and major developments. Consequently, understanding the movement and spatial usage patterns of skate in the Bristol Channel is crucial for effective spatial planning and management. Since 2023, 275 individual skate have been tagged with acoustic transmitters in the English and Welsh regions of the Bristol Channel. Skate have been tracked through a channel-wide array of over 150 acoustic receivers, producing data to inform environmental impact assessments and marine licensing applications across the region. Over 75,000 detections from 180 skate demonstrate broad movements throughout the Bristol Channel, with areas of high residency and species-specific differences. For example, thornback and spotted ray activity was concentrated in English waters around Devon, with some movements to Welsh sites such as Swansea and Carmarthen Bays, while blonde and small-eyed ray movements were more dispersed throughout the wider array. Moreover, individual variation in movement propensity was high: some individuals were only detected within the area of tagging while others moved between sites over 100 km apart. Seasonal detections of mature females indicate potential important areas, e.g. egg-laying sites, for future research attention. Additionally, network analyses highlight areas that may facilitate connectivity between English and Welsh regions. Current results provide promising preliminary insights, directing ongoing research into the spatial and reproductive ecology of Bristol Channel skates.

SESSION 3 – NOVEL METHODS, TECHNIQUES AND INTEROPERABILITY IN ACOUSTIC TELEMTRY

Emergent opportunities of next-generation marine fish tracking

Josep Alós & Eneko Aspillaga

Fish movement underpins key ecological and evolutionary processes, yet remains poorly quantified at relevant scales. Recent technological advances are driving a paradigm shift towards high-throughput movement ecology (HTME), enabling the simultaneous tracking of hundreds of individuals at high spatiotemporal resolution. Here, we implement HTME in a marine system using high-resolution acoustic tracking, revealing previously hidden patterns of behavioural organization, including fine-scale environmental responses, collective dynamics, and consistent individual differences in diel activity (chronotypes). Importantly, HTME provides a direct framework to quantify behavioural responses to anthropogenic pressures such as warming, pollution or fishing. Despite its transformative potential, HTME faces critical challenges in tag miniaturization, data integration, and the development of AI-based analytical tools. Overcoming these barriers will enable a shift from descriptive to predictive marine ecology, with major implications for understanding and managing marine ecosystems under global change.

Estimating space use of mobile animals inside an Offshore Wind Farm with acoustic telemetry and state-space modelling

Lotte Pohl, Edward Lavender, Dries Bonte, James Thorburn, Peter Goethals, David Casals & Jan Reubens

Offshore Wind Farms (OWF) are a cornerstone of the transition towards renewable energy, with the North Sea as a pioneering area. The ongoing global expansion of Offshore Wind results in an increased urgency to understand the effects of these human-made infrastructures on mobile marine animals, especially in soft-sediment environments like the Belgian North Sea. Belgium started operating OWFs in 2008 and has installed over 400 wind turbines to date, making the Belgian North Sea a suitable area to study effects of OWF on mobile aquatic animals. Acoustic telemetry has emerged as a major technology to investigate the movement of mobile aquatic animals. As part of the European Tracking Network (ETN), the Permanent Belgian Acoustic Receiver Network (PBARN) has been actively maintained for several years, with up to two dozen hydrophones listening for tagged fish inside a Belgian OWF. This study will use acoustic detection data from the ETN database to identify space use patterns of a fish species inside the OWF. A state-space model (SSM) connecting the unobserved animals' locations to acoustic observations via a species-specific movement model and a location-specific observation model will be formulated. Bayesian filtering algorithms, suitable for non-linear, non-Gaussian SSMs, will be used to infer animals' locations. This approach will generate statistically sound estimates of fish positions between detection timestamps, enabling robust estimation of centres of activity, residency and occupancy. This research is an important step towards understanding the effect of OWF on mobile aquatic species.

Seeing before settling: a guided deployment system for acoustic receivers in challenging seafloor terrain

Felix Mittermayer-Schmittmann, Hendrik Hampe & Christopher T. Monk

The placement of acoustic receivers can have large impacts on study success as detection range is highly dependent on the habitat and orientation of the receiver. Effective deployment of acoustic receivers in heterogeneous offshore environments remains a major challenge, particularly where complex bathymetry and seafloor features increase the risk of unsuccessful “blind drops”, risking accidental placement within rocky structures or dense algae. We present a novel receiver deployment unit designed to enhance placement accuracy, operational safety, and data collection efficiency. The system enables real-time visual assessment of the seafloor during the approach to the planned location using camera feeds transmitted via coaxial or fiber-optic cable. This allows operators to identify suitable landing sites and avoid hazards such as boulders, crevices, or uneven substrates. Once an optimal position is confirmed, the mooring can be released remotely from the deployment unit. Simultaneously, a high-precision onboard GNSS system records the exact deployment location, significantly improving retrieval success. This approach facilitates reliable receiver deployment in deeper offshore waters and areas characterized by highly heterogeneous habitats. In addition to improving deployment success rates, the system provides valuable visual habitat data collected during the approach phase. Overall, the deployment unit and workflow may be a useful model for offshore receiver installation generally, and supports a more efficient and informed monitoring of fish movements in challenging offshore marine environments.

Recent developments in state-space modelling and model-based inference for animal geolocation with passive acoustic telemetry and biologging sensors

Edward Lavender, Andreas Scheidegger, Matthew H. Futia, Stanisław W. Biber, Carlo Albert, James Thorburn

Animal geolocation lies at the heart of animal tracking. Analyses of movement patterns, space use, residency and habitat selection all require individual location estimates through time, but formal geolocation methods remain underutilised in passive acoustic telemetry systems. This presentation reviews recent developments in state-space modelling and model-based inference for animal geolocation with passive acoustic telemetry and biologging sensors, with a focus on Bayesian particle and grid-based filtering algorithms and our associated R and Julia packages. Using case studies of flapper skate (*Dipturus intermedius*) in Scotland and lake trout (*Salvelinus namaycush*) in North America, we show how these methods can strengthen the value of acoustic telemetry data for ecology and management. In our flapper skate analysis, we integrated acoustic and archival data to inform protected area design. Our algorithms led to 5-fold improvements in space-use maps and 30-fold improvements in residency estimates compared to prevailing methods. By integrating tracking datasets, we were uniquely able to examine movements beyond receivers, assess residency in the protected area and identify specific habitats further afield that warrant protection. In our lake trout study, we upscaled the approach by two orders of magnitude and directly embedded detailed complementary datasets from accelerometry, swim-tunnel calibrations, field range tests and close-kin mark-recapture in our analysis to resolve movement patterns, movement speeds and drivers of movement behaviour over a four-year period. This work takes state-space modelling for acoustic telemetry into the real world, enabling robust inference of movement patterns at scale in systems across the globe.

Predation on behavioural phenotypes maintains individual variation independently of trait integration

Bradley E. Howell, Mitchell B. Shorgan, Leah C. Howitt, Christian J. Bihun, Aaron T. Fisk, Steven J. Cooke, Graham D. Raby

The pace-of-life syndrome (POLS) hypothesis predicts that metabolic rate integrates physiology, behaviour, and life history along a single slow-fast continuum, with predation maintaining variation along it. We tested these predictions simultaneously on free-ranging individuals by combining lakeside intermittent-flow respirometry, predation-sensing acoustic telemetry, stable isotope analysis, and scale-based aging to measure five pace-of-life traits and track confirmed predation fate in 78 prey (bluegill *Lepomis macrochirus*, $n = 31$; pumpkinseed *L. gibbosus*, $n = 47$) and their predator (largemouth bass *Micropterus nigricans*, $n = 25$) in a north temperate lake in Ontario, Canada. The five traits did not covary as an integrated syndrome. Instead, daily movement distance and home range size clustered independently of metabolic rate, growth, and trophic position, forming what we term behavioural pace. Predation selected strongly on this dimension in pumpkinseed, with slow-paced individuals suffering twice the predation hazard of fast-paced conspecifics (Cox HR = 0.446, $p = 0.0004$). Both prey species shared identical covariance structure despite differing in predation outcomes. Fast-paced prey shifted into structurally complex vegetation, which independently reduced predation risk. In the predator, behavioural pace predicted trophic position and dietary specialisation, indicating consequences across trophic levels. Predation maintains behavioural variation through differential mortality without requiring the trait integration the POLS hypothesis assumes.

Incorporating individual behaviour on population dynamics of exploited fish through IBM

Enrique Sánchez-Fabrés & Josep Alós

Understanding the drivers of marine fish population dynamics remains a central challenge for ecology and fisheries management. In this study, we investigate how individual behavioural variability influences population-level outcomes using an Individual-Based Model (IBM) of the pearly razorfish (*Xyrichtys novacula*). The model incorporates key life-history processes (recruitment, growth, and mortality) together with acoustic telemetry-derived spatial behavioural traits such as home range and chronotype. We implement different fishing scenarios to explore how exploitation interacts with individual behavioural variability and shapes population dynamics under contrasting pressures. The aim of this approach is to provide a flexible framework for integrating behavioural traits into population models. Overall, this study provides a flexible modelling framework that integrates empirically derived behavioural traits into population models, highlighting the role of acoustic telemetry-based knowledge in improving ecological realism and supporting more effective management strategies.

High-resolution telemetry and brain transcriptomics link territory size to neural remodelling and cell cycle arrest in a teleost fish

Bernat Morro, Margarida Barcelo-Serra, Eneko Aspillaga & Josep Alós

Continuous tracking of free-living marine animals remains a major challenge in telemetry, especially when the goal is to link fine-scale space use to physiological measurements. Here, we used a high-resolution acoustic telemetry system to track wild pearly razorfish (*Xyrichtys novacula*) across their reproductive season and quantify how individual territory size relates to brain gene expression. A total of 320 fish were tagged, and 28 adults were later recaptured for RNA sequencing after months of sub-meter, high-frequency tracking. Territory use was estimated from telemetry detections as 50% kernel utilization distribution, allowing repeated movement data to be transformed into an individual-level measure of core territory size. This tracking-based approach confirmed a known sex difference, with males occupying much larger territories than females. Females only revealed 4 genes associated to territory size. In males, larger territories were associated with coordinated changes in 46 genes grouped into two major functional networks: extracellular matrix remodelling with endoplasmic reticulum stress, and suppression of cell-cycle and mitotic activity. These results show how acoustic tracking can uncover hidden behavioural and physiological trade-offs in the wild, and demonstrate that territory expansion is constrained not only by ecology and behaviour, but also by the brain's capacity to sustain the costs of maintaining larger defended spaces.

Integrating acoustic telemetry into a Chapman mark–recapture framework for silver eel escapement estimation in a Mediterranean lagoon

Lorenzo Jacopo De Santis, Leander Höhne, Chiara Leone, Valeria Esposito & Eleonora Ciccotti

The European eel is a catadromous species that spawns in the Atlantic and grows within European and Mediterranean coastal and continental ecosystems. Since the 1990s, human-driven pressures have caused the global stock to decline, necessitating management frameworks reconciling protection with sustainable use. Recovery measures focus on maximising outmigration (escapement) of potential spawners from continental waters. Field measurements of escapement are feasible and can thus support validation of model-based assessment. While acoustic telemetry has been applied to study eel spatial ecology, its integration into migratory silver eel biomass quantification remains underexplored. Here, as part of a broader telemetry programme in the Orbetello Lagoon (Italy) investigating eel migration patterns, we demonstrate how the receiver network can be used also to refine a mark–recapture (M-R) abundance estimator, thereby reducing estimation uncertainty. A total of 627 silver eels were externally tagged, 181 of which also carried acoustic transmitters. Telemetry data were integrated into the Chapman estimator, correcting the marked pool by removing confirmed migratory exits and rescaling pool size by its availability to the array, while empirically validating estimator assumptions through individual movement tracking. Acoustic telemetry confirmed a detection-corrected escapement rate of 48.8% from tracked migratory individuals. Monthly M-R estimates were stratified by fishing gear to account for gear-specific catchability. Seasonal M-R biomass estimates were 29 t at the barrier trap and 14 t at the fyke net. These results will contribute to validating assumptions and predictions of a recently developed stock assessment model to support conservation management of the Mediterranean eel stock.

Beyond distance: Quantifying the interplay of hardware inter-operability and environmental dynamics in acoustic telemetry performance

Stijn Bruneel, Pieterjan Verhelst, Eneko Aspillaga, Josep Alós, David Abecasis, Kim Aarestrup, Kim Birnie-Gauvin, Pedro Afonso, Miquel Palmer, David Casals, Lotte Pohl, Robert Lennox, Jan Reubens

Acoustic telemetry is a cornerstone of aquatic spatial ecology, yet its effectiveness is governed by a complex intersection of hardware specifications and the physical environment. This study provides a comprehensive synthesis of how detection range is shaped by the interplay between hardware brands, equipment versions, and transmission protocols, all while operating under fluctuating environmental conditions. To achieve a holistic understanding, we examined how cross-brand compatibility, OP versus R64K protocols, and generations of equipment affect signal reception and data loss across diverse environmental conditions in a regulated shipping canal. System performance is inherently dynamic, and we analyze how varying environmental conditions—such as water flow, ambient noise, boat passage, water depth, etc.—disproportionately impact the detection range. By distilling lessons from experimental setups, we provide a framework for rigorous range testing that accounts for these variables simultaneously rather than in isolation. As telemetry networks expand globally, the uncertainty inherent in signal transmission must be treated as a primary data component rather than a secondary nuisance. By standardizing how we measure and report the performance of varying protocols and brands across fluctuating environments, the scientific community can improve both the reliability of individual studies and the comparability of tracking data across collaborative, inter-operable networks. These advancements ensure that researchers can maximize the ecological insights derived from increasingly complex acoustic data sets.

Using Inverse Reinforcement Learning to understand drivers of Habitat Selection in Cod

David R. M. Graf, Christopher T. Monk & Sören Christensen

Movement ecology has undergone a revolution in the availability and quality of tracking datasets, yet methods to analyse these datasets are lacking. We explore a novel approach for analysing movement data with Inverse Reinforcement Learning (IRL) to recover the environmental drivers of animal movement. IRL aims to extract the reward function underlying (assumed) optimal behavior as demonstrated by individuals. In Deep Maximum Entropy IRL (DME-IRL), a convolutional neural network (CNN) is used to model complex, non-linear dependencies of the reward on the input features. Using DME-IRL, the reward structure underlying the diel vertical migration (DVM) of Atlantic Cod, *Gadus morhua*, tracked with acoustic telemetry in a Norwegian Fjord, is extracted. Cod typically use shallower habitats during the night, retreating to deeper water during the day, possibly related to a combination of predator avoidance and temperature regulation (hunt warm, rest cold). As sunlight plays a strong role in this behavioural pattern, each recorded position of a cod is mapped to a cell in a grid of depth and sun angle. This simplifies movement to one spatial and one temporal dimension, and further enables the CNN to learn the cyclical dynamics of illumination and DVM in cod. The reward structure is learned from a suite of environmental covariates (salinity, air pressure, vertical temperature profiles) to disentangle the drivers of diel habitat selection in cod. This early application of IRL to fish movement suggests that it could be expanded to more complex 2d and 3d fish movement applications in future iterations.

SESSION 4 – REGIONAL-SCALE, RARE AND PILOT ACOUSTIC TRACKING IN APPLIED RESEARCH

From Pilot Receiver to Full Array: Deploying the EUsKal Tracking Network for Shark Movement Ecology

Maite Erauskin-Extramiana, Lennart Vossгаetter, Leire Lopetegui, Alex Salgado, Martin Cabello de los Cobos, Lander Larrañaga, Lukas Müller & Cristina Claver

Acoustic telemetry has become a key tool for understanding habitat use, connectivity, and movement ecology of highly mobile marine predators. In 2024, we launched the EUsKal Tracking Network (EUTN), a new acoustic receiver initiative in the Bay of Biscay designed to enhance monitoring capacity for pelagic shark species whose spatial ecology in this region remains poorly described. A single pilot receiver deployed throughout 2023 yielded unexpected yet highly informative cross regional detections, including Atlantic bluefin and other tunas tagged in Denmark, as well as European seabass tagged in the United Kingdom, France, and Belgium. These early detections highlight the role of the Bay of Biscay as a significant migratory corridor and emphasize the value of expanding acoustic infrastructure. Building on these results, a network of 29 receivers will be fully operational during summer 2025. Part of the array is installed within an offshore wind farm, offering a unique opportunity to study predator movements in an emerging anthropogenic environment. Additionally, two receiver “gates” along the Basque coast have been strategically designed to detect fine scale movements and coastal transit patterns. To date, 15 blue sharks (*Prionace glauca*) have been tagged with long duration acoustic transmitters, complemented by ongoing porbeagle (*Lamna nasus*) tagging efforts in Brittany. The expanded EUTN will provide unprecedented insight into residency, migratory behaviour, and environmental drivers of movement, strengthening collaborative, transboundary monitoring of vulnerable shark species in the Northeast Atlantic.

A new array: Turkish Tuna Tracking Array

Evrin Kurtay, Altan Lök, M. Tunca Olguner & Aytaç Özgül

Turkey is one of the leading countries in bluefin tuna farming in the Mediterranean, with a production volume of 6226 tons. Tuna cage systems attract various wild pelagic species, primarily bluefin tuna, but also rays, sharks, and dolphinfishes, by acting as fish aggregating devices. In order to detect tagged bluefin tuna in different regions, a new acoustic receiver array was established in Gerence Bay in the Aegean Sea in 2025. This array was created in collaboration with Denmark Technical University, consisting of Innovasea VR2W (OP) and Thelma Biotel TBR800 (OP) receivers. 5 different tuna cage system were instrumented with acoustic receivers aiming to detect bluefin tuna, especially those tagged by ICCAT or ETN members as well as other pelagic. Tagging activities began in September 2025 as a part of a tuna fishing tournament held in the region. The "tag & release" category was added to the "catch & release" category in the competition, encouraging the tagging of bluefin tuna. Due to adverse weather conditions, only one bluefin tuna was tagged with an Innovasea V16P-6L acoustic transmitter. It was determined that this individual remained around the cage systems between October 2025 and February 2026. This result is proves the visual counting studies results conducted around the cages. It is assumed to collect more data on the migratory behavior of bluefin tuna populations in the Eastern Mediterranean and the effect of tuna cages on this behavior by increasing the number of tagged fish in future sport tuna tournaments.

Species-specific sluice passage and upstream migration of anadromous fishes in the heavily modified Rhine–Meuse delta using regional acoustic telemetry

Melanie P. Meijer zu Schlochtern, Leopold A.J. Nagelkerke, Hendrik V. Winter, F. Tim Vriese, Niels W.P. Brevé, Rob Kroes & Anthonie D. Buijse

Estuaries are critical migratory corridors for diadromous fish species. However, connectivity is often severely constrained by anthropogenic infrastructure, e.g. dams, tidal barriers and sluices. Discharge sluices in estuaries are particularly challenging to pass, as high flow velocities and limited passage windows restrict upstream movement, even for large migratory species. The impact of such barriers on migratory pathways and upstream success at the regional scale often remains unclear. Here, we use a regional large-scale acoustic telemetry network to track anadromous fishes including Atlantic salmon, sea trout, sea lamprey, North Sea houting, and allis shad from the North Sea coast to the Rhine and Meuse rivers. The network provides insights into upstream fish passage through the Haringvliet estuarine discharging sluices following recent management adjustments, which allow controlled seawater inflow to facilitate fish migration. It also reveals alternative river routes and movement patterns within the delta. In addition, the network detects many fish of various species tagged in other studies, supporting collaborative projects. We studied upstream sluice passage and subsequent upstream movements, and route choice of anadromous fish, including alternative entry routes through the port of Rotterdam. Our findings underline species-specific differences in passage conditions and movement within the Rhine-Meuse delta, and we explore whether passage conditions and upstream migration have improved since sluice management was adjusted. Overall, our findings highlight the complexity of migration behaviour in a heavily modified delta and demonstrate how regional telemetry networks and collaboration can reveal movement patterns that remain undetected in single-site studies.

Acoustic tracking in the complex hydraulic environment below weirs to assess the attraction efficiency of fishways

Kaat Thienpont, Stijn Bruneel, Tom De Mulder, Santiago Castano Lopez, Klaas Pieter Visser & Ine Pauwels

Fishway success is highly dependent on the ability of fish to locate and enter the fishway amidst complex currents. Barriers such as weirs create turbulent flow conditions that can mask the attraction flow and exceed the swimming capacities of upstream migrating fish, potentially impeding successful approach and entrance of the fishway. To improve our overall fishway efficiencies, it is crucial to gain insights into the behaviour of fish near weirs. However, turbulent flow downstream of weirs significantly impacts detection range, complicating the use of acoustic telemetry to gain behavioural insights in these regions. Hence, a key methodological objective is evaluating the feasibility of fine-scale acoustic positioning in highly turbulent, aerated flows downstream of overflow-type weirs. Therefore, a comparative field experiment is conducted testing three acoustic frequencies (69, 180 and 307 kHz) at increasing distances from a weir. Simultaneously, PIT and 1D-acoustic telemetry are explored as alternatives to fine-scale tracking for the zones close to the weir, for which preliminary results indicate that fine-scale tracking is severely compromised. Here we present the first results of the comparative field experiment, as well as migration data of river lamprey, bream, roach and ide tracked with 1D-acoustics. Insights into the methods to assess the migration limit near weirs with wild upstream migrating fish are essential for improving fishway efficiency. Furthermore, these data provide the necessary validation of hydraulic models used to define the design and location of fishway outflows and can inform to find alternative weir operational modes that improve fishway attraction efficiencies.

A shared infrastructure for river fish movement ecology: insights from the Swiss Rhine–Aare acoustic telemetry network

Jakob Brodersen, Luis Habersetzer, Sara Süess, Henrik Baktoft, Karl Øystein Gjelland, Jan Reubens, Luiz Silva & Jelger Elings

Large transnational acoustic telemetry networks are increasingly essential for understanding aquatic animal movement across ecological and political boundaries. Many fish species move across large parts of major drainages and jurisdictions, making fragmented, local monitoring insufficient. Coordinated networks enable continuous tracking over large spatial scales, improve data comparability, and support evidence-based management of shared water resources. They are particularly valuable for assessing cumulative impacts of river fragmentation, hydropower infrastructure, and climate change on connectivity and survival. At Eawag, we developed the Swiss acoustic telemetry network within the Rhine–Aare river system by strategically deploying receiver arrays along key migration corridors, tributary confluences, and hydraulic structures. The design emphasized modularity and interoperability, allowing integration with existing regional infrastructures and future expansion across borders. Standardized protocols for tagging, data management, and quality control were established to ensure consistency among projects. Close collaboration with cantonal authorities, hydropower operators, and research partners enabled efficient site access, long-term maintenance, and data sharing. This coordinated network has facilitated a wide range of practitioner-led and research-driven projects. For example, studies on European eel migration will use the system to quantify downstream passage routes, timing, and mortality risks at hydropower plants. More broadly, the network supports assessments of fish movement between and across barriers, and habitat choice, including use and access to thermal refuges during heat waves. By providing a shared infrastructure, the Swiss network reduces costs, increases statistical power, and fosters collaboration, ultimately improving management decisions aimed at restoring longitudinal connectivity and sustaining fish populations.

Marinas as functional fish habitats for coastal fish assemblages

Bernat Hereu, Eneko Aspillaga, Skye Brown, Nicolas Lucchini, Angela Palomino, Joan Lluís Riera, Miquel Sacanell, Gilles Saragoni & Philippe Lenfant

Marinas are a common feature of coastal landscapes. Despite their urban and artificial nature, increasing evidence suggests that they may provide ecological value by offering shelter, food, and space for a variety of fish species. This raises the possibility that such environments could play a relevant role in marine biodiversity conservation, both as regular habitats and as feeding grounds for predators that enter these areas, particularly in the Mediterranean, where a large number of ports occupy essential coastal habitats. To assess the use of this habitat by different species, several taxa were studied using acoustic telemetry. Individuals were tagged both inside ports and in adjacent external areas, and acoustic receivers were deployed within the ports to monitor detected individuals. The results reveal a notable species diversity within ports, with 24 species recorded using this habitat. Evidence of stable residency was observed for some species, while others exhibited periodic movement patterns, indicating a functional use of these spaces as refuges or feeding grounds. Furthermore, connectivity with nearby protected natural areas suggests that ports could be integrated into a broader network of coastal habitats, providing an often underestimated ecological value.

Monitoring the distribution and seasonal behaviour of the invasive lionfish (*Pterois miles*) in Gökova Bay using acoustic telemetry

M. Tunca Olguner, Aytaç Özgül, Altan Lök & Evrim Kurtay

The invasive lionfish (*Pterois miles*), native to the Indo-Pacific, has rapidly expanded throughout the Mediterranean Sea, becoming a major threat to native biodiversity. Since its first record in 1991, its spread has been facilitated by high reproductive capacity and effective larval dispersal. This study presents the first acoustic tagging and tracking of lionfish in the Mediterranean, focusing on their regional-scale behaviour and distribution patterns in Gökova Bay, Türkiye. The study was conducted between 04-09-2024 and 31-08-2025. Over a one-year monitoring period, lionfish were tracked using acoustic telemetry to investigate habitat use, depth preferences and seasonal movement patterns, particularly in relation to Marine Protected Areas (MPAs). Acoustic receivers (2 VR2Tx, 6 VR2W and 1 VR2AR) were deployed in a bay along a coast-to-deep transect (15 to >50 m), with spacing determined through prior range testing. Individuals were captured and tagged with acoustic transmitters and detection data were retrieved. The collected data were analysed to assess movement dynamics, habitat connectivity and spatial distribution of lionfish across the study area. Results provide the first empirical insights into the spatial ecology of lionfish in the Mediterranean using acoustic telemetry, highlighting their regional behavioural patterns and habitat use. Understanding where and when lionfish aggregate can directly support fisheries management by enabling more targeted removals, ultimately improving control efforts for this invasive species.

The Bristol Channel Array: evolution of a Regional Scale Network

David Clarke, Novella Franconi, Rachel Mawer, Carina Rees, Georgina Blow, Toby Linley-Adams, Amelia Jones, Oliver Duke, Jessica Rodger, Charles Crundwell, Robert Britton, Ida Neilsen, Jonathan D. Bolland & Randolph Velterop

In 2019 Swansea University deployed an acoustic receiver array of 20 receivers in Swansea Bay to track twaite shad (*Alosa fallax*) tagged by the “Unlocking the Severn” project. Since then, through a combination of funding from many partners, both the array and tagging operations have expanded to encompass the wider Bristol Channel, with ca. 200 receivers currently deployed and a database of more than 4 million detections from 10 species and ca. 3000 acoustically tagged fish. The data is complemented by far field detections in other arrays, notably arrays deployed off the Welsh West coast (Project Siarc), the Irish East and South coasts (CETUS) the Celtic Sea (Celtic Energy) and English Channel (FishINTEL). With our array we have also been able to provide detections to other researchers of tope tagged in North Wales, Ireland, the English Channel and the Azores, bass tagged in the English Channel, tuna tagged in the Gulf of St Lawrence, eels, spurdog and lamprey. The array also contains cetacean passive acoustic detectors (FPODS) at 12 locations. The presentation will discuss the current and future development of the array and the importance of extensive partnerships in the absence of a single large grant, as well as the value obtained from economy of scale and longevity.

Integrating deep-sea acoustic receivers into an oceanographic lander system – listening at a strategic location

Catherine Waters, Rachel Morgan, Hugo Maxwell & Caroline Cusack

The MOSAIC (Multi-disciplinary Ocean Sensing for Adaptive International Conservation) project funded by PEACEPLUS and managed by SEUPB was launched this year. The purpose of the MOSAIC project is to establish an interregional, multi-sensor marine biological observation network to gather data on key threatened and declining species and their habitats to produce a suite of forward-looking, evidence-based action plans and decision-making tools to underpin monitoring efforts in an ever-changing ocean. As part of this project the Marine Institute will lead an innovative deployment of deep-sea receivers at strategic locations from the west of Ireland on the continental shelf. This array of 4 receivers will be incorporated into the Irish pilot oceanographic lander programme. For the first time, fixed open protocol acoustic receivers shall determine whether any species acoustically tagged within the inshore environment are utilising the habitat and ecosystem of the continental shelf. The Irish lander pilot programme, part of an emerging Atlantic Arc Lander Monitoring network, is progressing well with multiple landers successfully deployed on the shelf and the Irish continental margin, including the Porcupine Bank. These lander arrays are collecting year-long records of bottom currents and temperature, with planned recoveries and new deployments in 2026 extending coverage to additional regions, including the north-south focus areas of the MOSAIC project. A LanderPick is used for the deployment and recovery of the landers. This cost-effective, remotely operated towed vehicle enables precise deployment and recovery of seabed landers without the need for buoyancy or acoustic release systems.

Migration Dynamics of Silver Eels in the Narva River Basin District

Meelis Tambets, Einar Kärgerberg & Priit Bernotas

A study was carried out to investigate the migration patterns of silver eels originating from Lake Võrtsjärv within the Narva River Basin District in Estonia. The migration route, extending at least 240 km, was found to be highly complex, involving not only downstream movement towards the Baltic Sea but also frequent pauses, delays, and unexpected upstream migrations within the freshwater system. Although some individuals (less than 10%) followed a direct downstream route and reached the sea within as little as three weeks, the majority exhibited prolonged residency in various freshwater habitats. Several eels remained in Lake Peipsi for up to 1–1.5 years, particularly near the mouth of the River Emajõgi, and a considerable number returned upstream, in some cases migrating back to Lake Võrtsjärv. Mortality during migration was also assessed. Approximately 2% of tagged eels were caught by fishermen in the River Emajõgi and 6% in Lake Peipsi. A further 9% died while passing through the Narva Hydroelectric Power Plant, indicating a moderate anthropogenic impact on migration success.

DRIFT: Drone-based Radio telemetry in Insular ecosystems for Fish Tracking

Inês Órfão, Pieterjan Verheslt, Bernardo Quintella, Marisa Gouveia, Isabel Domingos, Ruben Freitas, André Almeida, João Monteiro, Victor Azevedo & Marc Fernández

Radio telemetry is a commonly used method for tracking fish when studying home ranges, site fidelity, and daily activity in freshwater ecosystems. However, tracking animals using radio telemetry can be challenging in hard-to-reach locations, particularly on volcanic islands and in other landscapes with steep slopes. This can lead to a spatial monitoring bias, resulting in data gaps, particularly on upstream habitats. Overcoming this knowledge gap requires technological advancements in telemetry that allow tracking fish throughout occupied habitats. Drone-coupled radio tracking may offer a solution, but it is a technology at an early stage and is currently used primarily for terrestrial taxa and ecosystems. Its limited use is likely due to potential challenges with freshwater systems and the high cost of available commercial devices. The DRIFT project proposes to tackle these issues and expand the field of operation of new tracking technologies into freshwater ecosystems by developing, testing, and improving a cost-effective radio-tracking drone. Simultaneously, potential limiting environmental conditions are evaluated, and the data quality and precision are compared with those obtained using hand-held manual tracking and fixed passive tracking. To this end, we are tracking the Critically Endangered European eel, *Anguilla anguilla*, in one stream on Madeira Island as a case study. Comparative results will help evaluate whether this method is standalone or requires complementary methods to address ecologically relevant questions. Results will set the pace for future studies on aquatic ecosystems in critical, accessible habitats, contributing to the collection of valuable ecological data for species conservation.

SESSION 5 – FROM DATA TO DIGITAL TWINS: PIPELINES, CENTRALISATION AND MORE

Bringing ETN data to policymakers: incorporating tracking data into the EU's Data Lake

Claudia Meneses Moreno, Peter Desmet, Ruben Moreel, Samuel Fooks, Stijn Vermaere, Frederic Leclercq & Jan Reubens

Digital Twins (DTs) are virtual representations of real-world physical objects, products, systems, or processes, and can be used for simulations and monitoring for decision support or research. DTs are rapidly gaining momentum by offering a powerful framework to assess the state of natural systems in the past, present, and future. In the marine domain, Digital Twins of the Ocean (DTOs) can be used to monitor changes in marine ecosystems, evaluate the impacts of climate change, and support sustainable use and long-term management. However, most existing DTOs remain heavily focused on oceanographic and physical components and have not yet fully integrated animal-movement data. Within the European Digital Twin Ocean (EDITO), launched by the European Commission, ocean knowledge is made readily available to everyone. EDITO integrates data from satellites, sensors, computer models, and personal device, including all EMODnet (European Marine Observations and Data Network) and Copernicus Marine data, among other sources. Since November 2025, aquatic animal tracking data from the European Tracking Network (ETN) is incorporated. The ETN database host tracking data of a wide variety of aquatic animals - such as teleost fish, elasmobranchs and molluscs - with a focus on acoustic telemetry and data storage tags. These data contribute to studies on movement ecology, species distribution modelling, wildlife management and conservation. By contributing its tracking data to EDITO, ETN strengthens its commitment to open, interoperable, and accessible data. Securing the continuous update of data to the EDITO requires the establishment of reliable pipelines between data sources and the EDITO Data Lakes. To achieve this, ETN has developed pipelines that deliver down-sampled data in Darwin Core format via EMODnet, and full-resolution data in Parquet format via SpatioTemporal Asset Catalog (STAC) standard. The harmonized ETN data streams ensure that researchers, managers, and developers can readily access animal-movement information for modelling, forecasting, and visualization within the EDITO platform. In this presentation, we outline our best practices for integrating bio-logging and tracking data into Digital Twin initiatives and highlighting lessons learned.

Towards digital-twin-ready fish tracking workflows with GFTS and PANGEO-fish

Tina Odaka, Etienne Cap, Jean-Marc Delouis, Anne Fouilloux & Mathieu Woillez

Fish tracking datasets are essential for understanding aquatic ecosystems, but their growing volume and heterogeneity still limit their reuse, comparison with environmental data, and integration into broader modelling frameworks. We present ongoing developments around the Global Fish Tracking System (GFTS) and PANGEO-fish, with the goal of making open, reproducible fish movement estimation workflows easier to use, share and connect to Digital Twin Earth infrastructures. PANGEO-fish provides an open-source Python workflow for fish movement and biologging analysis, building on the Pangeo ecosystem, including Jupyter, Xarray, Dask and Zarr. It supports fish track reconstruction using Hidden Markov Models by combining biologging observations with Earth-science reference fields such as light, temperature at depth and bathymetry, together with constraints from acoustic telemetry detections, release and recapture locations. PANGEO-fish is using the HEALPix-based Discrete Global Grid Systems and cloud-optimised data formats, enabling scalable comparison between animal tracking observations and high-resolution geophysical datasets. PANGEO-fish is a flexible modeling platform providing transparent, reusable workflows that can be adapted by movement ecology scientists. Within the ESA Destination Earth use-case context of GFTS, we aim to make tracks produced with PANGEO-fish easier to reference, visualise and compare with environmental datasets available through the DestinE ecosystem, including future climate-change simulations. This would allow reconstructed fish tracks to be analysed alongside present and projected ocean conditions, supporting biological interpretation of movement, habitat use and potential climate-driven changes.

Can moonlight and waves tell us where the tagged fish was?

Etienne Cap, Corentin Hue, Jean-Marc de Louis, Tina Odaka (presented by **Clement Chauveau**)

Fish live in highly dynamic ocean environments, where physical signals such as waves, storms, and moonlight are part of what they experience. These signals may leave detectable traces in biologging observations. Fish may also change their behaviour in response to such conditions. A key question is therefore whether environmental signals can be detected directly from biologging data, and whether they can help constrain fish position or behaviour in the absence of precise geolocation. In this work, we explore the potential and limitations of biologging sensors to capture environmental variability, focusing in particular on light and pressure signals detected in the sea. We investigate whether moonlight can be detected from light sensors embedded in tags, and whether wave-induced variability or rapid environmental changes can be inferred from depth, temperature, or derived signals. These observations are compared with external environmental datasets to assess their consistency and interpretability. Our experiments are conducted using PANGEO-fish, an open-source Python workflow built on the Pangeo ecosystem (Jupyter, Xarray, Dask, Zarr), which enables scalable analysis and integration of biologging and Earth system data. The framework supports trajectory reconstruction using Hidden Markov Models, combining in situ observations with environmental reference fields such as light, temperature at depth, and bathymetry. We present both positive and negative results, highlighting current capabilities and limitations of existing biologging instrumentation. By sharing this “trial-and-error” approach, we aim to clarify what environmental signals are realistically observable from tags today, and how they can (or cannot) contribute to improving fish tracking and behavioural interpretation.

SESSION 6 – FROM INSIGHTS TO IMPACT: HOW TELEMETRY RESULTS FIND THEIR WAY INTO POLICY

Estimating survival in the pearly razorfish (*Xyrichtys novacula*) using acoustic telemetry: seasonal and behavioural effects

Miquel Àngel Cortès, Albert Fernandez, Eneko Aspillaga, Amalia Grau & Josep Alos

Estimating survival in exploited marine populations is essential for understanding population dynamics and informing management, yet remains difficult for many species in the marine environment due to limitations of traditional tagging methods. Acoustic telemetry offers an alternative by enabling continuous monitoring of individuals and allowing survival to be inferred directly from detection data or derived using behaviour-based approaches. It also provides the opportunity to assess how individual behavioural traits influence survival. Here we used acoustic telemetry to estimate apparent survival in a coastal fishery targeting the pearly razorfish (*Xyrichtys novacula*) in the Balearic Islands (NW Mediterranean). A total of 132 individuals were tagged and monitored across six areas differing in protection status. Survival was inferred from diel detection periodicity and analysed using Cormack–Jolly–Seber models including temporal (season), spatial (protection status) and behavioural (home range and awakening time) covariates. Apparent survival varied primarily with season, with higher values during the closed (reproductive) period than during the fishing season. Models including protection status received some support, with survival generally higher in protected areas and differences between areas increasing during the fishing season. Behavioural covariates showed consistent relationships with survival, with lower survival associated with larger home ranges and higher survival associated with later awakening times. These results highlight the value of acoustic telemetry for estimating survival in fisheries, and suggest that individual behavioural differences may contribute to variation in survival.

Fish passage solutions in highly regulated catchments: an individual-based framework for adaptive water management in Belgium

Hanna Jaspaert, Pieterjan Verhelst & Jan Baetens

Habitat fragmentation caused by anthropogenic structures—including weirs, pumping stations, shipping locks, and hydropower turbines—is a primary driver of the global decline in diadromous fish populations. Despite legislation and management efforts to restore these populations, the desired results are still to be reached. This project takes action on the urgent need to include data and knowledge-driven measures into water management in Belgium for diadromous species restoration. As traditional fishways are often insufficient, effective restoration of aquatic connectivity in highly regulated catchments demands a shift towards dynamic, adaptive management of the water-regulating structures themselves. This work presents the development of a novel, model-based decision support tool that moves beyond fixed physical passage solutions to enable smart regulation of existing infrastructure. It integrates acoustic telemetry data, with the European eel (*Anguilla anguilla*) as a demonstrator species, and environmental variables with mechanistic modelling to estimate when fish want to migrate across a barrier and thus optimize the timing for water management opportunities. The core of the approach is the development and application of an Individual-Based Model (IBM) framework. This IBM is built on behavioural rules derived from state-space models which allow for the explicit incorporation of observation uncertainties. This IBM framework will be applied for a free-flowing reference case and across two characteristic and highly regulated Flemish water systems: polder areas and canalized rivers.

SEASCAPE - coaStal Ecotones At Stress: Capturing the importance of migration behavior in Area Planning and Environment assessments

Sindre Håvarstein Eldøy, Rosa Maria Serra-Llinares, Tormod Haraldstad, Jan Grimsrud Davidsen, Knut Wiik Vollset, Rune Nilsen, & Robert Lennox

A key challenge in coastal zone management is striking a balance between conservation and resource use. In Norway, salmon farming is the second-largest export industry, but there are increasing concerns about its sustainability. Wild sea trout are particularly vulnerable to the environmental impacts of salmon farming. There are ongoing efforts to implement sea trout as a sustainability indicator in the Traffic Light System, Norway's management tool for regulating salmon farming production volumes. In SEASCAPE, we combine acoustic telemetry, PIT-tracking and video monitoring with controlled salmon lice infestation procedures to gain increased insights on the consequences of salmon lice on sea trout along the Norwegian coast. The project runs from 2026-2029, and the poster cover highlights from the first field season.

OPEN TRACKING SESSION

Acoustic telemetry as an innovative tool to investigate fish behaviour and habitat use around offshore wind farm structures

Peer Krause, Esben M. Olsen & Christopher T. Monk

Diel vertical migration (DVM) is a common movement pattern in marine ecosystems, but its variability in large fish is still not well understood. In Atlantic cod (*Gadus morhua*) individuals have been observed to skip DVM for several days, before resuming regular DVM patterns. This so-called "skipping" of DVM has received little attention, even though it may have important consequences for energy use, feeding interactions and habitat connectivity. In this study, we examine when and why Atlantic cod skip DVM in a Norwegian fjord system, using a long-term acoustic telemetry dataset of 280 cod tracked over an 8 year-period, with individual fish monitored for varying durations. Using generalized mixed effects models, we focus on how often this behaviour occurs and whether it can be explained by environmental conditions or individual characteristics. Environmental factors considered include temperature, light, lunar phase, salinity and wind speed. We also account for biological differences such as sex, body size and ecotype (fjord vs. offshore) to better understand variation among individuals. Additionally, we test whether interactions between environmental conditions and individual traits influence the likelihood of skipped DVM, hypothesizing that this behaviour may reflect flexible, behavioural strategies. By clarifying when and why cod vary from typical DVM, this study will improve our understanding of behavioural flexibility in a top predator, potentially illuminating underlying drivers of DVM and anticipated changes in future environments.

Preliminary results of pikeperch acoustic telemetry studies in River Emajõgi and River Pärnu, Estonia

Laur Tammeorg, Roland Svirgsden, Markus Vetemaa & Mehis Rohtla

Pikeperch (*Sander lucioperca*) is a common predatory fish species in Europe. In Estonia, pikeperch is under strong commercial, and of lately also recreational fishing pressure in both inland and coastal Baltic Sea waters. Several local stocks are in poor (Pärnu) or moderate (Peipsi) condition, and there is an urgent need to manage these stocks more sustainably by gathering new data on different pressures and pikeperch ecology in dynamic ecosystems. This year we started two multi-year acoustic telemetry studies, which focus on our most important local populations: Lake Peipsi–River Emajõgi and Gulf of Riga–River Pärnu. River Emajõgi disembogues into Estonia's largest inland lake (Peipsi), which has high fish productivity and is therefore under strong commercial, and probably also recreational, fishing pressure. In this study system, we aim to study the extent of pikeperch spawning migrations and spawning habitat preferences in River Emajõgi, but also estimate fishing mortality. Pikeperch entering River Emajõgi from Lake Peipsi are tagged with acoustic and dart tags. River Pärnu disembogues into Pärnu Bay (NE corner of the Gulf of Riga), which is the most fished coastal region in Estonia. Pärnu Bay hosts a dynamic fish community of both marine and freshwater origin, with some of them moving between the river and the bay. About eight years ago, Sindi dam on River Pärnu was dismantled, which freed an extensive watercourse for migratory species. After this event many freshwater species, that were not that abundant in the lower reaches of River Pärnu before, became very abundant (including pikeperch). Pikeperch is known to predominantly spawn in the bay, but it is speculated, that river spawning may have also become important after the removal of Sindi dam. In this study system, we aim to study the extent of pikeperch movements between the river and the bay, but also estimate fishing mortality and spawning habitat preferences in the river and the bay. Pikeperch from River Pärnu are tagged with acoustic and dart tags.

Swimway Rijnland: Preferred migration routes of Silvereel in the Rijnlandse Boezem

Remko Verspui, Marcus de Boer, Jan Kamman & Mike Dijkstra

Silver eels (migratory adult *Anguilla anguilla*) are highly responsive to waterflow during their downstream migration towards sea. In the Netherlands many waterbodies are however heavily modified, including the flow through it. Especially in polders and their adjoining canal networks, both water level and flow are precisely regulated by pumping stations and sluices. In these artificially managed areas, silver eels rely on the flows created to successfully exit the area. In project Swimway Rijnland, we are collaborating with the local water authority, Hoogheemraadschap van Rijnland, in a 3-year study to determine the preferred migration routes of silver eels in the Rijnlandse boezem. This large system (approx. 4500 ha) is composed of interconnected lakes, canals and polders, where water flow is artificially controlled by pumping stations located at each of the 4 exit points. To determine how both artificially controlled waterflows as well as the passability of each pumping station affects silver eel migration, we have installed a network of 23 acoustic receivers and will equip 210 silver eels with Thelma Biotel 2M9L tags. In addition, utilizing ETN will also allow us to track animals passing through adjacent networks of acoustic receivers in Dutch (coastal) waters. Here we present the preliminary results from the first batch of 105 silver eels we have tagged in 2025.

Seasonal Habitat Shifts in Hydropower-Fragmented Rivers: Network-Scale Evidence from Acoustic Telemetry

Luis Habersetzer, Jelger Elings, Luiz G. M. Silva, Sara Süess, Roman Stocker & Jakob Brodersen

Run-of-the-river hydropower plants (HPPs) fragment the river continuum into contrasting habitat types: increased depth (5-15m), impounded reaches upstream of barriers and shallower (3-9m), non-impounded reaches downstream. While these alterations are well-documented at the hydromorphodynamic level, questions remain on their consequences for fish habitat use, particularly at larger scales (e.g. mesoscale). We assessed fish habitat use at 10 altered river stretches using a large-scale acoustic telemetry network comprising 140 receivers deployed across the Rhine-Aare River system in Switzerland. Between two HPPs, two receivers were placed on each river reach, i.e. impounded and non-impounded, enabling presence/absence analysis. Fish detections were linked to continuous riverbed texture metrics derived from side-scan sonar imagery, providing habitat characterization beyond simple hydromorphological categories. We focused on three species representing distinct ecological guilds: barbel (*Barbus barbus*, n = 55) as a rheophilic species, catfish (*Silurus glanis*, n = 30) as a limnophilic apex predator, and chub (*Squalius cephalus*, n = 80) as a generalist. Barbel and chub regularly used reservoir sections, with notable affinity for deep habitats during summer. Catfish showed opposite seasonality, occupying shallow reaches in summer and deep ones in winter. Chub showed increased association with coarser substrate sites in spring, while catfish occupancy of these reaches emerged only later in the season. These findings challenge established assumptions about rheophilic and limnophilic habitat partitioning and highlight the importance empirical data showing basin-wide species-specific patterns of habitat use for informing water management and conservation planning.

Homeward-bound? Movements and connectivity of reef-associated sharks in the Dutch Caribbean

Erwin Winter & Guido Leurs

Reef-associated shark populations have strongly declined globally, mainly due to fisheries and habitat degradation. In large parts of the Caribbean, status and movement ecology of shark species that use coral reefs during at least one life stage remain largely unknown. This long-term study focuses on tracking individual behaviour of reef-associated sharks with acoustic telemetry to determine their movement ecology at different scales. A network of 34 acoustic receivers was deployed on the reefs around Saba, St Eustatius, St Maarten and the Saba Bank in the northeast Caribbean. Small marine parks are present around Saba, St Eustatius and St Maarten. The large “Yarari” marine mammal and shark sanctuary encompasses the Saba Bank, Saba, St Eustatius reefs and the pelagic waters in between these reefs. Since 2014, 121 sharks were implanted with acoustic transmitters (V16/V16p, InnovaSea): 68 Caribbean Reef Shark *Carcharhinus perezi*, 22 Nurse Shark *Ginglymostoma cirratum*, 18 Tiger Shark *Galeocerdo cuvier* and 15 Silky Shark *Carcharhinus falciformis*. Juvenile and adult Caribbean reef sharks, and juvenile nurse sharks showed strong residency within relatively small home ranges. Juvenile silky sharks mainly occupied one site on the Saba Bank. adult nurse sharks and juvenile tiger sharks showed higher mobility and shorter lasting residency. Larger scale movements between reefs separated by deep waters (>500m) were observed for adult Caribbean Reef sharks, often short and directed back-and-forth trips, juvenile silky sharks, adult nurse sharks and juvenile tiger sharks. The results of this study have implications for assessing the effectiveness of marine protected areas

News from the South European Regional ETN network

Polona Pengal & Marija Smederevac-Lalić

The BluCorridors project aims at building a network of institutes and experts to study migratory routes and use of space of endangered migratory marine species in the Adriatic Sea. The transboundary movements of migratory species imply the need of cooperation and shared initiatives among countries in order to develop effective management strategies. This project, lasting three years and involving 10 partners from all the countries overlooking the Adriatic and Ionian Sea, will use acoustic and satellite telemetry to track the movements of migratory marine species. In addition, the project will contribute to the capacity building through the establishment of an Adriatic-Ionian Regional Working Group within the European Tracking Network (ETN) to foster collaboration among telemetry experts, and deploy acoustic receivers for long-term monitoring integrated with other existing networks of acoustic telemetry that will be part of the European Tracking Network and the training of young researchers on this topic. The project will perform two pilot actions dedicated to acoustic and satellite telemetry on migratory endangered species, including Teleost and elasmobranch species, of the Adriatic Sea. Specifically, each partner will tag one or two target species in the different Adriatic and Ionian areas. In addition, acoustic receivers will be deployed in the different areas. The recording of their occurrence through the array of acoustic receivers and the retrieval of satellite tags data from the partners will allow tracking their movements and identify migratory routes. The results of these pilot activities will allow showing case studies and highlighting priority areas for endangered species. In addition, they will eventually highlight connectivity among protected areas in the Adriatic and Ionian Seas. Therefore, the results will contribute to the improvement of marine/natural protected management in the area driven by collaborations among countries.

Spatial behavioral types across years: sub-populations or environmentally driven plasticity?

Lucas Martínez-Ramírez, Alex Winkler, Miguel Gandra & David Abecasis

Over six years (2019-2024), 58 adult meagre (*Argyrosomus regius*) within the same population were acoustically tagged. Detection data up to 2025 showed markedly higher frequency at a particular array in South Portugal among later-tagged fish compared to those tagged in earlier years. This pattern raised two questions: 1) whether it reflects the existence of distinct behavioral types within the population, and 2) whether its temporal shift is driven by environmental change (e.g. predominant ocean currents, upwelling frequency) or by unintentional sampling of sub-populations. Cluster analysis based on acoustic array residence indices revealed two well-separated behavioral types. Individuals tagged during the first three years showed predominantly low residency in the key array, with only 6 out of 34 individuals exceeding 1% local residence index. In contrast, 19 out of 24 individuals tagged during the last two years exceeded this threshold, mirroring the pattern of the few early-tagged fish. These results suggest the existence of distinct behavioral types within a meagre population. Additionally, temporal environmental analyses were performed to address the mechanisms underlying the differential representation across the study period.

GATE (Gemeinschaft für Aquatische Telemetrie Deutschland): A national initiative to facilitate aquatic fish telemetry research in Germany

Felix Mittermayer-Schmittmann, GATE-Community & Christopher T. Monk

Movement ecology is a discipline that inherently benefits from strong collaborative research networks, as animals often move beyond the boundaries that can be covered from investment by a single research group. By contrast, the study of fish movement in Germany has been highly fragmented, with projects often constrained by limited resources, permitting complexity, inconsistent infrastructure, and little collaboration. Therefore, we have established GATE (Gemeinschaft für Aquatische Telemetrie Deutschland) as a national initiative to support greater coordination, efficiency and collaboration among aquatic telemetry research activities in Germany. Through this network we hope to grow the available research infrastructure and capacity at a national level. GATE seeks to pool resources for the deployment and maintenance of acoustic receiver networks, enabling broader spatial coverage and long-term data continuity. The initiative also promotes joint training efforts to build technical capacity and standardize methodologies across institutions, and provides a collaborative platform to navigate complex permitting processes. Importantly, GATE is not intended to replace existing international frameworks such as the European Tracking Network (ETN), which will remain the central hub for data sharing and integration. Instead, GATE focuses on addressing national-level challenges, particularly those related to infrastructure, logistics, and regulatory processes within Germany. An initial meeting to establish GATE was hosted in February 2026. Currently, participants of GATE are developing a national presence through conference presentations, online visibility, and stakeholder engagement, as well as developing systems for internal coordination and participants will meet at least once per year. Any fish movement ecology researchers in Germany not aware of GATE are encouraged to join and can contact the authors for more information.

Acoustic tracking of Anadromous brown trout use of minimally disturbed estuarine habitats

Håvard Frafjord, Jan Grimsrud Davidsen, Eva Bonsak Thorstad & Sindre Håvarstein Eldøy

Sea trout (*Salmo trutta*) are anadromous salmonids of high ecological and recreational value in Norway, yet their populations have declined in many regions due to cumulative anthropogenic pressures. Habitat degradation, coastal development, and interactions with aquaculture have contributed to reduced survival and altered migratory behavior, prompting national concern and protective measures, including seasonal fishing bans. Despite this, knowledge gaps remain regarding sea trout ecology in fjord systems, and especially from fjords without open-net salmon farming. This project aims to investigate the migratory behavior and habitat use of sea trout in the inner Trondheimsfjord, a region largely free from aquaculture installations. Using acoustic telemetry, individual fish was tagged and tracked across fjord habitats and river mouths to assess spatial use, seasonal movements, and behavioral responses to environmental conditions. Key research questions include: i) sea trout use of estuaries; ii) potential conflicts between sea trout area use and human land use; iii) effects of river mouth degradation on foraging and movement. In the study, we deployed 29 listening stations covering the inner part of the fjord. To obtain high-resolution tracking of the use of estuaries, one estuary has a high density of listening stations. We tagged 40 fish (>27,5cm) with acoustic tags in April 2026. Environmental loggers measuring temperature, salinity and tidal waters are placed across the fjord. The project will generate detailed knowledge on sea trout ecology in fjord systems including estuaries, inform mitigation and restoration strategies, and contribute to regional management through scientific publications and stakeholder engagement.

Ecological and Social Dimensions of Brown Trout Management: Migration Patterns, Life History and Recreational Fishing in Lake Mjøsa

Margrethe Olsen, Jan Davidsen, Mikkel Emil Lange Friis & Eva Thorstad

Brown trout (*Salmo trutta*) are ecologically, culturally, and recreationally important in Norwegian freshwater ecosystems. In Lake Mjøsa, Norway's largest lake, landlocked populations of trout migrate between the lake and multiple rivers where they spawn and complete early life stages. This migratory behaviour, combined with natal homing, contributes to population structuring and potential local adaptation, making trout sensitive to environmental variation and human impacts across the watershed. This project aims to investigate variation in migration timing and life history traits among trout populations from different tributaries, and how these patterns relate to environmental conditions and fishing pressure. Specifically, it tests whether (i) migration timing differs among tributaries, (ii) populations vary in growth rate and age at lake entry, and (iii) migration timing is associated with environmental variables such as water temperature, discharge, and river size. Migration patterns will be studied using acoustic telemetry, allowing detailed tracking of individual fish movements between lake and river habitats. In addition, scale analysis is used to estimate age, growth trajectories, and timing of key life stages. To incorporate the human dimension, a survey of recreational fishers examines fishing effort, gear use, and catch-and-release practices. By integrating ecological and social data, this study aims to evaluate whether existing regulations effectively protect diverse trout populations. The aim is to support science-based management that account for both biological variation and recreational fishing behaviour, hopefully contributing to the sustainable management of the Mjøsa trout system.