Fisheries Society of the British Isles Symposium

5th-8th July 2021
KU Leuven, Belgium

Symposium Handbook

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An International Society for Fish Biology

KU LEUVEN

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Contents

Welcome to FSBI 2021

Ecosystems play a crucial role in the functioning of the Blue Planet through the linking of the abiotic and biotic components with nutrient cycles and energy flows.

While the importance of ecosystem interactions is increasingly acknowledged, freshwater and marine ecosystems remain unfortunately understudied. The role of fish in the natural environment, acknowledged for long but not always properly understood, receives a reappraisal through regime shifts, the role of microbiomes, the influence of pathogens and symbionts on meta-communities, the evolution of ecosystems and the role of biota in global functioning. Adapted techniques such as microchemistry, –omics, modelling, data analysis and data management have given ecosystem research and the role of fish a new impetus.

It is time to bring the scientific community together for a state-of-the-art meeting. In addition humans have a large impact on the functioning of ecosystems, so much that the proper functioning of ecosystems is changing fast, probably too fast. Fish and fisheries biologists increasingly collaborate with social scientists and society towards a sustainable and equitable use of the living natural resources.

The 2021 Annual Symposium of the Fisheries Society of the British Isles focuses on the functional role of fish and fisheries in aquatic ecosystems, at a time when the impact of man has never been so extensive. Topics range from the fundamental to the applied, from a small to a large scale, from the past to the future, provided that fish and fisheries take a prime role.

For the first time we would have had the honour to welcome you outside the UK at the small university town of Leuven (Belgium). We would have met downtown in the historic Irish College and enjoyed evenings mixing with the locals in the many bars and restaurants. We would have organized a barbecue, a banquet with music, a … But all those ideas remained a paper plan. The COVID-19 pandemic has decided differently. We welcome you instead virtually with an adapted program: pre-recorded talks, short daily meetings, breakout rooms, but still with the familiar keynote lectures, the medal awards, the best presentation award and the FSBI Annual General Meeting. For some of you short of time, with family commitments and limited funds, a virtual meeting might even be a blessing.

The conference has been organized with the support of Leuven Congress and Events, the Local Organizing Committee, the Scientific Advisory Committee, the Publication Committee and the FSBI Council.

We wish you a memorable and learned FSBI 2021 Symposium.

Professor Filip Volckaert
KU Leuven, Belgium
Conference organiser

Welcome from the FSBI Honorary President

On behalf of the Fisheries Society of the British Isles (FSBI), I am delighted to welcome you to the FSBI 2021 Virtual Symposium hosted by KU Leuven. The FSBI is a learned Society and charity that supports fish biology and fisheries science through several mechanisms, including the publication of the Journal of Fish Biology, funding of PhD studentships and research and training grants, and through international collaboration with other Societies. Crucially, the FSBI is an **International** Society for Fish Biology, exemplified here by the hosting of our annual event outside the British Isles for the first time in its 54-year history. It is a particular pleasure to see at the last count, the Leuven symposium has attracted 136 participants from no less than 28 countries scattered across the globe. While the event has a virtual format in 2021, the organisers have secured an impressive level of engagement and inclusivity through reduced registration for students and colleagues from the global south, and a strong focus on early career researchers; a hallmark of all FSBI symposia.

The diversity of the programme will foster active scientific exchange and networking via pre-recorded and live presentations, including leading international keynote speakers, break-out rooms, meet the speaker options, poster sessions and informal meetings/discussion groups, together with the FSBI Annual General Meeting and all-important medal award ceremonies. Our international symposia aim to explore established and emergent topics that utilise interdisciplinary approaches, a focal point of our activities, and this year's symposium – which brings together scientists interested in the role of fish and fisheries in the functioning and management of aquatic ecosystems - is no exception.

I am extremely grateful to Filip Volckaert - the convenor of this year's symposium – the local organising team and the international scientific committee, for putting together such a diverse and fascinating set of presentations. I am sure you will agree that despite the challenges of virtual format, you will enjoy a programme of high-quality science, stimulating discussions, and an opportunity to meet others. As ever, I hope you will conclude the symposium having made new acquaintances, collaborators and friends, as well as taking away some fond memories. Do remember that highlights from the symposium, including keynote talks, will be published in a special issue of the Journal of Fish Biology.

Professor Gary Carvalho
Bangor University, UK
Honorary FSBI President

History of KU Leuven

KU Leuven will celebrate its 600th anniversary in 2025, making it one of Europe's oldest universities. Our institution has the double honour of being the oldest university in the Low Countries and the oldest extant catholic university in the world. The University that is now known as KU Leuven was founded with the papal bull *Sapientiae immarcessibilis*. This was issued by Pope Martin V on 9 December 1425 after the city of Leuven had requested permission for the foundation of the University with the support of John IV, Duke of Brabant, and the city's clergy. The university of Leuven initially comprised four faculties: humanities ('Artes'), canon law, civil law, and medicine. In 1432, the Pope gave permission to add theology to that list.

Today, KU Leuven is dedicated to education and research in nearly all fields. Its fifteen faculties offer education, while research activities are organized by the different departments and research groups. The university boasts fourteen campuses, spread across 10 cities in Flanders. For research, KU Leuven ranks among the world's finest. It has become a cosmopolitan institution in a rapidly changing urban environment. Its unique profile reconciles cutting-edge science with quality of life and openness to talent. The research-intensive university accommodates 50,000 students and employs almost 10,000 people.

The Biology Department is responsible for the bachelor and master training of some 1070 biology students. We are involved in the master programs of Sustainable Development, Biophysics, Biochemistry & Biotechnology, and Bioinformatics. Our research programs span multiple areas and levels of biological organization, creating a dynamic training environment for the next generation of bio-scientists interested in cross-disciplinary research. The 32 faculty and 220 researchers and staff are interested in molecular and cellular biology, genomics, ecology, environmental biology, computational biology, plant and animal physiology, microbiology and neurobiology. We are dedicated to building an inclusive research environment that brings together scientists from diverse disciplines and life experiences to creatively address critical questions and discover fundamental knowledge in the life sciences. We address the urgent challenges of biodiversity and conservation, global change, epidemiology and health and well-being, and integrate new fundamental biological knowledge with social and medical ethics, public policy and outreach.

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The City of Leuven

The city of Leuven appears in historical documents for the first time in the year 884, when Vikings settled around an old fortification on the Dijle river, called *Luvanium* in Latin or *Lovon* in the local vernacular. Later, the settlement became home to the Counts of Leuven who were given the right to rule over the middle part of what is now Belgium in 1190. From then on, Leuven became an important administrative and commercial centre, with the cloth trade as the cornerstone of the city's wealth and prosperity.

The 14th century saw Leuven's fortunes change. The cloth trade lost its importance and Brussels took over Leuven's title as 'capital of the Duchy of Brabant'. However, an important event in the following century was the foundation of the University of Leuven in 1425, which remains the most important centre of higher education in Belgium and one of the leading catholic universities in the world. Luminaries, such as the 16th-century humanist and theologian Erasmus, have studied or taught at the university.

In the 18th century, a brewery that is now owned by InBev, maker of Stella Artois, was established on the outskirts of the city, and Leuven's fortunes changed again. However, it is still the university that gives the city much of its character today, not just through the many impressive buildings but also through the influx of thousands of young people each year.

Today, Leuven counts 102,000 inhabitants which makes it the eighth largest city in Belgium. It is located about 25 kilometres east of Brussels, the capital of Belgium and the heart of Europe. In 2020, the city of Leuven became The European Capital of Innovation.

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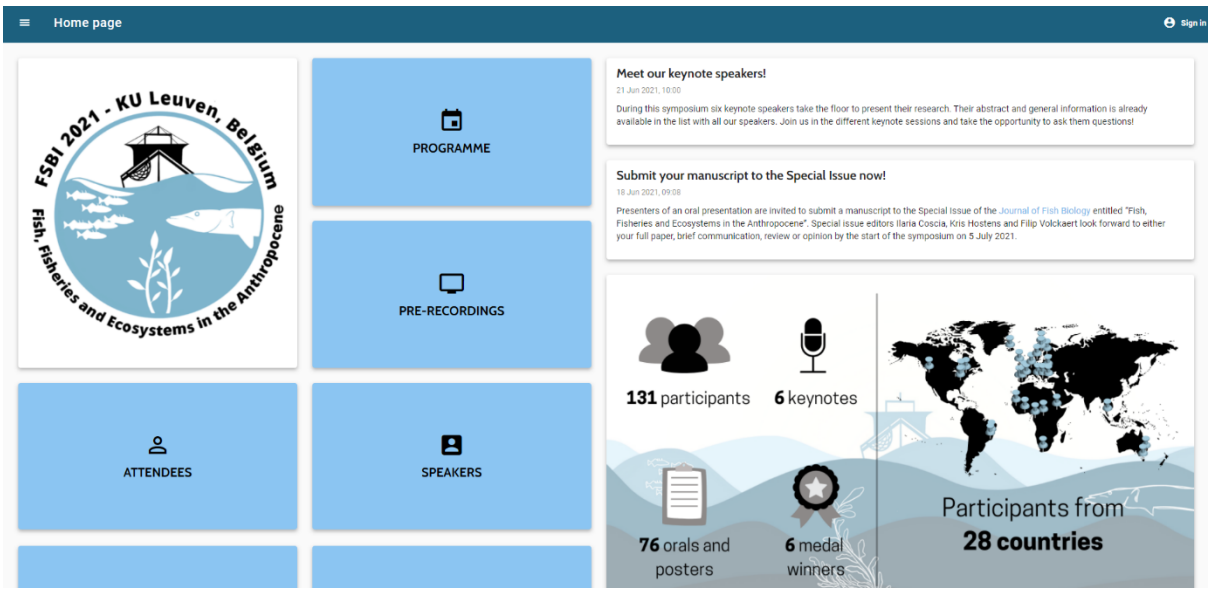
FSBI 2021 Virtual Platform

The 2021 FSBI symposium will be held online on the virtual platform hosted by *Conference Compass* (The Hague, NL). You can access the platform through this link.

Once you entered and created your attendee account, you can move freely through the platform by clicking on the light blue buttons or the three dashes at the top left of the screen. On the right side of the platform's home page, you will find the conference's statistics, other interesting notifications and useful live messages.



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2020 Medallists

Each year, the FSBI awards medals for life-long individual contributions to fish biology, with a focus on: ground-breaking research; for conservation, training or public understanding of the discipline; and for exceptional advances in the early career. As the 2020 award ceremony was cancelled due to the COVID-19 pandemic, the three medallists are honoured during this year's symposium.

FSBI Medal - Julien Cucherousset

Julien Cucherousset is a freshwater ecologist interested in understanding how human-induced changes in biological diversity affect the structure of food webs and the functioning of ecosystems. Based at CNRS in Toulouse (France), his work focuses on the consequences of intraspecific and interspecific changes in biological diversity. Julien Cucherousset is developing stable isotope approach to quantify the trophic structure of communities and the architecture of food webs and determine how such changes can subsequently affect the functioning of stream and lake ecosystems.

Beverton Medal - Beth Fulton

Dr Beth Fulton is a Principal Research Scientist with CSIRO Oceans and Atmosphere, where she has spent 19 years developing various system modelling tools for looking at marine ecosystems and sustainability. Beth is also an Adjunct Professor and Deputy Director at the Centre of Marine Socioecology, a collaboration between University of Tasmania, CSIRO and the Australian Antarctic Division, which focuses on finding transdisciplinary, equitable and sustainable solutions to the problems facing coasts and oceans. In 2019 Beth also became Research program Leader for Environment & Ecosystems at the Blue Economy CRC, one of Australia's largest CRCs, which looks to deliver innovation around sustainable seafood and renewable energy production. The common theme to Beth's work has been on developing system-scale decision support tools in support of sustainable management of potentially competing uses of marine environments and adaptation to global change. Beth has more than 160 peer reviewed publications, has contributed to IPCC and IPBES reports, and is a highly cited researcher in her field. Her contribution to marine resource management and science have been recognised with numerous awards, including the Kay Radway Allen award (2019) for lifelong and outstanding contributions to fisheries science; biennial medal of the Modelling and Simulation Society of Australia and New Zealand (2017); Ecological Society of America Sustainability Science Award (2011); a Pew Marine Conservation Fellowship (2010-2014); and the 2007 Australian Science Minister's Prize for Life Scientist of the Year.

Le Cren Medal - Herman Wanningen

Herman Wanningen is a Dutch aquatic ecologist and entrepreneur specializing in fish migration and water management. He is the founder and director of the World Fish Migration Foundation. He is recognized internationally for his work promoting the maintenance and recovery of free-flowing rivers by raising global awareness of rivers and migratory fish through the biennial event 'World Fish Migration Day'. In 2019 Herman received the President's Fishery Conservation Award at the 2019 American Fisheries Society Conference. This award is awarded for singular accomplishments or long-term contributions that advance aquatic resource conservation at a regional or local level.

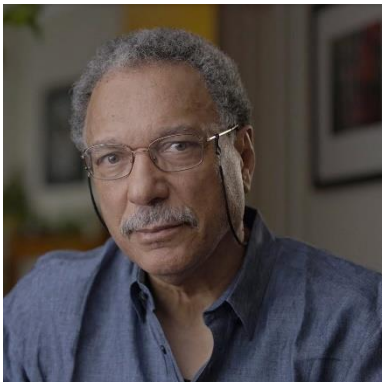
2021 Medallists

Each year, the FSBI awards medals for life-long individual contributions to fish biology, with a focus on: ground-breaking research; for conservation, training or public understanding of the discipline; and for exceptional advances in the early career.

FSBI Medal - Christos Ioannou

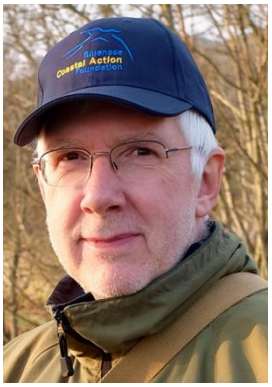
Christos's interest in behavioural research began during his undergraduate degree. It was only in his PhD (2008) with Prof. Jens Krause at the University of Leeds that he got his first hands-on experience, and quickly fell in love with fish. He then joined Prof. Iain Couzin's lab at Princeton University as a postdoc, expanding his research on the predatory behaviour of fish to include their collective behaviour. After a year teaching at the University of Exeter, he's been at the University of Bristol since 2011, initially on Leverhulme and NERC fellowships and now as Associate Professor in Behavioural Ecology. Christos has established himself as an influential fish biologist and is especially noted for ground-breaking contributions in the fields of predator-prey relationships and collective decision-making. His contributions are exemplified by a strong publication record, which include many first- and last-authorships in Science, PNAS, Nature Communications and Science Advances. He is recognised as a gifted experimental biologist, characterised by an unusual talent to work with mathematicians and computer scientists. Most recently, he has broadened his research to take an applied perspective to understand how the predatory and social behaviour of fish interacts with changing habitats driven by anthropogenic activity.

Beverton Medal - Daniel Pauly



Daniel Pauly is a Professor of Fisheries at the University of British Columbia, where he directs the Sea Around Us research initiative. He is devoted to studying, documenting and mitigating the impact of fisheries on the world's marine ecosystems. The concepts, methods and software he (co-)developed are documented in over 1000 scientific contributions. For his outstanding contribution to the field, he has received several scientific awards, including an honorary doctorate at KU Leuven, and becoming a Fellow of the Royal Society of Canada. Among these contributions are an equation for the estimation of natural mortality in fishes, a computer-based method for estimating the growth of tropical fishes, papers on human impacts on the oceans as well as the demonstration that that we are 'fishing down' the oceans, the hugely influential essay on 'shifting baselines' . He is also amongst those responsible for the creation of FishBase, an online encyclopedia of all fish in the world.

Le Cren Medal - Ian Winfield



Following a degree in zoology in 1980 from the then University College of North Wales, Ian was awarded his PhD in fish ecology by the University of East Anglia in 1983. He then left the UK in 1984 for a research fellowship at the University of Lund in Sweden, before returning in 1985 to a lectureship in fish biology at the University of Ulster. In 1990 Ian moved to the English Lake District to join the forerunner of the UK Centre for Ecology & Hydrology, for which he worked on lake fish ecology and conservation until his retirement in 2019. Ian is a name known to many people involved in fish and fisheries science within the UK, and globally. Not only for his impressive research output, but through his long-standing relationship with the FSBI – where he is perhaps one of the few to have occupied several Officer roles within the Society, including Honorary Treasurer (1997-2005), Honorary Secretary (2017-2021) and President (2011-2015). In a professional career of 40 years Ian has authored over 200 scientific papers in peer-reviewed journals on topics that range from behavioural ecology, genetics, population biology and invasive species to climate change. When added to the over 350 contracted science reports and 43 popular scientific articles that he has published, he has made a significant, and long-term, contribution to our field.

2021 Keynote Speakers

Mark Dickey-Collas (Denmark)

As the Chair of the Advisory Committee of ICES (www.ices.dk), **Mark Dickey-Collas** oversees requests from international commissions and governments for impartial evidence on meeting society's marine conservation, management and sustainability goals. Mark has 25 years experienced in providing fisheries and marine science advice having previously worked as a national fisheries science expert in Northern Ireland and the Netherlands. Mark liaises with regional and international organisations across the North Atlantic and Arctic on issues such as ecosystem assessment, ocean health, data provision, Good Environmental Status (Marine Strategy Framework Directive of the European Commission), vulnerable species and impacts of fishing. His scientific experience is in the field of population dynamics, ecosystem modelling and the policy/science interface. Mark is a member of the IMBER science steering committee and adjunct professor at the Danish Technical University National Institute of Aquatic Resources (DTU AQUA).

Pierre-Alexandre Gagnaire (France)

Pierre-Alexandre Gagnaire is a CNRS researcher within the Biodiversity and Marine Evolution group at the Montpellier Institute for Evolutionary Sciences, University of Montpellier, France. His research focuses on the evolutionary mechanisms that influence genetic variability and its relationship to phenotype at genomic and spatial scales. These range from micro-evolutionary changes within populations to the divergence process eventually leading to speciation. His work has contributed to a better understanding of the evolutionary histories associated with the formation of cryptic evolutionary lineages within species. He is now implementing a comparative genomic analysis of genetic diversity in several fish species from the Atlantic and Mediterranean Sea, with a special focus on the historical and ecological determinants of cryptic evolutionary lineages formation. This research has implications for the consideration of hidden layers of biodiversity for the conservation and management of natural populations

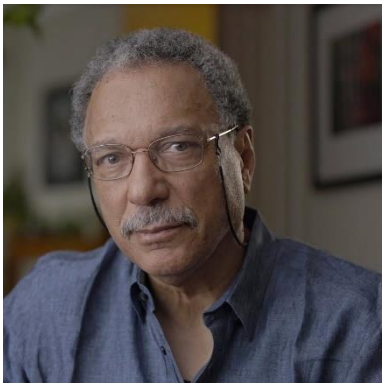
Brian Hayden (Canada)

Dr. **Brian Hayden** is a Research Associate at the Canadian Rivers Institute, University of New Brunswick where he leads the Stable Isotopes in Nature Laboratory. Brian's work examines the trophic ecology of aquatic ecosystems to understand how populations and communities respond to environmental change. His research spans the entire food webs of tropical streams to frozen subarctic lakes and coastal marine habitats, but with a primary focus on freshwater fishes. Much of this work uses stable isotopes, naturally occurring biomarkers, to determine the trophic ecology of specific populations and also define the structure of food webs supporting entire communities. Brian's current research attempts to develop a better understanding of how fish forage, develop and interact during winter, especially in temperate regions which experience extended periods of ice cover, and how this relates to annual patterns in aquatic ecosystem function.

Martine Maan (the Netherlands)

Martine Maan is Associate Professor and Rosalind Franklin Fellow at the Groningen Institute for Evolutionary Life Sciences, University of Groningen, the Netherlands. She studies the biology of species formation, specifically asking how adaptations to different ecological conditions contribute to the development of reproductive barriers. She is particularly interested in the role of individual behaviour in reducing gene flow between diverging populations, and the effects of environmental heterogeneity on habitat choice and mate choice. Her main study organisms are African cichlid fish, in which she investigates the diversifying effects of two major environmental factors: parasites and visual conditions. Her research employs a combination of field sampling, behavioural experiments, molecular genetics and comparative analyses.

Daniel Pauly (Canada)



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growth of tropical fishes, papers on human impacts on the oceans as well as the demonstration that that we are ‘fishing down’ the oceans, the hugely influential essay on ‘shifting baselines’. He is also amongst those responsible for the creation of FishBase, an online encyclopedia of all fish in the world.

Ruth Thurstan (United Kingdom)

Ruth Thurstan is a Marie Skłodowska-Curie Actions fellow and a lecturer at the Centre for Ecology and Conservation, University of Exeter, UK. Her PhD was completed in the UK, and before joining the University of Exeter she held research fellowships at the University of Queensland and Deakin University in Australia. Her research primarily focuses upon marine historical ecology, an interdisciplinary approach that draws upon the ecological, historical and social disciplines to understand what our marine and coastal ecosystems looked like and how they functioned in the past, how humans have valued and interacted with these ecosystems over time, and the extent to which our interactions have altered these systems and the production of the goods and services we rely upon. Her research into the past is motivated by a desire to use this knowledge to inform contemporary conservation and management actions to improve the future health and sustainability of our seas.

Full Programme

Monday 5th July

11:00 – 16:00	**Free platform viewing**
16:30 – 17:00	**FSBI 2021 Welcome Ceremony**
17:00 – 18:30	**Award ceremony of the medal winners 2020**
18:30 – 19:00	**Workshop: An intro to FishBase, the world' largest fish encyclopaedia**
18:30 – 20:00	The Pub: *Café Allee*
19:00 – 20:00	Networking room: meet the medals

Tuesday 6th July

11:00 – 14:00	**Free platform viewing**
14:00 – 14:30	**KS1: Martine Maan – *Ecology and evolution in cichlid fish diversity***
14:30 – 15:30	**Oral presentations: Ecosystems, communities and fish (1)**
15:30 – 15:45	*Break*
15:45 – 16:45	**Oral presentations: Ecosystems, communities and fish (2)**
16:45 – 17:15	**KS2: Pierre-Alexandre Gagnaire – *Hidden layers of genetic diversity in marine fishes from the northeastern Atlantic and Mediterranean ecosystems***
17:15 – 17:30	*Break*
17:30 – 18:15	**Workshop: Discussion room I *Communicating fishy matters***
17:30 – 18:15	**Workshop: Discussion room II *Highs and lows of the movie Seaspiracy***
18:15 – 19:00	**Wiley workshop: *Don't slip through the net when trying to***

	get published – tips on getting your research published
18:15 – 20:00	The Pub: *Kaminsky*
18:15 – 20:00	Networking room 1

Wednesday 7th July

11:00 – 14:00	**Free platform viewing**
12:00 – 14:00	**FSBI Annual General Meeting**
14:00 – 14:30	**KS3: Ruth Thurstan – *Blast from the past: Understanding historical change in marine social-ecological systems***
14:30 – 15:00	**Poster presentations**
15:00 – 15:30	**KS4: Brian Hayden – *Life under lake ice: How winter affects the ecology, biology and evaluation of freshwater fishes***
15:30 – 15:45	*Break*
15:45 – 16:45	**Award ceremony of the medal winners 2021**
17:15 – 17:30	*Break*
17:30 – 18:30	**Oral presentations: Ecosystems and global change**
18:30 – 20:00	The Pub: *Bar Vista*
18:30 – 20:00	Networking room 1: meet the medals

Thursday 8th July

11:00 – 14:00	**Free platform viewing**
14:00 – 14:30	**KS5 & Jack Jones Lecture: Daniel Pauly – *The need for synthetic studies in ichthyology, or putting Humpty Dumpty together again***
14:30 – 15:30	**Oral presentations: Ecosystems as a resource**
15:30 – 15:45	*Break*

15:45 – 16:15	**KS6: Mark Dickey-Collas – *The ecosystem based management pilgrimage***
16:15 – 16:45	**Oral presentations: Ecosystems, Fish and Fisheries in policy and governance**
16:45 – 17:00	*Break*
17:00 – 17:45	**Award session/Closing ceremony FSBI 2021 – Introduction FSBI 2022**
17:45 – 20:00	The Pub: *Louvain Louvain*
17:45 – 20:00	Networking room 1

Orals

Ecosystems and Global Change

Michael G. Bertram (Swedish University of Agricultural Sciences)
Fish on Prozac: Impacts of pharmaceutical pollution on pre- and post-copulatory mechanisms of sexual selection in aquatic wildlife.

Abstract
Contamination of aquatic habitats with pharmaceuticals is a major environmental concern. One such pollutant is fluoxetine (Prozac), a widely prescribed antidepressant, which is frequently detected in surface waters globally and can alter physiology and behaviour in aquatic organisms. Despite this, little is known about the potential for this drug to disrupt mechanisms of sexual selection. Here, we investigate the impacts of exposure to environmentally realistic levels of fluoxetine (low and high) on mechanisms of pre- and post-copulatory sexual selection in the eastern mosquitofish (*Gambusia holbrooki*). We found that high-fluoxetine exposure increased male copulatory behaviour, and exposure at both concentrations increased total sperm count relative to males from the control group. Our study is the first to show altered mechanisms of both pre- and post-copulatory sexual selection in an aquatic species resulting from environmentally realistic fluoxetine exposure, highlighting the capacity of pharmaceutical pollution to interfere with sensitive reproductive processes in wildlife.

Nikola Pfauserová (Czech University of Life Sciences Prague)
An increase in the water level as a motivation for nonnative fish species to migrate to reservoir tributaries.

Abstract
Reservoirs interrupt natural riverine continuity and reduce the overall diversity of the environment. Therefore, reservoirs, as a suitable environment for nonnative fish species, enhance their spread. Under favourable conditions, invasive species migrate to tributaries to benefit from local resource supply and return to reservoirs as a safe refuge to avoid harsh conditions. Fish migrations from reservoirs to tributaries are facilitated by increasing temperature and flow in riverine environments. However, changes in reservoir physical conditions that motivate fish to migrate are poorly understood. We equipped three nonnative (asp, *Leusiscus aspius; ide, Leuciscus idus; and bream, Abramis brama*) and two native (chub, *Squalius cephalus*; and pike, *Esox lucius*) fish species with radio tags and monitored their migration between a reservoir and its tributary for five years. The dataset was used to analyse the relationship between variability in the water level in the reservoir and fish migrations into the tributary. We found that two nonnative species, *L. aspius* and *L. idus*, migrated to the tributary when water levels in the reservoir increased, while no relationship was observed for the native species. Our results tended to show that an increase in the water level in the reservoir could be an important signal for nonnative species to migrate to a new environment that provided beneficial resources, such as food and spawning sites.

William Bernard Perry (Bangor University)
Domestication, introgression and eye size: a vision of the uncertain future of wild Atlantic salmon (*Salmo salar*) in the Anthropocene.

Abstract
Domestication leads to changes in traits which are under directional selection in breeding

programmes, though unintentional changes in non-production traits can also arise. In offspring of escaping fish and any hybrid progeny, such unintentionally altered traits may reduce fitness in the wild. Atlantic salmon breeding programmes were established in the early 1970s, targeting commercially important traits, such as growth and size. The impact on other aspects of body morphology with functional significance, such as eye size, however, remain poorly studied. We measured eye size, correcting for body size, in 4,000 salmon sampled across six common garden experiments carried out under artificial and natural conditions, in freshwater and saltwater environments, in two countries. Within these common gardens, offspring of domesticated farm and wild parents were crossed to produce 11 strains, with varying genetic backgrounds (wild, domesticated farm, F1 hybrids, F2 hybrids and backcrosses). Size-adjusted eye size was influenced by both genetic and environmental factors. Farm domesticated fish reared under artificial conditions had smaller adjusted eye width when compared to wild fish reared under identical conditions, in both the freshwater and marine environments, and in both Irish and Norwegian experiments. However, in parr that had been introduced into a river environment shortly after hatching and sampled at the end of their first summer, differences in adjusted eye width observed among genetic groups was of a reduced magnitude, and were non-significant in two-year-old sea migrating smolts sampled in the river immediately prior to sea entry. Collectively, our findings could suggest that where natural selection is present, individuals with reduced eye width are maladapted and consequently have reduced fitness, building on our understanding of the mechanisms that underlie a well-documented reduction in the fitness of the progeny of farm domesticated salmon, including hybrid progeny, in the wild.

Philip Richard Hollyman (British Antarctic Survey)
Ecology of the marbled rockcod, *Notothenia rossii*, at South Georgia: a slow recovery from over-exploitation.

Abstract
Exploitation is one of the major drivers of change in marine ecosystems. Following discovery in 1775, South Georgia saw sequential over-exploitation of living resources, including seals, whales and fish. Although exploitation is now tightly regulated, the ecosystem is still recovering from these perturbations. Marbled rockcod, *Notonthenia rossii*, was one of the first fish species to be exploited and high catches in the 1960s and 70s resulted in a dramatic decline in the stock. Here we use 30 years of trawl survey data to provide the first evidence of a sustained increase in the population of *N. rossii* starting almost two decades after a prohibition of targeted fishing in 1985. The way that species respond to change is mediated in part by their feeding relationships with other organisms. We present the first multi-year, spatially resolved comparison of adult *N. rossii* diet at South Georgia, highlighting a highly variable diet with less reliance on Antarctic krill than previously thought. We discuss possible mechanisms for the apparent increase in biomass. Life history factors and possible heavy predation on early life stages might have delayed the recovery of *N. rossii* while diet plasticity may have supported recent population growth. Due to the dynamic ecosystem at South Georgia and questions over initial catch reports from the period of heaviest exploitation, it is unlikely the current ecosystem could support a recovery to estimated pre-exploitation levels.

Mulugeta Wakjira (Jimma University)
Fish diversity and Fisheries of Omo-Turkana Basin in the face of hydrological modifications.

Abstract
The Omo-Turkana basin spans a large part of southwestern Ethiopian highlands and northern Kenya and consists of the Omo River and a northern portion of Lake Turkana. It is undergoing a period of rapid environmental and social changes, principally in response to the development of cascades of hydropower dams as well as sugarcane plantation on Omo River, which are

transforming the river's regime and its input to Lake Turkana. While these development activities and the associated hydrological modifications bear potential ecological impacts on the fish and fisheries, the basin generally lacks comprehensive study or full scientific documentation on its fish diversity, and socioeconomics and management conditions of fisheries. The main purpose of this study, therefore, was to assess fish diversity, socio-economic aspects, and related problems of the basin fisheries for better management and sustainable use of the resources. In our surveys, we identified 31 species from the Lower Omo River and Ethiopian side of Lake Turkana, with some new records for the basin. Our survey supplemented with verified historical data provides an annotated list of 69 native species, for the basin within the Ethiopian limit, out of the 79 total for the Turkana Basin. The fisheries in the basin support a considerable number of the local communities, who have much fewer other livelihood options apart from pastoralism. However, despite their considerable socio-economic benefits, the basin fisheries face a number of challenges including lack of material and technical support to the fishers cooperatives, lack of government commitment to capacitate the institutions that work on fisheries management and development, the continued conflicts between Ethiopian and Kenyan fishers in an apparent competition over a fertile fishing ground, and lack of proper fisheries management and regulation. For comprehensive insight, we developed a fisheries value chain and discussed major issues arising out of it. To sustain the fisheries' contributions to community livelihoods, it is recommended that due attention be given to conflict resolution between the Ethiopian Daasanach and the Kenyan Turkana fishers. Additionally, the co-management arrangement by the two basin countries (Ethiopia and Kenya) is urgently needed to regulate illegal fishing.

Casey Jay Broom (South African Institute for Aquatic Biodiversity)
Native fish recovery, habitat associations and management following the eradication of invasive predatory fish from the Rondegat River.

Abstract
The Rondegat River, situated in the Cape Floristic Ecoregion biodiversity hotspot of South Africa, is regarded as a keystone case study for the eradication of invasive alien fishes and subsequent recovery of an imperilled endemic fish community. Milestone conservation management steps including an environmental impact analysis and the chosen intervention are discussed. This study evaluates the recovery of the native fish community by monitoring fish diversity, abundance and size structure for eight years after rotenone treatment in 2012, using snorkel surveys and remote underwater video (RUV) footage. Snorkel surveys demonstrated that no smallmouth bass were detected following the rotenone treatment and that native fishes rapidly re-colonised the previously invaded reach. While the recovery of the fish community following alien fish eradication has been largely elucidated, another major anthropogenic impact on this system, habitat degradation, had not been explored fully. The current study combines habitat associations of the focal species with presence/absence, abundance and size structure data. Based on these multiple lines of evidence, suggestions for directed management interventions required for the continued recovery of the fish assemblage are made. In 2017 native fish densities in the treated reach were similar to those in previously uninvaded environments. A more intensive RUV programme was initiated in April 2018 to assess responses to additional threats, such as fire events and associated habitat degradation. Surveys in 2019 and 2020 enhanced the ongoing monitoring programme by use of stereo remote underwater video (S-RUV). The data from the more intensive surveys indicate that the Rondegat fish assemblage shows signals of resilience to stressors such as sedimentation and drought conditions, though it remains vulnerable to external impacts. This data enhances the ability for management decisions to be made going forward based on patterns of population size and structure in the treatment and control reaches.

Nobuhle Phumzile Mpanza (South African Institute for Aquatic Biodiversity)

The biology of *Oreochromis mossambicus* and vulnerability to the invasion of *Oreochromis niloticus*.

Abstract
Invasive species threaten both the biodiversity and integrity of aquatic ecosystems through hybridisation with the congeneric native species, predation and competitive exclusion of native biota. *Oreochromis niloticus*, native to the Nile River basin, is one of the most widely distributed invasive fish and has established viable feral populations in most tropical and sub-tropical environments to which it has gained access. The spread of *O. niloticus* in South Africa was attributed to escapes from aquacultural facilities aimed at supporting food security in the Limpopo basin. Its invasion in southern African rivers has placed *O. mossambicus* at risk due to their habitat and trophic overlap. To manage invasions, a comprehensive understanding of the biology, ecology and behaviour of both native and invasive species is needed. The Cape region of South Africa is one such area in which *O. niloticus* pose a risk. The challenge in this region is that relatively little is known of the biology of the native *O. mossambicus*. To address this, 300 *O. mossambicus* samples were collected from a natural lake and their age and growth determined using otoliths; and condition factor and reproductive status assessed. Comparisons with *O. niloticus* were based on literature and historical data in similar environments. This information is of value in informing invasion risk assessment and consequent management strategies to prevent further spreads of *O. niloticus* in southern African rivers.

Joshka Kaufmann (BEES, UCC)
The impact of genetic interactions between domesticated and wild Atlantic salmon on winter torpor and seaward migration.

Abstract
Hundreds of thousands of farmed Atlantic salmon escape into the wild every year where they can interbreed with natural populations. To understand how farm-wild hybridization can affect important life history traits, and consequently the future performance and fitness of wild fish in dynamic environments a common garden experiment was carried out under natural river conditions. Through intensive monitoring and sampling of the experimental river, we acquired high quality phenotype data for the progeny of both farmed and wild salmon (pure and reciprocal hybrids). We focus here on two critical phases of the salmon life cycle in the river: the first winter where a proportion of the salmon parr population undergo a type of torpor, and the spring smolt migration, during which fish abandon freshwater territories to move towards the sea. We found significant differences between farmed and wild progeny in the timing of these critical life history transitions, accompanied by differences in morphology, behaviour and brain neurochemistry. In the wild, the progeny of farm fish resumed growth earlier in the spring at lower temperatures, and were consistently larger than their wild conspecifics. Furthermore, farm progeny initiated and completed seaward migration earlier than wild progeny. Dissimilarities in energy use and temperature-related growth between the natural and the artificial settings demonstrate the extend of plastic responses in a changing world. We show that life history decisions (and associated life history traits) of wild fish can be greatly affected by the dual threat of genetic introgression and environmental change.

Sarah Borsetti (Rutgers University, Haskin Shellfish Research Lab)
Using a sclerochronological approach to determine a climate-growth relationship for waved whelk, *Buccinum undatum*, in the U.S. Mid-Atlantic.

Abstract
Using growth rings observed in statoliths, the size-at-age relationship was modeled for waved whelk (*Buccinum undatum*) populations within the Mid-Atlantic Bight. A total of 45 sites in the

Mid-Atlantic were sampled between 2016-2019 using a scallop dredge, and a subset of the whelk collected were aged (n=318). Lab-reared individuals and back-calculation methods were used to fill missing juvenile observations. The Mid-Atlantic Bight population appears to differ in the fit of growth curves, compared to other assessed populations, due to a timing difference in hatching. Growth curves for whelk from the Mid-Atlantic Bight show that maturity is reached between 4 and 6 years of age. A statolith chronology spanning a 10-year period was developed using a mixedeffects modeling approach. The chronology was used to explore the influence of temperature variation on growth during ecologically relevant periods. Growth increased with higher annual temperatures however specific seasonal bottom temperature had varying effects on growth. Increasing bottom temperature during summer, the anticipated egg-development and hatching period in this region, resulted in an age-dependent decline in growth with a positive effect on younger whelk and a negative effect on older whelk growth. Higher summer temperatures provide larger time-windows for growth, facilitating increased growth in early life stages. It appears that whelk in this region possess sufficient growth plasticity to adapt to warmer conditions throughout the year, but increased warming during specific seasons may depress growth in older individuals, potentially affecting fitness and population persistence. Understanding these temperature-growth dynamics are critical for disentangling the effects of climate change on whelk growth, allowing for population predictions in the future.

Robert Rolls (University of New England)
Consequences of hydrological alteration for beta diversity of fish assemblages at multiple spatial scales.

Abstract
Effects of dam operation and extraction of water from rivers on spatial variation in hydrological regimes, and consequences for freshwater biodiversity, are widely predicted but seldom assessed empirically. Evidence of linkages between hydrology and beta diversity contributes to water-management decisions to support landscape-scale biodiversity and avoid inadvertently contributing to further biodiversity decline. Using six lowland rivers that formed a gradient of hydrological alteration, we examined (1) spatial variation in hydrology under modelled scenarios of low water-resource development and flow modification by dams and extraction, (2) how beta diversity of fish among and within rivers was associated with spatial hydrological variation, (3) whether the exclusion of non-native species from analyses altered patterns of beta diversity, and (4) the associations of spatial and environmental variables and both recent and long-term hydrology with beta diversity. Spatial variation in hydrology among rivers was higher under the modified scenario than under the low-development scenario, yet change in the magnitude of within-river (longitudinal) variation was inconsistent between rivers. Beta diversity among rivers was significantly associated with spatial variation in hydrology only in certain circumstances (native species assemblages in specific years). Within-river beta diversity varied among rivers yet was unrelated to longitudinal variation in modified hydrological regimes. Patterns of beta diversity did not change appreciably if non-native species were included in analyses. These findings fail to support predictions adopted in ecohydrological science that water resource development homogenises hydrological regimes, in turn causing biotic homogenisation in lowland rivers.

Samuel Westrelin (INRAE)
How does the European catfish *Silurus glanis* behave under an hypoxic stress?

Abstract
Hypoxic events have always naturally occurred in freshwater ecosystems but are worsening due to anthropogenic activities. We analysed the movements of 40 subadult and adult European catfish *Silurus glanis* exposed to a natural summer hypoxic event in a shallow

eutrophic mediterranean lake. Catfishes could resist to the hypoxic stress without any alteration in their behaviour down to 1.2 mg/L dissolved oxygen concentration. Below this threshold, they showed panic-like movements that led them to find a more oxygenated refuge zone where they aggregated. While all individuals' movements were significantly reduced during this aggregation, the smallest individuals however showed a higher activity than the largest ones. They all rapidly recovered their normal activity level once oxygen became suitable again. All individuals survived this severe hypoxic event. The ability of catfish to withstand very low oxygen concentrations, along with its high optimum temperature range, could give it a competitive advantage over other predatory species in the context of global change.

Karen Bussmann (University of Basel)
Intrapopulation niche partitioning along a vertical depth gradient in a benthic invasive fish, the round goby.

Abstract
In aquatic environments, anthropogenic structures like concrete walls or pontoons can form novel niches in an ecosystem. Invasion biology in particular deals with topics like species composition and habitat use in these anthropogenic niches, as invasive species are often especially successful in occupying these habitats and use them as beachheads for further translocation. For example, the highly invasive round goby (*Neogobius melanostomus*) readily uses vertical concrete walls as habitat and bridge to reach boat hulls. As the round goby is inherently a bottom-dwelling fish, this behaviour can be considered as a niche expansion. Here, we investigate the significance of vertical walls as habitat for the round goby compared to their traditional habitat on the bottom. Specifically, we studied whether this niche expansion is driven by individuals specialized on wall- and surface-feeding, or if the entire population generalistically expands their niche to the walls in a population inhabiting an industrial river port. We compared trophic niche and levels of individual specialization of round gobies between vertical harbour walls and the adjacent harbour bottom using a two-tissue stable isotopes approach. Additionally, we compared differences in nest building frequencies, demographic structure, and morphology between both habitats. Our results will provide new insights into habitat use, niche partitioning and behavioural plasticity in invasive fish. As round gobies use walls to reach boat hulls, it is important to know which part of the population makes use of this habitat to estimate which individuals are more likely to be translocated.

Ben Parker (Bournemouth University)
Microplastics in UK freshwater fishes: factors influencing counts and characteristics.

Abstract
Microplastic (MP) pollution is a relatively recent global stressor instigated by rapid human population growth and a consequent reliance on plastics. MP particles, ranging from 1 µm-5 mm, are released from numerous products or form from the biological, chemical or physical degradation of larger plastics, reaching water courses through surface runoff, wind dispersal and waste outflows. While many MPs are known to pass through freshwaters and to be ingested by fish, less is known about the factors impacting MPs ingestion, particularly of those particles < 100 µm. Through the processing of numerous freshwater fishes collected from two different systems, we explore how factors such as season, site, fish body size, parasite load

and trophic ecology affect the number and characteristics of MPs found. Fish MPs were generally dominated by small blue fibres with some system-specific variation between sites, fish species and guilds. MP loads did not vary between sexes but varied with body size in the larger system, while infected individuals tended to have fewer MPs. The results show that many factors can impact the ingestion patterns of MPs but that patterns are often system-specific. The finding of fewer MPs in infected fish may suggest a novel interaction between parasites and MPs that requires further investigation.

Marta Bolgan (University of Liège)
Passive Acoustic Monitoring of Fishes in the Mediterranean Sea: past, present and future perspectives.

Abstract
In the Mediterranean Sea, Passive Acoustic Monitoring of fishes has been carried out since 2002. Studies have shown that the same species can be monitored over wide geographical and temporal scales thanks to the consistency of its acoustic signature, which can also be used to identify cryptic species that would otherwise remain undetected. The monitoring of single species vocalizations in presence of boat noise has provided information about the strategies which fish might use for coping with the ever-increasing level of human-generated noise. The monitoring of whole vocal fish communities has provided high resolution information on fish taxonomic diversity and dynamics. Finally, recent investigations have started to shed light on the possibility of extending the monitoring of vocal fish populations to deep-sea environments. Past and present studies are discussed at the light of future perspectives for fostering the monitoring of vocal fish populations in our rapidly changing seas.

Takudzwa Comfort Madzivanzira (South African Institute for Aquatic Biodiversity)
Potential ecological and socioeconomic impacts of invasive crayfish in Africa.

Abstract
Quantifying ecological and economic impacts of invasive species is crucial for management and policy making. Two freshwater crayfish, *Cherax quadricarinatus* and *Procambarus clarkii* have established naturalised populations in African countries. Concerns are being raised on their impacts on native biodiversity as documented in other continents and there is very little evidence from Africa. To fill this literature gap, lab experiments were used to determine ecological and socioeconomic impacts conferred by the crayfish species relative to a functionally native analogue, *Potamonautes perlatus* on two static different resources. Consumption rates were derived for *Oreochromis mossambicus* and *Potamogeton nodosus* under different temperatures with maximum feeding rate used to infer impact. Scavenging on dead *O. mossambicus* was used as proxies for fish catches in artisanal gillnet fisheries whereas *P. nodosus* represents ecologically important macrophytes. Consumption of both resources by all decapods increased with temperature. Damage by *C. quadricarinatus* on fish was significantly higher than the other two decapods whilst *P. clarkii* had a significantly higher consumption of macrophytes than the other two decapods at all temperatures. This study combined fisheries data to estimate the potential monetary losses that are due to catch spoilage by *C. quadricarinatus* in Kafue Flats. We show that there is a potential for fisheries

damage of up to 1500 t/year in catch losses which translates to an annual potential loss of US$2 million. These impacts are of high concern, especially in an overexploited floodplain fishery such as the Kafue, and warrant efforts focus on population reduction and preventing further spread.

Mandla Leon Magoro (South African Institute for Aquatic Biodiversity)
The distribution of non-native Nile Tilapia (Oreochromis niloticus) in the Limpopo and Mpumalanga Provinces.

Abstract
Management of alien invasive species is complicated by species that are valuable economically but also cause harm to biodiversity. The Nile tilapia *Oreochromis niloticus* is currently listed as a NEMBA category 2 alien invasive species. Due to its relatively fast growth rate in comparison with most other cichlids, this is a highly favoured species in the global warm water aquaculture industry. However, its ability to hybridize with indigenous Mozambique tilapia *Oreochromis mossambicus* makes Nile tilapia a major threat to the genetic integrity of Mozambique tilapia, thus its use in aquaculture is currently not permitted in certain provinces in South Africa. The main aim of the project is to map the current distribution of non-native Nile tilapia and its hybrid forms in rivers and dams through presence-absence surveys in the Limpopo and Mpumalanga Provinces. Surveys conducted at 40 sites between October 2019 and March 2020 resulted in Nile tilapia or its hybrid forms being detected in several dams, thus providing an up to date mapping of the current distribution of this species in the two provinces. The results obtained thus far have deeper implications for the conservation of Mozambique tilapia, particularly in systems where Nile tilapia was not below detection level. The results from this study further highlight the need for an adapted strategy for Mozambique tilapia conservation in South Africa.

Ecosystems as a Resource

Jeremy F. Jenrette (Virginia Tech)
Data mining Instagram as a tool for tracking global shark populations.

Abstract
Abundance and distribution data of global shark populations is necessary for effective conservation and management. While there are operative direct methods to retrieve data from scientific surveys and fisheries monitoring, species specific indices of population abundance coming from these sources are rare for most shark species. Sharks are among the most data-poor groups of marine animals. Yet, there is an abundance of unconventional and unstructured information within social networks that is virtually untapped and has great potential to fill the information gap. Instagram contains over a billion users worldwide making it the largest image-sharing platform in the world. Despite its popularity, there is little research that implements social media for shark conservation. We show the biological importance of transforming variably tagged, non-time-stamped, non-geocoded images into occurrence records. By using an image detection model trained to identify shark photos, we outsourced a massive cloud of shark images posted by Instagram users worldwide. We developed programs that geolocated

and time stamped these images from text in Instagram posts and generated inferred shark sightings. These data were then compared with Instagram user density maps to produce proxies of shark population abundance. Our approach generated a substantial 3,400 sightings directed towards blue shark and tiger shark coverage over the span of nine years. Social networks like Instagram can be efficiently exploited to reveal important spatiotemporal trends of global shark populations. Refining alternative sources of abundance data is strongly needed for promoting management and conservation of this important, endangered, and data-poor group of marine animals.

Imanol Aguirre-Sarabia (AZTI)

Genetic connectivity and hybridization with its sister species challenge the current management paradigm of white anglerfish (*Lophius piscatorius*).

Abstract

Understanding the inter and intraspecific dynamics of fish populations is essential to promote effective management and conservation actions and to predict adaptation to changing conditions. This is possible through the analysis of thousands of genetic markers, which has proven useful to resolve connectivity among populations. Here, we have tackled this issue in the white anglerfish (*Lophius piscatorius*), which inhabits the Northeast Atlantic and Mediterranean Sea and coexists with its morphologically almost identical sister species, the black anglerfish (*L. budegassa*). Our genetic analyses based on 16,000 SNP markers and 700 samples reveal that i) the white anglerfish from the Mediterranean Sea and the Atlantic Ocean are genetically isolated, but that no differentiation can be observed within the later, and that ii) black and white anglerfish naturally hybridize, resulting in a population of about 20% of, most likely sterile, hybrids in some areas. These findings challenge the current paradigm of white anglerfish management, which considers three independent management units within the North East Atlantic and assumes that all mature fish have reproductive potential. Additionally, the northwards distribution of both species, likely due to temperature raises, calls for further monitoring of the abundance and distribution of hybrids to anticipate the effects of climate change in the interactions between both species and their potential resilience.

Thango Dao (IGB Berlin)

Heterogeneity in behavior and tipping points in a coupled human-natural model.

Abstract

Diversity, e.g. diversity in species or functional traits, is usually associated with increasing resilience of natural and coupled human-natural systems. Yet, we believe heterogeneity in human behaviors may also predispose a coupled human-natural systems to cross tippling points, caused by the feedback among ecological and social system. We develop a bio-economic harvest model with heterogeneous participants to characterize the necessary and sufficient conditions for the emergence of multiple steady state equilibria and an anthropogenic tipping point, below that the population of an exploited natural resource will collapse to undesired state characterized by low resource abundance. To outline our case, we use a recreational fishing model with heterogeneous anglers that vary in fishing skill. We show that the necessary condition for the emergence of a tipping point is the presence of a fish population level at which the elasticity of aggregate fish landing with respect to fish population,

that measures the responsiveness of fish harvest to a change in fish population, is less than that of fish population growth. Under the necessary condition and given a certain fishing skill distribution, the sufficient condition holds when the angler population size is big enough but not too big to rule out the case only one undesired steady state prevails. Finally, we provide a two-stage strategy of fishing fees to help a system initially locked below the tipping point level escape such the low regime during the first stage of fishing fee program. During the second stage, the fishing fee trajectory enables the fish population to trace the optimal path towards the first best steady state equilibrium in the long run. We provide a discussion addressing that the fat tail of the distribution, rather than the degree of heterogeneity, may play a role on the emergence of the anthropogenic tipping point.

Sven Matern (Leibniz Institute of Freshwater Ecology and Inland Fisheries)
Impact of littoral habitats on fish distribution and abundance in gravel pit lakes: implications for fisheries management.

Abstract
Structured littoral zones represent a key habitat for lentic fish communities. Young gravel pit lakes are characterized by steep slopes and low amounts of coarse woody habitat (CWH). These man-made lakes are often managed by recreational fisheries and shape agricultural landscapes as dominant type of water body. We used transect-based and point abundance electrofishing data to model the influence of littoral habitats on the abundance of the six most abundant fish species in gravel pit lakes using boosted regression trees. In contrast to earlier studies from natural lakes, lake-level environment and transect-level habitat type more or less equally influenced the abundances of differently sized fish species in the littoral zone. The abundance of almost all analysed fish species increased with lake productivity and extent of structured littoral habitats, mostly following non-linear relationships. CWD was used in all seasons with strongest, positive effects on the abundances of larger piscivores. During winter, roach *Rutilus rutilus*, perch *Perca fluviatilis* and pike *Esox lucius* particularly and highly intensively used CWH, with the potential to reduce overwinter mortality. Our work shows that the presence of CWH shapes the within-lake distribution of the fish community. We thus recommend fisheries managers to enhance littoral habitats via the implementation of CWH, rather than to remove CWH for the benefit of angling sites, in order to create and maintain essential fish habitat.

Philipp Czapla (Leibniz-Institute of Freshwater Ecology and Inland Fisheries Berlin)
Long-term hook avoidance of common carp (*Cyprinus carpio*) as a function of private and social cues.

Abstract
Earlier studies have shown that a one-time, private experience of hooking and releasing carp (*Cyprinus carpio*) can reduce individual catchability in the future. In the short term within a few days, carp can also learn from a social hooking experience that does not involve the private hooking experience and instead involves the experience of seeing a conspecific being hooked and released. It is unknown how long the hook aversion is retained in the carp's memory. The study aim was to analyze whether private or social hooking experiences can be remembered

7 and 14 months after the experience. To that end, 76 one year old carp were either exposed to a private or social hook experience in aquariums or remained naive (control). 7 and 14 months later, the fish were exposed to a fishing situation, and their behavior in relation to the fishing bait was recorded. Corn kernels were used for fishing baited on sham rigs without a sharp hook. In comparison to angling-naïve control fish, fish from the private and social exposure both showed a reduced vulnerability to angling either after 7 or 14 months of the initial experience. Specifically, fish with a private hooking experience needed significantly more time to ingest the sham rig in comparison to controls in both time periods. Social carp also showed altered responses to angling hooks, being more suspicious towards a piece of corn when offered in a presence of a sham rig in both retention periods. Common carp are able to remember a single hooking experience for at least 14 months. These findings will influence catch rates experienced by anglers and can modify fishery-dependent stock assessments in lakes and rivers.

Tamal Roy (Leibniz-Institute of Freshwater Ecology and Inland Fisheries Berlin)
Size-selective mortality affects collective risk-taking under predation threat in zebrafish, Danio rerio: implications for fisheries-induced evolution.

Abstract
Size-selective mortality is common in fish populations and can operate either in a positive size-selective fashion (like in fisheries that selectively catch the largest members of a stock) or be negative size-selective (like gape-limited predators that preferentially capture the smaller members of a stock). Through various mechanisms (like genetic correlations among behaviour and life-history traits or direct selection on behaviour co-varying with growth rate or size-at-maturation), both positive- and negative size-selection can result in evolutionary changes in behavioural traits. Theory suggests that size-selection alone favours boldness, but little experimental evidence exists about whether and to what extent size-selection can trigger its evolution. Here we investigated the impact of size-selective mortality on risk-taking behaviour across ontogeny using three experimental lines of zebrafish (*Danio rerio*) generated through positive (large-harvested), negative (small-harvested) and random (control line) size-selective mortality for five generations. We measured risk-taking behaviour as a measure of boldness under aerial predation threat and in presence of a live cichlid predator by estimating the cumulative time spent at the water surface for feeding. Under aerial predation threat, fish among selection lines did not differ in boldness when 7-day old but both large- and small-harvested line fish were bolder than the control line as 15-day old juveniles. Post this life stage and as adults, the small-harvested line fish continued to be bolder than the control, while the large-harvested and control line fish did not differ. In adults in presence of a cichlid predator, the small-harvested line fish spent less time at the surface and were less bold when they perceived only olfactory cues from the cichlid while the large-harvested line fish did not differ from controls in their responses. Our results suggest that size-selective harvesting may evolutionarily alter risk-taking tendency. Size-selection alone favors bold fish when selection acts on small fish while selection typical of fisheries operating on large fish did not seem to alter the behavioural phenotype.

Homère J. Alves Monteiro (DTU aqua)

Applied population genomics in the European flat oyster (*Ostrea edulis*).

Abstract
Endemic to European coasts, the flat oyster *Ostrea edulis* represents a valued food source and wild oyster beds are providing numerous important ecosystem services. The huge drop in production of *O. edulis*, which started around the sixties, is the direct result of overfishing and disease outbreaks. Numerous, often unregulated, translocations of flat oysters have occurred between the European countries to support regional production, and have increased the spread of the lethal infectious parasite *Bonamia ostreae* in natural populations. Interestingly, while the translocation of French *B. ostreae*-infected flat oyster into the Limfjorden (Denmark) has been documented, the environmental conditions could have prevented the settlement of the parasite (or of the host: the translocated French flat oysters) in the Danish naïve flat oyster population until 2014 when *B. ostreae* was detected for the first time after more than 30 years. Putative evolutionary patterns in natural flat oyster populations in Denmark and the rest of Scandinavia (Swedish and Norwegian), must consequently be addressed to get an understanding of mechanisms for establishment and maintenance of oyster populations and their parasites. Comparisons with other flat oyster population are highly relevant to look at similar evolutionary adaptations. Available genetic studies for the flat oyster are historically done with allozymes and microsatellites. One of the conclusions implies a possible genetic structuring of the European flat oyster into three distinct genetic clusters: The Danish-Dutch, French-English-Irish, and lastly a Spanish cluster. It is crucial now to verify this assertion by increasing the number of molecular markers, from 16 microsatellites to more than ten thousand SNPs, and to increase the spatial resolution in the locations sampled in the greater Scandinavia and all-around European natural habitats. Ditto their first study, a unique ""Scandinavian"" location (Limfjorden) was sampled and gave different signals from any other European flat oysters giving even more traction to our hypothesis and our project. The overall range of sampling can be improved as well as the sequencing ""power"". This is what we intend to do, and for the first time, trying to decipher the impact of translocations from a genetic standpoint.

Jochen Depestele (ILVO)
Assessing spatial and gear-related measures to reduce seabed impacts of flatfish-directed beam trawl fisheries in the North Sea.

Abstract
Flatfish-directed beam trawls penetrate the seabed and alter the functioning of the benthic ecosystem of its target species. A framework was developed to assess these types of seabed impacts for bottom-contacting mobile gears in the North Sea. The framework combines fishing effort (swept area ratio) with the gear penetration depth to assess the instantaneous mortality of benthic species living in the seabed. The recovery rate of the depleted benthic community is estimated using a population dynamic model to assess the relative change in benthic state. In this study we apply this framework to the Belgian beam trawl fisheries to estimate their seabed impact, while accounting for the fishing pressure of other European fleets. The objective of the study is twofold. First, we will assess the evolution of the annual seabed impact of the Belgian beam trawl fleet. Second, we will assess how this fleet may reduce its impact through gear modifications or changes in spatial effort distribution. The reduced impact of gear modifications, such as the Sumwing, is due to a reduction in seabed penetration and

subsequent benthic mortality. The reduced impact of spatial effort distribution is related to the differences in recovery potential and equilibrium state of benthic communities. Our case study will test a quantitative means to assess seabed impacts of a specific, national fleet and allows to trade-off spatial and gear-related measures to reduce that impact.

Pieter Johannes Swanepoel (South African Institute for Aquatic Biodiversity)
Assessing the suitability of baited long line fishing for small-scale fisheries in South Africa's largest impoundment, Lake Gariep.

Abstract
South Africa's freshwater fish resources are mainly used by recreational and subsistence fishermen. In order to address the South African government's imperatives of job creation, poverty alleviation and economic development in rural areas, there is a renewed interest to develop the inland fisheries sector. Lake Gariep is South Africa's largest man-made impoundment and a study was done to investigate the suitability of baited long lines for the harvesting of the indigenous sharptooth catfish, *Clarias gariepinus*, in small-scale fishery development. From December 2019 until December 2020 monthly surveys were done by using three 120 meter long lines, equipped with 20 hooks each fitted with a baited 6/0 circle hook at five meter intervals. Long lines were set randomly at three pre-determined stratums, in areas with a mud/silt, gravel or rocky substrate to ensure a comprehensive and balanced sampling of all habitat types. The catch composition consisted mainly of *C. gariepinus* (n=480), but also included six specimens of the largemouth yellowfish, *Labeobarbus kimberleyensis* which is an IUNCN red-listed species. The total catch per unit effort (CPUE) for *C. gariepinus* was 35.3 ± 26.4 kg•line-1•night-1 from a total of 73 line nights. This CPUE for Lake Gariep is regarded as generally high, and therefore it is concluded that baited long lines are a suitable gear to be used in small-scale fisheries at Lake Gariep.

Paulina Urban (National Institute of Aquatic Resources (DTU Aqua))
Can genetic tools help to assess bycatch in fisheries effectively?

Abstract
Fisheries management needs precise information about bycatch quantities to make sound assessments of exploitation rates. Likewise, bycatch information is important for industries to maximize and document the quality of their products, and as a means for fishermen to document their catches in relation to vessel-based quotas. Current practices for visual assessment of catch composition are time-consuming, require extensive manpower, and have low resolution. Moreover, the aggregated distribution of target and bycatch species within and among catches limits the replicability of the methods, resulting in relatively large uncertainties of estimates. In recent years, molecular methods have revolutionized common monitoring practices by providing methods for fast species identification based on DNA present in the environment (eDNA). Following the concept of eDNA, it is feasible to reliably assess species composition through sampling the medium in which a given species was present. In our study, we use aqueous solutions (so-called "blood water") that arise in connection with fishing and processing of catches in the industrial fishery. We explore the applicability and precision of molecular-based methods on blood water for the assessment of mixed catches in selected fisheries. We hypothesize that due to mixing the DNA composition in the blood water will be

more homogeneous, and therefore more representative of the catch composition as a whole, than visual assessments. Developing faster, cheaper, and more precise methods for the assessment of bycatch is needed, to improve the quality of fisheries-dependent data and to secure sustainable fisheries.

Lina Mtwana Nordlund (Uppsala University)
Seagrass, fish and fisheries.

Abstract
The significant role seagrass meadows play in supporting fisheries productivity and food security across the globe is not adequately reflected in the decisions made by authorities with statutory responsibility for their management. Seagrasses are marine flowering plants forming extensive coastal meadows, providing nursery habitat for commercial fishery species, providing trophic subsidies to adjacent habitats, and key fishing grounds; however, the nature and extent of seagrass exploitation are poorly understood. Here we demonstrate the extent, importance and status of fisheries exploitation of seagrass meadows, focusing on four key areas: the purpose of fishing in seagrass habitats, the methods used, target species, and how fishers access seagrass fishing grounds. Our review of fish species utilising seagrass meadows at some stage in their lifecycle, resulted in 746 species of fish documented to utilise seagrass meadows the Indo-Pacific, 486 in Australasia, 222 in the North East Pacific, 313 in the Caribbean, and 297 in the North Atlantic. Assessing this data shows that seagrass meadows provide valuable nursery habitat to over a 1/5th of the world's largest 25 fisheries. The analysis of available small scale fisheries data (in metric tonnes) from 13 locations across the tropics and sub-tropics found 79 ± 18% of species to be seagrass associated. Seagrass meadows are also commonly used as invertebrate fishing habitats. Expanding research into the links that seagrass meadows provide in support of global fisheries and supporting policy is needed to support their sustainability.

Robert Arlinghaus (Leibniz-Institute of Freshwater Ecology and Inland Fisheries)
The battle of natural and fisheries selection creates small and shy fish.

Abstract
Harvest of fish and wildlife, both commercial and recreational, is a selective force that can induce evolutionary changes to life-history and behaviour. Natural selective forces may create countering selection pressures. Assessing natural fitness represents a considerable challenge in broadcast spawners. Thus, our understanding about the relative strength of natural and fisheries selection is slim. In a multi-year experimental field study, we compared the strength and shape of harvest selection to natural selection on body size and behaviour in a natural population of a freshwater top predator, the northern pike (*Esox lucius*). Natural selection was approximated by relative reproductive success via parent-offspring genetic assignments over four years. Harvest selection was measured by comparing individuals vulnerable to recreational angling with individuals never captured by this gear type. Individual behaviour was measured by high-resolution acoustic telemetry. Harvest and natural size-selection operated with equal strength but opposing directions, and harvest size-selection was consistently negative in all four study years. Harvest selection also had a substantial

behavioural component, while natural behavioural-selection was not documented, suggesting the potential for directional harvest selection favoring inactive, timid fish. Simulations of the outcomes of different fishing regulations showed that traditional minimum-size based catch limits are unlikely to counteract harvest-selection without being completely restrictive. Our study suggests harvest selection may be inevitable and recreational fisheries may consistently promote evolution of small, inactive, shy and difficult-to-capture fish. Such evolution would have substantial consequences for stock assessment and global fisheries that operate with hook-and-line.

Josephine Pegg (South African Institute of Aquatic Biodiversity)
Why fisheries fail.

Abstract
The prospect of creating new fisheries, in particular those which make use of unwanted alien species can be viewed as a positive step towards food security, environmental remediation and sustainable development goals. In practice this simple concept can turn into a complex reality and ultimately a failed fishery. Using an example of a failed catfish long-line fishery in the Eastern Cape of South Africa, we show the challenges at each step, from stock assessment to fish capture, user conflicts, market chains, product quality and customer demand. Opportunities to observe the entire life-cycle of a fishery from conception to closure are rare and many of the lessons learned here are applicable not just at a local level but for any start-up fishery.

Osman Crespo (Okeanos Institute)
Best statistical model for standardizing LPUE, CPUE, and survey-derived abundance data of target and bycatch species.

Abstract
Standardizing catch rates is an important approach for stock assessment, as it provides abundance indices representative of the fraction of the stock that is vulnerable to fishing. Often, catch distributions are zero-inflated bringing the need to evaluate the appropriateness of the statistical models for the standardization process. In this research, we analyzed different generalized linear models to select the best technique to standardize catch rates of target and non-target species from fishery-dependent and fishery-independent data. Three databases were analyzed: landings per unit effort (LPUE; kg landings^{-1} vessel^{-1}) from Azores Auction Service, catch per unit effort (CPUE; kg days at sea^{-1} vessel^{-1}) collected under the EU Data Collection Framework through sampling schemes and structured interviews to captains of the local fleet, and relative population number (RPN; kg 10^{-3} hooks) from the Azorean bottom longline survey. Examined error distribution models were gamma, lognormal, tweedie and hurdle models. For hurdle, positive observations were analyzed assuming a lognormal (hurdle-lognormal) or gamma (hurdle-gamma) error distribution. Three diagnostic plots were used to define the best modelling approach: (i) the Pearson residuals plotted against the fitted values to check the assumed variance function, (ii) standardized deviance residuals plotted against the estimated linear predictor to check for systematic departures from the assumptions underlying the error distribution; and (iii) the dependent variable plotted against the estimated

linear predictor as a check of the assumed link function. Based on the results, the hurdle-lognormal was the statistical model that best satisfied the underlying characteristics of the different datasets.

Ecosystems, Communities and Fish

Xavier Raick (University of Liège)
Acoustic range of the biophony of a coral reef in the context of fishes larval recruitment.

Abstract
In the context of climate change, increased damage to coral reefs causes an acceleration of the degradation of coral reef soundscapes impacting the attraction of fishes larvae. The ability for fishes larvae to use acoustic cues is known but the maximal detection distance of coral reef sounds is still unknown. Using drifting antennas (made of a floater and an autonomous recorder connected to a hydrophone), six transects were realized from the reef crest to 10 kilometers in the open ocean on Moorea island (French Polynesia), we estimated that the chorus created by the sounds of benthic invertebrates is a major contributor to the ambient noise at more than 90 kilometers under flat/calm sea state conditions and more than 50 kilometers with an average wind (6 knots wind regime), while fishes sounds can be detected up to less than two kilometers. These distances decrease when the wind or the ship traffic increase. Using audiograms of different taxa, we showed that fishes post-larvae likely hear the reef at distances up to 0.5 kilometers, while it is half this distance for invertebrates. Some cetaceans would be able to detect reefs up to more than seventeen kilometers. These results are essential to understand fishes larval recruitment and the effect of soundscape degradation on coral reef fishes.

Pierre Barry (ISEM - University of Montpellier)
Comparative population genomics of the Atlantic-Mediterranean suture zone reveals heterogeneous cryptic subdivisions in marine fishes.

Abstract
Delineating species boundaries is an important aspect of biodiversity and ecosystem conservation. Despite high potential for gene flow, marine fish frequently display genetic subdivisions below the species level. Because evidence for genetic differentiation has long relied on low-coverage genetic data and is rarely accompanied by morphological differences, the existence of cryptic subdivisions is usually contentious. This may cause difficulties in recognizing biologically relevant units for the management and conservation of biodiversity. Refined descriptions of genetic diversity are thus needed at the whole-genome scale to better understand how genetic variation is structured within species. Here, we described the partitioning of within-species genetic variation in the northeastern Atlantic and Mediterranean Sea for 20 different marine fish species with contrasted life-history traits. For each of them, we sequenced the whole-genome of 20 individuals and used genome-wide polymorphism data to screen within-species subdivisions, as revealed by highly differentiated genomic regions. Genetic subdivisions within the 20 species were distributed along a continuum of divergence, reflecting a variety of genomic architectures ranging from a few narrow differentiated regions

to high genome-wide divergence. Moreover, the spatial structure of divergence and gene flow varied considerably among species. These results raise questions about the eco-evolutionary drivers of species' heterogeneous responses to a shared biogeographical context, particularly with respect to the influence of species' life-history traits.

Io Deflem (Department of Biology, KU Leuven)
Contrasting patterns of genetic divergence in three sympatric fish species.

Abstract
Understanding environmental and spatial processes driving patterns of genetic structure is essential to protect species' evolutionary potential, especially given the current rate of human-induced environmental change. Moreover, focusing on patterns of multiple sympatric species will help to generalize such patterns within entire communities. In this study, we focus on population genomic structure of two native and one highly invasive riverine fish species with contrasting dispersal capacity, life history strategy, ecology, and environmental tolerance: three-spined stickleback, stone loach, and topmouth gudgeon. By focusing on genome-wide data, we aim to characterize spatial (responses to natural riverscape variation and barriers) and environmental (responses to physico-chemical parameters) patterns of genetic diversity and divergence in three co-occurring fish species in order to provide recommendations regarding the conservation of genetic diversity in communities. Genetic responses to natural and anthropogenic riverscape variation differed strongly between species. Strong population genetic structure was observed in three-spined stickleback, a pattern strongly driven by local environmental factors and pollution. Stone loach populations, on the other hand, were most affected by spatial distances and general patterns overlapped more strongly with topmouth gudgeon. Topmouth gudgeon populations were significantly differentiated, but to a lesser extent than the two native species. Population differentiation was mainly driven by spatial factors such as waterway distances and the presence of migration barriers, potentially reflecting the species recent colonization history. The results indicate that conservation and restoration actions cannot be generalized, suggesting the importance of both species- and location- specific actions.

Owen O'Shea (The Centre for Ocean Research and Education (CORE))
Evidence and description of a nursery habitat for the recently reclassified stingray *Styracura schmardae* from The Bahamas.

Abstract
While definitions of elasmobranch nurseries remain fluid within the literature, the identification and description of nursery habitats for batoids remain relatively scarce. The Atlantic chupare stingray (*Styracura schmardae*) is a large bodied demersal ray considered data deficient by the International Union for the Conservation of Nature and recently described from The Bahamas. Using a combination of mark-recapture and benthic habitat surveying, we describe for the first-time, long-term site fidelity of *S. schmardae*, and provide evidence and characteristics of a nursery environment for this species in South Eleuthera, The Bahamas. Overall, 190 capture events were recorded from 86 tagged individuals from April 2014 to August 2017 (1,222 days), with 51 % of individuals recaptured at least once, 36 % at least

twice and 2 % six times. Ninety-five percent of rays captured were considered immature (mean disc width WD, 553.5 mm) and had an average residence time ± SD of 243 ± 177 days. Residence time did not differ among sites, sex and disc width of individual rays at time of capture. Of four creeks sampled, Deep Creek had the highest prevalence of captures and recaptures, and correspondingly the highest values for soft sediment cover and sediment depth among sites, suggesting these habitat characteristics in particular may be important in supporting juvenile *S. schmardae* populations. Results of this study will better inform effective management and conservation efforts for *S. schmardae*, as well as concentrating on localised conservation efforts on these ecosystems.

Natalia Díaz-Arce (AZTI)
Genetic admixture in a newly discovered spawning ground shape the genetic connectivity of Atlantic bluefin tuna.

Abstract
Efficient conservation plans for commercial fish species require understanding of population connectivity and demography. Despite efforts on Atlantic bluefin tuna (ABFT, *Thunnus thynnus*) conservation during the last years, this species has still not recovered from decades of overfishing. The current paradigm for ABFT management assumes two populations that spawn mainly in the Mediterranean Sea and the Gulf of Mexico and mix throughout the Atlantic Ocean. Yet, potential population connectivity suggested by weak genetic differentiation, coupled with the discovery of a new spawning ground in the North-western Atlantic, questions the assumption of two demographically independent populations used for proposing conservation strategies. Here, we have further studied the genetic connectivity of ABFT using thousands of genome-wide single nucleotide polymorphisms (SNPs) of five hundred larvae, young of the year and spawning adult samples covering the three spawning grounds. We found i) that Mediterranean origin individuals are found in the Gulf of Mexico but not inversely, ii) that the Slope Sea is a mixing spawning ground where individuals from both populations reproduce, and iii) that adaptive signatures present in the ABFT genome occur at different frequencies between ABFT populations. Altogether, these results strongly support an asymmetric trans-Atlantic gene-flow from the Mediterranean to the Gulf of Mexico through the Slope Sea. This potential population inter-dependence, whose temporal stability needs to be further understood, might indicate risk of potential genetic diversity loss and should be considered for future ABFT conservation endeavors.

Isaac Trindade-Santos (University of St Andrews)
Global rarity of bony and cartilaginous marine fishes.

Abstract
The biological diversity in ecological assemblages is composed largely of rare species. As the ecosystem functioning upon which we depend relies on the contribution given by these species, the functional role played by these rare species has relevance in conservation policy. The measurement of rarity traditionally includes two main aspects: species relative abundances and/or occupancy patterns. However, current literature suggests that we should also now consider the functional dimension of biodiversity when calculating rarity. In this work

we integrated these two facets - species spatial occupancy patterns and the distinctiveness of species combinations of traits. We then investigated the global biogeography of rare marine fish (using a dataset containing around 13,000 species). We uncovered hotspots of rarity, in excess of that predicted by species richness, at higher latitudes and near the continental coasts. We also note mismatches between marine protected areas and these rarity hotspots. This investigation was completed separately for each group of fish, the Actinopterygii (bony fish) and Elasmobranchii (sharks, skates and rays) and the same patterns were revealed for both groups. Our study highlights the importance of using metrics that incorporate information on the species combination of traits in the conservation and management of global marine fishes.

Sum Yi Lai (Marine and Freshwater Research Institute and University of Iceland)
Spatial and seasonal changes of food availability for juvenile Atlantic salmon (*Salmo salar*) in rivers of Northeast Iceland.

Abstract
The purpose of this project is to determine the role of food and resources availability in juvenile Atlantic salmon growth rates and population abundances in the rivers of Northeast Iceland. In addition, other salmonids species in rivers, like the arctic charr (*Savelinus alpinus*), are also affected by prey availability and the presence of interspecific competition. The trophic relationships within the river could be described using long-term data, collected annually, on abundance of juvenile fish, stomach content, and river invertebrate abundance, and algae. Food availability may also vary spatially between and within rivers as well as seasonally. This could give a better indicator on the current feeding conditions and the population trend of Atlantic salmon in different rivers over time in Iceland. Freshwater ecosystems contain many species which depend on one another for survival. Therefore, studying food web dynamics of rivers could improve our knowledge on the state of the ecosystem, how energy is transferred between organisms, and the potential future trends of the inhabiting species. The drivers for survival and growth of Atlantic salmon (*Salmo salar*) populations in their northern limit needs to be further studied to better predict and manage the changes in population dynamics, especially as each population may respond differently to environmental variables. Additionally, the River Continuum Concept (RCC) shows that invertebrate communities will change along the river due to stream size and nutrients, and by investigating whether the invertebrate community within the river follows the RCC allows managers to better support the production of Atlantic salmon.

Ada Fontrodona-Eslava (University of St Andrews)
Spatial heterogeneity in tropical freshwater fish diversity revealed by a multidimensional analysis.

Abstract
Freshwater fish are one of the most imperilled biological groups on Earth due to the many anthropogenic impacts affecting freshwaters. Accordingly, a major research challenge is to identify diversity hotspots for this group. In order to do so, it has become increasingly apparent that one must measure the distribution of multiple dimensions of biodiversity. With the aim of informing conservation decision making, we quantified the geographic distribution of three

diversity dimensions of the tropical ichthyofaunas of Trinidad and Tobago using an extensive dataset of fish abundances collected in the late 1990s. We uncovered substantial spatial heterogeneity in the distribution of the phylogenetic (PD), functional (FD) and taxonomic (TD) dimensions of fish diversity in both islands. Our analyses revealed that the currency used to measure fish abundance (i.e. numerical abundance or biomass) changes our perception of which areas harbour the highest levels of PD, FD and TD. These results reaffirm the idea that species, ecological traits and evolutionary distances provide unique insights into the spatial distribution of fish diversity. They also show that the abundance currency is an important element that determines which patterns are observed for any biodiversity dimension. We discuss the importance of these findings in elucidating ecological understanding and their implications for informing conservation priorities for tropical fish assemblages.

Faye Moyes (University of St Andrews)
Spatio-temporal trends in rarity in Scottish marine systems.

Abstract
As is well known, the world's oceans are experiencing a biodiversity crisis. However, to date, little attention has been devoted to temporal trends in the rarity of marine fishes. The concept of rarity covers variation in abundance, geographic distribution, and functional traits. This paper takes this multi-faceted approach to quantifying rarity and asks how rarity in fish communities is varying over space and time in Scottish waters. To do this we use 30 years of scientific trawl data, and employ a range of statistical tests to identify the species that have become rarer over this time period. The analyses uncover substantial heterogeneity in the geographic distribution of rarity patterns with some species emerging as 'winners' in some localities and 'losers' in others. Overall there is greater evidence of increasing rarity in the NE Atlantic than the North Sea. Our results also show that metrics that quantify taxonomic and functional rarity describe complementary aspects of species status, and demonstrate the importance of a multi-pronged approach is assessments of biodiversity change. Scotland's fisheries are of important economic value and understanding patterns of change in these systems is vital in protecting this valuable resource.

Jean-Hervé Mvé Beh (Institut de Recherches Agronomiques et Forestières)
Structure of Ichthyological biodiversity in an equatorial estuarine mangrove ecosystem, the Akanda National Park (Gabon).

Abstract
Mangrove ecosystem are among the most productive tropical and subtropical coastal forest ecosystems in the world. Their function in supporting the renewal of fish stocks is well documented. However, in Central Africa, specifically in Gabon, few scientific studies on the ichthyofaunal biodiversity of mangrove ecosystems have been carried out. Many protected areas including mangroves, notably the Akanda National Park, have been created and used as strategic tools to preserve the renewal of fish populations exploited by fishing in Gabon. The purpose of this study is to draw up an inventory of the different fish species in the Akanda Park and to study ichtyofaunal community organization. With a surface area of about 53.780 ha, the Akanda Park is located between the Libreville peninsula and Equatorial Guinea.

Ichthyofauna was collected using trammel gillnets during the four main hydro-climatic seasons of the region: High Rainy Season, High Dry Season, Low Rainy Season and Low Dry Season. The results reveal the presence of 59 fish species belonging to 30 families. The best-represented family is the Clupeidae family with 5 species. The most abundant species is *Pseudotolithus elongatus* (18% of the total abundance). From a biomass point of view, *P. elongatus* (24% of the total biomass) is in first place followed by *Chrysichthys nigrodigitatus* (21%) and *Plectorhinchus macrolepis* (11%). The size spectrum reveals a fish assemblage dominated by small size individuals. The Shannon index and equitability justify the absence of strongly dominant species. The evolution of the depletion curve reflects an increase in species richness as a function of sampling effort. Estuarine species of marine origin and Marine-estuarine species, first level predators mainly benthophagous and second level generalist predators mainly feeding on fish, shrimps and crabs are the most present, whatever the season and the site. *Pellonula leonensis*, *Chaetodipterus lippei*, *Eucinostomus melanopterus*, *P. macrolepis*, *Pomadasys jubelini*, *Periophthalmus barbarus*, *Neochelon falcipinnis* and *Pellonula vorax* form the characteristic fish assemblage in the mangrove zone of Akanda National Park. The results of this study are useful for the sustainable management of fisheries in Akanda Park and its surroundings.

Nathan Vranken (Department of Biology, KU Leuven and Royal Museum for Central Afrika)
The diversity of haplochromine cichlids from the Lake Edward system.

Abstract
About one out of ten extant fish species is a cichlid. Cichlids acquired their extraordinary species richness and diversity in morphology and ecology through their ability to undergo adaptive radiation in lacustrine environments. Especially well-known are the large East African cichlid flocks of Lakes Malawi, Tanganyika, and Victoria, which count 250–1,000 species each. Extensive research on these cichlid flocks has propelled them as a well-established model system in evolutionary biology. The extraordinary species richness of cichlids coupled with subtle interspecific morphological differences explains why many species remain undescribed and unknown to science. This especially holds for the cichlid assemblage from the Lake Edward system (Uganda, DRC). After the cichlid assemblages of Lakes Malawi, Tanganyika, and Victoria, the cichlid assemblage of the Lake Edward system is the fourth largest. Of the estimated 60–100 Haplochromis species that are endemic to this system, 34 have been formally described. We are performing a systematic revision of the Haplochromis species from the Lake Edward system. We group specimens based on morphological characteristics that suggest a similar trophic ecology. For each group, we perform a morphometric study and species are delineated and (re)described. Additionally, the morphological variation of all species and trophic groups is quantified and compared using a geometric morphometric method. Hitherto, we revised 23 Haplochromis species within five trophic groups, 17 of which are newly described in our study. The latter include three species of oral snail shellers with very different oral jaw shapes and dentitions and ten piscivores with different body shapes and colour patterns. Our geometric morphometric framework currently includes 28 (presumed) species. While some trophic groups are not yet represented, preliminary results suggest partial separations between piscivores, zooplanktivores, algae scrapers, and all other trophic groups combined.

Aurélien Delaval (Nord University)
Unravelling patterns of population structure, adaptation, and local abundance in the critically endangered blue skate *Dipturus batis* using molecular approaches.

Abstract
Many elasmobranch species have undergone drastic population declines as a consequence of fishing pressure during the last century, and qualify as critically endangered. Despite landing bans, they still come into conflict with fishing activities and are sometimes *unavoidably caught as by-catch*. Once abundant in European waters, common skate (*Dipturus batis*-complex) are now effectively extirpated in the North and Irish Seas, and their status in other areas is unknown. By-catch of common skate, despite fishing restrictions, represents both a conservation and a socio-economic concern. To complicate matters, taxonomic confusion among large European skates has clouded the already limited historical catch data on these species, undermining species-specific assessments and conservation measures. In fact, common skate have only recently been recognized as two distinct species, the flapper skate (*Dipturus intermedius*) and the blue skate (*Dipturus batis*), which have an overlapping range. *D. batis* has a patchy distribution characterised by zones of high abundance, sometimes occurring at or near important fishing grounds. It has become imperative to evaluate the degree of spatial connectivity among extant populations of *D. batis*, and to investigate patterns of local adaptation and habitat use, in order to help inform distribution-wide conservation measures. Furthermore, population demographic models are urgently needed to inform local actions in areas particularly prone to by-catch. Addressing these challenges requires a multidisciplinary and multi-stakeholder effort. Recent advances in molecular approaches offer new solutions to address longstanding questions, and may play an important role in elasmobranch conservation efforts.

Heleen Maetens (Royal Museum for Central Africa)
Unravelling the species diversity of the genus *Enteromius* (Cyprinidae) from the Lake Edward system (East Africa).

Abstract
Enteromius Cope, 1867 (Cypriniformes: Cyprinidae), harbouring species of small African diploid barbs, is currently the third largest fish genus in the world. The identification of several species of *Enteromius* is difficult, because many species are morphologically similar and identification keys or large-scaled revisions are lacking. We performed a case study on the species of *Enteromius* from the Lake Edward system, situated in the East-Coast Ichthyofaunal Province, and found an unrecognised diversity within the species of *Enteromius*. Initially, five species were recognised for the system: three species with an ossified dorsal spine with serrations (*E. apleurogramma, E. kerstenii, E. pellegrini*) and two species with a smooth dorsal spine (*E. perince, E. stigmatopygus*). Based on a combined approach of genetics (COI, mtDNA) and morphometrics, we found the presence of nine putative species within the initially presumed five species of *Enteromius* from the system. No additional species were found for the specimens with a smooth dorsal spine, though they were re-identified as *E. alberti* and E. cf. mimus based on morphological differences and a genetic distance of 8.5%. Within the three species with an ossified and serrated dorsal spine, *E. apleurogramma, E. kerstenii* and *E. pellegrini*, we found respectively 2, 2 and 3 lineages with genetic distances between 2.38%

and 13.45% and morphological differences based on multivariate analyses. An extension of our study to neighbouring systems showed that some populations from outside the study area represent other lineages within the three species complexes of specimens with an ossified and serratulated dorsal spine from the Lake Edward system. Unrecognised diversity was also found in a.o. the Congo basin (23 genetic lineages in four species) and Kenyan rivers (6 genetic lineages in two species). The results of all these studies suggests that *Enteromius* is even much more species-rich than currently known: 211 valid species and counting.

Oriol Canals (AZTI)
Unveiling deep-sea fish ecological patterns and diel vertical migratory behaviour through environmental DNA.

Abstract
Despite the still poor understanding of the deep-sea, recent estimates suggest that its upper layer, the mesopelagic zone (from 200 to 1000 m depth), holds up to 90% of the total fish biomass, which, in a context of increasing global human population and need to end overfishing, uncovers an alternative source of food and other resources. However, mesopelagic fish also provide other critical ecosystem services by contributing to global carbon sequestration and ensuring vertical marine trophic connectivity through diel vertical migrations; they travel hundreds of meters towards the surface at night to feed and return to the depths at sunrise to avoid predation. Therefore, in view of the potentially critical role of the deep-sea in climate change regulation and imminent vulnerability to biodiversity loss, an understanding of the fish diversity and ecology inhabiting this realm is required. This knowledge, that cannot be obtained through traditional methods due to the vastness and inaccessibility of the deep-sea, could be provided by the analysis of the environmental DNA (eDNA) released by fish into the water column. Here, we have amplified and sequenced fish eDNA from ocean vertical profile samples (down to 2000 m depth) from the Bay of Biscay. We found that fish eDNA is vertically structured according to species distribution and reflects diel community shifts that are consistent with the vertical migratory behaviour of many mesopelagic fish. Our results highlight the potential of eDNA-based studies to improve knowledge on the remote dark ocean, which is critical to promote a sustainable use of its resources.

Michael E. Curtis (Texas A&M University - Corpus Christi)
Variation in habitat use and trophic dynamics of catadromous fish (*Anguilla rostrata*) in Sub-Tropical Texas.

Abstract
Habitat use and food-web dynamics of American eel (*Anguilla rostrata*) have been rigorously studied in temperate regions along the East Coast of North America. This research has been vital in identifying essential habitat and delineating migration patterns for the species in that area, but similar rigor has yet to be applied to studying the species in sub-tropical regions of North and Central America. This project in sub-tropical Texas attempts to remedy this by using otolith microchemistry to elucidate the frequency, duration, and intensity of transhaline migrations and muscle tissue stable isotope analysis to serve as a secondary migration proxy

and differentiate between primary food sources and trophic levels. Barium (Ba) is the preferable trace element to quantify fish migrations in Texas' hydrological systems due to the state's limestone dominant geological make-up. Patterns in the ratio of Barium to Calcium (Ba:Ca) deposition in fish otoliths are indicative of temporal shifts in salinity most commonly associated with migrations between freshwater and estuarine or marine environments. This method will be used in conjunction with stable isotope analysis of δ13C, δ15N, and δ34S in muscle tissue to shed light on individual habitat use and food-web ecology. δ13C and δ15N will provide insight into the trophic dynamics and serve as a second proxy for elucidating migration histories, while inclusion of δ34S analysis should help identify and differentiate primary food sources.

Sam Fenton (University of Glasgow)
Adaptive divergences in head and body shape show divergence in phenotypic and genetic parallelism across ecomorph pairs of Arctic charr.

Abstract
The repeated, independent, evolution of similar phenotypes under similar environmental stimuli, known as 'parallel evolution', is a potentially powerful predictive tool. However, to be used effectively we first need to know the extent to which the evolutionary trajectories of key phenotypic traits are truly parallel, and secondly whether parallelism is achieved through similar genomic pathways across replicates. To explore this, we investigated parallelism in head and body shape morphology across four sympatric benthivorous-planktivorous ecomorph pairs of Arctic charr (*Salvelinus alpinus*) found in Scotland (N=341). Morphological analyses showed that the patterns of divergence in head and body shape morphology between ecomorphs were not consistent across lakes. Departures from parallelism in evolutionary trajectories were not clearly explained by differences in ecosystem size. Additionally, a Genome-Wide Association Study (GWAS) from ddRADseq data (13,071 loci) found that none of the SNPs that were significantly associated with head or body morphology were consistently differentiated between ecomorphs across all four lakes. These results suggest that even these seemingly similar phenotypes, identified in repeated eco-morphological divergence across many Arctic charr populations, can show strong departures from true parallelism across replicates and can arise through different genomic bases.

Alexandrea Dickey (University of New Brunswick)
An inter-connected benthic to pelagic baseline of the Bay of Fundy marine food web.

Abstract
Food webs are fundamental to ecosystem function and, by extension, an understanding of food web processes is intrinsic to understanding how ecosystems function. Marine ecosystems are fueled by two primary food chains, the pelagic (open water) food chain and the benthic (seafloor) food chain, which are combined through the movement of nutrients, energy, and mass in a process called benthic-pelagic coupling. Where species predominately obtain their resources ranging from benthic to pelagic will influence the quality and quantity of prey they consume and aid in understanding their potential response to environmental changes, but these dietary relationships are often challenging to describe. We analyzed diet

and benthic-pelagic resource use of 41 fish and 49 invertebrate species in the Bay of Fundy, Eastern Canada to estimate how benthic and pelagic resources are coupled in this ecosystem. While much is known about individual key species in the Bay it is understudied regarding resource pathways that fuel these species. Preliminary data suggests that benthic and pelagic food chains are quite distinct within the Bay, with few species integrating both resources. The benthic portion of the food web may be fueled by inshore production. The Bay has some of the largest tides globally and the movement of such a large volume of water could also be displacing inshore production which ultimately settles on the seafloor to be a resource for benthic consumers. This food web will provide information about the connectedness of the ecosystem and assist fisheries and aquaculture in operating sustainably within the Bay.

Clive Trueman (University of Southampton)
An overview of the use of isotope-based estimates of field metabolic rate and experienced temperature in fishes.

Abstract

The relationship between temperature, oxygen availability and fish performance is fundamental to our understanding of the response of fish communities and species to climate change. The responses of fish to challenges imposed by temperature and oxygen conditions reflects physiological potential, phenotypic plasticity and behaviour. Most research into fish metabolic physiology draws on laboratory-based quantifications of aerobic scope. The extent to which fishes mitigate limiting effects of warming or oxygen availability through behavioural or phenotypic responses is unclear and limited by our relative lack of knowledge of physiology of aquatic animals operating in the wild. Recently, we have developed a method to infer relative and in some cases absolute field metabolic rates retrospectively based on the stable isotope composition of fish otoliths. While this method is still in early stages, here we will outline some potential applications across the growing field of fish eco-physiology.

We provide insights into:

(1) Seasonal variations in field metabolic rates within populations and their relationships to experienced temperature and feeding and reproductive cycles
(2) Ontogenetic variations in field metabolic rate and relationships to life history traits
(3) Thermal preferences and thermal sensitivity of field metabolic rates
(4) Effects of marine protected areas on thermal preferences and field metabolic rates
(5) Body mass and temperature scaling of field metabolic rates across broad taxonomic and functional groupings.

Coupled with oxygen based isotope thermometry and increment analyses, our proxy provides unparalleled insight into the environmental conditions chosen by individual fish throughout ontogeny and their metabolic responses.

Henrik Christiansen (Department of Biology, KU Leuven)
Genomic differentiation and indications for spatially divergent adaptation in an Antarctic fish.

Abstract

Genomic differentiation is determined through the interplay of genetic drift, gene flow and

selection. The marine ecosystems of Antarctica harbor a unique endemic fish fauna, but global change is threatening these species, albeit with opposite effects in time and space. Populations near the West Antarctic Peninsula are facing warming and sea ice reduction, while sea ice cover recently increased in parts of East Antarctica. We investigated genetic variation and differentiation in the Antarctic fish *Notothenia coriiceps* from these localities through reduced representation sequencing. Large scale population structure was apparent but subtle (FST up to 0.02) suggesting that high connectivity across vast distances occurs, likely via ocean currents. Genotype-environment associations and genome scans for selection indicate spatially divergent adaptation patterns that may be interpreted as local and/or recent adaptation. Selection signatures near antifreeze glycoprotein genes show that potentially important genomic variability is distributed unevenly across the Southern Ocean. Although warranting further corroboration, these results are likely important for spatial conservation plans, such as the envisioned Antarctic marine protected area network. Population resilience and adaptation potential should be considered to maximize the long term impact of conservation under rapid climate change.

Diana Santos (ICBAS - University of Porto)
Gonadal staging and selected biometric and blood parameters along a breeding cycle of brown trout cultured in Portugal (North).

Abstract
Brown trout (*Salmo trutta fario*) has a recognized environmental and economic valuation. However, the limited knowledge regarding the physiological variations in adult cultured individuals can restrict its use as a model organism. In this context, this study evaluates fitness parameters and gonadal maturation of cultured adult brown trout from both sexes, along a reproductive cycle (North of Portugal). Sampling was performed in four different seasons: spawning capable (December), regressing (March), regenerating (July) and developing (November). A systematic characterization of distinct parameters was carried out, including biometric, biochemical, hormonal, and a histomorphological grading of the gonads. In general, overlapping patterns were obtained between November and December, and March and July. The body weight, length and liver weight were lower in spawning capable season, while gonad weights were the highest. Cholesterol, low-density lipoprotein (LDL) and total protein showed the lowest concentrations during the developing and spawning capable seasons, probably due to the higher metabolic demand at these stages. As to the hormones, 11-ketotestosterone (11-KT) and testosterone (T), for males, and estradiol (E2) and T, for females, mostly explained the seasonal hormonal changes. In males, 11-KT concentrations reached a peak in the developing season, as occurred for E2 in females. Along the different seasons, male and female gonads were histologically categorized into four and five maturation stages, respectively. The established multi-parameter profile in brown trout was found to be sex- and season-specific, having high potential to be used as a reference to assess the gonadal status of aquacultured and likely wild populations.

Sarah R. Alewijnse (University of Southampton & Natural History Museum London)
How does field metabolic rate scaling vary across a broad taxonomic and functional groups of fishes?

Abstract
Many hypotheses seeking to explain how fishes respond to climate change are informed by aerobic potential as determined in laboratory measures of standard and maximum metabolic rates. Field metabolic rates (FMRs) - the total (time-averaged) metabolic cost experienced by a wild organism living in its natural environment – provide a more ecologically relevant measure of the energetic response of fishes to experienced conditions. Despite this interest, there are relatively few studies of FMR in fishes; largely due to a lack of suitable measurement techniques. Consequently, we have little understanding of the thermal sensitivity of FMR in fishes, or scaling of FMR with body size and temperature across functional or taxonomic groups.

Carbon in fish blood, and otolith aragonite, is derived from metabolic and external sources which are isotopically distinct. The isotopic composition of carbon in otoliths reflects the proportion of metabolic carbon in the blood and therefore the rate of metabolic oxidation of diet (i.e. oxygen consumption rate); therefore it is possible to use otolith δ13C as a proxy for FMR. The availability and ease of sampling otoliths available makes this technique ideal for the study of FMR at a macroecological scale. Here we explore variations in FMR across 50+ species of marine fishes. We examine body mass and temperature scaling of FMR and how this is influenced by factors such as habitat, depth and shared evolutionary histories. By understanding macroecological patterns in FMRs we hope to better understand how wild fishes will respond to warming oceans.

Kirthana G. Pillay (Bangor University)
Insights into adaptive dietary preferences of cichlid ecomorphs (*Astatotilapia calliptera*) from Lake Massoko using metabarcoding.

Abstract
Haplochromine cichlids from the Great African Lakes of Malawi, Tanganyika and Victoria have been textbook examples of adaptive divergence. However, the mechanisms that underpin the early stages of adaptive radiations are still poorly understood. Close relatives of haplochromines from Lake Malawi exist in neighbouring lakes and streams. One such species is *Astatotilapia calliptera* or commonly known as the Eastern Happy is found in Lake Massoko in Southern Tanzania. The species occurs in two ecomorphs, the yellow (littoral) and blue (benthic). Previous studies have shown that individuals from the extremes of the depth continuum (5 – 25m) differ in overall body shape, pharyngeal jaw morphology and microhabitat and mate preference, highlighting early stages of divergence. Dietary studies conducted in the past have indicated presence of trophic specialisation between the ecomorphs. However, only stable isotopes were used to analyse these dietary preferences. To obtain greater clarification of the presence of dietary partitioning between the ecomorphs and consequent insights into mechanisms underpinning adaptive divergence, we used high throughput sequencing (HTS), specifically metabarcoding of stomach contents. A combination of COI and 18S metabarcoding markers were used to amplify target prey DNA in the stomach contents, resulting in a broad assessment of dietary content. The prey composition will be compared and contrasted between the two colour morphs, in relation to spatial and trophic ecological strategies in order to investigate if dietary partitioning could have contributed towards potential incipient sympatric speciation. Findings will contribute to broader understanding of speciation mechanisms and identify drivers of adaptive divergence.

Maria João Rocha (ICBAS – University of Porto)
One-year-old brown trout juveniles are often experimentally dealt with as equals regarding morphological characteristics and sex-hormonal profile, but, are they?

Abstract
Salmonids have vast ecological and economic importance. Additionally, they are used in experimental research, both connected with aquaculture and with biomedicine and toxicology. The brown trout (*Salmo trutta*) is one salmonid commonly used in experiments, including those investigating impacts of chemicals considered endocrine disruptors (EDCs). In these assays, it is typically assumed that juveniles “have no sex”, meaning that they are viewed as being equally governed by endogenous sex-steroids and evenly impacted by EDCs. Yet, basic information about sex-steroid levels and gonadal structure in brown trout juveniles is missing in the literature. It is essential to fill this caveat, even more because the *S. trutta* complex includes populations with ecological, physiological and phenotypical differences. We studied the body biometry, gonadal histology and blood sex-steroids (n = 38) of 1.5-year-old cultured brown trout (North of Portugal). The sex was disclosed exclusively by histology. Males and females had similar biometry (body mass = 90 g). The plasma levels of ten fundamental sex-steroid hormones were measured by gas chromatography-mass spectrometry: i) androstenedione, ii) 17α,20β-dihydroxy progesterone, iii) 17α-hydroxypregnenolone, iv) 17α-hydroxyprogesterone, v) oestrone, vi) 17β-oestradiol, vii) 11-ketotestosterone, viii) pregnenolone, xix) progesterone and x) testosterone. Depending on the steroid, averages ranged from 0.16 to 0.53 ng/L. Males and females statistically differed in the levels of oestrone, progesterone and 17α-hydroxyprogesterone. In summary, the analysed male and female juveniles had histologically distinct gonads and differed in three sex-steroids average concentrations. The findings are useful to improve experimental designs with brown trout juveniles and data interpretation.

Bethany Smith (FSBI/The University of Glasgow)
Performance consequences of thermal adaptation in geothermal sticklebacks.

Abstract
Climate change represents the greatest anthropogenic threat to global biodiversity in human history. Fish, as ectotherms, are expected to be particularly vulnerable to climate-change driven increases in surface temperatures. Wild fish populations will need to either migrate to cooler temperatures or adapt to persist. While physiological traits have so far been the focus for temperature adaptation, entire habitats will be altered under climate change with adaptation reflected in a range of traits. To address this, I used a field reciprocal transplant experiment to test the influence of morphology on the performance of three-spined sticklebacks (*Gasterosteus aculeatus*) putatively adapted to different but adjacent thermal habitats as a result of natural geothermal activity. The results of this experiment showed an effect of the transplant on measures of performance (survival and *Schistocephalus* solidus parasite prevalence) suggesting adaptive divergence between warm and cold sticklebacks. Morphology was found to interact with weight and length change performance measures in the transplant, with allometry of shape also playing an important role.

Olivia Meredith Simmons (Bournemouth University)
Predicting the effects of environmental factors and juvenile body length on adult marine return rates of Atlantic salmon *Salmo salar*.

Abstract
Globally, populations of Atlantic salmon, *Salmo salar*, have declined for decades. There are many factors thought to be contributing to this trend, including habitat degradation, over-exploitation, and climate change. As an anadromous species, adult return rates from marine habitats to freshwater are typically quite low. Recent work has shown that smolts with large body lengths at the onset of their seaward migration are more likely to survive at sea and return to freshwater as adults. Knowing that larger smolts have higher adult return rates, we tested whether this signal is robust to a suite of biotic and abiotic factors, such as sea surface temperature and sea bass abundance, in the estuary during the early part of their migration. To do so, we used data from a thirteen-year dataset where up to 600 PIT-tagged smolts were captured and measured annually during their migration down the River Frome, UK. We developed a state-space model to describe the probability of individual *S. salar* returning as one sea winter or multi sea winter adults while accounting for imperfect detection. These results should be of interest to scientists and river managers working on salmon restoration projects.

Yuan Tian Chou (University of Southampton)
Predicting whether high resolution otolith isotope compositions can shed light on early life history migrations- A case study with Atlantic.

Abstract
Marine fishes commonly transition between distinct habitats throughout their lifetime, particularly in larval stages. Such transitions are essential as environmental demands and predation pressures experienced by fishes change dramatically with increases in body size. Understanding the nature of habitat use, habitat connectivity and ontogenetic timing of habitat transitions is key to establishing management practices covering whole life histories for commercially, recreationally and ecologically significant species.

Tracing movements of individual larval fishes is extremely challenging as they are too small for most conventional tagging approaches and high natural mortality means large tagging programs are needed. Otolith microchemistry is an attractive alternative for reconstructing high-resolution movements if fishes move across suitable chemical gradients.

The stable isotope composition of oxygen in otolith aragonite is a very attractive tracer as it is relatively predictable based on widely measured and modelled ocean variables (temperature and salinity). Emerging analytical methods enable subsampling of larval fish otoliths and generation of time-resolved isotopic records potentially revealing larval movements. However such analyses are logistically challenging and costly to commit.

Here we draw on particle drift modelling to predict a priori whether high-resolution otolith analyses of North East Atlantic mackerel larvae have potential to discriminate among different larval drift scenarios. We show the potential and limitations of using otolith δ18O file to identify the early life history characteristics. Our method is directly transferrable to species with pelagic larval stages and may help to focus resources on species and regions where larval drift questions are reasonably tractable using stable isotope tracers.

Roweena Patel (University of Reading)
Seasonality of diet overlap among small pelagic fish in the waters southwest of the UK.

Abstract
Small pelagic fish (SPF) are of considerable commercial importance, representing more than 25% of the world's fisheries landings. They are predominantly planktivorous and therefore play an important role in marine ecosystems, linking lower and higher trophic levels. The Celtic Sea, English Channel, and Irish Sea are home to several SPF that spend some or all their life in these waters. The recent increase of European anchovy in this area is one example of changes in the SPF community composition, which may alter interspecific competition, and, in turn, may affect SPF population dynamics. This study analysed the seasonal diet composition and prey selectivity (distinguished by size of prey) of six co-occurring pelagic species (anchovy, herring, horse mackerel, mackerel, sardine, and sprat) in the waters southwest of the UK. Primary data on fish stomach content (FSC) was collected during Cefas' Peltic Survey in October 2019 to supplement historical data from DAPSTOM (a FSC database). Using the compiled data, diet-overlap indices (e.g. Pianka index) were computed to quantify and understand potential intra- and inter-specific competition. The results show that although calanoid copepods were the dominant prey for many species, they all exhibited generalist characteristics, exploiting different size prey groups across seasons. To our knowledge, this is the first study in this region that showed seasonal variability in diet overlap among the six SPF, providing novel insights into pelagic food-web dynamics. Ecosystem-based fisheries management and modelling approaches should account for the seasonal variability in diet composition and overlap to sustainably manage SPF stocks.

Ryan Alexander Saunders (British Antarctic Survey)
Spatial and temporal patterns in the benthopelagic ecology of *Gymnoscopelus nicholsi* around South Georgia (Southern Ocean).

Abstract
Myctophids (Family Myctophidae) are the most abundant and diverse mesopelagic fishes in the Southern Ocean. They are a conduit of energy between primary consumers and higher marine predators, and between the surface layers and mesopelagic depths. However, there remain major uncertainties about the ecology of all species, particularly regarding the spatial and temporal patterns in their biomass and their population dynamics in waters south of the Antarctic Polar Front. *Gymnoscopelus nicholsi* is a relatively large and biomass-dominant species in the Southern Ocean community that has a benthopelagic phase in its lifecycle. It plays a key role in local food webs, but little is known of its ecology, particularly in the benthopelagic habitat. Here, we examined inter-annual variation in benthopelagic *G. nicholsi* biomass and distribution patterns at South Georgia using bottom trawl data collected around the island's shelf slope between 1987 and 2019. We found that *G. nicholsi* occurred mostly to the northwest of South Georgia and that there was high inter-annual variation in its mean biomass, ranging between 1 and 2480 tonnes in austral summer. There was a significant ($P<0.01$) positive linear relationship between mean *G. nicholsi* biomass and both monthly mean sea surface temperature (SST) and chlorophyll a at the island. There was also a significant ($P<0.01$) positive linear relationship between its mean depth distribution and SST, further indicating that temperature is an important driver of its ecology. We found evidence of

distinct cohorts, which we attribute to ages III-V, variability in recruitment and that Antarctic krill dominated the diet (>95 %M) of the largest cohorts. Our study provides important information for new ecosystem studies in the Southern Ocean.

Sarah J. Salisbury (Dalhousie University)
The Loss of Anadromy in an Arctic Fish (*Salvelinus alpinus*) and its Genomic Causes, Consequences, and Consistency.

Abstract
Although many anadromous fishes are known to occasionally remain in freshwater year-round, the genetic underpinnings of this life history change are not well understood. Populations of anadromous fishes that have recently become trapped in freshwater, resulting in a “landlocked” population, therefore offer a unique opportunity to investigate the genetic causes and consequences of the loss of anadromy. Physically and genetically isolated, landlocked populations may quickly genetically differentiate from anadromous populations due to consistent divergent selective pressures. Alternatively, the genetic isolation of landlocked populations may lead to genetic drift and hinder parallel adaptive genetic differentiation across replicate landlocked populations. Knowledge of the repeatability of genetic differentiation between landlocked and anadromous populations is critical for understanding how morphs evolve and how to manage them in the face of climate change. This is particularly salient for Arctic Charr (*Salvelinus alpinus*), the most northerly freshwater fish in the world, as climate change is predicted to select against anadromy in this species and instead favour non-anadromous morphs. Anadromous Arctic charr, however, are highly economically and culturally significant as the basis of multiple subsistence, recreational, and commercial fisheries throughout their Holarctic distribution. We therefore employed an 87k SNP array to investigate seven replicate pairs of geographically proximate landlocked and commercially harvested anadromous Arctic charr populations within Labrador, Canada. As expected, paired landlocked and anadromous populations were characterized by high genetic differentiation. There was generally little consistency in outlier SNPs differentiating landlocked and anadromous populations, potentially due to high levels of genetic drift in landlocked populations. However, we detected several outlier SNPs which were consistently differentiated between multiple pairs of landlocked and anadromous populations. These parallel outlier SNPs were associated with functionally-relevant genes suggesting the potential for consistent adaptive genetic differentiation among anadromous and non-anadromous populations. These results suggest that the loss of anadromy may be at least partially genetically predictable. The candidate loci uncovered by this work therefore provide an important resource for conserving anadromous and non-anadromous morphs in Arctic charr and other fishes in light of these morphs' different potential vulnerabilities to ongoing climate change.

Joseph Jones (University of Southampton)
The relationship between Field Metabolic Rate and temperature expressed by North Sea Pleuronectes platessa among sexes, seasons and years.

Abstract

The performance of fishes in the wild is constrained by experienced temperature and oxygen availability. Attempts to predict fish distributions and performance in future oceans hinge on predicting how aerobic scope will change with a given temperature change, and the proportion of aerobic scope that is available to maintain fish performance above maintenance levels. The extent to which behavioural and or phenotypic plastic responses are able to act as an “aerobic buffer” is, however, uncertain – largely as we lack detailed observations of the metabolic rates expressed by fish operating in natural conditions.

Here we report seasonal variations in temporally-averaged field metabolic rate recovered from 600 free-roaming European plaice from the North Sea. We use a new proxy for field metabolic rate based on the isotopic composition of carbon in archived otoliths. We report variations in expressed field metabolic rates across seasonal, annual and decadal time scales to explore the proportion of metabolic variability that is explained by external water temperature compared to behavioural activities.

We show that body temperature has a minor positive influence on expressed field metabolic rate, but seasonal and among-individual variations in FMR far exceed predicted thermal effects on SMR. Estimated FMR peaked in autumn months prior to spawning, and overall females displayed higher FMR than males. The majority of individuals expressed time-averaged FMR estimates less than 3 times the predicted SMR.

These data provide a framework for considering the implications of thermal influences on physiological performance in wild fishes across populations, seasons and sexes.

Sarah M. Maes (Department of Biology, KU Leuven)

Traditional and DNA-based diet assessment reveal novel prey items of polar cod.

Abstract

Polar cod (*Boreogadus saida*), an abundant circumpolar fish, functions as a key species in the Arctic marine food web. We investigated its stomach content from samples collected in the Barents Sea in July 2017. Two methods of prey identification were used in parallel to obtain an inventory that is as complete as possible: DNA metabarcoding and visual morphological identification. Both methods showed that the diet was dominated by pelagic amphipods and krill. Many prey items identified visually could be classified at a higher taxonomic resolution, often up to species level, with COI barcodes. Moreover, the molecular approach allowed for the genus/species-level taxonomic identification of digested and unidentifiable prey. For example, molecular identified fish and barnacles were undetected by visual analysis, suggesting a higher importance of these prey items than previously recorded. Metabarcoding failed, however, in some cases to find prey species either identified morphologically or documented in the literature. In summary, DNA-based identification revealed several novel and previously undetected prey items of polar cod in the Barents Sea. Moreover, the prey of several Atlantic fish species and the temperate-boreal Northern krill point to the increasing presence of boreal species in the Barents Sea. The combination of traditional visual analysis and DNA metabarcoding provides powerful and complementary information of partially digested prey and insights on the diet composition of polar cod.

Ryan Alexander Saunders (British Antarctic Survey)

Trophodynamics of Southern Ocean lanternfish (Family Myctophidae) in the Scotia Sea.

Abstract
Lanternfish are the most abundant and diverse mesopelagic fishes in the Southern Ocean. They are an important conduit of energy between primary consumers and higher marine predators, and between the surface layers and mesopelagic depths. However, there remain major uncertainties about their ecology, particularly regarding their abundance, population dynamics and trophodynamics in Antarctic waters. Here, we give an overview of the trophic ecology of the biomass-dominant species in the Scotia Sea, using conventional stomach content data from samples collected between the Antarctic Polar Front (APF) and the sea-ice zone in different seasons. Our data show that Southern Ocean lanternfish are opportunistic zooplankton feeders, consuming mostly copepods, small euphausiids and amphipods, although there are inter- and intra-specific, regional and seasonal variations in diet. Lanternfish size appears to be the most important determinant of diet, with larger species and life stages able to predate increasingly larger prey. The Scotia Sea community appears not be in direct competition for food resources and their overall predatory impact on most zooplankton prey taxa are relatively low. Crucially, our analyses show that, in a system otherwise dominated by Antarctic krill, lanternfish link primary consumers to higher predators through both krill-dependent and krill-independent trophic pathways, emphasising their importance in regional food webs. We found that large lanternfish consume substantial proportions of krill across their distributional range and in different seasons, and collectively, they could consume as much krill as do all other vertebrates in the region. Conversely, there are several small lanternfish species that do not eat krill, consuming mostly copepods and other small euphausiids. The importance of lanternfish in this food web is likely to increase with projected redistribution and/or reductions in krill population biomass under realistic scenarios of ocean-warming in the region, as higher predators turn increasingly to alternative food sources. The consequences of such change for lanternfish are likely to be multi-faceted, highlighting the need for further studies to determine how lanternfish will respond directly to ocean-warming, and indirectly to changes in food web structure. This, in turn, will be crucial for understanding local food web and ecosystem stability under sustained environmental change.

Ecosystems, Fish and Fisheries in policy and governance

Charlie Huveneers (Flinders University)
Cross-jurisdictional movement patterns of sympatric temperate whaler sharks: implication for fisheries management.

Abstract
There is increasing number of global acoustic tracking network worldwide, including the Australian Integrated Marine Observing System Animal Tracking Facility (IMOS ATF) which facilitates large-scale, collaborative animal tracking research through the deployment of continental-scale curtains and grids of acoustic receivers. The network of receivers facilitated through IMOS ATF provides an opportunity to inform management of long-ranging, cross-jurisdictional species that are targeted by fisheries or of conservation concern. The bronze whaler *Carcharhinus brachyurus* and the dusky shark *C. obscurus* are globally distributed species, which are commercially and recreationally targeted in many parts of their distribution. Recent studies have shown that dusky sharks are found in South Australia (SA) and that large-scale movement occurs between SA and Western Australia (WA). A genetic study also

suggested that dusky sharks are panmictic across their Australian distribution, but that the bronze whaler population in WA might be separated. However, whether stocks represent demographically-independent units that can be modelled separately and the extend of movement across the species' distribution is still unknown. Here, we further investigate the broad-scale movement and level of connectivity of bronze whalers and dusky sharks between WA and SA using the network of acoustic receivers facilitated through IMOS ATF. A total of 163 *C. brachyurus* and 114 C. obscurus were tagged across both states. Most sharks were not detected in both states, those that did (9 *C. brachyurus*; 3 *C. obscurus*) showed frequent migration between the two states. Regularity of movement was species and state of origin dependent. While ~30% of SA-tagged C. obscurus were detected in WA, no WA-tagged C. obscurus were detected in SA. In contrast, only 2% of SA-tagged *C. brachyurus* were detected in WA, but 10% of WA-tagged *C. brachyurus* were detected in SA. Movement between the two states was regular and seasonal for both species. The ability to combine IMOS ATF receivers with community receivers enabled to identify annual migrations of coastal sharks not previously documented using other methods. Finding of this study will be relevant to the management of fisheries and provide information useful for understanding population dynamics, stock structure, and connectivity scales.

Josie South (South African Institute for Aquatic Biodiversity)
Cultural and socio-economic drivers of freshwater invasion pathways and management conflicts.

Abstract
Invasive species are a major driver of global change which are on track to continue rising for the next thirty years. Invasions can happen via stowaway and contaminant pathways; however, intentional human translocation is the main culprit. Invasive species are regarded as being predominantly negative with respect to biodiversity and there is compelling evidence of high economic cost as a result of management interventions. Total eradication of an established species is very rare and costly therefore effective policy to prevent introduction is integral for management. Considering the prevailing negative impacts of invasive species, understanding the positive perceptions and motivations for species introductions should be assessed with respect to socio-economic context. When there are both positive and negative aspects of a species there can be management and stakeholder conflicts which pose a barrier to conservation and legislation. We use case studies of common introduced freshwater fishes in the United Kingdom, South Africa and Brazil to show how different socio-economic forces drive patterns of introduction pathways between north and south hemispheres. The predominant pathways are aquaculture and fisheries enhancements and recreational angling. We combine this information with examples of specific changes and differences in legislation between the regions which exacerbate or ameliorate stakeholder conflicts. This information can be used to pre-empt management challenges and the development of "wicked problems" on a global scale.

Melina Nalmpanti (Aristotle University of Thessaloniki)
How effective are the varying protection levels within MPAs? A Mediterranean case study.

Abstract
Marine protected areas (MPAs) have been used as a successful management tool aiming to the conservation of fish stocks, habitats, and endangered species. MPAs are usually monitored to assess their effectiveness, with numerous studies demonstrating favorable results for fish communities within the boundaries of the protected areas. In the present study, we assessed the effect of varying levels of protection on the coastal fish species richness, abundance and diversity within the multiple-use National Marine Park of Alonissos Northern Sporades – NMPANS, Greece. Sampling was conducted using a non-destructive underwater recording method in three locations of different protection level (fully, partially and least protected area) inside the NMPANS during two seasons (early summer, when fishing pressure is still low, and late summer when fishing pressure is at its maximum by both professional and recreational fisheries mainly due to the peak of the touristic season). Overall, our results indicated that full and partial protection had a positive effect on richness, abundance and diversity. This was mainly attributed to the commercial species, which significantly benefited from fishing restrictions even when moderate measures were being applied. Concurrently, non-commercial species did not exhibit any significant community-level metric difference among the studied locations supporting that the observed differences for commercial species may be attributed to protection from fishing. Season had an effect on the fish diversity and richness, which were higher, in early summer, in the fully and partially protected zones compared to the least protected area. However, in late summer all three areas had similar community-level metric values which indicated homogenization of the communities and especially the FPA showed a significant decrease in diversity and richness. This points towards a decline in fish stock status in late summer, possibly linked to the intense fishing pressure as a result of insufficient enforcement of the fishing ban in the no-take zone of the marine park, as well as the high tourist season. In conclusion, protection from fishing seems to positively affect the coastal fish community within the NMPANS, however a more effective enforcement needs to be established especially during the summer months when tourist flow is high.

Masirika Joseph Matunguru (University of Burundi Doctoral School)
Lake Albert: The way forward for the sustainable use and conservation of this anthropo-ecosystem.

Abstract
Lake Albert is an international water body among the most important anthropo-ecosystem in African Great Lakes region shared between the Democratic Republic of Congo and the Republic of Uganda. It has a rich diversity of fish species and its significant contribution to the livelihoods of riparian communities in terms of water, fish supply, and opportunities employment.

Past and current research has enabled the research community to go this far, but long-term processes are needed to have more complete information to develop good policies and sound resource management for the millions of people who depend on this lake. This article describes past and current research, presents challenges and gaps, and suggests specific interventions to gain better knowledge for a healthier and sustainable Management. Thus, the long-term dynamics of this lake is under the constraint of many factors that act at different scales of space and time, namely: (i) Climate change, (ii) Changes in the composition of biological populations resulting from population dynamics: extension of the distribution area of

species or introductions of species, intentional or accidental, by man, by animals, by geological events which isolated or on the contrary ensured the connection between hydrographic basins. These changes can be manifested as well by the appearance of new species in the hydro system, as by the disappearance of other species, and (iii) Changes related to human activities that affect the lake. These changes may be the result of activities at local, regional, or global scales.

In Lake Albert, we note that fishing is the largest independent economic activity dependent on the lake and is probably the greatest threat to biodiversity. The conversion of fishermen into artisans requires support from the public authorities. It is at this level that we perceive that protecting the environment is ultimately everyone's business.

Therefore, there is a need to develop a transboundary plan for the sustainable management and conservation of fisheries and water resources of Lake Albert through an anthroposystemic approach consisting of the participation of all stakeholders including fishermen and fishmongers.

Agnes Dettai (Muséum national d'Histoire naturelle, Paris)

New insights in freshwater fish diversity in France and Western Europe and consequences on ecology studies and management.

Abstract

The ichthyofauna of Western Europe has been extensively studied and described over several hundred years, yet our understanding of the patterns of this diversity is changing to this day. In the last ten years, the boundaries between species have been reassessed in many freshwater fish groups with sometimes surprising results, and species has been revalidated or described in groups as diverse as pikes (*Esox* spp.), bullheads (*Cottus* spp.), chubs (*Squalius* spp.), minnows (*Phoxinus* spp.), stone loaches (*Barbatula* spp.), ninepsined-sticklebacks (*Pungitius* spp.), graylings (*Thymallus* spp.), and others. Beyond strictly taxonomic interest, these changes reflect new insights on the structure of genetic and morphological diversity with far ranging consequences. In many groups, these previously undetected new species are endemic to more restricted areas, such as river basins. This changes their potential protection status as well as policy and management recommendations, from river management to reintroductions. In particular, reintroduction with stock from different basins can threaten rather than help, as these can hybridize with or potentially compete with and replace the local species. As many of these new species were previously fused in single biological entities, physiological and ecological differences between these distinct groups inhabiting widely different environments (for instance the rivers from Southern and Northern Europe) went unexplored, and offer a vast field of study to re-evaluate their use as bioindicator species, potential as an economic resource or resistance to ecological change. Lack of knowledge has, and is still threatening these new endemic species with high patrimonial value.

Io Deflem (Department of Biology, KU Leuven)

Predicting fish community responses to environmental targets.

Abstract

The European Union (EU) adopted the Water Framework Directive (WFD) more than two

decades ago to diminish the degradation of freshwater ecosystems in the EU. Yet, both ecological and environmental quality targets do not reach the imposed standards and overall water quality remains poor, especially in Flanders (Belgium). Hence, identifying successful management actions should be prioritized to efficiently increase ecological water quality. To do so, we built a joint species distribution model (Hierarchical Modelling of Species Communities, HMSC) for riverine fishes in Flanders with the aim of increasing our understanding of responses of entire fish communities to current environmental policy targets. Environmental parameters represented physico-chemical and hydromorphological pollution and degradation, while we included pairwise waterway distances to account for spatial variation.

Targeting a 'good' environmental status, according to WFD targets, increased species richness with only a fraction of species (0.13 to 0.69 change in accumulated occurrence probabilities). When targeting a 'very good status', species richness increased with an average of 0.17 to 1.38 species. Simulations suggested that improving riverbed quality, nitrogen and conductivity levels led to the greatest increase in total number of species and should thus be the focal point of future policy actions. However, the overall low response to 'good' environmental quality, accompanied by complex interactions of nutrient-associated problems', indicate a challenging future for the restoration of Flemish riverine systems.

Darren M. Gillis (University of Manitoba/Biological Sciences)

Vessel performance and association networks in the Dutch offshore beam trawl fleet: an investigation with temporal exponential random graph models.

Abstract

Networks play a key role in the functioning of socio-ecological fishery systems. Most network studies among fish harvesters examining fishing success utilize interviews and questionnaires. Though insightful, such studies are resource and time-intensive and thus unlikely to be replicated frequently among years. Alternatively, records from commercial landings and vessel monitoring systems (VMS) provide continuous sources of information that can be used to examine variation in vessel networks through time. We used VMS data to define association networks among vessels that can be compared to their performance, as derived from landings data. The dynamics of vessel associations (changes in the networks) through four consecutive years was found to be related to vessel performance, target species, and landing port using temporal exponential random graph models (TERGMs). Ultimately, the relationship between vessel performance and network structure could affect the relationship between catch and nominal effort, influencing stock assessments and responses to management actions.

Posters

Ecosystems and dynamics of fish communities

Benié Rose Danielle Aboua (UFR Biosciences/Félix Houphouët-Boigny University)
A multimetric fish Index of Biotic Integrity (IBI) to assess the biotic integrity of Hana River in Tai National Park.

Abstract
The Hana River, a tributary of the Cavally River, is the main stream that crosses Tai National Park from northeast to southwest. This park, located in the south-west of the Ivory Coast, is the largest primary tropical rainforest in West Africa and known to be a biodiversity hotspot. However, anthropogenic activities around the park (agriculture, gold washing) could disturb the Hana River.

The purpose of this study is to assess the water quality of this river from the analysis of the structure of the fish population. Three stations (T1:5°55'332" N– 6°52’536" W, entry point to the park in the northeast, T2:5°24’318" N – 7°14’707" W, inside the park and T3:5°24’052" N – 7°14’662" W outside the park in the southwest) were sampled in the dry season (January and March 2016) using a battery of 10 gillnets (8-40 mm mesh) placed between 5 p.m. and 7 a.m. and 7 a.m. and 12 p.m. The identification of the collected species was made using the keys of Paugy et al. (2003); Decru et al. (2013); Dunz and Schliewen (2013). The Hana River Biotic Integrity Index is based on the ten metrics used for the analysis of community structure. These are: specific richness, density, biomass, Shannon index, Simpson's diversity index, Piélou equitability, Hill index, k-dominance, Clarke index, and Shannon Eveness Proportion index (SEP). Scoring criteria were established from these metrics. Scores for each variable range from 1 (poor) to 5 (excellent) (Belpaire et al., 2000). The biotic index for each site was calculated as the average of the scores of all metrics. The biotic integrity index obtained in each station indicates that the highest value (3.7) was obtained at station T3 outside the park, the average value (3.3) at T2 in the park and the lowest (2.5) at station T1 in the northeast of the park. The biotic integrity index allowed to show a pollution gradient along the Hana River from southwest to northeast, the most polluted. With the anthropization around the Taï National Park, these results could serve as references for subsequent investigations in the monitoring of ichthyological fauna.

Ecosystems and global change

Dinah Lorraine Mukhari (Rhodes University)
Alien species management: Can acoustic telemetry data be used to optimise catch rates of invasive common carp?

Abstract
Common carp, *Cyprinus carpio* is an invasive species around the world and was first introduced to South Africa for ornamental purposes in the late 19th Century. In 1991, carp were illegally introduced to the Groenvlei Lake, within the Goukamma Nature Reserve. Groenvlei is a natural lake popularly used for bass-angling and to a lesser extent for subsistence fishing by the local community. In recent years there has been a noticeable decrease in macrophyte abundance and increased turbidity levels, which have been attributed to the benthic feeding behaviour of the now large biomass (>700kg per hectare) of carp within

the lake. In addition, declines have been observed in other fish species. In an attempt to rehabilitate the Groenvlei Lake, the local management authority (Cape Nature) introduced a suite of measures to reduce carp numbers. These included a gill-netting program and the recruitment of volunteer bowfishers. In this study we used acoustic telemetry to monitor carp movement patterns with the aim of optimising capture rates. Six acoustically tagged carp were manually tracked during dedicated fieldtrips over a period of one year. The results showed that the local carp population display distinct seasonal habitat-use patterns. Site specific aggregations during the spawning season suggest that these data can be used to facilitate strategic and targeted harvests by tracking tagged individuals to aggregation sites. The findings suggest that acoustic telemetry can be used as a tool to manage invasive species in sensitive aquatic ecosystems such as the Goukamma Nature Reserve.

Ecosystems as a resource

Francine Luhusu Kutshukina (Ecole Régionale post universitaire d' Aménagement et de gestion Intégrés des Forêts et Territoires Tropicaux (ERAIFT))
A targeted resource, the giant freshwater shrimp "*Macrobrachium* sp." in the Mangroves Marine Park in D.R. Congo.

Abstract
The present study addresses the exploitation of this excellent resource in an anthroposystemic way with a view to contributing to its sustainable exploitation in the Mangroves Marine Park (PMM), a wetland listed in the Ramsar Convention (1996), surrounded by a growing fishing population. It is therefore necessary to attempt to exploit this resource sustainably to ensure its conservation while securing the livelihood of the exploiting populations (fishermen, fish mongers). Our preliminary results reveal that shrimp of the genus *Macrobrachium*, called locally "Kosa", is caught on the banks of the Congo River near the Kimuabi and Malela islands, located in the PMM' s fully protected zone. The shrimp *Macrobrachium* sp is caught individually using a cylindrical pot baited with palm nuts and dead crabs. This shrimp is fished throughout the year in an excessive manner without taking into account the reproduction period and the size of the individuals caught. In its adult state, this shrimp *Macrobrachium* sp lives in the mangrove where typical plant species dominate : *Rhizophora* sp, Raphia sese and Pandanus candelabrum. It is in this area that fishermen's camps are proliferating, jeopardizing the future of this unique anthroposystem in the Democratic Republic of Congo. This is why we began by inventorying and characterizing the exploiting populations of this resource in order to involve their representatives in our study concerning the biology, ecology, sustainable exploitation and conservation of this species.

Alain Bolonga (Department of Hydrobiology, Université de Kisangani)
Ichtyofauna of the Lomami National Park (LNP): evaluation of ichthyobiodiversity and its possible use in fish farming for wildlife conservation.

Abstract
This investigation deals with freshwater fish populations in thirteen sampling rivers of LNP and its hinterlands. The objectives of this study were to inventory the ichthyofauna in freshwater bodies of LNP and determine fish species with high economic value.

Fish were collected using gill nets. A survey was administered to fishermen in order to determine fish species with high economic value.

A total of 9127 fish were caught belonging to 129 species, 54 genera, 20 families and 7 orders. The family of Mormyridae dominated in the fish collection with 30 species followed by family of Alestidae with 23 species.

Clarias spp, *Schilbe* spp, *Chrysichthys* spp, *Auchenoglanis occidentalis*, *Polypterus* spp, *Hydrocynus* spp, *Alestes* spp, *Parachana* spp and species of Mormyridae were recorded as fish species with high economic value.

Osman Crespo (Okeanos Institute)
Spatial distribution and movement patterns of *Raja clavata* in the Azores based on survey-derived abundances and conventional tagging data.

Abstract
The thornback ray *Raja clavata* is commonly caught as bycatch by bottom longliners in the Azores (mid-North Atlantic Ocean). Knowledge about the species spatial distribution and preferences is very important to better understand its dynamics in such outermost regions. *R. clavata* was analyzed for the Azores archipelago through the evaluation of horizontal movements identified by the tagging-recapture effort as well as from the relative abundance information collected on the annual scientific survey. Besides that, the vertical distribution was also inferred from the catch data, since the surveys covered a wide range of vertical habitats (50 to 1200m depth). Scientific surveys took place from 1996 to 2019 around the islands, banks and major seamounts of the Azores with a total of 2362 conventional plastic tags deployed over twenty years (since May 1999). The main distribution areas were identified close to the islands with significantly higher captures in waters above 250m. Twenty-nine tags recovered (1.22%) were reported with size information and general catch location, being 13 with specific capture location coordinates. Time-at-liberty ranged between 11 and 1913 days (5.2 years) with a mean of 573 days (1.5 years). The spatial distribution was also analyzed for differences between sexes and sizes. Knowledge about dispersion and preferences of the species around the archipelago is important to define habitat range and better understand its behavior and strategies, which are useful information for stock assessment and species management purposes.

Hima Kachmira Rama (South African Institute of Aquatic Biodiversity)
Using Baited Remote Underwater Video Systems (BRUVS) in the conservation of a popular aquarium species, *Metriaclima estherae*, in Lake Niassa.

Abstract
Great Lake Niassa is bordered by three African countries (Malawi, Mozambique and Tanzania) and contains the most diverse fish fauna of any lake in the world, making it a biodiversity hotspot of global significance. The fish community includes populations of endemic cichlids that are commercially and biologically valuable. The lake supports a variety of small-scale fisheries that provide food security and livelihoods to local communities. Some cichlids are also collected from the lake for sale as aquarium ornamentals due to incredible variation in colour and morphology between species. However overfishing and habitat degradation have led to a decline in some cichlid populations.

A conservation strategy used to alleviate these impacts is the designation of Key Biodiversity Areas (KBAs), protected areas that are managed specifically to maintain biodiversity. In order for KBA's to be effective, their management must be underpinned by good data. This requires

efficient, long term monitoring plans for exploited species, without putting excessive financial burden on the countries surrounding the lake. Baited Remote Underwater Video Systems (BRUVS) have already proven useful for observing larger species exploited in the Niassa fishery. In this study BRUVs deployed between 2016-2018 in Minos Reef (Meleluca), a designated KBA, have been used to observe *Metriaclima estherae* (Red Zebra Cichlids), a small species collected as an ornamental fish in the aquarium trade. The video system was effective in collecting population information on *M. estherae*, including habitat use and depth profiles, which could be used to determine key factors for the effective management of the species.

Ecosystems, communities and fish

Katerina Rebok (ICBAS – University of Porto)
Histology and 3D-reconstruction of a presumptive hepatic lipoma in a black barbel from the River Bregalnica, Republic of North Macedonia.

Abstract
A lipoma is a benign slow-growing tumour consisting of well-differentiated white adipocytes. In humans, this neoplasm is the most prevalent soft tissue tumour, mostly locally subcutaneously. Lipomas were rarely diagnosed in fish, generally as isolated cases. Such tumours may be encapsulated. In line with studies in higher vertebrates, most reports about fish lipomas refer to dermal or hypodermal locations, with visible skin extrusions. More rarely, they appeared in the paravertebral muscle, main body cavity, stomach and spleen. A fish liver lipoma was reported once in the Atlantic pollack (1933). Our study is a case report of a barbel (*Barbus balcanicus*) captured in a biomonitoring survey in one reference area of the River Bregalnica (Republic of North Macedonia). When analysing over 600 fish, one adult female had a unique attribute. This consisted of a well-delineated focus of white adipose tissue buried inside the liver. The focus did not protrude the liver surface being discovered after histological study. The focus was well-delimited and had no connective tissue capsule. At some marginal locations, there were small agglomerates of lymphocyte-like cells. The fatty focus was not associated with venous or arterial blood vessels and had no connection with the organ hilus. This fact excludes the adipocytic focus as being an extension of the body cavity fat. The 3D computer-assisted reconstruction exposed the nodule as an oblate ellipsoid. This shape likely resulted from non-homogenous growth. No matter the cause and importance, we named the agglomerate as a liver lipoma, the first reported in a barbel.

Golam M. Mustafa (University Putra Malaysia (Bintulu Campus))
Ichthyofaunal Diversity of a Tropical Deltaic Estuary, East Malaysia: A Spatio-temporal Distribution Nature.

Abstract
The Batang Lassa Estuary is an important deltaic estuary located in north-eastern Borneo island of East Malaysia. The study was conducted to assess the ichthyofaunal diversity by ESBN sampling in spatio-temporal scale, governed by ecological variables. About 24km of the Batang Lassa Estuary connected with the South China Sea was divided into three zones considering the natural setting and anthropogenic activities.

The study was conducted from April 2019 to September 2020. Samplings were carried out using ESBN (locally called Gnian) for four seasons (South-west monsoon, first intermediate

monsoon, North-East monsoon and second intermediate monsoon). Fish diversity, dominance, richness and evenness with spatial and temporal scale were analyzed. A total of 66 species (58 finfish, 6 crustaceans and 2 others) combined 48835 individuals from 36 families were recorded with composition of 80.76% crustaceans, 19.17% finfish and 0.07% others. Major contributing finfish families were Engraulidae (27.36%), Sciaenidae (14.68%), Ambassidae (13.17%), Scatophagidae (9.19%), Tetraodontidae (7.75%) and Polynemidae (6.65%). Shannon diversity index values were highest in intermediate monsoon (2.31) and lowest in North-East monsoon (1.36). Zone 2 was highest (1.87) followed by Zone 1 (1.83) and Zone 3 (1.58).The Margalef richness index was highest in inter-monsoon (6.33) and lowest in South-west monsoon (5.18) and lowest in Zone 3 (5.34). Pielou's evenness index showed highest value in inter-monsoon (0.228) and lowest in North-east monsoon (0.075) and lowest in Zone 3 (0.097).Dominant index showed highest in North-east monsoon (0.388) and in Zone 3 (0.369).Salinity and seasonality are two major influences towards biodiversity in Batang Lassa Estuary.

Oumar Sadio (IRD Institut de Recherche pour le Développement)
Ichthyological biodiversity of Madeleine Islands National Park (Dakar, Senegal).

Abstract
Marine reserves are important for the conservation of biological diversity of marine areas. They protect rare and threatened species, important natural habitats and provide benefits for fisheries species. Scientific research around the world supports the concept that marine reserves are one of the best ways of protecting marine biodiversity. National Parks are a category II of IUCN protected area classification, which plays a role in connectivity of the landscape / seascape. Madeleine Islands National Park Is one the smallest marine park in the world. However, there is no inventory of aquatic species since its creation. The objective of our study is to make an inventory of fish species, crustaceans, mollusc and echinoderms that exist inside the park. For this, two sampling campaigns took place: in June 2017 using mesh gill nets of 40 and 60 mm mesh size, and in January 2018 by submarine diving. Thus, the fishing trips allowed to capture two molluscs (*Murex duplex* and *Cymbium glans*), a crustacean (*Scyllarides chentilotsii*), an echinoderm (*Eucidarus tribuloides africana*) and 52 fish distributed into 21 species belonging to 15 families. The best-represented family is that of Sparidae with 4 species followed by Serranidae, Haemulidae and Exocoetidae each represented by 2 species. The remaining 11 families are monospecific. Scuba diving has identified species of molluscs, sea cucumbers, echinoids and asteria. This ichthyofauna is characterized by the presence of marine and amrine affinity species. This reflects the important role plays by Madeleine Islands National Park in connectivity between estuarine and marine environments for several fish species. In addition, several fish species were sexually active and others breeding inside the park, this means that the park is a spawning ground for several fish species. Also, the survey results show that the park protect species of least concern, species with data deficient, endangered species and near threatened species. If the sampling covers all seasons, other species can be caught. It clarified the role of Madeleine Islands National Park in marine biodiversity conservation and in sustainability of connectivity between the park and various protected sites in West African marine protected area network.

Mayara Pereira Neves (Department of Zoology, Universidade Federal de Rio Grande do Sul)

Morphological divergence and niche partitioning of tetra fish in subtropical streams.

Abstract
Morphological differences among species may be related to their trophic ecology (ecological divergence-convergence) or reflect their phylogenetic relationships (niche conservationism) with implications for coexistence. Herein we investigated whether external and internal morphology traits (body shape and internal trophic apparatus) were associated with trophic niche (stomach contents and stable isotopes) and if these traits were congruent with phylogenetic relationship of tetra fish in neotropical streams. Tetra fish species showed several complex examples of convergence and divergence in morphology, consume and assimilation; refuting the hypothesis phylogenetic niche conservationism. Species with elongated bodies, such as *Brvconamericus ikaa* and *Psalidodon* aff. *paranae* distantly related, tend to have teeth with fewer cusps, few and shorter gill rakers, and also shorter intestine and fewer pyloric caeca associated with greater assimilation of aquatic invertebrates. Species with teeth with a higher number of cusps, such as *Psalidodon bifasciatus* and *Psalidodon* aff. *gymnodontus*, had gill rakers in greater number and more elongated, as well as greater intestinal length and greater number of pyloric caeca associated with greater proportions of assimilation of terrestrial invertebrates. External and internal morphology was significantly related to stable isotopes ratios, but not to stomach content analysis. Only *B. ikaa* had congruent diet and assimilation, reinforcing the aquatic insectivore diet. The three species of *Psalidodon* and *Astyanax lacustris* ingested similar proportions of plant material, terrestrial and aquatic invertebrates. However, the plant material was not assimilated by any of the species. There was intermediate and high overlap between both close (*P. bifasciatus* x *P.* aff. *gymnodontus*) and distant (*P. bifasciatus* x *A. lacustris*; *P. bifasciatus* x *B. ikaa*) related species. Specially in relation to *P. bifasciatus*, the niche contraction or expansion seems to be related to the species in co-occurrence. Morphological divergences of the tetra fish species might reflect on ecological differences, related to the capture, ingestion and assimilation of food resources which facilitate niche partitioning, and consequently, their coexistence.

Jean-Daniel Mbéga (Institut de recherches Agronomiques et Forestières IRAF)
Spatio-temporal variation of ichthyofauna biodiversity of lagoon ecosystems: the case of the Ngowé and Ndougou lagoons in Gabon (Central Africa).

Abstract
Coastal lagoons are aquatic environments at the interface continental and marine waters. They are places of refuge, spawning and feeding grounds for many marine fish species. In Gabon, there is still a significant lack of knowledge on the fishing resources in coastal lagoons. In this context, with the aim of sustainable management of these ecosystems as well as the associated local fisheries that this work has been carried out. The goal of this study was to study the spatiotemporal structure of fish assemblage of Ngowé and Ndougou lagoons (Gabon). The sampling strategy was the same in both lagoons. Fishes were collected during four seasons using trammel nets and a beach seine. In the Ndougou lagoon, 2864 fish were caught. They are divided into 10 orders, 27 families, 41 genera and 58 species. Perciformes (14 families), Alestidae (7 species), *Monodactylus sebae* (85% occurrence) and *Parotropius debauwi* (13% total abundance) dominate. In the Ngowé lagoon, 1413 fish have been recorded. They are divided into 16 orders, 22 families, 47 genera and 47 species. Perciformes (8 families), Cichlidae (6 species), *Gerres nigri* (100% occurrence and 15% total abundance) dominated. The species richness as well as the structure of the stands vary from one season

to another and from one area to another in the two lagoons. Families of species with continental affinity are more diversified upstream, while those with marine affinity are more diversified downstream. The abundance of species with continental affinity increases from downstream to upstream and they are more abundant during the rainy season. Abundance of species with marine affinity decreases from downstream to upstream and they are more abundant during the long dry season. This study revealed the spatio-temporal structure of fish assemblages in the two lagoons that can help for fishery management.

Rita Castilho (University of Algarve / Centre for Marine Science)
Temporal stability of genetic composition of marine fish species.

Abstract
Population genetics studies frequently aim at uncovering the existence of groups often associated with geographical locations. However, these studies are frequently simply synchronic snapshots of genetic composition, disregarding temporal fluctuations and moreover, with samples pooled based on their geographical origin and ignoring their data of collection. Furthermore, temporal monitoring also allows following the trajectory change over time, which is pivotal to understand the evolutionary dynamics of natural populations of marine fish species. By disregarding temporal fluctuations we are assuming the stability of genetic groups that may or may not be persistent. In wild contemporary species, it remains largely unknown if inferences from patterns of spatial genetic variation are temporally stable. We aim to assess whether the genetic composition of five coastal fish species (*Atherina presbyter, Gobius niger, Spondyliosoma cantharus, Symphodus bailloni* and *Chelon labrosus*) remains stable over a short-time period of four consecutive years by a recurrent sampling of juveniles-of-the-year from the same location. We will use the highly variable non-coding control region of mitochondrial DNA and approach comparatively the life-history traits of these species to create a hierarchical framework of variation drivers to understand their possible role and contribution to genetic stability. The resulting data will inform future studies regarding the consideration that must be given to temporal sampling.

FSBI Symposium 2022

FSBI 2022: Fish in a Dynamic World
25th-29th July 2022
Organisers: Iain Barber, Carl Smith, Andrew Hirst
Nottingham Trent University, UK

Fish show a remarkable capacity to adapt to aquatic environments, occupying oceans, lakes, rivers, streams and even temporary pools. Fish also show a striking radiation in modes of feeding, life history, reproduction and behaviour. The aquatic ecosystems that fish inhabit are also often subject to highly dynamic changes, over diurnal, tidal and seasonal cycles, and fish exhibit remarkable plasticity to allow them to prosper in the face of such changes. However, aquatic environments across the globe, and the fish that live in them, are subject to myriad threats, including the input of anthropogenic pollutants, overexploitation, species introductions, physical barriers to movement, the manipulation of flow regimes and global climate change. Fish are responding to these perturbations at all organisational levels, with consequences for gene expression, physiology and patterns of behaviour, and the impact of these changes on populations, communities and ecosystem processes is now beginning to be revealed. The symposium, which has been re-arranged from 2020, will explore the ways in which fish are able to occupy such a broad range of naturally dynamic environments, as well as their capacity to adapt to habitat loss and directional environmental change.

Proposed Themes: Sex and reproduction in a dynamic world; Feeding in a dynamic world; Behaviour in a dynamic world; Population & community consequences of a dynamic world; Plasticity in a dynamic world; Analysing dynamic worlds; Conservation in a dynamic world; Invasion ecology; Parasites and pathogens in a dynamic world; Anthropogenic noise, stress and behaviour; Creating and inclusive, diverse and transparent fish and fisheries research community.

Venue: Nottingham Trent University (NTU) is a modern university based across five campuses in the city of Nottingham and the county of Nottinghamshire, UK. It has recently won many plaudits for teaching and research and has been a **top 10** in the People and the Planet League since 2009, making it a perfect venue for FSBI 2022. The symposium will be based at NTU's stunning rural Brackenhurst campus, close to the cathedral town of Southwell,

with the Symposium banquet and medal awards ceremony to be held at the City campus in the centre of Nottingham. The newly completed Lyth Building will house all scientific sessions. Our expectation is that this Symposium will be held as a face-to-face, in person event, with an alternative online opportunity for delegates that are unable to attend in person to participate in the meeting.

Image 1. NTU Brackenhurst Campus – Main Hall view across the lake

Image 2. NTU Brackenhurst Campus – Lyth Building (venue for FSBI2022 scientific programme)