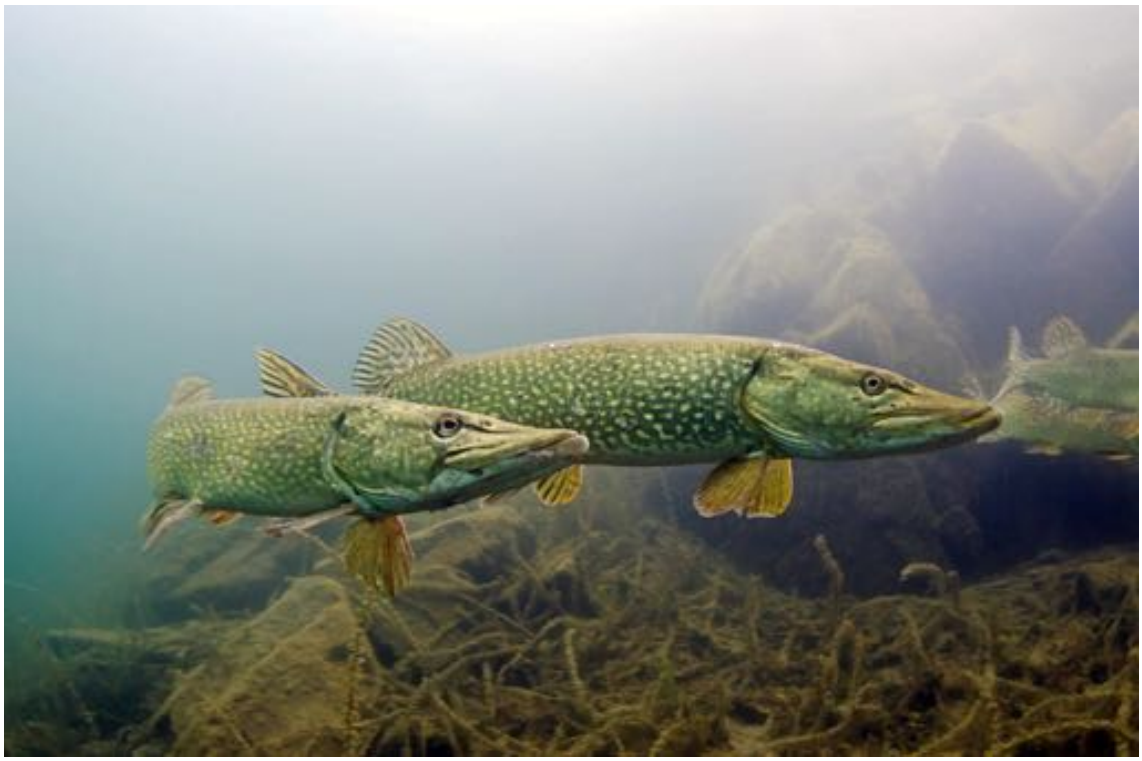
50th Anniversary Symposium of the Fisheries Society of the British Isles

3–7 July 2017, University of Exeter, UK



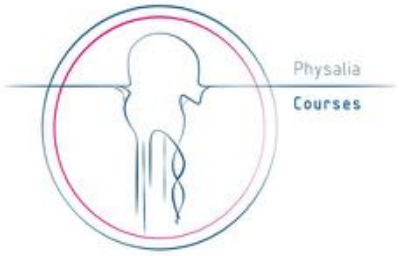
UNDERSTANDING FISH POPULATIONS

Symposium Handbook

fsbi
An International Society for Fish Biology

UNIVERSITY OF EXETER

FSBI17 has been generously sponsored by:



Front cover image is of pike (*Esox lucius)* spawning at Stoney Cove; a famous flooded quarry in Leicestershire where novice UK divers don a drysuit in midwinter and blow their first bubbles. Image provided by Jack Perks, author of "*Freshwater Fishes of Britain*", who will present a film and discuss the making of this ambitious book during the Thursday lunch break, with an opportunity to buy a signed copy of his book. © Jack Perks

Symposium Logo

Almost exactly a year ago I sat at the back of the FSBI16 Symposium in Bangor. In between moments of doubt as to how on earth we would ever deliver a Symposium that could succeed Prof. Gary Carvalho and his team, and honour this significant Anniversary for the FSBI, I doodled what I wanted for FSBI17. The result was this working logo. I am pleased that all the themes crammed into the logo are strongly represented at FSBI17. We have talks and posters on freshwater and marine fish, migratory species, commercial fisheries, studies on a whole range of environmental stressors, effects of climate change, life cycles of fish, and, of course, the celebrations of the big 5-0!

What my logo also proved is that to honour this significant birthday, I needed to bring in a professional. I am delighted to have hooked up with Bristol-based street artist *FaceFirst*, who has designed the official 50th Anniversary logo. The logo now has a fish at its core, proudly showing off its 50-themed markings, with a cutting-edge vibrancy to the style. *FaceFirst* is a renowned West Country graffiti artist and celebrated member of the Pirate Wall Art (PWA) Crew: **https://tinyurl.com/yczffqgp**

Contents

Welcome to FSBI17

Welcome from the FSBI17 Symposium Convenor – Dr Steve Simpson

Dear Friends,

Welcome to FSBI17 and to Exeter. It is a great honour to host the 50th Anniversary Symposium of the Fisheries Society of the British Isles (FSBI). To mark this milestone, we deliberately chose the broad theme of *Understanding Fish Populations* to reach out to the whole FSBI community. We have been delighted by the response from so many individuals and groups around the world, and warmly welcome our 200+ delegates representing at least 26 countries.

Organising this Symposium has certainly kept me out of trouble for the past 14 months, but thanks to the positivity, creativity and enthusiasm of the fish biology and fisheries science community, it has been a real joy. I would like to thank you all for your encouragement, advice, patience and generosity as we have developed the programme. Many familiar names and renowned experts have become friends along the way, and the exciting response from postgraduates and early career scientists has always kept the communications fresh, fun and full of ambition. We are pleased that through generous support from the FSBI and our many sponsors, we have been able to fund 34 student bursaries.

We trust that you will enjoy this action-packed week, featuring 7 plenary lectures, 94 oral presentations, 38 speed talks and 84 posters, as well as two guest acts. We also hope you will actively participate in the discussion groups, training events, lunchtime meetings and afternoon activities, and enjoy the range of evening events (many of which have been inspired by our postgraduates).

I am sure that by the end of the week you will have strengthened your research network, renewed existing and forged new friendships, made peace with past reviewers (!) and identified future collaborators, as well as sampling the food, drink, fresh air and stunning scenery of Devon.

On behalf of the Scientific and Local Organising Committees, I hope you will reap the benefits of attending FSBI17 for many years to come.

Cheers,

Steve Simpson, Associate Professor in Marine Biology & Global Change

Welcome from the FSBI President – Dr Iain Barber

Dear Colleagues,

I am delighted to welcome you to Exeter on behalf of the Fisheries Society of the British Isles (FSBI). The FSBI is a learned society and charity that supports research in the fields of fish biology and fisheries science through a number of mechanisms, including the publication of the *Journal of Fish Biology*, through the funding of PhD studentships and research grants, and through international collaboration with other Societies. This year the FSBI celebrates its 50th Anniversary, and so I am delighted that you have chosen to join us in this landmark year.

Our sponsorship of annual international symposia on topics of critical importance to the fish and fisheries research community form a focal point for our activities. This year's symposium – which brings together scientists from the global fish and fisheries community to consider how well we understand fish populations – is no exception, and continues a trend towards more generally-themed meetings that have attracted diverse audiences.

I am extremely grateful to Steve Simpson – 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 enjoy a week full of stimulating discussion and outstanding hospitality. I hope you will leave the meeting feeling inspired, having made new friends and collaborators, and with fond memories of this beautiful part of England.

I look forward to meeting you,

Best wishes

Iain Barber

FSBI Honorary President

Practical Information

TRAVEL AND PARKING

Directions to the Streatham Campus

University of Exeter
Streatham Campus
Northcote House
Exeter EX4 4QJ

On Foot

The University is within easy walking distance of Exeter city centre. The city centre map **www.exeter.ac.uk/visit/directions/streatham/#map** shows the location of the Streatham Campus plus routes to Exeter St David's and Exeter Central train stations, all within walking distance.

By Bike

Exeter is a Cycling Demonstration Town and the University is well served with traffic-free cycle routes. You can download the Exeter Cycle map to plan your route from the Cycle Devon website **www.cycledevon.info/cycle-routes/.**

The University provides a range of cycle parking facilities across the Exeter campuses. To find your nearest cycle parking facility, use the campus map **www.exeter.ac.uk/visit/directions/streathammap/**

Note: Bike storage facilities are located at Holland Hall

By Bus/Coach

The Streatham Campus is served by Stagecoach D and H bus routes **www.stagecoachbus.com/.** The D bus route includes St Luke's Campus, the City Centre and Streatham Campus. The H bus route includes the RD&E hospital, St Luke's Campus, the City Centre, St David's station and Streatham Campus.

National Express coaches **www.nationalexpress.com/** (08705 808080) call at Exeter Coach Station. The Coach Station is a short walk to the High Street where you can catch the local D bus which will take you to the Streatham Campus.

By Rail

Exeter has two railway stations - Exeter St David's (main station) and Exeter Central. Exeter St David's Station has a taxi rank outside the main entrance and is a 10 minutes walk from Streatham Campus. The average journey time from London Paddington is 2.5 hours to Exeter. See Streatham Campus map for the walking route.

National Rail Enquiries: **www.nationalrail.co.uk/** (08457 484950)

By Taxi

Apple Central Taxis, 3-4 Isambard Parade, Exeter EX4 4BX (phone: **01392 66 66 66**) is the University's preferred taxi company. If arriving by train to Exeter St David's, Apple's booking office can be found in the parade of shops to the right of the main exit.

By Car

The M4/M5 links Exeter directly to London, the Midlands, South Wales and the North including Scotland. The average journey time from either London or the Midlands is 3 hours. Download our detailed directions to Streatham Campus by car **www.exeter.ac.uk/media/universityofexeter/webteam/shared/pdfs/directions/streathamdirections2014.pdf**

Satellite Navigation
To Holland Hall – use postcode EX4 4QR. This will lead you to Streatham Campus. Then follow signage to Holland Hall.
Note: Please avoid Clydesdale Road, which is a residential area.

Residential Delegate Car Parking
Residential delegates will be issued a free of charge Residential Car Parking Permit on key collection.
Please display your permit, marked with your car registration number, clearly in your vehicle.
Subject to availability, you may use any of the Residential campus car parks. If you are unable to find a residential car parking space, then you would be required to purchase a standard car parking ticket – see further information below.

Day Delegate Car Parking
Day Delegates must purchase a car parking ticket from the machines located near to the car parks on campus. Full information including charges, accessibility and location of car parks can be found on our website **www.exeter.ac.uk/visit/directions/carparks/**

By Air

Exeter International Airport operates flights to and from international destinations including Paris, Dublin, Amsterdam and Geneva and airports in the United Kingdom including Aberdeen, Belfast, Edinburgh, Glasgow, Guernsey, Jersey, Leeds/Bradford, Manchester, Newcastle, Norwich and St Marys. The airport is five miles from the city of Exeter and is situated adjacent to the A30, close to junction 29 of the M5 motorway. Shuttle buses run to Exeter St David's train station (which has a taxi rank outside the main entrance and is a 10 minute walk from Streatham Campus).

Bristol Airport operates flights to and from hundreds of international destinations. From Bristol Airport, it is possible to take a 20 min shuttle bus to Bristol Temple Meads train station and then a 1 hour train to Exeter St David's station.

Heathrow Airport operates flights to and from thousands of international destinations. From Heathrow Airport, it is possible to take a 15 min shuttle bus to London Paddington and then a 2.5 hour train to Exeter St David's station.

Streatham Campus Map, University of Exeter

ACCOMMODATION

Check In: On the day of your arrival you may check in to your accommodation from 3pm onwards.

Holland Hall – for guests staying in Holland Hall, please check in at Holland Hall reception: Holland Hall, Clydesdale Road, Exeter, EX4 4SA.

If you arrive early, you may contact reception to request luggage storage until your designated check in time. This service is also available after checkout. You may also store luggage securely in the Forum at the FSBI17 Symposium Office (Forum Seminar Room 4).

The Holland Hall reception desk is open daily from 08:00–22:30 during FSBI17.

If, on the day, you arrive after 10.30pm please call 24hr Campus Security on: 01392 723999 (Provide your name and your residence)

If you know in advance that you will be arriving after 10.30pm please telephone the Event Exeter: 0300 555 0214.

Check Out: Please return your keys to Reception and vacate your room by 10.00am on the day of your departure.

Facilities

En-suite rooms are equipped with their own private bathroom. All of the bedrooms are well equipped and accommodation comprises of:

- Tea and coffee making facilities
- A selection of toiletries
- Full linen, including towels
- Rooms serviced daily
- Free WiFi – passwords provided – via a leaflet in each bedroom
- Access to laundry facilities – please ask at reception for further information
- Small fridge
- Safes are available in Holland Hall bedrooms
- Hairdryers and alarm clocks can be requested from reception
- Irons and Ironing boards can be found in the Utility Rooms
- Televisions are not provided in our bedrooms.

If you require any further assistance during your stay please ask at the reception desk for the Duty Manager, who will be delighted to help you.

Emergency Information: In the event of any type of emergency please dial: 01392 263999 to contact our 24hr Campus Security team.

If, for any reason, you are not able to get in touch with our security team please dial 999 for emergency response from Fire, Police, Ambulance, or 101 for events that do not require an emergency response.

If you feel unwell at any time, please inform a member of staff on site, or the Duty Manager who will help you with information about local GP services and pharmacies.

SMOKING

Smoking is prohibited in all accommodation in University residences or residences managed on behalf of the University. These restrictions apply to private study bedrooms and all shared areas such as corridors, stairways, rest-rooms, kitchens, entrances or reception areas.
The grounds of the University support a wide range of biodiversity and wildlife and we ask that you dispose of any smoking litter conscientiously.

ACCESSIBILITY

All buildings on campus have been reviewed with regards to accessibility and have been updated to comply with the Disability Discrimination Act. Please advise us if you have any special requirements such as wheelchair access requirements, vibrating alarm pillows and warning lights on the walls, and hearing loops so that the necessary arrangements can be put in place.
Designated disabled car parking is available at a variety of locations on campus, listed on our web site **www.exeter.ac.uk/visit/directions/carparks/accessible/**

MEAL TIMES

Breakfast is served in Holland Hall from 07.00–08.00. For details of all other meal times, please refer to your event programme.

RESTAURANTS AND SHOPS

The University has a range of cafés, restaurants and shops on campus including:

- Reed Hall Restaurant and Café
- Costa Coffee, upstairs at the Forum
- Pret a Manger, downstairs in the Forum
- La Touche Café, in Building:One, The Business School
- Northcott Theatre Bar, upstairs at Northcott Theatre

Please visit **www.exeter.ac.uk/campusservices/cafesandshops/** and **www.exeter.ac.uk/retailoutlets** for further details.

Useful shops located around the campus include the Market Place, located in the Forum providing take away food including sandwiches and snacks, groceries, confectionery, alcohol, newspapers, stationery and toiletries. Vending machines are located around campus, offering hot and cold drinks, snacks and confectionery and even toasted sandwiches **www.exeter.ac.uk/campusservices/cafesandshops/vending/**

Other on-campus services include Print and Copy services and Blackwell's Books.

CASHPOINTS AND BANKS

Natwest Bank is located on the ground floor of the Forum. Open: 09.00–16.30.
Santander is located on the first floor of Devonshire House. Open: 10.00-18.00.

SYMPOSIUM DETAILS

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Venue

FSBI17 will take place in the flagship Forum building at the heart of the Streatham Campus (Forum, Stocker Rd, Exeter, EX4 4PT). The main plenary sessions will be in the Alumni Auditorium on the ground floor. Drinks and lunches will be served on the main "street" in the Forum, with plenty of outside eating areas available through both entrances from the street. The posters will be on display all week in the main street. Parallel sessions and meetings will take place in neighbouring Seminar Rooms (details in programme).

The Tuesday night BBQ will take place on the lawns outside Reed Hall. Optional morning runs and Wednesday afternoon sports activities will take place across campus. The Thursday Banquet will be held in the Great Hall.

Registration and helpdesk

A registration desk will be open in the main street of the Forum from 10:00–13:00 on Monday 3 July. Delegates arriving outside this time can register at the FSBI17 Symposium helpdesk (Forum Seminar Room 4), which can also be used for safe storage of bags.

Wifi

Wifi is available throughout all University buildings, including the Forum, Reed Hall and the Great Hall. Delegates can use either **Eduroam**, or register each day using **UoEGuest**. Wifi is also available in Holland Hall accommodation buildings (details in bedrooms).

Social Media

Twitter: FSBI17 will be tweeting through the week from **@FSBI17**, and using **#FSBI17**. Feel free to join in the conversation from your own accounts. **Presenters should indicate during their presentations if they do not want information, data or images shared on social media.**

Flickr: Photos will be uploaded through the week to: http://www.flickr.com/fsbi17

Facebook: Search FSBI17, or https://www.facebook.com/groups/232711597232520/

Presentations

- Plenary lectures are 50 mins with 5 mins for questions.
- Oral presentations are 12 mins with 2 mins for questions.
- Speed Talks are 3 mins, and >80% have accompanying posters on display all week.
- Posters should be A0 portrait (841 mm wide x 1189 mm high), and will be displayed all week in the Forum. **Contact the FSBI17 team on arrival to set up your poster.**

Presenters will be kept strictly to time by the session chairs to ensure everyone has their allocated time available.

Please upload your Powerpoint presentations at the FSBI17 Office (Seminar Room 4) well in advance of your session, preferably at least two sessions before your presentation. To ensure a smooth transition, presentations cannot be run from personal computers, so if you have audio and video, please check in advance that it will work.

Video Capture

The University of Exeter uses the ReCap lecture archiving facility. We plan to use this, so if you would not like your talk to be recorded, please inform your session chair.

THINGS TO DO ON CAMPUS

Health and Fitness

Exeter University's Sports Park, on Streatham Campus, is home to some of the most advanced sporting facilities in the South West including: Exeter Tennis Centre; the Sir Christopher Ondaatje Devon Cricket Centre; the Russell Seal Fitness Centre; and the Vic Ambler Golf Centre which all provide an unrivalled sporting and athletic experience. We are dedicated to providing an excellent sporting experience to a wide cross-section of users.

For a virtual tour of the Sports Park facilities please follow the link below
http://sport.exeter.ac.uk/facilities/virtualtour/

As guests of the University of Exeter the Russell Seal Fitness Centre is available free of charge as part of your stay with us.

Russell Seal Fitness Centre: The 200 station fitness centre offers gym users the latest technological innovations alongside state of the art Life Fitness equipment to maximise your workouts at all levels and to suit all goals.

For more information please visit our website **http://sport.exeter.ac.uk/healthandfitness/russellseal/**

As a guest prior to using the fitness centre please complete our online induction: **http://sport.exeter.ac.uk/join/induction/**

On arrival at reception you will be asked if you have completed the induction and asked for your name. Please state you are a guest staying on campus.

Exeter Sport offers many other sports facilities and services that can be used as a guest on a pay as you go basis. These include:

- Fitness Classes
- Badminton
- Indoor tennis
- Squash
- Swimming: Cornwall House pool, open seven days a week during the summer months, is our four lane 25m outdoor swimming pool set in a large grass and patio area, heated to a constant 29°C and staffed by qualified lifeguards making it great for relaxing during those warm summer days.

For further information please go to Sports Park reception 01392 724452, email **exetersport@exeter.ac.uk**, or visit **www.sport.exeter.ac.uk/facilities/**

Northcott Theatre - www.exeternorthcott.co.uk/
The Northcott Theatre opened in 1967 on Streatham campus with a production of The Merchant of Venice, The Theatre continues its popular year-round family programme presenting high quality national companies including English Touring Theatre, Theatre Alibi, Out of Joint, Richard Alston Dance Company, Ballet Black, Jasmin Vardimon Company and English Touring Opera.

Bill Douglas Cinema Museum - www.artsandcultureexeter.co.uk/
The Bill Douglas Cinema Museum is home to one of the largest collections of material relating to the moving image in Britain. We are both an accredited public museum and an academic research facility and we hold a collection of over 75,000 items. Over 1,000 of our items are on display in our Galleries and are
available to be viewed by the public 7 days a week.

The museum chronicles the development of optical entertainment from shadow-puppets and 17th century manuscripts to the most recent Hollywood blockbusters, including artefacts such as Magic Lanterns, rare books, prints, and an extensive variety of publicity materials. The diversity of this collection provides an insight into the changing dynamics of the moving image and the history of our relationship with it.

Botanical Tours of Streatham Campus
Self-guided or seasonal tours are available for the Streatham Campus. The University of Exeter's Green Flag awarded Streatham and St Luke's Campuses are amongst the most beautiful and botanically interesting of any UK University. Streatham Campus is described by The Times as the 'best-gardened campus in Britain' and by The Independent as having a 'sublime' setting.

Our experienced guides will lead you through the botanical gardens, past lakes and woodland, taking in many of the rare species of plants and trees.

To find out more about the beautiful and diverse grounds and gardens at the University please visit **www.exeter.ac.uk/visit/campuses/gardens/aboutus/**

THINGS TO DO IN AND AROUND EXETER

Exeter is a vibrant, cosmopolitan city steeped in history, with something for everyone. Full information on all the city has to offer can be found at **www.heartofdevon.com**

Cycling Routes

Exeter is a cycle friendly city with a range of traffic-free cycle routes which enable easy cycle commuting to the campuses, and provide fantastic leisure cycling opportunities for the weekend**.** **www.cycledevon.info/cycle-routes/**

Event Exeter's three recommended routes can be found here:
www.exeter.ac.uk/eventexeter/3-scenic-cycle-routes-self-catering-stay-exeter/

Shopping

With a wide range of high street and independent shops, Exeter has a wealth of places for shopping. The modern Princesshay shopping area, High Street and Guildhall and Harlequins centres, mixed with independent boutiques around the city centre offer a fantastic shopping experience.

Cathedral Quarter

Exeter Cathedral is one of England's most impressive medieval cathedrals and a fine example of decorated Gothic architecture. Open for visits all year round.
The Cathedral Green is a popular place for alfresco picnics, and for taking in some of the historical sites.

Castle Quarter

Rougemont Gardens and Exeter Castle provide a green retreat from the busy city. Situated just off the High Street, these areas of significant historical importance can be explored by the City Wall Trail or on a Red Coat Guided Tour.

Free Red Coat Guided Tours - www.exeter.gov.uk/guidedtours
An ideal way to explore Exeter, with various tours available covering the different aspects of the history of the city

Underground Passages - www.exeter.gov.uk/passages
Originally built as a means of bringing clean drinking water to Exeter, the underground passages make for an exciting tour. The heritage centre provides further information through interactive exhibits and interpretation.

Historic Quayside
Exeter Quay offers a wealth of history, interesting architecture, cafés, pubs and restaurants. The area also hosts many events throughout the year.

Royal Albert Memorial Museum (RAMM) www.rammuseum.org.uk
Exeter's Royal Albert Memorial Museum takes visitors from pre-history to the present day with displays and prestigious loans and exhibitions from Exeter and national partners. Awarded the national title of "Museum of the Year" (Art Fund Prize 2012), the museum offers free entry.

The Exe Estuary and Topsham - www.exe-estuary.org / www.topsham.org.uk
Fantastic views across the estuary and home to diverse wildlife and plants, the Exe Estuary is a beautiful place to visit. Topsham is an historic estuary port with a strong maritime atmosphere. Specialising in good local food establishments and an eclectic mix of independent shops, Topsham also offers spectacular sunsets and views across the estuary.

Killerton House - www.nationaltrust.org.uk/killerton
National Trust property, Killerton House was donated by the Aclands, one of Devon's oldest families. This historic house offers regular exhibitions, and is surrounded by beautiful gardens to explore. Located off the Exeter to Cullompton road (B3181); Exit the M5 at junction 28.

Castle Drogo - www.nationaltrust.org.uk/castle-drogo
The 'last castle to be built in England', this National Trust property is well worth a visit to explore the rooms inside or the beautiful gardens, including the rhododendron valley and rose gardens. Open all year round. 5 miles south of A30. Take A382 Whiddon Down to Moretonhampstead road; turn off at Sandy Park.

Dartmoor National Park - www.dartmoor.co.uk
368 square miles of moorland, impressive granite tors, woodlands, streams, quiet villages, bustling towns and of course the famous Dartmoor ponies. From Exeter, take the A30 towards Cornwall and turn off onto the north of Dartmoor at Whiddon Down. Or take the A38 towards Plymouth and turn off onto the eastern edge of Dartmoor at Bovey Tracey. Both routes take approximately 40 minutes by car.

Exmoor National Park - www.exmoor-nationalpark.gov.uk
A spectacular variety of landscapes set across 267 square miles, including moorland, woodland, valleys and farmland, with cosy pubs and tearooms offering delicious local produce. Travel north from Exeter on the M5 and take junction 27 then follow the brown tourist signs to Exmoor – between 40 and 60 minutes by car.

Powderham Castle - www.powderham.co.uk
Located in a unique, picturesque setting beside the Exe estuary, six hundred years of history are contained within the walls of one of England's oldest family homes. The farm shop which is free to enter provides an excellent range of food and drink from across the region. Open March to October, Sunday to Friday. From Exeter take the A379 to the Matford Roundabout, then take the 1st exit continuing on the A379 signposted to Dawlish, then follow the Powderham Castle brown tourist signs.

South Devon Railway - www.southdevonrailway.co.uk
A seven mile former Great Western Railway branch line, built in 1872, which runs along the stunning valley of the River Dart between Buckfastleigh and Totnes. The longest established steam railway in the South West. Varying timetables running between February and December with standard fares from £12.00 per adult. Located at Buckfastleigh between Exeter and Plymouth. Leave the A38 at the Dart Bridge junction and follow the brown signs.

Paignton Zoo - www.paigntonzoo.org.uk
Home to thousands of amazing plants and animals including giraffes, lions, gorillas, cheetahs, crocodiles, meerkats, snakes and monkeys.

Jurassic Coastline - www.jurassiccoast.org
The Dorset and East Devon Coast World Heritage Site is England's first natural World Heritage Site, known as The Jurassic Coast. It covers 95 miles of truly stunning coastline from East Devon to Dorset, with rocks recording 185 million years of the Earth's history.

Spotted eagle ray (*Aetobatus narinari*). © Steve Simpson

Smooth trunkfish (*Lactophrys trigueter*). © Steve Simpson

FSBI17 Committees

We wish to thank the FSBI17 Scientific Committee, FSBI17 Local Organising Committee and FSBI Council for support, advice, expertise and creative input.

FSBI17 Conveners

Steve Simpson, University of Exeter
Iain Barber, FSBI & Nottingham Trent University

Scientific Advisory Committee

John Armstrong, Marine Scotland Science
Iain Barber, FSBI & Nottingham Trent University
Safi Darden, University of Exeter
Jennifer Fitzgerald, Kings College London
Martin Genner, University of Bristol
Alistair Lyndon, Heriot-Watt University
Neil Metcalfe, University of Glasgow
Sophie Nedelec, University of Exeter
John Pinnegar, Cefas
Eduarda Santos, University of Exeter
Steve Simpson, University of Exeter
Jamie Stevens, University of Exeter
Rachel Turner, University of Exeter
Rod Wilson, University of Exeter
Ian Winfield, Centre for Ecology & Hydrology (Guest Editor)

Local organising committee

Darren Croft, Psychology, University of Exeter
Safi Darden, Psychology, University of Exeter
Brendan Godley, Centre for Ecology & Conservation, University of Exeter
Tim Gordon, Biosciences, University of Exeter
Andrew Griffiths, Biosciences, University of Exeter
Harry Harding, School of Biological Sciences, University of Bristol
Tetsu Kudoh, Biosciences, University of Exeter
Eduarda Santos, Biosciences, University of Exeter
Steve Simpson, Biosciences, University of Exeter
Jamie Stevens, Biosciences, University of Exeter
Rachel Turner, Environment and Sustainability Institute, University of Exeter
Rod Wilson, Biosciences, University of Exeter

FSBI Council

Honorary Officers

Iain Barber (Honorary President), Nottingham Trent University
Gary Carvalho (Honorary Vice-President), Bangor University
John Pinnegar (Honorary Secretary), Cefas & University of East Anglia
Robert Britton (Honorary Treasurer), Bournemouth University

Council Members

Darren Croft - Research Grants, University of Exeter
Julia Day - Research Grants, University College London
Siân Griffiths – Studentships, Cardiff University
Ioanna Katsiadaki - Research grants, CEFAS
Paul Kemp – Studentships, University of Southampton
Alastair Lyndon - Research grants, Heriot-Watt University
Philip McGinnity – Travel, University College Cork
Anne Gro Vea Salvanes – Travel, University of Bergen
Eduarda Santos – Travel, University of Exeter
Martin Taylor – Studentships, University of East Anglia

Guests of Council

John Craig - Editor-in-Chief, Journal of Fish Biology
Paul Hart - Newsletter Editor
Terry Langford – Publicity, Southampton University
Alan Pike - Webpages Editor, The Lucidus Consultancy

International Liaison

Victoria Braithwaite – USA, Penn State University
Culum Brown – Australia, Macquarie University
Paulo Pompeu - South America, Universidade Federal de Lavra
Jiashou Liu - China & Asia, (Institute of Hydrobiology Wuhan

Social Media Coordinator

Brian Hayden, University of New Brunswick

The FSBI: A Brief History

In the mid-1960s, several annual conferences on fish ecology were initiated in Liverpool by Jack W Jones, a member of the Department of Zoology University of Liverpool. During the third of these so-called Coarse Fish Conferences, in March 1967, informal discussion took place about the formation of a British society for fisheries biology. Participants in the discussion were: Jack Jones, David LeCren, a biologist at the Freshwater Biology Laboratory, Windermere, Peter Tombleson, an angling journalist and administrator, Lionel Mawdesley-Thomas a fish pathologist at the Huntingdon Research Centre and Alwyne Wheeler a taxonomist at the Natural History Museum, London. The discussions led to an inaugural meeting of the Fisheries Society of the British Isles on 21 October 1967 at the meeting rooms of the Zoological Society, London. James Chubb, also from the Department of Zoology, University of Liverpool, was appointed as the first editor of the *Journal of Fish Biology*. These five people were responsible for founding the new Society, and for guiding it through its early years.

Celebrating the FSBI at the 50th Anniversary Conference

In the 50 years that have passed since its founding, the FSBI has supported research and scholarship in the fields of fish biology and fisheries science through the publication of the *Journal*, the sponsorship of annual international symposia, and through a wide range of funding activities, including research grants, travel grants, PhD studentships, and – more recently – internships. Over the years, funding and support from the Society has played a major role in developing the careers of numerous scientists and practitioners in our fields. In our 50th year, we have commissioned a history project to document the role played by the FSBI in shaping fish biology and fisheries science. We hope that you will join us on **Thursday afternoon** to hear about the findings of this fascinating project, and to celebrate some of the achievements of our students and recipients of FSBI funding in the dedicated **'History of the FSBI'** session.

FSBI Membership

Membership of the FSBI is open to anyone with an interest in furthering the objectives of the Society, which are to encourage, promote and support all branches of fish biology and fisheries science and conservation. Details of how to join the Society, including subscription levels etc., are provided at http://www.fsbi.org.uk/membership/fsbi-membership/

This year we introduced a new symposium registration fee structure initiative to encourage symposium delegates to join the FSBI, so if you are one of our new or returning members, we welcome you wholeheartedly to the Society. We hope that you enjoy your membership benefits (which can be found online at http://www.fsbi.org.uk/membership/why-join-the-fsbi/) and hope that you will renew your membership in a years' time, knowing that by doing so you are helping secure the future for fish biology and fisheries science for future generations (of fish and researchers!)

Thank you for your interest in the Society! I look forward to meeting you in Exeter.

Iain Barber
FSBI Honorary President

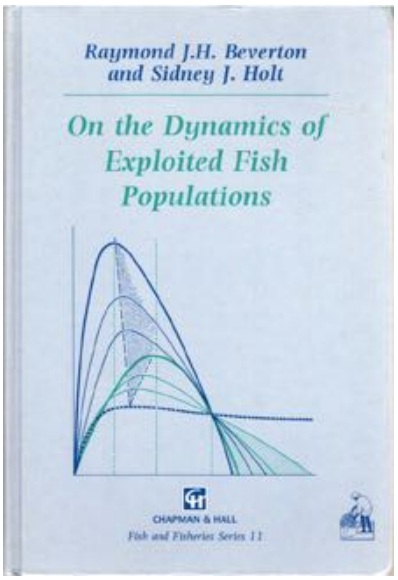
2017 Medallists

Beverton Medal – Prof. Sidney Holt

The Beverton Medal *is awarded to a distinguished scientist for a lifelong contribution to all aspects of the study of fish biology and/or fisheries science, with a focus on ground-breaking research*.

In 2017, the 50th year of the FSBI, we are delighted to award the Beverton Medal to Prof. Sidney Holt. Sidney worked with Ray Beverton in the 1940's and 50's at the Lowestoft Fisheries Laboratory. Their foundational book "*On the dynamics of exploited fish populations*" was written during this period and is widely by fishery scientists as "the bible of fisheries science".

In 1953, Sidney took a position with the Food and Agriculture Organization of the United Nations where he worked with international partners to address overfishing and concerns regarding global food security. Between 1960 and his retirement in 1979 Sidney diverted his attention to commercial whaling and achieving the recovery of baleen whale populations in the southern hemisphere. He worked as a representative of FAO, UNEP and the UN at the International Whaling Commission (IWC) and later he acted as a scientific advisor to the Republic of Seychelles and Italy (according to Beverton, Holt "saved the great whales in the early 1970s").



In addition to his work with the UN, Prof. Holt has held professorial chairs at the Universities of California Santa Cruz, of Rhode Island and of Malta, and a Senior Overseas Fellowship at St John's College, Cambridge.

"*On the dynamics of exploited fish populations*" remains one of the top 10 most cited fish and fisheries references of all time. First published in 1957, it has been printed 4 times and amassed over 4,000 citations.

Le Cren Medal – FishBase Consortium

The Le Cren medal *is awarded to one or more individuals who have made a lifelong contribution to all aspects of the study of fish biology and/or fisheries science, with a focus on conservation, training or public understanding of the discipline.*

The 2017 LeCren Medal is awarded to the consortium of scientists, programmers and archivists that conceived, developed and continue to maintain FishBase, an online global biodiversity information system and database of finfish species (**http://www.fishbase.org/**). It is the largest and most extensively accessed online database for fishes worldwide. As of October 2016, FishBase included descriptions of 33,400 species and subspecies in almost 300 languages, 57,800 pictures, and references to 51,600 works in the scientific literature. The site provides fisheries information to over 600,000 visitors every month. The Fishbase database has been referenced over 6,500 times in 160 different journals spanning fisheries, agriculture, and business management. Data made available through FishBase has been instrumental in some of the most high-profile, and highly cited papers of the past three decades – including: *Pauly et al. (1998) Fishing down marine food webs. Science 279: 860–863* [2309 citations]; *Worm et al. (2006) Impacts of biodiversity loss on ocean ecosystem services. Science 314: 787–790* [1775 citations]; *Pauly et al. (2002) Towards sustainability in world fisheries. Nature 418: 689–695* [1401 citations].

FSBI Medal – Prof. Nick Graham

The FSBI medal *is awarded to younger scientists who are deemed to have made exceptional advances in the study of fish biology and/or fisheries science in recognition of their achievements. Nominees must be under 40 years of age on 28 February of the year in which the medal is awarded.*

Prof. Nick Graham is Chair of Marine Ecology at Lancaster Environment Centre, Lancaster University. Nick completed a FSBI-funded PhD at Newcastle University before moving to James Cook University (Australia) as a Research Fellow (later Senior and Principal Research Fellow).

Nick's research tackles large-scale ecological and social-ecological coastal issues under the overarching themes of climate change, human use and resilience. His work assesses the long-term impacts of climate change on coral reef fish assemblages, fisheries and ecosystem stability, and how this can be incorporated into management action. Nick has published over 125 research articles which have been cited almost 10,000 times. In 2016, he was listed as an ISI Highly Cited Researcher.

FSBI17 Plenary Speakers & Special Guests

Prof. Charles Tyler – Jack Jones Lecture

University of Exeter, UK

Charles Tyler is a reproductive physiologist and ecotoxicologist and Deputy Head of Biosciences at the University of Exeter. His research focuses mainly on investigations into the effects endocrine disrupting chemicals, pharmaceuticals and nanoparticles on wildlife, principally fish, and he has published over 230 full research papers. He has received the Fisheries Society of the British Isles Beverton Medal for ground breaking research in fish biology and the Society of Environmental Toxicology and Chemistry's Founders Award, given to an individual with an outstanding career in the environmental sciences. His passion is natural history and he works also on various wildlife conservation projects.

Dr Joanna Alfaro-Shigueto

ProDelphinus & Universidad Científica del Sur, Peru

Joanna Alfaro-Shigueto is the President of Pro Delphinus. She is a trained biologist and began working on marine conservation issues in the final year of her bachelor studies in Biology at Universidad Ricardo Palma. From 1994–2000, as a member of the non-profit group Peruvian Center for Cetacean Research (CEPEC), she conducted assessments of cetacean bycatch along the Peru coast. From 1995–1997, Joanna also coordinated the Cetacean Survey Program at the government agency IMARPE. In 1995, she co-founded the non-profit group Pro Delphinus. Her research focuses on marine conservation and small scale fisheries and has a strong environmental education focus. In July 2001 she was fully supported as a Global fellow to attend the Duke Marine Laboratory. In 2002 Joanna became a member of the Marine Turtle Specialist Group MTSG or the IUCN. Since 2002 Joanna has continued to work as Pro Delphinus President, extending its work to other marine species including seabirds, sharks and marine otters. Joanna obtained her PhD at University of Exeter, UK in 2012. Also in 2012 she was awarded with the Whitley Award for Nature, received from Princess Anne in London. In 2015 she was also awarded with the Marsh Award for Marine Conservation Leadership in Latin America. In 2016 Joanna brought together over 700 marine conservationists from over 70 countries to Peru, to participate in the 36th International Sea Turtle Symposium. Joanna is a Faculty Member of Universidad Científica del Sur, where she continues to mentor the new generation of Peruvian marine researchers. Joanna has authored and collaborated on over forty peer reviewed publications in collaboration with the international research community.

Dr William Cheung

University of British Columbia, Canada

Dr. William Cheung is an Associate Professor at the Institute for the Oceans and Fisheries, UBC and the Director (Science) of the Nippon Foundation-UBC Nereus Program. His main research areas include studying marine ecosystems and fisheries under global change, and examining trade-offs in managing and conserving living marine resources. His works cut across multiple disciplines, from oceanography to ecology, economics and social sciences, and range from local to global scales. William has published over 100 peer-reviewed publications, including papers in leading international journals. William is also actively involved in international and regional initiatives that bridge science and policy. For instance, he was a Lead Author in the Working Group II of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), a Coordinating Lead Author of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) and Global Biodiversity Outlook. He serves as member of the editorial board of Fish and Fisheries, Fisheries Oceanography and Frontier in Marine Sciences, and as scientific advisors in a number of international and local organizations including BioDiscovery, IUCN and WWF Canada.

William obtained his BSc in Biology and M.Phil. from the University of Hong Kong. He worked for WWF Hong Kong for two years, after which he completed his PhD in Resource Management and Environmental Studies at UBC. From 2009 to 2011, he was Lecturer in Marine Ecosystem Services in the School of Environmental Sciences, University of East Anglia.

Prof. Isabelle Côté

Simon Fraser University, Canada

Isabelle Côté is a professor of Marine Ecology at Simon Fraser University in beautiful Vancouver, BC. She was lured back to the Canadian wilderness after spending 13 wonderful years at the University of East Anglia, U.K. She's a jill of all trades (despite the implications for mastery), and her interests in marine ecology and conservation are broad. Her recent research focus has been on marine invasive species – measuring their impacts, predicting their spread and devising the best ways to control them. She is passionate about science communication, particularly relating to ocean discovery, and is the Vice-President of the Canadian Society for Ecology and Evolution. She was awarded the Marsh Award for Conservation Biology of the Zoological Society of London in 2009, for contributions of fundamental science to the conservation of animal species and habitats, and selected as a Leopold Leadership Fellow in 2015 for her efforts at linking science, public engagement and policy. She is also happiest 10m below the surface, watching fish do their thing.

Prof. Iain Couzin

Max Planck Institute for Ornithology and University of Konstanz, Germany

Iain Couzin is Director of the Max Planck Institute for Ornithology, Department of Collective Behaviour, and the Chair of Biodiversity and Collective Behaviour at the University of Konstanz, Germany. Previously he was a Professor in the Department of Ecology and Evolutionary Biology at Princeton University, and prior to that a Royal Society University Research Fellow in the Department of Zoology, University of Oxford, and a Junior Research Fellow in the Sciences at Balliol College, Oxford. His work aims to reveal the fundamental principles that underlie evolved collective behaviour, and consequently his research includes the study of a wide range of biological systems, from insect swarms to fish schools and primate groups. In recognition of his research he has been recipient of the Searle Scholar Award in 2008, top 5 most cited papers of the decade in animal behaviour research 1999-2010, the Mohammed Dahleh Award in 2009, Popular Science's "Brilliant 10" Award in 2010, National Geographic Emerging Explorer Award in 2012 and the Scientific Medal of the Zoological Society of London in 2013.

Dr Beth Fulton

Principal Research Scientist, CSIRO, Australia

Dr Beth Fulton leads the CSIRO's Marine Ecosystem Modelling and Risk Assessment Group and is an Adjunct Professor at the Centre of Marine Socioecology in Hobart. Over the past two decades Beth has led work on the development and implementation of various system modelling tools for looking at marine ecosystems and sustainability. These tools give equal attention to biophysical and human components of marine and coastal ecosystems. The work of Beth's team underpins the CSIRO's research into sustainably managing potentially competing uses of marine environments, adaptation to global change and effective means of conserving and monitoring marine ecosystems.

Prof. Peter Mumby

University of Queensland, Australia

Peter Mumby began his career designing MPAs in Belize and realized how little science was available to guide the process. He then switched into a research career with the goal of providing solutions to common management challenges. He obtained his PhD in 1998 from the University of Sheffield (UK). He then moved to the Universities of Newcastle and eventually Exeter on NERC and Royal Society research fellowships. Peter was

promoted to Professor in 2005. In 2010, the call of better weather led Peter to move to the University of Queensland and take up a prestigious ARC Laureate Fellowship. Peter's research group look at questions concerning the ecology of coral reefs, the resilience of ecosystems, the design and functioning of MPAs, fisheries management, the connectivity of ecosystems, and the incorporation of ecosystem services into management design. Peter has published >230 journal articles, is a Pew Fellow in Marine Conservation, and was the inaugural mid-career award winner for contributions to coral reef science from the International Society for Reef Studies. He is happiest with a camera on a coral reef and at a depth of around 10 m.

Charles Clover - Banquet guest speaker

Executive Director, Blue Marine Foundation
Author of *The End of the Line*

As an environment journalist with 30 years' experience, Charles has covered virtually every issue that arises out of man's treatment of nature. It was his powerful and revealing book The End of The Line (2003) and the award-winning documentary film that it inspired (2009) which brought the problems of overfishing and the impact it is having on life in the oceans into public focus. He is now the full time executive director of the charity that film engendered, the Blue Marine Foundation, which has been involved in the protection of more than four million square kilometres of ocean since it was founded in 2010. He was a weekly columnist for the Sunday Times until last year and before that was Environment Editor of The Daily Telegraph for 20 years. Before taking a professional interest in the sea, he was the author, with HRH the Prince of Wales, of 'Highgrove: Portrait of an Estate' (1993).

Direct from Glastonbury 2017…

BBQ Guest Performance

LAND OF THE GIANTS

Since 2009, Land of the Giants have been pulling crowds to festival tents with their foot-stomping beats and contagious enthusiasm. A brass section that will make you grin from ear to ear, heavy toe-tapping basslines and Andy Quick's sensuous, soaring vocals will make you wonder why you've never danced your (b)ass off to The Giants before.

The last three years have seen The Giants unrelentingly tour the length and breadth of the UK, spreading their fresh and accessible sounds to venues and festivals alike. From packed out stages at Glastonbury, Boomtown and Beautiful Days to rocking venues from Ireland to India, LOTG are well on their way to global domination.

The six-piece collective scooped Best Band in the most recent Southwest Music Awards and have been tipped by many as one of the best emerging live bands in the country.

2017 IFS-AFS Fellow

Jane Sullivan

Sustainable Fisheries Division
NOAA Fisheries Alaska Regional Office

Jane Sullivan is an Alaska Sea Grant Fellow and fishery analyst at the NOAA Fisheries Alaska Regional Office in Juneau, Alaska. She currently collaborates on projects with the North Pacific Observer Program, including developing the annual observer deployment review into a reproducible research product and building an optimization algorithm for incorporating electronic monitoring tools into the observer program. Jane holds a Masters of Science in Fisheries from the University of Alaska Fairbanks, where she researched environmental and fishery effects on growth and size-at-age of Pacific halibut. Jane's primary interests lie in the field of applied marine fisheries research, and consequently, she gravitates towards projects that use population dynamics and estimation methods to inform policy and management.

Jane has benefited immensely through her involvement with the American Fisheries Society. She served as Vice President of the University of Montana subunit during her undergraduate program, President of the University of Alaska Fairbanks subunit, and the Student Representative to the Western Division of the American Fisheries Society (AFS) during graduate school. She is honored to serve as the 2017 International Fisheries Section (IFS) Fellow and represent IFS at the 50th Anniversary Symposium of the Fisheries Society of the British Isles. She loves living in Alaska, fishing, and meeting people who love fish as much as she does.

Freshly landed European plaice (*Pleuronectes platessa*) ready for auction at Brixham Fish Market. © Nigel Sainsbury

Full Programme

NB: If presenter is not first author, both are listed for searching the abstract.

Monday 3 July 2017

10:00–12:00 Optional Genomics Workshop, Life Sciences Building

10:00–12:00 Registration desk open, set up posters (Forum main street)

12:00–13:00 Welcome Lunch

13:00–13:30 Opening Ceremony with Prof Sir Steve Smith (Vice Chancellor)
Alumni Auditorium, Forum

13:30–14:30 Jack Jones Lecture: Prof. Charles Tyler
The Feminisation of Nature – An Unnatural History

14:30–15:15 Afternoon Session – Biology of Fish 1
Session Chair: Jamie Stevens

14:30 Brian Shuter
Fish life history dynamics in ecological and evolutionary time

14:45 Katja Häkli
Does phenotypic variation reflect the standing genetic variation along a speciation continuum?

15:00 John Armstrong
Population processes in Atlantic salmon as functions of individual characteristics: smolt to adult survival

15:15–15:45 Coffee + Posters

15:45–18:00 Afternoon Session – Biology of Fish 2
Session Chair: Ioanna Katsiadaki

15:45 Lengxob Yong
The genetics of reduced sexual dimorphic red ornaments in threespine sticklebacks

16:00 Martin Reichard
Reconciling field and lab research on African annual fishes to understand the causes of sex-specific mortality and lifespan

16:15 Kim Præbel
Decoding mitogenomes of extreme longevity: phylogenomics of the Greenland shark

16:30 Daria Zelenina
Population structure and historical origin of the most important sockeye salmon stock in the north-western area of the Russian far east

16:45 Josh Korman
Trends in recruitment, abundance, survival, and growth over a boom-and-bust cycle of a rainbow trout tailwater population

17:00 Alexandre Lemopoulos
Genome-wide divergence patterns support fine-scaled genetic structuring associated with migration tendency in brown trout

17:15 Deiene Rodriguez-Barreto
Transgenerational epigenetic signatures of domestication in Atlantic salmon (*Salmo salar*)

17:30 Jamie Stevens
Genetic analysis indicates marked population structure of Atlantic salmon and brown trout in the chalk streams of southern England

Speed Talks

17:45 Jenni Prokkola
Estimating diversity and divergence from individuals to populations – is RADSeq analysis worth the investment? (+ Poster)

17:48 Andrew Griffiths
Population genetics of the roach (*Rutilus rutilius*) in Western Europe

17:51 Monika Kłodawska
Expression of opsin genes in cichlids of the Bermin and Barombi MBO crater lakes (+ Poster)

17:54 Jen Lewis
You can't swim from the past! Using natural tags to explore range-expansion in gilthead seabream (+ Poster)

17:57 Lucie Montorio
The sensitivity of the population growth rate to vital rates of resident and anadromous individuals in a brown trout population (+ Poster)

18:00–19:00 **Poster Session with Wine Reception**

19:00–20:00 Check in to Holland Hall

20:00–21:00 **Welcome Dinner in Holland Hall**

21:00–23:00 **Themed Pub Quiz in Holland Hall bar**

Tuesday 4 July 2017

07:00–08:00 **Breakfast in Holland Hall**

08:30–09:30 **Plenary Lecture 1: Prof. Isabelle Côté**
Invasions from the top: The multi-faceted repercussions of a marine predator introduction

09:30–10:30 **Morning Session – Biology of Fish 3**
Session Chair: Suzanne Mills

09:30 Neil Metcalfe
Does individual variation in metabolic rate influence microhabitat use and the spatial structuring of juvenile salmon populations?

09:45 Allan Raffard
Environmental and historical determinants of the functional diversity in a generalist freshwater fish (*Phoxinus phoxinus*)

10:00 Jessica Duffill Telsnig
Contribution of pelagic and benthic pathways to North Sea fish food webs

10:15 Clive Trueman
Sharks connect food webs across the global ocean

10:30–11:00 **Coffee + Posters**

11:00–13:00 **Morning Session – Biology of Fish 4**
Session Chair: Gary Carvalho

11:00 Eef Cauwelier
Across rather than between river genetic structure in Scottish salmon: potential causes and management implications

11:15 Ricardo Beldade
Retention mechanisms and self-recruitment in a coral reef fish

11:30 Arne Jacobs
The evolution of parallel Arctic charr ecotypes via non-parallel evolutionary and genomic routes

11:45 Madeleine Carruthers
Ecological transcriptomics of trophic divergence in the highly polymorphic Arctic char: uncovering the molecular phenotype

12:00 Guy Marley
Carbon sources supporting food chains in a mangrove forest and adjacent intertidal mudflats: a stable isotope approach

12:15 Samantha Simpson
Ontogenetic shifts in feeding ecology of four sympatric Rajidae species

12:30 Alastair Lyndon (first author Thomson)
Understanding anadromous brown trout across contrasting landscapes: Orkney as a natural laboratory

Speed Talks

12:45 Tom Horton
Return of an apex predator to British coastal waters: the case of Atlantic bluefin tuna (*Thunnus thynnus*) (+ Poster)

12:48 Asa White
Superfoods and salmonids: experimental impact of watercress-derived phenethyl isothiocyante on the early life stages of brown trout (*Salmo trutta*) (+ Poster)

12:51 Abdulghani Abdulghani
Ecological and evolutionary trajectories of two Lessepsian fishes during their establishment in a novel habitat (+ Poster)

12:54 Stephen Gregory
Length of Atlantic salmon smolt and their subsequent marine survival (+ Poster)

13:00–14:00 **Lunch** (including meet the mentors (Anne Gro Salvanes, Neil Metcalfe) & themed conversations)

Optional Writing Workshop with Wiley Publishers

14:00–15:00 **Plenary Lecture 2: Prof. Peter Mumby**
The connectivity, ecosystem overfishing, and rebuilding of coral reef fisheries

15:00–16:15 **Afternoon Session – Biology of Fish 5**
Session Chair: Al Harborne

15:00 Justin Bridgeman
Behavioural thermoregulation and performance of a benthic fish species: An investigation on the thermal biology of invasive round gobies (*Neogobius melanostomus*)

15:15 Isla Keesje Davidson
Hearing Nemo: alarm-calling behaviour in coral reef fish

15:30 Henrik Christiansen
Growth of sneaker and territorial males, and females of the bearded goby (*Sufflogobius bibarbatus*) from the northern Benguela

15:45 Serra Örey
Thinner females - fewer eggs? Temporal trends in Eastern Baltic cod fecundity (2004–2016)

16:00 Colin Bouchard
Impacts of nest spatial aggregation on population productivity: the case of a small population of Atlantic salmon (*Salmo salar*)

16:15–16:45 **Coffee + Posters**

16:45–19:00 **Afternoon Session – Parallel Sessions**

Biology of Fish 6 (Alumni Auditorium)
Session Chair: Neil Metcalfe

16:45 Sylvia Dimitriadou
Mechanisms underlying the evolution and maintenance of cooperation

17:00 Johan Watz
Overwintering behaviour of stocked brown trout: effects of the rearing environment and river habitat complexity

17:15 Kate Laskowski
Individual behavioural composition in a predator population determines food web functioning

17:30 Carl Smith
Oviposition-site decisions in the population dynamics of European bitterling

17:45 Annie Murray
Leaders and followers in manta ray (*Manta alfredi*) foraging groups

18:00 Alessandro Macario
Disrupting guppy females social network affects negatively their fitness

18:15 Bridie Allan
Lionfish misidentification circumvents an optimized escape response by prey

18:30 Waldir Berbel-Filho
Sex in the mangroves: genetic diversity, parasite load and risk-taking behaviour in an androdioecious mixed-mating fish

Speed Talks

18:45 Katie Downes
Size related dichotomy in diet of yellowfin tuna at Ascension Island, central Atlantic (+ Poster)

18:48 Yulia Sapozhnikova (first author Avezova)
Hybrid forms of the Baikal whitefish and the perspectives of their artificial reproduction (+ Poster)

18:51 Valerio Visconti
Age, growth and reproduction of the leatherjacket, *Meuschenia scaber* (Forster 1801) (+ Poster)

18:54 Chloe Stevens
Linking stress and welfare in a popular ornamental fish (+ Poster)

18:57 Carolina Doran
Disentangling the roles of familiarity and relatedness on group foraging behaviour

Tools for Understanding Fish Populations 1 (Seminar 7)
Session Chair: Josie Paris

16:45 Florianne Marandel
Comparison of methods for assessing the status of thornback ray

17:00 Thomas Staveley
Habitat connectivity of Atlantic cod (*Gadus morhua*) in coastal shallow-water seascapes

17:15 Paul Hart
Seamounts as islands: consequences for the connectivity of fish populations

17:30 Carly Graham
Genome coverage vs sequencing depth: a case study examining population structure in the lake whitefish

17:45 Cristina Di Muri
Fish biodiversity defrosted: unveiling non-compliant seafood trade in British ethnic food

18:00 Stefano Mariani (first author Bakker)
Tropical shark diversity and abundance in contrasting levels of anthropogenic impact: an environmental DNA approach

18:15 Krista Sherman
Understanding genetic population structure of endangered Nassau grouper to support their conservation management

18:30 Rebecca Fox
Beer cans or thermoregulators? A field-based approach to testing for behavioural thermoregulation in tropical marine fishes

Speed Talks

18:45 Alice Manuzzi
Contrasting patterns of spatial genetic population structure in a model shark, *Scyliorhinus canicula* – insights from a multimarker approach

18:48 Olivier Lepais (first author Bacles)
Cost-efficient estimation of effective population size from single parr sample for Atlantic salmon conservation monitoring of rear-edge populations in Southern France (+ Poster)

18:51 Jane Usher
Utilising synthetic genetic analysis as a tool for functional genomic characterisation of metallothioneins genes in brown trout (+ Poster)

18:54 Andrew King
Has stocking contributed to an increase in the rod catch of sea trout (*Salmo trutta* L.) in the Shetland Isles? (+ Poster)

19:00–23:00 **Garden Party – BBQ (featuring Land of the Giants)**
Reed Hall Lawns

Wednesday 5 July 2017

07:00–08:00 **Breakfast in Holland Hall**

08:30–09:30 **Plenary Lecture 3: Dr William Cheung**
The future of fishes and fisheries in the changing oceans: interactions between human stressors

09:30–10:30 **Morning Session – Fish in a Changing World 1**
Session Chair: John Pinnegar

09:30 David Sims
Ocean warming and deoxygenation effects on pelagic shark behaviour and vulnerability to fisheries

09:45 Mark McCormick
Habitat degradation affects how fishes assess risk

10:00 Suzanne Mills
Hormone-mediated fitness responses to global change in coral reef fish

10:15 Timothy Gordon
Degraded Great Barrier Reef no longer sounds like home

10:30–11:00 **Coffee + Posters**

11:00–13:00 **Morning Session – Fish in a Changing World 2**
Session Chair: Eduarda Santos

11:00 Kimmo Kahilainen (first author Hayden)
Climate and productivity shape fish and invertebrate community structure in subarctic lakes

11:15 Matteo Zucchetta
Impact of climate warming on European whitefish: model based projection of population dynamic in the Lake Garda (Italy)

11:30 Nigel Milner
Climate change influences population dynamics of anadromous brown trout (*Salmo trutta*)

11:45 Louise Rutterford
The impact of climatic variability on growth of commercial fishes

12:00 Ian Cowx
Decoupling the impacts of societal development and climate change on fisheries in the lower Mekong Basin

12:15 Alastair Harborne
Multiple effects of climate change on the ecology and behaviour of fishes on Pacific reef flats

12:30 Felix Mittermayer
Cod and ocean acidification: direct and transgenerational effects

Speed Talks

12:45 Daniel Montgomery
Multi-stressor impacts of the 'deadly trio' on hypoxia tolerance of a commercial fish species (+ Poster)

12:48 Daniele D'Agostino
Coping with extreme environments: the influence of thermal variation on fish behavioural ecology (+ Poster)

12:51 Sonya Auer
Oligotrophication has evolutionary consequences for salmon populations (+ Poster)

13:00–14:00 **Lunch** (including meet the mentors (Peter Mumby, Brendan Godley) & themed conversations)

Optional "*Imposter Syndrome*" session – Isabelle Côté

14:00–15:00 **FSBI Annual General Meeting – all delegates welcome** (Seminar 7)

15:00–16:30 **Afternoon Session – Themed Discussion Groups**

- **Biology of Fish** (Seminar 7)
- **Fish in a Changing World** (Seminar 10)
- **Valuing & Managing Fish Populations** (Seminar 11)
- **Tools for Understanding Fish** (Seminar 12)

Option to attend LSI Symposium with two Nobel Laureates

16:30–19:30 Treasure Hunt, Sports & Games, Science Busking

20:00–21:00 **Dinner in Holland Hall**

Thursday 6 July 2017

07:00–08:00 **Breakfast in Holland Hall**

08:30–09:30 **Plenary Lecture 4: Dr Joanna Alfaro-Shigueto**
Small scale, large potential: Using artisanal fisheries to promote marine conservation research in South America

09:30–10:30 **Morning Session – Fish in a Changing World 3**
Session Chair: Brendan Godley

09:30 Murray Duncan
Marine protected areas provide species with physiological resilience to the impacts of climate change

09:45 Andrew Radford
Impacts of anthropogenic noise on fish: individual effects, population consequences and mitigation

10:00 Anne Gro Salvanes
Adaptation to extreme environments – Gobies in the Benguela Upwelling Ecosystem

10:15 Sophie Nedelec
Motorboat noise impacts parental behaviour and offspring survival in the spiny chromis (*Acanthochromis polyacanthus*)

10:30–11:00 **Coffee + Posters**

11:00–13:00 **Morning Session – Parallel Sessions**

Fish in a Changing World 4 (Alumni Auditorium)
Session Chair: Andy Radford

11:00 Aoife Parsons
Environmental impacts of brominated flame retardants: understanding the molecular mechanisms of thyroid disruption in fish embryo–larvae

11:15 Andrew Gill
The anthropogenic electromagnetic world of fish: understanding novel environmental stimuli effects on fish behaviour

11:30 Jennifer Fitzgerald
Hypoxia modulates the responses to chemical exposures in the threespine stickleback (*Gasterosteus aculeatus*)

11:45 Harry Harding
Fish in noisy habitats show reduced sensitivity to motorboat noise

12:00 Josie Paris
Brown trout and heavy metals: adaptation to the legacy of Britain's mining history

12:15 Ossi Keva
Total mercury concentrations in liver, muscle and scales of European whitefish (*Coregonus lavaretus* (L.)) in a subarctic lake – assessing the factors driving year-round variation

12:30 Ruth Cooper
Assessing the oestrogenic potency and health impacts of wastewater treatment work effluents using ERE-GFP transgenic zebrafish

Speed Talks

12:45 Tamsyn Uren Webster
Investigating the impacts of stress on the microbiome and immune status of Atlantic salmon (Poster)

12:48 Yulia Sapozhnikova
The effects of intense acoustic stimulation on the auditory behaviour and epithelium ultrastructure of Baikal fish (+ Poster)

12:51 Rebecca Fox (first author Head)
Mate choice decisions and parenting strategies in degrading environments: mind the evolutionary trap

12:54 Ioanna Katsiadaki
Tools for assessing welfare of laboratory fish (+ Poster; first author Sebire)

Tools for Understanding Fish Populations 2 (Seminar 7)
Session Chair: David Sims

11:00 Brian Hayden
Trophic ecology in the AGE of 'big data' – new insights from old numbers

11:15 Kristine Richter
Widening the net: using archaeological fish data

11:30 Clarisse Boulenger
Combining an innovative monitoring method and a hierarchical Bayesian model to estimate diadromous fish run

11:45 Paul Dolder
Using spatio-temporal population models to inform mixed fishery management

12:00 Kate Mintram
An individual-based model for the three-spined stickleback: assessing population-level effects of EDC-induced disruption of breeding behaviours

12:15 Richard Hedger
Diving behaviour of Atlantic salmon in the Norwegian and Barents Seas

12:30 Nicolas Humphries
Nocturnal activity and optimal searching: What do skates get up to, when they think we're not watching?

Speed Talks

12:45 Waldir Berbel-Filho
Reconstructing the past to understand the present: Palaeodrainages and phylogeography of *Trichomycterus zonatus*

12:48 Neil Burns
Application of life-stage distribution modelling to improve fishing selectivity and minimise bycatch (+ Poster)

12:51 Eva Bergman
Conservation of a landlocked salmonid population in a regulated river: taking a holistic approach (+ Poster)

12:54 Clara Obregon
Conservation of the European eel in the Thames Catchment: the power of collaboration

12:57 El-Mahdi, Mohammed
Genetic variation and phylogenetic relationship among four parrotfishes (Genus Scarus) from Hurghada, Red Sea coast, Egypt based on RAPD markers (+ Poster)

13:00–14:00 **Lunch** (including meet the mentors (Mark McCormick, Charles Tyler) & themed conversations)

Jack Perks: Freshwater Fishes of Britain – film preview (FSBI-funded project)

14:00–15:00 **Plenary Lecture 5: Prof. Iain Couzin**
Collective sensing and decision-making in schooling fish

15:00–16:00 **Afternoon Session – Fish in a Changing World 5**
Session Chair: Andrew Griffiths

15:00 Anssi Vainikka
Concurrent decline of whitefish stocks in Lake Oulujärvi: a result of pikeperch re-introduction or climate change?

15:15 Sara Kurland
Loss of natural Baltic salmon populations can severely reduce metapopulation capacity to retain genetic variation

15:30 Thomas Appleby
Maximum Sustainable Yield is dead: long live Maximum Sustainable Yield

Speed Talks

15:45 Catherine Gutmann Roberts
Movement and diet: Individual specialisations of barbel *Barbus barbus* in a disconnected and subsidised world (+ Poster)

15:48 David Murray
Assessing reproductive function and fillet quality in triploid Atlantic salmon

15:51 Agnès Bardonnet
Impact of low flow on young-of-year Atlantic salmon: density-dependent and density-independent factors interact to decrease population resilience (+ Poster)

15:54 Robert Potts
Investigating the sale of shark steaks and fins in the UK (+ Poster)

16:00–16:30 **Coffee + Posters**

16:30–18:50 **Afternoon Session – Celebrating 50 years of the FSBI**
Session Chair: Iain Barber

16:30 Iain Barber (FSBI Honorary President)
Introduction

16:35 Sally Horrocks & David Lean

The Fisheries Society of the British Isles: the first fifty years

17:00 Maria Quaggioto & Felicity Huntingford (FSBI project)
How smart are fish? Communicating to the public what scientists and fishers know using interactive e-learning

17:15 Ian Cowx
British coarse fisheries – decades of change: revisiting the legacy of Jack Jones

17:30 Nick Jones (2nd Year FSBI PhD student)
Stage fright: The effect of an audience on archerfish shooting behaviour

17:45 Agnieszka Magieriecka (2nd Year FSBI PhD student)
Does chronic maternal stress affect the next generation of sticklebacks?

18:00 Natasha Phillips (3rd Year FSBI PhD student)
Distribution and seasonal movements of the ocean sunfishes

18:15 Lauren Laing (recent FSBI PhD student)
Exposure to copper during embryogenesis caused increased tolerance in subsequent generations, in the three-spined stickleback (*Gasterosteus aculeatus*)

18:30 John Pinnegar (FSBI Honorary Secretary)
The 'afterlife' of a FSBI student – Mediterranean fishes: scaling up from populations to ecosystems

18.45 Iain Barber (FSBI Honorary President)
Summing up

19:30–23:30 **Festival Banquet (with Guest Speaker Charles Clover)**
Great Hall (arrive from 19:30, dinner served at 20:00)

Stoplight parrotfish (*Sparisoma viride*). © Peter Mumby

Friday 7 July 2017

07:00–08:00 **Breakfast in Holland Hall (+ check out)**

08:30–09:30 **Plenary Lecture 6: Dr Beth Fulton**
Fisheries induced ecosystem restructuring – what is acceptable?

09:30–10:30 **Morning Session – Valuing & Managing Fish 1**
Session Chair: Anne Gro Vea Salvanes

09:30 Hallvard Jensen
Long-term responses of fisheries in an oligotrophic lake of southern Norway – ecological consequences and management implications

09:45 Jane Sullivan (IFS-AFS Fellow)
Cumulative effects of size-selective fishing on size-at-age of Pacific halibut (*Hippoglossus stenolepis*)

10:00 Doug Austen (Executive Director, AFS)
The death, resurrection and potential future impacts of policy changes on U.S. inland fisheries

10:15 Rod Wilson
The role of fish in ocean chemistry and global biogeochemical cycling – past, present and future

10:30–11:00 **Coffee + Posters**

11:00–13:00 **Morning Session – Valuing & Managing Fish 2**
Session Chair: Rod Wilson

11:00 Larry Greenberg
Post-spawning survival and downstream passage of landlocked Atlantic salmon in the regulated River Klarälven

11:15 Rebecca Short
The use of mosquito nets in fisheries: a global to local perspective

11:30 Christopher Monk
Are individual differences in fish movement related to angling vulnerability? A whole-lake reality mining experiment in the wild using four species

11:45 Olaf Weyl
Non-native fish eradication facilitates the rapid recovery of native stream fishes in the Cape Fold ecoregion, South Africa

12:00 Joanna Barker
Multidisciplinary approach to identify the spawning ground of the European smelt (*Osmerus eperlanus*) in a modified urban estuary used to inform fish conservation during the planning process

12:15 John Piccolo (first author Andersson)
Recreational trolling effort and catch of salmon and trout in Vänern, the EU's largest lake

12:30 Peter Shaw (first author Langford)
Discontinuities in fish assemblages at habitat, reach and stream scales in relation to riparian land use in an ancient landscape and the implications for mitigating effects of raised temperatures.

Speed Talks

12:45 Chrystelle Delord
Fishery resources of the upper-Maroni River: Impacts of fishing pressure and life history traits on genetic diversity in several fish species (+ Poster)

12:48 Luke Holman
Modelling the success and profitability of selective breeding programs using individual based bio-economic simulations in R

12:51 Stefano Mariani
Food or wildlife? Consumers' poor knowledge of fish appearance hampers seafood market transparency and sustainability (+ Poster)

13:00–13:30 Closing Address + Student Prizes

13:30–14:30 Farewell Lunch

Posters

Posters – Biology of Fish

Abdulghani Abdulghani – Ecological and evolutionary trajectories of two Lessepsian fishes during their establishment in a novel habitat (+ Speed Talk)

Angelika Agud – Comparison of the skin microbiota of three-spined stickleback fish from different environmental locations

Agnès Bardonnet (first author Arevelo) – Effects of climate change on first-feeding brown trout growth and metabolism: a mesocosm experiment

Cyndi Mae Bandong – Comparison of the ovarian development among five strains of Nile tilapia and its implications on fish fecundity

Ellen Bell – Polyploidy and Parasites: Does polyploidy confer immune advantage in Corydoradinae catfishes?

Nikita Berry – Parent, kin or foe? Influence of adult presence on embryo physiology and behaviour in a selectively cannibalistic fish

Henrik Christiansen – Connectivity and genomic diversity of an Antarctic fish revealed through genotyping-by-sequencing

Katie Downes – Size related dichotomy in diet of yellowfin tuna at Ascension Island, central Atlantic (+ Speed Talk)

Stephen Gregory – Length of Atlantic salmon smolt and their subsequent marine survival (+ Speed Talk)

Wooseok Gwak (first author Shin) – Comparative development of three different winter-spawned prelarval fishes at the first feeding stage along the southern coast of Korea

Tom Horton – Return of an apex predator to British coastal waters: the case of Atlantic bluefin tuna (*Thunnus thynnus*) (+ Speed Talk)

Monika Kłodawska – Expression of opsin genes in cichlids of the Bermin and Barombi MBO crater lakes (+ Speed Talk)

Carole Lee – Change matters: creating stimulating environments for fish in captivity

Jen Lewis – You can't swim from the past! Using natural tags to explore range-expansion in gilthead seabream (+ Speed Talk)

Lucie Montorio – The sensitivity of the population growth rate to vital rates of resident and anadromous individuals in a brown trout population (+ Speed Talk)

Dmytro Omelchenko – Hemoglobin gene expression patterns in deep-water environment – the story of Cameroonian crater lakes cichlid fishes

Chiara Papetti – In (white) cold blood: Speciation, introgression and hybridization in Antarctic fish

Chiara Papetti – Non-Antarctic notothenioids: phylogenetic history and contemporary phylogeographic implications in the face of environmental changes

William Perry – From morphology to microbiome: integrated common garden study in Atlantic salmon (*Salmo salar*)

Natasha Phillips – Seeking the sun in deep, dark places: mesopelagic sightings of ocean sunfishes (Molidae)

Jenni Prokkola – Estimating diversity and divergence from individuals to populations –is RADSeq analysis worth the investment? (+ Speed Talk)

Deiene Rodriguez-Barreto – Behavioural and transcriptome responses of Nile tilapia (*Oreochromis niloticus*) to crowding conditions

Yulia Sapozhnikova (first author Sidorova) – Baikal sympatric coregonids as a model system in ecological genomics

Yulia Sapozhnikov – Hybrid forms of the Baikal whitefish and the perspectives of their artificial reproduction (+ Speed Talk)

Chloe Stevens – Linking stress and welfare in a popular ornamental fish (+ Speed Talk)

Alice Tebb (first author Dapling) – Monitoring the movements of the black seabream (*Spondyliosoma cantharus*, L.) utilising Kingmere Marine Conservation Zone as a spawning site

Sebastian Theis – Food-dependent development of behavioural types over ontogeny

Asa White – Superfoods and salmonids: experimental impact of watercress-derived phenethyl isothiocyante on the early life stages of brown trout (*Salmo trutta*) (+ Speed Talk)

Valerio Visconti – Age, growth and reproduction of the leatherjacket, *Meuschenia scaber* (Forster 1801) (+ Speed Talk)

Valerio Visconti – Age, growth and reproductive characteristics of the blue-barred parrotfish *Scarus ghobban*

Benjamin Whittaker – Genetic profiling of lumpfish (*Cyclopterus lumpus*) across the native range

Posters – Fish in a Changing World

Sonya Auer – Oligotrophication has evolutionary consequences for salmon populations (+ Speed Talk)

Agnès Bardonnet – Impact of low flow on young-of-year Atlantic salmon: density-dependent and density-independent factors interact to decrease population resilience (+ Speed Talk)

Friederike Clever – Assessing dietary versatility of reef fishes in response to environmental degradation

Corbett, William – In a renewable world: behavioural responses of benthic communities to pile driving noise

Daniele D'Agostino – Coping with extreme environments: the influence of thermal variation on fish behavioural ecology (+ Speed Talk)

Catherine Gutmann Roberts – Movement and diet: Individual specialisations of barbel *Barbus barbus* in a disconnected and subsidised world (+ Speed Talk)

Beccy Heath – Does development stage affect tolerance to copper in zebrafish embryos?

Kimmo Kahilainen – Parallel ecomorphological divergence drives differential mercury bioaccumulation in polymorphic whitefish (*Coregonus lavaretus*) populations of subarctic lakes

Ioanna Katsiadaki – Tools for assessing welfare of laboratory fish (+ Speed Talk)

Lauren Laing – Bisphenol a (BPA) causes reproductive toxicity, decreases dnmt1 transcription, and reduces global DBA methylation in breeding zebrafish (*Danio rerio*)

Hannah Littler – Does pre-exposure to BPA affect susceptibility upon re-exposure?

Tânia Madureira – Estrogenic disruption of lipid metabolic signalling in juvenile brown trout (*Salmo trutta f. fario*)

Tânia Madureira (first author Abruneiro) – Studying effects of oestrogens and of PPAR agonists in the development of eyed-stage embryos of brown trout (*Salmo trutta f. fario*)

Daniel Montgomery – Multi-stressor impacts of the 'deadly trio' on hypoxia tolerance of a commercial fish species (+ Speed Talk)

Robert Potts – Investigating the sale of shark steaks and fins in the UK (+ Speed Talk)

Ana Ruiz-Navarro – Climate change and freshwater fishes in Great Britain: implications for species, invasion and management

Yulia Sapozhnikova – The effects of intense acoustic stimulation on the auditory behaviour and epithelium ultrastructure of Baikal fish (+ Speed Talk)

Tamsyn Uren Webster – Investigating the impacts of stress on the microbiome and immune status of Atlantic salmon (+ Speed Talk)

Fredric Windsor – Endocrine disruption in aquatic systems: up-scaling research to address ecological consequences

Posters – Valuing & Managing Fish Populations

Eric Aikins – Challenges and strategies for achieving sustainable marine fishing: a review of the state of marine fisheries in Ghana

Joanna Barker – Securing the future of the Critically Endangered angelshark (*Squatina squatina*) in its unique stronghold of the Canary Islands

Chrystelle Delord – Fishery resources of the upper-Maroni River: Impacts of fishing pressure and life history traits on genetic diversity in several fish species (+ Speed Talk)

Georgina Hunt – Analysing unnoticed large-scale changes to Northumberland's marine ecosystems

Stefano Mariani – Food or wildlife? Consumers' poor knowledge of fish appearance hampers seafood market transparency and sustainability (+ Speed Talk)

Emma Nolan – Invasive zander *Sander lucioperca* in an impounded lowland river: a 'stocked up' river food-web or a successful recreational fishery?

Nigel Sainsbury – The elephant in the room: are severe weather events the greatest risk to fisheries?

Peter Shaw (first author Langford) – Changes in the fish community over twelve years following heavy modification of a small stream as part of a restoration scheme

Bryony Townhill – The effect of recreational fishing on UK fish populations

Rebekah Weatherhead – Challenges in aquaculture: the influence of water temperature on juvenile Nile tilapia (*Oreochromis niloticus*) immune function when challenged with *Saprolegnia parasitica*

Anke Zernack – Project Tuna: Towards establishing an environmentally, economically and socially sustainable shortfin eel aquaculture industry in New Zealand

Posters – Tools for Understanding Fish

Eva Bergman – Conservation of a landlocked salmonid population in a regulated river: taking a holistic approach (+ Speed Talk)

Gloria Blanco – Pedigree and kinship analysis in *Sparus aurata* based on SNP-haplotypes

Neil Burns – Application of life-stage distribution modelling to improve fishing selectivity and minimise bycatch (+ Speed Talk)

Cristina Di Muri – Environmental DNA (eDNA) monitoring of conservation priority fish in UK waters

Gareth Davies – Morphometrics of sagittae otoliths as a tool for the rapid age estimation of wild silvering *Anguilla anguilla*

Paul Dolder – Bringing together fish and fishery spatial dynamics: development of an exploratory individual based simulation framework

Mohammed El-Mahdi – Genetic variation and phylogenetic relationship among four parrotfishes (genus Scarus) from Hurghada, Red Sea coast, Egypt based on RAPD markers (+ Speed Talk)

Atyaf Hamied – The Arabian killifish (*Aphanius dispar*) as novel model for fungal infection of *Candida albicans*

Brian Hayden – IsoBank: Stable Isotope Ecology in the Age of 'Big Data'

Richard Hedger – Dynamically modelling the sensitivity of Atlantic salmon population abundance to hydropeaking-induced stranding mortality

Andrew King – Has stocking contributed to an increase in the rod catch of sea trout (*Salmo trutta* L.) in the Shetland Isles? (+ Speed Talk)

Andrew King – The sex ratio of sea trout (*Salmo trutta* L.) smolts and adults: preliminary results from the River Tamar

Olivier Lepais – Cost-efficient estimation of effective population size from single parr sample for Atlantic salmon conservation monitoring of rear-edge populations in Southern France (+ Speed Talk)

Felix Van der Meijs – Diel patterns of Atlantic cod (*Gadus morhua*): a study using acoustic telemetry

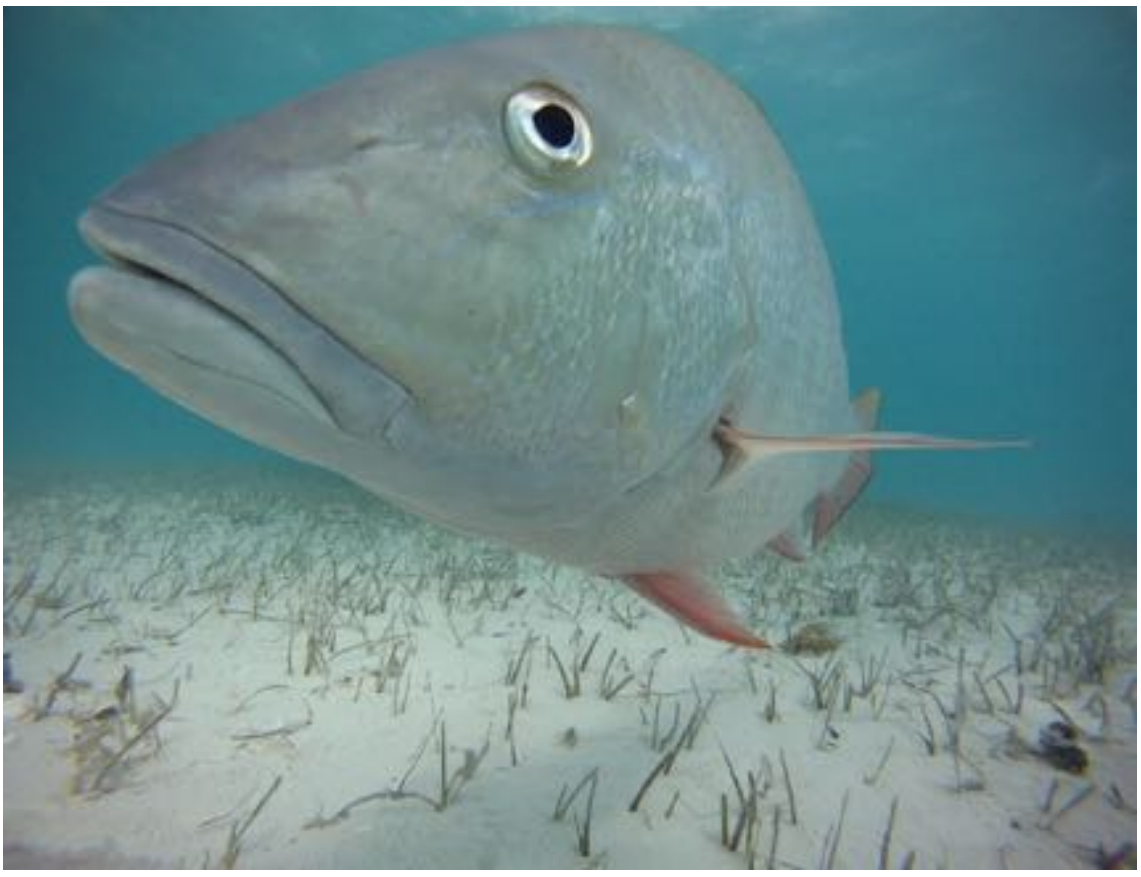
Jane Usher – Utilising synthetic genetic analysis as a tool for functional genomic characterisation of metallothioneins genes in brown trout (+ Speed Talk)

Posters – Celebrating 50 years of the FSBI

John Craig – A history of the *Journal of Fish Biology*, 1969 to 2016

Alastair Lyndon – Impact of the FSBI research grants scheme: an analysis and appraisal

Christophe Payne – Exploring the role of the rainbow trout (*Oncorhynchus mykiss*, W. 1792) gut microbiome in supporting fish health (FSBI funded PhD project)

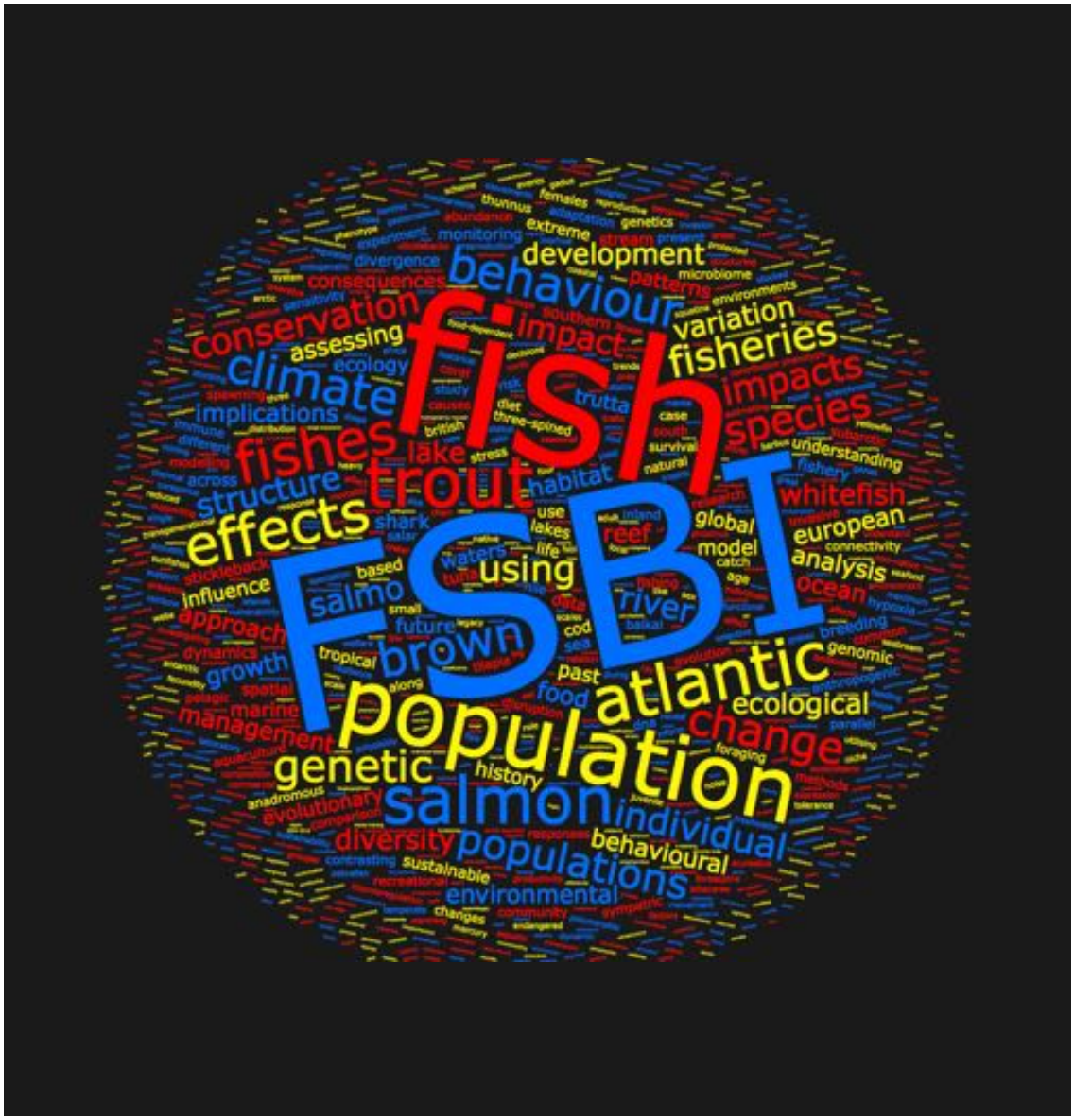


Mutton snapper (*Lutjanus analis*). © Alastair Harborne

Symposium Abstracts

All Symposium abstracts can be downloaded here:

http://www.exeter.ac.uk/fsbi17/programme/



Word cloud based on FSBI17 Abstracts (www.wordclouds.com)

Plenary Lectures

SMALL SCALE, LARGE POTENTIAL: USING ARTISANAL FISHERIES TO PROMOTE MARINE CONSERVATION RESEARCH IN SOUTH AMERICA

Dr Joanna Alfaro-Shigueto

ProDelphinus & Universidad Científica del Sur, Peru
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Peru is home to the world's largest single species fishery, but the vast majority of the catch is processed industrially and exported as fish meal or fish oil. However, Peru also has large and vitally important small-scale fisheries whose fish catch largely remains in the country for domestic consumption. These small-scale fisheries are the socio-economic backbone for millions of people, providing food and jobs for many coastal and riverine communities. Unfortunately, oftentimes there are more than just target fish in a fishing net. Our research has shown that these fisheries also impact many large vertebrate species in the form of incidental catch (or "bycatch"), including of seabirds, marine mammals, and sea turtles. Ideally, fisheries will follow an ecosystem-based approach that takes into account target and incidental catch species, but also the human population that depend upon these resources and fisheries. However, in many cases this information is absent, and limits researchers who seek to understand and conserve fish populations. I will share with you our experience in working with small-scale fisheries in South America, the human factor within them, and what tools have been useful, which have not, and the steps we have taken to move from understanding the bycatch issue to working to prevent it.

THE FUTURE OF FISHES AND FISHERIES IN THE CHANGING OCEANS: INTERACTIONS BETWEEN HUMAN STRESSORS

Dr William Cheung

University of British Columbia, Canada
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Fish is an important component of the marine ecosystems and the services to human societies. However, climate change and ocean acidification are affecting the physiology, population dynamics, community structure of marine fishes as well as the ecosystem functions and their contributions to human wellbeing. These changes add to or interact with other human stressors including fishing, habitat degradation and pollution. Here, I use three examples to illustrate how the future of fishes and fisheries may look like in changing oceans and the opportunities for solutions. Firstly, fisheries catches are projected to decrease in tropical areas as a result of distribution shifts of fishes and changes in ocean productivity under climate change. However, scenarios that reduce fishing in the high seas suggest that increased abundance of these straddling fish populations would help reduce climate-vulnerability of coastal fisheries. Secondly, warming leads to increase in the dominance of heat-tolerant fishes in the Caribbean coral reef fisheries. However, countries with larger area of coral reefs are less sensitive to such temperature-induced impacts on fish and fisheries. Thus, maintain and/or restoring habitat complexity and structure may fish communities and fisheries to adapt to some climate impacts. Thirdly, climate change-contaminant interactions are projected to increase the bioaccumulation of methylmercury in marine ecosystems in the Northeast

Pacific, threatening the health of marine mammals and human through seafood consumption. As coal-fired power generated is a major source of both carbon and mercury, transformation to renewable energy sources is an effective solution to mitigate such climate change-mercury impacts. While achieving the Paris Agreement warming goal would largely reduce these impacts, the above examples suggest that some of the remaining impacts may be reduced by adaptations through improving fisheries management, restoring critical habitats and reducing pollution.

INVASIONS FROM THE TOP: THE MULTI-FACETED REPERCUSSIONS OF A MARINE PREDATOR INTRODUCTION

Prof. Isabelle Côté

Department of Biological Sciences, Simon Fraser University
Website: http://www.sfu.ca/biology/faculty/cote/tmel/Home.html, Twitter: @redlipblenny

Introductions of non-native predators are expected to have large ecological impacts on recipient environments. This is particularly true for marine ecosystems, where predators are often large-bodied and communities are strongly size-structured. I use the case of the Indo-Pacific lionfish to explore the many repercussions – ecological and beyond – of marine predatory invaders. The lionfish invasion of the Atlantic basin continues to unfold at a rate and magnitude never before documented in any marine system. Indo-Pacific lionfish, released from aquaria, were first reported on western Atlantic coral reefs in 2004 and have since spread around the Caribbean region. My group was the one of the first 'in the water' to quantify the ecological impacts of this invader on native fauna. Here, I present the story as we understand it so far: comparisons with the native range, predation rates and prey decline, effectiveness of potential mitigation strategies, and some glimpses at our most recent findings on indirect ecological impacts, ranging from trophic reorganization of coral reef fish communities to alterations of coral reef soundscapes that have implications for fish recruitment. We have also begun to delve into quantifying the potential economic impacts of this invasion on tourism-dependent industries. Some hope that the lionfish invasion was a unique event, but this might be wishful thinking given the slow speed of regulatory changes to prevent re-occurrences.

COLLECTIVE SENSING AND DECISION-MAKING IN SCHOOLING FISH

Prof. Iain D. Couzin

Director, Department of Collective Behaviour, Max Planck Institute for Ornithology, Konstanz, Germany; Chair of Biodiversity and Collective Behaviour, Department of Biology, University of Konstanz, Germany
Website: http://collectivebehaviour.com/

Understanding how social influence shapes biological processes is a central challenge in contemporary science, essential for achieving progress in a variety of fields ranging from the organization and evolution of coordinated collective action among cells, or animals, to the dynamics of information exchange in human societies. Using an integrated experimental and theoretical approach, I will address how, and why, animals, such as schooling fish, exhibit highly-coordinated collective behaviour. I will demonstrate new imaging technology that allows us to reconstruct (automatically) the dynamic, time-varying networks that correspond to the visual cues employed by fish when making movement decisions. Sensory networks are shown to provide a much more accurate representation of how social influence propagates in schools, and their analysis allows

us to identify, for any instant in time, the most socially-influential individuals within groups, and to predict the magnitude of complex behavioural cascades before they actually occur. I will also investigate the coupling between spatial and information dynamics in groups and reveal that emergent problem solving is the predominant mechanism by which Golden shiner fish sense, and respond to complex environmental gradients. Evolutionary modelling demonstrates such 'physical computation' readily evolves within populations of selfish organisms, allowing individuals to compute collectively the spatial distribution of resources and to allocate themselves effectively among distinct, and distant, resource patches, without requiring information about the number, location or size of patches. Finally, I will reveal the critical role uninformed, or unbiased, individuals play in effecting fast and democratic consensus decision-making in collectives, and will test these predictions with experiments involving schooling fish and wild baboons.

FISHERIES INDUCED ECOSYSTEM RESTRUCTURING – WHAT IS ACCEPTABLE?

Dr Beth Fulton

Principal Research Scientist, CSIRO, Australia
Contact email: Beth.Fulton@csiro.au

People love to eat fish and that's just one of the many pressures modern fish stocks have to cope with. Fisheries and conservation managers have to make day-to-day decisions about what is acceptable and what is not. What happens when you overfish an ecosystem? Can the way fisheries operate make a difference to that structural signature? We can see from the history of fished systems that ecosystem structures can be substantially modified by intensive fishing pressure – from either industrial or "small scale" fleets. Drawing on modelling results, it does appear that there can also be strong hystereses in ecosystem structure, but that the patterns of fishing can make a difference. Recognising this in fisheries management is not yet straightforward. Building indicators of ecosystem structure and function into fisheries management may be a way towards pragmatically achieving rapid advances in such ecosystem based considerations.

For now, however, the single most outstanding question is – what is "acceptable"? Desirability and acceptability are social decisions, that discussion needs to be held openly and clearly. It will benefit from scientific input and I would love to hear what you all have to say: https://www.surveymonkey.com/r/CYPKX38

THE CONNECTIVITY, ECOSYSTEM OVERFISHING, AND REBUILDING OF CORAL REEF FISHERIES

Prof. Peter Mumby

University of Queensland, Australia
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The study of demographic processes of connectivity has followed two disparate paths with different conservation outcomes. The first is larval dispersal of fish on coastal and ocean currents, which promotes the use of networks of marine protected areas (MPAs). The second is the ontogenetic migration of fishes from nursery adult habitats, as is typified by migrations from seagrass beds to mangroves to coral reefs. I begin by showing how these two processes are in fact systematically related such that areas of high larval dispersal potential tend to be associated with a lack of nursery habitat

potential. These results help explain how ontogenetic migration evolved and imply that MPA functioning in mangrove-containing seascapes will differ from that elsewhere (offering relatively localised benefits). I then move on to consider how patterns of larval and adult dispersal influence MPA design and the ability of marine reserves to rebuild fisheries. Analysis of millions of model fisheries reveals heuristic rules over when reserves will provide net benefits to fisheries (vs. causing long-term loss of yield). Lastly, I consider the need to combine MPAs with fisheries regulations in order to prevent the ecosystem overfishing of coral reefs. This is an exciting frontier that combines population biology, community ecology, and climate modelling to resolve safe operating spaces for sustainable ecosystem use.

JACK JONES LECTURE
THE FEMINISATION OF NATURE – AN UNNATURAL HISTORY

Prof. Charles R. Tyler

Biosciences, University of Exeter, Exeter, United Kingdom
Contact email: c.r.tyler@ex.ac.uk

Jack Jones, the founding President of the Fisheries Society of the British Isles, may well have been aware of chemicals in the aquatic environment that have the potential to mimic hormones – as this has been known since before the Fisheries Society of the British Isles was established 50 years ago. More recently, however, it has been shown that exposure to these so-called endocrine disrupting chemicals (EDCs) can lead to disruptions in reproduction in wildlife and humans. More than 1000 chemicals discharged into the aquatic environment have been shown to be endocrine active, illustrating the potential scale of the issue. In fish, exposure to one group of EDCs, the environmental oestrogens, has been associated with alterations in sexual behaviours, reduction in sperm production and quality, and intersex - the presence of both male and female sex cells in gonads, and these effects can result in reduced reproductive fitness in males. There may also be consequences for these feminised responses for some wild fish populations but this is less well established. This lecture will present a critical overview on the current knowledge for health effects of exposure environmental oestrogens on fish and fish populations and illustrate how molecular methods, including the use of novel transgenic fish, have helped to unravel the mechanisms. In the final analysis, an attempt will be made to place endocrine disruption into context with some of the other environmental pressures that fish populations are facing in the modern world.

Arctic char (*Salvelinus alpinus*). © Jack Perks

Biology of Fish – Oral Presentations

LIONFISH MISIDENTIFICATION CIRCUMVENTS AN OPTIMIZED ESCAPE RESPONSE BY PREY

Allan, Bridie J. M.[1,2], McCormick, Mark I.[1,2]

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[2] Department of Marine Biology and Aquaculture, James Cook University, Townsville, QLD 4811, Australia

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Invasive lionfish represent an unprecedented problem in the Caribbean basin, where they are causing major changes to foodwebs and habitats through their generalized predation on fishes and invertebrates. To ascertain what makes the red lionfish (*Pterois volitans*) such a formidable predator, we examined the reaction of a native damselfish prey, the whitetail damsel (*Pomacentrus chrysurus*), to a repeatable startle stimulus once they had been forewarned of the sight or smell of lionfish. Faststart responses were compared with prey forewarned of a predatory rockcod (*Cephalopholis microprion*), a corallivorous butterflyfish (*Chaetodon trifasctiatus*) and experimental controls. Forewarning of the sight, smell or a combination of the two cues from a rockcod led to reduced escape latencies and higher response distances, speed and maximal speed compared with controls, suggesting that forewarning primed the prey and enabled a more effective escape response. In contrast, forewarning of lionfish did not affect the fast-start kinematics measured, which were the same as in the control and nonpredatory butterflyfish treatments. Lionfish appear to be able to circumvent mechanisms commonly used by prey to identify predators and were misclassified as non-predatory, and this is likely to contribute to their success as predators.

POPULATION PROCESSES IN ATLANTIC SALMON AS FUNCTIONS OF INDIVIDUAL CHARACTERISTICS: SMOLT TO ADULT SURVIVAL

Armstrong, John D.[1], McKelvey, Simon[2], Smith, Gordon, W.[1], Fryer. Rob, J.[1]

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[2] Cromarty Firth Fishery Trust, CKD Galbraith, Reay House, 17 Old Edinburgh Road, Inverness, IV2 3HF.

Contact email: John.Armstrong@gov.scot

Survival of wild-reared Atlantic salmon from the stage of freshwater emigrants (smolts) to adults returning from sea to spawn was assessed over a 15-year period in a Scottish river. Samples of 1000 or more smolts each year were individually tagged with passive integrated transponders (PITs) and released. Survivors were detected automatically by a PIT detector as they returned and migrated upstream in subsequent years. Survival and date of detection as returning adult were analysed as functions of year of tagging, emigration date, fish size and condition. The data are presented in two contexts. First, individual characteristics of smolts are related to fitness. Together with other data consideration is made of how variations in growth and behaviour at the early freshwater life stage influence the adult spawning population and its resilience. Secondly, trends in survival measured directly using PITs are compared with those that are routinely inferred from fisheries catch data and used to populate models for managing Atlantic salmon populations.

RETENTION MECHANISMS AND SELF-RECRUITMENT IN A CORAL REEF FISH

Beldade, Ricardo[1], Holbrook, Sally[2], Schmitt, Russell[2], Planes, Serges[1], Bernardi, Giacomo[3]

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[2] Marine Science Institute, University of California Santa Barbara, CA, USA
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Oceanographic features influence the transport and delivery of marine larvae, and physical retention mechanisms, such as eddies, can enhance self-recruitment (i.e. the return of larvae to their natal population). Knowledge of exact locations of hatching (origin) and settlement (arrival) of larvae of reef animals provides a means to compare observed patterns of self-recruitment 'connectivity' with those expected from water circulation patterns. Using parentage inference based on multiple sampling years in Moorea, French Polynesia, we describe spatial and temporal variation in self-recruitment of the anemonefish Amphiprion chrysopterus, evaluate the consistency of net dispersal distances of self-recruits against the null expectation of passive particle dispersal and test the hypothesis that larvae originating in certain reef habitats (lagoons and passes) would be retained and thus more likely to self-recruit than those originating on the outer (fore) reef. Estimates of known self-recruitment were consistent across the sampling years (~25–27% of sampled recruits). For most (88%) of these self-recruits, the net distance between hatching and settlement locations was within the maximum dispersal distance expected for a neutrally buoyant passive particle based on the longest duration of the larval dispersive phase and the average direction and speed of current flow around Moorea. Furthermore, a parent of a given body size on the outer (fore) reef of Moorea was less likely to produce self-recruits than those in passes. Our findings show that even a simple dispersal model based on net average flow and direction of alongshore currents can provide insight into landscape-scale retention patterns of reef fishes. The differential probabilities of certain areas in the reef harbouring self-recruit producing parents has direct implications for marine protected area design in coral reef islands.

SEX IN THE MANGROVES: GENETIC DIVERSITY, PARASITE LOAD AND RISK-TAKING BEHAVIOUR IN AN ANDRODIOECIOUS MIXED-MATING -FISH

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Pathogens are powerful selective agents involved in maintaining genetic variation in host immune-related genes. However, asexual or self-fertilising populations that persist despite low genetic diversity challenge the traditional idea that low variation results in reduced ability to respond to pathogens. We tested the hypothesis that sex may have evolved to fight pathogens by examining the relationship between genetic diversity, behaviour and parasite loads in the mangrove killifish (*Kryptolebias hermaphroditus*), a species with a mixed-mating strategy. Most of the individuals (73%) were selfed, and harboured little or no genetic variation at 27 microsatellite loci. However, some individuals (27%) showed heterozygosity across multiple loci, provides evidence of recent sexual outcrossing. This finding confirms *K. hermaphroditus* as one of the rare cases of mixed mating among vertebrates. A significant negative correlation was found between higher genetic diversity (originating from sexual outcrossing) and parasite loads, supporting the idea that sex confers disease resistance in mixed-mating species. We also found a positive association between boldness and parasite loads, which suggests a potential case of parasite control of host behaviour.

IMPACTS OF NEST SPATIAL AGGREGATION ON POPULATION PRODUCTIVITY: THE CASE OF A SMALL POPULATION OF ATLANTIC SALMON (*SALMO SALAR*)

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In natural populations, individuals are often distributed in such a way that aggregation increases at some places, and decreases at others. Aggregation may modify ecological processes acting at individual level such as breeding interactions or competition, and affect population demography and evolution.
Aggregation of Atlantic salmon (*Salmo salar*) redds is expected to (*i*) diminish recruitment through an intensified density-dependent mortality of eggs and Young Of the Year (YOY), and (*ii*) exacerbate impact of environmental stochasticity on eggs and YOY, and thus raise recruitment variability.
Yearly redd mapping in the small Atlantic salmon population of the Nivelle (France) was used to compute patchiness which was incorporated in a Beverton-Holt stock-recruitment model, linking egg density to YOY density over a 30 years period.
Contrary to predictions, population recruitment was not impaired by local aggregation of redds, but its variability was diminished by an increase in aggregation. The originality of this work was to use local distribution to compute population aggregation, and link it to the stock-recruitment of the whole population over a long time scale. The results contrast with previous studies showing that local aggregation diminished local recruitment. Explanation could be that aggregation permits to compensate lower recruitments at some sites by others, and that females tend to aggregate in sites with little variations.
This work is a part of a PhD subject on Atlantic salmon, encompassing two others sections dealing with (*i*) the reconstruction of sexual network, and (*ii*) a field work to assess space use tactics of mature parrs.

BEHAVIOURAL THERMOREGULATION AND PERFORMANCE OF A BENTHIC FISH SPECIES: AN INVESTIGATION ON THE THERMAL BIOLOGY OF INVASIVE ROUND GOBIES (*NEOGOBIUS MELANOSTOMUS*)

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Fish are adept at selecting microclimates to avoid potential thermal stresses in their native habitats. Diurnal fluctuations are especially evident in streams and rivers that round gobies (*Neogobius melanostomus*) inhabit in the Great Lakes region. Round gobies became invasive to the region in 1990, yet little is known about their thermal biology. The focus of this study is to gain a better understanding of round goby thermal preference, and to investigate the velocity of burst swimming when exposed to moderate warm acute temperatures. The behavioural thermoregulation of wild-caught gobies acclimated at 21°C was observed in a shuttlebox (temperature range: 10°C-30°C). Thermal preference was 19°C, with a mean lower escape temperature of 19°C and mean upper escape temperature of 23°C. Interestingly, almost half of the individuals chose to stay at either the extreme cool (10°C) or extreme warm (30°C) throughout experimentation. We subsequently examined burst velocity of gobies acclimated to the same temperature in a T-maze over a period of 3 days at 21°C, 24°C, and 27°C. Burst velocity significantly decreased with increasing temperature. The decrease in velocity at moderate warm temperatures was surprising, as it occurs well below the temperatures known to incapacitate gobies (i.e. CTmax), but does span the temperatures of normal, voluntary thermoregulatory behaviour. The results suggest that voluntary behaviours could reflect physiological performance curves in round gobies. This study is important in understanding the effect of acute temperature change on swimming performance of round gobies, and the individual differences in behavioural thermoregulation of a bottom-dwelling fish species.

ECOLOGICAL TRANSCRIPTOMICS OF TROPHIC DIVERGENCE IN THE HIGHLY POLYMORPHIC ARCTIC CHARR: UNCOVERING THE MOLECULAR PHENOTYPE

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Trophic polymorphisms are distinct intraspecific variations that arise as a result of niche specialization, and are hypothesised to form an important early step in speciation. Salmonid invasions of postglacial lakes represent model examples of rapid diversification into distinct trophic ecotypes and can thus be used as powerful systems for investigating evolutionary processes, such as adaptive trait divergence and subsequently speciation. One common aspect is divergence along the benthic-limnetic habitat axis, which has evolved repeatedly within and between localities. At present, it is unclear whether the parallel divergence in phenotype is associated with parallel molecular divergence. One area of genetics that is revolutionising this field is the study of gene expression. Gene expression can be used as a 'molecular phenotype' (influenced by genetics and environment) to gain insight into the formation of incipient species within adaptive radiations. This research applies transcriptomic techniques to investigate diversification in the highly polymorphic salmonid, Arctic charr (*Salvelinus alpinus*). Using a new, species-specific *de novo* reference of 24,194 annotated transcripts, we analyse differential gene expression (based on RNA-seq) between sympatric Arctic charr ecotypes within and across lakes, and across two postglacial lineages. Our study system includes populations of varying genetic admixture and divergence, allowing us to determine whether increasing signatures of genetic divergence are associated with increasing levels of gene expression divergence. Results show consistency in patterns of differential gene expression between ecotypes, linked to adaptive pathways. Our research shows that ecological transcriptomics based on wild samples can informatively reflect the different ecotypes of Arctic charr.

ACROSS RATHER THAN BETWEEN RIVER GENETIC STRUCTURE IN SCOTTISH SALMON: POTENTIAL CAUSES AND MANAGEMENT IMPLICATIONS

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Atlantic salmon (*Salmo salar*) stocks have historically been managed on a river-by-river basis, reflecting a balance between practical management and available information (or lack of) regarding stock structure. Here we examine the underlying genetic structure in salmon sampled from 14 rivers in eastern Scotland. Information was obtained from over 2,000 juveniles caught at 85 sites and screened for ~4,300 single nucleotide polymorphic markers. Two genetically and geographically discrete groups of rivers were identified, with no clear between-river differentiation within each group. Within the two groups, sites in the upper and lower sections of different rivers were more closely related than sites from the upper and lower sections of the same river. For each of the two groups differentiation between fish from upper and lower sections was related to distance from the sea and/or altitude. The occurrence of such cross-river genetic grouping may be the result of similar adaptive differences within each river or from a recent common ancestry. Examination of historical tagging information illustrated patterns of between-river straying that may help maintain the observed structure. Although the causes of such cross-river groupings are not clear, their existence highlights the complex structuring of salmon stocks and may confound genetic identification of single river stocks. The general paradigm of river-based management has been acknowledged to be an oversimplification with regards to within-river structuring and the results we present show that cross-river structuring is an important consideration in managing salmon stocks.

GROWTH OF SNEAKER AND TERRITORIAL MALES, AND FEMALES OF THE BEARDED GOBY (*SUFFLOGOBIUS BIBARBATUS*) FROM THE NORTHERN BENGUELA

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While parental care is overall uncommon in marine fish, it is prevalent in the Gobiidae family. Not all males are caretakers, and there are at least two Alternative Reproductive Tactics (ARTs). Best known are i) males that are territorial, nest-building and guarding; and ii) smaller males that adopt a sneaking tactic to fertilize eggs in moments of negligence of the nest-owner. Consequently, the different behaviours are directly linked to body size. It is, however, still largely unknown whether ARTs are flexible, linked to size or age, or genetically predetermined. We here examine interactions between growth and size and reproductive characteristics of marine gobies in nature, of the endemic bearded goby (*Sufflogobius bibarbatus*) from the Benguela, southern Africa. Bearded gobies show remarkable adaptations to low oxygen levels and have a flexible diet, which makes them an integral, ecological link between lower and higher trophic levels in this large marine ecosystem. Male bearded gobies were found to perform ARTs, a factor that potentially may contribute to the species' success in the Benguela.
We identified females, and males of different tactics based upon examination of gonado-somatic indices. Subsequently, otolith analyses and a combination of fisheries biology tools, such as von Bertalanffy functions, back-calculation, and Fourier analysis were used to investigate patterns of growth and size differences. Clear differences in growth patterns, with sneaker males being consistently younger and smaller, underlined the importance of body size in relation to ARTs. We discuss potential mechanisms behind male reproductive tactics throughout and individual's ontogeny.

HEARING NEMO: ALARM-CALLING BEHAVIOUR IN CORAL REEF FISH

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Alarm calling, particular vocalisations that warn of impending danger, is a major antipredator strategy seen in a wide range of bird and mammal species. Receivers of alarm calls that respond adaptively to these acoustic signals obtain fitness benefits through increased survival. Although fish are known to be highly vocal and use acoustic cues to obtain information about the environment, the potential use of alarm calls has received little empirical attention. Our ongoing study adapts established terrestrial experimental protocols—combining video and multi-track audio recordings, detailed observations, model predators and call playbacks—to explore alarm-calling behaviour in the anemonefish *Amphiprion chrysopterus* and Domino damselfish *Dascyllus trimaculatus* in Moorea, French Polynesia. This research deepens our understanding of fish vocal behaviour, identifying the ecological and social contexts in which different sounds are made, and the responses they elicit. As alarm-calling can appear altruistic, studying such behaviour will also increase understanding of the roles of reciprocal altruism and cooperation in fish. More generally, this research reflects the growing interest in understanding how fish species inhabiting coral reefs interact whilst navigating their acoustic environment.

MECHANISMS UNDERLYING THE EVOLUTION AND MAINTENANCE OF COOPERATION

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The evolution of cooperation among unrelated individuals poses a paradox to the traditional theory of natural selection. Theoretical work suggests that assortment between cooperators is a crucial requirement for the emergence and maintenance of cooperation among non-kin. However, the active and passive mechanisms that underlie such assortment still remain largely unclear. Here we use the Trinidadian guppy (*Poecilia reticulata*) to explore the bio-behavioural mechanisms underpinning cooperative behaviour. Guppies cooperate with shoal mates during predator inspection, a behaviour in which a small number of individuals leaves the relative safety of the shoal and approaches a potential predator to assess the level of threat, and then returns to the shoal to transmit this information. Previous research has shown that guppies show consistent individual differences in predator inspection tendencies, and that the level of cooperative investment is conditional on past experiences. Behavioural traits such as cooperative behaviour have been shown to strongly affect the social structure of wild guppy populations, with individuals being assorted by predator inspection tendency. We selectively bred guppies for high and low cooperative propensity over 3 generations, and then determined the behavioural traits associated with cooperation. This work explores the mechanisms underlying population assortment by behavioural traits, and ultimately leading to the emergence and maintenance of cooperation in this species.

CONTRIBUTION OF PELAGIC AND BENTHIC PATHWAYS TO NORTH SEA FISH FOOD WEBS

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Understanding the structure of marine food webs is essential for predicting how ecosystems will respond to large-scale changes such as overfishing or climate change because food web structure influences ecosystem resilience. Coupling between benthic and pelagic pathways is a key determinant of food web structure and resilience to perturbations. This study establishes the extent to which 13 fish species are trophically affiliated with benthic and pelagic pathways in the North Sea. Using stable isotope analysis and how this changes with consumer biomass and across years (2002-2006). Carbon ($\delta^{13}C$) and sulphur ($\delta^{34}S$) stable isotope data were used to differentiate between the pathways using source indicator species as end-members. Using mackerel and plaice respectively as pelagic and benthic sources, a bayesian mixing model estimated the relative amount of pelagic production consumed by species, with mass and year as covariates. $\delta^{13}C$ and $\delta^{34}S$ together estimated benthic-pelagic coupling more tightly than with $\delta^{13}C$ alone, but the estimates were similar, suggesting that $\delta^{13}C$ alone is sufficient to differentiate between pathways. Generally, year had little effect on species' affiliation to pathways whilst body mass had a negative effect; as mass increased, species were more affiliated to benthic sources, although the strength of this trend varied among species. Understanding species' affiliations to trophic pathways can identify species which might be more resilient to perturbations in a single pathway, aiding management measures towards sustainable fisheries.

DOES PHENOTYPIC VARIATION REFLECT THE STANDING GENETIC VARIATION ALONG A SPECIATION CONTINUUM?

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Adaptive radiation is the evolution of ecological and phenotypical diversity that arises via ecological opportunity. This exploration of new niches mediates specialization, and may lead to reproductive isolation. In the early stages of this divergence process, standing genetic variation is essential for natural selection to operate. But it is less known about how the different levels of standing genetic variation influence the diversification process. Post-glacial lakes in northern Fennoscandia are relatively young (6,000-10,000 ybp) and exist as natural replicates across the landscape. European whitefish is a highly abundant fish species in these lakes and has in post-glacial time repeatedly radiated in sympatry. The variation in the degree of divergence among the morphs throughout these lakes represents a speciation continuum from monomorphic to polymorphic whitefish populations. This speciation continuum occurs in three replicated watercourses that was colonized from East to West, where the radiations in the most western watercourse display half the standing genetic variation compared to the eastern watercourse. Here we used this speciation continuum to assess whether the phenotypic diversity is reflected by the standing genetic variation. We used adaptive phenotypic traits and life history traits of three different whitefish morphs to investigate the relationships between standing genetic variation, phenotypic diversity, and the spatial distribution of the whitefish. We then analyzed mono and polymorphic whitefish populations in replicated adaptive radiations across a large spatial scale to study the correlation between phenotypic and genotypic variation, and whether evolution is restricted by time or standing genetic variation.

THE EVOLUTION OF PARALLEL ARCTIC CHARR ECOTYPES VIA NON-PARALLEL EVOLUTIONARY AND GENOMIC ROUTES

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Some of the most longstanding questions in evolutionary biology concern the origin of biodiversity and the ability of species to rapidly diversify in the face of gene flow. Fundamental to answering these questions is the ability to understand the extent to which evolution is predictable. To understand if parallel ecotypes evolved using parallel or non-parallel evolutionary routes, we examined phenotypic and population genomic patterns of replicated divergence in 19 Arctic charr (*Salvelinus alpinus*) populations from two evolutionary lineages (Atlantic and Siberian).
We found that ecotypes show strong levels of phenotypic parallelism among populations within lineages, but differing levels of phenotypic parallelism among lineages. A population genomic analysis based on 648 individuals genotyped at ~200,000 loci from ddRADseq, revealed a pronounced speciation continuum, ranging from no neutral genetic divergence to strong reproductive isolation between ecotypes. Furthermore, coalescence modelling to reconstruct the evolutionary history of each population suggested that most intralacustrine divergence is the result of secondary contact. However, the detailed histories of divergence, admixture and phylogenetic relationships between ecotypes differ substantially among populations. We used a

multivariate Random Forest approach to identify loci linked to the contemporary ecotype divergences, which revealed a mainly non-parallel genomic basis.
Our study highlights the flexibility of evolution through the interplay of parallel and non-parallel evolutionary and genomic patterns across populations and gives insights into mechanisms underpinning rapid diversification in the face of gene flow.

TRENDS IN RECRUITMENT, ABUNDANCE, SURVIVAL, AND GROWTH OVER A BOOM-AND-BUST CYCLE OF A RAINBOW TROUT TAILWATER POPULATION

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Data from a large-scale mark-recapture study was used in an open population model to determine the cause of a 10-fold decline in the abundance of a Rainbow Trout population in the tailwater of Glen Canyon Dam, AZ. The population declined in part because annual recruitment between 2012 and 2016 was an order of magnitude lower than an exceptionally large recruitment that occurred in 2011 due to high and steady flows during spring and summer. Relative to average survival rates in 2012 and 2013 for trout ≥ 225 mm, survival rates in 2014, 2015, and 2016 declined by 11%, 21%, and 22%, respectively. Even with the large decrease in recruitment, abundance at the end of the study would have been three- to five-fold higher had survival rates for these larger trout remained at the elevated levels estimated for 2012 and 2013. The collapse in the abundance of larger fish began when relative condition reached low values of ~ 0.9-0.95 in the fall of 2014. Reduced growth in 2014 occurred when trout biomass and other indices of the energetic demand of the population were at least half of what they were relative to at the start of the study, indicating that availability of prey had declined. Reduced growth affected multiple life history stages and processes causing negative feedbacks that regulated the abundance and biomass of the population, including: higher mortality of larger fish; lower rates of recruitment in years when growth was reduced; and lower rates of sexual maturation the following year.

INDIVIDUAL BEHAVIORAL COMPOSITION IN A PREDATOR POPULATION DETERMINES FOOD WEB FUNCTIONING

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Predators often play critical roles in structuring whole food webs through trophic cascades. Increasing recognition of the functional significance of intra-specific trait variation suggests that even within the same species, different individual predators may have differing influences on a food web. Here, we test the hypothesis that differences in behavioral composition within predator populations modulate the predators' impact on lower trophic levels. We used replicated pond mesocosms where we added small groups of European perch (*Perca fluviatilis*) as top predators. We created three predator treatments (plus a no-predator control): a "bold" treatment where all perch exhibited bold and active behavior, a "shy" treatment, and then a "mixed" treatment where half the perch were bold and half were shy. We measured multiple aspects of food web dynamics including macro and micro-invertebrate abundances, periphyton growth and decomposition rates of leaf litter. As expected, the presence of predators, regardless of behavioral composition, had strong impacts on lower trophic levels by decreasing abundance of macroinvertebrates (amphipod and dragonfly larvae) leading to increased abundances of smaller invertebrates (chironomid spp.). Importantly, the strength of this cascade was influenced by the predator treatment: ponds with bold predators exhibited stronger trophic cascades than ponds with shy or mixed populations. These results suggest that intra-specific variation in functional traits such as behavior may have large scale effects on whole food web dynamics, and that particularly bold and active individual predators may be especially influential in mediating these effects.

GENOME-WIDE DIVERGENCE PATTERNS SUPPORT FINE-SCALED GENETIC STRUCTURING ASSOCIATED WITH MIGRATION TENDENCY IN BROWN TROUT

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Brown trout (*Salmo trutta*) displays a high diversity of life-history strategies from early maturing, slow growing and resident to fast-growing, late maturing and migratory. These strategies can be present in a single population, but the resident strategy is typically more common in small headwater brooks and the migratory strategy in large rivers. In this study, we sampled eleven locations in a Finnish-Russian watershed to evaluate genomic differences between headwater and main stem populations. The study area included both isolated (with migrations barriers) and connected tributaries. Restriction site associated sequencing (RADSeq) revealed that the majority of headwater localities supported unique, isolated populations with low heterozogocity. Three main stems showed signals of admixture despite significant pairwise genetic differences. Our results suggested that the headwaters supported only resident brown trout and that the population genetic structuring had evolved also in the absence of migration barriers. SNP outlier analyses revealed that more than a hundred SNPs could possibly be under divergent selection between main channel and tributaries populations. These loci could potentially play a role in the migration tendency of brown trout. Our results suggest that the population genetic structuring in brown trout is not only caused by genetic drift in isolated populations, but different environments likely exert divergent selection leading to significant local adaptations even in geographically close populations.

UNDERSTANDING ANADROMOUS BROWN TROUT ACROSS CONTRASTING LANDSCAPES: ORKNEY AS A NATURAL LABORATORY.

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Understanding of the biology of anadromous brown trout (sea trout – *Salmo trutta*) has tended to be hampered by problems of large river catchments, sympatry with Atlantic salmon and complex relationships with riverine and lacustrine resident trout populations. Further complications have arisen from confounding of latitudinal variation in population characteristics with geological, and hence trophic, factors. Brown trout in Orcadian burns (small streams) avoid these problems and allow a clearer analysis of variation in life-history traits between contrasting catchments at the same latitude and with a “common garden” sea in Scapa Flow. Detailed analysis of four catchments draining into Scapa Flow will be presented which supports the key role of nutrient availability in freshwater, independent of day-length, in determining life history characteristics such as smolt age. Further, whole catchment population budgets will be presented indicating the likely relationship between returning spawners and smolt production. Orkney is presented as a near-ideal natural laboratory to look at catchment level effects of such factors as land-use at a tractable scale, as well as being a key example of the importance of small catchments in sustaining sea trout populations.

DISRUPTING GUPPY FEMALES SOCIAL NETWORK NEGATIVELY AFFECTS THEIR FITNESS

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Animal living in groups display complex social organisation based on non-random interactions amongst individuals. The structure of a social network has important fitness consequences as it influences behaviours such as mating, foraging or antipredator strategies. Whilst a growing number of studies have uncovered the mechanisms and functions underpinning the social fine structure of a population, little has been done to evaluate the adverse effects of disrupting an established network. Using guppies as a model system, we aimed at quantifying the potential costs of disrupting female-female social ties. To do so, we exposed groups of females to three different levels of experimentally induced social disruption where 0, 5 or 30% of them (no, low and high disruption respectively) were weekly replaced with an equal number of novel females during a six-week period. Based on their social interactions, we constructed a social network for the different groups of females. For each individual in the networks, we quantified their fecundity and growth, two fitness-related traits. Embryo counts, ageing and size were measured as proxies for females' fecundity. The results strongly suggested that the fish in the high disruption treatment had lower specific growth rate and less embryos than both no and low disruption treatments. In other words, high level of network disruption implies significant fitness cost, which in turn imposes strong selection pressures on female social behaviours. When studying animal societies exposed to recurrent network instability due to factors such as sexual harassment, it is important to consider this previously neglected cost.

CARBON SOURCES SUPPORTING FOOD CHAINS IN A MANGROVE FOREST AND ADJACENT INTERTIDAL MUDFLATS: A STABLE ISOTOPE APPROACH

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The abundance of food resources has been touted as one of the principal attributes of mangroves and mudflats as nursery habitats for juvenile fish. Identifying the primary producers sustaining the food webs in these systems is the foundation for informed management plans to conserve biodiversity and commercial resources in a habitat mosaic. These habitats are also thought to be interlinked through diurnal or tidal fish migrations and carbon exchange. We use carbon and nitrogen stable isotope analysis (SIA) of primary producers, benthic and planktonic meiofauna, invertebrates, fishes and birds to identify the autotrophs underpinning food webs in a mangrove forest and adjacent intertidal mudflat in the Gulf of Paria, Trinidad and Tobago. We find isotopically distinct food webs in the two habitats, and even isotopic distinctions for the same species collected in both habitats. MixSIAR mixing models show that mangrove carbon does not support fish populations in an adjacent mudflat ecosystem and may only partially support fishes in mangroves along with other carbon sources. This reaffirms findings from previous studies that question the role of mangrove carbon in food webs and the 'outwelling' hypothesis. In both habitats, phytoplankton and/or benthic microalgae support foodwebs for fishes and waterfowl. We observed little evidence of connectivity between the two environments in terms of carbon exchange and feeding migrations for several planktivorous and demersal fish species. We present the possible reasons for this isolation between the two habitats and what it means for management of fish nursery habitats.

DOES INDIVIDUAL VARIATION IN METABOLIC RATE INFLUENCE MICROHABITAT USE AND THE SPATIAL STRUCTURING OF JUVENILE SALMON POPULATIONS?

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Metabolic rates can differ as much as 3-fold among individuals in a population. These differences in metabolism co-vary with a range of other physiological and behavioural traits, including maximum daily food intake, maximum sustained swimming speed and dominance status (fish with higher metabolic rates usually being more dominant). A higher metabolism also means a higher cost of living, so we can therefore predict that different microhabitats will favour different metabolic phenotypes: sites requiring greater swimming capacity may favour fish with a high maximal metabolic rate, while those with low food availability but also reduced competition may favour fish with low metabolic costs. In the case of stream-living juvenile salmonids that feed on drifting invertebrates, these microhabitat differences can be stark: fast-flowing riffles are only a few metres from pools where the water flow is minimal. We examined the distribution of metabolic phenotypes among microhabitats in Atlantic salmon fry. Eggs from 30 full-sib families were planted into 10 tributary streams of the River Conon, northern Scotland, with equal representation of each family in each stream. Five of the streams received a nutrient boost equivalent to that provided by the carcasses of spent spawners, so generating differences in invertebrate food supply among streams independent of their flow regimes. We then mapped the fine-scale distribution of 3 month old fry among microhabitats in each stream, and assigned fry to families using microsatellites. Meanwhile a subsample of eggs from each family was reared under standardised conditions in the laboratory for measurement of family differences in both standard (= minimal) and maximum metabolic rate of fry. In this presentation, we show how the variation in metabolic rates among families influenced the distribution of families among microhabitats, and hence population structure.

LEADERS AND FOLLOWERS IN MANTA RAY *(MANTA ALFREDI)* FORAGING GROUPS

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Coordinated actions within groups can be expedited by the emergence of a leader who initiates and/or directs group movement, with other members of the group adopting the role of follower. Leaders (or decision makers) are those individuals that, even when animals decide collectively, are more influential with respect to the decision outcome whereas the others will simply accept their decision. This study investigated whether environmental factors (food available, current strength), demographic traits (age and sex) and personality traits (social phenotype) were associated with the propensity of Manta Rays to take the leadership or follower role in group foraging contexts. We filmed these large filter-feeding elasmobranchs as they fed in large aggregations in areas of high plankton abundance. Within aggregations, individuals fed either solo or in groups, forming chains with a clear leader and on average one follower. Group feeding was when two or more animals were recorded feeding together within two body lengths of each other. Our data showed that age had no effect on leadership or grouping behaviour over three years, however, sex, aggregation size and food availability interacted to affect the propensity of individuals to lead foraging groups. As females are generally larger than males, our results indicate a benefit to them adopting the leadership role such as increased plankton intake. This long-term study of an unfished population of Mantas resident in the Maldives provides unique opportunities to test hypotheses concerning sociality.

THINNER FEMALES - FEWER EGGS? TEMPORAL TRENDS IN EASTERN BALTIC COD FECUNDITY (2004–2016)

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Baltic cod (Gadus morhua) due to its high trophic level in the food web and economic value for humans, has been a very important species for scientific research in Baltic Sea. To improve stock assessment and recruitment estimates, it is important to have a detailed understanding of the species fecundity. This is particularly crucial for Eastern Baltic cod as condition indices have shown a major decline over time, however fecundity information about recent years remain not investigated.
We hypothesize that the strong decline in Eastern Baltic cod condition during the last decade led to lower fecundity. As part of Geomar's annual multidisciplinary cruises, fisheries data is available from 1987 until now to assess stock structure and egg production of cod alongside other species. To subsequently calculate annual fecundity, pre-spawning female stage 4 ovaries have been collected and stored in -20°C. These long-standing samples have great potential to assess the temporal development of fecundity.
The study includes the period with average condition decline from 2004 until 2014 as well as the increased abundances of small sized (<30 cm) cod from 2007 until 2016. Females from a range of nutritional conditions and several size classes that exist among all the years will be included for analysis. Area of focus will primarily be the principle spawning ground, Bornholm Basin. The effect of environmental factors, such as surface water temperature or inflow events, on annual potential fecundity will be investigated for the stock of interest.
Fecundity data that will be obtained by this study will provide valuable long-term information for better management strategies of this important species.

DECODING MITOGENOMES OF EXTREME LONGEVITY: PHYLOGENOMICS OF THE GREENLAND SHARK

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Vertebrates with extreme longevity represent a window to the past, but also provide novel insights into vertebrate adaptation to long life spans and changing environments. Since long-lived fishes are rare, and often endangered, little is known about their biology and genetics. The Greenland shark (*Somniosus microcephalus*) is distributed throughout the northern Atlantic Ocean and is currently the longest living vertebrate species known to science, with a documented lifespan exceeding 270 years. Here we used massively parallel sequencing of 94 complete mitogenomes to show that the Greenland shark display population structure throughout its northern distributional range. Based on the population structure we infer that homing via long distance migration versus resident individuals may be an important component for the structuring. Due to this apparent discrepancy in life histories, and hence in metabolic cost, we also addressed the patterns of selection on mitochondrial oxidative phosphorylation genes and their role in shaping the population structure of the Greenland shark. As the present populations of Greenland shark are composed of individuals dating back to the 1750s´, i.e. before the industrial revolution and peak in commercial fisheries, we investigated how these activities may have affected the signatures of population expansion and reduction. We will conclude by discussing the application of these results for the continued conservation of long-lived fish species.

ENVIRONMENTAL AND HISTORICAL DETERMINANTS OF THE FUNCTIONAL DIVERSITY IN A GENERALIST FRESHWATER FISH (*PHOXINUS PHOXINUS*)

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By linking ecological and evolutionary dynamics, intraspecific phenotypic diversity is increasingly recognized as one of the major facet of biodiversity. Functional traits -defined as traits impacting fitness indirectly via their effects on individual performances- have a pivotal role because they are directly affected by evolutionary processes and can have strong influences on ecosystem functioning. For instance, individual metabolism depends on key environmental drivers such as temperature, and co-varies with many other traits related to energy acquisition. Using Eurasian minnows (*Phoxinus phoxinus*) as a model species, we aimed to quantify the variability (i.e. within and among populations) of functional traits diversity in multiple populations, and to understand the environmental and historical determinants of this variability. We selected a set of traits contributing to organism adaptation and affecting ecosystem functioning including resting metabolic rate, behaviour (i.e. boldness) and excretion rate (nitrogen). Traits were measured in 13 stream populations varying in their environmental conditions (e.g. characterized as temperature regime and predation pressure) and with diverging evolutionary histories (reflecting the past colonization history and the genetic isolation of populations). We found significant differences in trait means and trait co-variations among populations. Surprisingly, the evolutionary history of populations and measured environmental conditions were weak predictors of the observed trait variability, which suggests alternative underlying drivers. The potential implications of these findings on population phenotypic syndromes and ecosystem functioning are discussed.

RECONCILING FIELD AND LAB RESEARCH ON AFRICAN ANNUAL FISHES TO UNDERSTAND THE CAUSES OF SEX-SPECIFIC MORTALITY AND LIFESPAN

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Sexual dimorphism in lifespan is often pronounced in taxa where males and females differ markedly in their means of improving fitness. *Nothobranchius* are short-lived fish with promiscuous breeding and strong sexual dimorphism in colouration. We used extensive field data combined with results from laboratory studies in protected conditions to compare sex differences in lifespan, mortality schedules and functional declines at the physiological level across four coexisting *Nothobranchius* species. In the wild, male-biased mortality was found across species. When fish were housed in conspecific groups of 12 individuals, sex differences in lifespan and mortality schedule were detected only in two species (in which males were most aggressive) and those differences disappeared altogether when fish were housed singly. At the functional level (in captive fish), no sex differences were found in markers of oxidative stress and incidence of liver and kidney tumours. However, males suffered from elevated liver steatosis (abnormal lipid accumulation in liver cells). Overall, male-biased mortality appears to result primarily from differential predation risk (high male-bias in mortality in the wild) and male-male aggression (group-living laboratory setting) rather than by sex-specific functional declines. An on-going analysis of steatosis from samples collected in the wild will reveal whether pronounced steatosis is a consequence of a suboptimal diet in captivity or pertains to wild populations and derives from male hormonal interference with lipid metabolism.

TRANSGENERATIONAL EPIGENETIC SIGNATURES OF DOMESTICATION IN ATLANTIC SALMON (*SALMO SALAR*)

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Epigenetic mechanisms (e.g. chromatin modifications, DNA methylation) modulate changes in gene expression and function that do not involve changes in DNA sequence creating phenotypic variation that could be heritable across generations, without being disrupted by recombination. If inherited, epigenetic variation might provide an initial step for selection during the course of evolutionary divergence. However, the extent to which epigenetic signatures induced by the environment can be inherited remains controversial.
In order to assess epigenetic differences between wild and farm populations of Atlantic salmon that could be passed to subsequent generations, we compared sperm methylation patterns of wild and hatchery-reared salmon from a similar genetic background to those of their offspring at the embryo stage, and with methylation patterns in the offspring's sperm.
Methyl-CpG binding domain protein-enriched genome sequencing (MBD-seq) analyses of DNA methylation patterns identified a large number of differentially methylated regions (DMRs) among parental groups which were compared to those in the offspring and their sperm.

FISH LIFE HISTORY DYNAMICS IN ECOLOGICAL AND EVOLUTIONARY TIME

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We present a comprehensive analysis of how life history traits like age and size at maturity should vary in response to changes in both individual productivity and probability of survival. We argue that ecologically-driven changes in productivity can be detected at the level of the individual and hence may be expressed in ecological time, through physiological responses at the level of the individual and/or thru intergenerational responses that are driven by epigenetic effects rather thru selection. This is in contrast to changes in survival probability which are not directly detectable at the individual level: responses to such changes must be driven by selective forces operating at the population level and hence will be expressed on a longer, evolutionary time scale. We use life history models, founded on simple representations of biphasic growth, to predict patterns of optimal life history dynamics that should be evoked by specific changes in both productivity and probability of survival. We test these predictions empirically using life history data from over 50 well studied lake trout (*Salvelinus namaycush*) populations. We go on to suggest ways to allow for these predictable changes in life history when developing exploitation management strategies.

ONTOGENETIC SHIFTS IN FEEDING ECOLOGY OF FOUR SYMPATRIC RAJIDAE SPECIES

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The stable isotope ratios of carbon and nitrogen in animal tissues provide powerful tracers for trophic level and foraging location. Carbon isotope ratios vary between sources of primary productivity, which differ between habitats such as inshore and offshore zones and can therefore be used to predict foraging location. Within a single food web, predator tissues are progressively more enriched in ^{15}N with increasing trophic level.
The success of juveniles in a population is vital for the survival of a species, and governs the rate at which a population may recover from exploitation pressure or environmental perturbation. This is especially the case for threatened species which are late maturing and have relatively low fecundity, such as the Rajidae, yet our understanding of their ecology is limited. The eye lens of vertebrates grows over the lifetime of an animal by adding layers of protein to its surface. The core of the eye lens is deposited from nutrients assimilated by the mother and therefore records maternal foraging behaviour. The vertebrate eye lens therefore provides a chronological biochemical record that can be used to infer ontogenetic changes in trophic level and foraging location particularly during early juvenile phases of life.
Here we provide the first records of the isotopic ontogeny of 47 individuals of 4 sympatric Rajids. We identify ontogenetic shifts in feeding ecology and demonstrate distinct differences in early juvenile tropho-special ecology between species. The vertebrate eye lens offers new insights into the cryptic early life stages of elasmobranchs and has the potential to aid management and conservation of these species.

OVIPOSITION-SITE DECISIONS IN THE POPULATION DYNAMICS OF EUROPEAN BITTERLING

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Bitterling fishes lay their eggs in the gills of living freshwater mussels and make sophisticated decisions, using multiple cues, on where to deposit their eggs. Based on 22 years of field and experimental data on European bitterling populations in central Europe, an analysis is presented that demonstrates a key role of behavioural decision making in the population dynamics of this fish. Using Generalised Mixed Models in a Bayesian framework, it is shown that behavioural decisions that maximise individual fitness have direct implications for population level processes. Notably, the spatial distribution of spawning sites is shown to interact with oviposition-site decisions to drive population dynamics.

GENETIC ANALYSIS INDICATES MARKED POPULATION STRUCTURE OF ATLANTIC SALMON AND BROWN TROUT IN THE CHALK STREAMS OF SOUTHERN ENGLAND

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Recent research has identified genetically distinct groups of Atlantic salmon (*Salmo salar* L.) and brown trout (*Salmo trutta* L.) that show association with geological and environmental boundaries; this study focuses on Atlantic salmon and brown trout inhabiting the chalk streams of the Hampshire Basin in southern England. These fish are genetically distinct from other British and European salmon and trout populations, and demonstrate markedly low admixture with fish in neighbouring regions. We explored the genetic population structure of fish within these chalk streams using panels of 16 (salmon) and 19 (trout) microsatellite loci. For salmon, our analysis provides evidence of significant isolation by distance between fish within these rivers and identifies three genetic sub-groups comprising salmon from: 1) the Frome and Piddle, 2) the Avon, and 3) the Test and Itchen. Similarly, for trout, our research confirms chalk stream-dwelling fish as genetically distinct from other trout populations in both southwest Britain (acid rivers) and southeast England (rivers on chalk but not categorised as chalk streams). Within the Hampshire Basin similar structure to that observed in salmon was found, with three sub-groups: 1) the Frome and Piddle, 2) the Avon and 3) the Test, Itchen, Wallington and Meon. The possible roles of river geochemistry, in-river ecology and phylogeography as drivers of observed genetic differences between salmonid populations are discussed.

SHARKS CONNECT FOOD WEBS ACROSS THE GLOBAL OCEAN

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Sharks are mobile predators that forage across diverse spatial scales and have the potential to shape or stabilise food webs. These characteristics suggest that recent global declines in shark biomass may have broad scale ecological consequences. However, the impacts of global shark declines on ecosystem structure and function remain uncertain. As typically highly-mobile consumers, sharks have the capacity to act as mobile-links, moving and foraging across seascapes, and connecting disjunct food webs through trophic interactions. Cross-habitat foraging modifies the flow of nutrients and energy within and among food webs, influencing trophic structure and resilience. Changes in the abundance of sharks are therefore expected to affect ecosystem dynamics across a range of spatial scales, dependent on the extent of shark movements within and across habitat boundaries and the nature of trophic interactions
Using stable carbon isotopes to track the original site of photosynthetic fixation of carbon atoms ultimately assimilated into muscle tissues of 5350 sharks from 110 species, we identify global patterns of shark-mediated nutrient transfer and cross-ecosystem foraging. We show that shelf-dwelling sharks derive the majority of their carbon from regional pelagic sources, but forage across diverse local food webs. In contrast, intermediate latitudes are globally important sources of energy and nutrients for oceanic shark populations. Shelf-dwelling sharks therefore connect regional energetic pathways, while oceanic sharks serve as long-distance mobile links between otherwise isolated food webs. Combining nutrient sourcing with animal tracking offers a powerful tool for marine spatial ecology and the future of conservation planning.

OVERWINTERING BEHAVIOUR OF STOCKED BROWN TROUT: EFFECTS OF THE REARING ENVIRONMENT AND RIVER HABITAT COMPLEXITY

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In channelized and structurally simple temperature streams and rivers, adverse winter conditions may challenge the ability of riverine fishes to adapt in terms of their behaviour and physiology. Access to shelter is a key habitat factor that may influence overwinter survival chances and, consequently, population dynamics. In many river restoration projects, structural elements are added to the river to increase the complexity of the physical environment. When this habitat enhancement is combined with a stocking programme, the stocked fish may adopt different behavioural strategies to cope with the winter season depending both on the rearing environment in the hatchery and the level of habitat complexity in the river. In this study, young-of-the-year brown trout were reared in either barren or structurally enhanced tanks, and the effects of the rearing environment on resting ventilation rate (proxy for resting metabolic rate) and score in an open field test (proxy for activity) were assessed. In side channels of a Swedish regulated river, trout were then released at untreated control sites or at sites that were structurally enhanced by adding whole trees to the water. Throughout winter, trout were tracked on a weekly basis, and their movements as influenced by the river habitat complexity and the previous hatchery environment were analysed. The rearing environment affected resting metabolic rates and activity, which resulted in different behavioural overwintering strategies, and adding trees to the side channels increased apparent survival. These results have implications for managing river restoration projects and further studies of stream fish winter ecology.

THE GENETICS OF REDUCED SEXUAL DIMORPHIC RED ORNAMENTS IN THREESPINE STICKLEBACKS

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Sexual dimorphism in ornamentation is widespread across the animal kingdom, yet males and females can also express similar ornaments. This reduction in sexual dimorphic ornamentation is often suggested to evolve predominantly via mutual sexual selection. However, an alternative hypothesis is that sexual selection only favors the ornament in males, but the ornament arises and persists in females due to a shared genetic basis between the sexes. In threespine stickleback (*Gasterosteus aculeatus*) fish, both males and females sometimes exhibit red ornaments, the orange-red throat and red pelvic spine. The throat coloration is male-specific in ancestral marine populations but has evolved in females in some derived freshwater-resident populations, whereas the pelvic spine color is nearly monomorphic in the ancestral population, but variable in many derived populations. Understanding how such mutually shared ornaments arise and persist between sexes also requires determining their genetic basis. Using quantitative trait loci mapping, we find that ornaments in both sexes share a common genetic basis. Specifically, three independent genomic regions contribute to red throat coloration, and one of these regions is also associated with spine coloration, indicating that both ornaments might be mediated in part via pleiotropic genetic mechanisms. Our findings provide evidence that is consistent with a genetic correlation between the sexes and suggest that selection on one sex might have influenced ornament evolution in the other, thereby contributing to the evolution of shared ornaments.

POPULATION STRUCTURE AND HISTORICAL ORIGIN OF THE MOST IMPORTANT SOCKEYE SALMON STOCK IN THE NORTH-WESTERN AREA OF THE RUSSIAN FAR EAST

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The most valuable representative of genus Oncorhynchus sockeye salmon (Oncorhynchus nerka) inhabits the northern part of the Pacific Rim and its coasts. Due to the high level of homing peculiar to this anadromous species several different populations may spawn in the same water body. Moreover, concerning intraspecific structure one should mention different ecological types of sockeye salmon as well as distinct spawning runs. The aim of the current study was to explore sockeye salmon population structure in Apuka river – one of the largest rivers of the North-eastern part of Kamchatka peninsula in the Russian Far east. Two spawning runs whose timing ranges are partly overlapping exist in this river and the early-run sockeye salmon differs a lot from the late-run fish. Early sockeye salmon spawn in the lower river basin and migrates into river when it has already pre-spawning changes in morphology and high GSI value. Late-run salmon spawns in the higher basin and enters the river mouth less mature. The genetic studies based on neutral and adaptive nuclear markers demonstrate the presence of noticeable population structure in the river basin. Furthermore, the mtDNA haplotype distribution allows to propose different origin of these population and existence here of more than one recolonization event.

Harlequin ghost pipefish (*Solenostomus paradoxus*). © Steve SImpson

Biology of Fish – Speed Talks

ECOLOGICAL AND EVOLUTIONARY TRAJECTORIES OF TWO LESSEPSIAN FISHES DURING THEIR ESTABLISHIMENT IN A NOVEL HABITAT

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The rabbitfishes *Siganus luridus* and *S. rivulatus* are two Lessepsian species that have invaded a large part of the Mediterranean Sea and offer a unique opportunity to examine ecological and morphological variation during the process of invasion and establishment. Using and integrated geometric morphometric and stable isotope approach we investigated ecological adaptation in this two species from native into novel Southern Mediterranean habitats. A total of 490 fish were collected over two years (2014 and 2015), which showed a greater overlap in morphological variation in the novel habitat (Mediterranean Sea) compared to the native Red Sea. On the other hand, stable isotopes indicated that the invading populations segregated trophic niches more starkly than in the native habitat.
The introduction of genetic markers to infer population expansion uncovered a more marked decrease in genetic variation in *S. luridus* compared to *S. rivulatus*, during the process of invasion. Collectively, data contribute to reconstruct the jigsaw puzzle underpinning the success and ecological diversification of these coastal species, raising considerations for their management and that of the environment that changes around them.

DISENTANGLING THE ROLES OF FAMILIARITY AND RELATEDNESS ON GROUP FORAGING BEHAVIOUR.

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Animals living in groups must balance the potential benefits of group living, such as predator protection, against the costs, such as increased competition and aggression. Both familiarity and relatedness are known to modulate the trade-off between these costs and benefits. As an important step forward we disentangled the roles of familiarity and relatedness by monitoring the group behaviour of genetically identical fish that had been housed together for differing amounts of time. We allowed groups of Amazon Mollies to live together during 3, 1 or 0 weeks and then measured their behaviour when presented with a defensible food source. These fish form robust hierarchies early on. So we predicted that fighting would occur but that the ratio of fighting versus eating would decrease once familiarity increased. We measured the number and duration of feeding and aggressive behaviours (tale beats and bites) before and after the food was added. All groups showed aggression and there was extensive variation among the different groups. Furthermore, every group spent some time eating but not all individuals managed to gain access to food. Both the environment and the genetic background influence an individual's ontogeny. Working with genetically identical individuals that are housed under identical conditions provides an important step into disentangling between these different factors. Thus, we can investigate the role of repeated social interactions alone in shaping both individual and collective behaviours.

SIZE RELATED DICHOTOMY IN DIET OF YELLOWFIN TUNA AT ASCENSION ISLAND, CENTRAL ATLANTIC

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Yellowfin tuna, *Thunnus albacares*, occur globally in tropical and sub-tropical oceans, including the waters surrounding the remote Ascension Island in the central Atlantic. Sportsfishing businesses place high value on record breaking yellowfin caught within inshore waters and fishing fleets in surrounding international waters catch yellowfin for commercial markets. Considering the proposals to designate Ascension's waters as a Very Large Marine Protected Area (VLMPA), research to understand the spatial dynamics of tuna is critical. Stomach contents (*n*=170) were analysed for the Index of Relative Importance (IRI) and prey specific abundance, revealing an ontogenetic shift in prey species composition. Small (<150 cm Fork Length) yellowfin fed predominantly on crustaceans (76.2% IRI), cephalopods (16.9% IRI), bathydemersal and mesopelagic fish (4.1% IRI). Above 150 cm FL, the principal prey species of large yellowfin shifted to an epipelagic Balistidae, *Melichythys niger,* (99.6% IRI), a keystone species at Ascension that is notably abundant in near-shore areas. Pop-up satellite archival tags (*n*=13) indicated variation in vertical habitat use and diving behaviour around Ascension. Significant differences in diving behaviour between small and large yellowfin tuna were observed, trends directly corresponding with prey species distribution. Small tuna spent a higher proportion of time at depths below 50m (70.01%), than large tuna (48.37%), despite the apparent associated physiological costs of foraging in lower temperature waters. This is the first study to observe and associate a change in diving behaviour with an ontogenetic shift in the diet of yellowfin tuna and has direct implications for fisheries management in Ascension's waters.

LENGTH OF ATLANTIC SALMON SMOLT AND THEIR SUBSEQUENT MARINE SURVIVAL

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Migrating Atlantic salmon smolts encounter a range of risks, such as novel predators, strong currents and salinity, *en route* to their marine feeding grounds. Their primary defence against such encounters is avoidance: individuals swim away from threats, whether traveling in a shoal or alone. In avoiding such threats, they will have a higher chance of surviving to return to their natal rivers as adults to spawn. We therefore predict that larger smolts will have a higher probability of returning to their natal river as an adult. We test this prediction with data from the river Frome, Dorset, UK, where individual salmon have been tracked emigrating as smolts and returning as adults since 2006 using Passive Integrated Transponder (PIT) technology. We build and test Bayesian State Space models to explain the probability that individual smolts survive to return as adults. We do this by describing post-smolt survival (i.e., survival in their first year at sea) as a function of individual smolt length. We extend the model to test alternative hypotheses, such as the role of environmental variables, including sea surface temperature, on the probability to return as an adult to spawn. River Frome salmon smolt are shrinking, as they are on other rivers across Europe. If shorter smolt are less likely to return as adults to spawn, then managers will need to maximise both the number and the size (condition) of emigrating smolts to reverse salmon population declines.

POPULATION GENETICS OF THE ROACH (*RUTILUS RUTILIUS*) IN WESTERN EUROPE

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The Roach (*Rutilus rutilius*) has been widely adopted as a sentinel species in freshwater biology and as an indicator of water quality. Increasingly, it is also being used in laboratory and field ecotoxicology. In a somewhat different context, the genus *rutilis* has a very broad geographical distribution (from West Europe to East Siberia) and this, together with uncertainty regarding the large numbers of species described have also made the roaches a focus for phylogenetic and phylogeographic study. Genetic methods (largely single gene mitochondrial DNA sequencing) have been successful in revealing complex relationships between species, distinct lineages and patterns of postglacial range expansion. However, a consistent set of nuclear markers has yet to be applied to the roach over a large geographic scale, which could act to verify broad phylogeographic signals and allow investigation of smaller-scale patterns of genetic differentiation, significant in the ecology and conservation of the species. This study utilised a set of 17 microsatellite loci to analyse 1,500 roach, largely collected from Western Europe, to investigate patterns of genetic differentiation from within-catchment to regional scales. Importantly, sample collection included northern regions (e.g. UK, Scandinavia, Russia and Estonia), often overlooked due to recent glacial coverage, but which recent studies of fish have sometimes demonstrated contain surprising complex population structure. Whilst the results generally support the stark differences in lineages between eastern and western Europe that have already been observed, significant differences are detected at a smaller scale than ever before. Work is ongoing to complement the analysis with an additional >1kb cytochrome-b mitochondrial DNA sequence.

RETURN OF AN APEX PREDATOR TO BRITISH COASTAL WATERS: THE CASE OF ATLANTIC BLUEFIN TUNA (*THUNNUS THYNNUS*)

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There is a growing body of literature detailing distributional shifts in marine organisms, largely attributed to climate change. Multiple factors influence the spatio-temporal distribution of marine fish populations, including fisheries, regional oceanography, recruitment and resource availability. Atlantic bluefin tuna (*Thunnus thynnus*) are large, endothermic predators that range widely in the North Atlantic. Populations have shown long-term variability in abundance and distribution, which has been attributed to over-exploitation, regional oceanography and climate change. Historically, Atlantic bluefin tuna occupied shelf waters off the coast of England, Ireland and Scotland, arriving in the autumn to feed on a variety of lipid-rich pelagic fish. By the early 2000's Atlantic bluefin tuna had become regionally scarce. Their disappearance was likely symptomatic of the critical state of the eastern breeding stock at the time, which had been fished to record low levels. Our recent work demonstrates that Atlantic bluefin have returned to British coastal waters, and even to regions where they have seldom been seen in the past in any appreciable numbers, including inshore waters of the English Channel and Celtic Sea. In recent years, the eastern stock is purported to have made a dramatic recovery and here we use historic electronic tagging archives, fisheries data, dedicated survey data and anecdotal data to investigate whether recent trends in Atlantic bluefin tuna appearance in British coastal waters are a result of a stock recovery or multiple factors acting in concert.

EXPRESSION OF OPSIN GENES IN CICHLIDS OF THE BERMIN AND BAROMBI MBO CRATER LAKES

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Vision is a crucial sense for an organism survival. In fishes, visual spectral sensitivities are often strongly shaped by the aquatic environment with different optical properties. Usually, in shallow water the entire light spectrum, i.e. wavelengths from UV to infrared, is present, whereas in deep water the light spectrum is dominated by blue and green wavelengths at a depth below 0 m^2. Cichlid fishes are a suitable model to study visual adaptations to life in different light environments. They possess four opsin clusters in the genome with seven cone opsin genes: SWS1, SWS2A, SWS2B, RH2Aalpha, RH2Abeta and RH2B and LWS, which are sensitive from ultraviolet to the red end of the light spectrum, and one rodopsin gene (RH1). In this study, we compared the genetic basis of visual systems of two monophyletic cichlid flocks from Barombi Mbo and Bermin crater lakes in Cameroon. Using next-generation sequencing (transcritome and long amplicon sequencing) we examined the opsin genes and retinal transcriptomes in 11 species from Bermin and in 11 species from Barombi Mbo. Our preliminary results indicate that different light environments have caused differences in visual sensitivity mainly on the gene expression level. In shallow water species, the expression of red-sensitive opsin is high, while deep water species express only blue and green-sensitive opsin genes.

YOU CAN'T SWIM FROM THE PAST! USING NATURAL TAGS TO EXPLORE RANGE-EXPANSION IN GILTHEAD SEABREAM

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The gilthead seabream *Sparus aurata* is highly sought after in Europe both commercially and recreationally, and is currently the most prolifically farmed marine fish in the Mediterranean. Warming sea water temperatures are thought to be responsible for an apparent recent range expansion of *S. aurata* into the English Channel and Celtic Sea. Currently little is known about the UK population, but adult fish are being caught more frequently in the spring/summer months, and juveniles have been observed in recent years. Current climate trends suggest that further northward expansion in the coming decades is likely. In the Mediterranean successful wild populations rely on brackish lagoons and estuaries as juvenile nursery areas, with some regions being more important for early life stages than others. Understanding critical habitats for the successful completion of each life-stage will form part of an important evidence base to ensure that healthy local populations are safeguarded for future years. Stable isotope and multiple trace element otolith signatures will be applied to investigate key nursery areas for juveniles in the UK; to identify whether individuals caught in the UK demonstrate broad or fine scale site fidelity over their life span (in the UK or further afield); and whether different individuals exhibit specific estuarine/marine migration strategies. Greater understanding of this target fish will benefit sea-anglers and fishers, the coastal tourism sector and conservationists managing the long term sustainability of inshore fisheries.

THE SENSITIVITY OF THE POPULATION GROWTH RATE TO VITAL RATES OF RESIDENT AND ANADROMOUS INDIVIDUALS IN A BROWN TROUT POPULATION

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Partial migration population, where both resident and migrant coexist, appear more resilient to global change than fully migratory or resident populations. However, the contributions of resident and migrant strategies to population growth rate λ and to the resilience of these populations are unclear. The goal of this study was to quantify the influence of vital rates of resident *vs* anadromous strategies on λ of a brown trout (*Salmo trutta*) partial migratory population. Based on an individual long term monitoring in the Oir River (France) and using prospective and retrospective analyses of matrix population models, we estimated the sensitivity of λ to the vital rates and the contributions of these rates to observed change in λ. Our results revealed that λ was the most sensitive to the survival of resident adult females. Actually, an increase in the survival of anadromous adult females over the study period was the vital rate that contributed the most to the observed increase in λ. This change was correlated to an increase in the sensitivity of λ to this rate and an increase in juvenile density. Overall, the strategy that drives λ in an iteroparous partial migration population may change over time. Environmental variability, through a contrasted impact on adult survival at sea and in freshwater, may drive the relative contribution of resident and migrant strategies to λ. Our study demonstrated that intraspecific diversity may allow partial migration populations to better cope with environmental changes and explain their higher resiliency than fully resident or migratory populations.

ESTIMATING DIVERSITY AND DIVERGENCE FROM INDIVIDUALS TO POPULATIONS: IS RADSEQ ANALYSIS WORTH THE INVESTMENT?

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Obtaining information on genetic structure of small populations with high extinction risk is necessary to optimize strategies for management and population rebuilding. Microsatellite analysis has been an extensively used tool in these studies, but recently, analyzing single nucleotide polymorphisms (SNPs) generated by high throughput sequencing of restriction site associated DNA (RADSeq) has become a competitive technique due to the greater number of produced markers and its suitability for non-model species. Here, we compared estimates of genetic diversity at the individual and population levels as well as population structure and divergence in three resident brown trout (*Salmo trutta*) populations applying both RADSeq and 16 microsatellite loci. We also estimated introgression of the wild populations with a hatchery strain occasionally used in stockings in the area. Both SNPs and microsatellites suggest similar levels of divergence (as indicated by F_{ST} values) and diversity among populations, identifying each study population as genetically distinct from the others. The F_{ST} values were roughly similar when measured with microsatellite variation and 3 495 (bi-allelic) SNPs (overall population F_{ST} 0.20) and both methods indicated an occurrence of introgression from hatchery-reared fish into wild populations. We also estimated the performance of a lower number of SNPs in the analysis. The conditions in which the benefits of RADSeq can outweigh the additional costs compared to microsatellites are discussed.

HYBRID FORMS OF THE BAIKAL WHITEFISH AND THE PERSPECTIVES OF THEIR ARTIFICIAL REPRODUCTION

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The hybrids of commercial fish are currently widely used in water bodies for fishery. In Russia, the most widely distributed are the hybrids of two families of carps (Cyprinidae) and whitefish (Coregonidae). The hybrids of whitefish are more profitable for commercial breeding due to their gastronomic properties. Baikal whitefish differ from the whitefish species from other water bodies due to their higher fertility and growth rate. However, the stocks of Baikal whitefish are not very abundant, and are in fact under a threat of complete disappearance. We have set up a Unique Scientific Base “Experimental freshwater complex of Baikal aquatic organisms”, where experimental multidisciplinary studies of endemic whitefish from Lake Baikal are performed. These studies provide identical conditions for roe incubation and for consequent reproduction for all the variants of crossbreeding. The work resulted in obtaining of hybrid breeds of Baikal fishes: 7 variants of individual crossbreeding. The experiments demonstrated that roe and juveniles of Baikal pidschian and hybrids of lacustrine Baikal whitefish with Baikal pidschian have better survival potential as well as better qualitative and quantitative parameters. In particular, we discovered significant differences in the content of physiologically important ω3 polyunsaturated fatty acids in the muscles of hybrids (lacustrine Baikal whitefish x Baikal omul) and non-hybrid forms. Carrying out our experiments and keeping the fish in the freshwater complex allowed us to perform both basic scientific investigations such as genetic mapping of loci responsible for adaptation, studies of intestinal metagenomes, of biochemical and behavior peculiarities of fishes, as well as applied work such as obtaining of sustainable aquatic cultures of hybrids, maintaining of live collections and establishing Cryobank. This work was performed with the support from the State Project Grant VI.50.1.4 (№0345-2016-0002).

LINKING STRESS AND WELFARE IN A POPULAR ORNAMENTAL FISH

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Chronic stress is linked to negative physiological effects in fish, such as immunosuppression, reductions in appetite, growth and reproduction, and reduced ability to cope with future stressors. Inappropriate housing conditions may lead to poor welfare in fish, and may also constitute one such chronic stressor. Preference tests have been used extensively in animal welfare research to assess which kind of conditions might promote welfare in a range of taxa, including fish. For example, both zebrafish and checker barbs have been shown to have a preference for environmental enrichment in their tanks when presented with a choice between enriched and barren tanks. However, few studies have assessed whether these preferences are associated with lower levels of stress. We presented groups of neon tetras with a series of binary choice tests using tanks with two compartments to establish whether they displayed preferences for particular types of environmental enrichment, including substrate, background and tank ornamentation. These tests were used to establish the conditions for which the fish displayed the strongest and weakest preferences. Fish were then housed for 4 weeks in tanks containing either the most-preferred or least-preferred conditions, and a number of measures of chronic stress were taken, including cortisol response to an acute stressor, growth rate, and body condition. Results we will present have implications for the holding of fish in the ornamental fish trade, and application also in aquaculture, and in research laboratories.

AGE, GROWTH AND REPRODUCTION OF THE LEATHERJACKET, *MEUSCHENIA SCABER* (FORSTER 1801)

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The leatherjacket *Meuschenia scaber* is widely distributed in Australasian waters and was added to the New Zealand Quota Management System in 2003. The Ministry for Primary Industry (MPI) of New Zealand recognises leatherjacket as a priority for research because of the lack of data on its biology (e.g. growth rate, longevity, and reproduction) and to ensure its sustainability for commercial fisheries. Some information is available on the early life history stages and diet, but age and reproductive biology data are still scarce. The main aim of this research is thus to provide MPI with the necessary biological information to inform the management of this species. Here, we present results on age (otolith based), growth and reproductive biology of *M. scaber.* No evidence of hermaphroditism was found, indicating that leatherjacket is a gonochoristic species. Spawning starts in late austral winter and finishes at the end of spring. Sizes at sexual maturity (L_{50}) estimated for females (189.9 mm TL) and males (188.4 mm TL) was not significantly different, with both sexes reaching maturity between the first and second year of life. The size distribution of males differed from females (X^2=20.3, d.f.=8, p=0.009), with the mean size of mature males (276.5 ± 13.6mm TL) being slightly greater than that of mature females (271.9 ± 16.3 mm TL) (F=12.99, d.f.=1, p<0.001). The maximum size recorded for males was 315 mm TL and 320mm TL for females. Leatherjacket showed a fast growth in the first two years of life, and a maximum age of 17.

SUPERFOODS AND SALMONIDS: EXPERIMENTAL IMPACT OF WATERCRESS-DERIVED PHENETHYL ISOTHIOCYANTE ON THE EARLY LIFE STAGES OF BROWN TROUT (*SALMO TRUTTA*)

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Watercress (*Nasturtium officianale)* is an important commercially produced salad crop, typically grown in beds connected to chalk river headwaters. In response to mechanical damage, watercress tissue produces the anti-herbivore secondary metabolite phenethyl isothiocyanate (PEITC). This can be discharged into chalk rivers through commercial harvesting and washing processes. Chalk river headwaters are favoured spawning grounds of salmonids, providing a potential route for their early life stages to be exposed to PEITC. The aim of this research was to investigate the potential lethal and sublethal effects of PEITC exposure on the early life stages of brown trout (*Salmo trutta*). Laboratory trials assessed the toxicity endpoints of egg mortality and hatch rate, as well as the behaviour and morphometry of alevins. Fertilised *S. trutta* eggs were exposed to PEITC at 1 µg/L, 0.1 µg/L and 0.01 µg/L for 24hrs once every three days during the 40-51 days of embryonic development. Egg mortality was recorded at 100%, 61% and 28% respectively, with control mortality at 11%. Hatch time was significantly delayed in the 0.1 µg/L and 0.01 µg/L treatments. The locomotory response to light/dark stimulus of alevins were analysed using DanioVision™ (Noldus) and EthoVision XT 11, which showed a significant negative correlation between PEITC concentration and movement; in terms of both cumulative movement and response to stimulus. Alevins from the 0.1 µg/L treatment had reduced total length, and a significantly increased incidence and degree of lordosis. These results suggest the potential for watercress farm discharges to negatively impact salmonid recruitment.

Biology of Fish – Posters

Abdulghani, Abdulghani – Ecological and evolutionary trajectories of two Lessepsian fishes during their establishment in a novel habitat (Abstract in Biology of Fish Speed Talks)

COMPARISON OF THE SKIN MICROBIOTA OF THREE-SPINED STICKLEBACK FISH FROM DIFFERENT ENVIRONMENTENTAL LOCATIONS

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Ectoparasite infection is a major issue concerning the aquaculture industry, causing problems on salmon farms through sea lice infection. It is likely that ectoparasitism has an effect on the normal flora of skin and could result in the development of secondary microbial infections. However, the healthy skin microbiota of fish and the effect of ectoparasites on the microbiota require further investigation. This FSBI undergraduate summer internship aimed to compare the normal skin microbiota of wild three-spined stickleback fish living in different environments and identify their suitability as a model organism to study ectoparasite infections in salmon. Bacterial swabs were collected from fish living in different environments from North Uist, Scotland, with varying water quality and salinity. Bacteria were cultured on Tryptone Soy Agar (TSA) under anaerobic conditions, a number of which were identified by 16s rRNA based sequencing analysis as Gram-negative, rod-shaped bacteria belonging to the phylum Proteobacteria. Antibiotic susceptibility profiles showed that all cultured bacteria were resistant to B-lactam antibiotics, but 41% were susceptible to erythromycin and all isolates were susceptible to tetracycline. Differences in the bacterial populations were analysed by DGGE based separation of the V3-V6 region of the 16s rRNA gene. Based on the results of the sequencing and DGGE analysis, it is likely that there is a difference between the microbiota of sticklebacks living in different environments and that the anadromous populations may be suitable models for studying the effects of ectoparasites on the skin microbiota of other fish species, in particular salmonids.

EFFECTS OF CLIMATE CHANGE ON FIRST-FEEDING BROWN TROUT GROWTH AND METABOLISM: A MESOCOSM EXPERIMENT

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Along the Atlantic coast of Europe, climate change will (1) alter precipitation patterns leading to more severe and frequent extreme hydrologic events in freshwater ecosystems and (2) increase temperature. At gravel emergence, young trout have limited reserves and need to quickly start exogenous feeding. Then, climate change might affect young trout growth and survival by decreasing the availability of their prey though hydrology and modifying their metabolism through water temperature increase. Our project aims are to assess climate change consequences on the abundance of trout prey and, consequently, on alevins' growth and survival. In the present experiment, we maintained 146 emerged alevins at 8°C and at 11°C until 3 endpoints: yolk sac exhaustion (D_0), 5 days (D_5), and 9 days (D_9). Fish were either fed (F_5, F_9) or starving (S_5, S_9), with a third group that was starving 5 days and then fed (DF_9). Fish growth and whole body gene expressions for proteins involved in lipid and amino acid catabolism, protein degradation (proteasome) and autophagy (which provides essential components – amino acids, fatty acids, and carbohydrates – required to meet the cell's energy needs during energy stress) were

assessed at each endpoint. Proteasome and autophagy-related genes, overexpressed following starvation as expected, were still over-expressed despite delayed food availability. Moreover, their induction was significantly higher at 11°C. Our results suggest that short events related to climate change (floods or heat waves lasting some days) could negatively impact young trout growth and survival.

COMPARISON OF THE OVARIAN DEVELOPMENT AMONG FIVE STRAINS OF NILE TILAPIA AND ITS IMPLICATIONS ON FISH FECUNDITY

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The farming of economically significant aquatic organisms such as fish, crustaceans, and mollusks, is a common practice worldwide and contributes to a vast industry in food production. In the Philippines, *Oreochromis* sp., more commonly known as tilapia, is farmed widely as this species is easy to grow and that it thrives in a wide range of environments. In the study, the ovarian development of five strains of Nile tilapia (GET-EXCEL, FAST, GIFT-FF, GIFT-MALAYSIA, and SEAFDEC) was observed over a span of five months through histological sections, from July to November 2014, in terms of the oocyte counts and oocyte diameters of the developmental stages which are as follows: chromatin nucleolar, perinucleolar, cortical alveolar, vitellogenic, and ripe. The presence of both atresia and post-ovulatory follicles were also taken into account, and the gonadosomatic indices were recorded and evaluated. The findings of the study, both qualitative and quantitative, are important in knowing their implications on the reproductive performance of the different Nile tilapia strains, and ultimately, how this would affect the population dynamics of the strains over time.

POLYPLOIDY AND PARASITES: DOES POLYPLOIDY CONFER IMMUNE ADVANTAGE IN CORYDORADINAE CATFISHES?

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The Corydoradinae are a species rich group of neotropical armoured catfishes comprising some 170 species. They have a convoluted history of whole genome duplication (WGD) events and associated genome size change. Whole genome duplications are a phenomenon commonly observed amongst plants. However, two rounds of WGD are thought to have occurred early on during the diversification of vertebrates with an additional round of fish-specific WGD occurring during the early diversification of teleosts and several teleost groups display more recent WGDs including the *Salmonidae*, *Catastomidae* and *Corydoradinae*. *Corydoras maculifer* (diploid) and *C. araguaiaensis* (polyploid) are sympatric (and mimetic) species that coexist in the Rio Araguaia drainage in Brazil. Preliminary data indicates that *C. maculifer* (diploid) has on average a nine times higher parasitic abundance then *C. araguaiaensis* (polyploid) (parasites identified down to phylum). Given their co-occurrence, individuals of both species are expected to share similar histories of pathogenic exposure. Here we investigate whether *C. araguaiaensis* (polyploid) has a more diverse immune system than *C. maculifer* (diploid) by deep-sequencing two Toll-like receptor (TLR) genes – TLR1 and TLR2. We also investigated, at an individual level, whether parasite burden is related to TLR gene diversity within the two species. Finally, by sequencing parasites, we investigate whether the macroparasite faunas of the two sympatric species are unique (discrete) or whether the two species are susceptible to the same parasites (cosmopolitan). This has implications for their long-term coexistence and more broadly, the evolution of mimicry.

PARENT, KIN OR FOE? INFLUENCE OF ADULT PRESENCE ON EMBRYO PHYSIOLOGY AND BEHAVIOUR IN A SELECTIVELY CANNIBALISTIC FISH

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Mangrove killifish (*Kryptolebias marmoratus*) populations consist mainly of highly inbred strains, resulting from multigenerational self-fertilizing hermaphroditism. In the wild, different strains are found in the same microhabitats, which results in strong intraspecific competition among strains. Egg cannibalism is a potential mechanism by which adults could selectively predate on unrelated eggs and maximize fitness. We tested this hypothesis by comparing the behaviour and stress response of embryos in the presence of adult fish of different relatedness. To this end, eggs from six isolated individuals (from 2 inbred strains) were reared in water scented by adults of varying relatedness (parents, fish of the same selfing strain, fish from a different strain and blank controls). Embryo heart rate, activity, oxygen consumption and boldness after hatching were assessed to evaluate any potential differences among treatments. These approaches will help to understand the importance of selective egg cannibalism on strain competition and fitness.

CONNECTIVITY AND GENOMIC DIVERSITY OF AN ANTARCTIC FISH REVEALED THROUGH GENOTYPING-BY-SEQUENCING

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Understanding connectivity and concomitant spatio-temporal genetic structure patterns remains an important, albeit sometimes challenging task in marine fish populations. High levels of connectivity and gene flow are often associated with entirely pelagic lifestyle or a pelagic phase at the larval stage, where long-distance dispersal happens via oceanic currents. The latter is the case in marbled rockcod, *Notothenia rossii*, one of the most abundant fish species in the lower Southern Ocean. Following extensive fisheries in the 1960s and 1970s, however, rockcod populations crashed and only slowly recovered. It is unclear whether this dramatic reduction had consequences for standing genetic variation and effective population size. Furthermore, previous population genetic studies of the species did not detect any signifcant genetic differentiation using neutral genetic markers. Adaptive differentiation persisting in small parts of the genome might nevertheless be present.
We utilize current advances in sequencing technologies to characterize thousands of single nucleotide polymorphisms (SNPs) through genotyping-by-sequencing. Genomic diversity of more than 350 specimens collected off various Antarctic islands was thus described. Small and large scale genetic differentiation patterns were assessed, putatively selection-affected loci screened, and effective population sizes estimated. Results are discussed with regard to potential drivers of observed patterns and possible implications under future change scenarios. These insights are valuable in light of ongoing management and protections plans for the Southern Ocean, where the largest marine protected area so far has recently been declared and more are to follow.

Downes, Katie – Size related dichotomy in diet of yellowfin tuna at Ascension Island, central Atlantic (Abstract in Biology of Fish Speed Talks)

Gregory, Stephen – Length of Atlantic salmon smolt and their subsequent marine survival (Abstract in Biology of Fish Speed Talks)

COMPARATIVE DEVELOPMENT OF THREE DIFFERENT WINTER-SPAWNED PRELARVAL FISHES AT THE FIRST FEEDING STAGE ALONG THE SOUTHERN COAST OF KOREA

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The aim of the present study was to elucidate the survival strategies used by the larvae of three winter-hatching fish species from hatching through first feeding. To this end, the external characteristics, digestive systems, and swimming abilities of Pacific cod (*Gadus macrocephalus*), Tanaka's snailfish (*Liparis tanakae*), and spotty belly greenling (*Hexagrammos agrammus*) larvae were recorded. First feeding occurred at 3, 2, and 0 d after hatching in the *G. macrocephalus*, *L. tanakae*, and *H. agrammus* larvae, respectively. At hatching, the average total lengths of the *G. macrocephalus*, *L. tanakae*, and *H. agrammus* larvae were 4.35 ± 0.10 mm, 5.26 ± 0.08 mm, and 7.48 ± 0.35 mm, respectively, which indicated that these winter-hatching species produced larger larvae than species that hatch in other seasons. Newly hatched larvae of these species also possessed more developed digestive tracts. Regarding sustained swimming ability, newly hatched *H. agrammus* larvae scored higher than newly hatched larvae of the both *G. macrocephalus* and *L. tanakae*. However, around the time of the first feeding, the sustained swimming ability of *L. tanakae* and *H. agrammus* larvae was similar. Although sustained swimming ability of *G. macrocephalus* larvae barely improved between hatching and first feeding, its burst swimming speed improved dramatically. Newly hatched larvae of the three winter-hatching species examined in the present study featured large bodies, well-developed digestive tracts, and excellent swimming abilities, all of which increase their survival rates during the winter.

Horton, Tom – Return of an apex predator to British coastal waters: the case of Atlantic bluefin tuna (*Thunnus thynnus*) (Abstract in Biology of Fish Speed Talks)

Kłodawska, Monika – Expression of opsin genes in cichlids of the Bermin and Barombi MBO crater lakes (Abstract in Biology of Fish Speed Talks)

CHANGE MATTERS: CREATING STIMULATING ENVIRONMENTS FOR FISH IN CAPTIVITY

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Fish welfare is of increasing public and regulatory concern, but in the rapid global expansion of aquaculture and in facilities housing fish for research, most attention has focused on facility economics and maximising production, rather than on fish welfare. Most cultured fish are kept in conditions far removed from nature and some of these conditions inevitably result in acute and/or chronic stress. Environmental enrichment is often purported as the solution to improving wellbeing in laboratory fish. However, many enrichments are not compatible with aquaculture or research facilities. We hypothesise that significant welfare benefits are achievable through simple practical solutions easily adapted to current practices in research laboratories. To investigate these new approaches, this initial study examines the effects of simple changes in the tank environment on the wellbeing of captive fish, using zebrafish as our experimental model. We hypothesise that moving fish between tanks of identical status (bare) and changes in water supply will provide positive stimulation equating to more complex enriched environments. We housed groups of zebrafish in 'stable' environments (colonies maintained in the same tanks throughout the study) or in 'changed' environments (colonies periodically moved to novel tanks with replacement system water). Comparisons between treatments include effects on behaviour (aggression, stereotypies, and occupation of tank areas), morphometry (length, weight and condition) and reproductive success (egg output and viability). Our initial insights are presented here. Findings from this and subsequent studies are likely to have application for other captive species including those important to aquaculture and the aquarium trade.

Lewis, Jen – You can't swim from the past! Using natural tags to explore range-expansion in gilthead seabream (Abstract in Biology of Fish Speed Talks)

Montorio, Lucie – The sensitivity of the population growth rate to vital rates of resident and anadromous individuals in a brown trout population (Abstract in Biology of Fish Speed Talks)

HEMOGLOBIN GENE EXPRESSION PATTERNS IN DEEP-WATER ENVIRONMENT – THE STORY OF CAMEROONIAN CRATER LAKES CICHLID FISHES

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Hemoglobin is a protein responsible for oxygen transport in most vertebrates, and for deep-water organisms' oxygen management is a crucial task with various adaptations potentially reflected also on gene level. Fish are characterized by the highest number of hemoglobin genes organized in multiple genomic clusters (two in cichlids). Cichlid fishes from Barombi Mbo crater lake in Cameroon are known for adaptive and ecological speciation and we study evolution of hemoglobin genes under different environmental conditions in the lake. We sequenced transcriptomes of blood and retina tissue in four species living in different depths of the lake. We used the sequenced genome of closely related species Nile tilapia (*Oreochromis niloticus*) as a reference for the differential gene expression analysis employing Tophat and Cufflinks software with subsequent visualization in CummeRbund package. The results based on sister species comparison of *Konia dikume* (deep water) and *Konia eisentrauti* (shallow water) show significant differences in expression of four hemoglobin genes. By further comparisons, we have identified the hemoglobin gene expression profile specific for life in the depths of tropical crater lakes.

IN (WHITE) COLD BLOOD: SPECIATION, INTROGRESSION AND HYBRIDIZATION IN ANTARCTIC FISH

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Correct species identification is essential to assess biodiversity and species richness in ecosystems threatened by environmental changes. This is particularly important when secondary contacts between phylogenetically closely related species occur and hybridization is a potential outcome. In this study, we investigate these issues in the genus *Chionodraco* (Channichthyidae, Notothenioidei, Perciformes) in the Weddell Sea, the Ross Sea and the Antarctic Peninsula. The three species are the only representatives of the genus *Chionodraco* and have a different distribution on the Antarctic continental shelf. Two species are sympatric (*C. hamatus* and *C. myersi*, primarily with a circum-High-Antarctic distribution) and one is largely allopatric (*C. rastrospinosus*, off the Antarctic Peninsula and along the southern Scotia Arc). Our goal is to draw an overall picture of the genus *Chionodraco* in terms of distribution and genetic structure providing tools and protocols to assist the identification of species and hybrids and to be possibly applied to other Antarctic notothenioid fishes. The huge ambiguity in the morphological identification of both larvae and adults of the three species and the documented occurrence of hybrids between *Chionodraco* species pairs require that multidisciplinary tools are developed for a straightforward species identification. We have therefore considered several life history traits for the three *Chionodraco* species, such as geographic distribution and otolith morphology, and related them to genetic structure and phylogeography patterns. These studies are relevant to better describe

the Antarctic marine biodiversity, a prerequisite to properly establish management and conservation measures.

NON-ANTARCTIC NOTOTHENIOIDS: PHYLOGENETIC HISTORY AND CONTEMPORARY PHYLOGEOGRAPHIC IMPLICATIONS IN THE FACE OF ENVIRONMENTAL CHANGES

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Most attention is presently paid to Antarctic notothenioids for their purportedly limited physiological tolerance to climate change and increased temperatures. However, three non-Antarctic Notothenioidei families, Bovichtidae, Pseudaphritidae and Eleginopsidae, diverged early from the main notothenioid lineage and have never established populations on the Antarctic shelf. While it is expected that early-diverged notothenioid species may appear to be more robust to effects of climate change than high-Antarctic congeners, it is difficult to predict how climate changes might alter the geographic range, behaviour, phenology and ultimately genetic variability of these species. Various factors involved in the species response to environmental changes including dispersal capacity, fitness, ecotype, and genetic variability are crucial to understanding population structure and connectivity, and hence vulnerability to local extinctions. The integration of these factors with life history traits and molecular genetic footprints left by past and present demographic events provide key tools to disentangle the biotic and abiotic factors that drive differentiation of populations. These tools can be used to model and project future population viability. Through a review of major life history traits that are characteristic of the three non-Antarctic early-diverged notothenioid taxa and by discussing what genetic resources and population differentiation information is available, we emphasise the population fitness and dynamics of these taxa to strengthen resource management and conservation through an integrative approach. Finally, we suggest an integrated approach within a phylogeographic framework that could build on existing knowledge, and provide information on key components of the species adaptation potential.

FROM MORPHOLOGY TO MICROBIOME: INTEGRATED COMMON GARDEN STUDY IN ATLANTIC SALMON (*SALMO SALAR*)

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The process of domestication has long been part of agriculture, but up until the 19th century had only occurred in a handful of aquatic organisms, including tilapia and carp. Despite the slow establishment of aquaculture, numerous aquatic systems are now undergoing rapid change in response to controlled anthropogenic pressures. Growth in salmonid aquaculture has resulted in fundamental shifts in their biology, including growth rate, behaviour, and morphology. One area in which the implications of domestication are not well known, however, are in relation to the salmonid gut microbiome. The impact of perturbations on the microbiome have been well explored in relation to human diseases in mammalian hosts, but due to the vital role the

microbiome plays in organism function, it is becoming increasingly important to examine these processes in other taxa. These other taxa include commercially reared species, such as salmonids. Here we will examine the interactions between the genetic background of the host, and bacterial communities within the gastro intestinal tract of the Atlantic salmon (*Salmo salar*). Studies will be carried out using 16s amplicon data and common garden experimentation. Microbial community data on fish from wild, farmed and hybrid backgrounds will also be combined with gut morphological data, with morphology being categorised at the macro and micro scale.

SEEKING THE SUN IN DEEP, DARK PLACES: MESOPELAGIC SIGHTINGS OF OCEAN SUNFISHES (MOLIDAE)

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Technological advances for the study of mesopelagic species have increased dramatically in recent years; from baited remote underwater videos through to remotely operated vehicles (ROVs). Although sightings of fish below surface waters decrease exponentially with depth, fleeting or unexpected encounters can still provide insights into performance maxima and predator-prey associations.
Here, we present serendipitous mid-water sightings of three sunfish species, sourced from industrial and research submersibles, made available through the SERPENT project and other online resources.
The remit of the SERPENT project is to connect the advanced technologies used by the oil and gas industries with marine scientists by providing anecdotal footage of marine species encountered during routine surveys. A total of 13 sightings of Molidae, distributed from Scotland to Australia, were obtained at depths of up to 500 m with a new depth record obtained for *Mola ramsayi*, providing further evidence of the deep ranging capabilities of this family. More broadly, these records taken together with previous ROV sightings of large oceanic predators such as hammerhead sharks, add weight to the idea that mesopelagic environments may be of greater importance than previously thought for taxa often considered as epipelagic.

Prokkola, Jenni – Estimating diversity and divergence from individuals to populations –is RADSeq analysis worth the investment? (Abstract in Biology of Fish Speed Talks)

BEHAVIOURAL AND TRANSCRIPTOME RESPONSES OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) TO CROWDING CONDITIONS

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Fish domestication is likely to be constrained by the capacity of species to perform at high densities, which can affect their social behaviour and health. In order to investigate how species adapt to different crowding conditions, we used Nile tilapia (*Oreochromis niloticus*), one of the most common farmed species worldwide. We combined experimental and transcriptomic approaches to understand the influence of the social environment (density) affects gene expression and individual behaviour.

A mirror test was used as proxy for the individual tendency to aggression under two different rearing densities (20 and 80 fry/litre). A brain (hypothalamus) sample of the most and least aggressive fish from each treatment was RNA Illumina sequenced, and differentially expressed genes were compared among densities and behaviours. Density had a significant effect on the individual tendency to display aggressive behaviour, as well as on activity, with fish stocked at low densities being more aggressive and active than those stocked at higher densities. A list of responsive genes related to the neurological regulation of aggression were identified, including *pmhcl,cyp3a65, cdh7, ppp1r16a, asb3, abca1b, gmr6, dbh, MME, scl18a2, mmel1, pomcb, nos1, cacng5a, grid2ipb, GADL1, gmr5a, adora2aa.*

BAIKAL SYMPATRIC COREGONIDS AS A MODEL SYSTEM IN ECOLOGICAL GENOMICS

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Coregonidae are becoming a model system for studying the genetic basis of the adaptive divergence and reproductive isolation due to their unusual propensity for rapid speciation and adaptive radiation. Particularly relevant is the occurrence of lacustrine forms of whitefishes living in sympatry (pelagic and benthic ecotypes) both in North America (Coregonus clupeaformis) and Eurasia (C. lavaretus). Baikal omul (C. migratorius) and lacustrine Baikal whitefish (C. baicalensis), species endemic to lake Baikal, - represent one more case of sympatric divergence into the pelagic and benthic niches. Natural selection in Lake Baikal, in comparison with other lakes, has been acting even more strongly on pelagic ecotype. The multi-level structure of the pelagic form is determined by the availability of multiple ecological niches in this large, deep and oligotrophic lake with highly structured water body. In addition, it is becoming clear that such a divergence has repeated many times within the borders of the lake over the long period of Pleistocene climate oscillations. Gene expression divergence is one of the mechanisms thought to be involved in the emergence of populations and the incipient species. In this work, we present the preliminary findings from the comparative RNA-Seq analysis of brain transcriptomes of Baikal omul and lacustrine Baikal whitefish. The quantitative differences between the studied species and the presence of parallels in gene expression patterns with the similar sympatric whitefish pairs of Europe and North America were revealed. We need to resolve the issue in details, whether both the complete isolation between benthic and pelagic ecotypes, and the multi-level pattern of intraspecific phenotypic divergence within pelagic ecotype are accompanied by differences in the extent of gene expression or not. This work was conducted with the support from the State Project Grant VI.50.1.4 (№0345-2016-0002).

Sapozhnikov, Yulia (first author Avezova) – Hybrid forms of the Baikal whitefish and the perspectives of their artificial reproduction (Abstract in Biology of Fish Speed Talks)

Stevens, Chloe – Linking stress and welfare in a popular ornamental fish (Abstract in Biology of Fish Speed Talks)

MONITORING THE MOVEMENTS OF THE BLACK SEABREAM (*SPONDYLIOSOMA CANTHARUS,* L.) UTILISING KINGMERE MARINE CONSERVATION ZONE AS A SPAWNING SITE

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Using Floy identification tags and Vemco acoustic tags, Sussex Inshore Fisheries and Conservation Authority (IFCA) conducted 2 black seabream tagging studies pre and post spawning seasons (April - June) from 2014 to 2016. Black seabream are a Conservation Feature of Kingmere Marine Conservation Zone (MCZ). Survey aims were to assess feasibility of tagging bream, better understand bream movements during and outside spawning seasons, improve understanding of bream nesting site fidelity and develop relationships with local fishers.
Between April 2014 and October 2016, 2'397 black seabream were Floy tagged by 10 charter boat skippers. Floy tagging effort predominantly occurred during the spawning season, over or near to Kingmere MCZ (<1nm). To date (28/2/17), 85 recapture events have been reported to Sussex IFCA by both commercial and recreational fishers. From April – June 2015, 4 bream were recaptured having been tagged in the 2014 spawning season. From April – June 2016, 5 recaptured fish were tagged in the 2014 spawning season and 12 were tagged in the 2015 spawning season. In April 2014, 5 bream were Vemco tagged and in the same spawning season, 4 were reheard. During the 2015 spawning season, 1 Vemco tag was reheard. These two tagging studies both give indications of bream nesting site fidelity. It had also been previously thought that black seabream over-winter west of the Channel Islands and Devon. Our study has shown no evidence to support this, but does instead indicate migration to northern France and the central English Channel.

FOOD-DEPENDENT DEVELOPMENT OF BEHAVIOURAL TYPES OVER ONTOGENY

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Animal behaviour is diverse to say the least but not random. However, behaviour can change in its form and function over ontogeny. Results presented are part of a master thesis, monitoring changes in behaviour under varying food levels for individual specimen of *Heterandria formosa*, a small live bearing fish. The experimental fish were raised individually and under constant environmental conditions, leaving food as the main limiting factor for development and potential driver for the shaping of different behavioural types. These consistent differences among individuals were assessed across different live stages with forced open field tests. Evaluating recorded tracks for movement and considering variables such as swimming speed and zonal positioning of the test fish gave valuable insights into behavioural changes across life stages besides the regularly collected life history data. Furthermore, utilizing mixed effect models, identified the interactions between treatment groups, sex and life stage that ultimately comprised the differences in behaviour. Finally, within-individual and among-individual differences were compared suggesting the consolidation of behaviour with age and the reduction of within-individual differences while fostering increased among-individual differences. Overall results underline the importance of longitudinal studies, covering multiple life stages.

White, Asa – Superfoods and salmonids: experimental impact of watercress-derived phenethyl isothiocyante on the early life stages of brown trout (*Salmo trutta*) (Abstract in Biology of Fish Speed Talks)

Visconti, Valerio – Age, growth and reproduction of the leatherjacket, *Meuschenia scaber* (Forster 1801) (Abstract in Biology of Fish Speed Talks)

AGE, GROWTH AND REPRODUCTIVE CHARACTERISTICS OF THE BLUE-BARRED PARROTFISH *SCARUS GHOBBAN*.

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Age, size, growth and reproductive characteristics of the Blue-barred parrotfish *Scarus ghobban* were investigated in Taiwan and Solomon Islands. While both populations exhibited similar rapid early growth, the longevity, maximum size and asymptotic length of *S. ghobban* in Taiwan were significantly higher than in the Solomon Islands. Histological evidence from Solomon Islands points to a diandric protogynous life history, where 100% of the oldest age classes were male. This was in contrast to *S. ghobban* from Taiwan, which exhibited persistence of females in the oldest age classes, indicating that not all females changed sex to males. The drivers for sex change in this protogynous hermaphrodite may be more a function of genetics and longevity, and less so due to fishing pressure.

GENETIC PROFILING OF LUMPFISH (*CYCLOPTERUS LUMPUS*) ACROSS THE NATIVE RANGE

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Lumpfish are of growing commercial interest within aquaculture owing to their success as a cleaner-fish on salmon farms. At present, brood stocks supplying the salmon industry largely comprise of wild lumpfish caught on an annual basis. The status of wild populations is unknown, though reports suggest catches are becoming increasingly infrequent. Three distinct genetic groups have been identified (West Atlantic, East Atlantic and Baltic), however, the structure and diversity of populations across large areas of the species' range has yet to be investigated. As the demand for lumpfish intensifies and stocks are exported internationally, wild populations face growing pressure from harvest and the risk of diluting native genetic profiles via farm escapees. Using microsatellite analysis, this study seeks to build knowledge on the suggested ranges of known genetic groups. The project assesses structure and diversity of populations from previously unsampled locations of significance to the salmon industry (UK, Ireland, Denmark and Faroe Islands). We also discuss initial data regarding behavioural differences identified between individuals originating from distinct genetic groups.

Fish in a Changing World – Oral Presentations

MAXIMUM SUSTAINABLE YIELD IS DEAD: LONG LIVE MAXIMUM SUSTAINABLE YIELD

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When the Byzantine Emperor Justinian codified the law of the sea he enshrined a principle of open access to fisheries which persisted globally until the latter half of the twentieth century. The United Nations Convention on the Law of the Sea endorsed coastal states' fishing rights to a maximum of 200 nautical miles limited to maximum sustainable yield (MSY). Both science and law used the term MSY but for very different effect. In law MSY related to a national boundary over fishing rights. In science MSY became associated with an increasingly discredited suite of methods for working out the carrying capacity of a fish stock. However, discrediting the term in science does not necessarily impact on the law. Indeed, the effects of MSY as a legal concept are in relatively early stages of definition. However, the UK's impending departure from the EU will potentially thrust legal MSY into the spotlight as never before. Currently the EU allows shared access to member states' fisheries. It is almost universally accepted the extant EU common fisheries policy (CFP) has, for many years, distributed quota to European fishers in excess of scientific advice (and therefore legal MSY). The EU and its member states thus breached international law in the process. As the UK leaves the EU (if it seeks to substantively alter the CFP) legal MSY will be the key definition around which fish stocks will be divided.

ASSESSING THE OESTROGENIC POTENCY AND HEALTH IMPACTS OF WASTEWATER TREATMENT WORK EFFLUENTS USING ERE-GFP TRANSGENIC ZEBRAFISH

Cooper, Ruth[1], Kudoh, Tetsu[1], Tyler, Charles R.[1], David, Arthur[2], Hill, Elizabeth[2]

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Exposure to estrogenic wastewater treatment works (WwTW) effluents is widely associated with adverse health effects in fish, including intersexuality, impaired reproduction, and both genotoxic and immunotoxic disruption. Discharge of these effluents and the chemicals they contain may therefore have implications for wild fish populations and for the future sustainable management of the world's aquatic resources. Using an Estrogen Responsive Element (ERE) – Green Fluorescent Protein (GFP) transgenic zebrafish model (3×ERE:Gal4ff and UAS:GFP) that shows high sensitivity for detecting environmental estrogens, we exposed zebrafish embryos (from early fertilization to 96 hours post fertilization) to three WwTW effluents to assess for tissue specific responses and seasonal variation in the estrogenic potency of the different WwTWs effluents. We also compared GFP responses in our model (in terms of sensitivity for the detection of estrogens) with vitellogenin (VTG) induction, a well-established biomarker for estrogen exposure in fish. Measured concentrations of steroidal estrogens varied between the different effluents and within an effluent over time and this was reflected in the biological responses in the ERE-GFP transgenic zebrafish. Key target tissues for estrogenic responses were the liver, heart and muscle somites, with responses also seen in the brain. GFP induction (measured via imaging, mRNA levels and Western Blotting) was less sensitive as a biomarker than for VTG mRNA. The ERE-GFP transgenic fish, however, detected responses for exposure to environmentally relevant samples and provides a highly integrative model for application to health effects analysis for understanding the potential health risks of the oestrogenic chemicals.

DECOUPLING THE IMPACTS OF SOCIETAL DEVELOPMENT AND CLIMATE CHANGE ON FISHERIES IN THE LOWER MEKONG BASIN

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The Mekong is one of the world's largest and most important rivers based on productivity, biodiversity and the livelihoods it supports. It, like many other large rivers, supports high population densities of economically and resource poor communities, dependent on the freshwater ecosystems for both their water and protein sources, making them highly vulnerable to the impacts of environmental change, of which climate change is of particular concern. Unfortunately, there is little understanding of the impacts of climate change on the livelihoods and food security of people dependent directly or indirectly on the fisheries and subsistence agriculture of these rivers. Climate change scenarios suggest higher precipitation in the wet season but more extreme dry season low flows. This paper explores the likely impacts of climate change, and specifically the recent El Niño event, on the hydrology and ecosystem productivity and the services they offer in the Lower Mekong Basin. We will tease out hydrological changes associated with climate change events from other development projects (hydropower and agricultural development), and show how they will potentially impact on ecosystem functioning, especially flooding extent which is the key driver of ecosystem productivity, and food security (fishery and rice production) in the Cambodian floodplain and Vietnam Delta. Strategies for how rural communities will likely respond to, and cope with, these impacts will be elucidated from livelihood responses other major stressors. Attention will be paid to how water resource development projects may mitigate or exacerbate the potential impacts.

MARINE PROTECTED AREAS PROVIDE SPECIES WITH PHYSIOLOGICAL RESILIENCE TO THE IMPACTS OF CLIMATE CHANGE

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Marine protected areas (MPA) are championed as a fisheries management tool to mitigate the effects of climate change on fishes, however little is known regarding the underlying mechanisms of how this may occur. To explore these mechanisms we compared the thermal physiology of a resident South African reef fish species; *Chrysoblephus laticeps*, between two areas with identical temperature profiles but variable levels of exploitation; the longstanding (53 years) Tsitsikamma National Park (TNP) and the Port Elizabeth linefishery (PE). We used intermittent flow respirometery to gather metabolic data across an ecologically relevant temperature gradient and develop aerobic scope curves (an indicator of the energy available for fitness related processes at various temperatures). Results showed that the TNP population had a lower standard metabolic rate, higher maximum metabolic rate and hence higher overall aerobic scope compared to the PE population. A higher aerobic scope provides an individual with a physiological advantage which is selected against in the PE linefishery but proliferated within the TNP due to higher levels of competition. Within the TNP *C. laticeps'* metabolic process will be less compromised should temperatures exceed optimal ranges resulting in better capability for adaption to adverse conditions. This study provides some of the first evidence of how MPA's may reduce species' sensitivity to climate change and suggests that they are important reservoirs of resilience to the impacts of climate change.

HYPOXIA MODULATES THE RESPONSES TO CHEMICAL EXPOSURES IN THE THREESPINE STICKLEBACK (*GASTEROSTEUS ACULEATUS*)

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Hypoxia is a widespread stressor in aquatic ecosystems, and hypoxic waters are also often contaminated with environmental chemicals. Despite this, little is known about the potential for hypoxia to modulate chemical toxicity. Current knowledge spans only a few chemicals and species, and has incompletely investigated the life cycle of aquatic organisms, highlighting a major knowledge gap for evaluating the environmental impact of chemicals, where exposure often occurs under reduced oxygen. We have investigated the interactions between hypoxia and copper toxicity using the three-spinned stickleback as a model. During embryogenesis, prior to hatching hypoxia reduced copper toxicity (10% reduction in mortality), but after hatching hypoxia increased copper toxicity (17% increase in mortality). In adult males, combined exposures to copper and hypoxia resulted in a decreased tolerance to hypoxia. For example, fish were able to lower their critical oxygen tension in response to low oxygen conditions when exposed to hypoxia alone but not when exposed to hypoxia in combination with copper. Our findings provide strong evidence for interacting effects of hypoxia and copper, which are strongly dependent on the life stage of this species. Given the ubiquity and increasing prevalence of hypoxia and chemical contaminants in aquatic systems, our data provide important evidence for environmental risk assessments in environments affected by multiple stressors globally.

THE ANTHROPOGENIC ELECTROMAGNETIC WORLD OF FISH: UNDERSTANDING NOVEL ENVIRONMENTAL STIMULI EFFECTS ON FISH BEHAVIOUR

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The modern world has created novel sources of potential stimuli, which when considered with existing environmental stimuli provide a complex environment for fish to inhabit. How fish respond to a changing stimulus environment depends on understanding the way the fish respond in the existing conditions and how they respond to the new conditions that have arisen through anthropogenic activity. This is particularly true for species that use environmental cues to move around, orient to and navigate or when stimuli are associated with a resource, such as a prey item. The novel environmental stimulus of electromagnetic fields (EMFs) is particularly of interest for many fish species as it is used as a cue for moving around the marine environment over many spatial scales and also for some species for finding food or mates. The fascinating aspect is that fish have evolved in a natural electromagnetic environment yet significant human activity in the form of subsea cable networks (associated with subsea power transmission or cable exporting electricity from offshore wind farms) has created the potential for the natural EMF to be altered. He we present findings on how the EMF environment changes and draw on experimental evidence of behavioural response by electromagnetically receptive elasmobranchs to artificially produced EMF; a novel stimulus in a multistimuli environment.

DEGRADED GREAT BARRIER REEF NO LONGER SOUNDS LIKE HOME

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Tropical coral reefs feed hundreds of millions of people worldwide, but are amongst the most threatened ecosystems on the planet. Major disturbance events such as climate-induced bleaching and storm damage are occurring globally with increasing frequency and magnitude. Recruitment of juvenile reef fish is important for recovery from such disturbance events, through the replenishment of functionally important taxa. Recent work has shown that settling reef fish use acoustic cues to guide their orientation, with many families of fish 'hearing their way home'. However, disturbance events that alter reef ecology are also likely to change natural soundscapes, through decreases in the abundance and diversity of sound-producing organisms. Here, we compare soundscapes from Australia's Northern Great Barrier Reef before and after recent major cyclone- and bleaching-related disturbances. Soundscapes changed significantly and consistently across multiple acoustic parameters; post-disturbance reefs were quieter and less acoustically diverse than before disturbance. Complementary approaches using light traps and artificial patch reefs were then used to assess behavioural preferences and levels of recruitment of fish to site-matched post-disturbance soundscapes compared to their pre-disturbance equivalents. Using both methods, the abundance and diversity of settling fish attracted to post-disturbance soundscapes was significantly lower than to their pre-disturbance counterparts. Reduced recruitment due to altered soundscapes may severely impair the recovery potential of damaged reefs. It is not enough simply to look for solutions to coral reef degradation; we must also learn to listen.

FISH IN NOISY HABITATS SHOW REDUCED SENSITIVITY TO MOTORBOAT NOISE

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Anthropogenic noise has been shown to have negative impacts on many taxa worldwide, but little is known about whether observed impacts in local populations are influenced by previous disturbance. Detrimental impacts of noise pollution could be diminished by habituation, selection for tolerant genotypes or hearing threshold shifts, but intraspecific variation in sensitivity to noise is yet to be tested in wild populations. This study uses an endemic cichlid fish in a tropical conservation hotspot, Lake Malawi National Park, to demonstrate detrimental effects of motorboat disturbance on physiology and behaviour. When exposed to motorboats at a site with low current and historic motorboat activity, free-swimming territorial males displayed higher rates of aggressive behaviour and had elevated oxygen consumption rates. Using the same oxygen consumption assays at seven further sites, oxygen consumption rates were found to be affected by acoustic history; responses to noise were consistent at sites with low levels of current and historic motorboat traffic, but reduced at louder sites. These results demonstrate that the acoustic history of an ecosystem is likely to impact the extent to which anthropogenic noise affects its inhabitants. Understanding the influence of previous human-generated noise levels is important when considering mitigation of current noise pollution.

CLIMATE AND PRODUCTIVITY SHAPE FISH AND INVERTEBRATE COMMUNITY STRUCTURE IN SUBARCTIC LAKES

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Climate change and land-use intensification are increasing productivity in subarctic lakes. Simultaneously, fish and invertebrate species adapted to temperate conditions are expanding their range northwards into subarctic habitats. Community level studies are required to predict long-term effects of these dual stressors on subarctic freshwater ecosystems. We conducted a space-for-time study examining the fish, benthic invertebrate and pelagic zooplankton communities in littoral, profundal and pelagic habitats in 19 subarctic lakes situated on a temperature, land-use and productivity gradient in northern Europe. Fish density (ranging between 0.5 and 150.5 fish per net series h^{-1}) and biomass (range between 92 and 5147 g per net series h^{-1}) increased significantly with increasing lake temperature and productivity. This was associated with significantly decreasing body size (26 to 12 cm total length; 174 to 19 g body mass) and a shift in fish community structure from salmonid (Arctic charr *Salvelinus alpinus*, whitefish *Coregonus lavaretus*), to percid (ruffe *Gymnocephalus cernua*, perch *Perca fluviatilis*) and ultimately cyprinid (roach *Rutilus rutilus*, bleak *Alburnus alburnus*) dominance. Changes in fish community composition were most apparent in littoral and pelagic zones. Benthic macroinvertebrate density peaked in mesotrophic lakes, zooplankton density was highest at either end of the gradient, indicating habitat specific differences in predation and top-down control. Body size of zooplankton and benthic macroinvertebrates was negatively related to temperature and productivity. These results suggest that circumpolar climate change and intensification of land-use are gradually turning subarctic lakes into warmer, less transparent and more productive systems harbouring abundant, small-sized and warmer adapted communities.

TOTAL MERCURY CONCENTRATIONS IN LIVER, MUSCLE AND SCALES OF EUROPEAN WHITEFISH (*COREGONUS LAVARETUS* (L.)) IN A SUBARCTIC LAKE – ASSESSING THE FACTORS DRIVING YEAR-ROUND VARIATION

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Subarctic lakes are subject to extreme seasonal variation in light and temperature influencing growth, maturation, condition and resource use of fish. However, our understanding of how seasonal changes affect mercury concentration of fish is limited. We conducted a year-round study of total mercury concentrations (THg) and ecological characteristics of the European whitefish (*Coregonus lavaretus* (L.)) from a subarctic lake. We measured the accumulation of THg in tissues with fast (liver), moderate (muscle) and slow (scale) turnover rates. In liver and muscle tissues, THg were highest in winter (liver: 1.70±0.88, muscle: 0.24±0.05 µg/g) and the lowest in summer (liver: 0.87±0.72, muscle: 0.19±0.04 µg/g). THg increased in winter following the summer-autumn dietary shift to pelagic zooplankton and starvation after spawning in mid-winter. Whitefish THg decreased towards summer, and were associated with consumption of benthic macroinvertebrates and subsequent growth dilution. THg of scales were low and displayed high variance, showing lowest value in May (0.012±0.001 µg/g) and highest in July (0.016±0.005 µg/g). THg in liver and muscle tissue were correlated throughout year, whereas scale and other tissues only showed significant relations during summer. Multiple linear regression models revealed that seasonally varying variables i.e. sexual maturity, $\delta^{13}C$ values, and condition factor explained most of variation in liver (50%) and muscle (55%). In a model examining scale, THg explained 6% of variation. The higher level of seasonal variation (21-33%) in whitefish THg in muscle and scale, than their inter-annual accumulation (8-7%), highlights the importance of seasonal factors in future studies and monitoring of THg in fish.

LOSS OF NATURAL BALTIC SALMON POPULATIONS CAN SEVERLY REDUCE METAPOPULATION CAPACITY TO RETAIN GENETIC VARIATION

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The Atlantic salmon of the Baltic Sea is a species of ecological importance and socioeconomic value. Historically, 96 rivers entering the Baltic Sea held wild salmon populations. Dam construction during the 19th and 20th centuries obstructed the salmons' migratory pathways to upstream spawning grounds in the rivers, leading to limited reproduction in the wild, and a depletion of unique populations. Today, wild populations remain in 30 of the rivers, of which 11 are self-sustaining. This study addresses whether the loss of separate subpopulations has restricted the overall capacity for Baltic salmon to maintain genetic variation, and if so, what the expected magnitude of such a reduction is.

We applied a novel interdisciplinary framework to model the metapopulation effective size and inbreeding dynamics of Baltic salmon prior to and after the subpopulation decline. Our modeling approach allows large flexibility in metapopulation structure. Empirical data from Baltic salmon populations assisted in parametrizing the model.

Preliminary results show that with subpopulation sizes, migration rates, and migration models aimed at mimicking Baltic salmon population structure, metapopulation effective size is drastically reduced following the loss of separate river populations. The reduction exceeds the loss expected based on the proportion of populations lost. This indicates that the capacity of the Baltic salmon to maintain genetic diversity is likely seriously compromised as a consequence of local extinctions. The future survival and adaptive potential of the Baltic salmon relies on management efforts retaining remaining wild populations and restoring populations in rivers that have lost their local stocks.

HABITAT DEGRADATION AFFECTS HOW FISHES ASSESS RISK

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Habitats are degrading worldwide and such change leads to a major loss of biodiversity. This talk will summarise our recent research that explores how the degradation of coral reefs affects how fishes assess risk. For fish that closely associate with live coral, the loss of live coral nearby can modify important olfactory cues that indicate risk, alter how they learn the identity of predators and their ability to pass this information to others. These fish are no longer able to develop a neophobic, risk-averse, phenotype and die much faster than when not affected by odours from degraded coral. Luckily, they can still learn risk from other non-affected species, but this learning mechanism is not as efficient as learning first-hand and leads to reduced survival. Determining the mechanisms that underlie why some species are affected while others are not will improve our understanding of species resilience to coral degradation.

HORMONE-MEDIATED FITNESS RESPONSES TO GLOBAL CHANGE IN CORAL REEF FISH

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To our knowledge, no studies have demonstrated a mechanistic link between the activation of hypothalamic-pituitary-adrenal/-interrenal (HPA/I) axis with life-history traits in wild animals exposed to natural or anthropogenic perturbations. Here, we report the endocrine and fitness responses of individual reef fish, the anemonefish *Amphiprion chrysopterus*, to two environmental perturbations: a recent large-scale sea-warming event that caused worldwide bleaching on coral reefs and engine noise, a global pollutant. We show a direct causal link between warming-induced anemone bleaching, anemonefish stress response and reproductive hormones that decreased spawning by 51%, increased egg mortality by 38% and reduced viable pre-hatching eggs by 73%. We also show a direct link between engine noise playback, anemonefish stress response and reproductive hormones. These findings suggest that physiological stress responses could play a vital role in changes in population demography following such environmental perturbations. Plasticity in such endocrine responsiveness may therefore be a key mechanism enabling individual acclimation to environmental change.

CLIMATE CHANGE INFLUENCES POPULATION DYNAMICS OF ANADROMOUS BROWN TROUT (*SALMO TRUTTA*)

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Brown trout (*Salmo trutta* L.) exhibit facultative anadromy, in which the returning adult spawning migration to freshwater is thought to be related to maturation timing and survival of post-smolts and adults in the marine phase. Theory suggests that life history traits that are responsive to the environment should adjust to maximise population fitness. Responses may include shifts in maturation timing as growth and survival vary in relation to environmental heterogeneity. Climate change has occurred in freshwater and marine habitats occupied by sea trout (anadromous brown trout) populations around the Irish Sea, driving changes in ecosystem characteristics of both habitats, including such key features as sea temperature and feeding opportunity. Our studies on sea trout in the Irish Sea have revealed a complex pattern of spatial and temporal variation in adult growth, annual survival and timing of first return, with an underlying marine climate signal expressed through sea surface temperature and NAO. This paper will describe evidence for such observations and consider also the links with corresponding freshwater environmental change. We then outline the processes underpinning climate-associated variability as a driver of population dynamics in anadromous salmonids and discuss the implications of such phenotypic plasticity for sea trout fisheries.

COD AND OCEAN ACIDIFICATION: DIRECT AND TRANSGENERATIONAL EFFECTS

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Ocean acidification (OA), the dissolution of excess man-made CO_2 into the world's oceans, is one of the major threats to life in the future ocean. Even though adult fish have long been considered robust to the projected decrease in pH, evidence is accumulating that early life stages of many fish species, eggs and larvae in particular are negatively impacted by rising pCO_2. Larval stages of several Atlantic cod populations are negatively affected by predicted ocean acidification levels, with effects such as increased larval mortality, changed growth patterns, altered otolith development and severe tissue damage. While this could result in severe population decline of cod, these studies only addressed the direct effects of OA on larvae, excluding the possibility of transgenerational acclimatization that can potentially mitigate these adverse effects. We present our most recent experimental results on the effects of predicted end-of-century ocean acidification (~1100 µatm pCO_2) in larval stages of Atlantic cod. First results on the potential of parental acclimation to elevated pCO_2 (parents being acclimatized to ambient ~400 µatm pCO_2 or ~1100 µatm pCO_2 for 6 weeks) and its impacts on larval mortality will be presented. We also addressed gene expression in newly hatched to 36 day old larvae under the direct effects of OA and hypothesize that expression patterns will show signs of acclimation based on the treatment the parental generation has received, visible as parental * F1-generation interaction.

MOTORBOAT NOISE IMPACTS PARENTAL BEHAVIOUR AND OFFSPRING SURVIVAL IN THE SPINY CHROMIS (*ACANTHOCHROMIS POLYACANTHUS*)

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Anthropogenic noise is a pollutant of international concern, with mounting evidence of disturbance and impacts on animal behaviour and physiology. However, empirical studies measuring survival consequences are rare. We use a field experiment to investigate how repeated motorboat-noise playback affects parental behaviour and offspring survival in the spiny chromis (*Acanthochromis polyacanthus*), a brooding coral reef fish. Repeated observations were made for 12 days at 38 natural nests with broods of young. Exposure to motorboat-noise playback compared to ambient-noise playback increased defensive acts, and reduced both feeding and offspring interactions by brood-guarding males. Anthropogenic noise did not affect the growth of developing offspring, but reduced the likelihood of offspring survival; while offspring survived at all 19 nests exposed to ambient-noise playback, six of the 19 nests exposed to motorboat-noise playback suffered complete brood mortality. Our study, providing field-based experimental evidence of the consequences of anthropogenic noise, suggests potential fitness consequences of this global pollutant.

BROWN TROUT AND HEAVY METALS: ADAPTATION TO THE LEGACY OF BRITAIN'S MINING HISTORY

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Anthropogenic pollution affects natural habitats worldwide. Amongst the most prevalent environmental pollutants are metals, for which ambient levels have been significantly augmented by human activity dating back thousands of years. The southwest of Britain has been impacted by mining activity and, as a consequence, is marred by a patchwork of highly metal-contaminated aquatic environments. Although rivers affected by mining are broadly referred to as 'metal-impacted', no two rivers share an identical contaminant profile. There is variation in both the quantity and type of contaminant within each metal-impacted river, such that each contains a different 'cocktail' of metals. Metal-naïve fish do not fare well in such waters and yet many rivers harbour healthy breeding populations of brown trout (*Salmo trutta* L.). These populations frequently experience metal concentrations above and beyond levels known to cause acute damage and death (LC50s) to naïve fish; they also display some of the highest recorded levels of metals in their body-tissues. Our research suggests that metal populations show signatures of local adaptation. Neutral genetic markers show that metal-adapted fish are genetically distinct from populations inhabiting unpolluted waters, as well as other metal-impacted populations. In metal-exposure experiments, RNA-seq shows that naïve fish over-express genes involved in stress and metal-handling, whereas metal-adapted fish show no such response. RAD-seq analysis and genome scans have identified markers and genes under divergent selection that are unique to each metal-impacted trout population. The ability of natural populations to undergo rapid adaptation is an essential mechanism for surviving in human-altered environments.

ENVIRONMENTAL IMPACTS OF BROMINATED FLAME RETARDANTS: UNDERSTANDING THE MOLECULAR MECHANISMS OF THYROID DISRUPTION IN FISH EMBRYO–LARVAE

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Thyroid hormones (TH) play a key role in a wide range of developmental processes and physiological functions in vertebrates. In fish, developmental roles include mediating the metamorphic transition from larval to adult stages and influencing maturation of tissues including bone, gonads, intestine and the central nervous system. In adults they modulate growth, energy homeostasis, cardiac rhythm, osmoregulation and the behaviours/physiology associated with rheotaxis and migration. As a consequence, even minor alterations in TH levels, particularly during sensitive developmental windows, can have significant acute and potentially long-term health effects. Brominated flame retardants (BFRs) are halogenated flame retardants that are used to effectively inhibit the flammability of various materials including plastic products, electrical appliances, construction materials and textiles. Many traditional BFRs have been phased out of production in many parts of the world but they are still widely detected in both abiotic and biotic environmental matrices. Several *in vivo* studies have shown BFRs can disrupt circulating levels of TH in fish, however the molecular mechanisms underlying BFR-induced thyroid disruption are still poorly understood. Our recent work demonstrates that TBBPA and BDE-47 (two BFR compounds) can disrupt the transcription of genes at multiple levels of the hypothalamic-thyroid-

axis, and these changes are tissue and developmental stage specific. TH signalling in the brain appears to be particularly sensitive to BFR exposure. This presentation will consider these findings in the wider context of thyroid disrupting chemicals and their potential impacts on fish populations.

IMPACTS OF ANTHROPOGENIC NOISE ON FISH: INDIVIDUAL EFFECTS, POPULATION CONSEQUENCES AND MITIGATION

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Since the Industrial Revolution, human activities have changed the soundscape of many aquatic ecosystems, both increasing the amount of acoustic energy and generating sounds that are different from those arising from natural sources. International legislation recognises the need to assess and manage the biological impacts of this anthropogenic noise. Over the last 8 years, we have developed a research programme considering how a range of man-made noise sources (including shipping, motorboats, pile-driving and seismic gun arrays) might affect a variety of fish species. Our initial experiments were conducted in aquaria using playbacks to consider short-term effects of single noise exposures; a logistically simple approach allowing tight control of conditions. Having demonstrated the potential for anthropogenic noise to impact fish, we have subsequently developed our research programme in four main ways. First, by considering how repeated or chronic exposure to noise – the more usual situation experienced by animals – leads to changes in responses. Second, by conducting experiments in open-water conditions and using real-world noise sources, thus providing greater ecological and acoustic validity. Third, by testing fitness impacts directly, rather than extrapolating from short-term behavioural or physiological responses. Fourth, by examining intra-population variation in effects arising from both intrinsic (e.g. body condition) and extrinsic (e.g. prior exposure) factors. Our ongoing goal is to provide strong conclusions to inform policy makers and managers, as well as working with industry to test potential mitigation measures that may lessen the impacts of this global pollutant on fish populations.

THE IMPACT OF CLIMATIC VARIABILITY ON GROWTH OF COMMERCIAL FISHES

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North Sea fish stocks are often characterised by geographically discrete subpopulations, which will each experience different local environmental conditions. Recent studies indicate that some North Sea species shift to track preferred temperatures in warming seas, but emerging research suggests distributions can be constrained by depth or oceanographic features, meaning that fish are consequently exposed to warmer conditions. The impacts of warming on subpopulations of targeted species should thus be an important consideration when determining how fisheries are managed into the future. Using analysis of otolith growth patterns and size-at-age data from fisheries surveys, here we examine subpopulation-specific responses of European plaice to warming seas, and gauge the level to which stock subdivision modulates predicted impacts of warming climate. This research helps to identify whether sub-populations have differing capacities to respond to warming; a factor largely overlooked in existing studies of marine environmental change.

ADAPTATION TO EXTREME ENVIRONMENTS – GOBIES IN THE BENGUELA UPWELLING ECOSYSTEM

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The oceans of the world are slowly losing oxygen, in part because of climate change and in part because of cultural eutrophication. An increase in hypoxia is a major cause of concern because it compresses the habitable area for many marine organisms. Naturally hypoxic areas are found in highly productive eastern boundary current ecosystems, and temporal variations in hypoxia there are linked to climate. The northern Benguela ecosystem off Namibia is one such ecosystem, and 9000 km^2 of the continental shelf there is considered hypoxic. Here, we review the literature on the remarkable adaptations of the endemic goby (*Sufflogobius bibarbatus*) to this environment; a species that in recent decades has fed the commercial fish populations. Unlike their predators, *S. bibarbatus* can remain alert in anoxic and severely hypoxic waters, and it can cope with sulphide shocks. Populations display diel vertical migration and shuttle between suboxic seabed refugia during the day to more oxic, shallower waters at night, and whilst they may share the water column with predators, they associate with jellyfish, perhaps for protection. The spatial distribution of gobies varies with changes in available oxygen, and populations expand and contract with climate induced changes in the distribution of hypoxic waters. Gobies have an unusual diet and play an important role in ecosystem functioning. This species is a batch-spawner, with a protracted spawning season. Remarkably, males display alternative reproductive tactics and reproduction can take place at oxygen levels < 0.5 ml O_2 L^{-1}.

OCEAN WARMING AND DEOXYGENATION EFFECTS ON PELAGIC SHARK BEHAVIOUR AND VULNERABILITY TO FISHERIES

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Permanent oxygen minimum zones (OMZ) in the oceans are expanding geographically and vertically due to climate-driven reductions in dissolved oxygen. OMZ expansion resulting in shallower upper boundaries (shoaling) is hypothesised to concentrate large pelagic fish further in surface waters potentially making them more vulnerable to surface fisheries. It seems likely that such effects will be particularly marked for high-oxygen demand fish such as tunas and sharks. But how ocean warming, deoxygenation and fisheries may interact to impact oceanic fish populations in the future remains poorly resolved. In this presentation, we will describe our recent work to help address this knowledge gap. Firstly, we satellite tracked the movements and diving behaviour of blue (*Prionace glauca*) and shortfin mako sharks (*Isurus oxyrinchus*) above the eastern tropical Atlantic OMZ, the world's fastest expanding OMZ. Empirical data were used to model the interactive effects of sea surface temperature warming and hypoxia on shark maximum daily depth, and to predict how vertical habitat may be affected by expanding OMZs. Second, we analysed Global Positioning System (GPS) tracks of surface longline vessels to assess how vulnerability of sharks to fisheries capture may change above OMZs presently and in future, warmer seas. Open-ocean fishery catches of many pelagic sharks including blue and mako sharks remain largely unregulated by the authorities tasked with their management. I will discuss our results in the context of the need to understand the consequence of OMZ expansions for shark populations given the absence of fishery catch controls.

CONCURRENT DECLINE OF WHITEFISH STOCKS IN LAKE OULUJÄRVI: A RESULT OF PIKEPERCH RE-INTRODUCTION OR CLIMATE CHANGE?

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Identification of direct and ecologically mediated mechanisms that drive population dynamics in fish communities requires data that are seldom available in freshwater systems. Data-based knowledge is needed for efficient ecosystem-based fisheries management and conservation of polymorphic fish stocks such as those of whitefish, *Coregonus lavaretus*. We assessed the stock of each morphologically distinguishable whitefish form (native lesser sparsely-rakered whitefish, native blue whitefish and stocked northern densely-rakered whitefish) in Lake Oulujärvi during 1973-2014, and explained temporal variations in the population dynamics of each form by environmental data and catch per unit of effort (CPUE) data on other species with fisheries significance. The results demonstrated a major decline in the abundance of the native whitefish forms and a decline in the length-at-age of all forms. During the study period, summer time water temperature increased and surface water phosphate phosphorous concentration decreased. Recruitment in all whitefish forms showed Ricker-type dependence on spawning stock biomass but little residual correlation with the environmental parameters. Cross-correlation analyses suggested that the re-establishment of pikeperch *Sander lucioperca* population, a predator with modelled capacity to consume substantial amounts of prey fish, affected negatively both the recruitment and biomass of whitefish but the exact effect mechanisms require further assessment. Our results exemplify that ecosystem-based fisheries management in inland waters must take into account both natural and human-induced environmental changes as well as stockings, and that knowledge-based inland fisheries management is inherently data-intensive.

IMPACT OF CLIMATE WARMING ON EUROPEAN WHITEFISH: MODEL BASED PROJECTION OF POPULATION DYNAMIC IN THE LAKE GARDA (ITALY)

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The whitefish *Coregonus lavaretus* is a cold water species introduced in Italy at the end of the 19th / beginning of the 20th century, that soon became an important resource for the local fishing industry and several decades later a relevant target of the recreational fishery. In this work we used an individual based / size structured population model to reconstruct the whitefish population dynamic in the Lake Garda, the largest Italian lake. The exploration of alternative raised temperature scenarios and different exploitation management alternatives highlighted a strong interaction among climate and fishery effects. In Italy, whitefish populations show faster growth rates and earlier maturation than other European populations. A moderate temperature increase could still stimulate fish growth and lead to higher fishery production, but higher temperatures, and even faster growth rates, could alter population structure and negatively affect fishery yields. More importantly, the magnitude of the impacts of climate changes depends on the levels and modalities of fish exploitation. Hence, as the temperature changes cannot be managed locally, it is very important to consider their potential effects in the management of cold water species. Climate adaptation strategies should be included in the next management plans, in order to preserve whitefish populations and to secure the fishery sector. Due to the southern location of Lake Garda with respect to the whitefish distribution range, the experience of Italian case studies could anticipate the dynamic expected in more northern regions.

Fish in a Changing World – Speed Talks

OLIGOTROPHICATION HAS EVOLUTIONARY CONSEQUENCES FOR SALMON POPULATIONS

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Salmon migrating from the ocean to inland rivers and streams can be an important source of nutrient input to freshwater ecosystems. However, barriers to their upstream migration, coupled with the net export of nutrients by emigrant juveniles stocked above these migration barriers, are causing a decline in the productivity of upland rivers and lakes in many north temperate and boreal regions. This process of oligotrophication can have negative impacts on freshwater ecosystems, but its longer-term evolutionary consequences for fish populations are unknown. Here we show experimentally that oligotrophication intensifies selection on two of three key fitness-related traits in Atlantic salmon (*Salmo salar*). We found evidence for strong positive directional selection on both egg mass and early juvenile maximum aerobic capacity in oligotrophic but not nutrient-restored streams. Differences in the intensity of selection among oligotrophic and nutrient-restored streams led to rapid phenotypic divergence among the two stream types between the egg and early juvenile stage. Greater selection pressures in oligotrophic streams resulted in a lower genetic diversity of surviving juveniles compared to nutrient-restored streams. We discuss the implications of these altered selection pressures for the migratory capacity of salmon populations facing different degrees of oligotrophication in their natal streams.

IMPACT OF LOW FLOW ON Y-O-Y ATLANTIC SALMON: DENSITY-DEPENDENT AND DENSITY-INDEPENDENT FACTORS INTERACT TO DECREASE POPULATION RESILIENCE

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Atlantic salmon (*Salmo salar*) is an emblematic anadromous species whose spawning and juveniles' growth occur in freshwater. The predicted episodes of low summer flow associated to climate change will modify year-over-year (YOY) growing conditions through density dependent and independent factors since flow reduction will result in lower velocities and reduction of wetted area. To assess the potential impact of flow reduction on Atlantic salmon YOY, we conducted an experiment in a predator-free semi-natural brook where juveniles issued from 7 families (4F, 7M) were allowed to grow from emergence time up to six months in 16 riffle units (14 m² each). We created two levels of density and two levels of water velocity and crossed them to end with 4 conditions, replicated four times. Survival (80% on average) and growth were negatively impacted by density, and in both cases the negative impact of density was weaker at low velocity. Such pattern was valid at the family level, even if large differences were observed among families. A negative relationship between standard metabolism and growth was evidenced under low flow x high density condition, suggesting that fish with high potential for growth will be penalized by flow reduction. Higher mRNA levels for catabolic enzymes and mitochondrial proteins were observed in the livers of small fish but only at high velocity, which strengthens the idea that selection by dominance is lowered by low flow. Overall, results suggest that low flow could decrease the resilience of salmon populations by reducing the impact of density-dependent regulation.

COPING WITH EXTREME ENVIRONMENTS: THE INFLUENCE OF THERMAL VARIATION ON FISH BEHAVIOURAL ECOLOGY

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Human-induced climate change is one of the most profound threats to global biodiversity. Biodiversity loss associated with increasing variability in temperature is predicted to be particularly extreme within tropical ecosystems, especially coral reefs. Despite this, little is known about how coral reef species will cope with future scenarios of climate change. Plasticity in behaviour will clearly be important, but there is little work focusing on the role of behaviour in structuring tropical species within thermally extreme environments. We focused on examining the foraging activity, vertical movement and sheltering of populations of the Paletail damselfish (*Pomacentrus trichrourus*) within the Persian Gulf – this region has seasonal temperature extremes higher than those Indo-Pacific reef fish can tolerate, with summer temperatures comparable to those predicted for the tropical ocean by 2090-2099. We found substantial differences in all three behaviours between winter, spring and summer (21, 27 and 34 °C water, respectively); particularly at low and high water temperatures, fish were significantly less active and bold compared to more benign intermediate temperatures. Understanding how Persian Gulf fish populations cope with living in extreme conditions may provide an insight into how marine communities may be impacted, but also cope with increasing changes in global climate.

MATE CHOICE DECISIONS AND PARENTING STRATEGIES IN DEGRADING ENVIRONMENTS: MIND THE EVOLUTIONARY TRAP

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Environmental stochasticity and habitat degradation can change the rules of the game for organisms. Sexual cues, physical traits and behaviours that were selected for under one set of conditions may suddenly become costly maladaptions, with consequences for the strength or direction of selection within a population. In a series of experiments using the three-spined stickleback, we manipulated the dissolved oxygen (DO) content of water to create high or low DO environments in which male fish built nests, female fish selected mates and in which males provided parental care to embryos. We examined the effect of these environmental fluctuations on sexual cues, female mate choice, parental care provided by males, and embryo survival. Males responded to environmental stochasticity by adjusting sexual cues associated with nest-structure. Females showed evidence of context-dependent mate choice when it came to some traits (nest-structure), but not others (larger males that courted vigorously were always preferred). Levels of male parental care associated with degraded (low DO) conditions did not vary, but the *type* of care did, resulting in a lower reproductive output from larger, preferred males than their less-preferred counterparts. The maladaptive behavioural response exhibited by larger males represents a classic example of an evolutionary trap, with habitat degradation resulting in males unable to accurately assess optimal parental care strategy and females unable to accurately assess the fitness value of mates. Our results highlight the potential for environmental degradation to influence the direction of selection within a population, by increasing the fitness of poorer quality male phenotypes.

MOVEMENT AND DIET: INDIVIDUAL SPECIALISATIONS OF BARBEL *BARBUS BARBUS* IN A DISCONNECTED AND SUBSIDISED WORLD

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Globally, riverine fish communities are impacted by multiple disturbances, including impoundment, exploitation and impacts of invasive species. In many Western European rivers, impoundment is from navigation weirs, exploitation is now primarily from recreational angling and invasive species include fishes released to enhance angling. These angling activities then drive further disturbances via the release of large amounts of angling bait, often based on marine fishmeal that acts as a strong trophic subsidy that directly delivers marine nutrients across the marine: freshwater boundary. This combination of anthropogenic disturbances is strongly apparent in the lower reaches of the River Severn, England, where navigation weirs block fish passage, species introduced for angling include barbel *Barbus barbus*, and anglers now utilise large amounts of pelletized marine fishmeal during angling activities. Here, we reveal strong patterns of individual specialisations in the behavioural ecology of the *B. barbus* population, where individual variability in home range size varies between 0.5 and 16.5 km. Weir impoundments provide largely impermeable barriers that limit the home range size of the most vagile individuals. Home range is then a strong predictor of diet composition, with individuals of small home range sizes having dietary specialisations based on marine fishmeal from angler baits. Thus, impoundment, angler trophic subsidies and invasive fishes are having profound influences on behavioural ecology within this riverine fish community, with the implications outlined and discussed.

MULTIPLE EFFECTS OF CLIMATE CHANGE ON THE ECOLOGY AND BEHAVIOUR OF FISHES ON PACIFIC REEF FLATS

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Shallow reef flats are one of the most extensive zones on Pacific coral reefs, supporting a diverse fish assemblage that is exposed to significant variations in water depth and temperature. Using a study site on the Great Barrier Reef, Australia (~2m tidal range), we investigated multiple aspects of how climate change may affect reef flat fishes. Firstly, we used video to monitor herbivory and invertivory across diurnal and tidal cycles, and demonstrated that herbivory is strongly affected by water depth because of the absence of large grazers at low tide as they migrate to deeper habitats. We then predict that sea-level rise may reduce this migration and increase herbivory by ~20%. Secondly, we used acoustic tracking to build a predictive model of the foraging behaviour of a carnivorous lethrinid (*Lethrinus nebulosus*). Foraging on the reef flat by *L. nebulosus* was significantly affected by diel, tidal, and seasonal cycles, and suggest that climate change (sea-level rise and increased water temperatures) will increase carnivory on reef flats by this species. Finally, we link these results with additional data to investigate climate change effects on reef-flat food-web dynamics. Parameterising an ECOPATH model at different tidal states indicated that the increased foraging opportunities for large-bodied carnivores under sea-level rise scenarios may negatively impact populations of inshore invertivores that currently have temporal relief from predation at low tide. The multiple effects of climate change on the ecosystem services provided by extensive Pacific reef flats underscore the need for local and global conservation efforts.

TOOLS FOR ASSESSING WELFARE OF LABORATORY FISH

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The use of fish in research and regulatory testing is increasing, but there is concern that the housing environments under which laboratory fish are being kept are not specifically designed to meet their welfare needs. In addition, several species are held in opaque aquaria, not allowing direct observations. Here we report a series of experiments carried out to investigate the impact of different tank environments on three fish species welfare. In each experiment, fish were exposed to three treatments (standard, sub-standard, supra-standard environments) for four weeks. The two latter were based upon putative adverse or beneficial changes to visual, acoustic, rheologic and husbandry aspects of the environment. Potential impacts of the changes on the fish were assessed through somatic, physiological, behavioural and biochemical measures. In addition, metabolites excreted in the water (the exometabolome), were captured using passive sampling devices and measured using non-targeted direct infusion mass spectrometry. Cortisol release rates were elevated after transfer from a common holding-tank environment, and decreased to a stable baseline within one week, indicating acclimation to the experimental tank environments. Behavioural observations of rainbow trout via underwater cameras are also discussed. The results indicate that environmental factors can markedly affect fish behaviour, but the outcomes are often difficult to interpret and predict. The novel application of telomere attrition as an integrated stress history indicator for fish appears to hold promise but requires further validation studies. The lack of fish metabolite annotation made difficult to put results into fish welfare context.

MULTI-STRESSOR IMPACTS OF THE 'DEADLY TRIO' ON HYPOXIA TOLERANCE OF A COMMERCIAL FISH SPECIES

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The impact of anthropogenic stressors upon the natural environment is of increasing concern, which includes the unpredictability of interactions between combined environmental stressors. There is therefore an urgent need for greater understanding of the interactive effects of multiple stressors, specifically to identify whether these are additive (equal to the sum of their individual effects), antagonistic (less than the sum of their individual effects) or synergistic (greater than the sum of their individual effects). In marine systems a 'deadly trio' of ocean warming, CO_2-induced acidification and decreased oxygen content is predicted to co-occur over the next century. Hypoxic events are predicted to become both more prevalent and extreme as a result of ocean warming. Additionally, ocean acidification (from rising atmospheric CO_2) combined with respiratory production of CO_2 in hypoxic zones means that fish will experience elevated CO_2 and low pH during hypoxic events. Warming and elevated CO_2 may exacerbate future susceptibility of fish to hypoxia through increased oxygen demand and decreased capacity of oxygen supply. We aim to assess whether interactions of temperature and elevated CO_2 cause changes in hypoxia tolerance (P_{crit}) of four species of commercially important marine fish through a combination of respirometry (in fed and unfed fish for Pcrit and SDA), and blood analysis (e.g. affinity of haemoglobin for O_2; P_{50}). We anticipate presenting data from the first series of experiments with one of these species.

ASSESSING REPRODUCTIVE FUNCTION AND FILLET QUALITY IN TRIPLOID ATLANTIC SALMON

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Providing relatively cheap but nutritious food for an increasingly demanding human population is becoming ever more important. Atlantic salmon have been successfully cultured since the 19th century with current production exceeding 2 million tonnes. Unfortunately, salmon farming has encountered some bottlenecks, with feed sustainability and escapees hybridising with wild populations being two important issues placing concerns on the industry's growth. Triploidy could provide a solution to both these issues. Triploid Atlantic salmon are reported to be sterile, which will prevent farm introgression with wild fish and, without gonadal development, dietary nutrients should be allocated to somatic tissues, increasing the amount of lipids and omega-3 fatty acids (FA) available for consumers. Here we examine the reproductive status of triploid Atlantic salmon, and explore their fillet quality under standard salmon farming conditions. Having confirmed ploidy status using a suite of microsatellites, and comparing farm-strain triploid and diploid age-classes reared under standardised conditions, our results demonstrate that no female triploids displayed reproductive maturation. However, we found that 3-year triploid males can develop normal-sized gonads capable of producing motile spermatozoa, but their fertilisation success was minimal. In terms of fillet quality, we found that triploid salmon had fewer lipids, and consequently less omega-3 fatty acids compared to diploid salmon reared in similar conditions. In conclusion, our results indicate that triploidy will constrain reproduction by farm escapes, but that the nutritional quality of farmed salmon in the triploid state may be more of a challenge to maintain compared to diploid salmon.

INVESTIGATING THE SALE OF SHARK STEAKS AND FINS IN THE UK

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Shark steaks sold in the UK are sourced from a range of different species, which vary in their vulnerability to fisheries pressure and conservation status. Products are commonly sold by fish mongers and take aways in the UK under a range of different names such as 'rock salmon' and 'huss'. Therefore, it is very difficult for consumers to identify the species that they are purchasing, and for regulating authorities to monitor the sale of threatened species. Additionally, shark fins traded within the UK are mostly imported in the processed form, which can be extremely difficult to identify even with genetic approaches, due to the processing methods of fins. There is significant conservation concern worldwide around declining shark populations, especially in species targeted by the fin trade, which includes CITES listed species. Using CO1 DNA barcoding and mini-barcoding of shark products sold in the UK, this study identified that endangered and prohibited species formed a large proportion of shark steaks tested (64% from *Squalus acanthias*) and of shark fins tested (30% from *Sphyrna lewini*). This demonstrates the potential of the UK shark trade to cause ecological damage, but the use of umbrella names for products and unknown levels of imports makes reliable assessment challenging. Furthermore, the majority of UK sharks do not have species specific quotas and landing data, which could have major consequences as declines in one or more species can be masked by stability of others.

THE EFFECTS OF INTENSE ACOUSTIC STIMULATION ON THE AUDITORY BEHAVIOUR AND EPITHELIUM ULTRASTRUCTURE OF BAIKAL FISH

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The study of the acoustic behavior of fish is immensely important due to the increasing levels of sound pollution in recent years. The consequences for fish hearing both in the natural habitat and aquaculture are still largely unknown. We carried out a comparative analysis of morphological characteristics of the hearing apparatus of different species of two groups of Baikal sculpins (Cottoidei) and whitefish (Coregonus sp., Coregonidae) who live in different environmental conditions. Ultrastructural and functional characteristics of the auditory epithelium (hair cell types, distribution, range of maximum acoustic sensitivity, audibility thresholds) were examined in order to correlate them with the differences in the behavioral activity of these Baikal fish. Our main finding was that the intense acoustic stimulation caused variable degrees of hair cell damage depending on the area of the macula, confirming the existence of regions with different tonal specialization in the auditory maculae of Baikal fish. The acoustic impact included not only mechanical damage to the sensory epithelium, causing temporary (and possibly permanent) hearing loss, but also a violation of normal fish behavior, correlating with the acoustic signal intensity. Our work demonstrates that fish are very sensitive to environmental changes, and this entails adaptations at all structural levels: both at level of the cell and the organism as well as at level of populations and species. This work was performed at the Baikal Joint Instrumentation Centre and in the Unique Scientific Installation “Experimental freshwater complex of Baikal aquatic organisms” with the support of the State Project VI.50.1.4 (№0345-2016-0002).

INVESTIGATING THE IMPACTS OF STRESS ON THE MICROBIOME AND IMMUNE STATUS OF ATLANTIC SALMON

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Microbial communities in the gut, and other mucosal surfaces, have a fundamental influence on many aspects of host health, fitness and disease. Environmental stressors can disrupt the finely tuned symbiotic relationship between the host immune system and the microbiota. This may lead to perturbation of microbial communities and, potentially, adverse health effects and increased disease incidence in the host. We are investigating the impact of early-life stress in Atlantic salmon on gut and skin microbial communities, immune status and disease susceptibility. We performed a series of stress experiments during the embryonic, larval and fry phases of development in Atlantic salmon (*Salmo salar*), then characterised the gut and skin microbiome using Illumina sequencing of the V4 hypervariable region of the bacterial 16S gene, followed by analysis in Mothur. We found that stress during embryogenesis caused marked, lasting changes in microbial community structure in the gut and on the skin, including a specific increase in *Pseudomonas* sp. and *Acinetobacter* sp. abundance. We also found evidence of altered basal immune status and altered response to an immune stimulus, bacterial lipopolysaccharide (LPS), in fish subject to this stress. To conduct comprehensive analysis of the molecular mechanisms underlying these effects, we are currently performing transcriptomic and epigenetic analysis using RNA-sequencing (RNA-seq) and Reduced Representation Bisulfide Sequencing (RRBS).

Fish in a Changing World – Posters

Auer, Sonya – Oligotrophication has evolutionary consequences for salmon populations (Abstract in Fish in a Changing World Speed Talks)

Bardonnet, Agnès – Impact of low flow on young-of-year Atlantic salmon: density-dependent and density-independent factors interact to decrease population resilience (Abstract in Fish in a Changing World Speed Talks)

ASSESSING DIETARY VERSATILITY OF REEF FISHES IN RESPONSE TO ENVIRONMENTAL DEGRADATION

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With on-going coral reef decline it becomes increasingly important to understand the mechanisms by which habitat change affects the resilience of fish communities and populations. How fishes are influenced depends largely on their degree of dependence on specific aspects of the habitat for food and shelter; whereby, the most specialized species are expected to be the most vulnerable. Recent findings suggest that determining the degree of specialization alone may not allow us to understand the complex ways in which communities function, but rather that we must examine the whole spectrum of resource use by fishes. This study investigates feeding strategies of generalist invertebrate-feeding fishes that closely associate with coral reef habitat during foraging. We combine behavioural observations of feeding events with a DNA-based approach (metabarcoding of gut contents) to achieve a detailed analysis of variation in fish diets across coral reef habitat states. By assessing fish responses in terms of both diet composition and behaviour to different levels of habitat quality, we identify mechanisms shaping the actual dietary niche of different generalist feeding strategies that influence resilience in a predominant group of coral reef fishes.

IN A RENEWABLE WORLD: BEHAVIOURAL RESPONSES OF BENTHIC COMMUNITIES TO PILE DRIVING NOISE

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Recently there has been a substantial increase in the construction of offshore wind farms along the British coastline. These are being built to reduce reliance on fossil fuels for energy production to meet renewable energy targets. During construction of offshore wind farms, pile driving is required to fix the tower to the seabed resulting in loud impulsive noise in the ocean. This disturbance has been linked to changes in marine mammal behaviour. The aim of this study is to test for changes in behavioural responses of benthic communities to pile driving playback, focussing on fish and marine invertebrates. Our approach is to use baited camera traps that are lowered from harbour walls along the South Devon coastline, coupled with underwater speakers playing back ambient and pile driving tracks. From analysis of video recordings, we expect to see

a reduction in species richness and abundance during pile driving playback, as well as changes in behavioural interactions between species. Findings from this research will make clearer the impact of pile driving on coastal communities across taxa, including some species of commercial interest. This research will help underpin future management decisions that can lessen the impact of this activity.

D'Agostino, Daniele – Coping with extreme environments: the influence of thermal variation on fish behavioural ecology (Abstract in Fish in a Changing World Speed Talks)

Gutmann Roberts, Catherine – Movement and diet: Individual specialisations of barbel *Barbus barbus* in a disconnected and subsidised world (Abstract in Fish in a Changing World Speed Talks)

DOES DEVELOPMENT STAGE AFFECT TOLERANCE TO COPPER IN ZEBRAFISH EMBRYOS?

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Copper is essential for life but when concentrations are elevated, it can become toxic. Previous studies have shown that the susceptibility of zebrafish (*Danio rerio*) to copper varies at different embryonic stages of development. Little is known about how these differences in toxicity occur or the specific developmental stages when changes in tolerance to copper are most pronounced. The aim of this study was to investigate whether there is a sensitivity 'tipping point' after fertilisation where zebrafish embryos become more tolerant to copper exposure. Zebrafish embryos were exposed to a range of concentrations of copper (from 0 to 0.19 mg/L) for 24h and the exposures were initiated at various stages of development corresponding to 1, 4, 6 and 7 hours post fertilisation. Mortality curves for each exposure window were generated and compared, to identify if differences in occurred between the exposure scenarios. Copper toxicity decreased with developmental stage at which exposures were initiated. Therefore, we provide evidence for a gradually increased tolerance to copper in zebrafish embryos when exposures are initiated later in development, supporting the hypothesis that stage of development strongly influences chemical toxicity. These results have implications for the design of testing systems for regulatory toxicity and for the management of fish populations where exposures likely occur continuously from fertilisation, when fish appear to be most sensitive to environmental exposures.

PARALLEL ECOMORPHOLOGICAL DIVERGENCE DRIVES DIFFERENTIAL MERCURY BIOACCUMULATION IN POLYMORPHIC WHITEFISH (*COREGONUS LAVARETUS*) POPULATIONS OF SUBARCTIC LAKES

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Resource polymorphism is common in many salmonids inhabiting subarctic lakes, but the effects of resource specialization into the three lake habitats (littoral, profundal and pelagic) to total mercury concentrations (THg) and bioaccumulation remains unexplored. We compared of

whitefish (*Coregonus lavaretus* (L.)) THg and their invertebrate prey in relation to potentially explanatory ecological metrics across six subarctic lakes inhabited by polymorphic (lake n=3, four morphs) and monomorphic populations. Amongst invertebrate prey, highest THg were observed in profundal macroinvertebrates, followed by pelagic zooplankton, with concentrations lowest in littoral macroinvertebrates in both lake types. Parallel patterns were apparent in polymorphic systems, where average THg and bioaccumulation rates were highest in pelagic morphs, intermediate in profundal morph and lowest in littoral morph. In monomorphic systems, THg were generally lower, and showed pronounced lake-specific variation. In the polymorphic systems, we found significant relationships between whitefish muscle tissue THg and gill raker count, resource use, lipid content, growth and maximum length, whilst no such relationships were apparent in the monomorphic systems. Across all polymorphic lakes, the major variables explaining THg in whitefish were gill raker count and age, whereas in monomorphic systems, the factors were more lake-specific. In compound analyses of all polymorphic and monomorphic lakes, a total of 71% and 39% of the observed variance was explained by the examined variables, respectively. Whitefish divergence across the three lake habitats therefore appears to have profound impacts on mean THg and bioaccumulation. This highlights the importance of recognizing intraspecific diversity in future studies and mercury monitoring programs.

Katsiadaki, Ioanna – Tools for assessing welfare of laboratory fish (Abstract in Fish in a Changing World Speed Talks)

BISPHENOL A (BPA) CAUSES REPRODUCTIVE TOXICITY, DECREASES *DNMT1* TRANSCRIPTION, AND REDUCES GLOBAL DNA METHYLATION IN BREEDING ZEBRAFISH (*DANIO RERIO*)

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BPA is a commercially important high production chemical widely used in the production of plastics. As a result of the use and disposal of products containing BPA, it is ubiquitous in the environment leading to the continuous exposure of humans and wildlife. Evidence suggests that BPA can affect reproduction via estrogenic and anti-androgenic signalling pathways. Recent studies also suggest that BPA may affect epigenetic signalling pathways, and there is a significant need to document these effects both in wildlife and humans.
We aimed to investigate the epigenetic and reproductive effects of BPA in a fish model. Breeding groups of zebrafish (*Danio rerio*) were exposed to 0.01, 0.1 and 1mg BPA/L for 15 days, and reproduction was quantified over time. We observed a significant increase in egg production, together with a reduced rate of fertilization in fish exposed to the highest concentration (1mg BPA/L). Exposure to BPA was associated with significant alterations in the transcription of genes involved in reproductive and epigenetic processes in both hepatic and gonadal tissue. Of note, reduced expression of DNA methyltransferase 1 (*dnmt1*) was observed at all concentrations tested, including environmentally-relevant concentrations (0.01mg BPA/L), together with a significant reduction in global DNA methylation in testes and ovaries following exposure to 1mg BPA/L. These findings demonstrate that environmentally-relevant concentrations of BPA are associated with altered transcription of key enzymes involved in DNA methylation maintenance. Our findings, provide evidence of reproductive and epigenetic effects of BPA in a model vertebrate, and advocate for its reduction in the environment.

DOES PRE-EXPOSURE TO BPA AFFECT SUSCEPTIBILITY UPON RE-EXPOSURE?

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Bisphenol A (BPA) is a commercially important chemical used in the production of widely used epoxy resins and polycarbonate plastics. Consequently, BPA is ubiquitous in the environment leading to frequent exposure of humans and wildlife. Evidence suggests that BPA exposure can cause reproductive disruption through estrogenic and anti-androgenic mechanisms, as well as being associated with other pathologies, including cardiovascular disease and behavioural abnormalities. Recent studies suggest that BPA exerts its toxicity through epigenetic signalling pathways, demonstrating an association between BPA exposure and alterations in transcription of key enzymes involved in DNA methylation maintenance and altered methylation profiles. This study aims to investigate how previous exposure of adult fish to BPA affects their response upon re-exposure and whether there is an epigenetic basis for these effects. Breeding groups of zebrafish (*Danio* rerio) were exposed to 10 and 100µg BPA/L for 5 days, allowed to depurate for 13 days, and re-exposed for a further 5 days. In parallel, groups were exposed only during the first 5 day period, only during the second 5 day period, or kept under control conditions. Reproduction was quantified over time, and embryos from each treatment group were then exposed to a range of BPA concentrations from 0-72hpf to measure their susceptibility to BPA exposure. The adult gonads were sampled and we are now analysing transcription and promoter DNA methylation of genes involved in reproductive processes and epigenetic regulation, as well as global DNA methylation, to elucidate the molecular mechanisms mediating these effects.

ESTROGENIC DISRUPTION OF LIPID METABOLIC SIGNALING IN JUVENILE BROWN TROUT (*SALMO TRUTTA* F. *FARIO*)

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Hormonal disturbances have been associated with negative effects in lipid metabolic cascades in many species, including fish. With this in mind, and using an experimental assay with juvenile brown trout, we aimed to evaluate the *in vivo* lipidic interferences of the estrogen 17α-ethinylestradiol – EE2. Two exposure conditions were considered (EE2 – 50 µg/L, and solvent control – SC – 0.001% of ethanol) and several endpoints were assessed after 28 days of water exposure. These included from gross condition parameters (e.g. hepatosomatic index – HSI, condition factor – *K*), blood/plasma biochemistry analyses (e.g. cholesterol, triglycerides, low-, high- and very low density lipoproteins), fatty acid plasmatic profile, to gene expression by quantitative real time polymerase chain reaction (qRT-PCR) of liver lipid-related targets (e.g. acyl-CoA long chain synthetase 1 – Acsl1, acyl-CoA oxidase – Acox, peroxisome proliferator activated receptor alpha and gama – PPARα and PPARγ, apolipoprotein AI – ApoAI, fatty acid binding protein 1 – Fabp1). Estrogen-exposed fish had an HSI five times higher than the SC animals, although no differences were found for *K* values. Triglycerides and very low density lipoprotein levels in plasma were also significantly elevated after EE2 exposure. Regarding plasmatic fatty acids, by comparing both exposure conditions, the most relevant result was the increase of polyunsaturated fatty acids (PUFA), after EE2. These animals expressed increased mRNA levels of PPARα and Acsl1. On the contrary, a down-regulation was found for Acox1–3l, Acox3, PPARγ, Fabp1 and ApoAI, compared with SC. The relevance of these kinds of influences for high demanding activities, such as reproduction, should be further deciphered.

STUDYING EFFECTS OF OESTROGENS AND OF PPAR AGONISTS IN THE DEVELOPMENT OF EYED-STAGE EMBRYOS OF BROWN TROUT (*SALMO TRUTTA* F. *FARIO*)

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Lipid profiles and mobilization are crucial for the development and survival of fish larvae, and they can be impacted by pollutants. Facing evidence of effects of oestrogens and PPAR agonists on fish eggs/larvae, we are studying influences of ethinylestradiol (EE2) and clofibrate (CLF) injected into brown trout eyed-stage eggs. Targeted phenotypic endpoints were larval physical condition parameters (heart rate, body area, yolk sack volume, and condition index), liver volume (LV), and hepatocyte ultrastructure. The latter covered: volume density (V_V) (Mitochondria and Peroxisome, Cell) (%); numerical density (Peroxisomes, Cell) (no./µm3); V_V (Nucleus, Cell) (%). The experiment included 5 treatments (control – no injection; solvent control – 1µL of DMSO/egg; EE2 – 0.5 ng of EE2/egg; CLF – 200 ng of CLF/egg; and mixture – 0.5 ng of EE2 plus 200 ng of CLF/egg), each with 100 eyed-eggs. These were injected once with a fixed volume (1 µL). Embryos were maintained with flowing spring water at 10-11ºC, and were sampled before the complete absorption of the yolk sack. For control larvae, mean values were: 47.6/20 seconds (heart rate), 0.87 cm^2 (body area), 0.28 cm^3 (yolk sack volume), and 0.87 g/cm^3 (condition index). In the EE2 treatment, yolk sack volume and condition index were ca. 1.1x above control, despite being statistically non-significant. Larvae from CLF had a 1.25x higher LV than control. For the V_V (Mitochondria, Cell), the control average was 12.5%, and, despite no statistical proof, the mixture was ca. 1.27x lower than controls. The phenotypic data do not suggest major impacts, but the trends deserve further analyses.

Montgomery, Daniel – Multi-stressor impacts of the 'deadly trio' on hypoxia tolerance of a commercial fish species (Abstract in Fish in a Changing World Speed Talks)

Potts, Robert – Investigating the sale of shark steaks and fins in the UK (Abstract in Fish in a Changing World Speed Talks)

CLIMATE CHANGE AND FRESHWATER FISHES IN GREAT BRITAIN: IMPLICATIONS FOR SPECIES, INVASION AND MANAGEMENT

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Predictions of the impacts of climate change for native fishes include changes in range and phenology, and shifts towards smaller body sizes. For non-native fishes that have been introduced but are yet to establish, warming potentially releases thermal constraints on their reproduction, facilitating establishment and invasion. In Great Britain, such predictions are strongly apparent for freshwater fishes during this century. For native fishes, the climate niche for salmonid fishes is predicted to substantially reduce, potentially limiting populations to areas of relatively high altitude and latitude. Conversely, for many cyprinid fishes, their climate niche will expand, potentially enabling range expansion, and will be coupled with a shift to individuals being smaller-bodied but faster growing. Concomitantly, the changing climate will enable introduced species such as carp *Cyprinus carpio* and pumpkinseed *Lepomis gibbosus* to develop highly invasive populations. This is allied to warming also potentially providing more suitable thermal conditions for non-native fishes that are currently not present, such as largemouth bass

Micropterus salmoides. These predictions suggest there could be substantial changes in the freshwater ichthyofauna of Great Britain during the 21st Century. For this to be avoided, strong mitigation actions require implementation, including 'climate-proofing' salmonid rivers to minimise warming and associated impacts, preventing the further release of native cyprinids outside of current biogeographic limits, and better regulating the use of non-native fishes in angling enhancement.

Sapozhnikov, Yulia – The effects of intense acoustic stimulation on the auditory behaviour and epithelium ultrastructure of Baikal fish (Abstract in Fish in a Changing World Speed Talks)

Uren Webster, Tamsyn – Investigating the impacts of stress on the microbiome and immune status of Atlantic salmon (Abstract in Fish in a Changing World Speed Talks)

ENDOCRINE DISRUPTION IN AQUATIC SYSTEMS: UP-SCALING RESEARCH TO ADDRESS ECOLOGICAL CONSEQUENCES

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Endocrine Disrupting Chemicals (EDCs) at environmentally relevant concentrations can alter biological function in aquatic organisms and are a potential threat to biodiversity. Considerable research has been conducted on the effects of EDCs on individuals, but there remains little understanding of the consequences for populations, communities and ecosystems. The pervasive nature of EDCs and their multiple, sub-lethal effects, makes assessments of these chemical types especially important and equally extremely challenging. Here we demonstrate the importance of incorporating ecological theory into assessments of endocrine disruption at population and community scales. Biological processes, including bioaccumulation, biomagnification, population genetics and trophic cascades, influence the effects of EDCs within aquatic systems. Furthermore, mixtures of EDCs and their interaction with other abiotic stressors can alter the nature and severity of endocrine disruption. The synthesis presented herein illustrates how effect thresholds for EDCs generated from experimental bioassays based on individuals and commonly applied in chemical test guidelines (e.g. OECD) may not necessarily reflect the hazards associated with endocrine disruption. We argue that improved risk assessment for EDCs in aquatic ecosystems requires more ecologically-oriented research and more focus on field-based assessments at population-, community- and food web-levels.

Chub (Squalius cephalus). © Jack Perks

Valuing & Managing Fish – Oral Presentations

THE DEATH, RESURRECTION AND POTENTIAL FUTURE IMPACTS OF POLICY CHANGES ON U.S. INLAND FISHERIES

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Inland fisheries in the United States have suffered many egregious harms as a result of a series of human impacts on the landscape and through serious water pollution, many of these going back to early settlement times. These impacts initially resulted from widespread timber clear cutting of immense landscapes with resulting massive sediment delivery to streams. A second wave of energy extraction - initially coal, oil and metals, now natural gas through fracking and other technology - and extensive industrialization has had long-lasting if not permanent impacts on streams, rivers and lakes. Throughout this time, but particularly in recent decades, a third wave of massive land development through agricultural transformation and urbanization has greatly impacted aquatic systems. The health of the nation's inland waters declined precipitously as a result of these series of impacts. However, foundational clean water legislation at the state and federal levels and related environmental laws have, in many cases, led to dramatic improvements in water quality and commensurate recovery in fisheries. Three case studies related to Pennsylvania waters will review this history of impact and recovery: Lake Erie, the Susquehanna River and a key tributary, and the Chesapeake Bay. Proposed budget proposals and policy changes by the new administration threaten to stall or reverse these improvements with possible immense impacts on water quality and highly valuable recreational and commercial fisheries. The implications of these proposals will be reviewed and impacts explored along with a review of actions by conservation, environmental and businesses to counteract these proposals.

MULTIDISCIPLINARY APPROACH TO IDENTIFY THE SPAWNING GROUND OF THE EUROPEAN SMELT (*OSMERUS EPERLANUS*) IN A MODIFIED URBAN ESTUARY USED TO INFORM FISH CONSERVATION DURING THE PLANNING PROCESS

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Since 1964, 125 fish species have been recorded in the Tidal Thames, 15% of which are protected under local, national and international regulation. The European smelt (*Osmerus eperlanus*) is a small predatory fish that inhabits cold-water estuaries including the Tidal Thames. Once common in the UK, it has suffered significant declines since the early 19th century due to water pollution, over exploitation and destructive river engineering. Improvements to water quality in the latter half of the 20th century have allowed smelt to return to 36 water courses in England including the Tidal Thames. Although the Tidal Thames holds one of the largest-known breeding populations of smelt in the UK, the specific spawning location had not been identified. ZSL initiated a collaborative project, to identify the spawning ground through a combination of ichthyoplankton and micromesh seine netting surveys; citizen-science led river observations; hydrogeographic modelling; and larval analysis. During the two-year survey period, 392 juvenile smelt and 28 smelt eggs were sampled. The data indicated that smelt spawn over an elongated period of five weeks during March and the beginning of April, and narrowed down the spawning location to a 600m stretch of river upstream of Wandsworth Bridge. Results were written up as a Guidance Document for planners and developers to better conserve Tidal Thames fish during the planning process. This pioneering document outlines fish ecology in the region, identifies ways in which development could impact fish and provides suggestions on how these could be mitigated.

POST-SPAWNING SURVIVAL AND DOWNSTREAM PASSAGE OF LANDLOCKED ATLANTIC SALMON IN THE REGULATED RIVER KLARÄLVEN

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Repeat salmonid spawners may make large contributions to total recruitment and long term population stability. Despite their potential importance, relatively little is known about this life stage for anadromous populations and nothing has been reported for landlocked populations. Here, we studied post-spawning behaviour and survival of landlocked Atlantic salmon in relation to downstream dam passage in the River Klarälven, Sweden from 2011-14. Eight hydropower stations separate the feeding grounds in Lake Vänern from the spawning grounds in the river, and no measures to facilitate downstream migration are present. Nearly 50% of the salmon survived spawning and initiated downstream migration. Females and small fish had higher post-spawning survival than males and large fish. The post-spawners migrated downstream in autumn and spring and remained relatively inactive in the river during winter. During years with high spill, 84% of the fish passed the first dam, mostly via upward-opening spill gates after a median delay of 25 min. During a year of low spill, 41% of the fish passed the dam, mostly through the turbines, where mortality was high. Observations based on radio-telemetry and underwater sonar showed that turbine passage rate was higher at night than during the day and increased with increasing hydropower generation. In addition, most fish that approached the turbine intake were near the surface. For all years combined, only 2% of the tagged fish successfully passed all eight hydropower stations to reach Lake Vänern. This result underscores the need for remedial measures to increase survival of downstream migrating kelts.

LONG-TERM RESPONSES OF FISHERIES IN AN OLIGOTROPHIC LAKE OF SOUTHERN NORWAY – ECOLOGICAL CONSEQUENCES AND MANAGEMENT IMPLICATIONS

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Commercial inland fisheries have declined throughout Western Europe over the past 30 years. In Norway, Lake Fyresvatn (59°05'N, 8°10'E; 281.1 m.a.s.l.) is one of the few lakes where fisheries for native European whitefish (*Coregonus lavaretus*), brown trout (*Salmo trutta*) and Arctic charr (*Salvelinus alpinus*) still exist. Fish sampling with survey nets prior to the establishment of the fisheries in 1999 and 6-10 years after showed an overall positive response for the three salmonids. The whitefish and charr enhanced their individual growth, mean length at age and condition factor (K) whereas the proportion of fast-growing piscivorous brown trout increased. Although brown trout and whitefish occupied the littoral zone of the lake, the density of charr increased from 0.6 to 2.9 CPUE before and after the fisheries, respectively. The predominant explanation for the effects of the fisheries is an improvement of the quality and growth of whitefish, and enhanced ecological conditions for the charr because of reduced interspecific competition from the other salmonids. The results suggest that an active management strategy should sustain fisheries for medium sized (25-35 cm) whitefish and charr, and minimize the harvest of large-sized brown trout (>40 cm).

ARE INDIVIDUAL DIFFERENCES IN FISH MOVEMENT RELATED TO ANGLING VULNERABILITY? A WHOLE-LAKE REALITY MINING EXPERIMENT IN THE WILD USING FOUR SPECIES

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Passive fishing gears, such as hook-and-line angling, are expected to selectively capture fish of certain behavioural types because by definition passive gears exploit fish behaviour. Behaviours increasing angler encounters (e.g., activity or activity space size) and behaviours promoting bites (e.g., boldness or aggression) are good candidates for angling induced behavioural selection, but the importance of specific behaviours is likely a function of a given species' foraging mode in light of the lures and baits by which it is targeted. Further, fishing induced behavioural selection is expected to be modified by the searching strategies and techniques of fishers. Our aim was to comprehensively tease apart the role of fish and fisher behaviour as it relates to fish vulnerability in the wild by analyzing long-term acoustic tracking data at a whole lake-scale collected from both piscivorous and omnivorous fishes, viz.: perch (*Perca fluviatilis*), carp (*Cyprinus carpio*), tench (*Tinca tinca*) and pike (*Esox lucius*). All species were experimentally angled. Direct encounters with anglers and related behaviours including activity, activity space size, or distance to the shore were unrelated to angling vulnerability in carp, tench and perch. Perch preferring a certain habitat (north lake shore) were, however, preferentially captured independent of angler encounters. By contrast, activity and activity space size were significant drivers of vulnerability in pike, supporting the idea that the relationship between fish behaviour and vulnerability is species specific. All behaviours we assessed were repeatable in the wild, such that ultimately our data suggest angling-induced selection targets different behaviours in different species.

RECREATIONAL TROLLING EFFORT AND CATCH OF SALMON AND TROUT IN VÄNERN, THE EU'S LARGEST LAKE

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Recreational fishing has grown substantially worldwide and in some areas, both catch and economic value now exceeds that of commercial fisheries. Monitoring of recreational fisheries effort and catch are therefore important for maintaining sustainable fisheries. The purpose of this study was to develop an angler survey to estimate recreational fishing effort and catch of landlocked Atlantic salmon (*Salmo salar*) and brown trout (*S. trutta*) in Lake Vänern, Sweden, the largest lake in the European Union. Major challenges included a large spatial scale, highly dispersed effort, and a lack of fishing licence and catch reporting requirements. A complemented roving/mail-in survey was used to estimate effort and catch of salmon and trout in a recreational trolling fishery during the major fishing periods in 2014. Instantaneous counts from major access sites were combined with reports from mail-in surveys distributed to anglers around the lake. Recreational fishing effort (boat hours) was higher in the spring (9 969 ±2 213) than in the fall (7 765 ±2 661), and there were seasonal differences in catch rates for trout but not for salmon. Our estimates show that the recreational trolling fishery now harvests more salmon and trout annually (over 10,000 kg) than do the commercial and subsistence fisheries combined. Vänern supports by far the largest recreational fishery for landlocked salmon in Europe with impressive catch rates; an increasing emphasis on a growing wild salmon population means that managers and anglers will require improved monitoring to maintain sustainable fisheries in the future.

DISCONTINUITIES IN FISH ASSEMBLAGES AT HABITAT, REACH AND STREAM SCALES IN RELATION TO RIPARIAN LAND USE IN AN ANCIENT LANDSCAPE AND THE IMPLICATIONS FOR MITIGATING EFFECTS OF RAISED TEMPERATURES

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The New Forest in southern England is an ancient landscape that has retained many of its land use features for over a thousand years. It is mainly managed woodland, open grazing lawns and heathland with very little arable activity or urban development. The major land disturbances were conifer afforestation since the 18th century and land clearance during the Second World War when a number of airfields were built. The New Forest is drained by a network of small, acid-neutral streams noted for their flashy flow regimes.
Since 1996, quantitative samples of fish have been collected at various intervals, concentrating mainly on three stream systems with different proportions of land-uses. This paper analyses the differences between fish assemblages both within and between streams in relation to the catchment and riparian land use. The extent of shade and the instream habitat have a significant effect on abundance and community composition at habitat, reach and stream scale. Evidence suggests that in the event of increased water temperatures the planting of riparian trees could alleviate potential problems for salmonids and bullheads while reducing preferred habitat for stoneloach and chub.

THE USE OF MOSQUITO NETS IN FISHERIES: A GLOBAL TO LOCAL PERSPECTIVE

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Free or subsidised mosquito net (MN) distribution has been an increasingly important tool in efforts to combat malaria in recent decades throughout the developing world, contributing great strides towards eradicating this hugely detrimental disease. However, there has been increasing concern in the natural resource management and healthcare communities over alternative use of MNs, particularly in artisanal fisheries where they pose a threat to sustainability of fish stocks. So far, little evidence has been presented as to the global prevalence and characteristics of MN fishing, limiting global management initiatives. We conducted a global review of mosquito net fishing (MNF) observations from witnesses living and/or working in malarial zones using an internet survey. MNF was found to be a broadly pan-tropical activity, particularly prevalent in sub-Saharan Africa, exhibiting a variety of deployment methods and habitats, target species and scales of use. Respondents' perceptions of the drivers of MNF revealed potentially complex and detrimental livelihood and food security implications if MN fishing is managed inappropriately. Both health policies regarding net distribution and natural resource management policies regarding restrictions on use are likely to influence future impacts of MNF. We outline critical directions for research and highlight the need for a collaborative, interdisciplinary approach to development of both localised and broad-scale policy. Preliminary results from a localised, in-depth socio-ecological case study in Cabo Delgado, Mozambique will also be presented.

CUMULATIVE EFFECTS OF SIZE-SELECTIVE FISHING ON SIZE-AT-AGE OF PACIFIC HALIBUT (*HIPPOGLOSSUS STENOLEPIS*)

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The biomass of Pacific halibut (*Hippoglossus stenolepis*) has been declining since the late 1990s, and reductions in size-at-age since the 1980s explain more than half of the observed decline in halibut biomass. For example, on average an age-20 female halibut weighed 55 kg in 1988 but weighed only 20 kg in 2014. We hypothesize that declines in size-at-age are, in part, the result of size-selective fishing. An age- and size-structured equilibrium model was developed to examine the long-term relationship between fishing mortality and size-at-age. Historical estimates of fishing mortality for Pacific halibut ranged between 0.18 and 0.60, with a mean of 0.40 over 2000-2014. Fishing mortality was significantly higher in the eastern Gulf of Alaska than in the central or western Gulf of Alaska. Results suggest that fishing can explain between 30% to nearly 100% of the observed declines in size-at-age since the 1980s, depending on sex, age, and region. Given that length-at-age for any given cohort is highly variable, Pacific halibut are vulnerable to the cumulative effects of size-selective fishing. The most effective management action to potentially reverse trends in size-at-age would be to reduce harvest rates to diminish the intensity of size selection. Additional research is needed to better understand the contribution of other mechanisms to variability in size-at-age of Pacific halibut.

NON-NATIVE FISH ERADICATION FACILITATES THE RAPID RECOVERY OF NATIVE STREAM FISHES IN THE CAPE FOLD ECOREGION, SOUTH AFRICA

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The global spread of non-native sport fishes has had severe impacts on native fish communities. Impacts are particularly severe when piscivorous fishes are introduced into ecosystems containing predator naïve fish communities. While the removal of non-native fishes is often a priority management action for conservation authorities, the response of native fishes to such removals is not well documented. Snorkel surveys of 22 tributary streams of the Olifants-Doorn River system in South Africa's Cape Fold Ecoregion showed that introduced sport-fishes had extirpated small native fish species from more than 80% of the river. To test the potential of non-native fish eradication as a remediation strategy, local conservation authorities eradicated non-native smallmouth bass *Micropterus dolomieu* from the Rondegat River, a small headwater stream, using the piscicide rotenone in 2012 and 2013. This provided a unique opportunity to assess the response of native fish populations to the removal of this non-native predator. Fish diversity and densities were monitored in 47 sites representing "treatment" and upstream "control" region from one year before, during and for four years after the eradication, using multiple survey methods. Data demonstrated that smallmouth bass had been effectively eradicated from the river and that four native fishes began colonising the river almost immediately thereafter. Differences in colonisation rates and population structure between species are discussed in the context of their life-history and dispersal behaviour and the impact of non-native fish removals as a conservation strategy is evaluated for each of the species.

THE ROLE OF FISH IN OCEAN CHEMISTRY AND GLOBAL BIOGEOCHEMICAL CYCLING – PAST, PRESENT AND FUTURE

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The majority of oceanic production of calcium carbonate is conventionally attributed to marine plankton. However, it is a surprise to many that marine teleost fish also produce carbonates within their intestine and excrete these at remarkably high rates. This is a by-product of their physiological need to drink sea water and precipitate ingested calcium ions as calcium carbonate within the intestine, which plays roles in osmoregulation, calcium homeostasis and acid-base balance. Ecosystem modelling estimates that fish are previously unrecognised major calcifiers, contributing between 3 and 45 % of the global surface production of marine calcium carbonate. Fish carbonates often have a higher magnesium content than most biotic sources. This makes them dissolve faster and so likely to raise the alkalinity of the ocean surface, which in turn would help to buffer against ocean acidification and enhance the absorption of atmospheric CO_2. Conversely, fish carbonate crystals can sometimes remain intact making a major contribution to shallow marine sediments. Lab experiments show that the rate of carbonate production by fish increases dramatically with feeding and also across the oceanic range of salinities. Elevated temperature and CO_2 also increase carbonate production, with future climate projections for 2100 suggesting >70% increase in fish production rates. Furthermore, fish held in conditions that mimic seawater chemistry in the mid-Cretaceous period (~110 Mya) produce carbonates up to 10 times faster. Modelling is planned to test whether incorporation of data on fish carbonates affects our understanding of carbon cycles and climate change in the past, present and future.

Bigeye trevally (*Caranx sexfasciatus*). © Tim Gordon

FISHERY RESOURCES OF THE UPPER-MARONI RIVER: IMPACTS OF FISHING PRESSURE AND LIFE HISTORY TRAITS ON GENETIC DIVERSITY IN SEVERAL FISHES

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On the Maroni, largest watershed of French Guiana, subsistence fishing is a long-living practice for native people communities. However, due to local demographical expansion and disruptions within the traditional everyday life brought by modernity, the sustainability of fish resource might be challenged. It seems essential to assess the current state of these scarcely known fisheries in order to preserve this biological and cultural patrimony. The national Amazonian Park of French Guiana initiated this process through a description of fishing practices. A genetic approach was chosen to provide a complementary biological insight. This project aims to decipher the potential impact of fishing pressure on genetic diversity in several fish species. We can expect a reduction in genetic diversity when fishing pressure is high, particularly in species with limited dispersal abilities that could not compensate for local genetic diversity loss. Firstly, we will analyze the intraspecific variability between populations sampled from locations with various fishing pressure across Upper-Maroni and its tributaries to get preliminary insights on the potential impact of fishing. Secondly, we will compare results obtained between actively harvested species and those that are less exploited to see if this corroborates our first findings, while taking into account inherent biological characteristics, such as dispersal abilities, to determine if fishing impact is consistent across species that present similar life history traits. This would make this impact potentially predictable, especially for harvested species that were not studied here. A focus on the Serrasalmidae (piranhas) and the Loricariidae (catfishes) is proposed here.

MODELLING THE SUCCESS AND PROFITABILITY OF SELECTIVE BREEDING PROGRAMS USING INDIVIDUAL BASED BIO-ECONOMIC SIMULATIONS IN R

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Selective breeding programs in aquaculture require substantial resources and may take many years to become profitable. Additionally, stochastic processes during breeding and unknown genetic architectures for traits can complicate the prediction of gains in trait values over time. This can make it difficult to accurately assess the pros and cons associated with establishing a breeding program for even the best described fish species. One approach to overcome this difficulty is to explicitly simulate the entire breeding program according to the proposed breeding design. Using trait parameters determined from empirical experiments selection and breeding are simulated with genetic and phenotypic values of offspring for each generation determined as the mean of parent values. Here we present a stochastic simulation of a selective program for the gilthead seabream (*Sparus aurata* L.). The simulation models the change from a non-selective breeding program to a scheme improving growth rate by mass selection. The effect of selection on growth rate, inbreeding and projected profits are modelled explicitly. The simulation predicts a profitable and sound breeding scheme for gilthead seabream under the trailed conditions. The simulation has been written in the readily accessible R programming language and is highly amenable to being adapted for new traits in any species of interest.

FOOD OR WILDLIFE? CONSUMERS' POOR KNOWLEDGE OF FISH APPEARANCE HAMPERS SEAFOOD MARKET TRANSPARENCY AND SUSTAINABILITY

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Seafood has represented a mainstay of human consumption for millennia. Since the industrial revolution, food supply chains have changed dramatically, loosening the connection between living resources and consumers. To date, there is little more than anecdotal information on the degree to which human societies in the developed world appreciate the diversity and the appearance of the fish species that underpin our foods. To fill this gap, we interviewed 720 European citizens from Belgium, Greece, Ireland, Italy, Spain and the United Kingdom, and measured their ability to recognize six commonly marketed European fish species: cod (*Gadus morhua*), Atlantic salmon (*Salmo salar*), anchovy (*Engraulis encrasicolus*), mackerel (*Scomber scombrus*), sea bass (*Dicentrarchus labrax*) and sole (*Solea vulgaris*).
We found that the overall people's accuracy was less than 30%; cod and salmon were significantly more recognised in Northern countries, and sole, seabass and anchovy, more accurately detected in Italy, Greece and Spain. Overall differences were observed among countries and could in part be explained by age group and background of the interviewees. We note that such a stark disconnection between the population and the diversity of life at the basis of key elements of people's diet creates a fertile ground for non-compliant operation in the seafood industry. In the context of the global challenge of food security, we stress the importance of revisiting current education practices in European countries and beyond.

Beam trawlers and scallop dredgers in Brixham Port. © Katherine Maltby

Valuing & Managing Fish – Posters

CHALLENGES AND STRATEGIES FOR ACHIEVING SUSTAINABLE MARINE FISHING: A REVIEW OF THE SATE OF MARINE FISHERIES IN GHANA

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Traditionally, Ghana is a marine fishing country. Marine fishing accounts for over 80 percent of Ghana's total fish consumption. Currently, the fishing industry dominated by the artisanal marine fishing industry provides employment to about 2.5 million people and contribute to about five percent of Agricultural Gross Domestic Product (GDP). Nonetheless, the marine fishing industry is confronted with challenges that have contributed to a declining fish production in recent past decade. Bad fishing practices and the general limited knowledge on sustainable management of fisheries resources are limiting factors that affect sustainable fish production and sustainable marine biodiversity management in Ghana. This paper discusses the challenges and strategies for attaining and maintaining sustainable fishing in Ghana. It concludes that an increase in the level of involvement of local fishers in the management of fisheries resources of the country would help local fishers to employ sustainable fisheries resources exploitation methods that could improve the spatio-economic development of affected fishing communities in particular and Ghana in general.

SECURING THE FUTURE OF THE CRITICALLY ENDANGERED ANGELSHARK (*SQUATINA SQUATINA*) IN ITS UNIQUE STRONGHOLDOF THE CANARY ISLANDS

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Three species of angel shark (Angelshark (*Squatina squatina*), Smoothback Angelshark (*Squatina oculata*) and Sawback Angelshark (*Squatina aculeata))* were once widespread throughout the Northeast Atlantic and Mediterranean Sea. During the past century, they have suffered steep declines due to the intensification of demersal fishing practices. All three species were assessed as Critically Endangered on the IUCN Red List of Threatened Species and the angel shark family was identified as the second most threatened of all sharks and rays.

Today, information on Sawback Angelshark and Smoothback Angelshark is severely lacking. However, the Canary Islands have been identified as a unique stronghold for the Angelshark, as this species is still regularly sighted. Even in their last stronghold Angelsharks are under significant threat

The Angel Shark Project (ASP) (a joint project between ULPGC, ZFMK and ZSL) has been working to better understand and protect Angelsharks in the Canary Islands since 2014.Through collecting citizen science sightings of Angelshark from divers and fishers; completing a visual ID tagging programme across the archipelago; and focusing research on investigating Angelshark nursery areas, we better understand Angelsharks ecology and distribution to inform conservation measures.

In 2016, the ASP, IUCN Shark Specialist Group, Submon and Shark Trust organised an Angelshark conservation workshop in the Canary Islands to develop an Angelshark Action Plan. The workshop gathered a multi-disciplinary group of stakeholders alongside the Canary Island Government and Spanish Government, to identify and address the major threats to Angelshark populations.

Delord, Chrystelle – Fishery resources of the upper-Maroni River: Impacts of fishing pressure and life history traits on genetic diversity in several fish species (Abstract in Valuing & Managing Fish Speed Talks)

ANALYSING UNNOTICED LARGE-SCALE CHANGES TO NORTHUMBERLAND'S MARINE ECOSYSTEMS

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Commercial fishing has taken place around the British Isles for centuries, and many fisheries have experienced unprecedented declines in catches as fishing activities have intensified. Today, landings in the North east of England are dominated by low trophic level species, almost entirely by invertebrates such as the European lobster, Nephrops and brown crab. Due to the absence of long-term monitoring data, we are unable to fully understand the magnitude of this profound change, and thus how the ecosystem has responded to intense fishing pressure and other drivers, including climate change. Through the collection and analysis of underutilized historical fisheries data dating back to the 1890s, this study examines changes in community composition between the late 19th century and the present, interpreting this in light of fishery impacts and climate change. Using reconstructed gear, repeat surveys conducted at early trawl inshore sites will enable assessment of baseline community structures and relative species abundances. Outputs will be of value to fisheries scientists, as effective policy advice on the management of fisheries implicitly relies on an understanding of past ecosystem states. Historical baselines are imperative as they allow measurement of long-term changes and evaluation of management strategies.

Mariani, Stefano – Food or wildlife? Consumers' poor knowledge of fish appearance hampers seafood market transparency and sustainability (Abstract in Valuing & Managing Fish Speed Talks)

INVASIVE ZANDER *SANDER LUCIOPERCA* IN AN IMPOUNDED LOWLAND RIVER: A 'STOCKED UP' RIVER FOOD-WEB OR A SUCCESSFUL RECREATIONAL FISHERY?

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The lower reaches of the River Severn basin is already stressed by environmental changes, principally impoundments from navigation weirs constructed approximately 200 years ago, and the introduction and invasion of European barbel *Barbus barbus* following their introduction into the middle reaches of the Severn in the 1950s. A further stressor that has occurred in more recent decades is the invasion by zander *Sander lucioperca*, a piscivorous non-native fish that is coveted by many recreational anglers. In general, concerns relating to the introduction or stocking of apex predators relate to the increased predation pressure that might result on prey communities - often referred to as 'stocking-up' the food-web, where top-down processes start shaping the size structure of the prey fish communities. Notwithstanding, the drivers of these introductions - recreational angling - can deliver substantial socio-economic benefits, including supporting the local economies of rural areas. Consequently, the aim of this poster is to assess: (1) the trophic interactions of invasive *S. lucioperca* in the lower river in relation to prey fish communities and their native trophic analogue pike *Esox lucius*; and (2) the patterns in angler catch rates of *S. lucioperca* and in relation to the fishery performance of both invasive *B. barbus* and native *E. lucius*. These perspectives are discussed in the context of 'stocking-up' the food-web of an already stressed river ecosystem and in relation to the substantial benefits that can be provided to fisheries by such introductions.

THE ELEPHANT IN THE ROOM: ARE SEVERE WEATHER EVENTS THE GREATEST RISK TO FISHERIES?

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Millions of fishers risk their lives every day in one of the most dangerous livelihoods on Earth. Severe weather events, the principal risk that fishers face, are becoming more frequent as the climate destabilises. This dynamic has the potential to markedly reduce the productive capacity of the world's fisheries. Given the global reliance on fisheries for essential nutrition and livelihoods, increasing storminess may pose climate change's most immediate ocean- related risk to human health and the global economy. A continued focus on the long-term impacts of climate change on ocean ecosystems may prove of little use for fishery policymakers and mangers if severe weather events render global operations economically redundant in the meantime. Despite this, we know very little about how storms affect fisher effort and catch, the potential economic consequences of future storminess and how fishers make weather-related decisions. The University of Exeter is leading an interdisciplinary research program in partnership with Cefas, Willis Research Network, Met Office and the University of Bristol to address these questions. Using a data-rich UK case study, the behaviour of fleets will be modelled with meteorological and oceanographic data over five years to predict fishing activity in different conditions. The model will be validated through known data and five years into the theoretical future. It will be employed to identify the potential weather-related disruption and economic consequences from storminess under future climate change scenarios. Psychological and economic frameworks will be applied to explore fishers' decision making. Methods, datasets and preliminary analysis will be presented.

CHANGES IN THE FISH COMMUNITY OVER TWELVE YEARS FOLLOWING HEAVY MODIFICATION OF A SMALL STREAM AS PART OF A RESTORATION SCHEME

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The Highland Water, draining part of the New Forest in southern England, is a small, circum-neutral, flashy tributary of the Lymington River. Drainage work for conifer plantations over many years over-deepened the channel and led to serious bed incision. During 2004, as part of a designated restoration scheme, the upper part of the Highland Water was heavily modified by re-constituting meanders and introducing over 3000 tonnes of small gravel, mixed with clay and sand to raise the bed to its historic level. These materials were mostly displaced by flood flows in the first few years following the initial restoration works and were subsequently replaced by introducing larger gravel without fine sediments. The stream fish and invertebrates were sampled at intervals from 1998 (prior to the restoration) and until 2016. This paper analyses and describes the changes in the fish community of the restored and unrestored reaches of the stream since 1998 and discusses stream restoration in terms of fish habitat and recovery of communities after restoration.

THE EFFECT OF RECREATIONAL FISHING ON UK FISH POPULATIONS

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Recreational sea fishing is a popular and high value activity in the UK with catches of some species significant. However, in many cases recreational catches are not included in stock assessments affecting our ability to manage fish stock sustainably. In Europe, mandatory annual reporting of recreational catches is now required for certain species as part of the data collection programme that underpins the Common Fisheries Policy. Collecting recreational fishing data is not easy and so to fulfil this requirement in the UK, the Sea Angling research programme was instigated in 2016. A combined approach with a population survey and diary panel is used to estimate the expenditure and catches of all species by recreational sea anglers. The national survey provides estimates of the numbers of recreational fishers by region across the UK and their avidity. In 2016 a diary panel of almost 500 fishers reported catches monthly using a bespoke online system developed for the project. This information has been raised to give estimates of catches and expenditure for the total population, and at the regional sea level. The results of the 2016 survey are discussed in the context of the methods for data collection, management of recreational sea fishing in the UK and comparison with commercial fish catches. A further programme, Sea Angling 2017, is now underway with a redeveloped diary tool, involving 1,000 diarists.

CHALLENGES IN AQUACULTURE: THE INFLUENCE OF WATER TEMPERATURE ON JUVENILE NILE TILAPIA (*OREOCHROMIS NILOTICUS*) IMMUNE FUNCTION WHEN CHALLENGED WITH *SAPROLEGNIA PARASITICA*

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Fish are an essential food source for billions of people worldwide reflected by a rise in aquaculture alongside the expanding global human population. The sustainability of the aquaculture industry is therefore vital for global food security, but is threatened by many factors, most notably infectious disease, a major economic and welfare problem for the industries future. Most fish are poikilothermic and temperature influences their immune function. Nile tilapia (*Oreochromis niloticus*) is an increasingly popular production species, due to its hardy nature. However, being a tropical fish, heating costs are likely to be contributing to its limited production in temperate climates. Novel approaches using advanced molecular techniques, allowing the culture of tilapia at lower temperatures should improve production cost and energy efficiencies.
To explore the effect of lowering production temperatures on the immune response of Nile tilapia, an infection experiment was conducted using the common aquaculture pathogen *Saprolegnia parasitica* at 19°C, 23°C and 27°C. Saprolegniasis prevalence suggested that juvenile Nile tilapia were more likely to be infected within 24 hours of exposure at 19°C and 23°C relative to 27°C. This is consistent with reports of Nile tilapia intolerance to colder temperatures and cold-weather related outbreaks of saprolegniasis in fish.
The mechanisms underpinning these differences in disease prevalence are currently being explored using differential gene expression, with the goal to identify potential biomarkers of disease-resistance for selective breeding programmes. This would aid production of a more sustainable Nile tilapia stock that can be maintained at lower temperatures, helping improve production cost efficiency.

PROJECT TUNA - TOWARDS ESTABLISHING AN ENVIRONMENTALLY, ECONOMICALLY AND SOCIALLY SUSTAINABLE SHORTFIN EEL AQUACULTURE INDUSTRY IN NEW ZEALAND

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Tuna (freshwater eels) are a valued fishery worldwide and an important customary, recreational and commercial species for Māori. In recent years, concerns have grown over increasing man-made and environmental pressures on New Zealand's wild eel stocks with aquaculture regarded by many as the only way to ensure the sustainable future use of this resource. As major quota holders, there are Māori organisations who are seeking active participation in the development of eel aquaculture for both customary and commercial benefit. However, one of the most significant bottlenecks to establishing a shortfin eel aquaculture industry in New Zealand is the difficulty in obtaining a consistent annual supply of glass eels for on-growing, without adversely impacting wild populations and current regulations that forbid catching eels <220 g, except under special permit. In the past three years, Rangitāne North Island and partners have been carrying out research that provided valuable data on glass eel recruitment in the Lower North Island, harvest impacts, species separation and ongrowing to market size. However, several hurdles remain that need to be overcome before commercial access to shortfin glass eels can be considered. Future work will have to demonstrate that glass eel harvest is indeed sustainable and culturally and socially acceptable and that adequate quantities are available to supply farms. Further targeted research is required to enable the essential change in regulation for the inclusion of glass eels in the existing Quota Management System and to feed into fisheries management models for ongoing sustainable management of this treasured resource.

Three-spined stickleback (*Gasterosteus aculeatus*). © Jack Perks

Tools for Understanding Fish – Oral Presentations

COMBINING AN INNOVATIVE MONITORING METHOD AND A HIERARCHICAL BAYESIAN MODEL TO ESTIMATE DIADROMOUS FISH RUN

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Over decades, diadromous fish have strongly declined and many species are now protected through national and international regulations. They account for less than 1% of worldwide fish species; however they are one of the most tangible linkage between freshwater and marine ecosystems, and can reveal changes in the functioning of both ecosystems. Juvenile and adult migrations are key transitions of their life cycle, during which abundance estimates are of critical interest for managing the populations. Fish counting facilities such as traps, video or resistivity counters, have been installed for decades on many rivers to provide abundance time series. However, the number of fish counted does not necessarily reveal real fish run (limited coverage, detection efficiency dependent on turbidity, etc.). Here we propose a two-step approach to assess the efficiency of fish counting facilities and to estimate diadromous runs in streams. First, an acoustic camera (ARIS) is implemented to complement the current counting facility during a short period of the fish run. Secondly, the acoustic data produced and the usual fish counts are analyzed jointly thanks to a hierarchical Bayesian model to estimate detection efficiencies. To that end, a generalist model has been developed and can be applied to various species and counting systems. Simulated data were used to test the model robustness and the approach was performed on real data to estimate the adult salmon run in the Sélune River, France. The relevance of this approach and its potential transfer to managers is discussed.

FISH BIODIVERSITY DEFROSTED: UNVEILING NON-COMPLIANT SEAFOOD TRADE IN BRITISH ETHNIC FOOD

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Out of more than 26,000 teleosts dwelling in our planet's water bodies, only hundreds of them are commercially exploited and prevail on the global food market. Yet, our estimates of the species actually underpinning global trade is severely hampered by inaccuracy and non-compliance in labelling and reporting. Here, we target UK's ethnic food stores (Liverpool and Manchester metropolitan areas), whose numbers are increasing throughout Europe, to gauge the accuracy of traceability information available to consumers. Despite the existence of EU labelling regulation (EU No 1379/2013), we unveil a high level of non-compliance, with a diverse range of poorly-known fish species, often sold without any label, or with erroneous information, as demonstrated by DNA barcoding. Results indicate that about 41% of the samples were mislabelled, in stark contrast with a recent study that, in 2015, found less than 5% mislabelling in EU supermarkets and fishmongers. These results highlight that inspectors and governments might not be fully aware of the wide diversity of fish species traded, indicating the need for a stronger enforcement of the EU labelling legislations. Compliance with regulations is required not only to protect consumers, but also fish stocks, as for many of the species identified in this survey population assessment is poor on lacking altogether.

USING SPATIO-TEMPORAL POPULATION MODELS TO INFORM MIXED FISHERY MANAGEMENT

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Fisheries exploit fish populations that are heterogeneously distributed in space and time, yet different species exhibit spatial correlation where there is similar habitat or environmental preference. Consequently, some species are more likely to be caught together in 'mixed fisheries', which may impact the success of management when a weaker population is caught along with a healthier population. In Europe, where fisheries are predominantly managed by species-specific landings quotas, discarding of the weaker population (the throwing back of fish for which you don't have quota) has undermined efforts to rebuild depleted populations. Since the 2013 reform of the Common Fisheries Policy (CFP) a requirement to land all fish caught has started to come into force which means this is no longer possible. To maximise benefit from fisheries that catch multiple species there is a need to allow catches from healthy populations while protecting weaker ones. Thus, there is increasing interest in spatial management measures that can decouple exploitation among species, which requires a detailed understanding of spatio-temporal dynamics of fish populations. Here, we employ advanced model based geostatistical methods to understand co-occurrence of nine of the most commercially important quota species in the Celtic Sea. We fit a 'Vector Autoregressive Spatial-temporal model' (VAST) to 25 years of survey data, integrating across seven fisheries independent research surveys. We use the results to draw inference on how geostatistical methods can be used to understand inter-species dynamics and support spatio-temporal management measures to improve sustainability in mixed fisheries.

BEER CANS OR THERMOREGULATORS? A FIELD-BASED APPROACH TO TESTING FOR BEHAVIOURAL THERMOREGULATION IN TROPICAL MARINE FISHES

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Being able to forecast the impact of global warming on fish populations relies on an understanding of particular species' sensitivity to environmental temperature. In most research to date, this has been achieved by examining physiological responses to temperature within a laboratory setting. But out in the wild, fishes could potentially buffer the negative effects of increasing environmental temperature using behaviour. The question of whether fish use behavioural thermoregulation has been understudied, partly due to the observational difficulties associated with aquatic environments. However, advancements in biotelemetry technology are now allowing for some of the difficulties to be overcome. Here we report on a field-based approach to explore whether coral reef fishes use behavioural thermoregulation to mitigate their exposure to increasing ocean temperatures. Using biotelemetry (internally implanted archival data loggers) to obtain real-time measurements of animal body temperature and constructed null distributions of a hypothetical thermoconforming control, we examine (1) the variability of body temperatures expressed by wild individuals of the tropical marine rabbitfish *Siganus doliatus* (Siganidae), (2) how closely those temperature distributions match up with the species' laboratory-expressed thermal preference and (3) to what extent thermoregulatory behaviours may be helping these animals regulate their body temperature relative to a hypothetical thermoconformer in the same habitat. With this approach we hope to determine the sensitivity of critical herbivorous reef fish species to temperature increases and thereby improve our ability to model the impacts of climate change on reef ecosystem functioning and fisheries.

GENOME COVERAGE VS SEQUENCING DEPTH: A CASE STUDY EXAMINING POPULATION STRUCTURE IN THE LAKE WHITEFISH

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The lake whitefish (*Coregonus clupeaformis*) is an economically and culturally important species in Canada. To manage this species appropriately it is important to understand population structure on different geographic scales. The application of next generation DNA sequencing of thousands of single nucleotide polymorphisms (SNPs) potentially allows for the detection of fine scale (within-lake) population structure, which was not possible with previous technology. Reduced representation sequencing approaches dramatically lower sequencing costs, but the trade-off between sequencing depth and genomic coverage has not been adequately investigated. To address this knowledge gap, we used nextRAD to sequence a reduced representation library from n = 142 lake whitefish in Lake Huron and Dore Lake, SK to investigate scenarios of both weak and strong population differentiation. NextRAD sequencing is similar to other RAD approaches that incorporates hybridization to target a small fraction of the genome. The same individuals were prepared and sequenced twice in fully independent runs, both at high and low sequence coverage (>15X and >3X, respectively). As a result of fixed output, individuals sequenced at low depth have higher genome coverage (>50,000 loci), compared to those sequenced at high depth (~20,000 loci). After preliminary analyses the low coverage library generated 15,874 and 9,510 loci at 3X and 6X coverage and the high coverage library produced 1,179 and 7,927 loci at 15X and 20X read depth. In this presentation, we compare these two sequencing datasets to address the trade-off between genome coverage and sequencing depth, an important issue for study design in fisheries applications.

SEAMOUNTS AS ISLANDS: CONSEQUENCES FOR THE CONNECTIVITY OF FISH POPULATIONS

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Seamount peaks within the photic zone of the open ocean, can be treated as if they were equivalent to terrestrial oceanic islands. Consequently the theory of island biogeography can be applied to understanding speciation and species abundance. This paper describes an agent-based model of reef-dwelling seamount fish designed to examine the connectivity between fish populations on different seamounts. Connectivity determines the likelihood of individual seamounts developing endemic species. The modelled environment is the photic region of a 400 nautical mile square section of ocean representing part of the Emperor-Hawaiian chain in the Pacific. The area includes nine seamounts with peaks below the surface varying in depth down to 600m. There is a unidirectional current flowing through the area at a given speed and the surface water has a given temperature. The model includes members of one species of reef dwelling fish. The fish produces eggs and larvae which drift in the current and are subject to mortality. The larvae eventually metamorphose and start looking for a seamount on which to settle. The output is the number of offspring that find a suitable place to settle. The effects on settlement rate of variations in current speed, the existence of eddies behind seamounts and the lengths of developmental stages are explored.

TROPHIC ECOLOGY IN THE AGE OF 'BIG DATA' – NEW INSIGHTS FROM OLD NUMBERS

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Biodiversity is integral to ecosystem function; the most biodiverse regions of the planet contain functionally diverse communities of innumerable species. How this relationship is reflected in the consumer ecology of these communities is less well understood however, especially on a macro-scale. Data mining of biological archives offers an opportunity to define this relationship on a global study without the costs associated with a large traditional study.

We aggregated data from multiple archives to characterise the diet, dietary niche width and trophic level of > 4,000 marine fishes. We then mapped the geographic range of these species to determine the species assemblages in 500 grid-squares encompassing the marine regions of the Earth. Using these datasets, we examined the effect of biodiversity, temperature and associated variables on mean dietary niche width and trophic level of the fish communities across the globe.

Mean dietary niche width displayed a negative relationship with biodiversity and sea surface temperature. The smallest mean dietary niche widths were observed in equatorial biodiversity hotspots and the largest mean niche widths were observed in polar regions with low biodiversity. In contrast, mean trophic level was highest in the open ocean and was not influenced by biodiversity or temperature.

According to our data, we surmise that the positive relationship between biodiversity and ecosystem function is maintained by the presence of innumerable dietary specialists in biodiversity hotspots and by the trophic plasticity of fishes in less diverse seas.

DIVING BEHAVIOUR OF ATLANTIC SALMON IN THE NORWEGIAN AND BARENTS SEAS

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There is only sparse information on the behaviour of Atlantic salmon (*Salmo salar* L.) in the polar waters of the Norwegian and Barents Seas. We therefore studied the diving behaviour of Atlantic salmon post-spawners in these seas for individuals from three northern populations using pop-up satellite archival tag and data storage tag telemetry. Salmon quickly migrated offshore to population-specific destinations, ranging from the Mid-Atlantic ridge in the west, Svalbard Island in the north, and near Novaya Zemlya in the east. The three populations showed similar depth use patterns. They were pelagic and spent most time near the surface, but occasionally dived several 100 m down into the water column (deepest dive ≈ 707 m). Increased daytime diving occurred in the months between polar day and polar night; this diurnal pattern was weaker during polar day and polar night. Diving changed seasonally. Frequent but shallow dives occurred when the mixed layer was near to the surface; there was a reduction in shallow diving but an increase in deep diving (> 200 m in depth) when the mixed layer depth extended to ≈ 200-300 m in winter and spring. Deep dives were mainly 'U'-shaped, possibly indicative of mesopelagic foraging. We hypothesise that geographically-dependent seasonal light conditions affect salmon diving, and that changes in diving concurrent with changes in stratification may be due to seasonal differences in prey aggregation. We also discuss potential sources of bias, in terms of diving depth and frequency, introduced by the use of a telemetry study.

NOCTURNAL ACTIVITY AND OPTIMAL SEARCHING: WHAT DO SKATES GET UP TO, WHEN THEY THINK WE'RE NOT WATCHING?

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Until the advent of electronic tags the patterns of activity in free ranging benthic marine predators, such as skates, remained largely unknown, as a result of the difficulties of observing these animals in the wild. Consequently, our understanding of how the behaviour of benthic predators changes over daily or seasonal timescales is poorly understood. As indeed are the details of what activities the animals are engaged in when they are active. However, the timing, pattern and nature of periods of activity (and rest) have important ecological consequences, as well as conservation implications related to catchability and, consequently, population assessments. Here, using depth time-series data from 89 skates from 4 species (*Raja brachyura, R. clavata, R. microocellata* and *R. montagui*) with a total of 12,000 days of data, we investigate fine scale activity patterns determined from vertical move step lengths. We find that activity in skates is more complex than expected with significant variation between both individuals and species. However, some clear trends and similarities emerge; in particular we present the first evidence of optimal foraging and searching in skates. Knowing the times of day when skates are most active can be used to restrict fishing efforts to other times in order to reduce the likelihood of these threatened species being captured.

COMPARISON OF METHODS FOR ASSESSING THE STATUS OF THORNBACK RAY

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During the 20th century, several shark and ray populations declined in European waters. Estimating the status of these species can be challenging due to low samples sizes in monitoring programs. We will present the results from applying traditional and genetic methods for estimating the population status of thornback ray (*Raja clavata*), the most widespread ray species in the Northeast Atlantic. A Bayesian state-space model provided biomass trajectories in the Bay of Biscay based on commercial landings and research vessel catch per unit effort (CPUE). The results confirmed the depletion of the population but were also highly uncertain due to poor data quality and lack of knowledge. Using simulations, we evaluated the conditions for using effective population size (N_e) to inform on population status. We focused on suitable sampling designs and the maximum population size for which sufficiently reliable estimates might be obtained. A large genetic data set was simulated and used for estimating N_e with the Linkage Disequilibrium method. First results indicated a negative estimation bias, due to effects of overlapping generations, with low precision even for small absolute population sizes (1 000 individuals). The strengths and weaknesses of both types of assessment methods for the management of thornback ray and other skates and rays will be discussed.

TROPICAL SHARK DIVERSITY AND ABUNDANCE IN CONTRASTING LEVELS OF ANTHROPOGENIC IMPACT: AN ENVIRONMENTAL DNA APPROACH

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Sharks are charismatic predators that play a key role in most marine food webs. Their demonstrated vulnerability to exploitation has recently turned them into flagship species in ocean conservation. Yet, the assessment and monitoring of the distribution and abundance of such mobile species in marine environments remains challenging, often invasive and resource-intensive. Here we pilot a novel, rapid and non-invasive environmental DNA (eDNA) metabarcoding approach specifically targeted to infer shark presence, diversity and abundance in tropical habitats. We identified at least 21 shark species from both Caribbean and Pacific Coral Sea water samples, whose geographical patterns of diversity and abundance coincide with geographical differences in levels of anthropogenic pressure and conservation effort. Compared with available data from baited underwater cameras, eDNA appears to have a much more favourable detection/effort ratio. We demonstrate that eDNA metabarcoding can be effectively employed to study shark biodiversity; further developments in this field have the potential to drastically enhance our ability to assess and monitor elusive oceanic predators, and lead to improved conservation strategies.

AN INDIVIDUAL-BASED MODEL FOR THE THREE-SPINED STICKLEBACK: ASSESSING POPULATION-LEVEL EFFECTS OF EDC-INDUCED DISRUPTION OF BREEDING BEHAVIOURS

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Population modelling has the potential to be employed to extrapolate from individual- to population- level effects in the environmental risk assessment (ERA) of chemicals. Population models that incorporate ecological processes such as density dependent competition, individual variability and aspects of behaviour would add further realism to risk assessments. This is further evidenced by the European Commission's recent inclusion of population modelling as a potential tool for identifying the population relevance of effects within the draft criteria for the identification of endocrine disrupting properties of chemicals.
Here, we present an individual-based model (IBM) for the three-spined stickleback (*Gasterosteus aculeatus*) with the purpose to simulate realistic scenarios relevant for assessing the effects from exposure to endocrine disrupting chemicals (EDCs). The three spined stickleback is widespread geographically, and potentially sensitive to a number of potential effects given its complex breeding strategy, low fecundity and the provision of high level of parental care. This IBM has been structured using a series of sub-models, based on empirical data obtained from published literature. Density dependent reproduction, growth, and mortality along with individual breeding behaviours are key parameters within the model. In the three-spined stickleback it has been shown that nest building, courtship displays and parental care, may be disrupted by exposure to certain endocrine disrupting chemicals (EDCs), possibly affecting population recruitment. We describe the development, validation and sensitivity of the stickleback IBM and display its potential for application in the ERA of EDCs using EDC-induced disruption of breeding behaviours as an endpoint.

WIDENING THE NET: USING ARCHAEOLOGICAL FISH DATA

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Archaeological remains can improve the understanding of animal ecology and response to environmental change. However, this work is very rarely extended to fish as they are a challenging group of organisms to identify in the archaeological record. The vast majority of fish bones are not identified even to a family level, making them practically useless for ecologists and fisheries biologists. This presentation will explore how ZooMS (Zooarchaeology through Mass Spectrometry) can greatly improve fish identification in the archaeological record allowing the possibility to ask ecological questions of the past. ZooMS uses protein fingerprinting of collagen to identify bones and scales to species. It can be particularly useful for ecologists when closely related species can be identified in the archaeological record. I will review the technology and the possibilities as it applies to three groups of fish: flatfish, tuna, and cyprinids.

UNDERSTANDING GENETIC POPULATION STRUCTURE OF ENDANGERED NASSAU GROUPER TO SUPPORT THEIR CONSERVATION MANAGEMENT

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Sustainable fisheries management is often hampered by a lack of information on the population biology of the species of interest. Advancements in molecular biology and population genetics have proven to be extremely valuable in generating information on population status, genetic diversity and connectivity of a variety of fish species. Fisheries and marine resource managers are becoming increasingly aware of the role and importance of genetics to understand and sustainably manage fish populations. Nassau grouper is an endangered coral reef fish that has experienced drastic declines in population abundance because of anthropogenic impacts (e.g. fishing of spawning aggregations). The Bahamas contains the majority of Nassau grouper fish spawning aggregations (FSAs) globally, but the status of spawning stocks is poorly known and there is a paucity of information on the genetic composition of these fish. We used a panel of species specific polymorphic microsatellite loci to investigate 1) genetic population structure, diversity and differentiation and 2) the impacts of fishing on the genetic composition of Nassau grouper throughout The Bahamian archipelago. For this work, fin clips were collected during August 2014 – January 2017 from 12 islands in The Bahamas. Results from DNA microsatellite analysis of over 400 genotyped fish (including fish sampled from an active FSA over three spawning seasons) will be presented. This research represents the most comprehensive assessment of the genetic architecture of Nassau grouper in The Bahamas and will contribute to enhancing the management of remaining stocks within the country.

HABITAT CONNECTIVITY OF ATLANTIC COD (*GADUS MORHUA*) IN COASTAL SHALLOW WATER SEASCAPES

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Tracking the movement of individual organisms is one of the most informative ways to assess connectivity between species and their environments. Using acoustic telemetry as a tool for studying ecological connectivity with relation to seascape configuration has become a more common approach to understanding coastal systems. Here, we assessed spatial movement patterns of individual older juvenile Atlantic cod (*Gadus morhua*, age 2-3 years, n=48) throughout two shallow-water coastal seascapes in the Gullmarn Fjord, western Sweden. Atlantic cod was used as this is a commercially important species known to inhabit these areas and is one of the major predatory fish that use, for instance, vital habitats, such as seagrass meadows, both as nursery and feeding grounds. An array of acoustic receivers was distributed throughout the seascapes to capture and determine individual fish's movements for a period of up to 150-200 days. Thus demonstrating habitat visitation, from benthic habitat maps, and typical species-specific pathways. Preliminary data and analyses suggest that Atlantic cod were utilising these shallow-water coastal areas with some fish specimens expressing signs of high site-fidelity. Some individuals showed strong diel patterns moving between areas within and outside (i.e. deeper waters) the receiver detection range. We also highlight how different seascape features may affect the movement of Atlantic cod throughout the study sites. This information offers insights into detailed spatial and temporal movements of an important mobile organism in the shallow-water seascape, which contributes to a further understanding of species-habitat connectivity, and trophic linkages in temperate coastal waters.

Juvenile queen angelfish (*Holacanthus ciliaris*). © Adam Porter

Tools for Understanding Fish – Speed Talks

RECONSTRUCTING THE PAST TO UNDERSTAND THE PRESENT: PALAEODRAINAGES AND PHYLOGEOGRAPHY OF *TRICHOMYCTERUS ZONATUS*

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Exclusively freshwater fishes have their dispersal capacity regulated by hydrological connectivity. This implies that currently isolated drainages which share common freshwater fauna were somehow connected in the past. Two geomorphological events (headwaters captures and palaeodrainages connections) are commonly used to explain strictly freshwater fishes distributed among isolated rivers basins. However, the role of those historical connections remains elusive and is usually taken as *a posteriori* explanation for phylogeographical patterns. Using GIS-based palaeodrainage reconstruction tools and phylogeographical approaches (mtDNA and nuDNA), we tested the hypothesis that the current population structure of *Trichomycterus zonatus*, small catfish inhabiting coastal basins from Southeast/South Brazil, matches the palaeodrainages connections since the last glacial maximum event. Our phylogenetic reconstruction used samples from eleven currently isolated drainages and revealed five major clades, which generally agreed with the major palaeodrainages connections. However, some haplotypes were inserted on different palaeodrainages clades, suggesting potential headwater capture events after sea level rising. GIS-based palaeodrainages reconstruction arises as a powerful tool on the understanding of freshwater fish population genetic structure, revealing previously hidden drainages connections and shedding light on geomorphological events that contributed to population isolation and dispersal among coastal drainages.

CONSERVATION OF A LANDLOCKED SALMONID POPULATION IN A REGULATED RIVER: TAKING A HOLISTIC APPROACH

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The regulated River Klarälven hosts an endemic population of landlocked Atlantic salmon. During the 1960s the population reached an all-time low, and extensive stocking, trapping and transportation of spawners past eight dams, together with a no-fishing policy in the lake, has led to an increase in the population. In an attempt to improve the situation for this landlocked population, we have taken a holistic approach in evaluating where further measures are needed. Hence, we have measured trap efficiency for upstream migrating spawners at the lowermost dam, spawning success, overwinter survival of post-spawners, downstream passage success of smolts and kelts and smolt production. Here, I present an overview of our research in the River Klarälven, focusing on smolt production. Estimates of smolt numbers, based on mark-recapture studies, were difficult to obtain in high flow conditions, and our best estimates revealed a minimum smolt run of approximately 4,000 in one year and 20,000 in a subsequent year. A simple population model was developed for the River Klarälven, where we used our own data and data from the literature to estimate the number of return spawners. We ran the model with different scenarios, where we varied trap efficiency at the lowermost dam and smolt and kelt survival for downstream migration pass the eight dams. The model predictions did not always match well with the observed return rates. We believe that this discrepancy is related to the difficulties in estimating smolt production and downstream passage success in large rivers with highly variable discharge regimes.

APPLICATION OF LIFE-STAGE DISTRIBUTION MODELLING TO IMPROVE FISHING SELECTIVITY AND MINIMISE BYCATCH

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Understanding spatial distributions of fish species is essential for effective fisheries management. Occupancy patterns and their underpinning spatial dynamics often vary ontogenetically. Therefore, knowledge of key life-stage distributions is critical to provide meaningful advice on area closures and measures that minimize bycatch. Here we investigate the physical and density-dependent mechanisms influencing distribution over the life-cycle of whiting across the UK west coast. Bottom trawl survey data from the Scottish west coast and Irish Sea from 2009 to 2015 were used to examine three key life-stages. Density distributions were modelled for age-0, age-1 and mature fish as functions of environmental variables using generalized additive mixed effects models. Geostatistical aggregation curves were used to define whether spatial occupancy was aggregated or dispersed. A high proportion of age-0 whiting were found in aggregations which displayed high levels of spatio-temporal constancy. In contrast, age-1 and mature individuals exhibited more dispersed distribution patterns. General trends showed coastal aggregations of age-0 whiting dispersing during the age-1 stage, while mature fish occupied offshore areas at higher densities than in other locations. The spatial dynamics and areas of persistent life-stage aggregation identified here could enable informed targeting and avoidance of particular age-class whiting to reduce bycatch. Given that Landing Obligation legislation is counterproductive unless it encourages greater fishing selectivity, the ability to avoid this species and in particular undersized individuals would aid conservation measures and fishers alike. Elsewhere this approach could be applied to counterbalance the effects of fisheries induced evolution where selective life-stage targeting is deemed fruitful.

GENETIC VARIATION AND PHYLOGENETIC RELATIONSHIP AMONG FOUR PARROTFISHES (GENUS SCARUS) FROM HURGHADA, RED SEA COAST, EGYPT BASED ON RAPD MARKERS

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Random amplified polymorphic DNA (RAPD) fingerprints were obtained for four Parrotfishes (genus Scarus) namely, *Scarus collana* [Rüppell, 1835], *Scarus fernatus* [Lacepède, 1802], *Scarus (Chlorurus) sordidus* [Forsskål, 1775] and *Scarus niger* [Forsskål, 1775] using RAPD-PCR analysis with 12 deca-oligonucleotides [A-01, A-02, A-03, A-04, A-05, A-06, A-07, A-08, A-09, A-10, A-11, and A-12]. All primers amplified discrete number of DNA bands of various lengths ranging from 200 to 2000 base pair. A total of 111 bands were produced, from them 13 monomorphic (common) and 98 polymorphic, those correspond to level of polymorphism of 88.29 % with an average number of polymorphic fragments per primer of 8.17 band. The *Scarus fernatus* recorded the highest band frequencies among the studied species. Under phenetic approaches "clustering using unweighted pair group method average (UPGMA) based on Nei-72 genetic distance, and principal coordinate analysis (PCOA)", the studied scarus species formed two groups as sister taxa sharing common ancestor. There was close genetic relatedness among group members [*Scarus collona*/*Scarus niger* and *Scarus fernatus*/*Scarus sordidus*]. According to parsimony (Cladistic) analysis, the RAPD markers obtained here are reliable and phylogenetically instructive. The 4 parrotfishes are related, however *Scarus fernatus*, *Scarus sordidus*, and *Scarus niger* are evolutionarily closer to each other than they are to *Scarus collona*. The splitting of *Scarus collana* as a basal group suggested common ancestor that would have unique features (synapomorphies) existing in the studied parrotfishes. The results of this study possibly will support understanding the genetic diversity and taxonomic structures of that controversial taxon of parrotfishes.

HAS STOCKING CONTRIBUTED TO AN INCREASE IN THE ROD CATCH OF SEA TROUT (*SALMO TRUTTA* L.) IN THE SHETLAND ISLES?

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Stocking of trout and salmon is generally an attempt to fix a problem – typically with fish numbers – that is either real or perceived, and is usually undertaken when salmonid stocks have been degraded due to processes such as habitat change or over-exploitation or to enhance catches for commercial or recreational fisheries. The practice of stocking in salmonid fisheries is now recognised as having generally detrimental effects on the wild populations into which fish are stocked. These effects can include the introgression of 'domestic' genes leading to the loss of local adaptations.

However, in some circumstances, stocking may have positive effects on salmonid populations. One such case concerns sea trout stocks in the Shetland Isles. Over the last ten years there has been extensive stocking of brown trout in many of the streams of the Shetland Isles by the Shetland Anglers Association (SAA). This has coincided with a reported 15-fold increase in the rod catch of sea trout and it is believed that the dramatic increase in the sea trout catch is due to the stocking effort.

Using a microsatellite baseline incorporating samples from the SAA broodstock and fish sampled from seven streams on the east and west of Mainland, Shetland, we determined whether sea trout caught in the marine environment and streams were of wild or stocked origins.

COST-EFFICIENT ESTIMATION OF EFFECTIVE POPULATION SIZE FROM SINGLE PARR SAMPLE FOR ATLANTIC SALMON CONSERVATION MONITORING OF REAR-EDGE POPULATIONS IN SOUTHERN FRANCE

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Southern France is at the rear-edge of the distribution of *Salmo salar* L. where the species remains in a handful of costal streams. Extant populations are put at increased extinction risk from the combined effect of small size and climate change calling for critical population monitoring to allow sustainable recreational fishing activities of local socio-economic importance. Abundance monitoring practices usually require large investments in both river infrastructure and technical staff time to estimate adult census size (N_c) from direct count or from demographic modelling based on capture-mark-recapture (CMR) of anadromous individuals during their upstream migration for spawning. While N_c is a well-understood parameter practical for conservation decisions on a management timescale, it may not best reflect population viability and adaptive potential if anadromous adults do not effectively contribute to reproduction, or do not do so equally, which would decrease the effective population size (N_e). Conversely, N_e may be larger than expected due to reproductive contribution of mature parr unaccounted for in reproductive population size estimates based on sampling of anadromous individuals. Here, we introduce a management protocol for estimating the effective number of breeders (N_b), easily implemented on any river from a single sample of young-of-the-year. We perform a sibship reconstruction of young-of-the-year of the river Nivelle ($N_c < 100$) genotyped at 14 microsatellite markers in the full-probability pedigree reconstruction model available in Colony 2, for 10 consecutive years, excluding or including sampled anadromous adults and mature parr as potential parents, and by means of simulation, for method validation.

CONTRASTING PATTERNS OF SPATIAL GENETIC POPULATION STRUCTURE IN A MODEL SHARK, *SCYLIORHINUS CANICULA* – INSIGHTS FROM A MULTIMARKER APPROACH

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The lesser spotted catshark *Scyliorhius canicula* is a small benthic shark, common in the Northeast Atlantic (NEA) and Mediterranean waters. Its life history traits, such as female philopatry and low dispersal ability, suggest the species may form localized populations along its range. Although this was observed within the Mediterranean Sea, no evidence of genetic population structure was found across the Northeastern Atlantic (NEA) using traditional molecular markers. Here, we build on previous work and re-evaluate the population structure of *S. canicula* along the NEA incorporating additional samples from western Iberia. Traditional molecular markers, i.e. mitochondrial DNA control region (mtDNA CR) sequences and eleven microsatellite markers, are also employed alongside 300 newly developed SNP markers using a 2bRAD approach. Our results based on nuclear microsatellite markers suggest a pattern of isolation by distance, in line with expectations of the species' life history, although no signal was present on the mtDNA CR. The SNP loci further indicate the presence of a strong genetic break in southwestern Iberia, which may be tied to the distinct environmental conditions in this region (e.g. warmer water temperatures) leading to local adaptation. Thus, these new results support the current management of *S. canicula* as multiple populations in the NEA and indicate that local adaptation could be present. Furthermore, these results represent one of the few studies to isolate SNPs in understudied elasmobranchs and provide an exciting opportunity to directly compare the power of multiple genetic markers.

CONSERVATION OF THE EUROPEAN EEL IN THE THAMES CATCHMENT: THE POWER OF COLLABORATION

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The European eel (*Anguilla anguilla*) has been listed as Critically Endangered on the IUCN Red List due to dramatic declines in abundance recorded across all stages of its life cycle and much of its natural range (Jacoby & Gollock 2014). Several anthropogenic, oceanic and climatic factors have been identified as potential causes of this decline (Chadwick et al. 2007). In freshwater, barriers to migration, such as weirs and sluices that prevent access to upstream habitat have been identified as a key threat.
Since 2011, ZSL has been working in partnership to recover the European eel in the Thames Catchment. Working with the Environment Agency's Thames Eel Management Plan Implementation Group (EMPIG), over 20 other NGO's, and more than 120 citizen scientists each year; we have developed a number of tools with the aim to better understand eel movement and ecology. These include: i) using citizen science to monitor of upstream eel migration and ii) building passes in collaboration with the Environment Agency to facilitate eel's upstream migration.

With around 2,500 identified barriers to fish migration in the Thames region and with the limited resources available, there is a need for further collaboration with all stakeholders and members of the public in order to enhance eel conservation status. This presentation will show how ZSL has used collaboration and citizen science to help understand eel populations in the region and make conservation impact.

UTILISING SYNTHETIC GENETIC ANALYSIS AS A TOOL FOR FUNCTIONAL GENOMIC CHARATERISIATION OF METALLOTHIONEINS GENES IN BROWN TROUT

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Metal pollution has made a significant impact on the earth's ecosystems and tolerance to metals in a wide variety of species has evolved; resulting in extensive research in the field of metal adaptation. The southwest of Britain has historically been a central hub for harbouring metal resources. Study of these "metal-tolerant" trout populations in southwest Britain has shown that their genetic structure is markedly different compared to fish in neighbouring clean rivers. They can tolerate very toxic levels of metals, in some cases above the LC50 for fish. The key physiological mechanisms affected include increases in metal-binding proteins; a significant up-regulation of metallothioneins. Yet the full basis of the underlying genetic mechanisms and physiology of metal tolerance in these brown trout populations is still to be determined in any great detail.

In this body of work, we examined *MetA* and *MetB* genes from brown trout in the southwest of Britain. We wanted to explore whether the yeast, *Sacchromyces cerevisiae*, could be used as a model in understanding the ecology and evolution of a non-model species. In particular, our working hypothesis was that through the utilisation of functional genomics in the model organism *S. cerevisiae*, we could (i) determine the genetic interaction maps of *MetA* and *MetB*; (ii) identify the subtle differences between these genetic interactions in both genes and (iii) establish if pre-exposure to metal contaminants in metal-impacted fish influences these interactions.

Juvenile timucu (*Strongylura timucu*) in Bahamian mangroves. © Adam Porter

Tools for Understanding Fish – Posters

Bergman, Eva – Conservation of a landlocked salmonid population in a regulated river: taking a holistic approach (Abstract in Tools for Understanding Fish Speed Talks)

PEDIGREE AND KINSHIP ANALYSIS IN *SPARUS AURATA* BASED ON SNP-HAPLOTYPES

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Pedigree information among individuals is infrequent in wild and cultivated populations, however avoidance of mating between relatives is very important to the success of any breeding programs and in the management and conservation of endangered populations. To date microsatellite loci are considered as genetic marker par excellence to establish parental relationship among individuals without parental information, whereas the efficiency of SNPs (Single Nucleotide Polymorphism) as a parentage tool is questioned mainly due of their bi-allelic characteristics.

The present study has evaluated the accuracy of SNP-haplotypes (genotypic combination of SNPs located in the same gene) as a paternity tool. Previously, a total of 398 SNPs were indentified in 7 genes and 58 selected and genotyped by SequenomMassARRAYiPLEX platform [CEGEN-ISCII, USC, Spain] in 441 *Sparus aurata* individuals (54 breeders and 387 offspring). SNP-haplotypes were reconstructed using Phase-v.2.1.1 software. According to this approach, the polymorphism of each gene behaves as a *locus* with an allelic series, ranging the number of haplotypes (alleles) per gene from 3 to 29. Parentage assignment was determined using CERVUS-v.3 software. More than 99% of the progeny were assigned to a parental pair. The use of ML-Relate software allowed these markers to be capable of discriminating between related and unrelated individuals in a situation where pedigree information was unknown, reporting a misclassification where only a 0.5% of full-sibs and 1.3% of half-sibs individuals were classified as unrelated. In conclusion, SNP-haplotypes are markers with a comparable or even higher potential than microsatellite *loci* and represent a suitable tool for managing broodstocks.

Burns, Neil – Application of life-stage distribution modelling to improve fishing selectivity and minimise bycatch (Abstract in Tools for Understanding Fish Speed Talks)

ENVIRONMENTAL DNA (eDNA) MONITORING OF CONSERVATION PRIORITY FISH IN UK WATERS

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Biodiversity monitoring through non-invasive approaches is essential to avoid additional loss of individuals within vulnerable *taxa* or threatened environments. Freshwater ecosystems are particularly jeopardized by climate change, habitats decline and land-use. Therefore, environmental DNA (eDNA) has increasingly drawn attention for its inoffensive and reliable species detection. Despite the proved power of eDNA metabarcoding to describe freshwater fish communities, the full potential of eDNA to provide conservation relevant information has not yet

been fulfilled. The main goal of this study is to further develop eDNA metabarcoding as a tool for monitoring three rare conservation priorities fish species in the UK waters (vendace, *Coregonus albula*; powan, *Coregonus lavaretus*; arctic charr, *Salvelinus alpinus*) and to use this approach to understand the factors driving the decline of these species. In order to achieve this objective we want to: i) optimize eDNA sampling and extraction methods to efficiently capture eDNA from rare aquatic species; ii) develop methods to translate eDNA abundance into species-specific biomass estimates; iii) understand the seasonal distribution of the target species and identify timing and location of spawning; iv) use novel approaches to obtain population genetic parameters such as effective population size and gene flow from eDNA.

Seeking a step-change for eDNA methodologies and applications, we expect that our outcomes will strongly contribute to the enforcement of management plans and conservation actions in order to protect endangered species in freshwater environments whose biodiversity is already facing an intensive erosion.

MORPHOMETRICS OF SAGITTAE OTOLITHS AS A TOOL FOR THE RAPID AGE ESTIMATION OF WILD SILVERING *ANGUILLA ANGUILLA*

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Age and growth determination of fishes are essential tools for understanding basic life-history traits, such as individual and population growth rates, year class strength and mortality rates. Age estimation can be deduced via the analysis of bony structures, including vertebrae, fin-ray spines, otoliths and scales, each with their own advantages and disadvantages. Whilst non-lethal means of age determination are preferable, they are not always practical, particularly in fish with embedded scales or scaleless species. Thus, the use of otoliths is sometimes the only method available. Otolith examination is the primary method for the ageing of *Anguilla* species. A number of methods exist for the analysis of *Anguilla* spp. otoliths, all of which require significant preparation time and high levels of expertise in their interpretation.

Here, we examine the application of sagittae otolith morphometrics, specifically minor and major axis measurements and otolith weight in the age estimation of the European eel *Anguilla anguilla*. Samples (*n* = 169) of 'silver stage' *A. anguilla* were obtained from two lowland rivers in East Anglia and a fully enclosed lentic waterbody. *A. anguilla* ranged from 364 to 1018 mm TL and were found to be 10 to 35 years old using direct observations of otolith sections. Initial findings indicate that sagittae otolith morphometrics correlates positively to observed ages of otoliths processed via traditional methods. These findings indicate that otolith morphometrics may be a valuable tool for the rapid age estimation, ecology and management of wild fish populations, in particular eels that are currently critically endangered.

BRINGING TOGETHER FISH AND FISHERY SPATIAL DYNAMICS: DEVELOPMENT OF AN EXPLORATORY INDIVIDUAL BASED SIMULATION FRAMEWORK

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Fishers' exploit fish populations that are heterogeneously distributed in space and time without full knowledge of species distributions and with fishing gear that is not fully selective. This encompasses two separate but linked spatial processes: dynamics of the fish populations and the fishers exploiting patches of fish. Fish population movement is a result of a combination of diffusive density dependent processes and directed ontogenetic niche shifts and migrations, while fishers' motives for location and timing of fishing spans the full gambit of economic and social drivers. The ability for fishers to exploit fish populations efficiently is limited by species mix at a location, knowledge of fish distribution and time and the capture characteristics of the fishing gear.

These dynamics occur at several spatial scales and it's not possible to collect data at each of these, due to cost and feasibility. A simulation framework, where the dynamics of the system are known, can help to inform how we interpret data collected from the field. We develop a simulation framework to allow investigation of the importance of scaling on the interactions between fish populations and fisheries dynamics. The framework is developed to provide i) a realistic but tangible biological model of fish population in space and time, and, ii) a realistic fishing simulation model to capture how fishers may exploit heterogeneously distributed fish populations that move in space. We seek to capture the main processes in a simplified model that can be used for analysing realised fisheries-dependent catch data.

El-Mahdi, Mohammed – Genetic variation and phylogenetic relationship among four parrotfishes (Genus Scarus) from Hurghada, Red Sea coast, Egypt based on RAPD markers (Abstract in Tools for Understanding Fish Speed Talks)

THE ARABIAN KILLIFISH (*APHANIUS DISPAR*) AS NOVEL MODEL FOR FUNGAL INFECTION OF *CANDIDA ALBICANS*

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Candida albicans is an opportunistic fungal pathogen of humans. The yeast is present as commensal and can reside harmlessly on the skin and in the oral cavity but it can cause superficial disease or life-threatening systemic infections. In this project, we have developed a novel fish embryo model of infection for better understanding of *C. albicans* infection and the host response. Arabian killifish embryos are particularly useful in this context as they are transparent making live-cell imaging possible, and can live at a variety of temperatures (4-40˚C). The interaction between the pathogen and immune cells in the transparent embryo has been examined using a combination of live-cell imaging, paraffin sectioning, western blot, immunofluorescence, tissue lysis and plating to reveal Candida burdens. The behaviour of *C. albicans* in the fish embryo at human body temperature (37˚C) was examined with different doses. Despite high levels of growth of *C. albicans* which killed the zebrafish, the killifish embryo survived up to 144 hpi. We observed apparently increased colonization and switching of *C. albicans* from yeast-to-hypha forms inside killifish embryos at 3dpi and then there was declined in Candida growth at 5dpi and that may become as a commensal model. These studies confirm that the Arabian killifish embryo can be used as a mini vertebrate host model to study fungal pathogenesis, highlighting the advantages of using this species in future studies of bacterial, fungal and viral pathogens at a physiologically relevant temperature for human infection.

ISOBANK – STABLE ISOTOPE ECOLOGY IN THE AGE OF 'BIG DATA'

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The analysis of stable isotopes provides valuable information to fish biologists working in a diverse range of fields: ecologists, population biologists and fishery managers. Ecologists take advantage of stable isotope ratios to estimate the diet and migration history of consumers or to characterise food web structure and ecosystem function, and to see how these change over time and space. However, most studies using stable isotopes are conducted by independent research

groups working in relative isolation, and the resulting data are not available to researchers outside of these groups.

IsoBank is the initial result of an international collaboration of isotope ecologists, natural history museums, and data managers who are developing a data federation resource for stable isotope scientists. This data-repository, housing stable isotope data from organisms around the globe, represents a novel resource with which to portray local, regional and global patterns in food web structure. As data are geo-archived they can be related to land use, temperature or productivity gradients providing novel insights into the factors determining spatial and temporal patterns in biodiversity, biological responses to climate change, and ecosystem function at a global scale.

Using data drawn from *IsoBank* we present a comparison of sexual variation in isotope ratios throughout the animal kingdom as a 'proof of concept' case study. *IsoBank* can be found at www.isobank.org and on Twitter @iso_bank. CH was funded by Fondecyt 115151.5

DYNAMICALLY MODELLING THE SENSITIVITY OF ATLANTIC SALMON POPULATION ABUNDANCE TO HYDROPEAKING-INDUCED STRANDING MORTALITY

Hedger, Richard D.[1], Sauterleute, Julian[2], Sundt-Hansen, Line E.[1], Forseth, Torbjørn[1], Ugedal, Ola[1], Diserud, Ola H.[1], Bakken Tor H.[3].

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Hydropeaking – short-term discharge fluctuations in rivers regulated for hydropower – has contributed to the decline in salmonid populations via hydropeaking-induced stranding mortality. Studies of stranding mortality on salmonid populations have been confined to empirical data analysis or hydraulic-habitat modelling of individual events, and are limited with regard to inferring long-term effects on populations. In this study, the effects of stranding mortality on an Atlantic salmon (*Salmo salar* L.) population were simulated using an individual-based salmon population model with the objective of determining the sensitivity of population dynamics to stranding. It was found that repeated hydropeaking had a greater effect on older than younger salmon parr because older parr, by virtue of how long they had been in the river, experienced more stranding events. This caused a change in age distribution towards a younger population. A reduction in density-dependent mortality (an alternate source of mortality in parr) partially compensated for stranding mortality, acting as a negative feedback mechanism. Stranding caused a perturbation in population dynamics, and effects of individual stranding events persisted in time across the life-stages of the population. We concluded that empirical measurements of stranding mortality have limited potential for inference of overall effects on the population, and a more dynamic modelling approach, incorporating system feedback, allows for a better modelling of the impact of stranding. Sensitivity analysis showed that population abundance was highly sensitive to parr density-dependent mortality, and we suggest that this area should be prioritized for further research when investigating the effects of hydropeaking on salmon populations.

King, Andrew – Has stocking contributed to an increase in the rod catch of sea trout (*Salmo trutta* L.) in the Shetland Isles? (Abstract in Tools for Understanding Fish Speed Talks)

THE SEX RATIO OF SEA TROUT (*SALMO TRUTTA* L.) SMOLTS AND ADULTS: PRELIMINARY RESULTS FROM THE RIVER TAMAR

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Biological Reference Points (BRPs) are widely used in fisheries management. They provide a means of comparing current stock status against a reference level and offer a scientific basis by which to assess measures designed to aid in the conservation of salmonid stocks. While BRPs are currently used to set conservation limits for Atlantic salmon, their use in sea trout management has until now been limited.

As an Environment Agency Index River, the Tamar is subject to intensive monitoring of all life stages of sea/brown trout and is thus an ideal system on which to develop BRPs for sea trout. There have already been attempts to develop BRPs for the River Tamar using an egg-deposition-based reference point. However, some of the parameters used were based on data from other rivers. As a first step towards deriving BRPs specific to Tamar sea trout, we have determined the sex of different components of the sea trout run using recently developed genetic methods.

We present data on the sex ratio of smolts collected over three years (2007, 2015 & 2016). In addition, sex ratio data from the finnock component of the Tamar sea trout run sheds light on sex-biased mortality in the few months that these fish spend at sea.
Our results suggest short-term stability in smolt sex ratios and indicate sex-biased mortality between the smolt and finnock stage.

Lepais, Olivier – Cost-efficient estimation of effective population size from single parr sample for Atlantic salmon conservation monitoring of rear-edge populations in Southern France (Abstract in Tools for Understanding Fish Speed Talks)

DIEL PATTERNS OF ATLANTIC COD (*GADUS MORHUA*): A STUDY USING ACOUSTIC TELEMETRY

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Assessing movements of fish is crucial for understanding linkages between these organisms and their environments. Atlantic cod (*Gadus morhua*) are important predators in North Atlantic food webs, but also economically important as a food resource across the region. In this study, we tagged and tracked Atlantic cod (n=48) activity for 5 months during autumn-winter on the Swedish Skagerrak coast using acoustic telemetry. An array of acoustic receivers (n=22) was deployed in two shallow-water coastal areas to assess specific night-day migration patterns of juvenile Atlantic cod (2-3 year-old). Approximately one-third of the tagged specimens showed signs of high site fidelity together with strong diel patterns, being particularly active during dawn and dusk. For example, one fish moved consistently during these periods between deeper, less vegetated areas and shallower waters with higher cover of vegetation. Other observations showed shoal-like behaviour, where fish moved in groups within and outside of the receiver detection range, specifically linked to changes in daylight. These distinct diel patterns could be due to a trade-off between predator avoidance and prey availability. This research strengthens the overall understanding of how temperate marine habitats are being utilised by Atlantic cod and thereby ascertaining vital information that can be used in science-based resource management and conservation efforts.

Usher, Jane – Utilising synthetic genetic analysis as a tool for functional genomic characterisation of metallothioneins genes in brown trout (Abstract in Tools for Understanding Fish Speed Talks)

Celebrating 50 Years of the FSBI – Oral Presentations

BRITISH COARSE FISHERIES – DECADES OF CHANGE: REVISITING THE LEGACY OF JACK JONES

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Jack Jones, although best known for his seminal work 'The Salmon', was instrumental, along with other founder members of the FSBI, in establishing the research environment for working on coarse fish and fisheries in the British Isles. In 1963 he established the British Coarse Conference series that ran biennially until 1985, although latterly under the guise of the British Freshwater Fisheries Conferences. These conferences provided the platform for exchange of research ideas on coarse fish and fisheries that has now transformed into a mix of field and laboratory based research, ecological modelling and genetics to name but a few. This presentation explores this transition and the role the vision of Jack Jones made towards steering the science and management of coarse fishing in the UK through the 50-year history of the FSBI.

STAGE FRIGHT: THE EFFECT OF AN AUDIENCE ON ARCHERFISH SHOOTING BEHAVIOUR

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Archerfish (*Toxotidae*) are unique in their ability to forage by "shooting", spitting jets of water at targets above the water surface. This allows them to capture prey inaccessible to most other fish, but also incurs a risk of losing prey to conspecifics that are able to predict where a prey item will land once shot. Previous studies have shown that archerfish foraging in groups will jump for food rather than shoot in order to capture the prey more securely. In this study we investigated how the shooting performance of individual fish (*Toxotes jaculatrix*) is influenced by the presence of conspecifics. We trained individual archerfish to shoot at an artificial target for a food reward and then compared the latency to shoot in trials with and without a conspecific audience. Overall, fish took longer to shoot when a conspecific was present, the strength of the effect, however, varied between individual shooters. Our study suggests individuals can vary in their sensitivity to an audience. We are currently exploring this further to identify what factors may contribute to these between-fish differences.

THE FISHERIES SOCIETY OF THE BRITISH ISLES: THE FIRST FIFTY YEARS

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The Fisheries Society of the British Isles was founded in 1967 as an outgrowth of the Coarse Fisheries Conferences held in Liverpool since the early 1960s. Although originally intended by founders, scientist Jack Jones and angling journalist Peter Tombleson, to bring fish scientists and anglers together, it rapidly developed the features of a learned scientific society, including its own

journal, the *Journal of Fish Biology*. Edited initially by Jimmy Chubb, the success of this journal provided funds for the FSBI to expand its activities into a broad range of initiatives that supported the discipline and served its members. Our paper draws on recently collected oral history interviews and the written records of the society to outline and assess the history of the society and reflect on its achievements. We suggest that the FSBI has played an important role in building and sustaining the discipline and its academic community through its own ability to adapt and change as both the science done by its members and the organisational landscape in which they operate have been transformed. This in turn has been possible by the willingness of individuals to commit increasingly scarce time to its governance.

EXPOSURE TO COPPER DURING EMBRYOGENESIS CAUSED INCREASED TOLERANCE IN SUBSEQUENT GENERATIONS, IN THE THREE-SPINED STICKLEBACK (*GASTEROSTEUS ACULEATUS*)

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Aquatic environments worldwide are impacted by chemical pollution. The sustainability of fish populations within these polluted ecosystems is critically dependent on their ability to adapt to change via (epi)genetic mechanisms. We conducted a series of copper exposures in the stickleback to explore if prior exposure can result in altered susceptibility in later life or subsequent generations. Stickleback embryos were exposed to 0.015mg/L copper during early life (0-9dpf), a concentration causing ~1.2% mortality, ensuring that selection for a tolerant genotype did not occur. Fish were then kept under control conditions until sexual maturation, when they showed differential responses to copper compared to a control population.
Mortality curves on F1 embryos revealed that the embryos originating from parents who were exposed to copper during embryogenesis were significantly more tolerant to copper when compared to the control population kept in parallel. We also carried out mortality curves on F2 embryos in order to establish if this effect can be inherited across generations, and confirmed that F2 embryos were also significantly more tolerant to copper compared to the control population. In addition, a greater proportion of these embryos were able to hatch under copper exposure when compared to the control population. Our data supports the hypothesis that exposure to low levels of copper during early life has the potential to reduce the susceptibility of a vertebrate model in later life and across generations. We are now conducting WGBSeq in order to explore the molecular mechanisms responsible for the differential susceptibility observed in this study.

DOES CHRONIC MATERNAL STRESS AFFECT THE NEXT GENERATION OF STICKLEBACKS?

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Research on a wide range of animal taxa has shown that stress experienced by females can profoundly affect the survival, phenotype and behaviour of offspring. However, this has usually been studied in the context of acute stress, and little is known about the effects of protracted mild maternal stress on offspring phenotype, especially in fish. In particular, it is unclear whether successive clutches produced by a female in a single breeding season are affected in the same way. Answering these questions would give an insight into the effects that any increase in

environmental stress (resulting from environmental change) might have on wild fish populations. I manipulated environmental conditions in an unpredictable manner to induce chronic stress in female three-spined sticklebacks (*Gasterosteus aculeatus*) in the period leading up to egg production and spawning. Levels of the stress hormone cortisol were measured in half of the unfertilised eggs, while the remaining eggs were fertilised *in vitro* and offspring reared to maturity. I assessed the behaviour of parental females during the period of chronic stress, and of their offspring at approximately 9 months old. Females in the chronic stress treatment were more active than controls (even between times when the stressors were being applied), but did not produce eggs with higher cortisol levels. However, eggs produced earlier in the season had elevated concentrations of cortisol. I will present these results in detail and assess the effect that the maternal chronic stress treatment and egg cortisol levels had on the behavioural phenotype of the offspring.

DISTRIBUTION AND SEASONAL MOVEMENTS OF THE OCEAN SUNFISHES

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The ocean sunfishes (Family Molidae) have often been described as rare, inactive drifters; however, recent studies have revealed many high density aggregations in coastal seas, with potential interchange through long-distance movements. Anecdotally, the Molidae are believed to have a pan-global distribution within temperate and tropical latitudes, although disparate sightings records and inherent difficulties in species identification have led to an incomplete picture of their range and seasonal movements. There is a pressing need to address this gap in our knowledge as current fishing pressures (both targeted and bycatch) remove 100,000's of sunfishes each year, leading the IUCN to evaluate the four species as "vulnerable" or "data deficient" globally.

Here we present a primary range map of the family Molidae which suggests that ocean sunfishes are not randomly distributed, but significantly clustered globally. We used Random Forest distribution models to assess the annual movement of sunfishes, which suggests that the total area of suitable habitat changes significantly in size and shifts latitudinally with the seasons. It is hoped that such efforts will identify areas with high seasonal pulses of sunfish, which can inform fisheries management to minimise accidental bycatch.

THE 'AFTERLIFE' OF AN FSBI STUDENT – MEDITERRANEAN FISHES: SCALING UP FROM POPULATIONS TO ECOSYSTEMS

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Twenty one years ago, starting in 1996, the FSBI agreed to fund my PhD at the University of Newcastle upon Tyne. The aim of this studentship was to investigate planktivorous fishes as a possible link between littoral and pelagic food-webs in the Mediterranean. The geographic focus was in the Bay of Calvi, Corsica and the PhD involved 3 years of spear fishing, scuba-diving, experimental work and computer modelling. In this presentation I provide a brief account of 'what happened next' including the main outcomes and how this Mediterranean work fundamentally shaped my later career.

The primary focus of my FSBI PhD was a small, brown, somewhat obscure fish that people generally overlook throughout much of it's distribution. *Chromis chromis* (the Mediterranean damselfish) is by far the most abundant species in the rocky littoral environment around Corsica, where it feeds in great shoals on incoming zooplankton and 'rests' near the seabed each night. My research showed that large populations of *Chromis* play a fundamental role in Mediterranean food-webs by transferring nutrients (carbon, nitrogen and phosphorus) directly from the pelagic system to the littoral in the form of solid and liquid wastes and that this species also represents a major prey item for predatory fish and seabirds. The Mediterranean seas are among the most oligotrophic anywhere in the world. Many nutrients are in short supply (particularly phosphorus) and hence this hither to unknown flux turns out to be incredibly important.

Understanding the role that *Chromis* plays in Mediterranean food-webs was also achieved using stable isotope analysis. Species ranging in size from copepods (millimeters) to conger eels (meters) were sampled and passed through a mass-spectrometer. This revealed clear patterns of carbon and nitrogen uptake from the plankton, via *Chromis*, to higher tropic levels. Subsequent studies using stable isotopes, revealed simplified deep-sea food-chains off the Balearic Islands, parasite-host interactions, and indirect trophic impacts of trawling in northern Sicily.

Within the first year of my PhD, I was included in an EU research project that focused on Mediterranean marine protected areas, and specifically evidence that 'trophic cascades' might be caused by overfishing and reversed inside marine reserves. Having identified potential trophic cascade effects from field evidence, complex ecosystem models were constructed to simulate the indirect consequences of increasing or reducing fishing pressure on fish populations. The skills I gained through this FSBI-funded studentship were instrumental in my subsequent employment (in 2000) as a fisheries modeler at the UK government fisheries laboratory (Cefas) in Lowestoft.

As a 'post-script', in 2014 (14 years after completing my PhD), I ended up dusting off my original Mediterranean food web model to test the possible trophic consequences following sudden arrival and proliferation of a non-native fish species *Fistularia commersonii*, that had appeared via the Suez Canal and was now threatening the Bay of Calvi ecosystem. The FSBI has been crucial to the development of my ongoing career, I now serve on the FSBI Council as 'Honorary Secretary' and I will act as lead-convener for the 2018 symposium in Norwich.

HOW SMART ARE FISH? COMMUNICATING TO THE PUBLIC WHAT SCIENTISTS AND FISHERS KNOW USING INTERACTIVE E-LEARNING

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There is a commonly-held view of fish as robot-like animals with no intelligence and a 30 second memory. This view is very far from the truth. As a group, fish have a well-developed capacity for learning, a good memory when this is needed and perform many complex behaviours that in mammals would be deemed "smart". The dissonance between popular image and reality arises because most people do not have the opportunity to discover how complex fish behaviour is. Moreover, the scientists who have evidence about the smart capabilities of fish are often seen living in an ivory tower, inaccessible to ordinary people. Public engagement becomes, therefore, a fundamental tool to promote effective communication between scientists and the non-specialised audience. An interactive e-learning presentation to enhance the public understanding on how smart fish are was produced with funding from the FSBI by using the software Articulate Storyline. The scientific facts about fish smartness, its impact on the efficacy of fisheries and implications for successful conservation (collected from more than 30 publications, including those expressing the views of fishers themselves) have been summarised so as to be accessible to and easily interpreted by the general public. By navigating the multi-media presentation, the readers can acquire as much information as they wish, through the available narration, photos, footages and interviews to fishers and scientists, and can develop their own opinion on how smart fish are. This talk will briefly introduce the e-learning presentation, which will be available for view during the conference.

Celebrating 50 Years of the FSBI – Posters

A HISTORY OF THE *JOURNAL OF FISH BIOLOGY*, 1969 TO 2016

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The *Journal of Fish Biology* (*JFB*), in comparison to many well known journals of learned societies, is relatively young having been started in 1969 by the *Fisheries Society of the British Isles* (*FSBI*) which itself was only established in 1967. From 1969 to 2016 it has had seven editors whose tenure has varied from 1 to 16 years. For most of this period (1969 to 2002) *JFB* was published by Academic Press, then by Elsevier (who took over Academic Press, Harcourt Publishers Ltd), for less than 1 year, followed by Blackwell who were taken over by Wiley in 2008 to the present. There has been a significant expansion in all aspects of the *Journal* from 1969 to the present. In 1969, one volume containing four issues and 394 pages was published. In 2016, there were two volumes, 12 issues and 5078 pages. In 1969, 87.0% of the first authors of papers came from the U.K. (6.5% from the rest of Europe and 6.5% from Asia) compared to 6.0% (22.0% rest of Europe, 1.0% Eurasia, 8.0% Asia, 2.0% Africa, 26.0% North America, 28.0% South America and 7.0% Australasia) in 2016. The *Journal* has always encouraged the submission of studies over a wide spectrum of disciplines: *Original research papers on any subject relevant to the central theme of fish biology will be considered for publication*. Ecology has been the dominant subject area providing 50% of papers published in 1969 (3% behaviour, 7% distribution, 7% methodology, 27% parasitology and disease, 3% physiology and 3% toxicology) compared with 36% ecology (1% aquaculture, 14% behaviour, 4% distribution, 16% genetics and cell biology, 5% methodology, 5% morphology and histology, 1% parasitology and disease, 10% physiology, 2% reproductive physiology, 5% taxonomy and 1% toxicology) in 2016. Since its inception *JFB* has published book reviews. During its history *JFB* has changed its editorial structure to cater for an increasing number of disciplines and types of issues (*e.g.* standard, supplement, molecular and special), to accommodate the ever greater number of submissions and to encourage review papers. Submissions have been handled electronically through Editorial Manager since 2004. The *Journal* has always attempted to keep abreast of current concerns such as the ethical use of fishes and plagiarism. Despite its young age, *JFB* in 2009 was voted among the 100 most influential journals in biomedicine and life sciences of the past 100 years by the *Special Libraries Association*. From the outset, the *FSBI*'s main source of income has been derived from *JFB* (the earliest record of *FSBI* monies was in the AGM Secretary's Report of 1972 at *c.* £1550). In 2016 the income from *JFB* was >£1 million with the profit (*c.* 70%) being shared between the Publishers and the Society. In 2016 the *FSBI* decided to form a Publications Committee, which has led to the Society taking a more active role in *JFB*.

IMPACT OF THE FSBI RESEARCH GRANTS SCHEME: AN ANALYSIS AND APPRAISAL

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The FSBI Research Grants scheme has been running for some years, with awards under two categories: standard small grants and Wyn Wheeler grants, the latter open to retirees who wish to continue some work in fish biology. This presentation will analyse the contribution of the Research Grants to the charitable aims of the FSBI; investigate the extent to which funding has supported research development and publications; and pick out some highlights across the years from previous funded awards.

EXPLORING THE ROLE OF THE RAINBOW TROUT (*ONCORHYNCHUS MYKISS,* W. 1792) GUT MICROBIOME IN SUPPORTING FISH HEALTH

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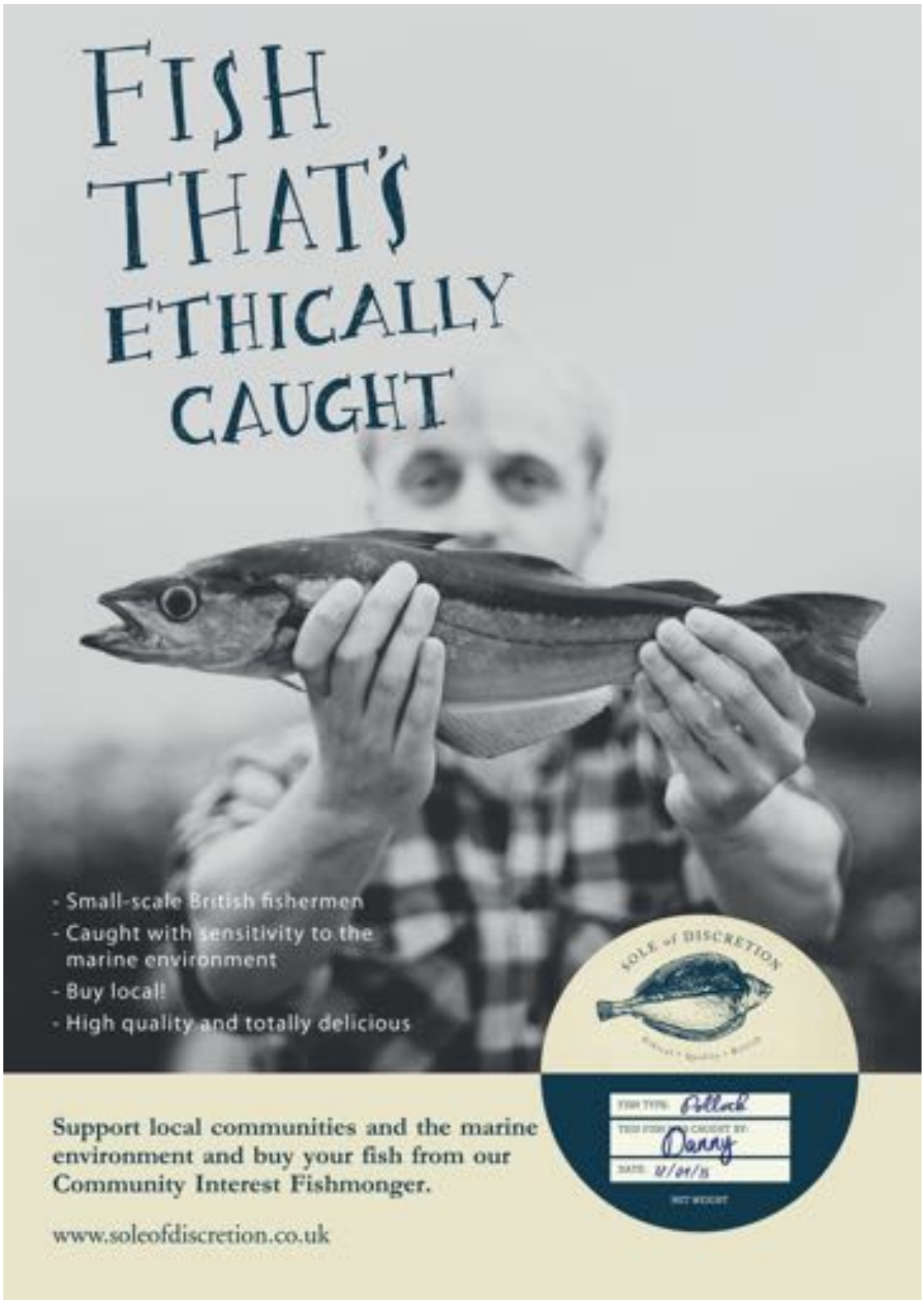
Aquaculture is now the fastest-growing food production sector globally. The industry is currently on track to surpass capture fisheries as the main source of food fish, which in a resource-constrained world with rising demand in animal protein, provides an attractive option for maintaining supply. As aquaculture expands, there will be a huge potential for technical innovation to improve production, however this must be coupled with the development of best management practices that directly benefit the host's response to disease threats. The gastrointestinal environment of vertebrates is colonised by a complex assemblage of microorganisms termed the gut microbiome. Besides from contributing in metabolism, growth and reproduction of their host, evidence also indicates that a healthy gut microbiome facilitates in immune system modulation, where the two units form an 'integrated defence system' (IDS) against communicable disease. Recently, the fish gut microbiome was proposed as an attractive biomarker for stress as alterations in community composition were observed following stress-mediated mucosal changes. Here, I present an introduction to my FSBI-funded PhD which will aim to explore the relationship between the gut microbiome and immune system of rainbow trout. Following a review of the teleost gut microbiome composition, I will discuss the evidence for a 'core gut microbiome' and introduce the concept of an IDS in teleost fish. I will conclude by outlining key methods which will facilitate in mapping the community composition during rainbow trout development and measure any changes in community structure, function and immune responses following an antibiotic treatment.

Blacktip reef shark (Carcharhinus melanopterus). © Steve Simpson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OUR LOCATION: BERLIN

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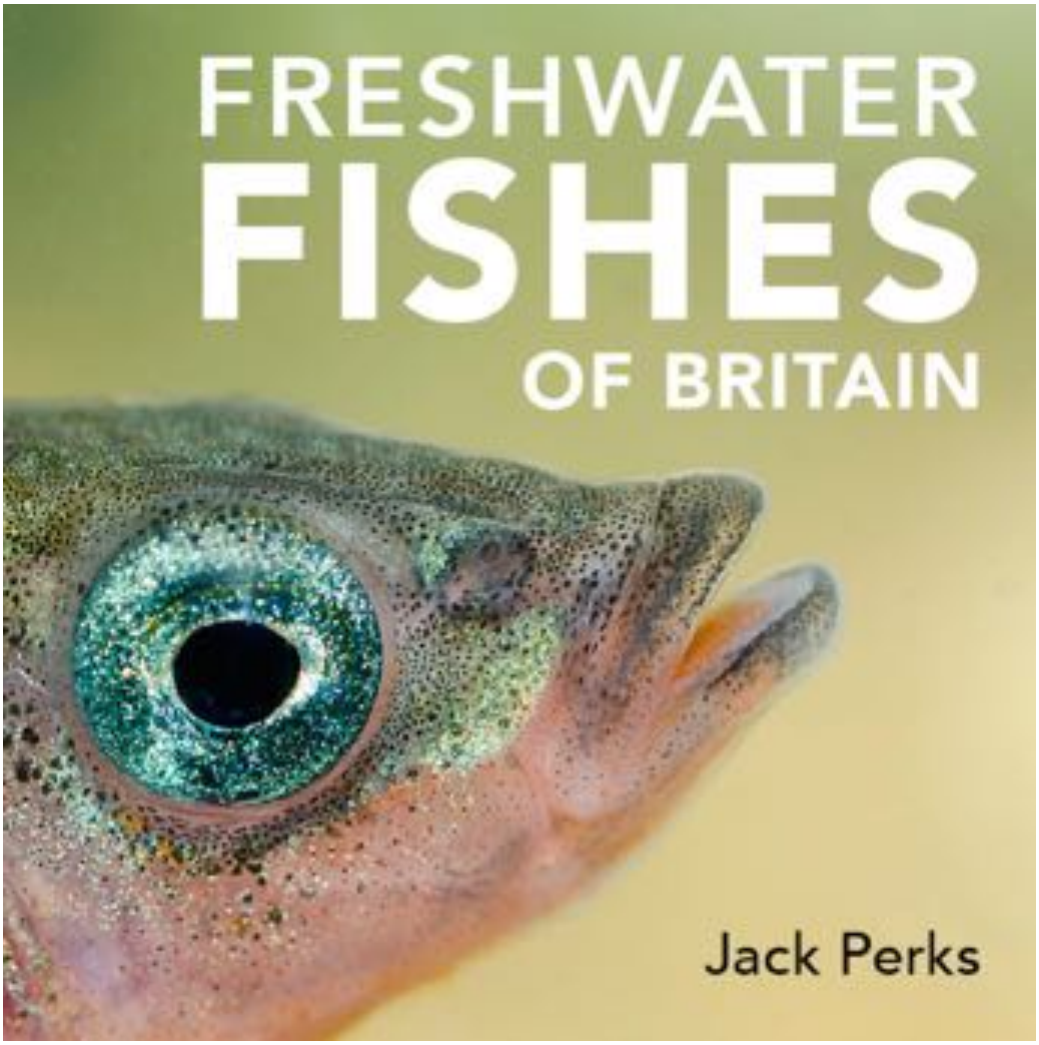

About this book

This is the ultimate photographic guide to the freshwater fish of the UK. Jack Perks has fast been gaining a reputation for his innovative photographic techniques, which include specialist underwater methods involving long lenses and super macro, and the format is intended to show off the stunning images to their full potential.

Over 60 species are covered, from the mighty Atlantic Salmon to the tiny but beautifully coloured Three-spined Stickleback, and including fish with amazing lifecycles such the European Eel, which travels thousands of miles to the Sargasso Sea in the western Atlantic Ocean to spawn. Each species is illustrated with at least one (usually more) colour photograph and the accompanying text describes the author's encounters with the species, and also covers key identification features, habitat, distribution, and other useful information.

Covering every British species, including all of those that are common and widespread, Freshwater Fishes of Britain will have strong appeal to both naturalists and anglers across the country.

Biography

Jack Perks has written and photographically illustrated dozens of articles for magazines such as Outdoor Photography and BBC Wildlife. He runs private photo workshops and short courses on wildlife photography with Nottingham Trent University and is also a lecturer for the MSc Biological Photography and Imaging course at the University of Nottingham. His work has featured on various BBC nature shows, including Springwatch, Countryfile and The Great British Year.

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Brown trout (*Salmo trutta*). © Jack Perks