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Introducing the Keynote Speakers

Dr Michelle Heupel

University of Tasmania, Hobart, TAS, 7001 Australia



Dr Michelle Heupel is a research scientist with over 25 years' experience working on ecology, conservation and management of sharks. Michelle was an early adopter of passive acoustic telemetry as a tool to observe and understand shark movement ecology. Her career has included research ranging from rivers to coral reefs and neonate to adult sharks. Michelle has produced over 200 peer reviewed scientific publications, has held various editorial positions with several scientific journals and has previously or currently sits on several national and international committees relevant to science, conservation and management. Michelle is a US and Australian citizen having completed her

undergraduate degree in Zoology at Colorado State University (USA) and a PhD at the University of Queensland (Australia). Her career has spanned a range of sectors in marine science (university, public funded research agency, private non-profit laboratory, joint ventures). In 2019 Michelle took a position as Director of Australia's Integrated Marine Observing system (IMOS) where she drives coordination and delivery of sustained observations of Australia's marine environments to support research, sustainable use, management and industry activities.

Dr Enric Cortes

National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Panama City, FL 32408, USA



Dr. Enric Cortés received his training in biology and marine resource assessment in Spain and the USA, holding degrees from the University of Barcelona in Spain and the University of Miami's Rosenstiel School of Marine and Atmospheric Science. After spending several years as a post-doctoral scientist at Mote Marine Laboratory in Sarasota, Florida, Enric became a research associate at Florida State University in Tallahassee, shortly after which he was hired by the National Oceanic and Atmospheric Administration in 1998 at the Panama City Laboratory, Florida. He is currently a Senior Scientist leading the shark population

assessment program, and has been leading Atlantic shark stock assessments for the past 25 years. Enric served as the chair of ICCAT's shark species group from 2013 to 2020, has been a member of the IUCN SSG since 1998 and an invited expert, reviewer, and contributor for various shark-related activities at tuna RFMOs and other national and international conservation organizations such as CITES and FAO. Enric has diverse fields of interest and expertise that include earlier work on feeding ecology, followed by life history theory, demographic modelling, quantitative fisheries techniques, and stock assessment methods, including the application of methods more suitable to data-poor situations, which are often encountered when working with chondrichthyan fishes

Prof Mohamed Nejmeddine Bradai



Mohamed Nejmeddine Bradai is Professor of Higher Education. He works on the biology, ecology and conservation of marine vertebrates (fish, turtles and cetaceans).

He got an engineer degree in marine living resource exploitation from the High Institute of Agriculture in Tunis. He also prepared three postgraduate degrees (Master, Doctorate (PhD) and State Doctorate.

He is member of the Shark Specialist Group of the IUCN and contributed as scientific expert in some elasmobranchs species assessments, former coordinator of the Sub Committee "Marine Environment and Ecosystems » of the Scientific Advisory Committee (SAC) of the GFCM.

More than 150 publications mainly in international scientific journals; more than 60 of them concerning elasmobranchs (Biology, ecology, fisheries and systematic). Two identification manuals were elaborated for national trainings in the frame of some projects. He is contributing to the Mediterranean Large Elasmobranchs Monitoring (MEDLEM) database.

In addition, M N Bradai has worked as consultant on marine turtles and elasmobranchs of the UNEP's Regional Activity Centre for Specially Protected Areas (SPA/RAC) and elaborated (concerning sharks) mainly: the Action Plan for the Conservation of Cartilaginous Fishes (Chondrichthyans) in the Mediterranean Sea (2020) and the action plan for the conservation of cartilaginous fishes (chondrichthyans) in the Mediterranean coast of Egypt (2021).

Sonja Fordham

Shark Advocates International, % The Ocean Foundation, Washington, DC 20036



Sonja Fordham is the founder and president of Shark Advocates International, a non-profit project of The Ocean Foundation dedicated to the conservation of sharks and rays. She has 30 years of elasmobranch policy experience through this role and former positions with the Brusselsbased Shark Alliance and the Washington, DC-based Ocean Conservancy. Her work focuses on publicizing the plight of threatened elasmobranchs and advocating science-based remedies before fishery management and wildlife conservation bodies.

Ms. Fordham has been a leading proponent of many landmark shark conservation advances, including the United Nations International Plan of

Action, national and regional finning bans, numerous elasmobranch listings under the Convention on International Trade in Endangered Species and the Convention on Migratory Species, and catch limits under Regional Fishery Management Organizations.

Ms. Fordham maintains appointments to most U.S. government advisory panels relevant to sharks and rays. She chairs the American Elasmobranch Society's Conservation Committee and served as deputy chair of the IUCN Shark Specialist Group for nearly two decades. She has co-authored many fisheries management and shark status publications, including the global Red List assessment of chondrichthyan fishes. Ms. Fordham is a proud recipient of the U.S. Department of Commerce *Environmental Hero Award*, the Mid-Atlantic Council *Fishery Achievement Award*, the *Peter Benchley Shark Conservation Award*, and the *IUCN Harry Messel Award for Conservation Leadership*.

Prof Nick Dulvy

Simon Fraser University, Burnaby, BC 5A 1S6 Canada



Nick Dulvy seeks to lift the lid on the oceans and census the life hidden beneath. He combines Darwin's toolbox–of natural history field guides, thermometer, microscope, and dissection kit–with big-data approaches solve global environmental challenges. He measures the effects of overfishing and climate change on marine biodiversity, particularly sharks and rays. He discovered how (1) overfishing unleashes trophic cascades mediated by crown-of-thorns starfish on coral reefs, (2) marine fishes deepen due to climate change, (3) ecological subsidies from salmon and plankton can shape trophic pyramids, (4) metabolism

underlies the diversity of life histories and population dynamics, and (5) the loss of biodiversity can be predicted from species life histories and national macroeconomic attributes. Further, he is a recognised authority on extinction risk and co-chaired the International Union for the Conservation of Nature's Shark Specialist Group (SSG) for 11 years. During this time, the SSG trained 350+ scientists, producing four conservation strategies, eight key reports, publishing 1,200+ Red List assessments and the first Living Planet and Red List Indices, all of which laid the foundations for the international trade regulation of 38 shark and ray species. He is a Distinguished Professor and Canada Research Chair and is recognised as a Highly Cited Researcher in the "Cross-Field' category. He is training the next generation of conservation biologists, equipping them with tools to rewild our oceans.

Thursday, 20th October 2022

Tracking, Movement & MPAs

Keynote Address

Dr Michelle Heupel

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Movements of sharks and the people who study them

Movement ecology is fundamental to the performance and survival of species. There are a range of reasons why movement is so crucial to animals. It is often a mechanism for finding and capturing food and helps individuals encounter potential mates to ensure species persistence. Movement can also help animals avoid adverse conditions. In some cases this takes the form of seasonal migrations, in other cases it is a response to environmental change or extreme events. Therefore, how, when and where to move is vital to individuals as well as populations. Understanding how, when and where sharks move is also critical to our ability to manage and conserve their populations.

A range of tools are available for tracking shark movements, with acoustic telemetry being one of the most common. The advent of passive acoustic receivers has created the potential to monitor shark presence and movement at temporal scales not previously possible. This technology has lent itself to understanding shark home ranges in two and three dimensions, identified dispersal and connectivity within populations and identified behavioural responses to extreme weather events. The accumulation of this knowledge creates the ability to inform and underpin management and conservation efforts ranging from use of marine protected areas to identification of biologically important areas, aggregation sites and more.

Shark researchers also move as part of their performance. The ability, or inability to move to locations where shark conferences are being held was the genesis of Sharks International. Costs to travel to the US and EU to attend large conferences can be prohibitive for students, early career researchers and scientists from developing nations which reduces their ability to network with colleagues. This knowledge prompted the organisation of the first Sharks International conference in Australia in 2010. Since then the original organisers have worked to try to move the conference around the world to promote and support participation by as many people as possible by creating access to the conference in their region and supporting international connections and networks.

Diana Pazmino

1Galápagos Science Center, Universidad San Francisco de Quito, Isla San Cristóbal, Galápagos 200150, Ecuador

A combined approach to monitor elasmobranchs in marine protected areas of the Galapagos Islands

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- 2. Luke E. Holman; GLOBE Institute, University of Copenhagen, Denmark.
- 3. Alexander Forryan; School of Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton, Southampton, United Kingdom.
- 4. Alberto Naveira-Garabato; School of Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton, Southampton, United Kingdom.
- 5. Carlos Robalino; Centro Interdisciplinario de Ciencias Marinas, Instituto Politécnico Nacional, La Paz, Baja California Sur, México.
- 6. César Peñaherrera; MIGRAMAR, Bodega Bay, California 94923, United States.
- 7. Alex Hearn; Galápagos Science Center, Universidad San Francisco de Quito, Isla San Cristóbal, Galápagos 200150, Ecuador; MIGRAMAR, Bodega Bay, California 94923, United States of America.

The Galapagos Marine Reserve (GMR), a Marine Protected Area (MPA) of about 138,000 Km2 was created in 1998 to preserve its unique ecosystems and resources. More recently, in February 2022, the new MPA Hermandad was created to increase protection for highly migratory species, including elasmobranchs. This corridor of about 60,000Km2 follows the Cocos Ridge that connects Galapagos with Cocos Island in Costa Rica, and thus offers protection from industrial fisheries outside the GMR. Key seamounts within this corridor are critical to maintain population processes such as connectivity across the Eastern Pacific. The creation of Hermandad highlights the need for a baseline on the species' biology within this MPA, as well as a long-term monitoring program to track and minimise anthropogenic perturbations. Here, we used environmental DNA (eDNA), combined with cutting-edge oceanographic modelling, and Baited Remote Underwater Video Stations (BRUVS) to assess elasmobranch diversity within and among Galapagos MPAs. We deployed BRUVS and collected seawater samples in the GMR and Hermandad. We used eDNA metabarcoding to identify elasmobranch species and used particle-tracking simulations to generate maps that allowed us to estimate the potential of eDNA dispersal at unprecedented resolution. Finally, we compared our molecular results with those from BRUVs for a more comprehensive understanding of species diversity. We aimed to provide the accompanying foundations for the creation of Hermandad by providing data and monitoring tools to be used at regional scale. Such tools will foster multi-country conservation initiatives and spatial management strategies to sustain healthy population stocks and migratory processes.

Keywords: Galapagos; Marine Protected Areas (MPAs); eDNA; BRUVS; SI Abstract Ref: 286

Alex Hearn

Universidad San Francisco de Quito USFQ; MigraMar

The Hermandad Marine Reserve – Ecuador's first step to protecting migratory sharks as they leave the Galápagos Marine Reserve

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- 2. Cesar Peñaherrera-Palma, MigraMar.
- 3. Harriet Allen, York University.
- 4. Leo Zurita Arthos, Universidad San Francisco de Quito.
- 5. Maria Virginia Gabela-Flores, Universidad San Francisco de Quito.
- 6. Susana Cárdenas, Universidad San Francisco de Quito.

For twenty-five years, the Galápagos Marine Reserve (GMR) has been a global icon for marine conservation, yet there are signs that populations of sharks and other highly mobile marine species in the region are declining. Tracking studies show that species such as the Critically Endangered scalloped hammerhead shark move from Galápagos to Costa Rica's Cocos Island, across 690 km of unprotected waters, where they are vulnerable to purse seine and longline fleets. In 2019, in response to growing concerns about the effectiveness of the GMR at grassroots and political leadership levels, a task force was created to compile existing information on the distribution and movements of endangered sharks and other highly mobile marine species, to evaluate the emerging threats in the open waters outside Galápagos, and to develop and compare scenarios to strengthen protection in the region.

This culminated with the creation of the Hermandad Marine Reserve: a 30,000 km2 no-take corridor linking the GMR to the border with Costa Rica, with a further 30,000 km2 along the edges where longline gear is prohibited. Together with recent landings bans for some shark species on mainland Ecuador (where over 200,000 sharks are landed each year, despite no formal recognition of a directed shark fishery), these measures are important first steps in addressing shark conservation in Ecuador and across the region. However, challenges remain: Costa Rica must continue this protected corridor through to Cocos Island National Park; while in the GMR, ongoing illegal longline activities that threaten shark aggregations must be curtailed.

Keywords: Marine Reserve; Connectivity; Migration; Endangered; Eastern Tropical Pacific SI Abstract Ref: 35

Samantha Andrzejaczek

Hopkins Marine Station, Stanford University

Diving into the vertical dimension of elasmobranch movement ecology

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Knowledge of the three-dimensional movement patterns of elasmobranchs is vital to understanding their ecological roles and exposure to anthropogenic pressures. To date, comparative studies among species at global scales have mostly focused on horizontal movements. Our study addresses this knowledge gap by taking a large collaborative effort (170 co-authors) to compile the first global synthesis of elasmobranch vertical habitat use. Data was obtained from 989 biotelemetry tags deployed across 38 elasmobranch species spanning those inhabiting coastal and oceanic habitats from polar to tropical latitudes. Elasmobranch sdisplayed high intra- and interspecific variability in vertical movement patterns. Significant vertical overlap was observed for many epipelagic elasmobranchs, indicating an increased likelihood to display spatial overlap, biologically interact, and share similar risk to anthropogenic threats that vary on a vertical gradient. We highlight the critical next steps towards incorporating vertical movement into global management and monitoring strategies for elasmobranchs, emphasising the need to address geographic and taxonomic biases in deployments and to concurrently consider both horizontal and vertical movements.

Keywords: biotelemetry; spatial ecology; habitat use; diel vertical movement; biologging SI Abstract Ref: 9 $\,$

Vital Heim

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Large-scale movements of great and scalloped hammerheads, *Sphyrna mokarran* and *S. lewini*, between the US Atlantic and the Gulf of Mexico

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A detailed understanding of animal movement is needed to design efficient conservation strategies. Great and scalloped hammerheads, *Sphyrna mokarran* and *S. lewini*, are two large-bodied and highly mobile shark species known to suffer from high bycatch mortality in commercial and recreational US fisheries due to their high sensitivity towards stress. In this study we aimed to better understand their regional movement and residency patterns in the US Atlantic and the Gulf of Mexico using satellite telemetry and employing state-space and dynamic Brownian Bridge Movement models. Additionally, we present methods for a faster and more accurate tag-deployment protocol potentially reducing the stress experienced by the sharks. A total of 19 great and 13 scalloped hammerheads were tagged with fin-mounted Smart Position and Temperature tags (SPOT-380 and -364, Wildlife Computers) and their movements were monitored for an average of 155 days and 144 days, respectively. In both species we documented multiple long-distance (> 3000 km) migrations between the US Atlantic and the Gulf of Mexico as well as area-restricted movements as far up north as Massachusetts were recorded. Our results show that great and scalloped hammerheads use both ocean basins but also highlight the species' high individual variability in movement patterns. These data are currently being used to inform US stock assessments to determine stock identification and movement patterns.

Keywords: conservation; satellite telemetry; movement modelling; endangered SI Abstract Ref: 152 $\,$

Application of New Techniques

Guuske Tiktak

Manchester Metropolitan University

Genetic identification of three CITES-listed hammerhead sharks (*Sphyrna lewini*, *S. mokarran* and *S. zygaena*) using a paper-based Lab-on-a-Chip (LOC)

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- 2. Aaron, Carlisle, University of Delaware
- 3. Margarita, Brandt; Universidad de San Francisco de Quito
- 4. Fernando Rey, Diz; WWF Fisheries Ecuador
- 5. Karla Estefania Bravo, Vasquez; Viceministerio de Acuacultura y Pesca del Ecuador
- 6. Cesar, Peñaherrera; MigraMar
- 7. Jean-Denis, Hibbit; Sea Life
- 8. Alexandria, Gabb; Manchester Metropolitan University
- 9. Bradley, Cain; Manchester Metropolitan University
- 10. David, Megson; Manchester Metropolitan University
- 11. Richard, Preziosi, University of Plymouth
- 12. Kirsty, Shaw; Manchester Metropolitan University

Threatened species of sharks are caught in large numbers by fishers either through by-catch or when they are specifically targeted. Monitoring of threatened shark species is essential to reducing illegal fishing and sale of sharks listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Identifying sharks, particularly threatened species, can be challenging as recognisable features may be lost, especially if samples are heavily processed (e.g., dried fins, meat or supplements). Current methods of identification rely heavily on visual examination of whole caught sharks by experts or genetic techniques such as DNA Barcoding or high throughput sequencing that require specialist laboratory facilities which are costly and time consuming. We have developed a paper-based Lab-on-a-Chip (LOC) which allows for the on-site identification of three CITES-listed hammerhead sharks (*Sphyrna lewini, S. mokarran* and *S. zygaena*). The LOC integrates three processes: DNA extraction, amplification and visualisation, that can be done in under 30 minutes, and cost approximately \$0.12 per sample. The LOC incorporates Loop Mediated Isothermal Amplification (LAMP) to produce a simple "yes/no" result via a colour change from pink to yellow when the target species is present. This tool can be used by non-scientifically trained personnel, especially in areas where sharks are caught in large numbers, or where there are high instances of mislabelling and species substitution. We tested over 50 LOCs at three major artisanal fish markets in Ecuador and proved the successful identification of species from both dried fin and meat samples.

Keywords: Lab-on-a-Chip; identification; CITES; genetics; fieldwork SI Abstract Ref: 31

Colin Simpfendorfer

James Cook University; University of Tasmania

The world's largest shark survey reveals widespread diversity deficits and elevated extinction risk of coral reef sharks and rays

- 1. Colin Simpfendorfer; James Cook University.
- 2. Michael Heithaus; Florida International University.
- 3. Michelle Heupel; University of Tasmania.
- 4. Aaron MacNeil; Dalhousie University.
- 5. Mark Meekan; Australian Institute of Marine Science.
- 6. Euan Harvey; Curtin University.
- 7. Demian Chapman; Mote Marine Laboratory

The Global Finprint project surveyed elasmobranchs on 391 coral reefs in 67 nations or territories using 22,756 baited remote underwater video stations. Early results showed that reef sharks, a combination of ~50 species, had declined in many parts of the world, and were functionally extinct at ~20% of surveyed reefs. However, the aggregation of species can mask changes in individual species and species assemblages. To address these limitations we used the Global Finprint dataset to investigate (1) decline of key coral reef elasmobranchs at reef and global scales, (2) how species assemblages change with declines in shark abundance, and (3) identify the factors that influence species assemblage composition and species declines. Analyses of the five most common shark species revealed global declines of 59-73% from pre-fishing levels, meeting IUCN Red List criteria for Endangered; and that individual shark species were not detected at 34-47% of expected reefs. Ray species showed variable results at the reef level, including increases in abundance at some reefs with high shark depletion; but none had an elevated risk of extinction. Multivariate analysis identified multiple clusters of reefs with assemblages that ranged from those with intact shark populations to those with highly depleted shark populations that were dominated by rays, and those without elasmobranchs. Shark-dominated species assemblages occur in wealthy nations with strong governance that manage sharks using protected areas or shark sanctuaries; while poverty, weak governance and a lack of shark management is associated with ray-dominated assemblages.

Keywords: Baited Remote Underwater Video Stations (BRUVS); population decline; extinction risk; assemblage change SI Abstract Ref: 58

Mark Meekan

Australian Institute of Marine Science

Internal organs and body tissues of free-swimming whale sharks (Rhincodon typus) imaged using

underwater ultrasound

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- 2. Farand Thompson; Mira Mar Veterinary Hospital
- 3. Kim Brooks; Australian Institute of Marine Science
- 4. Rui Matsumoto; Okinawa Churaumi Aquarium
- 5. Kiyomi Murakumo; Okinawa Churaumi Aquarium
- 6. Alistair Dove; Georgia Aquarium
- 7. Emily Lester; Australian Institute of Marine Science
- 8. Belinda Hopper; Animalius Ltd

Ultrasound imaging can be used to measure the reproductive status and condition of sharks. This usually requires restraint of the subject, which is not feasible in the wild when the target species is of conservation concern and very large, as is the case for whale sharks. Here, we invoked a behavioral response in free-swimming whale sharks that allowed snorkelers to access and image internal organs and structures using a submersible ultrasound scanner linked to an iPhone. We were able to reliably locate and monitor the heart and other internal organs inside the head (including the brain) and body cavity of sharks and along the dorsal surface. We evaluate the technique as a means for assessing the condition and reproductive status of free-swimming whale sharks in coastal aggregations.

Keywords: condition; reproduction; heart; liver; ultrasound SI Abstract Ref: 85

Keith Fuller

Alaska Pacific University

Exploration of machine learning as a tool for sleeper shark population assessment

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Electronic Monitoring (EM) technology has found extensive applications in the field of fishery sciences. While on-vessel video recording does allow for fleet coverage beyond what on-board observers could reasonably provide, the amount of data generated from these videos requires significant investment and time to review and disseminate catch information. This has prompted exploration into machine learning technology as a tool to review EM data more quickly and accurately for fisheries assessments. The Pacific sleeper shark (*Somniosus pacificus*) are data-limited in Alaskan waters and may greatly benefit from increased EM coverage and improved, efficient processing. To test the utility of machine learning technology in the identification of *S. pacificus* from EM video data, we examined the prediction accuracy of a novel machine learning algorithm process at both a class and species taxonomic level. Results suggest that machine learning has the potential to significantly increase EM processing capability with minimal loss of accuracy for *S. pacificus* and may strengthen our understanding of the *S. pacificus* population status throughout Alaskan waters. As this technology is easily adaptable for use in other systems, the tools developed and described have potential applications for many other fisheries environments. Ongoing research seeks to build upon this foundation and develop a process to gather size data from EM video.

Keywords: electronic monitoring; machine learning; assessment; management; distribution SI Abstract Ref: 7

AZTI

Worldwide assessment of genetic diversity and demographic history of tiger sharks using historical samples

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Over the last century, species across the globe have experienced the effects of environmental and anthropogenic changes, and genetic analyses of historical collections represent a unique resource for tracking their impact on the demographic and evolutionary history of species. In this study, we focused on the tiger shark, a globally distributed highly mobile apex predator, which displays clear signs of declining abundance after decades of unregulated fishing and shark control programs. However, precise estimates of how this decline is reflected at the genetic level are still lacking. Specimens were collected worldwide, covering a wide spatial and temporal scale, dating back to 1820 and covering the South, Central and North Atlantic, the Indian Ocean from South Africa to Australia, and the Pacific from eastern Australia to Hawaii. Four hundred individuals (239 contemporary, 161 historical) were subject to DNA capture using 20.000 gene associated "baits" from which ~3000 validated SNPs were genotyped. This allowed us to perform genomic analysis of temporal changes in genetic diversity, population structure and connectivity at both spatial and temporal level. Firstly, confirming the presence of a deep evolutionary split between Atlantic versus Indo-Pacific groups, but also highlighting the presence of temporal genetic changes at a more local scale. This study has shown for the first time that genetic diversity has changed over time for tiger shark populations, raising the question whether a similar genetic pattern can be found in other apex predator species and highlighting the importance of genomic data to inform decisions for protection and management purposes.

Keywords: historical DNA; tiger shark; exome capture; population structure; phylogeography SI Abstract Ref: 163

Thomas J. Farrugia

Alaska Ocean Observing System

Adding value to data: Publicly releasing a juvenile white shark (*Carcharodon carcharias*) biologging database

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Species occurrence records are vital data streams in marine conservation with a wide range of important applications. From 2001-2020, the Monterey Bay Aquarium led an international research collaboration to understand the life cycle, ecology, and behavior of white sharks (*Carcharodon carcharias*) in the southern California Current. The collaboration was devoted to tagging juveniles with animal-borne sensors in the northeast Pacific. In total, 59 pop-up archival transmitting tags and 20 smart position and temperature transmitting tags were deployed on 63 individuals and recorded pressure, temperature, and light-level data, and computed depth and geolocations. Raw data files from successful deployments (n = 70) were auto-ingested from the manufacturer into the Animal Telemetry Network's (ATN) Data Assembly Center, where they are attributed a full suite of metadata, visualized within their public-facing data portal, compiled for permanent archive under the DataONE Research Workspace member node, and are accessible for download from the ATN data portal. Here, we report on the process of collecting, aggregating, managing, and sharing these biologging data and we discuss the benefits of making the database public. These data have spawned dozens of research papers and helped inform fisheries managers on the collective knowledge of juvenile white sharks. Truly free, complete dataset releases such as this add continuous value to initial investments, support scientific advancement and collaborative research, and further enable effective species management and conservation. We encourage other shark researchers to publicly release their biological and environmental data to a recognized data center in a timely manner.

Keywords: open data; satellite tags; FAIR principle; ecosystem-based science SI Abstract Ref: 241

Jurgen Batsleer

Wageningen Marine Research

INNORAYS: Improving our knowledge-base for North Sea rays using 'Electronic Monitoring'

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- 3. Karolina Molla Gazi; Wageningen Marine Research
- 4. Morgane Amelot; IFREMER
- 5. Gert Kootstra; Wageningen University

Under the EU landing obligation the transition from landing quota to catch quota may impede fishing activities. Especially in mixed fisheries when restrictive catch quota are fully exploited at an early stage. Skates and rays are managed under a restrictive combined TAC making them one of the main choke species within demersal fisheries in the North Sea. For most of the elasmobranch stocks in the North Sea, advice is based on an indicative trend of available scientific survey data. These surveys were initiated primarily to sample the main commercially exploited stocks and sample comparatively few elasmobranch species. This results in imprecise estimates and greater uncertainties within stock assessments. The INNORAYS project aims to gain insight in the catch composition of ray species in commercial catches using 'Electronic Monitoring'. By manually reviewing random samples of video recordings we produce representative samples of ray catches on the commercial fleet. These are validated using observer trips in which on-board observers determine the species composition, numbers and weight of rays in the catch. Manual reviewing EM recordings require relatively high costs, and human resources needed for video review can be a limiting factor. As such, the potential of automated detection of ray species in catches is explored. Improved data collection of commercial ray catches will contribute to better understand and manage 'the choke effect', stock assessments, and eventually, more sustainable fisheries management. Also, automated detection is expected to be applicable to register other species, benefiting the European policy objective of 'Fully Documented Fisheries'.

Keywords: discards; electronic monitoring; demersal fisheries SI Abstract Ref: 225

Lisa Hoopes

Georgia Aquarium

Ex-situ breeding programs as a conservation tool for imperiled sharks and rays

- 1. Grant Abel, Seattle Aquarium.
- 2. Alistair Dove, Georgia Aquarium.
- 3. Christine Dudgeon, University of the Sunshine Coast.
- 4. Mark Erdmann, Conservation International.
- 5. Fahmi, National Research and Innovation Agency Indonesia.
- 6. Charlie Danny Heatubun, Research and Development Agency of the Provincial Government of West Papua Indonesia.
- 7. Nesha Ichida, Konservasi Indonesia.
- 8. Erin Meyer, Seattle Aquarium.
- 9. Selvia Octaviani, National Research and Innovation Agency Indonesia.
- 10. Mochamad Iqbal Herwata Putra, Konservasi Indonesia.
- 11. Abraham Sianipar, Murdoch University.

Approximately one third of elasmobranch species are listed as threatened or endangered. Historically, efforts to protect and restore elasmobranchs have focused on accurate assessments of their conservation status on the IUCN Red List of Threatened Species, creation of marine protected areas where elasmobranchs aggregate, introduction and enforcement of fisheries management regulations, bycatch mitigation, and policy or legislative interventions aimed at aiding population recovery or at least arresting further declines. Now, serious consideration is being given to the potential of breeding sharks and rays in captivity and releasing offspring to the wild. This effort aligns with IUCN guidelines promoting the integration of in situ and ex situ conservation interventions by applying the One Plan approach to ensure effective use of all available conservation tools. Informed by this guidance, we show through a case study of endangered zebra sharks (*Stegostoma tigrinum*) that ex-situ management and breeding of appropriate genetic shark stocks for wild release is not only possible, but a promising approach. Public aquariums are in a unique position to lead these initiatives, taking advantage of knowledge gained about their life histories learned through professional animal care, including expertise in long-distance transport of live animals. Ex-situ approaches could therefore find a rightful place in the toolbox of methods available to conservation biologists interested in the preservation of these extraordinary animals.

Keywords: Conservation breeding; public aquariums; StAR project; reintroduction program; Indonesia SI Abstract Ref: 182

Pablo García-Salinas

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- 3. Associació Lamna

Developing new strategies for chondrichthyan conservation: the role of assisted reproduction techniques

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- 2. Victor, Gallego; Universitat Politècnica de València.
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Ex-situ breeding programs can become a complementary strategy when working towards the conservation of certain chondrichthyan species. However, controlling the reproduction of these species is essential for the development of these programs. Therefore, assisted reproductive techniques, such as sperm obtention and preservation, should be further developed.

Through a detailed description of the reproductive anatomy of 19 species, we have been able to develop techniques to obtain viable sperm, even from females in some of them. Sperm extraction has been performed through cannulation, abdominal massage, and dissection, in both live and dead animals. Moreover, we have formulated an artificial seminal plasma that can be used to maintain sperm motility for >30 days at 4 °C. By supplementing this formulation with different combinations of cryoprotectants, i.e., methanol, dimethyl sulfoxide (DMSO), and fresh egg yolk, we were able to successfully cryopreserve the sperm of 15 chondrichthyan species. Sperm samples were frozen using liquid nitrogen vapour and were preserved in liquid nitrogen. Post-thawing sperm quality was assessed by studying the sperm cells motility and their membrane integrity. In batoids, the use of 10% DMSO or 10% methanol rendered motility values higher than 40%. In selachimorphs and the holocephalan studied, the best motility values were obtained by combining 5% DMSO, 5% methanol, and 10% egg yolk, which induced mean values close to 35%.

All this new information expands our knowledge on the use of reproductive techniques applicable to chondrichthyans. It also lays the groundwork for the first sperm cryobanks for these or similar species.

Keywords: sperm extraction; cryopreservation; ex situ conservation; cryobanking; captive breeding SI Abstract Ref: 243

Rhett Bennett

Wildlife Conservation Society

Chondrichthyans of the Western Indian Ocean: threats, research and management

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- 2. Dave, van Beuningen; Wildlife Conservation Society

Forty percent (89) of the 224 chondrichthyan species in the Western Indian Ocean (WIO) are threatened, due mainly to overfishing. This is worse than the global situation (33%). The WIO contributed 12% (±90,000 mt annually) of chondrichthyan catches globally over the past decade, as reported to FAO, yet these figures are gross underestimates. Poorly-monitored artisanal fisheries dominate, contributing up to 90% of total marine fish catch in some WIO countries. Actual chondrichthyan mortality is therefore many times higher than reported. WIO states contribute 1.2% (±1,250 mt annually) of reported global chondrichthyan trade. Yet importing states report nearly double the export volumes reported overall by WIO states. These major reporting discrepancies render reported trade volumes highly unreliable. WIO countries harbour many threatened chondrichthyan species, including national and regional endemics; yet few chondrichthyans are protected. WIO states are also party to numerous multilateral environmental agreements, yet none fully implements the measures of these agreements. Domestic policy and legislation are inadequate for effective chondrichthyan management. Movement behaviour, population connectivity, ecologically important areas and reproductive aspects remain unknown for at least 75% of WIO chondrichthyan species, while aspects of age and growth remain unknown for approximately 25% of species. Ecological and biological information are inadequate for management. WIO chondrichthyans need strengthened management and conservation measures, strengthened policy and legislation, improved compliance and enforcement, improved information (ecological, biological, fishery and trade), strengthened capacity for management and improved awareness of the issues chondrichthyans face, if there is any hope of improving their dire conservation status.

Keywords: conservation; fisheries management; research priorities SI Abstract Ref: 333

Dave van Beuningen

Wildlife Conservation Society

Informing improved conservation and management of elasmobranchs in the Western Indian Ocean: insights from baited remote underwater video surveys

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- 2. Rhett Bennett, Wildlife Conservation Society
- 3. Anthony Bernard, South African Institute for Aquatic Biodiversity
- 4. Jorge Sitoe; Wildlife Conservation Society
- 5. Mike Markovina; Formerly Wildlife Conservation Society
- 6. Stela Fernando; Instituto Oceanográfico de Moçambique
- 7. Naseeba Sidat; Wildlife Conservation Society
- 8. Remy Oddenyo; Wildlife Conservation Society
- 9. Roxanne Juby; South African Institute for Aquatic Biodiversity
- 10. Aseegah Davids; South African Institute for Aquatic Biodiversity
- 11. Katie Heckendorn; Rhodes University
- 12. Isabel da Silva, Universidade Lúrio

Elasmobranchs in the Western Indian Ocean (WIO) are heavily overexploited, with 41% of the 215 known species considered threatened with extinction. Limited information and increasing fishery threats call for the improved conservation and management of elasmobranchs in this region. We conducted ecological surveys using stereo baited remote underwater video (stereo-BRUV), to provide data on elasmobranch distribution ranges, diversity, relative abundance and habitat associations. Over 1900 hour-long BRUV deployments were conducted over reef and sand habitats (5–98 m deep) across Comoros, Kenya, Madagascar, Mozambique, South Africa and Tanzania, from November 2016 to March 2022. The surveys revealed inter alia a hotspot for the Critically Endangered whitespotted wedgefish *Rhynchobatus djiddensis*, a 2000-km range extension of the Critically Endangered shorttail nurse shark *Pseudoginglymostoma brevicaudatum*, and the importance of sand habitats for elasmobranchs. Overall, South Africa and southern Mozambique displayed the highest frequency of occurrence (52% and 40% of samples with at least one elasmobranch recorded, respectively) and species richness (21 and 16 species, respectively), supporting this area's recognition as a global elasmobranch hotspot. However, frequency of occurrence overall was generally much lower than results from other regions globally. Notably, zero sharks were recorded in 165 deployments throughout Kenya, and 120 deployments in Antongil Bay in northeast Madagascar, the only designated shark sanctuary in the WIO. These findings confirm the incredible impacts of coastal fisheries on elasmobranchs in the WIO; they will help to inform area-based management measures and identify areas for focused conservation efforts for elasmobranchs in this region.

Keywords: elasmobranch; conservation; management; BRUV SI Abstract Ref: 353

Phil Doherty

University of Exeter

Artisanal fisheries catch highlights hotspot for threatened sharks and rays in the Republic of the Congo

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- 2. Godefroy De Bruyne; Wildlife Conservation Society.
- 3. Baudelaire Dissondet Moundzoho; Wildlife Conservation Society.
- 4. Emmanuel Dilambaka; Wildlife Conservation Society.
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- 12. Brendan J. Godley; University of Exeter.
- 13. Kristian Metcalfe; University of Exeter.

Global catch rates of sharks and rays from artisanal fisheries are underreported with a lack of data on landings, forming a major barrier to developing effective management plans. We undertook the first systematic quantitative assessment of sharks and rays landed by an artisanal fishery in the Republic of the Congo to address this knowledge gap. Across 507 sampling days, 73,268 individuals were recorded from 42 species; 81% of which are considered at an elevated risk of extinction. Observed landings were dominated by immature individuals, especially species of conservation concern such as scalloped hammerhead sharks (*Sphyrna lewini*) and blackchin guitarfish (*Glaucostegus cemiculus*). Individuals from species thought to have largely disappeared from the region such as the African wedgefish (*Rhynchobatus luebberti*), as well as new records of smoothback angelshark (*Squatina oculata*) were identified suggesting that Congolese waters are a potential stronghold that warrants increased protection. Intra-annual variation was shown to occur in catch levels, but no evidence of inter-annual variation, suggesting seasonal fluctuations, but consistent levels of catch year-on-year. An interaction effect between species and temporal scales occurred whereby intra- and inter-annual trends were evident for some species. Overall catch of sharks and rays was higher between the short-wet and long-wet seasons (January-February) and towards the end of the long-dry season (August-September), with lowest level of shark catch observed during the short-wet and short-dry seasons (October-December). These findings emphasise the need to increase engagement with the artisanal fisheries sector to fill key knowledge gaps, that may identify hotspots for otherwise imperilled species.

Keywords: Africa; bycatch; conservation; management; smale-scale fisheries SI Abstract Ref: 41

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Past, present, and future status of deepwater sharks and rays

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- 2. Nathan, Pacoureau
- 3. Cassandra L., Rigby
- 4. C. Samantha, Sherman
- 5. Wade J., VanderWright
- 6. Colin A., Simpfendorfer
- 7. Nicholas K., Dulvy
- 7. INICIOIAS K., DUIVY

Deepwater sharks and rays comprise half of the global diversity of all 1,199 chondrichthyans but are amongst the most challenging species to monitor and evaluate. Increased exploration into deeper waters and new regions, combined with technology advances, has improved our knowledge of this relatively poorly known habitat. Fisheries have also expanded into deeper waters leading to concerns for the ability of deepwater sharks and rays to withstand the expansion and intensification of exploitation. The global extinction risk of all 521 deepwater sharks and rays were recently updated as part of the Global Shark Trends Project, providing insight into the life histories, threats (e.g., fisheries), and drivers (e.g., liver oil trade) these species face. We show that many deepwater sharks and rays have low maximum intrinsic rates of population increase more comparable to marine mammals, and find examples of localised depletion and rapidly collapsing stocks in many parts of the world. Deepwater sharks and rays are noted as priorities for assessment and protection, with some fisheries bodies adhering to strict management actions such as no take policies and spatial closures. However, most species lack species-specific management and are still subject to intensive fishing activities, particularly in countries where they are an important marine

resource for local communities. The global status of deepwater sharks and rays and future research directions to address knowledge gaps will be presented.

Keywords: extinction risk; liver oil; skate trade; deep-sea SI Abstract Ref: 138

Eva Meyers

Zoological Research Museum Alexander Koenig; Angel Shark Project

Coordinated action for the conservation of Critically Endangered angel sharks

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 David Jiménez Alvarado; Universidad de Las Palmas de Gran Canaria; Angel Shark Project
- 4. Michael Sealey: Angel Shark Project: Canary Islands
- 5. Maria Belén Caro; Angel Shark Project: Canary Islands
- 6. Hector Toledo; Angel Shark Project: Canary Islands
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- 10. Airam Sarmiento Lezcano; Universidad de Las Palmas de Gran Canaria
- 11. Lucy Mead; Institute of Zoology, Zoological Society of London
- 12. David M.P. Jacoby; Lancaster University
- 13. Sara A.A Al Mabruk; Marine Biology Libya
- 14. Ioannis Giovos; iSea
- 15. Roxani Naasan Aga Spyridopoulou, iSea
- 16. Patrick Krstinic; WWF Adria
- 17 Simone Niedermueller, WWF
- 18. Caroline Bousquet; University of Corsica
- 19. Louise Overy, Irish Elasmobranch Group
- 20. Jake Davies, Zoological Society of London & Natural Resources Wales
- 21. Ben Wray, Natural Resources Wales
- 22. Cat Gordon: Shark Trust
- 23. Ali Hood; Shark Trust

Eight years ago, the Angel Shark Project was established with the aim of securing the future of Critically Endangered angel sharks (*Squatina squatina, S. aculeata* and *S. oculata*) across their ranges. The Canary Islands was identified as a uniquely large stronghold for the Angelshark (*Squatina squatina*) and has quickly become a natural laboratory to investigate the biology and ecology of this cryptic shark.

Today, the data gathered in the Canary Islands has contributed to the development and implementation of targeted conservation measures and has led to the expansion of regional Angel Shark Projects across the Eastern Atlantic and Mediterranean Sea, to deliver priority policy outcomes across six countries. This two-way exchange of information between partners across the angel shark species' ranges has been vital to better coordinate conservation action.

In this presentation we will highlight some of the key research elements and milestones from our work in the Canary Islands, such as the identification and use of the largest nursery area known to date for *Squatina squatina* and first results from our population connectivity analysis.

The information obtained from these projects has been key to implement conservation activities such as those included in the Angelshark Action Plan for the Canary Islands, a plan developed by a multi-disciplinary group of stakeholders alongside the Canary Island Government and Spanish Government, to address the major threats to Angelshark populations.

Keywords: angel shark; conservation; ecology; collaboration; squatina SI Abstract Ref: 330 $\,$

Dr KK Bineesh

Zoological Survey of India

Guitarfishes and Wedgefishes in Indian fisheries: Catch, species composition, distribution and current status

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- 2. Jithu Sunny; Zoological Survey of India
- 3. K. K. Bineesh; Zoological Survey of India

India is one of the leading chondrichthyan fishing nations. Guitarfishes and Wedgefishes are the most threatened species of elasmobranchsin India. The present paper is an attempt to provide new information on catch, taxonomy, current distribution, fleet size, trade and usage of Guitarfishes and Wedgefishes in India. This study based on the landing site surveys conducted during the years 2017-2020 at major fish landing centres along west and east coast of India and Andaman and Nicobar Islands.

The present findings revealed a total of 10 species caught in commercial and artisanal fisheries. Trawl survey show that Acroteriobatus variegates distribution restricted to southern cost of India. Rhinobatos lionotus also restricted to north east coast of India from West Bengal to Tamil Nadu coast. Our survey found that Glaucostegus typus and Rhina ancylostoma contribute average of 12% of total batoids catch in the target ray fisheries in the Andaman and Nicobar Islands. Bottom set gill net contribute 90% of the catch and others by longliners catch. However, trawlers targeting shrimp contribute 94% of the catch and remaining catch by gillnets. Present study observes over 120 location sightings of Giant Guitarfish (Glaucostegus typus) indicate that giant Guitarfishes occur widely in Andaman and Nicobar Islands and the frequent sightings of juveniles (<75 cm) individuals in shallow reef and sandy beaches using as nursery areas. Our data suggest that population of all Guitarfishes and Wedgefishes in Indian waters declined drastically pointing out immediate management actions to protect Guitarfishes and Wedgefishes.

Keywords: Rhinopristiformes; species composition; Indian EEZ; Conservation; diversity SI Abstract Ref: 344

Jane Williamson

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Diversity, diets, dynamics, and destinations of sawsharks from southern Australia

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Sawsharks inhabit deeper waters of the continental shelves and slopes and comprise regular by-catch in commercial fisheries in southern Australia. Unfortunately, our knowledge of their biology, behaviours, genetic diversity, geographic distribution, and trophic ecology is poor in comparison to other elasmobranchs caught. Here we discuss outcomes from a concerted research effort on the common (*Pristiophorus cirratus*) and southern (*P. nudipinnus*) sawshark that inhabit these waters. Spatiotemporal data from commercial fishery datasets show that sawsharks occur at shallower and deeper depths than previously thought, and that their geographical range is wider than previously documented. Pop-up satellite archival tags (PSATs) deployed on three *P. cirratus* showed a surprising amount of diel vertical movement for this species, and that sawshark horizontal and vertical movement is likely to be complicated. Both species of sawshark differ in their trophic niches yet appear to display commonalities in rostrum use. Genetic analyses indicate that the two species caught in Australian fisheries display differing population structures, suggesting that separate management units may be required for effective management of these sawshark species. Understanding the drivers of diversity, dynamics, and diets of these sawsharks and how these relate to movement will help to better define the physiological, behavioural, and ecological roles of these sawsharks in their ecosystems. Such outcomes can be used to inform management decisions for this lesser-known group of elasmobranchs.

Keywords: fisheries; genetics; movement; Pristiophorus; trophic ecology SI Abstract Ref: 191

Jim Ellis CEFAS, UK

Understanding the status of data-limited, coastal skates: A case study of small-eyed ray *Raja microocellata*

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- 3. Joana Silva; CEFAS
- 4. Sophy McCully Phillips; CEFAS

Small-eyed ray *Raja microocellata* is a medium-sized (to 91 cm total length) skate species which occurs in discrete areas of localised abundance (typically shallow-water sandy bay) across its geographical distribution, which ranges from Morocco to the British Isles. This species is not encountered frequently in many trawl surveys, given its localised and shallow-water distribution, and it is a data-limited species over much of its geographical range. Two areas where the species is encountered more frequently include the Bristol Channel and English Channel, and the available information for these nominal stocks are summarised here. It is one of the more frequent skates in the Bristol Channel, especially in Carmarthen Bay. Biomass indices

of small-eyed ray in this area have shown a decline over the time-series, though the index has been relatively stable since 2006. Small-eyed ray has a patchy distribution in the English Channel, occurring in certain bays along the southern UK coastline from Mount's Bay (western Channel) to Pevensey Bay (eastern Channel), as well as around the Channel Islands and coast of France (e.g. Baie de Veys). The smallest size classes generally occur in shallow water, including the shallow sublittoral zone, with larger individuals occurring further from shore. The lengths of the smallest mature (and largest immature) specimens were 65 cm (74 cm) for males, and 73 cm (82 cm) for females. Their diet is composed primarily of *Crangon crangon*, mysids, teleosts and amphipods, with smaller individuals predating on small crustaceans and larger fish becoming increasingly piscivorous.

Keywords: Rajiformes; North-east Atlantic; population status; life-history SI Abstract Ref: 42

Edy Setyawan

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Long term residency of juvenile reef manta rays in the nursery habitat of Raja Ampat's Wayag Lagoon

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- 3. Rahmad, Hidayat; Balai Kawasan Konservasi Perairan Nasional Kupang.
- 4. Ferdinand, Bata; Balai Kawasan Konservasi Perairan Nasional Kupang.
- 5. Azhar, Muttaqin; Balai Kawasan Konservasi Perairan Nasional Kupang.
- 6. Yusup, Wailegi; Balai Kawasan Konservasi Perairan Nasional Kupang.
- 7. Imanuel, Mofu; BLUD UPTD Pengelolaan KKP Kepulauan Raja Ampat.
- 8. Orgenes, Ambafen; BLUD UPTD Pengelolaan KKP Kepulauan Raja Ampat.
- 9. Mochamad, Putra; Konservasi Indonesia.
- 10. Abdi, Hasan; Konservasi Indonesia.
- 11. Rochelle, Constantine; The University of Auckland.
- 12. Ben, Stevenson; The University of Auckland.
- 13. Fabrice, Jaine; Sydney Institute of Marine Science/Macquarie University

The behaviour and spatial use patterns of juvenile manta rays within their critical nursery habitats remain largely undocumented. Here, we report on the residency and fine scale movements of juvenile reef manta rays (*Mobula alfredi*) at a recently confirmed nursery site in the Wayag lagoon, Raja Ampat, Indonesia. Using photo-identification and acoustic tracking, we provide evidence of long-term residency of juvenile *M. alfredi* in Wayag lagoon. A total of 39 juvenile rays were photo-identified from 62 sightings in the nursery between 2013–2022. Five (12.8%) of these individuals were resighted for at least 486 days (~1.3 years), including two juveniles resighted after 744 and 745 days (~24 months), still using the nursery. Nine juveniles were tracked using passive acoustic transmitters for 69–439 days (mean \pm SD: 182 \pm 109) from May 2019–September 2021. All acoustically tagged individuals displayed high residency within the nursery area with some detected continuously for up to 4 months in the lagoon, and no acoustic detections recorded outside the lagoon in the broader Raja Ampat region. These juveniles were detected by receivers in the lagoon throughout the 24 h diel cycle, but showed different patterns of spatial use of the lagoon between day and night. The observed long-term residency of juvenile M. alfredi provides further compelling evidence that the Wayag lagoon is an important nursery area for this globally vulnerable species. Further updates on the fine scale movements of the juvenile *M. alfredi* in the Wayag lagoon in 2022 will also be presented.

Keywords: acoustic telemetry; marine megafauna; elasmobranch; coral reefs; site fidelity SI Abstract Ref: 346

Rachel T Graham MarAlliance

The status of sharks and rays in Belize: a decadal country-wide assessment

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- 2. Ivy E. Baremore
- 3. Hilmar Salazar
- 4. Alexander Zeddy Seymour
- 5. Dan Castellanos
- 6. Clara Sabal
- 7. Kate Philpot

Large-scale and repeatable standardized monitoring of marine megafauna in low and middle income tropical countries is often difficult to achieve due to limited resources and lack of governmental will. As sharks and rays tend to have long generational times, long-term surveys are needed to assess the recovery of these species in response to policies and conservation measures. Although sharks and rays are integral to the tourism economy of Belize, baseline information for the iconic marine species is lacking across much of the Belize Barrier Reef. We implemented country-wide surveys of marine megafauna in 2012

and 2022 using three complementary standardized methods: underwater visual census (UVC) snorkel transects, baited remote underwater video (BRUV), and scientific longline. Species diversity, abundance, and density was estimated overall and compared among sites and across the decade to determine the status of the coral reef-associated elasmobranch species. These surveys will enable conservation and management agencies to assess how the decade-long protection of nurse sharks, implementation of marine reserves, and managed access have affected the nearshore elasmobranch populations. Results will also serve as a benchmark from which to gauge the effectiveness of recent legislation, including a gillnet ban, restrictions on shark fishing at remote atolls, and the protection of all ray species in Belize. The use of three concurrent methods allowed for robust assessment of most coral reef-associated elasmobranchs, as each method was uniquely suited to observe species with differing behavior and habitat preferences.

Keywords: BRUV; longline; UVC; Elasmobranch; marine reserve SI Abstract Ref: 369

Fisheries & Trade

Kevnote Address

Dr Enric Cortes

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A historical overview of data and approaches used to assess the status of shark populations: experiences from the USA and ICCAT in the Atlantic Ocean

The status of shark stocks in the U.S. Atlantic has been assessed since the 1990s and ICCAT started assessing the main pelagic species in 2004. Concurrent with the development of stock assessment methods used to determine population status and recommend sustainable catch levels, conservation-oriented approaches (e.g., matrix populations models, extinction risk equations) were also being developed to gain a basic understanding of the population ecology of species and assess their vulnerability to fishing and extinction. Although these two approaches-fisheries and conservation-have different philosophies, both share biological data requirements that have allowed for cross-pollination to ultimately address practical fisheries and conservation issues. Examples of these synergies are the derivation of intrinsic population growth rates, position of the inflection point of population growth curves, and generation times that can be used in both approaches. Models used to assess stock status have evolved in part as data availability improved, ranging from production models initially to models with increasing data requirements, such as integrated models. More recently, there has been an emergence of data-poor methods that will increasingly be used for species with limited data. Of the 46 shark stocks currently managed in the U.S. and of all the species managed by ICCAT only a small proportion has been formally assessed owing to a variety of reasons, in many cases scarcity or unreliability of data. Among the main data gaps preventing more reliable stock assessments are a better characterization of total catches, an issue plagued with uncertainty owing to the difficulty of estimating discard rates in many fisheries; development of more reliable indices of relative abundance (CPUE); and lack of dedicated biological (e.g. length, age) data collection programs for elasmobranchs. While life history information for sharks is relatively well known, there remain notable knowledge gaps for most species, including breeding frequency, stock-recruitment relationship, longevity, and natural mortality (M). In particular for M, more extensive use of satellite tagging data will allow empirical estimation to compare to values derived with life-history invariant methods. It is also anticipated that a more generalized use of genetic approaches (e.g., close-kin mark-recapture, genomics, epigenetics) in the future will allow independent estimation of critical parameters used in stock assessment and conservation approaches, such as total abundance, M, and lifespan.

Maria José Juan-Jordá

AZTI, Spain

Seventy years of tunas, billfishes, and sharks as sentinels of global ocean health

Maria José Juan-Jordá, Hilario Murua, Haritz Arrizabalaga, Gorka Merino, Nathan Pacoureau, Nicholas K. Dulvy

Fishing activity is increasingly monitored but its effects on biodiversity are mostly not. Using the iconic and well-studied tunas, billfishes, and sharks, we calculate a continuous Red List Index of yearly changes in extinction risk over 70 years to track progress towards global sustainability and biodiversity targets. We show that this well-established biodiversity indicator is highly sensitive and responsive to fishing mortality. After almost 58 years of increasing risk of extinction, effective fisheries management has shifted the biodiversity loss curve for tunas and billfishes while the undermanaged sharks continue to worsen. While the rebuilding of highly valuable commercial species is happening, the next management challenge is to halt and reverse the harm afflicted by these same fisheries to broad oceanic biodiversity.

Keywords: Red List index; extinction risk; fisheries management; highly migratory species; oceanic biodiversity SI Abstract Ref: 93

David Curnick

Institute of Zoology, ZSL

Double trouble: Illegal fishing and climate change are negatively impacting reef sharks within a large MPA

It has been suggested that large, remote marine protected areas (MPAs) offer considerable refuge to populations of reefassociated sharks. A large no-take MPA around the Chagos Archipelago was established in 2010, covering 640,000 km2 of then near pristine tropical coral reefs and habitats. However, since the MPA's creation, the area has been targeted by illegal fishers and subject to significant pulses in sea surface temperature.

Through a multidisciplinary approach of telemetry, stable isotope analysis, environmental DNA and fisheries surveys, we illustrate the impact these two stressors are having on the elasmobranch community and specifically two sympatric reef shark species, silvertip sharks Carcharhinus albimarginatus and grey reef sharks Carcharhinus amblyrhynchos.

Reef sharks make up the majority of catches seized from illegal fishers targeting the archipelago, with boats predominantly coming from Sri Lanka and India. This extraction has significantly suppressed local populations, especially in regions far from where the patrol vessel is based. Simultaneously, reef health has significantly deteriorated as a result of a mass coral bleaching event in 2015/16. This has led to a convergence and narrowing of the feeding ecology of silvertip and grey reef sharks, indicating greater inter-specific competition. This impact was less evident in offshore habitats and submerged banks, where coral reefs were less impacted by bleaching due to greater flushing.

Our results demonstrate that whilst MPAs can provide real conservation benefits for reef sharks, they need to be well-enforced for these benefits to be realised but, regardless, are still subject to global stressors beyond their boundaries.

Keywords: illegal, unreported, unregulated fishing (IUU); bleaching; shark conservation; marine protected areas; climate change

SI Abstract Ref: 360

Sophy McCully Phillips

Cefas; IUCN SSG

Threatened, endemic and harvested - two overlooked European skates

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- 3. Pascal, Lorance; IFREMER.
- 4. Francisco, Baldó; IEO.
- 5. Jim, Ellis; Cefas.

Sandy ray Leucoraja circularis and shagreen ray *L. fullonica* are large-bodied skate species occurring in the Northeast Atlantic and Mediterranean on the edge of the continental shelf and upper slope. These areas are not sampled effectively by fishery-independent trawl surveys, and fisheries-dependent data are also limited, as these species are landed as a bycatch. Consequently, there are no formal assessments or reference points, even though they are harvested as part of the Total Allowable Catch (TAC) for generic skates and rays. The implementation of data-limited assessment methods is often reliant on robust life-history data, which was lacking. Therefore, biological data were collected from 116 specimens of *L. circularis* (21–116 cm LT) and 54 specimens of *L. fullonica* (19–100 cm LT). Length at 50% maturity for *L. circularis* was estimated at 81 cm LT and 100 cm LT for males and females, respectively. This large size at maturity makes them more biologically vulnerable than other skate species managed under the generic TAC. This inherent vulnerability, low representation of mature individuals in trawl surveys and bycatch risk due to spatial overlap with important commercial fisheries suggests that both species, assessed as Threatened, would benefit from precautionary species-specific management measures. *L. circularis* and *L. fullonica* are respectively, the only IUCN listed Endangered and Vulnerable elasmobranchs that are endemic to Europe and also occur in UK waters. Therefore, with the eastern Atlantic being the main part of their distribution, urgent research and management action is of even greater importance to conserve them.

Keywords: Endemic; IUCN Red List; life-history; Rajidae; fisheries-independent SI Abstract Ref: 49

Ho Kooi Chee

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Developing solutions to mitigate impacts of fishing trawlers on elasmobranch, Sabah, Malaysia

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- 2. Manjaji Matsumoto, Bernadette Mabel; Borneo Marine Research Institute, University Malaysia Sabah.
- 3. Pilcher, Nicolas James; Marine Research Foundation

The seas around Sabah are home to the richest elasmobranch biodiversity in Malaysia. However, many elasmobranch species are caught accidentally by fishing trawlers. These incidental catches of elasmobranch are one of the greatest threats faced by the species. In Malaysia, elasmobranch is mainly caught in the commercial fishing industry, especially by demersal trawlers. This has led to changes in their species composition and abundance, and in some cases, drastic population declines. Moreover, there is no information on where and when these capture events occur. To ascertain when and where these species are caught, electronic monitoring cameras were installed on fishing trawlers to capture images of elasmobranch that were landed on fishing vessel decks. Images of species such as Scalloped Hammerhead Shark, Spottail Shark, Brownbanded Bambooshark, Coral Catshark, Eastern Cowtail Stingray, Longtail Butterfly Ray, and Bottlenose Wedgefish were captured by the electronic monitoring cameras. These images are time- and GPS-stamped, and this provides us with accurate location data for each capture. Images of trawl-caught elasmobranch that were captured by the cameras were identified by using a field guide, and species distribution maps were produced by combining all the location data. These data will be used to investigate the spatial and temporal trends of trawl-caught elasmobranch, that hopefully can be used for future conservation management of the species to address the accidental catches of elasmobranch, such as to protect the species in the hotspot areas from trawling.

Keywords: accidental catch; electronic monitoring cameras; elasmobranch; fishing trawlers; hotspot area SI Abstract Ref: 247

Aaron MacNeil

Dalhousie University

Decomposing the global shark meat trade

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- 2. Christopher, Mull; Dalhousie University
- 3. Elizabeth, Babcock; University of Miami
- 4. Demian, Chapman; Mote Marine Laboratory
- 5. Luke, Warwick; Wildlife Conservation Society
- 6. Zoya, Tyabji; Dalhousie University
- 7. Devanshi, Kasana; Florida International University

Understanding trade in marine resources is challenging given the high uncertainty surrounding total catches, domestic consumption, imports, and exports. This challenge is further confounded for sharks and rays that present very different markets for fin versus non-fin commodities – including meat, oil, and cartilage. While the global trade in shark fins is relatively well understood, trade in shark meat presents a potentially increasing threat to populations, driven in part by increasing demand and potential emergence of new markets as the result of "fins attached" policies. Here we decompose global trade in shark and ray meat products using a unique statistical modelling approach and expert opinion, revealing both broad trends in demand as well as the identities of the species involved. This work establishes a new baseline for monitoring trade in shark meat and understanding the role of regulatory change in addressing demand for shark and ray products.

Keywords: trade; landings; Bayesian; CITES SI Abstract Ref: 167

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Shark and ray meat consumption as a threat to India's elasmobranchs

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The consumption of shark and ray products is increasingly recognised as a significant driver of their fisheries, globally. Historically driven by medicinal and cultural uses, and the low price of elasmobranch meat, the economics of consumption are shifting, although very little data exists, especially on elasmobranch meat consumption. We examined elasmobranch consumption in India, a top shark fishing nation globally. We surveyed 2649 seafood restaurants across nine coastal states and found that 9% advertised elasmobranch meat. 137 restaurants in four cities alone accounted for 58.5 tonnes of meat sales annually. In Goa, the state with the highest number of restaurants advertising elasmobranchs, we identified that not only local residents, but foreign tourists were driving the demand for elasmobranch meat. Small-bodied and juvenile sharks seem to be most at risk. Increasing prices of elasmobranch meat could dissuade the majority of restaurants from serving elasmobranchs, but might also drive future conspicuous consumption.

Keywords: threatened species; shark meat; wild meat; wildlife trade SI Abstract Ref: 150 $\,$

Carolina de la Hoz Schilling

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The role of Mauritania in regional and international elasmobranch trade

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Mauritanian waters are some of the worlds' most productive and highly sought-after fishing grounds for foreign industrial and regional small-scale fisheries. They are home to over 110 elasmobranch species, many of which have been heavily exploited in recent decades. However, catches and landings remain poorly monitored with limited data available and frequently reported illegal, unreported, and unregulated activities. We assessed Mauritania's role as a potentially important commercial hub for elasmobranch products using various survey approaches including molecular methods for species identification, fisher and trader interviews, and processing site surveys. We report our species diversity checklist, estimates of composition and size of elasmobranch landings, and regional and international trade characteristics and routes. Preliminary results suggest that a conservative estimate of 20,000 - 30,000 individuals of over 30 species are traded monthly through Mauritania's largest elasmobranch processing site, with over two thirds of species classified as Vulnerable, Endangered or Critically Endangered by the IUCN Red List of Threatened Species. Fins and meat are destined for different consumer markets, including Asia, Europe and West African countries. Shark landings are dominated by the milk shark (*Rhizoprionodon acutus*), smoothounds (*Mustelus spp.*), and hammerhead sharks (*Sphyrna spp.*), while ray landings are primarily composed of butterfly rays (*Gymnura spp.*), bulcated species include those listed on Appendix II of CITES. Our results suggest that Mauritania plays an important role in regional trade and that current exploitation levels are likely unsustainable.

Keywords: West Africa; data poor region; threatened species; conservation; genetics ${\it SI}$ Abstract Ref: 132

Demian Chapman

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Monitoring the species composition and species incidence over time in a globally important dried fin trade hub as an indicator of regulatory outcomes for threatened species

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- 3. Andrew Fields; Texas A & M University
- 4. Huarong Zhang; Kadoorie Farm & Botanic Garden
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- 8. Kevin Feldheim; Field Museum of Chicago
- 9. Kwok Ho Shea; Bloom Association

Hong Kong Special Administrative Region of the Peoples Republic of China ("Hong Kong") is one of the world's largest fin importers, trading with ~ 80 nations annually. We monitored the species composition of this market from February 2014 to the present. We randomly selected ten out of ~ 300 dried seafood vendors on a monthly basis and from each purchased two bags of "fin trimmings", tissues that have been trimmed from the primary fins (i.e., dorsal, pectoral, caudal) to improve their visual appeal. We randomly selected ten trimmings per bag and used DNA mini-barcoding of the cytochrome oxidase I to identify them to species and in some cases used DNA zip-coding of the control region to trace them to population-of-origin. Here, we present analyses of the species composition of the trade and incidence of key species from 2014-2018 (N=9,820 trimmings). Eighty-six chondrichthyan species were detected, 70.9% of which are listed in threatened categories by the International Union for the Conservation of Nature. Since ~34% of all chondrichthyans are in threatened categories, the species in the Hong Kong fin market are disproportionately threatened with extinction. Listings of some threatened species on Appendix II of the Convention on International Trade of Endangered Species (CITES) and species-specific retention bans by nations and Regional Fishery Management Organizations appear to be having mixed outcomes on species incidence in trade. Continued monitoring of this trade hub will help us understand how upstream regulatory mechanisms affect international trade of these species and the implications for their conservation.

Keywords: fin trade; Asia; DNA barcoding; trade regulation; global conservation SI Abstract Ref: 235

Spatio-temporal Patterns

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Moving North, season 2 - how does the "Arctic Sea Rabbit" extend its range into polar waters?

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Many species inhabiting the deep oceans migrate horizontally and vertically through the water, exposing them to different environmental conditions and allowing them to choose their preferred habitat within their physiological limits, including temperature. Ongoing northward expansions of boreal species, an increasingly connected food chain and a gradual reduction in the ice-associated ecosystem are consequences of ongoing "Atlantification" in the Barents Sea. Here, we show with habitat modelling based on a 26-year survey time series that a frequently bycaught cartilaginous fish, the rabbitfish (Chimaera monstrosa), has significantly shifted

its abundance centre of gravity northwards by over 1 degree in the Norwegian Sea, now crossing the Arctic Circle. This can largely be explained by environmental changes through time. Additionally, individuals are now caught up to 73.8°N in the Barents Sea and Arctic fjords. In addition, we analysed and compared the life history traits of individuals emerging beyond the Arctic Circle of C. monstrosa which may, together with other tools, allow the delimitation of stock boundaries to define exploitable units and determine the spatial scales at which fisheries can best be managed. With forecasts indicating intensification of "Atlantification" in the coming years, monitoring and managing emerging species in the vast Arctic coastline is a real challenge for the future. Industries are turning towards the warming Arctic to find expeditious shipping routes, exploit new fisheries, and install new infrastructure in the Arctic that will create synergistic stressors with the changing water encountered by animals.

Keywords: Climate change, Community shift, Chimaera monstrosa, Life history traits, Species distribution modelling SI Abstract Ref: 319

Diana Catarino

Okeanos - Marine Sciences Institute (University of the Azores)

Challenges in deep-water sharks monitoring and conservation: Comparing non-invasive monitoring techniques with longlines catches

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Deep-sea elasmobranchs are characterized by low reproductive rates, slow growth, and late maturity, which makes them particularly vulnerable to changes in their environment and to direct or indirect fishing mortality. Deep-water elasmobranchs are also difficult to monitor since they live in a harsh, extreme and remote environment, making it difficult to assess their population trends and specific vulnerabilities.

Traditional biomonitoring methods typically rely on fishing methods and on the observation and collection of whole organisms, combined with morphology-based identifications. Fishing methods are extremely invasive, and in many cases lethal. Here we aim to compare the efficiency of two non-invasive techniques: environmental DNA (eDNA) and Baited Remote Underwater Video (BRUV) surveys, with traditional methods (longline fishing scientific surveys) to study the biodiversity and abundance of deep-sea elasmobranchs. For this purpose, we performed water sample collection along with longline deployments from depths between 150-1500 m around the 9 islands of the Azores and on several seamounts, from 2018 to 2021. For some of the deployments we also conducted BRUV surveys between 700-800m depth. The eDNA was analyzed using a metabarcoding approach with 12S and COI markers to unravel Elasmobranch biodiversity and relative abundances. The eDNA sequence reads were compared with CPUE for correlation of relative abundances between the two methods. Species composition for eDNA, BRUV and longline assemblages are compared for biodiversity assessment between methods, and eDNA reads are compared with BRUV abundances and CPUE from longline catches, for correlation of relative abundances between methods.

Keywords: deep-sea ; eDNA; BRUV; longline fishery; SI Abstract Ref: 339

24

Guido Leurs

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Separated by a tide: trophic interactions of sharks, rays and migratory shorebirds in tropical intertidal areas

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- Sidi Yahya Cheikna Lemrabott, Institut Mauritanien de Recherches Océanographiques et de Pêches, Mauritania & University of Groningen. Netherlands.
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- 4. José Alves, University of Aveiro, Portugal.
- 5. Assana Camará Asca, , Instituto da Biodiversidade e das Áreas Protegidas, Guinea-Bissau.
- 6. Ana Coelho, University of Aveiro, Portugal.
- 7. Lilísio Dos Santos, Instituto da Biodiversidade e das Áreas Protegidas, Guinea-Bissau.
- 8. Hacen el-Hacen, University of Groningen, Netherlands.
- 9. Can Kahyaoglu, University of Groningen, Netherlands
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- 14. Afonso Rocha, University of Aveiro, Portugal.
- 15. Marc van Roomen, SOVON Vogelonderzoek Nederland, Netherlands.
- 16. Han Olff, University of Groningen, Netherlands
- 17. Laura L. Govers, University of Groningen, Netherlands & Royal Netherlands Institute for Sea Research, Netherlands.

Intertidal areas are highly dynamic coastal ecosystems, which traditionally have been studied from a shorebird-perspective. We show that these areas are also important for marine predators like sharks and rays, as these species use intertidal habitats during high tidal phases as refuge or as feeding areas to feed on benthic communities. We focused on two tropical intertidal areas, the Banc d'Arguin (Mauritania) and the Bijagós Archipelago (Guinea-Bissau) to show that intertidal areas allow 'high-tide predators' (e.g. sharks and rays) to (in)directly interact with 'low-tide predators' (e.g. migratory shorebirds), as these predatory guilds use the same intertidal habitats and associated resources in different tidal phases. Specifically, we determined the trophic niches of sharks and rays within these systems, and how their niches overlap with those of migratory shorebirds; how resources and niches are partitioned by both predator guilds; and how predation by sharks and rays has changed over the past decades. We show that changes in elasmobranch abundance due to overexploitation in these intertidal areas undermine the role of this vulnerable species group. Changes in the relative abundance of these important high-tide predatory guilds such as migratory shorebirds. We argue that intertidal areas, with possible consequences for other predatory guilds such as migratory shorebirds. We argue that intertidal areas should be studied from a perspective including both low-tide and high-tide predatory guilds, and their possible ecological interactions. The loss of elasmobranch predatory species and intertidal habitat globally provides additional convincing arguments for the conservation of these important coastal areas.

Keywords: Elasmobranchs; fisheries; ecological interactions; foodweb; intertidal ecology SI Abstract Ref: 221

Robert Priester

Okeanos - Unversity of the Azores

A multidisciplinary glimpse at the coastal habitat use of two highly migratory shark species around the Azores, Mid Atlantic

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- 3. Robert, Priester; Okeanos University of the Azores.
- 4. Diya, Das; Okeanos University of the Azores.
- 5. Miguel, Gandra; CCMAR University of the Algarve.
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- 9. Jan, Dierking; GEOMAR Helmholtz Centre for Ocean Research Kiel.
- 10. Thomas, Hansen; GEOMAR Helmholtz Centre for Ocean Research Kiel.
- 11. David, Abecasis; CCMAR University of the Algarve.
- 12. Pedro, Afonso; IMAR/Okeanos University of the Azores.

Identifying, understanding, and protecting areas that support life stages essential to population persistence can have a significant contribution to species conservation. The Azores Islands, Mid Atlantic, are thought to serve as essential fish habitats (EFH - habitats necessary to fish for spawning, breeding, feeding or growth to maturity) for tope (*Galeorhinus galeus*) and smooth hammerhead (*Sphyrna zygaena*) sharks, but data to better assess their importance and functioning are scarce.

We investigate the habitat and feeding ecology of these two species using complimentary approaches (active and passive biotelemetry, baited remote underwater video systems, scientific fishing, local ecological knowledge interviews, and stable isotope analysis). We found that young smooth hammerhead sharks (< 160 cm total length) use the north shore of Faial Island as a nursery area, characterised by localized aggregations persisting across years, insular residence times of up to 4 years and predominantly coastal-benthic isotopic signatures. Tope sharks appear to use the islands as a pupping and nursery ground across years, with indications of an ontogenetic shift after maturity (ca. 140 cm total length) with only adult females remaining in inshore waters with persisting coastal-benthic isotope profiles. The competition in the shared EFH seems to be alleviated by intra- and interspecific niche partitioning mechanisms including differences in depth distribution, diel movement, aggregation sites, and diet composition. The identification and characterisation of these EFHs highlight the importance of the Azores archipelago for the conservation of these highly mobile predators in the wider Atlantic Ocean.

Keywords: essential fish habitats; multidisciplinary study; oceanic island nurseries; habitat use; niche partitioning SI Abstract Ref: 359

Nathan Pacoureau

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Half a century of global decline in oceanic sharks and rays

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Overfishing is the primary cause of marine defaunation, yet declines in and increasing extinction risks of individual species are difficult to measure, particularly for the largest predators found in the high seas. Here we calculate two well-established indicators to track progress towards Aichi Biodiversity Targets and Sustainable Development Goals: the Living Planet Index (a measure of changes in abundance aggregated from 57 abundance time-series datasets for 18 oceanic shark and ray species) and the Red List Index (a measure of change in extinction risk calculated for all 31 oceanic species of sharks and rays). We find that, since 1970, the global abundance of oceanic sharks and rays has declined by 71% owing to an 18-fold increase in relative fishing pressure. This depletion has increased the global extinction risk to the point at which three-quarters of the species comprising this functionally important assemblage are threatened with extinction. Strict prohibitions and precautionary science-based catch limits are urgently needed to avert population collapse, avoid the disruption of ecological functions and promote species recovery.

Keywords: overfishing; extinction risk; global biodiversity indicators; population time-series SI Abstract Ref: 3

Matias Braccini

Department of Primary Industries and Regional Development of Western Australia

Is the west coast of Australia a global shark risk hotspot or an example of sustainable management? Matias Braccini

There is a general perception that global shark populations are at high risk of extinction and that commercial fishing and shark conservation are incompatible. A recent big-data global comparison of longline and purse seine fishing effort and shark movements concluded that the west coast of Australia is likely to be a high risk hotspot for shark conservation. In this presentation, I provide evidence that the west coast of Australia is not a global shark risk hotspot, and, on the contrary, that the west coast of Australia is an example of the sustainable use of shark resources. In response to a substantial increase in fishing pressure between the 1980s and 1990s in Western Australia, sharks have been regulated through a range of catch and fishing effort control measures, gear restrictions and fishing closures, resulting on a drastic reduction in fishing exploitation. In this presentation, I provide a synopsis of the available information and scientific tools implemented that have allowed sustainable fishing for sharks in the west coast of Australia and of the lessons learnt during the process. This research shows that sustainable fishing and shark conservation are not opposing goals and can be achieved when management and enforcement are implemented in an adaptive fashion underpinned by scientific research.

Keywords: fisheries management; stock assessment; conservation; modelling SI Abstract Ref: 14

Paddy Walker

Dutch Elasmobranch Society

The Good, the Bad and the Unknown: determining Good Environmental Status for sharks, skates and rays

Paddy Walker; Dutch Elasmobranch Society

The Marine Strategy Framework Directive (MSFD) is the overarching legal framework for nature and environment conservation in Europe. It's goal is to achieve clean, healthy and productive European seas and good environmental status (GES). The Directive is based on three pillars: protected ecosystems; sustainable use; and common approaches at EU and regional level. Implementation is based on eleven descriptors covering aspects of the ecosystem and sustainable use. The Netherlands made a commitment in the National Plan of Action for Sharks to manage shark and ray populations through Descriptor 1 (biodiversity) of the MSFD, which looks at species distribution, population size and population condition. To determine Good Environmental Status (GES) indicators are necessary to inform the policy cycle for identifying measures, monitoring programmes and for policy evaluation. Currently there are no workable indicators for Descriptor 1 for elasmobranchs. In order to address this issue and to move a step closer to protecting sharks and rays in Dutch waters, a suite of indicators for the species have been developed. Based on ongoing research on elasmobranch life-cycles and results from stakeholder dialogues on North Sea fisheries, this paper will present our current understanding of the Good Environmental Status of sharks, skates and ray and discuss how spatial and technical measures can help achieve this.

Keywords: indicators; biodiversity; life-cycle; conservation; management SI Abstract Ref: 135 $\,$

Krystan A. Wilkinson

Chicago Zoological Society's Sarasota Dolphin Research Program; Sharks and Rays Conservation Research Program, Mote Marine Laboratory

Times they are-a-changin': shifts in shark assemblage and relative abundance along the Florida Gulf coast, 1955-2022

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- 2. Valerie N., Hagan; Sharks and Rays Conservation Research Program, Mote Marine Laboratory
- 3. William H., Aeberhard; Swiss Data Science Center
- 4. Brianna V., Cahill; Sharks and Rays Conservation Research Program, Mote Marine Laboratory; Harbor Branch Oceanographic Institute, Florida Atlantic University
- 5. Dean A., Dougherty; Marine Operations, Mote Marine Laboratory
- 6. Greg L., Byrd; Marine Operations, Mote Marine Laboratory
- 7. Demian D., Chapman; Sharks and Rays Conservation Research Program, Mote Marine Laboratory
- 8. Robert E., Hueter; Sharks and Rays Conservation Research Program, Mote Marine Laboratory; OCEARCH
- 9. Eugenie, Clark; Sharks and Rays Conservation Research Program, Mote Marine Laboratory

For more than two decades (2001-2022), seasonal surveys of large coastal shark species have been conducted off Florida's central Gulf of Mexico coast to determine patterns of species assemblage, relative abundance (catch-per-unit-effort, CPUE), and seasonality of shark species. Effort, measured in hook hours, was variable across this time period. Blacktip sharks, *Carcharhinus limbatus*, made up the largest proportion of the overall catch (22.6%), followed by nurse sharks, *Ginglymostoma cirratum* (19.2%), and sandbar sharks, *C. plumbeus* (15.8%); the lowest proportion of the overall catch was scalloped hammerhead sharks, *Sphyrna lewini* (0.8%). There was a slight increase in overall shark CPUE from 2001 to 2022, which may be primarily driven by an increasing trend in sandbar sharks. Other shark species did not show a strong increasing or decreasing trend. These data were compared with historical records of shark catch collected in the same region by Eugenie Clark from 1955-1980. Data were represented in a 2-dimensional space with non-metric multidimensional scaling (NMDS). When the two datasets were compared, a shift in species assemblage was detected. Additionally, modern surveys showed a loss of dusky sharks (*C. obscurus*), which were present in the historical records, potentially indicating depletions and/or range shifts in this species in the eastern Gulf of Mexico. This study highlights the importance of longitudinal surveys which allow us to track changes over time and provides critical insight for effective species management.

Keywords: catch/effort; temporal trends; historical patterns; longitudinal data SI Abstract Ref: 137

Friday, 21st October 2022

Keynote Address

Prof Mohamed Nejmeddine Bradai

Decline of sharks threatens the ocean and humanity urgent awareness is needed

Cartilaginous fishes are a very ancient group, they have been able to survive and overcome five mass extinctions since their appearance. They play in fact a key role in maintaining the balance of marine ecosystems.

More than 97% of the shark population has disappeared in the last two centuries. Currently, a high percentage is threatened, many are data deficient. Many menaces face sharks but fishing pressure seems to be most critical.

This presentation focusses on the current status of cartilaginous fishes and progress on conservation through my experience in Tunisia and the actions taken through regional plans.

Governing a Shark Hotspot

Lydia Koehler

University of Plymouth

Shark governance in the Mediterranean Sea and the contribution of non-state actors

- 1. Lydia Koehler; University of Plymouth
- 2. Jason Lowther; University of Plymouth

This research reviewed the applicable legal obligations that concern shark conservation and management in the Mediterranean Sea and assessed how non-governmental organisations (NGOs) contribute the fulfilment of these obligations. While NGOs have no legal mandate for enforcement or an obligation to establish or implement conservation and management measures, they have an important role. As contributors to the implementation of measures, their value is recognised under legal instruments such as the Convention on Biological Diversity, and the Convention on the Conservation of Migratory Species of Wild Animals. Through survey questionnaires and supplementary web-based research, the study analysed over 70 initiatives (short-term projects and long-term programmes) led by 20 NGOs in the region (15 countries). The results show that NGOs contribute to different obligations under various legal instruments, which include education and awareness raising, species monitoring, research progression, as well as bycatch mitigation efforts. The majority of these initiatives (68.49 %) involve local stakeholders, thereby building capacity and fostering public support. Furthermore, NGOs are increasingly involved in policy development within the Mediterranean, while establishing cross-border cooperation.

Keywords: Mediterranean; shark governance; non-governmental organisation; implementation; conservation management SI Abstract Ref: 81

Zaid Samaha

General Fisheries Commission for the Mediterranean (GFCM)

The role of the GFCM in improving the knowledge and the status of elasmobranchs in the Mediterranean and the Black Sea region

- 1. Paolo, Carpentieri; GFCM.
- 2. Pilar, Hernandez; (GFCM).
- 3. Margherita, Sessa; (GFCM).
- 4. Miguel, Bernal; (GFCM).

In the Mediterranean and Black Sea several species of elasmobranchs are considered by regional conventions or regulations to require conservation efforts, such as those described by the Barcelona Convention and both in GFCM and EU recommendations, among others. In the region, though almost no fishing activity currently targets elasmobranchs and finning is banned by international decisions, elasmobranchs are often still caught as incidental catch in many fisheries; depending on the species, individuals are either discarded or landed despite generally low market values. In order to better understand the impact of those fisheries on elasmobranchs, and to identify correct management measures, it is necessary to carefully monitor all fishing activities. Following this issue, the GFCM has developed standard methodologies and designed operational protocols for the collection of data, among others, on incidental catches of elasmobranchs vulnerable species, with a view to support harmonized monitoring across the Mediterranean and Black Sea and thus produce comparable results to underpin the formulation of sound scientific advice towards sustainable fisheries management and conservation. Even if in the last 20 years, the GFCM has adopted several recommendations and measures to reduce and mitigate this impact, new technologies must continue to be tested and implemented, and standardized procedures for data collection should be established. Raising awareness amongst fishers and relevant stakeholders of the threats currently facing elasmobranch populations across the region, as well as their importance to local ecosystems, will also help to improve relations between fisheries and these species and to ease transitions toward safer practices.

Keywords: GFCM; data collection; elasmobranchs; vulnerable species; management SI Abstract Ref: $\rm 37$

Javier Guallart

Independent researcher

Present challenges for the knowledge and conservation of the Mediterranean Centrophorus

1. Javier GUALLART

The genus Centrophorus includes deep-sea species of medium size (generally < 1.5 m). In the Mediterranean Sea, despite some a long controversy, it is confirmed that only one species of the genus is present. Work in progress will allow solving the last remaining problems, related to nomenclature.

This species has some very unique biological parameters. Being an aplancentary viviparous species, it has the lowest fecundity of all known sharks: a single embryo per gestation, which lasts 2 (maybe even 3) years. Oocytes at the time of ovulation are huge, up to 380 g (probably the largest uninucleated cell in the animal kingdom). Although not validated, it is presumed to have a low growth rate, similar to other Squaliformes.

Despite all this, the species can become locally very abundant, which made it a target species for local fisheries in many Mediterranean areas during the 20th century. The economic potential comes from both their flesh (quite appreciated) and their liver (very large, which has one of the highest squalene concentrations known among deep-sea sharks).

Unsurprisingly, local fishing interest in the Balearic Sea (western Mediterranean) has almost disappeared when, after periods of semi-intensive fishing activity, catches have been drastically reduced.

Assessing this decline, widely understood by local fishermen, requires the implementation of campaigns that use techniques independent of fishing activity. However, the species is "low-sensitive" to population evaluation through general sampling surveys (e.g. MEDITS). We suggest that other initiatives (e.g. BRUVs) are essential to evaluate and plan the conservation of the species.

Keywords: gulper shark; Centrophorus uyato; deepsea fishery; endangered species SI Abstract Ref: 54 $\,$

Maria Vittoria lacovelli

University of Bologna

Past species diversity and zoogeography of historical sawfishes from the Mediterranean area

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- 2. Valentina, Crobe; University of Bologna.
- 3. Federico, Lugli; University of Modena and Reggio Emilia
- 4. Elisabetta, Cilli; University of Bologna
- 5. Alice, Ferrari; University of Bologna
- 6. Francesco, Ferretti; Virginia Polytechnic Institute and State University
- 7. Gianluca, Frijia; University of Ferrara
- 8. Paola, lacumin; University of Parma
- 9. Agostino, Leone; Institut Français de Recherche pour l'Exploitation de la Mer
- 10. Fausto, Tinti; University of Bologna
- 11. Stefano, Benazzi; University of Bologna
- 12. Alessia, Cariani, University of Bologna

The unprecedented global reduction of sawfish populations addressed huge research efforts on the recovery of remaining world populations to assess the status of the species in poorly studied regions. In this perspective, we implemented a multidisciplinary investigative approach to reconstruct species diversity and abundance of past sawfish fauna using 172 historical rostra collected from museums and private collections in the Mediterranean area. The combination of ancient DNA analysis with traditional and geometric morphometrics permitted the species identification of all dried rostra and their assignment to *Pristis zijsron* (N=81), *Anoxypristis cuspidata* (N=39), *P. pristis* (N=30), and *P. pectinata* (N=22). Sixteen specimens were labelled as Mediterranean: seven *P. zijsron*, five *A. cuspidata*, three *P. pectinata* and one *P. pristis*.

The extensive trade of these distinctive and curious objects was quite common and unbanned in the last centuries among public and private collectors. We thus estimated the isotopic composition of oxygen (18O/16O) from the inorganic matrix (hydroxyapatite), and carbon (13C/12C) from the collagen of 35 rostral teeth from individual sawfish. We identified the most likely origin of the specimens and tested the historical presence of these tropical/subtropical elasmobranchs in the temperate Mediterranean Sea. The geographical isoscape-based assignment associated most of the individuals to one or two areas, including one *P. zijsron* assigned to the Mediterranean and 11 *P. zijsron* and *P. pristis* to the Red Sea/Persian Gulf.

Using this integrated approach, we effectively contributed to increase the knowledge of historical ecology of sawfishes, retrieving novel information and data on their past distribution.

Keywords: Pristidae; morphometric measures; ancient DNA; stable isotopes; isoscape SI Abstract Ref: 131

Sara A.A Al Mabruk

Marine Biology in Libya Society; Higher institution science and technology-cyrene

Libya: A last hotspot for Critically Endangered Angel Sharks in the Mediterranean Sea

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- 2. Eva Meyers, Zoological Research Museum Alexander Koenig
- 3. David Jiménez Alvarado; Universidad de Las Palmas de Gran Canaria
- 4. Joanna Barker; Zoological Society of London
- 5. Abdulghani Abdulghani, Marine Biology in Libya Society
- 6. Abd Alati Elsowayeb, Libyan organization for conservation of nature

Libya has a vast Mediterranean coastline, which is little studied and faces a significant threats from human activities, such as illegal fishing and ongoing habitat degradation. Using mainly citizen science, social media and fish market surveys, the Angel Shark Project: Libya has started collecting observations on the three Critically Endangered Angel Shark species: *Squatina squatina, S. oculata* and *S. aculeata*. The main goal of this study is to investigate whether Libya holds one of the last angel shark hotspots in the Mediterranean Sea.

To date, we have collected 100 sightings and taken 74 genetic samples for further analysis. Results so far revealed two angel shark hotspots, one on the northern coast of Libya (Gulf of Sidra) and one in the West coast (Misrata) for *Squatina squatina* and *S. oculata* respectively. However, these two hotspots are vulnerable to illegal fishing activities and the lack of protected areas.

Conducting fieldwork in Libya is a challenge in itself yet the use of social media has proved to be a cost-effective method to obtain more data on these vulnerable shark species. Urgent steps are needed to continue monitoring efforts and to ensure the protection of these Critically Endangered sharks in possibly one of their few remaining hotspots in the Mediterranean.

Keywords: Angel Shark; Libya; hotspots; *Squatina squatina*; conservation SI Abstract Ref: 268

Àlex Bartolí SUBMON

Review of the presence of basking sharks (*Cetorhinus maximus*) in the Balearic Sea (*Western Mediterranean*)

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- 2. Àlex Bartolí; SUBMON
- 3. Javier Guallart; Independent Researcher

A total of 179 basking sharks have been recorded in the Balearic Sea since the early 20th century from different sources. These include sightings at sea (43,8%), by-catch events (52,8%) and strandings of dead individuals on or near the coast (3,4%). In most cases, the records consisted of single sharks (70,7% of specimens) but in some cases (29,3%) groups of several specimens were recorded.

Most of them (69,4%) were subadults or adults >6 m TL and found over the continental shelf or in open waters; some small juveniles (<3 m TL) were also recorded (5,0%), mainly in coastal waters.

Basking sharks showed a marked seasonality in the area, with most of them occurring between February and May (78,6%) and showing a minimum presence in late summer and autumn.

There are differences in by-catch by fishing gear and areas: while in Catalan and Valencian waters they are mainly caught by bottom trawlers, in the Balearic Islands they are more frequently caught in small scale gears (e.g. trap nets and trammel nets). The data indicates the regular occurrence of basking sharks in the Balearic Sea. Their seasonal pattern suggests that there is not a stable local population but that they conduct wide range displacements at least along the Western Mediterranean basin (and probably linked to Atlantic populations). However, further research is needed in order to know whether they follow a regular migration pattern or the movements are simply related to variations in oceanographic factors.

Keywords: seasonality; endangered species; bycatch; conservation; basking shark SI Abstract Ref: $\rm 55$

Patrik Krstinić WWF Adria

Saving the last Angel Sharks of the Mediterranean Sea: X-ray report on spatial protection, with a focus

on the Adriatic Sea

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- 2. Joanna Barker, Zoological Society of London
- 3. Branko Dragičević, Institute for Oceanography and Fisheries Split
- 4. Pero Ugarković, Institute for Oceanography and Fisheries Split
- 5. Patrik Krstinić, WWF Adria
- 6. Danijel Kanski, WWF Adria
- 7. Eva Meyers, United Nations Environment Programme
- 8. David Jiménez Alvarado, Angel Shark Project
- 9. Marina Gomei, WWF Med
- 10. Simone Niedermüller, WWF Austria

Angel shark occurrence data were gathered from the Angel Shark Sightings Map and a Local Ecological Knowledge (LEK) case study conducted in Croatia by WWF Adria. These data were analysed in the context of the existing network of MPAs and FRAs designated in the Adriatic Sea.

Keywords: Squatina squatina (Angelshark); Adriatic Sea; Local Ecological Knowledge (LEK); Marine Protected Areas SI Abstract Ref: 114

Manfredi Di Lorenzo

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Small-scale fisheries catch more threatened elasmobranchs inside partially protected areas than in unprotected areas

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- 3. Antonio Di Franco; Stazione Zoologica Anton Dohrn
- 4. Giacomo Milisenda; Stazione Zoologica Anton Dohrn
- 5. Giorgio Aglieri; Stazione Zoologica Anton Dohrn
- 6. Carlo Cattano; Stazione Zoologica Anton Dohrn
- 7. Marco Milazzo; University of Palermo
- 8. Paolo Guidetti; Stazione Zoologica Anton Dohrn

Elasmobranchs are heavily impacted by fishing. Catch statistics are grossly underestimated due to missing data from various fishery sectors e.g., small-scale fisheries (SSF). Marine protected areas (MPAs) have been proposed as a tool to protect elasmobranchs and counter their ongoing depletion. We assessed elasmobranchs caught in 1,256 SSF fishing operations with fixed nets carried out in partially protected areas (PPAs) within MPAs and unprotected areas (UPAs) beyond MPA borders at 11 locations in 6 Mediterranean countries. Twenty-four elasmobranch species were recorded, more than one third belonging to the IUCN threatened categories (Vulnerable, Endangered, Critical-ly Endangered). Catches per unit of effort of Threatened and Data Deficient species were higher (with more immature individuals being caught) in PPAs than in UPAs. Our study suggests that de-spite PPAs having the potential to deliver ecological benefits for threatened elasmobranchs, poor SSF management inside MPAs could hinder them from achieving this important conservation objec-tive.

Keywords: Elasmobranchs; Marine Protected Areas; small-scale fisheries; Mediterranean Sea SI Abstract Ref: 154

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Are we doing enough? Guitarfish conservation along Israel's Mediterranean coast

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Two species of Guitarfish inhabit the Mediterranean coast of Israel, the Blackchin Guitarfish *Glaucostegus cemiculus* and the Common Guitarfish Rhinobatos rhinobatos. Both are assessed as critically endangered by the IUCN. Recent studies show that certain areas on the Israeli Mediterranean coast also function as a nursery ground for *G. cemiculus*, further stressing how the conservation of both species in Israel is vital.

Guitarfish species are protected in Israel but they are subjected to bycatch and habitat degradation. In 2012, Nature Protection Authority of Israel issued a master plan for marine protected areas (MPAs) with a set goal to preserve 20% of Israel's marine territory through the declaration of seven large MPAs in addition to existing smaller MPAs. However, in a spatial analysis of the recorded observations collected by the MECO citizen science project, only ~9.5% of the Guitarfish observations overlap with existing MPAs, and most of these (~7%) are within one small (<1 km2) reserve. Out of 33 observations in that reserve, 25 are confirmed adults, and only two are juveniles. Another 18% of observations are within planned MPAs, which are not part of the master plan, and their establishment was suspended. One of those planned MPAs, Ma'agan Michal, was found to be a nursery ground for *Glaucostegus cemiculus*.

These results show more room for improvements in the conservation of Guitarfish in Israel. The reserve planning should consider the life stages of the two species and protect them within large-scale MPAs.

Keywords: guitarfish; conservation; Mediterranean; MPAs SI Abstract Ref: 273

Ignasi Nuez

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Filling the gap: the unique isotopic niche of medium-sized and large sharks in the northwestern Mediterranean Sea

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The Mediterranean Sea is considered a biodiversity hotspot and hosts a broad diversity of shark species. Unfortunately, many shark populations have suffered a long story of overexploitation and their abundance has strongly declined over the last decades. This is especially noticeable in medium-sized and large sharks. A few studies have addressed the trophic role of sharks in the northwestern Mediterranean Sea, yet little is known about their ecological niche. In this study, the isotopic niches of 6 medium-sized and large shark species (*Alopias vulpinus, Galeorhinus galeus, Hexanchus griseus, Isurus oxyrinchus, Prionace glauca* and *Squalus acanthias*) from the northwestern Mediterranean Sea were determined and compared with those of sympatric predatory bony fishes and marine mammals. Overall, δ 13C and δ 15N values were similar amongst all species except for G. galeus, which was excluded from the analyses as their high δ 15N values suggested that the three analysed individuals had recently moved from a distinct area with a different isotopic baseline. The mixing models identified cephalopods as the dominant prey of the other five shark species and revealed that those medium-sized and large shark species filled a unique isotopic niche. The trophic position of sharks was similar to those of predatory bony fishes and small dolphins but lower than that of larger dolphins, pilot whales and beaked whales. The high contribution of cephalopods to the diet of sharks in the northwestern Mediterranean Sea might be indicative of fish scarcity and deserves further research.

Keywords: sharks; diet; isotopes; niche; Mediterranean SI Abstract Ref: 30

Wade Vanderwright

Simon Fraser University

Metabolic Morphology and Ecological Lifestyle in Sharks

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Metabolism underpins life histories, population dynamics, and extinction risk. Morphological traits that are linked to an organism's metabolism may provide a first approximation to the ecological needs to support growth, survival, and reproduction. Here we examine the relationship between respiratory physiology (i.e. gill slit height in proportion to total length) and activity level (caudal fin aspect ratio) in nearly all extant shark species (n=456). Gill slit heights and caudal fin aspect ratios were collected and measured from the field guide Sharks of the World (Ebert 2013). We used a Bayesian-phylogenetic inference model that accounts for each species' maximum size, primary habitat type, and evolutionary history. We found a strong positive relationship between gill slit height and activity level. We also show that primary habitat had a strong effect on this relationship with pelagic sharks exhibiting the highest gill slit heights and activity levels while deep water sharks showed the opposite trend. These findings suggest that proxies for metabolic demand may be available via external and easy to measure morphological traits and natural history. Insight into the metabolic demand of these animals may allow us to estimate vital life history traits that could inform ecological risk assessments.

Keywords: Metabolic Theory of Ecology; Gill-Oxygen Limitation Theory; macroecology; shrinking fishes SI Abstract Ref: 2

Sarah Gravel

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The ecophysiology underlying patterns in population growth across marine fishes

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The intrinsic rate of population increase (rmax) estimates a population's maximum turnover rate at low adult abundance, and hence reflects the summed performance of individual organisms. Both temperature and oxygen availability are key environmental factors shaping the metabolism and fitness of ectothermic fishes, and there is increasing evidence that population growth rates vary latitudinally and with depth, suggesting a metabolic basis of population dynamics. Yet, little is understood of how oxygen and temperature effects on physiological performance relate to population dynamics. We bridge from the individual to population scales with a comparative analysis of rmax and metabolic rate, in relation to oxygen, temperature, and body size across 38 chondrichthyan and 102 teleost species, using population-matched life history and metabolic traits mined from primary literature and environmental data from the World Ocean Atlas. Specifically, we ask whether: (1) variation in metabolic rates across species are best explained by models including mass, temperature and oxygen, including an interaction between oxygen and mass, best explained variation in resting metabolic rates and rmax. Using model selection, we found that body mass, temperature and oxygen, including an interaction between oxygen and mass, best explained body mass on metabolism and further support these underpin similar patterns in population growth rates. We also highlight the central role of oxygen availability in shaping population patterns underlined by metabolic physiology in aquatic ectotherms, and the importance in considering how it affects smaller and larger species disparately.

Keywords: metabolic scaling; environmental temperature; oxygen limitation; aerobic capacity; maximum population growth rate SI Abstract Ref: 156

Dr Victoria Camilieri-Asch

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Cartilage under pressure: what can we learn from deep-sea chondrichthyans?

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Cartilaginous fishes have evolved a unique skeletal system consisting mainly of unmineralised cartilage, a tissue that resembles the articular cartilage found in the joints of other vertebrates. Compared to other vertebrate taxa (including other fish groups), most of their skeleton is 'tessellated', i.e., made up of an unmineralised core covered by a thin layer of mineralised tiles' or tesserae. Deep-sea species are able to adapt to high hydrostatic pressures ranging from 10 to 300 times greater than sea level depending on the depth they inhabit (typically no greater than about 3000m). Such high pressures, when applied to the cartilage of terrestrial mammals, would inevitably produce serious mechanical stress resulting in acute tissue damage. Therefore, we predict that the extracellular matrix secreted by cartilage cells (chondrocytes) within the skeleton of species found at different depths would show interspecific differences in microstructure, composition, and mechanical properties, and even site-specific differences in mineralisation and biophysical properties, to maintain tissue integrity according to functional load. The study aims to develop a multimodal and multiscale approach to compare and cross-correlate 2D histo-morphological and immunohistochemical data with 3D bioimaging and biomechanical analyses across several skeletal areas in representative species of chondrichthyans occupying different depth profiles. Preliminary results reveal marked histological differences, suggesting a gradation of adaptations. Adaptations in the structure and composition of cartilage exposed to extreme high pressure environments may inform future applications in tissue engineering and regenerative medicine, in addition to elucidating how many species are able to make large vertical movements within their depth range and maintain skeletal integrity.

Keywords: deep-sea; chondrichthyan; cartilage; adaptations; biomechanics SI Abstract Ref: 161

Haley Dolton

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Are plankton-feeding basking sharks Cetorhinus maximus warm-bodied?

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The world's second largest fish, the planktivorous basking shark *Cetorhinus maximus*, lies within the order Lamniformes and is the sister taxon to a family (Lamnidae) comprising predatory species with anatomical and physiological specialisations thought to facilitate athletic lifestyles. However, it has not been reported whether basking sharks, widely assumed to be fully ectothermic, possess similar specialisations that may confer energetic advantages, especially while ram filter-feeding. Here, we combined dissections of stranded specimens with biologging of free-swimming individuals and found basking sharks have

centralised skeletal red muscle along the trunk, almost 50% compact myocardium of the ventricle, and subcutaneous white muscle temperatures consistently 1.0 - 1.5°C above ambient water temperature. These findings suggest basking sharks do not have the anatomy and physiology typical of a fully ectothermic species, but instead share more traits with regionally endothermic Lamnidae than previously assumed given their planktivorous lifestyle. Our results may help explain how endangered basking sharks can power relatively high-speed ram filter-feeding and rapid transoceanic movements.

Keywords: regional endothermy; basking shark; ectotherm; physiology; anatomy SI Abstract Ref. 199

Betty LagIbauer

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Diversity in the visual opsin repertoire of pelagic sharks and rays

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Marine organisms have evolved diverse visual systems to detect prey, mates and predators under varying evolutionary constraints. Among elasmobranch species, photoreceptor repertoires reflect different visual adaptations. However, we know comparatively little about the vision of pelagic and filter-feeding sharks and rays. Using transcriptomics, we show dichromatic vision in mobulid rays (*Mobula tarapacana, M. eregoodoo, M. mobular, M. birostris*) and blue sharks (*Prionace glauca*), and an achromatic vision based on rod-only retina in the megamouth shark (*Megachasma pelagios*). These findings suggest an unforeseen diversity of visual systems among pelagic elasmobranchs. The presence of RH2, but not LWS, in blue sharks corroborates recent evidence of independent evolution of cone monochromacy in Carcharhinids. Additionally, the absence of LWS and RH2 in the megamouth shark suggests a loss of cone-opsins in the genus, and warrants further attention to the evolution of visual opsins among Lamniform sharks, and among elasmobranch visual systems in general.

Keywords: vision; opsin; evolution; pelagic; transcriptomic SI Abstract Ref: 263

Ellen Barrowclift

Newcastle University; Durham University

Tropical rays are intrinsically more sensitive to overfishing than the temperate skates.

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- 3. Sebastian A. Pardo; Ecology Action Centre.
- 4. Jennifer S. Bigman; Alaska Fisheries Science Center.
- 5. Per Berggren; Newcastle University.
- 6. Nicholas K. Dulvy; Simon Fraser University.

Overfishing, habitat loss, and climate change are driving population declines in many species. Understanding a species' capacity to recover is necessary for prioritising management. The maximum intrinsic rate of population increase (rmax) can be used as a tool to assess which species or groups are particularly vulnerable to ongoing threats. To investigate global patterns of ray and skate (superorder Batoidea) intrinsic sensitivity, we estimated rmax of 85 species using a modified Euler-Lotka model that accounts for survival to maturity. We examined how rmax varies with body mass, temperature, and depth using an information-theoretic approach through model selection, accounting for phylogenetic non-independence. Although we observed a positive relationship between rmax and temperature, we found that warm, shallow-water rays were more intrinsically sensitive to exploitation (lower rmax) than cold, deep-water skates (higher rmax). These differences in rmax have conservation implications for our understanding of the geographic patterns in extinction risk, suggesting that tropical rays are more intrinsically sensitive. We hypothesise this pattern is likely driven by their different reproductive strategies as live-bearing rays have fewer offspring compared to egg-laying skates. The findings of the study highlight the high vulnerability of warm, shallow-water ray species to overexploitation and other threats due to their intrinsically low maximum population growth rates.

Keywords: demography; Life History Theory; metabolic scaling; Temperature Size Rule SI Abstract Ref: 264

Claudia Junge

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Sharks on a mission to recovery in the North

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- 2. Keno Ferter; IMR
- 3 Jon Albretsen IMR
- 4. Romaric Jac; IMR.
- 5. Otte Bjelland; IMR. Jan Hinriksson; IMR.
- 6. Antonia Klöcker; IMR.
- 7. Victor G Triginier; IMR, UNIS. 8
- 9. Ole Thomas; IMR.

Sharks are declining worldwide due, in large part, to conflicts with human activities such as fisheries, and increasingly because of habitat loss and climate change. Highly mobile sharks are more at risk of encountering human activities such as fisheries. putting high bycatch pressure on shark populations. In Norway, spurdog (Squalus acanthias), porbeagle (Lamna nasus) and basking shark (Cetorhinus maximus) are bycaught in fisheries, yet relatively little is known about their large-scale movements and habitat preferences, as well as their population dynamics after their stocks collapsed. We here used a variety of data types and methods depending on the species in question, a.o. survey, fishery and environmental data, citizen science observations, dissections, satellite tagging and spatial mapping to decipher the spatial distribution, vertical movement and life history patterns in Norwegian waters. We found that spurdog prefer relatively warm and shallow waters within their distribution area in the northern Northeast Atlantic; in line with the results from our tagging study which indicated that they stay close within Norwegian coastal waters. Local hotspots for all three species were confirmed with various data sources and converge in the same areas. Our dissection of almost 4,000 spurdog individuals indicated the potential for a much swifter recovery of the stock than previously projected. These findings are now used to inform national and international assessments as well as the mapping of vulnerable marine habitats. The next steps will involve increasing our understanding of how changing environmental conditions might affect spurdog, and other cartilaginous species.

Keywords: bycatch; distribution and hotspots; stock recovery; tagging stract Re

Carlo Zampieri

University of Padova, Padova, Italy.

Evaluating biases when describing ecosystem roles of Elasmobranchs with food web models

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- 2. Davide Agnetta; OGS OCE, Trieste, Italy.
- 3. Simone Libralato; OGS OCE, Trieste, Italy
- 4. Alberto Barausse; University of Padova, Padova, Italy.

Elasmobranchs are usually considered to be apex predators in marine environments where their decline has caused cascading effects on the lower trophic levels. However, many Elasmobranch species, especially demersal ones, are not classified as top predators. They may be the prey of other species, and belong to a lower trophic level than bony fishes, e.g. because their diet is limited to benthic organisms such as crustaceans and bivalves. This functional diversity of elasmobranch species is often neglected in food web models used for fishery management and conservation, where these species are usually clumped together in one or few functional groups (FG), with a consequent possible bias in the description of their role in the ecosystem. The main reason for this is that data needed to build these models, especially quantitative diet information and reliable fishery-independent biomass estimates, are hard to find for many sharks and rays. Here we focus on published models built for Mediterranean sub-basins using the Ecopath with Ecosim approach, regarded as a standard in marine trophic network modelling. We extracted all the species with enough available data from the broader sharks and rays FGs defined by the model authors and then we generated other models by aggregating species at different levels. Finally, we compared ecological network analysis descriptors and modelled management scenarios (e.g., overfishing) to investigate how the degree of aggregation affects the food web properties and dynamics. Our results call for more awareness of the model limitations deriving from food web aggregation driven by data scarcity, especially when models are used to advise conservation and management.

Keywords: Elasmobranch; Ecological modelling; Trophic interactions; Management; Conservation SI Abstract Ref: 361

Gabriel Morey

Save the Med Foundation

Unveiling the secret life of the spinetail devil ray around the Balearic Islands (NW Mediterranean): from its occurrence to its behaviour and movement patterns

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- 2. Brad Robertson; Save the Med Foundation
- 3. Miguel Pozo; Save the Med Foundation
- 4. Sergio Ruiz Halpern; Save the Med Foundation
- 5. Dan Abbott; Save the Med Foundation
- 6. Mari Gutic; Save the Med Foundation
- 7. Francesc Verger; Save the Med Foundation
- 8. Olga Reñones; Save the Med Foundation
- 9. Eric Clua; PSL-CRIOBE, SharkMed
- 10. Agustí Torres; SharkMed
- 11. Bernadí Alba; APERS
- 12. Ramón Bonfil; El Colegio de la Frontera Sur Unidad Chetumal

The first record of the spinetail devil ray (*Mobula mobular*) around the Balearic Islands dates back to 1784. We collected records on 33 sightings and fisheries by-catch for individuals of the spinetail devil ray in the area up to 2018. Since then, we started surveying offshore waters for the species and called fishers and researchers to gather additional encounter information. Our data includes now more than 200 new records.

Our data reveals that the abundance of *M. mobular* in balearic waters is much higher than previously thought, peaking between May and August. During this season, devil rays are commonly seen in groups (up to 30 individuals), composed of individuals of similar size-range (2-3 m DW). In addition, we have managed to film their courtship behaviour.

As a result of the predictable encounters with spinetail devil rays, we launched a satellite tracking program with the objective of investigating their movement patterns and their environmental drivers, which in turn can be compared to maps of anthropogenic threats (fisheries, maritime traffic, pollution) to generate risk maps. Genetic studies are also planned to investigate the population structure of this species in the Mediterranean and its connectivity with extra-Mediterranean populations.

Keywords: Mobula mobular; migration; conservation

SI Abstract Ref: 184

Carlo Cattano

Stazione Zoologica Anton Dohrn. Integrative Marine Ecology Deparment. Palermo, Italy

Characterization and management of the seasonal sandbar shark aggregation around the remote island of Lampione, central Mediterranean Sea

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- 2. Desirée Grancagnolo, University of Palermo, Italy
- 3. Giorgio Aglieri, Stazione Zoologica Anton Dohrn. Palermo, Italy
- 4. Marco Milazzo, University of Palermo, Italy

An aggregation of the sandbar shark, *Carcharhinus plumbeus*, occurs every summer around Lampione island, in the central Mediterranean Sea (Pelagie Islands MPA, Italy), and attracts a large number of divers willing to make a shark-watching experience. This recreational activity may potentially contribute to enhancing people's awareness of the protection of this endangered shark species, but at the same time, it may affect shark persistence around the island. Here we summarise the findings of three years of BRUV and questionnaire surveys aimed at 1) characterising the transient sandbar shark aggregation, 2) evaluating the potential impact of tourism on sharks, 3) implementing a code of conduct to regulate tourism frequentation around the island, and 4) assessing perceptions and attitudes of different stakeholders toward sharks. The peak of sandbar shark aggregation occurred every year in mid-July and mainly consisted of mature males and immature individuals. The number of shark sightings detected by BRUVs was negatively influenced by high frequentation levels of divers and boats. Despite the number of divers increasing by 64% from 2019 to 2021, no temporal differences were found in the number of shark sightings and relative abundances, although a decreasing trend was observed in 2021. The questionnaires administered to tourists and divers suggested that shark diving activities in Lampione may improve people's perceptions of sharks and increase their willingness to support conservation measures. We conclude that if well managed and monitored, responsible shark tourism activities may conclude that if well managed and monitored, responsible shark tourism activities may contribute to enhancing the protection of this threatened shark species.

Keywords: endangered sharks; shark conservation; baited underwater video; shark-tourism SI ${\rm Abstract}$ Ref: 188

Roxani Naasan Aga Spyridopoulou

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Five years of monitoring elasmobranch fisheries and trade in Greece; Lessons learned and future steps.

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More than 1/3 of the chondrichthyans species are threatened with extinction globally as the demand for elasmobranch products is increasing due to (i) commercial fish stock overexploitation, (ii) the emerging demand for seafood and protein, and (iii) the increasing finning regulations that triggers the creation of new shark meat markets. Despite that Greece is the EU's third-largest exporter of elasmobranchs, there is a discrepancy between export trade and landing data, stimulated by gaps in the legislative framework, lack of monitoring, and illegal fishing and trade. This work presents five years of monitoring elasmobranch fisheries and trade in Greece (2018-2022) as part of the "ByElasmoCatch" project. During the first four years the project was focused on the North Aegean Sea, while this year it is focused on the Ambracian gulf. The sampling scheme involves 96 visits to auction and fish markets of 4 towns, 456 logbooks of fishing trips, 47 on board surveys, 157 interviews conducted to stakeholders and >50 ad-hoc records of illegal fishing. First results highlight a mismatch on the number of elasmobranch species reported from on board surveys compared to that reported from the auction markets, indicating that numerous species are sold directly to restaurants rather than through auction markets. The discrepancies found between the data collected from the official statistical authorities and those collected by the project confirms that elasmobranch imports are underreported. Illegal fishing, trade, and mislabelling are all prevalent, implying that institutional improvements in these links are required to sustainably manage elasmobranchs.

Keywords: ByElasmoCatch; sharks; rays; bycatch; discards SI Abstract Ref: 329

Amadeu Ros

Posit de Xabia

Release of sharks accidentally caught by bottom trawling in the slope in the Balearic Sea (western Mediterranean)

1. Amadeu Ros

2. Javier Guallart

The accidental catches of sharks by fishing gears is considered one of their main negative issues for their conservation. Strategies to reduce this problem involve both trying to minimize these captures and, if they occur, releasing the specimens alive.

Here we present examples of handling specimens caught accidentally during deep trawling on the slope of the Ibiza channel. Among several shark species, catches of adult specimens of *Hexanchus griseus* stands out for its frequency and size. Traditionally, most of the specimens arrived dead on the deck or were left to die on it to avoid risks and, later, they were thrown into the water, often arriving their corpses floating to the coast.

Experiences are presented that show that the installation in the net of elements that prevent large elements from reaching the codend (which also protects the catches of inert elements frequantly present in the fishing grounds) together to the immediate release once the net reaches the deck, often allows these animals to be released alive. Some examples in: https://youtu.be/qHYZUsVya04, https://www.youtube.com/watch?v=JDcINpzkroY&t=3s

We consider necessary to establish a protocol to maximize the survival of the specimens, but also minimizing the economic losses (material, time...) that these actions may cause to fishermen.

On the other hand, these situations may represent an opportunity to carry out tagging campaigns of adults of various species at a relatively low cost and that would provide not only data on the survival of the specimens after release but also on unknown biological issues of these deepsea species.

Keywords: *Hexanchus griseus*; Bluntnose sixgill shark; fishery; survival; tagging SI Abstract Ref: 87

Massimiliano Bottaro

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Reducing bycatch and mortality in the Med: the project LIFE ELIFE (Elasmobranch Low Impact Fishing Experience)

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- 9. Periklis Kleitou, Marine & Environmental Research (MER) Lab., Limassol, Cyprus
- 10. Ioannis Giovos, Marine & Environmental Research (MER) Lab., Limassol, Cyprus
- 11. Carlotta Mazzoldi, University of Padua, Department of Biology, Padua, Italy.
- 12. Licia Finotto, University of Padua, Department of Biology, Padua, Italy.
- 13. Christian Melchiorre, AlgoWatt, Genoa, Italy.
- 14. Paolo Pelusi, Consorzio Mediterraneo, Rome, Italy.
- 15. Elena Principato, Marine Protected Area of Isole Pelagie.
- 16. Bruna Valettini, Costa Edutainment, Genoa, Italy.

Considering the European waters, the IUCN indicates more than 30% of elasmobranch species as threatened. Despite some recent efforts in EU to reduce shark by-catch and mortality, the main goals is far from being achieved, and conservation actions need to be set up there. This because the current legislation set out only prevents retention but not the actual capture or the mortality that may occur as a result.

The factors that contribute to the by-catch and the mortality of elasmobranch during fisheries capture are - in fact - many, firstly the fishermen attitude. The consciuous and responsible behavior of the employed in professional fishing activities is fundamental to mitigate the impact of marine biodiversity, cartilaginous fishes included.

The project LIFE LIFE (Elasmobranch Low Impact Fishing Experience), funded by the EU LIFE programme for the environment protection, aims the reduction of elasmobranch by-catch and mortality and promoting best conservation practices in the context of the EU professional fishing activities in the Mediterranean Sea.

It targets several sharks listed as endengered or critically endengered in the Red List of the European marine fishes of the IUCN and it includes the partecipation of 3 EU countries (Italy, Cyprus and Greece). LIFE ELIFE is based on the direct involvement of the professional fishermen by using low impact fishing gears and correct methods of manipulation for the elasmobranch incidental caught, as well as the use of digital technology, like satellite tags and a smartphone application.

Keywords: by-catch; conservation; elasmobranch; professional fishery; Mediterranean Sea SI Abstract Ref: 364

David Ruiz-García

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Demersal chondrichthyan assemblages in the western Mediterranean Sea

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The situation for chondrichthyans in the Mediterranean Sea is particularly concerning, with 53% of the assessed species classified as threatened (IUCN). Chondrichthyans constitute an important percentage of the catch for multi-specific fisheries, particularly for bottom trawling, but a minor part of landings. Monitoring programs are essential to assess the status of chondrichthyan communities. Our research provides updated information on the structure and status of the demersal chondrichthyan assemblage inhabiting trawling fishing grounds from the northern Spanish Mediterranean (GFCM GSA06). Data was obtained from 187 hauls conducted by commercial bottom trawlers on a seasonal basis between June 2020 and January 2022 as part of the projects ECEME and SAP-ICATMAR. Surveys ranged from 50 to 800 m deep. A total of 17 chondrichthyan species belonging to 12 families occurred throughout the area, shaping two different assemblages in relation to depth. Richness increased with depth and decreased with latitude, but the most common species all along the area were *Scyliorhinus canicula, Galeus melastomus, Etmopterus spinax* and *Torpedo marmorata*, accounting for the largest proportion of total density and biomass. We mapped the geographical, bathymetrical, and seasonal distribution patterns in relation to sex and maturity stage for the most common species. Thus, we shed light into their sexual and ontogenetic segregation patterns and unravel important aspects of their ecology. The aim of this work was to improve the required knowledge to assess the status and susceptibility of the chondrichthyan populations inhabiting the western Mediterranean Sea, aiding to a more efficient management of the associated fisheries.

Keywords: Mediterranean; distribution; abundance; seasonality; biological parameters SI Abstract Ref: 216

Saturday 22nd October, 2022

Human Dimensions & Communications

Nadia T. Rubio-Cisneros

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Fishers' traditional knowledge of sawfishes in coastal towns of Southeast Mexico

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- 7. Brianna K. Montes-Ganzon; Seattle University, Seattle, WA, United States
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Local Ecological Knowledge (LEK) of sawfishes is still scant for many regions in Latin America. In southeast Mexico, *Pristis pristis and Pristis pectinata* inhabited coastal ecosystems of Campeche and Quintana Roo's islands in the Mexican Caribbean. *P. pristis* (largetooth sawfish) and *P. pectinata* (smallthooth sawfish) are critically endangered. We developed interdisciplinary research on coastal exploitation, including LEK fishers' surveys, to understand the past presence of sawfishes. We collected 290 surveys with a geospatial component and 74 literature sources. Fishers' structured LEK surveys denote the absence of sawfishes in coastal areas over time. Elder fishers only documented sightings of juvenile sawfishes. Fishers' open interviews provided fishing and behavioral narratives of sawfishes in coastal, lagoonal, and island environments of Campeche and Quintana Roo. For example, the rostrum was used as an ornament and a tool to sweep the floor). Only a pair of fishers' narratives from Isla Mujeres evince sawfishes were caught incidentally five years ago. Geospatial results prove 52 geographic sites where sawfishes were popular in Southeast Mexico. Results support the development of research methodologies to study human-nature interactions using LEK of coastal people. This matters in southeast Mexico, where socio-cultural values and coastal landscapes changed rapidly by increasing tourism development and human migration to coastal areas. Our information can help us understand the delivery of coastal ecosystem services such as biodiversity through time. This is critical for managers to help develop sustainable actions that preserve nature tourism and fisheries activities on which coastal communities of southeast Mexico rely for subsistence.

Keywords: sawfishes; megafauna; small-scale fisheries; coastal exploitation; local ecological knowledge SI Abstract Ref: 237

Alifa Bintha Haque

University of Oxford

Can fishers be the conservation heroes? - insights from the rhinopristiformes ray fishery in Bangladesh

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Rhinopristiformes rays are the most globally threatened cartilaginous fishes. Fishing pressure in the Indo-West Pacific resulted in an unnoticed population decline of 99%. Guitarfishes are an essential component of the Bangladeshi artisanal fishery; however, they are notoriously understudied. We studied these species' populations, fisheries, and trade between 2018 and 2022. Three species of sawfishes and eleven guitarfishes and wedgefishes were taxonomically verified. Fishers reported lifelong catch in sizable numbers, either targeted or bycaught in different gears; noted a steep decline in the past decade and cited the disappearance of Rhynchobatus spp. and sawfishes. The unregulated catch is fuelled by substantial international trade in high-quality products and local prejudices and remains undocumented. We used fishers' knowledge to evaluate these species' temporal population trends and mapped critical habitats. To ground truth, we used very low-tech mobile devices to incentivise the fishers and document geo-referenced catch locations of these species for spatial management. Finally, we conducted

coast-wide workshops to understand fishers' barriers to adhering to conservation actions to devise how these fishers can act as conservation champions. We propose actions rooted in sustainability (based on the biological sustainability of the species). Encouraging and facilitating the engagement of fishers in science (co-creating knowledge), local governance (policy-making), and field implementation (bycatch mitigation) is vital. With appropriate training, these interventions must be rooted in sustainable approaches and co-designed with fishers. Developing this work through enhanced engagement with fishers can potentially transform the elasmobranch fishery situation in Bangladesh and could be used as a model for data-poor regions.

Keywords: Bay of Bengal; rhino rays; co-designed fisheries management; local governance; local/traditional knowledge SI Abstract Ref: 60

llena Zanella

Misión Tiburón

Engagement through local empowerment in shark conservation: the case of the Scalloped Hammerhead Shark Sanctuary Golfo Dulce, Costa Rica

- 1. Ilena Zanella, Misión Tiburón;
- 2. Andrés López Garro, Misión Tiburón

Golfo Dulce is located in the south Pacific of Costa Rica, in Central America. Based on Mision Tiburon scientific results, in May 2018 the Government of Costa Rica created the Hammerhead Shark Sanctuary Golfo Dulce, to protect the wetlands used as a nursery area by the critically endangered scalloped hammerhead shark, Sphyrna lewini. The Sanctuary represents a new model of governance for Costa Rica since it acknowledges the key role of local communities in coastal ecosystems protection. Golfo Dulce is a region rich in marine diversity, but the local communities have the lowest social and economic opportunities in Costa Rica, characterized by cantons that have high rates of extreme poverty and low rates of social development. With this background, we consider that a successful shark conservation initiative should be inclusive and bring direct benefits, in a short term, to local communities. We have been working to strengthen the Sanctuary governance model, engaging, and empowering local leaders, and involving vulnerable groups (such as women and girls in social risks) into the conservation actions. We consider that the initiative is a collaborative and a holistic solution to shark conservation, addressing the degradation and restoration of one of the most important and threatened coastal ecosystems (the mangroves), and the recovery of endangered shark species, that use these ecosystems as nursery grounds.

Keywords: Local leadership; Sustainable community development; Mangroves restoration; Shark nursery grounds SI Abstract Ref: 258

Benaya Simeon

Wildlife Conservation Society - Indonesia Program

Reviewing the conservation actions: A lesson learned from village which depends on threatened species for their livelihoods

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- 3. Muhsin; WCS Indonesia Program
- 4. Kurniasih Nur, Afifah; Nature Conservation Agency of West Nusa Tenggara Province, Indonesia
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Indonesia known as country with rich natural biodiversity which the people also depend on the natural resources including marine resources. The dependency also occurs on elasmobranch group which has been being commodity for decades, meanwhile it had been concerned and prioritizing to be managed and conserved. West Nusa Tenggara is a province who led conservation actions for elasmobranch in Indonesia, which some of the fishers targeting and highly depends on elasmobranch catches. There were about 150 elasmobranch fishers' families, while the main economics domino effect could influence at least 3 villages. The complexity of socio-economics conditions made the conservation actions very challenging to be done. Since 2018 to 2021 conservation actions have been conducted, there were: (1) habitat protection, (2) catch-effort limitation, and (3) livelihood approach. From 3 years monitoring and evaluation of conservation actions, we recorded that the number of juvenile catches of critically endangered species has decreased which showed a good indicator for the conservation effort. But we found due to pandemic COVID-19 the fluctuation of utilization was found which also influenced the local compliance of catche-effort limitation. Livelihood approaches were conducted to shark fisher and wives, whose shark fishers supported by additional job as tourism operator and the wives as fish processor. We found that the livelihood approach to the wives group stood well and helped them better through the pandemic compared with tourism operators. We found that those conservation actions could not be separated due to the economic aspects to support any conservation actions for elasmobrance.

Keywords: conservation; elasmobranch; habitat protection; catch effort limitation; livelihood approach SI Abstract Ref: 176

David Shiffman

Arizona State University

Why everything people know about shark conservation is wrong: an interdisciplinary analysis of knowledge and attitudes along the science policy interface

Shiffman, D.S.

Sharks face serious conservation challenges, and while more people care and want to help than ever before, misinformation and misunderstanding plague the discourse. When the interested public has an inaccurate understanding of the threats to sharks and the evidence supporting the effectiveness of different policy solutions, they are unlikely to support the same policy solutions that experts prefer. Over the last decade, my work has examined what members of the public know about shark conservation, whether it's factually correct, and where they learned it. This talk will summarize the causes and consequences of public misunderstanding of shark conservation issues, and what we as experts can do about it.

Keywords: conservation; social science; human dimensions; survey SI Abstract Ref: 169

Dr Clova Mabin

Save Our Seas Foundation Shark Education Centre

Challenges in developing ocean stewardship in young people from under-resourced communities Clova Mabin; Save Our Seas Foundation Shark Education Centre

If we want future generations to care about ocean conservation, we need to ensure they connect with the ocean. A greater connection with nature (in childhood and as adults) leads to increased pro-environmental values and behaviours. But, in the current climate, how do we balance a positive love for the ocean and its inhabitants with the negative emotions experienced when faced with the hard facts regarding biodiversity loss, habitat destruction and climate change? The Save Our Seas Foundation Shark Education Centre in Cape Town, South Africa, faces this question daily. As an environmental education centre, we focus on experiential education programmes on local marine ecosystems and sharks. We aim to share knowledge, encourage environmentally responsible actions and address misconceptions about sharks. However, our target audience is young people from under-resourced and densely populated communities, with low levels of personal connection with nature. These school children often have other priorities that many of us take for granted, including access to food, water and safe shelter. So, how do we make this subject matter to our target audience? And how can we sustain this feeling of stewardship and hope for the future once the education programme is completed? Our experience suggests that a combination of long-term programmes and constructive hope nurtures the greatest engagement, but accessibility remains a challenge.

Keywords: experiential learning; young people; ocean stewardship; under-resourced communities SI Abstract Ref: 349

Jade Schultz Save Our Seas Foundation

Learning to love sharks

- 1. Jade Schultz; Save Our Seas Foundation
- 2. Kelli Whitehead; Save Our Seas Foundation
- 3. Nicola Poulos; Save Our Seas Foundation

Science communication for conservation.

Increased access to social media has brought about a change in the way people find and digest information. This has meant that how we communicate science and conservation topics in this rapidly evolving communication landscape also needs to change.

We have seen a move from people reading longer, more text-heavy full-length articles to a preference for video and graphics with a short text caption. Communicating years of research into a single social media post, which has to stand out amongst millions of other social media posts on one shared timeline, is exceptionally challenging.

Save Our Seas Foundation (SOSF) communication has used a mix of media (imagery, video, artwork) in various ways to effectively engage with a larger audience to teach them about sharks and our oceans, encourage a sense of custodianship, educate them about the anthropogenic threats that need to be addressed, foster an interest in research and create advocates. This presentation will look at the multi-layered communication approach adopted by SOSF communication to appeal to a larger audience, foster an interest in sharks, communicate science, and create advocates for sharks; while upholding the scientific integrity of the work involved.

Keywords: communication; science; sharks; conservation; online SI Abstract Ref: 351

Jim Wharton, PhD

Seattle Aquarium; AZA SAFE: Sharks & Rays

Diversifying Shark Media

Jim, Wharton; Seattle Aquarium; Confirmed

During the online portion of the event, a workshop has been proposed to gather a diverse group of expert speakers to lead a conversation around the diversification of popular media programming that focuses on sharks and shark conservation. The workshop, as proposed, includes presentations on a recent paper concerning representation on SharkWeek, issues concerning representations of women, trans and LGBTQIA+ visibility in media and sciences, disabilities within shark sciences, and others. Breakout sessions proposed on guidelines for working with media companies, creating databases of diverse scientists and conservationists, and working with media companies to facilitate change will be followed by a conversation about the potential participants and outcomes for a Diversifying Shark Media Summit proposed for 2023. This presentation will summarize content, share results and deliverables, and provide a high level overview of the Association of Zoos and Aquarium's SAFE Sharks & Rays conservation initiative.

Keywords: media; representation; sharks SI Abstract Ref: 249

Christopher Mull

Dalhousie University

Estimating the species composition of global shark and ray fisheries

- 1. Christopher Mull; Dalhousie University.
- 2. Elizabeth Babcock; University of Miami.
- 3. Ana Paula Barbosa Martins; Dalhousie University.
- 4. Zoya Tyabji; Dalhousie University.
- 5. Devanshi Kasana; Florida International University.
- 6. Luke Warwick; Wildlife Conservation Society.
- 7. Demian Chapman; Mote Marine Laboratory.
- 8. M. Aaron MacNeil; Dalhousie University.

Shark and ray fisheries landings have decreased over the past decade. While more than 300 species are caught in global fisheries, reliable species-specific landings information is scarce as statistics are often reported as aggregate categories (e.g. "sharks, skates, and rays, nei"). Aggregate data masks important species-specific trends, complicating stock assessment efforts and obscuring the ecological footprint of fishing. Generating reliable species-specific landings estimates across the globe is critical for effective fisheries management. Here, we present an estimate of species-specific landings across more than 100 countries from 2000 to 2019 based on the FAO Fisheries Capture Production Database. Aggregate landings were allocated to species based on taxonomy, FAO Major Fishing Area, and estimates of fishing pressure. Unsurprisingly, blue sharks dominate global landings though batoids represent a greater proportion than expected. Our results provide species-specific trends in fisheries landings and will assist with estimating biological reference points across all landed shark and ray species globally. These refined landings estimates will improve stock assessments and strengthen the implementation and enforcement of conservation initiatives such as CITES.

Keywords: Global Fisheries Production; species identification; shark and ray conservation; extinction risk SI Abstract Ref: 73

Ana Paula Barbosa Martins

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Global correlates of shark and ray meat consumption

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- 2. Christopher Mull; Dalhousie University
- 3. Devanshi Kasana, Florida International University
- 4. Samantha Renshaw, Ocean Wise
- 5. Merle Schlawinsky; James Cook University
- 6. Aaron Judah; Dalhousie University
- 7. Zoya Tyabji; Dalhousie University
- 8. Rima Jabado; Elasmo Project
- 9. Elizabeth Babcock; University of Miami
- 10. Aaron MacNeil; Dalhousie University

The commercialization of sharks and rays, and their products generate jobs and income for a range of stakeholders, with shark and ray meat playing an important role in food and nutritional security in many coastal communities. The consumption of shark and ray meat is directly influenced by ecological (e.g., species diversity, and availability) and economic (e.g., product value and catch effort) factors. However, the influence of social and cultural characteristics, aspects that strongly influence eating habits and dietary preferences of communities, are poorly understood. Here, we identify the main correlates of shark and ray meat consumption through a systematic literature review, focusing on socioeconomic and cultural dimensions, and evaluate regional variation in shark and ray meat consumption on a global scale. Across the studied regions, several correlates were reported in the literature as drivers or barriers of shark and ray meat consumption, such as price and sensory perception (taste, texture, smell), health benefits or risks, eating habits, convenience of preparation, cultural and religious traditions, and livelihood and food security. We identify critical areas with overlap between high shark and ray production, proportion of threatened species, and meat consumption. With the decline of some shark and ray populations worldwide and lack of data to inform management, we emphasize the incorporation of correlates of consumption to help identify key aspects of shark and ray meat production and trade, as well as guide managers to ensure both shark and ray conservation and livelihoods.

Keywords: Chondrichthyes; patterns of meat consumption; meat production and trade SI Abstract Ref: 20

Zoya Tyabji Dalhousie University. Canada

Utilization and trade of sharks and rays in the Andaman Islands, India

- 1. Zoya Tyabji, Dalhousie University
- 2. Dr. Rima W. Jabado, Elasmo Project
- 3. Dr. Dipani Sutaria, James Cook University

Overfishing is recognized as the most pervasive threat to sharks and rays globally. While there is increasing emphasis on ecological aspects of shark and ray fisheries, socio-economic factors are often poorly incorporated in management policies. Here, we assess the utilization and trade of sharks and rays across the Andaman Islands by conducting semi-structured interviews with 87 fishers and eight traders. Sharks and rays were caught as bycatch and in targeted fisheries and exported to supply the meat market in peninsular India and support international trade in fins, gill plates, and liver oil. Many fishers consumed sharks and rays due to declines in reef fish, as an accessible and cheap protein source, while a majority of traders mentioned a rising demand for ray meat from peninsular India, leading to the development of a targeted ray fishery. Respondents stated overfishing as the cause of declines in sharks, with localised population declines of sharks and rays recorded. Our results highlight the need to monitor and regulate exports from the Andaman Islands by imposing sustainable harvest and export limits for priority species, community-based awareness programs, and fine-scale monitoring of fish landing and trade sites. We also propose to target consumers through awareness programs across India to reduce demand for shark and ray meat and improve management at local scales by engaging with socio-economic dimensions.

Keywords: elasmobranchs; fishing communities; interviews; fisheries; management SI Abstract Ref: 12

Barbara E. Wueringer

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Impacts of trophy collection and commercial fisheries on sawfishes in Queensland, Australia Griffin A. Pinkus, Veronika Biskis, Barbara E. Wueringer

Globally populations of sawfish (Batoidea: Pristidae) have declined due to fishing and bycatch. Before their protection, sawfish rostra were often collected as trophies, and sawfish fins could fetch some of the highest prices in the shark fin trade. The present study analyses a dataset of n = 723 sawfish rostra belonging to specimens of all four Australian species originating from Queensland over the last 100 years. Morphometric data from rostra were used to calculate sawfish total lengths and ages at death via published ratios. Rostra were split into the mass retention subgroup (n= 569), which originated from \leq 5 active commercial inshore gillnet fishers, and for which large geographic origin regions and decades of origin were known; and small scale retention subgroup (n = 154), for which individual years and locations were known. Species composition across six zones in Queensland changed significantly before and after the year 2000. After 2000, *Anoxyprisis cuspidata* dominated the species diversity on the east coast with *Pristis zijsron* present in low numbers. Large, adult *P. zijsron* were present across Queensland before 2000, and disappeared after 2000. The majority of rostra (92.2 %) originated from gillnet captures, both historically and after the year 2000. The commercial gillnet industry likely impacts all life history stages of Sawfishes. Since 2020, it is compulsory for commercial fishers to report interactions with sawfishes in SOCI (Species of Conservation Interest) logbooks. Comparison of rostra in the mass retention group with reported SOCI data indicates that underreporting is higher than previously assumed.

Keywords: sawfish; critically endangered; fisheries impacts; batoid; rostrum SI Abstract Ref: 328

Amos Barkai

OLSPS, Cape Town Western Cape, South Africa

SharkTrace: a supply chain traceability method and mobile application for tracing shark products in the seafood supply chain

- 1. Amos, Barkai; OLSPS, Cape Town Western Cape, South Africa
- 2. Ian, Knuckey; Fishwell Consulting, Melbourne Victoria, Australia
- 3. Glenn, Sant; TRAFFIC, Cambridge, United Kingdom

Overfishing and illegal fishing of sharks is depleting populations worldwide. Whether they are caught on purpose in target fisheries, or by accident, as bycatch, while targeting other species, there is a lack of management and control that leads to unsustainable fishing and illegal trading of shark products. To support the transparency of the provenance of shark products, the Shark Conservation Foundation funded a joint project with TRAFFIC, Fishwell Consulting and OLSPS to develop "SharkTrace" – a software and procedures to trace shark products from the fishing vessel through processing and wholesale

distribution supply chain. The SharkTrace team worked closely with shark fishing vessels and processing companies in southern Australia to develop the most appropriate procedures for collecting and tracing product data. OLSPS developed the software platform that enables the recording and viewing of relevant shark product information, from the point of capture through the supply chain. It utilizes proven hardware and software technologies, which include tamperproof RFID and QR tags and data validation systems.

The SharkTrace system is comprised of four components: three mobile applications and an integrated webserver database. The "Vessel" mobile application is used to record and "tag" the shark catch and any processing that occurs onboard the fishing vessel out at sea, while the "Factory" mobile application is used to record reprocessing and repacking of landed catch information. The webserver application stores data from the vessel and factory applications and communicate to the "on the road" application all data required to identify the source of the delivered product.

Keywords: Overfishing; Shark Bycatch; Illegal catch; Traceability; Tagging SI Abstract Ref: 197

Issah Seidu

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Socio-economic drivers of a guitarfish fishery in Ghana

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- 2. Fran, Cabada; EDGE of Existence Program, Zoological Society of London, UK.
- 3. Lawrence K. Brobbey; Department of Silviculture and Forest Management, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
- 4. Berchie, Asiedu; Department of Fisheries and Water Resources, University of Energy and Natural Resources, Ghana.
- 5. Paul, Barnes; EDGE of Existence Program, Zoological Society of London, UK.
- 6. Moro, Seidu; AquaLife Conservancy, P.O. Box SN 228. Santasi- Kumasi, Ghana.
- 7. Nicholas, K. Dulvy; Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada V5A 1S6

We address a significant data gap concerning the characteristics and drivers of guitarfish fisheries in four key ray-fishing communities in Ghana. We conducted landing and market surveys of guitarfishes over a 80 day period from November 2020 to August 2021. Further, we interviewed 51 fishers actively involved in the guitarfish fishery in the Western Region using semistructured interviews. The findings confirm the disappearance of sawfishes Pristis spp as they have not been captured by fishers for several decades and we also confirm the absence of recent captures of the *Rhynchobatus luebberti*. A total of 537 individual guitarfish from four species were documented. *Rhinobatos irvinei* was the most frequently landed species comprising 71% of all individual guitarfishes landed, with most of the specimens not yet sexually mature. Most fishers (71%) stated that the abundance of the two larger guitarfishes (*Glaucostegus cemiculus* and *Rhinobatos rhinobatos*) have declined by 80–90% based on their recollection. The main drivers for the catch or retention of guitarfishes were for both international trade of their fins and meat which are both traded locally (45%) and used as a source of food for local consumption (37%). While we know that high economic value drives catch and trade of giant guitarfishes and wedgefishes, here we show that this trade now extends to the other guitarfish species. The interviews and contemporary pattern of catches are consistent with a serial depletion of rhino rays from the largest most valuable species to the remaining smaller-bodied less valuable guitarfishes.

Keywords: by catch; small-scale fisheries; livelihoods; elasmobranch; Ghana SI Abstract $\mathsf{Ref:}\,43$

Keynote Address

Sonja Fordham

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Taking Stock of Shark Conservation: What's Working, What's Not, and What's Next?

Elasmobranchs' inherent vulnerability to fisheries and tendency to cross jurisdictional boundaries has fueled gradual yet steady elevation of their conservation priority worldwide. Thirty years after the IUCN established a Shark Specialist Group, there are both significant accomplishments in sustainability and increasingly dire warnings of extinction to report. A look back at three decades of shark and ray policy offers important lessons for preventing further depletion. Looking ahead, myriad improvements in information collection present new opportunities for overcoming chronic conservation hurdles. Researchers play a critical but not yet optimized role in the development of elasmobranch policy. By learning from the past and taking advantage of recent breakthroughs, conservationists and scientists can improve collaboration and chart a course for a brighter future.

Samantha Sherman

Simon Fraser University; TRAFFIC International

M-Risk: a framework for assessing global fisheries management efficacy of sharks, rays, and chimaeras

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- 2. Glenn Sant; TRAFFIC International; Australian National Centre for Ocean Resources and Security, University of Wollongong
- 3. Colin A. Simpfendorfer; Institute of Marine and Antarctic Studies, University of Tasmania
- 4. Eric D. Digel; Earth to Oceans Research Group, Department of Biological Sciences, Simon Fraser University
- 5. Patrick Zubick; Earth to Oceans Research Group, Department of Biological Sciences, Simon Fraser University
- 6. Grant Johnson; Department of Industry, Tourism and Trade, Fisheries Branch, Northern Territory Government
- 7. Michael Usher; Department of Industry, Tourism and Trade, Fisheries Branch, Northern Territory Government
- 8. Jay Matsushiba; Earth to Oceans Research Group, Department of Biological Sciences, Simon Fraser University
- 9. Nicholas K. Dulvy; Earth to Oceans Research Group, Department of Biological Sciences, Simon Fraser University

Fisheries management is essential to guarantee sustainable capture of target species, and to avoid undesirable impacts on incidentally caught species. A key challenge is to assess the status of species and the degree to which management is sufficient to avoid declines in relatively data-poor fisheries. While ecological risk analyses focus on intrinsic 'productivity' and extrinsic 'susceptibility', one would ideally understand the third axis of 'fisheries management'. Currently, there is no single management evaluation that can be applied to a range of data-poor fishery types. Here, we outline a management risk (M-Risk) framework for sharks, rays, and chimaeras that can be used to evaluate a species' risk to overfishing resulting from ineffective management. We evaluated whether management of individual species was sufficient for their relative sensitivity by combining the management risk score for each species face the greatest risk of overfishing and be used by fisheries managers to identify effective management policies by replicating regulations from countries with lower risk scores. This presentation will explain the M-Risk framework and discuss initial results of completed assessments in over 20 countries and all 4 tuna RFMOs

Keywords: Ecological Risk assessment; intrinsic sensitivity; resource management; socio-ecological resilience; data-poor fisheries

Abstract Ref: 28

Simon Dedman

Florida International University

Advances in our understanding of the ecological importance of sharks and their relatives

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- 2. Ruth E. Dunn; Lancaster University.
- 3. N. Frances Farabaugh; FIU.
- 4. Emily Lester; AIMS.
- 5. Elizabeth Madin; University of Hawaii.
- 6. Mark G. Meekan; AIMS.
- 7. Yannis P. Papastamatiou; FIU.
- 8. George Roff; CSIRO.
- 9. Jeremy J. Vaudo; Nova Southeastern University.
- 10. Aaron J. Wirsing; University of Washington.
- 11. Simon Dedman; FIU.

Sharks and their relatives fill many roles in their ecosystems, including as predators, competitors, and prey, as well as facilitators of other species. We synthesize and present the ecological importance of elasmobranchs within a theoretical context and relative to key marine ecosystems. Although sharks and their relatives do not always play critical roles in ecosystems, studies increasingly provide insights into where, when, and why they might be important to overall ecosystem dynamics. Research gaps remain, but in general elasmobranchs likely play a greater role in marine communities when (1) they prey upon, or threaten, longer-lived species that are more likely to invest in anti-predator behaviour or are more susceptible to predation; (2) they are the primary predator on a limited number of prey and therefore could have larger impacts on population sizes of these species; (3) they prey upon or threaten species that are likely to play important ecological roles themselves (e.g., large herbivores); (4) their predation is focused on life-history stages of prey where density-dependent selection occurs (although trophic cascades are possible in the absence of effects on mesoconsumer population sizes); and (5) they are transporting nutrients in generally oligotrophic ecosystems. Further work is needed to definitively make the link between loss of sharks and ecosystem disruption and to predict when and where it will be most pronounced.

We present the results of a synthesis workshop, outlining a conceptual pathway towards resolving the context dependence of the ecological importance of sharks including a call of broader international working groups.

Keywords: ecological importance; trophic level; predation; risk effects; nutrient transfer SI Abstract Ref: 234

Rima Jabado

IUCN SSC Shark Specialist Group; Elasmo Project

Delineating important shark and ray areas – a case study in the South East tropical and temperate Pacific Ocean

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- Peter M. Kyne; Research Institute for the Environment and Livelihoods, Charles Darwin University, Darwin, Australia
 Daniel Fernando; Blue Resources Trust, Colombo, Sri Lanka
- 4. Colin A. Simpfendorfer; Institute of Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania, Australia; College of Science and Engineering, James Cook University, Townsville, Australia
- 5. Giuseppe Notarbartolo di Sciara; IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force, Gland, Switzerland; Tethys Research Institute, Milan, Italy

With an estimated 37% of sharks, rays, and chimaeras (hereafter 'sharks') facing an elevated risk of extinction, immediate action is required to halt population declines and allow for species recovery. Despite the increasing number of marine protected areas around the world, most still fail to provide adequate protection for sharks. The Important Shark and Ray Areas (ISRA) approach was developed to put sharks on the map by identifying discrete, three-dimentional portions of habitat, important for one or more shark species, that have the potential to be delineated and managed for conservation. A set of four science-based criteria was developed, incorporating seven sub-criteria that allow the identification of sites most important to sharks and consider species' vulnerability, range restriction, life-history, distinctiveness, and diversity. Through a regional expert-based process, the first global candidate ISRAs were identified in the South East Tropical and Temperate Pacific Ocean (Mexico to Chile) and highlight areas of interest. Examples are provided on the use of the criteria to identify ISRAs; the ISRA peer-review process; the online searchable database and eAtlas; and the ISRA regional implementation strategy. The ISRA process will contribute the data needed to meet global conservation targets while providing a foundation for marine spatial planning and a starting point for policy-makers to consider sharks and their habitat needs in the design of protected areas. This in turn will support species conservation and, over time, allow some shark populations to recover.

Keywords: biodiversity; conservation; marine spatial planning; protected areas SI Abstract Ref: 302

Keynote Address

Prof Nick Dulvy

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A shark's eye view of ocean conservation

The oceans remain vast and inscrutable, while technology has revolutionised our capacity to track threats to biodiversity on land -- our understanding of the status of marine biodiversity remains limited. Fisheries offer glimpses of what is removed from the ocean, yet there are regular fisheries assessments for only around 350 fishes and catch data are often crudely identified to genus, family, or higher taxonomic categories ('nei'). IUCN Red List Assessments distil the natural history, threats, conservation actions and extinction risk of each species from this patchwork of data. But the assessment outcome depends on (1) attitudes to risk, and (2) how we treat missing data. Does no data mean that we can't determine status (Data Deficient), or that the species is gone (Extinct)? Two major advances have transformed our understanding of risk over the past two decades. First, comparisons of the performance of the IUCN Criteria reveal a high degree of harmony with fisheries assessments, giving greater confidence in the value and relevance of Red List Assessments for policy processes. Second, new methods of borrowing information (based on phylogenetic, spatial, and temporal proximity) have improved our understanding extinction risk for data-poor species. These advances, combined with retrospective and repeated assessments, can be used to track the decline or recovery of species, can be used to calculate the Red List Index needed by nations to track their progress towards biodiversity and sustainability targets. From this deep historical view, we can set the conservation agenda for the next decade.

Trisha Gupta

University of Oxford

Is shark and ray research in India relevant to their conservation?

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- 2. Divya Karnad; Department of Environmental Studies, Ashoka University, Sonipat, Haryana, India; Foundation for Ecological Research, Advocacy and Learning, Morattandi, Tamil Nadu, India
- 3. Shruthi Kottillil; Foundation for Ecological Research, Advocacy and Learning, Morattandi, Tamil Nadu, India
- 4. Sudha Kottillil; Foundation for Ecological Research, Advocacy and Learning, Morattandi, Tamil Nadu, India
- 5. E.J. Milner Gulland; Interdisciplinary Centre for Conservation Science, Department of Zoology, University of Oxford, UK.

With chondrichthyans (sharks, rays and chimaeras) currently threatened by overexploitation, it is critical that resources are used effectively to mitigate these threats, especially in resource-limited tropical countries of the global south. India is amongst the top fishing nations for these species and a priority region for their conservation. We conducted a scoping review of chondrichthyan literature in India to assess the relevance of this research to the conservation of these threatened species. Between March and April 2021, we searched for peer reviewed and grey literature across national and international databases and found 482 chondrichthyan publications. While the number of publications exponentially increased with time, the literature is dominated by short-term fisheries studies, biological records and observations, with less than 10% of studies addressing socio-economic and management themes. Research was biased towards specific states, particularly Tamil Nadu and Kerala, and towards charismatic species like the whale shark, leading to under-representation of potentially important regions and taxa. Overall, our study found low relevance and applicability of India's research literature to chondrichthyan conservation. There is a need for improved understanding of the socio-economic aspects of chondrichthyan fisheries, species risk assessments at the regional level, data on critical habitats, and the evaluation of existing policies. Addressing these gaps can help ensure that effort is allocated to the regions, species and topics that need it the most, for improved conservation outcomes.

Keywords: scoping review; fisheries management; policy; Elasmobranchs; SI Abstract Ref: 78

Rosalind Bown

Blue Resources Trust

Managing the overlooked sharks and rays of Sri Lanka

- 1. Daniel, Fernando; Blue Resources Trust
- 2. Akshay, Tanna; Blue Resources Trust

Shark and ray landings peaked in the late 1990s in Sri Lanka and despite declining since, did not halt owing to demand from the expanding and lucrative global market for fins, liver oil, skins, and gill plates. They are captured in multispecies fisheries ranging from beach seines to pelagic gillnets and longlines. Available data is poor and exacerbated by the existence of ~50,000 vessels landing at >900 sites along the 1,340 km coastline. National statistics lack species-specific data for rays and have

marginal resolution for ~10 pelagic sharks through sporadic surveys focusing primarily on 21 fishery harbours. Our >1,800 fishery surveys conducted over 5 years across 85 sites have documented >30,995 Chondrichthyans, comprising 53 shark, 49 ray, and 1 chimaera species. Recent listings on CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) along with some conservation and management measures in the IOTC (Indian Ocean Tuna Commission) has increased national awareness. However, despite 65% of the recorded species considered threatened by the IUCN Red List, only five are protected and others lack sufficient management. A balance between improving data collection and establishing precautionary regulations to prevent species being driven closer towards extinction is necessary and urgent. We highlight the successes and challenges in improving knowledge to develop stock assessments, understanding socio-economic needs, encouraging sustainable fisheries, and advancing proactive national and international policy; all with the goal of halting declines and enabling recovery of the overlooked sharks and rays of Sri Lanka.

Keywords: Fisheries; Research; Policy; Species diversity; SI Abstract Ref: 318

Dillys Pouponeau

Save Our Seas Foundation D'Arros Research Centre (SOSF-DRC), Rue Philippe Plantamour 20, 1201 Geneva, Switzerland

Challenges for shark and ray conservation in large ocean developing states – a perspective from the Republic of Sevchelles

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- 2. Ellie Moulinie; Save Our Seas Foundation D'Arros Research Centre (SOSF-DRC), Rue Philippe Plantamour 20, 1201 Geneva, Switzerland
- 3. Robert Bullock, Save Our Seas Foundation D'Arros Research Centre (SOSF-DRC), Rue Philippe Plantamour 20, 1201 Geneva, Switzerland
- 4. Henriette Grimmel; Save Our Seas Foundation D'Arros Research Centre (SOSF-DRC), Rue Philippe Plantamour 20, 1201 Geneva, Switzerland

The Republic of Seychelles is an archipelagic island state in the Western Indian Ocean that is home to a vast array of marine biodiversity including many threatened elasmobranchs. Seychelles has a land mass of only 455 km2 but its exclusive economic zone stretches across 1.3 million km2. In recent years the country has taken major steps to conserving its marine environment and resources, committing to protecting 30% of its national waters. Despite this, Seychelles faces challenges with regards to the protection of some of its most important and most threatened species. Unregulated fishing for sharks and rays persists in Seychelles with critically endangered species frequently present at local markets, including juvenile and sub-adults to a large extent. Illegal and unreported fishing also poses a significant problem. The human, financial and institutional resources needed to tackle these issues are limited and the accepted consumption of sharks and rays alongside the perception of sharks as a threat may hinder legislative efforts. This investigation considers the nuanced challenges to shark and ray conservation in the Seychelles, discusses the efforts being made to address them and asks what must be done to find long-term solutions for all stakeholders in a country where eating sharks and rays is normal.

Keywords: conservation; elasmobranchs; unregulated fishing; social dimension; Seychelles SI Abstract Ref: 305

Diya Das

Institute of Marine Science - Okeanos, University of the Azores

How to avoid an unavoidable bycatch – lessons from distribution models of deep-sea elasmobranchs in the Mid-North Atlantic Ocean

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- 2. José, Gonzalez-Irusta; Instituto Español de Oceanografía, Centro Oceanográfico de Santander
- 3. Telmo, Morato; Institute of Marine Science Okeanos, University of the Azores
- 4. Laurence, Fauconnet; Institute of Marine Science Okeanos, University of the Azores
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- 6. Pedro, Afonso; Institute of Marine Science Okeanos, University of the Azores
- 7. Cláudia, Neto Viegas; Institute of Marine Science Okeanos, University of the Azores
- 8. Luís, Rodrigues; Institute of Marine Science Okeanos, University of the Azores
- 9. Gui, Menezes; Institute of Marine Science Okeanos, University of the Azores
- 10. Alexandra, Rosa; Institute of Marine Science Okeanos, University of the Azores
- 11. Mário, Rui Rilhó Pinho; Institute of Marine Science Okeanos, University of the Azores
- 12. Hélder, Guerreiro Marques da Silva Silva; Institute of Marine Science Okeanos, University of the Azores
- 13. Eva, Giacomello; Institute of Marine Science Okeanos, University of the Azores

Deep-sea elasmobranchs that mostly inhabit depths beyond 200 m, are highly susceptible to overexploitation due to their conservative life history traits, but continue to be extracted by fisheries worldwide. Due to the remoteness of this habitat, there is a lack of information available to formulate management strategies to reduce elasmobranch-fishery interactions in the deep sea. We used over 20 years of fisheries-independent and fisheries-dependent data to model the spatial distribution of 15

species of deep-sea elasmobranchs (12 sharks and 3 rays) captured frequently in the Exclusive Economic Zone of the Azores Archipelago (Mid-Atlantic Ridge) to explore spatial management to reduce unwanted catches of these species. We applied Generalised Additive Models to predict the probability of presence of 15 species, as well as the abundance of 6 of those species, within the Azores EEZ and neighbouring seamounts (up to 2000 m depth), using environmental and operational variables as predictors. Our results identified that depth is most influential in determining the distribution of these sharks and rays, in addition to seafloor topography. Distinctive bathymetric features such as seamounts and ridges were highlighted as areas where the probability of presence of the greatest number of species overlapped. Although not related to habitat, gear type influenced the capture probability of certain species, with the locally used artisanal handlines having lower captures than bottom longline. Our results suggest that inclusion of depth-based, area-based, and gear-based tactics in management measures may reduce elasmobranch bycatch, balancing livelihoods and species conservation, and contribute to more sustainable deep-sea fisheries.

Keywords: Delta GAMs; TAC Zero Species; bycatch mitigation measures SI Abstract Ref: 356

John Carlson NOAA Fisheries Service

They can't take it anymore! At what levels of fishing mortality can the giant manta ray recover?

- 1. John Carlson; NOAA Fisheries Service, Southeast Fisheries Science Center
- 2. Margaret Miller; NOAA Fisheries Service, Office of Protected Resources
- 3. Chelsey Young; NOAA Fisheries Service, Pacific Islands Regional Office

The giant manta ray (*Mobula birostris*) is a large pelagic ray with a circumglobal distribution in tropical and temperate waters. Within this broad range, the species is generally observed as small, isolated subpopulations with a high degree of philopatry. Previous demographic studies indicate giant manta ray have among the lowest productivity compared to other sharks and rays. The demand for meat and manta ray gill plates has led to increased fishing pressure (including directed harvest) and steep population declines in some locations. As a result, the giant manta ray has been listed as "Threatened" under the U.S. Endangered Species Act and classified as "Endangered" with extinction on the IUCN Red List. Their slow life history is likely a key reason why they have little capacity to withstand fishing pressure, however, no studies have examined the level of fishing mortality manta rays can withstand and still allow their population to recover. Therefore, we constructed an age-structured Leslie matrix population viability model for 5 subpopulations of giant manta ray in the eastern Pacific Ocean to determine their ability to recover under various scenarios of different levels of bycatch mortality from commercial fisheries and other anthropogenic activities. Population projections under various levels of fishing mortality resulted in extinction when mortality was highest and initial subpopulation sizes were small. Only under the most optimistic scenarios do giant manta rays have positive population growth. Effective recovery will likely only be achieved by reducing levels of fishing and anthropogenic-related mortality and promoting safe-release guidelines.

Keywords: population viability; manta; recovery; extinction; bycatch SI Abstract Ref: 56

Posters

Ana Lúcia Furtado Soares Ludwig-Maximilians Universität München, University of Munich Elasmobranch fisheries in Angola: a fishers' perspective

Andhika Prima Prasetyo

Centre Fisheries Research, Ministry for Marine Affairs and Fisheries, Indonesia Shark-dust: High-throughput DNA sequencing of processing residues unveils rife trade in endangered sharks and rays

Adrienne Gooden

1. Southern Shark Ecology Group; 2. Flinders University Accelerometers and animal-borne cameras reveal behavioural plasticity in white shark predatory strategy

Akshay Tanna

Blue Resources Trust Where have all the sawfishes gone? Perspectives on declines of these Critically Endangered species in Sri Lanka

Alba Martín-Lázaro

University of Valencia First record of the cirriped Anelasma squalicola Darwin, 1852 (Pollicipedidae) in the Mediterranean Sea.

Ana Maria Espino Ruano Universidad de las palmas de gran canaria Rays distribution and behaviour: surveys and telemetry as methodology

Ana María Espino Ruano

Universidad de las palmas de gran canaria Acusquat ii: acoustic monitoring of angelshark (*Squatina squatina*) behaviour in critical conservation areas".

Martin Anaïs

1;iSea, environmental organization for the preservation of the aquatic ecosystems 2; Sorbonne Université Monitoring elasmobranch bycatch in the small-scale fisheries of the North Aegean, Greece

Ana Paula Chaves Silva Universidade de São Paulo Metallic elements in a rare Holocephali specimen from southern Brazil

Ana Paula Chaves Silva Universidade de São Paulo Metal screening in two endangered hammerhead species captured in nursery areas in Southern Brazil

Amani Webber-Schultz Friday Harbor Labs; New Jersey Institute of Technology Comparative Morphology and Flow Analysis of Dermal Denticles at the Nares of the Pacific Spiny Dogfish, Squalus suckleyi

Martin Benavides

Center for Conservation and Sustainability, Smithsonian's National Zoo and Conservation Biology Institute Residency and movement patterns of elasmobranchs around a large marine infrastructure located in the central coast of Peru using acoustic telemetry Catherine S. Jones University of Aberdeen, UK Developing a genetic monitoring tool to assist conservation of North-east Atlantic benthic elasmobranchs conservation of North-east Atlantic benthic elasmobranchs

Caroline Bousquet UMS 3514 Stella Mare - University of Corsica / National Center for Scientific Research Artisanal fisheries bycatch reveals elasmobranch hot spot in Corsica

Cat Gordon

Shark Trust

Monitoring the development of Nursehound *Scyliorhinus stellaris* (Linnaeus, 1758) (Chondrichthyes: Scyliorhinidae) eggcases in-situ

Charlotte Nuyt

Institute of Marine Research, Tromsø, Norway; Université catholique de Louvain – UCLouvain, Louvain-la-Neuve, Belgium Genetic diversity and connectivity of the Northeast Atlantic spurdog Squalus acanthias stock

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Renata Daldin Leite Universidade Federal do Paraná (UFPR) Who's that Pokémon? The mystery of a Rhinoptera with hexagonal teeth

Renata Daldin Leite Universidade Federal do Paraná (UFPR) A toxic brain: metal contamination in the cerebral tissue of two apex sharks

Daniel Fernando

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Elasmobranch spawning areas from the northwestern Mediterranean with insights into reproductive seasonality and predation

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Desirée Grancagnolo

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Eloisa Pinheiro Giareta Universidade Federal do Paraná A global assessment of batoid stranding

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Francesca Romana Reinero

Sharks Studies Center-Scientific Institute, 58024 Massa Marittima, Italy; Italian Institute for Environmental Protection and Research (ISPRA), 57122 Livorno, Italy; Department of Earth Science, University of La Sapienza, 00185 Rome, Italy; Department of Earth Science, Environment and Life, University of Genova, 16126 Genova, Italy; Istituto Zooprofilattico Sperimentale delle Venezie (IZSVe), 35020 Legnaro (PD), Italy; Department of Biology, Ecology and Earth Sciences, University of Calabria, 87036 Rende (CS), Italy; Department of Physical Sciences, Earth and Environment, University of Siena, 53100 Siena, Italy.

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Giorgia Zicarelli

Department of Chemical, Biological, Pharmaceutical and Environmental Sciences, University of Messina, 98166 Messina, Italy 1; Department of Biology, Ecology and Earth Sciences, University of Calabria, 87036 Rende (CS), Italy 2; ARPAT Tuscany, Livorno, Italy

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Jena E. Edwards

1 NIOZ Royal Netherlands Institute for Sea Research, Den Burg, Netherlands; 2 Wageningen University and Research, Wageningen, Netherlands

Distribution and potential nursery function of the Dutch Wadden Sea for tope sharks (*Galeorhinus galeus*)

Jennifer Pytka

School of Ocean Sciences, Bangor University, Menai Bridge, Anglesey, LL59 5AB, UK; Department of Biology, University of Padova, Via U. Bassi 58/B, 35131 Padova, IT [current]

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Marcela Alvarenga de Almeida Simões

CIBIO, Research Centre in Biodiversity and Genetic Resources, InBIO Associate Laboratory – Universidade do Porto, Campus de Vairão, Vairão 4485-661, Portugal; BIOPOLIS Program in Genomics, Biodiversity and Land Planning, Campus de Vairão, Vairão 4485-661, Portugal; Departamento de Biologia, Faculdade de Ciências, Universidade do Porto, Porto 4099-002, Portugal; Faculdade de Ciências e Letras de Assis, Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Assis 19806-900, São Paulo, Brasil; Department of Marine Science, The University of Texas at Austin, Marine Science Institute, Port Aransas 78373, Texas, USA; Universidade do Estado de Minas Gerais (UEMG), Frutal 38200-000, Minas Gerais, Brasil; Instituto de Biociências de Botucatu (IBB), Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP), Botucatu 18618-689, São Paulo, Brasil;

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Institution 1; Colegio de Ciencias Biólogicas y Aplicadas and Galápagos Academic Institute for the Arts and Sciences, Universidad San Francisco de Quito-USFQ. Institution 2; Galápagos Science Center, Universidad San Francisco de Quito – University of North Carolina at Chapell Hill. Institution 3; Rosenstiel School of Marine and Atmospheric Science, Department of Marine ecosystems and Society.

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Patrick Burke

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Ana Pešić

1. University of Montenegro – Institute of Marine Biology, Put I bokeljske brigade 68, 85330 Kotor, Montenegro An important locality for elasmobranchs in the SE Adriatic Sea? Sharks and rays in the confined area – Bojana/Buna river estuary

Petter Lundberg

Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences (SLU), 90183, Umeå, Sweden

Behaviour and survival of hatchery-reared small-spotted catsharks in the north-east Atlantic

Pablo García-Salinas

Grupo de Acuicultura y Biodiversidad, Instituto de Ciencia y Tecnología Animal, Universitat Politècnica de València; Fundación Oceanogràfic de la Comunitat Valenciana, Ciudad de las Artes y las Ciencias; Associació LAMNA **Sperm collection procedures in chondrichthyans: a new perspective for ex situ conservation**

Pablo García-Salinas

Grupo de Acuicultura y Biodiversidad, Instituto de Ciencia y Tecnología Animal, Universitat Politècnica de València; Fundación Oceanogràfic de la Comunitat Valenciana, Ciudad de las Artes y las Ciencias; Associació LAMNA CT scan as a tool to detect necropsy overlooked injuries in stranded blue sharks

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Sara Asadi Gharabaghi Minority in shark science Foraging ecology of Bonnethead sharks *Sphyrna tiburo* in Biscayne Bay, Florida with stable isotope analysis

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Leire Lopetegui-Eguren

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Shari Schlueter

Marine Biology, College of Science and Engineering, James Cook University, Townsville, QLD 4811, Australia AND ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD 4811, Australia A co-produced study on the impacts of fluctuating sea surface temperatures and atmospheric pressure on male Galapagos shark sightings in Hawai'i

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Arlin Gabriela Ramos Rodriguez

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Age and growth of the banded guitarfish, *Zapteryx exasperata* (Jordan & Gilbert 1880), in the Gulf of California, México.

José Belquior Gonçalves Neto

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Noemi Pasini

Instituto Español de Oceanografía (IEO-CSIC), Centre Oceanogràfic de les Balears, Palma, Spain; Laboratori de Genètica, Universitat de les Illes Balears, Palma, Spain; Department of Biological, Geological and Environmental Sciences, Alma Mater Studiorum University of Bologna, Ravenna, Italy

Population genetics of the critically endangered Myliobatis aquila (Linnaeus, 1758) across the Gibraltar Strait

Ana Paula Chaves Silva

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Exploring the Genetic Diversity and Population Structure of *Mobula birostris* in Two Key Aggregation Zones in the Eastern Tropical Pacific

Francesco Luigi Leonetti

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Hannah Rudd

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Shark Hub UK: A model for building and maintaining resilient relationships between recreational shark anglers and scientists to research and conserve sharks

Sophie Loca

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Employing a multidisciplinary approach to establish reliable baseline information for a data-poor, critically endangered elasmobranch.