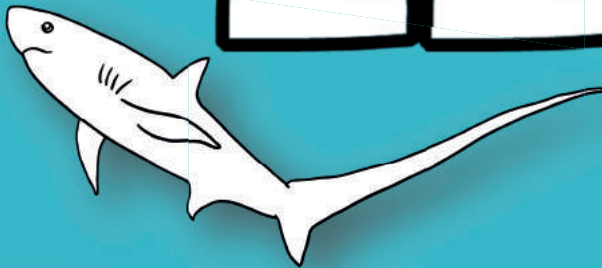


The 21st European Elasmobranch Association
Annual Scientific Conference



EEA



2017

October 12-14th, 2017

Amsterdam

The Netherlands



ABSTRACTS OF THE 2017 EUROPEAN ELASMOBRANCH
ASSOCIATION ANNUAL SCIENTIFIC CONFERENCE

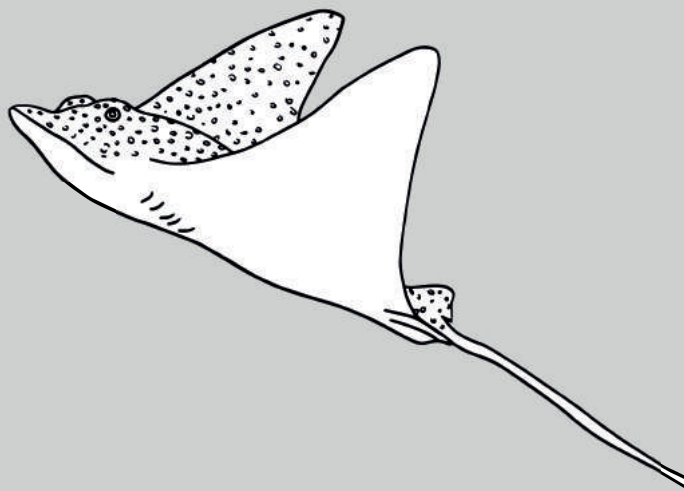
The science you need for
the policy you want

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Date of first Publication: October 12, 2017

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FOREWORD



Foreword

We are very proud to welcome you to the 21st Annual Scientific Meeting of the European Elasmobranch Association in the great city of Amsterdam. The overwhelming number of interesting abstract submissions promises to be the ingredient for an educational and enjoyable conference. The wide variety of subjects ranging from microchemistry to long distance migrations and from past to future will give everyone assembled here food for thought for years to come.

Natural sciences do not exist in a vacuum as the actions of man affect the natural world around us and as scientists we have a responsibility to share and advance our knowledge. Not only to make sure that this is reflected in the scientific literature, but that it also reaches the policy makers tasked with making decision on how we manage our interactions with nature. This is why we chose “The science you need for the policy you want” as the theme of this year’s conference, as it exemplifies what the EEA is aiming to accomplish. By being smart in how we ask our scientific questions we can ensure those in power have the best possible basis for decision making and we can hold them accountable should they choose to ignore the best available scientific advice.

On Saturday afternoon we will host break-out sessions around current themes in elasmobranch science and policy. This will allow delegates to interact on their chosen subject with other experts in their field. During the 2014 EEA these session yielded new research collaborations and some strong resolutions on management. We hope this year’s will equal or enhance that result.

When we hosted the 18th EEA conference in Leeuwarden in 2014 we described it as the coming of age for the conference, it is then only fitting that we use the 21st installment of the conference to guide it into adulthood. As the only dedicated annual elasmobranch conference on this continent it has grown as an event, not only attracting speakers and delegates from all over the world, but also as an influencer. Each year we come up with resolutions and recommendations that reach the relevant decision makers and this year we were able to host three side events where representatives from the European Commission and several EU member states participated, engaging with the world class scientist assembled at the conference to drive the shark conservation and management policy agenda.

We live in a world in flux where the impact of man-made climate change is becoming part of our everyday lives and growing unrest in the world is driving more and more people from their homes into an uncertain future. For this reason, we made the resolution to strive for environmental and social sustainability in the organization of EEA2017. All meals served will be vegetarian and we will limit the use of reusable products and plastics. For part of the conference we have asked refugees from the We Are Here group, a group empowering undocumented migrants in Amsterdam, to assist us. They will be responsible for photography and videography during the conference and will cater for the traditional conference dinner.

Amsterdam is a beautiful multicultural city with a lot of history and we certainly hope you will find some time to experience the city in all it has to offer.

We wish you all a pleasurable and stimulating conference!

-- The organizing team from the Dutch Elasmobranch Society --

Irene Kingma – General Director
Paddy Walker- Head of Science
Linda Planthof – Project Officer

Striving for sustainability

This year, the Dutch Elasmobranch Society made the resolution to strive for environmental and social sustainability with our organization of the 21st edition of the Annual Scientific Conference of the European Elasmobranch Association.

- All snacks and meals served at the conference will be vegetarian;
- We will limit, to our greatest ability, the use of reusable products;
- Delegates who own reusable coffee mugs are asked to bring their own;
- All the materials in your conference pack are made from ecological materials and produced in a sustainable way;
- There will be no use of plastic straws in drinks;
- All volunteers and employees are requested to strictly travel by public transportation.

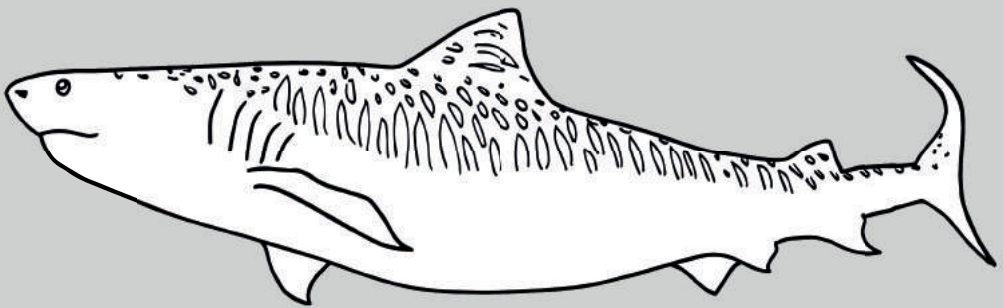
Carbon conscious

We are all familiar with the threat that climate change poses to the world and the oceans we care about. We have tried to keep our carbon emissions low with planning the conference, and we will compensate for the emissions we can't prevent. All speaker flights and accommodations, the use of the venue and all the conference meals will be compensated through a gold standard carbon credits scheme. If you are flying in for the conference, we invite you to do the same.

We Are Here

We are incredibly proud that the We Are Here foundation, an organization run by undocumented migrants, has agreed to be our host for the dinner this year. The diverse group consists of people from around the world, whom all have their own passions. One of these great passions is cooking. Several people have agreed to prepare an African feast for our conference dinner on Saturday, October 14th, 2017 with ethnic dishes from their home country. The dinner will be held in a very special location usually closed to the general public.

PROGRAM



Program EEA2017

Day 1- October 12th, 2017

11.00	Registration Desk open
12.30	Opening address
13.00	Session 1
14.35	Poster Pitch Session 1
15.05	Coffee Break
15.30	Session 2
17.45	Annual General Meeting of the EEA

19:00 – 21:00 Icebreaker reception at the Marble Hall of the KIT Royal Tropical Institute

Day 2- October 13th, 2017

09:00	Session 3
10.45	Coffee Break
11.15	Session 4
12.40	Poster Pitch Session 2
13.15	Lunch
14.15	Session 5
16.00	Coffee Break
16.30	Session 6
20:00 – 22:00	Cultural event at Jungle Amsterdam

Day 3- October 14th, 2017

09.00	Session 7
10.45	Breakout Sessions and Lunch
13.30	Report Back from Breakouts
14.00	Session 8
15.10	Coffee Break
15.40	Session 9
17.30	Closing address
19.00 -23.00	Annual conference dinner and auction to raise funds for student bursaries

Day 1 - Thursday October 12th, 2017

Session 1 & 2 – New perspectives – 12.30-17.35

Time	Speakers	Title
12.30	Dutch Elasmobranch Society	Opening address
13.00	Keynote: Dr. Robert Hueter	Connecting Elasmobranch Science with Elasmobranch Policy
13.50	<u>D. Barrios-O'Neill</u> , C. Bertolini, P. C. Collins	Trophic cascades and the transient keystone concept
14.05	<u>R.H.L. Walls</u> & N.K. Dulvy	Tracking 2020 marine biodiversity targets with Europe's Sharks and Rays
14.20	J. Lynch, I. Kingma, E. Brouckaert, NWWAC Focus Group on Skates and Rays, <u>S. Vandamme</u> , C.P. Nolan	Stakeholders point of view on alternative management for skates and rays
14.35 Poster Pitches		
15.05 Coffee Break		
15.30	<u>Christopher. S. Bird</u> , Clive. N. Trueman, Ana Verissimo	Trophic geography of sharks
15.45	<u>M. Dureuil</u> , K. Boerder, R. Froese, B. Worm	The conservation value of Marine Protected Areas for sharks in Europe
15.55	<u>David Kuntel</u> , Sofi Mardiah, Prayekti Ningtias, Dharmadi	Protecting the Ocean Predator (Sharks) in Indonesia
16.10	<u>S. Monsalve-Rocha</u> , J.G.Ramirez, C.J. Polo, F. G. Riet-Sapriza, S. J. Caballero	Integrating ecological and socio-economic limited data to identify critical areas for shark conservation
16.25	<u>I. Kingma</u> & P. Walker	Earth, wind and Fire - A holistic approach to elasmobranch management
16.40	<u>H.V. Winter</u> , G. Leurs, M. de Graaf	Reef sharks on the move, or not? Integrated telemetry and BRUV study on Saba Bank and adjacent islands
16.50	<u>R. van der Veer</u> & T. Bervoets	Save Our Sharks: Shark conservation in the Dutch Caribbean
17.00	J. Richardson	The importance of taxonomy in fisheries management
17.10	<u>E.K.M. Meyers</u> , D. Jiménez-Alvarado, J. Barker, J.J. Castro	Exploring critical areas to improve conservation planning for Angelsharks in the Canary Island
17.25	<u>J. Barker</u> , D. Jiménez-Alvarado, E.K.M Meyers, À Bartolí, J.J. Castro, J. Davies, N.K. Dulvy, C.A. Gordon, A.R. Hood, J.M. Lawson, B. Wray	Importance of stakeholder engagement to conserve angel sharks across the Eastern Atlantic and Mediterranean Sea
17.45 Annual General Meeting (AGM)		

Day 2 – Friday October 13th, 2017 / Morning

Lunch – 13.15-14.15

Session 3 & 4 – Elasmobranch Management – 9.00-13.15

Time	Speakers	Title
9.00	Keynote: Dr. Kim Friedman	People, Fisheries and Sharks
9.50	<u>S.L. Fowler</u> & P. A. Walker	CITES Non-detriment findings for elasmobranchs: the role of science, and the pros and cons of a regional approach
10.05	Sonja V. Fordham	A New Era in North Atlantic Elasmobranch Conservation
10.20	<u>S. J. Hetherington</u> , R. E. Nicholson, V. A. Bendall, J. Rendell, P. Trebilcock, A. Hood, C. O'Brien	Near real-time communication of the spatial and temporal abundance of spurdog (<i>Squalus acanthias</i> L.), to reduce by-catch, discards and fishing mortality in a mixed fishery: The Spurdog By-catch Avoidance Programme
10.35	<u>P. Walker</u> & I. Kingma	How are we managing? Developing new management tools for sharks and rays
10.45 Coffee break		
11.15	C. Gordon	No Limits? The Mako'ver.
11.25	<u>N. D. Walker</u> , B. García-Carreras, D. L. Maxwell, W. J. F. Le Quesne, S. Jennings	A vulnerability assessment of elasmobranchs and teleosts based on sensitivity and exposure to fishing pressure
11.35	<u>J. R. Ellis</u> , G. Burt, N. Hampton, J. Silva, S. R. McCully Phillips	Half a century of elasmobranch tagging
11.45	<u>L.M.F. Alves</u> , M. F. L. Lemos, H.N. Cabral, S. C. Novais	Elasmobranch fisheries in Portugal – a ten year health assessment
11.55	<u>Ilena Zanella</u> & Andrés López	Management of scalloped hammerhead shark in Golfo Dulce, Costa Rica
12.05	<u>P. Mayo</u> , S. Beggs, P.J. Mensink, J.D.R. Houghton	Spatio-temporal variation of dogfish (<i>Scyliorhinus canicula</i>) abundance in a highly fished area
12.20	<u>C. Barragán-Méndez</u> , I. Sobrino, J.M. Mancera, I. Ruiz-Jarabo	Survival and recovery responses in lesser spotted dogfish (<i>Scyliorhinus canicula</i>) after bottom trawling
12.30	C. Barragán-Méndez, Josefina Sánchez-García, I. Sobrino, J.M. Mancera, <u>I. Ruiz-Jarabo</u>	Stressful situations when being fished negatively affects muscle texture properties in the lesser spotted dogfish (<i>Scyliorhinus canicula</i>)
12.40 Poster pitches		
13.15 Lunch break		

Day 2 – Friday October 13th, 2017 / Afternoon

Session 5 – The Mediterranean - 14.15-16.00

Time	Speakers	Title
14.15	<u>A. Barash</u> , I. van Rijn, H. Lubinevsky, M. Goren, D. Tchernov	Long-term bottom trawl fishery surveys of Elasmobranchs off the Israeli Mediterranean coast
14.30	<u>Eyal Bigal</u> , Adi Barash, Aviad Scheinin, Dan Tchernov	Introduction of the Shark Tagging Programme in Israel and Preliminary Results from the First Two Seasons
14.40	<u>B. Azrieli</u> , A. Scheinin, A. Barash, D. Tchernov	Preliminary Assessment of a Nearshore Nursery Ground for the common Guitarfish, <i>Rhinobatos rhinobatos</i> and the Blackchin guitarfish, <i>Glaucostegus cemiculus</i>
14.50	M. Abudaya, <u>A. Ulman</u> , J. Selah, D. Fernando, C. Wor, G. Notarbartolo di Sciara	Speak of the devil ray (<i>Mobula mobular</i>) fishery in Gaza
15.00	<u>Shira Salingré</u> & Adi Barash	Seasonal distribution of Elasmobranchs in the Eastern Mediterranean using citizen science
15.10	<u>A.Chatzisprou</u> , E.Lefkaditou, C.Koutsikopoulos	Spatial distribution of skates and rays in the eastern Ionian Sea (Mediterranean Sea)
15.20	<u>H. Mendil</u> , F. Hemida, F. Sarano	Observations and distribution patterns of blue shark, <i>Prionace glauca</i> (Chondrichthyes: Carcharhinidae), along the Algerian basin (southern Mediterranean)
15.30	<u>F. Hemida</u> , C. Naib, A. Zoubir, C. Capapé	How many species of <i>Mustelus</i> (Elasmobranchs, Triakidae) occur off the Algerian coast? About morphological data to resolve such question
15.40	<u>M. S. Cashion</u> , N. Bailly, D. Pauly	A Shark by Any Other Name: Catch Reporting Quality in the Mediterranean Sea
15.50	A. Hood	Shark and ray management in the Mediterranean: a critical analysis
16.00 Coffee break		

Day 2 – Friday October 13th, 2017 / Afternoon

Session 6 – 16.30-17.45

Time	Speakers	Title
16.30	<u>Catalina Pimiento</u> & Jeroen Smaers	How to be a giant shark
16.40	<u>Jürgen Kriwet</u> , Thomas Mörs, Marcelo Reguero, Wolfgang Kiessling, Andrea Engelbrecht	Lessons from the past: Diversity dynamics are linked to climate change in elasmobranchs (Vertebrata, Chondrichthyes) in deep-time
16.55	K. Narváez & <u>F. Osaer</u>	ANGELSHARK-ID 2017: Photo-identification as a non-invasive monitoring tool
17.05	<u>M.T. Consol</u> , C. Gordon, J. Hepburn	Monitoring the development and success rate of <i>Scyliorhinus stellaris</i> eggcases
17.15	Paco Pinto de la Rosa	Embryonic development of the small spotted catshark (<i>Scyliorhinus canicula</i>)
17.25	<u>E.E. Becerril-García</u> , E.M. Hoyos-Padilla, P. Micarelli, F. Galván-Magañ, E. Sperone	Surface behavior of white shark, <i>Carcharodon carcharias</i> , related to legal and illegal baits in Guadalupe Island, México
17.35	<u>E. Sperone</u> , G. Rijllo, L. Bevacqua, S. Chiriaco, P. Giovannelli, V. Circosta, Y. Fabietti, A. Ranieri, G. Giglio, F.R. Reinero, A. Santoro, P. Micarelli	Do environmental factors affect the surface behavior of white sharks?

Day 3 – October 14th, 2017 / Morning

Session 7 & 8– Elasmobranch Ecology and Biology – 9.00- 15.10

Breakout sessions – 10.45-13.30

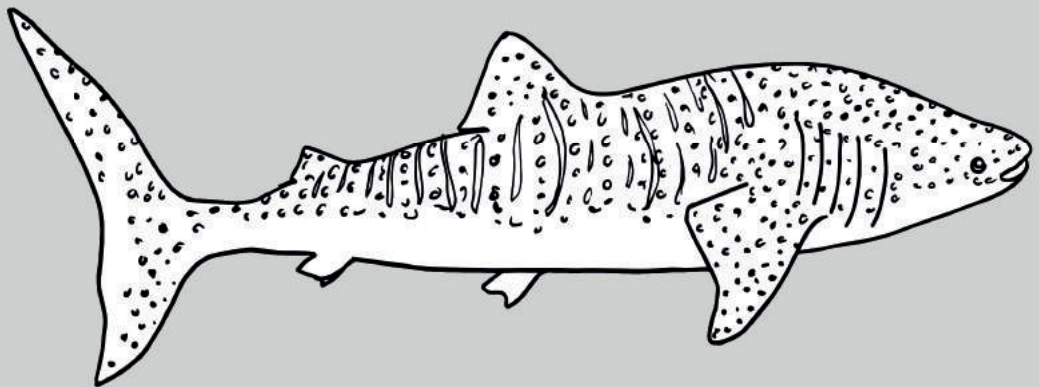
Time	Speakers	Title
9.00	Keynote: Dr. Neil Hammerschlag	Spatial ecology of highly migratory sharks: biophysical drivers, ecosystem effects, & conservation consequences
9.50	J. Thorburn, J. Dodd, F. Neat	Spatial Ecology of the flapper skate (<i>Dipturus intermedius</i>) in relation to an MPA
10.05	L. Lieber, R. Proud, T.B. Letessier, A.S. Brierley	Acoustic detection of sharks and rays in the BIOT Marine Reserve, Chagos Archipelago
10.20	K.L. Boswarva & J.A. Howe	In-situ identification of elasmobranchs using Autonomous Underwater Vehicles (AUVs) – a non-invasive method for assessing species distribution and habitat management
10.30	Michael Frisk, Keith Dunton, Chris Martinez, Catherine Ziegler, Josh Zacharias	Passive acoustic telemetry reveals seasonal long distance migrations in the winter skate (<i>Leucoraja ocellata</i>)
10.45 Breakout Sessions + Lunch break		
13.30 Report back from Breakout Session		
14.00	S. Weigmann	The western Indian Ocean as a newly discovered biodiversity hotspot for deep-water catsharks of the genus <i>Bythaelurus</i> , with presentation of a new species
14.15	S. R. McCully Phillips, P. Lorange, F. Marandel, M. Nicolaus, J. R. Ellis	Biological studies of shagreen ray <i>Leucoraja fullonica</i> and sandy ray <i>L. circularis</i>
14.25	D.C. Bernvi & G. Cliff	Red muscle distribution and liver anatomy contribute to warming of the stomach in white sharks (<i>Carcharodon carcharias</i>)
14.35	Claire Coiraton, David Jones, Felipe Amezcua Martinez	In Utero Vertebral Microchemical Signatures in Hammerhead Shark As a Proxy for Habitat Use and Dispersion Patterns in Pregnant Females
14.50	J. Williams	The Effect of Lipid and Urea Extraction on Stable Isotope Ratios in Coastal Demersal Shark Tissues
15.00	C. L. Gauci, L. van Herwerden, J. Strugnelli, B. D'Anastasi	Do female narrow sawfish mate multiply? A harrowing tale of low genetic diversity and elevated extinction risk
15.10 Coffee break		

Day 3 – October 14th, 2017 / Afternoon

Session 9 – Elasmobranch Ecology and Biology II - 15.40-17.30

Time	Speakers	Title
15.40	M. Sort, E. Nielsen, D. Meldrup, J. Ovenden	A global microsatellite genetic database for population assignment of tiger sharks; application to assignment of archived museum specimen back to population of origin
15.55	Judith Bakker, Owen S. Wangensteen, Demian D. Chapman, Germain Boussarie, Dayne Buddo, Tristan L. Guttridge, Heidi Hertler, David Mouillot, Laurent Vigliola, Stefano Mariani	Environmental DNA reveals tropical shark diversity and abundance in contrasting levels of anthropogenic impact
16.05	A.M. Batista-Morales, S.J. Caballero, C. Lasso, M. Morales	Phylogeography and genetic diversity of the common stingray (<i>Potamotrygon orbignyi</i>) through Amazonas and Orinoco basins
16.20	R. Bonfil, A. Janosik, O. U. Mendoza-Vargas, M. Ricaño-Soriano, I. Valladolid-Salazar, N. VanTassel	High-tech applied to saving sawfishes in Mexico
16.30	Barbara E. Wueringer	Is the protection of sawfishes in Queensland working?
16.40	G. Leurs, S. Y. Cheikhna Lemrabott, E. H. M. El-Hacen, H. Olff	Elasmobranchs of the Banc d'Arguin: conservation and ecological importance
16.50	L. Planthof & P. Walker	Tales from the wheelhouse: From anecdotal data to scientific evidence
17.00	Andres Lopez & Ilena Zanella	Residence and fidelity of bull shark (<i>Carcharhinus leucas</i>) in Islas Murcielago, North Pacific of Costa Rica
17.10	N. Pinte, P. Parisot, U. Martin, L. Duchatelet, V. Zintzen, J. Mallefet	Ecological features of several deep-water sharks species from New-Zealand infer by stereo video footage analyses
17.30 Closing address		

KEYNOTE ADDRESSES



Keynote 1 // Dr. Robert Hueter



Dr. Robert E. Hueter is a Senior Scientist and Director of the Center for Shark Research at Mote Marine Laboratory in Sarasota, Florida, where he also occupies the Perry W. Gilbert Chair in Shark Research. Dr. Hueter has been a marine biologist for more than 40 years, has published about 200 scientific articles and reports on sharks, and has edited six volumes on shark biology. His current research includes field and laboratory studies of shark abundance, behavior, ecology and fisheries in the northwest Atlantic Ocean, Gulf of Mexico and Caribbean Sea, including in Mexico and Cuba. In 2004, Dr. Hueter was selected by Florida Trend magazine as one of Florida's most influential people, in 2007 he was recognized with a Lifetime Achievement Award in Conservation by Sarasota County, Florida, and in 2008 he was awarded the Eugenie Clark Scientific Explorers Award.

Dr. Hueter earned his Bachelor's and Master's degrees from the University of Miami and his Ph.D. from the University of Florida. He is Past-President of the American Elasmobranch Society and currently serves on the AES Board of Directors. He also serves as the Chief Science Advisor for OCEARCH, a nonprofit organization dedicated to innovative ocean research and education. Much of his current work involves marine science policy as a diplomatic bridge between nations for the betterment of shared environments and human populations.

Connecting Elasmobranch Science with Elasmobranch Policy

Thursday October 12th, 2017 from 9.00-9.50

Scientists are often reticent about matters of public policy, feeling that it will somehow compromise their scientific objectivity, or damage their reputations, if they speak out in policy forums. But the world today needs science more than ever to help guide policy decisions. This is no less true than with policies that impact elasmobranch fishes, some of the most threatened vertebrates on the planet. It was scientists who raised the alarm that elasmobranchs were in trouble, and it also should be scientists who help guide resource managers and policy decision-makers towards a brighter future for elasmobranchs. In this talk I will describe my own journey as a marine biologist who was drawn into the policy arena, to educate and guide those who control the fate of elasmobranch populations. I will share lessons learned about how to do so without losing your scientific objectivity and identity, and why this can be a powerful force for elasmobranch conservation in both developed and developing nations.

Keynote 2 // Dr. Kim Friedman



Dr. Kim Friedman, an Australian national working as a Senior Fisheries Resources Officer for the United Nations Food and Agriculture Organisation in Rome, Italy. His main responsibilities include leadership of fisheries issues for Small Island Developing States (SIDS), fisheries and biodiversity, threatened species related matters and FAO's FishFinder commercially exploited species identification program. Kim holds a Bachelor of science (Hons) in Marine Biology, a Master's degree in Aquaculture and Fisheries, and was awarded a Doctorate from James Cook University in Queensland, Australia. Kim has experience salmon farming in Scotland, as well as working with New South Wales and Western Australian Fisheries Departments in Australia. Kim has led research programs for ICLARM (now WorldFish) in the western Pacific (Solomon Islands and Fiji), work that was written up as a PhD before Kim returned to the Pacific (working at the Secretariat of the Pacific Community in New Caledonia) surveying and assessing subsistence, artisanal and commercial coastal and inshore fisheries across 17 Pacific Island countries. Directly before working at FAO, Kim led the Department of Parks and Wildlife's Marine Science Program that oversaw research across 12,000km of Western Australia's coastline. Kim also worked as a consultant for FAO back in 2008, but now holds a Senior Fisheries Resources Officer position at headquarters in Rome.

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People, Fisheries and Sharks

Friday October 13th , 2017 from 9.00-9.50

Whatever your outlook, be it as a fisher, resource manager, conservationist, politician, educator or community member..., we all view sharks and rays through a different set of glasses.

This presentation tries to bring you a widescreen view of our options, as I see them, for working towards productive and sustainable oceans, with shark fisheries the main subject of the talk.

How do we achieve that? How do we get the interest and significant investment in shark management and conservation, now and tomorrow, converted into positive outcomes for people, sharks and the marine environment?

The talk examines the challenges we face, the opportunities and gaps that need to be filled, and talks to what we should do next to play our part in creating positive, lasting change.

Keynote 3 // Dr. Neil Hammerschlag



Dr. Neil Hammerschlag is a marine ecologist and Research Assistant Professor at the University of Miami Rosenstiel School of Marine & Atmospheric Science and Abess Center for Ecosystem Science & Policy. He also serves as Director of the Shark Research & Conservation Program at the University of Miami. His current research centers broadly on the behavioral ecology, conservation biology and movement ecology of marine predators, primarily focused on sharks. Neil's current research projects include investigating predators-prey interactions

between sharks and their prey, identifying shark critical habitats, examining the effects of urbanization on shark movement and health, evaluating effects of ecotourism and fishing capture stress on shark behavior and physiology, examining the ecosystem impacts of overfishing and also evaluating how sharks may respond to climate change stressors. In addition to his scientific research, Neil is dedicated to community outreach and public education. In 2010, Neil developed the Shark Research and Conservation Program (SRC) as a community outreach platform to provide high school students as well as public citizens with hands-on experiences in marine biology. Deeply committed to promoting STEM education and marine conservation, his team is joined by over 1000 students from a variety of socioeconomic backgrounds each year on shark tagging expeditions.

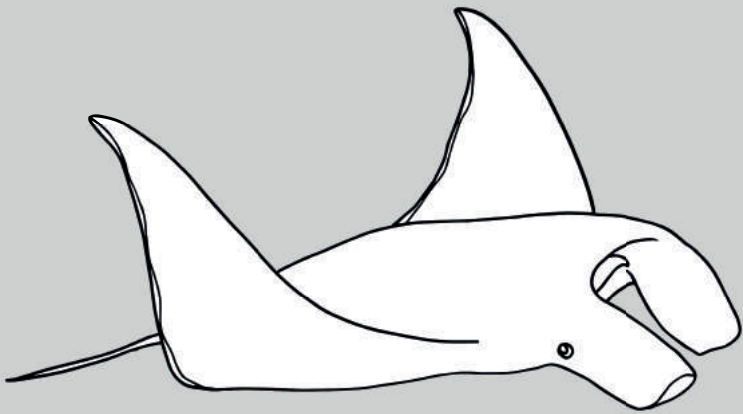
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Spatial ecology of highly migratory sharks: biophysical drivers, ecosystem effects, & conservation consequences

Saturday October 14th , 2017 from 9.00-9.50

Understanding the spatial ecology of animals is important for maintaining biodiversity, defining population dynamics, and for establishing effective conservation strategies. Determining the patterns and drivers of movement in highly marine apex predators is of particular significance since they can impact the structure and function of ecosystems and are also vulnerable to population declines from overfishing. Here a series of studies employing biotelemetry are used to assess the movement patterns and biophysical of great hammerhead (*Sphyrna mokarran*), tiger (*Galeocerdo cuvier*), and bull sharks (*Carcharhinus leucas*) in the western North Atlantic and demonstrate the associated ecological impacts on the behaviors of their prey. The consequences shark movement patterns on their vulnerability to commercial longline fisheries is also explored. Taken together, this research demonstrates how inter- and intra-specific difference in the spatial ecology of highly migratory sharks is driven by variation in biophysical drivers, which consequently can alter the habitat use of their prey, and also their vulnerability to exploitation.

ORAL PRESENTATIONS



Trophic cascades and the transient keystone concept

D. Barrios-O'Neill, C. Bertolini, P. C. Collins

Organization Queen's University Belfast
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The degree to which large elasmobranchs function as keystone predators is often debated. Answers vary among species and systems but, thus far, no concerted effort has been made to determine whether keystone function varies within species and systems, particularly as a result of changing environmental context. Here, we are motivated to explore the potential for changes in keystone-ecosystem interactions following a marked change in context: the demise of large tracts of *Modiolus modiolus* reef and associated habitat structure from Strangford Lough (Northern Ireland) preceded, several decades earlier, by the extirpation of Flapper skate, *Dipturus intermedius*. We used a tri-trophic study-system consisting of a proxy higher predator (*Raja microocellata*) a reef-forming basal bivalve (*Mytilus edulis*) and a representative crab mesopredator (*Carcinus maenas*) to experimentally test the effects of higher predator presence on mesopredator-reef interactions. We find that non-consumptive interactions between skate and crabs cascade down to consumptive interactions between crabs and bivalves, significantly reducing bivalve mortality. However, skate only functioned as keystone where crabs

foraged for bivalves in the absence of mature bivalve reef: where reef was present, bivalve mortality was not significantly different in the presence or absence of skate. By facilitating the establishment of basal species which, in turn, diminish higher predator effects on mesopredator behavior, the skate's keystone function is subject to negative regulation. Thus, we propose that keystone function can be transient with respect to environmental context. Our findings have two central implications for apex predator reintroductions and basic ecology: (i) species hitherto not considered as keystone may have the capacity to act as such transiently, and; (ii) keystones are known to regulate ecosystems, but transience implies that ecosystems can regulate keystone function. These experiments form part of a wider ecosystem restoration project that aims to reintroduce the critically endangered Flapper skate to Strangford Lough, and to modulate mesopredator populations and behavior to facilitate reef recovery. Our findings support the idea that a mooted reintroduction of Flapper skate to the Lough might have auxiliary benefits in the wider system, particularly by priming *Modiolus* reef recovery.

 **Keywords:** Skate, Trophic Cascades, Keystone Species, Reef Restoration

Tracking 2020 marine biodiversity targets with Europe's Sharks and Rays

R.H.L. Walls & N.K. Dulvy

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The main threat to marine biodiversity is overfishing, yet the trajectory of marine extinction risk remains largely unknown. Risk trajectories are required by 2020 to track progress towards imminent international policy commitments. Here, we report a regional Red List Index (RLI) for Class Chondrichthyes (herein 'sharks and rays') in Europe, while accounting for uncertainty from data deficiency with status predictions. Regional shark and ray extinction risk is higher and worsening faster than for all globally assessed terrestrial groups. Large-bodied species with shallow depth distributions that overlap with fisheries face the greatest risk

of extinction in Europe. This is particularly true in the Mediterranean Sea, where threat prevails compared with the Northeast Atlantic. Despite a decade of understanding the poor status of Europe's sharks and rays, there has been insufficient region-wide implementation of appropriate species protections and sustainable fisheries management to halt and reverse the loss of biodiversity. This is the first ever RLI for an exploited marine group, providing a powerful tool to track marine conservation and fisheries outcomes. Three years from the 2020 deadline, this RLI reveals Europe's failure to meet international policy obligations for sharks and rays.

Q Keywords: *Conservation Prioritization, Biodiversity Indicator, Predictive Modeling, Species Loss*

Stakeholders point of view on alternative management for skates and rays

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The North Western Waters Advisory Council (NWWAC) is a stakeholder organisation of industry and other interest groups, established under EU regulation to contribute to the achievement of the objectives of the Common Fisheries Policy. The introduction of an EU obligation to land all catches of quota species (a.k.a. the landing obligation) presents significant management challenges for mixed, commercial fisheries in the North Western Waters (NWW) of the European Union, especially those for skates and rays. The NWWAC has identified and informed the EU of the following challenges regarding the current management of skate and ray fisheries in NWW waters: That: (i) The combined TAC regime does not allow for adequate protection of stocks that are in a bad or unknown state, while for biologically healthy stocks exploitation may be unnecessarily restrictive; (ii) Although data availability has improved in recent years, data collection for several species remains

complicated as their abundance often lies outside the main survey areas; Some species are not very abundant in EU waters, or show a patchy distribution and (iii) The current management regime will lead to an almost immediate “choke”* situation under the application the landing obligation. An overview of the work conducted by the NWWAC on improving the management of skate and ray stocks in North Western Waters is presented. The effect of incorporating skates and rays into the landing obligation is discussed in the context of directed and mixed fisheries in the area, and an emphasis placed on the need for integration and collaboration with scientific experts and fisheries managers, in order to develop appropriate management solutions for these stocks.

*where fulfillment of a quota for one species in a management area prevents or “chokes” the capture of other quota species in that management area.

 **Keywords: *Rajidae, North Western Waters Advisory Council, Landing Obligation, Management***

Trophic geography of sharks

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Sharks are a diverse group of mobile predators that forage across varied spatial scales and have the potential to shape or stabilise food webs. Global-scale ecological consequences from declining shark numbers are more likely, and may be more detectable, if shark taxa perform broadly similar roles across different habitat types, so that local effects may scale across wider regions. In marine systems, the impact of an individual on the wider ecosystem is primarily influenced by trophic interactions, and thus the composition and spatial origin of the diet. By tracking the original site of photosynthetic fixation of carbon atoms ultimately assimilated into muscle tissues of 5285 sharks from 110 species, we identify globally consistent biogeographic traits between sharks found in different habitats.

We show that populations of shelf-dwelling sharks likely derive a substantial proportion of their carbon from regional pelagic sources, but contain individuals that forage within additional isotopically diverse local food webs. In contrast, oceanic sharks appear to utilise energy and nutrients that have originated from a relatively narrow latitudinal range. Combining nutrient sourcing with additional methodological approaches, such as animal tracking, offers a powerful tool for marine spatial ecology that may aid in future conservation planning.

The 'Chondrichthyan Stable Isotope Data Project' encourages future collaborations using these data and invite the addition of chondrichthyan stable isotope data moving forward.

 **Keywords:** *Stable Isotopes, Trophic Ecology, Food Web, Data Compilation*

The conservation value of Marine Protected Areas for sharks in Europe

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Overfishing and incidental capture place sharks among the most threatened marine wildlife in Europe, and around the world. Protected areas that provide shelter for vulnerable life stages could potentially play a key role in their preservation. Here we combine satellite data on European trawl fishing with scientific trawl-survey data for different life stages and modeled data on

shark distributions to investigate to what extent the current Marine Protected Area system can act as refuge for European sharks. We identify certain shark hotspots in Europe and find that Protected Areas are well placed to protect sharks. However, fishing regulations in these areas need to be substantially improved in order to achieve conservation benefits.

 **Keywords:** *Management, Marine Protected Areas, Protection, Spatial Ecology*

Protecting the Ocean Predator (Sharks) in Indonesia

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Indonesian marine territory is considered as the centre of marine biodiversity in the world and it has 113 shark species. The marine territorial water of Indonesia has almost one third of shark species worldwide. In Indonesia, sharks have been utilized to support the economy of coastal communities in many places, socio-cultural as well as research programs. Furthermore, sharks species have been traded in domestic and international markets due to its high value of shark fin. This paper examines the regulations and policies of the Indonesian government to protect shark species and to implement the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). There are two ministries have the authorities to manage shark species, namely Ministry of Environment and Forestry and Ministry of Marine Affairs and Fisheries. The overlapping authorities leads them to develop separate regulations to protect shark species. Several regulatory

frameworks are in place to support the conservation of shark species in Indonesia water territory, namely Ministerial Regulation No.48/2016 (four species prohibited to be exported), Ministerial Decision No.18/2013 (one species is fully protected) and Ministerial Regulation No.57/2014 as well as Ministerial Regulation No.12/2012 (management measures to conserve two shark species). National Plan of Action for Conservation and Management of Sharks and Rays 2016-2020 is being implemented by the Indonesian Government, and it is reviewed annually. There is a high pressure on Indonesia regarding the international trade of shark species. Thus, it is essential for the Government of Indonesia to better manage shark species so that they will not be threatened, endangered or become extinct because of the lack of management measures in terms of national and local policies as well as regulatory frameworks.

 **Keywords: Indonesia, CITES, Shark Policies, Regulatory Frameworks**

Integrating ecological and socio-economic limited data to identify critical areas for shark conservation

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Shark distribution and fishing grounds used by local communities are usually overlapped, although this coincidence is not straightforwardly distinguished in a data-limited context. We aim to determine critical areas for shark conservation using a comprehensive spatial model that combines shark species co-occurrence areas and socio-economic factors related to small-scale fisheries in the Colombian Caribbean. The distribution areas for the species *Ginglymostoma cirratum*, *Carcharhinus perezii* and *Rhizoprionodon* spp. were obtained using a maximum entropy (MaxEnt) species distribution model by R environment after performing sensitivity analyses for every species. Additionally, shark species co-occurrence areas were overlapped with current Marine Protected Areas (MPA's) and spatially related with socio-economic factors from local fishery communities. We identified four critical areas for shark conservation along the

Colombian Caribbean coast (Capurgana Bay, Morrosquillo Gulf, Southwest Tayrona and South and northern Guajira Peninsula). Only one of the identified critical areas partially overlaps with a MPA (Tayrona National Natural Park). The other three critical areas were strongly associated to fishing communities with low income, low educational level, high Unsatisfied Basic Needs Index and high population density. Our results suggest a relationship between shark co-occurrence areas and the fishing grounds used by economically deprived fishing communities. Moreover, our findings revealed that MPA's in the Colombian Caribbean may be insufficient, undersized and spatially inaccurate for shark conservation purposes. This study highlights the need of addressing shark conservation efforts beyond fishery and market controls by promoting well-being and better livelihood for fishing communities.

 **Keywords:** *Shark conservation, Spatial Model, Socio-economic Factors, Fisheries*

Earth, wind and Fire - A holistic approach to elasmobranch management

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What defines a successful strategy for shark conservation? This is a question many policymakers and conservationist struggle with. We believe that in order to reduce unwanted mortality in sharks and rays and create an improved situation for their environment over time, an all-encompassing approach is needed. A holistic strategy should include the right legislation as a starting point, coordinated management to ensure the laws can be implemented, effective control and enforcement to dissuade illegal activities and active communication to stakeholders to leverage support.

Scientific work is the basis for this approach and has a vital role to play in strengthening the conservation process by asking the right questions at the onset of a research project. Only by doing the science you need you can get the policy you want.

We propose a science-based holistic approach to campaigning which encompasses all four essential elements: legislation, management, control, and communication. Using two examples of a management system currently under development, one for the EU the other for the Dutch Caribbean, we showcase how such a process can be shaped and pitfalls to avoid.

 **Keywords: Management, Holistic Approach, European Union, Caribbean**

Reef sharks on the move, or not? Integrated telemetry and BRUV study on Saba Bank and adjacent islands

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To evaluate measures and marine reserves to protect amongst others reef sharks on the Saba Bank and around adjacent islands Sint Maarten, Sint Eustatius and Saba, we investigated occurrence and movements patterns of Caribbean Reef Sharks and Nurse Sharks at these sites. For this, we used stereo Baited Remote Underwater Video (sBRUVs), acoustic telemetry and Underwater Visual Census scuba diving database (UVC, citizen science). The project was carried out in cooperation with DCNA and local nature agencies. We installed a network of 32 acoustic receivers at the Saba Bank, Saba, Sint Maarten en Sint Eustatius, tagged 21 Caribbean Reef Sharks and 7 Nurse Sharks, starting in 2014. We also performed ~500 drops of ~1 hour at these sites. UVC of Saba were available since 2013. Both species showed restricted movement

patterns and relative small home ranges for most individuals (< 100s m to several 1000s m). Movements over deep water between different coral reef systems were rare. For Caribbean Reef sharks there were clear hot spots in occurrence, mainly near steeper drop-offs. All life stages from juveniles to adults were observed. Both species were present year-round and showed only weak seasonal changes in abundance. Diurnal patterns in movement, activity and occurrence varied for different individuals. When compared to other reef systems in the Caribbean the reef systems of Saba Bank, Saba, Sint Maarten en Sint Eustatius are still home to relatively healthy Caribbean reef shark and nurse shark populations. Our results indicate that marine reserves, when of sufficient size, will protect at least part of the reef sharks populations present.

 **Keywords:** *Caribbean Reef Sharks, Telemetry, Spatial Behaviour, Marine Coral Reserves*

Save Our Sharks: Pioneering Shark Conservation in the Dutch Caribbean

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The Save Our Sharks project is a shark conservation project in the Dutch Caribbean aimed at finding fitting solutions to improve the status of shark populations around Aruba, Bonaire, Curacao, Saba, St. Eustatius, and St. Maarten. The three-year project, headed by the Dutch Caribbean Nature Alliance (DCNA), includes conducting scientific research, doing communication, working on legislation, and working with fishermen on the reduction of bycatch. Since the beginning of the project, Shark Sanctuaries were established around three of the six islands, and eight elasmobranch species were successfully added to the Specially Protected Areas and Wildlife

(SPAW) Protocol, which is the only cross-border legislative instrument for nature conservation in the Wider Caribbean Region. All six islands were video monitored for the structure of elasmobranch populations, and both acoustic telemetry and satellite tracking studies were conducted. The main event of each year is the organization of Dutch Caribbean Shark Week, which is organized simultaneously on all six islands and the Netherlands. This presentation will provide an overview of the main progress and achievements of the Save Our Sharks project, covering the different elements associated with shark conservation.

Q Keywords: Conservation, Dutch Caribbean, Specially Protected Area and Wildlife (SPAW)

The importance of taxonomy in fisheries management

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Central to the management of any fishery is the accurate, consistent identification of its component species, including target, bycatch, restricted/prohibited and threatened species. Here, taxonomy provides the fundamental building blocks for effective management: the ability to capture data on each individual species.

Shark, skate and ray (hereafter 'shark') fisheries can pose a challenge. Historically conspicuous by its absence, management for this diverse group can be characterised more recently by focus on a small number of charismatic or high-value species, aggregated recording, wide regional variations in nomenclature and a paucity of practical ID materials. The sharks

themselves are not helpful: groups of look-alike species with overlapping distributions and widely varying life-histories.

Taxonomy remains central to the work of the Shark Trust and upcoming projects: updating and reprinting ID Guides to the Sharks, Skates and Rays of the Northeast Atlantic (for distribution throughout the wider commercial fishing industry); Commercial Fisheries Advisories; highlighting the importance of full discard recording and reporting (especially for Data Limited Species); participation in Fisheries-Science partnerships; and sharing the Trust's experience in developing ID materials with other regions around the world.

 **Keywords:** *Taxonomy, Fisheries, Management*

Exploring critical areas to improve conservation planning for Angelsharks in the Canary Island

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Knowledge of the ecology and movement of coastal shark species is critical for the designation and management of protected areas. The Angelshark *Squatina squatina* is assessed as Critically Endangered on the IUCN Red List of Threatened Species and belongs to the second most threatened family of all sharks and rays. In the Canary Islands, coastal shallow areas have been highlighted as critical areas for this species, however, there is still a lack of understanding about the use of these areas for example as nursery grounds or mating areas. Through a two year tag-recapture programme, 68 adult and 320 juvenile Angelsharks were tagged and released in four islands, including a marine reserve. Seasonal site fidelity was observed based on a 22,1 % (adult) and 14,1 % (juvenile) recapture rate of tagged individuals.

Juvenile Angelsharks (23-48 cm total length) exhibit a long-term residency up to 15 months in a nursery area, while adult Angelsharks remain in an area for several months and then disappear to return to the same areas the next year. Our findings document the use of critical areas as important nursery and breeding habitats for Angelsharks and emphasize the urgent need for their protection and management. In addition, the information obtained from this study has been key to implement activities 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 identify and address the major threats to Angelshark populations.

 **Keywords:** Angelshark, Conservation Planning, Tagging, Critically Endangered

Importance of stakeholder engagement to conserve angel sharks across the Eastern Atlantic and Mediterranean Sea

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Angel sharks are among the most threatened fish in European waters. This family of elasmobranchs is particularly susceptible to the combined impacts of fishing and habitat degradation, due to their coastal location and biology (large, flat-bodied animals with low fecundity). Three species of angel shark (Angelshark (*Squatina squatina*), Smoothback Angelshark (*S. oculata*) and Sawback Angelshark (*S. aculeata*)) were once widespread throughout the Eastern Atlantic and Mediterranean Sea. All three species are listed as Critically Endangered on the IUCN Red List of Threatened Species, following severe declines over the last 100 years. The Angel Shark Project (ASP), a collaboration between Universidad de Las Palmas de Gran Canaria, Zoological Society of London and Zoologisches Forschungsmuseum Alexander Koenig, have been working to better protect Angelsharks (*S. squatina*) in their unique stronghold of the Canary Islands since 2013. Part of the ASP focuses on working with key stakeholders to reduce disturbance and

better understand Angelshark ecology. In particular, our work with sportfishers focus on ensuring any Angelsharks accidentally caught are quickly released in the best condition to improve chances of survival. In addition, the ASP has collected over 730 sightings of 1,100 Angelsharks from the diving community, leading to improved understanding of Angelshark distribution and ecology in the region.

The ASP has worked alongside partners to develop the Angel Shark Action Plan for the Canary Islands and Eastern Atlantic and Mediterranean Angel Shark Conservation Strategy to identify and address the major threats to angel sharks in the region.

Together, these documents initiated the launch of the Angel Shark Conservation Network in June 2017 to foster angel shark conservation across the range. Already, this led to a new project between the ASP and Natural Resources Wales to better understand the remnant Angelshark population found in Welsh waters by working with the fishing community.

 **Keywords:** Angelshark, Stakeholder, Conservation, Network

CITES Non-detriment findings for elasmobranchs: the role of science, and the pros and cons of a regional approach

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The preparation of a Non-detriment Finding (NDF, a form of sustainability certification) is required before an export permit can be granted for products derived from a species listed in Appendix II of CITES, or for trade in the species itself. NDFs may include a quota, based on scientific advice. NDFs and export permits must be issued by national CITES authorities, at national level. There is no standard mechanism within the text of the Convention for adopting a regional approach. This contrasts with regional fisheries management measures, which routinely set a total allowable catch, divided into several national quotas, for shared and transboundary fish stocks. Although CITES does not explicitly envisage the development of regional CITES NDFs for

Appendix II species, this approach has been used in the past for Appendix II sturgeon stocks. A draft regional NDF for the common thresher (*Alopias vulpinus*) in the NE Atlantic was prepared following the listing of the species on Appendix II in 2016. This will be presented to illustrate the NDF process and the role of science in the development of NDFs. The premise that the NDF might be developed in an iterative process with stakeholders and science over a number of years in order to allow parties to develop relevant and biologically meaningful management measures will be developed. The differences and similarities between CITES management and fisheries management, and how these might be coordinated, are discussed.

 **Keywords:** *CITES, Non-detriment Finding, Fisheries Management*

A New Era in North Atlantic Elasmobranch Conservation

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The rapidly changing political climate brought on by “Brexit” and a new US administration is complicating efforts to seize critical opportunities for international advances in North Atlantic elasmobranch conservation. In November, the International Commission for the Conservation of Atlantic Tunas (ICCAT) faces its starkest scientific advice to date for a shark population (North Atlantic shortfin makos) at a time when the influence of EU’s strongest shark champion (the UK) is waning, and the US government’s long-held commitment to science is wavering. EU, UK, and US policies stances should be more predictable by September of 2018, when the Scientific Council of the Northwest Atlantic Fisheries Organization (NAFO) presents for fishery managers’ consideration its advice

for rebuilding thorny skates and safeguarding exceptionally long-lived Greenland sharks. As the US and EU change, Canada – a key player in international Atlantic fisheries bodies -- is significantly improving its shark conservation profile, and other smaller countries are being encouraged on many fronts (including through the Convention on Migratory Species) to do the same. Ensuring progress toward sustainability (and preventing setbacks) for shared North Atlantic elasmobranch populations depends on proactive, coordinated, creative engagement by conservationists and conservation-minded scientists in many countries at multiple stages of policy development processes. Recommendations for specific beneficial actions will be offered.

 **Keywords:** *Common skate, Population, Genetics*

Near real-time communication of the spatial and temporal abundance of spurdog (*Squalus acanthias* L.), to reduce by-catch, discards and fishing mortality in a mixed fishery: The Spurdog By-catch Avoidance Programme

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Spurdog (*Squalus acanthias* L.) in the North-east Atlantic is classed as Endangered by the International Union for the Conservation of Nature (IUCN) and under recent EU fisheries legislation, spurdog is classed as a prohibited species, which fully precludes landings. Zero landings does not result in zero take from the stock, as incidental by-catch occurs in mixed fisheries, leading to fishing induced mortality and wasteful discarding of dead fish. The current management of spurdog does not address the continued issue of dead discarding, nor contribute to reducing fishing pressure. A collaborative research partnership between Government policy advisors, scientists, the fishing industry and an environmental non-governmental organisation (ENGO) informed the development and trial of the near real-time avoidance of spurdog. Through an ArcGIS on-line portal, fishermen

self-report their by-catch in near real-time by area. This information is compiled and reported back to fishers using a RAG traffic light system; Red (high risk of spurdog by-catch), Amber (medium risk of significant by-catch) and Green (low risk of significant by-catch). This empowers fishers to make informed fishing behaviour decisions in real-time, enabling active avoidance of recent by-catch “hotspots”, reducing by-catch and fishing mortality of spurdog. As well as facilitating a real-time understanding of the interaction between fishers and this threatened stock, this information will underpin future decisions on by-catch avoidance in key ‘hotspot’ areas. Our data will provide a valuable evidence base for future long-term stock rebuilding and stock recovery plans, and regional solutions to the sustainable management of spurdog and potentially for other species.

 **Keywords: Spurdog, By-catch, Avoidance, Real-time**

How are we managing? Developing new management tools for sharks and rays

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Our lack of basic ecological knowledge of sharks and rays and understanding of their population dynamics and stock structure make it very difficult to fulfill high-level international policy commitments and implement management measures. Fisheries management aimed at maximum sustainable yield (MSY) needs tailoring for elasmobranchs, and the potential for the conservation and management of species within the Marine Strategy Framework Directive is not straightforward. With the introduction of the CFP Landing Obligation (LO), many elasmobranchs have the potential to become “choke” species, preventing fishers taking their legitimate quotas within MSY limits. In many cases we lack the information on the bycatch and post-catch mortality necessary to underpin any “high survival” exemption. Finally, information on species’ distributions,

movements and habitats are incomplete, especially for juvenile and spawning stages. There is increasing concern over the current state of many elasmobranch species, including ensuring that depleted stocks can recover whilst also guaranteeing that commercially-exploited species are being harvested sustainably. Concerted action is needed to improve management of those fisheries exploiting skates, rays and sharks, both in European waters and elsewhere.

This presentation will highlight those areas in which advancement could be made to improve our understanding of the biology/ecology and stock structure of elasmobranch species. An overview of emerging assessment methodologies will be given and how collaborative work between science, industry, policy and NGOs can help in the development of best management practices.

 **Keywords: Management Tools, Landing Obligation, Assessment Methodologies**

No Limits? The Mako'ver

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Management of shark fisheries has notoriously lagged behind that of commercially important bony fish and existing regulations are often inadequate. Although many species of shark, skate and ray have been awarded protection or allocated quotas, many more are still left unprotected or unmanaged - allowing them to be caught in unlimited numbers. The Shark Trust's No Limits? campaign was launched in May 2014 in response to the escalating fishing pressure faced by many species of shark. Initially concerned with Blue Sharks (*Prionace glauca*), Shortfin Mako (*Isurus oxyrinchus*), Tope (*Galerorhinus galeus*), smoothhounds (*Mustelus* spp.) and catsharks (*Scyliorhinus* spp.) - species subject to expanding fisheries or emerging markets - the campaign's primary focus to date has been the Blue Shark, which is caught in staggering numbers. In March 2017, over 130,000 petition signatures calling for an end to uncontrolled shark fishing were delivered to the EU

Commission, who reiterated their commitment to securing science-based management.

This year, focus has shifted to securing management for the Shortfin Mako. Although caught in far lower volumes than Blue Sharks, the life history of this species is especially conservative, leaving the fastest shark in the ocean at greater risk of rapid over-exploitation.

With new scientific advice resulting from the 2017 ICCAT Shortfin Mako stock assessment, this year's International Commission for the Conservation of Atlantic Tunas (ICCAT) meeting in November presents a critical opportunity to protect this species from overfishing in the Atlantic. The Shark Trust will be attending with its Shark League partners to advocate for international catch limits to be set for this valuable yet exceptionally vulnerable shark.

 **Keywords: Overfishing, Management, Catch-limits, Atlantic**

A vulnerability assessment of elasmobranchs and teleosts based on sensitivity and exposure to fishing pressure

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Elasmobranchs often have slower life histories than targeted teleosts in the same fish community. This can make elasmobranchs especially vulnerable to fishing in relatively unselective mixed fisheries. We develop and present a method that combines swept-area estimates of fishing mortality with minimal life history data to assess the vulnerability of elasmobranchs to demersal trawl fisheries. The swept area analysis accounts for catchability and species distribution to predict absolute abundance, biomass and

fishing mortality; outputs that are usually provided by full analytical stock assessments. Estimated fishing mortalities are fed into spawner-per-recruit models, parameterized with life-history relationships, to rank species by sensitivity to fishing mortality and identify species potentially at risk from current fishing mortality rates. When the methods are applied to the North Sea fish assemblage, several elasmobranch species are shown to be below proxy Maximum Sustainable Yield reference points.

 **Keywords:** *Vulnerability, Sensitivity, Mortality, Catchability*

Half a century of elasmobranch tagging

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The Lowestoft laboratory has tagged and released a range of elasmobranch species for over half a century. Historically, the main species investigated were skates (Rajidae) and spurdog *Squalus acanthias*. Between 1959 and 2016, some 20,815 skates and rays, primarily thornback ray *Raja clavata*, spotted ray *R. montagui* and blonde ray *R. brachyura*, were tagged and released, with 3,627 (17.4%) recaptured. Over a similar

period, 13,490 spurdog have also been tagged and released, with 1,664 (12.3%) recaptured. Since 2000, a range of scyliorhinid ($n = 777$) and triakid sharks ($n = 1324$) have also been tagged and released, of which 1.7–1.8% have been returned. Mark-recapture data are summarized for the main species, and these data interpreted in relation to stock units.

 **Keywords:** Stock identity, Tagging, British Isles, Movements

Elasmobranch fisheries in Portugal – a ten year health assessment

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Despite the ecological and economical importance of elasmobranchs, the management of these animals is still a low priority when compared to other marine predators. According to recent data, Portugal remains one of the top players in European elasmobranch fisheries. In order to assess the health of Portuguese elasmobranch fishing stocks, data from commercial landings were analyzed for a ten year period, ranging from 2006 to 2016. Yearly landings averaged 3,523 metric tons (mt), with the ten year period totalizing 38,757 mt. 40 species of sharks, skates and rays were captured and identified, spanning over 10 different orders. *Raja clavata* was the most caught species in the studied timeframe, accounting for 7,518 mt and representing 19.4% of the landings, followed

by *Prionace glauca* (15.4%), *Scyliorhinus stellaris* (12.9%), *Isurus oxyrinchus* (10.9%) and *Raja brachyura* (9%). Generally, annual elasmobranch landings decreased over the ten year period, with shark landings being more affected. This trend had already been reported in studies performed in Portugal for previous periods. Our results support the notion that some species appear to be over-exploited and in need of immediate management measurements. This is particularly noticeable in the case of *Isurus oxyrinchus*, where an abrupt decline in landings was observed for the last three years analyzed. There is a clear need for the implementation of a Shark Plan of Action in Portugal and we hope these data contribute to that goal.

 **Keywords: Fisheries, Elasmobranchs, Portugal**

Management of scalloped hammerhead shark in Golfo Dulce, Costa Rica

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The scalloped hammerhead, *Sphyrna lewini*, is specifically threatened by human activities, including targeted fishing. The abundance of *S. lewini* in Isla del Coco National Park, Costa Rica, has decreased by approximately 45% in 21 years. In 2008 the IUCN Red List classified *S. lewini* as Endangered, and in 2013 it was included on the CITES Appendix II list. In the Eastern Tropical Pacific, *S. lewini* is protected in oceanic islands, but a lack of conservation effort in coastal and nursery areas exists, leaving the future population source vulnerable. The aim of this project is to identify and protect coastal critical habitats (such as nursery areas) in Golfo Dulce, Costa Rica. The project started in 2010 and had the following phases: 1) 2010. Collection of Ecological traditional knowledge; 2) 2010-12. Identification of critical habitats in Golfo Dulce; 3) 2012-2016. Study of the residence

and fidelity of *S. lewini* in critical habitats identified; 4) 2017. Elaboration of a proposal for the protection of *S. lewini* in Golfo Dulce. Thanks to the collection of fisheries-dependent biological data and acoustic telemetry, we identified critical habitats for newborns and juveniles of the specie in Golfo Dulce. We estimated the spatio-temporal distribution of *S. lewini* in the Gulf and the residence on each habitat (using the Residence and Attendance Index). Based on these results, we started a process with the local fishermen of Golfo Dulce and the support of the Ministry of Environment and National Institutions of Fisheries, to elaborate strategies for the protection of *S. lewini*. We carried out workshops in each community to evaluate the proposed strategies and elaborated a final proposal, which was validated by the fishermen and submitted to the Government Institution.

 **Keywords: Scalloped Hammerhead Shark, Nursery Area, Golfo Dulce, Management**

Spatio-temporal variation of dogfish (*Scyliorhinus canicula*) abundance in a highly fished area

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Changes in Irish Sea target fisheries towards Norway lobster (*Nephrops norvegicus*; hereafter *Nephrops*) have led to higher occurrences of bottom trawling, generating large amounts of bycatch / discards and modifying benthic habitats. As an indirect consequence, some non-target species appear to have flourished. Demersal elasmobranchs represent such a group owing to their resilience to trawling activity, high survival rate when discarded and generalist scavenging behaviour around recently trawled areas. In light of recent EU legislation aimed at stopping discarding at sea (EU landing obligation), such dietary subsidies for demersal elasmobranchs will stop. For such species this change in fisheries practice may shift the balance between scavenging and predation, with increased top down control of *Nephrops* a potential outcome.

In order to identify focal species for this study we investigated the relative

abundance and demographics of known scavengers and predators of *Nephrops* between 1991-2015 from Irish Sea groundfish data. Lesser-spotted dogfish (*Scyliorhinus canicula*) displayed a dramatic 300% increase during this time and were thus adopted as a model species. We tested whether a spatial relationship existed between dogfish and *Nephrops* densities over the period 1994 to 2015 and found that correlations changed distinctly between positive and negative at different sites. To explore these relationships further we deployed baited remote underwater videos (BRUVs) on key *Nephrops* grounds in the Irish Sea to directly observe the fate of discards at the seabed. Preliminary results indicate that although dogfish were recorded feeding on discards, plaice (*Pleuronectes platessa*) appeared to be the most abundant scavenger of fisheries discards.

 **Keywords: Demersal Elasmobranchs, Discards, BRUV**

Survival and recovery responses in lesser spotted dogfish (*Scyliorhinus canicula*) after bottom trawling

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European Union Fisheries Policy aims at a progressive discards elimination. The last proposal declares that the non-commercial captured species should be released after the fisheries procedure if their survival is scientifically proven. Sharks are especially vulnerable as discards due to their slow growth rates, late age of maturity and low fecundity, so it results mandatory to direct efforts towards this group. The main goal of the present study is to evaluate survival and recovery of a common demersal shark in Europe, the lesser spotted dogfish (*Scyliorhinus canicula*) after bottom-trawl fisheries. To achieve this objective, we conducted an experience aboard a oceanographic vessel in the Gulf of Cadiz (SW Spain). Survival and physiological recovery were studied in dogfish captured at two depths (shallow, less than 100 m; and deep, more than 450 m). Blood samples were taken just after trawling (0 h) and animals allowed to recover in tanks, being re-sampled 24 h later. Recovery behavior

was video-recorded. Blood plasma analysis included stress biomarkers such as ions and energy metabolites. Furthermore, to evaluate complete recovery of these sharks, a second experiment was performed in ground facilities under controlled conditions. Our results show that 96.7-98.5% of the animals manage to survive 24 h after trawling. We confirmed that trawling elicited acute stress responses at time 0 h, as seen by plasma lactate and osmolality levels in all the animals, but manage to recover after 24 h. The use of a non-invasive technique such as video analysis revealed that differences exist between shallow and deep sub-populations, with the last group requiring more time to recover. In conclusion, this study confirms that demersal *S. canicula* manage to successfully recover to bottom-trawling. We thus pave the way with a simple but robust protocol to further study survival in other elasmobranch species captured during fishing procedures.

 **Keywords:** *Scyliorhinus canicula*, Survival, Discards, Bottom-trawl

Stressful situations when being fished negatively affects muscle texture properties in the lesser spotted dogfish (*Scyliorhinus canicula*)

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World consumption of elasmobranchs has increased during the last years and yet there are no international laws to regulate slaughter of these species. It has been confirmed in mammals, fowls and teleost fish that stressful situations in the last moments of life negatively affects the quality of the flesh. However, to date there are no studies involving sharks. This study aimed to evaluate effects of pre-slaughter handling on muscle fillets' quality of a widely captured species in Europe, the lesser spotted dogfish (*Scyliorhinus canicula*). An experimental group was maintained outside the water for 18 min (mimicking fisheries procedures) and returned to water tank for recovering. Physiological and biochemical parameters were quantified by samplings after 0, 5 and

24 h post-stress. The content of lactate and water in the muscle were measured altogether a muscle texture profile analysis. Stressed animals significantly increased their lactate after air exposure, recovering control levels after 5 h. Muscle water content evidenced a dehydration process at 0 h due to secondary stress responses, followed by an overhydration at 5 h. Muscle consistency positively correlates with water content. The results indicated for the first time that pre-slaughtering handling of elasmobranchs will result in muscle fillets with differentiated sensory conditions. This study supports and encourages the implementation of welfare techniques in fishing practices, as it would produce shark-derived food of higher quality while minimizing suffering of these animals.

 **Keywords:** *Scyliorhinus canicula*, Slaughter, Welfare, Muscle Texture

Long-term bottom trawl fishery surveys of Elasmobranchs off the Israeli Mediterranean coast

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Composition and biomass of elasmobranchs was recorded from catch data of bottom trawl fisheries in the Mediterranean Levantine basin over a period of 10 years (2008-2017). Records of elasmobranchs include 238 hauls along the Israeli Mediterranean coast, in depths of 15m – 400m. This dataset includes a total of 768 individuals, belonging to 17 species - five species of sharks (5 families), four species of skates (1 family), and eight species of rays (4 families).

Records in our dataset differed notably from published literature focusing on neighboring areas. For example, the second most abundant species was the brown ray, *Raja miraletus*, found in 26% of hauls, while rarely found in similar surveys from Turkey and the Aegean Sea. On the other hand, the lesser-spotted dogfish, *Scyliorhinus canicula*, was among the most common and abundant species in surveys from Greece and Turkey, while our data contains only a single individual of *S. canicula*. Similarly,

30% of the biomass of elasmobranchs in surveys from Turkey where comprised of the spiny butterfly ray, *Gymnura altavela*, whereas in our surveys it was not found at all. We find some indication of seasonal moments, for example, during the summer the thornback ray, *Raja clavata*, is found only in depths of approximately 80m, while in the winter *R. clavata* are only found in 400m (maximal survey depth). Other species such as guitarfishes (*Rhinobatidae* spp.) and stingrays (*Dasyatis* spp.) exhibit a narrower distribution, and are found in shallow waters year-round.

Extensive and long-term bottom-trawl surveys are a useful tool to describe distribution and composition of elasmobranch, especially in light of their unique life history traits and rarity. Further research based on surveys designed to place more emphasis on chondrichthyans is required and will contribute to the clarification of the observed trends.

 **Keywords:** Trawl surveys, East Mediterranean, Elasmobranch

Introduction of the Shark Tagging Programme in Israel and Preliminary Results from the First Two Seasons

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By virtue of their position at the top of the food chain, marine top predators play a crucial role in maintaining the integrity of ecosystems by means of function and structure. In the Eastern Mediterranean Sea, a Prestonian shortfall exists for highly migratory, pelagic mega fauna which may well translate into inadequate policies with regards to top predators. The shark tagging programme of the University of Haifa's Morris Kahn Marine Research Station thrives towards the development of long-term monitoring indicators and new technological stock assessment tools. The capture-mark-release procedure includes several steps supporting different studies on the biology and ecology of sharks at both, the population and individual levels. First, physiological data including weight and length measurements are gathered, providing for morphological species identification and the development of remote sensing methods, such as aerial and acoustic surveys using advanced marine technologies. Next, the sharks are marked

with a visual tag, a PIT tag and an acoustic or satellite tag. These generate data about the fidelity of sharks to coastal hotspots and their distribution across the Mediterranean Sea. Finally, genetic and biochemical (blood and stable isotope) samples are collected, providing for research on the structure of the general population, and its biological characterisation. To date, 17 female *Carcharhinus obscurus* sharks (mean total length of 2.87 m), and 4 male *Carcharhinus plumbeus* sharks (mean total length of 1.81 m) have been tagged at a seasonal aggregation spot near the power station of Hadera, Israel. One shark was captured twice within the second season. Preliminary data including lab results and field measurements will be presented, as well as implications for management and decision making processes. This is a first introduction of the marine top predator long-term ecological monitoring project to the scientific community of the international sphere.

 **Keywords: Capture-Mark-Release, Seasonal Aggregation, Management, Israel**

Preliminary Assessment of a Nearshore Nursery Ground for the common Guitarfish, *Rhinobatos rhinobatos* and the Blackchin guitarfish, *Glaucostegus cemiculus*

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Elasmobranchs, such as the Common and the Blackchin guitarfish, seasonally use coastal areas and bays for mating, pupping, and foraging. These areas are susceptible to increasing anthropogenic pressures and overfishing, which limits species recruitment. Both species are endemic to the Mediterranean and considered endangered throughout their entire distribution, according to the IUCN redlist. There are no species specific conservation measures currently in place, limited information is available regarding their abundance, migration patterns and nursery use. Following a large number of observations, preliminary surveys have been conducted since 2013 indicating a seasonal presence of young guitarfish off the Israeli Mediterranean coast, near Kibbutz Ma'agan Michael. The neonate guitarfish in this region show unique behavior, they can be seen ascending the beach and staying outside of the water for short periods of time before returning to the shallow water. This study will examine if this region is in

fact a nursery ground. For an area to be identified as a nursery, three criteria must be met : (1) Neonates are more commonly encountered in the area compared to other areas, (2) Individuals\rays have a tendency to remain or return for extended periods, and (3) The area or habitat is repeatedly used across years. The first criteria will be addressed by mark- recapture techniques, beach seine nets and visual abundance surveys. The surveys will compare selected regions along the Israeli coast in order to quantify neonate abundance. To address the second criteria Mark recapture techniques will be used to examine neonate growth across region residence time. For the third criteria, genetic techniques such as microsatellites and SNP will provide supporting data by demonstrating the occurrence of a phenomena such as philopatry. Providing evidence for a local nursery ground can greatly improve the specie conservation in Israeli coastline and in the entire Mediterranean basin.

 **Keywords: Guitarfish, Nursery, Conservation, Mediterranean**

Speak of the devil ray (*Mobula mobular*) fishery in Gaza

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Little is known about the giant devil ray (*Mobula mobular*), an endangered species endemic to the Mediterranean. Gaza is the only region where this species is targeted, hence, this fishery was studied to address the knowledge gap on fishery interactions, species behavior, and life-history traits. Devil rays have been frequenting this maritime area for at least the past 50 years for a short window from February to April. Landings are reported from 2005 to 2016, along with disc-width (DW) measurements for recent years. A total of 304 *M. mobular* (over 90% males) were landed in Gaza from 2014 to 2016, most which were mature and appeared to be mating (over 90% of males had sperm-filled claspers), providing critical insight that this area may serve as a mating ground. Yearly landings are shown here to

closely match the allowed fishing distance from shore, which changes regularly, indicating that the rays are normally caught between 6 and 12 n. m. offshore. Width-weight conversion parameters are calculated for the first time for this species: $a=2.68 \times 10^{-6}$ and $b=4.39$. Fresh protein drives this local fishery, as food security is a major issue. An export market for gill plates was reported intermittently, and is no longer possible due to strict trade restrictions. We highlight the lack of awareness of fishers regarding the IUCN's Red List 'Endangered' status of devil rays, and stress the urgent need for national protection of this species, particularly due to the species' very slow life-history traits and probable usage of this area as a mating ground.

 **Keywords:** Conservation, Endangered Species, Food Security, Mediterranean Sea

Seasonal distribution of Elasmobranchs in the Eastern Mediterranean using citizen science

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Understanding temporal and spatial distribution patterns is an essential step in assessing species' status, and formulating protection strategies. The Mediterranean Sea is among the most detrimental regions for cartilaginous fish worldwide with over half of the species under threat of extinction. In the Levantine basin, the problem is compounded by a deficiency in information and documentation, meaning long term data is practically non-existent. Lack of basic knowledge on the distribution of species that inhabit the eastern Mediterranean is a major hindrance for establishing management and conservation policies.

Through social media we compiled a database of sightings by divers, fishermen and other sea-goers, documenting species, time, location and other biological data. Only photographed sightings which could be verified were used for analysis in this research. So far, we have collected over 1,000 observations from 2001-2017. By restricting entries from divers limited to a depth of 30m, we were able to examine distribution pattern representing the shallow, coastal water of the Israeli shore.

Overall, we documented ten species of batoids and two species of sharks. Species richness was higher in diving sites with high habitat complexity, and in sites within marine reserves. Several distribution patterns emerged from the data, for example, *Dasyatis* sp. is sighted primarily in May and June, while *Taeniura grabata* exhibited stable occurrences year-round. *Himantura uarnak*, a non-indigenous tropical species is present year-round but is found during winter in areas of artificially warmer waters (e.g. power plant outflows). *Rhinobatos* sp. were present almost exclusively during the summer, coinciding with their breeding season.

This database provides basic information on distribution and seasonality, described for the first time for elasmobranchs in the region. Improved understanding of distribution dynamics of elasmobranchs will serve as an initial, yet fundamental step in establishing an informed protection plan in a region where populations are undergoing dramatic declines.

 **Keywords:** *Species Distribution, Eastern Mediterranean*

Spatial distribution of skates and rays in the eastern Ionian Sea (Mediterranean Sea)

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Species belonging to the Superorder Batoidea occur to a wide range of habitats from shallow estuarine and coastal waters down to 3000 m depth, playing an important role in structuring ecosystem dynamics. Although some species have been evaluated under threat, they have received less attention than teleost and other elasmobranchs. The present study investigates for the first time the occurrence and distribution of batoid species along enclosed gulfs, semi-enclosed and open sea regions of the eastern Ionian Sea. A total of 19 species have been recorded up to date, including 11 skates (Rajiformes), 5 stingrays (Myliobatiformes) and 3 electric rays (Torpediniformes). Multivariate analyses applied to the square root transformed for MEDITS data matrix (1994-2016) for the 8 most frequently caught demersal batoid species (*Raja clavata*, *Dipturus oxyrinchus*, *Torpedo marmorata*, *Raja miraletus*, *Dasyatis pastinaca*, *Raja asterias*, *T. torpedo*,

R. radula), showed that their abundance and assemblages were primarily determined by depth, presenting also a considerable geographic variation particularly over the continental shelf. *R. clavata* was the most frequently caught (>50% hauls) and over wider depth-range distributed species, being more abundant over the shelf break (150-350m). *D. oxyrinchus* was the most frequently caught species over middle slope (350-700 m) while on the continental shelf, *D. pastinaca* and *R. miraletus* were indicator species in the northern Ionian upper shelf. In addition *R. clavata* and *T. marmorata* dominated among batoid species catches in hauls located over lower shelf and southern sub-regions. Species specific distribution patterns are discussed in relation to the species biological characteristics, the topography of the eastern Ionian Sea, as well as to the observed gradients of salinity, eutrophy/oligotrophy and oxygen level.

 **Keywords:** *Batoidea*, *Depth*, *Abundance*, *Environmental Gradients*

Observations and distribution patterns of blue shark, *Prionace glauca* (Chondrychthyes: Carcharhinidae), along the Algerian basin (southern Mediterranean)

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The blue shark, *Prionace glauca* (L. 1758), is the sole representative of the genus *Prionace*. A highly migratory species, this pelagic shark is cosmopolitan and occupies tropical and temperate waters (Fisher et al., 1987). In the Mediterranean and mainly in the Algerian basin, studies on *Prionace glauca* are rare or discontinuous.

As a part of an ongoing research project for the collection of data on the biology and eco-ethology of certain species of shark on Algeria's coast, the information collected by the project observers along the coast (East Region, Central Region and West Region) were analyzed. The dataset includes geographic location information of some catches, gear, size and sex. A total of 268

blue shark record ranging from 59 to 312 cm TL (122 were observed between 2007 and 2008, 146 individuals observed between 2014 and 2017), were considered for the sex ratio study by size, season and region. Catches are higher in the Western and Central region; the eastern region is less represented. The sex ratio varies by region and size classes. The spatial distribution of females according to size classes suggests that the Center region is probably a mating area. The projection data and results on a GIS (Geographical Information System) has allowed better understand the various aspects of the distribution of this species and the potential for the presence of distribution models in the Algerian Basin.

 **Keywords:** Blue shark, Sex Ratios, Eco-ethology, Spatial Distribution

How many species of *Mustelus* (Elasmobranchs, Triakidae) occur off the Algerian coast? About morphological data to resolve such question

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Systematic problems of the genus *Mustelus* Linck, 1790 have already been studied by Quignard & Capapé (1972) and Cadenat & Blache (1981) in the Mediterranean Sea. However, we tried to take up each of these problems to take into account new observations made off the Algerian coast. Three species of *Mustelus* occur in the Mediterranean (Fischer & al., 1987; Serena, 2005): the smoothhound *M. mustelus* (Linnaeus, 1758), the starry smoothhound *M. asterias* Cloquet, 1819 and the blackspotted smoothhound *M. punctulatus* Risso, 1827 also known as *M. mediterraneus* (Quignard & Capapé, 1972).

Check list of Elasmobranchs recorded during a taxonomic project started in 1996 off the Algerian coast, highlights the difficulties using keys determination, very different from each other.

Data were collected during investigations conducted from 1996 to 2006 in the area. More than two hundred individuals of *Mustelus* were examined: coloration,

position of dorsal fins, shape (pectoral fins and placoid scales) and ratios have all been used as diagnostic features of the genus and compared to the characters given by the referenced guides.

A taxonomic uncertainty still remains regarding this genus; the study tries to check the number of species occurring off the Algerian coast and characters that distinguish these species between them. Morphology analysis determines that most specimens belong to two putative species *M. mustelus* and *M. punctulatus*, although sharing some similarities with *M. asterias* and *M. schmitii*. Multivariate analysis (Hemida & al., 2011) don't discriminate individuals and suggest that only one species of *Mustelus*, with great variability, occurs in the studied area and could be considered as a complex '*mustelus-punctulatus-asterias*', while morphology plead for more than three species. Molecular analysis is needed but quite impossible due to the current scarcity of *Mustelus* specimens.

 **Keywords: Morphology, Placoid scales, *Mustelus*, Algeria**

A Shark by Any Other Name: Catch Reporting Quality in the Mediterranean Sea

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One in four fishes of the class Chondrichthyes is threatened with extinction, according to the IUCN Red List. Their primary threat is overfishing, but data deficiency makes conventional fishery science methods of stock assessment difficult, if not impossible for many species. Over 50% of shark and ray species are listed as Data Deficient, in part because the taxonomic resolution of existing catch statistics is often too low for researchers to identify species-level trends of abundance. Less than 25% of the shark catch reported to the FAO is identified below the genus level; the other 75% is lumped into more ambiguous categories like, “sharks, rays, skates, etc. not elsewhere included”. Detailed fisheries catch statistics are a prerequisite to effective management, but are influenced by a country’s geopolitical and economic stability. A new indicator, the context-adjusted Reporting Quality Index (RQI), compares the taxonomic resolution of reported catches, expressed as a percentage, between countries within a

given region that exploit the same species. Using this method, we have tracked the effectiveness of different reporting systems by plotting national RQI scores in a time series (1950-2014). In the Mediterranean and Black Seas, an area of special concern for shark and ray conservation, reporting quality of chondrichthyan catches has increased although a third of countries show declining trends. Malta consistently ranked among the highest RQI scores, and reported over 90% of their commercial shark and ray taxa on average. Spain’s reporting quality increased suddenly in the mid-1990s, which may correspond to improved fishery observer coverage in its pelagic swordfish fisheries. Similar patterns arose for other countries, and our results suggest that the RQI method is sensitive to fishery management policy changes as well as changes in national government administrations. Countries should strive for high-quality reporting to drive reliable stock assessments that support sustainable fishing practices.

 **Keywords:** *Overfishing, Catch Reporting, Sustainability, Mediterranean*

Shark and ray management in the Mediterranean: a critical analysis

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The Shark Trust is a member of the Shark League for the Atlantic and Mediterranean – a coalition focused on responsible, regional conservation of sharks and rays, and comprising Shark Advocates International, Project AWARE and the Ecology Action Centre.

The Coalition's efforts are focused on securing management through the Regional Fisheries Management Organisations (RFMOs), specifically: the International Commission for the Conservation of Atlantic Tunas (ICCAT), the General Fisheries Commission for the Mediterranean (GFCM), and the Northwest Atlantic Fisheries Organisation (NAFO). For the many sharks and rays that are fished by multiple countries, the international actions of RFMOs have the potential to swiftly safeguard species throughout their ranges. Focusing on the Coalition's work in the Mediterranean, a region which, with regards elasmobranchs, reports declines of 97% in number & catch weight (Bradai 2012) and over 50% of native species at an increased

risk of extinction (IUCN 2016), this presentation will explore the 2012 GFCM prohibition on fishing and retention of 24 species of threatened sharks and rays (GFCM 36/2012/3). The level of implementation and compliance will be discussed, as well as the associated domestic regulations which vary significantly across the 24 Contracting Parties, 10 of whom are EU Member States. This is in the context of reported landings of prohibited species by GFCM Parties, an issue which came to the fore in March 2017 when 30 Giant Devil Rays (*Mobula mobular*) were landed into Izmir, Turkey, allegedly destined for markets in Greece.

While this autumn offers many opportunities for commitment to improving the implementation of management in the Mediterranean (Our Oceans, the ongoing Medfish4ever campaign, and the GFCM 41st Session), it remains clear that significant and immediate action is required to safeguard the future for Mediterranean sharks and rays.

 **Keywords: RFMO, GFCM, Mediterranean, Implementation**

How to be a giant shark

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During their 450 myr of evolutionary history, the maximum size sharks have reached is 18 m of total length. Two phylogenetically distant species achieved this size: the extinct megalodon (*Otodus megalodon*) and the living whale shark (*Rhincodon typus*). How did these sharks evolve such enormous size? We answer this question using a phylogenetic, trait-based approach and a global dataset of ~1,000 species. We found that to be able to reach gigantism, these sharks followed two contrasting pathways: 1) The Homeothermic Fish (HF) pathway, followed by megalodon, consists on feeding at the highest trophic level by active predation while developing homeothermy. 2) The Ectothermic Whale (EW) pathway, followed by the whale shark, consists on filter feeding at the lowest trophic level while remaining an ectotherm with a slow life-style. Large, but not extreme sizes were also attained by sharks that followed these routes; however, some sharks following the

HF pathway did not develop homeothermy. Although energetically demanding, homeothermy grants sharks with two main ecological benefits: niche expansion (vertical and latitudinal) and efficient predation/competition (by enhancing swimming). Despite its advantages, homeothermy played a key role in the extinction of megalodon by making it particularly vulnerable to the loss of habitat and large prey during the Pliocene. We hypothesize that by coupling gigantism with homeothermy, the HF pathway results in high extinction susceptibility. Alternatively, sharks can exploit the benefits of homeothermy without increasing extinction risk by being large, but not gigantic (e.g., white shark, max TL = 7m). Therefore, to be a giant, sharks must follow the EW pathway, which provides the basic benefits of homeothermy (i.e., high mobility and predatory release) without strongly relying on the availability of large prey.

 **Keywords:** Evolution, Gigantism, Thermoregulation, Trophic Level

Lessons from the past: Diversity dynamics are linked to climate change in elasmobranchs (Vertebrata, Chondrichthyes) in deep-time

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It is widely accepted that global climate change affects marine fish diversity patterns and the few available studies suggest that marine species respond to ocean warming by shifting their latitudinal and/or depth ranges. Such species responses may lead to local extinction and invasions, resulting in changes in marine species richness patterns. Nevertheless, the extent and severity of these environmental shifts still are ambiguous. To test long-term climatic effects on marine fish assemblages, we analysed diversity dynamics of Eocene (56 – 33 Ma) chondrichthyans from Antarctica combined with detailed environmental and ecological data, because the Eocene was one of the most important time intervals in global climatic developments with short thermal maxima at ca. 56 Ma (PETM), at ca. 52–50 Ma (EECO), and at ca. 40 Ma (MECC) resulting in extensive greenhouse conditions. This was superseded by a transition to icehouse conditions resulting in extended Antarctic glaciations at ca. 33 Ma (EOT). The material for this study is

based on abundant elasmobranch remains from the Antarctic Peninsula and covers a time-span from 54 to 33 Ma. These Eocene Antarctic elasmobranch assemblages, which represent the most complete and diverse collection of Paleogene elasmobranchs from high-latitudes includes mostly globally distributed taxa on genus level but displays a high amount of endemic species. Diversities in Antarctic elasmobranch assemblages increased significantly from 54 to 42 Ma correlating with a rise in sea-surface temperatures. This high diversity equals that of contemporaneous lower latitude elasmobranch faunas. A gradual decrease in species diversity started at ca. 39 Ma and resulted in the final disappearance of elasmobranchs at ca. 34Ma, which is linked to the establishment of Antarctic ice sheets. Our results indicate that increasing sea-surface temperatures result in elevated local origination rates at species level and high endemisms, while declining temperatures cause local extinctions and latitudinal shifts.

 **Keywords:** *Diversity, Origination, Extinction, Antarctica*

ANGELSHARK-ID 2017: Photo-identification as a non-invasive monitoring tool

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ANGELSHARK-ID responds to the need to create a baseline for the assessment of angelsharks *Squatina squatina* in the Canary Islands. Recently, there are growing concerns about the conservation status of this species in what is presumed its last stronghold. Spite of having been a fisheries resource in this part of a once very broad distribution, there is no information or local knowledge available that can help in the evaluation of its population. Therefore, this research action was developed to create a baseline for the long-term monitoring of *S. squatina* in the Canary Islands and to generate scientific base knowledge that allows the development of effective species management. In line with the fears for its conservation status a non-invasive technique is used for individual

identification and to minimize the research impacts.

Data and tissue sample collection is done during visual underwater census in coastal areas since 2006. Our results indicate that the innovative way of implementing photoidentification for *S. squatina* is a viable monitoring technique, with resightings detected in juveniles and in adults up to nine years after their first observation. This methodology allows the description of activities, behaviour, population structure, habitat use, growth and longevity, as well as to identify critical habitats and potential threats. Genetic (ongoing) and isotopic assessment of the tissue samples will further help to inform conservation management.

 **Keywords:** Angelote, *Squatina squatina*, Non-invasive, Canary Islands

Monitoring the development and success rate of *Scyliorhinus stellaris* eggcases

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The Nursehound *Scyliorhinus stellaris* is a species of catshark that resides in the North-east Atlantic through to the Mediterranean Sea. Although Nursehound egg-laying has been observed as long ago as 1876, quantitative research is limited to captive populations, or outdated within the North-east Atlantic.

In 2012, a site was identified off the South coast of Devon, UK, where Nursehounds have continued to deposit eggs. Since April 2014, bi-monthly surveys have been conducted, during low spring tides, to monitor eggcases within a sheltered channel. The aim of this research is to monitor the average embryonic development period to gain further insight on the species egg-laying in situ, and to understand the environmental factors that impact the eggcase development and success rate.

As of March 2017, 85 eggcases have been tagged and monitored within the channel. Results show that Nursehounds lay all year

round, laying a higher number of eggs within the summer months. Out of the 85 eggcases tagged, complete records from laying to hatching were obtained for 28, 25 were not observed again so are unaccounted for, 16 eggcases have incomplete records, 9 had no visible yolk sac and were deemed as eggcases produced with no content, or 'wind eggs', and 7 may still be developing.

For the 28 records deemed as complete, an average embryonic development of 255 (+/- 41) days was recorded. This development period was found to be significantly related to temperature and cover of biofouling species. The lower the water temperature is during embryonic development, the longer the eggs take to hatch ($p < 0.01$, $n = 28$). The heavier percentage of biofouling cover correlates to an increased development time ($p < 0.01$, $n = 28$). These findings contribute towards a better understanding of this species, and may have implications for the effective management of this species under changing climate and fishing pressures.

 **Keywords: Eggcase, Nursehound, Embryonic Development, Great Eggcase Hunt**

Embryonic development of the small spotted catshark (*Scyliorhinus canicula*)

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We have been researching the mating and the embryonic development of the small spotted catshark (*Scyliorhinus canicula*), in captivity for several years. We could see the mating when the male bit the left pectoral fin of the female. The male wound around the female in order to insert its left swollen clasper (in that occasion). It could be that the male used its right one with another female on another occasion. The mating started at 11:37 a.m. until 11:57 a.m. Consequently, they were mating for 20 minutes (personal observations). The water temperature was 18 ° 9° C and all the lights were on, over the display.

After five months the female laid two eggs. The egg case measures four centimetres long and two centimetres wide in the Mediterranean sea. The egg case has tendrils on its corners. Tendrils help the female to anchor the egg case to rocks, corals, seaweed, etc.

We started to see the embryo inside the egg case in two weeks time, after the female had laid the eggs. The embryo is formed from the germinal disk.

- When the embryo was 0 ' 5 centimetres long, it was almost transparent.
- When the embryo was 1 ' 5 centimetres long, we could see the yolk cord attaching the embryo to its yolk sac.
- When the embryo was two centimetres long, we could see its head, eyes, body and caudal fin.
- When the embryo was three centimetres long, we could see its head, eyes, body, caudal fin and external gill slits.
- When the embryo was four centimetres long, we could see its head, eyes, body, caudal fin and obviously, its yolk sac was getting smaller.
- When the embryo was six centimetres long, we could see its head, eyes, body, pectoral fins, dorsal fins, caudal fin, black spots and dermal denticles.
- When the embryo was seven centimetres long, it opened the egg case and then it became a neonate.

A neonate grew up 11 ' 5 centimetres in one year, and it weighed 29 grams. In all these stages the water temperature was 18 ' 5 ° C.

Surface behavior of white shark, *Carcharodon carcharias*, related to legal and illegal baits in Guadalupe Island, México

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The present study constitutes the first ethological analysis of baited attracted white sharks *Carcharodon carcharias* in the North American continent. Until the cage diving in Guadalupe Island is one of the most important activities for the economic exploitation of this species, the information related to the effect of the baits stills scare. The objective of this study was to describe the behaviour of white sharks related to three illegal and one legal bait during August-November of 2012-2014. The type of bait, behavioural events and pictures for Photo-ID were recorded aboard tourist boats. Transitional matrices were used to describe the behavior with flow charts and their significance was determined using a Chi-square test. The surface behavior of 106 individual white sharks was recorded in 5,783 episodes during 534 h of direct observation. Each event was classified into one of the 11 following units: Parading,

close inspection, horizontal attack, vertical attack, bait caught, feeding, no feeding, buoy caught, encounter, escape, and stay. A total of 1,542 ethograms were registered and each ethogram consisted on an average of 6.3 ± 5.6 units with a minimum and maximum of 2-62 behaviors. The begging of a general ethogram started with inspection or aggressive behaviors, with a consequent capture of the bait, but a different behavioral pattern was observed depending of the type of bait. The illegal baits generate significant behavioral patterns constituted by aggressive behaviors related to feeding, whereas the legal bait did not generate a defined behavioral pattern. Our results suggest that the fresh (illegal) stimuli generates an aggressive behavior and increase the potential of conditioning and accidents related to the divers in the cages, while the frozen (legal) bait must be used for the ecotourism.

 **Keywords: Ethology, Biosphere Reserve, Protected Species, Management**

Do environmental factors affect the surface behavior of white sharks?


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The surface behaviour (both individual and social) of white sharks in the presence of bait has been studied from 2005 to 2017. Observations were made from a commercial cage-diving boat. We observed 220 white sharks that exhibited 9 different types of individual behaviour (parading, bait following, visual inspection, breach, tail slap, tail stand, spy hop, repetitive aerial gaping, and head-up vertical emerging) and seven types of social behaviour (parallel swimming, piggybacking, follow, swim by, give way, follow give way, splash fights). We compared the exhibition of these behaviors and the complexity of the ethograms to different environmental factors: tides, cloud cover, underwater visibility, sea surface conditions, temperature. We observed that individual behaviors were exhibited with

environmental conditions opposed to those in which social behaviors were observed. This could be related to the functional ecology of individual and social interactions for white sharks. But environmental conditions affected also the sequence and structure of individual behaviors and in particular the approach to the bait, the duration of the ethograms and the complexity of decisional trees and transitional matrices.

Our observations suggested that the surface behaviour of white sharks is a complex tactical situation in which animals show plastic responses to environmental conditions. In particular, we observed a strong influence of the cloud cover and, consequently, underwater visibility.

 **Keywords:** *White Shark, Behaviour, Environmental Factor, South Africa*

Spatial ecology of the flapper skate (*Dipturus intermedia*) in relation to an MPA

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The Critically Endangered flapper skate (*Dipturus intermedia*) has been declared locally extinct in several areas of its former range over the last 100 years, placing accentuating the importance of managing the remaining population appropriately.

The Loch Sunart to the Sound of Jura Marine Protected Area (MPA) on the west coast of Scotland is designated to protect this species. To investigate the movement of skate within the MPA and assess management measures, 34 acoustic receivers were installed for a 14-month period. Forty-one skate of varying size and sex were double tagged with acoustic

transmitters and data storage tags (DSTs) recording depth and temperature. Four DST records with over a year's worth of data were recovered. Acoustic data showed some individuals remained near the MPA for the duration of the project while archival data give fine scale insight into the depth use of the individuals within the MPA.

The data is suggestive of partial migration and strong site fidelity in the flapper skate that occupy the MPA, a behaviour that should be considered when reviewing management options for the species in the area.

 **Keywords: Management, Skate, Tagging, Acoustics**

Acoustic detection of sharks and rays in the BIOT Marine Reserve, Chagos Archipelago

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The distribution of large pelagic predators can be highly heterogeneous. Investigating pelagic predator-prey interactions around localised geo-physical features (reefs, seamounts) helps elucidate and predict potential foraging mechanisms that support relatively persistent levels of elevated biomass. The Chagos Archipelago (British Indian Ocean Territory; BIOT) hosts various elasmobranchs, tunas and forage fish and was declared a no-take marine reserve in 2010. To help understand the spatial dynamics of shark and ray aggregations in BIOT, we set out to detect large elasmobranchs using scientific echosounders and multibeam, while simultaneously characterising their immediate physical habitat. We conducted small-scale multibeam sonar transects in two distinct habitats, an atoll and a seamount and ground-truthed our acoustic observations with underwater downward-facing cameras or directly with snorkelers. Additionally, we ran larger-scale echosounder (EK60) surveys to quantify adjacent mid-water prey fields (sound scattering layers). Within the atoll, we identified 'Manta Alley', a 60m deep channel

bounded by the steep slope to the shallow reef on one side, and a 10m lip separating the channel from the deeper waters, potentially providing a mechanism to concentrate planktonic prey sustaining reef manta (*Manta alfredi*) feeding aggregations. Secondly, during repeated multibeam surveys around a seamount, we detected large numbers of silvertip and silky sharks (*Carcharhinus albimarginatus*, *C. falciformis*) forming a 'halo' around the rim. We also observed concurrent bird surface feeding aggregations making use of driven-up forage fish. This is the first study to systematically use multibeam sonar to provide high-resolution bathymetry and 3D spatial information on midwater elasmobranchs. Quantifying aggregations within geographically remote and pristine environments this way enables more accurate baseline biomass estimates elsewhere. Also it specifically allows for the evaluation of no-take reserves as part of on-going monitoring of pelagic predators within BIOT. This study contributes to an interdisciplinary investigation into the bio-physical mechanisms underlying pelagic predator-prey distributions in BIOT.

 **Keywords: BIOT, Multibeam Sonar, Bathymetry Mapping, Shark Spatial Distribution**


In-situ identification of elasmobranchs using Autonomous Underwater Vehicles (AUVs) – a non-invasive method for assessing species distribution and habitat management

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Monitoring elasmobranch populations is an expensive, laborious, and invasive task where they often need to be caught and brought to the surface to gain valuable information. Tagging studies provide us with spatial and temporal datasets of an individual's movements but are rarely at a high enough resolution to provide accurate information of fine-scale habitat use. Autonomous Underwater Vehicles (AUVs) offer an innovative and novel approach to collect non-invasive data of elasmobranchs within their habitat, with the aim of complimenting current research methods. Equipped with high resolution cameras, they can cover large areas quickly and be deployed in places where access is restricted. The concept was developed during surveys collecting seabed habitat data in the fjords of Chilean Patagonia. A GAVIA Offshore Surveyor AUV was deployed, equipped with interferometric side scan sonar and a high definition camera

capturing 4 frames per second in monochrome, two meters from the seabed. Numerous sharks, skates, rays, and chimera resting on the seabed were seen on images and it was possible to ID most to species level. Evidence of individuals on multiple images showed that the AUV could pass over without causing disturbance. To test the methodology further, the AUV will be deployed throughout the Firth of Lorn Special Area of Conservation, on the west coast of Scotland to collect fine-scale benthic habitat data and imagery. This is within the Loch Sunart to Sound of Jura Marine Protected Area, designated to protect the flapper skate (*Dipturus intermedius*). Effective management and monitoring of the MPA is paramount to the skates continued survival. AUV involvement could become a valuable management tool to inform policy, providing information on preferred skate habitat, identification of nursery areas, and tagged individuals.

 **Keywords:** AUV, Flapper Skate, Habitat Mapping, Photography

Passive acoustic telemetry reveals seasonal long distance migrations in the winter skate (*Leucoraja ocellata*)

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The movement ecology of western Atlantic skates is poorly understood and existing information has been derived from short-term seasonal surveys and a limited number of traditional tagging studies. It has been hypothesized that large changes in the abundance of winter skate in the western Atlantic were the result of periodic migration events and not tied to a closed-population level response. Previously published population models have highlighted the importance of migration to the population ecology and management of winter skate. However, no direct observations of winter skate movement have been published supporting long distance migration. We tracked the movements of 61 winter skates, *Leucoraja ocellata*, along coastal New York between 2012 and 2014 using passive acoustic telemetry. Individuals were monitored with the coastal New York receiver network from Montauk to the Hudson River, and the ACT Network receiver arrays provided extended

coverage between Cape Hatteras and Massachusetts. Days at liberty averaged 138, and ranged from 3 to 490. Preliminary results indicated that some individuals performed considerable north-south migrations between coastal Massachusetts and North Carolina, with the total distance traveled ranging from 27 to 1376 km, and averaging 330 km. The daily rate of movement averaged 7 km per day; however, spring and fall movements were considerably higher, and often exceeded 20 km per day. These observations provide new insights into the seasonal movements of western Atlantic winter skates, which add complexity to our understanding of stock structure and broader management concerns. Importantly, the observations support the hypothesis that winter skate regularly undertake large coastal migrations. Implications for the development of stock assessment models and management strategies for skates are explored.

 **Keywords:** *Winter Skate, Migrations, Acoustic Telemetry, Western Atlantic*

The western Indian Ocean as a newly discovered biodiversity hotspot for deep-water catsharks of the genus *Bythaelurus*, with presentation of a new species

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Species of *Bythaelurus* Compagno, 1988 are small to medium-sized catsharks (maximum total lengths from 30 cm to 76 cm) that live in deep water on continental and insular slopes in temperate and tropical latitudes of the Indian and Pacific oceans, between depths of 200 and 1443 m. Due to very recent research efforts, the western Indian Ocean has turned out to be a hotspot of *Bythaelurus* species diversity with eight of the 13 currently valid species occurring there. Seven of the eight species are found exclusively in this area, whereas the eighth species, *B. hispidus* (Alcock, 1891), is also known from the eastern Indian Ocean.

Research in progress on *Bythaelurus* species in the Indian Ocean is presented, which is based mainly on specimens collected during cruise 17 of the Russian RV 'Vityaz' in 1988/89 as part of one of the largest collections of deep-water chondrichthyans

from the western Indian Ocean. In addition, historic material from the German 'Valdivia' expedition in the 19th century was examined, which was found to contain two undescribed species, as well as comparative material from different museum collections. The 'Vityaz' collection contains 255 *Bythaelurus* specimens, 33 of which were published very recently as type specimens of two new species. The remaining 222 specimens belong to three different species, *B. clewai* (Séret, 1987) (one specimen), *B. hispidus* (100 specimens) and an undescribed species (121 specimens), which is morphologically closest to *B. hispidus*. A comparison of the latter two species taking into account morphological, morphometric and meristic data is presented. Differences include morphometrics and meristics, characters of the claspers, morphology of dermal denticles, maturity and maximum sizes, and ventral colouration.

 **Keywords:** Systematics, Taxonomy, Deep Water, Catsharks

Biological studies of shagreen ray *Leucoraja fullonica* and sandy ray *L. circularis*

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Three skates in the genus *Leucoraja* occur in the North-east Atlantic, of which only the shallower-living cuckoo ray *L. naevus* has been subject to relatively detailed biological investigation. Both shagreen ray *L. fullonica* and sandy ray *L. circularis* are found in deeper water, occurring on the outer continental shelf, upper continental slope and on some offshore banks. Official landings data are unreliable, and these

species are among the most data-limited in the skate assemblage with assessments hampered by a lack of information on abundance, exploitation or discarding. Data on the distribution of these species have been collated, and the results from recent biological investigations, including reproductive biology, diet and trace metal concentrations, are summarised.

 **Keywords:** *Data-limited, Skate, Celtic Sea, Bay of Biscay*

Red muscle distribution and liver anatomy contribute to warming of the stomach in white sharks (*Carcharodon carcharias*)

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The red muscle scaling to body mass was investigated in six juvenile white sharks using transverse sections along the body. Red muscle mass was found to be 3.3 % (range 3.2-4.1 %) of body mass, with an isometric relationship ($b = 1.02$) to body mass, as reported previously for other endothermic shark species. Red muscle mass was 7.8 % (range 6.8-8.4 %) of white epaxial muscle, excluding fin musculature. There was a lateral transition in the red muscle position along the body; it occurs close to the spinal column in the anterior trunk to the pelvic fins (the end of abdominal cavity). Posterior to the pelvic fins through to the caudal peduncle the red muscle is subcutaneous, as observed in other endothermic sharks. The red muscles increased in size at the anterior epaxial muscles as the white sharks increased in

body mass. Results suggest that as juvenile white sharks grow, they derive increased warming of the anterior part of the body where the vital organs are located, thereby increasing endothermic capacity. Additionally the two liver lobes were found to completely envelope the entire gastrointestinal tract and showed pronounced vascularisation on the inner surfaces. This vascularisation, together with the liver's rich lipid content, suggest that the liver may provide thermal insulation. White sharks warm their stomachs by anterior red muscle distribution and liver envelopment, aided by warm blood delivered from the suprahepatic rete. The warm blood is then distributed through the flattened inner surface vessels of the liver to heat the stomach.

 **Keywords:** White Sharks, Endothermy, Anatomy, Red Muscles

In utero vertebral microchemical signatures in Hammerhead Shark as a proxy for habitat use and dispersion patterns in pregnant females

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The Scalloped Hammerhead Shark (*Sphyrna lewini*) is a highly migratory coastal and pelagic species that is an important component of the catch of artisanal and semi-industrial fisheries in the Mexican Pacific. This species is particularly susceptible to overfishing because of its slow growth, low fecundity, late age of maturity, and dependence on the coast for reproduction. Recent work suggests that chemical signatures derived from trace elements deposited in the vertebrae of sharks during growth reflect the environmental conditions of the surrounding water mass in which they have been exposed. Since *S. lewini* is a viviparous species displaying a long gestation period,

the microchemical signatures deposited in the vertebrae of developing embryos could potentially provide a maternal tag reflecting the habitats occupied by their mother. This offers great potential to examine questions related to habitat use change, dispersion patterns, connectivity, and philopatric behavior of pregnant females indirectly by analyzing the *in utero* vertebral elemental signatures of the coastal juvenile stages of their offspring. This study attempts to validate the use of *in utero* signatures as maternal tags during the gestation period by comparing LA-ICP-MS derived elemental signatures in the vertebrae of pregnant mothers with their corresponding embryos.

 **Keywords:** *Environmental Markers, Vertebrae Microchemistry, Life History, Philopatry*

The effect of lipid and urea extraction on stable isotope ratios in coastal demersal shark tissues

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Background: Trophic dynamics of elasmobranchs are rapidly changing and stable isotope analysis (SIA) is a tool being applied to investigate and understand these changes. Lipids and urea are known to vary between shark tissues and across species and have been shown to significantly lower SIA values in muscle tissue of both pelagic and deep-sea species of shark. There is a lack of information on the impact of lipids and urea on multiple types of tissue in coastal demersal sharks, and it's essential to determine these impacts in order to improve the accuracy of SIA and allow inter-tissue and inter-species comparisons.

Methods: Four different tissues were subjected to three different treatments (deionized water rinsing [DW], chloroform/methanol rinse [LE] and a combination of both [DW+LE]) to: (i) Assess the impact of lipids and urea on $\delta^{15}\text{N}$ values, $\delta^{13}\text{C}$ values and C:N ratios in the different types of tissue. (ii) Determine the best extraction treatment for each type of tissue.

Results: In muscle tissue the largest increase in $\delta^{15}\text{N}$ values was from DW+LE. $\delta^{15}\text{N}$ values in fin tissue increase significantly with all treatments, LE showed the largest increase in $\delta^{13}\text{C}$ values in fin. RBC $\delta^{15}\text{N}$ values showed no significant difference between any of the treatments and the control, whilst all treatments decreased $\delta^{13}\text{C}$ values. In plasma, all treatments increased $\delta^{15}\text{N}$ values, whilst $\delta^{13}\text{C}$ values all decrease across treatments. C:N ratios in all tissues across all treatments increased.

Conclusions: Compared with other treatments, DW+LE displayed the most consistent effect on $\delta^{15}\text{N}$ on $\delta^{13}\text{C}$ values across all tissues, compared with other the other treatments. The DW+LE treatment showed the most consistent results and is recommended to be used on all types of tissue prior to SIA, in order to standardise isotopic values and provide increased accuracy in inter-tissue comparisons.

 **Keywords:** *Stable Isotope Analysis Treatment*

Do female narrow sawfish mate multiply? A harrowing tale of low genetic diversity and elevated extinction risk

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Sawfishes are arguably the most vulnerable of all marine fishes, with their elongated toothed rostra making them particularly prone to entanglement in fishing nets. A largely coastal distribution combined with K-selected life history traits and low genetic diversity, have all contributed to the vulnerability of the *Pristidae* Family. Three of the five extant sawfish species are listed by the IUCN as critically endangered, and the remaining two as endangered. Despite this, knowledge of reproductive behaviour and genetic mating systems is lacking, hindering effective conservation and management. Multiple paternity, where multiple males sire offspring within a single litter, is considered to play an important role in increasing population genetic diversity. Multiple paternity has been found in 27 of 30 elasmobranch species investigated. However, notable sampling limitations appear throughout the literature; such as sampling a small number of litters or microsatellite loci or incomplete litter sampling (which reduces our ability to

detect multiple paternity). Nonetheless, up to nine sires have been observed within a single litter in some species. A chance bycatch event of 14 gravid narrow sawfish (*Anoxypristis cuspidata*) females in Princess Charlotte Bay (Queensland, Australia) has created a rare opportunity to study multiple paternity across a large number of litters (200 embryos) at five previously developed microsatellite loci. Preliminary results indicate either single paternity or very low levels of multiple paternity. Results of more in-depth analyses will be available in October. However, this initial finding is in stark contrast to the literature to date on multiple paternity in elasmobranchs and challenges the working assumption that multiple paternity is ubiquitous throughout this group. This study represents the first investigation of multiple paternity in a sawfish and will thus fill an important knowledge gap by providing information on genetic diversity crucial to the management and conservation of this endangered species.

Q Keywords: *Anoxypristis cuspidata*, Multiple Paternity, Microsatellites, Conservation Management

A global microsatellite genetic database for population assignment of tiger sharks; application to assignment of archived museum specimen back to population of origin

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Information on genetic population structure of marine fish is increasingly used in conservation and management. Knowledge about demographically and reproductively independent units is especially important in highly exploited migratory marine species such as sharks.

Population genetic approaches can not only be applied to answer questions of population subdivision but also in relation to movement ecology of individuals concerning contemporary dynamics of natural populations. In addition, genetic tools can be used not only to determine the species but also the geographic origin of catch and thus be an important tool for fighting IUU fishing.

Genetic assignment methods are very suitable tools for identification of the population of origin of individual fish. These methods use genetic information to ascertain which population an individual originate from, based on the multilocus genotype of that individual and the probabilities of that genotype occurring in each of the potential populations can be estimated. This enables researchers to address the question: as “Where was this

shark caught?”. These methods have proven very useful in relation to tracking illegal fishing, and false eco-certification of conventional teleost fish.

Here, we present a method for calibrating two large databases of published tiger shark genetic information, together constituting at global baseline database enabling population assignment on a global scale for this highly migratory species.

As proof of concept, we have assigned eleven archived tiger shark jaws of unknown origin from the 18th century back to their most likely population of origin. Shark jaws have always been a collector’s object, and are hence found in large numbers in the archives of natural history museums, and private collections, e.g. as trophies with anglers. Many of them have been gathered before the era of genetic analysis, making archived shark jaws a potential goldmine of DNA that can enable extension of temporal scales of population genetic studies of sharks by decades and even centuries. Historical DNA can be used to infer past population structure, demographics and also potentially adaptations to climate change through genomic analyses using Next Generation Sequencing.

 **Keywords:** *Population Genetics, Assignment Methods, Microsatellite, aDNA*

Environmental DNA reveals tropical shark diversity and abundance in contrasting levels of anthropogenic impact

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Background: Sharks are key components in virtually all marine trophic webs, but many species are suffering from overexploitation and stock declines. The conservation of sharks and their functions in an ecosystem and the development of management strategies rely heavily on our ability to assess and monitor their distribution and abundances. Yet, the assessment of mobile species in marine environments remains challenging, often invasive, resource-intensive and dependent on taxonomic expertise. The advent of parallel sequencing technologies offers new, powerful tools for biodiversity assessment. This includes the retrieval, amplification and sequencing of fragments of environmental DNA (eDNA) shed by organisms in aquatic habitats, with the possibility to rapidly gauge vast amounts of information on taxonomy and community structure.

Results: Here we employ this novel, rapid and non-invasive eDNA metabarcoding approach, specifically targeted to infer shark presence, diversity and abundance, across a range of impacted vs protected/remote areas in both tropical Pacific and Atlantic regions. We detect tens of shark species whose geographical distribution and relative abundance coincide with established knowledge on biogeographic patterns and levels of anthropogenic pressure and conservation effort. These findings indicate that eDNA metabarcoding can be effectively employed to study shark diversity in pelagic habitats.

Significance: Further developments in this field have the potential to drastically enhance our ability to assess and monitor elusive oceanic predators such as sharks, which are particularly difficult to quantify by means of traditional methods, and lead to improved conservation strategies.

 **Keywords:** *eDNA, Metabarcoding, Monitoring, Conservation*

Phylogeography and genetic diversity of the common stingray (*Potamotrygon orbignyi*) through Amazonas and Orinoco basins

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Freshwater stingray delimitation and identification is a priority in order to regulate its ornamental fisheries and management. *Potamotrygon orbignyi* complex of species exhibit a high coloration variability and large haplotype diversity, which makes difficult its identification based only on morphological characteristics. A genetic approach was conducted to clarify the population composition of *P. orbignyi*, considered one of the most widely distributed stingrays across the South American basins. Our goal was to determine if all individuals of *P. orbignyi* collected in this study correspond to the same lineage. Fragments of COI and CytB were sequenced and 5 microsatellite loci were obtained for 110 individuals from the Orinoco and Amazon Basin. Phylogenetic, divergence, genetic diversity and flux analysis were performed. A high genetic diversity was obtained, with the presence of high number of haplotypes and unique alleles, many of them segregated spatially by rivers. This was consistent with

a calibrated bayesian phylogeny, which revealed two clades that started the population differentiation during the Miocene; when the Amazon and Orinoco Basin started to drain and eventually separated. These two groups occupy mainly two waterbodies (Clade A: Amazonas, Clade B: Orinoco). In addition, the genetic distance in F_{st} between clades was high and significant, while it was low inside each clade. However, some gene flow detected between them could be understood as an ongoing speciation process. The results evidence the presence of two management units (A and B) belonging to Orinoco and Amazon basins, respectively. We suggest them as Evolutionary Significant Units' candidates. These results support the region's biogeographical story for freshwater stingrays and determines clades boundaries. Complementary evaluations of phenotypic traits and ecological adaptations are necessary to adjust current management strategies on this group.

 **Keywords:** Freshwater, Stingray, Phylogeography, ESU

High-tech applied to saving sawfishes in Mexico

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Sawfishes are the most endangered group of marine fishes worldwide, mainly due to large population declines and range contraction caused by fishing and habitat destruction. Two sawfish species (*Pristis pectinata* or smalltooth and *P. pristis* orargetooth) were formerly known from Mexico and were known to be important for pre-Columbian civilizations. However, the first-ever study devoted to sawfishes in Mexico – a recent interview-based survey – showed that they were common before the 1990s but both species might be now nearly or already extirpated from Mexican waters. Evidence of the existence of smalltooth sawfishes surfaced in early 2016 when commercial fishers delivered to us a live juveniles female who now lives safe at the Veracruz Aquarium. Since 2016, we are using traditional and high-tech methods to find the last remaining sawfishes in Mexico and

identify the areas where they still live. During 4 field campaigns to different coastal areas of the Gulf of Mexico and Caribbean and the Usumacinta River, we have used fishing gear, Unmanned Aerial Vehicles (UAVs or drones) and environmental DNA (eDNA) to try to find live smalltooth orargetooth sawfishes. No sawfishes were found through fishing gear or UAVs in any of the surveyed areas. However, water samples tested positive for *Pristis* DNA at some of the sampled sites. Our preliminary results suggest that sawfishes are still found in Mexican waters and that eDNA might be the best alternative to determine presence of sawfishes under very low abundance situations. Our results also stress the urgency of surveying the entire former range of both sawfishes in Mexico before it is too late to save them.

 **Keywords: eDNA, UAVs, Largetooth Sawfish, Smalltooth Sawfish**

Is the protection of sawfishes in Queensland working?

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Sawfish (fam. *Pristidae*) are considered the most threatened family of all sharks and rays. In Australia, 3 species of *Pristis* are listed as Vulnerable and Migratory on the EPBC (Environmental Protection and Biodiversity Conservation) Act of 1999, while *Anoxypristis cuspidata* is listed as Migratory. A national sawfish recovery plan was created in 2008.

The Gulf of Carpentaria in Northern Australia is considered the last global retreat for four species of sawfish. Since October 2015, Sharks And Rays Australia has sampled nine different river systems along Queensland's coast of the Gulf of Carpentaria. Sampling locations include the river mouths, plus various sites extending into the freshwater

reaches. Survey methods included gill netting, drum lining as well as hand lining. As this gear is only selective by fish size but not by species, all sharks and rays caught were identified, measured, tagged, DNA sampled and released.

Around 25 species of sharks and rays have been recorded, including two species of sawfish. Sawfish have not been recorded in all rivers that were sampled. Ongoing outreach efforts combined with a 'report a sawfish capture' program have provided additional records of sawfish, however, three out of four species appear to be quite rare. Future directions of this project will be discussed.

 **Keywords:** *Sawfish, Queensland, Australia*

Elasmobranchs of the Banc d'Arguin: conservation and ecological importance

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Catches of elasmobranchs increased in the last decades resulting population declines of these vulnerable species. Globally, elasmobranchs are primarily targeted for fins destined for Asian markets, but regional markets for elasmobranch meat exist throughout the world. This study focused on the elasmobranch fishery within the Banc d'Arguin National Park (Mauritania) and its management. Since the 1970s local communities have been catching elasmobranchs and, being linked to international markets, the fishery within the park has commercialized over the years.

This study reviewed the status of elasmobranch species within the park using semi-structured interviews, the catches over ten years and previous and current management plans. Presented management priorities for the park include the implementation of a zonation system prohibiting large mesh-sized nets in intertidal areas, defining a clear definition of targeted catch and more effective regulation of the markets associated with elasmobranch products. Finally, this study presents species on which conservation efforts should be focused.

 **Keywords:** *Mauritania, Intertidal, Subsistence Fisheries, Artisanal*

Tales from the wheelhouse: from anecdotal data to scientific evidence

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Identifying the role of different habitat and ecological niches in the life history of migratory sharks is essential for the scientific underpinning of management and conservation action. The southern North Sea is home to several shark species that undertake substantial migrations, such as the spiny dogfish (*Squalus acanthias*), the starry smoothhound (*Mustelus asterias*), and the tope (*Galeorhinus galeus*). In the Netherlands, we know virtually nothing about the utilization of our coastal waters and the potential importance of this area in the life cycle of migratory sharks. However, cooperation with recreational and commercial fishermen provided some

valuable insights into the occurrence, distribution, and migration of sharks in Dutch waters. Data collected by commercial fishermen led to the hypothesis that the intertidal Wadden Sea may be a critical pupping and/or nursery area for tope. Verification of these findings is now needed. In this presentation, the opportunities and challenges of working with fishermen to obtain scientific data will be discussed, as well as how an increase in participation from the fisheries sector could lead to an improvement in the availability of information on the spatial ecology of sharks in North Sea coastal areas.

Q Keywords: Fisheries, Spatial Ecology, Tope, Wadden Sea

Residence and fidelity of bull shark (*Carcharhinus leucas*) in Islas Murcielago, North Pacific of Costa Rica

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The Islas Murcielago is an UNESCO World Heritage Site located in northwestern of Costa Rica and visited by tourist diver's n especial to see the natural congregations of bull sharks (*Carcharhinus leucas*) adults. The bull shark has a worldwide distribution and live in marine and freshwater ecosystems. At Islas Murcielagos the bull sharks aggregate during the rainy season months (April to November). In order to promote conservation actions for the specie, we started to study the residence and site fidelity of bull sharks at Islas Murcielagos, using acoustic telemetry. Between 2013 and 2015 the team of Mision Tiburon tagged thirteen adults females of bull sharks with acoustic transmitters (VEMCO V16) in Islas Murcielago. During this period the receiver has recorded near to 50.000 detections mainly during daylight hours (06:00-18:00). The data showed a strong fidelity of females to the islands; however the number of

detections is different between sharks. Some females demonstrate high fidelity to the site, for example the female "30322" transmitted more than 16,000 detections. On the other hand, some females were detected only for a few weeks; the "30321" have transmitted 707 detections and stay at the islands only one month period. The tendency to aggregation during daylight hours in the island (more that 75% of detections), it related to reproductive aspects, since it is common to see females with post-copula marks and females and males swimming with marked signals of pre copula. During the dry season are significantly less detections than during the rainy season. In turn, the absence of detections during the night suggests that bull sharks move to other surrounding areas to feed and come back early in the morning to cleaning and continue with your reproduction strategies.

 **Keywords: Aggregation, Bull Shark, Acoustic Telemetry, Costa Rica**

Ecological features of several deep-water sharks species from New-Zealand infer by stereo video footage analyses

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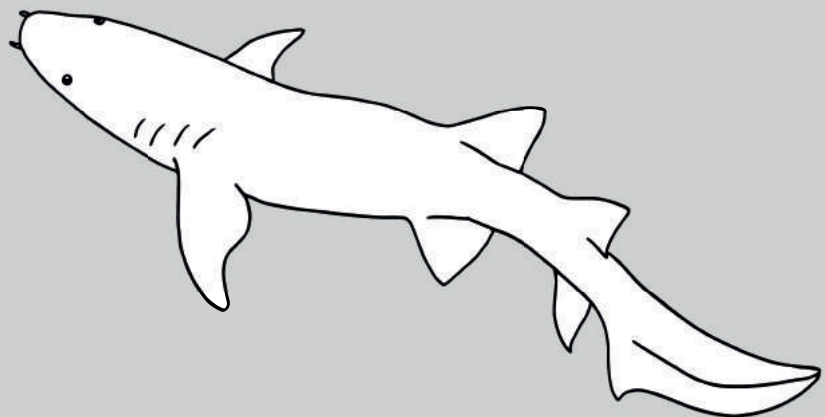
Actually, the ecology of deep-water sharks is poorly documented. While the majority of information on deep-sea organisms are mostly obtained via long liners or trawling by-catches, the improvement of technology these last years allowed to gain unique data. Recently, one method make a breakthrough providing, new insights on deep-sea organisms ecological information : the stereo video recording.

Between 2009 and 2010, the faunal diversity of New-Zealand continental slopes was studied using stereo baited remote underwater video deployments from 50 to 1200 meter depth at seven different locations. Up to now, fauna diversity index was the most commonly data extracted from this video deployment. Here, we describe the possibility to extract velocity and size from video using MatLab software.

Indeed, thanks to this software, it's possible to reconstruct sharks movements in three dimensions. In this work some ecological features of Eight sharks species will be recorded (depth range, abundance, sexual segregation, ...). The velocity and the displacement of each species is measured from in vivo recordings for the first time. The result show differences of abundancy between species, with some sociable and other solitary. The range depth increase for two species in comparison with literature and the swimming speed study show a higher cruise swimming speed for luminous deep-water sharks than non-luminous counterpart. This data show that ecological information of deep-water organisms (and shallow-water organisms) could be obtained without destructive method such as trawling.

 **Keywords:** *Deep-Water Sharks, Ecology, Stereo-Video, Size*

POSTER PRESENTATIONS



Stable eye-sotope analysis gives insight into the lives of Portuguese Dogfish (*Centroscymnus coelolepis*)

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The cryptic lifestyles of many deep-sea sharks means that direct observation of their behaviour is impossible. This has meant that much of the study of deep-sea sharks' life histories has relied upon catch data, often causing bias towards adult life stages. This is the case for *Centroscymnus coelolepis*, an ovoviviparous sleeper shark, often caught as bycatch in the *Aphanopus carbo* fishery in the North-East Atlantic. Stable isotope (SI) analysis of shark eye lens tissue is a relatively novel technique. The incremental growth of the eye lens allowed us to peel back time and view isotopic signatures across the whole life history of a shark; from in utero to sexually mature stages. Ratios of SIs of carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) give information about spatial and trophic ecology; essential for

developing evidence-based management strategies. For the first time, this study used SI analysis of the eye lenses of *C. coelolepis*, allowing us to observe isotopic life history patterns in nineteen individuals from the North-East Atlantic. By using a combination of interpretation of the SI values, and the relationship between eye lens diameter and total length, results were subdivided into different life history stages: in utero (from yolk deposition), juvenile and sexually mature. These results showed that there was a difference in foraging location between pregnant female *C. coelolepis* and other life history stages, and also between sexually mature males and females. The success of this technique in this species indicates that it may be applicable to other deep-sea shark species.

 **Keywords:** *Stable, Isotope, Foraging, Location*

Morphology and organization of the brain in deep-sea sharks - *Squalus blainville*

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In this study, the different correlations between the somatometric characteristics, the ecological parameters, the evolutionary position and the brain measurements (length, weight, volume, relative sizes of the brain sub regions) in the species *Squalus blainville*, Elasmobranchii> Squaliformes> Squalidae. Measurements were taken in a total of 66 specimens of which six were embryos found in three gravid female. In addition, for comparison purposes, the same measurements were made in another 11 species of Chondrichthyes of Greek waters in a small group of individuals of each species as part of binary analysis. *Squalus blainville* is a demersal shark found on the continental shelves and upper slopes, and is ovoviviparous. The allometric coefficient of brain weight with body weight was found to be 0.61. There was no statistically significant

difference in brain weight in the correlations between the two sexes.

The relative brain size expressed as encephalization quotient EQ *S.blainville* = 1.26 was researched as well as the relative size of the five major brain sub-regions (telencephalon, diencephalon, mesencephalon, cerebellum and medulla oblongata) observing that the cerebellum , telencephalon and medulla oblongata were longer than the other brain sub-regions. Finally, through the binary analysis, the coefficient of allometry was found to be 0.53.

Phylogenetically, lower evolutionary sharks have a smaller brain with less structural hypertrophies. The relative brain size seems to correlate with the reproduction method. There is a clear pattern of increasing cerebellar foliation (which was found for all species) along the evolutionary time.

 **Keywords :** *Squalus blainville*, Neuromorphology, Allometry, Ecology

Potential importance of Welsh waters for the critically endangered Angelshark (*Squatina squatina*)

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The Angelshark (*Squatina squatina*), Smoothback Angelshark (*Squatina oculata*) and Sawback Angelshark (*Squatina aculeata*) were once found throughout the Eastern Atlantic and Mediterranean Sea. However, due to severe population declines they are now listed as Critically Endangered on the IUCN RED list of Threatened Species. The ecology and behaviour of angel sharks, including their Sedentary nature, affiliation to shallow coastal locations and biology (slow growing, low fecundity) has made them vulnerable to certain fishing pressures, habitat disturbance and potentially other factors.

Over the past 10 years there has been an apparent upturn in the number of sightings of Angelsharks (*Squatina squatina*) around the Welsh Coast in areas where they were regularly reported in the 1960s and 1970s. To help understand more about the Angelshark population, Natural Resources Wales (NRW), in partnership with Zoological Society London (ZSL) working on behalf of the Angel Shark Project (ASP), have set up a

project to gather more information about this species in Welsh waters. Data on historic and more recent sightings have been collated through active engagement with commercial and recreational fishers using a variety of sources and methodologies. Fishers and other sea users are being encouraged to report any sightings of Angelsharks through the production of an information and best-practice handling leaflet. The leaflet (developed in collaboration with NRW, ZSL, ASP, The Shark Trust and Welsh Fishermen's Association) will help to ensure the safe release of Angelsharks if accidentally caught as well as awareness raising on the species. Working with the fishing community and building a positive rapport is a crucial element of the project to gain the trust of the fishing community. The project is the first step to better understanding the ecology of the species in Wales and helping to establish the reasons for the increased sightings in Wales.

 **Keywords: Angelsharks, Wales, Threatened, Conservation**

Shark bioluminescence control possibly evolved\co-opted from vertebrate skin pigmentation control

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Etmopterus spinax displays a specific hormonal control to regulate its bioluminescence. Photophores, the luminous organs, are composed of a cup-shaped pigmented cells, which form a pigmented sheath enclosing the emitting cells, the photocytes, surmounted by one or several lens cells. A multilayer cell zone called the iris-like structure (ILS), used as the light organ shutter, is present between the lens and the photocytes. The ILS contains melanin pigments allowing the modulation of the light coming through the organ. Recent studies demonstrated that melatonin (MT) and prolactin (PRL) trigger the light emission. Conversely, alpha melanocyte stimulating hormone (α -MSH) actively inhibit the luminescence. These three hormones are member of the hormonal cluster that regulate the vertebrate skin pigmentation. Interestingly, the hormones that regulate the shark light emission, were known to be regulators of the shallow-sea sharks skin pigmentation. Here, we investigated the effect of two other hormones on the light emission,

Adrenocorticotrophic hormone (ACTH) and melanin concentrating hormone (MCH) that are also members of the skin pigmentation regulator cluster: ACTH acts as a melanin pigment degranulation factor and conversely for the MCH. Our results demonstrated that ACTH inhibits luminescence while MCH have no effect on the light emission. Moreover, as MT and α -MSH receptors are members of the G-protein coupled receptor (GPCR) family which act on the cAMP intracellular level through the adenylate cyclase, we investigated the potential effect of hormonal injection on the cAMP level within the light organ. Results suggest a potential functional switch from the skin pigmentation control to the luminescence control mechanism via the ILS cell pigmentation. The ancestral mechanism of countershading to camouflage the body and mimic the background in the shallow-water sharks was hypothetically coopted for the counterillumination system of this lanternshark and possibly luminous sharks in general.

 **Keywords:** *Bioluminescence Control, Skin pigmentation, Pharmacology, Etmopteridae*

Deep-sea sharks caught as bycatch in the *Aphanopus* spp. fisheries around the Macaronesian archipelagos and nearby seamounts (NE Atlantic)

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There has been fishing activity in Madeira ever since the early days of the discovery, starting with the deep-sea shark fishery, which later gave rise to the black scabbardfish (*Aphanopus carbo* Lowe, 1839) fishery, one of the most important fisheries nowadays in Madeira.

This fishery is performed by the Madeira fishing fleet using drifting midwater longlines set between 800 and 1200 m depth, throughout the Madeira EEZ and also off the Canaries and in the seamounts in international waters and in the EEZ of the Azores within the framework of fisheries agreements.

Bycatch associated with longline fishing gears is usually regarded as being of conservation concern (Yokota et al., 2006) and the main bycatch of this fishery is a deepwater shark with worldwide distribution: the leafscale gulper shark, *Centrophorus squamosus* (Bonnaterre 1788) (Martins and Ferreira, 1995; Nicolau, 1998; Silva, 1998).

Deep-water species and sharks in particular are characterized by having low growth and fecundity rates, a late age at first maturity and complex geographical and bathymetric distribution patterns. These characteristics and the increasing fishing pressure imposed to these resources may seriously lead to their overexploitation long before effective management measures can be implemented. International authorities such as IUCN, FAO and EU have already expressed their concern about the sustainability of these fisheries. Despite the interest in deep-water sharks in the NE Atlantic, there are relatively few studies available. A great lack of knowledge still exists on the species life cycle and population(s) structure, particularly for the Portuguese EEZ. The management of fish population requires substantial and reliable scientific information, namely for growth, reproduction aspects and species dynamics.

 **Keywords:** Deep-sea Sharks, *Aphanopus* spp. Fisheries, Bycatch

Chimaeroid fishes from Madeira Island and Seine seamount (North Atlantic Ocean)

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According to Weigmann (2016) there are 40 valid species of chimaeras representing two genera, *Chimaera* Linnaeus, 1758 and *Hydrolagus* Gill, 1862. The separation of those two genera is based only on the presence or absence of a distinct anal fin (Didier and Séret 2002, Weigmann 2016). *Hydrolagus* is represented by 22 described species (James et al. 2009, Eschmeyer 2010), four of them known from the north-east Atlantic: *Hydrolagus affinis* (de Brito Capello, 1868), *H. lusitanicus* Moura, Figueiredo, Borlado-Machado, Almeida et Gordo, 2005, *H. mirabilis* (Collett, 1904), and *H. pallidus* Hardy et Stehmann, 1990.

In Madeira there are only two valid species of chimaeroid fishes: the small-eyed rabbitfish, *Hydrolagus affinis* (de Brito Capello, 1868) recorded in 2011 (Freitas et al. 2011) with specimens from Madeira and

Seine seamount and *Chimaera opalescens* Luchetti, Iglésias et Sello, 2011 recorded this year (Freitas et al. 2017) with new records of this fish from Madeira and Morocco.

Before this study, only two species of the family Chimaeridae were known to occur in Madeira, *Chimaera monstrosa* (Maul 1949) and *Hydrolagus affinis* (de Brito Capello, 1868) (Freitas et al. 2011). While reexamining the specimens of the Funchal Natural History Museum (MMF), originally identified as *C. monstrosa*, we came to the conclusion that they were in fact *Chimaera opalescens*. Since we were not able to locate specimens of *C. monstrosa* from Madeira in museum collections and Maul's (1948) reference is older than the oldest specimen in MMF, the occurrence of *C. monstrosa* in Madeira remains dubious.

 **Keywords:** *Chimaeridae*, *Madeira*, *Seine seamount*, *North Atlantic Ocean*

Characterization of the buoyancy of 3 species of deep-sea sharks

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Unlike fishes, sharks do not possess a swim bladder. As a consequence, their buoyancy depends on two types of lift: the hydrostatic and the hydrodynamic lift. Compounds in the body of the shark that are less dense than the surrounding water provide the hydrostatic lift (e.g. different lipid classes in the liver, muscles and serum). Water that flows below the body surface and the shape and size of fins create the hydrodynamic lift. Hence, sharks compensate the lack of a swim bladder by a large liver, filled with lipids. Despite this voluminous liver, shallow-water sharks are usually negatively buoyant and balance this with large pectoral and pelvic fins that provide them more lifting surface. Regarding deep-sea sharks, several studies have shown that their buoyancy is getting closer to neutral buoyancy, even reaching it in some cases. Bone in 1966 suggested that the red fibers volume in sharks can be correlated to the

liver volume and to its lipid composition. Several authors have suggested that if the shark is close to neutral buoyancy, less red fibers should be observed, as these would take action only in the hydrodynamic lift and not in the hydrostatic one. This work investigated the proportion of the three major lipid classes (Squalene, Diacylglycerol, Triacylglycerol) found in the liver of three deep-sea species (*Etmopterus spinax*, *Etmopterus molleri*, *Isistius brasiliensis*) and one shallow-water species (*Galeus melastomus*), as a comparison. We also examined the lipid composition of the red and white muscle fibers of the myotome for the three deep-sea species. We compared the obtained data with the red fiber volume to confirm/infirm the hypothesis made by Bone. Finally, the data collected were used to determine the buoyancy of the three deep-sea species studied.

 **Keywords:** Deep-Sea Shark, Buoyancy, Lipid Content, Spectrophotometry

Evaluating the conservation genetics of the bonnethead shark *Sphyrna tiburo* in Bocas del Toro, Panama, with preliminary evidence for an evolutionary significant unit

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Population structure and the preliminary findings of a potential evolutionarily significant unit (ESU) for the highly philopatric and non-dispersive bonnethead shark *Sphyrna tiburo*, was assessed in the Bocas del Toro Archipelago, Panama. *Sphyrna tiburo* is a species that is distributed along the Western Atlantic, with preferences for continental margins of North, Central and South America, including the Caribbean. Recent studies show that this species could be under a process of cryptic speciation, and individuals seem to be philopatric to the original sites where they are born. In Bocas del Toro Archipelago, Panama, a site identified as Hospital Point in Solarte Island, was sampled, and adult and juvenile individuals of *S. tiburo* were found to be abundant. Two mitochondrial fragments of the genes cytochrome oxidase I (COI) and control region (CR) were used to

test the genetic structure of *S. tiburo* in this area, in comparison with other populations of the Western Atlantic. These analyses found significant genetic differentiation between Caribbean bonnethead sharks from Bocas del Toro, suggesting high population structure between sites (Φ_{ST} : 0.9568. $P < 0.000$; F_{ST} : 0.72961 P : 0.000). These results suggest that this location could constitute a different genetic population unit for this species. The information obtained will help to understand natural population dynamics of the bonnethead shark throughout its distribution, and could be used as a baseline to design and develop conservation strategies and management policies for coastal sharks, which are poorly studied in the Caribbean and are highly threatened due to overfishing, particularly in Latin America.

Q Keywords: *Sphyrna tiburo*, Conservation Genetics, Evolutionarily significant unit (ESU), Caribbean

Eastern Atlantic and Mediterranean Angel Shark Conservation Strategy

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The Angel Shark Conservation Strategy (launched in June 2017) provides a framework for improved protection of the three Critically Endangered species present in the Eastern Atlantic and Mediterranean – the Angelshark *Squatina squatina*, Sawback Angelshark *S. aculeata* and Smoothback Angelshark *S. oculata*. The Strategy aims to: improve the overall profile of angel sharks; increase the number of sightings reported; generate a better understanding of current distribution; contribute to IUCN Red List re-assessments and identify new collaboration opportunities to increase conservation action.

As well as providing a summary of available information for these three Critically Endangered species, some of the key threats are outlined within the Strategy. Three priority goals and associated headline objectives have been identified as crucial to

achieving the vision that: Angel sharks in the Eastern Atlantic and Mediterranean are restored to robust populations and safeguarded throughout their range. Recommended next steps are outlined and serve as guidelines for targeted conservation actions. It is the intention that this Strategy serves as a catalyst for action, bringing together regional experts and resources, and increasing the community's capacity to deliver effective conservation for these Critically Endangered species.

Researchers and advocates in all regions are therefore invited to contribute additional information to support this document and help develop specific actions to safeguard these vulnerable species.

The full Conservation Strategy can be downloaded in English, French and Spanish from:

<http://angelsharknetwork.com/#action>

 **Keywords: Angel Shark, Critically Endangered, Conservation Strategy**

Tooth mineralization and histology in the rare snaggletooth shark, *Hemipristis elongata* (Hemigaleidae; Carcharhiniformes) – evolutionary significance or an ecological adaption?

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The evolution of jaws and teeth in vertebrates is considered a crucial step for their success. This is especially apparent in elasmobranchs, armed with several series of highly specialized teeth, allowing them to occupy a variety of different ecological niches at the top of aquatic food webs. Most research on the implications of shark teeth on feeding ecology and systematics focused, however, on external tooth morphology only, while tooth histology has been widely ignored. Shark teeth normally represent one of two histotypes: orthodont teeth having hollow pulp cavities surrounded by a specific type of dentine, orthodentine (known from different sharks) are distinguishable from osteodont teeth, which have the pulp cavity filled with a different type of dentine, osteodentine (in lamniform sharks and some batoids). Sharks of the order Carcharhiniformes, comprising ca. 60% of all extant shark species, are known to have orthodont teeth, with a single exception – the snaggletooth shark, *Hemipristis elongata*. High resolution micro-CT images of jaws and teeth from selected

carcharhiniform sharks (including extant and fossil *Hemipristis* specimens) and tooth sections of teeth from *Hemipristis*, other carcharhiniform and lamniform sharks, have revealed that (1) *Hemipristis* is the only carcharhiniform shark filling its pulp cavity additionally with osteodentine, (2) histology and development of teeth of *Hemipristis elongata* differ from the osteodont histotype which evolved in lamniform sharks and instead represent modified orthodontology, (3) this modified orthodontology was already present in extinct *Hemipristis* species, but orthodentine was reduced over time, and (4) real osteodontology is only found in lamniform sharks. Although our results suggest that tooth histology provides a phylogenetical signal and osteodontology represents a synapomorphy for lamniform sharks, it also raises the question about the reasons for the convergent development of similar histotypes. Future research employing FEM (Finite Elements Method) might help solving the ecological implications of different histotypes.

 **Keywords:** Ecological Adaption; Histotype; Orthodentine; Osteodentine

Angelshark breeding areas in Canary Islands

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The Angelshark (*Squatina squatina*) is one of the most endangered fish in European waters. This was based on estimated declines of at least 80% over three generations and the likelihood of continued future declines. The angel shark family is identified as the second most threatened sharks and ray taxa after a global review of extinction risk by the IUCN Shark Specialist Group.

Even in their last stronghold, the Canary Islands, Angelsharks are under significant threat from incidental catch through poorly-managed fisheries; habitat degradation through pollution, coastal development and marine infrastructure; and disturbance by divers and beach users.

In 2013, the University of Las Palmas de Gran Canaria, the Zoological Research Museum Alexander Koenig and the Zoological Society of London, and set up the **Angel Shark Project** with the overall goal to safeguard the future of Critically Endangered angel sharks throughout their natural range. One of the major research lines is the study of juvenile Angelsharks in the first nursery area identified for this species in the Canary Islands; Las Teresitas

(Tenerife). To expand this work, we used the results obtained from this area to identify potential new breeding areas around the Archipelago using a three-pronged approach:

1. Identified beaches with similar characteristics to Las Teresitas.
 2. Completed scoping surveys to assess habitat type and Angelshark presence; identified priority beaches for research
 3. Completed transect surveys at priority beaches throughout the year to evaluate Angelshark abundance in different seasons.
- This poster will outline the results of transect surveys completed in six beaches on Gran Canaria and Tenerife. In all beaches studied, except one in Tenerife, juvenile Angelsharks were identified. This suggests that the number of beaches used by this species as breeding areas could be much more widespread than originally thought. Furthermore, all beaches studied had a large variation in the number and variety of Angelshark prey species, however one prey species was found in relatively high abundance in all the beaches studied, the sand smelt (*Atherina presbiter*).

 **Keywords:** Angel Shark, Breeding Area, Canary Islands

Preliminary observations on the biology of marbled electric ray *Torpedo marmorata* Risso, 1810 in the Ligurian Sea (NW Mediterranean)

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The marbled electric ray, *Torpedo marmorata* (Risso, 1810) is a typical by-catch species of the small scale and trawl fisheries and, is frequently discarded at sea due to its low commercial value. Over the period 2016-2017, a total number of 127 specimen (57 males and 70 females, from 13 cm to 42.5 cm TL) were sampled under the National Data Collection Framework (DCF), in order to investigate different aspects of the biology of the species. The majority of the specimen was collected directly onboard as by-catch of the trammel net fishery targeting cuttlefish and common sole, mainly during winter and spring; some

specimens were collected at the auctions of the bottom trawl fisheries in the Gulf of Genoa. The stomach contents analysis showed a diet based mainly on bony fish. Morphometric observations were done on the basis of 34 body size measurements. Study on age and growth was carried out on vertebral rings counts using different staining methods and the Von Bertalanffy growth function was calculated both on males and females. A preliminary study of the maturity stages was performed following the standard maturity scale used under the MEDITS survey (Mediterranean International Trawl Survey).

 **Keywords:** *Torpedo marmorata*, Growth, Feeding, Reproduction

Assessing marine life interactions with a subsea kite in a tidal channel using active acoustics

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The global drive towards marine renewable energy (MRE) extraction has led to a rapid increase in tidal turbine installations in coastal channels experiencing high (>2ms⁻¹) current speeds. Despite a variety of mobile marine predators exploiting tidal channels for foraging opportunities or as means of transport/migratory routes, there is still high uncertainty surrounding potential animal-device interactions (e.g. collision, entanglement, displacement, attraction). To date most of the concern regarding collision risk has focused on marine mammals and seabirds, however elasmobranchs in pursuit of mobile prey, including filter-feeders, may be equally vulnerable to entanglement or collision. Characterised by extremely energetic, acoustically noisy environments, tidal streams continue to pose a particular challenge to monitoring interactions using more conventional methods (i.e. underwater cameras). Recently, hydroacoustics have emerged as a powerful tool for the environmental monitoring of MRE devices. Using multibeam sonar, large vertebrates can be detected and tracked, allowing for the collection of ecologically

relevant, empirical data required for collision risk models. Moving away from manned operations, high-frequency multibeam sonar systems allow autonomous, in-situ subsurface monitoring of MRE installations for longer time-scales and can be operated in areas in which traditional boat surveys are less effective. A novel, quarter-scale tidal turbine, Minesto's Deep Green 'kite', is being tested in a tidal channel in Strangford Lough, Northern Ireland, UK. The kite consists of a wing with a turbine and is attached to the seabed by a tether, 'flying' in figure-eight shaped trajectory underwater. Here, we present an acoustic monitoring approach under the EU-funded project 'PowerKite', using three Kongsberg multibeam sonar heads to evaluate fine-scale (10s of meters) interactions of mobile predators with the kite. To better understand the hydrodynamic processes driving animal passes and water column use at the site, current velocities and tidally-driven oceanographic features are concurrently collated using Acoustic Doppler current profilers.

 **Keywords:** *Marine Renewable Energy, Environmental Monitoring, Multibeam, Collision Risk*

A temporary exhibition to enhance public awareness of shark vulnerability and conservation

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Despite the poor conservation status of several shark populations worldwide, and their ecological and economic importance, one of the main problems faced by conservation efforts is the lack and/or misleading public knowledge, often fostering negative unjustified attitudes. Therefore, the development of outreach activities aimed at increasing public awareness of shark biology, vulnerability and conservation becomes mandatory. In this perspective we are organizing a temporary exhibition, based at the Museum “G. Olivi” in Chioggia (Lagoon of Venice, Italy; <http://www.museoolivi.it/en/>). The museum permanently hosts an Historical collection of Marine Zoology, with more than 1200 (300 exposed to the public) preserved specimens collected in the Adriatic Sea between the late 19th century and the Second World War. An 8 meters female basking shark opens the museum. Our temporary exposition will take the basking shark as a starting point to develop a knowledge path through the

Mediterranean sharks, with particular focus on those species that are commercially exploited in the area but whose biology and vulnerability are mostly unknown for the general public. Indeed, the Mediterranean Sea represents a hotspot of marine biodiversity, including sharks, and, at the same time, half of the species of sharks and relatives have been evaluated threatened in this basin.

Artefacts with description panels on shark life history traits, ecology and behavior, will come up beside interactive panels and virtual images to let the visitors entering into the Mediterranean sharks’ world, their vulnerability and conservation. The exhibition will be mainly addressed to young visitors, considering that school classes represent a wide proportion of visitors of the museum.

Our aim is to take the opportunity of the 21st EEA Annual Scientific Conference to discuss our initiative with the expert audience, exchange ideas and benefit of invaluable suggestions.

 **Keywords:** *Outreach Activities, Public Exhibition, Shark Vulnerability, Mediterranean Species*

Three-dimensional speed analysis of deep-sea sharks

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The deep-sea is a particular environment with low temperature, high hydrostatic pressure, low or absent light and scarce food resources altogether making it a harsh place for life. It has been suggested that deep living species display lower metabolic rate than their shallow-water relatives. Lower metabolism induces changes in life traits like speed performance. Thus it has been hypothesized that deep-sea sharks are slower than shallow-ones. The few comparative studies made on shallow and deep-sea sharks bring indirect evidences like a lower enzymatic activity in white muscle fibers. But due to the difficulty of working with deep-sea species, there is no direct measured speed for deep-sea sharks

apart for one study measuring relative speed with traditional 2D video.

The development of video techniques in marine biology has improved during the last years but mainly for biodiversity and size measurements. Here, we investigate the possibility to estimate actual swimming speed values for deep-sea sharks using stereo-video. Videos were recorded in New Zealand at seven locations and various depths. Cruise and burst speeds have been measured. The obtained speed values were correlated with depth and associated features then compared between species. In addition to that, speed measurements were compared with shallow-water species values coming from the literature.

 **Keywords:** *Velocity, Deep-sea Shark, Stereo-video Analysis*

Understanding the public perception of sharks as a tool for their conservation

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The development of successful conservation measures for wildlife and, specifically, marine fish, depends on the cooperation among different stakeholders, including scientists, fishers, managers and the public. Public support and engagement may direct management priorities and support or counter management interventions. In this context, elasmobranchs, in particular sharks, have historically been associated with a bad reputation, due to their portrayal as dangerous predators in myths, stories and contemporary movies. Nowadays, almost one third of shark species are threatened due to human impacts; clearly, more effective conservation strategies are required to preserve these threatened populations. Our study aims to evaluate the public perception towards sharks at a global scale and to identify potential drivers that shape such public opinion. To accomplish this, we developed an online questionnaire consisting of three parts. The first part collects respondent background and demographic information; the second part aims to the assessment of respondents'

attitude based on a closed-ended Likert scale matrix (Kellert, 1985); the third part evaluates the shark knowledge of participants. So far, the questionnaire was translated into 19 languages, and received more than 11600 non-randomly selected responses from 123 countries during its first ten months. While every attempt has been made to obtain a wide geographical spread of responses, 21 countries contributed 90% of the total. The majority of respondents frequent marine environments (87%) and almost half declared to have some specific knowledge on the questionnaire topic. Initial results reveal a general positive attitude towards sharks. For instance, 79% of the respondents view sharks as beautiful animals and 95% of the respondents believe that sharks should be protected. However, sharks do elicit fear in a large proportion of the sample (40-50%, depending on the question). The results indicate a positive relationship between knowledge and attitude, supporting the important role of education for wildlife conservation.



HAMMERHEAD SHARK RESEARCH: Knowledge from the populations in the Canary Islands

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HAMMERHEAD SHARK RESEARCH is a project that studies hammerhead sharks *Sphyrna* spp in the Canary Islands with the aim to contribute scientific base knowledge of these species in an understudied distribution.

Knowledge of hammerhead sharks in the Canary Islands is limited to the presence of the scalloped hammerhead shark *S. lewini* and the smooth hammerhead shark *S. zygaena*, isolated records about behaviour, and scant sighting reports by citizens in

social media. To get insights into the population dynamics, tagging and tissue sampling is combined with biological and fisheries data collection. In order to understand the role of the coastal areas in the Canary Islands in the life cycle of these sharks and their potential for conservation, telemetry will be implemented. These two study methods will provide the information to document the first local knowledge that can help in effective decision making for the species.

 **Keywords:** *Cornudas, Hammerheads, Tagging, Telemetry*

Scuba diving effects on bull sharks *carcharhinus leucas* behavior in Cabo Pulmo National Park, México

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Cabo Pulmo, National Park (CPNP), is one of the principal dive spots in México to dive with bull sharks *Carcharhinus leucas*.


However, there are no studies about the diving effects on this specie's behavior. In this project, we evaluated three different stages. For stage one, 30 dives were carried out with tourist groups where the observations did not have an observation protocol (no rules). In stage two, 30 dives were conducted with professional divers where the divers followed an observation protocol (rules). This was done at hot spots for shark observation for one year (2016); diver and shark behavior were recorded with ethograms. In stage three, to identify if there were differences in behavior, 2 video cameras were installed at the main site for shark observation and in a site without tourist access as a control. In both situations divers were not present.

The transition matrix obtained from bull shark ethograms showed interesting transitions between behavioral units. The interaction comparisons in stage 1, 2 and 3 showed highly significant differences. Bull

sharks exhibited a great variety of behaviors when divers did not have a diving protocol, however the interaction time was short.

With protocol diving, the sharks exhibited less variety of behaviors but the interaction time was longer. Finally, significant differences were found between the no-dive observations and the sites with cameras. The sharks exhibited the least number of behaviors and intraspecific behaviors not present in stages 1 and 2. We had found a significant relationship between the number of divers and the number of sharks present at the sites.

These differences can be explained by the fact that divers cause stress to the sharks when they do not have an observation protocol. With a protocol, the shark has a lower stress level and stays longer at the spot. Furthermore, the number of sharks sighted was higher at the site not used for ecotourism. This information will be useful to improve ecotourism activities and manage conservation programs for the bull shark in the park.

 **Keywords:** Bull Shark, Ecotourism, Behavior, Shark-human Interactions

A pilot project for reconstructing life history traits of a population of *Scyliorhinus canicula*

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Since 2016, a project on the Biology of Target Species of Bathypelagic Elasmobranchs in the Central Mediterranean Sea has started. At present, only 400 species of sharks are known and it's essential to protect them as they are top predators at the apex of the marine food chain, playing a crucial role in the marine ecosystems. Their decline or even extinction would cause huge trophic waterfalls within the food network, with drastic consequences for the entire ecosystem. The target species chosen for this study is the common Spotted catshark, *Scyliorhinus canicula*, since it is abundant, commercial, easy to sample and its withdrawal does not cause particular damage to the survival of the population. The goals of the research for the target species is to know the parasitic elminths communities and describe their status through epidemiological indices, to describe the food ecology of the species through the use of stable carbon and

nitrogen isotopes, to describe the population growth rates and correlate them to food ecology and to parasitic communities, and, at the end, to define the heavy metal accumulation rates and their effects on the immune system of the species and, consequently, on parasitic charge. The sampling area is located in Tuscany (coast off Follonica) and the specimens will be obtained in collaboration with the local fishing boats; then, all samples will be preserved for consequent analysis to the laboratory of Centro Studi Squali in Massa Marittima and to the University of Calabria. About 80 sharks will be sampled in three years. At present 22 sharks have been collected and the analysis of presence and concentration of heavy metals in the vertebrae have been performed by inductively coupled plasma mass (ICPM), revealing high levels of lead, zinc and manganese.

 **Keywords:** *Scyliorhinus canicula*, Parasites, Heavy Metals, Trophic Niche

Diversity patterns of sharks and rays (Chondrichthyes, Elasmobranchii) in the Adriatic Sea off Croatia

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It is assumed that the Adriatic Sea was strongly affected by overfishing, pollution and climate change over the last years resulting in species decline and local extinction of defined populations. Elasmobranchs are exceedingly vulnerable due to their biology. Species with slow growth, late sexual maturity and low fertility are not able to recover from serious exploitation. Although survey studies were conducted in the Mediterranean, there still is no detailed information about the existence and development of local populations available. This study aims at documenting the occurrence of elasmobranchs in the Kvarner area, North Croatia, by bibliographical research, dive sessions and commercial trawl surveys in 2016. Furthermore, radiographs of cranial morphology and scanning electron microscopy of dermal denticles were used to verify collected specimens. This data collection presents a current species list of elasmobranchs in the Kvarner area featuring a historical background with a focus on the changing diversity.

Fourteen shark and ten batoid species were identified in this area. Most commonly captured species are the small-spotted catshark, *Scyliorhinus canicula*, and the brown skate, *Raja miraletus*. Two skates were also captured representing potentially undescribed species. Larger species like smooth hammerhead, *Sphyrna zygaena*, are highly probable locally extinct but still present in the Adriatic Sea. Although the Kvarner area is not very deep in average two deep-sea sharks still are rarely seen. This diversity list still is incomplete but first data shows local extinctions of defined populations and increased occurrence of smaller elasmobranchs than larger ones, presumably attributed to their life history parameters. Long-term monitoring of an enlarged region is needed for further information on occurrence, abundance and habitat use. Defined knowledge on population dynamics is valuable and provides the basis for possible fishing time restrictions in areas with nursery, breeding areas or of rare species supporting populations' recovery and the ecosystem.

 **Keywords:** Adriatic Sea, Diversity, Elasmobranchs

On the occurrence of phosphatic otoliths in cartilaginous fishes (Chondrichthyes, Elasmobranchii)

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Dense bodies made of calcareous crystals are found in the skeletal inner ear labyrinths of living and extinct vertebrates and vary regarding both the material composition and the morphology. While large, solitary structures termed otoliths consisting of aragonite have long been known and analyzed in bony fishes, the presence, significance, and function of such structures are largely ignored in cartilaginous fishes. Holocephalans (chimaeras) and elasmobranchs (sharks, rays and skates) are considered to develop single crystalline structures made of different calcium carbonate polymorphs as well as to incorporate exogenous material in their inner ears via the endolymphatic duct. In the present study, we directly investigated the morphology and composition of these structures in two extant rays and one shark, and additionally analyzed their distribution in 39 extant chondrichthyans. Dissections, non-invasive micro-CT scanning with 3D reconstructions were used to examine the presence, shape, and positioning of the structures within the skeletal labyrinth. Infrared spectroscopy analysis provided

information on the phase composition. Contrary to earlier findings, almost all investigated specimens show solid, solitary apatite structures within their skeletal labyrinths. Elasmobranch otoliths differed by a specific morphology from the sagitta, lapillus, and asteriscus in bony fishes and are clearly identifiable in micro-CT scans. The ray otoliths resembled each other more closely than those in sharks, indicating a phylogenetic and taxonomic signal in their morphology between different elasmobranch clades. According to our results, phosphatic otoliths are plesiomorphic for vertebrates occurring in both agnathans and chondrichthyans and the presence of calcium carbonate otoliths in bony fishes thus is a derived feature. The underlying reasons for the shift from phosphatic to carbonatic otoliths within gnathostomes remains unknown. However, more detailed investigations on the chemistry of these otoliths, specifically regarding stable isotope analysis, will provide further insights into the spatial ecology of chondrichthyans in the future.

 **Keywords:** *Gnathostomata, Apatite, 3D Reconstruction, Vestibular System*

Dental ontogeny of embryonic tiger sharks (*Galeocerdo cuvier*): a link between tooth development and ovoviviparous reproduction

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Sharks are a small but very dominant group of fishes, which are perfectly adapted to their lives as predators, with most species being apex predators. The key for their success obviously lies in their dentition and tooth development. In shark embryos, different forms of tooth development, which are linked to their reproduction modes, can be observed. For some species, like the viviparous great white shark *Carcharodon carcharias*, teeth are already vital during gestation. Embryos of *Carcharodon carcharias* are oophagous, which means they feed on nutritive eggs during early ontogeny and therefore develop functional teeth already in utero. When the sharks become adults, a morphological change of the dentition happens, adjusted to their altered diet.

Besides *Carcharodon carcharias*, the tiger shark *Galeocerdo cuvier* is one of the largest predatory sharks worldwide. Unlike the viviparous and oophagous great white shark, *Galeocerdo cuvier* is ovoviviparous and therefore needs to be nourished to its

large size in another way. In addition to yolk nutrition, *Galeocerdo cuvier* embryos are fed by an intrauterine fluid, which they simply imbibe.

Using high resolution micro-CT images of jaws of embryonic, juvenile and adult tiger sharks, we demonstrate that (1) early-term embryos show no functional teeth respectively no dentition at all, (2) full-term embryos, which were close to birth, only have replacement teeth and no functional teeth, (3) the mineralization pattern of tooth rows is reversed just until birth, (4) younger replacement teeth are larger than older ones in embryos, and (5) there is an increase in numbers of teeth from embryonic to juvenile to adult sharks.

In summary, *Galeocerdo cuvier* also shows changes in dentition during its ontogeny from an early embryo to an adult individual, but differs from *Carcharodon carcharias* in many ways, which is the result of the different reproduction modes of both species.

 **Keywords:** *Galeocerdo cuvier*, Embryonic, Teeth, Reproduction

Can observations of the reproductive biology of the African catshark help in understanding movement patterns?

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Movement is an important feature in an individual's life, having different origins or causes.

Knowing that one component of this movement is the individual internal state, the knowledge of the biology of a species will help in the identification of ecological patterns, which in turn will lead to a better population management.

In this study, we have looked closer into the reproductive biology of a total of 559 specimens (273 males and 286 females) of the African sawtail catshark, *Galeus polli* (Cadenatt, 1959), caught in Angolan waters. Sex, total length, and maturity stages were recorded individually. Inner clasper length was recorded for each male.

The number and proportion of juveniles, adolescents, and adults of each sex was analyzed and differences in sex ratios evaluated.

Size, sex and maturity stages were found to be correlated with depth, with the larger, and mature specimens occurring predominantly at greater depths. There also seems to be a depth related migration of pregnant females between the deeper mating grounds and the shallower nursery grounds. The sex ratios were relatively similar in the shallower end of the distribution range, but females dominated at more than 600 m depth. No male was found deeper than 700 m.

Since this not a commercial species, understanding its behavior and spatial ecology will depend on time-series observations of different biological aspects. On the management aspects, fishing related mortality may have complex and significant repercussions on this species, given that commercial fisheries are impacting different segments of the population differently.

 **Keywords:** *African sawtail catshark, Reproduction, Movement*

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Handwriting practice lines consisting of 20 sets of three horizontal dashed lines.



Handwriting practice lines consisting of 20 sets of three horizontal dashed lines.



Warsan Shire - Home

no one leaves home unless
home is the mouth of a shark
you only run for the border
when you see the whole city running as well

your neighbors running faster than you
breath bloody in their throats
the boy you went to school with
who kissed you dizzy behind the old tin factory
is holding a gun bigger than his body
you only leave home
when home won't let you stay.

no one leaves home unless home chases you
fire under feet
hot blood in your belly
it's not something you ever thought of doing
until the blade burnt threats into
your neck
and even then you carried the anthem under
your breath
only tearing up your passport in an airport toilets
sobbing as each mouthful of paper
made it clear that you wouldn't be going back.

you have to understand,
that no one puts their children in a boat
unless the water is safer than the land
no one burns their palms
under trains
beneath carriages
no one spends days and nights in the stomach of a
truck
feeding on newspaper unless the miles travelled
means something more than journey.
no one crawls under fences
no one wants to be beaten
pitied

no one chooses refugee camps
or strip searches where your
body is left aching
or prison,
because prison is safer
than a city of fire
and one prison guard
in the night
is better than a truckload
of men who look like your father
no one could take it

no one could stomach it
no one skin would be tough enough

the
go home blacks
refugees
dirty immigrants
asylum seekers
sucking our country dry
niggers with their hands out
they smell strange
savage
messed up their country and now they want
to mess ours up
how do the words
the dirty looks
roll off your backs
maybe because the blow is softer
than a limb torn off

or the words are more tender
than fourteen men between
your legs
or the insults are easier
to swallow
than rubble
than bone
than your child body in pieces.
i want to go home,
but home is the mouth of a shark
home is the barrel of the gun
and no one would leave home
unless home chased you to the shore
unless home told you
to quicken your legs
leave your clothes behind
crawl through the desert
wade through the oceans
drown
save
be hunger
beg
forget pride
your survival is more important

no one leaves home until home is a sweaty voice in
your ear saying-leave,
run away from me now
i dont know what i've become
but i know that anywhere
is safer than here



Netherlands Organisation
for Scientific Research



save our seas
FOUNDATION

Mogelijk gemaakt door



Ministry of Economic Affairs



SAVE OUR
SHARKS



KIT Royal
Tropical
Institute



university of
groningen



van hall
larenstein
university of applied sciences

