WHITE SHARKS GLOBAL 2023

Bamgarla Land

SOUTH AUSTRALIA

Photo by Andrew Fox

Abstract Book

White Sharks Global

12th—17th November

Port Lincoln, South Australia, Australia

Conference Sponsors

Humpback Whale

Queensland Government

Fur Seal

ATLANTIC WHITE SHARK CONSERVANCY

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GEORGIA AQUARIUM

INNOVASEA

ECHOTOP

IMBeR Integrated Marine Biosphere Research

SOUTHERN SHARK ECOLOGY GROUP

GOVERNMENT OF WESTERN AUSTRALIA

Department of Primary Industries and Regional Development

IMOS Integrated Marine Observing System

City of Port Lincoln Seafood Capital of Australia

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ATLANTIC SHARK INSTITUTE

DO YOUR PART.

BE SHARKSMART.

REDUCE YOUR RISKS

S **wim** between the flags at patrolled beaches and check signage

H **ave** a buddy and look out for each other

A **void** swimming at dawn or dusk

R **educe risk,** avoid schools of bait fish or diving birds

K **eep** fish waste and food scraps out of the water where people swim

S **wim** in clear water and away from fishers

For more **SharkSmart** tips, search **SharkSmart QLD**

Queensland Government

DAF18504 12/22

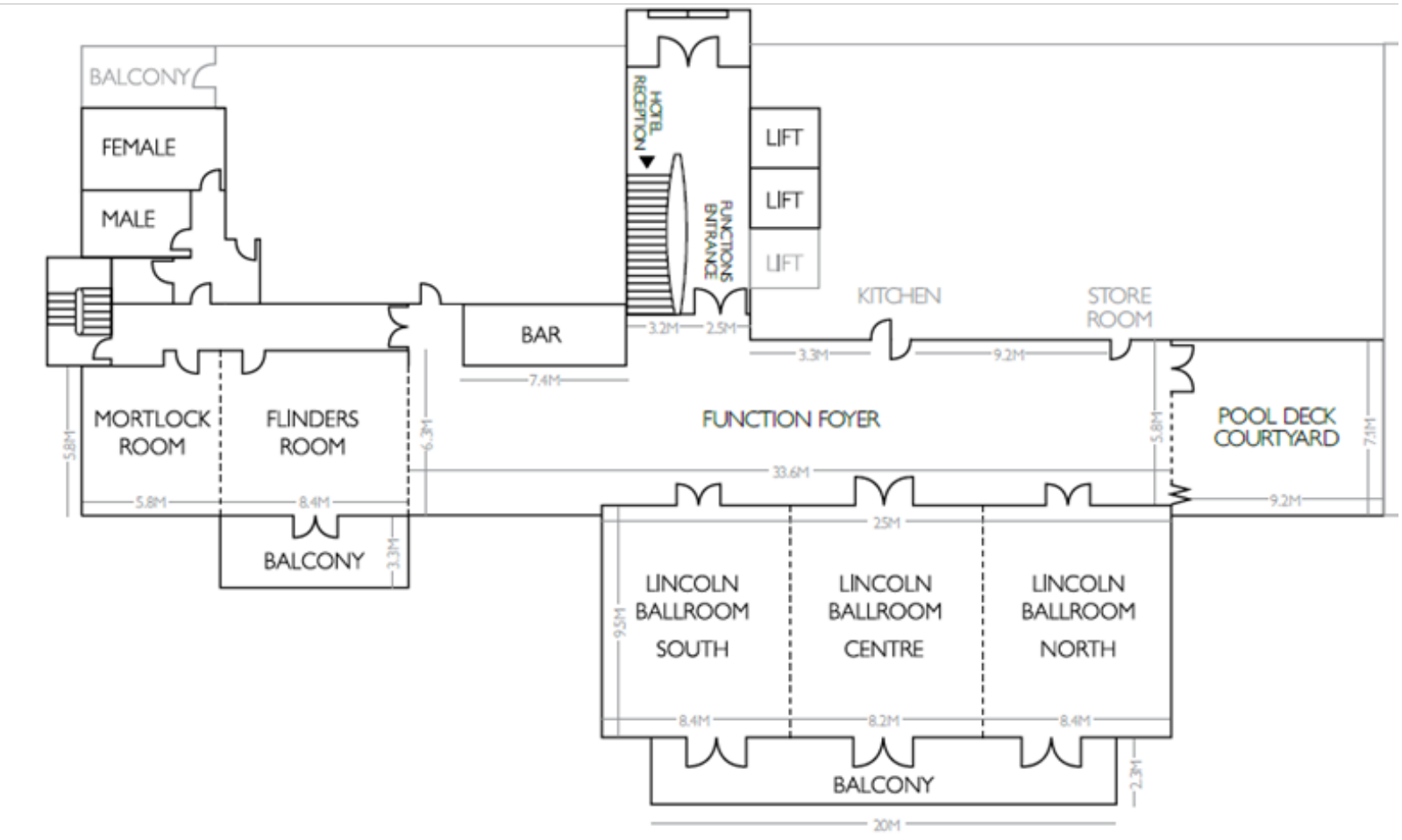
First Nations art in the White Sharks Global logo by Shania Richards from Barngarla country

Bou Wilya (Hello Spirit), this design was made with the Barngarla's connection to land and sea in mind. In particular, their dynamic relationship with the sacred water warrior: The shark. A creature they used to sing out at Sleaford Bay (The seven sisters flying cliff), in sacred rituals and ceremonies. It was believed that the frequencies from the singing out be "felt" by the creature and would lure them closer to shore (alongside fish, dolphins, etc) to either eat or communicate. This is reflected by the usage of shapes, colour, and space in the design. The white represents the sacred frequencies of sound vibrating within the shark's body and local ochre (representing spiritual connection). The different shapes of the lines show the songlines travelled and the circles resonating the abundance of spirit in water, always present in perfection. And of course the double dotted spine, the supporting bone of strength and courage, which is what the Gallinyalla sharks are known for.

PORT LINCOLN
HOTEL

1 Lincoln Highway

Port Lincoln, South Australia



Day 1 Sunday 12th of November 2023			
Icebreaker event			
12:00	ongoing	Registration	Function foyer
13:00	17:00	Workshop—*The fundamentals of using acoustic telemetry to understand shark migration and behaviour*	Lincoln room
13:00	17:00	Workshop—*The genomic era of white shark ecology*	Flinders & Mortlock room
17:00	20:00	Icebreaker	Function foyer (drinks and food provided)

Day 2 Monday 13th of November 2023		
1st day of presentations — Lincoln room		
08:15:00	**Welcome and opening including address by Mayor Diana Mislov, City of Port Lincoln**	
08:30:00	**Plenary: Michael Domeier**	
Session 1 — sponsored by WA Department of Primary Industries and Regional Development		
09:15:00	Alexandra DiGiacomo	Quantifying Juvenile White Shark Swimming Kinematics using Unoccupied Aircraft Systems (UAS) and Deep Neural Networks
09:22:30	Paul Butcher	From trials to triumph: examining the progress of bather protection tools in the New South Wales Shark Management Program
09:30:00	Enrico Gennari	Post-prandial metabolism of the white shark
09:37:30	Wesley Ogloff	White shark movement behaviours in a high recreational use coastal bay in Atlantic Canada
09:45:00	Oliver Jewell	Using multi-sensor technology to tackle white shark ecology at varying scales
10:00:00	Alen Soldo	Great white shark distribution change in the Mediterranean in the 21st century: real shift or better data?
10:07:30	Adrienne Gooden	Shark activity is impacted by changing environmental conditions.
10:15:00	Kristen Smith	The Gills Club: Creating the next generation of shark and ocean stewards through a diverse array of educational opportunities.
10:22:30	Michael Doane	Informing multifaced, multidisciplinary analysis of evidence for shark incident species identification
10:30:00	**Morning tea (30 mins)**	
Session 2 — sponsored by the Georgia Aquarium		
11:00:00	Charlie Huveneers	Shifts in the incidence of shark bites and efficacy of beach-focussed mitigation in Australia
11:07:30	James Anderson	Hungry hungry shark? Examining the roles of movement behaviors, foraging strategies and spatial scale in apparent sociality in aggregating juvenile white sharks
11:15:00	Tobey Curtis	Consequences of Climate Change-Driven Shifts in White Shark Nursery Habitat in the North-west Atlantic Ocean
11:22:30	Alison Towner	Orca-mediated displacement of white sharks along the South African coast: current insights and future directions.
11:30:00	Sofia Gabriel	The search for sociality in white sharks: Investigation of the co-occurrence of juvenile white sharks (*Carcharodon carcharias*) within a nursery area off New South Wales, Australia using social network analysis
11:45:00	Taylor Chapple	Class-specific seasonal migrations of White sharks in the Northeast Pacific.
11:52:30	Jeremy Jenrette	Detecting Mediterranean white sharks with environmental DNA and particle distribution hindcasting
12:00:00	Yuri Niella	Sample size effectiveness of a machine learning algorithm to predict risk of white shark bites
12:07:30	Elizabeth Jahn	Relative Abundance and Community Composition of Juvenile White Shark (*Carcharodon carcharias*) Prey Species along Southern California Beaches
12:15:00	Nigel Hussey	Examining post release behaviour following capture and ecosystem interactions of white sharks (*Carcharodon carcharias*) in Atlantic Canada through novel biologger packages
12:30:00	Monterey Bay Aquarium	**Lunch (1:15 hrs)**

Day 2 Monday 13th of November 2023 1st day of presentations — Lincoln room		
13:45:00	**Plenary: Senator Peter Whish-Wilson**	
Session 3		
14:30:00	Oscar Sosa-Nishizaki	What happened with the White Shark cage diving at Guadalupe Island: an official statement
14:37:30	Ryan Hesse	Denticle Hygiene: Viral Communities on Elasmobranch Epidermis
14:45:00	Megan Winton	An open spatial capture-recapture framework for estimating the abundance and seasonal dynamics of white sharks at aggregation sites
15:00:00	**Afternoon tea (30 mins)**	
Session 4 — sponsored by Atlantic Shark Institute		
15:30:00	Adam Miller	New genomic assessments of Australian white sharks (*Carcharodon carcharias)* challenge current assumptions relating to population structure and highlight the need for revised spatial management
15:37:30	Douglas Long	Evolution of the Carcharodon lineage: Rapid morphological change creates a major shift in a predator's trophic niche.
15:45:00	Nick Debere	Catch composition, immediate mortality and post-release survival of animals caught on SMART drumlines off south-eastern Australia
15:52:30	Sasha Whitmarsh	Chum dine with me: assessing the effects of wildlife tourism on non-target fish assemblages
16:00:00	Emily Spurgeon	The Influence of Micro-Scale Thermal Habitat on the Movements of Juvenile White Sharks in their Southern California Aggregation Sites
16:15:00	Greg Metzger	Habitat and migratory range expansion of white sharks (*Carcharodon carcharias)* during the first five years of life
16:22:30	Emily Hunt	Ontogenetic change in body shape for white sharks, *Carcharodon carcharias*, in Australian waters
16:30:00	Gregory Skomal	The nearshore predatory behavior of the white shark off Cape Cod, MA, USA.
16:37:30	Jordan Matley	Continental-scale movements of white sharks in Australia using acoustic telemetry
16:45:00	Riley Elliott	Discovering New Zealand's first Great White shark nursery
16:52:30	Jess Fish	Using eDNA to characterise biological drivers of white shark nearshore visitation along the east coast of Australia
17:00:00	**Poster session in the Function foyer** **Posters displayed during the entire week, please have your poster up by 17:00 Sunday 12th November (drinks provided)**	

Day 3 Tuesday 14th of November 2023 2nd day of presentations — Lincoln room		
08:25:00	Housekeeping announcements	
08:30:00	**Plenary: Alison Kock and Michael Heithaus**	
Session 5 — sponsored by Port Lincoln City Council		
09:15:00	Patrick Rex	The Use of Artificial Intelligence to Analyze Close Proximity Encounters Between Humans and Juvenile White Sharks in Southern California
09:22:30	Jess Morgan	A new genetic assay for the individual identification of white sharks
09:30:00	Samantha Andrzejaczek	Seasonal patterns of adult and sub-adult white shark presence at coastal aggregation sites in Central California
09:37:30	Marco Antonio González León	Testing satellite-tagged white sharks as oceanographic sentinels of the dynamic Agulhas Current System
09:45:00	Francesco Ferretti	The White Shark Chase: Tracking the last White Sharks in the Mediterranean Sea
10:00:00	Zachariah Merson	Comparison of juvenile white shark abundance estimates from eDNA metabarcoding, acoustic telemetry, and drone surveys at Southern California aggregation sites
10:07:30	Lauren Meyer	Café or Buffet? Using fatty acids to reveal the generalist diet and coastal habitat use of Australia's white sharks
10:15:00	Jerry Moxley	Daily and seasonal movements of Cape Cod gray seals vary with predation risk from white sharks.
10:22:30	Rebecca Lipscombe	What's on the menu? Elucidating the diet and habitat use of immature white sharks in eastern Australia using biochemical tracers
10:30:00	**Morning tea (30 mins)**	
Session 6 — sponsored by Mile End Furniture		
11:00:00	Christopher Lowe	The California Shark Beach Safety Program – a holistic approach to measuring and mitigating white shark risk to ocean recreation and beach management.
11:07:30	Jonathan Werry	Bite-wound analysis of white shark bites on adult inshore bottlenose dolphins
11:15:00	Jackson Hooten	Assessment of Presence Probability of the White Shark (*Carcharodon carcharias)* in the Western North Atlantic using Passive Acoustic Telemetry
11:22:30	Gonçalo Miguel da Cruz e Cunha Guinote Ramos	Return ticket: capture-recapture data from white sharks tagged in the New South Wales Shark Management Program
11:30:00	Kristina Loosen	Abiotic and biotic drivers of white shark (*Carcharodon carcharias*) inshore occurrence in False Bay, South Africa
11:52:30	Alisa Newton	Population Health and Stress Response of White Sharks (*Carcharodon carcharias) in the Western North Atlantic Ocean*
12:00:00	Zachary Clark	Insights into the diet and trophic ecology of white sharks (*Carcharodon carcharias) gained through DNA metabarcoding analyses of cloacal swabs*
12:07:30	Patricia Charvet	White Shark or Shortfin Mako? Lamnid sharks in the equatorial southwestern Atlantic
12:15:00	Brittany Finucci	Preliminary age estimation of New Zealand white shark
12:30:00	**Lunch (1:15 hrs)**	

Day 3 Tuesday 14th of November 2023 2nd day of presentations — Lincoln room		
13:45:00	**Plenary: Sarah Waries and Christopher Lowe**	
Session 7 — sponsored by Deakin University		
14:30:00	Taylor Chapple	Connectivity between white shark populations off central California, USA and Guadalupe Island, Mexico
14:37:30	Amy Smoothey	SMART drumlines as a bather protection tool in New South Wales: capture response and long-term fate of white sharks (*Carcharodon carcharias)* released from SMART drumlines
14:45:00	Bryan Legare	Fine-Scale Shallow Water Movements of White Sharks (*Carcharodon carcharias)* on Cape Cod, Massachusetts.
15:00:00	**Afternoon tea (30 mins)**	
Session 8 — sponsored by Wildlife Computers		
15:30:00	Oscar Sosa-Nishizaki	Trends in the index of abundance of white sharks at Guadalupe Island: the last 20 years
15:37:30	Teah Burke	Are we overestimating the age of immature white sharks (*Carcharodon carcharias)?*
15:45:00	Joshua Moyer	Characterizing and Qualifying Coastal White Shark (*Carcharodon carcharias)* Nursery Habitat in Rhode Island and Massachusetts, USA
15:52:30	Phoenix De La Mer	Exploring the influence of shark relatedness on patterns of aggregation site use in white sharks from the Neptune Islands?
16:00:00	Elena Tamburin	Using stable isotopes to elucidate long-term habitat use by young sharks
16:15:00	Harley Newton	OCEARCH's Western North Atlantic White Shark Study: A Model of Collaboration, Shared Access and Public Education
16:22:30	Madeline Riley	Systematic review and meta-analysis of studies testing the efficacy of shark bite mitigation
16:30:00	Ryan Logan	Movement patterns and habitat use of white sharks of the Northeast Pacific across ontogeny using long-term acoustic telemetry
16:37:30	Amy Allen	Evidence-based policy and adaptive management framework leads to sustainable white shark cage-diving industry
16:45:00	Toby Rogers	Decline or shifting distribution? A first regional trend assessment for white sharks (*Carcharodon carcharias)* in South Africa
16:52:30	Thomas Clarke	Can bite-resistant fabric reduce injuries from white shark (*Carcharodon carcharias)* bites?
18:00	Oceania Chondrichthyan Society	**Student Night** Beer Garden pub (drinks provided for students)

Day 4 Wednesday 15th of November 2023		
White shark cage-diving (Neptune Islands Group Marine Park)		
5:30	14:00	Calypso Star Charter (Port Lincoln Marina)
8:00	18:00	Calypso Star Charter (Port Lincoln Marina)
12:00	20:30	Calypso Star Charter (Port Lincoln Marina)

Day 5 Thursday 16th of November 2023			
1st day of workshops			
8:30	12:30	Workshop—*Synthesising global white shark satellite telemetry studies to establish research priorities*	Lincoln room
8:30	12:30	Workshop—*Global analyses of white shark diet and contribution of non-pinniped food sources (AM)*	Flinders & Mortlock room
12:30	13:30	Lunch	Function Foyer
13:30	17:30	Workshop—*Tracking white sharks to uncover drivers of movement and important habitats*	Lincoln room
13:30	17:30	Workshop—*Global analyses of white shark diet and contribution of non-pinniped food sources (PM)*	Flinders & Mortlock room

Day 6 Friday 17th of November 2023			
2nd day of workshops			
8:30	12:30	Workshop—*Conserve, cull, compromise: the white shark conundrum*	Lincoln room
8:30	12:30	Workshop—*Is your science ready for TV? The art and trappings of documentary*	Flinders & Mortlock room
12:30	13:30	Lunch	Function Foyer
13:30	17:30	Workshop—*Ecological roles of white sharks across marine ecosystems*	Lincoln room
13:30	17:30	Workshop—*Global management and impact of tourism on white sharks and supporting ecosystems*	Flinders & Mortlock room
18:30	….	Conference dinner	The Line and Label / Peter Teakle Winery

Workshops

The fundamentals of using acoustic telemetry to understand shark migration and behaviour

led by Hugh Pederson

Sunday 13:00 – Lincoln room

Acoustic telemetry is a well-established tool that has been used by researchers worldwide for over four decades to gain a deeper understanding of the spatiotemporal movements and associated behaviour of a wide range of aquatic animals. This half day workshop will provide guidance on how to conduct a successful acoustic telemetry study as well as offer insight into managing and verifying your data prior to analysis. Topics include how acoustic telemetry works, designing a successful study, equipment and deployment tips, detection data management and QA, using receiver diagnostic data to assess system performance, and what's new in acoustic telemetry.

INNOVASEA

IMOS
Integrated **Marine**
Observing System

The genomic era of white shark ecology

led by Michael Doane, Adam Miller, Belinda Martin

Sunday 13:00 – Flinders and Mortlock room

White sharks are central to the marine environments they inhabit, influencing trophic energy transfer through top-down predation and mediating the behaviour of co-occurring animals. Understanding their ecology is, therefore, critical. The emergence of DNA-based tools has enabled a rich characterisation for the ecology of these animals. This workshop will provide an overview of genomic methods for characterising white shark ecology. We will first provide a brief overview of genomics, followed by an in-depth discussion focusing on genomic approaches that examine population-based questions and eDNA. We will then wrap up the workshop with a methodological section introducing the laboratory and emerging technologies used in white shark genomics. We will encourage workshop participants to provide any personal insight into experiences with different technologies and how they plan to or have used them to answer their own research questions.

Global analyses of white shark diet and contribution of non-pinniped food sources

led by Lauren Meyer and Jerry Moxley

Thursday 8:30 – Flinders and Mortlock room

We aim to address white shark diet and trophic roles at a global scale. While most countries where white sharks occur have several white shark ecologists that typically work together and that communication occur between countries, there is currently nothing that formally supports and facilitates greater collaboration between scientists across countries. Many location-specific studies using biochemical tracers to investigate white shark ecology and feeding have been published, with many more ongoing studies currently taking place. The data compiled will then be used to develop and plan global comparative analyses. The specific analyses which will be undertaken will depend on the dataset collated, but the task team will aim to address the following key ecological questions: (a) consistency of ontogenetic changes in the ecological role of white shark across its distribution; (b) comparison of isotope and fatty acid niche metrics (e.g. width and overlap) across white shark aggregation areas; (c) multi-disciplinary approach to investigate spatio-temporal dynamics of white shark movements through the combination of tagging and biochemical tracer data (i.e., habitat use and coastal vs. pelagic feeding in relation to movements); and (d) improve our understanding of what is driving white shark carbon production.

Synthesising global white shark satellite telemetry studies to establish research priorities

led by Wesley Ogloff and Nigel Hussey

Thursday 8:30 – Lincoln room

With the rapid growth of satellite telemetry as a tool to monitor white sharks, there is a need to periodically take stock of existing work to ensure efficient and effective use of research resources. This workshop will bring together global experts on white shark satellite telemetry to determine a best-practices framework for quantitatively assessing research conducted to date and to guide priorities moving forward. Participants will collaborate to determine approaches to quantitively synthesize data extracted from global literature and finalize a core research-themes framework. We will also assess interest in producing a public database of white shark telemetry metadata to facilitate data sharing and collaboration.

Tracking white sharks to uncover drivers of movement and important habitats

led by Jordan Matley

Thursday 13:30 – Lincoln room

Over the last 20 years, the movements and space use of white sharks (*Carcharodon carcharias*) have been investigated using a broad range of tracking technologies. This provides an opportunity to combine datasets collected across regions and jurisdictions to undertake a range of broad, national- and international-scale analyses. This workshop aims to develop and plan studies which can address questions using large-scale tracking tools. Possible studies include (but are not limited to) the identification of: (1) Biologically Important Areas, (2) drivers of movements and consistency in movement patterns (or lack thereof) across regions; (3) ecological-scale connectivity (i.e months to years) between regions and jurisdictions.

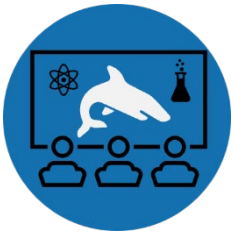
SOUTHERN SHARK ECOLOGY GROUP

Conserve, cull, compromise: the white shark conundrum

led by Paul Butcher

Friday 8:30 – Lincoln room

This workshop explores the complex and controversial issue of managing white shark populations globally. This aims to include a diverse group of stakeholders, including scientists, conservationists, managers, and fishers, as they navigate the difficult decisions surrounding the management of these iconic predators. Through workshop 'mini presentations' and 'discussions', we will highlight the ecological importance of white sharks, as well as the economic and social implications of their presence or absence. Ultimately, the workshop aims to have working groups to help structure and write paragraphs to build a manuscript that poses the question: how can we strike a balance between conservation and human interests in a changing world?



Is your science ready for TV? The art and trappings of documentary

led by Chris Lowe

Friday 8:30 – Flinders and Mortlock room

White sharks are one of the very few animal species on the planet that garner global name recognition and largely branded by their media appeal. Because of their large size, predatory nature, and reputation for occasionally biting humans, the media has helped cultivate a public appetite for anything white shark related. As a result, Discovery Channel, National Geographic Channels, BBC, PBS have all funded numerous features of white sharks and white shark related research. Thus, production companies are always on the lookout for new ways to film and portray them, often recruiting researchers to participate in productions. This is not always a mutually beneficial experience and has often been considered exploitative. Researchers are often challenged with how to work with production companies and networks to ensure their work is portrayed accurately and they are fairly compensated for their time. In addition, injuries or fatalities involving white sharks often lead to extensive and excessive news coverage that may further demonize white sharks regardless of current research or statistics. This workshop will focus on how white shark researchers can find and work with production companies and networks to deliver agreeable content, negotiate contracts and agreements, and better shape content and messaging. We will also provide some advice and practical training on working with the news media on controlling messaging related to white shark bites and incidents.

Ecological roles of white sharks across marine ecosystems

led by Jerry Moxley

Friday 13:30 – Lincoln room

White sharks are upper-trophic level predators that interact and affect coastal food webs, though full understanding is challenged by an elusive nature and depletion legacy. As marine predator communities recover from these legacies, novel ecological insights are emerging from population monitoring, animal tagging, and trophic and behavioral research of shark populations. We propose a global synthesis of the ecological role of white sharks and an evaluation of context dependencies mediating its importance. Collaborative approaches are designed to investigate topics including, but not limited to: (1) presence and/or strength of top-down prey regulation, particularly on pinniped populations; (2) risk-induced effects and anti-predator strategies across multiple behavioral scales; (3) diet shifts and intra-/inter-guild interactions amongst other marine consumers; (4) novel and/or emergent community interactions due to distributional shifts or changing habitat use; and (5) conservation conflicts in synchronized recoveries of white sharks and other protected taxa.

Government of South Australia

National Parks and Wildlife Service SOUTH AUSTRALIA

Global management and impact of tourism on white sharks and supporting ecosystems

led by Charlie Huveneers

Friday 13:30 – Flinders and Mortlock room

Wildlife tourism is growing in popularity, diversity of target species, and type of tours. This presents difficulties for management policy that must balance the complex trade-offs between conservation, animal welfare, and pragmatic concerns for tourist satisfaction and economic value. A multidisciplinary framework was developed recently to assess the impacts of wildlife tourism, focusing on industry tractability, socioeconomic values, and their effects on conservation, animal welfare, and ecosystem impacts (Meyer et al. 2021). White shark cage-diving tourism started in the early 1980s and has occurred in six countries with various levels of success and social acceptance. The workshop will use the recently developed framework to assess and compare the sustainability and acceptability of white shark tourism around the world. This comprehensive, multidisciplinary assessment will help identify factors (e.g. tourism practices, management regulations) contributing to sustainable and socially acceptable operations that supports the recovery plan of this threatened species vs. the pitfalls that can result in unsustainable activities negatively impacting white sharks or supporting ecosystems.

Plenaries

Michael Domeier

Marine Conservation Science Institute

Michael earned his Ph.D. in Marine Biology and Fisheries from University of Miami's Rosenstiel School of Marine and Atmospheric Science in 1992. As a graduate student and post-doc, he specialized in coral reef fish ecology, with a particular emphasis in reproductive strategies. His 1997 paper entitled Tropical Reef Fish Spawning Aggregations: Defined and Reviewed, has become a seminal work providing a framework for both conservation efforts and future research. Dr. Domeier has spent his entire career founding and running nonprofit organizations. He has founded, and served as President, three organizations that all still operate to this day: Pfleger Institute of Environmental Research, Science and Conservation Fish Aggregations, and Marine Conservation Science Institute. Michael has made significant contributions to the study of pelagic fishes and white sharks. He has been an innovator in the field of electronic tags, conducting studies using archival tags, acoustic tags, popup satellite tags and SPOT tags. Never satisfied with off-the-shelf products, he has guided the development of tag attachment hardware, acoustic release devices and the form and function of satellite tags. Michael has been studying white shark for nearly 25 years, with pioneering research that led to Guadalupe Island becoming one of the world's best known white shark hotpots. In recent years his team has discovered another white shark hotspot near California's Point Conception. Today he lives in Kailua Kona, Hawaii, continuing his white shark research while also owning and operating an organic honey company.

Research and Management Challenges presented by the White Shark (*Carcharodon carcharias*), A Creature of Habit

Michael Domeier[1]

[1] Marine Conservation Science Institute, Fallbrook, CA, 92028 USA

It has been 13 years since the last dedicated white shark symposium, and since that time there have been important research advancements, answering some questions while posing entirely new, unanticipated questions that remain unanswered. This talk will summarize some of the progress made since the last symposium while presenting a large amount of unpublished research findings, putting them into context alongside important global research and conservation priorities.

Senator Peter Whish-Wilson

Australian Greens Senator for lutruwita/Tasmania

Peter made the transition from leading community campaigns to protect Tasmania's forests and oceans to Greens Senator for lutruwita/Tasmania in 2012 when he replaced iconic conservationist Bob Brown in the Senate.

He is an economist by training and taught finance and economics at the University of Tasmania whilst building a small family agricultural and wine business.

Since entering the Australian parliament over a decade ago, he has held many portfolios for the Greens, including Treasury, Small Business, Finance, Defence, Agriculture and Waste & Recycling. As the longstanding Australian Greens Healthy Oceans spokesperson, he has fought tirelessly to protect our oceans and wild places and for real action on climate change. He has been a fierce advocate for the protection of all marine creatures, and in particular, sharks.

In 2016 Peter initiated and chaired a landmark Senate inquiry into shark mitigation and deterrent measures. Over 75 submissions were received from a wide range of stakeholders and ten hearings were held around the country. The inquiry report was tabled in 2017 and included 20 recommendations. Disappointingly, successive governments have failed to respond to the report's recommendations. Peter continues to press for a government response and for an increased focus on the protection of our sharks and oceans.

Sharks: Politics, Policy and Polarisation

Great white sharks, a protected species under federal Australian environment law, are the most feared predators in our oceans. Shark interactions with humans are a significant matter of public and media interest. Fear is a potent force in politics, and given the intersection between politics and policy, this presents significant challenges in balancing the ongoing conservation of great white sharks and other marine species with realistic public safety outcomes. This presentation outlines these challenges, including the role the media plays in polarising public opinion and influencing political outcomes on this significant matter of public interest. A 2017 Senate inquiry into how best to mitigate the risks of shark interactions, the first of its kind in Australia, collected significant evidence on these matters and much more. Submissions and public hearings held around the country, from all sides of the debate and a diverse range of stakeholders, provided an informed Senate report recommending a pathway to 'get the balance right' between conservation and safety, in both policy terms and informing public debate. Its large number of recommendations have not been responded to by any federal government six years later, which is highly unusual and very telling. The inquiry process and its findings are featured in this presentation and will speculate on what outcomes might come next.

Alison Kock

South African National Parks

Alison Kock is a marine biologist passionate about using science to conserve marine wildlife and their habitats. She works at the Cape Research Centre South African National Parks and is an Honorary Research Associate at the South African Institute for Aquatic Biodiversity. In her multifaceted role, Alison executes and coordinates research and long-term ecological monitoring within marine protected areas (MPAs). Her primary focus is assessing the effectiveness of MPAs and translating research findings into actionable measures for biodiversity conservation and effective management. In 2014, Alison earned her PhD in biological sciences from the University of Cape Town. During her doctoral studies, she co-established the Save Our Seas Foundation Shark Centre in Kalk Bay, South Africa. Alison has published over 40 peer-reviewed papers, 30 on white shark movement ecology, the ecological role of sharks, predator-prey interactions, population trends, white shark cage diving impacts, bather safety and co-existence between sharks and people. Alison's impact extends beyond academia. She has presented >100 public presentations, written >50 popular articles, participated in wildlife documentaries, written three book chapters, and led shark safety and women in STEM education campaigns. She played a pivotal role in the strategic growth of the nonprofit organization Shark Spotters and serves on its executive committee. Moreover, she actively participates in several national working groups, including the National Marine Biodiversity Scientific Working Group, the Top Predator Scientific Working Group, the South African Whale Disentanglement Network, and the Seabird Technical Team. She served as a member of an expert panel established by the Environmental and Fisheries Ministry of South Africa to assess the National Plan of Action for Sharks and currently serves on the scientific committee of the Southern Africa Shark and Ray Symposium.

Mike Heithaus

Florida International University

Dr. Mike Heithaus is Dean of the College of Arts, Sciences & Education (CASE) and Professor in the Department of Biological Sciences at Florida International University (FIU). At FIU, he served as the Director of the Marine Sciences Program and was the founding Executive Director of the School of Environment, Arts and Society (SEAS).

A marine ecologist, specializing in predator-prey interactions and the ecological importance of sharks and other large marine species like dolphins and sea turtles, Mike joined FIU as an Assistant Professor in Marine Biology in 2003. His research includes investigating the ecological consequences of overfishing large predators, predator-prey interactions, and the ecology of seagrass ecosystems, coral reefs, and deep-sea communities of the Gulf of Mexico. He has published more than 160 scientific papers and book chapters, co-edited four books on sharks, and attracted over $8 million in research support.

Elucidating the ecological roles and importance of white sharks: current knowledge and a pathway to advance our understanding

Alison Kock[1,2] and Michael Heithaus[3]

[1] Cape Research Centre, South African National Parks, Tokai, South Africa
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As iconic “top” predators, white sharks (Carcharodon carcharias) are often cited as being critical to marine ecosystems. But what is the empirical evidence to support this claim? In this session, we will explore the diverse ways in which sharks, including white sharks, might affect their prey and broader ecosystems, summarize our current state of knowledge for white sharks and propose pathways towards gaining a functional understanding of white shark ecological importance across diverse ecological contexts and through their ontogeny. Collectively, sharks can affect marine ecosystems through top-down pathways (e.g. modification of prey traits/behaviour, direct predation on prey), bottom-up pathways (e.g., nutrient translocation) and positive and negative species interactions (competition, facilitation). Carcharodon carcharias is the largest macropredatory shark, exhibiting a circumglobal distribution and occupying numerous ecosystems ranging from deep seas to coastal embayments. Despite their potential ecological importance and high profile, research on the ecological roles of white sharks remains limited. Most studies have focused on easily observable interactions between white sharks and marine mammals, revealing clear evidence of risk-mediated effects. The relative importance of these effects on marine mammal populations and broader communities remains poorly known. Recent studies suggest that juvenile white sharks may influence prey population sizes and that increasing white shark populations and range shifts may trigger cascading effects. The generality of these results needs to be explored. Investigations have further indicated that extended absences of white sharks from normal aggregation sites have led to notable increases in mesopredatory sharks. This suggests a prior top-down role of white sharks within their respective ecosystems. Our understanding of how white sharks might influence communities through bottom-up processes and scavenging remains in its infancy. Ecological surprises can provide valuable opportunities to advance our understanding of the ecological roles of sharks."

Sarah Waries

Shark Spotters

Sarah is the CEO of Shark Spotters, a pioneering South African Non-Profit Organisation that combines sustainable shark safety solutions, applied ecological research, environmental education and practical conservation interventions that provide a holistic approach to mitigating conflict between people and sharks. She has provided support to several shark-bite hotspots around the world on environmentally and socially responsible approaches to shark bite mitigation, working with local governments, conservation authorities, and civil society to better manage the negative repercussions of shark bite incidents in their regions.

Christopher G. Lowe

Calif. State Univ. Long Beach Shark Lab

Dr. Lowe is a Professor of Marine Biology and Director of the Shark Lab at California State University Long Beach and currently runs the California Shark Beach Safety Program. With over 30 years of experience studying sharks, he also serves as the U.S. west coast representative of the International Shark Attack File maintained by the American Elasmobranch Society. The CA Shark Beach Safety Program has focused on white shark research directly related to beach safety including socio-economics, with education as the primary mitigation tool.

Sharks or People - who really needs managing to reduce the risk of shark bites?

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Shark bite incidents are low-frequency, high-impact events that can have far reaching social, economic and environmental repercussions. Despite nearly a century of global white shark - human interaction data (shark bite statistics) and shark bite mitigation approaches, developing effective means of reducing risk has varied widely by location and is still hotly debated. While there have been considerable scientific gains and insight into white shark behavior, understanding and mitigating human behavior that may influence bite risk remains elusive. Recent expansions in shark-bite research from focusing solely on shark management to incorporating social and psychological research are therefore key in improving understanding of human perceptions of shark risk and the motivation for individual and government action to mitigate interactions. Socio-economic and political pressures associated with white shark bites, particularly fatalities, have varied by location and culture, and strongly influence the manner in which shark risk is managed. With recovering white shark populations and documented dynamic shifts in white shark distributions occurring globally, new regions are experiencing increases in shark-human interactions and investigating means to mitigate their potential impacts. Global comparison of existing shark safety programs and the driving factors for their implementation therefore provides valuable insight for these emergent regions with elevated shark bite risk, and has the potential to assist with more effective management going forward, including the implementation of new technologies or techniques of shark bite mitigation.

Presentation

Evidence-based policy and adaptive management framework leads to sustainable white shark cage-diving industry

Amy Allen[1], Lana Roediger[1], and Charlie Huveneers[2]

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The Neptune Islands (Ron and Valarie Taylor) Marine Park off South Australia's Eyre Peninsula is the only place in Australia enabling white shark cage-diving tours. The industry generates ~$15 million year for the State's economy, and engages ~10,000 tourists year in marine parks and education. The increasing interest in shark tourism globally has raised concerns about the potential impacts of this sector on the species it targets and supporting ecosystems. With little or no management, tourism can alter shark behaviour and residency patterns, which has contributed to the closure of several shark tourism operations. In South Australia, the number of days with cage-diving tours increased from 100 to 250 between in 2007, which led to concerns about its possible impacts on white sharks and to studies on the species residency and behaviour. The studies revealed a corresponding increase in the mean annual residency of white sharks from 11 days to 21 days and changes in space use. These prompted an industry review, which led to the development of South Australia's white shark tour licensing policy. The policy sets out strict rules and regulations for the licensing of the activity, with an adaptive component supported by a monitoring program and research partnership. The annual research report continues to demonstrate the success of the policy and management framework. White shark residency has returned and remained at baseline levels since 2013, enabling two increases in activity days for tour operators since 2020. The most recent increase in operating days to 13 per fortnight in March 2023 will support further data collection and monitoring, and enable the industry to continue to be environmentally sustainable, socially responsible, and economically progressive.

Presentation

Hungry hungry shark? Examining the roles of movement behaviors, foraging strategies and spatial scale in apparent sociality in aggregating juvenile white sharks

James Anderson[1], Emily Spurgeon[1], Patrick Rex[1], Christopher Lowe[1], and Marten Thompson[2]

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Central place foraging theory suggests that animals move to and from a central place or location in a predictable fashion, often with multiple individuals sharing that central place resource. A further assumption of central place foraging theory is that animals rest at the central place, expanding the distances over which they travel to exploit food resources. Juvenile white sharks have been documented to aggregate in large numbers, occupying a relatively restricted range in coastal locations in Southern California, remaining there for weeks to months at a time. Here, we present results of analyses designed to explore the relationships between movement patterns, association preferences (sociality) and central place foraging theory in juvenile white sharks at a Southern California nursery aggregation hot spot. Movement patterns and space use of tagged juvenile white sharks residing within the aggregation site demonstrated distinct relationships between diel period, activity and sociality, with likely foraging occurring at specific locations within the monitored area. However, despite this, and despite being resident within a restricted area for prolonged periods, tagged sharks did not conform to the classic definitions of central place foragers.

Presentation

Seasonal patterns of adult and sub-adult white shark presence at coastal aggregation sites in Central California

Samantha Andrzejaczek[1], Taylor K. Chapple[1,2], Alexandra DiGiacomo[1], Salvador J. Jorgensen[3], Scot D. Anderson[3], Michael Castleton[1], Paul E. Kanive[4], Theodore Reimer[1], Timothy D. White[1], and Barbara A. Block[1]

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Gaining insights into seasonal migrations of marine megafauna and how patterns vary among demographic groups is pivotal for evaluating anthropogenic risk exposure and modeling populations and ecosystem dynamics. In California, adult and sub-adult white sharks aggregate on the coast in fall and winter months, facilitating comprehensive long-term field studies. Using a dataset of 355 acoustically tagged individuals spanning from 2006 to 2022, our objective was to examine the seasonal dynamics of coastal habitat utilization among sub-adult and adult ontogenetic groups. The main aggregation sites of the Northeast Pacific (Año Nuevo, the Farallon Islands and Tomales Point) were continuously monitored, with an expansion of the acoustic network to the south in the latter years of the study. White sharks were tracked for an average duration of 594 ± 552 days (mean ± standard deviation), with total tracking days ranging from 9 – 3235 days. Notably, adult male sharks exhibited the highest residency to coastal aggregation sites and demonstrated earlier seasonal peak densities in late October. Adult females peaked in residency in early December. Adult sharks also displayed distinct seasonal gaps in detection where they have been shown with satellite tags to migrate offshore, with females displaying much longer average detection gaps than males (averaging 1.5 years versus 0.7 years). In contrast, while sub-adults have also been shown to migrate offshore, this group demonstrated more consistent and widespread detections across a higher number of coastal sites throughout the year, often extending beyond the main aggregation areas outside of the peak aggregation season, suggesting higher coastal affinity and residency. The observed differences between ontogenetic groups are likely attributed to sex- and size-specific foraging and reproductive strategies. Our study demonstrates the importance of long-term monitoring programs for delineating patterns among demographic groups.

Poster

How the environment shapes the individual behaviour of bait-attracted white sharks in South Africa?

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Direct observation of animals has always seduced the human being and has been commonly used in scientific research. Indeed, the wildlife tourism has been growing globally, with the cage-diving with bait attraction allowing for a closer contact with the white shark. Thus, the need of understanding the impacts of this industry is imperative. Additionally, the planet is going through critically rapid environmental changes and it is crucial to assess and understand how the abiotic factors are impacting this species behaviour. The individual surface behaviour of *Carcharodon carcharias* is not a simple stimulus-response reflex, but rather a complex tactical situation in which animals show plastic responses. Considering the economic and ecological value of the white shark, not only the tourism industry plays a critical role in public awareness and conservation, but it also provides an extra opportunity platform suitable for the research on this species. With this study, our main goal is to present an approach for understanding the influence of different environmental factors on the individual behaviour of white sharks, using ethological data collected in South Africa from 2007 to 2018, during cage-diving activities. We used 7 abiotic variables (sea surface temperature, tides, sea condition, cloud cover, lunar phase, time of day and El Niño Southern Oscillation) to analyse 9 behavioural responses (bait follow, breach, parading, visual inspection, tail stand, spy hop, tail slap, repetitive aerial gaping and head-up vertical emerging) of the white sharks towards the bait. Our results suggested a correlation between the abiotic factors and the activities performed by the white sharks, with some behaviours occurring in a higher or lower frequency than expected. Our findings show that the environmental conditions can trigger activity and influence the behaviour of the white sharks in proximity of the cage-diving vessels.

Poster

Parasitic interactions and their impact on white sharks in the Southern Hemisphere: Insights for conservation and ecosystem health

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Despite the vulnerability and declining population of white sharks, our understanding of infectious agents, particularly parasites, affecting these species remains notably limited. There is a growing body of evidence indicating a dramatic increase in parasite populations in our oceans, yet we have little knowledge of their impact on aquatic animal populations. This presentation builds upon current research and prior findings, with the aim of providing an overview of our current knowledge about the presence and diversity of parasites infecting white sharks in the Southern Hemisphere. Our goal is to unravel the complexities of parasitic interactions and their effects on the behaviour and health of white sharks. By doing so, we seek to offer actionable insights for the preservation of these remarkable animals and the delicate ecosystems they inhabit. Parasites can have a multifaceted impact on their host's behaviour, influencing foraging, reproduction, and social interactions. These changes in behaviour can significantly affect individual fitness and the persistence of populations. Thus, understanding the behavioural aspects of parasitic interactions is also crucial in the context of shark conservation and ecosystem health.

Poster

SharkOmni: A New Approach to Mitigation Strategies through Apex biomimicry

Christopher Bignell[1]

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The Shark Omni Zero-Harm bioacoustics shark repeller has the potential to address significant strategic issues in the fisheries sector at a national and possible international scale implementing Biomimicry of Apex predator frequencies affecting flight response in predating sharks and marine fauna. Shark depredation is causing considerable impact for both recreational and commercial (trawl and line) fisheries in all States. Preliminary tests in WA (in areas of high shark depredation) indicate that when the device is activated there is no shark depredation. Significantly, the Shark Omni technology also has the potential to mitigate the impacts of sharks on recreational water users. Clearly this is a major public issue, especially in Australia. In addition, the tests showed that the device also is able to clear dolphins from the area around fishing boats to reduce bycatch issues, barotrauma, Fisher effort, fish stock management and ocean plastics waste. The device also has the potential to mitigate impacts and interaction with TEPS (threatened and endangered and protected species). The commercial fishing sector needs to comply with increasingly stringent trade and environmental regulation to demonstrate that there are extremely low impacts on TEPs. Many fisheries are struggling to comply with the new regulations with existing technologies and fishing techniques. Chris understands government collaboration is important due to the considerable industry and public benefits of the device and its deployment in government managed waters. At this seminar, Chris will give an overview of the technology, device, applications and results of early testing along the journey. He believes support from his technology innovation will aid the vast fisheries industries, science research, fish stocks and preservation of other marine fauna as its core agenda, focusing on safer waters whilst also benefiting Recfisher's. Benefits to Government and industry Offering shared key data retained from observations gathered in their purpose designed SmartApp.

Presentation

White Sharks in the Eddies of the North Pacific Subtropical Gyre

B.A. Block[1], L. N. Thomas[1], J. Witting[1], J. Wenegrat[1], E. Portner[1], T. Chapple[1], N. Truelove[1], E. Allan[1], S. Johri[1], B. Robison[2], D. Haulsee[1,3], A. Carlisle[1,3], A. Netburn[5], S. Jorgensen[4], P. Kanive[4], T. White[1], S. Anderson[4], S. Andrzejaczek[1], C.M.L.S. Pagniello[1]

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The North Pacific Subtropical Gyre (NPSG) is one of the largest oceanic biomes on Earth. Satellite tagging has revealed that white sharks (*Carcharodon, carcharias*) migrate over 2,000 km from the coastal waters off central California to areas within the NPSG in the Winter and Spring. One focal area is located halfway between Hawai'i and California, an area we call the White Shark Café (WSC). We combined data from electronic tags with echosounder, net trawl, isotopic and eDNA data from shipboard and autonomous vehicle surveys as well as with high-resolution oceanographic models to understand the physical and biological ocean dynamics within the WSC. We found that the spatial extent of the WSC overlaps with that of Eastern Subtropical Mode Water (ESTMW). Numerical simulations show that the migration of sharks to the WSC is timed with the formation of ESTMW and the subsequent explosion of submesoscale instabilities within this area. When these submesoscale eddies subside, sharks return to the California Current System. Additionally, we found that the WSC is an oasis within the oligotrophic waters of NPSG, with high chlorophyll-a concentrations at the pycnocline which supports a biodiverse, multi-trophic biological community. Some white sharks migrate further to the west into the waters surrounding the Hawaiian Islands instead of the WSC. Here, the sharks utilize mesoscale, anticyclonic and cyclonic eddies that provide access to abundant mesopelagic communities. AIS observations reveal that white sharks are at risk from pelagic longlining by both US and international fishers in the WSC and Hawaiian Islands.

Presentation

Fierce loyalty or fragile future? Australian sub-adult white shark sibship alongside low genetic effective size and small predicted census size

Dean Blower[1], Zach Clark[2], Adam Miller[2], Jess Fish[2], Craig Sherman[2], Andrew Weeks[3,4], Paul Butcher[1,5]

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Regular genetic evaluations of animal populations can assist conservation and habitat management by providing valuable insights into genetic health, shifts in population sizes, and behaviour. These evaluations are particularly important for vulnerable species such as White sharks (*Carcharodon carcharias*), which are susceptible to population depletion due to slow maturity, low fecundity, and behaviour such as sub-adult site fidelity. Here, population genetic evaluation was performed using nearly 5,000 genomic SNP loci generated for a large set of sub-adult white sharks (n = 501) that habitually frequent eastern Australian waters. Unexpectedly, these cohabiting sharks were found to have high rates of full sibship: 323 individuals forming 121 groups of 2 to 6 full siblings (sharing both mother and father). Many of these full siblings share birth year, indicative at least 99 partial litters (sampling two or more full sibs sharing a birth year). Empirical estimation of genetic effective population size (Ne = 276) and genetic number of effective breeders per year (Nb = 99, averaged across the 2011 – 2017 cohorts) suggest a small population with low but constant yearly breeding numbers. Population size (N) modelling based on the empirical Ne and Nb estimates predicted adult population size (Nc: 580 – 2,030) and total population size including juveniles (N: 1,400 – 5,500), estimates which overlap with a previous independent population assessment. The extent of multiple-paternity breeding in these white sharks remained equivocal but population modelling suggested that higher effective size is maintained with fewer animals than for single paternity breeding. This is the first white shark population for which kin aggregation has been recorded, demonstrating the value of modern genomic datasets with large sample sizes. This evidence for extensive relatedness, in conjunction with low effective and census population sizes, highlights the genetic and demographic vulnerability of Australian white sharks to adverse natural or anthropogenic conditions.

Presentation

Decline or shifting distribution? A first regional trend assessment for white sharks (*Carcharodon carcharias*) in South Africa

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Unprecedented levels of change in ocean ecosystems bring an ever-increasing need for re-analyses of existing data to explore pressing conservation questions. Substantial declines in white shark (*Carcharodon carcharias*) presence at two primary aggregation sites have raised concerns about the species' status throughout South Africa. Using the most comprehensive suite of abundance indices compiled to date, we evaluated temporal trends and the strength of evidence for regional redistribution. Individual indices from all primary aggregation sites in South Africa were highly variable. The overall temporal trend from a log-linear Generalized Additive Model was relatively flat, indicating largely unchanged abundance throughout South Africa since protection in 1991. However, reports of human-shark incidents showed a general shift from the Western to the Eastern Cape. Correlations among individual abundance indices demonstrated that movements were not as simple as animals leaving one site to inhabit another. Further research is needed to explore the effect of movement on monitoring data. Our results reaffirm the need for better standardization in data collection methods to generate abundance indices and to develop long-term monitoring programs on the Eastern Cape. Ideally, environmental or operational factors affecting abundance indices should also be explored in future status assessments at a regional level. Our results provide a baseline for future work, directing research to understand drivers of localized and regional changes and focusing management on reducing anthropogenic sources of mortality within their Southwest Indian Ocean range.

Poster

Retrospective stable isotope analysis reveals ontogenetic population subdivision and specialization among Australian white sharks (*Carcharodon carcharias*)

T.G. Burke[1], C. Huveneers[2], L. Meyer[2], J.P.W Hollins[1], L. Loseto[3], J. Werry[4], N.E. Hussey[1]

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Our understanding of population and ecosystem level processes commonly considers conspecific individuals to be ecologically equivalent. Marine top predators can consume diverse prey of varying body sizes often resulting in their categorization as generalists at the population level. However, individuals of the same species may use resources differently supporting the prevalence of individual specialization or 'apparent specialized generalists'. White sharks (*Carcharodon carcharias*) are top predators in temperate to subtropical ecosystems. At the global scale, geographically isolated white shark populations demonstrate unique behaviours such as defined subpopulation movements whereby individuals reside in distinct coastal areas. In Australia, two discrete subpopulations of white sharks have been proposed based on genetics and limited movements between the two regions, but data are limited to characterize the extent of ontogenetic divergence. We used high-resolution stable isotope profiles (δ15N and δ13C) from 74 vertebrae to create retrospective ontogenetic trophic-habitat fingerprints for individuals sampled East and West of the Bass Strait. Our results demonstrate distinct isotopic separation between sharks sampled in eastern (-13.7 ± 0.72 δ13C; 14.2 ± 0.8 δ15N, n=47) and western (-14.4 ± 0.6 δ13C; 12.5 ± 1.2 δ15N, n=27) locations, but with both populations showing strong oscillatory trends related to known seasonal movements. Relative individual niche width revealed sharks within both east and west subpopulations demonstrated a high frequency of specialist behaviours. Data further suggest mature females are occupying similar habitat during gestation, juvenile phases occupy distinct coastal regions and as animals mature, habitat occupied by the two subpopulations potentially converges. Given many marine top predators are undergoing systematic population declines, understanding variation in diet and movement is central to understanding the extent of their ecological roles.

Presentation

Are we overestimating the age of immature white sharks (*Carcharodon carcharias*)?

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Accurate life history traits are essential for designing management practices, particularly for threatened predators that play a vital role in regulating food webs. Estimating key life history traits, such as age, is necessary for calculating growth, age of maturity, and longevity, yet has proven complicated for many species of elasmobranchs. The white shark (*Carcharodon carcharias*) is a highly mobile predator that has experienced systematic population declines, although certain geographically distinct populations are thought to be recovering. Similar to several other large shark species, age estimates for white sharks have evolved over time with the application of different methodological approaches. Original age estimates obtained from counting paired concentric vertebral bands estimated the longevity of the species to be 27 years with rapid growth during immature life stages. More recently, the application of radiocarbon dating (14C) extended the species lifespan to 73 years with slow growth throughout life. These markedly different age parameters have led to uncertainty in the accuracy of white shark age estimates. We used serial sampled carbon isotope profiles (δ13C) in vertebrae as a novel technique to provide an additional metric for estimating age given individuals undertake systematic seasonal movements between two locations that are isotopically distinct. Using a collection of eastern Australia white shark vertebrae (n=47), oscillations in δ13C profiles attributed to annual seasonal movements of immature white sharks were counted using standardized thresholds to assign age. Age estimates for immature white sharks based on isotopically inferred annual movements ranged from less than one (188 ± 28.7 cm total length; n=12) to seven (430 cm; n=1) and were similar to those derived from traditional vertebral band counts, contrasting the slower growth seen in bomb radiocarbon (14C). Given the significance of obtaining reliable life history demographics for informing management strategies for conservation, validating the age and growth of white sharks is critical.

Presentation

From trials to triumph: examining the progress of bather protection tools in the New South Wales Shark Management Program

Paul A. Butcher[1], Victor M. Peddemors[2], A F. Smoothey[2], and Marcel Green[2]

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The New South Wales Shark Management Program, initiated in October 2015 by the NSW Government, was a response to a spate of shark interactions in 2014/15, particularly along the NSW North Coast, Australia. With a primary focus on safeguarding bathers and surfers while minimizing harm to sharks and other marine life, this program has implemented a scientifically driven and integrated approach. By exploring innovative shark mitigation techniques and filling knowledge gaps on shark biology and ecology, the strategy aimed to provide the most effective measures for mitigating shark attacks at NSW beaches. Over the past seven years, significant investments have been made in various projects encompassing surveillance, detection and deterrents such as drones, tagged shark listening stations and SMART drumlines. Additionally, scientific research efforts have included shark tagging and tracking, personal deterrents, environmental eDNA and myth busting through education and community awareness initiatives. As a result, the Shark Management Program in NSW currently encompasses 305 SMART drumlines deployed daily (weather permitting) spanning from Tweed Heads to Pambula, 51 shark nets between Wollongong and Newcastle (deployed between 1 September and 30 April), drone surveillance at 50 beaches facilitated by Surf Life Saving NSW during peak swimming periods and 37 tagged shark listening stations operational throughout the year. Through scientific research and the systematic exploration of new technologies, the NSW Government remains committed to identifying the optimal combination of tools for bather protection. Stakeholder engagement has been crucial in establishing trust and collaborative partnerships between government agencies, non-government agencies and the public to ensure effective and sustainable approaches to bather protection along the NSW coast.

Presentation

Class-specific seasonal migrations of White sharks in the Northeast Pacific.

Taylor K. Chapple[1], Salvador J. Jorgensen[3], Scot D. Anderson[4], Samantha Andrzejaczek[2], Paul E. Kanive[4], Theodore Reimer[2], Alex G McInturf[1], Joshua Bowman[1], Timothy D. White[2], Aaron B Carlisle[5], Jamie M Cornelius[6] and Barbara A. Block[2]

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Spatial and temporal segregation of animals by class (i.e., maturity or sex) within a population can be an important life-history feature to consider in population assessment and management. Significant work has been done to identify large scale seasonal migrations of White sharks (*Carcharodon carcharias*) in the Northeast Pacific. However, these studies have largely focused on disparate movements between sex classes only. Here, we use 20 years of electronic tagging data to identify sex and stage-specific movements. We examined sex and stage differences in temporal and horizontal spatial use and vertical behavior in the offshore environment. These findings suggest disparate life history drivers of the seasonal migrations and have implications for susceptibility to fishing pressure.

Presentation

Insights into the diet and trophic ecology of white sharks (*Carcharodon carcharias*) gained through DNA metabarcoding analyses of cloacal swabs

Zach S. R. Clark[1], Jessica J Fish[1], Paul A. Butcher[1,2], Owen J. Holland[1], Craig D. H. Sherman[1], Justin Rizzari[1], Andrew R. Weeks[3], and Adam D. Miller[1]

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Information on white shark diet across life stages and the species' range is needed to identify critical trophic interactions supporting shark populations and to predict the resilience of white sharks to environmental changes. In this study we reassess the diet and trophic ecology of white sharks via the genetic analyses of cloacal swabs from 214 juvenile and subadult sharks from eastern Australia. Our findings are largely consistent with those of previous studies based on visual analyses of gut contents, but highlight the unprecedented taxonomic resolution of prey items offered by genomic assessments of shark cloacal swabs. Diets consisted primarily of ray-finned fishes, with Mugiliformes, Carangiformes, Perciformes and Scombriformes being dominant prey taxa, but with elasmobranchs, marine mammals, and birds also being common dietary constituents. Statistical analyses revealed a significant effect of sex and sampling location on diet composition, indicating biological and spatial variability in diets and predatory behaviour. Overall, these findings support the notion that juvenile and subadult white sharks are opportunistic predators, which may provide some level of resilience to shifts in marine resources. However, frequently consumed ray-finned fishes, many of which are commercially targeted, may be key to supporting white shark populations in eastern Australia. This study represents the most comprehensive analysis of juvenile and subadult white shark diet performed to date and provides added confidence in the genomic analysis of cloacal swabs for dietary assessments of predatory species. These results are expected to help inform management geared towards conserving this important marine predator across the world's oceans.

Presentation

Genomic assessments of Australian white sharks (*Carcharodon carcharias*) challenge assumptions of population subdivision and highlight the need for revised spatial management

Zach S.R. Clark[1], Paul A. Butcher[1,2], Andrew R. Weeks[3,4], Charlie Huveneers[6], Madeline Toomey[1], Owen J Holland[1], Jessica J. Fish[1], Craig D. H. Sherman[1], Dean C. Blower[5], Adam D. Miller[1]*

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The white shark (Carcharodon carcharias) is one of the world's largest and most recognisable marine predators but has suffered significant declines over the last half century, raising concerns for the conservation of the species and associated ecosystems. Conservation efforts remain complicated by persistent knowledge gaps associated with white shark biology and ecology, including the biological connectedness of white shark populations. We re-assess patterns of population genetic structure in Australian white sharks, where two distinct subpopulations — eastern and southern-western — are currently recognised based on previous animal tracking and genetic assessments. Population genomic analyses of ~650 individuals genotyped at ~7000 single nucleotide polymorphism (SNP) loci challenge current assumptions of population structure in Australian white sharks, indicating a lack of genetic structure between white sharks from eastern and southern-western Australia. These findings are further supported by population genetic simulations and kinship analyses indicating high levels of inter-generational migration and relatedness between regions. Consistent with recent reports from eastern Australia, we also detected high levels of relatedness among sub-adult white sharks and estimated the overall effective population size (Ne) of Australian white sharks to be less than 500 individuals. Overall, these findings raise concerns for the conservation of Australian white sharks and highlight the need for revised spatial management of this important marine predator.

Presentation

Can bite-resistant fabric reduce injuries from white shark (*Carcharodon carcharias*) bites?

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The frequency of unprovoked shark bites is increasing worldwide. In Australia, white sharks (*Carcharodon carcharias*) are responsible for 68% of unprovoked shark bite fatalities, which are mostly due to blood loss from vascular lacerations. Puncture-resistant fabrics offer a promising personal mitigation measure that might reduce the severity of injuries and haemorrhaging, providing additional time for shark bite victims to be attended to by emergency services before blood loss becomes fatal. Previous bite-resistant materials are heavy and cumbersome (e.g., chainmail armour), but new technological advances in textile fibre have allowed the development of lightweight alternatives that can be incorporated into traditional wetsuits. We tested the efficacy of four novel bite-resistant fabrics to reduce damage from white shark bites. We obtained 92 white shark bites on “bite packages” containing a wooden board, a sheet of ethylene and vinyl acetate foam on either side of the wooden board, and a neoprene pouch placed over the foam and wooden panel. We compared visible damage from white shark bites on puncture-resistant fabric to twenty “control” bites on standard 3-mm neoprene material. All four bite-resistant fabrics decreased substantial damages to the foam (i.e., large tear where some of the foam has been removed) by 34–52% regardless of bite intensity or shark size. Bite-resistant fabrics also increased the area that remained undamaged by 5–15%. Our findings show that lightweight bite-resistant fabrics incorporated into wetsuits may be a beneficial personal mitigation measure to reduce damage from white shark bites.

Presentation

Consequences of Climate Change-Driven Shifts in White Shark Nursery Habitat in the Northwest Atlantic Ocean

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Some shark species have high likelihoods of poleward distribution shifts under ongoing and projected ocean warming. Coastal waters off Long Island, New York, USA, a region of rapid warming, are a summer nursery area for young-of-the-year (YOY) white sharks (*Carcharodon carcharias*). Thermal habitat suitability models were developed using electronic tracking data collected during 2016-2019 (N=22; 138-166 cm total length), and habitat suitability was projected over historical conditions (to 1965) and future conditions (to 2099) using climate scenario projections. Historical projections reveal that suitable summer nursery habitat has already shifted since 1965. Suitable nursery habitat is projected to continue to shift northeastward along the U.S. Atlantic coast by 2100. This shift would increase overlap with the summer distribution of adult white sharks – natural predators of YOY white sharks. Increased water temperatures are also projected to increase overlap with regional fisheries, potentially increasing bycatch susceptibility. Ironically, expansion of renewable energy infrastructure in the form of offshore wind farms along the U.S. Atlantic coast may also result in disturbance to white shark nursery habitat, but the long-term effects of such construction on sharks is largely unknown. Thus, climate change may result in increased fishing and natural mortality for YOY white sharks, potentially reducing recruitment to adult populations and destabilizing recent abundance increases.

Presentation

Exploring the influence of shark relatedness on patterns of aggregation site use in white sharks from the Neptune Islands?

Phoenix De La Mer[1], Adam Miller[1], Owen Holland[1], Matt Symonds[2], Johann Mourier[3], Lauren Meyer[4], Charlie Huveneers[4]

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The white shark (*Carcharodon carcharias*) is a highly migratory species and is known to regularly form aggregations in key locations globally, with the Neptune Islands being recognised as the largest and most significant aggregation site for adult white sharks in Australia. Here seasonal white shark aggregations appear to be resource driven and associated with prey abundances. However, monitoring programs point to differences in seasonal habitat usage between individuals and the possibility of additional drivers influencing aggregation behaviours. A recent study showed that site usage of individual white sharks is not random and indicated four distinct shark communities with different site usage patterns. In this study we investigated the possibility of aggregation patterns and community structure among white sharks at the Neptune Islands being genetically determined and linked to underlying patterns of relatedness between individual sharks. To achieve this relatedness among 186 individual white sharks from southern Australia and the Neptune Islands were assessed using kinship analyses derived from a high-density panel of SNP genomic loci. Relatedness measures were then integrated with metadata associated with aggregation site use, inferred from acoustic tag data and a photographic identification register, for analytical purposes. In this presentation I will provide an overview of the findings from these analyses and the implications of our results with respect to understanding white shark biology and ecology and the management of white sharks in the Neptune Islands.

Presentation

Catch composition, immediate mortality and post-release survival of animals caught on SMART drumlines off south-eastern Australia

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In 2015, the NSW Government implemented the Shark Management Program which incorporated SMART (Shark-Management-Alert-in-Real-Time) drumlines as a bather protection tool. Improving operational procedures, quantifying capture mortality and post-release survival and movements of white sharks (*Carcharodon carcharias*) caught on SMART drumlines is an essential part of this program. On a daily basis, weather permitting, 305 SMART drumlines are currently deployed in 20 locations across the NSW coastline. We used SMART drumline catch data incorporating 1150 white shark capture events between December 2015 and March 2023 to quantify time of capture, time spent on the line and anatomical hook location before enumerating immediate, short and long-term survival rates and spatial displacement of individual white sharks. The results provide positive evidence-based results regarding the effectiveness of SMART drumlines as a bather protection tool while having little harm on target species.

Poster

Antimicrobial Resistant Pathogens in the Oral Cavity of White (*Carcharodon carcharias*)

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Infections arising from the transfer of bacteria from the oral cavity of sharks to a shark bite wound can pose significant health risks to victims People are often treated with broad-spectrum antibiotics, with guidelines for antimicrobial therapy derived from a limited number of studies. To date, no studies have been published on pathogens and associated antimicrobial resistance in the oral cavity of Australian sharks. In this study, 197 bacterial isolates were obtained from oral swabs taken from 153 sharks, including white (*Carcharodon carcharias*), tiger (*Galeocerdo cuvier*) and bull sharks (*Carcharhinus leucas*) caught along the east coast of Australia between May 2018 – April 2022. Isolates were identified using MALDI-TOF, and a disc diffusion assay was used to determine the antibiotic sensitivity of 79 isolates considered potential pathogens, including members of the genera Pseudomonas, Vibrio, Aeromonas, Enterobacter, Klebsiella and Psychrobacter. Resistance to one or more antibiotics was common, with 60%, 73% and 74% of isolates from white, tiger and bull sharks resistant to one or more antibiotics, respectively. This research provides insights into the identification of pathogenic bacteria that could cause infection post bite and which antibiotics are most suitable for treating shark bite wounds in eastern Australia, and possibly more broadly, to prevent infection.

Presentation

Quantifying Juvenile White Shark Swimming Kinematics using Unoccupied Aircraft Systems (UAS) and Deep Neural Networks

Alexandra E. DiGiacomo[1], Ann Marie Abraham[1], Samantha Andrzejaczek[1], and Barbara A. Block[1,2]

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Unoccupied Aircraft Systems (UAS) are increasingly being utilized to survey the behavior and distribution of marine megafauna. In the Northeast Pacific, an aggregation of juvenile white sharks seasonally occurs in Monterey Bay in summer and fall. The sharks occupy surface waters in protected coves, providing an opportunity to be observed using UAS. To date, a rigorous and quantitative extraction of behavioral data has not yet been performed. As juveniles are typically infrequent in temperate mid-latitude waters due to reduced thermoregulatory capacities, this age class may disproportionately rely on behavioral thermoregulation via swimming kinematics. In this study, we quantify the swimming behavior of juvenile white sharks aggregating in Monterey Bay using computer vision and deep learning to track key body features. We use a quadcopter UAS to perform 75 focal follows from June-September 2022, resulting in 181 total video minutes of free-swimming juvenile sharks 2-3m in size (189-289 cm TL). We employ DeepLabCut, a deep neural network-based computer vision framework, to train a model with minimal data (n = 105 images) to track white shark body pose at human-level labeling accuracy (RMSE: 1.4 cm (model), 1.33 cm (human)). Through the analysis of body feature coordinates, we compute tailbeat frequency (TBF), swim speed, and body length. White sharks in the aggregation display low TBFs (mean ± sd: 0.35 ± 0.057 Hz) that linearly reduce with body length ($r^2 = -0.82$, $p < 0.001$) and cruising swim speeds (mean ± sd: 0.97 ± 0.13 m/s; 0.43 BL s-1) similar to those of their adult counterparts. However, this population demonstrates elevated swim speeds as compared to juveniles at similar body sizes in nursery aggregations of southern California, potentially signifying behavioral thermoregulation in temperate waters. Moreover, this technique represents a non-invasive, low-cost, and scalable approach to analyzing surface-swimming in marine megafauna.

Presentation

Characterizing and Qualifying Coastal White Shark (*Carcharodon carcharias*) Nursery Habitat in Rhode Island and Massachusetts, USA

Jon Dodd[1], Joshua Moyer[1], Conor McManus[2], and Gregory Skomal[3]

[1] Atlantic Shark Institute
[2] RI Department of Environmental Management
[3] Massachusetts Division of Marine Fisheries

Identifying patterns in the habitat use and migration of apex predators, such as the white shark (*Carcharodon carcharias*), is a critical component of marine conservation and fisheries management, and documenting ontogenetic differences in habitat use is therefore also essential. In the case of *C. carcharias* in the Western North Atlantic, neonates and juveniles are most frequently encountered over the continental shelf in the New York Bight from New Jersey to Long Island. Historically, this area has been dubbed a white shark nursery. Using satellite-linked, acoustic, and acceleration data-logging tags, we are investigating the distribution, movement ecology, interactions with fisheries, and behavior of juvenile white sharks in the northern part of this species' Western North Atlantic nursery. Our goal is to characterize and to quantify the extent to which the coastal waters of Rhode Island and Massachusetts provide essential nursery habitat for this species, and how that might be shifting relative to climate change.

Poster

Analysis of Unprovoked, Fatal Great White Shark Attacks in South Africa

Emily Echevarria[1]

[1] Shark Research Unit, DePaul University

This poster utilizes data on all reported shark attacks in South Africa from 1851 to present day, relying on verified accounts sourced through Shark Attack Files, which uses first hand reports, news reports, and interviews of attacks. Breaking reported attacks down by fatalities, species, season, activity, and time of day, the poster investigates correlations between abiotic and biotic factors that may contribute to attacks. Specifically, the poster examines the rate of unprovoked, fatal Great White Shark attacks in South Africa, examining occurrences by Province.

This research finds that unprovoked, fatal Great White Shark attacks account for less than 2% of all shark attacks in South Africa in the last 170 years, adding further proof that the “Jaws Phenomenon” that led to the disproportionate culling of Great White Sharks post-1975 was unfounded. It also concludes that most attacks occur during summer months (Dec-March) which correspond to increased human presence in coastal waters, and in June and July, corresponding to previous data that there is a higher presence of Great White Sharks in South African waters in these two months due to colder waters.

The poster reveals the need for further research comparing populations of shark species with the proportion of attacks they are responsible for, as well as comparative studies of South African shark attacks with those in other comparable locations.

Poster

Raggy Charters and the Algoa Baywatch Project

Lloyd Edwards[1] and Jake Keeton[1]

[1] Raggy Charters and the Algoa Baywatch Project.

Raggy Charters is an established Whale Watching Company operating in Algoa Bay South Africa, and has recently entered the world of White Sharks. Raggy Charters has been running for 25 years with the purpose of funding the Algoa Baywatch Conservation Project. In 2020 Raggy Charters was granted the first permit to conduct Shark Cage Diving in Algoa Bay. The permitted sight of operation is Bird Island, situated at the eastern end of Algoa Bay. Bird Island falls within the Addo Elephant National Park Marine Protected Area. Raggy Charters has embraced a steep learning curve, and taken a keen interest in the research and conservation of White Sharks.

With the excitement of being able to operate in a new remote area, Raggy Charters hit the ground running with a successful season with guests and film crews. After a short while of operation a concern arised for the sharks in the form of an experimental shark fishery taking place in Algoa Bay. Raggy Charters and The Baywatch Project set out to stop the fishery. With the help of some dedicated individuals the Live Shark Project was started and proved successful. Regulations were put in place and as a result, there has been no long lining for sharks in Algoa Bay for the past two years.

Currently Raggy Charters is looking to expand on its White Shark research projects. The team is hoping to find a shark researcher to come on board and conduct White Shark research at Bird Island. In the meantime, Raggy Charters would like to assist any researchers that are wanting to access the site for research purposes.

Lloyd and Jake will share information about the site in which they operate and their observations made since 2020.

Poster

Human Behaviour In An Interactive Simulation Of Great White Sharks Hunting Cape Fur Seals

David 'Ed' Edwards[1]

[1] Staffordshire University

Various approaches to computer simulation exist, with video games arguably among the most unique. The medium is distinguished by its inherent capacity for interactivity and ability to demonstrate the consequences of autonomous user behaviours across a plethora of simulated variants in real-time

Although the field of wildlife research has made use of computer simulation, it is yet to explore the potential application of game design, or use of game-related technologies. This is despite evidence demonstrating that videogames could facilitate unique solutions for how we collect, visualise and investigate wildlife data, and improve our collective understanding of the natural world as a result.

The Goal of this project was to perform a preliminary investigation into what such an approach might involve. We started by broadly reviewing the use of computer simulation in wildlife research and its branching into the ALife movement. After presenting games design as a logical next step in tightening the relationship between science and interactive content, we chose the predator-prey relationship between great white sharks and cape fur seals as a case study from which to build a prototype for demonstration.

We established a custom gameplay scenario based on our findings and developed a videogame from the ground up. Participants played the game and then submitted their data for analysis. We identified a number of trends in Participant Behaviours in respect of attack preferences. Participants generally preferred the less demanding of the two methods, while the alternative demonstrated a higher capacity for success in certain conditions.

We likewise saw significant changes in approach depending on changes to the surrounding environment. Some of these facilitate comparisons to real-world observations, such as Participants favouring small/juvenile seals, adapting their behaviours in response to changes in the surrounding environment and improving their attack proficiency over time.

Presentation

Discovering New Zealand's first Great White shark nursery

Riley Elliott[1]

[1] The Great White Project New Zealand

As one of the few White shark aggregation sites on earth, New Zealand's southernmost Stewart Island is well known for sub-adult to mature Great whites of both sexes. Not so much is known however about the northern region of NZ for Great Whites. Over the past three years (coinciding with La Nina events), a growing presence of juvenile Great Whites has persisted in the Bay of Plenty, where they have historically been rare/absent. This area is also NZ's most populous summer holiday hotspot. In Jan 2021 a woman was fatally bitten by a 10ft Great White shark. Great White presence persisted for the summer. The following summer of 2022, two juvenile Great Whites were killed in set nets. Great White presence continued through 2022 with almost daily interactions with recreational fishing boats.

In order to investigate risks, for both sharks and people, Dr Riley Elliott generated funding for dart and tether, towed satellite tags, by utilising mainstream media to convey the growing issue to the NZ public. In order to co-exist, knowledge was required regarding what individuals were present, where they came from, what they were doing, and ultimately how that overlaps with human recreation.

Twenty SPOT 253 towed satellite tags were funded by the public, through the attraction of the Great White App, which publicly, live streams ARGOS satellite fixes of tagged Great Whites. Between Dec 2022 and Feb 2023 Dr Elliott photo identified 16 Great Whites in the location of the 2021 human and shark fatalities. Thirteen were juveniles (5-9ft TL), one a sub-adult (11ft TL) and two were new born pups (4ft TL). Four Great Whites were satellite tagged and tracked for periods of 3-6months and presently ongoing. A summary of findings will be presented.

Presentation

The White Shark Chase: Tracking the last White Sharks in the Mediterranean Sea.

Francesco Ferretti[1], Jeremy Jenrette[1], Brendan Shea[1], Felipe Carvalho[1], Chiara Gambardella[2], Stefano Moro[2], Khaled Echwikhi[3], Taylor Chapple[4], Austin Gallagher[5], Robert Schallert[6], and Barbara Block[6]

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Mediterranean white sharks are among the least known and most endangered populations worldwide. Though they were historically abundant and widely distributed in the region, white sharks are now Critically Endangered in the Mediterranean Sea. This population has declined to dangerously low levels of abundance, impacted by centuries of coastal and, more recently, industrial fishing. Scant information about its current abundance and ecology hinders conservation efforts. To address this issue, in 2020, we started an unprecedented search and conservation initiative to find and track the remaining white sharks in the region. This multidisciplinary effort involves integrated analyses of historical records, species distribution models, fisheries reconstructions, stock assessment, and cutting-edge marine technology to find the last white sharks in the region, tag live individuals, characterize their ecology and life history, and quantify their abundance. Informed by the statistical and research synthesis work, in spring 2021, 2022, and 2023 we conducted three field operations in the Sicilian Channel, covering four major sites. Here we conducted eDNA surveys, deployed pelagic and deep-water benthic BRUVs, and engaged in extensive chumming and fishing operations. Though we have not yet been able to tag live white sharks, this effort allowed us to detect their presence in the region, collect biological samples, and locate a population's stronghold and critical habitat where we are now intensifying our research. We will report on this endeavor sharing our most up-to-date information on this multi-institutional white shark program in the Mediterranean Sea targeted to understand this population, reveal its actual abundance, and plan conservation measures to avoid the species' extinction from the region.

Presentation

Preliminary age estimation of New Zealand white shark

Brittany Finucci[1]

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White shark is wide-ranging throughout most of waters of New Zealand (NZ), from the Kermadec Islands to Campbell Island/Motu Ihupuku and the northern Macquarie Ridge. Life history parameters for NZ white sharks are not well defined but are vital for estimating demographic parameters and informing developing technologies. Here, vertebral banding patterns and microCT imaging were used to estimate age and growth for NZ white sharks for the first time. Vertebrae were obtained from white sharks over a 30-year period (1991–2021). The final sample (n=38) included 20 females, 12 males, and six unsexed sharks ranging from 1.52 to 5.36 m total length (TL). Vertebrae were difficult to read, particularly for older sharks. There was strong agreement between readers for age estimates of young NZ white sharks, but large disagreement for older sharks. Nearly half of the sharks were young (1–2 years old) and only six sharks were estimated to be older than 10 years of age. Maximum age estimates were 30/45 years for males (4.85 m TL) and 19/44 years for females (5.36 m TL). The relationship between length and growth was found to be nearly linear for young sharks, and individuals were estimated to double their birth length to 3 m TL within five years. Age-at-maturity could not be assessed because of the small sample size but may occur 7–10 years for males and 14+ to 22+ years for females. The preliminary work here suggests NZ white sharks are relatively fast growing initially, and possibly long-lived. Additional samples of large sharks will be needed to comprehensively understand age and growth of white sharks that inhabit NZ waters. A combined NZ-Australia study should be carried out to characterise the life history parameters of the South Pacific white shark population.

Presentation

Using eDNA to characterise biological drivers of white shark nearshore visitation along the east coast of Australia

Jess Fish[1], Paul Butcher[1,4], Andrew Weeks[2,3], Craig Sherman[1], Adam Miller[1]

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Concerns for increasingly frequent human-shark interactions involving white sharks (*Carcharodon carcharias*) in Australia (particular NSW) have prompted investment in shark monitoring programs, aimed at detecting near shore shark visitations and communicating risks to the public. However, the potential drivers of near shore shark movement patterns remain largely uncertain. Previous studies have indicated white shark movements to be associated with abiotic and biotic factors such as sea surface temperatures and primary productivity, however, the influence of trophic interactions remain uncertain. We present the findings from a current project using genetic technologies aimed at exploring the associations between white shark presence and specific marine biota in near shore environments. Long-term eDNA sampling was performed bi-weekly over 24 months at several shark visitation hotspots from northern New South Wales, with white shark presence determined using a species-specific eDNA qPCR assay, and marine vertebrate community assemblages determined using vertebrate eDNA metabarcoding assays. We explore spatio-temporal patterns of white shark presence and absence and marine community composition from the region and perform association analyses to identify specific marine vertebrates potentially influencing near shore shark visitation. Findings from this study build on our recent work on eastern Australian white shark diets providing further insights into their trophic interactions and identifies potential bioindicator species that could be used to reduce future risks of human-shark interactions.

Poster

Predicting white shark (*Carcharodon carcharias*) presence from acoustic data from a coastal beach in New South Wales, Australia over a nine-year period

Sofia M. Gabriel[1], Patterson T.A.[2], Eveson J.P.[2], Semmens J.M.[3], Bradford R.W.[2]

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While white sharks (*Carcharodon carcharias*) are apex predators with a global distribution, their large size, longevity, and low reproductive rate have made them vulnerable to population decline. Particular beaches on the east coast of Australia are a known aggregation region for juvenile white sharks. This study used a nine-year dataset from a dense passive acoustic array deployed along a single beach to investigate the fine-scale occurrence of juvenile white sharks within a key white shark nursery (Hawks Nest) off New South Wales, Australia. White sharks detected in the array were on average 3 years of age, with the oldest returning individual being an 8-year-old subadult female, suggesting that sharks stop returning to the nursery area as adults. Juveniles were found to exhibit peak abundance at the beach in the austral spring and summer months, with up to 15 individuals being detected in a single week, suggesting overlapping occurrence of juveniles at this beach. Based on Generalised Additive Models (GAMs) used to investigate the relationship between weekly white shark occurrence and environmental factors, juvenile white shark occurrence across years and seasons was found to be best predicted by sea surface temperature (SST), with juveniles exhibiting the highest abundances at the beach between 19 and 21 o C. This temperature range is consistent with findings from studies of juvenile white shark behaviour in coastal areas across their global range, suggesting that this SST range could be a useful predictor of high juvenile occurrence generally at known coastal aggregation sites for this species.

Presentation

The search for sociality in white sharks: Investigation of the co-occurrence of juvenile white sharks (*Carcharodon carcharias*) within a nursery area off New South Wales, Australia using social network analysis

Sofia M. Gabriel[1], Patterson T.A.[2], Eveson J.P. [2], Semmens J.M.[3], Moreno D.[3], Bradford R.W.[2]

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Social network analysis (SNA) as a quantitative measure of animal grouping and social behaviours has been increasingly used in recent years to study the group dynamics and potential sociality of shark and ray species. Despite their mainly solitary swimming and hunting behaviours, white sharks (*Carcharodon carcharias*) are known to aggregate in large numbers at seasonal feeding sites as adults, and in spatially defined nursery areas as juveniles, exhibiting yearly site fidelity to these aggregation sites. This raises the question, does sociality influence white shark movement and feeding behaviours when in close spatial proximity with conspecifics at aggregation sites? In this study, detections of juvenile white sharks on a non-overlapping passive acoustic array in a nursery area off New South Wales, Australia were analysed over a nine-year period using SNA. To create yearly association networks, tagged individuals were defined as co-occurring if they were detected within the same hour on receivers < 1 km away from each other. Contrary to previous SNA studies of white shark association networks, the likelihood of white sharks co-occurring was not found to be correlated with sex, size class, or age of the individuals, and the observed co-occurrences were not found to be significantly different from expected co-occurrences based on random association. Due to the large spatiotemporal definition of an association and the fact that only tagged individuals could be observed in this study, however, this finding does not rule out the possibility that white sharks in coastal nursery areas may change their movement and foraging behaviours depending on the proximity of conspecifics, or that they may benefit from social learning such as gaining knowledge of prey locations and different hunting strategies. Further research is needed at smaller spatiotemporal scales to determine the potential impact of sociality on white shark behaviour when at aggregation sites.

Presentation

Post-prandial metabolism of the white shark

Enrico Gennari[1,2,3], Diego Bernal[4], Paul Cowley[3]

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Animal movement can be viewed as the complex manifestation of decisions that are influenced by an animal's internal state, imposed by physiological constraints and/or response to external cues. Seven white sharks (from 1.5 to 4.2 m TL) were actively tracked continuously in Mossel Bay for around 700 hours in total. The aim was to concurrently recording continuous data on the external and internal thermal environments of white sharks and their movements, in order to better understand the behavioural and physiological signatures of this species. Heat Increment of Feeding (HIF) areas were used as a relative quantitative proxy for digestive metabolic increment above basal metabolism.

All white sharks, similarly to bluefin tuna elevated their stomach temperature after ingestion of a meal by as much as 15 °C, over a 12– to 20–hour period, before returning to an average 5–6 °C basal thermal excess. While white sharks make physiological and behavioural trade-offs at landscape levels daily, the incredibly efficient digestion can explain the ability of this large, predatory, regionally endothermic, species to disperse even in oligotrophic areas during its large migrations. The capacity to reach a maximum stomach temperature of 27–30 °C after feeding, and the observed ontogenetic variation in stomach thermal excess, support the hypothesis of an evolutionary and ontogenetic "predatory" niche expansion toward colder waters for this species.

The combined advantages of more efficient kinematics and digestion, allow especially larger white sharks to better exploit colder waters around the world where more energetically viable prey are present.

Presentation

White Shark or Shortfin Mako? Lamnid sharks in the equatorial southwestern Atlantic

José Belquior Gonçalves Neto[1], Camila de França Lima[1], Bruno Jucá-Queiroz[1], João Eduardo Pereira de Freitas[1], Patricia Charvet[1], and Vicente Vieira Faria[1]

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The occurrence and distribution of Lamnidae species in tropical zones, particularly in the equatorial Southwestern Atlantic, remain poorly understood despite their wide distribution in all oceans. The two lamnid species recorded for this area are the White Shark (*Carcharodon carcharias*) and the Shortfin Mako (*Isurus oxyrinchus*). The Shortfin Mako shark has been captured in commercial fisheries, whereas the White Shark is rarely registered. The landing of processed carcasses makes species identification challenging, especially considering that the capture of these species is prohibited in Brazil. Misidentification is common, requiring a comprehensive investigation of the occurrences of Lamnidae in tropical zones. This study aimed to characterize lamnid records for the equatorial Southwestern Atlantic, as well as to apply molecular markers to identify a landed lamnid carcass. A bibliographic review on the records of the two species was carried out, focusing on the State of Ceará (Brazil), the only area with overlapping of these two species. The landed carcass, mistakenly identified as a White Shark, in fact was a Shortfin Mako, with a total of 99.6% and 100% similarity for nd2 and D-loop mitochondrial DNA markers, respectively. Despite well-recorded catches by commercial fisheries, landings of lamnids are still rare in this region and comprise only four well documented records for *I. oxyrinchus* and three for *C. carcharias*. The literature review evidenced that the coast of the State of Ceará is the second region, behind only the southernmost parts of the Atlantic, that has evidence of White Shark records.

Presentation

Testing satellite-tagged white sharks as oceanographic sentinels of the dynamic Agulhas Current System

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Using 33 satellite-tagged white sharks (*Carcharodon carcharias*), we explored their potential role as oceanographic sentinels for monitoring the Agulhas Current System (ACS). The SPOT5 transmitters (SPOT-257, SPOT-258; Wildlife Computers) were deployed between 2012 and 2014 at South African coastal aggregation sites, namely False Bay, Gansbaai, Struisbaai, Mossel Bay and Algoa Bay. The satellite tracks were analyzed against concomitant remotely sensed environmental observations: Sea Surface Temperature (SST), altimeter-derived ocean currents and chlorophyll (CHL). The results support the use of white sharks to collect in situ measurements as if they were ocean gliders of autonomous thinking, visiting oceanographic features of interest such as the Agulhas Current and Agulhas Return Current, eddies and, coastal and open ocean upwelling sites (e.g. minima in surface temperatures down to 15 oC and maxima in chlorophyll up to 1.7 mg/m3). They also performed long-distance migrations in the warm oligotrophic subtropical gyre (SST up to 29 oC and CHL below 0.05 mg/m3). These SPOT-based results combined with remotely sensed observations are further supported by the SST and depth-temperature observations collected from three PAT tags, also deployed in the same areas between 2012 and 2017. The latter provides an exceptional dataset of temperature measurements collected by white sharks as they navigate the surface and through the water column in the ACS. These records include vertical profiles extending to 1000 meters deep (temperature ranges between maxima values ~29 oC near the surface and minima values ~4 oC at depth), capturing near sea-surface seasonal variations, horizontal sea surface temperature gradients, and the thermal vertical structure of water masses beyond the mixed layer and deep within the thermocline. These results demonstrate white sharks' potential as effective oceanographic sentinels and reveal their diving behavior linked to the navigated oceanography.

Presentation

Shark activity is impacted by changing environmental conditions.

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Environmental fluctuations can drive changes in animal behaviour, triggering annual migrations for food, optimal weather, or reproduction, as well as short-term activity changes. Using acoustic accelerometer tags deployed on over 600 white (*Carcharodon carcharias*) sharks from 2020 to 2023 we explored how environmental conditions (i.e., temperature, tides, moon phase and time of day) influence the activity of sharks in Eastern Australian waters. We identified that white sharks were more active between 1800 - 2400 at lower latitudes (-25 to -30 oS) and least active between 1800 - 2400 at higher latitudes (-40 oS). Exploration of how environmental conditions influence the activity of white sharks is still being assessed. Overall, our study provides a comprehensive understanding of the assessment of long-term changes in shark activity for bite mitigation, as well as any impacts from ocean warming and coastal development.

Presentation

OCEARCH's Western North Atlantic White Shark Study: A Model of Collaboration, Shared Access and Public Education

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After 24 OCEARCH expeditions in the western North Atlantic (WNA), our objective of 100 white sharks measured, examined, sampled, tagged and released is nearing completion. Our collaborative approach has supported the multidisciplinary work of 42 investigators, 30 organizations and 24 projects, resulting in more than 30 publications. By applying the principles of Reduction and Refinement to maximize the number of projects served while minimizing the handling stress for each shark, we have learned critical aspects of spatial ecology and behavior, reproduction, trophic ecology, environmental health and physiology, population genetics, and microbiology in young-of-the-year (YOY) through adult WNA white sharks, a population that is currently rebuilding. Among our collaboration's major findings: 1) confirmation of the Mid-Atlantic Bight as the WNA primary nursery; 2) overall spatial and temporal dynamics, site fidelity and behavioral individuality of WNA white sharks from YOY to adult; 3) significance (>50% of tagged individuals) of Atlantic Canada and the Gulf of Mexico as summer and winter foraging areas, respectively, for multiple life stages; 4) evidence of reproductive activity in spring off the southeast U.S., followed by offshore forays by putatively pregnant females, which use mesoscale eddies for feeding and to conserve energy; 5) growth rates that indicate WNA white sharks mature at smaller sizes than in other populations; 6) comprehensive characterization of the WNA white shark microbiome and discovery of novel antibiotics from their external bacteria; and 7) proximity of white sharks to popular swimming beaches from Nova Scotia to Florida. These and other findings for the WNA population are driving policy measures in the U.S. and Canada and have contributed significantly to our understanding of the biology of the white shark. With our model of collaboration and shared access to data, we have advanced public education and conservation priorities for the white shark on a global scale.

Poster

Exploring Natural Great White Shark Interactions: Insights from the South Australian Abalone Industry

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The Abalone Industry Association of South Australia Incorporated (AIASA) presents a unique perspective as one of the few Industries globally with direct, natural interactions at eye-level with Great White Sharks (GWS). Acknowledging the dual nature of this privilege – high risk and exceptional opportunity – we delve into the depths of this remarkable relationship. The enduring presence of our Industry along the coastline of South Australia uniquely empowers us to provide valuable insights into shark population dynamics and behaviours. Serving as an untapped source of sustainable knowledge, we accumulate real-world observations over time. Central to our practice and ethos is the advocacy of unobtrusive observations within sharks' natural habitats. We firmly endorse ethical commercial and research practices, refraining from utilizing attractants such as baits, burley, or teasers to lure sharks towards vessels. This philosophy aligns with responsible and respectful research methods. At the core of our engagement lies the understanding behind our observations concerning behavioural shifts in sharks exposed to attractants. Insights gained from divers' experiences across the years reveal instances of heightened curiosity in GWS behaviour. These observations possess the potential to shed light on broader animal behaviour transformations, unveiling the intricate workings of marine ecosystems. AIASA's contribution to the White Sharks Global Conference encompasses our exceptional access to natural GWS interactions, decades of sustainable observations, and an unwavering commitment to ethical shark interactions. Through our insights, we invite collaboration, fostering a collective drive for deeper comprehension of shark behaviours. Our journey highlights the need to balance human activities with the natural world, ultimately benefiting industries, research and the conservation of these majestic creatures.

Poster

Faecal Microbiome of Great White Sharks (*Carcharodon carcharias*)

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The intricate relationship between sharks and the microbial communities residing on and within their bodies remains poorly understood, despite substantial evidence linking the microbiome to host physiology, immunity, and ecological dynamics in other animals. Investigating shark-microbe interactions poses considerable challenges, particularly when studying the larger, more elusive shark species. In this research, we employed 16s rRNA sequencing to analyse 450 samples obtained from white (*Carcharodon carcharias*) sharks. This comparative approach allowed us to examine the influence of sex, age, and interspecies similarities on the composition of faecal (anal/cloacal) microbial communities. By investigating the complex associations between sharks and their microbial communities, this study contributes to our understanding of the underlying mechanisms shaping shark health and ecological dynamics.

Presentation

Denticle Hygiene: Viral Communities on Elasmobranch Epidermis

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Marine animals rely on their external microbiomes (resident microbial communities, including bacteria and viruses) to outcompete and lyse pathogens prior to epidermal invasion. The virome, comprised of viruses and bacteriophages (viruses infecting bacteria), is critical to marine epidermal microbiome defense systems. Elasmobranchs demonstrate a unique ability to resist epidermal infections despite frequent injury and constant exposure to environmental and resident opportunistic pathogens. Part of this heightened immunity stems from innate mechanisms, such as skin morphology, immune responses, and antimicrobial secretions, but the role of the epidermal virome in elasmobranch health is an outstanding question. To investigate the epidermal virome, we sampled elasmobranchs from the southern and Pacific Oceans, including white sharks (*Carcharodon carcharias*) on the coast of New South Wales; tiger (*Galeocerdo cuvier*, n=13), dusky (*Carcharhinus obscurus*, n=12), sandbar (*Carcharhinus plumbeus*, n=13), and Galapagos (*Carcharhinus galapagensis*, n=24) sharks from Norfolk Island; port jackson *(Heterodontus portusjacksoni*, n=13), sevengill (*Notorhyncus cepedianus*, n = 8), and angel sharks (*Squatina australis*, n=12), fiddler (*Trygonorrhina dumerilii*, n=21) and eagle (*Myliobatis australis*, n=3) rays, guitarfish (*Aptychotrema vincentiana*, n=4), and whitespotted skates (*Dentiraja cerva*, n=18) from Gulf St. Vincent in South Australia. A few individuals (n=4) were captured with epidermal lesions at various healing stages, which were sampled along with nearby undamaged skin. Bacterial and viral abundances were estimated using flow cytometry. Elasmobranch epidermis had 10-fold lower microbial abundances than surrounding water and contained higher and more variable proportions of virus-like particles (VLPs) than surrounding water and sympatric teleosts and invertebrates. Wounded shark skin harbored similar bacterial populations and over 10-fold higher abundance of VLPs compared to undamaged skin on the same individual (n=3), and higher abundance than average on undamaged individuals of the same species. The differences in viral abundance suggest that bacteriophages may facilitate epidermal wound healing in sharks by lysing opportunistic pathogens on damaged skin.

Poster

Assessing the impact of jaw preservation methods on the stable isotopes of elasmobranch teeth

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Stable isotope analysis has become a widely used biogeochemical tool owing to its capacity to reveal predator foraging habitats, trophic level, and prey preferences. The breadth of applicable tissue types is quickly growing across taxa, including for elasmobranchs, with tooth isotopes gaining traction to trace within-individual variation in trophic ecology. However, most jaws in museums and private collections are chemically preserved to prevent degradation and whiten the teeth and jaws for long-term display. While these preserved trophy jaws present an important opportunity for sampling specimens of now protected species like white sharks (*Carcharodon carcharias*), we need to understand the impacts popular preservation methods have on carbon, nitrogen and sulphur isotopes of elasmobranch teeth. We assessed the effects of drying jaws compared to using bleach or hydrogen peroxide on tooth stable isotopes of three elasmobranch species with distinct tooth morphologies: gummy shark (*Mustelus antarcticus*), broadnose sevengill sharks (*Notorynchus cepedianus*), and cownose rays (*Rhinoptera bonasus*). Our study showed variable and species-specific impacts across preservation type, which was also affected by the quantity of processed tissue, potentially precluding the use of species or age-classes with small teeth. Understanding if and how preservation impacts stable isotopes of elasmobranch teeth will help us determine whether preserved jaws from museum or private collections can be usable to complement samples from fresh jaws to study the trophic ecology of elasmobranchs. This is especially relevant to trophy species that have been historically hunted and fished for their jaws like the white shark. The use of these display jaws could help reconstruct past trophic role and food webs, and improve our understanding of large shark feeding ecology for which samples and new jaws are logistically difficult to obtain.

Presentation

Assessment of Presence Probability of the White Shark (*Carcharodon carcharias*) in the Western North Atlantic using Passive Acoustic Telemetry

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The white shark (*Carcharodon carcharias*) is an apex predatory shark species with a global distribution. There is extensive literature analyzing fine-scale movements, population dynamics, migratory patterns, predatory ecology, and even reproductive biology of this species. However, the white shark population in the western North Atlantic (WNA) is understudied with a significant lack of data on their migration patterns, predatory ecology and reproductive habits. This study uses automated acoustic telemetry to address three research questions; 1) Do the WNA white sharks exhibit seasonal residency and shifts in migratory phase through biological season? 2) What environmental variable best determines shark presence within the WNA residency areas? 3) Do the WNA white sharks disproportionately use areas near structure during their overwintering period off the coast of the southeast United States? From 2016-2021, forty-one white sharks were tracked in the western North Atlantic Ocean using passive acoustic transmitters. White sharks in the WNA exhibited strong regional fidelity and seasonal residency with distinct periods of migratory movements. Spatial analyses support seasonality of migration patterns. Generalized additive models indicate that temperature is a statistically significant variable that drives shark presence within regional areas and that a definitive preferred temperature range (~ 10 – 20°C, $\bar{x}$ = 16 °C) exists. Boosted regression tree analysis further supports the notion that sea surface temperature is the primary catalyst when shifting between migratory phases and predicting presence. A statistical association was found with a Mann-Whitney U test for sharks and receivers within close proximity (0-1000m) to submerged structure. These findings add to the existing literature on the species as well as assist in the assessment of presence probability within residency areas of the WNA white shark population.

Poster

Space use by white sharks (*Carcharodon carcharias*) in their overwintering residency area in the western North Atlantic

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In recent years, the movement and migration of the white shark population in the western North Atlantic has become the subject of increasing interest to better understand areas of importance and habitat use for all life stages, as this population potentially rebuilds. Recent research on this population is beginning to reveal information regarding movements and habitat use, however, detailed data on 3-dimensional space utilization are needed to develop and ensure sound management strategies. This project seeks to better understand the space use, potential core habitats, and preferred environmental parameters of white sharks while in their overwintering residency area in the Carolinas region. Regularized and most probable tracks have been constructed from acoustic and satellite data to examine site fidelity, resident versus transient behaviors, diving behaviors, and potentially important areas or habitats within this region. Preliminary analyses are attempting to address trends in movements based on size, sex, class, or individual preference. Using multiple tag technologies over multi-year periods allows for a robust analysis of movements and habitat use for individual animals to contribute to the growing knowledge of the western North Atlantic white shark population. This will provide critical information to our understanding of the ecology of these apex predators to help create better informed management plans.

Presentation

Ontogenetic change in body shape for white sharks, *Carcharodon carcharias*, in Australian waters

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The analysis of how biological shape changes across ontogeny can provide us with valuable information on how species adapt behaviourally, physiologically, and ecologically. The white shark Carcharodon carcharias is one of the largest and most widely distributed apex predators globally, yet an understanding of ontogenetic changes in body shape and relative scaling of length and weight measures are limited, especially as to how these may relate to foraging ecology. Through analysis of a suite of shape-related metrics, we identified ontogenetic patterns of scaling throughout development. Positive allometric growth was exhibited for all length-length and weight-length relationships, showing a significant deviation from an isometric slope of 1.0. Additionally, the surface area of the fins and the dimensions of the mouth increased with body length and girth, facilitating locomotion and accommodating ontogenetic dietary changes. These changes are particularly important for hunting larger, fast-moving prey as the sharks mature. There were no significant differences in morphometric relationships within Australian waters nor for sex, however, the latter is likely an artifact of the few mature samples. Conversely, life stage was found to have a significant effect on the girth-length and weight-length relationships. The development of regression equations for morphometric measures allows the assessment of white shark body condition and may serve as an assessment tool to understand the potential impacts of human-induced environmental change on white sharks.

Presentation

Examining post release behaviour following capture and ecosystem interactions of white sharks (*Carcharodon carcharias*) in Atlantic Canada through novel biologger packages

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While the occurrence of white sharks in Atlantic Canada has historically been reported, it was considered a rare species and consequently no formal management plan was implemented. With an increase in sightings over recent years, repeatable return behaviour of satellite tracked individuals over consecutive years, and a suspected increase in relative abundance, deriving data for the management of this threatened species in Atlantic Canada is now a conservation priority. Here, we tagged white sharks with biologger packages including accelerometers integrated with either sonar (n=7, DTAG-4), hydrophone (n=1, DTAG-4) or swim speed (n=1, PD3GT; Little Leonardo) sensors to investigate (i) post release behavior and recovery times following capture, handling and tagging efforts and, (ii) to quantify feeding interactions and frequency of feeding events in the northern residency area (i.e. high latitude, high seal abundance) versus the southern residency area (diet less well understood). Through biologger deployments in Atlantic Canada (n = 4) and US Atlantic (n = 5), we generated high resolution data for periods ranging from 15.8 to 39.8 hrs (20.5 ± 8.1 [mean ± SD]). These initial data demonstrate that white sharks have highly variable post release behaviour, suggesting either individual behaviour is highly specialized or that some sharks show rapid recovery while others appear to take periods longer than the deployment duration. Sonar tags were effective at revealing interactions with potential prey, but the nature of the tag attachment to the dorsal fin identified some challenges with their application which require consideration. The collection of these high-resolution data and our current efforts to generate various data streams on white sharks in Atlantic Canada will be discussed in the context of their relevance for addressing recovery/management goals for this species.

Presentation

Shifts in the incidence of shark bites and efficacy of beach-focused mitigation in Australia

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Shark-human interactions are some of the most pervasive human-wildlife conflicts and their frequency are increasing globally. New South Wales (Australia) was the first to implement a broad-scale program of shark-bite mitigation in 1937 using shark nets, which expanded in the late 2010s to include non-lethal measures. Using 196 unprovoked shark-human interactions recorded off New South Wales since 1900, we show that bites shifted from being predominantly on swimmers to 79% on surfers by the 1980s and increased by 2–4-fold. We could not detect differences in the interaction rate at netted versus non-netted beaches since the 2000s, partly because of low incidence and high variance that reduced the power to detect small differences. Although shark-human interactions continued to occur at beaches with tagged-shark listening stations, but there were no interactions while SMART drumlines and/or drones were deployed. Our power analyses show that a small increase in the difference between mitigated and non-mitigated beaches could indicate reductions in shark-human interactions. Area-based protection alone is insufficient to reduce shark-human interactions, so we propose a new, globally transferable approach to minimise risk of shark bite more effectively.

Presentation

Relative Abundance and Community Composition of Juvenile White Shark (*Carcharodon carcharias*) Prey Species along Southern California Beaches

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Juvenile white sharks (JWS) in the Northeast Pacific utilize the coastline of the Southern California Bight (SCB) as nursery habitat, forming loose aggregations at “hotspot” beaches, or nursery aggregation sites. Because of their high residency at these sites, environmental conditions and prey resources likely drive fidelity to these aggregation sites. However, it is unclear how JWS select these nursery habitats and to what degree prey communities and abundances influence site selection. This study describes prey community composition and relative prey species abundance at aggregation sites and non-aggregation sites in Southern California using baited remote underwater videos (BRUVs) and beach seines. Six BRUVs were deployed monthly at four sites (two aggregation sites, one former aggregation site, and one non-aggregation site). Two seine nets (23m and 30m long) were towed along sandy, nearshore beaches monthly across three sites (one aggregation site, one non-aggregation site, and one former aggregation site). Over 300 hours of BRUV footage was collected, and 46 unique species were sampled from >200 beach seine tows. Beach seine data demonstrate differences in the prey community assemblage among active aggregation sites, former aggregation sites, and non-aggregation sites of similar habitats (PERMANOVA, $p < 0.01$). The abundance of barred surfperch, bat rays, and corbina drove differences in the community at the aggregation site, which are known components of JWS diet. Preliminary BRUV data suggest similar trends, with significant differences in community composition between the aggregation site and former aggregation site (PERMANOVA, $p = 0.041$), as well as the aggregation site and non-aggregation site (PERMANOVA, $p = 0.004$). Prey community compositions also differ between sampling methods, which may be driven by surf-zone associated species in beach seines and reef-associated species in BRUVs. Identifying the overall prey community composition at JWS aggregation sites and non-aggregation sites may help to predict future aggregation “hotspot” sites.

Presentation

Detecting Mediterranean white sharks with environmental DNA and particle distribution hindcasting

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The white shark (*Carcharodon carcharias*) is an important, globally-distributed apex predator whose basic biological parameters remain virtually unknown in the Mediterranean Sea due to its historically low population density, dwindling population size, and lack of substantial sightings. The Sicilian Channel is one of the remaining hypothesized hot spots for white shark reproduction and foraging and accounts for 19% of total historic sightings. Non-invasive molecular methods for determining the presence of organisms in nature, such as environmental DNA (eDNA) from water samples, is a developing but powerful technique for studying cryptic or rare species such as the Mediterranean white shark. Analyzing genetic material shed from white sharks may provide novel insights into their distribution and abundance. To aid traditional methods of discovering white shark presence in the Sicilian Channel, we developed a pipeline that has three main functions; 1) identify the best sampling season and location based on historical sightings, 2) sample water and detect white shark eDNA, and 3) predict where the white shark shed its DNA by hindcasting the movement of eDNA particles in a pelagic environment by incorporating oceanographic variables and degradation rates. Additionally, to expand the sampling effort in hot spots and involve the public, we developed water-sampling kits for citizen scientists. Over three years, we collected 170 samples throughout the Sicilian Channel in May and June, and we detected white shark eDNA at two stations with >95% confidence, and we predicted their spatiotemporal presence for the purpose of updating abundance and distribution maps. This pipeline is a powerful tool for detecting rare white shark individuals in a data-poor region. Expanded systematic monitoring and citizen science participation are crucial for developing conservation and management policies to protect the last strongholds of Mediterranean white sharks.

Presentation

Using multi-sensor technology to tackle white shark ecology at varying scales

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Biologging has emerged as a technology with tremendous value and potential, with new approaches and discoveries being published each year. In this talk, I will present the findings of several of these approaches, from testing the use of concept models of Customized Animal Tracking Solutions (CATS) Cam tags on white sharks in South Africa, to a global collaboration involving research groups from around the world. I will also talk on the strengths and challenges I found in using the technology during my own PhD thesis.

On a local scale, we discovered repeated foraging of the species within kelp forest, a study that built on previous research using traditional acoustic telemetry at Dyer Island in South Africa. We analysed accelerometer and magnetometer data, paired with video footage, finding kelp forest in over 17% of video, with activity and tortuosity significantly increasing during this time. We found entering kelp was a deliberate and repeated tactic that resulted in encounters with Cape fur seals. On a regional scale, we used multi-sensor data to describe the movement characteristics of 21 white sharks at foraging areas off Central California, in the North East Pacific. Here we used over 900 hrs of data and found unique patterns of habitat use in each area with location and size class explaining over 80% of the variation in movements. However, we also found some consistencies across locations and of individuals regardless of size or sex, with diel phase highly significant. Finally, we used mixed modelling to explore these trends further, using externally attached accelerometer data from eight aggregation areas and 104 individual sharks ranging in size from 190 to 550 cm total length. We found consistent trends through hours of the day and diel phase, suggesting a common circadian rhythm may be present across populations of white shark.

Poster

Does the white shark have a circadian rhythm? Consistent activity rhythms across populations and life stages of a globally-distributed marine predator

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Circadian rhythms are innate responses to cyclic daily changes in the environment (e.g. night and day) allowing physiological and behavioural processes such as feeding or resting to occur at the most suitable times. Given that circadian rhythms are thought to be an adaptive response to prevailing conditions, it raises the question of whether globally-distributed species display adaptative routines in response to local conditions. Here, we tested if the circadian rhythm of the white shark, *Carcharodon carcharias*, a circumglobally-distributed marine predator, differs among four populations and across eight aggregation sites in three of the world's oceans. We derived the diel activity of 104 sharks through motion-sensitive biologgers that collected over 2,500 hours of activity data. Overall, we found that diurnal circadian rhythm was conserved across all populations but found site-specific differences in this diurnality, with the activity of some populations peaking before noon, while others peaked in the afternoon. Our results suggest that despite diverging thousands of years ago, the circadian rhythm of white sharks has largely remained consistent with only minor local adaptation. We suggest that maintenance of this diurnality is a result of sensory specialisation, while the minor variations of the timing of activity is an adaptive response to the availability of prey.

Presentation

Connectivity between white shark populations off central California, USA and Guadalupe Island, Mexico

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Marine animals often move beyond national borders and exclusive economic zones resulting in a need for trans-boundary management spanning multiple national jurisdictions. Highly migratory fish vulnerable to over-exploitation require protections at international level, as exploitation practices can be disparate between adjacent countries and marine jurisdictions. In this study we collaboratively conducted an analysis of white shark connectivity between two main aggregation regions with independent population assessment and legal protection programs; one off central California, USA and one off Guadalupe Island, Mexico. We acoustically tagged 326 sub-adult and adult white sharks in central California (n=210) and in Guadalupe Island (n=116) with acoustic transmitters between 2008-2019. Of the 326 tagged white sharks, 30 (9.20%) individuals were detected at both regions during the study period. We used a Bayesian implementation of logistic regression with a binomial distribution to estimate the effect of sex, maturity, and tag location to the response variable of probability of moving from one region to the other. While nearly one in ten individuals in our sample were detected in both regions over the study period, the annual rate of trans-regional movement was low (probability of movement = 0.015 yr-1, 95% credible interval = 0.002, 0.061). Sub-adults were more likely than adults to move between regions and sharks were more likely to move from Guadalupe Island to central California, however, sex, and year were not important factors influencing movement. This first estimation of demographic-specific trans-regional movement connecting US and Mexico aggregations with high seasonal site fidelity represents an important step to future international management and assessment of the northeastern Pacific white shark population as a whole.

Poster

JAWS: "J"enomes Associated with Shark"-A new database of epidermal microbes

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Elasmobranch skin microbiomes are species-specific and distinct from the surrounding environment but vary across time and location. Denticles are hypothesized to inhibit bacterial attachment and biofilm formation, yet shark skin microbiomes are incredibly diverse. This indicates denticle and mucus structure select and maintain beneficial microbial communities. Metagenomics is a technique that utilizes DNA sequencing to analyze all the genetic material collected from the environment, in this case the skin of sharks. Metagenomics has allowed us to study the microbiomes of wild organisms, like sharks, to describe the role microbes play in their health, development, and behavior. To date, we have analyzed the metagenomes of 20 shark and ray species from across the world. Prominent members of shark microbial communities belong to Gammaproteobacteria including *Pseudomonas*, *Marinobacter* and *Psychrobacter* species. Microbes from sharks and rays from across the globe possess genes required for heavy metal tolerance which suggests that microbes facilitate adaptation to high concentrations of heavy metals due to biomagnification. While we have started to unravel the shark skin microbiomes, we have only started to scratch the surface. Shark metagenomes have a large proportion of unknown or novel microbes i.e., 60-85% of the sequences belong to novel microbes. Here we will describe our approaches to identify the novel microbes that are carried by sharks and rays as they travel around the world's oceans. First, metagenomic reads will be computational reconstructed into novel microbial genomes from short DNA fragments. We will isolate and sequence bacteria isolates grown from nine Elasmobranch species, including great white sharks (*Carcharodon carcharias*). DNA extracted from each bacterial isolate will be sequenced using Nanopore technology. Bacterial genomes and constructed genomes will be combined into a new database called JAWS ("J"enomes Associated With Sharks) to help unravel the role microbes play in shark health and disease.

Poster

Global review of acoustic telemetry research on white sharks

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Tracking the movements of white sharks provides valuable information about drivers of behaviour and potential interactions with humans. Acoustic telemetry is particularly useful at exploring spatiotemporal patterns at relatively small scales in areas important for the organisms themselves (e.g., foraging and reproduction), as well as human interactions (e.g., tourism and high-risk areas). Between 1999 and 2022, we found 27 peer-reviewed articles using acoustic telemetry to study white shark movements. Here, we explore these studies, summarizing common trends in terms of study objectives, findings, and overall impact. The use of complementary approaches (e.g., satellite telemetry, diet, genetics) is also explored providing a broad overview of white shark tracking research and affiliated questions that can be addressed. We also introduce TrackdAT, an online metadata portal housing acoustic telemetry study information of all species, with a brief tutorial on its application using white sharks.

Presentation

Fine-Scale Shallow Water Movements of White Sharks (*Carcharodon carcharias*) on Cape Cod, Massachusetts.

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Seasonal aggregations of white sharks (*Carcharodon carcharias*) form along Cape Cod, Massachusetts, posing a risk to public safety. Overlapping space use in shallow waters between white sharks and humans has led to an increase of white shark-human interactions. To address concerns of beach managers and the Cape Cod community, information on movements and behavior of white sharks in shallow water is necessary to inform public safety. Between 2019 and 2022, we quantified the movements of white sharks using a dense array of acoustic receivers to track acoustically tagged white sharks at five beaches along Cape Cod. Receivers are deployed in a manner to create a fine scale positioning system allowing for highly precise (~1- 2 m) geolocations of acoustically tagged white sharks. To link these positions to the local abiotic conditions, we collected high-resolution (2-3 cm) sidescan imagery and bathymetry with a phase-measuring sidescan sonar. In addition, data on oceanographic conditions were collected with an Acoustic Doppler Current Profiler, pressure loggers, and light meters. These efforts resulted in the positioning of over 80 individual white sharks moving through depths ranging from 1-12 m for residency periods up to 4.5 hours. White sharks were present during 40% of the study period and showed distinct affinity to waters near a gray seal (*Halichoerus grypus*) haulout. In general, individual movement patterns in these shallow water habitats were associated with bathymetry, changes in oceanographic conditions, and the occurrence of high-energy weather systems. This study sheds light on the daily movements of white sharks in the shallow waters of Cape Cod.

Poster

On the Presence of the White Shark in Calabria (Southern Italy)

Francesco Luigi Leonetti[1], Gianni Giglio[1], Giorgio Fedele[1], Sandro Tripepi[1], Emilio Sperone[1]

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Carcharodon carcharias is a large coastal and pelagic shark, wide-ranging throughout most temperate and tropical oceans to depths of 1,200 m. The species is also present in the Mediterranean Sea, where its conservation status has been evaluated as Critically endangered by IUCN. Calabria region lying in the center of the basin is strategic to collect data about chondrichthyans that historically occurred in the entire Mediterranean Sea. Through the present work it was possible to collect eight records of the great white shark from Calabrian waters, since the first half of the XX century. The sources of information were photographic evidence (3 records), field observations (3 records), fish markets (1 record) and bycatch (1 record). All observations were made during late spring and summer; only two records come from the Ionian Sea while most of them (6/8) come from the Tyrrhenian Sea. In only three cases it was possible to determine the sex of the sharks: a male and a female both young (250 cm and 200 cm respectively) and an adult female of 450 cm. Information on feeding observation are also provided.

Presentation

What's on the menu? Elucidating the diet and habitat use of immature white sharks in eastern Australia using biochemical tracers

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White sharks (*Carcharodon carcharias*) play a crucial ecological role, shaping ecosystems through direct predation and indirectly through predator-prey interactions. On the east coast of Australia, immature white sharks are broadly distributed, inhabiting a wide range of habitats and ecosystems from temperate regions of southern New South Wales and Bass Strait to tropical regions in north Queensland. Using stable isotopes and fatty acids in muscle and plasma, we examined the diet and habitat use of 136 immature white sharks (152–388 cm total length) captured on SMART drumlines on the east Australian coast. This facilitated the assessment of white shark trophic ecology across different timescales from a few weeks up to approximately a year. Biochemistry of muscle samples showed that white sharks predominantly feed at low trophic levels in coastal environments, with demersal elasmobranchs and mullet (*Mugil cephalus*) being the largest contributor to their diet. A seasonal shift in diet was evident, driven by higher proportions of essential fatty acids in muscle tissues in spring and summer compared to other seasons, suggesting that prey items consumed during these seasons are of higher nutritional quality. By combining stable isotope and fatty acid analysis, we gain a comprehensive understanding of immature white shark diet in eastern Australian waters. Our results confirm that white sharks are generalist predators that adapt to seasonal changes in prey availability. Their high use of coastal habitats reinforces the importance of these areas for foraging, which is crucial for growth and development during this critical life stage.

Presentation

Movement patterns and habitat use of white sharks of the Northeast Pacific across ontogeny using long-term acoustic telemetry

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Ontogenetic changes in habitat use are driven by shifting life-history requirements and play an important role in population dynamics. However, large portions of the early life history of many elasmobranchs are still poorly understood or unknown hindering our ability to effectively manage large segments of the population. While several studies have made inferences of ontogenetic changes in habitat use of white sharks (*Carcharodon carcharias*) based on tracking data from several individuals of different size classes, here we tracked individual sharks over long periods of time to determine how movements varied throughout ontogeny. Using data from 25 individual white sharks acoustically tracked for a minimum of two years, we found the probability of detection decreases and the latitudinal spread of detections increases over time. Maximum tracking duration was 10.2 years (mean 3.6 ± 2 years) but varied based on tagging method. Using published von Bertallanfy growth equations, we assigned a daily length and age estimate based on length at tagging to determine at what age and length juvenile white shark detections become less frequent, indicative of more offshore movement or further latitudinal range beyond receiver coverage. The conservation and management of highly migratory sharks relies on understanding age-related movements and nursery habitat use. As such, the information presented here provides an important knowledge gap in the management of understudied size classes for this highly protected species.

Presentation

Evolution of the Carcharodon lineage: Rapid morphological change creates a major shift in a predator's trophic niche.

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Current paleontological and morphological data confirm that the extant white shark *Carcharodon carcharias* is not descended from the extinct megatoothed shark Otodus (Carcharocles) megalodon (Otodontidae), but from an isurid (Lamnidae) ancestor. Moreover, the evolutionary sequence seen within the dentition of the *Carcharodon* lineage is a gradual morphological transition from the ancestral non-serrated C. hastalis (previously placed in the genus *Isurus* or *Cosmopolitodus*), through the semi-serrated *C. hubbelli*, to the fully serrated *C. carcharias*. We examined Carcharodon teeth from three uppermost Miocene (Messinian) to lowermost Pliocene (Zanclean) marine fossil sites in California, the San Mateo, Capistrano, and Purisima formations, which preserve the *Carcharodon hastalis-hubbelli-carcharias* transition. Geochronologic and biostratigraphic evidence shows the entire *C. hastalis* to *C. carcharias* evolutionary transition occurring within a span of time between 6.9–5.3 million years ago. The timing of this transition in these California localities coincides with similar sites in Peru and Chile, and with the first appearances of *C. carcharias* elsewhere in the world. We show that, based on dental morphology and on evidence of predation in the fossil record, broad teeth in the ancestral C. hastalis dentition likely shifted away from a piscivorous isurid ancestor, to a specialized predator on large marine vertebrates, particularly pinnipeds and small cetaceans. The serrations in the teeth of C. hubbelli and *C. carcharias* is attributed to a further increase in the effectiveness in consuming such large prey.

Presentation

Abiotic and biotic drivers of white shark (*Carcharodon carcharias*) inshore occurrence in False Bay, South Africa

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Recent changes in the occurrence of white sharks (*Carcharodon carcharias*) in coastal areas of South Africa have furthered the need to understand the biotic and abiotic drivers behind the fine-scale movements of these apex predators to inform marine conservation and management strategies. We used 1209 shark sightings made by trained Shark Spotters at two beaches: Muizenberg (n = 742) and Fish Hoek (n = 467), between January 2006 – 31 December 2015 to investigate the influence of prey fish availability on the inshore presence of white sharks in False Bay, South Africa. We also explored the influence of sea surface temperature (SST), El Niño/Southern Oscillation (ENSO), diatom patch presence, the occurrence of beach-seine fishing (treknetting) and dolphin presence on white shark presence. We used randomization tests to determine whether shark sightings were randomly distributed across the abiotic and biotic variables and investigated the dependencies between the predictor variables. White shark sightings were seasonal and peaked between 17.49 - 18.57 °C. Prey fish presence revealed a similar peak at 17.94 °C. Randomization tests indicated that a Shark Spotter was 66% more likely to detect a shark when prey fish are present, which supports our prediction of a prey-mediated cue. The occurrence of beach-seine netting was also non-randomly linked to white shark presence, increasing the probability of spotting a shark to 38% instead of 20% at random. Diatom patches were negatively correlated with SST, with numbers increasing in colder waters. The data revealed a significant influence of weak negative ENSO values on white shark inshore occurrence. The presence of dolphins (various species) did not show a significant pattern with the analysed variables. Our study contributes to our understanding of the drivers of white shark occurrence and provides a foundation for future studies investigating contemporary changes in their behavioural ecology.

Presentation

The California Shark Beach Safety Program – a holistic approach to measuring and mitigating white shark risk to ocean recreation and beach management.

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Fisheries protection for white sharks in California waters was implemented in 1994, along with banning of nearshore gillnets, which most likely explain the increase in white sharks along the California coastline and throughout the Northeast Pacific Ocean (NEP). The increasing occurrence of white sharks off California beaches and concern over public safety resulted in a State of California bill to form the Shark Beach Safety Program in 2018. The CA Shark Beach Safety Program consists of 3 arms - research, education, and outreach with a primary focus on understanding white shark behavior for the purpose of managing shark-human interaction risks. Research has focused on behavior and activity of white sharks found close to shore using acoustic and satellite telemetry, biologging, UAV surveillance, BRUVs, prey sampling, environmental monitoring and eDNA technologies resulting in a vast shared digital infrastructure. Research focuses on when are white sharks nearshore (near areas of highest human water activity), what are sharks doing while inshore, why do they aggregate and when do they leave? Since ocean recreation contributes over $1 billion to the CA economy, socio-economic research has focused on understanding human perceptions of sharks and other hazardous marine life, impacts of sharks on tourism and the economic impacts of shark bites. The outreach arm focuses primarily on distributing new science on sharks and other ocean safety risks (e.g., rip currents, stingrays, sea jellies, sick/injured marine mammals) to the public via mobile beach popups, covering over 30 California beaches and ocean piers, spanning over 600 miles of coastline. Infographics, comic books and social media have specifically targeted messages to provide appropriate information to both locals and CA visitors. The education arm has developed research-based curricula tailored for CA ocean lifeguards, fishers, and K-12 students, to inform these groups about white sharks and beach safety.

Presentation

Informing multifaced, multidisciplinary analysis of evidence for shark incident species identification

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Species identification following shark-related incidents is critical for effective incident management but often requires more reliable techniques than simple human observations. Analyses of morphological or genetic characteristics left in the wake of an incident can be used to inform species identification and, in more complex cases, may require a combination of both approaches. The collection and processing of genetic material have unique limitations in shark attack cases—samples often contain large quantities of human DNA due to victim injuries or post-incident contamination or DNA loss from limited access to appropriate collection resources or environmental influences. Following an incident where the ski of a paddler was bitten by a shark, which was not visually identified by witnesses, a new DNA sampling approach was applied to determine the efficacy of widely available gauze for species identification. In addition to the bite mark impressions left on the ski, a tooth was found and assumed to be associated with the incident. The characteristics of the bite impression, including shape and tooth indentation pattern, inferred the involvement of a white shark (*Carcharodon carcharias*). The morphology of the recovered tooth, however, was instead identified as belonging to a wobbegong (*Orectolobus* spp.). Although the discovery and identification of a tooth are typically suggestive of the shark of interest, genetic analysis of DNA transferred from the shark to the ski identified the presence of *C. carcharias*, which supported the conclusions drawn based on the bite morphology. Genetic analysis of the tooth also corroborated its morphological identification. This case study facilitated a unique opportunity for an experimental design to compare the effectiveness of gauze and forensically-standard swabs in collecting genetic material for species identification. The results were congruent between sampling methods with respect to species identification and the level of activity inferred by the donor-specific DNA contribution. This study represents the first application of gauze as a sampling medium after such an event and supports translating these methods to the field.

Presentation

Continental-scale movements of white sharks in Australia using acoustic telemetry

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Large-scale movements of white sharks have diverse implications affecting aquatic ecosystems and interactions with humans. For example, the predator-prey seascape can be altered from dynamic spatiotemporal shifts in white shark distribution. Similarly, changes in movement patterns can impact the potential for human-shark interactions requiring adaptive mitigation or management strategies. Here, we explore large-scale movements of white sharks throughout Australian waters to better understand the potential impacts from both shark (e.g., genetic mixing) and human (e.g., inter-state management) perspectives. Acoustic telemetry was used to track dozens of sharks across several years with monitoring arrays on eastern and southern coasts of Australia. The main objective was to quantify the proportion of sharks that cross the Bass Strait – the body of water between continental Australia and Tasmania – to disentangle ambiguity over spatial and genetic mixing between eastern and southern populations. Our research identifies broad-scale movements to help understand white shark distribution with emphasis on population level outcomes.

Poster

A pilot study for eDNA monitoring and detecting species interactions of North Atlantic white sharks

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Cape Cod, Massachusetts (USA) hosts the largest aggregation of white sharks (*Carcharodon carcharias*) in the North Atlantic. It is also a popular beach destination among both tourists and locals, which has led to an increase in human/white shark interactions over the past decade. A tagging program of individual white sharks carried out by the Atlantic White Shark Conservancy and Massachusetts Department of Fisheries to monitor shark movement throughout the area has resulted in a passive acoustic monitoring (PAM) network spanning the entire North-South length of Cape Cod. This PAM network provides unique spatiotemporal information about when and where white sharks are active in the area. Here, we test a framework using environmental DNA (eDNA) to compare the white shark-specific copy and read numbers derived from seawater around PAM receiver stations with corresponding abundance data received by the shark buoys along the shoreline of Cape Cod. We collected 2 replicate water samples (1 liter each) using a research vessel at 17 different stations across a transect from Provincetown to Monomoy Island, Cape Cod, covering both popular beaches, seal colonies and areas observed to be white shark hotspots. We hope to provide insight on the efficacy of eDNA as a white shark monitoring tool in Cape Cod. Furthermore, we hope to answer questions regarding habitat usage and species interactions between white sharks and both Harbor Seals (*Phoca vitulina*) and Grey Seals (*Halichoerus grypus*) across the transect. If successful, this framework could be applied to other areas where human/shark interactions are prevalent. It has the potential to inform early detection of white sharks along popular beaches and to complement other ongoing monitoring efforts including PAM and aerial surveys.

Presentation

Comparison of juvenile white shark abundance estimates from eDNA metabarcoding, acoustic telemetry, and drone surveys at Southern California aggregation sites

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White shark (*Carcharodon carcharias*) abundance is challenging to assess due to their size and scarcity. Juvenile white sharks (JWS) in the northeast Pacific form nearshore aggregations along the Southern California coast of varying group numbers. High JWS density at aggregations provides an opportunity to compare methods of abundance estimates to assess efficacy. We used metabarcoding to assess the community structure of JWS aggregation sites, including the abundance of white shark eDNA. Water samples were taken at two aggregation sites, Padaro Beach, Carpinteria, CA, and Del Mar, CA, from May-August 2022. Simultaneously to water sampling for eDNA, aerial surveillance was conducted using drones to count visible sharks. The sites are monitored by a passive acoustic telemetry system, which logs tagged JWS. In May, 6,199 DNA reads from JWS were captured at Del Mar across 12 samples, 3 sharks were detected via acoustic receivers, and 0 were spotted from aerial surveillance. At Padaro, 4,560 DNA reads, 22 sharks detected by telemetry, and 10 spotted by drone at the time of sampling. In June, neither site had any DNA reads, though 6 sharks in Del Mar and 4 sharks in Padaro were detected on the acoustic array. 5 sharks at Del Mar and 8 sharks at Padaro were also spotted by drone. Del Mar was not sampled in July, but at Padaro, no sharks were detected with any method. Lastly, in August, there were no eDNA reads, but Del Mar had 1 acoustic detection and Padaro had 2 sharks spotted from the air. These preliminary results indicate that drone surveys and acoustic telemetry correlate, but eDNA metabarcoding does not reflect JWS abundance. There may be a threshold of sharks before eDNA metabarcoding can reliably establish presence, though no false positives occurred. Additional sampling combined with environmental measurements may help explain relationships between methods.

Presentation

Habitat and migratory range expansion of white sharks (*Carcharodon carcharias*) during the first five years of life

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The New York Bight is an area in the northwest Atlantic that has been identified as a nursery for white sharks (*Carcharodon carcharias*). Satellite tagging has revealed the movements, migration, and habitat use of young-of-the-year (YOY) white sharks in their first year of life in this region, however, multi-year movement patterns have not yet been assessed. In 2016 and 2017, 20 YOY white sharks (119-158 cm fork length) were internally tagged with acoustic transmitters, allowing broad-scale tracking by coastal acoustic telemetry arrays for up to ten years. Here, we characterize the extent of movements observed in the first five years of life for each cohort. The rapid expansion, both north and south, of their migratory range was evident over the tracking period, with some individuals reaching the same latitudinal range as adult white sharks. Similarly, there was a commensurate expansion of habitat use with respect to depth and water temperature. Understanding these expansions can be used to better define essential fish habitat for different life stages, as well as predict how ongoing climate change could alter the migratory patterns of juvenile white sharks.

Presentation

Café or Buffet? Using fatty acids to reveal the generalist diet and coastal habitat use of Australia's white sharks

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White sharks (*Carcharodon carcharias*) have been shown to expand their diet and foraging strategies as they grow. As they approach ~ 3.5 m, they move from consuming inshore teleost and chondrichthyan prey to a mixed diet also including marine mammals and pelagic cephalopods. White shark diet has yet to be investigated in Australia, where ongoing tagging studies have revealed that they rarely travel off the continental shelf. This contrasts the eastern pacific white shark population where large sharks frequently migrate off the continental shelf. We assessed diet using signature fatty acid profiling from 145 individuals ranging from 1.6–5.5 m, collected from South Australia. Unlike the ontogenetic diet shifts observed in the eastern Pacific and off the coast of South Africa, white sharks in Australia show no size-related differences in diet or increase in pelagic foraging, with fatty acids indicating marine mammal consumption (22:5w3, 20:5w3 or 16:1w7) or pelagic foraging (22:6w3, 16:0, 18:0) remaining similar across all sizes. Instead of specialised apex predators, the South Australian white sharks of all sizes are generalist predators with less reliance on pinnipeds and a wider diet breadth than previously thought. This parallels their coastal habitat use, which affords them a wide variety of coastal prey items.

Presentation

A new genetic assay for the individual identification of white sharks

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Research is underway to better understand white shark movements and their biology. This research involves tagging and tracking individual animals. Genetic information is also captured to inform on species diversity and to estimate population structure, size, and resilience. Conventional tags can be expensive, and they have a limited life span. Tagging larger animals can also be challenging. A genetic tag can distinguish an animal for life and unlike conventional tags, DNA sampling does not necessarily require the direct handling of animals. The advent of next-generation sequencing (NGS) has revealed thousands of DNA mutations, known as single nucleotide polymorphisms, or SNPs, that can be used to identify individual animals. Using probability statistics, the minimum number of SNPs required to identify an individual from the Australian east coast population was calculated to be twenty-five. This study aimed to develop a cost and time effective genetic assay to differentiate individual white sharks. Using an NGS MiSeq platform, 10 animals of known genotype were accurately identified using multiplexed PCR reactions. In the first field application of the assay, an animal involved in a negative human-white shark interaction along the Australian east coast has been genotyped at 31 SNP loci.

Presentation

Daily and seasonal movements of Cape Cod gray seals vary with predation risk from white sharks.

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We investigated gray seal *Halichoerus grypus* movement behavior and coastal behavior under predation risk from white sharks Carcharodon carcharias in the northwestern Atlantic ocean. Similar to other shark-seal hotspots,activity around terrestrial haulouts are particularly risky for seals and can elicit anti-predator strategies. We investigated the nearshore movement, space use and at-sea activity cycles of gray seals on Cape Cod (USA) in relation to seasonal and diel changes in white shark activity. Analyzing 412 trips to sea by tagged gray seals and more than 25 000 acoustic detections from 23 individual sharks, we observed seasonally-homogenuous movements in seal behavior during months with greater shark presence. During riskier months, seal behavior manifested in near-exclusive nocturnal foraging, reduced offshore ranging, and limited at-sea activity. On nocturnal trips to sea, seals tended to avoid day break and traversed during diel minima in shark detections. However, seals tended to depart haul outs at dusk when shark presence was maximal. Dive behavior of tagged seals exhibited similar behavioral patterns consistent with predator avoidance. Understanding drivers of behavior in re-establishing marine predator populations is important for critical evaluation of their ecological role and importance in coastal ecosystems.

Poster

Twenty years of monitoring the Guadalupe Island White Shark Population using Photo Identification

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Photo-identification techniques have been used to monitor and track northeastern Pacific White Sharks (*Carcharodon carcharias*) at a seasonal adult aggregation site at Guadalupe Island, Mexico. Using pigment patterns in the gill, pelvic fin and caudal fin regions to identify individual sharks, a catalog of 454 white sharks was compiled between 2001 and 2021. This catalog consists of 51% males and 49% females. Sharks exhibited seasonal site fidelity with 68% of the sharks in the catalog sighted in at least two years and one male shark resighted in 19 consecutive years. The occurrence of multiple years of resighting has allowed for the examination of the stability of pigment patterns over time. This photo-identification database represents a long-term data series and is important in the management and conservation of northeastern Pacific White Sharks. At this time, the current Guadalupe Island closure by the Mexican government suspends our ability to continue to monitor the health of the Guadalupe Island White Shark population.

Presentation

Population Health and Stress Response of White Sharks (Carcharodon carcharias) in the Western North Atlantic Ocean

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Health assessments and development of blood analyte reference intervals in wild elasmobranch populations are essential to understanding individual animal, in situ population, and ecosystem health in the face of current and future environmental disturbance and anthropogenic stressors. As part of a multi-institutional, cross-disciplinary study of the western North Atlantic white shark population health evaluations were performed on 83 sharks (43 male; 40 female) across four life stages (20 young of year, 28 juvenile, 20 subadult, 15 adult) between 2016 and 2023. Evaluations included physical exam, ultrasound, baseline hematology (hematocrit, total solids, complete blood count, differential), plasma chemistry analysis, protein electrophoresis (fractions 1-5), and acute phase proteins (C-reactive protein [CRP], serum amyloid A, haptoglobin). Relationships between analytes and biologic data (ontogeny, seasonal, regional) were explored in tandem with toxicology results from concurrent studies. Sharks sampled during their winter residency in the southeastern United States in 2017 and 2019 had significantly elevated median CRP and white blood cell indices indicating inflammatory profiles. In 2019 elevations in muscle heavy metal levels (zinc, copper nickel, cadmium) were documented. Identification of blood biomarkers that predict species specific differences in stress response and post release survival are critical to conservation strategies and scientific sampling that involves handling and release. One-alpha hydroxycorticosterone [1□OHB] response, and traditional blood chemistry (electrolytes, metabolites, lactate), acid-base (pH, HCO3) and blood gas (pCO2) alterations were used to assess stress response during this study. Some sharks demonstrated changes in glucose mobilization and lactate, as expected, across the time of the study, but 1□OHB did not show any concomitant changes or correlations within the sampling period. Satellite tag movements indicate high survivorship. The data collected provide comprehensive blood analyte reference intervals, document response to possible biological and environmental stressors, and contribute to understanding the effects of capture on the western North Atlantic white shark.

Presentation

Sample size effectiveness of a machine learning algorithm to predict risk of white shark bites

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Human-wildlife conflicts arise when people and animals are forced to share the same, and often limited, resources, which may result in wildlife posing direct and recurrent hazards to people. While shark bite incidents are rare, when such incidents occur, they evoke negative emotions particularly due to sensationalist media portrayal. Shark bites are one of the most widespread of all human-wildlife conflicts, occurring in all major oceans of the planet, with white sharks being the main species involved. In Australia, a long-term monitoring program tracked a total of 960 white sharks between 2015 and 2022 with acoustic and satellite transmitters. Using this tracking data, we developed a machine learning algorithm to predict risk of white shark bites along the coast of New South Wales, Australia, using daily environmental data from a global reanalysis dataset (Bluelink) with 10-km spatial resolution. This algorithm accurately identified known white shark locations with 84.6% accuracy (64.1% absences accuracy), and predicted risk ranging from 55% to 97% (mean = 82%) at known locations where white shark bites occurred (n = 59) between 2009 and 2022. We then evaluated effectiveness of risk predictions as a function of sample size by gradually including random individuals, ranging between 10 and 900 sharks. Similar effective results to the total dataset were obtained with an average random sample of >80 sharks, suggesting that this might be the minimum effective sample size required to obtain accurate predictions of risk of white shark bites, also in other regions. We would like to invite researchers with telemetry data from other regions of the world to collaborate in a global analysis: do we need region-specific algorithms, or is it better to combine our tracking datasets to obtain a more robust model?

Poster

Record of Great White Sharks (Carcharodon Carcharias, Lamnidae) in the Santa Catarina State Coast and Comments on Occurrences in Brazil

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Carcharodon carcharias (Great White Shark - GWS) has a circumglobal distribution in tropical and temperate seas. In the Western South Atlantic, 27 occurrences of this species have been recorded for Argentina (n = 4) and Brazil (n = 19 old records + 3 recent ones in this study). This study aimed to record the catch of a GWS in an artisanal gillnet fishery (70 mm interknot mesh size), 10 miles off the coast of Passo de Torres, Santa Catarina State, on April 16, 1998. This GWS recording was distinct in two ways: 1) crew description of the catch; 2) photographs of the landing at a port to process the shark for market. The immature female weighed 510 kg and its size estimated in 3.5 m TL. The fishers who caught this GWS mentioned that they had already seen this kind of shark in this same region in different years, between late Spring and early Summer. They also observed that the sharks were always seen in pairs between 5 and 10 miles off the coast. Until now, 23 specimens of GWS have been recorded for the Brazilian Coast: 3 in the Northeast, 13 in the Southeast, and 7+1 (this study) in the South. It is observed that the Southeast is the region with more occurrences, which may be influenced an upwelling off the coast of Rio de Janeiro State, and most individuals were larger than 4.0 m TL. The GWS in the Northeast were larger than those in the Southeast. The GWS in the South measured less than 3.5 m TL and the observation of preyed pinnipeds suggests that this region is a feeding zone for specimens that are entering recruitment and looking for areas, towards the north, to reproduce. Few GWS specimens that were captured and taken to markets, or their parts, have been collected and deposited in research institutions. To date, the GWS is considered a rare species in the Brazilian coast, despite its extensive continental coastline.

Presentation

White shark movement behaviours in a high recreational use coastal bay in Atlantic Canada

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Atlantic Canada represents the northernmost extent of the western North Atlantic white shark population's range. Although considered relatively rare in the region historically, their presence in Atlantic Canada has increased markedly in recent years, highlighting a need to understand their movements and high-use areas to determine their ecological role and assess and mitigate the risk of human-shark conflict. Previous satellite tagging efforts have shown that white sharks enter Mahone Bay, Nova Scotia, a key recreational site for bathers, boaters, and surfers, but investigation into the frequency, timing, and duration of occurrence is needed. To address this knowledge gap, we deployed an array of 35 acoustic receivers in Mahone Bay between July 8 and November 11, 2022, to monitor white shark presence, distribution, and entry and exit timing. In total, 83 individual white sharks out of 307 acoustically tagged in the western North Atlantic were detected in Mahone Bay. Thirty-five of these were tagged in Atlantic Canada, of which 18 (51%) were detected; 211 were tagged in Massachusetts, of which 45 (21%) were detected; and 61 were tagged further south, between New York and Florida, of which 20 (33%) were detected. Preliminary analysis of these detections indicates three behavioural types within Mahone Bay: 1) use of the outer islands as a transit/migration corridor, with both northward and southward movements captured; 2) temporary residence for short periods (~1 week); and 3) longer-term seasonal residence (> 1 month). With satellite locations used to supplement acoustic detections, as well as access to the Ocean Tracking Network regional array of receivers, continued investigation into temporal patterns, site fidelity, and individual variation will elucidate the movement behaviour of white sharks detected in Mahone Bay throughout Atlantic Canada. These findings will inform the ongoing species recovery-management plan and support strategies to mitigate negative human-shark interactions.

Presentation

What happened with the White Shark cage diving at Guadalupe Island: an official statement

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Guadalupe Island Biosphere Reserve has been a protected natural area since 2005 due to the great diversity of its flora and fauna, endemism, and degree of conservation of different species, including the white shark (*Carcharodon carcharias*). For 20 years, cage diving was carried out to observe white sharks as a tourist activity in the area. During that time, the species was monitored, a code of conduct for white shark cage diving was developed and applied, and the interactions of sharks with the local fishing community, the behavior of other species present in the area, and their interaction with tourist activities were also monitored. However, the non-compliance with the code of conduct by tourists and tour operators was a constant. This was reflected in the impacts on marine species present in the area, such as the Cuvier's beaked whale (*Ziphius cavirostris*) due to noise pollution; nocturnal birds such as the storm petrels (Hydrobates spp.) due to light pollution; breeding colonies of the Guadalupe fur seal (*Arctocephalus towsendi*) during the period of birth and lactation. Likewise, great white sharks were found to be impacted by the cages, putting at risk the integrity of the tourists and the sharks. In 2016 and 2019, two accidents were documented, resulting in the possible death of a shark and one seriously injured. Additionally, the local artisanal fishing community expressed their concerns that sharks' interactions with their sustainable fishing activities were increasingly frequent and aggressive, putting their lives at risk during their diving operations. For these reasons, in 2023, tourist activities on Guadalupe Island were banned. However, we are encouraging the research on white sharks and other species to better understand their etiology and population dynamics without the interaction of tourist-recreational activities. We will explain the mechanism to reach this new goal at the Reserve.

Presentation

Return ticket: capture-recapture data from white sharks tagged in the New South Wales Shark Management Program

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Shark-Management-Alert-in-Real-Time (SMART) drumlines have been used since 2015 in New South Wales (NSW, Australia), as part of the NSW Shark Management Program. Individuals caught on SMART drumlines are tagged, presenting an opportunity to use capture-recapture data to study this species. We aimed to quantify the spatio-temporal variability of recapture events in SMART drumlines, describing what influences the recapture probability and the linear movement associated with recaptures. Between 2015−2022, 890 white sharks, ranging from 117−373 cm fork length, were tagged and released, 218 of which were recaptured (recapture rate = 24.5%) for a total of 272 recapture events (46 individuals were recaptured multiple times). Females and smaller individuals were more commonly recaptured, implying a significant sex and size effect on the recapture probability. Most sharks were recorded in the northern half of NSW and peak abundances were observed between winter-spring; individuals were more commonly caught in higher latitudes during the summer-autumn months, and caught at lower latitudes in colder months. Most recaptures were recorded within 180 days (52.7%), with a mean of 256 days between events. Very few recaptures were recorded in the same location of the previous event, demonstrating the efficiency of SMART drumlines as a reliable bather protection measure.

Poster

Fine Dining: discovering what drives killer whale's selective predation on prey tissue types

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Predator-prey dynamics greatly influence the trophic ecology of an ecosystem. Killer whales (*Orcinus orca*) are cosmopolitan apex predators found from the equator to the polar pack ice. Within the animal kingdom, they present the most extreme known case of selective predation on specific tissue types from their prey. Killer whales have been observed targeting specific tissue types in over 30 different species, including whale tongue and shark liver. This predation behavior is resulting in trophic shifts in local ecosystems, where other top predators such as white sharks (*Carcharodon carcharias*) are leaving their preferred hunting grounds due to predation pressure and risk. This unique behavior, combined with their intelligence and dexterity, suggests that their predations are driven by factors beyond prey availability and catchability. While this behavior has been attributed to the nutritional and calorie content of specific tissues, it has never been investigated. Therefore, we aim to investigate if nutrient and energy content drive killer whale prey specialization for specific tissue types by capitalizing on a dataset comprised of approximately 500 samples of targeted vs. non-targeted prey tissue. We anticipate that our research will provide novel insight into the driving factors of these extreme feeding habits and predator-prey dynamics and aid in the development of effective conservation strategies for their prey and these predators.

Presentation

The Use of Artificial Intelligence to Analyze Close Proximity Encounters Between Humans and Juvenile White Sharks in Southern California

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Southern California has increasing populations of humans and juvenile white sharks that concurrently use nearshore coastal areas for extended periods. As these populations continue to grow, there is a need to assess whether shark bite frequency will increase. However, there is a large gap in knowledge about how often humans and juvenile white sharks use the same habitat, how much distribution overlap there is between humans and sharks, and how juvenile white sharks behave in close proximity to humans. To determine distribution overlap, 1644 aerial drone surveys were flown monthly at 26 separate beach locations from Santa Barbara, California, USA to Coronado, California, USA from January 2019 through March 2021. The nearshore distribution of 5 water user groups (waders, swimmers, bodyboarders, surfers, and stand-up paddlers) and juvenile white sharks was quantified, identifying that juvenile white sharks spend the majority of time within 100 m of the wave break. Additionally, human-shark co-occurrence within aggregation sites was determined to be 97% within the study period. To determine how sharks behave during instances of co-occurrence, over 350 human-shark encounters were opportunistically recorded. Encounters, defined as when a shark is within 200 m of a human, ranged in duration from 2 seconds to 9 minutes and 45 seconds and occurred primarily between surfers and sharks. An artificial intelligence program has been developed and is being used to determine the distance between subjects, swim trajectory, swim speed, and orientation to the human subject for every frame of each encounter. Preliminary data indicates A.I. can be used to significantly reduce footage processing times, without dropping data accuracy, to quantify shark behavior when in close proximity to human subjects.

Presentation

Systematic review and meta-analysis of studies testing the efficacy of shark bite mitigation

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The rapid increase in the development, marketing, and implementation of measures for shark-bite mitigation has prompted a rise in independent studies testing their efficacy. However, most studies have used different methods and response variables, hindering direct comparisons of efficacy. We did a systematic review to compare the efficacy of current and newly developed strategies. We used the PRISMA method to obtain 79 peer-reviewed papers and government reports. We found that area protection measures were tested 76 times, personal mitigation 26 times, and injury reduction methods three times. Another 12 tested measures could be categorised as either area or personal mitigation. Spatial deterrents (e.g., meshing, drumlines, culls) and electric personal deterrents have been examined the most to date. Standardised analysis of variance found that most mitigation studies reported a level of efficacy, likely due to publication bias, while a minority had little to no effect. Electric deterrents showed consistently higher Hedges g values, signifying a greater effect. This is partly due to the ability of deterrent testing experiments to give an indication of the reduction in shark-bite risk. Studies were ranked according to their assessment reliability and inference type to reveal the robustness of findings when measuring the reduction of shark-bike risk. Our review also highlighted a lack of consistency in protocols and variables tested across studies. We therefore developed a framework to ensure that consistent, robust, and reproducible methods are used in future studies. Our framework is applicable to a broad range of mitigation measures and will help policy makers and consumers to make informed decisions when selecting and implementing mitigation measures.

Poster

The contribution of MECO (Mediterranean Elasmobranchs Citizen Observations) for improving the knowledge of the distribution of the white shark in the Mediterranean

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The Great White Shark, *Carcharodon carcharias* (Linnaeus, 1758), is one of the biggest top predator in Mediterranean Sea. Its presence in this area is ancient and sometimes well documented. Citizen Science is a useful tool if - in addition to other scientific method - provides data in a simple way like taking pictures or videos, especially for such an introverted animal like the great white shark. The M.E.C.O. project (Mediterranean Elasmobranchs Citizen Observations) is utilizing social media to collects data from all around the Mediterranean regarding sharks, rays and chimeras to create a database and increasing the possibility to have evidence about the presence of the different species in the water. In this work, we illustrate data about great white shark sightings since 1980 to date along the Mediterranean coasts from M.E.C.O. project database. The data are validated by marine scientists working on the project in different countries. Our results give us the opportunity to better understand the presence of an extremely rare and endangered species in the Mediterranean water.

Presentation

The nearshore predatory behavior of the white shark off Cape Cod, MA, USA.

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Over the past decade, the coastal waters off Cape Cod, Massachusetts have emerged as the only known aggregation site for the white shark (*Carcharodon carcharias*) in the western North Atlantic. The now-predictable presence of this species is linked to the regional recovery of gray seals (*Halichoerus grypus*), which are preyed upon by white sharks close to shore. The nearshore proximity of predatory sharks, their natural prey, and humans has become a public safety issue, and the number of reported white shark sightings and negative interactions between white sharks and humans has been on the rise. To better understand the predatory behavior of white sharks in this area, we deployed satellite-linked (n=14), acoustic (n=300), and acceleration data-logging camera (ADL, n=24) tags on free-swimming white sharks. To date, our findings indicate that white sharks spend 95% of their time in depths less than 31m and 47% of their time overlapping with recreational water users (i.e., depths <4.5m). Based on 130 hours of ADL video, it appears that white sharks exhibit a variety of predatory behaviors off Cape Cod, ranging from explosive attacks on seals in the surf zone to demersal predation on spiny dogfish (*Squalus acanthias*) during excursions into deeper water. Using these observations, our ultimate goal is to identify areas and time periods during which hunting white sharks may overlap with recreational water users so as to provide a science-based strategy for mitigating this conservation conflict.

Presentation

SMART drumlines as a bather protection tool in New South Wales: capture response and long-term fate of white sharks (*Carcharodon carcharias*) released from SMART drumlines

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The management of human-shark conflict has become a complex issue, given the increase in unprovoked shark bites over the past 30 years and concerns associated with the impacts of lethal mitigation measures on marine wildlife. This has led to a shift towards non-lethal bather protection strategies, particularly given white sharks (*Carcharodon carcharias*), a protected species, are responsible for most serious or fatal bites. SMART drumlines, a new non-lethal bather protection method, alert responders (researchers and contractors) when an animal takes the bait, providing the opportunity for rapid access to the catch, potentially relocating and releasing animals and, minimising harm to target and non-target animals. Since 2015, trials of SMART drumlines in NSW, Australia have successfully caught all three potentially dangerous/target species. However, one of the concerns of water users/stakeholders is that sharks released from SMART drumlines may remain inshore post-release. Here, we quantify the short-term post-release movements and longer-term survival of white sharks after capture, tagging and release from SMART drumlines. Between May and October 2016, 36 white sharks were caught on SMART drumlines and tagged with dorsal fin-mounted satellite linked radio transmitters (SLRTs) and acoustic tags before release. In the first three days post-release, most sharks moved and remained offshore (> 3.5 km from the coast), irrespective of their sex and length. Subsequently, in 10 days post-release, they moved inshore, yet most stayed an average of 5 km away from their tagging location and more than 1.9 km off the coast. Acoustically tagged sharks were detected for an average of 591 days post release (range 45-1075 days), although five of the 36 sharks were not detected by acoustic receivers. Complementary tagging by SLRTs revealed that these five sharks were detected between 43 and 639 days post release, suggesting zero mortality associated with capture. The findings here highlight the efficacy of SMART drumlines as a potential non-lethal bather protection tool for protected species such as white sharks, given that white sharks move away from their site of capture, reducing the immediate threat of shark interactions at that site.

Presentation

Great white shark distribution change in the Mediterranean in the 21st century: real shift or better data?

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Great white shark distribution in the Mediterranean area was usually based on historical and contemporary records. Hence, due to a large number of historical records decline in the distribution in some Mediterranean regions is often presumed as well as a significant decline in population abundance. However, it is questionable if all the historical records are accurate, thus even presumptions based on such unverified records are arguable. The aim of this paper is to use only confirmed records from the last two decades and to compare such distribution with some environmental and biological parameters that might change the usual perception of the distribution of the great white shark in the Mediterranean.

Presentation

Trends in the index of abundance of white sharks at Guadalupe Island: the last 20 years

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White Sharks aggregate seasonally at Guadalupe Island, and since 2001 the aggregation has been monitored via photo-ID using pigment patterns to identify individual sharks. We employed the encounter histories of 454 (232 males and 222 females) photo-identified White Sharks from 2001 to 2021 as the base information for a mark-recapture analysis for the Guadalupe Island aggregation site. We estimated apparent survival, recapture probabilities, permanent entry into the population, and the superpopulation size by using the Cormack- Jolly-Seber (CJS) model and a generalization of the Jolly-Seber (JS) model for the open-population mark-recapture experiments. We fitted several model structures for each CJS and JS type and selected the best-fit model structure using the corrected Akaike's Information Criterion. Our results indicated that six male sharks had been seen for more than 15 years at the aggregation, including one shark recorded yearly during the monitored period. The superpopulation size by sex was 92 females (SE = 2.3) and 103 males (SE = 1.8) N=195. Compared with our estimate up to 2009 of N=120 sharks, this new result is a 63% increase in the population. However, because not all the assumptions of the mark-recapture method are met, our encounter history analysis should only be considered as an index of abundance, allowing us to understand the aggregation trend but not its absolute abundance.

Presentation

The Influence of Micro-Scale Thermal Habitat on the Movements of Juvenile White Sharks in their Southern California Aggregation Sites

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Juvenile white sharks (JWS) from the northeastern Pacific population aggregate in nursery habitats throughout the Southern California Bight. JWS possess regional endothermic capabilities, allowing for elevated body temperatures, yet smaller individuals likely lack body mass for efficient thermoregulation. Smaller individuals may utilize behavioral thermoregulatory movements (vertical and horizontal distribution) to help optimize energetic gain. How, micro-scale water temperature influences JWS three-dimensional movement while they remain resident at these sites remains unknown. We tagged 41 JWS from May 2020 to December 2021 and used acoustic telemetry tracking and high-resolution water temperature data throughout an aggregation site (5.5 km2) to quantify and predict how temperature and vertical thermal stratification influenced JWS movement using several modeling approaches. JWS disproportionately selected for shallow and warmer temperatures spending 80% of their time between 16 and 22℃ and 71% of their time in depths between 0 and 2 m within the site and their depth distribution was directly related to the vertical thermal structure of the water. Sharks occupied deeper waters during crepuscular periods, and their distance from the seafloor and spatial orientation of their depth distribution was related to the thermal structure of the water column across the monitored area. Sharks predominantly used water temperatures above a thermal threshold of 16℃ and expanded or contracted their horizontal distribution based on the depth of that threshold. Overall, JWS 3D movements in a shallow (< 10 m) and nearshore (< 1 km) habitat are directly responding to ambient water temperature. Quantifying the thermal thresholds of JWS movements across space and time is necessary to improve distribution predictability and improve habitat suitability models as their movements may be affected by climate anomalies and climate change, resulting in potential impacts on, management and conservation policy of the species, and on the dynamics of local prey species.

Presentation

Using stable isotopes to elucidate long-term habitat use by young sharks

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Coastal nursery grounds are crucial habitats for shark development and conservation, but details such as diet, movement, and location of early life stages (i.e. neonates, young of the year [YOY], juveniles) remain elusive. Indeed, most ecology studies for white shark (*Carcharodon carcharias*) focus on adults, because it is difficult to identify YOY/juvenile aggregations and collect an adequate sample size. However, a more complete understanding of early life stage is critical to optimize conservation and management strategies. Coastal habitats support artisanal fisheries, often overlapping with juveniles preferred areas, which can result in high mortality rates of young white sharks. In Mexico, a permanent fishing ban prohibits its capture (NOM-029-PESC-2006), but juveniles are reported as bycatch in artisanal fisheries. The western coast of Baja California is a preferred habitat for young white sharks and our stable isotope analysis (SIA) research using carbon (δ13C) and nitrogen (δ15N) in multiple tissues (muscle, blood, red blood cells, and plasma) elucidated their trophic ecology and habitat use in this region over time. SIA providing information about prey preferences, habitat use and diet integrated in time and space, depending on tissue turnover rates and their metabolism throughout life. Our results indicated long-time residency of juvenile white sharks inside the nursery area of Sebastián Vizcaíno (SVB) and their resource-sharing with other lamnoid sharks (*Isurus oxyrinchus*). Likewise, a significant contribution of pelagic prey was determined in juvenile white shark diet, suggesting superficial foraging as an important strategy during early stages. Finally, our results indicated a natural “ontogenetic switch” from yolk to exogenous 15N-enriched food resources, due to newborns’ independent foraging. This suggested that young white sharks started to forage on SVB food chain immediately after birth, indicating that it can occur in the outer areas of the bay, as supported by fishery records of neonates in the same region.

Poster

Microbiome characterization of two epidermal regions displaying different denticle structures on the shark, *Heterodontus portusjacksoni*

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Shark dermal denticles facilitate fast and efficient swimming, but how do they interact with the microbial community that the sharks face daily. The water column is filled with millions of microbes and viruses, most of which are harmless and have important roles in biogeochemical pathways, such as producing carbon and oxygen through photosynthesis. There is a million bacteria and 10 million viruses in every millimeter of sea water, therefore the shark epidermis is being bombarded with trillions of microbes and viruses every minute. The epidermal microbiome of sharks is species specific and distinct from the water column, suggesting there is a strong filtering effect of the shark epidermis. Whether dermal denticles or epithelial mucus functions are the major structuring component of the epidermal microbiomes remains an outstanding question. My study will characterize the *Heterodontus portusjacksoni* dorsal and ventral epidermal microbiome which contain different denticle textures. The denticles on the dorsal surface are elevated, crowned-shaped, and non-overlapping, whereas on the ventral side they are flattened, and rounded with little interdenticle space. Therefore, epidermal microbiomes will be compared on the two surfaces using next-generation sequencing and compared to the microbial communities in the surrounding. This research will assist in developing baseline data of elasmobranch skin microbiomes and the potential discovery of anti-microbial components that maintain a healthy microbiome. Microbiome characterization of abundant shark species such as *H. portusjacksoni*, can be applied to species that are less accessible such as Carcharodon carcharias. Chondrichthyan provide an excellent opportunity to study mechanisms that contribute to evolutionary immunological capacity and resilience to microbial pathogens, which are increasing with changes to the global climate.

Presentation

Orca-mediated displacement of white sharks along the South African coast: current insights.

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Apex predators profoundly impact terrestrial and marine ecosystems, shaping their structure and functioning. The absence of apex predators can disrupt these ecosystems and trigger trophic cascades. However, the introduction of novel apex predators remains poorly understood. In 2015, a shark-eating morphotype of killer whales (*Orcinus orca*) was observed along the Western Cape coast of South Africa. A pair of highly identifiable killer whales targeted at least eight white sharks, primarily in Gansbaai. Sightings and telemetry data revealed that white sharks migrated away from the area upon subsequent killer whale sightings. This response resulted in the emergence of a mesopredator species, the bronze whaler shark (*Carcharhinus brachyurus*). In 2022, aerial footage from Mossel Bay provided direct evidence of killer whales hunting white sharks and a flight response linked to the predations. The footage shed light on the evasive strategies employed by white sharks and the reasons why they are ineffective at avoiding capture. Data from cage diving vessels and drone surveys supported the finding that white sharks exhibited flight responses for a minimum of 45 days after the Mossel Bay events, similar to those observed in Gansbaai. Additional adult killer whales were observed hunting white sharks in Mossel Bay, suggesting possible cultural transmission. The displacement of white sharks by killer whales in South Africa has significant ecological, economic, and safety implications for beachgoers. Although definitive solutions are lacking, we propose several research, monitoring and management suggestions to address the ongoing interactions between these predator species.

Presentation

The Gills Club: Creating the next generation of shark and ocean stewards through diverse array of educational opportunities.

Marianne Walsh[1], Cynthia Wigren[1], Dr. Heather Marshall[1], Julie Patterson[1], Maddie Poirier[1], Kristen Smith[1]

[1] Atlantic White Shark Conservancy

The Gills Club is Atlantic White Shark Conservancy's STEM-based education initiative dedicated to connecting girls with female scientists from around the world, sharing knowledge, and inspiring the next generation of shark and ocean advocates. The program offers free, in person programming to young girls, as well as developed a robust online presence through social media and its own podcast, Gills Talk.

During this presentation, we will share how the program has grown to where it is today, along with data on how we are impacting youth through hands on programming, scholarships, and digital learning opportunities.

According to the Federal Equal Opportunity Employment Commission, women account for less than 30% of the STEM workforce. Several studies demonstrate that exposure to role models can change a child's own self-stereotypes, their beliefs about their abilities, their goals, and their ambitions. The Gills Club has become an important endeavor, utilizing the work of female researchers, to educate youth on shark and ocean conservation and empower the next generation of ocean stewards.

By providing multiple stages of learning opportunities, across various outlets, Gills Club is having an impact on the development and career goals of young girls. One of the strongest pieces of this program is the direct access to leading female researchers who have donated their time to be a part of the Gills Club Science Team. As members of the team, these women provide insight into what programs, internships, career options, etc. have led them to where they are today.

Materials, resources, and content created for Gills Club are also used in other Atlantic White Shark Conservancy education programs. The material and content addresses learning standards, enabling us to use it across multiple platforms, engaging an average of 1,800 students each year with research-based information.

Presentation

Bite-wound analysis of white shark bites on adult bottlenose dolphins

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White sharks are key apex predators hypothesized to influence the behavioral ecology of cetaceans through predator-prey interactions. While there is a growing body of evidence describing these interactions, a step-by-step analysis to accurately identify bite wounds on surviving prey is lacking. Here we provide a detailed bite-wound analysis for several resident pods of common bottlenose dolphins, Tursiops sp., that can be used for identifying shark bites to the species level and distinguish these interactions from boat and cetacean-cetacean wounds. Further, we provide a before, during and for several years after analysis on individual dolphins to provide an accurate method for monitoring and correctly identifying healed white shark wounds. A combination of shark dental patterns, interdental width, teeth formation, bite width, bite circumference, and photos of wound formation and recovery was used from a known population of over 500 dolphins that reside close to seal colonies and monitored bi-weekly and surveyed monthly between 2010 to 2023. We identified both white shark, *Carcharodon carcharias*, and seven gill shark, *Notorynchus cepedianus*, wounds across approximately 1.5% of the dolphin population. Our analysis further provides a method to confidently identify healed white shark bites on dolphins and to test hypotheses on the importance of white shark-dolphin interactions.

Presentation

Chum dine with me: assessing the effects of wildlife tourism on non-target fish assemblages

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Wildlife tourism is becoming increasingly popular and often uses food-based attractant to ensure close encounters and improve customer experience. Most studies assessing the impact of wildlife tourism focus on the species targeted by tourism, but limited studies have investigated whether non-target species can also be affected by tourism operations. The Neptune Islands Group Marine Park in South Australia is home to Australia's only white shark cage-diving operations. Here, two operators use up to 2,000 kg of bait and chum per fortnight to attract white sharks, but its effects on local fish assemblages are unknown despite many fish species regularly observed to feed on the bait and chum used by the cage-diving operators. We used six years of baited underwater video surveys to characterise and compare fish assemblages at the Neptune Islands to similar offshore remote islands without cage-diving operations. We could not detect any changes in the overall diversity or abundance of demersal fish between the cage-diving and the control sites. The horseshoe leatherjacket *Meuschenia hippocrepis* was the only species consistently more abundant at the tourism site. The results show that despite operators using a large amount of food-based attractant on a near daily basis and observations of fish species feeding on bait and chum, the cage-diving industry has minimal impacts on demersal fish abundance and diversity within the area.

Presentation

An open spatial capture-recapture framework for estimating the abundance and seasonal dynamics of white sharks at aggregation sites

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In this study, we present the first estimate of abundance for the white shark at a new aggregation site in the western North Atlantic, which required the development of a novel modeling framework to accommodate the species' migratory behavior. Estimates of abundance are needed to evaluate the performance of existing conservation measures for white shark populations worldwide but have historically been infeasible to obtain in the region. Following the recent emergence of Cape Cod, Massachusetts, USA, as a seasonal aggregation site, we conducted a photographic mark recapture survey and identified 393 individual white sharks from 2015-2018. Because conventional capture-recapture models do not adequately represent the species' migratory behavior, we extended an existing open spatial capture-recapture framework to allow for movements into and out of the surveyed area and accommodate variation in residency and habitat use among individuals. Using simulations, we demonstrated that failing to account for these processes resulted in biased estimates of abundance that would be misleading if used as the basis for management advice. We applied the model developed to describe the seasonal dynamics of the Cape Cod aggregation site and estimated a superpopulation size of 800 (393 - 1286) individuals, which provides an important baseline for this species of conservation concern. Because it directly links changes in abundance over time to the demographic processes underpinning them, the model described provides a more mechanistic understanding of the dynamics of white shark aggregations and improves the applied relevance of the results for the conservation and management of the species.

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Code of Conduct

The organising committee of White Sharks Global 2023 is dedicated to providing an inclusive, welcoming, and safe conference environment for all participants, free from discrimination and where all participants are treated with dignity and respect. Harassment is unlawful under both federal and state anti-discrimination laws, and as such, people suspected of such misconduct may be reported to authorities. It is required that all attendees to White Sharks Global 2023 adhere to this Code of Conduct at the conference and during all subsequent communications, including that via email or social media. Participants of White Sharks Global 2023 are expected to:

- Treat all participants, presenters, staff members, and volunteers with respect;
- Communicate with others respectfully, and be considerate of the range of views and opinions different to your own;
- Be considerate during discussions and critiques;
- Respect the rules and policies of all venues associated with the conference;
- Support a welcoming and inclusive conference environment;
- Support efforts to reduce the environmental impacts of the conference.

Unacceptable behaviour includes, but is not limited to:

- Harassment, including verbal comments relating to gender, sexual orientation, disability, race, ethnicity, religion, age, or physical appearance;
- Inappropriate and/or unwanted physical contact;
- Stalking or deliberate intimidation;
- Unwanted photography or recording (if you are asked to stop photographing or recording someone, please do so; if someone indicates that they do not want to be photographed or recorded, do not record or photograph them);
- Discriminatory or sexual images in public spaces;
- Sustained or wilful disruption of talks or other events.

To report violations of this Code of Conduct, alert a member of the organising committee. Reports may be made by people subject to, or witnesses of, unacceptable behaviour.

If an individual participates in unacceptable behaviour, the organising committee may take lawful action that they deem appropriate, including removal of the individual from the conference without refund of registration and/or other applicable fees. Reports of unacceptable behaviour may be communicated to authorities, and individuals who participate in unacceptable behaviour may face consequences including being disallowed from attending future events. Individuals who are ejected will not be allowed to give any planned oral or poster presentations. Violations may be reported to the individual's employer or research funders.

All efforts will be made to protect the anonymity of persons reporting violations. Persons reporting violations of the Code may request that their report remain confidential and that no further action be taken. However, if the organising committee deems it necessary for the safety of event attendees, action will be taken, including referral of the report to authorities.

This Code of Conduct is designed to ensure that White Sharks Global 2023 can be enjoyed by all participants. We hope you have an inspiring and enjoyable time.