



NE PACIFIC SHARK
S Y M P O S I U M
SEATTLE AQUARIUM

March 14, 2024

Agenda



SEATTLE
AQUARIUM



TIME	Session 1-Ecology-Moderator Dave Ebert	PRESENTER(S)
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Thursday, March 14, 2024

1pm	Welcome and land acknowledgement	Erin Meyer and Shawn Larson
1:10pm	Assessing variation in the foraging ecology of Salmon sharks (<i>Lamna ditropis</i>) across geography, ontogeny, and sex	Alexandra McInturf
1:20pm	Feeding ontogeny and trophic ecology of the shortfin mako shark, <i>Isurus oxyrinchus</i> , on the west coast of Baja California Sur, Mexico	Colombo Estupiñán-Montaño
1:30pm	Life history traits of the pelagic thresher shark (<i>Alopias pelagicus</i>) in the Ecuadorian Pacific	Diego Mejía
1:35pm	Prey Species Spatial Use In a White Shark Nursery	Dylan Bachman
1:40pm	11 Years of Stings: Understanding Patterns of Stingray Injuries at Del Mar Beach, CA	Felicity Eriksson
1:45pm	Top-Down Trophic Ecology of the Abundant, Apex Predator Broadnose Sevengill Shark (<i>Notorynchus cepedianus</i>) in the Northern California Current System	Jessica Schulte
1:50pm	When the Hunter Becomes the Hunted: An Investigation of Chemical Alarm Signaling in Elasmobranchs	Joshua Bowman
2pm	Decoding White Shark Life History: A Collaborative Scar Analysis Approach	Kaitlyn Yee
2:05pm	How Environmental Variables Affect Overlap Between Juvenile White Sharks and a Common Food Source Bat Rays	Lauren Faulkner
2:15pm	Questions	

2:30pm Break

TIME	Session 2-Ecology-Moderator Nick Dulvy	PRESENTER(S)
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2:50pm	Overview of the taping of NEPSS VI	Animal Professionals
3:00pm	Big Fish, Little Plastics: Investigating Microparticle Accumulation and Trophic Transfer in Salmon Sharks	Maddie English
3:05pm	Identification of San Francisco Bay as a pupping and nursery ground for the vulnerable apex predator, the broadnose sevengill shark, <i>Notorynchus cepedianus</i>	Meghan Holst
3:15pm	Life in the slower lane: Metabolism, population growth, and the fast-slow life history continuum of sharks and rays	Nicholas Dulvy
3:25pm	Ecological lifestyle and gill slit height across sharks	Wade VanderWright
3:30pm	Examining the diet and habitat use of salmon sharks (<i>Lamna ditropis</i>) through eDNA and fatty acid analysis	Reilly Boyt
3:35pm	Reconstructing shark growth curves from individual sight re-sight data.	Salvador Jorgensen
3:40pm	Aggregations of Pacific nurse sharks (<i>Ginglymostoma unami</i>) in a tropical bay exposed to seasonal upwelling in Costa Rica.	Sergio Madrigal-Mora
3:50pm	Ray's Anatomy: from morphological traits to ecological function	Rachel Aitchison



4:00pm	Summary of breakout session K2A (Knowledge to Action)	Romney McPhie
4:15pm	Summary of basking shark meeting	Romney McPhie
4:30pm	Questions	
4:45pm	Adjourn to happy hour and announcements	

TIME	Session 3-Ecology/Management-Moderator Dayv Lowry	PRESENTER(S)
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Friday, March 15, 2024

9:30am	Characterizing sounds of beach goers in context of juvenile white shark (<i>Carcharodon carcharias</i>) hearing	Whitney Jones
9:35am	Metabarcoding assessment of juvenile white shark (<i>Carcharodon carcharias</i>) prey communities in Southern California	Zach Merson
9:45am	Roundtable discussion-ecology knowledge gaps/future research	
10am	Socio-economic aspects from the artisanal gillnet fishery targeting elasmobranchs in northern-central Peru	Francisco Córdova-Zavaleta
10:05am	Where do sharks stand? Evaluating marine protected area coverage across the species ranges of shark and rays	Amanda Arnold
10:10am	Investigation of a shark diversity "hot spot" in South Puget Sound	Dayv Lowry
10:20am	Proposed and realized federal protection for elasmobranchs in the North Pacific	Dayv Lowry
10:25am	Putting sharks on the map: identifying Important Shark and Ray Areas worldwide to inform marine spatial planning	Emiliano García Rodríguez
10:35am	Identifying potential nursery areas for the Galapagos Shark (<i>Carcharhinus galapagensis</i>) in the Revillagigedo Archipelago and Clipperton Atoll	Irene Casanova
10:45am	Questions	
11 am	Break	

TIME	Session 4-Management/Monitoring-Moderator Chris Lowe	PRESENTER(S)
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11:20am	Looking to the past to improve future management and conservation of guitarfishes in data-poor fisheries	Luz Erandi Saldaña-Ruiz
11:30am	Weighing in on Pacific shark fishery management	Sonja Fordham
11:40am	Assessing the economic value of the Munk's pygmy devil ray (<i>Mobula munkiana</i>) tourism in Baja California Sur, Mexico	Marine Lucy Brugès
11:45am	Investigating Bacterial Thermogenesis Via In Situ Sampling of a White Shark's Stomach	Duncan Campbell
11:50am	Roundtable discussion about management priorities	
12:05pm	Real-time monitoring of white sharks off California beaches	Chris Lowe
12:15pm	Global Shark and Ray Tracker tool launched for Scalable, Participatory Science and Iterative Conservation Strategies	Christine Ward-Paige



12:25pm	Questions	
12:40pm	Lunch	
TIME	Session 5- Management/Monitoring -Moderator Oscar Sosa-Nishizaki	PRESENTER(S)
2pm	What happened with the White Shark cage diving at Guadalupe Island: an official statement	Oscar Sosa-Nishizaki
2:05pm	Using UASs to Assess Juvenile White Shark (<i>Carcharodon carcharias</i>) Thermal Habitat Selection in the Monterey Bay	Dylan Moran
2:10pm	Influence of Environmental Factors on Juvenile White Shark Abundance in the Monterey Bay Area	Kelsey Montalto
2:15pm	Locating <i>Carcharodon carcharias</i> in Oregon waters	Kyra (Kiki) Kappos
2:20pm	The Effect of Object Depth and Drone Altitude on Image-Based Shark Length Measurements	Patrick Rex
2:30pm	Bat Ray Residency Within a White Shark Nursery	Victoria Gronwald
2:35pm	Questions	
2:50pm	Roundtable discussion-Monitoring priorities-research gaps	
3:00pm	BREAK	

TIME	Session 6-Movement/Behavior-Moderator Taylor Chapple	PRESENTER(S)
3:20pm	Southern Sharks: Unveiling the Trophic Dynamics and Movement Patterns of a Critically Endangered Species	Ethan Personius
3:25pm	Seasonal habitat use and inter-island movements of female scalloped hammerhead sharks (<i>Sphyrna lewini</i>) in Hawaii	James Anderson
3:35pm	Automatic identification and tracking of whale sharks (<i>Rhincodon typus</i>) from drone videos.	Paola Delgado
3:40pm	Movements, space use, and energetic requirements of white sharks across ontogeny in the northeast Pacific	Ryan Logan
3:50pm	Pacific Nurse Shark movement depending on upwelling season	Sara Stamos
3:55pm	Class specific seasonal migrations of White sharks in the northeast Pacific	Taylor Chapple
4pm	The Effects of Anthropogenic Electromagnetic Fields and Geomagnetic Displacement on the Behavior of Skates	Kyle Newton
4:10pm	Effects of tourism on whale shark behavior	Mariana Arguero Tejada
4:15pm	Swimming in circles: How electromagnetic fields affect the behavior of skates	Natalie Donato
4:25pm	Searching for Lost Sharks: Extinct or Alive?	Dave Ebert
4:35pm	Questions	
4:50pm	Adjourn	



TIME	Session 7-Species recovery/Conservation- Moderator Shawn Larson	PRESENTER(S)
Saturday, March 16, 2024		
9:30am	Ex situ conservation assessment for the Bowmouth Guitarfish (<i>Rhina ancylostomus</i>)	Riley Pollom
9:40am	Prioritizing Sharks & Rays for Ex situ Conservation	Riley Pollom
9:50am	Roundtable discussion: Knowledge gaps in conservation movement, behavior and conservation work	
10:05am	Questions	
10:25am	Molecular relatedness-based analyses reveal life history insights in a data limited species: possible evidence for philopatry in sixgill sharks (<i>Hexanchus griseus</i>)	Shawn Larson
10:35am	Roundtable discussion how to move the NEPSS community forward/connectivity	
10:50am	Announcement NEPSS VII 2026	
11am	Adjourn	



ABSTRACTS

Session 1-Ecology

Assessing variation in the foraging ecology of Salmon sharks (*Lamna ditropis*) across geography, ontogeny, and sex

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Assessing the ecosystem impact of a species requires information on its foraging ecology. In this study, we updated current knowledge on the foraging ecology of salmon sharks, an apex predator in the Northeast Pacific. By combining stomach content and stable isotope analysis of bulk tissues (muscle and liver), we determined the habitat and resource use in salmon sharks across three age classes (young-of-the-year, juvenile, and adult) in three regions (California, Oregon, and Washington). We found some overlap but also distinct differences between classes and regions in both diet and habitat. Collectively, our results fill critical life history gaps needed to determine the trophic role of this species in Northeast Pacific ecosystems.

Feeding ontogeny and trophic ecology of the shortfin mako shark, *Isurus oxyrinchus*, on the west coast of Baja California Sur, Mexico

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A total of 272 stomachs and 39 muscle samples of *Isurus oxyrinchus* were analyzed. The *I. oxyrinchus* has a wide trophic spectrum, with a consumption preference for *Dosidicus gigas*, *Prionotus albirostris*, and *Scomber japonicus*. The *I. oxyrinchus* is a specialist consumer occupying high trophic positions (TP; 4.7-5.2). The stable isotopes analysis (SIA) reflected signals between -17.3‰ and -15.7‰ for $\delta^{13}\text{C}$ and 15.5‰ and 19.5‰ for $\delta^{15}\text{N}$, with differences by maturity stages. The SIA suggests this species has a wide isotopic niche and occupies high TP (3.9-6.2). *I. oxyrinchus* presents segregation by sex and maturity stages, and ontogenic changes in habitat use and prey selection related to the physical characteristics of the zone (bathymetry).



Life history traits of the pelagic thresher shark (*Alopias pelagicus*) in the Ecuadorian Pacific

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The objective of this study was to estimate the age, growth and maturity parameters of *A. pelagicus* in the Ecuadorian Pacific. Field trips were conducted in Manta, Ecuador from June 2021 to May 2022. The vertebrae of 304 individuals were collected. Frequentist and Bayesian multimodels were used to estimate age and growth parameters. The best fit was given by the Bayesian logistic model for combined sex (Linf = 168.16 cm PCL, L0 = 73.76 cm PCL, $g = 0.34$), females (Linf = 163.70 cm PCL, L0 = 70.27 cm PCL, $g = 0.39$) and males (Linf = 169.44 cm PCL, L0 = 69.35 cm PCL, $g = 0.36$), according to leave-one-out-information-criterion (LOOIC). Age and length at maturity were estimated at 5.12 years and 141.28 cm PCL, respectively in males.

Prey Species Spatial Use In a White Shark Nursery

Dylan Bachman

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Within a known juvenile white shark nursery, individuals of several prey species were tracked using passive acoustic telemetry between June 16–December 7, 2022, including leopard sharks (*Triakis semifasciata*, $n=2$), shovelnose guitarfish (*Rhinobatos productus*, $n=2$), thornback guitarfish (*Platyrrhinoidis triseriata*, $n=2$), a sevengill shark (*Notorynchus cepedianus*, $n=1$) and a butterfly ray (*Gymnura micrura*, $n=1$). Acoustic detection patterns within the array offshore of Pado, CA, were spatially analyzed in the context of residency times and size frequency distributions. We characterized area use, site fidelity, and habitat overlap among these species.

11 Years of Stings: Understanding Patterns of Stingray Injuries at Del Mar Beach, CA

Felicity Eriksson

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The round stingray, *Urobatis halleri*, is a common elasmobranch that is known to cause injuries to beachgoers in Southern California. We analyzed 11 years of data (2011–2021) from logbooks of Del Mar Lifeguards, including incident reports, daily patron counts, and weather/oceanic conditions to assess the presence of temporal patterns in stingray



injuries. Over the 11-year period there was a total of 6,602 reported stings. There were hotspots at North Beach and the Del Mar headquarters. Statistical analysis shows increases in injuries during summer months as well as with a higher number of patrons, warmer water, and at lower surf heights. Understanding what can affect trends in stingray injuries is essential for beach safety management.

Understanding the Ecological Role of an Abundant, Apex Predator in the Northern California Current System

Jessica Schulte
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The broadnose sevengill shark (*Notorynchus cepedianus*) is a large and abundant predator in West Coast ecosystems, but little is known about their ecological and trophic role north of central California. Despite significant efforts to model and maintain the productivity of coastal ecosystems, the role of broadnose sevengill sharks (and other shark predators) has largely been overlooked—especially in relation to economically important fisheries (e.g., salmon, halibut, and crab) and species of concern (e.g., federally-listed green sturgeon, pinnipeds). We present preliminary results of an ongoing study looking at movement and foraging ecology of broadnose sevengill sharks caught in Willapa Bay, WA to address this knowledge gap.

When the Hunter Becomes the Hunted: An Investigation of Chemical Alarm Signaling in Elasmobranchs

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Phylogenetically distant species of teleost fishes have been found to warn conspecifics of nearby danger by releasing chemical alarm signals, suggesting ancient evolutionary origins of alarm signaling behaviors in fish. However, no studies have looked directly at an alarm signaling mechanism in elasmobranchs. The presence of chemical alarm signaling in elasmobranchs was investigated using California bat rays (*Myliobatis californica*) in a captive experiment. Our results provide the first evidence of chemical alarm signaling in elasmobranchs, revealing a previously undocumented communication mechanism in this group of marine predators, and adds to a growing body of knowledge on elasmobranch behavior and physiology.



Decoding White Shark Life History: A Collaborative Scar Analysis Approach

Kaitlyn Yee

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Distinctive wounds and scars on white sharks can reveal recent activities such as prey handling, aggression, and anthropogenic impacts. We designed a student-based research program at CSUMB drawing on a vast video database and expert classification key to engage large numbers of non-expert students in identifying, classifying, and analyzing scars. Our transferable research model uses a voting algorithm that aggregates student assessments of shark scars to generate a comprehensive consensus score. By integrating multiple perspectives, our methodology ensures a more precise classification, allowing us to investigate a variety of ecology-based research questions while lowering the research participation bar for early researchers.

How Environmental Variables Affect Overlap Between Juvenile White Sharks and a Common Food Source Bat Rays

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Juvenile white sharks (JWS) are abundant in the Southern California Bight where they spend long periods of time in nursery habitats. Within these habitats, a known food source for JWS is bat rays. This study examines spatial overlap between bat rays and JWS and if it's affected by environmental variables. Acoustic technology rendered fine-scale positions of JWS (n=42) and bat rays (n=16) in a year period. Positions were used to quantify percent overlap within defined regions in a JWS nursery. Data suggest there is spatial overlap throughout time between JWS and bat rays, with environmental variables significantly predicting this overlap. This study aids in a better understanding of how two highly mobile species share space in a small environment.



Session 2-Ecology

Big Fish, Little Plastics: Investigating Microparticle Accumulation and Trophic Transfer in Salmon Sharks

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Microplastic ingestion in marine organisms is a growing concern. Though described in many species, microplastic prevalence in sharks of the Northeast Pacific remains largely unexplored. Our study investigates microparticle (i.e. plastic and fiber) quantities and types in salmon sharks off the Oregon Coast, exploring trophic transfer as the predominant ingestion pathway. From stomach content analysis, high-resolution microscopy, and Fourier-transform infrared spectroscopy, our preliminary findings indicate a high presence of ingested microparticles of diverse morphologies, highlighting the need for further investigation into the impact of microparticles on Salmon Sharks as well as other elasmobranch species.

Identification of San Francisco Bay as a pupping and nursery ground for the vulnerable apex predator, the broadnose sevengill shark, *Notorynchus cepedianus*

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Nursery habitats are critical locations for juvenile sharks to forage and find refuge. Identifying these habitats is necessary for species management for populations at risk of decline. Recent reclassification of the broadnose sevengill shark, *Notorynchus cepedianus*, from “data-deficient” to “vulnerable” status, indicates a clear need for population demographic evaluation to ensure species persistence. This study is the first to demonstrate that San Francisco Bay fulfills the criteria defined for shark pupping and nursery grounds and may be the only such habitat for this population within its range, highlighting the clear need to better understand this critical habitat for this important and vulnerable apex predator.



Life in the slower lane: Metabolism, population growth, and the fast-slow life history continuum of sharks and rays

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In the classic book, *Life in the Slow Lane*, Jack Musick and contributors implicitly hypothesize of the special place occupied by long-lived turtles, seabirds, and sharks. We test this hypothesis, specifically asking whether there are fast and slow lanes in the nexus of fish physiology and life-histories. We show tight interrelationships among metabolic rate, life histories and maximum intrinsic population growth rate (r_{max}). Surprisingly, teleosts and sharks are aligned and interwoven along a common physiology/life history continuum with sharks with fast life histories, such as epaulette shark, with higher r_{max} compared to many teleosts, as well as species with very low r_{max} , such as the bigeye tuna and Greenland shark.

Ray's Anatomy: from morphological traits to ecological function

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In the current biodiversity crisis, sharks, rays, and chimaeras are threatened with an elevated risk of extinction. In sharks it is becoming clear that function follows form, such that gill slit height and caudal fin shape are related to metabolic physiology. Rays are highly diverse (and arguably cooler) yet the link between morphology and metabolism for this group remains largely unexplored. We compared morphometrics from museum specimens, taxonomic literature and *Rays of the World*, and found them to be highly complementary and a robust source of morphological data. These data open the door to connect morphological and metabolic traits while developing a trait-based approach to understand ray ecological function and extinction risk.



Examining the diet and habitat use of Salmon sharks (*Lamna ditropis*) through eDNA and fatty acid analysis

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Studies on elasmobranch diet often rely on the use of traditional stomach content analysis. While stomach contents can provide evidence of recent feeding from prey that is not yet fully digested, environmental DNA and fatty acid analysis offer a more detailed understanding of diet and habitat use over longer periods of time. In this study, we use these two new techniques to complement existing diet studies on salmon sharks (*Lamna ditropis*), an apex predator in the Northeast Pacific. Here we present our methodology and highlight future directions. Ultimately, this work will lay the foundation for more well-rounded dietary studies on elasmobranchs.

Reconstructing shark growth curves from individual sight re-sight data

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Determining growth rates in sharks is vital to population assessment and calculating resiliency. Age and growth estimation, however, is notoriously difficult for elasmobranchs due to uncertainty in age estimation, which is primarily derived from annular growth rings of various tissues. Mark and recapture (re-measure) studies provide validation for age and growth estimation, but most techniques are sacrificial—a barrier to studying rare or endangered species. In white sharks, published growth curves are highly divergent yet consequential in forming protected species policy. We leverage two decades of mark and resight data with size estimation, and estimate age as a fitted model parameter, to reconstruct a growth curve for white sharks in the Northeastern Pacific.



Aggregations of Pacific nurse sharks (*Ginglymostoma unami*) in a tropical bay exposed to seasonal upwelling in Costa Rica

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Pacific nurse sharks (*Ginglymostoma unami*) are often observed aggregating in Santa Elena Bay, Costa Rica. Here, *G. unami* is exposed to seasonal upwelling from December to April, when water temperatures can decrease as much as 16 °C. As ectothermic organisms, these changes likely induce thermoregulatory behavior, influencing their aggregating behavior. Using aerial drone surveys and passive acoustic telemetry we study occurrence of aggregations and how these may be influenced by water temperature changes during upwelling season. Though *G. unami* are not directly targeted by fisheries in Costa Rica, understanding their ecology in relatively undisturbed conditions can be valuable to inform management in other areas where they are exploited.

Ecological lifestyle and gill slit height across sharks

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Morphology that is linked to metabolic rate—metabolic morphology—provides broad comparative insights into the physiological performance and ecological function of species. Here, we assess the relationship between the metabolic physiology and ecology of nearly all extant sharks. Specifically, we examine the relationship between gill slit height and each of the three traits that comprise ecological lifestyle: activity, maximum size, and depth. Our work demonstrates that meaningful ecophysiological relationships can be revealed through measurable metabolic morphological traits from anatomically accurate drawings.



Session 3-Ecology/Management

Characterizing sounds of beach goers in context of juvenile white shark (*Carcharodon carcharias*) hearing

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Recovery of shark populations due to conservation success along with rising popularity in ocean recreational activities has resulted in higher likelihoods of shark-human interactions, raising concerns for beach safety. However, little is known about how sharks might detect and respond to human activities at coastal beach habitats. Juvenile white sharks have been shown to orient toward people from distances exceeding 20m, which suggests that acoustic-lateralis and olfaction are the two likely stimuli they are responding to. Using hydrophone recordings of swimmers, surfers, and kayakers at standardized paddle rates we describe the differences in frequency bandwidth, power spectra and attenuation of particle acceleration for each activity.

Metabarcoding assessment of juvenile white shark (*Carcharodon carcharias*) prey communities in Southern California

Zach Merson

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Southern California serves as a nursery habitat for juvenile white sharks (JWS). Although temperature is an important factor in JWS habitat selection, JWS aggregate at a much narrower section of beach than is available based on thermal optima. An additional element, such as prey availability, may be driving aggregation site selection. We investigate the relationship between the presence of a JWS aggregation and the prey community using metabarcoding. We took eDNA samples at three aggregation and two non-aggregation sites and found differences between sites and seasons. Benthic elasmobranchs, a preferred JWS prey group, were detected more at non-aggregation sites. We also collected more reef fish and forage fish DNA at aggregation sites.



Socio-economic aspects from the artisanal gillnet fishery targeting elasmobranchs in northern-central Peru

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Elasmobranchs are part of the gastronomy and cultural heritage for Peruvians, mostly in the northern region. In the last years, fishing regulation upon sharks, such as those for hammerheads (*Sphyrna zygaena*), and ordinance measures for sharks' landings are some of the challenges fishermen were forced to contribute to the management of these resources. Based on questionnaire surveys, fishermen declared changes in their captures and a reduction on the benefits due to fishing reduction that is related more to the diminution in trade pricing rather than the reduction of volume in captures. Finally, the main concern is the displacement of fishing efforts from banned species to other species, apparently of less ecological important but with good pricing.

Where do sharks stand? Evaluating marine protected area coverage across the species ranges of shark and rays

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Global conservation agreements often establish targets for international protected area coverage, such as Kunming-Montreal Global Biodiversity Framework's "30x30" target. Here we ask, how does the global footprint of No-Take Marine Protected Areas (MPAs) overlap with species ranges, especially the most threatened sharks and rays? We overlaid known species geographic ranges with current MPA coverage in Exclusive Economic Zones to determine species level MPA coverage. We show that no critically endangered shark or ray has >5% of its range covered by No-Take MPAs. Additionally, of threatened species, 84% have <1% of their range covered. We also take a closer look at the MPA coverage of threatened Northeast Pacific species.



Investigation of a shark diversity “hot spot” in South Puget Sound

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In 2021, an angler posted an image on Facebook of a broadnose sevengill shark, with the capture location “Walker Park, near Shelton WA.” Only one verifiable record existed before this of a sevengill in the Salish Sea. A team from NMFS, the WDFW, and OSU fished the site to find additional sevengills. The team has now caught, measured, fin clipped, tagged, and released nine sevengills; seven of these bear acoustic tags. Using an array of receivers deployed by WDFW colleagues tracking trout, the team has documented movement patterns for 20 months. The team also captured a tope shark, a species previously unknown from south Puget Sound. In summer of 2024, the team will tag additional animals and explore reasons for their occurrence.

Proposed and realized federal protection for elasmobranchs in the North Pacific

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In the last twenty years, NOAA Fisheries has received petitions to consider 57 species for listing under the Endangered Species Act. Of these, 15 are now listed and decisions are still pending on three species. In this brief update, listing considerations for species occurring in the North Pacific Ocean will be summarized, as well as recent and ongoing conservation actions aimed at those species for which listed status has been conferred.



Putting sharks on the map: identifying Important Shark and Ray Areas worldwide to inform marine spatial planning

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Chondrichthyans face a high risk of extinction and immediate action is required to halt population declines. The Important Shark and Ray Areas (ISRA) approach delineates discrete, three-dimensional habitats, important for one or more chondrichthyan species, with the potential to be managed for conservation. The ISRA project, launched in 2022, is working through 13 global regions, bringing together regional experts to identify critical habitats based on science-based criteria. ISRA findings provide the foundation to include these species in decision-making processes related to marine spatial planning. This can help governments and policymakers advance chondrichthyan conservation and meet global biodiversity and conservation targets.

Identifying potential nursery areas for the Galapagos Shark (*Carcharhinus galapagensis*) in the Revillagigedo Archipelago and Clipperton Atoll

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Immature Galapagos sharks has been observed around Clarion Island (CL), situated within the Revillagigedo Archipelago (RA), and Clipperton Atoll (CP), suggesting their potential role as nursery areas. We assessed these regions using the three criteria outlined by Heupel et al. (2007). Significant differences were detected among the islands, CP and CL exhibiting sizes associated with neonates and juveniles. Some individuals from CL and CP exhibited a high average residency index (≥ 0.4). Mitochondrial analysis revealed low differentiation between RA and CP but significant with other Pacific islands. Our results suggest that CL and CP are potential breeding areas for Galapagos sharks and their matrilineal lineage likely originated from AR.



Session 4- Management/Monitoring

Looking to the past to improve future management and conservation of guitarfishes in data-poor fisheries

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In the Mexican Pacific (MP) artisanal fisheries, batoids represent ~20% of elasmobranch catches, and guitarfishes are a significant part of the landings. However, data deficiencies on landings time series and fishing effort challenge their effective management. We reconstructed the historical landings of eight guitarfishes in the MP based on an exhaustive review of extant literature. We also summarize existing biological and ecological data to estimate local extinction risk and to identify priority species to focus future research and assessments. Findings here provide a baseline to advise CITES implementation for the newest guitarfishes listings in a data-poor fishery context and for developing future management and conservation strategies.

Weighing in on Pacific shark fishery management

Sonja Fordham

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The fishery management decisions of the Inter-American Tropical Tuna Commission (IATTC) are integral to the conservation of many Pacific elasmobranchs, including silky sharks, hammerheads, and mobula rays. The 2023 annual IATTC meeting held much promise for tightening inadequate shark fishing limits. In the end, however, IATTC Parties—including the US, Canada, and Mexico—agreed to measures that are weaker than scientists advise. Recent additions to the IATTC staff have grown the organization's expertise in shark science, but public support is lacking. Greater engagement by aquarists, researchers and NGOs is key to ensuring governments take a more precautionary approach to regional shark and ray recovery.



Assessing the economic value of the Munk's pygmy devil ray (*Mobula munkiana*) tourism in Baja California Sur, Mexico

Marine Lucy Bruges

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The Munk's devil ray (*Mobula munkiana*), endemic to the Eastern Pacific, faces vulnerability due to its biology, making it susceptible to fishing. Non-extractive alternatives, like tourism, have emerged, with global manta ray observation estimated at USD\$140 million annually. Baja California Sur sees significant interest in *M. munkiana* tourism, and this study assesses this tourism's economic impact. Surveys in tourists (n=310) and tourism companies (n=15) revealed tourists pay USD\$224.5 per tour, with USD\$109.2 for conservation. On average, tourists spend USD\$353 daily, staying 11.5 days, with tourism companies earning USD\$53,091 per season, totaling about USD\$1,539,651 across 29 registered companies.

Investigating Bacterial Thermogenesis Via In Situ Sampling of a White Shark's Stomach

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For large sharks, metabolic processes can be difficult to study in the wild, but emerging molecular techniques like metabolomics and metagenomics offer new insights into aspects of metabolism like digestion and gut microbiome community composition. Fermentation by gut microbes produces a significant amount of the heat needed by terrestrial endotherms. However, digestive fermentation is poorly documented in marine endotherms like white sharks. Examining the microbial processes in the gut of adult white sharks may help explain their elevated core temperatures and heat budget. We propose a novel tag system for collecting stomach fluid samples to investigate the role of the white shark microbiome in regulating temperature and aiding digestion.



Real-time monitoring of white sharks off California beaches

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As the white shark population in the Northeast Pacific continues to grow, there is increased white shark activity off public beaches in California. Much of this activity is part of well-defined juvenile nursery aggregations, which have resulted in concern for public safety and need for monitoring. A large-scale acoustic tagging program has been in place for over 15 years, consisting of a growing coastal array of underwater acoustic receivers. To provide lifeguards with more rapid monitoring data, we partnered with Innovasea to develop a real-time acoustic receiver buoy system. These buoys, located within 200m of the shoreline provide lifeguards with near real-time acoustic detection/environmental data and buoy diagnostics.

Global Shark and Ray Tracker tool launched for Scalable, Participatory Science and Iterative Conservation Strategies

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Current conservation strategies are not working to protect sharks. To address this critical issue, participatory and citizen science can help unravel trends, evaluate policies, and promote public awareness to push markets towards shark conservation. At the forefront of this effort is our global shark and ray project, eShark, which has been documenting trends since 2008. Today, armed with the new Shark and Ray Tracker™ within the eOceans® app and platform, we aim to massively scale shark science, collaboration, and conservation. This tool empowers all stakeholders and rightsholder to collaborate seamlessly across organizations and regions in real-time. I will discuss the eShark project and invite others across the Pacific northeast to join.



Session 5- Management/Monitoring

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. 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. Additionally, the local artisanal fishing community expressed their concerns that sharks' interactions risked their lives. For these reasons, in 2023, tourist activities on Guadalupe Island were banned.

Using UASs to Assess Juvenile White Shark (*Carcharodon carcharias*) Thermal Habitat Selection in the Monterey Bay

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Since the 2014–2016 Pacific marine heatwave, ranges of many marine species have shifted poleward movement, including white sharks. Due to Monterey Bay being on the cold edge of the white sharks' thermal range, we hypothesized that juvenile white sharks (JWS) select localized areas with higher water temperature, allowing more efficient thermoregulation. We used a small unmanned aerial system (sUAS) to monitor Monterey Bay's coastal waters, taking counts and length estimates of white sharks, combined with water temperature measurements. We found evidence suggesting that habitat use response to temperature was size dependent.



Influence of Environmental Factors on Juvenile White Shark Abundance in the Monterey Bay Area

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Climate warming has shifted marine species' ranges poleward, including juvenile white sharks (*Carcharodon carcharias*). Previous research has documented a climate-driven range shift on a regional scale, but less is known about the fine-scale habitat selection of this endothermic predator at the cold edge of its range. We analyzed high-resolution sea surface temperature (SST), chlorophyll-a, and turbidity obtained via satellite to identify persistent anomalies in relation to juvenile white shark abundance assessed from drone surveys. Preliminary analysis indicates that anomalously warm SST has a significant relationship with white shark abundance.

Locating *Carcharodon carcharias* in Oregon waters

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Little is known about white sharks (*Carcharodon carcharias*) in the Pacific Northwest (PNW). We need to develop more concrete predictions regarding the distributions of white sharks in the PNW to understand their spatial and temporal presence there. Using Geographic Information Systems technology, we mapped marine mammal strandings, acoustic detections and available shark occurrence data over the last 50 years with environmental characteristics in Oregon for the first time. Our preliminary results suggest that white sharks are more prevalent in Oregon between August and December with a broad distribution across the entire coastline. This is the first stage in a broader effort to study white sharks in the PNW.



The Effect of Object Depth and Drone Altitude on Image-Based Shark Length Measurements

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Drone footage can be used for image-based length measurements without the need to handle large species, such as white sharks. However, few studies have tested the accuracy of these measurements. This study assessed how depth of the target object and the altitude of the drone affect the accuracy of measurements of a moving target. We flew a drone directly over an Autonomous Underwater Vehicle (AUV) while it moved freely at 6 separate depths. We captured images at eight separate altitudes. Overall, we observed that at altitudes < 40m, measurements were underestimated by 40-60% in length. Furthermore, depths > 2m significantly affected the accuracy of measurements. We provide an algorithm to correct measurements to account for underestimation.

Bat Ray Residency Within a White Shark Nursery

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Fifteen bat rays, *Myliobatis californica*, were tracked using passive acoustic telemetry in Padaro, CA, a juvenile white shark nursery site. Rays were tracked from June 16–December 7, 2022. We characterized area use, site fidelity, and overall movement patterns within monitoring area. Since JWS are known to feed on bat rays, both species showed high area use overlap.



Session 6- Movement/Behavior

Soupfin Sharks: Unveiling the Trophic Dynamics and Movement Patterns of a Critically Endangered Species

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The soupfin shark (*Galeorhinus galeus*; SFS) is a critically endangered and highly migratory species found seasonally off Oregon and Washington. During the early to mid-20th century, SFS were heavily exploited for their vitamin A-rich livers, leading to the collapse of the fishery and regional population—with uncertain recovery. The status of SFS remains unclear, hindering effective conservation and management. Our project aims to determine the trophic role, habitat utilization, seasonal movement, and effective population size of SFS in the Northeast Pacific. Methods involve capturing and tagging SFS, alongside genetic and dietary analyses. This research aims to provide vital data for SFS management, impacting regional fisheries and conservation efforts.

Seasonal habitat use and inter-island movements of female scalloped hammerhead sharks (*Sphyrna lewini*) in Hawaii

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Scalloped hammerhead sharks are considered globally threatened or endangered across their range, but in Hawaii conservation and management strategies are hamstrung by data deficiency. This largely stems from their enigmatic nature and tendency toward sexual segregation. Here, we present the first ever data documenting seasonal habitat use and inter-island movement patterns of adult female scalloped hammerhead sharks in Hawaii via passive acoustic monitoring.



Automatic identification and tracking of whale sharks (*Rhincodon typus*) from drone videos

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Whale shark seasonal aggregations in coastal areas, like Bahía de Los Ángeles, México, facilitate their monitoring. Drones are an emergent technology for studying sharks in their natural habitat, and in combination with artificial intelligence, we aim to automate the monitoring. We use tracking techniques and develop image classifications from drone-recorded videos to identify, count, and measure individuals and explore their application in more complex tasks. Maintaining precise tracking of these elements, we aim to provide a low-cost tool to improve the ecological knowledge of the species in the area to aid in effective on-site management and conservation measures.

Movements, space use, and energetic requirements of white sharks across ontogeny in the northeast Pacific

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Ontogenetic changes in habitat use and trophic interactions play an important role in the ecology, demography, and ultimately population dynamics of many species. Assumed to be driven by shifting life-history requirements, trophic niche shifts in white sharks (*Carcharodon carcharias*) are well documented, but the accompanying spatial niche shift is poorly understood. While several studies have made inferences of ontogenetic changes in habitat use based on tracking data from different sharks of various size classes, here we tracked 27 individual white sharks tagged as juveniles over many years (mean 3.5 ± 1.9 years) to determine how movements varied during the ontogenetic shift to sub-adult and adult.



Pacific Nurse Shark movement depending on upwelling season

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The Pacific nurse shark (*Ginglymostoma unami*) is an understudied species, and listed as endangered due to overfishing. As ectothermic animals in a coastal benthic habitat, the water temperature of Pacific nurse sharks' habitats can influence the species' movement patterns along the coast. Using passive acoustic telemetry data spanning Santa Elena Bay and Gulf, we compared shark detections during Upwelling and Non-Upwelling seasons to look for trends in thermoregulatory behavior. Santa Elena Bay may serve as an important thermal refuge for sharks during strong upwelling periods.

Class specific seasonal migrations of White sharks in the northeast Pacific

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Spatial and temporal segregation of animals by class (e.g., maturity or sex) within a population can be an important life-history feature to consider in population management and when assessing ecosystem impacts. 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 class-specific movements. We examined sex and stage differences in temporal and horizontal spatial use and vertical behavior. These findings suggest disparate drivers of their seasonal movements and implications for broader management.



The Effects of Anthropogenic Electromagnetic Fields and Geomagnetic Displacement on the Behavior of Skates

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Marine renewable energy facilities convert the kinetic energy of offshore wind, waves, tides, or currents into electricity that is transported through high voltage subsea cables. These cables emit electromagnetic fields (EMFs) into seawater that alter the local geomagnetic field (GMF) and may impact the magnetically based navigation behavior of elasmobranchs. We tested the behavioral response of big (*Beringraja binocularata*) and longnose (*B. rhina*) skates to EMF from cables with fluctuating AC and constant DC electric current. 3D pose estimation software was used to analyze behaviors and we found species-specific effects of EMF-AC and EMF-DC on the velocity, body angle and swimming kinematics of congeneric big and longnose skates.

Effects of tourism on whale shark behavior

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The whale shark (*Rhincodon typus*) is the most popular shark species for tourism worldwide. Little is known about the acceleration forces related to their swimming, as well as their energy expenditure and behavior in the presence of tourists. This study analyzes, with precise numerical information from accelerometers, their swimming behavior with and without tourists to infer, if there is an effect of human interactions during ecotourism and, if so, to maintain good practices or adapt the guidelines indicated for these activities. Preliminary results show that the major trends of avoidance are gradual changes in the lateral and longitudinal axes, indicating left or right turns and a progressive change of acceleration in its course.



Swimming in circles: How electromagnetic fields affect the behavior of skates

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High voltage subsea cables from Marine Renewable Energy installations emit electromagnetic fields (EMFs) that may affect the behavior of EMF-sensitive species. Those species include elasmobranchs, which use electroreceptors to detect the bioelectric fields of prey and possibly the geomagnetic field (GMF) during navigation. To determine the possible impact of EMF on GMF-based behavior, big skates (*Beringraja binoculata*) and longnose skates (*B. rhina*) were repeatedly exposed to GMF and EMF stimuli. Preliminary analysis of video data with BORIS software resulted in no difference in the spatial use of tanks by the skates when exposed to GMF and EMF stimuli. Swimming kinematics analyses using 3D pose estimation software are ongoing.

Searching for Lost Sharks: Extinct or Alive?

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The movie *Jaws* brought a lot of attention to sharks, both good and bad. The negative consequences of sharks being overfished, culled from popular beaches or fished for sport have been well documented. It is hard to find an article, any article, that does not state and restate that sharks are overfished and populations declining globally. However, rarely reported on is the movie gave birth to the modern field of shark science. The field of shark science may eventually have come into its own, but it was this movie that really put sharks in the public conscience. From my perspective, Peter Benchley's real legacy is having brought the plight of sharks out of the shadows and to the forefront of public attention. Without his timely book and an exceptionally well-made blockbuster movie, the fields of shark science and conservation may never have come into being, and the vast majority of sharks would still remain lost from the public's conscience, with many suffering dire consequences!



Session 7- Species recovery/conservation

Ex situ Conservation Assessment for Bowmouth Guitarfish (*Rhina ancylostomus*)

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The bowmouth guitarfish (*Rhina ancylostomus*) is a highly evolutionarily distinct shark-like ray that is declining and critically endangered due to overfishing. In addition to addressing the primary threat of overfishing, further measures are likely needed to avoid extinction and promote recovery of the species throughout its range. The population may be depleted to the point of experiencing Allee effects that inhibit recovery and accelerate further population reduction. To avoid similar dire situations as the disappearance of the Yangtze River dolphin, Baiji (*Lipotes vexillifer*), and precipitous decline of the Vaquita porpoise (*Phocoena sinus*), ex situ conservation actions must be undertaken without delay. The *IUCN Species Survival Commission Guidelines on the Use of Ex situ Management for Species Conservation* highlights the value to be gained from conservation action outside a species' natural habitat, alongside strengthening conservation in the wild. A comprehensive assessment of the potential roles for an ex situ population to contribute to conservation and recovery of bowmouth guitarfish in the wild was convened at Shedd Aquarium in Chicago in November 2023. Despite large data gaps, ex situ roles that contribute to preventing extinction, supporting existing populations, and addressing key knowledge gaps are appropriate to pursue with participation and input of in situ experts. Parallel work should be conducted to ensure in situ conditions are amenable to future translocations. Embedding these ex situ actions into an integrated One Plan Approach is needed to ensure continued persistence and promote recovery of the charismatic bowmouth guitarfish.



Prioritizing Sharks and Rays for Ex situ Conservation

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Over a third of sharks and rays are threatened with extinction. Ex situ populations can serve various roles in preventing extinction and promoting recovery, including breeding and translocations. ReShark is a global collective of >90 partners that leverages the unique expertise and large audience of public aquariums for shark and ray recovery. In alignment with the IUCN guidelines on ex situ conservation, we developed a project filter and decision matrix to decide on which shark and ray species to embark on ex situ conservation efforts for. The initial filter asks three questions: 1) Is the species threatened? 2) Is there a safe place for in situ release? and 3) Is post-release monitoring possible? Our decision matrix then factors in other considerations, including urgency, feasibility, species knowledge, and release site quality. Storytelling potential and the potential to catalyze and amplify other conservation actions are additional factors. Although ex situ conservation is not suitable for all threatened sharks and rays, there are a subset for which such actions will be vital for continued persistence and eventual recovery.

Molecular relatedness-based analyses reveal life history insights in a data limited species: possible evidence for philopatry in sixgill sharks (*Hexanchus griseus*)

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Sixgill, *Hexanchus griseus*, tissue samples were collected over the course of an 18-year period from 2002 through 2019 from Puget Sound, Washington, a known sixgill pupping ground and nursery. Tissue samples were collected opportunistically from a variety of sources. In two cases, dead adult females were dissected, and tissue samples and metadata were also taken from unborn pups. DNA was extracted from a total of 286 individuals resulting in a final Single Nucleotide Polymorphic (SNP) dataset of 274 individuals genotyped at 681 informative biallelic loci, optimized for relatedness-based and neutral population genetic structure analyses. We found no genetic structure across time and space suggesting a single interbreeding population. Relatedness among the



litters of unborn pups from two stranded pregnant females resulted in both full and half siblings with multiple fathers (three in one and four in another) confirming polyandry in sixgills. Close-kin relationships were identified between 47 pairs of individuals of unknown origin. First order relationships (i.e., full siblings or parent-offspring) were identified from samples in four distinct year classes. All of these individuals were classified as subadults, indicating likely full sib pairs. We identified 38 second-order kin pairs (half siblings) that spanned most years of the dataset. Many were between individuals sampled a decade or more apart. It is unlikely that these pairs were half siblings from the same litter. We therefore conclude that these close kin pairs may provide evidence of philopatric behavior of females returning to give birth multiple times in Puget Sound.