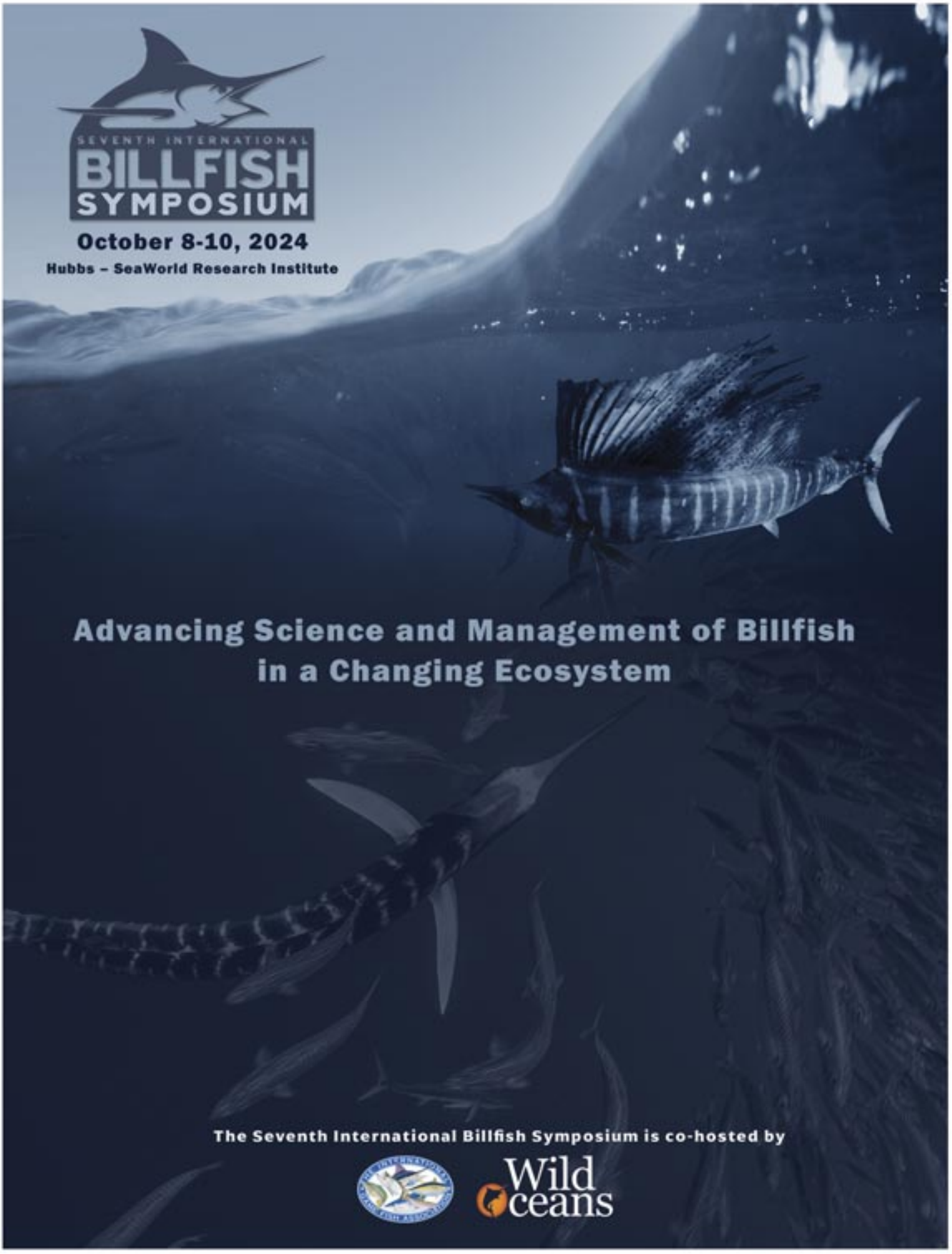
SEVENTH INTERNATIONAL
BILLFISH
SYMPOSIUM
October 8-10, 2024
Hubbs – SeaWorld Research Institute
Advancing Science and Management of Billfish
in a Changing Ecosystem
The Seventh International Billfish Symposium is co-hosted by
Wild
Oceans

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HUBBS SEAWORLD RESEARCH INSTITUTE

Chairmen's Message

Welcome to the 7th International Billfish Symposium!

Dear 7th International Billfish Symposium Attendees,

We are very excited for the IGFA and Wild Oceans to be hosting the 7th International Billfish Symposium at Hubbs-SeaWorld Research Institute in San Diego and we look forward to three full days of stimulating presentations and discussions that advance our understanding of billfish.

Billfish represent an ecologically significant and economically valuable suite of species with global distributions. Yet as important as billfish are, they unfortunately often take a metaphorical research and management back seat to other, usually more commercially valuable, highly migratory species. As such, the International Billfish Symposium series has significant importance as a forum dedicated to discussing aspects of billfish fisheries, biology, and management.

The very first International Billfish Symposium took place 52 years ago and is as relevant today as it was then (Shomura, R. S., and F. Williams, 1974a, 1974b, 1974c). Since that first iteration, symposiums have been held across the globe including Hawaii, Australia, California, Taiwan, and most recently, Florida, where the 6th International Billfish Symposium was held in 2016. Clearly, this symposium series has a rich history of providing a mechanism by which the various research elements can be openly discussed, research findings presented and ideas exchanged, and input from the recreational fishing community proffered. It is our hope that this 7th iteration lays the groundwork for a bright future for billfish research and management. As the years have passed, early discussions of stock status, distribution, socioeconomics, and life-history have evolved with modern techniques and computing to include ecosystem modeling, complex stock assessment modeling, satellite tagging, molecular genetics, and ecosystem-based management. As we move further into the future, we look forward to how future advances such as artificial intelligence will assist the research and management community.

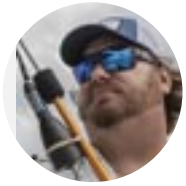
The International Billfish Symposium series has always been supported by the recreational fishing community and we strive to attract anglers to attend and offer their perspectives on billfish science and management. In fact, the third day of this 7th International Billfish Symposium will include presentations discussing research incorporating recreational fishery data and the meeting will end with a discussion on how anglers can assist and support the science and management communities.

In addition to the formal presentation sessions and panel discussions, we've endeavored to create some entertaining social events to allow participants to unwind and network with colleagues from around the world. We believe that oftentimes these informal events are just as important as the structured presentations in forging new scientific relationships and developing new research concepts.

We believe the International Billfish Symposium series provides a contribution to our understanding of billfish science and management that is not duplicated elsewhere. During the meeting, we invite attendees to engage in discussions, both formally and informally, regarding the future of the conference series. Subjects such as how regularly conferences should be held and emerging topics that should be incorporated into future conferences are important issues that can improve the meeting moving forward.

Finally, we'd like to thank all the sponsors that have helped make the 7th International Billfish Symposium come to fruition. As is tradition, funding for this Symposium has come from the recreational fishing community and NOAA Fisheries. We are especially grateful for this year's Grand sponsors, the MidAtlantic Tournament/South Jersey Marina and NOAA Fisheries. Additionally, we would like to express our sincere gratitude to Hubbs-SeaWorld Research institute for hosting.

Sincerely,



Dr. Bruce Pohlot
IGFA Conservation Director
International Game Fish Association

Dr. Gerard DiNardo
Senior Technical Specialist
SCS Global

Shomura, R.L., and F. Williams. 1974a. Proceeding of the International Billfish Symposium Kailua-Kona , Hawaii, 9-12 August 1972: Part 1: Report of the Symposium. NOAA Technical Report, NMFS SSRF-675.

Shomura, R.L., and F. Williams. 1974b. Proceeding of the International Billfish Symposium Kailua-Kona , Hawaii, 9-12 August 1972: Part 2: Review and Contributed Papers. NOAA Technical Report, NMFS SSRF-675.

Shomura, R.L., and F. Williams. 1974c. Proceeding of the International Billfish Symposium Kailua-Kona , Hawaii, 9-12 August 1972: Part 3: Species Synopses. NOAA Technical Report, NMFS SSRF-675.

Contents

Contacts

For more information, contact:

• Bruce Pohlot: **bpohlot@igfa.org**

• Gerard DiNardo: **gdinardo@scsglobalservices.com**

• Eric Combast: **ecombast@igfa.org**

The Seventh International Billfish Symposium is co-hosted by

Keynote Speaker

Dr. Barbara Block

The Migrations & Biology of Billfishes:

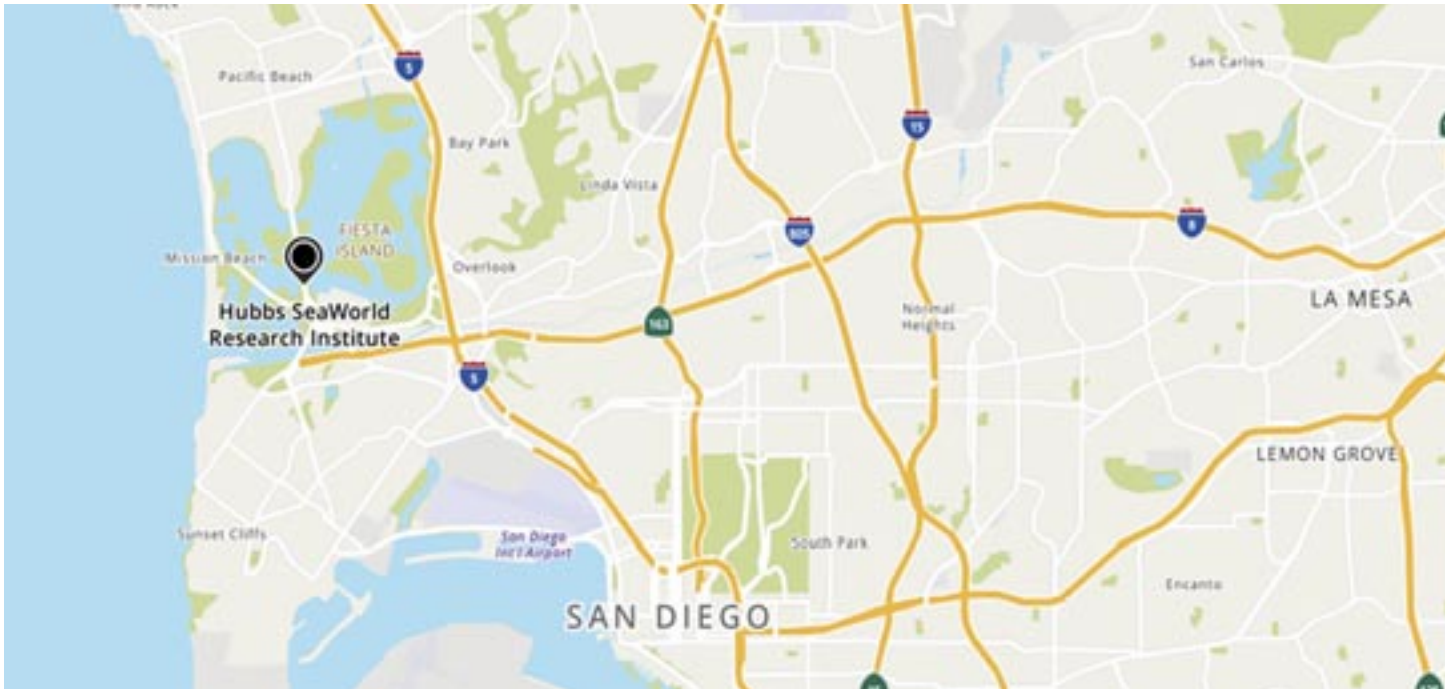
Reflections on the Past, Present and Future

Dr. Barbara Block is the Prothro Professor of Marine Science at Stanford University. Her research is focused on how pelagic fish utilize the open ocean. She and her team have pioneered the successful development and deployment of biologging tags on billfishes, tunas and sharks. Dr. Block co-founded the Tuna Research and Conservation Center at Stanford in 1996, one of the only captive facilities for bluefin tuna research on the planet. Her team studies pelagic fish from a whole organism to genomic perspective with interests in physiology of migrations, thermogenesis, cardiac biology, energetics, reproduction and genomics.

She is founder of the TAG-A-Giant bluefin tuna electronic tagging campaign which to date has put out over 3,000 archival and pop up satellite tags on northern bluefin tunas in the Atlantic and Pacific Oceans. Dr. Block was a co-Chief Scientist for the Tagging of Pacific Predators program (TOPP), organized under the Census of Marine Life. This international program, succeeded in placing 4,500 electronic tags on 23 predators in the California Current to understand how pelagic animals use the North Pacific ecosystem.

Block earned her B.A. at the University of Vermont and initiated her oceanographic career at WHOI in 1979 as Dr. Francis G. Carey's summer intern and later his technician. She earned a Ph.D. in 1986 at Duke University under Dr. Knut Schmidt-Nielsen, and was a postdoctoral fellow at the University of Pennsylvania. She was an assistant professor at the University of Chicago (1989-1993) and joined the Stanford faculty in 1994. Dr. Block and her team have won numerous awards including the National Science Foundation Young Investigator Award, a Pew Marine Fellowship, a Rolex Award for Enterprise and the Benchley Award for Ocean Science. She was inducted into the IGFA Fishing Hall of Fame in 2021 and elected to the US National Academy of Sciences in 2023.

Area Map


Pacific Beach
Bay Park
Linda Vista
FIESTA ISLAND
Mission Beach
Overlook
Hubbs SeaWorld Research Institute
San Carlos
LA MESA
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Quivira Rd
San Diego Whale Watch
Seaforth Boat Rentals & Jet Ski Rentals
Seaforth Marina
Directions to Hubbs-SeaWorld Research Institute
1 Follow the Marina Walkway toward public boat launch.
2 Continue on the Marina Walkway until you pass Dana Landing Tackle Shop.
3 Cross the crosswalk at Ingraham Street, keep to your left and you have arrived.
Approximate walk 8 minutes

General Information

October 8-10, 2024
Hubbs–SeaWorld Research Institute (HSWRI)
2595 Ingraham St.
San Diego, CA 92109

For more information:
Contact the 7th International Billfish Symposium co-chairs:
- Bruce Pohlot**: bpohlot@igfa.org**
- Gerard DiNardo: **gdinardo@scsglobalservices.com**

Food & Beverage Services

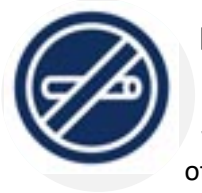
All food and beverage services at Hubbs - Seaworld Research Institute will be held in the courtyard area.

Breakfast will be served daily from 7:30 a.m. to 8:30 a.m. There will be a morning coffee break from 9:45 a.m. to 10:00 a.m. during the Tuesday session and from 9:40 a.m. to 10:00 a.m. on Wednesday and Thursday sessions. The afternoon coffee break will be from 3:00 p.m. to 3:20 each day. Lunch will also be provided each day.

The poster session will take place at HSWRI on Tuesday evening immediately following the session adjournment. Light appetizers and beverages will be served.

Restroom Locations

Restrooms at located in the courtyard area of HSWRI.



No smoking policy

Smoking is not permitted anywhere inside, or on the premises of HSWRI.

Poster Session & Banquet

Scientific posters will be displayed throughout the conference, but authors will be available at their posters during a Poster Reception on Tuesday from 5:00 p.m. - 7:00 p.m. in the HSWRI courtyard. Join us for cocktails and hors d'oeuvres during the poster reception.

The conference banquet will take place on Wednesday evening at The Dana on Mission Point in the Marina Garden. The dinner will include appetizers, dinner, desserts, and alcoholic and non-alcoholic beverages.

Audio Visual (A/V) Upload

Speakers who do not submit talks prior to the meeting should bring a copy of their presentation on a USB memory stick to the A/V Upload located in the back of the HSWRI conference room each morning from 7:00 a.m. to 8:30 a.m. After uploading your presentation, you will have an opportunity to view your presentation. You must ensure the style and format of your presentation is maintained before you leave the A/V upload area. Computer technicians will be available to help you deal with any compatibility issues. Speakers will not be allowed to load presentations directly onto in-session computers nor will they be allowed to use personal laptops.

Committees

Organizing Committee

Gerard DiNardo
Senior Technical Specialist
SCS Global

Bruce Pohlot
IGFA Conservation Director

Rob Kramer
Wild Oceans President

Steering Committee

Martini Arostegui
Postdoctoral Investigator
Woods Hole Oceanographic Institution

Danielle Haulsee
Chief Science Officer, Hubbs-SeaWorld Research Institute

Julian Pepperell
Pepperell Research & Consulting Pty Ltd

Sylvain Bonhommeau
Researcher IFREMER

Nelly Isigi Kadagi
Director of World Wildlife Fund's (WWF) Education for Nature Program and Conservation Leadership and the Co-Principal Scientist of the WIOMSA-MASMA funded BILLFISH-WIO project

Sean Tracey
Centre Head for Fisheries & Aquaculture at the Institute for Marine and Antarctic Studies, University of Tasmania

Yi-Jay Chang
Associate Professor, Institute of Oceanography, National Taiwan University (IONTU)

Anne-Elise Nieblas
International Fisheries Data Consultant, FAO

Nina Wambiji
Assistant Director
Kenya Marine and Fisheries Research Institute

Russell Dunn
Senior Advisor for Recreational Fisheries, NOAA Fisheries

Symposium Schedule

Monday, October 7, 2024		
5:00-7:00	Registration/Welcome	The Dana on Mission Bay (Firefly Garden)

Tuesday, October 8, 2024 ALL EVENTS AT HUBBS-SEAWORLD RESEARCH INSTITUTE (HSWRI)		
7:00-8:30	Presentation Upload for Day 1 Speakers	HSWRI DeMotte Interpretive Center
7:30-8:30	Breakfast	HSWRI DeMotte Interpretive Center
8:30-9:00	IGFA/Wild Oceans/HSWRI Welcome	Jason Schratwieser/Rob Kramer/Don Kent
9:00-9:10	Co-Chairs Welcome	Bruce Pohlot/Gerard DiNardo
9:10-9:45	Keynote Speaker	Barbara Block
9:45-10:00	Coffee break	HSWRI DeMotte Interpretive Center

Movement and Habitat Use Session 1 HSWRI Shedd Auditorium		
10:00-10:20	**Anne-Elise Nieblas** -Company for Open Ocean Observations and Logging (COOOL)	**1** Findings from 111 satellite tags deployed on Indian Ocean billfish during the FLOPPED project
10:20-10:40	**Eric Orbesen** - NOAA Southeast Fisheries Science Center	**2** Movement behavior of white marlin (*Kajikia albida*) satellite-tagged in the Eastern North Atlantic
10:40-11:00	**Barrett Wolfe** - Institute for Marine and Antarctic Studies, University of Tasmania	**3** Movement behaviour of swordfish provisions connectivity between the temperate and tropical southwest Pacific Ocean
11:00-11:20	**Chugey Sepulveda** - Pfleger Institute of Environmental Research	**4** Using electronic tags to inform on swordfish stock structure and fishery development in the Eastern North Pacific
11:20-11:40	**Martin Arostegui** - Biology Department, Woods Hole Oceanographic Institution	**5** Fishery-independent and -dependent movement data aid in defining the stock structure of a data-deficient billfish
11:40-12:00	**Wei Chuan (Riyar) Chiang** - Eastern Fishery Biology Research Center, Fisheries Research Institute, Taiwan	**6** Environmental influences on the vertical movements of blue marlin (*Makaira nigricans*) in the northwest Pacific Ocean
12:00-1:00	Lunch (HSWRI Courtyard)	

Movement and Habitat Use Session 2 HSWRI Shedd Auditorium		
1:00-1:20	**Peter Gaube** - Applied Physics Laboratory, University of Washington	**7** The structuring of open ocean ecosystems by eddies, meanders, and fronts
1:20-1:40	**Samantha Andrzejaczek** - Hopkins Marine Station, Stanford University	**8** Illuminating the effects of the moon: ecological impacts of the lunar cycle on tuna, billfish, sharks and rays

1:40-2:00	**Ryan Logan -** Nova Southeastern University	**9** Patrolling the border: Billfish exploit the hypoxic boundary created by the world's largest oxygen minimum zone
2:00-2:20	**Nima Farchadi** - San Diego State University	**10** The Press and Pulse of Climate Change on Billfish Spatiotemporal Distributions
2:20-2:40	**Camrin Braun** - Biology Department, Woods Hole Oceanographic Institution	**11** Using top predators and novel technologies to explore and understand the deep ocean
2:40-3:00	**Danielle Haulsee** - Hubbs-SeaWorld Research Institute	**12** Two Decades of Electronic Tagging Efforts for Blue Marlin and Sailfish in the Eastern Tropical Pacific
3:00-3:20	Coffee break (HSWRI Conference Room)	

Movement and Habitat Use Session 3 **HSWRI Shedd Auditorium**		
3:20-3:40	**Martin Arostegui** - Biology Department, Woods Hole Oceanographic Institution	**13** Satellite-linked tag technology enables billfish research at finer scales
3:40-4:00	**Jiangang Luo** - Rosenstiel School of Marine, Atmospheric, Earth Sciences, University of Miami	**14** Recent improvements in Geolocation methods: Use of machine learning and ocean models to bridge the gaps in satellite tagging data
4:00-5:00	PSAT Panel Discussion	The Good, The Bad, and The Next Step
5:00-7:00	Poster Session in Courtyard of HSWRI	HSWRI DeMotte Interpretive Center

Wednesday, October 9, 2024 **All Presentations at Hubbs-SeaWorld Research Institute (HSWRI)**		
7:00-8:30	Presentation Upload for Day 2 Speakers	HSWRI Shedd Auditorium
7:30-8:30	Breakfast	HSWRI DeMotte Interpretive Center
8:30-8:40	Welcome to Day 2	Bruce Pohlot/Gerard DiNardo

Biology/Fisheries Session 1 **HSWRI Shedd Auditorium**		
8:40-9:00	**Matthew Hammond** - Charles Darwin University	**15** The role of life cycles in temperature resilience and global billfish distributions
9:00-9:20	**Ciara Willis** - Woods Hole Oceanographic Institution, MIT-WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering	**16** Dining in the deep: Quantifying the contribution of twilight zone food webs to swordfish and tunas across seasonal migrations
9:20-9:40	**Antonella Preti** - Institute of Marine Studies, University of California Santa Cruz	**17** Feeding Ecology of Broadbill Swordfish (*Xiphias gladius*) in the California Current
9:40-10:00	Coffee break at the HSWRI DeMotte Interpretive Center	

Biology/Fisheries Session 2 HSWRI Shedd Auditorium		
10:00-10:20	**Sylvain Bonhommeau** - IFREMER	**18** Biometric and allometric relationships for billfish species in the Indian Ocean: towards a global open database
10:20-10:40	**Nelson Ehrhardt -** Rosenstiel School of Marine, Atmospheric and Earth Sciences, University of Miami	**19** On the long term catch rate trends of Black Marlin, *Istiompax indica*, and Sailfish, *Istiophorus platypterus*, in the eastern-most regions of the Tropical Eastern Pacific Ocean off the coast of Panama
10:40-11:00	**Yi-Jay Chang** - Institute of Oceanography, National Taiwan University	**20** Estimation of the two-stanza growth curves with ageing uncertainty for the Pacific blue marlin (*Makaira nigricans*)
11:00-11:20	**Joseph Dello Russo** - School of Marine Sciences: University of Maine	**21** Diet Composition of Atlantic blue marlin (*Makaira nigricans*), White Marlin (*Kajikia albida*), and Roundscale Spearfish (*Tetrapturus georgii*) in the Mid-Atlantic Bight with Implications for the Atlantic Chub Mackerel (*Scomber colias*) Commercial Fishery
11:20-11:40	**Michelle Sculley** - NOAA/NMFS Pacific Islands Fisheries Science Center	**22** Incorporating Environmental Data into a Stock Assessment Model and Future Population Projections
11:40-12:00	**Roselyn D. Aguila** -Texas A&M University at Galveston	**23** Swordfish population structure of swordfish (*Xiphias gladius L.*) in the Eastern Pacific Ocean based on the combined analysis of genomic SNP data and satellite tracking
12:00-1:00	Lunch at HSWRI DeMotte Interpretive Center	

Biology/Fisheries Session 3 HSWRI Shedd Auditorium		
1:00-1:20	**Jaime Alvarado-Bremer** - Texas A&M University at Galveston, Department of Marine Biology	**24** Distinct evolutionary arrangement of the male billfish urogenital system with implications towards sex identification by external examination
1:20-1:40	**Sylvain Bonhommeau** - IFREMER	**25** Genetic and epigenetics tools to estimate the chronological age and sex of swordfish (*Xiphias gladius*)
1:40-2:00	**Laura Smith** - School of the Environment, The University of Queensland	**26** Sailfish science: building collaborations to delineate the global population structure of a migratory pelagic fish
2:00-2:20	**Thomas Chevrier** - Company for Open Ocean Observations and Logging (COOOL)	**27** Genetic techniques to investigate population structure and estimate population size of Indian Ocean swordfish, *Xiphias gladius*
2:20-2:40	**Jan McDowell** - Virginia Institute of Marine Science	**28** Using Genetics to Further the Understanding of Istiophorid Billfishes: How Far Have We Come?
2:40-3:00	**Jackson Martinez** - Virginia Institute of Marine Science, William & Mary	**29** Taking Stock of the Population Genetic Structure of Striped Marlin, *Kajikia audax*, in the Central North Pacific Ocean
3:00-3:20	Coffee break at HSWRI DeMotte Interpretive Center	

Biology/Fisheries Session 4 HSWRI Shedd Auditorium		
3:20-3:40	**Jhen Hsu** - Institute of Oceanography, National Taiwan University	**30** Applying multi-species spatiotemporal models to guide the reduction of bycatch in longline fisheries
3:40-4:00	**Emilius Aalto** - Hopkins Marine Station, Stanford University	**31** Overlap between Atlantic fishing fleets and distributions of highly migratory pelagic species reveals hotspots of potential management interest
4:00-5:00	Panel Discussion: Current State of Management/Science	What is needed, where do we go from here?
5:00	Adjourn	
6:00-7:30	Dinner at The Dana on Mission Bay	

Thursday, October 10, 2024 ALL EVENTS AT HUBBS SEAWORLD RESEARCH INSTITUTE (HSWRI)		
7:00-8:30	Presentation Upload for Day 3 Speakers	HSWRI Shedd Auditorium
7:30-8:30	Breakfast	HSWRI DeMotte Interpretive Center
8:30-8:40	Welcome to Day 3	Bruce Pohlot/Gerard DiNardo

Biology/Fisheries Session 5 HSWRI Shedd Auditorium		
8:40-9:00	**Andrea Schmidt** - PIFSC/CIMAR	**32** Using a 20-year time series to understand larval habitat and seasonality of four billfish species in West Hawai`i's 'Kona Hotspot'.
9:00-9:20	**Michael Musyl** - Pelagic Research Group LLC	**33** Systematic Review and Meta-Analysis of Larval Istiophorid Distribution Patterns in the Pacific Ocean with Relevance for Management
9:20-9:40	**Yanli Jia** - International Pacific Research Center-University of Hawai`i at Mânoa	**34** Computer simulations of larval billfish movements
9:40-10:00	Coffee break at the HSWRI DeMotte Interpretive Center	

Biology/Fisheries Session 6 HSWRI Shedd Auditorium		
10:00-10:20	**Julian Pepperell** - Pepperell Research & Consulting Pty Ltd	**35** Dear Diary: Fifty years of self-recorded catch-effort data from the black marlin heavy tackle charter fishery off the Great Barrier Reef, Australia
10:20-10:40	**Sean Tracey** - Institute for Marine and Antarctic Studies, University of Tasmania	**36** Evaluation of catch and release practices in a recreational swordfish (*Xiphias gladius*) fishery in southeast Australia
10:40-11:00	**Derke Snodgrass** - NOAA Fisheries Southeast Fisheries Science Center	**37** Estimation of increasing catchability of recreational fishing fleets through the use of magazine data and stock assessment

Biology/Fisheries Session 6 *(continued)* HSWRI Shedd Auditorium		
11:00-11:20	**Daviana Berkowitz-Sklar**- Stanford University	**38** A social-ecological study of a Costa Rica fishery through fisher local ecological knowledge (LEK) and satellite tracking
11:20-11:40	**Nelson Ehrhardt** - Rosenstiel School of Marine, Atmospheric and Earth Sciences, University of Miami	**39** On the seasonal availability and catchability of Sailfish, *Istiophorus platypterus*, in the Tropical Eastern Pacific Ocean off Guatemala
11:40-12:00	**Tristan Guillemin** - School of Natural Sciences, Macquarie University	**40** Interviewing anglers to understand changing catch composition in the 100-year-old east coast marlin fishery
12:00-1:00	Lunch at the HSWRI DeMotte Interpretive Center	

Human Dimensions Session 1 HSWRI Shedd Auditorium		
1:00-1:20	**Jeff Kneebone** - Anderson Cabot Center for Ocean Life at the New England Aquarium	**41** Characterizing recreational fishing effort for billfishes and other pelagic fishes in relation to wind development in the Atlantic, Gulf of Mexico, and US Caribbean
1:20-1:40	**Nelly Kadagi** - World Wildlife Fund	**42** Strengthening capacity for billfish research and science in the Western Indian Ocean
1:40-2:00	**Marina Marrari** - Costa Rican Sportfishing Federation, FECOP	**43** Marine recreational fisheries in Costa Rica: Opportunities for coastal community development
2:00-2:20	**Sylvia Adisa** - University of Florida	**44** Understanding contributions of women in billfish fisheries: A Kenyan case study
2:20-2:40	**Kevin Rafferty** - Halmos College of Arts and Sciences, Nova Southeastern University	**45** Census of Non-U.S. Billfish and Swordfish Recreational Tournaments in the ICCAT Convention Area
2:40-3:00	**Laura Smith** - The University of Queensland	**46** How can we motivate citizen scientists to help uncover the secrets of billfish?
3:00-3:20	Coffee Break at the HSWRI DeMotte Interpretive Center	

Human Dimensions Session 2 HSWRI Shedd Auditorium		
3:20-3:40	**Damian Martinez-Fernandez** - Costa Rican Sportfishing Federation, FECOP	**47** Review of marine recreational fisheries regulations for billfish in Central America
3:40-4:00	**Cliff Hutt** - NOAA Fisheries Office of Sustainable Fisheries, Atlantic Highly Migratory Species Division	**48** Managing the Apex of Sportfish: The Case of U.S. Atlantic Billfish Management
4:00-5:00	Panel Discussion: Recreational Angling Community Input	How can we further leverage the power of this community to progress science and management of billfish?
5:00	Adjourn	

Abstracts

1 Findings from 111 satellite tags deployed on Indian Ocean billfish during the FLOPPED project

Presenting Author: Anne-Elise Nieblas, Company for Open Ocean Observations and Logging (COOOL)
Email : anne.elise.nieblas@company-coool.io

Authors:
Anne-Elise Nieblas, Company for Open Ocean Observations and Logging (COOOL)
Serge Bernard, LIRMM, CNRS
Big Game Fishing Réunion
Blandine Brisset, Délégation Océan Indien, IFREMER
Maxime Bury, Fishing Reunion
Jérémie Chanut, Company for Open Ocean Observations and Logging (COOOL)
Thomas Chevrier, Company for Open Ocean Observations and Logging (COOOL)
Rui Coelho, Instituto Português do Mar e da Atmosfera
Yann Colas, Rod Fishing Club, Rodrigues
Hugues Evano, Délégation Océan Indien, IFREMER
Cyril Faure, L'Oiseaux des Îles, Rodrigues
Gaetan Hervé, Oringa, Mayotte
Vincent Kerzerho, LIRMM, CNRS
Amelie Nithard, Délégation Océan Indien, IFREMER
Ross Newton, Reel Teaser Fishing Adventures
Tracey Newton, Reel Teaser Fishing Adventures
Tristan Rouyer, MARBEC, IFREMER
Sean Tracey, Institute for Marine and Antarctic Studies, University of Tasmania
Josh Worthington, Morjana
Sylvain Bonhommeau, Délégation Océan Indien, IFREMER

The FLOPPED project (2019-2023) aimed to investigate the reproduction zones of five billfish species in the Indian Ocean through a comprehensive data collection initiative, including satellite tagging. Within this project, 111 satellite tags were deployed around the Indian Ocean on blue marlin (*Makaira nigricans*; n=51), black marlin (*Istiompax indica*; n=16), striped marlin (*Kajikia audax*; n=6), swordfish (*Xiphias gladius*; n=7), sailfish (*Istiophorus platypterus*; n=30) and a shortbill spearfish (*Tetrapturus angustirostris*,n=1). Tags were deployed around the Indian Ocean, including around and to the south of Reunion Island, in the waters around Mayotte, Mauritius (Rodrigues), Seychelles, and Australia. Tags were programmed to release from the fish ("pop") after 3 months and up to 12 months. Two tags are still at sea. The other 109 tags have either popped and reported data (n=88) or have surpassed the programmed time with no data received (n=21). The average duration of tag deployment was about 34% of the programmed time, with a maximum deployment duration of 208 days. Position estimates indicate that most individuals of all species tagged in the south-western Indian Ocean tend to swim to the north-west Indian Ocean off Somalia. Though some individuals tagged in the southwestern basin appeared to have a northeastern trajectory, no observations of mixing between the eastern and western basin were observed. Marlin and sailfish inhabit the top 200 meters during the day and restrict their depth range to the upper 50-100 m at night. Swordfish in the southern Indian Ocean have a much deeper distribution and inhabit the top 600 meters during the day, and restrict their depth range to the top 200 m at night.

2 Movement behavior of white marlin (*Kajikia albida)* satellite-tagged in the Eastern North Atlantic

Presenting Author: Eric Orbesen, NOAA Southeast Fisheries Science Center
Email: Eric.Orbesen@noaa.gov

Authors:
Eric Orbesen, NOAA Southeast Fisheries Science Center
Derke J. G. Snodgrass, NOAA Southeast Fisheries Science Center
Jan McDowell, Virginia Institute of Marine Science, College of William & Mary
Joseph E. Serafy, NOAA Southeast Fisheries Science Center

White marlin, *Kajikia albida*, are caught throughout the Atlantic Ocean from latitudes 45N to 45S and are presently managed by the International Commision for the Conservation of Atlantic Tunas (ICCAT) as a single Atlantic-wide stock. The majority of previous studies on white marlin have been conducted in the northwest Atlantic Ocean, and despite the large number of electronic and conventional tags deployed, only a handful of conventionally-tagged fish have exhibited trans-Atlantic or trans-equatorial movements. In the present study, we deployed 13 satellite tags on genetically-confirmed white marlin off the coast of Morocco. The tags reported after 3-210 days-at-large. Five fish exhibited trans-Atlantic movements (defined as crossing the mid-Atlantic ridge), and two fish crossed the equator. These are the first documented trans-Atlantic and trans-equatorial movements for satellite-tagged white marlin. We also examine the depth and temperature selection (vertical habitat use) during their movements within and across eastern Atlantic waters.

3 Movement behaviour of swordfish provisions connectivity between the temperate and tropical southwest Pacific Ocean

Presenting Author: Barrett Wolfe, Institute for Marine and Antarctic Studies, University of Tasmania
Email: barrett.wolfe@utas.edu.au

Authors:
Sean Tracey, Institute for Marine and Antarctic Studies, University of Tasmania
Klaas Hartmann, Institute for Marine and Antarctic Studies, University of Tasmania
Julian Pepperell, Pepperell Research and Consulting Pty Ltd
Sam Williams, School of Biomedical Sciences, The University of Queensland
Barrett Wolfe, Institute for Marine and Antarctic Studies, University of Tasmania

Swordfish (*Xiphias gladius*) are a large-bodied, widely distributed (45°N–45°S) pelagic predator targeted by fisheries worldwide. Swordfish occurring at high latitudes tend to be larger adults, so their movements have implications for population dynamics. In the southwest Pacific the cool-temperate subset of swordfish is largely undescribed but existing evidence suggests limited movement here from the subtropics.
We capitalized on the recent emergence of a recreational swordfish fishery off temperate southeast Australia to characterize movements of swordfish with pop-up satellite archival tags. Data were recovered from tags deployed in the western Tasman Sea (38–43°S) on 11 swordfish (50–350 kg) for 56–250 days. Five swordfish entered the Coral Sea (<30°S), up to 3275 km away from capture. Behavior modelling suggests partial seasonal migration: four swordfish rapidly transited north to 23–27 °C water (potential spawning habitat), where they lingered for several months. One migrating swordfish still carrying a tag post-spawning season returned to ~120 km of its release location, suggesting site fidelity. Swordfish predominantly demonstrated diel vertical migration, descending into the mesopelagic zone at dawn to 495 m (95% CI 460–530 m). At night, swordfish were deeper during full moons, 46 m (38–55 m) versus 18 m (15–22 m) during new moons, and we demonstrate the effect of moon phase

varies dynamically across time of night with implications for fisheries interactions. Tagging highly migratory fishes near range limits enables characterization of the breadth of movement phenotypes present, a key consideration for fish stocks in changing oceans.

4 Using electronic tags to inform on swordfish stock structure and fishery development in the Eastern North Pacific.

Presenting Author: Chugey Sepulveda, Pfleger Institute of Environmental Research (PIER)
Email: Chugey@pier.org

Authors:
Chugey Sepulveda, Pfleger Institute of Environmental Research (PIER)
Scott A. Aalbers, Pfleger Institute of Environmental Research (PIER)

This work reports on swordfish electronic tagging studies performed by the Pfleger Institute of Environmental Research (PIER) in the eastern-north Pacific Ocean (ENPO) from 2011 to 2024. Tagging objectives have addressed questions related to West Coast fishery development work through the Pacific Fisheries Management Council (PFMC) as well as evaluating swordfish stock structure through International Scientific Committee Billfish Working Group. Tagging activities were performed in conjunction with commercial fishing gear development research and resulted in the deployment of >400 electronic tags on 227 individual swordfish since 2011. To date, 34 of the tagged individuals (15%) have been recaptured by national and international fleets. Swordfish tagged off California have exhibited wide-spread seasonal migrations ranging down to the equator (0.8°N/132.0°W) and out towards the Hawaiian Islands (22.0°N/165.0°W). In general, swordfish moved into the West Coast foraging grounds during the summer and fall months before departing towards the warmer subtropical spawning grounds during the winter and springtime. Seasonal migration trends followed two general patterns with swordfish either moving along the Baja California peninsula along the eastern portion of the Pacific Basin or to the southwest towards the Hawaiian Island archipelago. This work did not reveal any trans-equatorial movements and all tracks were confined to the area east of the Hawaiian Islands (165°W). Long term tracks (>365d) showed that some individuals exhibit a high level of site fidelity towards the foraging grounds off Southern California. Collectively these data have been used by regional managers to: (1) Develop a deep-set fishery for the California coast, (2) Refine stock structure estimates for swordfish in the North Pacific and (3) identify putative spawning areas for swordfish in the Eastern North Pacific

5 Fishery-independent and -dependent movement data aid in defining the stock structure of a data deficient billfish

Presenting Author: Martin C. Arostegui, Biology Department, Woods Hole Oceanographic Institution
Email: martin.arostegui@whoi.edu

Authors:
Martin C. Arostegui, Biology Department, Woods Hole Oceanographic Institution
Peter Gaube, Applied Physics Laboratory, University of Washington
Mathew Bowman, Sweet Sadie Sportfishing, Kailua-Kona, HI
Kevin Nakamaru, Northern Lights Sportfishing, Kailua-Kona, HI,
Camrin D. Braun, Biology Department, Woods Hole Oceanographic Institution

The shortbill spearfish (*Tetrapturus angustirostris*) is a data-deficient billfish frequently encountered near the Main Hawaiian Islands where it is taken as non-target bycatch in commercial fisheries. The lack of information on the species' movement and stock structure is a primary management concern given uncertainty in its population dynamics and the lack of a formal stock

assessment. Here, we combine fishery-independent satellite telemetry with fishery dependent conventional tagging to describe the movement ecology of shortbill spearfish in the central North Pacific and contextualize it with respect to stock structure and the management considerations implicit with that structure. We show that shortbill spearfish are highly migratory like other billfishes and large pelagics, exhibiting multiple scales of movement with general fidelity to the region of the Hawaiian Islands and surrounding high seas but no discernible seasonality to their movements. The species' displacements from the island group into areas beyond national jurisdiction result in exposure to multiple distinct commercial fishing fleets, suggesting the need for multi-national cooperation in quantifying harvest. By comparing the limited sources of information on shortbill spearfish with the far more expansive knowledge base of other highly migratory fishes, we suggest a first-order division of stocks between the North and South Pacific. Continued interdisciplinary efforts are needed to confirm and further understand the proposed stock structure.

6 Environmental influences on the vertical movements of blue marlin (*Makaira nigricans*) in the northwest Pacific Ocean

Presenting Author: Wei-Chuan Chiang, Eastern Fishery Biology Research Center, Fisheries Research Institute, Taiwan
Email: wcchiang@mail.tfrin.gov.tw

Authors:
Wei-Chuan Chiang, Eastern Fishery Biology Research Center, Fisheries Research Institute, Taiwan
Shian-Jhong Lin, Eastern Fishery Biology Research Center, Fisheries Research Institute, Taiwan
Michael K. Musyl, Pelagic Research Group LLC
Chi-Lu Sun, Center of Excellent for the Oceans, National Taiwan Ocean University, Taiwan
Sen Jan, Institute of Oceanography, National Taiwan University, Taiwan
Yuan-Shing Ho, Eastern Fishery Biology Research Center, Fisheries Research Institute, Taiwan
Yi-Jay Chang, Institute of Oceanography, National Taiwan University, Taiwan
Gerard T. DiNardo, SCS Global Services

In the open ocean, temperature, hydrostatic pressure, dissolved oxygen, and prey availability are thought to be dominant features that influence acceptable habitat. Satellite tracking of blue marlin (*Makaira nigricans*) has revealed movement patterns that span months and thousands of kilometers across open ocean. 14 blue marlin satellite-tagged between 2010 and 2014 off eastern Taiwan and pop-up satellite archival tags (PSATs) remain affixed from 27 to 360 days-at-liberty. Linear displacements ranged from 56 to 3,759 km from deployment to pop-up locations. Diving depths ranged from the surface to ~441 m and water temperatures occupied ranged from 32.3°C to 6.8°C, and the distributions of time spent at depth were significantly different between daytime and nighttime. Tagged blue marlin spent the majority of daytime in the surface mixed-layer to ~50 m, and at nighttime they were exclusively confined to the surface. The movements of blue marlin appeared to be restricted during the 2010 La Niña. Blue marlin exhibited residency patterns exclusive to the northwest Pacific Ocean during 2010-2013, when sea surface temperatures across the equatorial Eastern Central Pacific Ocean were higher. During 2014, blue marlin undertook movements across the equator and exhibited residency patterns near coastal areas. As a result of low oxygen and/or temperature conditions closer to the surface, the depth distribution of blue marlin was restricted in those areas. It is postulated the El Niño Southern Oscillation (ENSO) affected movement behaviors over temporal and spatial scales by shaping the available thermal habitat of blue marlin. Climate change will drive a complex shift in the three-dimensional distribution of blue marlin. To understand these drivers, it will be important to use other technologies, such as oxygen sensor tags.

7 The structuring of open ocean ecosystems by eddies, meanders, and fronts

Presenting Author: Peter Gaube, Applied Physics Laboratory, University of Washington
Email: pgaube@uw.edu

Authors:
Peter Gaube, Applied Physics Laboratory, University of Washington
Martini Arostegui, Biology Department, Woods Hole Oceanographic Institution
Camrin Braun, Biology Department, Woods Hole Oceanographic Institution

On land, life is structured by mountains, valleys, lakes, streams, etc. In the open ocean, what might appear as a featureless landscape, in fact is a soup of swirling vortices, uncrossable thermal fronts, and current 'highways' that pelagic predators have evolved to use. This presentation will introduce the features that structure pelagic ecosystems and how they are observed from space. We will then present recent results from our work looking at the association of 14 commercially-important pelagic species with mesoscale eddies, rotating bodies of water that can travel for thousands of kilometers and persist for weeks to years. Eddies can be identified in maps of sea surface height and tracked allowing us to analyze fisheries-based observations in a frame of reference that moves with the eddies. This moving frame of reference reveals that 12 of the 14 species analyzed had significant increases in both the odds of encountering as well as how much was caught in the cores of anticyclonic eddies when compared to cyclonic eddies. To conclude we present our hypothesis as to the mechanisms that drive enhanced catch in anticyclones and how fisheries could use these results to optimize efficacy and protect vulnerable species.

8 Illuminating the effects of the moon: ecological impacts of the lunar cycle on tuna, billfish, sharks and rays

Presenting Author: Samantha Andrzejaczek, Hopkins Marine Station, Stanford University
Email: sammyaz@stanford.edu

Authors:
Samantha Andrzejaczek, Hopkins Marine Station, Stanford University
Alexandra E DiGiacomo, Hopkins Marine Station, Stanford University
Chloe S Mikles, Hopkins Marine Station, Stanford University
Camille M Pagniello, Hopkins Marine Station, Stanford University
Theodore EJ Reimer, Hopkins Marine Station, Stanford University
Barbara A. Block, Hopkins Marine Station, Stanford University

The moon's influence on marine ecosystems is a popular subject of discourse among scientists, fishing communities, and the public. As the moon orbits the earth across an approximate 29.5-day cycle, it influences marine ecosystems by altering night-time light availability and shaping the strength and timing of tides. Numerous studies have documented the effects of the lunar cycle on large epipelagic fishes (here referring to tuna, billfish, sharks and rays), however, there has been no concerted effort to systematically compare these patterns across studies. Here, we review a total of 190 studies documenting the effects of the lunar cycle on the ecology of large epipelagic fishes and discuss the potential underlying factors that contribute to the observed patterns. Most studies focused on fisheries science and movement ecology, examining metrics such as catch rate and depth of tagged individuals respectively. A smaller proportion of studies delved into foraging behaviors and behavioral patterns. The effects observed varied among study types and taxa, yet vertical movement patterns consistently indicated a trend of deeper movements with increasing lunar illumination. Many factors likely contribute to this variation, including study specific methods (both field and analytical), local site variation (such as local oceanography and prey distribution), species

specific traits (such as distribution and foraging strategy) and individual traits (such as ontogenetic stage and body condition). We conclude by proposing a framework for future studies on lunar effects, aimed at addressing this variation and promoting comparative analyses.

9 Patrolling the border: Billfish exploit the hypoxic boundary created by the world's largest oxygen minimum zone

Presenting Author: Ryan K. Logan, Nova Southeastern University
Email: rklogn@gmail.com

Authors:
Ryan K. Logan, Nova Southeastern University
Jeremy J. Vaudo, Nova Southeastern University
Bradley M. Wetherbee, University of Rhode Island
Mahmood S. Shivji, Nova Southeastern University

Pelagic predators often contend with low prey densities that are irregularly distributed and dynamic in space and time. Based on satellite imagery and telemetry data, many pelagic predators have been observed to concentrate search behavior on surface fronts—gradients between water masses—due to enhanced local productivity and increased forage fish densities, which tend to be ephemeral. However, vertical fronts (e.g. thermoclines, oxyclines) can be spatially and temporally persistent, and aggregate lower trophic level organisms due to sharp changes in temperature, water density or available oxygen. Thus, vertical fronts represent a stable and potentially energy rich habitat feature for diving pelagic predators but remain little explored in their capacity to enhance foraging opportunities. Here, we use a novel suite of high-resolution biologging data, including in situ oxygen saturation and video, to document how two top predators in the pelagic ecosystem exploit the vertical fronts created by the oxygen minimum zone of the eastern tropical Pacific. Prey search behavior was dependent on dive shape, and significantly increased near the thermocline and hypoxic boundary for blue marlin *Makaira nigricans* and sailfish *Istiophorus platypterus*, respectively. Due to the high-resolution data of the tags, we identify a behavior not yet reported for billfishes, whereby the predator repeatedly dives below the thermocline and hypoxic boundary (and by extension, below the prey). We hypothesize this behavior is used to ambush prey concentrated at the vertical fronts from below, and present an example of such behavior culminating in an assumed successful foraging attempt on video. We suggest that this behavior is likely shared among many pelagic predators where strong vertical fronts occur, and additional high-resolution tagging is warranted to confirm this.

10 The Press and Pulse of Climate Change on Billfish Spatiotemporal Distributions

Presenting Author: Nima Farchadi, San Diego State University
Email: nfarchadi@sdsu.edu

Authors:
Nima Farchadi, San Diego State University
Camrin D. Braun, Biology Department, Woods Hole Oceanographic Institution
Martin C. Arostegui, Biology Department, Woods Hole Oceanographic Institution
Michael Alexander, NOAA Earth System Research Laboratory
Rebecca L. Lewison, San Diego State University

Climate change and variability are altering the structure and function of ecosystems worldwide causing disruption and uncertainty to human and ecological communities. Globally, oceans are experiencing gradual climate trends (e.g. long-term warming; *presses*) as well as extreme events (e.g. marine heatwaves (MHWs); *pulses*) that can push ecosystems in states rarely or

never observed before. These combined climatic presses and pulses pose challenges for the conservation and management of marine predators as they may exhibit divergent responses in the direction and magnitude of redistribution to such novel conditions. Here, we present applications exploring how climate change has and will continue to impact billfish and fisheries in the Northwest Atlantic (NWA) and Gulf of Mexico (GOM). First, we project and compare the distributions for four billfish species - blue marlin, white marlin, Atlantic sailfish, and swordfish - using two downscaled climate models that vary in their ocean modeling frameworks: regional ocean modeling systems and modular ocean models. Our second application used fishing vessel tracking data from the automatic identification system (AIS) to investigate how MHW variability translates to changes in fishing opportunities and the displacement of the U.S. Atlantic pelagic longline fishery, which targets swordfish within the NWA and GOM. Both analyses revealed widespread impacts on billfish and fishery distributions in response to climatic press-and-pulse dynamics, with the U.S. Southeast and GOM regions identified as the most vulnerable to ongoing and future climate-driven changes. As climate change and variability continue to impact billfish distributions, there is an urgent need for developing adaptive and proactive management strategies for dynamic marine ecosystems.

11 Using top predators and novel technologies to explore and understand the deep ocean

Presenting Author: Camrin D. Braun, Biology Department, Woods Hole Oceanographic Institution
Email: cbraun@whoi.edu

Authors:
Camrin D. Braun, Biology Department, Woods Hole Oceanographic Institution
Martin C. Arostegui, Biology Department, Woods Hole Oceanographic Institution
Seth Cones, Biology Department, Woods Hole Oceanographic Institution
Ciara Willis, Biology Department, Woods Hole Oceanographic Institution
Connor F. White, Museum of Comparative Zoology, Harvard University
Peter Gaube, Applied Physics Laboratory, University of Washington
Simon R. Thorrold**,** Biology Department, Woods Hole Oceanographic Institution

The deep ocean comprises ~75% of the global biosphere and hosts the highest vertebrate biomass on Earth. Many large marine predators make excursions from surface waters to the deep ocean, which is a behavioral mode that has evolved independently across marine mammals, reptiles, birds, teleost fishes, and elasmobranchs. The ubiquity of deep ocean habitat use by seemingly epipelagic predators demonstrates this behavior is intricately tied to many fundamental questions in ocean ecology, but the functional role(s) and ecological significance of these movements remain poorly understood. First, we integrate results from 344 tagged individuals from 12 species of pelagic predator, including swordfish and blue marlin, with model predictions of deep prey layers in the North Atlantic Ocean to determine if prey distributions are correlated with vertical habitat use. Using a predictive model, we found clear alignment of predator depth use with the expected location of deep pelagic prey for at least half of the predator species. Our large-scale results suggest that deep pelagic biomass likely has high ecological value for a suite of commercially important predators in the open ocean. However, testing specific interactions between predators and potential prey layers at depth requires new ways to quantify animal behavior and biophysical oceanographic processes at coherent spatio-temporal scales. Therefore, we designed custom multi-sensor “biologger” tag packages to study high performance, deep diving fish predators from the surface to deep ocean. We collected the first high-resolution movement and behavior data from fish predators in the mesopelagic, including broadbill swordfish (*Xiphias gladius*) and bigeye tuna (*Thunnus obesus*). Preliminary results from accelerometers, magnetometers, cameras and depth-temperature sensors provide novel insights ranging from organismal physiology to fundamental mesopelagic ecology.

12 Two Decades of Electronic Tagging Efforts for Blue Marlin and Sailfish in the Eastern Tropical Pacific

Presenting Author: Danielle Haulsee, Hubbs-SeaWorld Research Institute
Email: daulsee@swri.org

Authors:
Danielle Haulsee, Hubbs-SeaWorld Research Institute
Hannah Blondin, University of Miami; NOAA Southeast Fisheries Science Center
Ryan Logan, California State University
Andre Boustany, Monterey Bay Aquarium
Taylor Chapple, Oregon State University
John Dean, University of South Carolina
Michael Domeier, Marine Conservation Science Institute
Eric Hoffmayer, NMFS Southeast Fisheries Science Center
Nicole Nasby-Lucas, NOAA Southwest Fisheries Science Center; University of California
Eric Orbesen, NOAA Southeast Fisheries Science Center
Robbie Schallert, Hopkins Marine Station of Stanford University
Virginia Shervette, University of South Carolina Aiken
George Shillinger, Hopkins Marine Station of Stanford University; Upwell Turtles
Mahmood Shivji, Guy Harvey Research Institute, Nova Southeastern University
Derke Snodgrass, NOAA Southeast Fisheries Science Center
Jamie Walker, The Billfish Research Project
Bradley Wetherbee, University of Rhode Island
Elliott Hazen, NOAA Southwest Fisheries Science Center; University of California; Hopkins Marine Station of Stanford University
Larry B. Crowder, Hopkins Marine Station of Stanford University

The Eastern Tropical Pacific (ETP) Ocean supports vibrant recreational and commercial fisheries targeting tunas and tuna-like species like billfish. However, the population status of many of these species is unclear. Disentangling shifting spatiotemporal distributions of populations from anthropogenic impacts on their populations remains difficult because we lack robust understanding of the occurrence and response to environmental change for these species. To support more informed management efforts, we collated a long-term tagging data set to analyze movement patterns of Indo-Pacific sailfish (*Istiophorus platypterus*) and Pacific blue marlin (*Makaira nigricans*) in relation to various environmental parameters. Our dataset consists of 59 sailfish and 56 blue marlin outfitted with pop-off satellite archival tags deployed between 2003 and 2021 in the Eastern Tropical Pacific. Tag deployments ranged 16-365 days (mean = 81) for sailfish and 16-241 days (mean = 91) for blue marlin. Average distance travelled was slightly longer for blue marlin (mean = 2266.42 km, range = 261.97- 8598.33 km) than sailfish (mean = 1997.21 km, range = 513.19 - 4751.25 km), however most fish remained constrained within the ETP regardless of species. Interestingly, only one blue marlin tagged within the Costa Rican exclusive economic zone displaced over 6,500 km westward into the middle of the Pacific Ocean over the course of 3 months. Our findings reveal that both species exhibit significant residency within the ETP but show variable movement patterns influenced by ENSO phases, with blue marlin moving further offshore during La Niña and inshore during El Niño, while sailfish movements related to ENSO were less pronounced. Analysis of transboundary movements highlight the necessity for cooperative regional management, as these species frequently traverse multiple jurisdictions. This research underscores the importance of integrating climatic variability into management frameworks to better conserve these highly migratory marine predators.

13 Satellite-linked tag technology enables billfish research at finer scales

Presenting Author: Martin C. Arostegui, Biology Department, Woods Hole Oceanographic Institution
Email: martin.arostegui@whoi.edu

Authors:
Martin C. Arostegui, Biology Department, Woods Hole Oceanographic Institution
Peter Gaube, Air-Sea Interaction and Remote Sensing Department, Applied Physics Laboratory, University of Washington
Amie Vo, Wildlife Computers Inc.
Camrin D. Braun, Biology Department, Woods Hole Oceanographic Institution

Satellite-linked transmitters have revealed a wealth of information on the movement ecology of diverse fauna such as marine mammals, turtles, and sharks. In contrast, satellite telemetry studies of bony fishes have almost exclusively relied on archival tags. However, track reconstructions based on archival data exhibit orders-of-magnitude-higher positional error than those based on satellite-linked transmitters, limiting our understanding of the movement ecology of bony fishes to coarse scales. Although archival satellite tags continue to be the technological workhorse of the billfish research field with more than 1000 data records published to date, a handful of pioneering studies have tried using satellite-linked transmitters to better understand these taxa. We assess the applicability of satellite-linked transmitters to billfish in the context of their depth distribution and by comparing alternative tag attachment strategies and form factors. Case studies are presented to highlight how these data can explicitly be used for fine-scale ecological applications. This work culminates with the introduction of a new Smart Position and Temperature (SPOT) transmitting tag designed specifically for billfish and other pelagic fishes that has the potential to open new avenues of research, revealing dimensions of behavior that previously could not be investigated.

14 Recent improvements in Geolocation methods: Use of machine learning and ocean models to bridge the gaps in satellite tagging data

Presenting Author: Jiangang Luo, University of Miami, Rosenstiel School of Marine, Atmospheric, Earth Sciences
Email: jluo@miami.edu

Authors:
Jiangang Luo, University of Miami, Rosenstiel School of Marine, Atmospheric, Earth Sciences
Jerald S. Ault, University of Miami, Rosenstiel School of Marine, Atmospheric, Earth Sciences
Jim S. Franks, Center for Fisheries Research and Development, Gulf Coast Research Laboratory, The University of Southern Mississippi
Barbara A. Block, Hopkins Marine Station, Stanford University
Bruce Pohlot, International Game Fish Association
Michael R. Castleton, Hopkins Marine Station, Stanford University
Jeremy M. Higgs, Center for Fisheries Research and Development, Gulf Coast Research Laboratory, The University of Southern Mississippi
Peter Chaibongsai, The Billfish Foundation

The Ocean Heat Content (OHC) geolocation method of Luo et al. (2015) is known to reveal accurate and detailed migration tracks of satellite-tagged billfish, Atlantic tarpon, and other large pelagic fishes. However, this method requires a complete spatial vertical temperature profile. Due to battery power limitations of satellite tags, there are always substantial gaps in available data for complete vertical temperature profiles. The original OHC method used interpolation to fill these data gaps, whereas our more recent research, uses an advanced machine learning technique utilizing a hybrid community ocean model (HYCOM) to extrapolate these missing values. First, we use interpolation to generate initial vertical profiles and an OHC track.

Then, a second vertical temperature profile is created by combining the actual tag vertical temperature profile and a HYCOM temperature profile given the initial OHC track. Thus, OHC values are updated and used to rerun the OHC track algorithm. These steps are repeated iteratively until OHC values do not change significantly. In this talk we present examples of OHC tracks generated from satellite-tagged fishes in the Gulf of Mexico, North Atlantic, and eastern Pacific Ocean. These refined tracks revealed significant use of fronts and eddies by tagged large pelagic fishes, thus providing extremely valuable information on migration and habitat utilization. This work lends itself to future opportunities for collaborations with additional research groups to reanalyze their historic popup satellite tag data sets to improve our collective understanding of fish migrations, habitat utilization, and fishing gear interactions.

15 The role of life cycles in temperature resilience and global billfish distributions

Presenting Author: Matthew Hammond, Charles Darwin University
Email: matthew.hammond@cdu.edu.au

Authors:
Matthew Hammond, Charles Darwin University
Vinay Udyawer, The Australian Institute of Marine Science
Richard Crabbe, Charles Darwin University
Julian Pepperell, Pepperell Research & Consulting Pty Ltd
Daniel Boyce, Fisheries and Oceans Canada
Keller Kopf, Charles Darwin University

Understanding a species' physical tolerances can be highly informative when predicting how organisms will respond to changing environments. To date, most of the research that has been conducted on temperature tolerances of fishes focuses on adults. This is problematic because a population's resilience to a changing environment is dependent on the most sensitive life stage. This is particularly relevant when trying to understand how billfish will respond to changing ocean temperatures as a result of climate change. Most of the information on thermal tolerances of this group derives from commercial fisheries, bycatch data or electronic tags. Both sources focus almost exclusively on adults. In the present study, ambient water temperature data has been extracted from a much more diverse range of sources to calculate the preferred global mean sea surface temperatures or thermal niches of different life stages for seven billfish species. Mean temperature tolerance data has then been used in conjunction with Intergovernmental Panel on Climate Change (IPCC) predictions and remotely sensed sea surface temperature data from 2023 to compare the water temperature at historically occupied regions to those in 2023, 2050 and 2100. Preliminary results collected from 74 sources suggest that the thermal niche of billfish species changes as they develop, and that spawning adults have the narrowest thermal tolerance, while juveniles and adults have the widest. IPCC projections also predict that mean seasonal sea surface temperatures at many of the locations where the most vulnerable, reproductive life stages occur could be between one and two degrees higher by the year 2100. This study will help to more accurately define the thermal tolerances of billfish populations over their life spans and also predict how billfish might respond to global increases in ocean temperature.

16 Dining in the deep: Quantifying the contribution of twilight zone food webs to swordfish and tunas across seasonal migrations

Presenting Author: Ciara Willis, Woods Hole Oceanographic Institution; MIT-WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering
Email: willis@mit.edu

Authors:
Ciara Willis, Woods Hole Oceanographic Institution; MIT-WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering
Kayla G. Gardner, Woods Hole Oceanographic Institution; MIT-WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering
Martin C. Arostegui, Biology Department, Woods Hole Oceanographic Institution
Camrin D. Braun, Biology Department, Woods Hole Oceanographic Institution
Walt Golet, University of Maine
Leah Houghton, Biology Department, Woods Hole Oceanographic Institution
Joel K. Llopiz, Biology Department, Woods Hole Oceanographic Institution
Simon R. Thorrold, Biology Department, Woods Hole Oceanographic Institution

The ocean's twilight zone is a vast area of the global ocean that lies between the sunlit surface waters and perpetually dark midnight zones, covering depths from c. 200 to 1000 meters. While marine science has historically focused on shallow and nearshore regions, recent work in the twilight (or mesopelagic) zone has revealed unexpected biomass and diversity that may not only challenge scientific understanding of marine systems but also provide a new and largely untapped resource for fisheries harvest. One of the key knowledge gaps in our understanding of the mesopelagic is how its food webs support unquantified foraging activity by commercially valuable, highly migratory top predators. Here, we trace the flow of carbon through pelagic ecosystems in the northwest Atlantic to three predators – bigeye tuna (*Thunnus obesus*), swordfish (*Xiphias gladius*), and yellowfin tuna (*Thunnus albacares*) – via compound-specific stable carbon isotope ratio ($\delta^{13}C$) analyses using a sample collection made possible by collaboration with a commercial longlining vessel and a recreational fishing charter. Mesopelagic-associated carbon was estimated to have contributed greatly to predator biomass with overall mean contributions by species of 63%, 33%, and 51%, respectively. At the individual level, mesopelagic carbon contributions to predators ranged from 8% to 92%. Additionally, we describe the seasonally shifting carbon sources of predators as they move between temperate and tropical waters by contrasting tissues (liver, muscle) and season of sampling (summer, fall). This work informs the motivations of deep diving in large marine predators, and provides key estimates of food web linkages to inform multi-species pelagic fisheries management of both mesopelagic prey and migratory predators.

17 Feeding Ecology of Broadbill Swordfish (*Xiphias Gladius*) in the California Current

Presenting Author: Antonella Preti, Institute of Marine Studies, University of California Santa Cruz; NOAA Fisheries, Southwest Fisheries Science Center
Email: Antonella.Preti@noaa.gov

Authors:
Antonella Preti, Institute of Marine Studies, University of California Santa Cruz; NOAA Fisheries, Southwest Fisheries Science Center
Stephen M. Stohs, NOAA Fisheries, Southwest Fisheries Science Center
Barbara A. Muhling, Institute of Marine Studies, University of California Santa Cruz; NOAA Fisheries, Southwest Fisheries Science Center

Gerard T. DiNardo, SCS Global Services
Camilo Saavedra, Centro Oceanográfico de Vigo, Instituto Español de Oceanografía
Ken MacKenzie, Institute of Biological and Environmental Sciences, School of Biological Sciences, University of Aberdeen
Leslie R. Noble, Faculty of Biosciences and Aquaculture, Nord University
Catherine S. Jones, Institute of Biological and Environmental Sciences, School of Biological Sciences, University of Aberdeen
Graham J. Pierce, [7]Instituto de Investigaciones Marinas; Oceanlab, University of Aberdeen

Diet data can help quantify trophic links across time and space, thereby supporting effective ecosystem-based and climate-ready fisheries management. Diet patterns, by year, linked with oceanographic variables, can be used for predicting future prey abundance and feeding behaviors in similar conditions. The feeding ecology of Broadbill Swordfish (*Xiphias gladius*) in the California Current was described over 17 years (2007-2023). Stomachs were collected by fishery observers aboard commercial drift-gillnet and deep-set buoy gear vessels. Prey were identified to the lowest taxonomic level and diet was analyzed using univariate and multivariate methods. Of 688 Swordfish sampled (74 to 245 cm eye-to-fork length), stomachs contained remains from 77 prey taxa. Diets consisted primarily of cephalopods, epipelagic and mesopelagic teleosts. Jumbo Squid (*Dosidicus gigas*) was the most important prey during 2007-2014. The range expansion of Jumbo Squid during the first decade of this century may explain their prominence in Swordfish diets. Jumbo Squid disappeared from the diet in 2015. In contrast, Pacific Hake (*Merluccius productus*) and Northern Anchovy (*Engraulis mordax*) gained importance in Swordfish diets in recent years, and both have been prominent prey since 2016. Market Squid (*Doryteuthis opalescens*) importance fluctuated by year, but was very high in 2010 and 2018. Swordfish diets also varied with body-size and location. Jumbo Squid, *Gonatus* spp. and Pacific Hake were more important for larger Swordfish, reflecting their ability to catch large prey. Jumbo Squid, *Gonatus* spp. and Market Squid were more important in inshore waters, while *G. borealis* and Pacific Hake predominated offshore. Swordfish size, area, year, and sea surface temperature influenced dietary variation. Diet variation by area and year may reflect differences in Swordfish preference, prey availability, distribution, and abundance. Quantifying Swordfish diets through multiannual time-series can allow us to track changes in ecosystem state and food web structure through time.

18 Biometric and allometric relationships for billfish species in the Indian Ocean: towards a global open database

Presenting Author: Sylvain Bonhommeau, IFREMER
Email: sylvain.bonhommeau@ifremer.fr

Authors:
Sylvain Bonhommeau, IFREMER
Anne Elise Nieblas, Company for Open Ocean Observations and Logging (COOOL)
Emmanuel Chassot, Indian Ocean Tuna Commission Secretariat
Serge Bernard, LIRMM-CNRS
Hugues Evano, IFREMER Délégation Océan Indien
Blandine Brisset, IFREMER Délégation Océan Indien
Jérémie Chanut, Company for Open Ocean Observations and Logging (COOOL)

Biometric relationships and conversion factors are instrumental to convert various types of size measurements performed on fish that may have been processed (e.g., beheaded, gilled-and-gutted) into standard measurements. Harmonizing size measurements (e.g., fork length) is essential to combine different datasets for stock assessment and scientific purposes. In the Indian Ocean, while tuna species are relatively well described, there is a critical lack of information for billfish and the interannual and seasonal variations of these relationships are rarely investigated. To cope with this issue, some of the morphometric relationships used at the Indian Ocean Tuna Commission have been borrowed from studies performed in other oceans

or for similar, but not identical species, which could result in some bias. We present biometric relationships built for the principal market billfish species based on more than 10 000 samples collected at a processing factory between 1992 and 2023. While the relationships fit the data, extending the data collection to other fishing grounds would be useful to provide robust relationships encompassing the entire species distributions. This analysis also shows the need to share and build a global biological database which can be regularly updated and provide the best scientific knowledge. These data could be also used for other scientific needs and could be easily made freely accessible as they are not sensitive.

19 On the long term catch rate trends of Black Marlin, *Istiompax indica*, and Sailfish, *Istiophorus platypterus*, in the eastern-most regions of the Tropical Eastern Pacific Ocean off the coast of Panama

Presenting Author: Nelson Ehrhardt, Rosenstiel School of Marine, Atmospheric and Earth Sciences, University of Miami
Email: nehrhardt@miami.edu

Authors:
Nelson Ehrhardt, Rosenstiel School of Marine, Atmospheric and Earth Sciences, University of Miami
Alexis Peña, Aquatic Resources Authority (ARAP), Panama

The Black Marlin is an epic billfish species that generated a race for the "granders" early in the 1950's. Between 1954 and 1957 the largest and heaviest individuals were all caught in regions of the tropical eastern Pacific Ocean off northern Peru. Due to a significant seasonal availability detected for Black Marlin and Sailfish in regions to the east of the area of influence of the Panama Canal wind-driven upwelling, a billfish sport fishing operation was established in 1964 in a remote region at Bahia Piñas in the Darien Province of Panama. This base of sport billfishing fleet operations allowed access to the billfish resources seasonally available in the region. With the advent of commercial longlining operations in the eastern Pacific in the mid 1960's, billfish were caught incidentally, significantly impacting their abundance in the tropical eastern Pacific Ocean. With the advent of coastal semi-industrial longline fleets in Peru, Ecuador, Panama, and Costa Rica in the early 1990s, a notorious decrease in Black Marlin and Sailfish catch rates have been observed in the sport fishing operations in Panama. In this work I show potential mechanisms regulating the seasonal availability of the species to the sport fishing fleets in eastern Panama as well as some indirect impacts of commercial longlining and critical recruitment trends that correlate with ecosystem-wide trends of major ocean undercurrents prevailing the tropical Pacific Ocean. The combined detrended mechanisms influencing the availability effects on catch rates of Black Marlin and Sailfish in this region allow a better understanding of the need for local as well as regional billfish conservation and management.

20 Estimation of the two-stanza growth curves with ageing uncertainty for the Pacific blue marlin (*Makaira nigricans*)

Presenting Author: Yi-Jay Chang, Institute of Oceanography, National Taiwan University
Email: yjchang@ntu.edu.tw

Authors:
Yi-Jay Chang, Institute of Oceanography, National Taiwan University
Tamaki Shimose, Nagasaki Field Station, Demersal Fish Resources Division, Fisheries Stock Assessment Center, Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Miyuki Kanaiwa, Nagasaki Field Station, Demersal Fish Resources Division, Fisheries Stock Assessment Center, Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Xu-Bang Chang, Institute of Oceanography, National Taiwan University

Takahito Masubuchi, Nagasaki Field Station, Demersal Fish Resources Division, Fisheries Stock Assessment Center, Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Atsuya Yamamoto, Faculty of Bioresources, Mie University
Minoru Kanaiwa, Faculty of Bioresources, Mie University

Age-structured stock assessments are dependent on accurate estimates for age and growth rates. In this study, length-at-age data of the Pacific blue marlin (*Makaira nigricans*) collected among various published and unpublished studies were used to construct growth models to describe the overall growth dynamics of the Pacific blue marlin. Sex-specific growth was modeled by means of the traditional von Bertalanffy growth model (VBGM) and the two-stanza growth model (TSGM), respectively, coupled with the ageing uncertainty. The results of model selection criteria support the use of the TSGM over the VBGM for both sexes. This study suggests that the TSGM coupled with the ageing-error approach appeared to be suitable for modelling the growth of the Pacific blue marlin while VBGM tends to underestimate the median maximum size.

21 Diet Composition of Atlantic blue marlin (*Makaira nigricans*), White Marlin (*Kajikia albida*), and Roundscale Spearfish (*Tetrapturus georgii*) in the Mid-Atlantic Bight with Implications for the Atlantic Chub Mackerel (*Scomber colias*) Commercial Fishery

Presenting Author: Joseph Dello Russo, School of Marine Sciences, University of Maine
Email: joseph.dellorusso@maine.edu

Authors:
Joseph Dello Russo, School of Marine Sciences, University of Maine
Riley Austin, School of Marine Sciences, University of Maine
Zachary Whitener, Gulf of Maine Research Institute
Isabelle Sée, Quahog Bay Conservancy
John Logan, Massachusetts Division of Marine Fisheries
Lisa Kerr, School of Marine Sciences, University of Maine
Joseph Quattro, School of the Earth, Ocean, & Environment, University of South Carolina
Jeffrey Buckel, Center for Marine Sciences & Technology, NC State University
Walter Golet, School of Marine Sciences, University of Maine

The Middle Atlantic Bight (MAB) serves as a crucial foraging ground for several *Istiophoridae* species, including the Atlantic blue marlin (*Makaira nigricans*), white marlin (*Kajikia albida*), and roundscale spearfish (*Tetrapturus georgii*). These highly migratory species support an active recreational fishery in the MAB and their consistent presence has allowed for a series of annual prestigious offshore fishing tournaments. Through this network of tournaments and recreational anglers, we collected stomachs of 30 Atlantic blue marlin, 35 white marlin, and 44 roundscale spearfish from 2018 to 2020 to investigate diet composition. Stomach contents were identified to the lowest taxonomic group possible based on morphological characteristics; highly digested tissue was genetically barcoded. 834 prey items were found which represented 26 families that were organized into 7 higher classifications. Blue marlin diet was predominantly piscivorous as fish prey contributed 98.98% of prey weight. Roundscale spearfish diet also contained substantial contributions from fish (80.34%W and 95.45% FO) but had a higher prevalence of cephalopods (19.37%W and 81.82% FO) compared to blue marlin. In contrast, the diet of white marlin was predominantly cephalopods, which contributed 79.64% to the total prey weight and were found in 74.29% of stomachs, whereas fish prey that was present in 54.29% of stomachs, accounted for 19.86% of the total prey weight. These forage patterns are consistent with the published literature on marlin diet and represent predators specialized to feed on pelagic schooling squids and fishes. Atlantic chub mackerel were identified as natural prey in two white marlin stomachs. This diet composition data was reported to the Mid-Atlantic Fishery Management Council and used as an ecosystem consideration during their stock assessment for Atlantic chub mackerel, which were subsequently added to the Mackerel, Squid, and Butterfish fishery management plan in 2020.

22 Incorporating Environmental Data into a Stock Assessment Model and Future Population Projections

Presenting Author: Michelle Sculley, NOAA NMFS Pacific Islands Fisheries Science Center
Email: michelle.sculley@noaa.gov

Authors:
Michelle Sculley, NOAA NMFS Pacific Islands Fisheries Science Center
Hirotaka Ijima, Fisheries Research Agency, Yokohoma, Japan
Phoebe Woodworth-Jefcoats, NOAA NMFS Pacific Islands Fisheries Science Center
Yi-Jay Chang, Institute of Oceanography, National Taiwan University

It is becoming more and more important to consider climate when managing fish stocks, with climate change poised to play a major role in the sustainability of fisheries into the future. This can be challenging for highly migratory species due to the difficulty of collecting fisheries independent data and large−scale environmental data beyond the remote sensing data available. Furthermore, the value of including environmental data is lessened if we are unable to propagate those data into future short-term projections to provide management advice. The 2018 western and central North Pacific swordfish stock assessment was modified to include environmental covariates to inform recruitment deviations in using Stock Synthesis and into future projections using the projection software SSFutures. We tested several climatological indices for which it was possible to obtain short-term (< 5 years) future estimates including a phytoplankton size composite, the Southern Oscillation Index (SOI), the Pacific Decadal Oscillation (PDO) Index, and the ENSO Oceanic Nino Index. Of these, the SOI has been shown to correlate strongly with swordfish recruitment for the western and central North Pacific stock. We compare multiple climate scenarios to show how environmental variable can change future projections of the WCNPO stock, and highlight the value of continuing work on near-term climatological prediction models.

23 Swordfish population structure of swordfish (*Xiphias gladius* L.) in the Eastern Pacific Ocean based on the combined analysis of genomic SNP data and satellite tracking

Presenting Author: Roselyn D. Aguila, Texas A&M University at Galveston
Email: raguila@tamu.edu

Authors:
Roselyn D. Aguila, Texas A&M University at Galveston
Chugey Sepulveda, Pfleger Institute of Environmental Research
Scott Aalbers, Pfleger Institute of Environmental Research
Giovanni Madrigal, University of Illinois Urbana-Champaign
Michael Hinton, Senior Scientist Emeritus, IATTC
Jaime R. Alvarado Bremer, Texas A&M University at Galveston

Pacific swordfish (*Xiphias gladius* L.) is a eurythermal apex predator found in most tropical and temperate oceanic waters, where it is subject to intense commercial fisheries and is also targeted by recreational fishers. Until very recently, the Eastern Pacific swordfish population was managed as belonging to two stocks–the Eastern Pacific Ocean (EPO) and the Western and Central North Pacific Ocean (WCNPO), as one of several hypotheses of stock membership proposed since the 1980's. Conversely, several genetic studies have shown genetic heterogeneity, but have failed to provide a clear delineation of population subdivision. In other highly migratory fishes with similar Pacific-wide distributions, genome-wide analyses of single nucleotide polymorphisms (SNPs) has revealed genetic structuring (e.g., yellowfin tuna and striped marlin) that could not be resolved with other markers. Here, we characterized 61 swordfish sampled within the Southern California Bight (SCB) using

ddRAD-sequencing to generate SNP data to test seven alternative models of population structure. Each of these swordfish was outfitted with an Argos satellite transmitter to provide a known track history from which a geographic affiliation could be assigned. The genomic analysis of the tracked individuals revealed that more than 83% of the specimens within each region displayed a distinct genomic signature that was respectively geographically affiliated to either the EPO or the WCNPO. Accordingly, this study demonstrates for the first time in Pacific swordfish a significant genomic association with geographically defined regions. These results are consistent with the stock affiliation of SCB swordfish published previously and are consistent with two three-Pacific wide stock models. These findings have important implications towards the management of the Eastern Pacific and the Western and Central North Pacific swordfish populations as separate units and reject the single North Pacific stock model that is being proposed as the working model to manage swordfish.

24 Distinct evolutionary arrangement of the male billfish urogenital system with implications towards sex identification by external examination.

Presenting Author: Jaime R. Alvarado Bremer, Texas A&M University at Galveston, Department of Marine Biology
Email: jaimeab@tamu.edu

Authors:
Jaime R. Alvarado Bremer, Texas A&M University at Galveston, Department of Marine Biology
Ching-Ping Lu, National Taiwan Ocean University
Eric D. Prince (retired), NOAA Fisheries, Southeast Fisheries Science Center
Sascha Cushner, NOAA Fisheries, Southeast Fisheries Science Center
Lawrence R. Beerkircher, NOAA Fisheries, Southeast Fisheries Science Center

Billfish are gonochoristic (i.e., separate sexes at maturity) teleosts that display sexual dimorphism in size-at-age, with females reaching larger body sizes. Without other secondary sexual characteristics, and with substantial overlap in body sizes, size-alone is not a reliable parameter to identify sex. Previously, we reported diagnosable differences between male and female istiophorid billfish by examining the openings within the urogenital groove. Here we report these differences in more detail and discuss the evolutionary trajectories that led to these changes. In primitive fish there is a common discharge of urine and sperm via the mesonephric duct into the cloaca. By contrast, in adult higher teleosts urine and gametes are discharged separately. Urine passes down the mesonephric duct and it is discharged through a urinary pore, whereas sperm travels through the vas deferens and eggs via the oviduct, exiting through respective gonadal pores. Accordingly, both sexes in higher teleost should display two external openings, and with the addition of the anus, three. However, observations of the urogenital groove of billfish by Merrett (1970), while often contradictory, show that male has only two openings: the anus plus the urogenital pore where both urine and sperm are discharged. By contrast, mature female billfish maintain the expected upper teleost arrangement of the three openings in the following order (anterior to posterior): the anus, the egg discharge opening, and the urinary pore. We examined male and female specimens of sailfish and roundscale spearfish and concluded that it is possible to sex billfish by examining the urogenital groove. We discuss the implications of using this approach by observer programs monitoring fisheries.

25 Genetic and epigenetics tools to estimate the chronological age and sex of swordfish (*Xiphias gladius*)

Presenting Author: Sylvain Bonhommeau, IFREMER
Email: sylvain.bonhommeau@ifremer.fr

Authors:
Sylvain Bonhommeau, IFREMER
Matteo Pellegrini, Molecular, Cell and Developmental Biology, University of California Los Angeles,
Michael J Thompson, Molecular, Cell and Developmental Biology, University of California Los Angeles
Anne Elise Nieblas, Company for Open Ocean Observations and Logging (COOOL)
Dominique A. Cowart, Company for Open Ocean Observations and Logging (COOOL)
Thomas Chevrier, Company for Open Ocean Observations and Logging (COOOL)
Serge Bernard, LIRMM-CNRS
Hugues Evano, IFREMER Délégation Océan Indien
Blandine Brisset, IFREMER Délégation Océan Indien
Jérémie Chanut, Company for Open Ocean Observations and Logging (COOOL)

Animal age and sex is a prerequisite for most biological and ecological studies. This information is widely used to track ongoing changes in population dynamics and is fundamental to determine life-history parameters such as growth, age-at-maturity, age-related fecundity. For fish species it can be difficult to collect this biological information as individuals caught at sea are landed without heads and guts leaving no access to gonads and otoliths. DNA methylation at cytosine-phosphate-guanine (CpG) sites is known to change with age and their profiles have been used to develop biomarkers of age known as epigenetic clocks, which predict chronological age with remarkable accuracy. Sex has also been predicted using DNA methylation for different fish species. Here we show that DNA methylation can be used to predict the age and sex for swordfish. We used 96 samples of swordfish with known sex and age estimated from otolith readings. A targeted bisulfite method was used to target an ultra-conserved element of the fish genome. Predictions of age had a mean absolute error of 1.2 years. Sex was predicted with good accuracy. The analysis of DNA methylation seems to be a very reliable way to predict the age and sex of swordfish from a single tissue sample. As we target areas in the genome which are conserved through fish species, these markers may be used for any other species to estimate age and sex.

26 Sailfish science: building collaborations to delineate the global population structure of a migratory pelagic fish

Presenting Author: Laura Smith, School of the Environment, The University of Queensland
Email: laura.smith@uq.edu.au

Authors:
Laura Smith, School of the Environment, The University of Queensland
Samuel Williams, Queensland Department of Agriculture and Fisheries
Bruno Ferrette, Senckenberg Biodiversity and Climate Research Centre
Bonnie Holmes, University of the Sunshine Coast
Nelly Isigi Kadagi, World Wildlife Fund
Ching-Ping Lu, National Taiwan Ocean University
Sofia Ortega-Garcia, Instituto Politécnico Nacional-Centro Interdisciplinario de Ciencias Marinas
Julian Pepperell, Pepperell Research and Consulting Pty Ltd

Ian Tibbetts, The University of Queensland
Nina Wambiji, Kenya Marine and Fisheries Research Institute
Sammy Wambua, Pwani University
Christine Dudgeon, The University of Queensland and University of the Sunshine Coast

The sailfish (*Istiophorus platypterus*) is a highly mobile epipelagic billfish whose range extends across the world's tropics and sub-tropics. Once thought to be different two species in the Indo-Pacific and Atlantic, molecular techniques revealed a single global species in the 1990s. Its patchy but widespread distribution in the open ocean means that it can be challenging to study. Our current understanding of the global population structure of sailfish is limited due to the low number of molecular markers used in previous studies and the difficulty in sampling across its range.

Collaboration with fisheries researchers and the game fishing community has been a key element in building an extensive tissue sampling collection.

The high dispersal and movement ability of marine pelagic species, along with the lack of obvious barriers in the marine environment, can result in dilute genetic signal from population differentiation. My research reveals population structure for sailfish at a finer scale than previously detected by making use of a genome wide approach. I investigated the structure and connectivity among sailfish populations across its circumtropical range in the Indian, Pacific, and Atlantic oceans with a substantial single nucleotide polymorphism (SNP) dataset. Novel genomic population structure provides a baseline and informs future stock assessment and management, particularly where this information is lacking for the Indo-Pacific.

27 Genetic techniques to investigate population structure and estimate population size of Indian Ocean swordfish, *Xiphias gladius*

Presenting Author: Thomas Chevrier, Company for Open Ocean Observations and Logging (COOOL)
Email: t.chevrier.cooolresearch@gmail.com

Authors:
Thomas Chevrier, Company for Open Ocean Observations and Logging (COOOL)
Dominique A. Cowart, Company for Open Ocean Observations and Logging (COOOL)
Anne-Elise Nieblas, Company for Open Ocean Observations and Logging (COOOL)
Grégory Charrier, Univ. Brest, CNRS, IRD, Ifremer, LEMAR
Serge Bernard, LIRMM-CNRS
Hugues Evano, IFREMER Délégation Océan Indien
Blandine Brisset, IFREMER Délégation Océan Indien
Jérémie Chanut, Company for Open Ocean Observations and Logging (COOOL)
Sylvain Bonhommeau, IFREMER Délégation Océan Indien

Reliable estimates of population structure and abundance are key elements for stock assessments. Currently, the Indian Ocean Tuna Commission considers *Xiphias gladius*, an ecologically and commercially important stock, as a single panmictic population and uses abundance indices developed from fisheries-dependent catch and effort data to inform stock assessment models. New advances in genetic sequencing and tools can provide new insights both for the population structure and the population size of this species. Here we apply new genetic sequencing and close-kin mark recapture techniques to first investigate the genetic structure of *X. gladius* in the Indian Ocean and second to develop a fisheries-independent index of abundance of the adult population. To do this, we analyzed Single Nucleotide Polymorphisms (SNPs) from 1 694 swordfish sampled in 23 distinct locations around the Indian Ocean. Using Discriminant Analysis of Principal Components statistical technique, designed to identify and describe clusters of genetically related individuals. Our results highlight the presence of two swordfish

sub-populations in the north and the south of the Indian Ocean. This genetic differentiation may be explained by regions of the genome subject to selection pressure, indicating that both populations are demographically connected but remain differentiated by selective pressure. Secondly, a CKMR approach was applied to the dataset to identify kinship within the sampled individuals. We identified one parent-offspring pair and at least two half-sibling pairs. Though too few kin-pairs were obtained to fit an abundance model, this study confirms that the sample selection and genetic protocols were successful and could be used to scale up and develop a routine CKMR approach for swordfish stock assessment. Current estimates indicate that samples from approximately 15 000 individuals with an adult/juvenile ratio of 1:1 collected over 3 years, would likely provide a more precise estimate and help to decrease key management uncertainties regarding this species.

28 Using Genetics to Further the Understanding of Istiophorid Billfishes: How Far Have We Come?

Presenting Author: Jan R. McDowell, Virginia Institute of Marine Science
Email: mcdowell@vims.edu

Authors:
Jan R. McDowell, Virginia Institute of Marine Science
Nadya R. Mamoozadeh, Virginia Institute of Marine Science
Jackson L. Martinez, Virginia Institute of Marine Science
John E. Graves, Virginia Institute of Marine Science

Over the past 30 years, the Fisheries Genetics Laboratory at the Virginia Institute of Marine Science has used a variety of molecular markers to survey stock structure and evaluate the taxonomic relationships of istiophorid billfishes (marlins, spearfishes, and sailfish), including allozymes, restriction fragment length polymorphism analysis of mitochondrial DNA (mtDNA), sequencing of mtDNA, sequencing of nuclear gene regions, nuclear microsatellite loci, and genotyping-by-sequencing of single nucleotide polymorphisms (SNPs). These analyses have contributed to the understanding of genetic population structure in sailfish, *Istiophorus platypterus* (Shaw in Shaw and Nodder, 1792) and blue marlin, *Makaira nigricans* Lacépède, 1802, in the Atlantic and Pacific oceans, striped marlin, *Kajikia audax* (Philippi, 1887), in the Pacific and Indian oceans, white marlin, *K. albida* (Poey, 1860), in the Atlantic Ocean, and to clarify range uncertainties among the spearfishes (*Tetrapturus*). More recently, genetics have been used to resolve long-standing uncertainty about the relationship of white marlin and striped marlin and to understand the stock composition of striped marlin in the central North Pacific Ocean. This talk will review progress to date and identify knowledge gaps.

29 Taking Stock of the Population Genetic Structure of Striped Marlin, *Kajikia audax*, in the Central North Pacific Ocean

Presenting Author: Jackson L. Martinez, Virginia Institute of Marine Science, William & Mary
Email: jacksonleemartinez@gmail.com

Authors:
Jackson L. Martinez, Virginia Institute of Marine Science, William & Mary
Jan R. McDowell, Virginia Institute of Marine Science, William & Mary
John E. Graves, Virginia Institute of Marine Science, William & Mary

Relative to many highly migratory fishes, Striped Marlin, *Kajikia audax*, exhibit considerable stock structure. At least four genetically distinct stocks of Striped Marlin have been delineated in the Pacific and Indian oceans, however, stock composition in the central North Pacific (CNP) remains unclear and the presence of an additional stock in the North Pacific has been suggested in recent studies. This research aimed to clarify the number of Striped Marlin stocks in the North Pacific and utilize temporal sampling to better understand the stock dynamics of Striped Marlin exploited by the Hawaii-based pelagic longline fishery (HBPLLF). Fishery observers collected 417 samples of Striped Marlin from the HBPLLF from 2019-2020. Of these, 85 samples underwent genotyping-by-sequencing, and the data were co-analyzed with an existing single nucleotide polymorphism (SNP) dataset for 256 Striped Marlin collected from throughout the species' range and reported in a previous study. Clustering analyses of the resulting dataset strongly supported a single North Pacific stock and the Striped Marlin sampled from the HBPLLF clustered into either the North Pacific (NPO; Japan, Taiwan, Hawaii, and California sample locations) or Oceania (New Zealand, western Australia, and eastern Australia sample locations) stocks, indicating mixing of the two stocks in the CNP. A panel of 48 SNPs with the highest power to discriminate between the two stocks was developed and 32 of these loci were used to genotype and assign an additional 325 Striped Marlin collected from the HBPLLF to stock of origin. Overall, 305 of these fish were assigned to stock of origin with high (> 90%) confidence and both stocks were present throughout the sampling period (NPO: 41.3%; Oceania: 58.7%). Temporal changes in stock composition were identified and factors that may influence the stock composition of Striped Marlin in the CNP are discussed.

30 Applying multi-species spatiotemporal models to guide the reduction of bycatch in longline fisheries

Presenting Author: Jhen Hsu, Institute of Oceanography, National Taiwan University
Email: jhene.hsu@gmail.com

Authors:
Jhen Hsu, Institute of Oceanography, National Taiwan University
Zi-Wei Yeh, Institute of Oceanography, National Taiwan University
Yi-Jay Chang, Institute of Oceanography, National Taiwan University
Andre E. Punt, School of Aquatic and Fisheries Sciences, University of Washington

Longline fisheries targeting tunas often result in the incidental capture of species such as swordfish, billfish, and sharks, which can be ecologically and economically challenging. Identifying bycatch hotspots is therefore crucial for effective fisheries management. The recent increase of swordfish bycatch mortality in tuna fisheries north of 20°S in the Southwest Pacific Ocean (SPO) raises concerns about the long-term sustainability of the stock. We used multi-species spatiotemporal models to identify swordfish bycatch hotspots in the SPO north of 200S during 2016-2021 associated with bigeye tuna using the operational data of the Taiwanese longline fisheries. The results of these models are used to identify potential locations for fishery closures given the trade-off between swordfish bycatch reduction and the loss of bigeye tuna catch. Our results found distinct spatial distributions of swordfish and bigeye tuna in the study area, with a negative spatial correlation between the two species. Swordfish exhibit a high-density area east of 140°W and north of 10°S, whereas bigeye tuna are predominantly found in high density in the region north of 20°S. Implementing optimal areas for longline tuna fishery closures within the swordfish hotspot regions east of 140°W and north of 5°S could reduce swordfish bycatch by 14% while retaining up to 95% of the bigeye catch. The findings of this study contribute to a practical framework for understanding and managing the bycatch of non-target species in longline fisheries, highlighting the importance of spatial management strategies.

31 Overlap between Atlantic fishing fleets and distributions of highly migratory pelagic species reveals hotspots of potential management interest

Presenting Author: Emilius Aalto, Hopkins Marine Station, Stanford University
Email: aalto@stanford.edu

Authors:
Emilius Aalto, Hopkins Marine Station, Stanford University
Jonathan Dale, Hopkins Marine Station, Stanford University
Timothy White, Global Fishing Watch
Camrin Braun, Biology Department, Woods Hole Oceanographic Institution
Simon Thorrold, Biology Department, Woods Hole Oceanographic Institution
Greg Skomal, MA Division of Marine Fisheries
Pedro Afonso, Institute of Marine Research, University of the Azores
Christian Jones, [6]Southeast Fisheries Science Center, NOAA
John Walter, Southeast Fisheries Science Center, NOAA
Barbara Block, Hopkins Marine Station, Stanford University

Due to their large ecological niche and high commercial value, highly migratory pelagic species such as bluefin tuna and blue marlin are exposed to fishing pressure across the Atlantic. Although spatial catch and effort data are provided to the International Commission for the Conservation of Atlantic Tunas (ICCAT) under the organization's Task 2 program, the accuracy and representativeness of these statistics are difficult to verify. However, fleet behavior (e.g., vessel course and speed, deployment of fishing gear) can increasingly be monitored using data from ship detection technologies such as the Automatic Identification System (AIS) and a wide range of vessel monitoring systems. At the same time, electronic tagging has provided both direct daily location estimates for individuals of a species as well as broader insights into the suitable seasonal habitat they occupy. Here, we combined tagging-based species distribution maps with estimates of monthly pelagic longline effort derived from AIS data to identify times and regions of high overlap between species and fleet. By comparing these regions with the species-specific CPUEs reported to ICCAT (typically at 5°x5° resolution), we identified combinations of species, regions, months, and fleets that are of potential interest to management of the species. We examined regions where fleets are fishing and used presence data and habitat models to project the potential catch species, allowing us to estimate the accuracy of reported catch records. This approach may be useful to management enforcement agencies and may provide evidence of fleets that are underreporting.

32 Using a 20-year time series to understand larval habitat and seasonality of four billfish species in West Hawai'i's 'Kona Hotspot'.

Presenting Author: Andrea Schmidt, PIFSC/CIMAR
Email: andrea.schmidt@noaa.gov

Authors:
Andrea Schmidt, PIFSC/CIMAR
Jonathan Whitney, National Oceanic and Atmospheric Administration (NOAA)'s Pacific Islands Fisheries Science Center (PIFSC)
Justin Suca, Cooperative Institute for Marine and Atmospheric Research, University of Hawai'i at Mānoa; National Oceanic and Atmospheric Administration (NOAA)'s Pacific Islands Fisheries Science Center (PIFSC)
Jessica Perelman, Cooperative Institute for Marine and Atmospheric Research, University of Hawai'i at Mānoa; National Oceanic and Atmospheric Administration (NOAA)'s Pacific Islands Fisheries Science Center (PIFSC)
Lillian Tuttle Raz, Hawai'i Cooperative Fishery Research Unit (HCFRU) at the University of Hawai'i at Hilo (UHH)

Bruce Pohlot, International Game Fish Association
Tim Grabowski, Hawai'i Cooperative Fishery Research Unit (HCFRU) at the University of Hawai'i at Hilo (UHH)
Rob Kramer, Wild Oceans

Larval fish and other ichthyoplankton are largely understudied across the Hawaiian Archipelago, despite the area's likely importance as a spawning ground, and billfishes are no exception. Details about spawning timing and larval habitat can serve as important first steps toward understanding the environmental factors that drive fish abundance, distribution and thus recruitment variability. Furthermore, identifying essential habitats used by larval and juvenile fishes has become a critical component of Ecosystem-Based Fisheries Management (EBFM) especially for commercially important fisheries species. Researchers from six different organizations have come together to examine the spatial and temporal variability in larval distribution and abundance of four target billfish species (Blue Marlin *Makaira nigrican*s, Striped Marlin *Kajikia audax*, Shortbilled Spearfish *Tetrapturus angustirostris*, and Swordfish *Xiphias gladius*) that are known to spawn in waters off West Hawai'i. This project leverages an underutilized 20-year (1997-2018) time series of neustonic ichthyoplankton collections from West Hawai'i and beyond that has recently been reinvigorated by the Pacific Islands Fisheries Science Center (PIFSC). We compiled a metadataset consisting of collection information for 770 samples from 19 research expeditions spanning 1997 to 2018. A total of nearly 1900 billfish larvae were collected from 6' IKMT and 1m Neuston net trawls as a part of this sampling effort. We obtained species level IDs for larvae that were only identified to family (Istiophoridae) in the collection using genetic barcoding methodology from Hyde et al. 2005. Those, combined with morphologically identified larvae, were examined and yielded species-specific specimen metrics, ratios of billfish community composition by location and temporal variability. This work creates a fundamental baseline of larval billfish presence, density, and associated habitat characteristics off West Hawai'i. This baseline will improve stock assessments related to spawning and recruitment and could also support future efforts to explore impacts of changing ocean conditions on preferred larval habitat.

33 Systematic Review and Meta-Analysis of Larval Istiophorid Distribution Patterns in the Pacific Ocean with Relevance for Management

Presenting Author: Michael Musyl, Pelagic Research Group LLC
Email: Michael.Musyl@gmail.com

Authors:
Michael Musyl, Pelagic Research Group LLC
Lianne McNaughton, TissueGrab Biopsy Systems LLC
Rob Kramer, Wild Oceans

Our initial focus was on scouring available literature to analyze larval istiohphorid distribution patterns in the Pacific. Understanding these patterns is crucial for determining the breadth of spawning and nursery habitats, the variables affecting habitat quality and consistency, and ultimately, the survival rates of larval populations, which influence recruitment trends in fisheries. Our literature search yielded 10 papers meeting our criteria, which collectively provided data on approximately 1000 samples with ~60% collected from 1928 to 1970. Among these samples, roughly 40% included temperature data, 14% contained salinity data, and about 30% included length data. In addition to these papers, we identified supplementary reports that included an estimated 12,000 samples. However, these data were either not publicly accessible, aggregated at broad spatial scales (10°), or lacked clear distinctions in sample sizes on distribution maps due to extensive symbol overlap. Using the collected data, we conducted spatial analyses to assess patterns for randomness. Additionally, by utilizing length data, we approximated the ages of larval specimens to identify potential spawning areas. We also gathered information on salinity and temperature from the reports to further characterize habitat parameters. Our analysis revealed potential new spawning areas and non-uniform distribution patterns among larvae, underscoring the need for additional research on larval istiophorids in the Pacific. This research is essential for comprehending critical habitat elements and predictive factors influencing habitat extent and

quality. We also identified biases in the data arising from species misidentification and measurement/reporting errors. Despite these challenges, our study lays the groundwork, pinpointing gaps in knowledge to guide future research efforts. With sufficient evidence integrated into the existing baseline, it may become feasible to forecast the quality and quantity of spawning and nursery habitats. This, in turn, could enable the estimation of adult abundance indices across various spatial and temporal scales, offering valuable insights for fisheries management and conservation efforts.

34 Computer simulations of larval billfish movements

Presenting Author: Yanli Jia, International Pacific Research Center, University of Hawai'I at Mānoa
Email: yjia@hawaii.edu

Authors:
Yanli Jia, International Pacific Research Center, University of Hawai'I at Mānoa
Michael K. Musyl, Pelagic Research Group LLC

Knowledge of billfish spawning habitats and larval billfish movements is key to protection of a healthy population. As a first step, we explore larval dispersal and connectivity between areas where larval billfish have been found to determine the most likely spawning origins by utilizing a computer tracking program and the flow fields from an ocean circulation model. The concept is simple. For each larval sample represented by a synthetic particle (a virtual larva), tracking begins from the time and location of its capture, moves backward in time, and continues for a duration concordant with its estimated age. The end location is then considered its most likely spawning origin. This method can be used to estimate the origins of any larval fish. We have applied it to larval billfish samples collected in Kona which is off the west coast of the island of Hawaii and around Cross Seamount which is situated some distance to the southwest of Kona. The tracking results show that younger larvae (≤ 7 days) are most likely spawned near their capture locations in Kona or around Cross Seamount. If older larvae (≈ 14 days) can still be considered remaining in their passive planktonic state (i.e., freely drifting propagules by the flow environment), then there is a possible connectivity between Kona and Cross Seamount (i.e., larvae found in one location may have originated in the other). The accuracy of larval origins determined by this method relies heavily on the conditions that the larval fish are totally passive when riding with the ocean currents and the flow fields generated by the ocean circulation model are a realistic representation of the ocean. We will discuss these assumptions and other limitations of this method and future improvements.

35 Dear Diary: Fifty years of self-recorded catch-effort data from the black marlin heavy tackle charter fishery off the Great Barrier Reef, Australia

Presenting Author: Julian G. Pepperell, Pepperell Research & Consulting Pty Ltd
Email: julianp@internode.on.net

Authors:
Julian G. Pepperell, Pepperell Research & Consulting Pty Ltd
Barrett W. Wolfe, Institute for Marine and Antarctic Studies, University of Tasmania
Sam M. Williams, School of Biomedical Sciences, The University of Queensland
Sean R. Tracey, Institute for Marine and Antarctic Studies, University of Tasmania

The first capture of a 1000 pound black marlin off the northern Great Barrier Reef (GBR) in September 1966 initiated the rapid development of a charter fishery that has operated every year to the present day. The fishery has a distinct 2.5 month-long season, covers the same area off GBR each year and has used essentially similar fishing methods over its history.

For the first three decades of the fishery there was no mandatory logbook requirement. Fortuitously though, it was found that some charter captains had kept detailed personal diaries or logs of daily and/or seasonally summarised catch-effort records. These records nearly always took the form of numbers of black marlin raised (ie, following baits), bites/strikes, hooked-up and caught – either boated, tagged or free-released with no tag. Specific locations and estimated or actual sizes of fish were also usually included in the daily records.

A previous study analysed catch-effort data for this fishery extracted from such personal diaries and logs covering 4022 fishing days between 1970 and 1997. The current study repeated this exercise for the years 1998 through 2022, gathering 4911 daily records and a further 965 days of season summaries.

Data for both periods were merged to form a 53 year unbroken record of catch and effort. Fluctuations and trends in CPUE were analysed and possible explanatory environmental relationships explored. The study also compared personal diary data with mandatory logbook records required since the late 1990s by the Queensland Government. Lastly, incremental changes in equipment and methods used in the fishery over the 53 year time span were examined with a view to standardization of CPUE.

36 Evaluation of catch and release practices in a recreational swordfish (*Xiphias gladius*) fishery in southeast Australia

Presenting Author: Sean R. Tracey, Institute for Marine and Antarctic Studies, University of Tasmania
Email: sean.tracey@utas.edu.au

Authors:
Sean R. Tracey, Institute for Marine and Antarctic Studies, University of Tasmania
Julian G. Pepperell, Pepperell Research & Consulting Pty Ltd
Barrett Wolfe, Institute for Marine and Antarctic Studies, University of Tasmania

Swordfish (*Xiphias gladius*) are large, economically and ecologically important predatory fish with a wide circumglobal distribution. While swordfish are coveted by anglers, development of recreational fisheries has been limited historically, due in part to the species' tendency to migrate into the mesopelagic zone during the day (effectively out-of-reach of typical game fishing methods). Recently, however, the adoption of 'deep-dropping', targeting swordfish during day-time with baits at >300 m depth, has expanded access to the fish and led to the emergence of new regional fisheries. One such fishery emerged in the temperate waters of southeast Australia in 2014 and since has set a series of record-sized swordfish catches. To inform development of best practices for recreational swordfish fisheries, we present the first assessment of capture-related morbidity and post-release survival of swordfish caught deep-dropping in southeast Australia. Overall, the estimated survival rate for landed swordfish was 44% (n = 25). Severe abdominal distension and deep/gill-hooking injury were strong predictors of reduced survival. Among swordfish in suitable condition for release, affixed PSAT tags indicated 85.6% (n = 13) survived after release, with several undergoing equatorial migration into the tropical Coral Sea.

While recreational swordfishing may superficially appear similar to istiophorid billfish game fishing, the catch-and-release ethos typical of billfish game fishing does not appear to be appropriate here: these results suggest swordfish caught deep-dropping are a poor candidate for purely catch-and-release angling. Predictors of post-release mortality are readily observable, so fishers should be prepared to humanely dispatch fish exhibiting internal hooking injuries or severe abdominal distension.

37 Estimation of increasing catchability of recreational fishing fleets through the use of magazine data and stock assessment

Presenting Author: Derke J. G. Snodgrass, NOAA Fisheries Southeast Fisheries Science Center
Email: derke.snodgrass@noaa.gov

Authors:
Derke J. G. Snodgrass, NOAA Fisheries Southeast Fisheries Science Center
Francesca Forrestal, NOAA Fisheries Southeast Fisheries Science Center
Amy M. Schueller, NOAA Fisheries Southeast Fisheries Science Center
Michael J. Schirripa, NOAA Fisheries Southeast Fisheries Science Center
Eric S. Orbesen, NOAA Fisheries Southeast Fisheries Science Center

A multitude of changes in vessel size and electronic equipment over time has led to changes in the recreational fishery for billfish, which has had an increase in the fishery's ability to locate and catch fish. The majority of these changes have originated from or been heavily influenced by USA participants. For much of the history of the recreational fishing fleet, media outlets have included stories that are intended to educate and involve fishers. The utilization of the content of these forms of media could be a data mining source for representative information pertaining to the evolution of the billfish fishery. The available magazine media were used to collect data on the size of vessels in new and brokerage advertisements and electronic aids or assistance from 1982 to 2022. These data were used to estimate a change in the mean vessel size or the fishing power over time of the fleet mediated by factors such as whether the vessel is new or brokerage, electronic assistance, and month. Fishing power changes served as a proxy of changes in catchability of the fishery fleet for the stock assessment. The fishing power index estimated in this analysis was then incorporated into the standardization of the United States recreational tournament fishery dependent index of abundance for sailfish. This index was then included in the stock assessment to determine the impacts to stock status. Rates of change in catchability were compared across methods including raw data, standardized data, and with several options within the sailfish stock assessment. These data and analyses will be applicable to not only sailfish, but also for other billfish fisheries because changes in the fishery fleet and therefore catchability have occurred over time.

38 A social-ecological study of a Costa Rica fishery through fisher local ecological knowledge (LEK) and satellite tracking

Presenting Author: Daviana Berkowitz-Sklar, Stanford University
Email: daviana@stanford.edu

Authors:
Daviana Berkowitz-Sklar, Stanford University
Danielle Haulsee, Hubbs-SeaWorld Research Institute
Hannah Blondin, University of Miami; NOAA Southeast Fisheries Science Center
Ryan Logan, California State University Long Beach
Andre Boustany, Monterey Bay Aquarium
Taylor Chapple, Oregon State University
John Dean, University of South Carolina, University of South Carolina
Michael Domeier, Marine Conservation Science Institute
Eric Hoffmayer, NMFS Southeast Fisheries Science Center
Nicole Nasby-Lucas, NOAA Southwest Fisheries Science Center; University of California
Eric Orbesen, NOAA Southeast Fisheries Science Center

Robbie Schallert, Hopkins Marine Station of Stanford University
Virginia Shervette, University of South-Carolina Aiken
George Shillinger, Hopkins Marine Station of Stanford University; Upwell Turtles
Mahmood Shivji, Guy Harvey Research Institute; Nova Southeastern University
Derke Snodgrass, NOAA Southeast Fisheries Science Center
Jamie Walker, The Billfish Research Project
Bradley Wetherbee, 20University of Rhode Island
Elliott Hazen, NOAA Southwest Fisheries Science Center; University of California; Hopkins Marine Station of Stanford University
Larry B. Crowder, Hopkins Marine Station of Stanford University

Local ecological knowledge (LEK) is increasingly being recognized as a valuable component of ecological modeling, including in the creation of species distribution models (SDMs). SDMs are used to make inferences about the distribution of suitable habitat for species of interest and can provide valuable information about the occurrence of these species. However, data and monitoring limitations can be especially pronounced in remote areas, creating a need for affordable, reliable, and timely information. In fisheries studies, incorporating LEK from fishers may be a valuable way to fill data gaps in predicting fish species occurrence over spatiotemporal scales, and can be useful for marine spatial planning. In this study, we investigated the spatiotemporal and biophysical characteristics of a billfish fishery in Costa Rica through a mixed methods approach combining satellite tracking data of sailfish (Istiophorus platypterus) and blue marlin (*Makaira nigricans*), and sport fisher LEK elicited through semi-structured interviews and participatory mapping. To compare these two methods for understanding billfish distribution, we created SDMs using either satellite tag data or LEK participatory maps for billfish occurrences and examined the environmental profiles within the satellite tracking and participatory map locations. Overall, we found that although participatory mapping of fishing grounds is confined by distance to shore, the fisher-mapped sailfish and blue marlin niches overlap with several spatial and environmental features revealed by satellite tracking data. From this case study, we suggest key considerations that are important when incorporating LEK and other ecological monitoring methods for ecological modeling and marine management. Our findings provide a social-ecological perspective of the Costa Rican billfish fishery while assessing the utility of fisher's knowledge in addressing data gaps in ecological models of commercially and ecologically important billfish in Costa Rica and other data-poor fisheries around the world.

39 On the seasonal availability and catchability of Sailfish, *Istiophorus platypterus*, in the Tropical Eastern Pacific Ocean off Guatemala

Presenting Author: Nelson Ehrhardt, Rosenstiel School of Marine, Atmospheric and Earth Sciences, University of Miami
Email: nehrhardt@miami.edu

Authors:
Nelson Ehrhardt, Rosenstiel School of Marine, Atmospheric and Earth Sciences, University of Miami
Bruce Pohlot, International Game Fish Association
Julie Brown, Cooperative Institute of Marine and Atmospheric Science-NOAA/University of Miami

Sailfish in the tropical eastern Pacific Ocean off Guatemala support historically important sport fisheries with catch rates that are one of the highest in the world. Complex seasonal oceanographic regimes prevail in the region generating driving biophysical conditions that frame the availability and recruitment of the species to the sport fisheries. A small sport fleet operates from a single marina located in the only natural port available on the country's Pacific coast. Fishing grounds are well-defined in areas 40 to 70 nm offshore and characterized by a seasonally compressed habitat due to shallow dissolved oxygen influenced by

seasonal upwelling regimes to the east and west of the Guatemalan coast. In this work we present the first statistical deconstructing evaluation of regional and localized oceanographic regime effects on seasonal sport Sailfish catch rates realized over a period of 30 years. The co-occurring environmental variables and events affecting catch rates generate meaningful parameters for governance purposes. The results are compared with sailfish catch rates observed in neighboring regions; allowing a more comprehensive understanding of regional ecosystem conditions over more extensive regions, framing Sailfish habitat use in the study area.

40 Interviewing anglers to understand changing catch composition in the 100-year-old east coast marlin fishery

Presenting Author: Tristan A, Guillemin, School of Natural Sciences, Macquarie University
Email: tristan.guillemin@hdr.mq.edu.au

Authors:
Tristan A, Guillemin, School of Natural Sciences, Macquarie University
Julian G. Pepperell, Pepperell Research and Consulting Pty Ltd
Leah Gibbs, University of Wollongong
Jane E. Williamson, School of Natural Sciences, Macquarie University; Sydney Institute of Marine Science

As our world evolves and changes, so do our fisheries, and understanding these changes is key to their management. As scientists, we often focus on environmental or biological changes as these are easily measurable and analysable. However, social aspects can also be key drivers of fishery change, but are often overlooked by scientists who routinely value quantitative over qualitative data. The east coast of Australia is home to one of the world's oldest recreational marlin fisheries. Analyses of game fishing club records (1933-2022) and data from the NSW Department of Primary Industries (DPI) recreational gamefish tagging program (1973-2022) revealed long term changes in species composition of the catch. To understand the drivers of these changes, we conducted surveys of marlin anglers at fishing tournaments and online, and interviewed a subset of anglers to record changes they had observed during their time in the fishery. Anglers identified a range of factors that had changed over time including: improvements in boats facilitating fishing effort further offshore; adoption of new technologies such as sounders, GPS and sonar; and increased knowledge of fishing techniques specific to the different marlin species. Many of the changes that anglers identified and the timing of these changes aligned with changes observed in species composition of the catch data. This research highlights the importance of considering social aspects alongside traditional biological and ecological analyses in understanding and managing fisheries.

41 Characterizing recreational fishing effort for billfishes and other pelagic fishes in relation to wind development in the Atlantic, Gulf of Mexico, and US Caribbean

Presenting Author: Jeff Kneebone, Anderson Cabot Center for Ocean Life at the New England Aquarium
Email: jkneebone@neaq.org

Authors:
Jeff Kneebone, Anderson Cabot Center for Ocean Life at the New England Aquarium
Matthew Davis, Department of Marine Resources, State of Maine
Ryan Knotek, Anderson Cabot Center for Ocean Life at the New England Aquarium
Connor Capizzano, Anderson Cabot Center for Ocean Life at the New England Aquarium
Edward Kim, Anderson Cabot Center for Ocean Life at the New England Aquarium
Camilla T. McCandless, Northeast Fisheries Science Center
Peter Chaibongsai, The Billfish Foundation

Wessley Merten, Beyond Our Shores Foundation Dolphinfish Research Program
Eric S. Orbesen, NOAA/NMFS, Southeast Fisheries Science Center

The expansion of offshore wind interests in US waters has raised concern over potential adverse impacts to fisheries activity and productivity. Yet evidence-based platforms for assessing those impacts are lacking for many recreational fisheries, including those targeting highly migratory species (HMS; billfishes, tunas, and sharks). We demonstrate how data from a federal fishery survey [Large Pelagics Intercept Survey (LPIS)], cooperative tagging programs, and the direct survey of recreational fishermen can be used to characterize the spatial extent of baseline (pre-construction) effort in a recreational fishery that targets HMS in US territorial waters of the Atlantic, Gulf of Mexico, and Caribbean. To document the location of effort, LPIS catch data and tag, release, and recapture (CTR) records from four cooperative tagging programs were independently aggregated onto a grid of offshore wind lease blocks. An online survey of recreational fishermen was also executed to assess the spatial extent of effort in relation to a Draft Call Area (DCA) in the Gulf of Maine region. Collectively, the LPIS and CTR data described widespread recreational fishing effort for HMS, including within and around the majority of existing and planned offshore wind lease areas. Responses to the online survey revealed more widespread effort within the Gulf of Maine DCA than both the LPIS and CTR data, but some respondents may have overrepresented true levels of fishing effort. Our results demonstrate the need for multiple data types to comprehensively assess offshore wind impacts on the recreational HMS fishery and to inform marine spatial planning in regions into which offshore wind energy development may be expanded.

42 Strengthening capacity for billfish research and science in the Western Indian Ocean

Presenting Author: Nelly Isigi Kadagi, World Wildlife Fund
Email: nellykadagi@gmail.com

Authors:
Nelly Isigi Kadagi, World Wildlife Fund
S. Ater, Technical University of Mombasa, Kenya
Nina Wambiji, Mpala Research Centre, Kenya

The engagement of students and early career researchers is necessary for sustaining the pipeline of evidence-based science, conservation and policy to address environmental challenges and achieve effective leadership. However, recent years have seen a growing need for adequate expertise at the rates of which the prevailing capacity development systems and speed may fail to meet the increasing demand. Against this backdrop, regional and national institutions in the Western Indian Ocean (WIO) have continued to support efforts to enhance capacities and ensure a critical mass of early career researchers.
We provide a case study for successes, lessons, challenges and opportunities for capacity development and sharing using the BILLFISH-WIO project. The BILLFISH-WIO (Billfish Interactions, Livelihoods and Linkages for Fisheries sustainability in the Western Indian Ocean), a regional research on billfish that spans across 10 countries and brings together diverse collaborators, early career researchers and students. Our study aimed to examine the criteria, processes and changes, as well as outcomes for engaging students and early career researchers in billfish research to provide examples of practices and strategies for enhancing capacity for science, research, policy and leadership for the ocean Decade in the WIO.

43 Marine recreational fisheries in Costa Rica: Opportunities for coastal community development

Presenting Author: Marina Marrari, Costa Rican Fishing Federation, FECOP
Email: mmarrari@fecop.org

Authors:
Marina Marrari, Costa Rican Fishing Federation, FECOP

Marine recreational fisheries have an estimated global socio-economic importance of US$ 40 billion/year and have grown steadily becoming a major source of tourism and development in many countries. Although it has been shown that they provide important opportunities for the development of coastal communities, they are often overlooked by fishing authorities and the dynamics and socio-economic impact in many countries are poorly understood. In Central America, fishing tourism has grown considerably over the past decades and several recent research initiatives have focused on studying some of the main target species, including sailfish and marlins, and the conditions that favor the high abundances often observed in the region. In Costa Rica, sportfishing and fishing tourism are well-developed and attract over 150,000 foreign anglers every year, generating an estimated US$520 million to the national economy and supporting 33,000 jobs. This review work aims to characterize the sport and fishing tourism sector in Costa Rica and its social and economic importance, review recent results and assess the status of our knowledge about the main target species, and identify important gaps in the information available. Finally, we present successful initiatives that have stimulated opportunities for development and capacity building in coastal communities. Considering the recent growth of fishing tourism and the migratory nature of the main species, we highlight the importance of developing regional initiatives to improve our understanding of the factors that influence the dynamics and sustainability of recreational fisheries in Central America.

44 Understanding contributions of women in billfish fisheries: A Kenyan case study.

Presenting Author: Sylvia Adisa, University of Florida
Email: adisasylvia@ufl.edu

Authors:
Sylvia Adisa, University of Florida
Nelly Isigi Kadagi, World Wildlife Fund
Nina Wambiji, Mpala Research Centre, Kenya
Renata Serra, University of Florida

To understand the gender dynamics in billfish fisheries, it is essential to consider the participation of both men and women in the sector. However, there is limited data regarding women's involvement in billfish fisheries globally. As a result, it is challenging to accurately recognize, acknowledge, or estimate the extent of women's participation and their contributions in billfish fisheries and the blue foods production.

Our study aimed to improve understanding women's involvement in Artisanal Billfish fisheries (ABF) in the Western Indian Ocean (WIO) region using Kenya a case study. Surveys, interviews, and discussions were conducted in five locations with fishers, traders, and other stakeholders in the industry. Qualitative data was analyzed using content and thematic analyses, and quantitative data was analyzed using descriptive statistics.

Findings highlight women's significant and often overlooked role in billfish fisheries. Women serve as consistent buyers, creating a market for fishers and bridging the gap between producers and consumers for ABF. Despite their smaller numbers, their involvement at various stages notably enhances Billfish's availability as a food source.

Paying attention to the specific needs of men and women in billfish fisheries is not just a matter of gender equality but also a strategic move toward the industry's sustainability. Enhancing women's skills, facilitating their better access to financial resources, and improving fishers' skills and access to resources could further increase their involvement in promoting the availability of billfish species for recreational purposes and a vital food source in many regions across the globe.

45 Census of Non-U.S. Billfish and Swordfish Recreational Tournaments in the ICCAT Convention Area

Presenting Author: Kevin Rafferty, Halmos College of Arts and Sciences, Farquhar Honors College, Nova Southeastern University
Email: kr1710@mynsu.nova.edu

Authors:
Kevin Rafferty, Halmos College of Arts and Sciences, Farquhar Honors College, Nova Southeastern University
David W. Kerstetter, Halmos College of Arts and Sciences, Farquhar Honors College, Nova Southeastern University

Swordfish and the istiophorid billfishes are large pelagic predators with circumglobal distributions. In the Atlantic Ocean, these economically valuable fishes are considered highly migratory species (HMS) and managed domestically by NOAA Fisheries and internationally by the International Commission for the Conservation of Atlantic Tunas (ICCAT). Internationally, swordfish has long supported primarily commercial fisheries but is increasingly targeted by recreational fisheries; although occasionally landed as incidental catch, istiophorid billfish fisheries are primarily recreational. In the U.S. Atlantic, NOAA Fisheries tightly regulates HMS fisheries, including mandatory recreational tournament registration and monitoring. Commercial landings are often reported to ICCAT, but non-U.S. data on recreational billfish and swordfish landings are scarce, with some ICCAT members claiming to not have recreational fisheries. As a first step to address this data gap, we conducted an online (internet-based) census of all the billfish and swordfish recreational tournaments throughout the ICCAT Convention Area (124 countries and territories). The Caribbean region previously dominated in numbers of tournaments targeting billfishes and swordfish, but a recent shift can be seen in a shift and an increase in tournaments in the North/Central American region. These findings could indicate a shift in local billfish and swordfish abundance or economic reasons (including COVID restrictions). Additionally, tournaments for billfishes appear to be moving to mostly all-release formats, supporting conservation efforts for overfished blue and white marlins. Future analyses will examine publicized landings at non-U.S. tournaments, including individual fish weights and catch-effort trends, and temporal comparisons with U.S. tournaments from NOAA mandatory reporting data.

46 How can we motivate citizen scientists to help uncover the secrets of billfish?

Presenting Author: Laura Smith, School of the Environment, The University of Queensland
Email: laura.smith@uq.edu.au

Authors:
Laura Smith, School of the Environment, The University of Queensland
Samuel Williams, Queensland Department of Agriculture and Fisheries
Julian Pepperell, Pepperell Research and Consulting Pty Ltd
Ian Tibbetts, The University of Queensland
Sheridan Rabbitt, The University of Queensland
Bonnie Holmes, University of the Sunshine Coast
Vicki Martin, Mosaic Insights Consulting

Billfishes are both difficult to study and to manage because they are highly migratory and have very broad, patchy distributions that span international jurisdictions. Marlins and the sailfish are valued by recreational catch-and-release fishers, however, often the fisheries data that are required to accurately assess stocks are lacking, which has led to uncertainty about their stock statuses and the validity of current management controls. Engaging recreational anglers in data collection is a cost-effective tool to gather information on billfish that would otherwise be logistically difficult to survey independently by fisheries agencies. Game fishers have contributed to billfish research as citizen scientists for many decades. A great opportunity exists for researchers, fisheries managers, and game fishing organisations to collaborate to strategically improve our knowledge of billfish stocks and biology using citizen science. However, an important challenge is recruiting and maintaining the interest of citizen scientists. I used an Australia-wide online survey of game fishers to examine the drivers and barriers to game fisher participation in citizen science programs that have contributed to billfish research. Many of the respondents had been involved in past research activities, predominantly catch-tag-recapture programs. Eighty-eight percent of 153 respondents indicated that they were willing to participate in research activities in the next two years. They listed several factors that impact their future participation including project logistics, their personal situation, altruistic motivations, and fisheries management. Communications about project opportunities, expectations, data use and access, and research outcomes were identified as being important to overcome barriers to participation.

47 Review of marine recreational fisheries regulations for billfish in Central America

Presenting Author: Damian Martinez-Fernandez, Costa Rican Sportfishing Federation, FECOP
Email: dmartinez@fecop.org

Authors:
Damian Martinez-Fernandez, Costa Rican Sportfishing Federation, FECOP
Mariamalia Rodriguez Chaves, Costa Rican Sportfishing Federation, FECOP
Marina Marrari, Costa Rican Fishing Federation, FECOP

This review provides an in-depth analysis of the regulatory framework governing marine recreational fishing for billfish in Central America, specifically within the countries of the Central American Integration System (SICA). The study supports the Federation of Tourist Fishing (FECOP) in compiling a comprehensive normative compendium for recreational fishing in the Pacific region. Our review encompasses the collection of relevant regulations from Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama, focusing on billfish but also for some pelagic species such as tuna, sharks, and dorado. Key findings highlight the diversity in regulations across the region, with only Costa Rica, Honduras, and Panama having developed specific concepts for recreational and tourism fishing. Costa Rica stands out for having the most comprehensive regulations, whereas

other countries enforce stricter rules for certain species. For instance, Guatemala reserves sailfish (*Istiophorus platypterus*) exclusively for recreational fishing, prohibiting its commercial capture (Ley General de Pesca, art. 28). In Honduras, Acuerdo Nº 725/08 restricts all billfish species to recreational fishing, requiring species like Wahoo and Blue Marlin to be released if caught during tournaments. In El Salvador, Resolución 21-02 bans targeted fishing for roosterfish and billfish, allowing commercialization only for incidental captures certified by CENDEPESCA. Nicaragua's Ley de Pesca No. 489 and Decreto Ejecutivo No. 9-2005 prohibit the commercial capture of billfish, requiring accidental catches to be released. Panama restricts the commercialization of recreational fishing catches and reserves specific billfish species for recreational purposes (Decreto Ejecutivo 33 and Resolución ADM/ARAP No. 062). The study also examines governance and consultation mechanisms involving fishing authorities and tourism sectors, such as Guatemala's National Commission for the Protection of Sailfish, Honduras' consultation processes with indigenous communities, and Costa Rica's Marine Governance Committees. The review underscores the necessity for continuous updates and enforcement of these regulations to safeguard marine biodiversity and support the recreational fishing industry.

48 Managing the Apex of Sportfish: The Case of U.S. Atlantic Billfish Management

Presenting Author: Cliff Hutt, NOAA Fisheries Office of Sustainable Fisheries, Atlantic Highly Migratory Species Division
Email: cliff.hutt@noaa.gov

Authors:
Cliff Hutt, NOAA Fisheries Office of Sustainable Fisheries, Atlantic Highly Migratory Species Division
Randy Blankinship, NOAA Fisheries Office of Sustainable Fisheries, Atlantic Highly Migratory Species Division

For over 45 years, NOAA Fisheries has been actively engaged in the management of Atlantic billfish fisheries, including West Atlantic sailfish, blue and white marlin, and roundscale and longbill spearfish. Since the establishment of the 1988 Atlantic Billfish Fishery Management Plan (FMP), NOAA Fisheries has managed Atlantic billfish stocks with the objective to optimize social and economic benefits to the nation by maintaining the highest availability of billfishes to the U.S. recreational fishery, which is recognized as the traditional use of the fishery in the continental U.S. The 1988 FMP prohibited most commercial sale of Atlantic billfish, and established the first minimum size limits and reporting requirements in the recreational billfish fishery. Subsequent actions established conservation measures including registration and reporting requirements for Atlantic billfish tournaments, permitting and reporting requirements for HMS Charter/Headboat captains and private recreational Angling vessels, and the combination of time-area closures and prohibition of the use of live bait in the pelagic longline fishery to minimize billfish and other protected species bycatch. With the establishment of the 2006 Consolidated Highly Migratory Species (HMS) FMP, NOAA Fisheries also codified the annual landings limit of 250 Atlantic blue and white marlin recommended by ICCAT, in addition to requiring the use of non-offset circle hooks in tournaments when fishing with natural bait. Through these and efforts to promote international conservation of Atlantic billfish, NOAA Fisheries has supported the development of a thriving recreational billfish fishery in the Atlantic that includes over 150 registered billfish tournaments per year, and over $100 million USD in economic output supported by tournament and angler expenditures. Future conservation concerns for Atlantic billfish include continued overfishing in international fisheries, spatial management of marine resources, and climate change.

Poster Presentations

P1 Species identification of highly degraded DNA isolated from billfish larvae using small amplicon (SA) high resolution melting (HRM)

Presenting Author: Jaime R. Alvarado Bremer, Texas A&M University at Galveston, Department of Marine Biology
Email: jaimeab@tamu.edu

Authors:
Jaime R. Alvarado Bremer, Texas A&M University at Galveston, Department of Marine Biology
Savanna Watson, Texas A&M University at Galveston, Department of Marine Biology
Sydney Fox, Texas A&M University at Galveston, Department of Marine Biology
Glenn Zapfe, NOAA Fisheries, Southeast Fisheries Science Center, Population and Ecosystem Monitoring Division
Walter Ingram, NOAA Fisheries, Southeast Fisheries Science Center, Population and Ecosystem Monitoring Division
Denice Drass, NOAA Fisheries, Southeast Fisheries Science Center, Population and Ecosystem Monitoring Division

Recently, the use of high-resolution melting (HRM) has been advocated as highly sensitive molecular genetics alternative to identify tunas and billfish that lack diagnostic morphological characters (e.g., dressed fish or filets), or when dealing with cryptic life stages. HRM assays are particularly attractive because both the PCR amplification and genotyping are conducted in a single closed tube. Unfortunately, HRM assays available to identify billfish require the amplification of a relatively long fragments (>400 base pairs) of the mtDNA genome, precluding it's use with highly degraded samples or fixed in formalin. This applies to many ichthyoplankton collections, where PCR amplification success of DNA fragments longer than 120 bp results in greater than 90% failures. Here, we present a novel isolation method aimed to obtain PCR-ready DNA from degraded fish larvae that combines a high pH (9.0) lysis buffer with the non-destructive Shake and Stew protocol. The DNA obtained with this method from billfish specimens was then amplified with several small amplicon (SA) HRM assays targeting short segments of the 12s rRNA, ND1 and ND2 mtDNA genes to produced diagnostic melting curves whose shape and melting temperature Tm would be diagnostic for species identification. When these HRM assays are used in tandem, we successfully identified voucher specimens of blue marlin (*Makaira nigricans*), sailfish (*Istiophorus platypterus*), white marlin (*Kajikia albidus*), and longbill spearfish (*Tetrapturus pfluegeri*). These SA-HRM assays were then used to identify hundreds of billfish larvae (1.5 mm-6 mm BL) sampled by SEAMAP in the Gulf of Mexico.

P2 Climate variability drives changes in core habitat for two highly mobile predators in the Eastern Tropical Pacific

Presenting Author: Hannah Blondin, Cooperative Institute for Marine and Atmospheric Studies, University of Miami; NOAA Southeast Fisheries Science Center
Email: hannah.blondin@noaa.gov

Authors:
Hannah Blondin, Cooperative Institute for Marine and Atmospheric Studies, University of Miami; NOAA Southeast Fisheries Science Center
Danielle E. Haulsee, Hubbs-SeaWorld Research Institute
Ryan Logan, California State University Long Beach
Elliott L. Hazen, Hopkins Marine Station, Department of Biology, Stanford University, Environmental Research Division; NOAA Southwest Fisheries Science Center, University of California Santa Cruz
Stephanie Brodie, Marine Debris Research, Commonwealth Scientific and Industrial Research Organisation

Michael Domeier, Marine Conservation Science Institute
Eric Hoffmayer, Mississippi Laboratories, Southeast Fisheries Science Center, National Marine Fisheries Service
Nicole Nasby-Lucas, Southwest Fisheries Science Center, NOAA Fisheries; Institute of Marine Sciences, University of California, Santa Cruz
Eric Orbesen, Sustainable Fisheries Division, Highly Migratory Species Branch, NOAA/NMFS, Southeast Fisheries Science Center
George Shillinger, Upwell
Mahmood Shivji, Guy Harvey Research Institute, Halmos College of Arts and Sciences, Nova Southeastern University
James H. Walker, The Billfish Research Project
Larry B. Crowder, Hopkins Marine Station, Department of Biology, Stanford University

Pacific blue marlin (*Makaira nigricans*) and Indo-Pacific sailfish (*Istiophorus platypterus*) are two recreationally important species in the Eastern Tropical Pacific (ETP) Ocean, yet relatively little is known about their spatial ecology in this region. In this study, we aggregate a nearly 20-year dataset to understand general horizontal distribution patterns of these two populations and how these distributions may be changing due to increasing environmental variability. We fit species distribution models to quantify habitat suitability related to environmental and physical variables and compare distributions of both species across El Niño Southern Oscillation (ENSO) phases. We find that habitat suitability for blue marlin and sailfish showed similar responses to climatic variation within ENSO phases. In La Niña phases, habitat suitability compresses along with decreasing SSTs and increased upwelling. However, in El Niño years, we find that habitat suitability expands generally across the ETP, but is significantly degraded within certain national boundaries. Finally, we call for collective management across the ETP region to ensure equitable solutions for the future under increasing climate change.

P3 Larval billfish abundance in the Western Indian Ocean and future research endeavors

Presenting Author: Sylvain Bonhommeau, IFREMER
Email: sylvain.bonhommeau@ifremer.fr

Authors:
Akihiro Shiroza, IFREMER
Sylvain Bonhommeau, IFREMER
Thomas Chevrier, Company for Open Ocean Observations and Logging (COOOL)
Olivier Derridj, IFREMER MARBEC
Serge Bernard, LIRMM-CNRS
Hugues Evano, IFREMER Délégation Océan Indien
Blandine Brisset, IFREMER Délégation Océan Indien
Jérémie Chanut, Company for Open Ocean Observations and Logging (COOOL)
Mohan Julien, IFREMER Délégation Océan Indien
Evans Grondin, IFREMER Délégation Océan Indien

Stock assessment of highly migratory species such as tunas and billfishes from fisheries data alone is challenging. Using fisheries-independent larval data may be useful as a supplement to those models. As of date, billfish spawning is only reported in the Pacific and eastern Indian Ocean and no scientific record of billfish spawning in the western Indian Ocean has been reported. Opportunistic larval fish surveys were conducted on January 2022 in Tromelin and Reunion EEZ and on April 2023 in the Mozambique Channel within the French EEZ. Larval billfishes were collected from surface and subsurface tows. Maximum density was 19.77 istiophorids / 1000 m2 from the Mozambique Channel. Mean sea surface temperature was 28.79°C (± 0.69 SE). Istiophorids collected in 2022 were genetically identified to be blue marlin (*Makaira nigricans*, n = 25) and 2023 collection identified morphologically by pigment pattern and morphometrics relationships were blue marlin (n = 6) and Indo-Pacific sailfish (*Istiophorus platypterus*, n = 15). Monthly or bimonthly systematical sampling is recommended to reveal spatio-temporal spawning of the billfish species in the WIO and to better understand the role of the Mozambique Channel and adjacent water as spawning ground and nursery site for the billfish species.

P4 Spatial patterns of billfish richness in the Eastern Pacific Ocean

Presenting Author: Aura Buenfil-Avila, Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas
Email: abuenfila1900@alumno.ipn.mx

Authors:
Aura Buenfil-Avila, Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas
Sofia Ortega-García, Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas
Héctor Villalobos, Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas

The adequate spatial management is one of the main challenges that the tuna fisheries currently faces in the Eastern Pacific Ocean (EPO). Understanding the spatial patterns of species richness and the variability of suitable habitat constitutes an important basis for this purpose, especially when endangered species are included. For instance, billfishes are incidentally caught by the purse-seine tuna fishery in the EPO, and some species are included in the IUCN red list. The present study aims to determine the spatial richness in 5 billfishes (swordfish, *Xiphias gladius*; blue marlin, *Makaira nigricans*; striped marlin, *Kajikia audax*; sailfish, *Istiophorus platypterus*; and black marlin, *Istiompax indica*) to identify strategic areas for future planning efforts and their potential ecological importance for the habitat of these species. The information analyzed corresponds to a database of the Inter-American Tropical Tuna Commission, with 1º x 1º resolution, and catches by type of fishing set: 1) floating object set (OBJ), 2) unassociated tuna set (NOA), 3) dolphin set (DEL). The spatial richness analysis was carried out under three different environmental conditions (La Niña, El Niño and neutral). The ecological niche of the species was also characterized as an ecological explanation of the distribution of the richness, for this, the MaxEnt algorithm was used and applied to the global presence of each species and environmental variables such as sea surface temperature, dissolved oxygen, chlorophyll-*a*, salinity, and mixing layer depth. Preliminary results indicate that for NOA sets, the greatest richness is concentrated near the Galapagos Islands and the coast of South America, while DEL showed greater richness near the coast, at the Costa Rican Dome. Some high richness areas for OBJ indicator were close to the Corralito closure zone. It was observed that the spatial extent of richness tends to increase in events with positive temperature anomalies.

P5 Longline Fishery Landings in the Costa Rican Pacific During 2015-2021

Presenting Author: Allison Centeno Chaves, Federación Costarricense de Pesca (FECOP); Universidad Nacional de Costa Rica (UNA)
Email: allison.centeno.chaves@est.una.ac.cr

Authors:
Allison Centeno Chaves, Federación Costarricense de Pesca (FECOP); Universidad Nacional de Costa Rica (UNA)
Marina Marrari, Federación Costarricense de Pesca (FECOP)
Fausto Arias Zumbado, Universidad Nacional de Costa Rica (UNA)
Andrea García Rojas, Universidad Nacional de Costa Rica (UNA)
Moisés Mug Villanueva, Federación Costarricense de Pesca (FECOP)

Longline fishing in the Pacific of Costa Rica targets multiple species of large pelagics and faces challenges in assessment due to lack of data. The aim of this study is to analyze the landings of pelagic fish in this fishery using unconventional statistical methods to better understand its dynamics and provide recommendations for improving data collection and analysis. Landings reported by Incopesca during 2015-2021 were examined. A descriptive and comparative analysis of landings was conducted using Spearman correlation tests and Non-Metric Multidimensional Scaling (NMDS) to visualize patterns in catch composition. Permutational Multivariate Analysis of Variance (PERMANOVA) and Similarity Percentage Analysis

(SIMPER) were employed to identify significant differences between fleet types, landing ports, months, and years, as well as the species contributing most to these differences. The annual mean total landings of large pelagic fish were 7531.01 tons, with 39.14% sharks, 24.34% billfish (Istiophoridae and Xiphiidae), 18.05% mahi-mahi, and 14.94% tuna. Statistically significant differences were found between fleet types, landing ports, months, and years. Shark landings were the least correlated (rho=0.36) and had the greatest influence on variation by fleet type. An increase in the similarity of catch composition by port since 2015 was observed. The study emphasizes the need for advanced research approaches due to incomplete data and underscores the importance of informed management, especially regarding fleet type and landing port. Furthermore, a shift towards increasingly less selective fishing over the study period was evident. These findings underscore the urgency of a comprehensive strategy involving diverse stakeholders to ensure the sustainability of fisheries and the preservation of marine ecosystems in Costa Rica.

P6 Standardized capture per unit effort for sailfish, marlin and other pelagic species in Costa Rica using recreational data

Presenting Author: Johel Chaves Campos, Costa Rican Fishing Federation, FECOP
Email: jchaves@fecop.org

Authors:
Johel Chaves Campos, Costa Rican Fishing Federation, FECOP

Fishing tourism of sailfish and accompanying species represents a significant source of income for Costa Rica. Hence, Costa Rica should keep healthy populations of these species available to the recreational fleet. Unfortunately, the status of the sailfish stock for the Eastern Pacific Ocean is poorly known, and in general there is little information regarding trends in the availability of these species to the local recreational fleet. In this study, we estimated temporal trends in standardized capture per unit effort (CPUE) for sailfish (*Istiophorus platypterus*), marlin (*Istiompax indica*, *Kajikia* audax, *Makaira nigricans*), yellowfin tuna (*Thunnus albacares*) and mahi mahi (*Coryphaena hippurus*) using data provided by sportfishing operations from the Pacific Coast of Costa Rica. We found a large decrease in the CPUE for sailfish over the last decade. In contrast, CPUE for yellowfin tuna and mahi mahi increased in recent years. We did not find a clear trend for marlin species. We explored whether these trends were related to 1) environmental variables (several variables correlated to sea surface temperature-SST) and 2) commercial landings of these species at Costa Rican ports. The decrease in CPUE for sailfish corresponds to a strong increase in commercial sailfish landings over time, and to a lesser extend to an increase in SST. This result, along with recent satellite tagging data showing low mobility of sailfish in the region, suggest that overfishing is decreasing the availability of sailfish to the recreational fleet. The recent increase in CPUE for tuna and mahi mahi is partially related to SST but seems mostly related to the recent 80-mile offshore push of the industrial tuna purse seine fleet made by the Costa Rican government. Fluctuations in CPUE for marlin are unrelated to changes in SST but correlate weakly with fluctuation in commercial landings, but this analysis suffers from species identification problems.

P7 Seasonal Variability in Habitat Use and Movement Behavior for Marlin in the Gulf of Mexico

Presenting Author: Michael A. Dance, Department of Oceanography and Coastal Sciences, Louisiana State University
Email: mdance1@lsu.edu

Authors:
Michael A. Dance, Department of Oceanography and Coastal Sciences, Louisiana State University
Jay Rooker, Marine Biology Dept., Texas A&M University at Galveston
Maelle Cornic, Dept. Oceanography and Coastal Sciences, LSU
David Wells, Marine Biology Dept., TAMUG
Tom TinHan, School of Ocean and Earth Sci and Tech, University of Hawaii
Jennifer McKinney, University of Southern Mississippi
Brett Falterman, Fisheries Research Support

Highly migratory species (HMS), such as billfishes, tunas, and sharks are important predators in open ocean ecosystems, but their complex movements often complicate conservation and management strategies. Unfortunately, migratory patterns, habitat use, and residency of billfish in the northern Gulf of Mexico are poorly understood, limiting our ability to assess habitat quality and impacts of stressors on billfish populations. In response, a multiyear satellite tagging study focused on long-term deployments was conducted on blue marlin and white marlin in the northern Gulf of Mexico to address these questions. Individual blue and white marlin were captured in recreational fisheries in the northern Gulf of Mexico offshore of Louisiana and Texas from 2008-2013 and fitted with satellite tags programmed for 1-year deployments. Several tags remained on fish for a full year, and tagged individuals of both species displayed a high degree of residency within the GOM with a greater proportion of white marlin emigrating from the basin. Seasonal movement patterns were evident with individuals largely moving into the southern GOM during the winter months and back to the northern GOM during the summer. Both species spent considerable time in surface waters (< 50 m); however, pronounced diel vertical movement behavior was observed with both blue and white marlin making deeper dives during the day and remaining close to the surface at night. Vertical movements varied by season, and both species made deeper dives during the summer when surface temperatures were highest. Results provide critical information on billfish habitat in the GOM needed for ecosystem-based management and informing management efforts to minimize interaction with pelagic longline fisheries.

P8 Characterization of the Diet of Roundscale Spearfish (*Tetrapturus georgii*) using Morphology and Molecular Based Approaches

Presenting Author: Quinn L. Girasek, Virginia Institute of Marine Science
Email: qlgirasek@vims.edu

Authors:
Quinn L. Girasek, Virginia Institute of Marine Science
Jan R. McDowell, Virginia Institute of Marine Science

The roundscale spearfish, *Tetrapturus georgii* (Lowe, 1841), is a relatively rare, data-deficient istiophorid billfish that ranges from approximately 37°41'N to 28°52'S in the western Atlantic. The range in the eastern Atlantic extends from Portugal, south, to at least Madeira and includes the Mediterranean Sea. *T. georgii* is a highly sought-after sport and tournament fish, but tournaments generally do not discriminate between *T. georgii* and the morphologically similar white

marlin, *Kajikia albida* (Poey, 1860). *T. georgii* fall within the 250-fish US recreational quota for Atlantic billfishes that also includes blue marlin, *Makaira nigricans* (Lacépède, 1802), and *K. albida*, limiting sampling opportunities. Thus far, information about *T. georgii* diet has been anecdotal. To better understand the diet preferences of *T. georgii*, stomachs were sampled from fish landed at recreational tournaments along the east coast of the United States in 2024. Stomachs were frozen upon removal and transported to the Virginia Institute of Marine Science (VIMS) for analysis. Both morphological and molecular identification methods were used to identify prey items. For morphological identifications, the stomach of each individual was dissected, and prey taxa were sorted and identified to the lowest taxonomic level possible. For molecular-based identifications, stomach contents were homogenized, and DNA was extracted from a subsample of the homogenate. Isolated DNA samples from each fish were metabarcoded using the cytochrome c oxidase 1 (COI) gene region. Results from both approaches will be compared and analyzed across the sex and size of landed *T. georgii*. Advancing the understanding of *T. georgii* diet is important for the management and conservation of this data-poor species.

P9 Argos - Future Constellation Upgrades

Presenting Author: Thomas Gray, The Woods Hole Group Inc
Email: tgray@whgrp.com

Authors:
Thomas Gray, The Woods Hole Group Inc

For over 40 years, the Argos satellite telemetry system has emerged as the backbone of marine science research, serving environmental agencies, NGOs, foundations, charities, parks, reserves, and the broader scientific community worldwide. Since its inception, Argos has played a pivotal role in our understanding of how pelagic fisheries utilize our shared resource - Earth.

Currently the Argos satellite system is made up nine space-agency funded satellites. By the end of 2024, the constellation will be expanded to over 30. With a new constellation comes new features and capabilities, and this presentation will discuss those.

We will also highlight an Argos tool that is used to recover pop-up satellite tags. The Argos Goniometer has been used to recover tens if not hundreds of pop-up satellite tags at sea (and can be used to actively track tagged animals). We will share some of those experiences from researchers.

P10 Stomach content and metabarcoding analysis reveal high importance of key fishery species to marlin diet

Presenting Author: Tristan A Guillemin, School of Natural Sciences, Macquarie University, Wallumatagal campus
Email: tristan.guillemin@hdr.mq.edu.au

Authors:
Tristan A Guillemin, School of Natural Sciences, Macquarie University, Wallumatagal campus
Julian G. Pepperell, Pepperell Research and Consulting Pty Ltd
Joseph DiBattista, School of Environment and Science - Environment and Marine; Griffith University
Jane E. Williamson, School of Natural Sciences, Macquarie University, Wallumatagal campus; Sydney Institute of Marine Science

Marlin are large, fast growing predators, as such, a high abundance of prey is required to sustain marlin fisheries. Unfortunately, in many regions of the world, lack of knowledge about marlin diet limits our capacity to protect essential prey stocks. Home to one of the world's oldest recreational fisheries, the east coast of Australia is one such region. Little to no dietary research and

the presence of commercial fisheries targeting small and mid-sized pelagic species threatens the east Australian marlin fishery. We assessed the diet of the three species targeted by the fishery, black (*Istiompax indica*), blue (*Makaira nigricans*) and striped (*Kajikia audax*) marlin, through stomach content analysis and DNA metabarcoding to identify species crucial to sustaining marlin. Overall, we found differences in the prey consumed by the three species: blue marlin primarily ate scombrids (tuna and mackerel) and flying squid; striped marlin primarily ate schooling species, both fish (such as oceanic pufferfish, scads and bigeyes) and cephalopods (argonauts and flying squid); black marlin primarily ate a variety of small coastal fish species (scad, mackerel, trevallies). Several deepwater species including lancetfish, swordfish and lanternfish were also present across the diet of all three species, though it is unclear if the marlin dive to feed on these or hunt them on the surface at night. Small pelagic fish and squid, but in particular small scombrids, particularly blue mackerel and skipjack, bullet and frigate tuna were key to the diet of all three species. Management should strive to maintain a relatively high biomass of these species to ensure enough prey to sustain the economically important recreational marlin fishery.

P11 Using Angler Surveys to Observe Changes in the Recreational Billfish Fishery in the Eastern Pacific Ocean

Presenting Author: Erika Gutierrez, Coastal Science and Policy Program, University of California
Email: egutie55@ucsc.edu

Authors:
Erika Gutierrez, Coastal Science and Policy Program, University of California
Danielle Haulsee, Hubbs-SeaWorld Research Institute
Hannah Blondin, Cooperative Institute for Marine and Atmospheric Studies, University of Miami; NOAA Southeast Fisheries Science Center
Steve Teo, NOAA Southwest Fisheries Science Center
Larry Crowder, Hopkins Marine Station, Stanford University

Recreational fishing has increased in popularity over time, creating an opportunity to study highly elusive species, such as billfish, through the use of angler surveys and tagging reports. Many recreational billfish fisheries are also catch-and-release, offering a sustainable way to capture biological information about these highly valued species. Using the angler surveys and tagging reports collected by the Southwest Fisheries Cooperative Billfish Tagging Program between 1984 - 2019, we analyzed changes in fisher effort, nominal catch per unit effort (CPUE), and size for Indo-Pacific sailfish (*Istiophorus platypterus*) and blue marlin (*Makaira nigricans*) in the Eastern Pacific Ocean. We found that reported fisher effort and survey participation declined over time, providing important information about the viability of programs like this to provide information for scientists and resource managers. For both species, nominal CPUE appears related to ENSO events, with sailfish and blue marlin CPUE generally higher during El Niño events. This was especially evident during the 2015-2016 El Niño event. There was no significant change in blue marlin length over the time series, but the reported sailfish length decreased by 1.04in per year. This study shows the utility of recreational fisher-collected data to understand how climatic events and potential fishing pressure affect billfish species.

P12 Trophic competition of striped marlin and blue marlin during ENSO event in adjacent waters to Cabo San Lucas, Baja California Sur

Presenting Author: Amairani Hernández-Aparicio, Instituto Politécnico Nacional. Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN)
Email: ahernandeza2100@alumno.ipn.mx

Authors:
Amairani Hernández-Aparicio, Instituto Politécnico Nacional. Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN)
Sofía Ortega-García, Instituto Politécnico Nacional. Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN)
Arturo Tripp-Valdez, Instituto Politécnico Nacional. Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN)
Ulianov Jakes-Cota, Instituto Politécnico Nacional. Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN)
Rodrigo Moncayo-Estrada, Instituto Politécnico Nacional. Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN)
Leonardo A Abitia-Cárdenas Instituto Politécnico Nacional. Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN)
Sergio A Hernández-Briones Instituto Politécnico Nacional. Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN)

The striped marlin (*Kajikia audax*) and the blue marlin (*Makaira nigricans*) are of the most important species that support the sport-recreational fishery of Cabo San Lucas, B.C.S., México. In order to determine the trophic competition between these species, and to analyze the effect that the Sea Surface Temperature (SST) and Chlorophyll-a (Chl-a) concentration have on them, the stomach contents of organisms caught during 2010-2011 and 2014-2015 defined through the Oceanic Niño Index as the cold and warm phase, respectively, of the El Niño Southern Oscillation event. Trophic diversity, feeding habits (Prey-specific relative importance index; PSIRI), trophic position (TP), trophic niche amplitude (Bi), trophic overlap, and feeding strategy were calculated and compared. The relationship between SST and Chl-a in feeding and trophic competition was determined by applying Canonical Discriminant Analysis (CDA). *K. audax* fed on 37 preys during the cold phase and on 45 preys during the warm phase, being the jumbo squid *Dosidicus gigas* the most important in both (%PSIRI=30.4 and %PSIRI=18.5) with a TP= 4.7 in both periods. During the cold phase, *M. nigricans* fed on 20 prey items, and during the warm phase on 5 prey items, being the fish *Auxis* spp. the dominant prey in both phases (%PSIRI=46.3 and %PSIRI= 50) with a TP= 5.3. A greater trophic competition was recorded during the cold phase when striped and blue marlin shared 12 prey items, while during the warm phase, they shared only two. The species turned out to be specialist predators in both phases, which indicates that, despite a wide trophic spectrum, they feed on a reduced number of preys in a greater percentage, thus occupying different trophic spaces, which allows their coexistence in space and time.

P13 Costa's Marlin Fly Project: a fly-fishing expedition to satellite tag Striped Marlin off Magdalena Bay Mexico

Presenting Author: Jeremy M. Higgs, University of Southern Mississippi, Center for Fisheries Research and Development
Email: J.Higgs@usm.edu

Authors:
Jeremy M. Higgs, University of Southern Mississippi, Center for Fisheries Research and Development
Jim S. Franks, University of Southern Mississippi, Center for Fisheries Research and Development
Peter Chaibongsai, The Billfish Foundation
Bruce Pohlot, International Game Fish Association
Jiangang Luo, University of Miami, Rosenstiel School of Marine, Atmospheric, Earth Sciences
Cody Rubner, High Roller Guide Service
Hannah Trotter, Costa Del Mar
Joe Gugino, Costa Del Mar

The waters off Magdalena Bay (Baja California Sur, Mexico) are renowned for their diversity and abundance of sport fish during the annual sardine and mackerel run. During this period, anglers encounter concentrated schools of Striped Marlin feeding on bait balls, making this region a highly sought after destination for sport fishers. Owing to the high interest of anglers it is important that research be conducted to better understand the impact of the recreational fishery in this region, as well as the ecology of Striped Marlin in the eastern Pacific Ocean. Several studies focusing on the recreational fishery have been conducted in this region investigating topics such as: post-release survival, habitat use, and migratory patterns. These studies have been extremely beneficial in describing the biology and ecology of Striped Marlin in this

region but have also been largely conducted, either in conjunction with or following, the method of conventional recreational angling. Recently, there has been an increase in fly fishing anglers targeting Striped Marlin in this region. Due to the nature of this fishing style, it is important to understand the impact this gear may have while catching and subsequently releasing Striped Marlin. As such, during December of 2022 a multi-faceted stakeholder expedition, The Marlin Fly Project (i.e., local community, fishing industry, professional fly guides, non-governmental organizations, and academic researchers), was launched to better understand and examine Striped Marlin targeted by fly anglers. During this initial study, 15 PSATs were deployed on Striped Marlin caught via fly fishing in less than 24 hours. Six of these tags popped off between 33-121 days post-release and successfully transmitted data, while one additional tag popped off after the full deployment duration but was lost during a hurricane coinciding with the pop-off date. This study indicated post-release survival of Striped Marlin caught on the fly.

P14 Seasonally mediated niche partitioning in a vertically compressed pelagic predator guild

Presenting Author: Ryan K. Logan, Nova Southeastern University
Email: rklogn@gmail.com

Authors:
Ryan K. Logan, Nova Southeastern University
Jeremy J. Vaudo, Nova Southeastern University
Bradley M. Wetherbee, University of Rhode Island
Mahmood S. Shivji, Nova Southeastern University

Niche partitioning among closely related, sympatric species is a fundamental concept in ecology, and its mechanisms are of broad interest for understanding ecosystem functioning and stability. However, identifying mechanisms by which top marine predators partition available resources has been especially challenging given the difficulty of quantifying resource use of large pelagic animals. In the eastern tropical Pacific (ETP), blue marlin (*Makaira nigricans*), black marlin (*Istiompax indica*) and sailfish (*Istiophorus platypterus*), three large and ecologically similar pelagic predators coexist in a vertically compressed habitat. To evaluate each species' ecological niche, we leveraged a decade of recreational fisheries data, multi-year satellite tracking with high-resolution dive data, and stable isotope analysis. Recreational fishery data and satellite telemetry derived 3D seasonal utilization distributions suggested high spatial and temporal overlap among species; however, variability among species in seasonal and diel diving behavior produced spatial partitioning within the water column during periods of high prey abundance, leading to low trophic overlap among species. Globally expanding oxygen minimum zones will reduce the available vertical habitat within high oxygen-demand predator guilds, likely leading to increases in interspecific competition. Thus, understanding the mechanisms of habitat partitioning among predators in the vertically compressed ETP provide insight into how predators in other ocean regions may respond to vertically limited habitats.

P15 Unveiling the secret life of the Mediterranean spearfish: A Satellite Tagging Study of *Tetrapturus belone*

Presenting Author: Martin C. Arostegui, Biology Department, Woods Hole Oceanographic Institution
Email: martin.arostegui@whoi.edu

Authors:
Danilo Malara, Sicily Marine Centre, Stazione Zoologica Anton Dohrn
Pietro Battaglia, Sicily Marine Centre, Department of Integrated Marine Ecology, Stazione Zoologica Anton Dohrn

Martin C. Arostegui, Biology Department, Woods Hole Oceanographic Institution
Jonathan J. Dale, Hopkins Marine Station, Stanford University
Barbara A. Block, Hopkins Marine Station, Stanford University
Camrin D. Braun, Biology Department, Woods Hole Oceanographic Institution
Massimo Brogna, Sea Life Care International; International Game Fish Association
Silvestro Greco, Calabria Marine Centre, CRIMAC, Stazione Zoologica Anton Dohrn
Teresa Romeo, Sicily Marine Centre, Department of Biology and Evolution of Marine Organisms, Stazione Zoologica Anton Dohrn; ISPRA, National Institute for Protection and Environmental Research

The Mediterranean spearfish (*Tetrapturus belone*), a key apex predator in the Mediterranean Sea, is threatened by unregulated commercial and recreational fishing. This lack of oversight, coupled with the species' ecological importance, necessitates conservation action and robust data collection. Furthermore, robust ecological information, such as detailed knowledge of migratory routes and behaviors, is necessary to establish appropriate management measures for this species. The absence of a population assessment by the International Commission for the Conservation of Atlantic Tunas (ICCAT) further emphasizes the need for comprehensive research in this area.

Six Mediterranean spearfish were equipped with pop-up satellite tags in the Strait of Messina and Tyrrhenian Sea, revealing movement patterns primarily confined to the central Mediterranean region. Geolocation data identified the Tyrrhenian Sea and Strait of Sicily as core habitats for Mediterranean spearfish, with seasonal shifts in habitat use most pronounced during winter. Additionally, while typically inhabiting shallow waters (≤ 10 m), the *T. belone* exhibited surprising behavioural flexibility, occasionally venturing into depths exceeding 200 meters. Similar to other billfish species, Mediterranean spearfish exhibited a bimodal vertical migration pattern, occupying shallower, warmer waters at night and transitioning to deeper, cooler waters during the day. This investigation provides novel insights into the migratory ecology and habitat preferences of *T. belone*, filling critical knowledge gaps and facilitating informed management decisions for this understudied species. These findings highlight the importance of continued research and monitoring to ensure the sustainable management of this ecologically significant species.

P16 How much wealth and wellbeing does recreational fishing generate in Costa Rica

Presenting Author: Henry Marín, Costa Rican Fishing Federation, FECOP
Email: hmarin@fecop.org

Authors:
Henry Marín, Costa Rican Fishing Federation, FECOP
Adriana Chacón

An analysis of macroeconomic data on fishing tourism in Costa Rica was done with the goal of describing the impact of the industry on the Costa Rican national economy and local communities. Data from different sources were used under the Travel Cost Methodology to analyze the impact of angler visitation on the national economy. Different pieces of information were collected, including distribution of expenditure, number of fishing tourists, and contribution of recreational fishing tourism to the national tourism, among others, and used to calculate the economic impact of fishing tourism. Results indicate that sport fishing represents 13% of Costa Rica's tourism annual income, generating more than 500 million dollars each year; yet the socio-economic impact of the activity on coastal community families working in the sector is poorly understood. The Community Capitals Approach was used to assess the impact of sport fishing on the quality of life of captains and mates of sportfishing vessels. A structured survey was used to collect data at the local community level. A total of 304 individuals were contacted in seven communities along the Pacific coast of Costa Rica. People working directly on sportfishing boats were estimated at around 1500. Data showed that the self-perceived quality of life of people directly working in the sportfishing sector and their families is high. In addition, sportfishing related infrastructure, such as

moors, piers, and marinas, the perception of high availability of target species (natural capital), and access to training (human capital investment) positively impacted the quality of life of industry workers. Complementary investments from different sectors at the community level (environment, education, building infrastructure) are also key to increase the positive impacts of sportfishing on coastal communities of Costa Rica.

P17 Genomic Insight into the Evolutionary Relationships of the Istiophorid Billfishes

Presenting Author: Jan R. McDowell, Virginia Institute of Marine Science
Email: mcdowell@vims.edu

Authors:
Jan R. McDowell, Virginia Institute of Marine Science
Ellen Biesack, Virginia Institute of Marine Science
John E. Graves, Virginia Institute of Marine Science

Despite decades of research, the evolutionary history of the istiophorid billfishes is still not well understood. The phylogeny of the recent billfishes was revised by Collette et al., in 2006 based on three mitochondrial markers and a single anonymous nuclear locus, however this analysis was unable to definitively resolve the placement of black marlin or resolve white and striped marlin relative to each other. Although the spearfishes were resolved in the phylogeny, they have been historically difficult to differentiate even using 14 nuclear microsatellite loci, and specific identification has relied heavily on location of capture. Newer technologies such as high throughput genotyping-by-sequencing and whole genome sequencing can generate thousands of single nucleotide polymorphisms (SNPs) and can more clearly resolve relationships within and between species, for example these methods have been used to definitively resolve white (*Kajikia albida*) and striped marlin (*Kajikia audax*) as separate species. The current study combined genome surveys of representatives of each istiophorid billfish species using hundreds of billfishes sampled from across the geographic range of each species to re-examine the phylogeny of the recent billfishes.

P18 Review and update of the fossil history of billfishes (Istiophoriformes, Xiphioidei)

Presenting Author: Miguel Montalvo, Virginia Institute of Marine Science, William & Mary
Email: mmontalvo@vims.edu

Authors:
Miguel Montalvo, Virginia Institute of Marine Science, William & Mary
Eric Hilton, Virginia Institute of Marine Science, William & Mary

The billfishes of the suborder Xiphioidei (Istiophoriformes) are instantly recognizable acanthomorph teleosts, bearing fused premaxillae forming an elongate non-protrusible rostrum (i.e., the “bill”), small rasp-like teeth, and long fusiform bodies. Extant billfishes are split into two families, Istiophoridae (the marlins, sailfishes, and spearfishes) and Xiphiidae (the swordfish), and range from the middle Miocene to the present. The late Paleocene family Hemingwayidae is the earliest taxon recognized as belonging to Xiphioidei; there are two other families of billfishes, Palaeorhynchidae and Blochidae, that range in age from the early Eocene to early Miocene but are of unclear relationship to the Xiphioidei. Fierstine’s 2006 publication on the fossil history of Xiphioidei has been instrumental to billfish paleontology in part because of its review of the group’s taxonomy. Recent and ongoing research has contributed significant new systematic and biogeographic knowledge about the group by adding observations from fossil assemblages in Asia, Oceania, and South America. In this presentation we will examine recent advancements in the field, provide an overview of billfish fossils and fossil site locations, and further review the literature of the fossil record of xiphiioid fishes.

P19 Expansion of Data Fisheries Collection and Reporting

Presenting Author: Thomas Morrell, The Billfish Foundation
Email: thomas_morrell@billfish.org

Authors:
Thomas Morrell, The Billfish Foundation
Brett Pierce, Bluefin Data
Peter Chaibongsai, The Billfish Foundation
Andrew Petersen, Bluefin Data

For nearly four decades, The Billfish Foundation (TBF) has led collaborative efforts to engage recreational anglers in reporting billfish data, resulting in the creation of the largest, privately owned, open-sourced database for billfish in the world. Such efforts have allowed TBF to gather information related to billfish migrations, densities, and growth rates, as well support proper fisheries management, stock assessments, and socioeconomic research.

Regarding data collection, TBF has continuously made progressions to improve the efficiency of data reporting. From card improvements, tag modifications, online submission upgrades, and incentives for captains and anglers, TBF has made efforts to dramatically streamline the reporting process. Now, with the recent collaborative partnership with Bluefin Data, LLC and their platform VESL, TBF will expand its data collection efforts beyond the recreational community into multiple fisheries, regions, and gear types. Through VESL, Highly Migratory Species (HMS) recreational and for-hire permitted vessels will have the option to voluntarily report billfish data to TBF through their integrated data collections fields, which will help expand TBF's data collection program and lead to greater opportunities for billfish data analysis. Publications such as TBF's Conservation Record, can then use this increase in data to provide our community with a greater understanding of billfish populations, as well as the potential need for greater conservation efforts.

A collaboration like this provides many opportunities for data collection and has the potential to set the standard for electronic reporting moving forward. As TBF continues to mobilize recreational anglers to contribute essential fisheries data, and seemingly expands into charter and commercial fisheries, there are opportunities to shape conservation strategies, learn more about billfish, and ensure the longevity of these populations. This holistic approach to collaborative science, community involvement, and data-driven conservation efforts highlights the importance of partnerships in promoting sustainable management practices and safeguarding marine ecosystems.

P20 The feeding habits of striped marlin (*Kajikia audax*) in Cabo San Lucas, Baja California Sur, in response to seasonal and ontogenic influences

Presenting Author: Pamela Pacheco Aldana, Centro Interdisciplinario de Ciencias Marinas-IPN
Email: ppachecoa2300@alumno.ipn.mx

Authors:
Pamela Pacheco Aldana, Centro Interdisciplinario de Ciencias Marinas-IPN
Sofia Ortega Garcia, Centro Interdisciplinario de Ciencias Marinas-IPN
Leonardo Andres Abitia Cardenas, Centro Interdisciplinario de Ciencias Marinas-IPN
Ulianov Jakes Cota, Centro Interdisciplinario de Ciencias Marinas-IPN
Arturo Tripp Valdez, Centro Interdisciplinario de Ciencias Marinas-IPN
Antonella Preti, NOAA Fisheries, Southwest Fisheries Science Center

The striped marlin (*Kajikia audax*) is economically significant globally and important for recreational fishing in Cabo San Lucas, B.C.S., Mexico. Previous studies have described its trophic ecology using stomach content or stable isotope analysis. This study combines both methods to characterize changes due to sex, ontogenic development (juveniles and adults), and season (warm and cold). Stomach and muscle samples were collected from the Cabo San Lucas sportfishing fleet from 2019 to 2022.

To date, 275 stomachs have been successfully analyzed, with 227 (83%) containing prey items. Organism lengths range from 140 cm to 242 cm. There are 82 prey items currently reflected in the diet. Preliminary results from the Prey Specific Index of Importance (%PSIRI) indicate that fishes dominate the diet, followed closely by Cephalopods. The most important species overall are Humboldt squid *Dosidicus gigas* (13.7%), *Argonauta spp.* (13.4%), Pacific Mackerel *Scomber japonicus* (8.3%), *Balistes polylepis* (7.5%) and *Auxis spp.* (5.76%).

Female marlins mainly consumed *D. gigas* (16%), *Argonauta spp.* (15.5%), *S. japonicus* (7.7%), *Fistularia spp.* (7.67%), and *B. polylepis* (5.38%). Males primarily consumed *Argonauta spp.* (12.5%), *D. gigas* (12.2%), *S. japonicus* (8.63%), *B. polylepis* (8.54%), and *Lagocephalus lagocephalus* (7.1%). Juveniles (males ≤188 cm, females ≤197 cm) principally consumed *Argonauta spp.* (14.3%), *D. gigas* (14.3%), *B. polylepis* (7.9%), *Fistularia spp.* (6.6%), and *S. japonicus* (6.4%). Adults (males ≥189 cm, females ≥198 cm) primarily consumed *S. japonicus* (14.3%), *D. gigas* (12.2%), *Argonauta spp.* (11.8%), *L lagocephalus* (5.94%), and *B. polylepis* (4.93%) Diet varied by season: warm season diet included *D. gigas* (14.5%), *Argonauta spp.* (10.9%), *B. polylepis* (7.7%), *Auxis spp.* (7.6%), and *L. lagocephalus* (6.3%), while cool season diet included *Argonauta spp.* (18.8%), *S. japonicus* (18.1%), *D. gigas* (12%), *S. sagax* (11%), and *Fistularia spp.* (4.7%). The warm and cool seasons had sig nificantly different diets ($R = 0.103$, $p = 0.01$), with no significant changes in other categories.

Statistical analysis and interpretation of stable isotope data are currently in progress. The University of California Davis Stable Isotope Facility processed 80 muscle samples, and the final report was received in early June. Preliminary conclusions suggest striped marlins pursue similar prey regardless of sex and maturity, with prey availability fluctuating seasonally due to environmental conditions.

P21 Billfish dynamic habitat use in the Eastern Tropical Pacific Ocean off Central America

Presenting Author: Bruce Pohlot, International Game Fish Association
Email: bpohlot@igfa.org

Authors:
Bruce Pohlot, International Game Fish Association
Nelson Ehrhardt, Rosenstiel School of Marine, Atmospheric and Earth Sciences, University of Miami

Some of the world's highest billfish catch rates are reported from coastal regions of the Pacific Ocean off the Central American Isthmus. Such catch rates appear linked to high density of billfish prey resources mostly found closer to the ocean surface due to habitat compression; therefore, billfish availability and catchability to commercial and sport fishing gear is further enhanced by the observed biophysical characteristics of the local coastal ecosystems. Ecosystem dynamics are complex in this region due to seasonal atmospheric/ocean processes causing several discrete coastal upwelling regions that seasonally parcel the available habitat for the pelagic food chain. Such processes are the result of a combination of varying seasonal winds, currents, and geostrophic forces that enhance ocean productivity through upwelling and concentration of nutrients in specific locations that prompt the lower trophic level species such as plankton and small pelagic resources to excel and aggregate. With seasonally stratified food chains, predatory species find available prey created by the prevailing oceanographic processes. In this presentation we provide new knowledge on the spatial and temporal population dynamic characteristics and behavior of sailfish, *Istiophorus platypterus,* and blue marlin,

Makaira nigricans, in the tropical eastern Pacific Ocean in areas off Central America. Analyses incorporate satellite tagging databases secured by the authors, resulting in valuable information on the overall dynamics of billfish seasonal habitat use, residence within exclusive economic zones, and their linkage to oceanographic features. The results provide insights into the temporal and spatial availability of the billfish to recreational fisheries and their risk of exposure to exploitation as bycatch in commercial longlining. In the end, this information may prove significant to billfish resources conservation and management in the region.

P22 Citizen science is a porthole to investigating the influence of oceanographic factors on the recreational catch distribution of sailfish

Presenting Author: Laura Smith, School of the Environment, The University of Queensland
Email: laura.smith@uq.edu.au

Authors:
Laura Smith, School of the Environment, The University of Queensland
Jessica Bolin, University of the Sunshine Coast
Julian Pepperell, Pepperell Research and Consulting Pty Ltd
Ian Tibbetts, The University of Queensland
Bonnie Holmes, University of the Sunshine Coast
Samuel Williams, Queensland Department of Agriculture and Fisheries

Pelagic fish are influenced by complex ocean dynamics at varying spatial and temporal scales, which makes it difficult to measure ecological responses to pressures such as fishing and climate change. As such, current understanding of sailfish (*Istiophorus platypterus*) and their spatio-temporal habitat use in the western Pacific is poor. These knowledge gaps create substantial challenges for assessing the status of sailfish stocks, which is necessary for their sustainable management in this region.

Sailfish are predominantly targeted by recreational fishers that practice catch, tag-and-release in Australian waters. These valuable citizen science records can be used to monitor sailfish occurrence patterns and catch distribution. In this study, I used generalised additive mixed models to examine how recreational sailfish catches are related to oceanographic conditions. I determined that several oceanographic factors affected recreational catch probabilities and that these varied between regions. I characterised the seasonal and interannual variability in sailfish catch, and used recapture data to examine their movement patterns. My research provides novel information on the spatio-temporal dynamics and habitat preferences of sailfish in Australian waters, where information was sorely lacking. This study provides insight into the drivers of sailfish occurrence that allow us to better understand past trends but also their likely response to changing ocean conditions.

P23 Progression and Purpose of TBF's "Conservation Record"

Presenting Author: Peter Chaibongsai, The Billfish Foundation
Email: peter_chaibongsai@billfish.org

Authors:
Adelaide Spain, The Billfish Foundation
Thomas Morrell, The Billfish Foundation
Peter Chaibongsai, The Billfish Foundation

The Billfish Foundation (TBF) is a non-profit organization dedicated to the conservation of billfish species worldwide. Through TBF's Tag & Release Program and the citizen-science efforts of the sportfishing community, TBF has utilized its ~280,000 open-sourced records in support of proper fisheries management, stock assessments, billfish science, and socioeconomic research. When attempting to summarize the efforts of TBF in a given year, which can be more than 15,000 records annually, it can be difficult to capture the success of the foundation in its entirety.

In recent years however, a TBF report, internally referred to as TBF's Conservation Record has done an incredible job of relaying said efforts into a digestible yet comprehensive document that blends science and communication into an enjoyable, research-based publication. Locational distribution, seasonal trends, and mapped data for visualization are just a few examples of how this report has provided TBF with a better platform to conserve these species through scientific efforts, with the overarching purpose of creating a tangible representation of the data for the community to review. Essentially, this report helps to bridge the gap between science and policy and showcase the benefits of the sportfishing community for billfish populations worldwide.

Starting in 2005, these TBF reports have been completed intermittently, but in 2018, the "Conservation Record" shifted from a basic tag and release breakdown to a more complex and comprehensive illustration of the data being used, providing a snapshot of patterns occurring within billfish populations and showcasing some of the beneficial uses of collected billfish data. As this record has progressed, so too have the opportunities for research and fisheries institutions to utilize the data for the conservation of billfish and science-based endeavors.

P24 Physiological Thermoregulation in Swordfish: Insights from a Fourier Heat Transfer Model

Presenting Author: Ashley Stoehr, Sacred Heart University
Email: stoehra@sacredheart.edu

Authors:
Ashley Stoehr, Sacred Heart University
Alex Fowler, University of Massachusetts Dartmouth
Scott Aalbers, Pfleger Institute of Environmental Research
Chugey Sepulveda, Pfleger Institute of Environmental Research
Diego Bernal, University of Massachusetts Dartmouth

Swordfish (*Xiphias gladius*) are distinct in their ability to make long-duration, foraging dives from the warm surface (~20°C) to cold waters below the thermocline (~8°C), during which they maintain elevated temperatures in their red, aerobic swimming muscle (i.e., RM endothermy). Metabolic heat retention and reduced convective and conductive heat

transfer with the surrounding water are possible due to the presence of heat-exchanging retia supplying the RM and the movement of the RM mass towards the body core. Newtonian heat transfer models previously demonstrated low, stable heat transfer rates in RM and lower rates of heat transfer in the white, anaerobic swimming muscle (WM) during descents versus ascents through the thermocline. However, because Newtonian models cannot assess physiological mechanisms that drive heat transfer rates, a new Fourier-based model was developed to evaluate the effects of heat production, blood flow, and the efficiency of retia on muscle temperature. Parameters were optimized using heuristic hill-climbing methods to simulate muscle temperatures within a cylindrical cone of tissue extending from the vertebral column to the skin (i.e., temperature profile). Simulated temperatures from the profile, as well as temperature changes at specific points along the profile, were compared over time with *in vivo* temperature measurements obtained at three body depths (~1-10 cm penetration) in a free-swimming swordfish. Preliminary results suggest that high heat retention efficiency and slow blood flow through the retia and RM are most important for maintaining an elevated and stable RM temperature. Additional analysis and comparisons with other species will provide insight into how swordfish regulate muscle temperatures and access the deep, cold-water resources that are beyond the reach of many pelagic fishes.

P25 Assessment of existing and alternative data collection methods for recreational catches of billfishes and tunas in the southwest Pacific

Presenting Author: Barrett Wolfe, University of Tasmania, Institute for Marine and Antarctic Studies; Centre for Marine Socioecology
Email: barrett.wolfe@utas.edu.au

Authors:
Barrett Wolfe, University of Tasmania, Institute for Marine and Antarctic Studies; Centre for Marine Socioecology
Ashley Fowler, Department of Regional New South Wales
Julian Pepperell, Pepperell Research and Consulting Pty Ltd
Kate Stark, University of Tasmania, Institute for Marine and Antarctic Studies
Sam Williams, Department of Agriculture and Fisheries
Sean Tracey, University of Tasmania, Institute for Marine and Antarctic Studies

Despite international obligations to report catches of tropical tunas and billfishes (TTBF), collection from the recreational sectors of Australian fisheries targeting these species has a history of patchiness and uncertainty. A fuller understanding of recreational and charter catch data for not only commercial TTBF species like striped marlin but others such as black and blue marlin would add valuable information regarding trends in local abundance or availability, and the degree of overlap between recreational and commercial and international fisheries, and thus would help to inform resource sharing considerations and overall fisheries management. Despite the long-standing need for better recreational fishery data, there has not been a concerted effort to comprehensively review available data for TTBF species, and/or to map out what may or may not be feasible for future ongoing monitoring of the recreational / charter sector. Here we present on an ongoing project undertaken to fill this knowledge gap. Catch data from across the eastern seaboard of Australia were collated, including from tagging programs, tournaments, game fishing club records, state fishing surveys, charter logbooks. Data collection for some sources was extended to New Zealand, reflecting shared biological stocks. We present a workflow for data standardization and quality control and the identification of fishery performance indicators from these data sources, enabling a review and cost-benefit analysis of alternative options for ongoing data collection for TTBF species. By bridging existing knowledge gaps, this project aims to enhance monitoring capabilities and guide future data collection strategies for the region's recreational TTBF sector.

Contacts

Aalbers, Scott
scott@pier.org
Pfleger Institute of Environmental Research

Aalto, Emil
aalto@stanford.edu
Stanford University

Adisa, Sylvia
adisasylvia@ufl.edu
University of Florida

Alvarado-Bremer, Jaime
jaimeab@tamu.edu
Texas A&M University at Galveston

Andrzejaczek, Samantha
sammyaz@stanford.edu
Stanford University

Aquila, Roselyn
raguila@tamu.edu
Texas A&M University at Galveston

Arostegui, Martin
martin.arostegui@whoi.edu
Woods Hole Oceanographic Institution

Berkowitz-Sklar, Daviana
daviana@stanford.edu
Stanford University

Block, Barbara A
bblock@stanford.edu
Stanford University

Blondin, Hannah
hannah.blondin@noaa.gov
NOAA/University of Miami

Bonhommeau, Sylvain
sylvain.bonhommeau@ifremer.fr
IFREMER

Braun, Camrin
CBRAUN@WHOI.EDU
Woods Hole Oceanographic Institution

Buenfil Avila, Aura Estefany
abuenfila1900@alumno.ipn.mx
CICIMAR-IPN

Burns, Anthony
anthony@roffs.com
Upton Environmental Inc dba ROFFS

Centeno Chaves, Allison
allisoncenteno67@gmail.com
FECOP - Costa Rica Sportfishing Federation/National University of Costa Rica

Chaibongsai, Peter
peter_chaibongsai@billfish.org
The Billfish Foundation

Chang, Yi-Jay
yijay.chang@gmail.com
National Taiwan University

Chaves, Johel
jchaves@fecop.org
FECOP - Costa Rica Sportfishing Federation

Chevrier, Thomas
t.chevrier.cooolresearch@gmail.com
Company for Open Ocean Observations and Logging (COOOL)

Chiang, Wei Chuan
istiophorid@gmail.com
Fisheries Research Institute, Taiwan

Cobar de la Hoz, Juan Manuel
juanmanuel@billfishconservation.org
Billfish Conservation Project

Crowder, Larry
larry.crowder@stanford.edu
Ricketts Professor of Marine Ecology and Conservation

Contacts

Dance, Mike
mdance1@lsu.edu

Dello Russo, Joseph
joseph.dellorusso@maine.edu
University of Maine

DiNardo, Gerard
gdinardo@scsglobalservices.com
SCS Global Services

Drymon, Marcus
marcus.drymon@msstate.edu
Mississippi State University

Dunn, Russell
russell.dunn@noaa.gov
NOAA Fisheries

Ehrhardt, Nelson
nehrhardt@hotmail.com
University of Miami

Enslow, Lindsay
lmaxim@lotek.com
Lotek

Exley, Laura
manager@joingsc.org
Global Sustainability Collective

Farchadi, Nima
nfarchadi@sdsu.edu
San Diego State University

Garth, Fred
fred@billfishconservation.org
Billfish Conservation Project

Gaube, Peter
pgaube@uw.edu
Applied Physic Laboratory - University of Washington

Gebhardt, Brandon
president@joingsc.org
Global Sustainability Collective (GSC)

Girasek, Quinn
qlgirasek@vims.edu
Virginia Institute of Marine Science,
College of William & Mary

Gray, Thomas
tgray@whgrp.com
Woods Hole Group

Guillemin, Tristan
tristan.guillemin@students.mq.edu.au
Macquarie University/School of Natural Sciences

Gutierrez, Erika
egutie55@ucsc.edu
University of California Santa Cruz

Hammond, Matthew
matthew.hammond@cdu.edu.au
Charles Darwin University

Haulsee, Danielle
dhaulsee@hswri.org
Hubbs-SeaWorld Research Institute

Hernández Aparicio, Amairani
ahernandeza2100@alumno.ipn.mx
INSTITUTO POLITECNICO NACIONAL - CICIMAR

Higgs, Jeremy
j.higgs@usm.edu
University of Southern Mississippi Center for Fisheries Research and Development

Holdsworth, John
john@bluewatermarine.co.nz
Blue Water Marine Research

Holland, Melinda
melinda@wildlifecomputers.com
Wildlife Computers

Hsu, Jhen
jhene.hsu@gmail.com
Institute of Oceanography, National Taiwan University

Contacts

Jacoski, Greg
greg@guyharveyfoundation.org
Guy Harvey Foundation

Jia, Yanli
yjia@hawaii.edu
University of Hawai'i at Mānoa

Kadagi, Nelly
nellykadagi@gmail.com
World Wildlife Fund

Kehoe, Donna
dkehoe@lotek.com
Lotek

Kerstetter, David
kerstett@nova.edu
Nova Southeastern University

Kneebone, Jeff
Jkneebone@neaq.org
Anderson Cabot Center for Ocean Life

Kramer, Rob
rkramer@wildoceans.org
Wild Oceans

Labriola, Theresa
tlabriola@icloud.com
Wild Oceans

Logan, Ryan
rklogn@gmail.com
Guy Harvey Research Institute/NSU Florida

Luo, Jiangang
jluo@miami.edu
University of Miami

Marin, Henry
hmarin@fecop.org
FECOP - Costa Rica Sportfishing Federation

Marrari, Marina
mmarrari@fecop.org
FECOP - Costa Rica Sportfishing Federation

Martinez, Jackson
jacksonleemartinez@gmail.com
Virginia Institute of Marine Science

Martinez-Fernandez, Damian
damian.martinezcr@gmail.com
FECOP - Costa Rica Sportfishing Federation

McDowell, Jan
McDowell@vims.edu
Virginia Institute of Marine Science

Millender, Anna
anna.millender@usm.edu
University of Southern Mississippi Center for Fisheries Research and Development

Montalvo, Miguel
mmontalvo@vims.edu
Virginia Institute of Marine Science

Morrell, Thomas
thomas_morrell@billfish.org
The Billfish Foundation

Musyl, Michael
michael.musyl@gmail.com
Pelagic Research Group

Ng, Kevin
kevin@wildlifecomputers.com
Wildlife Computers

Nieblas, Anne-Elise
anne.elise.nieblas@gmail.com
Company for Open Ocean Observations and Logging (COOOL)

Orbesen, Eric
eric.orbesen@noaa.gov
NOAA

Contacts

Ortega-García, Sofía
sortega@ipn.mx
Instituto Politécnico Nacional-CICIMAR

Pacheco Aldana, Pamela
pamela.pachecoaldana@gmail.com
Instituto Politécnico Nacional CICIMAR

Pepperell, Julian
julianp@internode.on.net
Pepperell Research & Consulting

Pohlot, Bruce
bpohlot@igfa.org
International Game Fish Association

Preti, Antonella
antonella.preti@noaa.gov
NOAA/UCSC

Rafferty, Kevin
krafferty2121@gmail.com
Nova Southeastern University

Ruzicka, Zane
zane.ruzicka@gmail.com
Wild Oceans

Schmidt, Andrea
andrea.schmidt@noaa.gov
Cooperative Institute for Marine and Atmospheric Research (CIMAR)

Schratwieser, Jason
jschratwieser@igfa.org
International Game Fish Association

Sculley, Michelle
michelle.sculley@noaa.gov
NOAA NMFS

Sepulveda, Chugey
chugey@pier.org
Pfleger Institute of Environmental Research

Smith, Laura
laura.smith@uq.edu.au
The University of Queensland

Snodgrass, Derke
DERKE.SNODGRASS@NOAA.GOV
NOAA SEFSC

Stoehr, Ashley
stoehra@sacredheart.edu
Sacred Heart University

Taplett, Nanci
nanci@wildlifecomputers.com
Wildlife Computers

Tracey, Sean
Sean.tracey@utas.edu.au
University of Tasmania

Upton, Matthew
matt2@roffs.com
Upton Environmental Inc. dba ROFFS

Wambiji, Nina
nwambiji@gmail.com
Mpala Research Centre

Webb, Becca
rebecca@wildlifecomputers.com
Wildlife Computers

Wells, David
wellsr@tamug.edu
Texas A&M University

Willis, Ciara
willisc@mit.edu
MIT-WHOI Joint Program

Wolfe, Barrett
barrett.wolfe@utas.edu.au
University of Tasmania

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SEVENTH INTERNATIONAL
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