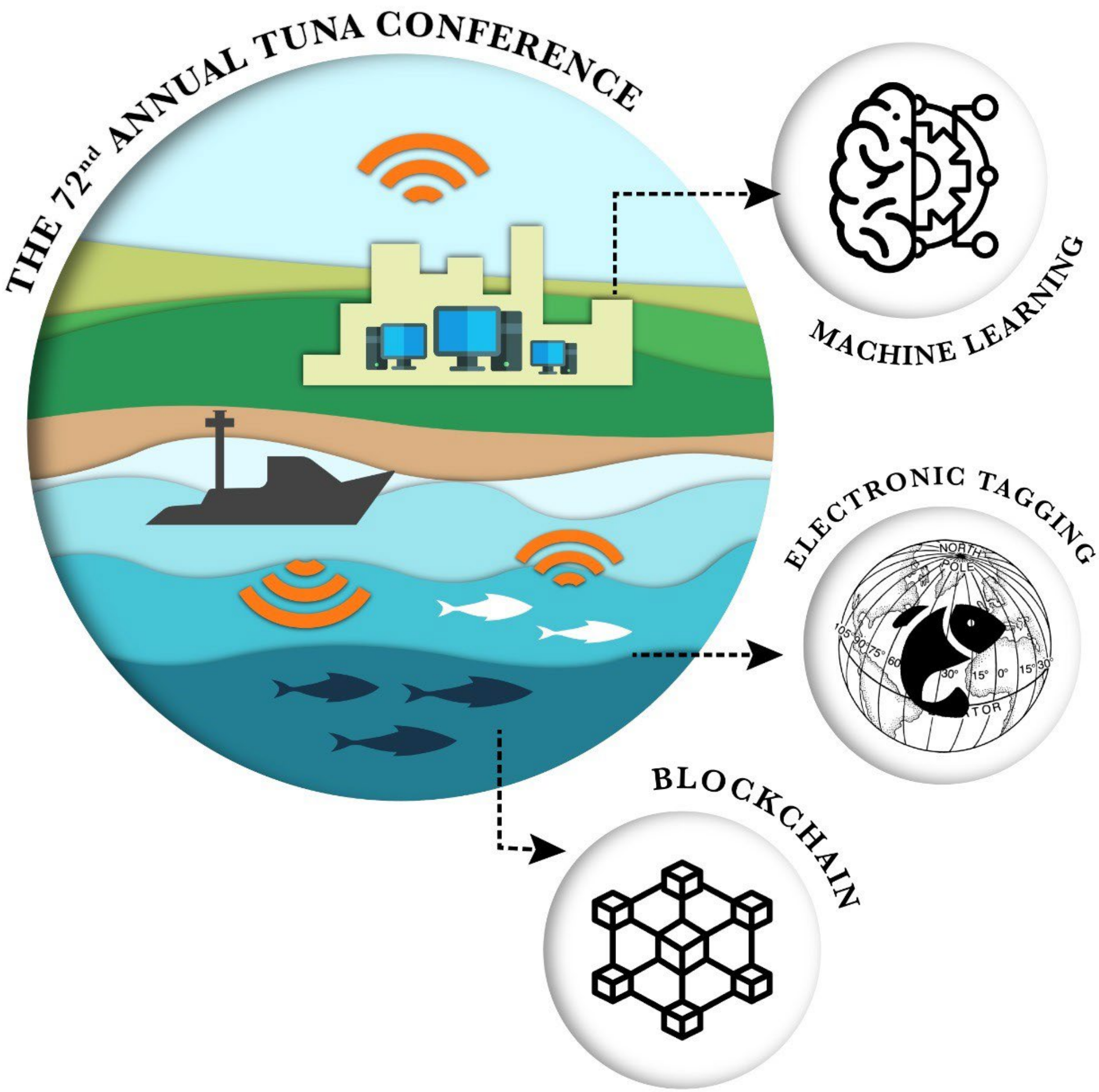
PROCEEDINGS OF THE 72ND ANNUAL TUNA CONFERENCE

Technological advances in fisheries science: applications, benefits and challenges



PROCEEDINGS OF THE 72ND ANNUAL TUNA CONFERENCE

Virtual Meeting
May 24-26, 2022

Jon Lopez and Marlon H Román – Chairs
Barbara Cullingford – Coordinator

PREFACE

Welcome to the 72nd Annual Tuna Conference. The goal of the Tuna Conference is to provide an open and informal forum for scientists, engineers, managers, fishermen, non-governmental organizations and other interested parties from around the world to exchange information and ideas including recent research findings on tunas and "tuna-like" species. The free and open exchange of ideas is key to the Conference's success.

The theme for this year's Tuna Conference is **"Technological advances in fisheries science: applications, benefits and challenges".** It is undeniable that large-pelagic fisheries science and management depends on tools and research supported by data collected and analyzed using the best innovative procedures, methods and techniques available. Technology evolves rapidly and it is important to be apprised on its improvements for science and management purposes. For example, the advances on remote sensing, electronic tagging, blockchain, or machine learning and artificial intelligence applied to improved methods for species distribution modelling, environmental analyses, fish and fishing behavior studies, traceability of products or electronic monitoring, among others, offer an opportunity to continuously improve our understanding of the species, the environment they live in as well as monitoring the different elements involved in the fishery at different scale in a more efficient manner. For this 2022 Tuna Conference, we are calling on scientists to showcase and share their experiences so as to gain insight into these technological advances, their benefits and associated challenges for the fishery science and management of the future.

Many of the oral and poster presentations at this year's conference directly relate to the theme and, as always, there is a diverse and interesting series of presentations on the agenda. Over the course of the next three days, there will be 29 oral presentations across 6 sessions. We also have an additional 4 presentations in the poster session. This year's conference features a dedicated session "Electronic Monitoring", conducted by Craig Heberer, in which 9 oral presentations will describe and discuss different aspects related to this important and promising tool for fishery data collecting. Special thanks to this year's session moderators: Kim Holland, Owyn Snodgrass, Melissa Cronin, Gala Moreno, Suzy Kohin, and Nadya Mamoozadeh. We sincerely appreciate their efforts to keep sessions running smoothly.

The abstracts for the oral and poster presentations contained in the Proceedings are listed as presented. Bold lettering denotes the author giving the presentation. All abstracts are considered reports of preliminary work. If readers are interested in the information presented in the abstracts, they should contact the author(s) directly. No abstract should be cited without prior consent from the author(s).

We'd like to express our thanks to Darinka Puente Alfaro for contributing her beautiful artwork to our cover page. Also, thanks to our graphic designer Chris Patnode for the Tuna Conference website and logo, and JoyDeLee Marrow contributed her time and expertise to answer all our questions regarding the Tuna Conference! We are also very grateful to the team of SWFSC and IATTC staff members, too numerous to be named here, for general assistance with preparation for the conference.

In closing, we would like to thank you all for participating in the second virtual Tuna Conference. After all, it is the quality of your presentations and camaraderie that make the Tuna Conference such a great event. We hope you have a productive and enjoyable time, and we look forward to seeing you back next year at the 73rd Tuna Conference!

Marlon H Román
72nd Tuna Conference Chair

Jon Lopez
72nd Tuna Conference Chair

Barbara Cullingford
72nd Tuna Conference Coordinator

72nd TUNA CONFERENCE AGENDA

Tuesday, 24 May 2022

12:00 Welcome and Introduction

SESSION 1: Tagging (Moderator: Kim Holland)

12:10 Two Decades of Electronic Tagging Efforts for Blue Marlin and Sailfish in the Eastern Tropical Pacific. **Danielle Haulsee**, Hannah Blondin, Ryan Logan, Andre Boustany, Taylor Chapple, John Dean, Michael Domeier, Eric Hoffmayer, Nicole Nasby-Lucas, Eric Orbesen, Robbie Schallert, Virginia Shervette, George Shillinger, Mahmood Shivji, Derke Snodgrass, Jamie Walker, Bradley Wetherbee, Elliott Hazen, and Larry B. Crowder.

12:25 Depth preference and catchability of billfish in the eastern tropical Pacific determined using pop-up satellite archival tags. **Hannah Blondin**, Danielle Haulsee, Elliott Hazen, and Larry B. Crowder.

12:40 Multi-year Tracking of Striped Marlin Reveals Residency in the East Pacific Ocean. **Chi Hin Lam**, Nicole Nasby-Lucas, Sofia Ortega-Garcia, Paxson Offield and Michael L. Domeier.

SESSION 2: Life history (Moderator: Owyn Snodgrass)

13:00 Review of research activities conducted at the IATTC's Achotines Laboratory from 2021-2022. **Susana Cusatti**, Daniel Margulies, Vernon Scholey, Yole Buchalla, Enrique Mauser.

13:15 Quantifying Trophic Linkage Between Pelagic and Coral Reef Habitats Using DNA Barcoding in Hawaiian Populations of the Epipelagic Predator, Mahi-Mahi (*Coryphaena spp*.). **Nan Himmelsbach**, Molly Timmers, Raymond Boland, Jonathan Whitney.

13:30 Hunting behavior and estimated energy expenditure by a solitary sailfish during prey pursuit and capture. **Ryan K. Logan**, Sarah M. Luongo, Jeremy J. Vaudo, Bradley M. Wetherbee, Mahmood S. Shivji.

13:45 Histological sampling and historical data show no evidence of Pacific bluefin tuna reproduction in the southern California Current system. Heidi Dewar, **Owyn Snodgrass**, Barbara Muhling and Kurt Schaefer.

POSTER SESSION 2: Life History

14:00 Age and Growth Estimation of Striped Marlin (*Kajikia audax*) through the use of Otoliths and Spines in Baja California Sur: Preliminary Results. **Worbis-Badias Mariana**, Ulianov Jakes-Cota, Sofía Ortega-García and Rubén Rodríguez-Sánchez.

SESSION 3: Bycatch research (Moderator: Melissa Cronin)

14:15 Reducing shark bycatch in tuna fisheries: adaptive spatio-temporal management options for the eastern Pacific Ocean. **Guillermo Ortuño Crespo**, Shane Griffiths, Hilario Murua, Henrik Österblom and Jon Lopez.

14:30 Harnessing Stakeholder Knowledge for the Collaborative Development of Mobulid Bycatch Mitigation Strategies in Tuna Fisheries. **Melissa Cronin**, Donald A. Croll, Martin A. Hall, Nerea Lezama-Ochoa, Jon Lopez, Hilario Murua, Jefferson Murua, Victor Restrepo, Stefany Rojas-Perea, Joshua D. Stewart, Jennifer L. Waldo and Gala Moreno.

14:45 A Machine Learning Species Distribution Model for the Critically Endangered East Pacific Leatherback Turtle (*Dermochelys coriacea*). **Jon Lopez**, Shane Griffiths, Bryan Wallace, Verónica Cáceres, Leslie Camila Bustos, Luis Cocas, Rodrigo Vega, Patricia Zárate, Ljubitza Clavijo, Ilia Cari, Juan Manuel Rodriguez-Baron, José Miguel, Carvajal, Rotney Piedra, Sandra Andraka, Lilian Rendón, Marco Herrera11; Jenifer Suárez, Heriberto Santana, Marino Abrego, Callie Veelenturf, Javier Quiñones, Miguel Perez, Joanna Alfaro, Jeff Mangel, Nelly de Paz.

15:00 Bayesian prediction of fishery biological impacts from limited data: A deep-set buoy gear case study. Stephen M. Stohs and **Karter M. Harmon**.

15:15 Vulnerability assessment of shark bycatch in EPO tuna fisheries using the EASI-Fish approach. **Shane Griffiths**, Leanne Fuller, Joanne Potts, and Simon Nicol.

15:30 Threatened species bycatch rates in longline fleets largely driven by variation in individual vessel behavior. **Leslie A Roberson** and Chris Wilcox.

POSTER SESSION 3: Bycatch research

15:45 Investigating the Potential of Helicopter-Vessel Communication for Bycatch Avoidance in Tuna Purse Seine Fisheries. **Jennifer L. Waldo**, Ernesto Altamirano, Donald A. Croll, Marta Diaz Palacios, Nerea Lezama-Ochoa, Jon Lopez, Gala Moreno, Stefany Rojas-Perea, Melissa R. Cronin.

15:50 **Close Day One**

Wednesday, 25 May 2022

12:00 Open Day Two

SESSION 4: FADs (Moderator: Gala Moreno)

12:00 Impact of the density of Fish Aggregating Devices on tuna behavior from an individual-based model. **Amaël Dupaix**, Jean-Louis Deneubourg, Laurent Dagorn and Manuela Capello.

12:15 Echosounder Buoys in Tropical Tuna Purse Seine Fishery. **Jon Uranga**, Manuella Capello , Yannick Baidai; Maitane Grande, Jon Lopez , Gala Moreno , Hilario Murua and Josu Santiago.

12:30 The Jelly-FAD A Paradigm Shift in Biodegradable FAD Technology: Benefits and Challenges. **Gala Moreno**, Joaquín Salvador, Iker Zudaire, Jefferson Murua, Hilario Murua, Jon Uranga, Maitane Grande, Victor Restrepo.

12:45 Modeling Drifting FAD Trajectories Arriving at Essential Habitats for Marine Turtles. **Lauriane Escalle**, Scutt Phillips J, Aires-da-Silva A, Corniuk R, Hampton J, Lopez J, Lynch J, Mcwhirter A, Murua H, Restrepo V, Royer S.J, Swimmer Y, and Gala Moreno.

SPECIAL SESSION: Electronic Monitoring (Conductor: Craig Heberer)

13:00 EM programs - Session overview.

13:00 From Pilot to Scale: The State of Play for Electronic Monitoring of Tuna Fisheries. (**Craig Heberer**).

13:15 The IATTC EM Program. (**Marlon H Roman**).

13:30 NOAA EM state of play. (**Brett Alger**).

13:45 An Emerging Industry-led EM program – TNC overview.

14:00 Program design. (**Ben Gilmer**).

14:15 Incentives, MSC, market access. (**Alvaro Teran**).

14:30 Sustainability commitments. (**Traci Murai**).

14:45 Current and Future EM Tech Innovations – Overview.

15:00 The Role of Automation using AI/ML - progress/gaps/challenges to scale. (**JT Mudge**).

15:15 Data Integrity and Transparency. (**Bubba Cook**).

15:30 Final Wrap up / Q&A.

15:45 Close Day Two

Thursday, 26 May 2022

12:00 Open Day Three

SESSION 5: Feeding and movement ecology (Moderator: Suzy Kohin)

12:00 Spatio-temporal Distribution of Juvenile Oceanic Whitetip Shark Incidental Catch in the Western Indian Ocean. **Leire Lopetegui-Eguren**, Jan Jaap Poos, Haritz Arrizabalaga, Gency Guirhem, Hilario Murua, Nerea Lezama-Ochoa, Shane Griffiths, Jon Ruiz Gondra, Philippe S. Sabarros, Jose Carlos Báez and Maria José Juan-Jordá**.**

12:15 A population in decline? Examining habitat use, temporal changes, and knowledge gaps for basking sharks (*Cetorhinus maximus*) in the California Current Ecosystem. **Alexandra G. McInturf**, Barbara Muhling, Joseph J. Bizzarro, Nann A. Fangue, David A. Ebert, Damien Caillaud and Heidi Dewar.

12:30 Movements and population dispersal of the dolphinfish (*Coryphaena hippurus*) across the Eastern Tropical Pacific inferred from carbon and nitrogen stable isotope analysis. **Sergio A. Briones-Hernández**, Ulianov Jakes-Cota, Fernando R. Elorriaga-Verplancken, Felipe Galván-Magaña, John M. Logan, John O'Sullivan, Esteban Elias, José Miguel Carvajal, Joanna Alfaro-Shigueto and Sofía Ortega-García.

12:45 Risk and Reward in Foraging Migrations of North Pacific Albacore Determined from Estimates of Energy Intake and Movement Costs. **Barbara A. Muhling**, Stephanie Snyder, Elliott L. Hazen, Rebecca E. Whitlock, Heidi Dewar, Jong-Yeon Park, Charles A. Stock and Barbara A. Block.

13:00 Juvenile Albacore Tuna (*Thunnus alalunga*) foraging ecology varies with environmental conditions in the California Current Large Marine Ecosystem. **Catherine F. Nickels**, Elan J. Portner, Owyn Snodgrass, Barbara Muhling, and Heidi Dewar.

13:15 Pacific bluefin tuna, *Thunnus orientalis*, exhibits a flexible feeding ecology in the Southern California Bight. **Elan J Portner**, Owyn Snodgrass and Heidi Dewar.

13:30 Feeding ecology of broadbill swordfish (*Xiphias gladius*) in the California Current. **Antonella Preti**, Stephen M. Stohs, Barbara Muhling, Gerard T. DiNardo, Camilo Saavedra, Ken MacKenzie, Leslie R. Noble, Catherine S. Jones and Graham J. Pierce.

POSTER SESSION 5: Feeding and movement ecology

13:45 Development of a Genotyping-in-Thousands by sequencing (GT-seq) panel to evaluate stock structure and sex-specific distribution patterns of Albacore Tuna (*Thunnus alalunga*) in the Pacific Ocean. **Kathleen G. O'Malley**, David. I. Dayan, Cristín K. Fitzpatrick, Nathan Campbell, Geoffrey Walker and Felix Vaux.

13:50 Evaluating the reliance of tuna and swordfish on forage species in the ocean's twilight zone using compound-specific stable isotope analysis. **Ciara Willis**, Kayla Gardner, Walt Golet, Leah Houghton and Simon Thorrold.

SESSION 6: Data collection (Moderator: Nadya Mamoozadeh)

14:00 Tun-AI: tuna biomass estimation with Machine Learning models trained on oceanography and echosounder FAD data. Daniel Precioso, Manuel Navarro-García, **Kathryn Gavira- O'Neill**, Alberto Torres-Barrán, David Gordo, Victor Gallego-Alcalá and David Gómez-Ullate.

14:15 Future technological applications for data collection in the Atlantic highly migratory species pelagic longline fleet. **Ian Miller** and Brad McHale.

14:30 Harnessing Advances in Artificial Intelligence and Genomics to Enable Scalable and Field- deployable Species Identification Capabilities. **Mariah Meek**, Nadya Mamoozadeh, Shannon O'Leary, David Portnoy and Nihar Mahapatra.

14:45 Advancing Tropical Tuna Fisheries Science with Biogeochemical ARGO (BGC-ARGO). **Michael P. Seki**.

15:00 Harvesting ship navigation radar to provide low-cost data on vessel activity at sea. **Chris Wilcox**, Adrien Ickowicz, Christian Moeseneder and Leslie A Roberson.

15:15 Business Meeting

15:30 Close Day Three – Final remarks.

Abstracts

DEPTH PREFERENCE AND CATCHABILITY OF BILLFISH IN THE EASTERN TROPICAL PACIFIC DETERMINED USING POP-UP SATELLITE ARCHIVAL TAGS

Hannah Blondin[1], Danielle Haulsee[1], Elliott Hazen[1,2,3], & Larry B. Crowder[1]

[1]Hopkins Marine Station of Stanford University, [2]NOAA Southwest Fisheries Science Center Environmental Research Division, [3]University of California Santa Cruz

120 Ocean View Blvd,
Pacific Grove, CA 93950

Pacific blue marlin (*Makaira nigricans*) and Indo-Pacific sailfish (*Istiophorus platypterus*) are two species of migratory billfish that occupy the epipelagic zone of the world's subtropical and tropical marine waters. Although their Atlantic counterparts are relatively well-studied, far less research has been completed on Pacific populations to date. Here we analyze depth data from 57 sailfish tags and 47 blue marlin tags deployed over 17 years in the Eastern Tropical Pacific. Generalized additive mixed models were used to fit environmental covariates to daily time spent below 10 meters. Both species exhibited a similar diel trend in depth use, being deeper during the day than at night. Blue marlin spent an average range of 7-60% of time below 10 meters whereas sailfish ranged from 25-47%. Patterns in GAMMs between the two species are similar and correlated with day of year and sea surface temperature. However, blue marlin time spent below 10 meters was also significantly correlated with log chlorophyll-a and linearly correlated with lunar illumination. We also fit separate models for daytime hours and nighttime hours to explore catchability of these species by longlining vessels. Using robust statistical models integrating biophysical variables, we can provide insights into the vertical distribution of blue marlin and sailfish in the ETP and can infer impacts and responses to local environmental variability, changes in climate, and anthropogenic stressors.

TWO DECADES OF ELECTRONIC TAGGING EFFORTS FOR BLUE MARLIN AND SAILFISH IN THE EASTERN TROPICAL PACIFIC

Danielle Haulsee[1], Hannah Blondin[1], Ryan Logan[2,3], Andre Boustany[4], Taylor Chapple[5], John Dean[6] Michael Domeier[7], Eric Hoffmayer[8], Nicole Nasby-Lucas[7], Eric Orbesen[8], Robbie Schallert[1], VirginiaShervette[9], George Shillinger[1,10,11], Mahmood Shivji[2,12], Derke Snodgrass[8], Jamie Walker[13], Bradley Wetherbee[14], Elliott Hazen[1,15,16], and Larry B. Crowder[1]

[1]Hopkins Marine Station of Stanford University, [2]Guy Harvey Research Institute, [3]Southeastern University, [4]Monterey Bay Aquarium, [5]Oregon State University, [6]University of South Carolina, [7]MarineConservation Science Institute,[8]USA NOAA Southeast Fisheries Science Center, [9]University of South-Carolina Aiken, [10]Upwell Turtles, [11]MigraMar, [12]NOVA Southeastern University, [13]BillfishResearch.Org, [14]University of Rhode Island, [15]USA NOAA Southwest Fisheries Science Center, [16]University of California Santa Cruz

120 Ocean View Blvd,
Pacific Grove, CA 93950

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 basic understanding of the distribution and occurrence for many of these highly migratory 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 57 sailfish and 47 blue marlin outfitted with pop-off satellite archival tags (PSATs) deployed between 2003 and 2021 in the Eastern Tropical Pacific. Tag deployments ranged 5-273 days (mean = 63.4) for sailfish and 2-368 days (mean = 75.46) for blue marlin. Average distance travelled was slightly longerfor blue marlin (mean = 1996.78 km, range = 13.785 - 8916.75 km) than sailfish (mean = 1867.16 km, range = 96.04 - 5255.21 km), however most fish remained constrained within the ETP regardless of species. Interestingly, one blue marlin tagged within the Costa Rican exclusive economic zone (EEZ) displaced over 6,500 km westward into the middle of the Pacific Ocean over the course of 3 months. Shifts in the spatial distribution and retention of these species over time and in different oceanographic conditions will informenvironmentally driven species distribution models and dynamic ocean management efforts in the region. A better understanding of the horizontal distribution of these species helps identify biological hot-spots, as well as where potential anthropogenic stressors (such as areas of heavy commercial fishing) may be impacting these species.

MULTI-YEAR TRACKING OF STRIPED MARLIN REVEALS RESIDENCY IN THE EAST PACIFIC OCEAN

Chi Hin Lam[1,*], Nicole Nasby-Lucas[2], Sofia Ortega-Garcia[3], Paxson Offield[4] and Michael L. Domeier[2]

[1] Large Pelagics Research Center, P.O. Box 3188, Gloucester, MA 01931, USA
[2] Marine Conservation Science Institute, PO Box 7140 Kamuela, HI 96743, USA
[3] Instituto Politecnico Nacional, Centro Interdisciplinario de Ciencias Marinas (CICIMAR), Avenida IPN s/n, Colonia Playa Palo de Santa Rita, La Paz B.C.S, C.P., 23096. Mexico.
[4] Deceased. Formerly at Offield Family Foundation, 151 Kalmus, Suite A-204, Costa Mesa, CA 92626, USA

*Corresponding author: tagtuna@gmail.com; +1-978-238-8208

A first successful application of archival tags on striped marlin has shown great potential in obtaining long-term tracks for an improved understanding of their movement ecology, and to inform fisheries management. Due to the failure of external sensor stalk, which houses the light sensor, full records of daily fish position, unfortunately, could not be attained for ten devices physically recovered off tagged fish from the Eastern Pacific between 2008 and 2016.

Depth-based geolocation that exploits the diel swimming patterns of striped marlin was developed to provide position estimates for archival-tagged fish for up to 7.7 years. Reconstructed tracks revealed tagged striped marlin remained in the Eastern Pacific throughout the tracked duration. Trans-equatorial movements were also documented for the first time for striped marlin in this region, as were extended occupancy of >1 year in pelagic waters.

Striped marlin connected both coastal and offshore habitats with seasonal runs, likely in fulfillment of their life history requirements from foraging to reproduction. Circadian rhythms in billfish and other pelagic fishes are well-established, and could provide a viable, alternative means to position an individual in a low or no light environment, and situations with sub-optimal or limited bio-logging capabilities.

REVIEW OF RESEARCH ACTIVITIES CONDUCTED AT THE IATTC'S ACHOTINES LABORATORY FROM 2021-2022

Susana Cusatti, Daniel Margulies, Vernon Scholey, Yole Buchalla, Enrique Mauser.

Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
San Diego, CA 92037 USA

The Inter-American Tropical Tuna Commission (IATTC) conducts research on the reproductive biology and early life history of yellowfin tuna at the Achotines Laboratory, Republic of Panama. Yellowfin broodstock have been spawning at near-daily intervals since 1996, which represents the only sustained spawning of yellowfin in captivity in the world. In October 2021, the Laboratory reached a milestone of 25 years of sustained spawning of yellowfin in captivity. The resulting eggs, larvae and early-juveniles are studied in experimental investigations focused on estimation of pre-recruit survival patterns.

Recent patterns of captive spawning of the tank population of yellowfin will be described. Spawning was sustained during the 2021-2022 period (2 years), with three periods of cessation ranging from a few weeks to 3 months. Two new fish were added to the tank in January 2022. A paper describing an updated genetic analysis of spawning ecology of the broodstock fish has been submitted for publication.

Pre-recruit research on yellowfin at the Achotines Laboratory has focused on growth and survival dynamics of larvae (the first 3 weeks). Results of recent larval ecology investigations, including studies of growth/survival dynamics and effects of ocean acidification on larval survival, will be described. Comparative studies of the early life histories of yellowfin and Pacific bluefin are ongoing with Kindai University since 2011. These investigations have been disrupted by COVID during 2020-2021, but will be resumed when international travel to Japan resumes.

In recent years the research focus on yellowfin at the Achotines Laboratory has expanded to the early-juvenile stages (1-6 months). Growth rates have been estimated for all transformation and early-juvenile individuals reared in land-based tanks or a sea cage; the early-juveniles have ranged from 1.6-28.0 cm in length and up to 158 days after hatch. Juvenile growth investigations planned for 2022 will be summarized.

Since September of 2021 and for two consecutive years, the Laboratory is involved in a project financed by the National Secretariat of Science, Technology, and Innovation of Panama (SENACYT). The project objective is to strengthen the Laboratory through the purchase of specialized equipment and instrumentation for research and development activities. Research with yellowfin tuna and spotted rose snapper will be carried out during the project and an educational component for Panamanian students has been included.

The Achotines Laboratory also supports research projects of interest within the IATTC. These investigations include planned pilot studies to test technologies developed to reduce bycatch and detect FADs remotely in the tuna purse seine fisheries. These pilot technology studies were planned at the Achotines Laboratory for 2020-2021 but have been delayed due to COVID travel restrictions, but there are plans to initiate these studies beginning in May 2022.

QUANTIFYING TROPHIC LINKAGE BETWEEN PELAGIC AND CORAL REEF HABITATS USING DNA BARCODING IN HAWAIIAN POPULATIONS OF THE EPIPELAGIC PREDATOR, MAHI-MAHI (*Coryphaena* Spp.)

Nan Himmelsbach[1,2], Molly Timmers[1,2], Raymond Boland[2], Jonathan Whitney[2]

[1]Cooperative Institute for Marine and Atmospheric Research (CIMAR), Honolulu, HI
[2]NOAA Pacific Islands Fisheries Science Center (PIFSC), Honolulu, HI

1845 Wasp Blvd, Honolulu, HI 96818

Dolphinfishes (*Coryphaena hippurus* and *C. equiselis*), otherwise known as mahi-mahi, are epipelagic predatory fishes that inhabit nearshore and offshore surface waters. They are important components of insular fisheries in Hawaii and throughout the tropical Pacific. *Coryphaena* spp. are opportunistic foragers, feeding on a wide variety of fishes, cephalopods, and crustaceans, as previously documented through morphological identification of prey items from dissected stomachs. To quantify trophic links and energy flow between ocean habitats and identify key prey species, life stages of prey, and functional groups, individual prey items are DNA barcoded and identified to species level. Stomachs from *Coryphaena* spp. were collected from recreationally and commercially caught fishes in nearshore Oahu waters from 2020-2021. Stomachs were dissected and all individual prey items were sequenced at the COI barcode region. Preliminary results indicate a high level of trophic connectivity between pelagic mahi-mahi and reef-associated fishes. Over half of all individual prey items were identified as juvenile stages of reef-associated fishes. This study provides evidence that insular populations of *Coryphaena* spp. rely on reef-associated fishes to support a majority of their diet, illustrating a distinct linkage between pelagic and coral reef habitats. Combined with species identification, the life stage of each prey item helps uncover additional details about *Coryphaena* spp. foraging habits. We evaluate trophic connectivity with respect to varying distances of catch from coral reefs and floating objects. We seek to further understand how environmental changes on coral reef systems, which impact availability of reef-associated species as a food source globally, may amplify the effects of bottom-up trophic cascades.

HUNTING BEHAVIOR AND ESTIMATED ENERGY EXPENDITURE BY A SOLITARY SAILFISH DURING PREY PURSUIT AND CAPTURE

Ryan K. Logan[1*], Sarah M. Luongo[2], Jeremy J. Vaudo[1], Bradley M. Wetherbee[1,3], Mahmood S.Shivji[1]

[1]Guy Harvey Research Institute, Nova Southeastern University, Dania Beach, FL USA [2]Department of Biological Sciences, Florida International University, North Miami, FL USA[3]Department of Biological Sciences, University of Rhode Island, Kingston, RI USA

8000 N Ocean Dr.
Dania Beach, FL 33004

Foraging behavior and interaction with prey is an integral component of the niche of predators but is inherently difficult to observe for highly mobile animals in the marine environment. Surface-based group feeding of sailfish, *Istiophorus platypterus,* is often observed;however, sailfish are largely believed to be solitary roaming predators, with high metabolic requirements suggesting that individual foraging must also represents a major component of predator-prey interactions. Here, we use biologging data and video to document an individual sailfish predation event and use speed measurements to estimate a mean active metabolic rate of 2.8 ± 0.3 mgO2 kg^{-1} min^{-1} associated with the foraging event. We estimate a net energy gain of 5.08 MJ (5.1 MJ acquired, 0.016 MJ expended) resulting from of the encounter. While group hunting is an established method used by sailfish to acquire energy, our data and calculations indicate that isolated, opportunistic foraging events also contribute to the fitness of these highlymobile predators.

HISTOLOGICAL SAMPLING AND HISTORICAL DATA SHOW NO EVIDENCE OF PACIFIC BLUEFIN TUNA REPRODUCTION IN THE SOUTHERN CALIFORNIA CURRENT SYSTEM

Heidi Dewar[1], **Owyn Snodgrass**[1], Barbara Muhling[1,2] and Kurt Schaefer[3]

[1]NOAA Fisheries Southwest Fisheries Science Center
[2]Institute of Marine Sciences
[3]Inter-American Tropical Tuna Commission

8901 La Jolla Shores Drive
La Jolla, California 92037, USA

Despite their broad distribution across the north Pacific Ocean, the only known spawning grounds for Pacific bluefin tuna (*Thunnus orientalis*: PBF) are around coastal Japan and in the East China Sea. However, an increase in the prevalence of large PBF up to 10 years of age in the southern California Current System (CCS) during exceptionally warm ocean conditions has led to speculation that they may be spawning in this region. To investigate this possibility, we collected samples from 36 females (estimated 3 to 8 years old) and 28 males (estimated 4 to 8 years old) between 2015 and 2019. Histological analyses revealed that all females were immature. Seven males were classified as functionally mature due to the presence of milt during sampling, although no histological evidence for spawning was observed. Further examination of historical ichthyoplankton collections from 1951 through 2020 showed no records of larval PBF, and confirmed the association of other tuna larvae with waters > 24°C. Fishery-dependent records showed that PBF are rarely recorded in purse seine catches where surface temperatures exceed 23°C. Our study, therefore, provided no evidence of PBF reproduction in the CCS. However, more comprehensive sampling, in particular off southern Baja California, may be required to confirm the absence of spawning.

AGE AND GROWTH ESTIMATION OF STRIPED MARLIN (*Kajikia audax*) THROUGH THE USE OF OTOLITHS AND SPINES IN BAJA CALIFORNIA SUR: PRELIMINARY RESULTS

POSTER

Worbis-Badias Mariana, Ulianov Jakes-Cota, Sofía Ortega-García* & Rubén Rodríguez-Sánchez*

Instituto Politécnico Nacional-Centro Interdisciplinario de Ciencias Marinas, Av. Instituto Politécnico Nacional s/n, playa Palo de Santa Rita, 23096 La Paz, B.C.S.*COFAA fellowship.

The striped marlin is the primary target of the sport fishery operating off Cabo San Lucas, Baja California Sur (CSL). The age of this species has been estimated by counting annual growth marks in dorsal-fin spines. However, due to the presence of vascularization, the loss of the first growth mark and consequently age underestimation and biases on the estimation of individual growth parameters are common. To avoid these problems, the use of a combination of spines and otoliths is recommended. The latter one is used for counting daily growth marks in organisms younger than 1 year of age. In addition, it allows corroborating growth mark formation periodicity in dorsal-fin spines. Monthly biological sampling of the sport-fishing fleet landings was conducted in CSL from 2015-2021. A total of 753 organisms (357 females, 379 males, and 17 unsexed) were sampled. Information of the lower jaw fork length (LJFL), total weight, and sex were recorded. The fourth dorsal-fin spine and sagittal otoliths of 269 organisms were extracted. The LJFL range for females was 132-242 cm with an average length of 185.66 cm and 133-228 cm with an average length of 185.69 cm for males. The average size by sex showed significant differences, contrary to length-weight relationship where no significant differences were found. The Student's *t*-test indicated that *b*-value for combined sexes was not significantly different from the theoretical value of isometric growth. The preliminary results showed two to nine growth marks in transverse sections in the dorsal spine and up to 247 daily micro-increments in polished otolith sections of younger organisms. Further analyses include finishing the count of growth marks in spines and otoliths to validate the first annual growth mark in spines with the use of daily growth marks in otoliths of organisms younger than one year of age and apply multi-model inference for individual growth parameter estimation.

REDUCING SHARK BYCATCH IN TUNA FISHERIES: ADAPTIVE SPATIO-TEMPORAL MANAGEMENT OPTIONS FOR THE EASTERN PACIFIC OCEAN

Guillermo Ortuño Crespo[1] , Shane Griffiths[2], Hilario Murua[3], Henrik Österblom[1] and Jon Lopez[2].

[1]Stockholm Resilience Centre, Stockholm University
[2]Inter-American tropical Tuna Commission (IATTC)
[3]International Seafood Sustainability Foundation (ISSF)

Purse seine tropical tuna fishing in the eastern tropical Pacific Ocean (EPO) results in the bycatch of several sensitive species groups, including elasmobranchs. Effective management of ecosystems balances conservation and resource use but requires actionable knowledge that accounts for both trade-offs and synergies. Seasonal and adaptive spatial management measures can be effective to reduce the impact of fisheries on non-target species while preserving, or even increasing, target species catch. Exploring the potential distribution and impact of fisheries closures in the open ocean, where highly dynamic environmental conditions drive distributional changes in biological communities throughout the year, requires the identification of persistently high-risk areas, where the likelihood of encountering and catching unwanted bycatch species, relative to the target species, is high. We used fisheries observer data from 1995–2021 to explore the spatio-temporal persistence of areas of high bycatch risk for two species of oceanic sharks, silky shark (*Carcharhinus falciformis*) and oceanic whitetip shark (*Carcharhinus longimanus*), and low tuna catch rate areas—defined as areas of high fishing inefficiency (i.e., poor fishing areas). We found that if areas of high fishing inefficiency were closed throughout the study period, and effort reallocated proportionally to reflect historical effort patterns, yearly tuna catch may have increased by 1–11% while the bycatch of silky and oceanic whitetip sharks could have decreased by 10-19% and 9%, respectively. Prior to fishing effort redistribution, bycatch reductions would have accrued to 21–41% and 14% for silky and oceanic whitetip sharks, respectively. Our analysis builds on past evidence and demonstrates the high potential for reducing elasmobranch bycatch in the EPO, while not compromising the catch rates of target tuna species. It also highlights the need to consider new dynamic and adaptive management measures to more efficiently fulfill conservation and sustainability objectives for exploited resources in the EPO.

HARNESSING STAKEHOLDER KNOWLEDGE FOR THE COLLABORATIVE DEVELOPMENT OF MOBULID BYCATCH MITIGATION STRATEGIES IN TUNA FISHERIES

Melissa R. Cronin[1], Donald A. Croll[1], Martin A. Hall[2], Nerea Lezama-Ochoa[1], Jon Lopez[2], Hilario Murua[3], Jefferson Murua[4], Victor Restrepo[3], Stefany Rojas-Perea[5], Joshua D. Stewart[5], Jennifer L. Waldo[1], Gala Moreno[3]

1. University of California, Santa Cruz, Santa Cruz, CA, 95060, USA
2. Inter-American Tropical Tuna Commission, La Jolla, CA, 92037, USA
3. International Seafood Sustainability Foundation, Washington, DC, 20005, USA
4. AZTI-Tecnalia/Herrera Kaia., Portualdea, z/g, 20110, Pasaia, Gipuzkoa, Spain
5. The Manta Trust, Dorset, DT2 0NT, United Kingdom

Corresponding author:
Melissa R. Cronin
Department of Ecology and Evolutionary Biology, UC Santa Cruz
UCSC Long Marine Lab, 115 McAllister Way, Santa Cruz, CA 95060
mecronin@ucsc.edu • 978-335-2962

Manta and devil rays (collectively Mobulids) face several immediate threats, including incidental capture in industrial tropical tuna fisheries. As a result, efforts have emerged to avoid or mitigate Mobulid bycatch in these fisheries. However, many bycatch mitigation efforts fail to incorporate fisher expertise from the outset, potentially leading to interventions that are not viable. Here, we combine survey and focus group data to synthesize knowledge of Mobulid bycatch and mitigation ideas in Eastern Pacific Ocean purse seine fisheries. Primary obstacles for mitigating Mobulid bycatch, according to respondents, are: 1) an inability to sight Mobulids before capture, 2) the lack of specific equipment on board, and 3) the difficulty of releasing large individuals; we suggest that the latter two can be addressed by simple operational modifications. We also find that Mobulids are most likely to be sighted by fishers after capture, suggesting that this is an important time in the fishing operation for post-capture bycatch mitigation interventions that ensure Mobulids survive capture. To address this, we share creative ideas brought by fishers for avoidance of Mobulids. This study provides a model of how to incorporate stakeholder input in the design of bycatch technology in large-scale fisheries and could inform similar efforts around the world.

A MACHINE LEARNING SPECIES DISTRIBUTION MODEL FOR THE CRITICALLY ENDANDERED EAST PACIFIC LEATHERBACK TURTLE (DERMOCHELYS CORIACEA)

Jon Lopez[1], Shane Griffiths[1], Bryan Wallace[234], Verónica Caceres[4], Leslie Camila Bustos[5], Luis Cocas[5]; Rodrigo Vega[6], Patricia Zárate[6], Ljubitza Clavijo[6], Ilia Cari[6], Juan Manuel Rodriguez-Baron[7], José Miguel Carvajal[8], Rotney Piedra[9], Sandra Andraka[10], Lilian Rendón[10], Marco Herrera[11]; Jenifer Suárez[12], Heriberto Santana[13], Marino Abrego[14], Callie Veelenturf[15], Javier Quiñones[16], Miguel Perez[16], Joanna Alfaro[17], Jeff Mangel[17], Nelly de Paz[18]

[1]Inter-American Tropical Tuna Commission, 8901 La Jolla Shores Drive, La Jolla, California, USA
[2]Ecolibrium, Inc., 5343 Aztec Drive, Boulder, CO 80303, USA
[3]Department of Ecology and Evolutionary Biology, University of Colorado Boulder, Boulder, CO, 80303 USA
[4]Inter-American Convention for the Protection and Conservation of Sea Turtles, Falls Church, VA USA
[5]Subsecretaría de Pesca y Agricultura, Chile
[6]Instituto del Fomento Pesquero, Chile
[7]JUSTSEA Foundation, University of North Carolina Wilmington
[8]Instituto Nacional Costarricense de Pesca y Acuicultura, Costa Rica
[9]Sistema Nacional de Áreas de Conservación, Costa Rica
[10]EcoPacifico+
[11]Instituto Nacional de Pesca, Ecuador
[12]Parque Nacional Galápagos, Ecuador
[13]Instituto Nacional de Pesca, México
[14]Ministerio de Ambiente, Panamá
[15]The Leatherback Project, Panamá
[16]Instituto del Mar del Perú, Perú
[17]ProDelphinus, Perú
[18]ACOREMA, Perú

Fisheries are an important source of food, income and cultural connection for millions worldwide. The pressure from fishing activity can have detrimental impacts on marine ecosystems and coastal livelihoods if not properly managed. Establishing appropriate management measures relies on understanding specific aspects of the fishery, for example what species were caught and recorded in logbooks. There are a wide range of reasons for wanting to reconstruct catch data from fishery independent data. Logbook records may be unavailable or inaccurately report landed species and biomass. Vessel operators or crew may take unregulated or prohibited species, either for sale or for personal consumption. Policy makers during international conventions (CMS, CITES) may make significant binding decisions and treaties with incomplete data. Unfortunately, trained observers who collect crucial independent data onboard vessels cover only a small percentage of total fishing activity. This leaves a significant opportunity for Illegal, Unreported and Unregulated (IUU) fishing practises, the likes of which pose a risk for the management and protection of vulnerable species.

This presentation will introduce a novel eDNA method for forensically reconstructing catch stored in the brine tanks of commercial fishing vessels. Our method allows for a small volume of water to be collected, sequenced and analysed to identify species and relative abundance. The eDNA collected on-board fishing vessels represents animals that have been in the hold since it was last emptied, providing a time-integrated record of species catch and transport. We propose the application of our eDNA sampling protocol is a cost-effective tool for monitoring and surveillance, particularly for protected or quota species and in under-resourced regions.

BAYESIAN PREDICTION OF FISHERY BIOLOGICAL IMPACTS FROM LIMITED DATA: A DEEP-SET BUOY GEAR CASE STUDY

Stephen M. Stohs and **Karter M. Harmon**

Southwest Fisheries Science Center and NMFS West Coast Regional Office
8901 La Jolla Shores Drive
La Jolla, California, United States

Predicting the biological impacts of new or expanding fisheries presents challenges due to limited data, high variability in catch rates, and the often low frequency of bycatch events. These issues arose in the case of the West Coast deep-set buoy gear fleet, which the Pacific Fisheries Management Council recommended in 2019 for authorization as a legal gear type. Deep-set buoy gear selectively targets swordfish (*Xiphias gladius*) with infrequent bycatch of other species. Limited effort and incomplete observer coverage result in a data-limited context for estimating the impacts of a fully authorized and expanded fishery.

Recently, data analysts have explored Bayesian estimation for modeling rare-event bycatch in a manner that incorporates uncertainty and enables updating as more data become available. Here, we apply a Bayesian methodology to an integrated dataset of deep-set buoy gear observer and logbook records to estimate bycatch rates under several plausible scenarios of deep-set buoy gear authorization.

We estimate posterior distributions of catch rates for three species caught in deep-set buoy gear Exempted Fishing Permit trials, and incorporate bootstrap samples of vessel-level effort to calculate posterior predictive distributions of catch counts under alternative management regimes. We discuss how our results can inform policy decisions about a new fishery with limited data, and how to extend this approach to other federal environmental actions. This approach allows policymakers to compare biological impacts of management alternatives while considering the uncertainty inherent in the predictions, and to determine whether the range of potential impacts is likely to significantly alter the affected environment.

VULNERABILITY ASSESSMENT OF SHARK BYCATCH IN EASTERN PACIFIC OCEAN TUNA FISHERIES USING THE EASI-FISH APPROACH

Shane Griffiths[1], Leanne Fuller[1], Joanne Potts[2], and Simon Nicol[2]

[1] Inter-American Tropical Tuna Commission, 8901 La Jolla Shores Drive, La Jolla, CA, USA.

[2] Secretariat of the Pacific Community, Noumea Cedex, New Caledonia, France

Sharks are a common catch, either as a target or incidental bycatch, in industrial and small-scale coastal (i.e., 'artisanal') pelagic fisheries in the eastern Pacific Ocean (EPO). In general, sharks are long-lived, slow growing, and have low reproductive output, resulting in conservation concerns for many species impacted by fishing. In recognition of these concerns for sharks the IATTC has implemented a range of conservation and management measures (CMMs) since at least 2005 to limit or prohibit the capture of sharks, or to promote handling practices to maximize their post-release survival. Due to the common paucity of catch and biological data available for the majority of shark bycatch species caught in EPO tuna fisheries an ecological risk assessment (ERA) approach, Ecological Assessment for the Sustainable Impacts of Fisheries (EASI-Fish), was used to quantify the vulnerability of bycatch species to the cumulative impacts of multiple fisheries in the EPO to guide fishery managers in prioritizing species that may require immediate management action to reduce the fishing mortality, or to highlight key information deficiencies that require to be addressed before re-assessment. A total of 49 shark species have been recorded to interact with industrial (purse-seine and longline) and artisanal (longline and gillnet) pelagic fisheries in the EPO of which 32 species were formally assessed using EASI-Fish for 2019 Estimates of a proxy for fishing mortality ($\tilde{F}_{2019}$) and the spawning stock biomass per recruit (SBR_{2019}) in 2019 exceeded biological reference points ($F_{40\%}$ and $SBR_{40\%}$) for 20 species, classifying them as "most vulnerable", including hammerhead sharks (4 species), requiem sharks (10 species), threshers (*Alopias superciliosus* and *A. pelagicus*), mesopelagic sharks (3 species) and the commercially important blue shark (*Prionace glauca*) and shortfin mako (*Isurus oxyrinchus*). The remaining 12 species were classified as "least vulnerable" (9 species) or 'increasingly vulnerable" (3 species), data reliability scores for 7 of these species were low, indicating high uncertainty in the model parameter values used. Key knowledge gaps identified was the location of fishing effort and the shark catch in artisanal fisheries and basic biological information for several species. The EASI-Fish assessment provided a first comprehensive assessment for prioritizing management and research on shark bycatch species. The flexibility and spatially-explicit framework of EASI-Fish can be used in future to rapidly and cost-effectively explore a range of potential hypothetical CMMs that may be implemented—in isolation or in combination—within the EPO to reduce fishery impacts on particularly vulnerable shark species identified, including silky, thresher and hammerhead sharks.

THREATENED SPECIES BYCATCH RATES IN LONGLINE FLEETS LARGELY DRIVEN BY VARIATION IN INDIVIDUAL VESSEL BEHAVIOR

Leslie A Roberson, Chris Wilcox

Leslie Roberson: CSIRO Oceans and Atmosphere, Hobart, TAS, Australia

Correspondence to: Leslie.roberson@csiro.au

Bycatch of threatened species such as seabirds, mammals, turtles, and sharks remains a formidable obstacle to improving the sustainability of global tuna fisheries. Bycatch management measures are typically fleet-level, command and control approaches such as bycatch quotas and time-area closures. Yet, anecdotal evidence suggests there are usually high and low performers within a fishing fleet, often with a small number of vessels causing most of the headaches for managers. Fishing crews have distinct cultures and practices, and it is widely understood that some vessels are consistently better than others at catching fish. Thus, if fishers differ in their ability to target species, it follows that they would also have differing abilities to un-target what they do not want to catch.

We use high quality observer and logbook data to show that this conventional wisdom is likely a systemic pattern. We analyzed variations in bycatch of threatened or protected species across individual vessels from an industrial longline fishery in Australia. After accounting for environmental and tactical factors affecting bycatch availability, we find that the individual vessel is a significant predictor of bycatch in all cases. For some species, the majority of the bycatch is generated by a small number of operators, which tend to be the less profitable vessels with below-average tuna catch. We compare bycatch types with different potential motivations for avoidance, such as economic loss or environmental concern from seabird bycatch, versus shark species that have value as byproducts and may be covertly targeted. Using observer and logbook data from the longline fleet operating in the Republic of the Marshall Islands, we further explore characteristics that potentially drive variability among vessels, such as physical characteristics of vessels and boat owners. Our results show there is untapped opportunity to reduce bycatch in tuna fisheries using incentive-based interventions that target specific performance groups of vessels, potentially at much lower cost than conventional approaches.

INVESTIGATING THE POTENTIAL OF HELICOPTER-VESSEL COMMUNICATION FOR BYCATCH AVOIDANCE IN TUNA PURSE SEINE FISHERIES

POSTER

Jennifer L. Waldo[1], Ernesto Altamirano[2], Donald A. Croll[1], Marta Diaz Palacios[3], Nerea Lezama-Ochoa[1], Jon Lopez[2], Gala Moreno[4], Stefany Rojas-Perea[5], Melissa R. Cronin[1]

1. University of California, Santa Cruz, Santa Cruz, CA 95060, USA
2. Inter-American Tropical Tuna Commission, La Jolla, CA 92037, USA
3. Interdisciplinary Center for Marine Sciences, La Paz, Baja California Sur, Mexico
4. International Seafood Sustainability Foundation, Washington DC 20005, USA
5. The Manta Trust, Dorset, DT2 0NT, United Kingdom

Corresponding author:
Jennifer L. Waldo
Department of Ecology and Evolutionary Biology, UC Santa Cruz
432 Dufour Street, Santa Cruz, CA 95060
jwaldo@ucsc.edu • 925-243-5392

The unintentional capture of non-target species (bycatch) in industrial fisheries impacts long-lived species, including manta and devil rays (collectively Mobulids), dolphins, sea turtles, and sharks. These species are particularly vulnerable to bycatch due to their life-history traits, including delayed maturity and low fecundity. Though some industrial fisheries have implemented policies to mitigate these declines, there is a need to develop additional bycatch mitigation strategies to reduce their mortalities. Including fishers' knowledge in these efforts can help to guide the development of effective conservation actions. Fishers have first-hand experience with vessel operations and bycatch protocols and may be uniquely positioned to identify feasible mitigation measures. Fleet-wide communication programs, in which vessels share information on interactions with bycatch species in real-time, is one way in which the involvement of fishers has helped address bycatch and may be a useful inclusion to mitigation strategies for Mobulids. Given previous conservation gains from fleet-wide communication, we investigate whether vessel-helicopter communication has the potential to help avoid bycatch of non-target species. Many tuna purse seine vessels in the Eastern Pacific Ocean (EPO) utilize helicopters that fly out miles ahead in search of dolphins and the tuna that often school with them. The ability of pilots and spotters aboard the helicopter to identify dolphin schools may suggest that they can also sight other non-target species in the area. We investigate whether communication between helicopters and vessel crew could be useful for large or schooling species. We surveyed helicopter pilots, spotters, and fishers working in the tuna purse seine fishery in the EPO to understand and identify visual perceptions of bycatch species prior to capture as well as their communication with the vessel. Surveys were administered in Spanish via the survey platform "Qualtrics" and results were translated prior to analysis. In-person interviews were conducted to gain an in-depth understanding of biological, environmental, and industrial factors that affect the ability to sight bycatch species. Questions were based on four components: participant demographics, indicators used to sight species, visual identification of species, and communication with the vessel (Table 1). Visual identification questions were asked for four bycatch species groups: Mobulids, dolphins, sea turtles, and sharks. We analyzed results quantitatively to investigate demographic differences among survey answers, such as how occupation or experience affects participants' abilities to identify bycatch species, and qualitatively to reveal any emerging themes among responses, such as specific species' characteristics that make them recognizable. We share preliminary results around the potential for helicopter-vessel communication as a bycatch avoidance technique. Communication between tuna helicopter pilots and spotters and their associated vessels about where bycatch species are located could advance potential bycatch avoidance strategies in large and impactful fisheries and at the same time help to fill knowledge gaps about the ecology of the most vulnerable species.

IMPACT OF THE DENSITY OF FISH AGGREGATING DEVICES ON TUNA BEHAVIOR FROM AN INDIVIDUAL-BASED MODEL

Amaël Dupaix[1a], Jean-Louis Deneubourg[2], Laurent Dagorn[1], Manuela Capello[1b]

[1] MARBEC, Univ. Montpellier, CNRS, Ifremer, IRD, Sète, France
[2] Unit of Social Ecology, Université Libre de Bruxelles (ULB), Bruxelles, Belgium
(a) amael.dupaix@ird.fr ; (b) manuela.capello@ird.fr

Many pelagic fish species, such as tropical tuna, are known to associate with floating objects (FOBs). The first FOBs were all natural, mainly parts of trees (logs) floating out in the ocean. Taking advantage of the associative behavior of pelagic species, tuna purse seine vessels began using drifting Fish Aggregating Devices (DFADs), i.e. man-made objects, in the early 1990s. If the exact number of DFADs is unknown, last global assessments evaluated that between 81 and 121,000 DFADs were deployed yearly. The impact of this significant increase in the number of floating objects on the behavior and the ecology of tuna is still largely unknown. Recent results, comparing tagging data in different DFAD arrays, demonstrated that as DFAD density increases, the time tuna spent associated increases. Using a field-based model of tuna movements, based on a Correlated Random Walk, we characterize the relationship between DFAD density and the time tuna spend unassociated. This model allows to quantitatively predict the mean Continuous Absence Time (CAT - the time between two associations) at a given DFAD density and to determine a general relationship between CAT and DFAD density. It also allows the calculation of the probability that tuna associate with a floating object depending on DFAD density, and hence has a great potential in informing non-spatial probabilistic models.

ECHOSOUNDER BUOYS IN TROPICAL TUNA PURSE SEINER FISHERY

Jon Uranga[1], Manuella Capello[2], Yannick Baidai; Maitane Grande[1], Jon Lopez[3], Gala Moreno[4], Hilario Murua[4], Josu Santiago[1]

[1] AZTI, Marine Research, Basque Research and Technology Alliance (BRTA). Txatxarramendi ugartea z/g, 48395. Sukarrieta - Bizkaia, Spain.
[2] MARBEC, Univ Montpellier, CNRS, Ifremer, IRD, Sète, France
[3] Inter-American Tropical Tuna Commission, 8901 La Jolla Shores Drive, La Jolla CA 92037, USA.
[4] International Seafood Sustainability Foundation (ISSF).1440 G Street NW Washington DC 20005.

Since the 2000s, the most significant technological advance in tropical tuna purse seiner fishery has occurred in instrumented buoy technology attached to FADs. These have evolved from working with a geo-positioning system to incorporating echo-sounders with one, which was later double, frequency. These improvements allow skippers to have daily information on the FAD location and the size of the aggregation underneath the FADs. From the echo of the aggregation, behaviour and depth distribution, skippers have an idea of the aggregation characteristics. As such, it is essential information for planning daily fishing operations. In addition, echosounder buoy are unique scientific observation platforms, which provided independent source of information of tuna and other aggregated species, that can be used to monitor tuna abundance and increase the knowledge of fish behaviour among others. In recent years research actions has been conducted to recover buoy derived information, develop methodological frameworks to extract from buoys reliable scientific biomass information, describe tuna behaviour around FADs, and provide buoy derived abundance indices. The aim of this work is to review the state of art of the technology and progress made on the analysis of the information provided by echosounder buoys to be used in scientific analysis.

THE JELLY-FAD A PARADIGM SHIFT IN BIODEGRADABLE FAD TECHNOLOGY: BENEFITS AND CHALLENGES

Gala Moreno[1*], Joaquín Salvador[2], Iker Zudaire[3], Jefferson Murua[3], Hilario Murua[1], Jon Uranga[3], Maitane Grande[3], Victor Restrepo[1]

[1]International Seafood Sustainability Foundation (ISSF).
655 15th Street NW, Suite 800 Washington D.C. 20005
[2]Institut de Ciències del Mar (ICM).
[3]Azti-Tecnalia.

Fishers and scientists in the three tropical oceans are investigating different designs of biodegradable Fish Aggregating Devices (bio-FAD) efficient for fishing. The tactic followed by most fishers is to maintain the same traditional drifting FAD (dFAD) design (submerged netting panels hanging from the raft) but constructed with organic ropes and canvas. Results of those experiences show that the lifetime of bio-FADs that maintain the traditional FAD design with organic materials, is shorter than that required by fishers. A recent collaboration between experts on FADs and physical oceanographers allowed understanding that, in order to use organic materials to replace strong plastic, and increase the lifespan of those bio-FADs, a paradigm shift is needed. Bio-FAD structures should be re-designed to suffer the least structural stress in the water. The presentation aims at summarizing what we have learned across the different experiences testing bio-FADs in the three oceans, and we propose a new concept in dFAD design, the "Jelly-FAD" design, discussing the benefits and the challenges we face to move towards the implementation of bio-FADs.

MODELLING DRIFTING FAD TRAJECTORIES ARRIVING AT ESSENTIAL HABITATS FOR MARINE TURTLES

Escalle Lauriane.[1], Scutt Phillips J.[1], Aires-da-Silva A.[4], Corniuk R.[3], Hampton J.[1], Lopez J.[4], Lynch J.[3], Mcwhirter A.[3], Murua H.[2], Restrepo V.[2], Royer S.J.[3], Swimmer Y.[5], Gala Moreno[2]

[1]The Pacific Community (SPC)
[2]International Seafood Sustainability Foundation (ISSF)
[3]Hawaii Pacific University (HPU), Center for Marine Debris Research (CMDR)
[4]Inter-American Tropical Tuna Commission (IATTC)
[5]NOAA Fisheries, Pacific Islands Fisheries Science Center

Fishers extensively deploy Drifting Fish Aggregating Devices (dFADs) to aggregate and catch tropical tuna, estimates vary from 46,000 to 65,000 dFADs deployed in the Pacific Ocean annually. Although dFADs are tracked with a geolocating buoy, fishers deactivate the buoy once FADs drift out of the fishing zone. Consequently, the fate of a high percentage of dFADs (some estimates are up to 80%) is unknown while beaching events have been estimated to be between 7 and 20% of the deployments, depending on the oceanic region. Because FADs are made of plastic netting, dFADs may entangle sea turtles and other marine fauna while drifting at sea, but also when beaching, they may cause damage to vulnerable ecosystems as well as to essential habitats for sea turtles and other marine fauna.

While highly informative, trajectories from real dFADs are currently limited in number in the Pacific Ocean, to explore and quantify the potential connectivity between drifting Fish Aggregating Devices (dFADs) and important sea turtle oceanic habitat and nesting areas in the Pacific Ocean, a series of passive-drift Lagrangian simulation experiments were undertaken. Two groups of areas between which to examine connectivity were defined, corresponding to zones of habitat importance in sea turtle life history, and equatorial zones, where dFADs are known to drift and be deployed.

Passively drifting Lagrangian particles, representing virtual dFADs (vFADs), were released evenly throughout the tropical, equatorial zone, and forced forwards in time with a dFAD-type drift profile, driven by the top 50 m current velocities from the Bluelink Reanalysis 2020 ocean circulation model. New particles were seeded weekly during a year, and left to drift for up to a further 2.5 years, beginning in a historic ENSO neutral year, 2012. Their simulated drift trajectories were then tracked, and metrics of potential connectivity were calculated as a function of transition between dFAD operational use zones and turtle habitat zones, and the length during which vFAD particles had drifted. These experiments were repeated for a comparable El Niño (2015) and La Niña (2010) period of deployment.

In parallel, similar time-backwards simulations were also run, in which vFAD particles were seeded into the identified small coastal nesting site regions, and then forced backwards in time by the same current velocities for up to 5 years prior to this 'arrival' into these zones. This provided more robust results into the potential changes in connectivity with equatorial dFAD zones, during different seasons of arrival, long drift-times, and, again, different periods of ENSO during which the vFADs arrived into these coastal nesting zones.

The presentation will cover the modelling results, discussing the potential risks faced by sea turtles Pacific populations from oceanic interactions with dFADs as well as with dFADs stranding in their essential habitats. Finally the solutions to limit the adverse impacts will be examined.

SPATIO-TEMPORAL DISTRIBUTION OF JUVENILE OCEANIC WHITETIP SHARK INCIDENTAL CATCH IN THE WESTERN INDIAN OCEAN

Leire Lopetegui-Eguren[1,2*], Jan Jaap Poos[2], Haritz Arrizabalaga[1], Gency Guirhem[1], Hilario Murua[3], Nerea Lezama-Ochoa[4,9], Shane Griffiths[5], Jon Ruiz Gondra[1], Philippe S. Sabarros[6,7], Jose Carlos Báez[8], Maria José Juan-Jordá[1]

[1]AZTI, Marine Research, Basque Research and Technology Alliance (BRTA), Pasaia, Gipuzkoa, Spain
[2]Aquaculture and Fisheries Group, Wageningen University & Research, Wageningen, Netherlands
[3]International Sustainable Seafood Foundation, Washington, DC, USA
[4]Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, USA
[5]Inter-American Tropical Tuna Commission, Ecosystem and Bycatch Program, La Jolla, CA, USA
[6]MARBEC, Univ Montpellier, CNRS, Ifremer, IRD, Sète, France
[7]Institut de Recherche pour le Développement, Ob7, Sète, France
[8]Instituto Español de Oceanografía, Centro Oceanográfico de Málaga, Fuengirola, Málaga, Spain
[9]Mobula Conservation, La Paz, Baja California Sur, Mexico.

[*]Correspondence**:**
Leire Lopetegui-Eguren
llopetegui@azti.es

Oceanic whitetip shark (*Carcharhinus longimanus*) is an important top predator in pelagic ecosystems currently classified as Critically Endangered by the International Union for the Conservation of Nature (IUCN). This species is incidentally caught by fisheries targeting highly migratory tunas and billfishes throughout the Indian Ocean. Despite significant amount of ecological research on this species there is little understanding of the relationship between their spatial distribution and prevailing environmental conditions across large spatial oceanic scales. This study investigates for the first time, the spatio-temporal distribution of the oceanic whitetip shark incidental catch related to environmental conditions. Understanding the temporal, spatial and environmental factors influencing the capture of this species is essential to reduce incidental catches. We developed yearly and seasonal species distribution models—using generalized additive models— to identify areas with high incidental oceanic whitetip shark catch probability in the western Indian Ocean. This was possible using the European Union and associated flags tropical tuna purse seine fishery observer data collected between 2010 and 2020. We found sea surface temperature and nitrate concentration to be the most important environmental variables predicting the bycatch probability of oceanic whitetip shark. A higher probability of capture was predicted in areas where sea surface temperature was below 24ºC and with low nitrate concentrations close to zero and intermediate values (1.5-2.5 mmol.m-3). We also found a higher bycatch probability in sets on fish aggregating devices than in sets on free schools of tuna. The Kenya and Somalia basin was identified to have higher bycatch probabilities during the summer monsoon (June to September) when upwelling of deep cold waters occurs. The approach taken in the current study is a practical and cost-effective approach to glean important aspects of the distribution of species for which data are scant and difficult to collect across vast oceanic environments, but which require management because of their high vulnerability to fishing. Our model can be used to inform the development of spatial management and conservation strategies such as time-area closures to reduce the bycatch of this vulnerable shark species and ensure the long-term sustainability of this species.

A POPULATION IN DECLINE? EXAMINING HABITAT USE, TEMPORAL CHANGES, AND KNOWLEDGE GAPS FOR BASKING SHARKS (*Cetorhinus maximus*) IN THE CALIFORNIA CURRENT ECOSYSTEM

Alexandra G. McInturf[1,2,3], Barbara Muhling[4,5], Joseph J. Bizzarro[6,7], Nann A. Fangue[1], David A. Ebert[8,9], Damien Caillaud[10] and Heidi Dewar[5]

[1]Department of Wildlife, Fish and Conservation Biology, University of California, Davis, Davis, CA, United States
[2]Animal Behavior Graduate Group, University of California, Davis, Davis, CA United States
[3]Coastal Oregon Marine Experiment Station, Oregon State University, Newport, OR, United States
[4]Institute of Marine Sciences, University of California, Santa Cruz, Santa Cruz, CA, United States
[5]NOAA Southwest Fisheries Science Center, San Diego, CA, United States
[6]Cooperative Institute for Marine Ecosystems and Climate, University of California, Santa Cruz, Santa Cruz, CA, United States
[7]Fisheries Ecology Division, NOAA Southwest Fisheries Science Center, Santa Cruz, CA, United States
[8]Pacific Shark Research Center, Moss Landing Marine Laboratories, Moss Landing, CA, United States
[9]South African Institute for Aquatic Biodiversity, Grahamstown, South Africa
[10]Department of Anthropology, University of California, Davis, Davis, CA, United States

Among the largest fish species, the basking shark (*Cetorhinus maximus*) is found circumglobally in temperate and tropical waters. Though historical documents have recorded their presence in the California Current Ecosystem (CCE), basking sharks are now only rarely observed in this part of their range. We compiled recent and historical data from systematic surveys (1962–1997) and other sources (1973–2018) to (i) examine temporal patterns of basking shark sightings in the CCE, and (ii) determine the spatial, temporal, and environmental drivers that have affected basking shark presence and distribution here for the last 50 years. We first calculated variation in basking shark sightings and school size over time. We then generated species distribution models using the systematic survey data and evaluated the performance of these models against the more recent non-systematic sightings data. The sightings records indicated that the number of shark sightings was variable across years, but the number and probability of sightings declined in the mid-1980s. The systematic survey data showed up to nearly 4,000 sharks sighted per year until the 1990s, after which there were no sightings reported. In parallel, there was more than a 50% decline in school size from the 1960s to the 1980s (57.2 to 24.0 individuals per group). During the subsequent decades in the non-systematic data (>1990), less than 60 sharks were sighted per year. There were no schools larger than 10 reported, and the mean school size in the last decade (2010s) was 3.53 individuals per group. Low sea surface temperature and high chlorophyll a concentration increased sightings probability, and prevailing climatic oscillations (El Nino-Southern Oscillation index, North Pacific Gyre Oscillation, Pacific Decadal Oscillation) were also correlated with basking shark presence. Lastly, we observed a significant shift in the seasonality of sightings, from the fall and spring during the systematic survey period to the summer months after the 2000s. We conclude by offering suggestions for future research and conservation efforts; specifically, coordinating the documentation of fisheries mortalities and sightings throughout the Pacific basin would facilitate more robust population estimates and identify sources of mortality. Additionally, monitoring shark fin markets and developing region-specific genetic markers would help ensure that convention on international trade in endangered species (CITES) regulations are being followed.

MOVEMENTS AND POPULATION DISPERSAL OF THE DOLPHINFISH (*Coryphaena hippurus*) ACROSS THEEASTERN TROPICAL PACIFIC INFERRED FROM CARBON AND NITROGEN STABLE ISOTOPE ANALYSIS

Sergio A. Briones-Hernández[1], Ulianov Jakes-Cota[1], Fernando R. Elorriaga-Verplancken[1], Felipe Galván-Magaña[1], John M. Logan[2], John O'Sullivan[3], Esteban Elias[4], José Miguel Carvajal[5], Joanna Alfaro-Shigueto[6], Sofía Ortega-García[1]

[1]Instituto Politecnico Nacional – CICIMAR, Mexico, [2]Massachusetts Division of Marine Fisheries,USA, [3]Monterey Bay Aquarium, Monterey, CA, United States of America, [4] Instituto Costarricensede Pesca y Acuacultura, Costa Rica, [5]Instituto Publico de Investigacion de Acuacultura y Pesca, Ecuador, [6]Universidad Cientifica del Sur, Peru

Av. Instituto Politecnico Nacional s/n Col. Playa palo de Santa Rita, La Paz, Baja California Sur,Mexico, C.P. 23096

The dolphinfish (*Coryphaena hippurus*) is a globally distributed marine predator that supports one ofthe most important coastal fisheries along the Eastern Tropical Pacific (ETP). However, the knowledge about its spatial movements in this area is scarce. The using of the variation of stable isotope values at the baseline, kwon as isoscapes, to track movements of marine predators trough their stable isotope signatures is a growing field in stable isotope ecology. Stable isotope values ($\delta^{13}C$and $\delta^{15}N$) of dolphinfish muscle (n=220) captured at different locations across the ETP (e.g., Mexico,Costa Rica, Ecuador, Peru, and Oceanic areas) were used to identify transitional and residency zonesin this area. Copepod $\delta^{13}C$ and $\delta^{15}N$ values were used as baseline values to estimate trophic position,movements, and population dispersal of the dolphinfish. Movement or residence patterns were assumed using the variation in the difference between copepod baseline and dolphinfish $\delta^{15}N$ values($\Delta^{15}N_{dolphinfish\text{-}copepod}$, ‰). Residency was considered when $\Delta^{15}N_{dolphinfish\text{-}copepod}$ showed values in a rangebetween 3 and 12‰ assuming a threshold where uncertainty of differences in trophic discriminationfactors (TDF) across taxa, physiological adaptations, and physical condition is taken into consideration. We further used baseline corrected isotope values ($\delta^{13}C_{Dol\text{-}copepod}$ and $\delta^{15}N_{Dol\text{-}copepod}$) of the dolphinfish muscle to estimate isotopic niche metrics to use individual variability of the organisms from different locations and sizes as proxy to infer population dispersal across isoscapes. Values of

$\delta^{13}C$ and $\delta^{15}N$ showed differences between juvenile and adult dolphinfish and across the ETP. Trophicposition estimates ranged 3.1 to 6.0 with a mean of 4.6. Adults and juveniles showed similar trophicposition estimates while isotopic niche areas (SEA ‰^{2}) of adults were greater relative to juveniles inevery location. Dolphinfish showed a "*moderate movement*" in all locations based on $\Delta^{15}N_{dolphinfish\text{-}copepod}$ values, except for Mexico where adults were classified with "*high degree of movement by someindividuals*" and had the greatest niche area (SEA=2.8 ‰^{2}). Population dispersal based on $\Delta^{15}N_{dolphinfish\text{-}copepod}$ values showed *"moderate"* and *"high"* dispersal for adults and *"no dispersal"* formost juveniles, except for Mexico. Further research is needed to discern the drivers of the bulk isotopic variation for the dolphinfish across the ETP; however, this study provides insight into potential spatial mobility of the dolphinfish across an area of interest for multiple nations, which actively fish on this resource, creating knowledge that will help to improve stock assessments and management of the species.

RISK AND REWARD IN FORAGING MIGRATIONS OF NORTH PACIFIC ALBACORE DETERMINED FROM ESTIMATES OF ENERGY INTAKE AND MOVEMENT COSTS

Barbara A. Muhling[1], Stephanie Snyder[3], Elliott L. Hazen[4], Rebecca E. Whitlock[5], Heidi Dewar[2], Jong-Yeon Park[6], Charles A. Stock[7] and Barbara A. Block[8]

[1] Institute for Marine Science, University of California – Santa Cruz, Santa Cruz, CA, USA
[2] NOAA Southwest Fisheries Science Center, San Diego, CA, USA
[3] Thomas More University, Crestview Hills, KY, USA
[4] NOAA Southwest Fisheries Science Center, Monterey, CA, USA
[5] Swedish University of Agricultural Sciences, Department of Aquatic Resources, Stångholmsvägen 2, 178 93, Drottningholm, Sweden
[6] Department of Earth and Environmental Sciences, Jeonbuk National University, Jeollabuk-do, Republic of Korea
[7] National Oceanic and Atmospheric Administration, Geophysical Fluid Dynamics Laboratory, Princeton, NJ, 08540, USA
[8] Hopkins Marine Station, Stanford University, Pacific Grove, California, 93950, USA

North Pacific albacore (*Thunnus alalunga*) is a commercially important tuna species known to undertake extensive migratory movements between nearshore waters of the California Current and offshore environments in the central Pacific. However, these migration behaviors are highly variable, with some individuals traveling thousands of kilometers within a season, and others largely resident in the southern California Current throughout the year. In this study, we use data from 33 archival-tagged albacore (released between 2003 and 2011) to examine the movements, physiology and ecology of tuna following different migratory pathways. We used direct measurements of body temperature and ambient water temperature from internal archival tags to estimate energy intake via the Heat Increment of Feeding (HIF), the increased internal heat production associated with digestion of a meal. Our results indicate that HIF was variable in space and time, but it was highest for individuals foraging in the offshore North Pacific Transition Zone and southern California Current during spring and summer, and lowest in the Transition Zone in fall. None of the migratory strategies examined appeared to confer consistently higher energetic benefits than the others. Fish remaining resident in the southern California Current year-round incurred lower migration costs, and could access favorable foraging conditions off Baja California in spring and summer. In contrast, fish which undertook longer migrations had much higher energetic costs during periods of faster transit times, but were able to reach highly productive foraging areas in the central and western Pacific. HIF was generally higher in larger fish, and when ambient temperatures were cooler, but was not strongly correlated with other environmental covariates. Our analyses offer new avenues for studying the physiology of wild tuna populations, and can complement diet and isotopic studies to further understanding of fish ecology.

JUVENILE ALBACORE TUNA (*Thunnus alalunga*) FORAGING ECOLOGY VARIES WITH ENVIRONMENTAL CONDITIONS IN THE CALIFORNIA CURRENT LARGE MARINE ECOSYSTEM

Catherine F. Nickels[1], Elan J. Portner[1,2], Owyn Snodgrass[1], Barbara Muhling[1,3], and Heidi Dewar[1]

[1] National Oceanic and Atmospheric Administration, Southwest Fisheries Science Center, La Jolla, CA 92037 USA
[2] Scripps Institution of Oceanography, University of California San Diego
[3] Institute for Marine Studies, University of California Santa Cruz

Juvenile North Pacific Albacore Tuna (*Thunnus alalunga*) support commercial and recreational fisheries in the California Current Large Marine Ecosystem (CCLME), where they migrate to forage in the summer and fall. Because Albacore migration is motivated by foraging, differences in diet are important for understanding variability in its abundance and availability to fishers. Previous diet studies in the CCLME are of short duration, and long-term variability in Albacore diet remains poorly understood. We describe the diets of juvenile Albacore tuna in the CCLME from 2007 to 2019 using stomach content analysis and use classification and regression tree (CART) analysis to explore environmental drivers of diet variability. Important prey include Northern Anchovy (*Engraulis mordax*), Rockfishes (*Sebastes* spp.), Boreal Clubhook Squid (*Onychoteuthis borealijaponica),* and Euphausiids (Order: Euphausiidae), each contributing more than 5% mean proportional abundance. Regional averages of chlorophyll-*a* and sea surface temperature averaged over the first six months of the year best explained diet variation in the CCLME. Across our time series, diet variability mostly reflected changes in the relative importance of common prey species rather than the inclusion of novel prey. Juvenile Albacore exhibit flexible feeding behaviors by switching between generalist and specialist strategies under different environmental conditions. Continuous data collection over multiple years allows us to identify patterns of Albacore prey over space and time, and make connections with the environmental variables that are associated with change.

PACIFIC BLUEFIN TUNA, *Thunnus orientalis*, EXHIBITS A FLEXIBLE FEEDING ECOLOGY IN THE SOUTHERN CALIFORNIA BIGHT

Elan J Portner[1, 2], Owyn Snodgrass[1], Heidi Dewar[1]

[1]NOAA Fisheries Southwest Fisheries Science Center
[2] Scripps Institution of Oceanography, University of California San Diego

8622 Kennel Way
La Jolla, California 92037, USA

Resource availability is a strong driver of predator movements in pelagic systems. Pacific bluefin tuna, *Thunnus orientalis*, undertakes trans-oceanic migrations from spawning grounds in the western Pacific Ocean to foraging grounds in the California Current System (CCS), where they are thought to specialize on high energy, surface schooling prey. However, there has been substantial variability in environmental conditions and estimates of forage availability in the CCS over the past two decades. To examine the feeding ecology of juvenile *T. orientalis* in the face of this variability, we quantified the diet and prey energetics of 963 individuals collected in the Southern California Bight from 2008 to 2016. Using classification and regression tree analysis, we observed three sampling periods characterized by distinct prey compositions. In 2008, *T. orientalis* diet was dominated by midwater lanternfishes and enoploteuthid squids. During 2009-2014, *T. orientalis* consumed high numbers of relatively small, diverse fishes, cephalopods, and crustaceans. Only in 2015-2016 did *T. orientalis* specialize on relatively high energy, surface schooling prey as observed in previous studies. Despite containing the smallest prey, stomachs collected in 2009-2014 contained the highest number of prey and had similar estimated energetic values to stomachs collected in 2015-2016. The diet diversity observed across our study period suggests that *T. orientalis* utilizes different foraging strategies to exploit distinct forage communities. Expanding our understanding of feeding ecology will improve our ability to predict the responses of predators and the fisheries they support to changes in resource availability.

FEEDING ECOLOGY OF BROADBILL SWORDFISH (*Xiphias gladius*) IN THE CALIFORNIA CURRENT

Antonella Preti[1,2,3*], Stephen M. Stohs[3], Barbara Muhling[1,3] Gerard T. DiNardo[4], Camilo Saavedra[5], Ken MacKenzie[2], Leslie R. Noble[6], Catherine S. Jones[2], Graham J. Pierce[7,8]

[1]Institute of Marine Studies, University of California Santa Cruz, Santa Cruz, California, USA
[2]Institute of Biological and Environmental Sciences, School of Biological Sciences, University of Aberdeen, Aberdeen, Scotland, UK
[3]NOAA Fisheries, Southwest Fisheries Science Center, La Jolla, California, USA
[4]SCS Global Services, Emeryville, California, USA
[5]Centro Oceanográfico de Vigo, Instituto Español de Oceanografía, Vigo, Spain
[6]Faculty of Biosciences and Aquaculture, Nord University, Bodø, Norway
[7]Instituto de Investigaciones Marinas, Vigo, Spain
[8]Oceanlab, University of Aberdeen, Newburgh, Aberdeenshire, Scotland, UK

The feeding ecology of broadbill swordfish (*Xiphias gladius*) in the California Current was described based on analysis of stomach contents collected by fishery observers aboard commercial drift gillnet boats from 2007 to 2014. Prey were identified to the lowest taxonomic level and diet composition was analyzed using univariate and multivariate methods. Of 299 swordfish sampled (74 to 245 cm eye-to-fork length), 292 non-empty stomachs contained remains from 60 prey taxa. Genetic analyses were used to identify prey that could not be identified visually. Diet consisted mainly of cephalopods but also included epipelagic and mesopelagic teleosts. Jumbo squid (*Dosidicus gigas*) and *Gonatopsis borealis* were the most important prey based on the geometric index of importance. Swordfish diet varied with body size, location and year. Jumbo squid, *Gonatus* spp. and Pacific hake (*Merluccius productus*) were more important for larger swordfish, reflecting the ability of larger specimens to catch large prey. Jumbo squid, *Gonatus* spp. and market squid (*Doryteuthis opalescens*) were more important in inshore waters, while *G. borealis* and Pacific hake predominated offshore. Jumbo squid was more important in 2007-2010 than in 2011-2014, with Pacific hake being the most important prey item in the latter period. Diet variation by area and year probably reflects differences in swordfish preference, prey availability, prey distribution, and prey abundance. The range expansion of jumbo squid that occurred during the first decade of this century may particularly explain their prominence in swordfish diet during 2007-2010. Some factors (swordfish size, area, time period, sea surface temperature) that may influence dietary variation in swordfish were identified. Standardizing methods could make future studies more comparable for conservation monitoring purposes.

DEVELOPMENT OF A GENOTYPING-IN-THOUSANDS BY SEQUENCING (GT-SEQ) PANEL TO EVALUATE STOCK STRUCTURE AND SEX-SPECIFIC DISTRIBUTION PATTERNS OF ALBACORE TUNA (*Thunnus alalunga*) IN THE PACIFIC OCEAN

POSTER

Kathleen G. O'Malley[1], David. I. Dayan[1], Cristín K. Fitzpatrick[1], Nathan Campbell[2], Geoffrey Walker[1], Felix Vaux[3]

[1]State Fisheries Genomics Lab, Oregon State University, 2030 SE Marine Science Drive, Newport, OR, USA E-mail: Kathleen.omalley@oregonstate.edu
[2]GTseek LLC, 124 Main Avenue North, Suite 201, Twin Falls, ID, USA
[3]Department of Zoology, University of Otago, Dunedin, New Zealand

To improve our understanding of stock structure of Albacore Tuna (*Thunnus alalunga*) in the Pacific Ocean, we previously used a genome-wide sequencing approach to identify thousands of single nucleotide polymorphisms (SNPs) that were categorized as putatively adaptive or presumed neutral. Three main findings from that study were: 1) Albacore sampled in the North and South Pacific Oceans can be distinguished using 84 putatively adaptive SNPs identified as F_{ST} outliers, 2) Albacore with South Pacific genetic profiles were caught in the North Pacific indicating that these fish migrated across the equator, and 3) Albacore with mixed ancestry (i.e. North-South hybrids) were detected suggesting that individuals from these two stocks sometimes spawn at the same location and time. To facilitate rapid, accurate, and cost-effective genetic analysis of Albacore sampled throughout the Pacific Ocean, we developed a Genotyping-in-Thousands by sequencing (GT-seq) SNP panel using the sequencing data from the previous study. After primer design, testing and validation, the GT-seq panel consists of 54 F_{ST} outlier, 81 spatial outlier, and 153 presumably neutral SNPs and a genetic sex marker. This panel is currently being used to test for fine-scale population genetic structure of Albacore Tuna in the Pacific Ocean, detect trans-equatorial migrants, identify North-South hybrids, verify the accuracy of the genetic sex marker and test for sex-specific distribution patterns.

EVALUATING THE RELIANCE OF TUNA AND SWORDFISH ON FORAGE SPECIES IN THE OCEAN'S TWILIGHT ZONE USING COMPOUND-SPECIFIC STABLE ISOTOPE ANALYSIS

POSTER

Ciara Willis[1,2], Kayla Gardner[1,2], Walt Golet[3], Leah Houghton[2], Simon Thorrold[2]

[1] MIT-WHOI Joint Program in Oceanography/Applied Ocean Science & Engineering, Cambridge and Woods Hole, MA, USA
[2] Biology Dept, Woods Hole Oceanographic Institution, Woods Hole, MA, USA
[3] School of Marine Sciences, University of Maine, Orono, ME, USA

Bigeye tuna (*Thunnus obesus*), broadbill swordfish (*Xiphias gladius*), and yellowfin tuna (*Thunnus albacares*) are top ocean predators of substantial value to commercial fisheries. Globally distributed between c. 50°N and 50°S, these species routinely dive to mesopelagic depths during the day, presumably to forage. While their behaviours and diets have been studied, most diet analyses have used gut content analysis. Gut content analysis has several shortcomings, including lack of recognition or identification of species without distinctive hard structures (e.g. bones), the possibility for contents to be regurgitated upon capture, and representation of only one time point of the animal's diet. These gaps can be filled in by stable isotope analysis (SIA). In particular, compound-specific SIA, usually focusing on individual amino acids, has been shown to have significantly more resolution than traditional bulk C and N isotope analysis. Essential amino acids are transferred between trophic levels with negligible fractionation of carbon, meaning that they can be directly linked to their source at the base of the food web. Here we use stable C isotopes of essential amino acids to determine the reliance of the three study species on surface and mesopelagic productivity in the North Atlantic, and to consider how emerging fisheries on mesopelagic forage fauna may impact top predator populations.

TUN-AI: TUNA BIOMASS ESTIMATION WITH MACHINE LEARNING MODELS TRAINED ON OCEANOGRAPHY AND ECHOSOUNDER FAD DATA

Daniel Precioso[1], Manuel Navarro-García[2,3], **Kathryn Gavira-O'Neill**[4], Alberto Torres-Barrán[3], David Gordo[3], Victor Gallego-Alcalá[3], David Gómez-Ullate[1*]

[1] Universidad de Cádiz, Spain
[2] Universidad Carlos III de Madrid, Spain
[3] Komorebi AI Technologies, Madrid, Spain
[4] Satlink S.L., Madrid, Spain
*Corresponding author: david.gomezullate@uca.es;
Av. Universidad de Cádiz, 10, 11519 Puerto Real, Cádiz, Spain

The use of dFADs by tuna purse-seine fisheries is widespread across oceans, and the echo-sounder buoys attached to these dFADs provide fishermen with estimates of tuna biomass aggregated to them. This information has potential for gaining insight into tuna behaviour and abundance, but has traditionally been difficult to process and use. The current study combines FAD logbook data, oceanographic data and echo-sounder buoy data to evaluate different Machine Learning models and establish a pipeline, named Tun-AI, for processing echo- sounder buoy data and estimating tuna biomass (in metric tons, t) at various levels of complexity: binary classification, ternary classification and regression. Models were trained and tested on over 5000 sets and over 6000 deployments. Of all the models evaluated, the best performing one uses a 3-day window of echo-sounder data, oceanographic data and position/time derived features. This model is able to estimate if tuna biomass was higher than 10t or lower than 10t with an F1-score of 0.925. When directly estimating tuna biomass, the best model (Gradient Boosting) has an error (MAE) of 21.6t and a relative error (SMAPE) of 29.5%, when evaluated over sets. All models tested improved when enriched with oceanographic and position-derived features, highlighting the importance of these features when using echo-sounder buoy data. Potential applications of this methodology, and future improvements, are discussed.

FUTURE TECHNOLOGICAL APPLICATIONS FOR DATA COLLECTION IN THE ATLANTIC HIGHLY MIGRATORY SPECIES PELAGIC LONGLINE FLEET

Ian Miller, Brad McHale

Atlantic Highly Migratory Species (HMS) Management Division, National Marine Fisheries Service (NMFS)
1315 East-West Highway, Silver Spring, MD

The U.S. Atlantic pelagic longline fishery targets bigeye, yellowfin tuna, and swordfish in the western Atlantic Ocean, including the Gulf of Mexico, and the Caribbean Sea. The management framework for this fishery includes various electronic technologies that are used to support multiple regulatory objectives. Vessel monitoring systems (VMS) collect spatial information, which allows for insight into geospatial fishing activities, and are used by pelagic longline fisherman for "real-time" self-reporting of bluefin tuna interactions. Reports must be submitted via the VMS unit at the end of each fishing set haul, and these data are vital to NMFS' individual bluefin quota (IBQ) program. The IBQ program is a catch share program that provides shareholders with an allocation of bluefin tuna quota to account for incidental catch. Video electronic monitoring (EM) has been implemented in the Atlantic pelagic longline fleet as a compliance tool to support the IBQ program. Pelagic longline vessel owners/operators are required to have EM systems installed on their vessels that record haul back activity so that NMFS can monitor bluefin tuna catch. The computer hard drives containing the video footage must be submitted within 48 hours of trip completion to NMFS for review. The video is processed on a local server before being exported to an Amazon Web Services cloud bucket for review via a web application. During local server processing, two artificial intelligence (AI) algorithms are used to look for activity and to conduct quality control. These tools were developed in 2015 for EM and have proven effective in the management of the IBQ program. Since then, EM technology has evolved and has enabled the HMS Management Division to explore future integration of technological advances that have the potential to expand data transmission methods, reduce review time and storage needs, and further reduce the volume of data collected to achieve programmatic goals. Through regulatory actions such as draft Amendment 13 to the 2006 Consolidated HMS Fishery Management Plan, the HMS Management Division is exploring the use of booms and mats to increase detection of in-water discard events and get more accurate measurements of retained fish. Future enhancements could include AI algorithms that could: tag footage for review, process footage in real-time, reduce data collected to only target species, and conduct data analysis in real-time. EM in 2030 may look remarkably different than EM today. This talk will discuss the future application of EM and how the HMS Management Division could transition our program to utilize the most recent technological advances to maintain a successful program while reducing review time, storage needs, and potential costs.

HARNESSING ADVANCES IN ARTIFICIAL INTELLIGENCE AND GENOMICS TO ENABLE SCALABLE AND FIELD-DEPLOYABLE SPECIES IDENTIFICATION CAPABILITIES

Mariah Meek[1], Nadya Mamoozadeh[1], Shannon O'Leary[2], David Portnoy[3], and Nihar Mahapatra[4]

[1]Department of Integrative Biology, Michigan State University,
288 Farm Lane, East Lansing, MI 48824, USA
[2]Biological Sciences Department, Saint Anselm College
[3]Department of Life Sciences, Texas A&M University-Corpus Christi
[4]Department of Electrical and Computer Engineering, Michigan State University

The need to rapidly and reliably infer species identity is central to many fisheries applications, including for verification at point of capture in commercial and recreational fisheries, traceability of products throughout seafood supply chains, and enforcement of harvest and trade regulations. However, determining species identity is challenging when species are morphologically similar, including at certain life history stages and when diagnostic features have been removed, such as for fillets and other parts. Here, we present new tools for inferring species identity that incorporate recent advances in artificial intelligence and genomics. These species identification tools consist of a smartphone app and a genetic test analogous to a COVID-19 rapid test, meaning there is no need for genetic equipment or expertise to apply the tools. Combined, our tools enable accurate, cost effective, and scalable species identification in the field, making rapid and reliable inference of species identity possible under most settings. We demonstrate the application of these tools to highly migratory species, including sharks and tunas. Development of our species identification tools for these and other highly migratory species will equip diverse users to perform species-specific monitoring of catches and conservation status and to reduce illegal trade. More broadly, we aim for the tools developed in this study to enhance the sustainable use and management of fisheries resources across the globe.

ADVANCING TROPICAL TUNA FISHERIES SCIENCE WITH BIOGEOCHEMICAL ARGO (BGC-ARGO).

Michael P. Seki[1], Cara Wilson[2]

[1] NOAA Pacific Islands Fisheries Science Center
[2] NOAA Southwest Fisheries Science Center

The ability to monitor and observe the open ocean environment is critical for acquiring the science needed for understanding and assessment of tuna fisheries and the integrated pelagic ecosystem. Of particular importance is obtaining environmental information through the water column; information that cannot be readily acquired with satellite remote sensing. Ship-based surveys provide some of these data however are greatly limited temporally and spatially.

New automated remote technologies may help address this large data acquisition gap. In particular, Biogeochemical Argo (BGC-ARGO) floats provide subsurface observations of physical (T, S, etc.) and biogeochemical (nutrients, chlorophyll, oxygen, pH, etc.) continuously over time through the water column. It's envisioned this capability will provide relief for the many days at sea requirement currently employed to acquire these data.

Deploying BGC-ARGO targeting "hot spots" (high engagement areas) would be invaluable for providing some of the necessary science for NMFS, NOAA and many other applications of shared interests with regards to pelagic ecosystems.

HARVESTING SHIP NAVIGATION RADAR TO PROVIDE LOW-COST DATA ON VESSEL ACTIVITY AT SEA

Chris Wilcox, Adrien Ickowicz, Christian Moeseneder, Leslie A Roberson

Chris Wilcox, CSIRO Oceans and Atmosphere, Hobart, TAS, Australia

Correspondence to: chris.wilcox@csiro.au

Existing observation systems able to detect "dark" vessels at sea are often prohibitively expensive, especially for developing countries with large marine estates and many small vessels not equipped with tracking technologies like Vessel Monitoring Systems (VMS). We developed a technique to provide low-cost data on vessel activities using ships' existing navigation radar systems, essentially using a ship as a sensor platform.

Over the past three years, we developed and trialed a technique to provide low-cost data on vessel activities using a donor ships' existing navigation radar systems. Output of radar targets to a plotter is a standard feature of ship radar systems; instead of the target appearing and disappearing from the plotter, we change the settings to write the target information to a palm-sized data logger. We piloted the technology on five vessels with a range of technical capacities and characteristics, including an Australian fishing vessel. The system costs about $1,200 and runs in the background without affecting the ship's normal operations. We have developed a software system to build tracks from these radar targets, fuses them across multiple donor vessels, and allow visualization and download by authorized users. We currently have use cases with several fisheries agencies.

We found that radar data addresses an important gap in our understanding of the distribution and density of vessels at sea. Navigation radars can detect non-transponding vessels, as well as vessels and objects such as FADs that are too small for most satellite-based radar systems to pick up. We propose that if radar harvesting were incorporated into electronic monitoring systems being implemented in many of the world's major tuna fisheries, the majority of fishing activity could be monitored by implementing the technology on even a portion of the fleet. For example, purse seine and longline fleets in the Western Pacific have vastly different monitoring requirements, but they operate in similar locations. Given that commercial radars typically have ranges up to 98 nautical miles, purse seine vessels equipped with radar harvesting would not only see their own fleet, but also a substantial portion of the longline vessels operating both on the High Seas and within EEZs. Over time, analysis of radar data from multiple vessels would build a much more complete picture of vessel distribution and dynamics, at minimal cost to management.

LIST OF ATTENDEES

Scott Aalbers
Pfleger Institute of Environmental Research
315 Harbor Drive S, Suite B
Oceanside, CA 92054
United States
+1 (760) 721-2178
Scott@pier.org

Brett Alger
NOAA Fisheries
55 Great Republic Dr
Gloucester, MA 01930
United States
brett.alger@noaa.gov

Ella Adams
Southwest Fisheries Science Center / GPA
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (619) 876-2098
ella.adams@noaa.gov

Allen H Andrews
University of Hawaii, Manoa
Vastra Vintergatan 136
Orebro 70344
Sweden
astrofish226@gmail.com

Roselyn D Aguila
Texas A&M University at Galveston
200 Seawolf Pkwy
Galveston, TX 77554
United States
+1 (409) 497-5358
raguila@tamu.edu

Heather Baer
Wildlife Computers, Inc.
8310 154th Avenue NE, Suite 150
Redmond, WA 98052
United States
+1 (425) 881-3048
conferences@wildlifecomputers.com

Lisa Ailloud
Southeast Fisheries Science Center
National Marine Fisheries Service
75 Virginia Beach Drive
Miami, FL 33149-1003
United States
+1 (305) 209-5313
lisa.ailloud@noaa.gov

Natalia J. Bayona Vásquez
Oxford College of Emory University
Oxford College 150 View Circle
Oxford, GA 30054
United States
+1 (706) 206-6864
njbayonav@gmail.com

Aitor Aizpurua
Zunibal
Mundaka, Bizkaia, Spain 48360
658748498
aitor.aizpurua@zunibal.com

Randy Blankinship
NOAA Fisheries
263 13th Ave South
Saint Petersburg, FL 33701
+1 (727) 824-5313
randy.blankinship@noaa.gov

Hannah Blondin
Hopkins Marine Station
Stanford University
120 Ocean View Blvd.
Pacific Grove, CA 93950
United States
+1 (860) 798-9774
hblondin@stanford.edu

Rémy Canet
UMR MARBEC - Ifremer
Sete, France 34200
(+33) 606815585
remy.canet@gmail.com

Andre Boustany
Monterey Bay Aquarium
Tuna Research and Conservation Center
886 Cannery Row
Monterey, CA 93940-1085
United States
+1 (831) 402-1364
aboustany@mbayaq.org

Ericka Carlson
American Fishermen's Research Foundation
P.O. Box 16338
Portland, OR 97292
+1 (971) 209-2030
erickac@afrf.org

Chris Bridges
Heinrich Heine University /TUNATECH
Merowingerplatz 2
Düsseldorf, NRW 40225
Germany
+49 (173) 9531905
bridges@hhu.de

Daniela A. Chanto
Instituto Español de Oceanografía
Carrer del Pare Bartolomeu Pou, 17, 7b
Palma de Mallorca, Balearic Island 07003
Spain
+34 666894492
daniela.chantoga@gmail.com

Sergio Alejandro Briones-Hernández
Centro Interdisciplinario de Ciencias Marinas
Instituto Politécnico Nacional
Av. Instituto Politécnico Nacional s/n
Col. Playa Palo de Santa Rita
La Paz, BCS 23096
sbrionesh1600@alumno.ipn.mx

Wei-Chuan Chiang
Eastern Marine Biology Research Center of
Fisheries Research Institute
No. 22 Wuchuan Road
Chenggong Township
Taitung County 96143
Taiwan (R.O.C.)
+886 (89) 850090 ext. 408
wcchiang@mail.tfrin.gov.tw

Tia Brown
NOAA Fisheries Service / NMFS
Pacific Islands Fisheries Science Center
1845 Wasp Blvd, Bldg. 176
Honolulu, HI 96818
United States
+1 (808) 725-5333
tia.brown@noaa.gov

Naomi Clear
CSIRO Marine and Atmospheric Research
Division of Marine Research
GPO Box 1538
Castray Esplanade
Hobart, Tasmania 7001
Australia
+61 (4) 10831614
naomi.clear@csiro.au

Bubba Cook
World Wide Fund for Nature - New Zealand
2/77 Thorndon Quay
Wellington 6011
New Zealand
+64 (0) 27 833 0537
acook@wwf.org.nz

Susana Cusatti Sousa
Inter-American Tropical Tuna Commission
Achotines Laboratory
Las Tablas, Los Santos
Panama
+507 68861611
scusatti@iattc.org

Michael Cornman
American Fishermen's Research Foundation
PO Box 2071
Westport, WA 98595
+1 (360) 581-0982
mike@westportseafoodinc.com

Jemery Day
The Pacific Community (SPC)
CPS B.P. D5
Noumea 98848
New Caledonia
(687) 26 20 00
jemeryd@spc.int

Matthew Craig
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7054
matthew.craig@noaa.gov

Heidi Dewar
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7023
heidi.dewar@noaa.gov

Melissa Cronin
University of California, Santa Cruz
207 Broadway, Apt 1
Santa Cruz, CA 95060
United States
+1 (978) 335-2962
mecronin@ucsc.edu

Gerard DiNardo
SCS Global Services
2000 Powell St., Suite 600
Emeryville, CA 94608
United States
gdinardo@scsglobalservices.com

Becky Curtis
NOAA Office of Sustainable Fisheries
Atlantic HMS Management Division
1315 East-West Hwy
Silver Spring, MD 20910
United States
+1 (414) 243-6503
becky.curtis@noaa.gov

Réka Domokos
Pacific Islands Fisheries Science Center
NOAA Fisheries Service
1845 Wasp Blvd. Bldg. 176
Honolulu, HI 96818
United States
+1 (808) 983-5368
reka.domokos@noaa.gov

Michel Dreyfus
Centro de Investigación Científica y de Educación-
Superior de Ensenada
Carretera Tijuana-Ensenada 3918
Zona Playitas
Ensenada, BC 22860
Mexico
dreyfus@cicese.mx

Johnathan Evanilla
Bigelow Laboratory for Ocean Sciences
60 Bigelow Drive
East Boothbay, ME 04544
United States
jevanilla@bigelow.org

Amael Dupaix
MARBEC, Univ de Montpellier, CNRS, IRD, Ifremer
Avenue Jean Monnet CS 30171
Sete 34200
France
+33760086122
amael.dupaix@ird.fr

Paige Eveson
CSIRO Marine and Atmospheric Research
Division of Marine Research
GPO Box 1538
Castray Esplanade
Hobart, Tasmania 7001
Australia
+61 (3) 62325015
paige.eveson@csiro.au

Lindsay Enslow
Lotek
115 Pony Drive
Newmarket, ON L2H 1Z2
Canada
705-340-3772
lenslow@lotek.com

Nima Farchadi
University of San Diego
1422 Oliver Avenue
San Diego, CA 92109
United States
nfarchadi@sandiego.edu

Brad Erisman
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (619) 792-6100
brad.erisman@noaa.gov

Jessica Farley
CSIRO Marine and Atmospheric Research
Division of Marine Research
GPO Box 1538
Castray Esplanade
Hobart, Tasmania 7001
Australia
+61 (4) 07255524
jessica.farley@csiro.au

Lauriane Escalle
Oceanic Fisheries Programme
The Pacific Community (SPC)
BP D5
Noumea, 98800
New Caledonia
+687 (23) 946958
laurianee@spc.int

Leanne Fuller
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-5692
lfuller@iattc.org

Kathryn Gavira O'Neill
Satlink S.L.
Arbea Campus Empresarial
Edificio 5, Plana baja
Alcobendas, Madrid 28108
Spain
673547499
kgo@satlink.es

Bob Gillett
Pew Charitable Trusts
2962 Hidden Valley Lane
Santa Barbara, CA 93108
United States
+1 (805) 940-5442
rgillett1@yahoo.com

Ben Gilmer
The Nature Conservancy
74 Wall St
Seattle, WA 98121
United States
+1 (276) 701-5119
ben.gilmer@tnc.org

Shairon González Duarte
Centro Interdisciplinario de Ciencias Marinas
Instituto Politécnico Nacional
Arrecife 110
La Paz, BCS 23090
Mexico
+612 197-5280
sgonzalezd2100@alumno.ipn.mx

Madeline Green
CSIRO Marine and Atmospheric Research
Division of Marine Research
GPO Box 1538
Castray Esplanade
Hobart, Tasmania 7001
Australia
+61 (3) 110-4410
madi.green@csiro.au

Peter Grewe
CSIRO Marine and Atmospheric Research
Division of Marine Research
GPO Box 1538
Castray Esplanede
Hobart, Tasmania 7001
Australia
+61 (3) 62325374
peter.grewe@csiro.au

Shane Griffiths
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7030
sgriffiths@iattc.org

Yuhong Gu
Southwest Fisheries Science Center
9269 Village Glen Dr. #129
San Diego, CA 92123
United States
+1 (619) 436-6520
yuhong.gu@noaa.gov

Gency Guirhem
University of the Philippines Visayas
Maspasan, Calinog
Iloilo 5040
Philippines
+639162646457
gencylloricoguirhem@gmail.com

Rasanthi Gunasekera
CSIRO Marine and Atmospheric Research
Division of Marine Research
GPO Box 1538
Castray Esplanade
Hobart, Tasmania 7001
Australia
rasanthi.gunasekera@csiro.au

Greg Hammann
Marine Instruments
21405 Alum Creek Ct
Ashburn, VA 20147
United States
+1 (703) 309-3738
ghammann@marineinstruments.es

Craig Heberer
The Nature Conservancy
2119 Wedgewood Dr
Oceanside, CA 92056
United States
+1 (619) 209-5830
craig.heberer@tnc.org

Karter Harmon
National Marine Fisheries Service / WCR
1306 Quintero St #3
Los Angeles, CA 90026
United States
+1 (317) 517-7783
karter.harmon@noaa.gov

Elizabeth Hellmers
California Department of Fish and Wildlife
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 334-2813
elizabeth.hellmers@wildlife.ca.gov

Shellie Harper
Tuna Vessel Management Corp
3687 Voltaire St # D
San Diego, CA 92106
United States
+1 (619) 994-3021
Shellie@tunavslmgt.com

Nan Himmelsbach
Pacific Islands Fisheries Science Center
1845 Wasp Blvd
Honolulu, HI 96818
United States
+1 (808) 725-5571
nan.himmelsbach@noaa.gov

Jason Hartog
CSIRO Marine and Atmospheric Research
Division of Marine Research
GPO Box 1538
Castray Esplanede
Hobart, Tasmania 7001
Australia
+61 (3) 04978441
jason.hartog@csiro.au

Kim Holland
University of Hawaii
Hawaii Institute of Marine Biology
Coconut Island
PO Box 1346
Kaneohe, HI 96744-1346
United States
+1 (808) 220-0112
kholland@hawaii.edu

Danielle Haulsee
Hopkins Marine Station
Stanford University
120 Ocean View Blvd
Pacific Grove, CA 93950
United States
+1 (717) 451-7636
dhaulsee@stanford.edu

Melinda J. Holland
Wildlife Computers, Inc.
8310 154th Avenue NE, Suite 150
Redmond, WA 98052
United States
+1 (425) 881-3048
melinda@wildlifecomputers.com

Michelle Horeczko
California Department of Fish and Wildlife
4665 Lampson Avenue, Suite C
Los Alamitos, CA 90720
United States
+1 (562) 342-7198
michelle.horeczko@wildlife.ca.gov

Harrison Huang
California Department of Fish and Wildlife
4665 Lampson Avenue, Suite C
Los Alamitos, CA 90720
United States
+1 (562) 342-7199
Harrison.Huang@wildlife.ca.gov

Robert Humphreys
Marine Biology Graduate Program
University of Hawaii at Manoa
2403 Orchid Street
Honolulu, HI 96816
United States
+1 (808) 779-1699
rhumphre@hawaii.edu

Taha Imzilen
Institut de Recherche pour le Développement (IRD)
IFREMER
Avenue Jean Monnet CS30171
34203 Sète cedex
France
taha.imzilen@ird.fr

David Itano
The Nature Conservancy
532 E. Main Street
Ventura, CA 93001
United States
+1 (808) 387-5430
daveitano@gmail.com

Kelsey James
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 334-2847
kelsey.james@noaa.gov

María José Juan Jordá
AZTI
Calle Alonso Quijano 71, 1, 3A
Madrid 28034
Spain
mjuanjorda@gmail.com

Donna Kehoe
Lotek Wireless, Inc.
115 Pony Drive
Newmarket, Ontario L3Y 7B5
Canada
+1 (905) 251-1102
dkehoe@lotek.com

Eric Kingma
Hawaii Longline Association
1131 N Nimitz Hwy
Honolulu, HI 96817
United States
+1 (808) 389-2653
eric.k.kingma@gmail.com

Suzy Kohin
Wildlife Computers, Inc.
8310 154th Avenue NE, Suite 150
Redmond, WA 98052
United States
+1 (425) 881-3048
suzy@wildlifecomputers.com

Peter Kuriyama
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-5657
peter.kuriyama@noaa.gov

Chi Hin Lam
University of Massachusetts - Amherst
Large Pelagics Research Center
PO Box 3188
Gloucester, MA 01931
United States
tagtuna@gmail.com

Matt Lansdell
CSIRO Oceans and Atmosphere
Castray Esplanade
Battery Point, Tasmania 7004
Australia
+61 (3) 6232-5447
Matt.Lansdell@csiro.au

Ryan Logan
Nova Southeastern University
Guy Harvey Research Institute
8000 N Ocean Dr.
Dania Beach, FL 33004
United States
+1 (303) 819-6150
rlogan@nova.edu

Leire Lopetegui Eguren
AZTI
Basque Research and Technology Alliance
Zumalakarregi 17, 3ºB
Zarautz, Gipuzkoa 20800
Spain
+34 (69) 576-2912
llopetegui@azti.es

Jon Lopez
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 334-2885
jlopez@iattc.org

María Teresa Losada Ros
Satlink S.L.
Arbea Campus Empresarial
Carretera de Fuencarral
Edificio 5, Planta baja
Alcobendas, Madrid 28108
Spain
+34 697633485
tlr@satlink.es

David Lowry
NOAA Fisheries
1009 College St SE
Lacey, WA 98503
United States
+1 (253) 317-1764
david.lowry@noaa.gov

Molly Lutcavage
Large Pelagics Research Center
Pacific Islands Fisheries Group
3908 Kiani St
Koloa, HI 96756
United Sates
+1 (603) 767-2129
me.lutcavage@gmail.com

Nadya Mamoozadeh
Michigan State University
405 Corwood Drive
Fuquay Varina, NC 27526
United States
+1 (724) 421-5429
mamooz@msu.edu

Ralph Mana
University of Papua New Guinea
PO Box 320
Port Moresby
National Capital, 134
Papua New Guinea
rmana@upng.ac.pg

Lauren Martin
NOAA Fisheries
Southwest Fisheries Science Center
8901 La Jolla Shores Drive
La Jolla, CA 92037
United States
lauren.martin@noaa.gov

Richard S. McBride
NOAA Fisheries
Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543
United States
+1 (508) 495-2244
richard.mcbride@noaa.gov

Bradley McHale
National Marine Fisheries Service
NOAA Fisheries Service
55 Great Republic Dr.
Gloucester, MA 01930
United States
+1 (978) 281-9139
brad.mchale@noaa.gov

Alexandra McInturf
Oregon State University
342 Bryant Street
Mountain View, CA 94041
United States
+1 (513) 504-8939
alexandra.mcinturf@oregonstate.edu

Mariah Meek
Michigan State University
PO Box 1651
Wilson, WY 83014
United States
mhmeek@msu.edu

Natalia Michelle Melgar Martínez
Centro Interdisciplinario de Ciencias Marinas
Instituto Politécnico Nacional
Instituto Politécnico Nacional s/n
La Paz, BCS 23090
Mexico
natmelmar@hotmail.com

Julia Merszei
Lotek
115 Pony Drive
Newmarket, ON L3Y 7B5
Canada
905-836-6680 ext. 2903
jmerszei@lotek.com

Ian P. Miller
National Marine Fisheries Service
NOAA Fisheries Service
Atlantic HMS
1315 East West Highway
Silver Spring, MD 20910
United States
+1 (302) 751-6684
ian.miller@noaa.gov

Gala Moreno
International Seafood Sustainability Foundation
Maestro Guridi 3 6B
Donostia, San Sebastian, Gipuzkoa 20008
Spain
+34646930923
gmoreno@iss-foundation.org

JT Mudge
productOps
110 Cooper St #201
Santa Cruz, CA 95060
United States
+1 (831) 419-0360
jt.mudge@productops.com

Barbara Muhling
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7197
Barbara.Muhling@noaa.gov

Laia Munoz Abril
Dauphin Island Sea Lab
1211 Biloxi Avenue
Dauphin Island, AL 36528
United States
+1 (251) 232-9762
lmunoz@disl.org

Tracy Murai
Thai Union
London, UK
tracy.murai@thaiunion.com

Nicole Nasby-Lucas
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 334-2826
nicole.nasby-lucas@noaa.gov

Kevin Ng
Wildlife Computers, Inc.
8310 154th Avenue NE, Suite 150
Redmond, WA 98052
United States
+1 (425) 881-3048
kevin@wildlifecomputers.com

Catherine Nickels
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
catherine.nickels@noaa.gov

Kathleen O'Malley
Oregon State University
2030 SE Marine Science Drive
Newport, OR 97365
United States
+1 (541) 961-3311
kathleen.omalley@oregonstate.edu

Sofia Ortega García
Centro Interdisciplinario de Ciencias Marinas
Instituto Politécnico Nacional
Av. Instituto Politécnico Nacional s/n
Col. Playa Palo de Santa Rita
sortega@ipn.mx

Shannon Penna
National Marine Fisheries Service
Southwest Fisheries Science Center
4518 Ocana Ave
Lakewood, CA 90713
United States
+1 (562) 544-5049
shannon.penna@noaa.gov

Julian G. Pepperell
Pepperell Research and Consulting Pty Ltd.
PO Box 1475
Noosaville DC, Queensland 4566
Australia
+61 (4) 1861339
julianp@internode.on.net

Antonella Preti
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-5640
antonella.preti@noaa.gov

Bruce Pohlot
International Game Fish Association
300 Gulf Stream Way
Dania Beach, FL 33004
United States
+1 (954) 937-5054
bpohlot@igfa.org

Catherine Purcell
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7189
catherine.purcell@noaa.gov

Elan Portner
Scripps Institution of Oceanography, UCSD
Sverdrup Hall
8165 Discovery Way
La Jolla, Ca 92037
United States
eportner@ucsd.edu

María Lourdes Ramos Alonso
Instituto Español de Oceanografía - CSIC
Centro Oceanográfico de Canarias
C/ Farola del Mar, 22 Dársena Pesquera
Santa Cruz de Tenerife, Islas Canarias 38180
Spain
mlourdes.ramos@ieo.es

Valerie Post
National Marine Fisheries Service
NOAA Fisheries Service
1845 Wasp Boulevard, Bldg 176
Honolulu, HI 96816
United States
+1 (808) 725-5034
valerie.post@noaa.gov

Lesbie Roberson
CSIRO
8 Midjimberry Rd
Point Lookout, Queensland 4183
Australia
+61 (0) 432675677
leslie.roberson@csiro.au

Nicola Potter
CSIRO Ocean and Atmospheric
3-4 Castray Esplanade
Battery Point, Tasmania 7004
Australia
nicola.potter@csiro.au

Marlon Román
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-5694
mroman@iattc.org

Andrés Romero
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7191
aromero@iattc.org

William Sardinha
Tuna Vessel Management Corp
3687 Voltaire St # D
San Diego, CA 92106
United States
Bill@sardinhacileu.sdcoxmail.com

Tom Schiff
Tom Sciff & Associates
6418 Caminito Listo
San Diego, CA 92111
United States
+1 (858) 342-3839
tschiffsd@aol.com

Daemian Schreiber
NOAA Fisheries - Affiliate
1315 East West Highway
Silver Spring, MD 20910
United States
+1 (301) 427-8104
daemian.schreiber@noaa.gov

Brittany Schwartzkopf
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7107
brittany.schwartzkopf@noaa.gov

Michael Seki
Pacific Islands Fisheries Science Center
NOAA Fisheries Service
1845 Wasp Blvd. Building #176
Honolulu, HI 96818
United States
+1 (808) 725-5393
michael.seki@noaa.gov

Chugey Sepulveda
Pfleger Institute of Environment Research (PIER)
315 Harbor Drive S, Suite B
Oceanside, CA 92054
United States
+1 (760) 721-2178
chugey@pier.org

Christina Show
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (619) 546-7078
christina.show@noaa.gov

Owyn Snodgrass
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 334-2879
owyn.snodgrass@noaa.gov

Carrie Soltanoff
NOAA Fisheries
1315 East-West Hwy
Silver Spring, MD 20910
United States
+1 (301) 427-8587
carrie.soltanoff@noaa.gov

Oscar Sosa Nishizaki
Centro de Investigación Científica y de Educación-Superior de Ensenada
Carretera Ensenada-Tijuana No. 3918
Fraccionamiento Zona Playitas
Ensenada, BC 22860
Mexico
+52 (646) 137 6335
ososa@cicese.mx

Jennifer Stahl
NOAA Pacific Island Office
1334 Center Street
Honolulu, HI 96816
United States
jennifer.stahl@noaa.gov

Dianne Stephan
National Marine Fisheries Service
NOAA Fisheries Service
Atlantic Highly Migratory Species Division
55 Great Republic Dr
Gloucester, MA 01930
United States
+1 (978) 281-9397
dianne.stephan@noaa.gov

Stephen Stohs
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7084
stephen.stohs@noaa.gov

Dale Sweetnam
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7170
dale.sweetnam@noaa.gov

Yonat Swimmer
National Marine Fisheries Service
NOAA Fisheries Service
Pacific Islands Fisheries Science Center
c/o Southwest Region
501 W. Ocean Boulevard, Suite #4200
Long Beach, CA 90802-4213
United States
yonat.swimmer@noaa.gov

Katherine Swiney
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 334-2820
katherine.swiney@noaa.gov

Steven Teo
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7179
steve.teo@noaa.gov

Álvaro Terán
Martec Costa Rica
Boca Vieja
Quepos, Puntarenas
Costa Rica
50688359040
alvaro.teran@martec.co.cr

Michael Thompson
Newport Landing Sportfishing
26032 Via del Rey
San Juan Capistrano, CA 92675
United States
+1 (949) 500-5901
thompsonmike148@gmail.com

Jon Uranga
AZTI-Tecnalia
Marine Research and Technology Alliance (BRTA)
Txatxarramendi ugertea z/g
Sukarrieta, Bizkaia 48395
Spain
664001098
juranga@azti.es

Jody Van Niekerk
Pacific States Marine Fisheries Commission
National Marine Fisheries Service
3740 Boyd Ave Apt 146
San Diego, CA 92111
United States
jody.vanniekerk@noaa.gov

Beth Vanden Heuvel
Cape Fisheries Management Company LLC
15375 SE 30th Pl, Suite 280
Bellevue, WA 98007
United States
+1 (206) 300-6014
bvandenheuvel@capefisheries.com

Jennifer Waldo
University of California, Santa Cruz
432 Dufour St
Santa Cruz, CA 95060
United States
+1 (925) 243-5392
jwaldo@ucsc.edu

William Watson
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-5647
william.watson@noaa.gov

Nick Wegner
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7080
nick.wegner@noaa.gov

Brett Wiedoff
NOAA Fisheries Service
Pacific Islands Regional Office
7700 NE Ambassador Pl
Portland, OR 97220
United States
+1 (503) 280-2424
Brett.L.Wiedoff@noaa.gov

Chris Wilcox
CSIRO Marine and Atmospheric Research
Division of Marine Research
GPO Box 1538
Castray Esplanade
Hobart, Tasmania 7001
Australia
+61 (3) 62325222
Chris.Wilcox@csiro.au

Ashley Williams
CSIRO Oceans and Atmosphere
Hobart, Tasmania 7001
Australia
ashley.williams@csiro.au
Australia

Ciara Willis
MIT-WHOI Joint Program in Oceanography
266 Woods Hole Rd, MS #50
Woods Hole, MA 02543
United States
+1 (857) 285-0269
willisc@mit.edu

Barrett Wolfe
University of Tasmania
Institute for Marine and Antarctic Studies
8/17 Sunvale Ave
Sandy Bay, Tasmania 7005
Australia
+61 (4) 13083690
barrettwwolfe@gmail.com

Phoebe Woodworth-Jefcoats
NOAA Fisheries
Pacific Islands Fisheries Science Center
Honolulu, HI 96818
United States
phoebe.woodworth-jefcoats@noaa.gov

Mariana Elisa Worbis Badias
Centro Interdisciplinario de Ciencias Marinas
Instituto Politécnico Nacional
Av. Instituto Politécnico Nacional s/n
Playa Palo de Santa Rita
La Paz, BCS 23096
Mexico
999 310 2928
mworbisb2100@alumno.ipn.mx

Johanna Wren
NOAA Fisheries
Pacific Islands Fisheries Science Center
1845 Wasp Boulevard, Bldg 176
Honolulu, HI 96816
United States
+1 (808) 725-5345
johanna.wren@noaa.gov

Daniel Margulies
Inter-american Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7120
dmargulies@iattc.org