PROCEEDINGS OF THE 70TH ANNUAL TUNA CONFERENCE

Data collection: emerging tools that address fundamental challenges in the research and management of large pelagic species

LAKE ARROWHEAD, CALIFORNIA
MAY 20-23 2019

PROCEEDINGS OF THE 70TH ANNUAL TUNA CONFERENCE

Lake Arrowhead, California,
May 20-23 2019

Marlon H Román and Enrique Mauser – Chairs
Sofia Webber and Marisol Aguilar – Coordinators

This meeting is for frank discussion of ideas, some of which may not be fully developed by the presenter(s). These proceedings are produced as an aid to the meeting and as an informal memory guide; they should not be cited. If readers wish to cite information or an idea from these pages, they should contact the author(s) so that a more proper citation can be used.

PREFACE

Welcome to the 70th 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 **"Data collection: emerging tools that address fundamental challenges in the research and management of large pelagic species".** Fisheries science and management hinge ultimately on the quality of the available data. More and more, fisheries science depends on analyses enriched by data collected using innovative procedures and techniques. For example, electronic monitoring systems are being increasingly used to collect effort, catch, and bycatch data, thus maximizing coverage of fishing activities while minimizing costly human observer programs, and satellite data now allow scientists to not only follow the movements of fish-aggregating devices (FADs) formerly estimated through simulation models, but also to remotely estimate the biomasses aggregated and gain insights on residence times of large pelagics around FADs. It is essential for fisheries scientists to be up-to-date with all these advances in data collection, and so, for the 2019 Tuna Conference, we are calling on researchers to share their experiences and opinions in this respect, and to illustrate the use of contemporary, novel, and promising data-collection tools in the assessment of large pelagic species.

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 four days, there will be 63 oral presentations across 9 sessions. We also have an additional 17 presentations in the poster session. This year's conference features a special "Dolphinfish symposium" courtesy of John O'Sullivan and Sofia Ortega-Garcia, in which 15 oral presentations will describe and discuss biological, fishery and management aspects Dolphinfish. Special thanks to this year's session moderators: Walter Golet, Mark Fitchett, Shane Griffiths, Lisa Ailloud, Russ Vetter, Noda Takuji, John Hyde, John Stieglitz, and Suzy Kohin. We sincerely appreciate their efforts to keep sessions running smoothly.

The abstracts for the oral and poster presentations contained in the Proceedings are listed in alphabetical order of the author giving the presentation (shown in bold lettering; abstracts are combined for oral and poster presentations). 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).

This year there were many excellent applications for student scholarships and ranking the candidates was a very difficult task. Many thanks to Nick Wegner, John Hyde, Owyn Snodgrass, Leanne Fuller, and Haikun Xu for helping to review the student application packages. Thanks to the generosity of our donors, we are very pleased to announce that funds were available to support 8 student scholarships this year. The *Tuna Conference Scholarship* was awarded to Lela Schlenker for her talk titled "Why tag a captive fish? Evaluating habitat utilization, migration patterns, and spawning behavior in mahi-mahi using pop-up satellite archival tags." A *Manuel Caboz Memorial Scholarship* was awarded to James Kilfoil for his talk titled "Seeing the bigger picture: using full-spherical cameras to reduce the influence of density independent factors on video survey metrics of relative abundance." A *Manuel Caboz Memorial Scholarship* was awarded to Sarah Luongo for her talk titled "Estimating energetic costs and foraging behavior of free-ranging dolphinfish, *Coryphaena hippurus*." A *Manuel Caboz Memorial Scholarship* was awarded to Caitlynn Birch for her talk titled "The effects of seasonal variation, El Niño-Southern

Oscillation events, and climate change on the tuna-dolphin association." Katie Downes received the *Wildlife Computers Scholarship* for her talk titled "Residency and reproductive status of yellowfin tuna in a proposed large-scale pelagic marine protected area." Meliza Le received the *Biologging Solutions Scholarship* for her talk titled "Trophic ecology of yellowfin tuna (*Thunnus albacares*) in the Gulf of Mexico inferred from stable isotope analysis and CSIA-AA." Brenda Rudnicky received the *Monterey Bay Aquarium Scholarship* for her talk titled "Stock specific growth patterns of Atlantic bluefin tuna (*Thunnus thynnus*) using otolith increment analysis." Alberto Abad Uribarren was awarded the *AFRF Scholarship* for his talk titled "Modelling environmental influence on Atlantic bluefin tuna bycatch by Mexican longliners in the Gulf of Mexico." Additional travel support for the 8 award winners was graciously provided by the International Seafood Sustainability Foundation.

In addition to support for student scholarships and travel, the Tuna Conference benefits from generous donations to support the various "social" functions such as the Sushi Social/Poster Session, the Tuna Barbecue and Tavern get-togethers. We thank Rex Ito and Prime Time Seafood Inc. for donating the sashimi-grade tuna for the poster Sushi Social/Poster Session and Wildlife Computers Inc. for providing refreshments. We gratefully acknowledge all our donors from the American Fishermen's Research Foundation, American Tuna Boat Association, International Seafood Sustainability Foundation (ISSF), Biologging Solutions Inc., Monterey Bay Aquarium, Prime Time Seafood Inc., and Wildlife Computers Inc.

We would like to thank also Scott Aalbers, Craig Heberer, Kim Holland, John Hyde, David Itano, Russell Ito, Chugey Sepulveda, and Owyn Snodgrass for volunteering to be our gracious team of sashimi and poke cutters. We are appreciative of Natalie Arnoldi for contributing her beautiful artwork, *Thunnus,* to our cover page. Natalie Arnoldi is an artist and graduate student living in Central California. Her work explores the fine line between abstract and figurative painting and the psychological effects of ambiguous representation. Trained academically as a marine biologist, with a bachelors and a masters degree from Stanford University, Arnoldi has had over 45 paintings exhibitions.

Thanks to Millie De Los Reyes for handling all the bank transactions. Our graphic designer Chris Patnode put her creativity and invaluable help to work on name tags, the Tuna Conference website and student certificates, and Joydelee Marrow contributed her time and expertise to answer all our questions regarding anything Tuna Conference! A special thanks to the UCLA Conference Center personnel for accommodating our numerous requests. 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, as well as the transportation of supplies and conference participants.

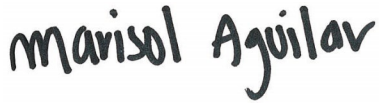
The stamps accompanying Natalie Arnoldi's artwork reflect the several aspects of theme of the 70th Tuna Conference, involving activities related to the fishery like fishing, tagging, sampling, acoustics and the "Dolphinfish symposium". These stamps were issued by post offices from different parts of the world. Clockwise from top-left, 1 and 2: Wallis and Futuna. "Tagging and weighing a skipjack". Year issued: 1979. Stanley Gibbons catalog: 314 and 311, respectively. 3: Iceland. "Fishing vessel catching Atlantic cod (*Gadus morhua*)". Year issued: 1971. Scott catalog: 436. 4: New Caledonia. "Pole-and-line boat fishing skipjack". Year issued: 1979. Scott catalog: C153. 5: Republic of Maldives. "Mahi-mahi (*Coryphaena hippurus*)". Year issued: 1973. Scott catalog: 443. 6: Faroe Islands. Fishing vessel probing the sonar over a school of Blue whiting fish (*Micromesistius poutassou*). Year issued: 2002. Scott catalog: 426b.

In closing, we would like to thank you all for participating. 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 71st Tuna Conference!

Marlon H Román
70th Tuna Conference Chair

Enrique Mauser
70th Tuna Conference Chair

Sofia Webber
70th Tuna Conference Coordinator



Marisol Aguilar
70th Tuna Conference Coordinator

Izadore Barrett
1926-2019

Tribute to Dr. Izadore Barrett

Dr. Izadore Barrett, former director of the Southwest Fisheries Science Center (SWFSC), passed away on 15 April 2019 with his wife Fulvia at his side. He enjoyed a long and productive career in fisheries science serving with the British Columbia Game Commission, Inter-American Tropical Tuna Commission (IATTC), United Nations and NOAA Fisheries before retiring in San Diego.

Iz remains the longest serving Director of the SWFSC. His tenure from 1977 through 1992 spanned a dynamic and transformative period of time that included the implementation of the Magnuson-Stevens Fisheries Conservation and Management Act (MSFCMA), the Marine Mammal Protection Act, the Endangered Species Act and the Antarctic Marine Living Resources Convention Act. These new responsibilities required an enhanced emphasis on strategic planning, realignment of existing programs, and recruitment from a broader range of disciplines.

Iz introduced a method for strategic planning that engaged scientists, constituents and stakeholders. It was first used to refine the albacore research program and subsequently expanded to develop plans to address critical information needs for a wide range of research programs from pelagic forage species in the California Current to Antarctic living resources. It is a testimony to his farsightedness that many of the elements of these plans are still relevant. Iz established two new divisions at the Center: the Marine Mammal Division and the Antarctic Ecosystem Research Division. He recruited resource economists to work with fishery biologists in developing a general framework for fishery management plans. The Anchovy Management Plan was the first of its kind under the new MSFCMA and served as a model for future plans. He was a proponent of inter-disciplinary teams and the use of new technologies. He was well-respected at the Center, generous with his time, open to new ideas, deliberate in his decision making, and unfailing in his defense of the Center's science.

Dr. Barrett was born in 1926 in Vancouver, British Columbia. He obtained a degree in zoology at University of British Columbia and did graduate work at University of Toronto and University of Washington. His PhD dissertation was titled "*Development of a Management Regime for the Eastern Pacific Tuna Fishery*." He led the hatchery program of the British Columbia Game Commission in the early 1950s before serving as chief of IATTC's Panama Laboratory from 1956-59 and subsequently as Senior Scientist from 1959-67. He then worked on United Nations fisheries programs in Chile for three years before accepting the position of Deputy Director of the SWFSC in 1970. He was promoted to Director of the SWFSC in 1977.

Iz had a keen interest in a broad range of management issues associated with fisheries on highly migratory species, including tuna. He formalized the provision of management advice to US delegations to international commissions. He advocated centralized data bases and the introduction of satellite oceanography to map tuna habitat. He expanded the scope and frequency of publication of the *Tuna Newsletter* which became a widely read source of information on tuna research, fisheries and trade throughout the world during the years prior to the internet. He established a multi-faceted program to assess the magnitude of dolphin mortality associated with purse seine fishing for tuna in the eastern tropical Pacific Ocean and develop mitigation strategies.

But most importantly for this audience, Iz was a major champion of the Tuna Conference. In the mid-1970s he committed to boosting attendance and encouraged people from academia, industry and other constituent groups to participate. He reached out to researchers in Europe, Latin America and the Pacific Rim to join their colleagues from California and Hawaii. He provided support for transportation and social events. He expanded the SWFSC *Director's Report to the Tuna Conference* and included a review of emerging issues regarding tuna/billfish fisheries throughout the world and outlined his vision and goals for tuna-related research at the Center. In response to Iz's encouragement over the years, the Conference has enjoyed a broader diversity of topics, geographic regions and presenters.

Although he officially retired 27-years ago, the effects of Izadore Barrett's remarkable foresight and leadership are still with us.

Roger Hewitt

70th TUNA CONFERENCE AGENDA

Monday, 20 May 2019

11:00 Registration opens in the Library (continued throughout the conference)

13:30 Welcome and Introduction (Pineview)

SESSION 1: Physiology and Foraging Ecology (Moderator: Walt Golet)

13:45 Physiological specialization for elevating the temperature of red muscle in swordfish. **Chugey Sepulveda,** Scott Aalbers, Michael S. Wang, Diego Bernal, Ashley Stoehr and Mark Okihiro.

14:00 Foraging ecology of bigeye and yellowfin tuna in the northwest Atlantic Ocean. **Riley Austin**, John Logan, Gayle Zydlewski, and Walter Golet.

14:15 Evaluating the foraging ecology and energetics of Atlantic bluefin tuna (*Thunnus thynnus*) in the Gulf of Maine. **Sammi Nadeau** and Walt Golet.

14:30 Coffee Break (15-minutes)

SESSION 2: Elasmobranchs: Bycatch and Ecology (Moderator: Mark Fitchett)

14:45 Assessing potential conservation measures for data-poor mobulid bycatch in the eastern Pacific Ocean tuna fishery using the "EASI-Fish" ecological risk assessment tool. **Shane P. Griffiths**, Nerea Lezama-Ochoa, Marlon H. Román.

15:00 Bycatches of the pelagic stingray *Pteroplatytrygon violacea* in the tuna purse-seine fishery of the EPO. **Andrés Romero**, Marlon H Román, Nerea Lezama, Jon Lopez, Martin Hall.

15:15 The role of species distribution models on the ecological risk assessment of the Spinetail Devil ray (*Mobula mobular*) in the Atlantic Ocean purse-seine fishery. **Nerea Lezama-Ochoa**, Hilario Murua, Francisco Abascal and P. Bach.

15:30 The porbeagle shark (*Lamna nasus*) in the southern hemisphere: searching for biological patterns among oceans and regions. **Enzo Acuña**, Rubén Alarcón, Alexander Arkhipkin, Rui Coelho, Alex Cortés, Charlene Da Silva, Andrés Domingo, Guy Duhamel, Malcolm Francis, María Teresa González, Pilar Haye, Santiago Montealegre, Gonzalo Mucientes, Robert Olson and Patricia Zárate.

15:45 Maternal provisioning gives young-of-the-year hammerheads a head start in early life. **Kady Lyons**, Douglas H. Adams, Eric A. Reyier, Ashley S. Galloway and Bryan S. Frazier.

SESSION 3: Trophic Ecology (Moderator: Shane Griffiths)

16:00 A review of methods to determine prey consumption rates, gastric evacuation and daily ration of pelagic fishes: a precursor to experimental estimation for key predators in the eastern Pacific Ocean ecosystem. **Jeanne Wexler** and Shane Griffiths.

16:15 Interplay between space and ontogeny in the trophic ecology of skipjack tuna, *Katsuwonus pelamis*, in the eastern Pacific Ocean. **Leanne Fuller**, Shane Griffiths, Robert Olson, Felipe Galván-Magaña, Noemi Bocanegra-Castillo and Vanessa Alatorre-Ramírez.

16:30 Trophic ecology of yellowfin tuna (*Thunnus albacares*) in the Gulf of Mexico inferred from stable isotope analysis and CSIA-AA. **Meliza Le Alvarado***, Sharon Z. Herzka, Alfonsina E. Romo-Curiel and Oscar Sosa-Nishizaki.
*Biologging Solutions Scholarship/ International Seafood Sustainability Foundation Travel Award winner (ISSF).

18:30 Dinner followed by 'Welcome Gathering' in the Tavern

Tuesday, 21 May 2019

8:00 Breakfast

SESSION 4: Data Monitoring (Moderator: Lisa Ailloud)

9:00 Seeing the bigger picture: using full-spherical cameras to reduce the influence of density independent factors on video survey metrics of relative abundance. **James P. Kilfoil***, Michael R. Heithaus, Matthew D. Campbell and Yuying Zhang.
*Manuel Caboz Memorial Scholarship/ISSF Travel Award.

9:15 Electronic monitoring on pelagic tuna longline vessels navigating beyond the era of self-reporting. **Craig Heberer**, Kydd Pollock and Amy Parks.

9:30 Electronic monitoring of purse seine catch data: do you see what I see? **David Itano**, Craig Heberer and Matthew Owens.

9:45 The use of electronic technologies in the management of Atlantic highly migratory species. **Ian Miller**.

10:00 Electronic reporting in the Hawaii longline fisheries. **Ashley Tomita**, Nathan Chan, Russell Ito and Keith Bigelow.

10:15 Improving the sampling protocol of electronic and human observations of the tropical tuna purse seine fishery discards. **Karine Briand**, Philippe Sabarros, Alexandra Maufroy, Antoine Bonnieux, Sarah Le Couls, Aude Relot-Stirnemann, Anne-Lise Vernet, Michel Goujon and Pascal Bach**.**

10:30 Developing observer data collection systems for the new west coast linked deepset buoy gear swordfish fishery. **CharlesVillafana**, Cristin Baer, Craig D'Angelo, Rick Pannell, Bob Ryznar, Jenny Suter and Jody Van Niekerk.

10:45 The IATTC Observer Program: 40 Years of science and management. **Michael D. Scott**, Martin A. Hall, Ernesto A. Altamirano, Enrique Urena, Marlon H Román, Jorge Párraga, Brad A. Wiley and Andrés F. Romero Caicedo.

11:00 Coffee Break (15-minutes)

SESSION 5: Fishery Policy and Assessment (Moderator: Russ Vetter)

11:15 Towards implementation of a sampling program for shark fisheries in Central America. **Ricardo Oliveros-Ramos**, Salvador Siu, Sonia Salaverria, José Miguel Carvajal, Cleridy E. Lennert-Cody, Alexandre Aires-da-Silva and Mark N. Maunder.

11:30 A fishery-dependent recruitment and forecast index for bigeye tuna (*Thunnus obesus*) in the Hawai'i-based longline fishery. **Johanna L.K. Wren** and Jeffrey J. Polovina.

11:45 Origin of Atlantic bluefin tuna (*Thunnus thynnus*) in the U.S. fishery and application of mixed stock information to fisheries management. Lisa A. Kerr, Steve Cadrin, Molly Morse, Dave Secor and **Walt Golet**.

12:00 Lunch

13:10 Breaking the silos: Integrating spatially-explicit environmental and fishery-dependent datasets. A case study for the Large-mesh Drift Gillnet Fishery targeting swordfish. **Jenny Suter**, Rob Ames, Brett Holycross, Rick Pannell, Craig D'Angelo, Charles Villafana, Jody Van Niekerk, Dan Lawson, Elizabeth Hellmers, Jordan T. Watson, Robert Ryznar, Camille Kohler and Robert Nigh.

13:25 Translating international stock assessments into U.S. domestic status determinations, or adventures in pounding a square peg into a round hole. **Sarah Shoffler**, Amber Rhodes and Steven Teo.

13:40 Use of AIS and machine learning to create a better understanding of transshipment activities in the western and central Pacific Ocean. **Janelle Hangen**.

13:55 Residency and reproductive status of yellowfin tuna in a proposed large-scale pelagic marine protected area. Andrew J. Richardson, **Katie J. Downes**, Emma T. Nolan, Paul Brickle, Judith Brown, Nicola Weber and Sam B. Weber.
*Wildlife Computers Scholarship/ISSF Travel Award.

14:10 Coffee Break (30 Minutes)

SESSION 6: Modelling (Moderator: Noda Takuji)

14:40 The effects of seasonal variation, El Niño-Southern Oscillation events, and climate change on the tuna-dolphin association. **Caitlynn A. Birch*** and Michael D. Scott.
*Manuel Caboz Memorial Scholarship/ ISSF Travel Award.

14:55 Modelling environmental influence on Atlantic bluefin tuna bycatch by Mexican longliners in the Gulf of Mexico. **Alberto Abad Uribarren*** and Sofía Ortega Garcia.
*AFRF Scholarship / ISSF Travel Award.

15:10 Predicting tuna availability through understanding migration dynamics and oceanographic influences. **Jason Hartog**, Toby Patterson, Paige Eveson and Alistair Hobday.

16:30 POSTER SESSION (with sushi) in Lakeview – Sashimi donated by Prime-Time Seafood, Inc. and refreshments by Wildlife Computers

Stock separation and relative abundance trends of bigeye opah (*Lampris megalopsis*) and smalleye opah (*Lampris incognitus*) in the Northeast Pacific Ocean. **Ross Cooper**, Heidi Dewar, Steve Teo and Heidi Batchelor.

Developing an automated data integration hub for a wide variety of distributed HMS data collection systems. **Craig D'Angelo,** John Childers, Rick Pannell, Robert Ryznar, Jenny Suter and Elizabeth Hellmers.

Bytes, not bites: Leveraging non-lethal shark bite mitigation technologies for increased data collection. **Nicholas DeNezzo**.

Obtaining behavioral information of migratory fish by accelerometer-integrated geolocation tag. **Takuji Noda,** Ko Fujioka, Ethan E. Estess, Alexander G. Norton, Charles J. Farwell, Takuya Koizumi and Takashi Kitagawa.

Seasonal movement patterns and areas of importance for juvenile smooth hammerhead sharks (*Sphyrna zygaena*) in the western North Atlantic Ocean. **Ryan K. Logan**, Jeremy Vaudo, Lara Souza, Bradley Wetherbee, Mark Sampson and Mahmood S. Shivji.

Preliminary analyses of satellite buoys echo-sounder data deployed on dFADs in the Western and Central Pacific Ocean. **Lauriane Escalle**, Beth Vanden Heuvel, Ray Clarke, Stephen Brouwer and Graham Pilling.

Traits-based tools to account for the effect of shifting predator-prey interactions on the distributions of tunas under climate change. **Stephanie J. Green**, Natasha A. Hardy, Michael Jacox, Elliott L. Hazen, Steven J. Bograd and Larry B. Crowder.

Reproductive biology and estimates of length and age at maturity of longtail tuna (*Thunnus tonggol*) in Australian waters based on histological assessment. **Shane Griffiths**, Mitchell Zischke, Tonya van der Velde and Gary Fry.

Harnessing diet data to model trait-based trophic interactions between tuna and their prey along gradients of change. **Natasha Hardy**, Elliott Hazen, Mike Jaccox, Steven Bograd, Larry B. Crowder and Stephanie J. Green.

Programmatic error checking of self-reported data for highly migratory species. **Elizabeth A. Hellmers**.

Dolphinfish Research Program: 17 Years of collaborative fisheries science. **Wessley Merten**, Roberto Rivera, Jacob Latour, Richard Appeldoorn and Don Hammond.

Dolphinfish bycatch distribution in the eastern Pacific Ocean: An environmental approach**.** **Sofia Ortega-Garcia**, Raul O. Martínez-Rincón, Ruben Rodriguez-Sanchez, Hector Villalobos and Michel Dreyfus.

Improving highly migratory species data using the eastern Pacific highly migratory species professional specialty group. John Childers, Craig D'Angelo, Taylor Debevec, Yuhong Gu, Elizabeth Hellmers, **Shannon Penna**, Bob Ryznar, Jacob Smith, Will Stahnke, Jenny Suter, Jody van Niekerk and Charles Villafana.

Recreational fisheries data collection for tunas led by the Sportfishing Association of California (SAC). **Alayna Siddall**, John Childers, Lyall Bellquist and Steve Crooke.

Partnering onshore data-collection efforts to improve stock structure information on bigeye tuna and opah. **Owyn Snodgrass**, Heidi Dewar, Dave Rudie, Mark Helvey and Gerard Dinardo.

Fisheries implications of niche overlap between blue shark (*Prionace glauca*), and shortfin mako shark (*Isurus oxyrinchus*) in the Southern California Bight. **Thompson Banez**.

Assessment of inter-consistency between acoustic data from different buoy brands. **Jon Uranga**, J. Santiago, G.Boyra, M. Grande, I. Quincoces and H. Murua.

Wednesday, 22 May 2019

8:00 Breakfast

Dolphinfish Symposium (Moderators: John O'Sullivan and Sofia Ortega-Garcia)

9:00 Dolphinfish diving and migratory behavior in the eastern tropical Pacific. **Stephanie Snyder**, Christopher Perle, Sofia Ortega-García, Ruben Rodríguez-Sánchez, Wessley Merten and John O'Sullivan.

9:15 Routine and postprandial oxygen consumption rates in dolphinfish (*Coryphaena hippurus*). **Nicholas C. Wegner**, Heather White, Sofía Ortega-García, Rubén Rodríguez-Sánchez and John O'Sullivan.

9:30 Estimating energetic costs and foraging behavior of free-ranging dolphinfish, *Coryphaena hippurus*. **Sarah M. Luongo***, Nicholas C. Wegner, Sofía Ortega-García, Rubén Rodríguez-Sánchez, Chris Perle, John B. O'Sullivan and Yannis P. Papastamatiou.
*Manuel Caboz Memorial Scholarship/ISSF Travel Award

9:45 Catch trend of dolphin fishes, *Coryphaena hippurus* Linnaeus and *Coryphaena equesilis* Linnaeus, monitored by National Stock Assessment Program in Region XII, Philippines **Emelyn A. Donia**, Al-Azeez T. Pautong and Maria Angelica Cecilio.

10:00 Mahi-mahi (*Coryphaena hippurus*) as a model species for impact assessment in apex pelagic predatory species. **John D. Stieglitz**, Ronald H. Hoenig Jr., Rachael M. Heuer, Daniel D. Benetti and Martin Grosell.

10:15 Analysis of dolphinfish (*Coryphaena hippurus)* population structure in the northwestern Pacific Ocean inferred by mitochondrial DNA sequences. **Ching-Ping Lu**, Sheng-Ping Wang and Wei-Chuan Chiang.

10:30 New genomic resources and population genetics of the cosmopolitan marine pelagic fish, dolphinfish (*Coryphaena hippurus*). **Natalia J. Bayona-Vásquez**, Travis C. Glenn, Manuel Uribe-Alcocer, Sofia Ortega-García and Píndaro Díaz-Jaimes.

10:45 Coffee Break (15 Minutes)

11:00 Preliminary analysis of age and growth of dolphinfish (*Coryphaena hippurus*) caught in waters of Costa Rican Pacific. Sofia Ortega-Garcia, José Miguel Carvajal-Rodríguez, **Ulianov Jakes-Cota**, Rubén Rodríguez-Sánchez and Fernando Mejía-Arana.

11:15 Dolphinfish (*Coryphaena hippurus*) otoliths chemistry analysis as a tool as a stock discrimination. **Vanessa Georgina Pelayo-González**, Sofía Ortega-García, Luis Lartuno-Rojas, Jose Miguel Carvajal, Jimmy Martínez and Angel Humberto Ruvalcaba-Díaz.

11:30 Variability in the distribution and availability of dolphinfish (*Coryphaena hippurus*) in Peruvian waters during 2000 – 2017, with emphasis at El Niño/La Niña scenarios**.** Miguel Ñiquen, **Marilú Bouchon**, Gladis Castillo, Ana Alegre, Luis Vasquez and Francois Colas.

11:45 Spatio-temporal distribution modeling of dolphinfish (*Coryphaena hippurus*) in the Pacific Ocean off Peru: evidence of seasonal migratory patterns. **Josymar Torrejón-Magallanes**, Daniel Grados and Wencheng Lau-Medrano.

12:00 Lunch

13:10 Spatio-temporal variation of incidental catches of dolphinfish (*Coryphaena hippurus*) in the central Mexican Pacific. Heriberto Santana-Hernández, **Sofia Ortega-Garcia** and Juan Javier Valdez-Flores.

13:25 Biometric relationship of the dolphinfish *Coryphaena hippurus* in southern Sinaloa, Mexico. **Marcela Selene Zúñiga Flores** and Concepción Enciso Enciso.

13:40 Dolphinfish fisheries and reproductive biology in Eastern Taiwan. **Wei-Chuan (Riyar) Chiang,** You-Yu Liou, Sheng-Ping Wang, Hung-Hung Hsu, Fu-Yuan Tsai, Shian-Jhong Lin, Ching-Tsun Chang, Ching-Ping Lu, Michael K. Musyl and Yuan-Shing Ho.

13:55 Alternative stock assessment tools, management strategies, reference points and harvest control rules for dorado (*Coryphaena hippurus*) across the eastern Pacific Ocean. **Juan Valero,** Alexandre Aires-da-Silva, Mark. N. Maunder, Carolina M. Vera, Cleridy Lennert-Cody and Marlon H. Román.

14:10 Coffee Break (20-Minutes)

SESSION 7: Tagging (Moderator: John Hyde)

14:30 Why tag a captive fish? Evaluating habitat utilization, migration patterns, and spawning behavior in mahi-mahi using pop-up satellite archival tags. **Lela S. Schlenker***, J.D. Stieglitz, R.H. Hoenig, R. Faillettaz, E.A. Babcock, C.H. Lam, D.D. Benetti, C.B. Paris and M. Grosell.
*Tuna Conference Scholarship/ISSF Travel Award

14:45 Data collection, transmission and storage on the Atlantic Ocean Tropical Tuna Tagging Programme (AOTTP) – experiences, successes and failures. **Doug Beare**, Lisa Ailloud, Seynabou Kebe, Ricardo Pastor, and Jesus Garcia.

15:00 Preliminary data and results from the Atlantic Ocean Tropical Tuna Tagging Programme (AOTTP). **Lisa Ailloud,** Doug Beare, Seynabou Kebe, Ricardo Pastor, and Jesus Garcia.

15:15 Insights into the horizontal movements, migration patterns and stock affiliation of California swordfish. Chugey A. Sepulveda, Michael Wang, Jaime Alvarado-Bremer and **Scott A. Aalbers**.

15:30 Coffee Break (20 Minutes)

15:50 Collecting empirical data regarding EFH for large fishes; the role of electronic tags – present and future. **Kim Holland**.

16:05 New tools, for mark-recapture studies using genetic identification, used to monitor the absolute abundance of juvenile southern bluefin tuna. **Russell Bradford**, Ann Preece, Peter Grewe and Andreas Marouchos.

16:20 Understanding the mortality rate of yellowfin tuna (*Thunnus albacares*) following catch and release in the U.S. east coast recreational troll fishery: is predation a natural event? **Jeff Kneebone**, Walt Golet, Hugues Benoît and Diego Bernal.

16:35 Business Meeting

18:30 Dinner – Tuna Barbeque sponsored by the American Fishermen's Research Foundation, American Tuna Boat Association, and Prime Time Seafood Inc.

Thursday, 23 May 2019

8:00 Breakfast

SESSION 8: FADs (Moderator: John Stieglitz)

9:00 Changes in the dynamics of the EPO tuna purse-seine FAD fishery. **Marlon H. Román**, Jon López, Cleridy E. Lennert-Cody.

9:15 Direct tuna abundance indices: Buoy derived abundance indices of tropical tunas. J. Santiago**, Jon Uranga**, I. Quincoces, M. Grande, H. Murua and G. Boyra.

9:30 Recently available dFAD tracking data in the WCPO: challenges, new research areas and potential useful tool to guide management. **Lauriane Escalle**, Maurice Brownjohn, Stephen Brouwer and Graham Pilling.

9:45 Fishers' echo-sounder buoys: new tools to assist scientific and management advance. **Jon Lopez**, Mark Maunder, Cleridy Lennert-Cody, Josu Santiago, Hilario Murua, Blanca Orue, Jefferson Murua, Guillermo Boyra, Jon Uranga, Gala Moreno, Emmanuel Chassot, David Kaplan, Manuela Capello, Laurent Dagorn, Lauriane Escalle, Joe Scutt-Phillips, Graham Pilling, Miguel Herrera, Alexandra Maufroy and Beth Vanden Heuvel.

10:00 Differential use of Fish Aggregating Devices (FADs) by recreational, charter, and commercial sectors as determined through vessel fishing trip histories around Puerto Rico. **Wessley Merten,** Roberto Rivera and Richard Appeldoorn.

10:15 Coffee Break (15 Minutes)

SESSION 9: Life History (Moderator: Suzy Kohin)

10:30 Striped Marlin: An Example on How Life History is Important to Fisheries Management **Mark D. Fitchett**

10:45 Stock specific growth patterns of Atlantic bluefin tuna (*Thunnus thynnus*) using otolith increment analysis. **Brenda Rudnicky*,** Drew Shane, Zach Whitener, Lisa Kerr, and Walt Golet.
*Monterey Bay Aquarium Scholarship/ISSF Travel Award

11:00 Natal origin and life history of Pacific bluefin tuna revealed from otolith chemistry. **John A. Mohan**, R. J. David Wells, Jay R. Rooker, Nathan R. Miller, Yosuke Tanaka, Seiji Ohshimo, Heidi Dewar, Suzanne Kohin and Owyn E. Snodgrass.

11:15 Validated longevity of yellowfin (*Thunnus albacares*) and bigeye (*T. obesus*) tuna of the northwestern Atlantic Ocean. **Allen H. Andrews**, Ashley Pacicco, Robert Allman, Brett J. Falterman, Erik T. Lang and Walter Golet.

11:30 Review of recent research activities focused on yellowfin tuna (*Thnnus albacares*) at the IATTC's Achotines Laboratory. **Enrique Mauser**, Dan Margulies, Vernon Scholey, Susana Cusatti, Jeanne Wexler and Maria Stein.

12:00 Lunch

Abstracts

INSIGHTS INTO THE HORIZONTAL MOVEMENTS, MIGRATION PATTERNS AND STOCK AFFILIATION OF CALIFORNIA SWORDFISH

Chugey A. Sepulveda[1], Michael Wang[1], Jaime Alvarado-Bremer[2] And **Scott A. Aalbers[1*]**

[1]Pfleger Institute of Environmental Research, PIER, Oceanside California
[2]Texas A&M University at Galveston, Galveston Texas

This study reports on the horizontal movements of 77 swordfish (*Xiphias gladius*) tagged during deep-set fishery gear trials off the southern and central California coastline from August, 2015 through December, 2018. Position estimates from multiple electronic tag types [data storage tags (n=13), pop-up satellite archival tags (n=4), mark–recapture tags (n=64), and fin-mounted ARGOS transmitters (n=9)] were used to better understand swordfish stock structure and regional affiliation with respect to current boundary hypotheses used to manage swordfish stocks in the Eastern North Pacific. Twenty-seven percent of tagged swordfish reported proximal (<225 km) to their tagging location within the southern California Bight (SCB). Of the 52 swordfish that moved outside the SCB, 77% exhibited affiliation to the Eastern Pacific Ocean (EPO) management unit, 19% moved into the Western and Central North Pacific (WCNP) and 4% spent time within both the EPO and WCNP (n=2). Mean displacement between tag deployment and pop-up locations was 1,336±1,115 km, with daily rates of movement up to 45 km. Wide-spread seasonal movements ranging from the Equator (0.8ºN.132.0ºW) to out beyond the Hawaiian Islands (17.0ºN/145.0ºW) validate the highly migratory nature of Pacific swordfish. Additionally, multiple individuals exhibited some degree of fidelity to the SCB, as several individuals returned to the tagging area in subsequent seasons following extensive migration. Findings suggest that SCB swordfish may exhibit a higher level of connectivity with the EPO management unit than previously proposed.

MODELLING ENVIRONMENTAL INFLUENCE ON ATLANTIC BLUEFIN TUNA BYCATCH BY MEXICAN LONGLINERS IN THE GULF OF MEXICO

Alberto Abad Uribarren, Sofía Ortega Garcia
Centro Interdisciplinario de Ciencias Marinas – IPN

Av. Instituto Politecnico Nacional s/n Col. Playa Palo de Santa Rita
CP 23098, La Paz, Baja California Sur, Mexico

Atlantic bluefin tuna stocks have been considered overfished over the last decades, being especially critical the situation of the western stock, whose main spawning grounds are in the Gulf of Mexico (GoM). Despite the current measures implemented, like no direct fishing allowed, bycatch of spawners is pointed as a key factor to explain the lack of recovery of local stocks. This situation demands the implementation of appropriate spatio-temporal management strategies based on the best available scientific knowledge. We present the bases of a decision-support tool (DST) for bluefin tuna management in Mexican waters of the Gulf of Mexico. Using catch and effort data from the Mexican commercial longline fleet, with a 100% scientific *observer's coverage* between 1994 and 2012, and satellite remote sensing derived environmental data, we investigate the influence of environmental conditions on the bycatch per unit effort (BCPUE) of bluefin and catch per unit effort (CPUE) of target species yellowfin tuna. General additive models (GAMs) were fitted using a negative binomial distribution, and to select the best model Akaike Information Criterion (AIC) was applied. Bluefin BCPUE exhibited a marked seasonality, reaching higher values in February and March, with two main locations identified to support higher bycatch rates, the Campeche Bay and the western-central GoM area. Higher BCPUE were significantly associated to areas with negative sea level anomalies and low sea surface temperatures, characteristics of cyclonic eddies. Yellowfin tuna, by contrast, was present in the area all year round, showing a recurrent CPUE spatio-temporal pattern and a much broader environmental habitat. Our DST proposal is to use the predictive capacity of the distribution models coupled with oceanographic data forecasts to identify one week in advance the suitable fishing zones under the management criteria of reducing bluefin bycatch while maintaining current yellowfin catch levels.

THE PORBEAGLE SHARK (*Lamna nasus)* IN THE SOUTHERN HEMISPHERE: SEARCHING FOR BIOLOGICAL PATTERNS AMONG OCEANS AND REGIONS

Enzo Acuña[1, 2,*], Rubén Alarcón[3], Alexander Arkhipkin[4], Rui Coelho[5], Alex Cortés[1], Charlene Da Silva[6], Andrés Domingo[7], Guy Duhamel[8], Malcolm Francis[9], María Teresa González[10], Pilar Haye[1], Santiago Montealegre[11], Gonzalo Mucientes[12], Robert Olson[13] and Patricia Zárate[14]

[1]Departamento de Biología Marina, Universidad Católica del Norte, Coquimbo, Chile. *Email: eacuna@ucn.cl.

[2]Millennium Nucleus Ecology and Sustainable Management of Oceanic Islands (ESMOI), Coquimbo, Chile.

[3]Universidad de Concepción, Chile

[4]Fisheries Department, Falkland Islands Government.

[5]Division of Modelling and Management of Fishery Resources, Portuguese Institute for the Ocean and Atmosphere.

[6]Fisheries Management, Department of Agriculture, Forestry and Fisheries, South Africa and Department of Biological Sciences, University of Cape Town, South Africa.

[7]Dirección Nacional de Recursos Acuáticos (DINARA), Uruguay.

[8]Muséum national d' Histoire naturelle (MNHN). Paris, France.

[9]NIWA, Wellington, New Zealand

[10]Instituto "Alexander von Humboldt", Facultad Ciencias Naturales y Recursos Biológicos. U. de Antofagasta, Chile

[11]Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP), Brasil

[12]CIBIO-InBIO, Universidade do Porto, Portugal

[13] Inter-American Tropical Tuna Commission (IATTC), La Jolla, California, USA.

[14]Instituto de Fomento Pesquero (IFOP), Chile.

Lamna nasus is a highly migratory species with a wide geographic distribution in the Southern Hemisphere, inhabiting a circumglobal band of cold-temperate waters in southern regions of all oceans. Although the porbeagle shark is one of the few known shark species that occurs in both the Arctic and Antarctic regions, it is not present in tropical waters between 20°S and 20°N. In 2013, the porbeagle was included in CITES Appendix II, which specified several necessary actions for exporting countries, among them to prepare a Non-Detrimental Finding for the species. In the Southern Hemisphere, porbeagle sharks have not been targeted, but are bycatch of several longline and midwater trawl fleets from Japan, New Zealand, Chile, Brazil, Uruguay, Argentina, the Falkland Islands, and Portugal, among others. Life history data for Southern Hemisphere porbeagle sharks derive primarily from studies in New Zealand and Australia; there is scant information for *L. nasus* in other areas. It is not known whether there is a single circumpolar Southern Hemisphere population or whether there are multiple stocks spread over this wide range. Recent studies have considered it unlikely that the population comprises a single well-mixed stock for management purposes. The first activity of the current research was to organize an international workshop to gather existing information, identify new sources of information, and incorporate new raw data concerning the spatial distribution of the porbeagle shark. The objective of the next stage of the study was to gather data from the newly identified sources and combine them with existing data to obtain a more comprehensive vision of the shark's spatial distribution in the southern hemisphere. This reanalysis of the porbeagle shark's spatial distribution will permit meaningful stratification in the study of biological data, including information about reproduction, genetics, and parasites. For example, mature females have been found to conduct seasonal latitudinal migrations from high latitudes in the summer to sub-tropical waters during the winter-spring in the Pacific and Atlantic Oceans, to give birth to pups. Our study demonstrates the importance of international collaboration in data collection and integration for highly migratory species, especially in the Southern Hemisphere that is dominated by open ocean areas.

PRELIMINARY DATA AND RESULTS FROM THE ATLANTIC OCEAN TROPICAL TUNA TAGGING PROGRAMME (AOTTP)

Lisa Ailloud, Doug Beare, Seynabou Kebe, Ricardo Pastor, and Jesus Garcia.
International Commission for the Conservation of Atlantic Tunas

Corazón de María, 8
28002, Madrid, Spain
lisa.ailloud@iccat.int

In 2010, the International Commission for the Conservation of Atlantic Tunas' scientific body put forth a proposal for a large-scale tropical tuna tagging program for the Atlantic. This proposal was driven by the need to increase data collection to reduce uncertainties in key biological parameters of the main tropical tuna species (namely, yellowfin, bigeye and skipjack tuna), and the concern over the uncertainty surrounding their recent levels of exploitation. This multi-year tagging project was to cover the entire Atlantic Ocean basin and have a funding level comparable to the large-scale tuna tagging projects of the Pacific and Indian Oceans. This data collection program was identified as a potential solution to the fundamental challenges of obtaining representative data on growth, mortality, movement and abundance for these highly migratory fish.

In 2015, the Atlantic Ocean Tropical Tuna Tagging Programme (AOTTP) was officially approved and, in 2016, tag release and recovery efforts began. Since its inception, over 100,000 tropical tunas have been tagged and nearly 1,000 fish sampled for biological data. More than 17,000 fish have been double-tagged, allowing tag-shedding rates to be estimated, and tag-seeding experiments are ongoing with our extensive network of observers throughout the Atlantic, allowing for tag reporting rates to be estimated.

Data are currently being analysed with the specific objective of improving estimates of age and growth, mortality, selectivity, movement/stock structure and the impact of FADs for the three main tropical tuna species. We, here, present preliminary results regarding the Atlantic yellowfin stock, for which a benchmark assessment is scheduled for July 2019. We present our progress up to date concerning the validation of the rate of increment formation in yellowfin tuna otoliths, the estimation of tag shedding and tag reporting rates and the resulting statistical adjustments made to the tagging data for input into the yellowfin assessment model.

VALIDATED LONGEVITY OF YELLOWFIN (*Thunnus albacares*) AND BIGEYE (*T. obesus*) TUNA OF THE NORTHWESTERN ATLANTIC OCEAN

Allen H. Andrews[1], Ashley Pacicco[2], Robert Allman[2], Brett J. Falterman[3], Erik T. Lang[3], & Walter Golet[4]

1. NOAA Fisheries – Pacific Islands Fisheries Science Center
1845 Wasp Boulevard, Honolulu, Hawaii 96818; 808-725-5373; allen.andrews@noaa.gov

2. Louisiana Department of Wildlife and Fisheries, 2000 Quail Drive, Baton Rouge, Louisiana 70808
504-286-4160; elang@wlf.la.gov, bfalterman@wlf.la.gov

3. National Marine Fisheries Service, Southeast Fisheries Science Center, Panama City Laboratory, 3500 Delwood Beach Road, Panama City, Florida 32408; 850-234-6541; robert.allman@noaa.gov, ashley.pacicco@noaa.gov

4. The University of Maine - Gulf of Maine Research Institute, School of Marine Sciences
350 Commercial Street, Portland, Maine 04101; 207-228-1671; walter.golet@maine.edu

The age, growth and longevity of yellowfin (*Thunnus albacares*) and bigeye (*Thunnus obesus*) tuna (YFT and BET) remain problematic in that attempts to validate age estimates have been limited and typically incapable of evaluating maximum age. Otolith growth zone structure can be complicated for tropical pelagic fishes because they live in a more aseasonal environment than higher latitude habitats. However, bomb radiocarbon (^{14}C) dating has evolved considerably over the last 25 years and is a well-founded approach that has been useful in accurately describing the life history characteristics of several tropical pelagic species. In this study, age reading protocols that produced maximum age estimates approaching 20 years for YFT and BET of the northwestern Atlantic Ocean were validated with bomb ^{14}C dating. A novel aspect of the method is use of the ^{14}C decline period (more recent than ~1980) — after nuclear testing and as described by regional coral records of the Gulf of Mexico — to provide valid estimates of age through ontogeny. Yellowfin tuna aged 2 to 18 years (n = 33, 1029–1810 mm FL) led to birth years that were coincident with the bomb ^{14}C decline reference, while BET aged 3 to 17 years (n = 10, 1280–1750 mm FL) were more variable but in agreement, as well. Results indicate that age reading discrepancies of previous studies may have led to truncated estimates of growth and longevity.

FORAGING ECOLOGY OF BIGEYE AND YELLOWFIN TUNA IN THE NORTHWEST ATLANTIC OCEAN

Riley Austin, John Logan, Gayle Zydlewski, and Walter Golet
University of Maine Graduate School, Department of Marine Sciences

350 Commercial Street
Portland, ME 04101

Stomach contents of 24 Bigeye (*Thunnus obesus*) and 243 Yellowfin (*Thunnus albacares*) tuna were collected from pelagic longline and recreational/charterboat vessels in the northwest Atlantic. Fish were captured from Massachusetts to North Carolina at offshore canyons along the shelfbreak from June to September of 2018. Prey items were categorized into lowest taxonomic level, total length or mantle length was recorded for whole prey, and items were weighed. By weight, cephalopods accounted for 92% of prey items found in bigeye stomachs with major contributions coming from *ommastrephid* decapods. Cephalopods made up 63% of yellowfin diet, while teleosts such as *ammodytidae*, *scombridae*, and *exocoetidae* contributed 35% of total prey weight. Crustaceans *phronima* and *hyperiidae* as well as megalopa contributed a small component to yellowfin and bigeye diet (2% and 0% respectively) but were observed in greater abundance (5%) in smaller size class yellowfin tuna. Ontogenetic shifts in diet were observed for yellowfin, as cephalopods accounted for 90% of prey weight in 60-70 cm tuna but shifted to a teleost dominated diet (73%) for fish larger than 110 cm. Results to date suggest a dietary shift, historical dietary consumption expressed higher prey weights of crustaceans (15%) and lower cephalopod weights (35-47%) where present results suggest a switch to a diet with higher contributions of cephalopods and a decrease in crustaceans.

NEW GENOMIC RESOURCES AND POPULATION GENETICS OF THE COSMOPOLITAN MARINE PELAGIC FISH, DOLPHINFISH (*Coryphaena hippurus*)

Bayona-Vásquez Natalia[1,2] J, Glenn Travis C[1], Uribe-Alcocer Manuel[2], Ortega-García Sofia[3], Díaz-Jaimes Píndaro[2]

[1] Department of Environmental Health Science, University of Georgia, Athens, GA 30602, USA
[2]Laboratorio de Genética de Organismos Acuáticos, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, 04510, Mexico.
[3] Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas. Apdo. Postal 592, La Paz B.C.S. 23000 México

Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México. Apdo. Postal 70-305, México D.F., México.

Low levels of population genetic structure detected in widely distributed marine pelagic fishes have been attributed to processes such as, large effective population sizes, high capacity to disperse through migration and/or larvae drift which promotes gene flow between distant populations, and/or very recent population divergence events that can't be detected with a limited number of variable molecular markers.
Coryphaena hippurus is a cosmopolitan fish found in tropical and subtropical waters, for which population genetic homogeneity has been previously reported. However, with advances in protocols based on Next Generation Sequencing (NGS) it has become possible to break the paradigm of population genetic homogeneity in other cosmopolitan pelagic species such as the yellowfin tuna.
Here, we used RAD-Seq to develop new genomic resources for the species as a set of baits to screen more than a thousand polymorphic nuclear loci. We implemented this bait set in hundreds of individuals from around the globe using the method RADcap. And, we also sequenced whole mitochondrial genomes in a limited set of samples.
We were able to study the global population genetics of this ecologically and economically important species. Our results reveal the presence of at least three distinct populations for dolphinfish, which corresponds to ocean basins Indo-Pacific, Atlantic and Mediterranean. The results highlight the importance of sea surface temperature breaks in South Africa and the Gibraltar Straight as biogeographic barriers and determine how these modulate the distribution of the genetic diversity and population demography of this pelagic species.

DATA COLLECTION, TRANSMISSION AND STORAGE ON THE ATLANTIC OCEAN TROPICAL TUNA TAGGING PROGRAMME (AOTTP) – EXPERIENCES, SUCCESSES AND FAILURES

Doug Beare, Lisa Ailloud, Seynabou Kebe, Ricardo Pastor, and Jesus Garcia.
International Commission for the Conservation of Atlantic Tunas

Corazón de María, 8
28002 Madrid, Spain
doug.beare@iccat.int

AOTTP is an Atlantic wide tag-recapture project focusing on the 3 most commercially important tropical tuna species; bigeye, skipjack and yellowfin tuna. The project will tag and release well over 100,000 fish, distributing them in space and time as much as possible. AOTTP is funded by the EU Directorate General for Development and Cooperation (90%) and by ICCAT Contracting parties, and hence includes an important capacity development and training component.

The project, which started in 2015, has now tagged fish in the Exclusive Economic Zones of over 20 countries as well as the High Seas and trained scores of people from developing coastal states in tagging at sea and tag-recovery activities. A range of tag types are being used, including conventional spaghetti tags, electronic tags (pop-ups and internal archival), and chemical 'tags' (chemicals mark the otoliths facilitating age validation). AOTTP has set up tag-recovery infrastructures in the most important landing locations around the Atlantic, and developed awareness-raising activities and incentive schemes encouraging tag-recovery. The impact of the awareness-raising work is being assessed with tag-seeding 'experiments' during which fish are surreptitiously tagged at various points along the supply chain to see if the tags are noticed and rewards sought. Ultimately all AOTTP tag-recapture data will be synthesized and used to improve our understanding of tropical tuna population biology in the Atlantic; informing a more sustainable exploitation. AOTTP is generating large amounts of data of very different types which must be collected, transmitted, checked, verified, stored and ultimately analysed. The project exploits various smartphone applications for collecting and sending tag-recapture data from disparate locations around the world to headquarters in Madrid. The protocols facilitate rapid data checking and querying, after which they are transferred to a relational database for permanent storage and dissemination. The project uses Open Source software (Memento, R, PostGreSQL, QGIS, and Telegram) wherever possible, which has been a significant advantage for economizing the training and capacity building; particularly during the research and data analysis activities.

The speaker will summarize progress on the project since its inception, emphasizing the 'modern' (smartphones, satellite for electronic tags) data collection and storage protocols being used. Experiences, successes and failures will all be described, and recommendations suggested.

THE EFFECTS OF SEASONAL VARIATION, EL NIÑO-SOUTHERN OSCILLATION EVENTS, AND CLIMATE CHANGE ON THE TUNA-DOLPHIN ASSOCIATION

Caitlynn A. Birch, Michael D. Scott
University of San Diego
Inter-American Tropical Tuna Commission

8901 La Jolla Shores Dr.
La Jolla, CA 92037

Large mixed-species aggregations of spotted dolphins (*Stenella attenuata*), spinner dolphins (*Stenella longirostris*), and yellowfin tuna *(Thunnus albacares)* are a distinct characteristic of the eastern tropical Pacific (ETP). As a result, dolphin-associated tuna have been targeted by the tuna purse-seine fishery for the better part of eight decades. The primary promoter of the association between tuna and dolphins is the oceanography of the ETP: warm surface waters of the mixed layer demarcated by a shallow thermocline, lying atop a thick oxygen minimum zone (OMZ). The association is most common where the tuna habitat is compressed to the shallow surface waters of the mixed layer by the hypoxic waters of the OMZ. Compression of the tuna's habitat brings the tuna in closer daytime proximity to the surface-breathing dolphins.

Global climate change is predicted to affect many aspects of the ETP; the trade winds will weaken, surface waters will warm, and the thermocline will shoal and strengthen. This study is investigating how seasonal oceanographic variations, El Niño Southern Oscillation cycles, and climate change affect the distribution and strength of the tuna-dolphin association in the ETP. Using Generalized Additive Models to analyze oceanographic and IATTC observer data from 1992-2015, we found that the area of shallow thermocline depth in the region has expanded overall, increasing the spatial distribution and frequency of the tuna-dolphin association, which expands and contracts under the influence of season and La Niña and El Niño events. These oceanographic changes have resulted notably in more-frequent sets on pure spinner dolphin herds.

These long-term oceanographic changes occurring in the ETP have predictive value for the management of the tuna fishery and dolphin bycatch. A long-term shift in the proportions of dolphin mortality has already been seen; the proportion of spinner dolphin *(Stenella longirostris)* mortality has increased over time, while spotted dolphin *(Stenella attenuata)* mortality has decreased. Climate change will likely further promote the tuna-dolphin association, and, in turn, influence where the tuna fishery operates and which dolphin species are affected.

VARIABILITY IN THE DISTRIBUTION AND AVAILABILITY OF DOLPHINFISH (*Coryphaena hippurus*) IN PERUVIAN WATERS DURING 2000 – 2017, WITH EMPHASIS AT EL NIÑO/LA NIÑA SCENARIOS

Miguel Ñiquen[1], **Marilú Bouchon**[1], Gladis Castillo[1], Ana Alegre[1], Luis Vasquez[1], Francois Colas[2]

[1]Instituto del Mar del Perú, Esquina Gamarra y General Valle s/n, Chucuito–Callao.
[2]IRD-France

Widely oceanic top predator fishes, mainly dolphinfish (*Coryphaena hippurus*), have significant ecological, social and economic value for Peruvian fisheries. We analyze the occurrence of these oceanic specie in the catches of the Peruvian artisanal fleet that fish with longlines and gillnets off Peru between 2000 and 2017. The average annual landing of this fleet in the last five years was 47 thousand tons and Peru occupies the first place in the landing of dolphinfish worldwide. Possible interdecadal changes were observed noting that there was a 35% increase in the availability of these species in 2010-2017 with respect to 2000-2009, associated with the increased frequency of warm events.

Also examined a clear example about the increased availability in central-southern part off Peru associated with the occurrence of the coastal El Niño event (warm conditions) during the first quarter of 2017 followed by a period of decreased availability in the same area, associated with the occurrence of a La Niña event (cold conditions) during the fourth quarter of 2017.

Moving from a short-term environmental signal we can move towards a longer-term signal, where environmental changes impacted the overall distribution of dolphinfish, which tend to be distributed off the central and southern parts of Peru during the warmer periods and off the northern part during the colder period. Moving north-west beyond the 200 miles off Peru in extreme cold conditions. The relation of these changes in distribution with different environmental scenarios including sea surface temperature and sea level is examined. This study provides a basis for improving knowledge about the impact of climate change on doplphinfish and other species of the ocean ecosystem off Peru and its implications in the South-Eastern Pacific Ocean.

NEW TOOLS, FOR MARK-RECAPTURE STUDIES USING GENETIC IDENTIFICATION, USED TO MONITOR THE ABSOLUTE ABUNDANCE OF JUVENILE SOUTHERN BLUEFIN TUNA

Russell Bradford, Ann Preece, Peter Grewe, Andreas Marouchos

CSIRO Oceans & Atmosphere, Australia.

CSIRO has developed a suite of novel sampling tools and techniques for high through-put genetic sampling. These tools are currently being used to monitoring the absolute abundance of juvenile southern Bluefin tuna, in a large mark-recapture program. Around 20,000 tissue samples are collected, processed and analysed each year. Following a successful trial phase, industry and management stakeholders have endorsed the tools and procedures. The absolute abundance estimates, made possible by these tools, will now be used in the next southern Bluefin tuna stock assessment and in a new management procedure to set the global total allowable catch. These initiatives were key components of two prestigious awards for their innovative nature and application to rebuilding the southern Bluefin tuna stock.

IMPROVING THE SAMPLING PROTOCOL OF ELECTRONIC AND HUMAN OBSERVATIONS OF THE TROPICAL TUNA PURSE SEINE FISHERY DISCARDS

Karine Briand [1,*], Philippe Sabarros[1], Alexandra Maufroy[2], Antoine Bonnieux[3], Sarah Le Couls[4], Aude Relot-Stirnemann[3], Anne-Lise Vernet[3], Michel Goujon[2], Pascal Bach[1,5]

[1]Institut de Recherche pour le Développement (IRD), UMR 248 MARBEC, OB7, Sète, France
[2]Organisation des Producteurs de thon congelé et surgelé (Orthongel), Concarneau, France
[3]Oceanic Développement (OD), Concarneau, France
[4]Compagnie Française du Thon Océanique (CFTO), Concarneau, France
[5]Institut de recherche pour le Développement (IRD), UMR 248 MARBEC, OB7, Victoria, Seychelles
* corresponding author, email : karine.briand@ird.fr

[1]Institut de Recherche et de Développement (IRD) /CRHMT
Avenue Jean Monnet, CS 30171
34203 Sète Cedex
Tél +33 (0)4 99 57 32 09

Observer programs have been implemented for many years in tuna purse seine fisheries to assess their impact on the pelagic ecosystem by monitoring tuna discards and bycatch among which sensitive species such as sharks or rays. On-board observers estimate discards using sampling and extrapolation methods when counting exhaustively is not possible. However, these methods may be biased because brailers may have different filling rates resulting in a heterogeneous flow of fishes on the discard belt, which may lead to over/underestimated estimations. Electronic monitoring system (EMS) on tuna fishing fleet has been tested as an alternative technology to complement and improve on board observer programs. EMS allows to monitor discards and non-target catch at an acceptable species identification level and allows exhaustive counts on the discard belt. In this study, we used EMS "counts per minute" from five purse seine vessels operating in Indian Ocean to evaluate total discards in numbers, as well as discards by species for each set. We analysed 48 fishing sets and simulated different observer strategies (using bootstrap without resampling) in order to optimise (i) the total sampling duration and (ii) the duration of sampling sequences. We finally propose an optimized sampling strategy, applicable to both electronic and human observations, for evaluating discards that reduces both sampling time and estimation bias.

STOCK SEPARATION AND RELATIVE ABUNDANCE TRENDS OF BIGEYE OPAH (*Lampris megalopsis*) AND SMALLEYE OPAH (*Lampris incognitus*) IN THE NORTHEAST PACIFIC OCEAN

Ross Cooper[1,2], Heidi Dewar[3], Steve Teo[3], Heidi Batchelor[1,2]

[1]Scripps Institution of Oceanography
[2]University of California, San Diego
[3]National Oceanic and Atmospheric Administration, Southwest Fisheries Science Center

8622 Kennel Way
La Jolla, CA 92037

In Northeast Pacific Ocean tuna and swordfish fisheries, Opah landings are listed as a single species (*Lampris guttatus*) though recent studies have shown that there are in fact two genetically distinct species: Bigeye opah (*Lampris megalopsis*) and Smalleye opah (*Lampris incognitus*). This project entails analyzing 15 years of long-line logbook catch data to define a confident separation between the two opah species based on their respective locations within the fishery range. Additionally, time series of catch-per-unit-effort (CPUE) will be calculated throughout the geospatial range of the fishery to determine relative abundances, general stock ranges, and any trends or fluctuations throughout the last 15 years. Despite landings and demand increasing, there is not a directed fishery for opah and therefore no official fishery management plans are in place. This project will help visualize important data and information regarding these under-studied fish in order to help guide appropriate management.

PRELIMINARY ANALYSIS OF AGE AND GROWTH OF DOLPHINFISH (*Coryphaena hippurus*) CAUGHT IN WATERS OF COSTA RICAN PACIFIC

Sofia Ortega-Garcia[1,*], José Miguel Carvajal-Rodríguez[2], **Ulianov Jakes-Cota**[1], Rubén Rodriguez-Sanchez[1,*], Fernando Mejía-Arana[2]

[1]Instituto Politécnico Nacional-CICIMAR. Av. IPN S/N Col. Playa Palo de Santa Rita. La Paz BCS. CP23096. *COFAA fellowship.
[2]Departamento de Investigación del INCOPESCA.

In Costa Rica, the main catches and landing of dolphinfish are made in the Costa Rican Pacific Ocean by sportfishing and commercial fishing fleets. Commercial fishing fleets can be small, medium or large scale depending on their autonomy. The fishing gear is longline, which is modified in terms of size and type of hook during the dolphinfish fishing season. Although dolphinfish is caught throughout the year, the highest catches are recorded from October to January. Despite the social and economic importance of this resource, little is known about its basic biology. Therefore, this study shows preliminary results of age and individual growth from a sampling of 363 organisms (215 females and 148 males) caught by medium and large-scale commercial fleet during January 2017 and January 2018. The fork length range for males and females was 72-134 cm and 77-122 cm, respectively. Saggittal otoliths were placed in a mold with crystal resin. The crystal block was then carefully positioned in a low speed diamond wafering saw and aligned to obtain a section containing both the primordium and the post-rostral tip. Sections were mounted on slides using a thermoplastic and polished to a thickness of approximately 5-15 µ. Daily increments were counted on those otolith sections by two independent readers and without previous knowledge of length and weight of the analyzed organisms. The von Bertalanffy model for mixed sexes obtained L_∞ = 131.12, k = 1.66 y t_0 = -0.01. Further studies should imply processing all otoliths and applying multi-model inference for individual growth parameter estimation. This study contributes to future stock assessments of the dolphinfish population of the Eastern Pacific Ocean.

DEVELOPING AN AUTOMATED DATA INTEGRATION HUB FOR A WIDE VARIETY OF DISTRIBUTED HMS DATA COLLECTION SYSTEMS

Craig D'Angelo [1], John Childers[2], Rick Pannell[3], Robert Ryznar[4], Jenny Suter[4], Elizabeth Hellmers[5]

[1] National Marine Fisheries Service, West Coast Region, Long Beach, CA, USA
[2] National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, CA, USA
[3]Resource Data, Inc. Portland, OR, USA
[4]Pacific States Marine Fisheries Commission, Portland, OR, USA
[5]California Department of Fish and Wildlife, La Jolla, CA, USA

Pacific Highly Migratory Fisheries (HMS) have a particularly wide variety of state, federal, and regional fishery management organization offices collecting fishery-dependent data. These data have been maintained within siloed databases making the already difficult task of providing fishery managers, scientists, and the public with comprehensive, accurate, and precise reporting even more challenging.

Traditionally, managing the distribution and integration of HMS fishery-dependent data has been the responsibility of each federal or state office involved in data collection. Recently, HMS fishery data managers from the National Marine Fisheries Service (NMFS) West Coast Region, the NMFS Southwest Fisheries Science Center, the California Department of Fish and Wildlife, and the Pacific Fisheries Information Network (PacFIN) working together as the Eastern Pacific Highly Migratory Species Professional Specialty Group began developing an automated data integration hub at PacFIN to centralize the integration and distribution of Pacific HMS fisheries data.

This presentation will share the logical steps used to develop an automated integration procedure capable of bringing together similar HMS fisheries data from different sources, coming in at different times, and of different quality. The methodology described is able to ensure that the next generation of fisheries data collection systems, which are expected to be collected and transmitted electronically, can be made available to analysts without the processing delays inherent to the existing decentralized, manual data integration process.

BYTES, NOT BITES: LEVERAGING NON-LETHAL SHARK BITE MITIGATION TECHNOLOGIES FOR INCREASED DATA COLLECTION

Nicholas DeNezzo

Scripps Institution of Oceanography
Eckart Building, Mail Code 0208
9500 Gilman Drive
La Jolla, CA 92093

Despite being incredibly rare events, shark bite incidents often provoke significant media attention, and can sometimes result in government actions to satisfy beachgoers' concerns of safety. Historically, these actions have involved lethal shark control methods, such as with the use of netting and drumlines to cull shark populations. However, as studies have begun to show that such methods may not be effective in reducing shark bites, and increased environmental awareness has triggered concerns over bycatch in the aforementioned lethal programs, there has been an increasing interest in non-lethal methods for mitigating shark bites. New and burgeoning technologies, including the use of drones, sonar, "smart buoys", and artificial intelligence, have begun to offer alternatives for monitoring coastlines for large sharks in proximity to humans. Far beyond their ability to enhance public safety, these new technologies also offer prime opportunities for increased data collection on the coastal habits of sharks (in addition to many other coastal species). This project seeks to analyze the benefits and drawbacks to some of these new technologies, and the opportunities they present for improved coastal data collection when incorporated into a shark bite mitigation program.

CATCH TREND OF DOLPHIN FISHES, *Coryphaena hippurus Linnaeus* AND *Coryphaena equesilis Linnaeus* MONITORED BY NATIONAL STOCK ASSESSMENT PROGRAM IN REGION XII, PHILIPPINES

Emelyn A. Donia, Al-Azeez T. Pautong, Maria Angelica Cecilio

National Stock Assessment Program
Bureau of Fisheries and Aquatic Resources (BFAR-12)

This paper reports on the catch trend of dolphin fishes based on stock assessment in Sulawesi Sea, Moro Gulf and Sarangani Bay monitored by National Stock Assessment Program in Region XII. This study was conducted to determine the abundance of the two species under family Coryphaenidae; *Coryphaena hippurus Linnaeus* and *Coryphaena equesilis Linnaeus*. *Coryphaena hippurus* or the common dolphin fish was the most dominant species rather than *Coryphaena equesilis* other knows as pompano dolphin fish. Results shows during the years of operations, high production was observed in 2015 for *Coryphaena hippurus Linnaeus* and 2014 for *Coryphaena equesilis Linnaeus*. However, a decreasing trend for both species was observed in 2016. It was shown in the analysis of fish samples caught an average of 65.3% immature in Sulawesi Sea and 79.4% immature in Sarangani Bay which did not even reach its length at first maturity.

RESIDENCY AND REPRODUCTIVE STATUS OF YELLOWFIN TUNA IN A PROPOSED LARGE-SCALE PELAGIC MARINE PROTECTED AREA

Richardson, Andrew J.[1], **Downes, Katie J.[1,2,3]**, Nolan, Emma T.[1], Brickle, Paul.[4,5], Brown, Judith.[1,4], Weber, Nicola.[1,2] & Weber, Sam B.[1,2]

[1] Conservation & Fisheries Department, Ascension Island Government

[2] Centre for Ecology and Conservation, University of Exeter

[3] Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, Suffolk, NR33 0HT

[4] South Atlantic Environmental Research Institute, Falkland Islands

[5] School of Biological Sciences (Zoology), University of Aberdeen

The designation of remote, large-scale marine protected areas (LSMPAs) has closed over 15 million km^2 of ocean to commercial fishing. Yet, while these mega-reserves have collectively made a major contribution towards meeting global targets for marine conservation, their effectiveness for the protection of highly-mobile, pelagic species remains largely unknown. Here, we report on the spatial behaviour and reproductive status of yellowfin tuna (*Thunnus albacares*) inhabiting a proposed LSMPA around Ascension Island, central Atlantic. Using a combination of satellite archival tags and conventional mark-recapture we show that individual tuna can remain within Ascension Island waters for periods of 100–200 days, with core residency areas generally extending <200 km from shore. The vast majority of activity occurred within 92.6 km of the island and coincided with a 'no-take-zone' established around the Island in 2016. However, dispersive movements out of this zone were observed in some satellite-tagged individuals, possibly marking the beginning of more extensive oceanic migrations. Gonad staging of 342 individuals sampled over a 32 month period found no evidence of reproductively active individuals, strongly suggesting that tuna foraging around Ascension Island migrate elsewhere to breed. Our results provide evidence of the importance of oceanic islands as residency areas for pelagic megafauna, helping to justify their inclusion within LSMPAs. In the absence of local recruitment, however, these individuals will remain susceptible to exploitation on spawning grounds located outside of reserves, ultimately limiting their effectiveness and thus calling for further research to identify and protect the areas where species are most vulnerable.

RECENTLY AVAILABLE DFAD TRACKING DATA IN THE WCPO: CHALLENGES, NEW RESEARCH AREAS AND POTENTIAL USEFUL TOOL TO GUIDE MANAGEMENT

Lauriane Escalle[1], Maurice Brownjohn[2], Stephen Brouwer[1], Graham Pilling[1]

[1] Oceanic Fisheries Programme
The Pacific Community (SPC)
[2] The Parties to the Nauru Agreement (PNA)

B.P. D5, 98848 Nouméa, New Caledonia

With the arrival of new technological developments to track drifting Fish Aggregating Device (dFAD) locations such as satellite and echo-sounder buoys, the use of dFADs by tropical tuna purse seiners has increased globally in the last few decades. These fine-scale data sources have shown great potential for research and could be useful tools to guide management of purse seine fisheries. The Parties to the Nauru Agreement (PNA) implemented a dFAD tracking programme in 2016, with a requirement to provide positions of satellite buoys attached to dFADs used by purse seine vessels within the PNA EEZs. These data, comprising more than 38,000 satellite buoy trajectories in the Western and Central Pacific Ocean between 2016–2018, along with fishing data (logsheet, observer and VMS) provided detailed insights into fisher and dFAD behaviour. This investigation assessed the deployment and drifting behaviour of dFADs in the WCPO, as well as main areas of deployment, dFAD densities, dFAD connectivity between EEZs, and dFAD beaching events. The number of dFADs used by vessel was also estimated, with most vessels deploying less than 350 dFADs per year in the WCPO. This corresponds to a total of 30,000–65,000 deployments in the whole WCPO in 2016 and 2017. Preliminary analysis of the influence of dFAD densities on CPUE indicated a slight decrease of total tuna CPUE on dFAD sets with increasing dFAD density. While this dataset allows the investigation of new research directions, there are some limitations. For example, the dFAD tracking data have been modified prior to submission with some portions of the trajectories being removed; and matching between trajectories and fishing events or deployments is complicated by the lack of consistent buoy identifiers in observer or logsheet data. However, a new PNA measure will be set up in 2020 to access complete trajectories of dFADs in the tropical WCPO. Nevertheless, even the current dataset can provide useful information for the investigation of dFAD behaviour and improve our understanding of purse seine fisheries.

PRELIMINARY ANALYSES OF SATELLITE BUOYS ECHO-SOUNDER DATA DEPLOYED ON DFADS IN THE WESTERN AND CENTRAL PACIFIC OCEAN

Lauriane Escalle[1], Beth Vanden Heuvel[2], Ray Clarke[3], Stephen Brouwer[1] Graham Pilling[1]

[1] Oceanic Fisheries Programme, The Pacific Community (SPC)
[2] Trimarine
[3] South Pacific Tuna Corporation (SPTC)

B.P. D5, 98848 Nouméa, New Caledonia

The deployments of satellite and echo-sounder buoys on drifting Fish Aggregating Devices (dFADs) has dramatically increased dFAD use by the purse seine fishery over the last decades. In the Western and Central Pacific Ocean (WCPO), while the number of dFAD sets has been relatively stable over recent years, dFADs are now deployed in the tens of thousands each year and this fishing mode corresponds to more than 40% of the purse seine tuna catch. Recently, data from over 4000 echo-sounder buoys deployed on dFADs in the WCPO has been provided by the private sector firms Trimarine and South Pacific Tuna Corporation. The dataset comprises position and biomass estimates from the echo-sounder of Satlink and Zunibal buoys between 2016–2018. Colonisation and recolonization (i.e. after a fishing set) mechanisms were studied using echo-sounder and catch data. However, while buoy deployments could be easily identified, it remains challenging to identify whether it corresponds to newly deployed dFADs or re-deployments. Biomass estimates in relation to total catch per set were also investigated but the raw biomass estimates from echo-sounder data were highly variable. In the future, the potential derivation of an index of abundance that could be used in stock assessments remain one of the key research areas. However, accessing a larger dataset covering all WCPO fishing grounds would be necessary.

STRIPED MARLIN: AN EXAMPLE ON HOW LIFE HISTORY IS IMPORTANT TO FISHERIES MANAGEMENT

Mark D. Fitchett, PhD

Western Pacific Regional Fishery Management Council, Honolulu, HI, USA

Striped marlin are currently assessed as a Western and Central North Pacific (WCNPO) stock, a Southwest Pacific (SWPO) stock, and an Eastern Pacific (EPO) stock. Stock structure and regional connectivity of the species remains equivocal, despite genetic and tagging studies. Growth studies on the species indicate significant spatial variation in expected size-at-age. WCNPO striped marlin are assessed using growth and maturity information originating from the westernmost extent of the stock. Alternatively, age and growth of Central North Pacific striped marlin (captured in Hawaii fisheries) were modeled by fitting von Bertalanffy growth functions (VBGF) to direct observations of age at size as well as tagging data. Models were fitted using 134 observations of age at size read from striped marlin fin spines and mark-recapture histories from 35 tagged striped marlin. Modeling efforts incorporating tagging data yielded VBGF parameters complementing those generated by independently incorporating fin spines. The asymptotic length (L_∞) was estimated to be 184.4 cm EFL; the annual growth coefficient (K) was estimated to be 0.53 yr^{-1}; the average coefficient of variation of size-at-age (CV) was estimated to be 0.13; and age at size 0 (t_0) was estimated to be -1.39 yr. L_∞ estimates from this study correspond to maximum expected sizes near a 50% maturity ogive from the Western North Pacific that is used to assess the entire WCNPO stock. This may reflect regional variation in life history characteristics of striped marlin in the Pacific Ocean, which reinforces the need to collect and update life history information for this species throughout the entire range of the stock. Uncertainty or misspecification of life history may impact characterization of stock status for the WCNPO striped marlin stock.

INTERPLAY BETWEEN SPACE AND ONTOGENY IN THE TROPHIC ECOLOGY OF SKIPJACK TUNA, *Katsuwonus pelamis*, IN THE EASTERN PACIFIC OCEAN

Leanne Fuller, Shane Griffiths, Robert Olson, Felipe Galván-Magaña, Noemi Bocanegra-Castillo, Vanessa Alatorre-Ramírez

Inter-American Tropical Tuna Commission

8901 La Jolla Shores Drive
La Jolla CA 92037 USA

The eastern Pacific Ocean (EPO) covers ~55 million km^2 of complex, dynamic oceanographic habitats that can affect the distribution of commercially-important skipjack tuna, *Katsuwonus pelamis*, and their forage. Early accounts of skipjack stomach contents in the EPO have been limited to measurements of prey volume by size class with sampling strata determined *a priori* based on presumed areas of high skipjack densities. Other studies have been focused on calculations of prey weight, number and frequency of occurrence of skipjack sampled opportunistically throughout the EPO. Little attention has been placed on quantitatively assessing the potential relationships between oceanography, ontogeny and skipjack food habits. Such information is essential for informing spatially-explicit ecosystem models, including a model of the EPO that is planned for development by the IATTC staff. We quantitatively identified predator-prey interactions of 320 skipjack—based on prey biomass (%)—by unique oceanographic regions and skipjack size using a classification tree approach. Significant differences in prey composition were identified by the classification tree with respect to space and fish size. Spatially, there was significantly lower species richness, and the prey assemblage composition of the diet differed in upwelling regions of the EPO at the extreme northern (California Current) and southern (Humboldt Current) extent of the purse-seine fishery, compared to those in other coastal and offshore regions. Within the upwelling systems, ontogenetic differences in skipjack diet were identified, where small-medium skipjack (≤600 mm FL) primarily foraged on anchovies (e.g. Engraulidae: *Cetengraulis mysticetus* and *Engraulis mordax*, >50%) while larger skipjack (>600 mm FL) consumed solely pelagic red crabs (Galatheidae: *Pleuroncodes planipes*). Pacific jack mackerel (Carangidae: *Trachurus symmetricus*) was an important prey for skipjack sampled in other coastal regions. Species richness was greater, while the relative biomass contribution of each prey was lower, in the offshore areas where distribution of forage is typically patchy, owing to various oceanographic features. Quantifying trophic linkages in ecosystem models provide descriptions of the magnitude of biomass transfer through the ecosystem and assist in assigning a more reliable proportion of both predator and prey in spatial strata using spatially-explicit ecosystem models, such as Ecospace.

ORIGIN OF ATLANTIC BLUEFIN TUNA (*Thunnus thynnus*) IN THE U.S. FISHERY AND APPLICATION OF MIXED STOCK INFORMATION TO FISHERIES MANAGEMENT

Lisa A. Kerr[1], Steve Cadrin, Molly Morse[2], Dave Secor[3] and **Walt Golet**[4]

[1]Gulf of Maine Research Institute
[2]Department of Fisheries Oceanography, School for Marine Science & Technology
[3]Univ. Maryland Center for Environmental Science Chesapeake Biological Laboratory
[4]University of Maine School of Marine Sciences/Gulf of Maine Research Institute. 350 Commercial Street Portland, Maine 04101

The highly migratory Atlantic bluefin tuna (*Thunnus thynnus*) is managed as two separate management units in the eastern and western North Atlantic, despite observed mixing that occurs across the management boundary. Characterizing the effects of stock mixing has been identified as a priority for improving the management of Atlantic bluefin tuna. The aim of our research was to apply otolith chemistry techniques to characterize the stock composition of Atlantic bluefin tuna caught in the U.S. rod and reel fishery in the Gulf of Maine and to demonstrate how this information can be applied in fisheries management. Identifying the stock composition of landings from the Gulf of Maine is of primary importance, because approximately 70% of the entire U.S. western Atlantic total allowable catch is removed from this region annually. Prior research established otolith stable isotope chemistry ($\delta^{13}C$ and $\delta^{18}O$) as an effective and reliable stock identification tool, and we applied this approach to determine the population of origin for Atlantic bluefin tuna collected from fishery dependent sampling (recreational and commercial) in the Gulf of Maine. Results indicated that the majority of fish caught in the Gulf of Maine from 2010 to 2013 were eastern origin. We found the highest proportion of eastern-origin fish were caught in 2012 and the proportion of eastern-origin fish was greater in late summer to fall. Although the majority of fish in small and intermediate size-classes were eastern-origin, fish in the largest size class (>250 cm) were predominantly western-origin. We demonstrated an approach for integrating mixed stock composition information into fleet-specific harvest data (catch, catch-per-unit-effort, and age composition). This information can be used to monitor mixed stock composition of the fishery, partition catch to population of origin, and to inform management decisions aimed at controlling population of origin harvest.

TRAITS-BASED TOOLS TO ACCOUNT FOR THE EFFECT OF SHIFTING PREDATOR-PREY INTERACTIONS ON THE DISTRIBUTIONS OF TUNAS UNDER CLIMATE CHANGE

Stephanie J. Green[1], Natasha A. Hardy[1,2], Michael Jacox[3], Elliott L. Hazen[3], Steven J. Bograd[3], Larry B. Crowder[2]

[1]Department of Biological Sciences, University of Alberta, Edmonton, AB, T6E4R4
[2]Hopkins Marine Station, Stanford University, Monterey, CA, 93940
[3]NOAA Southwest Fisheries Science Center, Monterey, CA, 93940

Climate change is shifting fisheries resources across jurisdictional boundaries, with potential consequences for communities that depend on these fisheries. When and where will shifts occur? While many analytical approaches are developing to link changing abiotic conditions and species distribution under future climate scenarios, there is also a need to account for the potential influence of dynamic trophic interactions on species' distribution and abundance. Here we outline an initiative that seeks to address this gap by using insights into species' foraging and anti-predation traits to flexibly incorporate the effect of climate-mediated range shifts on predator-prey interactions, and ultimately community structure and biomass. We describe the framework for this approach, and illustrate the process by which we are applying it to model the distribution of tunas and their prey in the California Current system. These are key fisheries species for which trophic interactions are variable and uncertain, and for which distributions are likely to change across multiple regional and international jurisdictions in the coming decades due to climate change. The project is occurring in three phases of work: (1) identifying the traits basis of foraging interactions, (2) integrating traits-based approaches into spatially explicitly food web models, and (3) coupling food web models with projections of species redistribution from regional ocean modeling in the CCLME.

ASSESSING POTENTIAL CONSERVATION MEASURES FOR DATA-POOR MOBULID BYCATCH IN THE EASTERN PACIFIC OCEAN TUNA FISHERY USING THE "EASI-Fish" ECOLOGICAL RISK ASSESSMENT TOOL

Shane P. Griffiths[1], Nerea Lezama-Ochoa[1,2], and Marlon H. Román[1]

[1] Inter-American Tropical Tuna Commission, 8901 La Jolla Shores Drive, La Jolla, CA, USA.
[2] AZTI-Tecnalia, Marine Research Division, herrera kaia, portualdea z/g, 20110, Pasaia, Spain

The Ecological Assessment for the Sustainable Impacts of Fisheries (EASI-Fish) tool is a new spatially-explicit ecological risk assessment (ERA) approach designed to quantify the cumulative impacts of multiple fisheries on data-poor bycatch species using conventional biological reference points (*e.g.*, F_{MSY}, $SSB_{40\%}$). The method is primarily used as a quantitative prioritization tool to allow fisheries managers to identify the most vulnerable species to which resources can be directed to either: i) implement mitigation measures to remove the key risk(s) or ii) subject vulnerable species to data collection programs to gather sufficient data to facilitate more traditional stock assessment. EASI-Fish also has the capability of simulating hypothetical conservation and management measure (CMM) scenarios (*e.g.*, spatial and/or temporal closures, reduction in post-release mortality (PRM)) that may mitigate fishery risks to a species, without incurring significant investment in costly data collection programs. This paper uses EASI-Fish to explore the changes in the vulnerability status of the spinetail devil ray (*Mobula mobular*)—a large, slow-growing species with low reproductive capacity—under 18 hypothetical CMM scenarios simulated for purse-seine and longline tuna fisheries in the eastern Pacific Ocean. CMMs involved various spatial and temporal closures of the EPO and 'hotspots', decreasing PRM, increasing the length at first capture, and various combinations of these CMMs. The "status quo" scenario for the 2106 assessment year revealed that *M. mobular* was classified as "most vulnerable". Increasing the duration and/or number of spatial closures significantly reduced the vulnerability of the species but was insufficient in changing its vulnerability status. Only 3 of the 18 scenarios resulted in the species being classified as "least vulnerable", which primarily involved reductions in PRM. This is fortuitous in that the development of best handling and release practices and the education of fishers is likely to be a far simpler, rapid, inexpensive and effective CMM than the implementation of increased spatial and temporal closures and gear modifications that will likely result in substantial decreases in the catches of target species. However, given the current lack of reliable information on the PRM of *M. mobular* and other mobulids, there is a need for electronic tagging studies to quantify the PRM of mobulids from purse-seine and longline fisheries in the EPO. Furthermore, data are required from the small-scale coastal fisheries (e.g., gillnet) throughout Central and South America where mobulid catches are significant but poorly documented. Therefore, the vulnerability status reported for *M. mobular* in the current assessment is likely to have been underestimated in the absence of data from these fisheries.

REPRODUCTIVE BIOLOGY AND ESTIMATES OF LENGTH AND AGE AT MATURITY OF LONGTAIL TUNA (*Thunnus tonggol*) IN AUSTRALIAN WATERS BASED ON HISTOLOGICAL ASSESSMENT

Shane Griffiths*, Mitchell Zischke, Tonya van der Velde, Gary Fry

*Inter-American Tropical Tuna Commission, 8901 La Jolla Shores Drive, La Jolla, CA, USA.

Longtail tuna is the second smallest *Thunnus* species and is found throughout tropical and subtropical neritic waters of the Indo-Pacific. As a result of their nearshore distribution, longtail tuna are caught in large- and small-scale commercial, artisanal and recreational multi-species fisheries of many developing and developed coastal nations. Since 1993, the annual reported global catch has almost tripled in the past 20 years, reaching a peak of 291,264 t in 2007. In the Indian Ocean tuna fishery, longtail tuna catches now exceed those of some principle target species (e.g., bigeye and albacore tunas)—that are approaching full utilisation, or are currently overexploited—resulting in numerous stock assessments concluding the species has been subject to overfishing and overfished for since at least the 1990s. Stock assessment is currently hindered by unreliable biological and catch data, which provided the impetus to study the reproductive dynamics of longtail tuna in Australian waters based on histological assessment of female ovaries. Length and age at 50% maturity was estimated at 535 (± 95% CI 463–570) mm and 2.51 (± 2.14–2.79) years, respectively. Spawning occurred during the summer monsoonal season between October and February, where females produced and average of 1,516,680 (± SD 743,980) oocytes per spawning. Three spawning locations were confirmed based on the presence of postovulatory follicles in a small number of ovaries, although major spawning areas may be located offshore. The present study provides reliable maturity and fecundity ogives that may improve future assessment of longtail tuna stocks throughout the Indo-Pacific region.

USE OF AIS AND MACHINE LEARNING TO CREATE A BETTER UNDERSTANDING OF TRANSSHIPMENT ACTIVITIES IN THE WESTERN AND CENTRAL PACIFIC OCEAN

Janelle Hangen

The Pew Charitable Trusts

Transshipment of catch between vessels plays an enormous role in the global commercial tuna fishing industry. Hundreds of refrigerated cargo vessels, or fish "carriers," take fresh catch from thousands of fishing vessels each year and bring it to shore for processing. Despite the vast impact on international fisheries, however, regulatory control and monitoring of transshipment are inadequate, especially when it occurs at sea. These gaps create opportunities for illicit activities, which result in the laundering of millions of dollars of illegally caught fish annually. These circumstances can also foster conditions that are conducive to trafficking in weapons, drugs, and people. The relative lack of transparency surrounding the movements of carrier vessels and their activities has meant that transshipment operations have remained poorly quantified at both the global and regional level. To create more transparency, and therefore a better understanding of transshipment activities, a case study was conducted examining transshipment in the Western and Central Pacific Ocean region. Commercially available Satellite Automatic Identification System (AIS) data combined with the application of machine learning technology was used to analyze the track histories of refrigerated carrier vessels operating in the Western and Central Pacific Fisheries Commission (WCPFC) Convention Area during calendar year 2016. The track histories and identification of carrier movements consistent with transshipment behavior were also cross-referenced against publicly available information on these vessels and their transshipments as reported by the WCPFC Secretariat and Commission members. The resulting analysis produced a profile of the typical "lifecycle" of these vessels as they operated within the WCPFC Convention Area and revealed significant inconsistencies and data gaps in the reported information that limits the overall effectiveness of the current WCPFC transshipment management framework.

HARNESSING DIET DATA TO MODEL TRAIT-BASED TROPHIC INTERACTIONS BETWEEN TUNA AND THEIR PREY ALONG GRADIENTS OF CHANGE

Natasha Hardy[1,2], Elliott Hazen[2,3], Mike Jaccox[3], Steven Bograd[3], Larry B. Crowder[2], Stephanie J. Green[1]

[1]Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada T6E4R4
[2]Hopkins Marine Station, Stanford University, Monterey, CA, USA 93940
[3]Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration, Monterey, CA 93940

Pelagic food webs are shifting in space and time due to climate change, and many components of food webs may become decoupled leading to climatic and trophic redistributions of species. Novel combinations of species are giving rise to new trophic dynamics within communities, which will in turn also shape species redistributions in changing oceanic habitats. We illustrate the relevance of a trait-based framework for understanding the dynamic composition of prey species within tuna diets. Our project aim is to identify key functional traits of prey and predator shaping the diet selection process for tunas along environmental gradients, and particularly for California Current food webs. Here, we use a fourth-corner modelling approach to analyzing statistical relationships between multiple arrays of data and to assessing the power of trait-based analyses for predicting tuna trophodynamics. Validation and extension of this approach requires harnessing existing data sets of tuna diet from across geographies and time periods to elucidate important prey traits that recur across time and space. We identify data needs and analyses for testing and validating our trophic-traits approach to predicting species redistributions. We then aim to apply trait-based insights from fourth-corner analyses to detect shifts in predator diets across climatic shifts. Ultimately, this approach could be used to forecast species redistributions and novel food webs under climate change in the California Current system, as well as globally. Analytical tools that incorporate predictive traits informing the predation process will add salient and cost-effective information to existing species distribution and ecosystem-based models. As climate change is shifting fisheries resources across jurisdictional boundaries, such as between the US, Mexico and Canada for the California Current system, our team hopes to foster international collaborations on tuna diet data to produce predictive tools for predator-prey interactions across gradients of environmental change.

PREDICTING TUNA AVAILABILITY THROUGH UNDERSTANDING MIGRATION DYNAMICS AND OCEANOGRAPHIC INFLUENCES

Jason Hartog, Toby Patterson, Paige Eveson, Alistair Hobday

Large scale migrations are a key component of the life history of many marine species. We quantified the annual migration cycle of juvenile southern bluefin tuna (Thunnus maccoyii; SBT) and spatiotemporal variability in this cycle, based on a multi-decadal electronic tagging dataset. Behaviour-switching models allowed for the identification of cohesive areas of residency and classified the temporal sequence of movements within a migration cycle from austral summer foraging grounds in the Great Australian Bight (GAB) to winter foraging grounds in the Indian Ocean and Tasman Sea and back to the GAB. The timing of individual arrivals to the GAB, which may be driven by seasonality in prey availability, was more cohesive than the timing of departures from the GAB, which may be subject to the physiological condition of SBT. Understanding oceanographic influences on the distribution of juvenile SBT whilst in the GAB is also important for industry and management. Thus, the same electronic tagging dataset was used to investigate oceanographic variables influencing SBT distribution, using two different types of models. Generalized additive models, which included spatiotemporal variables in addition to oceanographic variables as covariates, found distance from the continental shelf, sea surface temperature (SST) and mixed layer depth to be important predictors of fish distribution. “Environmental ratio” models, which compare environmental data for one or more variables at locations where fish were found with environmental data from the entire region of interest to see which conditions fish tended to 'prefer', found SST to be most highly correlated with fish distributions, and were used in conjunction with seasonal forecasting models of SST to predict SBT distribution in the GAB up to 2 months in future.

The target species of tuna in Australian east coast longline fishery (albacore, bigeye, yellowfin tuna) have a wide distribution outside the Australian EEZ, but the influence of oceanographic factors within the fishery region and the surrounding south-west Pacific region is poorly understood, creating uncertainty in current management arrangements. The Australian longline management agency and the fishing industry are seeking insight into past, current and potential future oceanographic and environmental impacts upon (i) the spatial and temporal distribution and level of longline catches, catch rates, fishing effort and fish sizes, and (ii) the interactions between focal species in the domestic and international fisheries. We seek to apply habitat models developed in previous work and utilise seasonal and decadal forecasting approaches to provide insights into potential long-term changes in the longline fishery that may result from phases of major climate signals (such as ENSO) or climate change. This effort will support decision making by Australian and south-west Pacific managers and fishers, and build capability for operating in a rapidly changing region.

ELECTRONIC MONITORING ON PEALGIC TUNA LONGLINE VESSELS NAVIGATING BEYOND THE ERA OF SELF-REPORTING

Craig Heberer[1], Kydd Pollock[2], Amy Parks[3]

The Nature Conservancy, Indo-Pacific Tuna Program

[1] 401 W A Street, Suite 1650, San Diego, CA 92101
[2] 923 Nuuanu Ave, Honolulu, HI 96817
[3] 532 E. Main Street, Suite 200, Ventura, CA 93001

The Nature Conservancy (TNC) has partnered with, among others, regional scientists at the Pacific Community's Oceanic Fisheries Program (SPC), representatives from the Western Central Pacific Fisheries Commission (WCPFC), managers and staff from Pacific Island domestic fisheries authorities, and fishing and seafood industry leaders to pilot the use of electronic monitoring (EM) systems on pelagic tuna longline vessels fishing in the Western and Central Pacific Ocean (WCPO). The overarching goals of the project have been to: 1) increase the capacity of and build infrastructure for domestic fisheries authorities to incorporate EM into their science and monitoring programs; 2) establish proof of concept and develop key partnerships to catalyze the scaling up of EM onto the 3,000 plus tuna longline vessels fishing in the WCPO, and 3) to invest in technology and spur innovation and competition to address the relevant technical challenges in play. Human observer coverage on WCPO tuna longline vessels has lagged considerably behind the desired WCPFC monitoring target of 5% coverage and EM offers a relatively cost-effective and verifiable tool to help address national and regional science and compliance monitoring goals and objectives.

The TNC Cooperative Tuna Longline EM Project commenced in the fall of 2016 and to date has resulted in the installation of EM systems on 28 tuna longline vessels based in multiple WCPO ports and 1 frozen tuna transshipment vessel, the first transshipment vessel anywhere in the world to be outfitted with an EM system. Four in-country data review centers (Federated States of Micronesia, Republic of Marshall Islands, Solomon Islands, Vanuatu) are now fully operational with SPC-trained Pacific Island fisheries observers converting raw video footage into actionable data for management and compliance purposes. To date more than 150 trips and 1,850 sets have been analyzed and uploaded to the regional SPC database allowing for comparative analyses among linked EM, logbook, observer, and port sampling data sets.

Preliminary results from the Project demonstrate biases in the estimation of both target tunas and non-target catch (e.g., sharks, rays, turtles) from self-reported logbook submissions and comparative observer data sets from trips with paired EM/observer monitoring. This presentation will discuss preliminary results and offer insights into the pathway to scaling up EM for broader adoption as a reliable and verifiable data collecting mechanism. It will also provide a snapshot of current advances and innovations, using machine learning and computer vision to automate the back-end video review process in a cost-effective manner which is one of the recognized challenges confronting advancement of EM on a larger scale.

PROGRAMMATIC ERROR CHECKING OF SELF-REPORTED DATA FOR HIGHLY MIGRATORY SPECIES

Elizabeth A. Hellmers

California Department of Fish and Wildlife
8901 La Jolla Shores Dr.
La Jolla, California

Self-reported fishery dependent data are inherently prone to a myriad of accuracy issues. For fishery managers and assessment scientists that rely on these data, inaccuracies can result in potential mis-management of stocks, loss of valuable time and resources, or have other negative impacts to fisheries and their participants. Fisheries for highly migratory species (HMS) can be complex and unpredictable, adding to the potential for erroneous data reporting. The California Department of Fish and Wildlife's (CDFW) Pelagic Fisheries and Ecosystem Project has developed an automated process which incorporates known fishery behaviors, management restrictions, state and federal permitting information, and a variety of other qualifiers to flag potential errors in HMS landings data. These flagged records are then reviewed, and the correct information verified with the reporting body, ultimately resulting in improved data quality. The Commercial Landings Data Improvement Procedure, or COLA DIP, is an ever-evolving system and has been successfully used for California HMS fishery data review. With the implementation of electronic landings reporting in California, COLA DIP may be adapted to process self-reported data for other California fisheries.

COLLECTING EMPIRICAL DATA REGARDING EFH FOR LARGE FISHES; THE ROLE OF ELECTRONIC TAGS – PRESENT AND FUTURE

Kim Holland

Hawaii Institute of Marine Biology
PO Box 1346 Kaneohe, Hawaii 96744

Essential fish habitat (EFH) is a key concept in modern fisheries biology. Collecting empirical data as to exactly which habitats large fishes (especially pelagic species) select and what environmental characteristics are associated with those habitats is difficult. However, the emergence and deployment of increasingly sophisticated electronic tags has made the task of collecting EFH data much more tractable – especially for larger species. In keeping with the theme of this year's Tuna Conference, and based largely on examples drawn from my research group's activities, I will present a brief overview of the emerging tools available in the realm of electronic tagging and give examples of the types of EFH and related data that can be collected. Future possible directions will be briefly presented.

ELECTRONIC MONITORING OF PURSE SEINE CATCH DATA: DO YOU SEE WHAT I SEE?

David Itano[1] and Craig Heberer [2]

[1] The Nature Conservancy, contractor
[2] TNC, Indo-Pacific Tuna Program

689 Kaumakani Street
Honolulu, HI 96825

Electronic monitoring (EM) of fishing operations is expanding rapidly as a means to obtain unbiased catch and effort data and increase data acquisition on bycatch, discards and operational characteristics of fisheries. EM technology is well suited for observing longline fisheries where each fishing event can be referenced to a sequentially set hook that is landed and processed in the same area of the vessel, one by one. Purse seine (PS) operations are more complex, requiring several camera locations and angles to effectively monitor fishing operations and vessel activity. Catches in the tropical tuna PS fishery can exceed 300 MT per set and are loaded rapidly at high volume. The landings are of mixed size and multi-species in nature, including juvenile yellowfin and bigeye tuna that can be difficult to distinguish.

Despite these challenges, scientists have proposed EM as an emerging tool to address data collection and monitoring of purse seine fisheries. If proven effective, EM could assist observers to concentrate on other duties, such as documentation of the handling and fate of non-target species. However, before EM data can be endorsed for incorporation into existing data streams for management, the accuracy of video interpretation of size and species must be checked and validated.

The Nature Conservancy (TNC), Indo-Pacific Tuna Program has partnered with the Tri Marine Group (http://www.trimarinegroup.com/), Satlink (https://satlink.es/en/tracking-monitoring/satlink-seatube/) and Digital Observer Services (DOS http://digitalobserver.org/en/) to explore the use of EM technology to obtain data useful for the estimation of size and species composition for target and non-target species. An eight-camera video EM system was evaluated on a Tri Marine PS vessel (1261 MT capacity) operating in the WCPO. TNC researchers boarded the vessel for a commercial trip in late 2018 to conduct species composition and length frequency sampling from each set. These data will be compared to the size and species composition estimates of the same fish determined from video analysis conducted by DOS, estimates made by the onboard observer, port sampling and cannery sorting data. The pros and cons of EM for data collection on purse seine vessels compared to onboard observers and port sampling will be discussed.

SEEING THE BIGGER PICTURE: USING FULL-SPHERICAL CAMERAS TO REDUCE THE INFLUENCE OF DENSITY INDEPENDENT FACTORS ON VIDEO SURVEY METRICS OF RELATIVE ABUNDANCE

James P. Kilfoil[1*], Michael R. Heithaus[1], Matthew D. Campbell[2] and Yuying Zhang[1]

[1] Florida International University
[2] National Marine Fisheries Service, Pascagoula Laboratory

3000 Northeast 151st
Street, North Miami,
Florida 33181
USA

Baited video surveys are increasingly used by resource managers to assess and monitor relative abundances for a variety of marine species. These methods offer a number of advantages over traditional fisheries surveys including their non-extractive nature, reduced issues with size and species selectivity, insights on behavior and habitat use, as well as being able to sample a variety of environments. A fundamental assumption of this technique, is that counts derived from videos accurately reflect changes in true abundance, while being simultaneously resilient to changes in density-independent factors (e.g., species swimming speed, ocean current speed, and visibility). We tested this assumption within a 2-D spatial simulation framework, while also exploring the potential of recently developed full-spherical cameras (cable of recording a field-of-view with 360 degrees vertical by 360 degrees horizontal) to reduce the variance introduced by density-independent factors. Simulations represented a pelagic 1km^2 area over a 30-minute baited video deployment, whereby for each simulation we varied the density of fish present (n=10-500), the mean swimming speed of fish (0.6-3.0m/s), fish movement behavior (correlated random walk, levy walk, or lie and wait predator), ocean current speed (0.5-10m/s), water visibility (5- 100m), and camera field-of-view (120 or 360 degrees). Each simulation scenario was repeated 1,000x with bait particle movement modeled using Brownian motion. A generalized linear model assuming a gamma distribution was created based on the simulation output, with all possible model combinations considered to explain counts derived from videos for both standard and full-spherical cameras. Results indicated that in addition to species density, animal swimming speed, current speed, and visibility were significant factors in explaining video counts for both camera types. Visual exploration of the results indicated that these effects were more pronounced at higher species densities. However, using full- spherical cameras did result in a stronger correlation between camera counts and species density, and resulted in a lower variance explained by density-independent factors. These results show that full- spherical cameras are capable of improving video survey counts used to generate indices of relative abundances, and likely represent the next leap forward in visual survey methods.

UNDERSTANDING THE MORTALITY RATE OF YELLOWFIN TUNA (*Thunnus albacares*) FOLLOWING CATCH AND RELEASE IN THE U.S. EAST COAST RECREATIONAL TROLL FISHERY: IS PREDATION A NATURAL EVENT?

Jeff Kneebone[1], Walt Golet[2], Hugues Benoît[3], Diego Bernal[4]

[1]Anderson Cabot Center for Ocean Life, New England Aquarium
[2]University of Maine/Gulf of Maine Research Institute
[3]Fisheries and Oceans Canada
[4]University of Massachusetts Dartmouth

Anderson Cabot Center for Ocean Life
New England Aquarium
1 Central Wharf
Boston, MA (USA) 02110

Recreational sportfishing for yellowfin tuna (*Thunnus albacares*) with rod and reel is a popular activity along the United States (U.S.) east coast from the Gulf of Mexico to New England. In addition to annual recreational landings, up to 40% of all the yellowfin caught by recreational anglers in this area are released due to minimum size limits, daily retention limits, or angler conservation ethics. Despite this high rate of release, the extent to which yellowfin experience mortality during capture and handling and after release remains poorly understood, which limits our understanding of this fisheries' impact on the overfished Atlantic yellowfin stock. To fill this data gap, the post-release fate of 52 yellowfin (76 – 127 cm curved fork length) was monitored with Wildlife Computers 'survival' pop-up satellite archival tags (sPATs) following capture with standardized fishing methods, gear, and tackle used in the popular U.S. Atlantic recreational troll fishery. Fight times for tagged fish ranged from 2 – 24 minutes, and all fish were hooked in the mouth with J-hooks (8/0 – 10/0). Data were recovered from 48 reporting sPATs following deployments of 1 – 60 days and indicated that 8 individuals suffered mortality at 0 – 30 days post-release. All but one mortality occurred >5 days post-release. Of the 8 mortalities, six individuals experienced predation events occurring at 7 – 30 days post-release. To better understand the factors influencing these mortality events, a suite of longitudinal survival models were constructed in an attempt to reconcile the influence of capture and handling mortality (immediate and post-release), natural mortality (predation), and tagging-induced mortality. Preliminary model results suggest that capture and handling mortality is low (~2%), however, natural mortality and/or tagging-induced mortality rates are considerably higher.

TROPHIC ECOLOGY OF YELLOWFIN TUNA (*Thunnus albacares*) IN THE GULF OF MEXICO INFERRED FROM STABLE ISOTOPE ANALYSIS AND CSIA-AA

Meliza Le Alvarado, Sharon Z. Herzka[1], Alfonsina E. Romo-Curiel, Oscar Sosa-Nishizaki

[1]Centro de Investigación Científica y Educación Superior de Ensenada (CICESE)

Departamento de Oceanografía Biológica, Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), 3918 Carretera Ensenada-Tijuana, Ensenada 22860, Baja California, México.

Yellowfin tuna (YFT, *Thunnus albacares*) is the second-most important species of tuna with respect to its commercial value among the tunas fished in the Atlantic Ocean. YFT is a top predator that performs extensive transoceanic migrations associated with spawning and feeding. The Gulf of Mexico (GoM) is one of the western Atlantic spawning grounds for YFT. Recent otolith chemistry studies indicate that half of adults and sub-adults caught in the GoM are born locally. The rest originate from spawning grounds in the eastern Atlantic, which implies migratory movements into and out of the gulf. Stable isotope analyses (SIA) have been widely used to assess trophic position (TP) and trace migratory movements of highly migratory pelagic species. Compound-specific stable isotope analysis of amino acids (CSIA-AA) has been shown to provide information regarding an ecosystem's isotopic baseline through the meaurement of the so-called source AA (e.g., Phenylalanine, $\delta^{15}N_{Phe}$). Trophic AA (e.g., Glutamic acid, $\delta^{15}N_{Glu}$) can be used on conjunction with source AA to estimate TP. In addition, the migration patterns of species that inhabit ecosystems with different isotopic baselines can therefore be inferred. The aims of this study are (a) to estimate the TP of YFT in the GoM and (b) discriminate residents from recent immigrants based on bulk SIA ($\delta^{13}C$ and $\delta^{15}N$) and CSIA-AA ($\delta^{15}N$) analysis of soft tissues that differ in isotope turnover rates (white muscle and liver). We collected samples from 73 tuna in August 2017 and August 2018. Mean (± SD) fork length was 139.44 cm (±7.47; 123-160 cm range). The isotopic baseline for the GoM was established based on analysis of zooplankton collected throughout the deep water region of the GoM in September 2017. Mean white muscle isotope values were 10.14‰ (±0.82) for $\delta^{15}N$ and -17.95‰ (± 0.57) for $\delta^{13}C$; mean liver isotope values were 7.96‰ (±0.91) for $\delta^{15}N$ and -18.74‰ (± 0.55) for $\delta^{13}C$. Mean (n=14) $\delta^{15}N_{Phe}$ values in white muscle for source AA was 6‰ (±1.15) and $\delta^{15}N_{Glu}$ for trophic AA was 26.36‰ (±0.51). Based on published isotope discrimination factors, we confirmed a high TP_{bulk} of 4.19 (±0.35), similar for previous reports from other regions of YFT distribution. However, TP_{CSIA}= 3.23(±0.18), seems to underestimate YFT trophic position. Once we analyze and compare the tuna-based isotopic baseline with those of zooplancton for the GoM and published values for the Atlantic, we expect to be able to discriminate residents from recent immigrants. This study may improve our undestanding of the trophic and migratory dynamics of the YFT subpopulation from the GoM.

THE ROLE OF SPECIES DISTRIBUTION MODELS ON THE ECOLOGICAL RISK ASSESSMENT OF THE SPINETAIL DEVIL RAY (*Mobula mobular*) IN THE ATLANTIC OCEAN PURSE-SEINE FISHERY

Nerea Lezama-Ochoa[1, 2]*, Murua, H[1]; Abascal, F. J[3]; Bach, P[4]

[1]AZTI Foundation
[2]IATTC
[3]Instituto Español de Oceanografía (IEO)
[4]Institut de recherché pour le développement (IRD)

*Herrera Kaia z/g, 20110, Pasaia (Spain)

Manta or devil rays (pelagic rays of the family Mobulidae) have been identified to form a component of the tuna purse-seine fishery bycatch in tropical regions worldwide. Among the mobulid rays species, *Mobula mobular* is one of the most frequently caught in purse-seine fisheries, but the impact of these fisheries on their populations is poorly known, particularly in the Atlantic Ocean. Assessing the vulnerability of the species to the fishery is crucial to develop effective management measures to assure their long-term sustainability. Unfortunately, many bycatch species in the Atlantic purse-seine fishery lack reliable catch data to quantitatively assess their population status using traditional stock assessment models. As an alternative, the Ecological Assessment of Sustainable Impact of Fisheries (EASI-Fish) model could be used to quantify the impact of the purse-seine fishery on the data-poor *M. mobular* in the Atlantic Ocean. To estimate the proportion of the population susceptible to capture, we first defined the species distribution with Generalized Additive Models (GAMs) using bycatch data from the Atlantic tuna purse seine fishery observer program (2005-2015). Preliminary results showed that the presence of *M. mobular* is directly explained by the presence of the upwelling systems of Mauritania and Angola in the Atlantic Ocean. As EASI-Fish results rely heavily on the defined species distribution, we compared GAMs with different distribution models (i.e. MaxEnt) and using different methodologies. This work provides an important step in understanding the vulnerability of *M. mobular* in the tropical Atlantic purse-seine fishery.

SEASONAL MOVEMENT PATTERNS AND AREAS OF IMPORTANCE FOR JUVENILE SMOOTH HAMMERHEAD SHARKS (*Sphyrna zygaena*) IN THE WESTERN NORTH ATLANTIC OCEAN

Ryan K. Logan[1*], Jeremy Vaudo[1], Lara Souza[2], Bradley Wetherbee[1,3], Mark Sampson[4], Mahmood S. Shivji[1]

[1]Guy Harvey Research Institute, Nova Southeastern University Oceanographic Center
[2]The Laboratory, Marine Biological Association of the United Kingdom
[3]Department of Biological Sciences, University of Rhode Island
[4]Fish Finder Adventures, Ocean City, Maryland

8000 North Ocean Drive
Dania Beach, FL 33004 USA

Overfishing is the most widespread threat to top ocean predators. While species specific catch data for smooth hammerhead sharks (*Sphyrna zygaena*) is sparse, harvest (in a directed fishery or as bycatch) has been identified as the major threat to this species, particularly juveniles. Consequently, it is important to identify habitats used and temporal patterns of occurrence by juvenile *S. zygaena* to determine when and where they are most vulnerable to exploitation. In this study we examined the seasonal movement patterns and habitats of importance for juvenile *S. zygaena* in the western North Atlantic. Six juvenile *S. zygaena* were tagged with fin-mounted satellite tags and tracked for an average of 187 days (49–441 days), representing the longest spatially-explicit tracks of this species to date. Individuals showed surprisingly low intraspecific variation in seasonal movements, displaying area-restricted movements in the waters of the New York Bight during the summer and transiting southward during autumn. Most sharks tended to overwinter in an area centered off Cape Hattaras, North Carolina and one individual returned to the New York Bight the following spring. Sharks were more likely to engage in area-restricted movements at the northerly extent of their range with high primary productivity, strong sea surface temperature fronts and elevated sea surface temperature. Findings from this study provide the first information on movements and behavior of this species in the western North Atlantic and can guide future conservation efforts and fishery management for an important life stage of this poorly understood predator.

FISHERS' ECHO-SOUNDER BUOYS: NEW TOOLS TO ASSIST SCIENTIFIC AND MANAGEMENT ADVANCE

Jon Lopez[1*], Mark Maunder[1], Cleridy Lennert-Cody[1], Josu Santiago[2], Hilario Murua[2], Blanca Orue[2], Jefferson Murua[2], Guillermo Boyra[2], Jon Uranga[2], Gala Moreno[3], Emmanuel Chassot[4], David Kaplan[5], Manuela Capello[5], Laurent Dagorn[5], Lauriane Escalle[6], Joe Scutt-Phillips[6], Graham Pilling[6], Miguel Herrera[7], Alexandra Maufroy[8], Beth Vanden Heuvel[9]

[1]Inter-American Tropical Tuna Commission
[2]AZTI Foundation
[3]International Seafood Sustainability Foundation
[4]Seychelles Fishing Authority
[5]MARBEC
[6]SPC
[7]OPAGAC
[8]ORTHONGEL
[9]TriMarine

*8901 La Jolla Shores Dr. La Jolla, CA, 92037

Thousands of drifting fish aggregating devices (DFADs) are constructed and deployed at sea annually by fishermen to facilitate their catch of tuna. These devices are usually equipped with satellite linked echo-sounder buoys, which provide fishers with accurate geolocation of the object and a rough index of the biomass aggregated underneath them. Because echo-sounder buoys are continuously streaming information, they can be used as scientific platforms to monitor the pelagic realm. Although they were not intended to be used for science but for fishing, the scientific community has started to use them to investigate several issues of interest, including the development of new fishery-independent abundance indices and a variety of ecological and behavioral investigations for tunas and non-tuna species. Mindful of these advantages, several regional and international initiatives are considering this data and the collaboration between fishing industry, buoy manufacturers and scientists is real now. Moreover, some tuna-RFMOs have partially incorporated buoy data reporting into their data requirements to try to improve the monitoring and management of the fishery. However, this data is not perfect and various issues can be anticipated when exploiting it. This paper will summarize the advantages and disadvantages of the use of this data, as well as will review the most sounded past, current and potential applications with regards science and management. The most important technological and technical challenges will also be described and a view into the future provided.

ANALYSIS OF DOLPHINFISH (*CORYPHAENA HIPPURUS)* POPULATION STRUCTURE IN THE NORTHWESTERN PACIFIC OCEAN INFERRED BY MITOCHONDRIAL DNA SEQUENCES

Ching-Ping Lu[1], Sheng-Ping Wang[2] Wei-Chuan Chiang[3]

[1] Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University.
[2]Eastern Marine Biology Research Center, Fisheries Research Institute.
[3] Pei-Ning Rd., Keelung 202, TAIWAN.

The genetic population structure of dolphinfish in the Pacific Ocean is limited and not well understood. For the preliminary results in this study, we characterized the 766bp of sequence of the mitochondrial DNA NADH dehydrogenase subunit 1 (mtDNA ND1) for 440 dolphinfish collected from Taiwan (Tungkang, SuAo, and Taitung), Japan (Nagasaki and Kagoshima) and Ecuador (Manta) to investigate the pattern of genetic differentiation of dolphinfish in the Pacific Ocean. For the pairwise comparison of Φ_{ST}, we report that the samples from PonHu showed significant genetic differentiation with three localities including Taitung 1314a (spring in 2013 and 2014), Taitung 1314b (autumn in 2013 and 2014) of Taiwan and Kagoshima in Japan. In additional, the samples from Kagoshima revealed the genetic differentiation with Nagasaki14a (spring in 2014). These results show that there is genetic heterogeneity among the localities of Taiwan and Japan. The genetic differentiation pattern between spring and autumn samples might be existed in the northwestern Pacific Ocean. However, the AMOVA results of multiple groupings didn't show the genetic differentiation pattern in different seasons. Therefore, we suggest that the more genetic loci, larger sample sizes and geographic coverage, and finer spatial-temporal scale should be essential and helpful to improve the resolution of genetic information and resolve the genetic population structure of dolphinfish in the Pacific Ocean in the future study.

ESTIMATING ENERGETIC COSTS AND FORAGING BEHAVIOR OF FREE-RANGING DOLPHINFISH, *Coryphaena hippurus*

Sarah M. Luongo[1], Nicholas C. Wegner[2], Sofía Ortega-García[3], Rubén Rodríguez-Sánchez[3], Chris Perle[4], John B. O'Sullivan[5], Yannis P. Papastamatiou[1]

[1] Florida International University, Department of Biological Sciences, North Miami, Florida, USA
[2]Fisheries Resources Division, Southwest Fisheries Science Center, National Marine [3]Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), La Jolla, CA, USA
[4]Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN), La Paz, Baja California Sur, Mexico
[5]Tuna Research and Conservation Center, Hopkins Marine Station, Stanford University, Pacific Grove, CA, USA

[1]Monterey Bay Aquarium, Monterey, CA, USA
Florida International University,
Department of Biological Sciences,
3000 NE 151st, North Miami, Florida 33181, USA

Pelagic marine teleosts often face tradeoffs between high energetic costs and sparse food sources. As such, several species are classified as "energy speculators," in which high energy requirements are hypothesized to bring even higher rates of return through high foraging and prey processing rates. Dolphinfish, *Coryphaena hippurus*, fit this description as they have high metabolic costs while displaying high growth rates. We coupled biologging with lab-based respirometry to simultaneously examine dolphinfish energy requirements and foraging behavior in the wild to determine strategies that enable these animals to survive as energy speculators. In September 2018 four dolphinfish were tagged off the coast of Baja California, Mexico, two with a biologging tag package (accelerometer/ magnetometer/ gyroscope/ depth/ temperature) and two with miniPATs as part of our developing field research program. Using prior estimates of routine metabolic rate (RMR) and temperature sensitivity (Q_{10}) we estimated field metabolic rates (FMR), based on temperature, for all four fish. Fish equipped with biologging packages (12 and 16 hr) had daily estimated FMRs of 224.7 ± 12.3 and 228.0 ± 5.9 mg O_2 kg^{-1} hr^{-1}, respectively, and exhibited diel patterns in dive behavior and activity. Fish equipped with miniPATs (16 and 67 d) had daily estimated FMRs of 317.9 ± 20.8 and 214.0 ± 9.2 mg O_2 kg^{-1} hr^{-1}, respectively. Future field and lab work will determine the relationship between activity and metabolic rate to generate more accurate measurements of field metabolic rates as well as behavioral search patterns used to locate prey. Energy requirements and foraging behavior will be related to consumption rates of two primary prey types; squid and sardines.

MATERNAL PROVISIONING GIVES YOUNG-OF-THE-YEAR HAMMERHEADS A HEAD START IN EARLY LIFE

Kady Lyons[1], Douglas H. Adams, Eric A. Reyier, Ashley S. Galloway, and Bryan S. Frazier

[1]Georgia Aquarium, Florida Fish and Wildlife Conservation Commission, Kennedy Space Center Ecological Program and Integrated Mission Support Services, South Carolina Department of Natural Resources

225 Baker St NW,
Atlanta, GA 30313

For species that do not provide parental care after birth, excess maternal provisioning during development beyond what is required for embryogenesis provides offspring with resources that may increase their chances of survival. Maternally-derived provisions, such as lipids, are expected to be important for buffering offspring against limited food resources or time needed to learn how to properly feed. Young-of-the-year (YOY) Scalloped Hammerheads (*Sphyrna lewini*) were sampled from two nurseries along the US Atlantic Coast and compared to near-term embryos collected from the same geographic region to make inferences on the reliance of maternal stores during early life. We found large declines in lipid content, corresponding to progression in umbilical scar healing (a proxy for time since birth), particularly during the period of time when scars were open to newly closed. In addition, while total body weight did not differ between YOYs and near-term embryos, the relative contribution of liver weight to total body weight was less in YOYs, highlighting the reliance on the liver as the energy storage organ in elasmobranchs. While the high metabolic rate of YOY *S. lewini* may shorten the period of time they can rely on maternal stores, the significant drop in lipid content and liver quality from near-term embryos to YOY sharks with newly closed scars indicates that this species heavily relies on maternal stores during early life. Therefore, access to high quality nursery habitat, with regards to food resources, may be an important factor for the survival of young *S. lewini* once they have depleted their maternal stores.

REVIEW OF RECENT RESEARCH ACTIVITIES FOCUSED ON YELLOWFIN TUNA (*Thunnus albacares*) AT THE IATTC'S ACHOTINES LABORATORY

[1]**Enrique Mauser**, [1]Dan Margulies, [1,2]Vernon Scholey, [2]Susana Cusatti, [1]Jeanne Wexler, [1]Maria Stein

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

[2]Inter-American Tropical Tuna Commission
Achotines Laboratory, Las Tablas,
Los Santos Province, Republic of Panama

The IATTC has been conducting research on the early life history and biology of tropical tunas at the Achotines laboratory in the Republic of Panama since 1986. Spawning from a population of yellowfin tuna (YFT) has taken place almost daily in the laboratory's land-based tank since 1996. Eggs and larvae collected from the broodstock tank are used to conduct biological and physical experiments aimed at gathering ecological information on early life history stages and pre-recruit survival. Recent research activities include modeling the results of earlier ocean acidification studies of early life stages, studies of density dependence in growth and survival of larvae, broodstock management, and formulated feeding trials with sub-adult YFT. Experimental investigations of the effects of ocean acidification (OA) on the eggs and larvae of yellowfin were conducted by the IATTC and collaborating scientists at the Achotines Laboratory in 2011. Study results summarizing OA effects on early-stage survival and growth and organ development were summarized in separate studies published in 2015 and 2016. Recent modeling studies conducted in 2017 and 2018 by members of our OA research team have utilized the experimental results of the studies at Achotines to predict future effects of OA on yellowfin larval survival in the Pacific Ocean. The predictions of larval survival were developed within the SEAPODYM model and included predictions based on scenarios of low, average and high-sensitivity of larvae to 50- to 100-year predicted changes in OA. The results of the modeling studies will be presented and discussed here.

Analysis of the stock-recruitment relationship of YFT by the IATTC's stock assessment group suggests that density dependence plays an important role in the pre-recruit survival of YFT. Our investigations on the early life stages indicate that fish density has a very significant effect on larval growth, and we are now shifting our focus to study density-dependent growth in the early-juvenile stages. These studies will be discussed.

YFT broodstock management at the Achotines laboratory has become a standard in the field of YFT husbandry and research. While our broodstock have spawned on a near-daily basis, there have been periods of spawning hiatus in which water temperatures decrease below a spawning minimum or the sex ratio of the broodstock group changes. In the past 1.5 years, there were no spawns from a small group of older, larger fish. In January of 2019, we introduced a new group of YFT into the main tank, and the fish resumed spawning in mid-April. Studies on formulated feed effects on growth and food conversion ratio (FCR) of sub-adult YFT are also ongoing by a collaborating research group.

DIFFERENTIAL USE OF FISH AGGREGATING DEVICES (FADS) BY RECREATIONAL, CHARTER, AND COMMERCIAL SECTORS AS DETERMINED THROUGH VESSEL FISHING TRIP HISTORIES AROUND PUERTO RICO

Wessley Merten[1], Roberto Rivera[2], Richard Appeldoorn[3],

[1] FAD Research Program, Beyond Our Shores, Inc. PO Box 662, Rockville, MD 20848
[2] College of Business, University of Puerto Rico, PO Box 9000, Mayagüez, PR 00681, USA
[3] Department of Marine Sciences, University of Puerto Rico, PO Box 9000, Mayagüez, PR 00681

Beyond Our Shores, Inc.
PO BOX 662
Rockville, MD, 20848

Open access moored fish aggregating devices (MFADs) have been consistently deployed by the Government of Puerto Rico since 2015 yet quantitative data on MFAD use and catch among recreational, charter, and commercial fishing sectors are lacking. Beginning in 2016, vessel tracking systems (VTS) were installed voluntarily on 25 vessels around Puerto Rico to gather daily fishing trip data. Following each trip, each vessel was surveyed to gather daily catch and trip related data. To date, 1,659 fishing trips have been logged between recreational, charter, and commercial fishing sectors with 75% from vessels operating near FADs (< 32 km). Individual vessel fishing trip histories provide detailed accounts of how vessel captains fish in the presence and absence of MFADs and lend insight into different dynamics between vessels and sectors as well as how geomorphology, seasonality, and weather may influence fishing patterns. Individual offshore charter vessels exhibit different fishing patterns when fishing near MFADs with multiple charters shifting fishing activity in response to the loss of MFADs nearest their port (< 8 km). Light-tackle nearshore charters shifted activity (up to 20.6% of charter days) from nearshore to offshore habitats when MFADs were near their port. While offshore one vessel caught dolphinfish and various billfish and tuna species; while inshore, 17 different species were caught but predominately tarpon, crevalle jack, and snook. Commercial vessels routinely visited the MFADs and exhibited seasonal changes in fishing methods to target other species away from the MFADs such as snappers. One commercial vessel frequently used live bait methods to target pelagic fish species at the MFADs while another preferred trolling ballyhoo. During some outings, commercial vessels targeted pelagic species at the MFADs, then shifted effort away and switched fishing methods to target demersal species. Monitored recreational vessels infrequently visited the MFADs with one vessel only traveling 31.2 km to fish a FAD once, despite having logged 137 offshore fishing trips. In the case of this vessel, and others monitored in the absence of MFADs, fishing trip histories set a baseline for comparative studies to assess changes in fishing dynamics in terms of catch, total distance covered, and time on the water as MFADs are deployed in their areas. These are key metrics that can be used to assess how MFADs influence fishing activity over different temporal and spatial scales, their impact on fishing trip catch, and performance as a fisheries management tool to increase fishing opportunities, catch, and shift fishing activity away from demersal and nearshore species toward pelagic species. Vessel fishing trip histories provide quantitative data to help guide MFAD management for a more sustainable network and placement of MFADs around Puerto Rico.

DOLPHINFISH RESEARCH PROGRAM: 17 YEARS OF COLLABORATIVE FISHERIES SCIENCE

Wessley Merten[1], Roberto Rivera[2], Jacob Latour[1], Richard Appeldoorn[3], Don Hammond[1]

[1] Dolphinfish Research Program, Beyond Our Shores, Inc. PO BOX 662, Rockville, MD, 20848
[2] College of Business, University of Puerto Rico, PO Box 9000, Mayagüez, PR 00681, USA
[3] Department of Marine Sciences, University of Puerto Rico, PO Box 9000, Mayagüez, PR 00681

[1]Beyond Our Shores, Inc.
PO BOX 662
Rockville, MD, 20848
Corresponding author: wess@beyondourshores.org

The Dolphinfish Research Program (DRP) has become the largest private research program aimed specifically at better understanding the movements, population dynamics, and life history of dolphinfish. Participants in the DRP are present in 25 countries and 43 states and represent the largest volunteer network to describe dolphinfish occurrence and movements. From 2002 to 2017, at least 1,313 captains, aboard 1,332 vessels, and more than 3,285 fishing mates, participated in the tag and release of over 23,174 dolphinfish around the world (U.S. East Coast: 87%, Bahamas: 5.6%; Caribbean Sea: 5.2%; Gulf of Mexico: 2.0%; Western Tropical Pacific: 0.1%; Eastern Tropical Pacific: 0.1%). Of those fish, 582 were recaptured, which amounts to the world's largest database on individual dolphinfish movements. In addition, the program deployed 26 satellite tags over this time period to describe dolphinfish habitat utilization and migration routes. In comparison to other marine offshore tagging programs, the DRP ranks 18th in terms of number of tag deployments. Currently, efforts are now focused on expanding this network and work into two locations: the Caribbean Sea and southwest Pacific Panama. Since 2008, 150 participants have tagged and released 742 dolphinfish and deployed 7 satellite and 9 acoustic tags in the U.S. Caribbean Sea, focused largely north of Puerto Rico and the United States Virgin Islands. These provided detailed accounts on movements in the tropical Atlantic Ocean but left movements within the Caribbean Sea largely unknown. The program is now focused on expanding data collection within the Caribbean Sea on an individual angler basis in Antigua, Guadeloupe, Barbados, the Cayman Islands, and Belize, with satellite tag deployments focused off southwest Puerto Rico. In the eastern tropical Pacific Ocean (ETP), sporadic tagging activity throughout the region over the history of the program has not led to enough data on movements until the program shifted effort to focus on program expansion to individual fishing lodges. The first lodge to participate is in southwest Panama, where 52 participants have tagged and released 368 dolphinfish and deployed 1 satellite tag since December 2018. This effort has led to the recovery of 9 dolphinfish in as little as three months of tagging activity. In contrast to the ETP, the lack of fishing lodges in the Caribbean Sea means expansion there is reliant on individual angler participation while in the ETP expansion is better focused on fishing lodges. Using both expansion techniques, the DRP intends to gather new data where information on movements, regional connectivity, and other important life history information remain unknown, information necessary to properly manage and conserve this species for future generations.

THE USE OF ELECTRONIC TECHNOLOGIES IN THE MANAGEMENT OF ATLANTIC HIGHLY MIGRATORY SPECIES

Ian Miller

NOAA Fisheries, Office of Sustainable Fisheries- Atlantic Highly Migratory species

1315 East-West Highway, Silver Spring MD

NOAA Fisheries Atlantic Highly Migratory Species Management Division is responsible for the management of sharks, tuna, and billfish species on the Atlantic seaboard, including the Gulf of Mexico and U.S. Caribbean. Emergent tools in the form of electronic technologies have become increasingly integral parts of the management of these species providing pathways for near real time quota management through the electronic dealer (eDealer) reporting system, which requires seafood dealers with HMS permits to submit weekly reports of their HMS purchases. Vessel monitoring systems have provided tracking tools for monitoring closed areas, while recently providing a tool for self-reporting of commercially landed bluefin tuna using a vessel monitoring system bluefin tuna set report. Electronic video monitoring has been implemented in the pelagic longline fleet as part of a catch share program referred to as the "individual bluefin quota" or "IBQ." Pelagic longline fisherman are required to have systems on their vessels that record haul back activity and submit that footage to HMS for review. Sets are reviewed for as part of an audit process to verify bluefin tuna bycatch. Additionally this video monitoring has been expanded to include verification of shortfin mako disposition, as a result of the recent shortfin mako fishery management plan amendment. Video monitoring exploration to include use of machine learning to increase review efficiency is underway, with a focus on compressing video, marking species of interest, and quality control functionality. These tools have led to more accurate management of Atlantic highly migratory species with a specific focus on the successful management of bluefin tuna as evidenced by the increase in western Atlantic bluefin total allowable catch by the International Commission for the Conservation of Atlantic Tunas.

NATAL ORIGIN AND LIFE HISTORY OF PACIFIC BLUEFIN TUNA REVEALED FROM OTOLITH CHEMISTY

John A. Mohan[1], R. J. David Wells[1,2], Jay R. Rooker[1,2], Nathan R. Miller[3], Yosuke Tanaka[4], Seiji Ohshimo[4,5], Heidi Dewar[6], Suzanne Kohin[6], Owyn E. Snodgrass[7]

[1] Texas A&M University at Galveston, Department of Marine Biology, 1001 Texas Clipper Rd., Galveston, TX 77553, USA
[2] Texas A&M University, Department of Wildlife & Fisheries Sciences, College Station, TX 77843, USA
[3] The University of Texas at Austin, Jackson School of Geosciences, 2275 Speedway Stop C9000, Austin, TX 78712, USA
[4] Pacific Bluefin Tuna Biology Group, Bluefin Tuna Resources Division, National Research Institute of Far Seas Fisheries, 5-7-1, Orido, Shimizu, Shizuoka, 424-8633, Japan
[5] Fisheries Management and Oceanography Division, Seikai National Fisheries Research Institute, 1551-8 Taira-machi, Nagasaki, 851-2213, Japan
[6] Southwest Fisheries Science Center, National Marine Fisheries Service, 8901 La Jolla Shores Dr., La Jolla, CA 92037, USA
[7] University of California – Santa Cruz, Ocean Sciences Department, Santa Cruz, CA, USA

Pacific bluefin tuna (PBT) exhibit complex life histories that include transoceanic migrations across the Pacific Ocean, which complicate international management of PBT populations. Spawning of PBT occurs in two discrete locations in the Western Pacific Ocean (WPO) including the East China Sea (ECS) and the Sea of Japan (SoJ). Age-0 PBT remain in waters around Japan, but at 1-2 years old, an unknown portion of fish migrate to the Eastern Pacific Ocean (EPO) where they often remain for several years during the juvenile life stage before returning to the WPO. Characterizing the natal origin of PBT captured in the EPO is important for determining population connectivity and understanding the factors that influence fish migration and recruitment from the two spawning grounds. In this study, PBT otolith chemistry was used to determine the natal source of age-1 recruits collected in the EPO. Otoliths of age-0 PBT collected from each spawning ground in the WPO were first used to characterize chemical signatures of individuals produced in each spawning area, which could accurately identify natal origin with 73-93 % classification success across four years (2014-2017). Otolith core chemistry of age-1 PBT collected in the EPO was then used to determine natal origin using mixed-stock analysis. The ECS spawning ground contributed more recruits in 2014 (69±19%) and 2016 (78±22%), slightly less recruits (43±20%) in 2017, and equal contribution from both ECS (49±20%) and SoJ (51±20%) in 2015 highlighting the importance of both spawning grounds to PBT in the EPO. Complete life history (otolith core to edge) profiles of large adult PBT (>180 cm FL) indicate fluctuations in barium may be related to exposure to upwelling or cold nutrient-rich deep water at older ages. These results demonstrate the utility of using otolith chemistry to investigate population dynamics of highly migratory PBT.

EVALUATING THE FORAGING ECOLOGY AND ENERGETICS OF ATLANTIC BLUEFIN TUNA (*Thunnus thynnus*) IN THE GULF OF MAINE

Sammi Nadeau, Walt Golet
University of Maine/Gulf of Maine Research Institute

350 Commercial Street
Portland, Maine, 04101

Atlantic Bluefin tuna (*Thunnus thynnus,* ABFT) have been a commercially and recreationally valuable species in the Gulf of Maine (GOM) since the 1950s. Over the past few decades, changes in abundance, spatial distribution, and physical condition of ABFT have shifted, possibly as a result of trophic changes including the composition, distribution, and condition of available prey. Historically, ABFT forage species such as Atlantic herring (*Clupea harengus*), Atlantic mackerel (*Scomber scombrus*), squid (Cephalopoda), and sand lance (*Ammodytes spp.*), have been the largest contributors to ABFT diet. In recent years, there has been an influx of Atlantic menhaden (*Brevoortia tyrannus*) in the Gulf of Maine including emergency allocations to the state of Maine to operate a commercial fishery. The current stock assessment for Atlantic herring, the dominant prey item for ABFT, suggests a reduction in spawning stock biomass and an overall decline in the population, which, given their contribution to historical ABFT diet and high energetic/lipid, may impact ABFT energetic condition and distribution. The recent presence of Atlantic menhaden and their high energetic/lipid content may provide an alternative prey resource for ABFT in the absence of their preferred prey, Atlantic herring. Given this information we evaluated whether a dietary shift in ABFT had occurred or, more specifically, whether Atlantic menhaden were consumed. Further, based on energetic contributions for a suite of prey items found in the stomach of ABFT we evaluated if higher quantities of alternative prey resources (specifically Atlantic menhaden) could fill the dietary role of Atlantic herring. To date, ~200 stomach samples have been analyzed. Preliminary results suggest frequency of occurrence was 86% for cephalopoda, 45% for Atlantic mackerel, 34% for Atlantic herring, 16% for river herring (Alewives (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*)), and 6.62% for Atlantic menhaden. These results suggest a dietary shift from previous studies, and while Atlantic menhaden were present, ABFT appear to have utilized an abundance of cephalopods in place of Atlantic herring.

OBTAINING BEHAVIORAL INFORMATION OF MIGRATORY FISH BY ACCELEROMETER-INTEGRATED GEOLOCATION TAG

Takuji Noda[1], Ko Fujioka[2], Ethan E. Estess[3], Alexander G. Norton[3], Charles J. Farwell[3], Takuya Koizumi[4], Takashi Kitagawa[5]

[1]Biosphere Informatics Lab, Graduate School of Informatics, Kyoto University

[2]National Research Institute of Far Seas Fisheries, Japan Fisheries Research and Education Agency

[3]Monterey Bay Aquarium

[4]Biologging Solutions Inc.

[5]Atmosphere and Ocean Research Institute, The University of Tokyo

In order to understand migration route of tunas, geolocation tag, which estimates latitude and longitude through the observation of light level of the sun, has been widely used. Geolocation tags are usually composed of a light, internal/external temperature, and depth sensors. On the other hand, accelerometer makes it possible to clarify detailed activities and movement of fish. However, in the past research, geolocation tag and accelerometer tag were often used separately, and both systems have not been used as an integrated system. Although it is possible to use both the geolocation tag and accelerometer tag on one fish, there are disadvantages in terms of the effect of tagging, recovery of tags, and time synchronization of data from different tags during data analysis. In this research, we have used a newly developed accelerometer-integrated geolocation tag which composed of an accelerometer as well as light, internal/external temperature, and depth sensors. In a tank experiment, the tag was implanted in the abdominal cavity of two juvenile yellowfin tunas *Thunnus albacares* (FL=87.5 and 89.5 cm), and the swimming of the tunas in the tank was monitored for a month. We have successfully obtained one-month acceleration data at the same time as depth, light level, abdominal cavity temperature and water temperature data. From the acceleration data, we were able to calculate activity level, body angle, and tail beat frequency. However, since we could not obtain the light level associated with sunrise and sunset inside the tank, we have also implanted the developed tag to the abdominal cavity of skipjack tunas *Katsuwonus pelamis* (FL=45.4±1.58 cm, N=17) at the ocean near Yonaguni islands of Japan and released to the natural environment. One fish was successfully recaptured, and we obtained light data of two months from a migratory fish. Sunrise and sunset times, and hence geolocation, were calculated from the light data, and we verified the geolocation system. The accelerometer-integrated geolocation tag evaluated in this research can not only grasp the migratory route but also detailed behavior such as activity and locomotion simultaneously.

TOWARDS IMPLEMENTATION OF A SAMPLING PROGRAM FOR SHARK FISHERIES IN CENTRAL AMERICA

Ricardo Oliveros-Ramos[1], Salvador Siu[1], Sonia Salaverria[1], José Miguel Carvajal[2,3], Cleridy E. Lennert-Cody[1], Alexandre Aires-da-Silva[1], Mark N. Maunder[1]

[1]Inter-American Tropical Tuna Commission . 8901 La Jolla Shores Dr, La Jolla, CA, USA, 92037
[2]Instituto Costarricense de Pesca y Acuicultura, Puntarenas, Costa Rica.
[3]Organización del Sector Pesquero y Acuícola del Istmo Centroamericano.

Under the Antigua Convention, developing stock assessments and providing management advice for some pelagic shark species in the eastern Pacific Ocean (EPO) is among the responsibilities of the Inter-American Tropical Tuna Commission (IATTC). Previous attempts to assess the status of pelagic sharks in the EPO, using conventional stock assessment models, have been severely hindered by major uncertainties in fishery catch data for longline fisheries of EPO coastal nations, particularly in Central America. To improve this situation, the IATTC staff obtained funding from the FAO-GEF Common Oceans program for Sustainable Management of Tuna Fisheries and Biodiversity Conservation in the Areas Beyond National Jurisdiction (ABNJ) to carry out a pilot data collection project for shark fisheries in Central America, in collaboration with the Organización del Sector Pesquero y Acuícola del Istmo Centroamericano (OSPESCA). The project focused on collection of data for estimation of: 1) total catch of artisanal fisheries, and 2) catch size composition for industrial longline fisheries. The data collected during this project were used, in combination with simulation approaches, to test the reliability and implementation trade-offs of several sampling designs for the shark fisheries in Central America. Lessons learned during the data collection phase of the project, as well as results from the sampling design simulations, are presented and discussed.

DOLPHINFISH BYCATCH DISTRIBUTION IN THE EASTERN PACIFIC OCEAN: AN ENVIRONMENTAL APPROACH

Sofia Ortega-Garcia[1], Raul O. Martínez-Rincón[2], Ruben Rodriguez-Sanchez[1], Hector Villalobos[1] and Michel Dreyfus

[1]Instituto Politécnico Nacional-CICIMAR. Av. IPN S/N Col. Playa Palo de Santa Rita. La Paz BCS. CP23096.COFAA fellowship.
[2]Centro de Investigaciones Biológicas del Noroeste, CONACYT, La Paz BCS
[3]Instituto Nacional de Pesca y Acuacultura-Ensenada, km 97.5 Carretera Tijuana-Ensenada, s/n, Col. El Sauzal de Rodríguez, CP 22760, Ensenada, Baja California, Mexico

Dolphinfish (*Coryphaena hippurus*) is a pelagic species that is ecologically and commercially important in the Eastern Pacific Ocean, where it is one of the most important species caught by recreational, artisanal, and as bycatch in longline and purse-seine fisheries. Considering that bycatch is a useful indicator of dolphinfish spatial distribution and variability, and that this species is the dominant non-tuna species under floating objects, in this study we used bycatch information on floating object sets of international purse-seine fleet that operated in the EPO during 1997-2017. Environmental data (sea surface temperature, chlorophyll-a concentration and sea surface height anomaly) derived from satellite images, and Oceanic El Niño Index (an indicator of ENSO event) were used as predictor variables. The total bycatch and average bycatch by fishing set were analyzed annually and seasonally using a one-degree latitude-longitude square resolution. To explore the relationship between catch rates and environmental preferences Generalized Additive Models were used. Significative interannual and seasonal variability were found. Using the general catch distribution pattern three important zones were found: 1) South of California Current, 2) waters offshore Central Tropical Pacific (-2°S - 12°N), and 3) Northwest of the Humboldt Current, which is the most important. Thus, three different models were applied using data of the main areas as reference in order to determine the preference habitat. Environmental preferences of the species change apparently related to size distribution.

SPATIO-TEMPORAL VARIATION OF INCIDENTAL CATCHES OF DOLPHINFISH (*Coryphaena hippurus*) IN THE CENTRAL MEXICAN PACIFIC

Heriberto Santana-Hernández[1], **Sofia Ortega-Garcia**[2], Juan Javier Valdez-Flores[1]

[1]INAPESCA-CRIP-Manzanillo
[2]Instituto Politecnico Nacional-Centro Interdisciplinario de Ciencias Marinas. COFAA fellowship.

The dolphinfish (*Coryphaena hippurus*) represents an important incidental species in catches of medium size longline vessels that operate with shark permits and are based on the Port of Manzanillo Colima, Mexico. From the analysis of catch and size recorded during fishing operations of this fleet from 2003-2017, interannual and seasonal variability, spatial-temporal catch and size (furcal length) distribution, as well as sex proportion were determined. A total of 1839 males and 1578 females were recorded. Interannual and seasonal variability was significant in both catches and catch per unit effort (number of organisms/1000 hooks). The maximum average catch per unit effort was recorded during last quarter and during 2012. Spatially, the quadrant with position 104.5° W 17.5° N recorded the highest value. The intra-annual and interannual size variations were significant. In general, 52% of the males were greater than 110 cm while only 24% were in females. For an average year, sex ratio (female:male) was significantly different throughout the year with males predominating except for September and December when the average values were 1.13 and 1.45, respectively.

DOLPHINFISH (*Coryphaena hippurus*) OTOLITHS CHEMISTRY ANALYSIS AS A TOOL AS A STOCK DISCRIMINATION

Vanessa Georgina Pelayo-González[1], Sofía Ortega-García[1], Luis Lartuno-Rojas[2], Jose Miguel Carbajal[3], Jimmy Martínez[4] (†), Angel Humberto Ruvalcaba-Díaz[1]

[1]Instituto Politécnico Nacional- Centro Interdisciplinario de Ciencias Marinas. Av.Instituto Politécnico Nacional s/n Col. Playa Palo de Santa Rita. C.P. 23096 La Paz, Baja California Sur. México

[2]Instituto Politécnico Nacional- Centro de Nanociencias y Micro-nanotecnología. Av. Luis Enrique Erro s/n, Nueva Industrial Vallejo, 07738 Ciudad de México, CDMX

[3]Instituto Costarricense de Pesca y Acuacultura. Puntarenas, Costa Rica

[4]Word Wildlife Foundation (WWF-Ecuador). Ciudadela Los Almendros, Manzana K, Villa 18. po-box 09-01-8993 Guayaquil-Ecuador

Dolphinfish (*Coryphaena hippurus*) is an epipelagic species which inhabits tropical and subtropical waters of the Atlantic, Pacific and Indian Oceans, from 41° N to 35° S, where it is limited by the isotherm of 20°C. Since this species is considered in high market demand, stock management is complicated by limited information concerning stock identification, population abundance and the degree to which the stocks mix regionally. Stock is a population unit for a specific management purpose in the fisheries practices. Recently an estimation of the chemical composition of otoliths of fish was developed as a tool to recognize of characteristic natural markers and stock identification. The otoliths are found in the vestibular apparatus of the ear of the fish and are composed 99% of calcium carbonate ($CaCO_3$). However, a small percentage of trace elements remains in their matrix, which are used as environmental markers. The core of otoliths is the most analyzed region for stocks discrimination, because it is created in the first stages of life, and in this way the concentration of certain elements and isotopes serves as a chemical fingerprint, which is characteristic of the environment where these stages were developed. Using this property to identify stocks of dolphinfish, we employed the techniques of X-ray Induced Electron Spectroscopy (XPS) and Stable Isotope Mass Spectrometry on sagitta otolith cores collected from three different regions in the eastern Pacific Ocean and one from the Atlantic Ocean, The elements Ca, Mg, Sr, P, S, Na and Si were quantified, as well as the isotopes of ^{13}C and ^{18}O. MANOVA analysis indicated significant differences between sampling areas, whereas Ecuador presented the greatest discrepancy. The discriminant analysis showed that the elements Mg, Na and Si, as well as the isotopes of ^{18}O were decisive for the segregation of the geographic groups analyzed, with 96% correct classification. Results suggest there is variability in the chemical composition associated with the geographic location of the dolphinfish landings. This may be attributed to stock identification within the Eastern Pacific Ocean.

IMPROVING HIGHLY MIGRATORY SPECIES DATA USING THE EASTERN PACIFIC HIGHLY MIGRATORY SPECIES PROFESSIONAL SPECIALTY GROUP

John Childers[1], Craig D'Angelo[2], Taylor Debevec[2], Yuhong Gu[1], Elizabeth Hellmers[3], **Shannon Penna**[2], Bob Ryznar[4], Jacob Smith[1], Will Stahnke[2], Jenny Suter[4], Jody van Niekerk[2], Charles Villafana[2]

[1] Southwest Fisheries Science Center
[2] National Marine Fisheries Service (NMFS), West Coast Region
[3] California Department of Fish and Wildlife
[4] Pacific States Marine Fisheries Commission

501 W. Ocean Blvd., Suite 4200
Long Beach, CA 90802

The Eastern Pacific Highly Migratory Species (HMS) Professional Specialty Group (EP PSG) was developed to improve West Coast HMS fisheries data for accuracy, standardization, and utilization. Consisting of a team of data managers, project leads, and policy liaisons, the EP PSG is a subgroup of a larger group which also includes representatives from the NMFS Pacific Island Regional Office and Pacific Islands Fisheries Science Center. The EP PSG uses Pacific HMS fisheries data collected through several sources to develop an integrated and accessible Pacific HMS data system; create an agile, and responsive HMS data governance program; and automation of standardized reports. These data sources include logbooks, vessel monitoring systems, observer data, landing receipts, and fishing permits. The EP PSG is able to use these sources to make high quality West Coast data available through database integration and automated processing. In addition, the same results are able to be provided to end users through a centralized HMS data repository. These data are ultimately made available to all users in their preferred format (i.e. SQL database, web-based tools, automated reports, or CSV files). This collaboration has been able to continuously improve the provision of holistic fishery information management services to customers and stakeholders, from data collection, through integration, to reporting services.

CHANGES IN THE DYNAMICS OF THE EPO TUNA PURSE-SEINE FAD FISHERY

Marlon H. Román, Jon López, Cleridy E. Lennert-Cody

Inter-American Tropical Tuna Commission, La Jolla, CA
8901 La Jolla Shores Dr,
La Jolla, CA, USA, 92037

FAD technology has been rapidly evolving in the last decade, potentially changing the dynamics and strategies of FAD fisheries worldwide. Understanding the effects of technological advances on fleet behavior may lead to better management of FAD fisheries. Because of the high level of onboard observer coverage of large purse-seine vessels in the eastern Pacific Ocean (EPO) tuna purse-seine fishery, and the detailed data collected by these observers, potential effects of evolving FAD technology can be studied. In this presentation, FAD fishing activities and strategies, by different time blocks during 2007 to 2017, are compared to explore the evolution of fleet behavior and to assess their effect on the dynamics of the EPO tuna purse-seine FAD fishery.

BYCATCHES OF THE PELAGIC STINGRAY *Pteroplatytrygon violacea* IN THE TUNA PURSE-SEINE FISHERY OF THE EPO.

Andrés Romero[1], Marlon H Román[1], Nerea Lezama[1-2], Jon Lopez[1] and Martin Hall[1]

[1]Inter-American Tropical Tuna Commission. 8901 La Jolla Shores Dr. La Jolla, CA 92037 USA
[2]AZTI Foundation

The pelagic stingray (*Pteroplatytrygon violacea*) is distributed in temperate and tropical waters and is the only known dasyatid to inhabit epipelagic waters. Little is known regarding the ecology of this species and limited information exists about its life history parameters. It is captured as bycatch species in purse seine and longline fisheries around the world where it has no commercial value and is usually discarded. For this presentation we analyzed the spatial distribution of the bycatches and other biological data of the pelagic stingray recorded by observers onboard purse seine vessels in the Eastern Pacific Ocean during 2000-2017. During this period a total of 6, 026 pelagic stingrays were caught. They were present in the three set types made by the purse seine fleet (DEL=dolphin associated, NOA=non-associated or school sets, and OBJ=floating objects sets on encountered or deployed drifting objects). Eighty % of the catches came from DEL and OBJ sets, being slightly higher in the dolphin associated fishery. The distribution and abundance of bycatches coincides with the fishing effort (number of sets) and in the case of DEL sets they were concentrated in waters close to the coast north of 5^0 N latitude. The majority of OBJ sets with this species were made in the Equatorial region, west of 90^0 W. The size distributions available from 2016 for sexes combined showed a size range between 10 and 89 cm disc width (DW) with the highest frequency between 30 and 49 cm DW, and the number of stingrays caught per set range between 1 and 80 being one ray the most common bycatch.

STOCK SPECIFIC GROWTH PATTERNS OF ATLANTIC BLUEFIN TUNA (*Thunnus Thynnus*) USING OTOLITH INCREMENT ANALYSIS

Brenda Rudnicky, Drew Shane, Zach Whitener, Lisa Kerr, and Walt Golet
University of Maine Graduate School, Department of Marine Sciences

350 Commercial Street
Portland, ME 04101

The Atlantic bluefin tuna (*Thunnus thynnus;* ABFT) is a long lived, highly migratory species distributed throughout temperate latitudes from June through November on the northwest Atlantic shelf. Commercial fisheries have exploited these assemblages for six decades and yet many aspects of life history remain unresolved, including stock specific growth. The International Commission for the Conservation of Atlantic Tunas (ICCAT) assesses and manages ABFT as two stocks, eastern and western, classified by their spawning grounds in the Gulf of Mexico and Mediterranean Sea, respectively. In this study, otolith increment analysis was used as an estimation method for stock specific growth. Otoliths were collected from ABFT landed in the Gulf of Maine commercial fishery from 2010-2013. A total of 105 samples were assigned a stock origin using otolith microchemistry analysis ($\delta^{13}C$ and $\delta^{18}O$) and the ICCAT accepted discrimination thresholds (>70% certainty is eastern, <30% is western). Subsequently, each sample was aged and assigned to a cohort based on the estimated birth year. Incremental measurements were taken for all 105 otoliths using ZenPro software and analyzed using a linear mixed model with repeated measures. For the first two years of life, eastern and western ABFT have significantly different growth patterns, with a cohort effect in year two. Growth patterns in year three and beyond exhibit no difference in growth between stocks or between cohorts. This information provides insight into the uncertainty of stock specific growth for ABFT, and could potentially be used as an additional tool for stock discrimination in future research.

WHY TAG A CAPTIVE FISH? EVALUATING HABITAT UTILIZATION, MIGRATION PATTERNS, AND SPAWNING BEHAVIOR IN MAHI-MAHI USING POP-UP SATELLITE ARCHIVAL TAGS

Schlenker, Lela S[1], Stieglitz, JD[1], Hoenig, RH[1], Faillettaz, R[1], Babcock, EA[1], Lam, CH[2], Benetti, DD[1], Paris, CB[1], Grosell, M[1]

[1]University of Miami, Rosenstiel School of Marine and Atmospheric Science
[2]University of Massachusetts, Boston

4600 Rickenbacker Causeway Miami, FL 33149

Mahi-mahi (*Coryphaena hippurus*) is a highly migratory ecologically and commercially important pelagic fish species that inhabit tropical and sub-tropical waters around the world. As a high-performance fish, the ecology of mahi-mahi is tied to their vertical dives and migrations; however, these remain understudied. In the Western Atlantic, while the assumption is that mahi-mahi are a sustainable fishery, the only stock assessment performed was unofficial and largely inconclusive. In order to ensure the sustainable management of this charismatic and economically important species, it is critical to expand our understanding of the migrations and spawning behavior of the population.

To better understand habitat utilization, migration, and spawning behavior in wild mahi-mahi, we used Wildlife Computers pop-up satellite archival tags (PSATs) to measure acceleration, depth, temperature, and light levels for geo-location modeling. To predict spawning events, we tagged three sets of wild-caught captive mahi-mahi male and female pairs with PSATs and observed them in a 30,000 L tank. The three trials were conducted cumulatively over five weeks and include data from 32 spawning events. Working collaboratively with Wildlife Computers, we established a summary statistic of the raw acceleration data that could be reliably transmitted over the Argos satellite system. Using the observed time of spawning from our captive pairs and the summary statistic of the acceleration data, we developed separate male and female boosted regression tree models to use on transmitted PSAT data from wild mahi-mahi to predict wild spawning events.

We followed the captive-based tagging experiments with the deployment of 19 PSATs on wild mahi-mahi in the Florida straits (n=17) and the Gulf of Mexico (n=2). Wild mahi-mahi tagged in the Florida straits generally migrated north and eastward moving up to 100 km per day, while mahi-mahi in the Gulf of Mexico remained in the Gulf for the duration of the tagging period. Overall, mahi-mahi inhabited water temperatures between 31 and 17 °C, explored depths from the surface to 250 m, and spent equivalent time at depth during night and day.

Spawning models were applied to PSAT data from wild mahi-mahi and the depths, temperatures, and locations associated with the potential spawning and non-spawning events were extracted. We found a significant difference in the median depth of predicted spawning and non-spawning mahi-mahi ($p<0.05$) with a median spawning depth of 13.7 meters (11.8 m for females and 16.3 m for males; $p>0.05$) and a median depth for non-spawning periods of 1.04 meters (0.96 m for females and 1.08 m for males). No differences were observed in median temperature between predicted spawning and non-spawning mahi-mahi; however, during predicted non-spawning periods we identified a significant difference in median temperature between males and females ($p<0.05$), but predicted spawning males and females were in water masses of the same temperature ($p>0.05$). These data are the first to predict spawning of a wild marine teleost from accelerometry data and add critical information about the vertical and horizontal migrations to our understanding of the ecology of mahi-mahi.

This research was made possible by a grant from The Gulf of Mexico Research Initiative. Grant No: SA-1520; Name: RECOVER.

THE IATTC OBSERVER PROGRAM: 40 YEARS OF SCIENCE AND MANAGEMENT

Michael D. Scott, Martin A. Hall, Ernesto A. Altamirano, Enrique Urena, Marlon H Román, Jorge Parraga, Brad A. Wiley, Andrés F. Romero Caicedo

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

This year marks the 40th anniversary of the IATTC observer program. When the IATTC Tuna-Dolphin Program began in 1979, one of its first goals was set up an observer program to monitor dolphin mortality and collect fishery-related and biological information. The US NMFS had been monitoring its fleet since 1972, so one task was to set up a comparable program to share the monitoring of the US tuna purse-seine fleet. A larger task was to build from scratch an international observer program. This took years and involved recruiting and training potential observers throughout Latin America, revising and translating training materials and forms into Spanish, setting up the field offices and infrastructure in Latin American ports to support the observers, and getting buy-in from countries and owners to voluntarily place the observers aboard their vessels. This last task proved slow and arduous, but by 1986 observers were being placed aboard all countries of the international fleet with a goal of 33% coverage of each fleet. As more US vessels became based in Latin America, the responsibility for monitoring them was transferred to the IATTC.

A series of international agreements during the early 1990's culminated in the Agreement for the International Dolphin Conservation Program (AIDCP) which produced dramatic changes in the management of dolphin bycatch and our observer program. Taking observers aboard was no longer voluntary, and observer coverage was 100%. This not only required a surge in the training of new observers but sharing our methods with the staffs of new national observer programs that were springing up in Latin American countries. Dolphin Mortality Limits were instituted on each vessel which created a new law enforcement role for the observers. This put the IATTC in an unfamiliar role. International agreements and subsequent resolutions imposed new rules that vessel owners and fishermen needed to follow, and our observers became responsible for recording those infractions. This policing role added new tensions between the crews and the observers and between the fleets and the Commission. Infractions are reviewed by the International Review Panel (IRP) whose membership includes not only country representatives of both industry and conservation groups. This transparency was innovative at the time but required to maintain the integrity of the program. However, the IATTC has no enforcement power so the IRP's findings must be passed on to the vessels' countries for adjudication and penalties.

The observers originally recorded dolphin mortality and information on vessel movements and set operations, but their duties have greatly expanded over time. They have sampled dolphins and tunas for life history studies, assisted in mortality-reduction gear evaluation and enforcement, expanded their bycatch monitoring to species other than dolphins and to sets on schoolfish, floating objects, and Fish Aggregating Devices, and monitored compliance with IATTC and AIDCP resolutions.

In our 40 years of operation we have seen our program grow from sampling a U.S.-dominant fleet to monitoring every vessel of the international high-seas fleet. We have seen dolphin mortality decline dramatically from 130,000 dolphins in 1986 to less than 1000 for the past 24 years. Our observers' workload has increased steadily however as more and more scientific, management, and enforcement information is collected. Throughout these 40 years however, the observers have remained the central to the two-way passage of information between the fishermen and the fishery, and the scientists and the managers.

PHYSIOLOGICAL SPECIALIZATION FOR ELEVATING THE TEMPERATURE OF RED MUSCLE IN SWORDFISH

Chugey Sepulveda[1*]; Scott Aalbers[1], Michael S. Wang[1]; Diego Bernal[2]; Ashley Stoehr[2] and Mark Okihiro[3]

[1]Pfleger Institute of Environmental Research, PIER, Oceanside CA
[2]University of Massachusetts Dartmouth, Dartmouth, MA
[3]California Department of Fish and Wildlife; Vista CA

* PIER, 315 Harbor Dr. S., Oceanside CA, 92054

This study reports on the morphology and circulatory specializations associated with red aerobic swimming musculature (RM) of swordfish (*Xiphias gladius*). Detailed specimen dissections were directed at documenting RM distribution, identifying circulatory pathways to and from RM, and identifying the presence of putative retia (central and peripheral) associated with RM. The longitudinal distribution of swordfish RM was found to be anteriorly shifted with maximal concentration at around 55% FL. Dissection of RM and associated vasculature identified two separate but overlapping major circulatory pathways, peripheral and central. The peripheral circulation was centered around paired left and right lateral arteries and veins, extending the full length of the body. Lateral arteries were found to originate from the proximal dorsal aorta, adjacent to the branchial cavity. The central circulation originated from the distal dorsal aorta, travelling posteriorly through the kidney, ventral to the spine, until reaching the peduncle. The peripheral and central vascular systems appear to be linked together via laterally branching segmental arteries, extending between the dorsal aorta and lateral arteries. Paired segmental arteries, arising from the dorsal aorta, were found for each vertebral body from vertebra 2 to vertebra 24. Both lateral and central circulations were found to have putative counter current retia located proximal to the RM interface. Extensive, highly branching retia were comprised of densely packed arterioles and venioles similar to those described in the heat exchange systems of tunas and other regional endotherms. *In-vivo* temperature measurements of the RM and surrounding environment confirm that swordfish are capable of elevating the temperature of their RM above that of the surrounding water. This study confirms the presence of circulatory specialization associated with RM endothermy in the swordfish and validates previous hypotheses regarding temperature elevation in this species.

TRANSLATING INTERNATIONAL STOCK ASSESSMENTS INTO U.S. DOMESTIC STATUS DETERMINATIONS, OR ADVENTURES IN POUNDING A SQUARE PEG INTO A ROUND HOLE

Sarah Shoffler

NOAA Southwest Fisheries Science Center, Amber Rhodes, NOAA West Coast Region and Steven Teo, Southwest Fisheries Science Center

NOAA Fisheries Service
Southwest Fisheries Science Center
8901 La Jolla Shores Dr.
La Jolla, CA 92037

US National Standard 1 guidelines provide technical guidance for how NOAA will determine stock status for highly migratory and other fished species. A key piece of this guidance includes specifying status determination criteria (SDCs) and updating values through domestic management processes, such as approval by a Regional Fishery Management Council. However, these tasks are complicated when a stock is managed by an international regional fishery management organization (RFMO). A RFMO may use different SDCs from NOAA or Councils, or not use SDCs at all. This has given rise to situations when a stock was considered overfished by the RFMO but not overfished when US domestic SDCs were used, or vice versa. Stock assessments from RFMOs also may not contain the information required to make a status determination according to domestic criteria. These issues confuse the process of communicating stock assessment results and making clear status determinations and recommendations. Recently, NOAA revised National Standard 1 guidelines and approved an amendment to the Fishery Management Plan for U.S. West Coast Highly Migratory Species to better integrate international and domestic processes for determining stock status. These updates have alleviated the need to pound the square pegs of international stock assessments into the round holes outlined in guidelines for domestic fishery management policy.

RECREATIONAL FISHERIES DATA COLLECTION FOR TUNAS LED BY THE SPORTFISHING ASSOCIATION OF CALIFORNIA (SAC)

Alayna Siddall[1], John Childers[2], Lyall Bellquist[3], Steve Crooke[4]
[1]Sportfishing Association of California
[2] NOAA Southwest Fisheries Science Center
[3]The Nature Conservancy
[4]Sportfishing Association of California

Founded in 1972, the Sportfishing Association of California (SAC) is a non-profit organization that represents the Commercial Passenger Fishing Vessel (CPFV) fleet in southern California. SAC has developed multiple collaborative programs with state and federal fisheries managers to fill data gaps that are critical for effective management of local fisheries. In 2014, SAC developed a collaborative program approved by both NOAA and the California Department of Fish and Wildlife (CDFW) to collect size structure data at-sea for all locally caught tuna species. Prior to our program, tuna catch data were collected solely from long-range CPFVs, which yielded biased estimates of size structure within the overall CPFV fishery. In the case of Pacific Bluefin Tuna (PBT), only 30% of landings are reflected in long-range trips. Virtually no data were being collected from medium-range trips (1-3 days) that account for the remaining 70% because the majority of these fish are filleted at sea. These medium-range trips historically caught smaller fish in greater numbers, although the 2015-2018 seasons contained anomalously large size classes. Since 2014, CPFV Captains and crewmembers have collected over 6969 records for 4 tuna species: Pacific Bluefin, Yellowfin, Bigeye, and skipjack. Size structure information shows multiple age classes of each species reflected in landings. These data were processed for quality control and provided to NOAA to incorporate into future stock assessments. This collaborative project indicates that SAC and the CPFV fleet can provide quantitative data that are valuable for informing fisheries management decisions.

PARTNERING ONSHORE DATA-COLLECTION EFFORTS TO IMPROVE STOCK STRUCTURE INFORMATION ON BIGEYE TUNA AND OPAH

Owyn Snodgrass[1,2], Heidi Dewar[2], Dave Rudie[3], Mark Helvey[4], Gerard Dinardo[2]

Institute of Marine Sciences- University of California Santa Cruz[1]
NMFS NOAA Fisheries[2]
Catalina Offshore Products[3]
California Pelagic Fisheries Association[4]

Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, CA 92037 USA

In collaboration with California Pelagic Fisheries Association (CPFA) and Catalina Offshore Products (COP), the SWFSC has been conducting a sampling program to collect data and biological samples needed for the management of Bigeye Tuna (BET, *Thunnus obesus*) and Opah (*Lampris incognitus)* in the eastern North Pacific. BET in the Pacific Ocean were originally believed to be a single stock. More recent evidence indicates considerable longitudinal separation suggesting that there may be as many as 9 putative stocks in the Pacific, which has obvious implications for management. Opah landings to the U.S. West Coast have increased. Opah is currently not actively managed domestically or internationally and consequently limited information is available on their basic biology. A further complication has been the recent identification of small-eye opah as a cryptic species in the eastern North Pacific All previous data collected were assumed to be for only one species rather than two. Consequently basic life history information needed for stock assessments is not available.

The sampling program is designed to fill these data gaps for the two species. Sampling collection began in November of 2017. After fish are offloaded at the COP in San Diego, a technician records fork length, weight, and collects samples. Vessel and landing date are also recorded so data can be linked to a fishing region. Additional Opah are sampled from the CA drift gillnet fishery (CA DGN) when available. Each month length, weight, and genetic samples are taken from 50 BET and 50 Opah. Additional biological samples are taken from 15-20 Opah including hard parts, stomach contents and gonads.

For BET, we have collected data and genetic samples from 761 fish. This provides information on catch composition and these data can be used to better understand stock structure.

For Opah, 791 fish have been sampled, with biological samples taken from 167. The analyses of biological samples are ongoing. Preliminary results into the reproductive biology identified actively spawning individuals in the winter months, based both on examination of eggs and gonad weight. Additional sample collection and histological analyses are underway. Efforts to age opah are hampered by the fact that their otoliths are made of vaterite. Aging efforts to date reveal that the scales are not a good candidate for aging and lack a consistent banding pattern. There appears to be some banding in the vertebrae and fin spines and efforts are ongoing to determine which hard part is the best candidate for aging.

DOLPHINFISH DIVING AND MIGRATORY BEHAVIOR IN THE EASTERN TROPICAL PACIFIC

Stephanie Snyder[1], Christopher Perle[2], Sofia Ortega-García[3], Ruben Rodríguez-Sánchez[3], Wessley Merten[4], John O'Sullivan[5]

[1]Department of Biological Sciences, Thomas More University
[2]Biomedical Sciences Department, Florida State College at Jacksonville
[3]Instituto Politécnico Nacional- Centro Interdisciplinario de Ciencias Marinas.
[4]Dolphinfish Research Program, Beyond Our Shores, Inc.
[5]Monterey Bay Aquarium Research Institute

[1]Thomas More University
333 Thomas More Parkway
Crestview Hills, KY 41017

Dolphinfish, *Coryphaena hippurus*, are fast-swimming, predatory fish capable of long migrations through fishery areas over short time periods. This behavior – combined with their global subtropical to tropical distribution, high growth rates and early maturation age – makes dolphinfish an important recreational and commercial fish worldwide. Yet, the majority of studies on dolphinfish use catch data – rather than behavioral data – to gain insight into dolphinfish habitat use. This study uses fisheries independent electronic tagging in conjunction with fisheries dependent conventional tags to explore the diving and migratory behavior of dolphinfish throughout the ETP. Beginning in 2010, mature dolphinfish (fork lengths between 82 cm and 129 cm) were tagged with conventional (n = 132 tags) and electronic tags (n = 30 tags, miniPAT and mrPAT) off the coast of Baja California Sur and Chiapas. Total recapture rate for conventional tags was 3.8%, but was approximately 5 times greater in males (6.9%), than females (1.4%). Electronic tagging data was received for 15 tags, with times at liberty ranging from 3 to 74 days (28 ± 22 days). The average home range (spatial extent of habitat) for the six fish with deployments longer than 30 days was 23,260 km^2 (minimum and maximum areas of approximately 12,000 and 41,000 km^2, respectively). Estimated sustained swimming speeds (distance per time at liberty) ranged from .2 body lengths per second to 1 body length per second (0.49 ± 0.24 body lengths per second). Dolphinfish occupied both shallow and midwater marine environments, with diurnal diving behavior observed solely in 2013. Ongoing work is investigating seasonal movements and habitat use in the region, which are particularly important to understand as they influence stock structure and resource availability.

MAHI-MAHI (*Coryphaena hippurus*) AS A MODEL SPECIES FOR IMPACT ASSESSMENT IN APEX PELAGIC PREDATORY SPECIES

John D. Stieglitz, Ronald H. Hoenig Jr., Rachael M. Heuer, Daniel D. Benetti, and Martin Grosell

University of Miami, Rosenstiel School of Marine and Atmospheric Science, 4600 Rickenbacker Causeway, Miami, FL 33149

The pelagic environment of the world's oceans faces increased challenges of both natural and anthropogenic origins. Impacts from climate change, fishing pressure, and pollution, among many others, while well documented on species in coastal nearshore environments are less so for species that inhabit the pelagic environment. Given the economic and ecological importance of mahi-mahi (*Coryphaena hippurus*), as well as its ability to be maintained and reproduced in captivity, makes this species a prime candidate for assessing the impacts of natural and anthropogenic environmental challenges to pelagic fish species. Following the *Deepwater Horizon* oil spill in the Gulf of Mexico in 2010 the University of Miami has maintained a captive population of mahi-mahi allowing for unprecedented research on nearly all levels of biological organization in this species, from molecular research to population dynamics using a variety of existing and emergent data collection tools. A summary of some of the key research findings will be presented, as well as a discussion on how such results may inform future work with this species and other pelagic fish. As with other valuable pelagic fish species, mahi-mahi not only play the role of a high-performance predatory fish species but also serve as a popular prey item for other pelagic predators. Furthermore, the species is targeted circum-globally wherever it is found in abundance by commercial and recreational fishing industries. With a rapid growth rate from egg to market size and an existing global market presence, the aquaculture potential of the species is well-known. Recent advancements have been made in developing this species further for commercial-scale aquaculture. These same advancements have enabled data collection on this species throughout its lifecycle providing novel insights on impacts of stressors on this species. Given the importance of the mahi fishery on a global scale, understanding the biological and physiological potential, as well as the constraints, of this species are key to sustainable management of this species throughout the world. This research was made possible by a grant from The Gulf of Mexico Research Initiative. Grant No: SA-1520; Name: Relationship of Effects of Cardiac Outcomes in fish for Validation of Ecological Risk (RECOVER).

BREAKING THE SILOS: INTEGRATING SPATIALLY-EXPLICIT ENVIRONMENTAL AND FISHERY-DEPENDENT DATASETS. A CASE STUDY FOR THE LARGE-MESH DRIFT GILLNET FISHERY TARGETING SWORDFISH

Jenny Suter[1], Rob Ames[1], Brett Holycross[1], Rick Pannell[2], Craig D'Angelo[3], Charles Villafana[3], Jody Van Niekerk[1], Dan Lawson[3], Elizabeth Hellmers[4], Jordan T. Watson[5], Robert Ryznar[1],Camille Kohler[6], Robert Nigh[6]

[1]Pacific States Marine Fisheries Commission, 205 SE Spokane St. Suite 100, Portland, OR 97202, USA
[2]Resource Data , Inc. Portland, OR, USA
[3]NOAA West Coast Regional Office, Long Beach, CA, USA
[4]California Department of Fish and Wildlife, La Jolla, CA, USA
[5]Alaska Fisheries Science Center, Juneau, AK, USA
[6]neXus Data Solutions, Anchorage, AK, USA

Integrating disparate fisheries data is the goal of many fisheries managers, however complications arise due to data being owned and or managed by or within independent government agencies ('silos'). Fishery-dependent data collected for west coast highly migratory species (HMS) may include vessel logbooks (State or Federal), on-board observer records (Federal), landings sale receipts (State), spatial and temporal positions from vessel monitoring systems (VMS, Federal), vessel identifiers, characteristics, and ownership from national permits and Coast Guard databases (Federal), and biological data collected from port sampling programs (State or Federal). Recently, HMS logbook and observer data were migrated to the data warehouse at the Pacific Fisheries Information Network (PacFIN), where they were restructured and standardized. PacFIN houses landings data for the west coast and has data sharing agreements to access the National Permit System, Coast Guard, and VMS data. PacFIN has the technical expertise to build comprehensive integrated data systems linking fishery-dependent data to readily available spatially-explicit environmental datasets. The goal is to implement automated data integration protocols to build comprehensive datasets available to fisheries researchers and managers.

Recent collaboration between state, federal, and PacFIN partners aimed to integrate these data streams for the large-mesh drift gillnet fishery that targets swordfish off the U.S. west coast. The initial step was to derive, from the VMS data, a suite of potentially informative fields, such as vessel activity (in port, at sea, depart port, arrive port), distance from shore, distance and time between pings (and a moving average of those), then to integrate temperature and depth data. Individual vessel trips were defined by matching landings, observer, and logbook data temporally to the VMS data. Additionally, machine learning algorithms were trained on the observed data, then applied to the unobserved data to estimate when vessels were fishing. Finally, with a suite of metrics about both observed and unobserved trips, such as trip length, trip distance, number of sets, total catch, average depth and temperature, the spatial behaviors of the fleet were analyzed.

FISHERIES IMPLICATIONS OF NICHE OVERLAP BETWEEN BLUE SHARK (PRIONACE GLAUCA), AND SHORTFIN MAKO SHARK (*Isurus oxyrinchus*) IN THE SOUTHERN CALIFORNIA BIGHT

Thompson Banez

Scripps Institution of Oceanography, University of California San Diego, La Jolla, California 92093-0218, USA

Both blue sharks and short fin makos coexist in the Southern California Bight (SCB) as exemplified in the interactions with the west coast gillnet fishery; however, they have significant physiological differences. The shortfin mako is an endothermic fish that can tolerate deep, cooler water, at the cost of requiring additional oxygen to maintain high metabolic rates. Conversely, the blue shark is an ectothermic fish likely limited more by the cooler, deeper water and has a higher tolerance to low oxygen environments. Climate change may further effect their distribution with increasing sea surface temperatures (SST) expanding their horizontal ranges, whereas the shoaling oxygen minimum zone in the SCB could influence their vertical movements. Additionally, diet data from the California Current suggests significant differences in their feeding ecology, providing further evidence for separate essential habitats. Historically, movements of blue sharks and shortfin makos in the SCB has been collected from fisheries dependent data sets relying on conventional tag and recapture techniques, which is biased to the locations frequented by commercial fisheries, where the sharks are tightly associated. The current study utilizes high resolution telemetry data from electronically tagged blue and shortfin mako sharks to document essential habitat in relation to oceanic factors. Depending on the factors dictating the sharks niche preferences the study could highlight gear vulnerabilities and predict shifts in abundance associated with both natural and human induced climate variability.

ELECTRONIC REPORTING IN THE HAWAII LONGLINE FISHERIES

Ashley Tomita, Nathan Chan, Russell Ito, Keith Bigelow

NOAA Fisheries – Pacific Islands Fisheries Science Center
1845 Wasp Blvd., Building 176
Honolulu, Hawaii 96818 USA

The International Fisheries Program (IFP) at the Pacific Islands Fisheries Science Center (PIFSC) is responsible for collecting, managing, and disseminating the Hawaii longline fisheries data used in stock assessments and reports that support the international management of highly migratory species. The Hawaii longline fisheries currently consist of 145 active vessels. Of those vessels, most conduct deep-set fishing trips targeting tuna species, while a smaller portion conduct shallow-set fishing targeting swordfish. As part of an ongoing effort to expedite the submission, receipt, and processing of the data, an electronic reporting project was initiated in 2014 to support near-real-time data collection in the Hawaii longline fisheries.
Utilizing advances in technology, vessel operators are able to record and submit daily fishing activity data on a mobile device and send it via the vessel's VMS unit to satellite. Due to quality control and data entry procedures, normal processing time of paper log submissions is 2 to 3 weeks from the date of return to port. Electronic reporting expedites the complete processing of a single trip to within a day of the vessel's return. Various challenges have been met and overcome throughout the life of the project and enhancements are continually being made to improve quota monitoring, data quality, and timeliness. In collaboration with contractors, other NMFS line offices, and the longline fishing industry, the IFP electronic reporting team was able to successfully deploy mobile devices on fishery vessels. An overview of the project, challenges met, progress, and results will be presented.

SPATIO-TEMPORAL DISTRIBUTION MODELING OF DOLPHINFISH (*Coryphaena hippurus*) IN THE PACIFIC OCEAN OFF PERU: EVIDENCE OF SEASONAL MIGRATORY PATTERNS

Josymar Torrejón-Magallanes[1], Daniel Grados[2], Wencheng Lau-Medrano[2]

[1]Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas, C.P 23096, La Paz, Baja California Sur, México
[2]Instituto del Mar del Perú, Esquina Gamarra y General Valle s/n Chucuito, Callao, Perú

Data from the dolphinfish longline artisanal fishery and oceanographic covariates for 2010 – 2017 period, were used to estimate dolphinfish relative density and characterize its spatial distribution in the Pacific Ocean off Peru from 4° S – 16°S. We identified that high relative densities were located between 9°S and 12°S in the period November – January and approximately at 190 nautical miles (nm) distance from the coast on average. On the other hand, low relative densities occur near and along the coast in the period February – March and at 115 nm distance from the coast on average, which suggested a migratory behavior of this species. Nevertheless, in this study, there is no evidence of a reverse migration to the northwest. According to the environmental variables, dolphinfish prefer to stay in sea surface temperature (SST) ranging from 21° - 24°C, lower chlorophyll-a concentration (CHL) < 1 mg m^{-3}, and surface sea height (SSH) ranged from 0.10 to 0.20. The information derived from this study such as maps, spatial indicators, and time series, could improve our knowledge of how the spatial distribution and relative density of dolphinfish is likely to vary with future conditions and give some clues to forecast fishing grounds in short or long term. Finally, these results can provide tools to develop and/or improve management and conservation plans for a sustainable harvest of this species that supports one of the most important artisanal fisheries in Peru.

DIRECT TUNA ABUNDANCE INDICES: BUOY DERIVED ABUNDANCE INDICES OF TROPICAL TUNAS

J. Santiago[1], **Jon Uranga**[1], I. Quincoces[1], M. Grande[2], H. Murua[2], G. Boyra[2]

[1]AZTI. Tatxarramendi Ugartea z/g, 48395 Sukarrieta, Bizkaia (Spain).
[2]AZTI. Herrera Kaia, Portualdea z/g, 20110 Pasaia, Gipuzkoa (Spain).

One of the most important technological developments that have been recently introduced by the purse seine fleet fishing with FADs are the satellite linked echo-sounder buoys. Their generalized use is causing rapid changes in the fishing strategy and fleet, as they continuously provide fishers with near real-time information about the accurate geolocation of the FADs and the presence and abundance of tuna aggregations underneath. The echo-sounder buoys have also the potential of being a privileged observation platform to evaluate relative abundances of FAD-associated fish using fishery independent data. The collaborative work among the fishing industry, buoys suppliers and AZTI is making possible to gather acoustic records derived from echo-sounder buoys to develop complementary relative abundance index, Buoy-derived Abundance Index (BAI), for the stock assessment of tropical tuna stocks. This potential source of information, independent from catching efficiency and fleets dynamics, may be used by scientist in future stock assessments. This work presents some preliminary results of an overall index of abundance of tropical tunas in the Indian Ocean from 2013 to 2017. The model used assumes that the signal from the echo-sounder is proportional to the abundance of fish. To ensure that the coefficient of proportionality can be assumed to be constant, the nominal measurements of the echo-sounders were standardized using a Generalized Linear Mixed Modelling approach.

ASSESSMENT OF INTER-CONSISTENCY BETWEEN ACOUSTIC DATA FROM DIFFERENT BUOY BRANDS

Jon Uranga[2], J. Santiago[1],G.Boyra[2], M. Grande[2], I. Quincoces[1], H. Murua[2]

[1]AZTI. Tatxarramendi Ugartea z/g, 48395 Sukarrieta, Bizkaia (Spain).
[2]AZTI. Herrera Kaia, Portualdea z/g, 20110 Pasaia, Gipuzkoa (Spain).

Satellite linked echo-sounder buoys are deployed on the majority of fish aggregating devices (DFADs) and a real time picture of the presence and abundance of tuna measured by the echo-sounders is provided. The extensive use of them has created a promising source of acoustic data for monitoring tropical tuna resources. Thanks to the collaboration of both, buoy manufacturers and the industrial tropical tuna purse seine fishery, historic information on echosounder buoys in the Indian ocean has been gathered for the 2010-2018 period, in this sense a way to manage large datasets is proposed. To rely on this acoustic data and obtain reasonable acoustic abundance estimates, an inter-consistency study has been conducted at the buoy/brand level. In this work a revision of technical characteristics of different brands, a general data description approach, a data filtering methodology for processing meaningful buoy echosounder pings and a first approach for setting all data sources at same acoustic units and sampling volume is proposed. Latest findings of species target strengths (TS) and updated fish lengths are integrated at the biomass estimation procedure. Resulting standardized data is used to set the optimum daily time window by ocean, in which estimates must be done, and a comparison between biomass estimates by brands and oceans is presented.

ALTERNATIVE STOCK ASSESSMENT TOOLS, MANAGEMENT STRATEGIES, REFERENCE POINTS AND HARVEST CONTROL RULES FOR DORADO (*Coryphaena hippurus*) ACROSS THE EASTERN PACIFIC OCEAN

Juan L. Valero, Alexandre Aires-da-Silva, Mark. N. Maunder, Carolina M. Vera, Cleridy Lennert-Cody and Marlon H. Román

Inter-American Tropical Tuna Commission
8901 La Jolla Shores Dr.
La Jolla, CA 92037

Dorado is one of the most important species caught in the artisanal and recreational fisheries of the coastal nations of the eastern Pacific Ocean (EPO), from Chile in the south to Mexico in the north representing between 47% and 70% of the total dorado world catches. The IATTC staff, at the request of coastal State Members, facilitated collaborative regional research that resulted in three technical meetings between 2014 and 2016. An exploratory stock assessment for the "core" of the dorado stock where it is the target of artisanal longline fisheries in Peru and Ecuador, but also caught incidentally (as bycatch) by the tuna purse-seine fisheries. The 2016 stock assessment concluded that catches have been near estimates of the maximum sustainable yield (MSY) and that the fishing mortality required to achieve MSY is poorly defined since the yield curve is very flat. An exploratory management strategy evaluation for the south EPO was also conducted in 2016, evaluating the current strategy and alternatives including different monthly fishery closures and openings, size limits for the fish in the catch, and discard mortality rates. Analyses were conducted on expected Yield per recruit (YPR) and spawning biomass ratio (SBR) as a function of age of entry to the fishery and annual fishing mortality. Alternative season closures and openings had similar general effects on SBR and total yield, however later season openings increase SBR without marked reductions in expected yield, while earlier closures increase SBR but at the expense of reduced catch. Maximum YPR corresponds to an age of entry to the fishery around 10 months, with fishing mortalities levels estimated by the assessment, consistent with fishery openings in October-November. SBR is expected to increase with minimum size limits, while yield is expected to increase under no or moderate discard mortality and to decrease al greater discard mortality rates. Under assumed moderate discard mortalities, increasing minimum size limits are expected to result in increased SBR, but at the expense of reduced yield. Available data in the north EPO are more limited, handicapping the use of conventional stock assessments. The IATTC staff developed a monthly depletion estimator approach that could be used as a basis for management advice if at least CPUE data are available. Currently there are no reference points, target or limit, for dorado in the EPO. In this work we summarize research to date and ongoing work on potential reference points and harvest control rules that could be considered for dorado in the EPO. Management quantities and major uncertainties such as stock structure, available data, assessment methods and management systems are presented and discussed for consideration.

DEVELOPING OBSERVER DATA COLLECTION SYSTEMS FOR THE NEW WEST COAST LINKED DEEPSET BUOY GEAR SWORDFISH FISHERY

Charles Villafana[1], Cristin Baer[3], Craig D'Angelo[1], Rick Pannell[3], Bob Ryznar[2], Jenny Suter[2], Jody Van Niekerk[2]

[1]National Marine Fisheries Service, West Coast Region Long Beach, 501 W. Ocean Blvd. Ste. 4200 CA, 92688 USA
[2]Pacific States Marine Fisheries Commission, Portland, OR, USA
[3]Resource Data, Inc. Portland, OR, USA

Linked Deepset Buoy Gear (LBG) is a newly developed modification to the Deepset Buoy Gear (DSBG) fishery that has been under development over the past ten years to target swordfish during the day at depth. Through the work of the Pfleger Institute for Environmental Research (PIER), fishermen, and the National Marine Fisheries Service (NMFS), DSBG has proven successful at catching swordfish with minimal bycatch. Additionally, LBG is able to be used under rougher weather conditions than DSBG, a higher number of hooks are placed in the target zone, and the gear can be handled by larger vessels more easily than single buoys. While the volume of fish landed by DSBG is not as high as from large-mesh drift gillnet (DGN) and pelagic longline, LBG provides an opportunity to increase harvest over DSBG while maintaining all of the positive minimal bycatch features

NMFS' West Coast Region Observer Program (WCROP) is responsible for deploying observers onboard both DSBG and LBG trips under a number of Exempted Fishing Permits (EFPs). Linked Buoy Gear created a challenge to the typical style of observer data collection as the configuration of the gear as deployed does not always match the gear configuration at the haul event. Multiple individual pieces of gear can be deployed simultaneously and individual links may be hauled separately or attached to gear already in the water. It was imperative to develop a consistent and logical way to capture the catch and effort from these dynamic gear configurations and to properly record the data for both DSBG and LBG on the same data forms. Additional challenges were training the observers on a novel way to collect gear configuration data while attempting to imagine all the possible iterations of the setting, modifying, and hauling of the linked buoy gear. Concurrently, the observer database was under remodel and new data entry systems were quickly developed to keep up with the observer data collections.

ROUTINE AND POSTPRANDIAL OXYGEN CONSUMPTION RATES IN DOLPHINFISH (*Coryphaena hippurus*)

Nicholas C. Wegner[1], Heather White[2], Sofía Ortega-García[3], Rubén Rodríguez-Sánchez[3], John O'Sullivan[2]

[1] Fisheries Resources Division, Southwest Fisheries Science Center, NOAA Fisheries, 8901 La Jolla Shores Drive, La Jolla, CA 92037
[2] Monterey Bay Aquarium, Monterey, CA, USA
[3] Instituto Politécnico Nacional - Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN), La Paz, Baja California Sur, México

Routine oxygen consumption rates were measured for Dolphinfish (*Coryphaena hippurus*) (4.25 – 11.57 kg) at two temperatures (21.5 and 24.5 °C) at preferred swimming speeds using a large 8850 l static respirometer. Postprandial oxygen consumption was measured at both temperatures following meals of 5-14% body weight of either sardine or squid to examine the magnitude of specific dynamic action. Postprandial oxygen consumption was elevated for up to 35 hours post ingestion and was linearly correlated with meal size, resulting in a maximum 2.4X increase in metabolic rate with the largest meals. These patterns are similar to those exhibited by other teleost fishes and are of similar magnitude to tuna. In addition to metabolic data, videos taken throughout the experiments show that Dolphinfish spend a significant proportion of their swimming tilted to the side. This may provide some hydrostatic lift resulting in energetic costs savings. Future efforts should seek to link lab-based energetic estimates and observations with field-based movements and behavior to estimate true energetic costs in the wild. The advent of accelerometers which can measure tilt, speed, acceleration, and tailbeat frequency along with environmental parameters (e.g., temperature) can further refine such energetic cost estimates.

DOLPHINFISH FISHERIES AND REPRODUCTIVE BIOLOGY IN EASTERN TAIWAN

Wei-Chuan (Riyar) Chiang[1*], You-Yu Liou[2], Sheng-Ping Wang[2], Hung-Hung Hsu[1], Fu-Yuan Tsai[1], Shian- Jhong Lin[1,2], Ching-Tsun Chang[1], Ching-Ping Lu[2], Michael K. Musyl[3], Yuan-Shing Ho[1]

[1]Eastern Marine Biology Research Center, Fisheries Research Institute, Taiwan
[2]Department of Environmental Biology and Fishery Science, National Taiwan Ocean University, Taiwan
[3]Pelagic Research Group LLC, Honolulu, USA
[1]No. 22, Wuchuan Rd., Chenggong Township
96134 Taitung County, Taiwan

Dolphinfish (*Coryphaena hippurus*), also known as dorado or mahi mahi, is a highly migratory species with strong proclivities to coastal areas. The species is sexually dimorphic with males larger than females and feeds primarily on smaller teleosts, such as flying fish and sardine. The preferred epipelagic habitat ranges from tropical to subtropical waters (~25-28°C). In eastern Taiwan, dolphinfish migrate with the Kuroshio Current comprise an important economic resource in coastal areas. There are two peak fishing seasons in eastern Taiwan for dolphinfish: April to June, and the other is from September to November. In general, most fishing vessels target dolphinfish in eastern Taiwan and return to the port daily for offloading but occasionally larger vessels spend ~3-7 days for trips. During the last decade, the annual catch of dolphinfish in eastern Taiwan was about 2,600 metric tons, with the value of ~5 million USD. The reproductive biology of dolphinfish was analyzed based on 442 gonad samples collected from January 2016 to April 2017. Body size of the samples ranged from ~40 to 140 cm in fork length (FL) and from 0.56 to 22.50 kg in round weight. The trends of monthly gonadosomatic index (GSI), mean oocyte diameters and proportion of gonadal development indicated dolphinfish can spawn in the entire year but peak spawning occur from March to July. Based on the histological examination and the distribution of oocyte diameters, the oocytes developed asynchronously and the smallest mature sizes were 46 and 48 cm FL for females and males, respectively. Estimated lengths-at-50% maturity were 52 cm and 56 cm for females and males, respectively. The results of the postovulatory follicle analysis indicated that the proportion of reproductively active samples was 82% during the spawning season and females were estimated to spawn once every ~1.25 days; the proportion of mature males was 33% and males were estimated to spawn once every ~3 days. Batch fecundity estimates ranged from ~87,000 to 473,960 oocytes and averaged 196,446 oocytes (hydrated oocyte method); relative fecundity ranged from 7.4 to 66.1 oocytes per gram of body weight and averaged 37.5 oocytes. The results of this study will provide an useful information for better understanding of the population dynamics and for the further stock assessments and management of this species.

A REVIEW OF METHODS TO DETERMINE PREY CONSUMPTION RATES, GASTRIC EVACUATION AND DAILY RATION OF PELAGIC FISHES: A PRECURSOR TO EXPERIMENTAL ESTIMATION FOR KEY PREDATORS IN THE EASTERN PACIFIC OCEAN ECOSYSTEM

Jeanne Wexler and Shane Griffiths

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

Ecopath with Ecosim is one of the most widely-used ecosystem models used in fisheries applications to explore the ecological consequences of fishing activities and other perturbations such as climate change on marine ecosystems. It is a mass-balance trophic model that characterizes marine ecosystems, by describing and quantifying the complex dynamics of predator/prey relationships. One of the four key parameters of the model is *Q/B*, the consumption biomass ratio (or annual ration), which quantifies the trophic impact of a predator on an ecosystem by determining the prey biomass that is required to be available to the predator, after taking into account the standing biomass, total mortality (P/B) and ecotrophic efficiency of both the predator and prey. Quantifying diet composition, daily ration, gastric evacuation, and the consumption rate of consumers within the ecosystem are all essential requirements for estimating Q/B. Having reliable estimates of Q/B for high trophic level predators (*e.g.*, tunas, billfish and sharks) is particularly important in open ocean ecosystems, such as the eastern Pacific Ocean (EPO), that can be strongly influenced by "top-down" regulation by these predators.

Although there are several direct and indirect methods to estimate food consumption of key predators within the EPO ecosystem, all are not without some limitations to producing reliable estimates of consumption rates. This presentation will review and discuss some of the methods to estimate daily ration, gastric evacuation, and consumption rate, and describe a proposed approach to experimentally quantify these rates and Q/B for some key predators of the EPO ecosystem. The facilities at the IATTC's Achotines Laboratory in Panama provide a unique and cost-effective opportunity to experimentally determine these rates on captive fish that are readily available for capture nearshore to the Achotines laboratory facility. Our initial goal will be to conduct controlled experiments on locally abundant species, such as black skipjack (*Euthynnus lineatus*) or dorado (*Coryphaena hippurus*). Based on these results, we hope to conduct daily ration experiments on other species representative of different trophic levels of the EPO ecosystem to facilitate the parameterization of a new spatially-explicit Ecopath model (*i.e.* Ecospace) as planned in the IATTC's recently proposed 5-year Strategic Science Plan.

A FISHERY-DEPENDENT RECRUITMENT AND FORECAST INDEX FOR BIGEYE TUNA *(Thunnus obesus)* IN THE HAWAIʻI-BASED LONGLINE FISHERY

Johanna L.K. Wren [1,2*] & Jeffrey J. Polovina[2]

[1] Joint Institute for Marine and Atmospheric Research, University of Hawaiʻi at Mānoa, Honolulu, Hawaiʻi, USA
[2] NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, Hawaiʻi, USA

1845 Wasp Blvd. bldg. 176
Honolulu, HI 96818

The Hawaiʻi-based deep-set longline fishery has annual landings valued at $100 million. One third of the number landed is composed of the target species bigeye tuna (*Thunnus obesus*). Bigeye tuna first recruit into the fishery at approximately age two and are exploited past age five. Virtually all the fish landed from the longline fishery in Hawaiʻi are weighed at fish buyers providing a complete weight frequency from the fishery. While the proportion of age two bigeye tuna caught by the fishery is relatively small, it is sufficient to construct an annual index of recruitment into the fishery and provide a 1-year forecast of bigeye tuna catch rates. The recruitment index showed a strong recruitment event in 2013 led to increased bigeye tuna catch rates in 2014-2016. Prior to that, the only other recruitment pulse was a moderate one in 2001, suggesting strong recruitment events for bigeye tuna in the central North Pacific are rare. This recruitment index provides a qualitative prediction for bigeye catch rates in the Hawaiʻi-based deep-set longline fishery, and the catch rate for 2019 is projected to decline from 2018 values. Additionally, we compare the recruitment index to recruitment estimates from stock assessments and El Niño Southern Oscillation indices to put bigeye recruitment into the Hawaiʻi-based longline fishery into a basin-wide population and climate context.

BIOMETRIC RELATIONSHIP OF THE DOLPHINFISH *Coryphaena hippurus* IN SOUTHERN SINALOA, MEXICO

Marcela Selene Zúñiga Flores and Concepción Enciso Enciso

Centro Regional de Investigación Pesquera- La Paz, Baja California Sur. Instituto Nacional de Pesca y Acuacultura. SADER. Carretera a Pichilingue km 1. Col. El Esterito, La Paz, Baja California Sur, México. CP. 23020.

The dolphinfish (*Coryphaena hippurus*) is captured by sport and incidental fishing by the artisanal fleet in the southern coast of Sinaloa. A major fishery publication (Carta Nacional Pequera, 2000 and 2004) considered it a potential resource wich required monitorind based on knowledge of this species' biology and population dynamics. During the period of 2006 – 2013, monthly biological sampling of the sport fishing and artisanal fleet catches near Mazatlan and Teacapan, Sin., were examined. The date of capture, fork length (FL, cm), total weight (TW, g), gutted weight (GW, g), sex and fishing gear used were recorded for 5,838 individuals (2,665 males and 3,173 females). Monthly and annual sizes variation was analyzed using the nonparametric Kruskal-Wallis (H)) test. Significant variation of the average sizes between sexes were found ($H_{(6,5838)} = 1555.632$, $p=0.00$). The FL-TW linear relationships indicated negative allometric growth in both sexes of dolphinfish ($b = 2.874$ and $b = 2.780$ in males). There was a high significant TW-GW linear correlation ($r= 0.98$), suggesting that the total weight can be estimated from the dolphinfish GW.

Notes

Notes

Notes

Notes

Notes

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

Allen H Andrews
National Marine Fisheries Service
NOAA Fisheries Service
Pacific Islands Fisheries Science Center
1845 Wasp Blvd, Bldg. 176
Honolulu, HI 96818
United States
+1 (808) 388-3776
allen.andrews@noaa.gov

Alberto Abad Uribarren
CICIMAR-IPN
Av. Instituto Politecnico Nacional S/N
Col. Playa Palo de Santa Rita
La Paz, B.C.S 23096
Mexico
+52(612) 1234658
sodepesca@outlook.com

Riley Austin
University of Maine
350 Commercial Street
Portland, MN 04101
United States
+1 (814) 596-7003
riley.austin@maine.edu

Enzo Acuna
Univeridad Catolica del Norte
Casilla 117
Coquimbo
Chile
+(569) 8888-1587
eacuna@ucn.cl

Thompson Banez
Scripps Institution of Oceanography
2049 Garnet Avenue, Apt. B
San Diego, CA 92109
United States
+1 (757) 206-9380
tbanez@ucsd.edu

Lisa Ailloud
ICCAT
Corazón de María 8
Madrid 28002
Spain
+1 (914) 165600 x 53
lisa.ailloud@iccat.int

Natalia Juliana Bayona
University of Georgia
150 E. Green St.
Athens, GA 30602
United States
+1 (706) 206-6864
njbayonav@gmail.com

Alexandre Aires-da-Silva
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7022
alexdasilva@iattc.org

Doug Beare
ICCAT
Corazón de María 8
Madrid 28002
Spain
+1 (914) 165600 x 53
doug.beare@iccat.int

Lyall Bellquist
The Nature Conservancy
2441 Baja Cerro Circle
San Diego, CA 92109
United States
+1 (562) 508-3459
Lyall.bellquist@tnc.org

Karine Briand
Institut de Recherche Pour Le Developpement (IRD)
Avenue Jean Monnet,CS 30171
Sete 34 203
France
+ (33) 499573209
karine.briand@ird.fr

Keith A. Bigelow
Pacific Islands Fisheries Science Center
NOAA Fisheries Service
Joint Institute for Marine and Atmosphere Research
2570 Dole Street
Honolulu, HI 96822-2326
United States
+1 (808) 983-5388
Keith.Bigelow@noaa.gov

Amy Brookman
Innovasea Marine Systems
20 Angus Morton Drive
Nova Scotia, B4B 0H8
Canada
+1 (902) 233-7666
amy.brookman@vemco.com

Caitlynn Birch
University of San Diego
5998 Alcala Park
San Diego, CA 92110
United States
+1 (831)-332-1757
cbirch@sandiego.edu

Wei-Chuan Chiang
Eastern Marine Biology Research Center of
Fisheries Research Institute
No. 22 Wuchuan Road
Chenggong Township
Taitung 96143
Taiwan
+886 (8) 9850090 ext. 408
wcchiang@mail.tfrin.gov.tw

Marilu Bouchon
Instituto del Mar del Peru (IMARPE)
P.O. Box 22
Callao
Peru
mbouchon@imarpe.gob.pe

John Childers
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7192
john.childers@noaa.gov

Russell Bradford
CSIRO Oceans & Atmosphere
GPO Box 1538
Hobart 7001
Tasmania
+61 362325222
russ.bradford@csiro.au

Bruce B. Collette
Smithsonian Institution
NMFS Systematics Lab
National Museum of Natural History
10th & Constitution Ave., NW, MRC-153
Washington, DC 20560-0153
United States
+1 (202) 633-1287
collettb@si.edu

Guillermo A. Compeán Jiménez
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7100
gcompean@iattc.org

Ross Cooper
Scripps Institution of Oceanography
8622 Kennel Way
La Jolla, CA 92037
United States
+1 (562) 480-0029
r6cooper@ucsd.edu

Craig D'angelo
NMFS West Coast Region
501 West Ocean Blvd. Suite 4200
Long Beach, CA 90802
United States
+1 (310) 499-6792
craig.dangelo@noaa.gov

Nicholas DeNezzo
Scripps Institution of Oceanography
4553 Oregon St. #1
San Diego, CA 92116
United States
+1 (714) 402-2905
ndenezzo@ucsd.edu

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

Katie Downes
University of Exeter, UK
Bluebell Barn, Stone Road
Mattishall, Norfolk NR20 3PF
United Kingdom
+ (44) 788-179-8341
kd375@exeter.ac.uk

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

Lauriane Escalle
Oceanic Fisheries Programme
The Pacific Community (SPC)
B.P. D5
Noumea, 98800
New Caledonia
+ (687) 94 69 58
laurianee@spc.int

Charles Farwell
Monterey Bay Aquarium
Tuna Research and Conservation Center
886 Cannery Row
Monterey, CA 93940-1085
United States
+1 (831) 594-7824
cfarwell@mbayaq.org

Mark D. Fitchett
Western Pacific Regional Fishery Management Council
1164 Bishop Street #1400
Honolulu, HI 96813
United States
+1 (808) 725-8141
mark.fitchett@wpcouncil.org

Walter J. Golet
University of Maine
Gulf of Main Research Institute
350 Commercial Street
Portland, ME 04101
United States
+1 (207) 228-1671
walter.golet@maine.edu

Stephanie Green
University of Alberta
Biological Sciences
CW405
Bio Sci Building
+1 (780)-492-2374
stephanie.green@ualberta.ca

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

Natasha Hardy
University of Alberta
Biological Sciences
CW 405
Bio Sci Building
+1 (780) 492-2374
nahardy@ualberta.ca

Jason Hartog
CSIRO Marine and Atmospheric Research
Division of Marine Research
G.P.O. Box 1538
Castray Esplanede
Hobart, Tasmania 7001
Australia
+61 (4) 04978441
jason.hartog@csiro.au

Craig Heberer
The Nature Conservancy
402 West Broadway, Suite 1350
San Diego, CA 92101
United States
+1 (619) 209-5830
craig.heberer@tnc.org

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

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

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

John Hyde
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7086
john.hyde@noaa.gov

David Itano
American Fishermen's Research Foundation
689 Kaumakani Street
Honolulu, HI 96825
United States
+1 (808) 387-5430
daveitano@gmail.com

Jeff Kneebone
Anderson Cabot Center, New England Aquarium
Central Wharf
Boston, MA 02110
United States
+1 (617) 226-2424
jkneebone@neaq.org

Russell Ito
National Marine Fisheries Service
NOAA Fisheries Service
Pacific Islands Fisheries Science Center
1845 Wasp Blvd, Bldg 176
Honolulu, HI 96818
United States
+1 (808) 725-5324
russell.ito@noaa.gov

Suzy Kohin
Wildlife Computers, Inc.
8310 154th Ave
Redmond, WA 98052
United States
+1 (425) 881-3048
suzy.kohin@gmail.com

Ulianov Jakes Cota
Instituto Politécnico Nacional-Cicimar
AV. IPN S/N Col.Playa Palo De Santa Rida,
La Paz,BCS 23096
Mexico
+ (52) 612 12 30350
ujakesc@ipn.mx

Takuya Koizumi
Biologging Solutions Inc.
YS Garden 409, Hon-cho
Nakano-ku, Tokyo 164-0012
Japan
+ (81) 3-6885-3725
koizumi@biologging-solutions.com

James Kilfoil
Florida International University
3000 NE 151st Street
North Miami, FL 331818
United States
jkilf001@fiu.edu

Kevin Lay
Wildlife Computers, Inc.
8345 154th Avenue NE
Redmond, WA 98052
United States
+1 (425) 881-3048
conferences@wctags.com

Takashi Kitagawa
University of Tokyo
Atmosphere and Ocean Research Institute
515 Kashiwanoha
Kashiwa, Chiba 2778564
Japan
+ (814) 7136-6262
takashik@aori.u-tokyo.ac.jp

Ryan Logan
Nova Southeastern University
Guy Harvey Research Institute
15051 Royal Oak Ln.
Apt 202
North Miami, FL 33181
United States
+1 (303) 8196150
rlogan@nova.edu

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

Mark Maunder
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7027
mmaunder@iattc.org

Ching-Ping Lu
National Taiwan Ocean University
2 Pei-Ning Road
Keelung 202
Taiwan
+ (886) -2-2462-2192 Ext 5035
cplu@mail.ntou.edu.tw

Enrique Mauser
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7031
emauser@iattc.org

Sarah Luongo
Florida International University
15051 Royal Oaks Lane
Apt. 202
North Miami, FL 33181
United States
+1 (562) 3946317
sluon007@fiu.edu

Wessley Merten
Beyond Our Shores, Inc.
2027 Deertree Lane
Rockville, MD 20851
United States
+1 (787) 436-8300
wess@beyondourshores.org

Meliza Lyn Le Alvarado
Centro de Investigación Científica y Superior de Ensenada
3918 carretera Ensenada-Tijuana
Ensenada, Baja California 22860
Mexico
+(52) 646-2555537
meliza@cicese.edu.mx

Ian P Miller
NMFS- Atlantic HMS
1315 East West HWY
Silver Spring, MD 20910
United States
+1 (301) 427-8551
ian.miller@noaa.gov

Kady Lyons
Georgia Aquarium
225 Baker Street NW
Atlanta, GA
United States
+1 (310) 387-7465
klyons@georgiaaquarium.org

John Mohan
Texas A & M University at Galveston
1001 Texas Clipper Road
Galveston, TX 77553-1675
United States
+1 (409) 740-4753
jmohan@tamu.edu

Mueller Janelle
The Pew Charitable Trusts
901 E Street NW
Washington DC 20001
United States
+1 (202) 510-2769
jhangen@pewtrusts.org

Nerea Lezama Ochoa
AZTI Tecnalia Marine Research Division
Herrera Kaia
Portualdea z/g
20110 Pasaia
Gipuzkoa
Spain
+34 (679) 342974
nlezamaochoa@gmail.com

Samantha Nadeau
Univeristy of Maine
16 Mainewood Avenue
Orono, MN 04473
United States
+1 (207) 951-6920
samantha.b.nadeau@maine.edu

Padraic O'Flaherty
Lotek Wireless, Inc.
472A Logey Bay Road
St John's, Newfoundland A1A 5C6
Canada
+1 (709) 746-9798
poflaherty@lotek.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
nnasby@yahoo.com

Ricardo Oliveros-Ramos
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7026
roliveros@iattc.org

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

Robert Olson
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7100
rolson@iattc.org

Takuji Noda
Kyoto University
Yoshida Honmachi, Sakyo-ku
Kyoto 606-8501
Japan
+81 (90) 5871-0721
takujinodan@gmail.com

Sofía Ortega-García
Instituto Politécnico Nacional-CICIMAR
Av. IPN S/N
Col. Playa Palo Sta. Rita
La Paz, B.C.S. 23096
México
+ (52) 612120350
sortega@ipn.mx

John O'Sullivan
Monterey Bay Aquarium
Tuna Research and Conservation Center
886 Cannery Row
Monterey, CA 93940-1085
United States
+1 (831) 648-4920
josullivan@mbayaq.org

Vanessa G. Pelayo
Instituto Politecnico Nacional
Insurgentes 28
La Paz, Baja California Sur 23090
Mexico
+ (52) 612 158 9238
vanessagpelayo@gmail.com

Shannon Penna
NOAA NMFS
501 W Ocean Blvd, Suite 4200
Long Beach, CA 90802
United States
+1 (562) 544-5049
shannon.penna@noaa.gov

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

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

Marlon Roman
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7100
mroman@iattc.org

Andres 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

Brenda Rudnicky
University of Maine
Gulf of Main Research Institute
350 Commercial Street
Portland, ME 04101
United States
+1 (862) 219-0009
brenda.rudnicky@maine.edu

Robert Ryznar
Pacific States Marine Fisheries Commission
205 SE Spokane St. Suite 100
Portland, OR 97202
United States
+1 (503) 595-3234
rryznar@psmfc.org

Lela Schlenker
University of Miami
4600 Rickenbacker Causeway
Miami, Florida 33149
United States
+1 (305) 421-4366
lschlenker@rsmas.miami.edu

Michael Scott
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7045
mscott@iattc.org

Stephanie Snyder
Thomas More University
Monterey Bay Aquarium
333 Thomas More Parkway
Crestview Hills, KY 41017
United States
+1 (859) 344-3374
smsnyder@thomasmore.edu

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

Jennifer Stahl
NOAA Pacific Island Office
1334 Center St.
Honolulu, HI 96816
United States
+1 (907) 723-7740
jennifer.stahl@noaa.gov

Sarah Shoffler
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-5678
Sarah.Shoffler@noaa.gov

John Stieglitz
University of Miami
RSMAS
4600 Rickenbacker Causeway
Miami, FL 33149
United States
+1 (305) 421-4303
jstieglitz@rsmas.miami.edu

Alayna Siddall
Sportfishing Association of California
5060 North Harbor Drive
Suite 165
San Diego, CA 92106
United States
+1 (619) 322-7421
alayna.siddallsac@gmail.com

Jenny Suter
Pacific States Marine Fisheries Commission
205 SE Spokane St. Suite 100
Portland, Oregon 97202
United States
+1 (503) 595-3148
jsuter@psmfc.org

Owyn Snodgrass
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 342-6372
owyn.snodgrass@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

Ashley Tomita
NOAA/NMFS/PIFSC
1845 Wasp Boulevard
Bldg 176
Honolulu, HI 96818
United States
+1 (808) 725-5693
ashley.tomita@noaa.gov

Jody Van Niekerk
Pacific States Marine Fisheries Commission/ NMFS
3605 Earnscliff Pl. Apt. 53
San Diego, CA 92111
United States
+1 (760) 453-8448
jody.vanniekerk@noaa.gov

Edgar Josymar Torrejon
Interdisciplinary Center for Marine Sciences
Ignacio Allende 2250 Los Olivos
La Paz, Baja California Sur 22040
Mexico
+ 51 1 (612) 2291 690
ejosymart@gmail.com

Russ Vetter
Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7125
russ.vetter@noaa.gov

Jon Uranga
AZTI-Tecnalia
Pasaia
Gipuzkoa, 20110
Spain
+ (34) 94 6574000
juranga@azti.es

Charles Villafana
National Marine Fisheries Service
501 W. Ocean Blvd. Ste. 4200
Long Beach, CA 92688
United States
+1 (562) 9804047
charles.villafana@noaa.gov

Juan Luis Valero
IATTC - Contractor
5557 38th Ave NE
Seattle, WA 98105
United States
+1 (206) 9621899
jvalero@iattc.org

Jonathan Walker
NOAA-SWFSC
836 Opal Street
San Diego, CA 92109
United States
+1 (619) 315-9717
jmwalker@ucsd.edu

Beth Vanden Heuvel
Tri Marine Fishing Management
10500 NE 8th St. #1888
Bellevue, WA 98115
United States
+1 (206) 300-6014
bvandenheuvel@trimarinegroup.com

Michael Wang
Pfleger Institute of Environment Research (PIER)
315 Harbor Drive S., Suite B
Oceanside, CA 92054
United States
+1 (760) 721-2178
mike.stewart.wang@gmail.com

Sofía P. Webber
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7100
swebber@iattc.org

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

Jeanne Wexler
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1509
United States
+1 (858) 546-7035
jwexler@iattc.org

Johanna Wren
JIMAR-NMFS PIFSC
1845 Wasp Blvd. Bldg. 176
Honolulu,HI 96818
United States
+1 (808) 725-5345
johanna.wren@noaa.gov

Marcela Selene Zuñiga
Instituto Nacional de Pesca y Acuacultura
CRIP - La Paz
La Paz, Baja California 23020
Mexico
+ (52) 6121251623
marcela.zuniga@inapesca.gob.mx