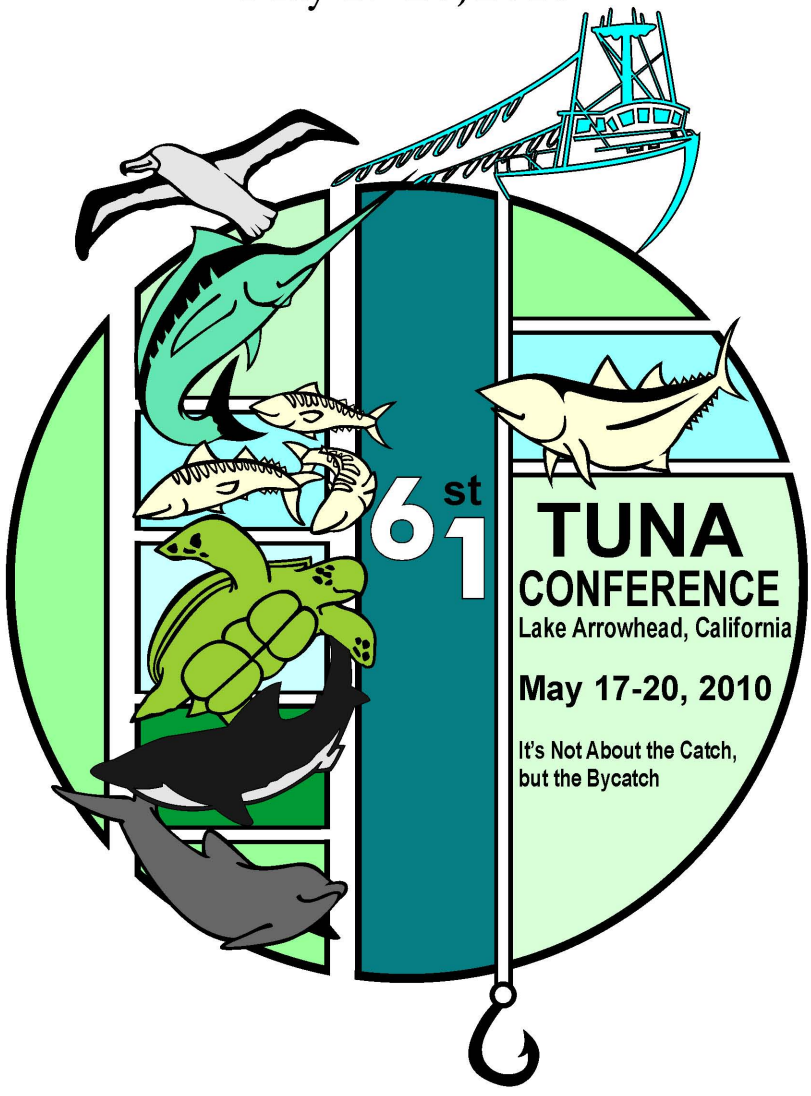
Proceedings of the 61st Annual Tuna Conference

Lake Arrowhead, California

May 17-20, 2010



Suzanne Kohin and Sarah Shoffler, Co-Chairs

NOAA Fisheries Service
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
San Diego, California 92037

Sponsored by the:
Inter-American Tropical Tuna Commission
NOAA, NMFS, Southwest Fisheries Science Center

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PREFACE

Welcome to the 61st Tuna Conference. The goal of the Tuna Conference is to provide an informal forum for scientists, engineers, managers, fishermen and non-governmental organizations from around the world to exchange information and ideas including recent research findings on the biology of tuna and tuna-like species, the operation of associated fisheries, and the ecosystems that support them. The free and open exchange of ideas is the key to the Conference's success.

This year the theme of the conference is **"It's Not About the Catch, but the Bycatch."** Fisheries for tuna and other highly migratory species are often constrained by the incidental take of vulnerable non-target species. Even fisheries that target productive, healthy stocks can face restrictions if interactions with protected species occur. In order to manage fisheries so that yield of target species is optimized and bycatch interactions are minimized, a multi-disciplinary, ecosystem approach is required. At the multi-species level, a better understanding of the pelagic ecosystem, species interactions, and how the environment affects species distribution is needed. For individual species, research into data-poor assessment methodologies, fine-scale habitat use patterns, and gear modifications to reduce bycatch will all contribute to inform management and help to promote healthy, sustainable fisheries for tuna and tuna-like species. The 2010 Tuna Conference will address some of these issues and papers addressing these challenges will be presented.

The Conference is hosting a special session focused on the Kobe II Bycatch Workshop, "Bycatch Reduction Measures with the Tuna Regional Fisheries Management Organizations", scheduled for June 2010. This session will preview topics to be covered at the workshop including an overview of global tuna fishery bycatch issues, bycatch assessment methods, effective bycatch mitigation strategies, economic approaches/incentives and successful collaboration and outreach efforts with fishermen. This timely session will also feature a panel discussion and representatives from NOAA Fisheries and IATTC, among others. We encourage all attendees to participate in the discussions.

We are pleased to announce that five scholarships were awarded this year, four to students. Melanie Hutchinson, a student at U. of Hawaii, was awarded the *Tuna Conference Scholarship* for her work on "Effects of Nd/Pr alloy on catch rates of pelagic and coastal shark species." The *Manuel Caboz Memorial Scholarship* was awarded to Brad Smith of Texas A & M for his research on the "Use of nuclear genetic markers and Bayesian genetic clustering to infer population admixture and neighboring stock bycatch in Atlantic swordfish (*Xiphias gladius*)." We are very pleased that our industry partners sponsored three scholarships this year. Wildlife Computers sponsored a scholarship, awarded to Daniel Madigan of Stanford U. for his work "Habitat utilization and trophic ecology of three co-occurring tuna species in the eastern Pacific Ocean." GeoEye sponsored a scholarship in memory of Dr. James Joseph which was awarded to Megan Bailey of U. of British Columbia for her work on "The cost of juvenile fishing: by-catch in the western and central Pacific Ocean tuna purse seine fishery." These students demonstrated

impressive research goals and progress, and we wish them continued success in their graduate careers. Finally, AD Model Builder sponsored a scholarship to promote and acknowledge creative use of modeling to examine fishery dynamics. The ADMB award was given to Jordan Watson of University of Washington for his work on "Trade-offs in the design of fishery closures: silky shark bycatch management in the eastern Pacific Ocean tuna purse seine fishery."

This year's Tuna Conference has the second highest number of attendees in its history and hosting this arcane and tradition-bound event could not be carried out without the assistance of a team of volunteers. The co-Chairs extend a special thank you to Anne Allen, keeper of the flame and organizer extraordinaire of the 61st Tuna Conference. We also thank Steve Teo, Dan Cartamil, Yonat Swimmer, David Kerstetter, Shane Griffiths, Bill Bayliff, William Walsh, Keith Bigelow, Marty Golden, Mark Helvey, Tim Sippel and Michael Laurs for moderating the scientific sessions. Christine Patnode has done an excellent job maintaining the Tuna Conference web site. Thanks to Mike Hinton, Michael Scott, Stephen Stohs and Steve Teo for reviewing the student scholarships. We thank Daniel Yanagi for designing this year's fantastic logo, and WikiTiki for offering Conference apparel. Thanks go to Kim Holland, Russell Ito, John Hyde, Craig Heberer and Scootch Aalbers for continuing the sashimi-cutting tradition for the Sushi Social/Poster Session. We also thank Prime Time Seafood for donating sashimi grade tuna and Marty Golden for delivering it to the Conference. Finally, thanks to a whole team of IATTC and SWFSC staff members, too numerous to be named here, for general assistance with transporting supplies and people to this year's Conference.

We gratefully acknowledge generous donations to the Tuna Conference to help support student scholarships and travel, the Welcome Gathering Party, Sushi Social/Poster Session and Tuna Barbecue. Our generous donors this year were: International Seafood Sustainability Foundation, Automatic Differentiation Model Builder (ADMB), American Fisherman's Research Foundation, American Tunaboat Association, GeoEye, Wildlife Computers, Monterey Bay Aquarium, and Prime Time Seafood.

The abstracts contained in these proceedings were edited solely for formatting. The abstracts are considered reports of preliminary work, and if readers would like further information about the presentations or to cite information or ideas contained in the abstracts, they should contact individual authors directly.

Thanks to all of you for participating and for your flexibility to help us meet scheduling and housing challenges. It is through all of your presentations, posters, and informal discussions around the camp fire and hot tub, and because of the broad diversity in expertise and experience that Tuna Conference is a success. We hope you enjoy yourselves, and please be careful!

Suzy Kohin and Sarah Shoffler,
61st Tuna Conference Co-chairs

In Memory of James Joseph, 1930-2009

Dr. James Joseph, Director of the Inter-American Tropical Tuna Commission (IATTC) for 30 years, from 1969 to 1999, died suddenly on December 16, 2009.

Dr. Joseph was born in Los Angeles, California, in 1930. After graduating from high school, he entered Humboldt State College (now Humboldt State University), in Arcata, California. His education was interrupted by service in the U.S. Army from 1952 to 1954. He returned to Humboldt State, from which he obtained a B.S. degree in 1956 and an M.S. degree in 1958. Dr. Joseph began working for the IATTC in 1958, and spent the next two years in Manta, Ecuador, studying baitfishes and tagging tunas. He was then transferred to Terminal Island, California, and then to La Jolla, California. Because of his obvious ability, Dr. J.L. Kask, Director of the IATTC at the time, named him Principal Scientist of the IATTC in 1964. He earned his Ph.D. degree from the University of Washington, where he studied population dynamics under the late Dr. Gerald J. Paulik, in 1967. In 1969, when Dr. Kask retired, Dr. Joseph was selected as the new Director of the IATTC.

Many changes took place in the tuna fisheries of the world, especially those of the eastern Pacific Ocean (EPO), during the three decades during which Dr. Joseph was Director of the IATTC. Larger, more efficient boats were constructed, and many of them were registered in nations that had not previously been important participants in the fishery. The concept of 200-mile Exclusive Economic Zones was not widely recognized at the beginning of this period, but by the end of his tenure it was vigorously enforced by most nations. The catches of tunas in the EPO and in other parts of the world increased greatly during this period, and many stocks of tunas now appear to be fully exploited. At least two of them, Atlantic bluefin and southern bluefin, are considered to be overexploited. As a result, many fisheries for tunas are now regulated. Dr. Joseph was definitely the right person at the right time to be Director of the IATTC. His vision and leadership were crucial in resolving the often contentious differences that arose among the countries, industries, and people involved. He commanded the highest respect and admiration for his extensive knowledge of all matters related to fisheries, his dedication, his fairness, and his extraordinary ability to get things done. He had the gift of finding the common ground among conflicting parties, and of bringing about consensus when none seemed possible. His reputation for unimpeachable probity made him perhaps the most widely respected and admired figure in international fisheries management. His uncanny knack for making all parties feel that they mattered, his ability to get along with a wide variety of people of every social, cultural, and national background, and his perspectives on many matters were unique, or nearly so. He thought, rightly, that in the complex world of fisheries conservation and management, in which many different parties—governments, fishermen, processors, environmentalists, scientists—have an interest, no lasting solution is possible unless all parties were involved.

In addition, there has been much concern about the effect of fishing on incidentally-caught species, particularly marine mammals. During most years of the 1960s, 1970s, and early 1980s the annual mortalities of dolphins in the EPO due to the purse-seine fishery for tunas exceeded

100,000 animals. In 1972 the U.S. Marine Mammal Protection Act (MMPA), which profoundly affected the fisheries for tunas in the EPO was passed, and its provisions were gradually strengthened during the ensuing period. Under Dr. Joseph's leadership, the IATTC initiated its Tuna-Dolphin Program to assess these issues, placing observers aboard fishing vessels to collect data on fishing activities and dolphin mortality, sponsoring seminars to facilitate the transfer of dolphin-saving techniques from the more skilled to the less skilled fishermen, and conducting basic research on the population dynamics of dolphins and the interaction between tuna fisheries and the dolphin populations. Dr. Joseph provided leadership through the many years of this complex and difficult process, and he deserves much of the credit for this remarkable achievement.

Under Dr. Joseph's leadership, tunas and billfishes were certainly not neglected during this period. For example, the IATTC staff pioneered in the development of methods for stock assessment of tunas, and, now, the population dynamics of yellowfin tuna in the EPO are probably better understood those of any other stock of tuna. In addition, the IATTC's Achotines Laboratory in Panama, responsible for great strides in understanding of the reproduction and early life history of tunas have been made through work in the field, was established during Dr. Joseph's tenure as Director. Ecosystem studies also increased in importance during his tenure, and set the stage for advances that came later. For example, the IATTC staff, in cooperation with several other organizations, developed multi-species modeling approaches to evaluate the relative ecological implications of alternative fishing strategies in the EPO and the effect of climate variation on the food web. Dr. Joseph appreciated the value of improving the understanding of food-web dynamics in the pelagic EPO, given that accurate depictions of trophic connections and flows are the backbone of ecosystem models. Studies of stable isotopes of nitrogen and carbon and of predator diets have provided insight into ecosystem modeling.

After his retirement in 1999, Dr. Joseph served as a consultant for various organizations in many parts of the world. At the time of this death, he was Chairman of the Science Committee of the International Seafood Sustainability Foundation.

Dr. Joseph was an affiliate professor at the University of Washington and at the Universidad Nacional Autónoma de México. He had served on numerous advisory committees, task forces, and consultative groups in the United States and elsewhere, including those of the U.S. National Academy of Sciences, Department of Commerce, and Department of the Interior. He lectured on subjects relating to marine research and resource conservation all over the world. Additionally, he served as a technical advisor to many international organizations, government ministries, and heads of state on matters pertaining to marine science, especially marine resource development, management, and conservation. He published numerous papers and articles in scholarly and trade journals, and co-authored three books.

His many awards and honors include the Distinguished Alumnus Award, Humboldt State University; Outstanding Achievement Award for Contributions to Marine Science, Portuguese Historical Society, San Diego; Outstanding Graduate in Fisheries, Humboldt State University;

Nautilus Award, Marine Technological Society; Dave Wallace Award, Nautilus Press, Inc.; *Docteur Honoris Causa*, Université de Bretagne, Brest, France; Roger Revelle Award, San Diego Oceans Foundation; *Al Mérito Pesquero* Award, Ministry of Commerce of Ecuador; Condecoración del Orden Antonio José de Sucre, Government of Venezuela. In addition, the IATTC was selected as the recipient of the Carl L. Sullivan Fishery Conservation Award of the American Fisheries Society in 1994.

Dr. Joseph is survived by his wife Patricia, two sons, Jerry and Michael, five grandchildren, three brothers, and three sisters.

Obituary kindly provided by Bill Bayliff, IATTC.

AGENDA

Monday, 17 May 2010

13:00 Registration Opens in Skyview

SESSION 1: Measuring and Monitoring Bycatch (Moderator: Steve Teo)

14:00 Welcome and Introduction (Pineview Theater)

14:10 Issues on tuna purse-seine bycatch information worldwide
E. Altamirano *and M. Hall*

14:30 Identifying areas with high rates of bycatch: can we consider a linear relationship between bycatch and tuna catch?
Monin-Justin Amandè*, Nicolas BEZ, Laurent Dagorn and Pierre Chavance*

14:50 Capacity estimation and bycatch reduction: An application to the western and central Pacific purse seine fishery and bigeye tuna
Eric Janofsky

15:10 Standardizing fishing gear descriptions for fisheries and bycatch studies
Takahisa Mituhasi, ***Martín Hall,*** *Marlon Román, Wilbert Marin, Simón Chapilliquén, Manuel Parráles, Jorge Villavicencio, Liliana Rendón, Erick Largacha, Marcos Loor, Mario Quirós, Berny Marin, Ronaldo Gutiérrez, Salvador Siu, Celina De Paz, Manuel Ixquiác, Samuel Ramos, Antonio Murillo, and Abel Pérez*

15:30 Beyond dolphin-safe: distinguishing sustainable tuna in the marketplace
Robin Pelc

15:50 Coffee Break

SESSION 2: Behavior and Survival Inferred from Tagging I (Moderator: Dan Cartamil)

16:10 Horizontal and vertical movements of satellite tracked blue shark around the Azores, Central North Atlantic
Pedro Afonso*, Fredéric Vandeperre, Marco Santos, Jorge Fontes, Alexandre Aires-da-Silva and Ricardo S. Santos*

16:30 Post-release survival of blue sharks captured in the California-based drift gillnet fishery
Natalie Spear*, Lyle Enriquez and Suzanne Kohin*

16:50 Oceanic spatial behavior and the impact of pelagic longline fishery on loggerhead sea turtles (*Caretta caretta*) in the wider Azores region
***Marco Aurélio Robalo dos Santos**, Alan Bolten, Frederic Vandeperre, Pedro Afonso and Karen Bjorndal*

SESSION 3: Gear Modifications I (Moderator: Dan Cartamil)

17:10 Bluefin tuna bycatch mitigation research in the Gulf of Mexico yellowfin tuna pelagic longline fishery
***Daniel Foster** and Charles Bergmann*

17:30 Catch and bycatch effects of large circle hooks in a tuna longline fishery
***Daniel Curran** and Keith Bigelow*

17:50 'Welcome Gathering Party' in the Tavern (Continued After Dinner)

18:30 Dinner

Socializing in the Tavern

20:00 Video Viewing Session (Pineview)

Tuesday, 18 May 2010

8:00 Breakfast

SESSION 4: Gear Modifications II (Moderator: Yonat Swimmer)

9:00 New designs of drifting fish aggregating devices to avoid ghost fishing of sea turtles and sharks
*Gala Moreno, **Igor Sancristobal**, Jose Franco and Laurent Dagorn*

9:20 Reducing Sea Turtle entanglements from the Eastern Pacific artisanal surface longline fisheries
*Takahisa Mituhasi, Yoshiro Hara, Manuel Parráles, Jorge Villavicencio, Liliana Rendón, Cleridy Lennert-Cody, Nicholas Vogel, and **Martín Hall***

9:40 Using visual cues to reduce sea turtle interactions with fishing gear
***John H. Wang,** Shara Fisler and Yonat Swimmer*

10:00 Effects of Nd/Pr alloy on catch rates of pelagic and coastal shark species
Melanie Hutchinson, *J.H. Wang, S. Kohin, H. Dewar, R. Vetter, J. Wraith, Y. Swimmer and K. Holland*

10:20 Coffee Break

SESSION 5: Behavior and Survival Inferred from Tagging II (Moderator: David Kerstetter)

10:40 Depth distribution and temperature preferences of wahoo (*Acanthocybium solandri*) in the eastern North Pacific
Chugey Sepulveda*, Scott A. Aalbers, Sofia Ortega-Garcia, Nick Wegner and Diego Bernal*

11:00 Geographic variation in movements, behavior, and habitat of yellowfin tuna in the Eastern Pacific Ocean, ascertained from archival tags
Kurt Schaefer, *Daniel Fuller and Barbara Block*

11:20 Behavioural and environmental influences on the distribution of striped marlin (*Kajikia audax*) in the southwest Pacific Ocean: Results from behavioural modelling of individual movements
Tim Sippel*, John Holdsworth, Todd Dennis and John Montgomery*

11:40 Defining habitat utilization for striped marlin in the Pacific
Chi H. Lam*, Nicole Nasby-Lucas and Michael L. Domeier*

12:00 Lunch

SESSION 6: Management Strategies (Moderator: Shane Griffiths)

13:00 It's about total removals, not just the bycatch: Metrics of ecosystem impact of the ETP purse-Seine fishery
Robert Olson*, Tim Gerrodette, Stephen Reilly, George Watters and William Perrin*

13:20 Swordfish bycatch in the Hawaii-based deep-set pelagic longline fishery: Does the current management regime promote regulatory discards?
Russell Y. Ito*, William A. Walsh and Karen L. Sender*

13:40 Does live release provide an effective means of reducing fishing mortality on istiophorid billfishes?
John E. Graves *and David Kerstetter*

14:00 Trade-offs in the design of fishery closures: Management of silky shark bycatch in the Eastern Pacific Ocean tuna fishery
Jordan T. Watson, *Timothy E. Essington, Cleridy E. Lennert-Cody and Martín A. Hall*

14:20 Coffee Break

14:40 The cost of juvenile fishing: bycatch in the western and central Pacific Ocean tuna purse seine fishery
Megan Bailey *and U. Rashid Sumaila*

15:00 The economic value of bycatch reduction
Stephen M. Stohs

SESSION 7: Recreational Fisheries (Moderator: Bill Bayliff)

15:20 Wall Street or Pacific Stocks? An analysis of the historical drivers of sportfishing demand
James Hilger *and Eric Janofsky*

15:40 Description of the historical and current south Florida recreational tournament fishery for swordfish, *Xiphias gladius*
Elaine Brewer *and David Kerstetter*

15:50 Catching the uncatchable: Use of respondent-driven sampling for obtaining representative catch estimates for target and bycatch species in specialized sport fisheries
Shane P. Griffiths*, Kenneth H. Pollock, Jeremy M. Lyle, Julian G. Pepperell, Mark L. Tonks and Bill Sawynok*

16:30 Poster Session (See List of Posters) and "Sushi Party" in Lakeview – Sashimi donated by Prime Time Seafood, Inc.

18:30 Dinner

Socializing in the Tavern

20:00 A Hands-On Introduction to TrackIt – Tim Lam (Lakeview)

20:00 Summary and discussion of the Sukarrieta meeting on bycatch in tuna purse seine FAD fisheries, November 2009 - Martin Hall, Gala Moreno and Laurent Dagorn (Pineview)

Wednesday, 19 May 2010

8:00 Breakfast

SESSION 8: Fish Aggregating Devices (FADs)
(Moderator: William Walsh)

9:00 The evolution of FADs in the tuna purse-seine fishery of the Eastern Pacific Ocean
Marlon H. Román-Verdesoto*, Martín Hall and Nickolas W. Vogel*

9:20 Behavior of the primary shark bycatch species by purse seiners, the silky shark, around drifting FADs
John D. Filmalter and ***Laurent Dagorn***

9:40 Where'd they go? The behavior of tuna after they leave FADs
Kim Holland, *David Itano and Laurent Dagorn*

10:00 Studying fish aggregations around drifting FADs using fishers' echosounder bouys
Gala Moreno, *Yolanda Sagarminaga, Dorleta García and Igor Sancristobal*

10:20 Coffee Break

SESSION 9: Stock Structure I
(Moderator: Keith Bigelow)

10:40 Is there stock heterogeneity in north Pacific albacore entering the North American west coast fishery?
R. Michael Laurs

11:00 Discrimination of age-0 Pacific bluefin tuna from two different spawning grounds in length-frequency distributions
Kazuhiro Oshima, *Momoko Ichinokawa and Yukio Takeuchi*

11:20 Genetic analysis of population structure of striped marlin in the Pacific Ocean
Catherine M. Purcell *and Suzanne Edmands*

11:40 Use of nuclear genetic markers and Bayesian clustering to infer population admixture and neighboring stock bycatch in Atlantic swordfish (*Xiphias gladius*)
Brad L. Smith

12:00 Lunch

SESSION 10: Stock Structure II
(Moderator: Marty Golden)

13:00 Genetic structure of dolphinfish, *Coryphaena hippurus*, in the Gulf of California using microsatellite loci
***Miguel A. Tripp-Valdez**, Francisco J. García de León, Sofía Ortega-García, Daniel Lluch-Cota, Juana López-Martínez and Pedro Cruz*

13:20 Back to basics for bycatch: Using parasites and morphometrics to assess stock structure of wahoo, *Aconthocybium solodri*, in Australian waters
***Mitchell T. Zischke,** Shane P. Griffiths, Robert J. G. Lester and Ian R. Tibbetts*

SESSION 11: Growth and Morphology
(Moderator: Marty Golden)

13:40 Review of joint research activities at the IATTC's Achotines Laboratory
***Vernon Scholey**, Dan Margulies, Jeanne Wexler and Maria Santiago*

14:00 Stage-specific density effects on growth in early stages of yellowfin tuna, *Thunnus albacares*
***Jeanne Wexler**, Dan Margulies, Maria Santiago and Vernon Scholey*

14:20 Ram ventilation in the shortfin mako, *Isurus oxyrinchus*: oxygen utilization and the bronchial pressure gradient
***Nicholas C. Wegner**, N. Chin Lai, Kristina B. Bull and Jeffrey B. Graham*

14:40 Coffee Break

SPECIAL SESSION: BYCATCH IN GLOBAL TUNA FISHERIES

15:00 Introduction: The Kobe Process and the Bycatch Workshop – ***Rebecca Lent***

15:10 Overview of Global Tuna Fishery Bycatch Issues – ***Nicole LeBoeuf***

Improving assessment and mitigation of bycatch in Tuna RFMOs
(Moderator: Mark Helvey)

15:40 Bycatch assessment – ***Guillermo Diaz***

15:55 Bycatch mitigation – ***John Graves***

16:10 Overview of economic approaches/incentives – ***Dale Squires***

16:25 Collaboration and outreach – ***Martín Hall***

16:40 Moderator wrap up – ***Mark Helvey***

16:50 DISCUSSION
(Moderator: Liz English)

17:35 Concluding Remarks – ***Rebecca Lent***

18:00 Business Meeting (Pineview)

18:30 Dinner – Tuna Barbeque

20:00 CAMPFIRE (Frontier Village)

Thursday, 20 May 2010

8:00 Breakfast

SESSION 12: Tag Design
(Moderator: Tim Sippel)

9:00 New tagging technologies increase position accuracy, tag capabilities, and sample size
Thomas Gray

9:20 Determining transmitter drag and best-practice attachment procedures for biotelemetry studies on sea turtles
T. Todd Jones*, Brian Bostrom, Michael Carey, Jon Mikkelsen, Yonat Swimmer, Jeffrey A. Seminoff and David R. Jones*

SESSION 13: Modeling Spatial Structure
(Moderator: Tim Sippel)

9:40 Spatial and seasonal distribution of 0-age Pacific bluefin tuna (*Thunnus orientalis*) based on analysis of Japanese troll fishery catches
Momoko Ichinokawa*, Kazuhiro Oshima and Yukio Takeuchi*

10:00 An evaluation of spatial structure in the stock assessment of bigeye tuna in the eastern Pacific Ocean
Alexandre Aires-da-Silva *and Mark Maunder*

10:20 Dynamic habitat mapping for large pelagic species of the California Current
Stephanie Snyder, *Daniel Harrison, Suzanne Kohin, Ed Armstrong, Frank O'Brien and Dale Kiefer*

10:40 Coffee Break

SESSION 14: Specialized Habitats (Moderator: Michael Laurs)

11:00 Habitat utilization and trophic ecology for three co-occurring tuna species in the EPO
Daniel Madigan*, Aaron Carlisle, Kurt Schaefer and Barbara Block*

11:20 Characterisation of the physical environment at Cross Seamount and its effects on micronekton
Réka Domokos

11:40 Nursery habitat of juvenile common thresher shark (*Alopias vulpinus*) in U.S. and Mexican waters
Daniel Cartamil*, Miguel Escobedo-Olvera, Omar Santana-Morales, Oscar Sosa-Nishizaki, Suzanne Kohin, Nick Wegner, Dovi Kacev and Jeffrey Graham*

12:00 Lunch

13:00 End of Conference

Thanks for coming, hope to see you next year!

LIST OF POSTERS

#1 **HOW DOES DELAYED HATCHING IN THE CALIFORNIA GRUNION, *Leuresthes tenuis*, AFFECT LARVAL LENGTH, ENERGY RESERVES, SWIMMING ACTIVITY AND SURVIVAL? -** Helena Aryafar and Kathryn Dickson

#2 **PATTERNS OF MOVEMENT AND BEHAVIOR OF COMMON THRESHER SHARKS (*Alopias vulpinus*) IN THE SOUTHERN CALIFORNIA BIGHT -** Daniel Yanagi, **Sam Chew Chin**, Andres Baquero, James Wraith, Russ Vetter and Suzanne Kohin

#3 **SLUTH: SWORDFISH AND LEATHERBACK USE OF TEMPERATE HABITAT -** Heidi Dewar, Scott Benson, Peter Dutton, Christina Fahy, Craig Heberer, Suzanne Kohin, Jeff Seminoff, Stephanie Snyder, Candan Soykan, Dale Squires and Stephen Stohs

#4 **AN EVALUATION OF THE CONSERVATION BENEFIT OF CIRCLE HOOKS IN THE RECREATIONAL FISHERY FOR BLUE MARLIN *Makaira nigricans* -** John E. Graves and A.Z. Horodysky

#5 **HABITAT UTILISATION AND MOVEMENTS OF LONGTAIL TUNA (*Thunnus tonggol*) AND INDO-PACIFIC SAILFISH (*Istiophorus platypterus*) IN NERITIC AUSTRALIAN WATERS AS DETERMINED BY POP-UP ARCHIVAL TAGS -** Shane P. Griffiths and Chi Hin Lam

#6 **EASTERN PACIFIC SHARK CONSERVATION AND MANAGEMENT WORKSHOPS: REGIONAL PROGRESS ON IMPROVING SHARK IDENTIFICATION, DATA COLLECTION, AND REPORTING -** Craig Heberer

#7 **OPTIMAL AGE-SPECIFIC SUSTAINABLE HARVESTING POLICY FOR TUNA -** Mikihiko Kai

#8 **MAKING LEMONADE FROM LEMONS: USING PELAGIC LONGLINE GEAR BEHAVIOR TDR DATA FOR INSIGHTS INTO POST-HOOKING BEHAVIOR OF FISHES -** Kerstetter, D.W. and G.M. Archer

#9 **MOLECULAR ASSAYS FOR GENDER DETERMINATION OF BILLFISH SPECIES -** Ching-Ping Lu and Jaime R. Alvarado Bremer

#10 **INCIDENTAL CATCH OF DOLPHINFISH (C*oryphaena* spp.) REPORTED BY THE MEXICAN TUNA PURSE SEINERS IN THE EASTERN PACIFIC OCEAN -** R.O. Martínez-Rincón, S. Ortega-García, J.G. Vaca-Rodríguez

#11 **FACTORS AND METHODS RELEVANT TO POST-RELEASE MORTALITY IN LARGE PELAGIC BILLFISHES AND SHARKS -** Michael K. Musyl, Richard W. Brill, Daniel S. Curran, Nuno M. Fragoso, Lianne M. M^{c}Naughton, Bert S. Kikkawa and Christopher D. Moyes

#12 **DOLPHINFISH (Coryphaena spp.) PURSE-SEINE BYCATCH IN THE EASTERN PACIFIC OCEAN: SPATIAL AND SEASONAL VARIABILITY -** Sofía Ortega-García, Rubén Rodríguez-Sánchez, Juan Guillermo Vaca-Rodríguez , Heriberto Santana-Hernández, and Héctor Villalobos

#13 **TRENDS OF PELAGIC SHARK BIODIVERSITY AND ABUNDANCE INDEX IN THE WESTERN INDIAN OCEAN -** Evgeny V. Romanov and Pascal Bach

#14 **FORAGING ECOLOGY OF TUNAS IN THE SOUTHERN CALIFORNIA BIGHT: ONE COMPONENT OF A BROADER COOPERATIVE BIOLOGICAL SAMPLING PROGRAM -** Owyn Snodgrass, Heidi Dewar, Marcus Medak, Ken Franke

#15 **USE OF SATELLITE TELEMETRY TO DETERMINE POST-RELEASE SURVIVORSHIP AND BEHAVIOR OF SEA TURTLES INCIDENTALLY CAUGHT IN LONGLINE FISHERIES -** Yonat Swimmer, Amanda Southwood, MariLuz Parga, Andrés Domingo, Caren Barceló, Philip Miller, Gilberto Sales, Bruno Giffoni, Lianne McNaughton, Ricardo Samarinaga

#16 **TUNA FISHERIES AND FADS SYMPOSIUM, FRENCH POLYNESIA, NOVEMBER 2011: FIRST ANNOUNCEMENT -** Marc Taquet

#17 **OCEANOGRAPHIC INFLUENCES ON ALBACORE TUNA CATCH IN THE NORTHEAST PACIFIC -** Steven L. H. Teo

#18 **SPATIAL DISTRIBUTION OF BLUE SHARK (*Prionace glauca*) FROM THE PELAGIC LONGLINE FISHERY IN THE WIDER AZORES REGION -** Frederic Vandeperre, Marco Santos, Alex Aires-da-Silva, Pedro Afonso, Alan Bolten, Ricardo Serrao Santos

#19 **NURSERY ORIGIN OF YELLOWFIN TUNA (*Thunnus albacares*) IN THE HAWAIIAN ISLANDS: AN OTOLITH CHEMISTRY APPROACH -** R. J. David Wells, Jay R. Rooker, and David G. Itano

#20 **MOVEMENTS AND BEHAVIOR OF BLUE SHARKS (*Prionace glauca*) IN THE EASTERN NORTH PACIFIC -** James Wraith, Heidi Dewar, Suzanne Kohin, Kevin Weng, Salvador Jorgensen, Oscar Sosa-Nishizaki, Erick Oñate-Gonzalez, Sandy McFarlane, Chi H. Lam, and Barbara Block

#21 **POPULATION DYNAMICS OF DOLPHINFISH (*Coryphaena hippurus*) CAPTURED OFF BAJA CALIFORNIA SUR, MÉXICO: MANAGEMENT IMPLICATIONS** - Marcela S. Zúñiga-Flores, Sofía Ortega-García, Carmen Rodríguez-Jaramillo and Rubén Rodríguez-Sánchez

PAPER ABSTRACTS

(In order of presentation)

ISSUES ON TUNA PURSE-SEINE BYCATCH INFORMATION WORLDWIDE

E. Altamirano and M. Hall

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As dolphin mortality declined steadily and remained low for over a decade, the focus of the IATTC observer program has shifted towards other bycatch issues, especially those in the FAD fisheries. A new process has begun to understand the causes and to reduce the bycatch in these sets, as part of an approach to ecosystem-based fisheries management. Currently, Regional Fisheries Management Organizations in the Atlantic, the Indian and the Western and Central Pacific Ocean have observer programs with increasing coverage. All these programs collect similar information, but there is a need to achieve full consistency to facilitate research, and to complete the gaps that appear when we attempt to understand the bycatches in the relatively new and growing FAD fisheries.

The new challenges bring to the surface new data needs, of variables that may influence capture and mortality of the different species that are not retained. It is necessary to identify which these factors are, and to include them in the data collection process. Considering that tuna purse-seine fishing vessels and crew are mobile and that frequently the same personnel and vessels are deployed in different ocean areas, comparative studies have a lot of potential to identify common issues and differences. Joint activities, including data analyses, bringing together the scientists working in, or around, every Tuna RFMO should be a major component of the strategy to face this issue. As always, the interactions with skippers and crews will be very valuable to find the solutions to the problems. We will identify some common needs of information for observer programs that are not been collected currently, mainly related to FAD data, vessel gear and operational data.

The technique known as FAD fishing has not only spread through different oceans but it has evolved through the years, and it is still evolving. At the same time, the industry on its own has started changing the patterns of utilization of other species formerly discarded, and some of the bycatches have turned into catches. This diversified harvest may help reduce fishing mortality on some of the tuna species where this reduction is desirable.

IDENTIFYING AREAS WITH HIGH RATES OF BYCATCH: CAN WE CONSIDER A LINEAR RELATIONSHIP BETWEEN BYCATCH AND TUNA CATCH?

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In the case of tropical tuna purse seine fisheries, bycatch and (or) discards estimations are routinely based on simple raising procedures based either on tuna abundances or on the number of fishing sets. These procedures postulate that a linear relationship exists between, say, bycatch and tuna abundances. By the way, they also assume that the residuals around such a relationship is symmetrical. The primary objective of this analysis was to check the reliability of such assumptions. This opens the question of the identification of the best variables and methods that can optimize the estimation of bycatch by taking several covariates into account. Finding the best modeling approach remains very important when examining practical fishery management aspects i.e. the identification of areas with high rates of bycatch for investigating measures. The present analysis was based on data collected by observers aboard French tropical tuna purse seiners during the last three years in the Atlantic Ocean, in the framework of European data collection regulation program. While more than fifty non target species including sharks, rays, turtles, billfishes and bony fishes were noted in the data, we only focus here on their global estimation and spatial distribution. The aim of this study was:

1. To test statistically the consistence of the hypothesis generally assumed for by-catch estimation in the case of tuna purse seine fishery by comparing two models at different levels of stratification.

Model 1: Bycatch as a linear function of tuna landing (respectively number of sets).
Model 2: Bycatch as a logistic function of tuna landing (respectively number of sets).

2. Uses the appropriate model to predict areas of high rates of bycatch.

The two models were compared on the basis of the Akaike Information Criteria (AIC). In all cases, comparison between the two models showed that the second one was the best, indicating that it is certainly best to predict bycatch with models accounting for non linear relationships between bycatch and the covariates. Thus, considering the traditional raising procedure can be misleading.

As far as spatial considerations are concerned, bycatch happened to be spatially clustered and showed clear regional patterns, decreasing from the coastal to the open sea, for both fishing modes (free schools or FADs). Most of free schools bycatch were located on the eastern south equator while the FAD sets were on the western north equator. Finally, the analysis showed that, while the fishery was dominated by free school sets (65%), the majority of the bycatch (both in terms of occurrence and amount) were caught under FAD sets.

Keywords : Bycatch, assumption, model, spatial, purse-seine.

CAPACITY ESTIMATION AND BYCATCH REDUCTION: AN APPLICATION TO THE WESTERN AND CENTRAL PACIFIC PURSE SEINE FISHERY AND BIGEYE TUNA

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Output-based measures of technical efficiency and capacity have served as important tools for assessing economic performance and informing management of fisheries. Capacity studies of the Western and Central Pacific Ocean (WCPO) tuna fisheries have made use of the mathematical programming technique data envelopment analysis (DEA) (Reid et. al, 2003, Managi 2009).

Less than 2% of WCPO purse seine catch by weight is that of bigeye tuna. This catch is untargeted small and immature bigeye caught with fish-aggregation devices (FADs) or log-sets targeting mature yellowfin tuna. However, this represents 20% of total WCPO bigeye catch. Scientists are particularly concerned about the impact of these young fish being removed from the fishery and it's consequences on biomass.

WCPO tuna fleets have begun to feel the economic impacts of bigeye overfishing. The Hawaii-based U.S. longline fishery was closed three days early in 2009, after reaching the maximum allowed bigeye yield of 3,763 metric tons. Scientific committees have recommended an overall reduction in bigeye catch in the range of 25-30% of recent levels.

Existing capacity studies of the WCPO purse seine fleet have combined yellowfin and bigeye catch, as they are usually caught by the same methods. However, given the current desire to reduce bigeye catch, as well as increased research on technologies to reduce such bycatch, it is advantageous to consider bigeye as an undesirable output in economic measurements of the fishery.

An overview of the DEA literature on undesirable outputs will be shown, as well as an application to the WCPO purse seine fleet. Furthermore, an outline of how bycatch reduction can be incorporated into the short-run Johansen Industry model to determine optimal fishery or fleet-specific allocations of capital in the presence of excess capacity.

STANDARDIZING FISHING GEAR DESCRIPTIONS FOR FISHERIES AND BYCATCH STUDIES

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To classify fishing gears into statistically meaningful groups, to identify risk factors for bycatch studies and for better measurement of CPUE and BPUE (Bycatch Per Unit Effort), it is essential to understand what are the characteristics of fishing gear that may affect their selectivity for species and sizes, and that determine the way they operate (e.g. depth, etc.). For example, in artisanal longline fishery of the eastern Pacific, the material used in the main line influences the buoyancy of the line, and therefore affects the rate of sea turtle entanglement in them. In such a case, different types of longlines could be combined by main line materials to assess the entanglements. Different hook sizes and shapes, bait types, breaking strength of net, hanging ratios, etc., can affect their performance with respect to catches and bycatches. Basic CPUE measures such as catch per thousand hooks may be a very poor description in a dynamic fishery, and if the changes in gear and ignored, they can mask the changes in the stocks involved.

Here we present standardized Fishing Gear Description Form for longlines, gillnets (including trammel nets) and purse seines. The description includes all details of the materials (e.g. mesh size, hanging ratio, type and size of hook, etc.), construction, mode of operation, etc., that can be significant for standardizing fishing effort, and for understanding the bycatch implications of the differences observed. These forms could be filled by observers on vessels, but they can also be done on the piers and beaches, helping fish managers to produce better sampling designs for landings, for bycatch estimation, and for many other uses. These forms have been circulated among experts on the different gears, and with their combined inputs we have produced the final product. The forms are being tested in several regions of the world, and they could serve as a basic element for comparative studies.

BEYOND DOLPHIN-SAFE: DISTINGUISHING SUSTAINABLE TUNA IN THE MARKETPLACE

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The Monterey Bay Aquarium's Seafood Watch program assesses the sustainability of fisheries and encourages consumers and businesses to choose sustainable seafood products. Tuna fisheries using unassociated purse seines have far lower bycatch rates than fisheries using floating object or fish aggregating device (FAD)-associated purse seines. Consumers and major seafood buyers have the power to transform the tuna industry by choosing tuna caught with unassociated purse seines – a choice that could translate to dramatic reductions in the bycatch of juvenile tuna, billfish, sharks and other species of concern. However, the inability to distinguish these products in the marketplace currently presents an obstacle to reducing bycatch in tuna fisheries through market-based approaches.

HORIZONTAL AND VERTICAL MOVEMENTS OF SATELLITE TRACKED BLUE SHARK AROUND THE AZORES, CENTRAL NORTH ATLANTIC

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The blue shark (BSH), *Prionace glauca*, is among the most abundant and wide ranging of all pelagic sharks in the global oceans. Fisheries patterns have shown that BSH segregate by sexes and sizes in space, probably as a strategy to avoid cannibalism and reduce competition. Demographic and risk analyses showed that overall BSH population growth is strongly dependent on the survival of the juvenile segment. Juvenile blue sharks are abundant in several regions of the eastern NA, including the wider Azores region, pointing out the potential of protecting central-eastern Atlantic nursery grounds for the conservation and management of the NA blue shark. However, the movements of immature BSH have not yet been studied in detail and this remains a major knowledge gap to verify such possibility. This paper reports BSH satellite tagging experiments carried out off the Azores since February 2009. 21 BSH, mostly immature (115 to 202 cm FL), were tagged with pop-up archival tags (PAT) and positioning tags (SPOT) to study their horizontal and vertical behavior. Three of such sharks have been double-tagged. All tagged BSH appeared to survive capture and handling. The vertical behavior data obtained so far clearly show that immature BSH dive extensively and repetitively down to 700 m depth when exploring the oceanic environment, depending on characteristics of local water masses. SPOT data revealed adequate to study not only the large scale, pan oceanic movements, but also the finer, mesoscale movements of BSH, for example those around seamounts and continental slopes. In contrast, three double tagged sharks showed that geopositioning from PAT tags can realistically depict the larger scale movements but not the shorter term mesoscale movements. Data available to date show that immature females tagged in the winter left the Azorean region within a few weeks after release, migrating northeast and to the gulf of Biscay, but returning to the region the next winter. Immature males tagged in autumn tended to stay within the wider Azores region. These results, together with the strong dominance of juveniles in the local population and the accentuated seasonal pattern in abundance and sexual segregation indicate that the region is part of a wider juvenile habitat, but that the spatial and temporal scales of this habitat are more dynamic than previously thought. In contrast, subadult and adult females migrated near the equator, supporting the hypothesis of putative pupping grounds located in the tropical eastern and central Atlantic.

POST-RELEASE SURVIVAL OF BLUE SHARKS CAPTURED IN THE CALIFORNIA-BASED DRIFT GILLNET FISHERY

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The California/Oregon Drift Gillnet (DGN) Fishery targets swordfish (*Xiphias gladius*) in the highly productive waters of the California Current. With the exception of ocean sunfish (*Mola mola),* blue sharks (*Prionace glauca*) are caught in greater numbers than any other finfish species caught in the fishery. Nearly all blue shark are discarded at sea due to lack of market value. Based on fishery observer records for seasons 1990-2008, 32% of blue sharks captured were released alive, and an additional 5% were discarded with their disposition unknown. Southwest Fisheries Science Center (SWFSC) and the Southwest Regional Office (SWRO) began a project in 2007 to determine the fate of blue sharks released alive from the fishery. Pop-off archival tags (Wildlife Computers MK10) were programmed to report after 30 days and were deployed on live sharks discarded in the fishery to assess their post-release survival. The goal was to tag sharks representative of the sharks that have been discarded with the sex ratio, range of sizes, and condition at release comparable to those released from the fishery. Observer data were examined to determine the appropriate sharks to tag. A set of criteria was also developed to document the condition of all blue sharks released: good, fair or poor. The remaining 63% were discarded dead.

Since initiating the study in 2007, 11 blue sharks (fork length: FL 100-200 cm, median 155 cm) have been tagged by fishery observers contracted through the NMFS California/Oregon Drift Gillnet Observer Program. Nine of these animals were male, and the sex of two animals was unknown. Three of the 11 sharks were released in “good” condition while the remaining eight were released in “fair” condition. To date, no sharks released in “poor” condition have been tagged. Satellite tag records suggest that all animals survived the acute effects of capture in the DGN fishery. Temperature, depth and movement data demonstrated behavior of blue sharks that was similar to that reported in other studies. One tag appears to have been ingested after 17 days and was regurgitated three days later.

Twenty-seven percent of blue sharks released during the 2007 and 2008 seasons (the only seasons for which this information has yet been collected and compiled) were released in poor condition. For seasons 1990-2008, the median overall FL of blue sharks caught was 112 cm, and 61% were female. Therefore, the sharks tagged to date do not represent all blue sharks caught and released in the fishery. In order to assess the fishery-wide mortality rate, this study will continue during the 2010-2011 season with tagging efforts focusing on smaller sharks, females and animals released in poor condition. Results to date suggest a 100% survival rate for male blue sharks released in fair or better condition after capture.

OCEANIC SPATIAL BEHAVIOR AND THE IMPACT OF PELAGIC LONGLINE FISHERY ON LOGGERHEAD SEA TURTLES (*Caretta caretta*) IN THE WIDER AZORES REGION

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Loggerhead sea turtles undergo significant alterations in their ecology that involve a series of ontogenetic shifts, often associated with changes in habitat. In contrast to the knowledge acquired on their ecology in terrestrial and neritic habitats, little is known about the ecology of the juveniles during the extended journey in their oceanic habitats. The wider Azores region is considered an important oceanic developmental habitat for the offspring of southeastern USA loggerhead population, the largest in the Atlantic and one of the most important worldwide. The most significant anthropogenic threat to the survival of juvenile-oceanic loggerhead turtles during the oceanic stage is the risk of incidental capture in commercial fisheries, mainly as by-catch of pelagic longline fleets, and this is suspected to have contributed to the dramatic decline in annual number of nests during the last decade. The identification of critical oceanic habitats is, therefore, a priority for the conservation of this endangered population. We investigated the movements and distribution patterns of loggerheads around the wider Azores region to identify important oceanic habitats and to elucidate the ecology of the oceanic-juvenile stage through the utilization of fishery-dependent (longline experiments) and independent (biotelemetry) data. This study demonstrates that juvenile loggerheads are associated with steeper slopes areas, such as seamounts, and that they also actively utilize mesoscale oceanographic features, namely eddies. These behaviors are interpreted as a strategy to improve their foraging efficiency during the oceanic stage, and establish a functional link between habitat characteristics and juvenile ecology. These results reinforce the need for mitigation measures on the impact of the longline fishery on loggerhead sea turtles.

BLUEFIN TUNA BYCATCH MITIGATION RESEARCH IN THE GULF OF MEXICO YELLOWFIN TUNA PELAGIC LONGLINE FISHERY

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Research was conducted in 2008 and 2009 by the Engineering and Harvesting Branch of NOAA Fisheries, Southeast Fisheries Science Center, Mississippi Laboratories to evaluate a new 16/0 “weak” circle hook designed to reducing the bycatch of bluefin tuna in the Gulf of Mexico yellowfin tuna fishery. Bycatch in this fishery has been identified as a major source of fishing mortality in the western Atlantic bluefin tuna spawning grounds. Five commercial vessels completed 197 pelagic longline sets, during which experimental hooks and standard 16/0 circle hooks were alternated, resulting in a total of 123,872 hooks set. A total of 20 bluefin were caught during the experiment, of which four were caught on the experimental hook (75% reduction). The difference in bluefin catch was statistically significant. Vessels landed a total of 1,573 yellowfin tuna. Catch rates for yellowfin tuna did not differ significantly by hook type.

CATCH AND BYCATCH EFFECTS OF LARGE CIRCLE HOOKS IN A TUNA LONGLINE FISHERY

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Eighteen vessels within the Hawaii-based tuna longline fleet were contracted to test the catch efficacy of large circle hooks versus the existing hooks in use by the fishery. Large circle hooks have been shown to reduce the catch and mortality of sea turtles in other longline fisheries. This study was intended to test the effects of using large circle hooks on target, incidental, and bycatch species in the fishery. The majority of the fleet uses "Japanese" style tuna hooks (3.6 sun, about the same size as most 14/0 circle hooks), but some of the vessels contracted use "J" style hooks (size 9/0). The large circle hooks tested were stainless steel (size 18/0) circle hooks made in Korea. Vessels were mandated to alternate hook type throughout the mainline and to maintain a 1:1 ratio of circle hooks to existing hooks. Every trip was accompanied by a National Oceanic and Atmospheric Administration certified observer who collected information on catch by hook type, the daily tally of the total numbers of each type of hook used, and a vessel's ability to follow experimental protocols. The experiment was conducted from July of 2005 until February of 2006. A total of 1393 sets were analyzed; 1182 sets were large circle hooks versus 3.6 sun tuna hooks, and 211 sets were large circle hooks versus 9/0 J hooks.

Two statistical methods were used to assess catch or catch rate differences for 19 individual species between hook types: randomization tests and Generalized Linear Mixed Models. There was no significant difference in the catch of the target species, bigeye tuna (*Thunnus obesus*) by hook type. However, results showed strong statistical evidence that the use of large circle hooks would reduce the catch of incidental species such as billfish, pelagic sharks, opah, and dolphinfish in the Hawaii-based tuna longline fishery. Mean fork length and survival upon longline retrieval showed little or no difference by hook type for most species. These results indicate that large 18/0 circle hooks maintained the target species catch rate and reduced incidental catch of billfish, other tunas, pomfrets and a variety of bycatch species. Large circle hooks show promise in reducing bycatch although there is economic concern of lost revenue due to lower catch rates of billfish and some pelagic sharks that are often retained and marketed.

NEW DESIGNS OF DRIFTING FISH AGGREGATING DEVICES TO AVOID GHOST FISHING OF SEA TURTLES AND SHARKS

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Purse seiners deploy thousands of Drifting Fish Aggregating Devices (DFADs) in all tropical oceans to catch tropical tunas. Although different designs of DFADs exist, fishers all over the world mainly use bamboo rafts with black netting hanging underneath. However, this type of FADs is responsible for incidental mortality of sea turtles and sharks through entanglement. It is now urgent that fishers use "Ecological FADs" that reduce such ghost fishing in order to move towards sustainable and responsible purse seine fisheries. In this study, we first identify the criteria for Ecological FADs and we propose various possible designs for Ecological FADs.

REDUCING SEA TURTLE ENTAGLEMENTS FROM THE EASTERN PACIFIC ARTISANAL SURFACE LONGLINE FISHERIES

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This talk will summarize research on the actual situation of sea turtle entanglements and fishing trials of a modified longline gear aiming at reducing those entanglements in artisanal surface longline fisheries of the eastern Pacific Ocean. The artisanal surface longline fishery is a major source of economic activity, an indispensable source of protein, as well as employment for local populations for Central and South American countries along the eastern Pacific Ocean. In this fishery, unwanted incidental capture of sea turtles is induced not only by hooking but also by entanglement in fishing lines. As entanglement in fishing lines may also lead to mortality, we estimated the number of entanglements, and attempted to develop effective and viable countermeasures against the entanglements.

First, we analyzed fishery observer data to assess entanglement rate (number of sea turtle entangled per 100 nautical miles of main line) of each fishery. The results show a clear relationship between the entanglement rates and main-line materials. Main lines made out of polypropylene (PP) or polyethylene (PE) have a much higher rate of entanglement than those made out of polyamide monofilament (PA-MF). At the same time, sea turtle entanglements were most prevalent around the floats in longlines made out of PP or PE. This result indicates that the reduction of entanglements in float-section is critical to mitigate the impact of entanglements.

Based on the above results, we modified float lines and a short portion of the mainline adjacent to them, replacing PP cordages with PA-MF. The portion of the PA-MF line and swivels make the portion of mainline sink below the surface. A series of fishing trails was conducted in Ecuadorian mahi mahi longline fishery to assess the effectiveness of the modified gear in the reduction of entanglements. Four small commercial longline fishing boats were contracted to perform 48 longline sets (12 sets X 4 boats), where float lines were modified in an alternating pattern (one float PP, one PA-MF). The results show very clearly the advantages of the PA-MF in reduction of entanglements.

USING VISUAL CUES TO REDUCE SEA TURTLE INTERACTIONS WITH FISHING GEAR

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Many nesting populations of Pacific leatherback (*Dermochelys coriacea*), olive ridley (*Lepidochelys olivacea*), green (*Chelonia mydas*), and loggerhead (*Caretta caretta*) turtles have dramatically decreased. Bycatch in fisheries has been implicated as a significant source of mortality and subsequently population declines for these sea turtle species. Recent studies have raised concerns regarding the high rates of incidental capture and mortality of sea turtles in coastal gill net fisheries. Some studies suggest that small scale coastal gillnet fisheries can have potentially high sea turtle interactions equal to or in some cases exceeding sea turtle interactions with industrial scale pelagic fisheries.

Visual cues play important roles in sea turtle foraging behavior and likely influence their interactions with fishing gear. Altering these cues may be a useful strategy to reduce the incidental catch of sea turtles in various fisheries. We examined the potential effectiveness to reduce green sea turtle catch of three visual cues: shark shapes, nets illuminated by LED lights, and nets illuminated with chemical lightsticks, to reduce bycatch of green sea turtles (*Chelonia mydas*) in gill nets. We then adapted these potential deterrents into commercial bottom gill net fishery to quantify their effects on target fish catch rates and the catch value. Our results indicate that the presence of shark shapes significantly reduced the mean catch rates of green turtles by 54% but also reduced target catch by 45% and, correspondingly, catch value by 47%. In contrast, nets illuminated by LED lights significantly reduced mean sea turtle catch rates by 40% while having negligible impacts on target catch and catch value. Similarly, nets illuminated by chemical lightsticks also significantly reduced mean sea turtle catch rates by 60% while having no significant impact on target catch and catch value. These results illustrate the potential for modifying fishing gear with visual deterrents to effectively reduce sea turtle catch rates.

EFFECTS OF Nd/Pr ALLOY ON CATCH RATES OF PELAGIC AND COASTAL SHARK SPECIES

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Bycatch of sharks in longline fisheries has become a matter of international concern. Shark bycatch rates often exceed that of the targeted species. As such, there is a great impetus to find strategies that will keep sharks off longline hooks. One strategy that is being tested is to exploit the unique electrosensory system of sharks. Sharks and other elasmobranchs use their electrosensory system to detect changes in electric fields in their environments. Previous studies have shown that spiny dogfish *Squalus acanthias* and sandbar sharks *Carcharinus plumbeus* are deterred from baits by the presence of electropositive metals.

This study tested the hypothesis that electropositive metals from the lanthanide series, comprised of neodymium (Nd) and praseodymium (Pr) have an effect on shark catch rates in two different ocean environments. We compared catch rates on longlines with these metals placed near baited hooks versus catch rates using inert lead weights (control). Longlines were deployed in the Southern California Bight targeting the pelagic species, juvenile shortfin mako sharks, *Isurus oxyrinchus* and juvenile blue sharks, *Prionace glauca* during the NOAA-SWFSC juvenile shark population survey and in a coastal embayment in Kaneohe, Hawaii targeting juvenile scalloped hammerheads sharks, *Sphyrna lewini.* We found no difference in the catch rates for sharks caught in the California Bight. In Hawaii we found a significant reduction between sharks caught on hooks with electropositive metal pieces from those that were caught on the controls. One hypothesis for the difference that the Nd/Pr metals had on catch rates between our two experiments are potential differences in interspecific feeding strategies and utilization of sensory modalities for detecting and attacking potential prey items.

DEPTH DISTRIBUTION AND TEMPERATURE PREFERENCES OF WAHOO (*Acanthocybium solandri*) IN THE EASTERN NORTH PACIFIC

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This work quantified the depth distribution and temperature preferences of wahoo (*Acanthocybium solandri*) in the eastern north Pacific (ENP) using archival tags. One hundred and eight data-loggers were deployed in wahoo (105 to 165 cm fork length) from 2005 to 2008. Twenty five individuals (23%) were recaptured within close proximity (<20 km) of their release sites by directed recreational fisheries (72%) and tuna purse seine vessels (28%). The highest site-specific recapture rate was 62% at the Hurricane Bank. Collectively, depth and temperature data from 499 days revealed wahoo predominantly within the upper mixed layer, maintaining an average (±SD) depth of 17.6 ± 11.2 m during the day and 17.3 ± 13.4 m at night. Wahoo spent 99.2% of the daytime and 97.9% of night above the thermocline, and the greatest depth achieved by any fish was 253 m. Tag temperature records ranged from 11.1 ºC to 27.9 ºC, with an average of 25.0 ºC ± 1.1 ºC. These data identify the importance of the upper mixed layer for the wahoo and the relatively high recapture rates validate the economic importance of this resource to the region.

GEOGRAPHIC VARIATION IN MOVEMENTS, BEHAVIOR, AND HABITAT OF YELLOWFIN TUNA IN THE EASTERN PACIFIC OCEAN, ASCERTAINED FROM ARCHIVAL TAGS

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Results are presented on the geographic variation in movements, behavior, and habitat of yellowfin tuna tagged and released with geolocating archival tags in the eastern Pacific Ocean (EPO) during 2002 to 2010. Yellowfin tuna have been tagged and released with archival tags off Southern (*n* = 376) and Northern (*n* = 122) Baja California, Mexico, between 2002 and 2008, in the equatorial eastern Pacific Ocean in 2006 (*n* = 45), and off Panama (*n* = 110), between 2007 and 2009. Yellowfin have also been tagged and released with archival tags within the Revillagigedo Islands Marine Reserve, Mexico, (*n* = 237), between 2006 and 2010. During these tagging cruises 890 yellowfin (47-161 cm in length, mean = 81.7 cm), were tagged and released with archival tags, and thus far 337 (37.9%), have been recaptured and their tags returned.

Results presented are based on analyses of the archival tag data records from 5 of the longest-at-liberty fish from each of the 5 geographically-distinct tagging areas of the EPO. The results include estimation of the most probable movement paths and parameters, and inferences regarding stock structure of yellowfin in the EPO. The discrimination and classification of the proportions of days and frequency of events in which yellowfin exhibited two unique behaviors, which comprise their behavioral repertoire, are described. Horizontal and vertical habitat utilization distributions are presented, and discussed with respect to physical oceanography.

BEHAVIOURAL AND ENVIRONMENTAL INFLUENCES ON THE DISTRIBUTION OF STRIPED MARLIN (*Kajikia audax*) IN THE SOUTHWEST PACIFIC OCEAN: RESULTS FROM BEHAVIOURAL MODELLING OF INDIVIDUAL MOVEMENTS

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The spatio-temporal distribution of striped marlin (*Kajikia audax*) has been historically inferred from commercial catch data, corroborated with some tagging data. However, understanding of the mechanisms that give rise to this distribution has been absent without specific information about the behaviour of individuals. Recently developed state-space interpolation methods have allowed pop-off satellite archival tag data to be combined with satellite-linked radio telemetry data (via Argos) into coherent striped marlin movement datasets. Using these valuable and detailed telemetry datasets, a movement model developed to partition trajectories into discrete behavioural phases shows how behavioural responses of individual fish can begin to reveal underpinnings of the population's broader distribution in the southwest Pacific Ocean. Directional reversals at ~20°S latitude, accompanied by shifts to directed movements and increased speeds at the time of reversal demonstrate how individual behavioural patterns are linked to behaviour of the population. Development of a movement model to investigate striped marlin behaviour and analysis of associated environmental patterns are described here, with outcomes of consequence to stock assessment.

DEFINING HABITAT UTILIZATION FOR STRIPED MARLIN IN THE PACIFIC

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Habitat utilization of striped marlin in the Pacific Ocean is ascertained with the use of pop-up satellite archival tags. 248 tags were deployed off the coasts of Australia, New Zealand, Baja California (Mexico), Costa Rica, Ecuador (Salinas and Galapagos Islands), California (USA) and Hawaii (USA). A total of 159 tags have successfully transmitted data, with the maximum number of data-days at about 120 days. With more than 50% of time spent at the top 0-10 m at various locations across the Pacific, the striped marlin is indeed the inhabitants of the mixed layer, as previous literature has suggested.

We will describe the vertical habitat of striped marlin in details by region and in relation to the oceanographic environment. Individual analyses will be presented with archival time series data collected from several recovered tags. We will also explore the dissolved oxygen as a limiting factor for the distribution of striped marlin in the water column. Oxygen can be very critical in defining the habitat of striped marlin, which has been shown to be the case for sailfish (Prince et al. 2006), and has biological implications with the expanding areas the minimum zones (Stramma et al. 2008; Portner 2010). Ultimately, our description of the vertical distribution could be used to help limit incidental by-catch by altering fishing methods to minimize interactions with non-target species.

IT'S ABOUT TOTAL REMOVALS, NOT JUST THE BYCATCH: METRICS OF ECOSYSTEM IMPACT OF THE ETP PURSE-SEINE FISHERY

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An ecosystem approach is a widely recognized, if not yet widely practiced, goal of ocean policy and fisheries management. Ecosystem-based fisheries management requires an understanding of the ecological implications of fisheries removals. The degree to which fisheries affect ecosystems depends on the composition, magnitude, life history, and ecological role of the different species captured. Previous analyses in the eastern tropical Pacific (ETP) compared the relative impacts of three methods of purse-seine fishing based only on numbers of individuals in the bycatch (defined here as non-target species, either retained or discarded), and found levels of discarded bycatch in floating-object sets thousands of times greater than in dolphin sets and hundreds of times greater than in unassociated tuna sets. We expanded the analysis by examining a mix of ecosystem indicators based on the *type* and *amount* of biomass of species and functional groups caught (total removals) by the fishery. We compared removals (landings and discards) in three ways: trophic level, replacement time, and diversity. We computed mean trophic level as the biomass-weighted mean of the trophic level of each ecological group, the mean replacement time as the biomass-weighted mean of the replacement time (1/(production/biomass ratio)) of each ecological group, and diversity of removals using the Shannon diversity index.

Total annual biomass removals averaged more than 500,000 metric tons per year over the 16-year period from 1993-2008, and were dominated by the primary target species, yellowfin, skipjack and bigeye tunas. Fishing by setting on dolphins, floating objects, and unassociated schools of tuna averaged 30%, 44% and 26% of the biomass removed, respectively. The mean trophic levels of total removals were similar for the three fishing methods, and there was no indication of a decline in trophic level over the 16-year period. Mean time to replace biomass varied by fishing method: lowest for dolphin sets (0.48 years), intermediate for unassociated sets (0.57 years), and highest for floating-object sets (0.74 years). Diversity of removals across the whole time period was lowest for dolphin sets (0.64), intermediate for unassociated sets (1.30) and highest for floating-object sets (1.41). Diversity declined over time for floating-object and unassociated sets and increased for dolphin sets, so that the differences among the three fishing methods were less in 2008 than in 1993. Discards (non-retained bycatch and target species), as a percentage of total removals in biomass, were 0.8% for dolphin sets, 11.0% for floating-object sets, and 2.3% for unassociated sets. The tunas were the major component (77%) of the discards. Discarded bycatch in floating-objects sets was 16 times greater than in dolphin sets and 9 times greater than in unassociated sets, not thousands and hundreds of times greater, when biomass and replacement time are considered.

Although reduction of bycatch has played an important role in the management of the purse-seine fishery for tunas in the ETP, a full evaluation of ecosystem effects must be based on total removals, not just the bycatch, and must take into account size, life history characteristics, susceptibility to overfishing, and position in the food web of the species taken from the ecosystem. Given the ecological tradeoffs between the three methods of purse-seine fishing, determining the optimal mix of the three depends on policy objectives for ecosystem management.

SWORDFISH BYCATCH IN THE HAWAII-BASED DEEP-SET PELAGIC LONGLINE FISHERY: DOES THE CURRENT MANAGEMENT REGIME PROMOTE REGULATORY DISCARDS?

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The Hawaii-based pelagic longline fishery is managed under two regimes according to gear configuration: a deep-set sector that targets bigeye tuna and a shallow-set sector that targets swordfish. The present management regime was developed after restrictions and prohibitions on shallow-set longline fishing began in 2000 due to relatively high sea turtle interaction rates. Shallow-set longline fishing was prohibited from the latter part of 2001. Early in the prohibition period for shallow-set longline fishing, a few operators declared that they were targeting bigeye tuna but landed volumes of swordfish that were comparable to those caught on shallow-set longline trips. This prompted the Western Pacific Regional Fisheries Management Council to impose a 10 swordfish per trip limit on deep-set longline trips in 2002. The shallow-set longline fishery was reopened in 2004 under new regulations intended to reduce sea turtle interactions but the 10 fish per trip limit imposed on the deep-set sector continued. In this presentation, we present evidence that this swordfish limit on the deep-set longline fishery has caused regulatory discards and, to a larger extent, probably promoted high grading of their swordfish catch. These results are discussed in relation to the mandate of the Magnuson-Stevens Fisheries Conservation Act to reduce bycatch, including regulatory discards to the extent practicable.

DOES LIVE RELEASE PROVIDE AN EFFECTIVE MEANS OF REDUCING FISHING MORTALITY ON ISTIOPHORID BILLFISHES?

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Many of the species targeted by the pelagic longline fishery in the Atlantic Ocean, such as bigeye tuna, yellowfin tuna, and swordfish, are estimated to have current biomasses at or near levels necessary for maximum sustainable yield. In contrast, stocks of most Atlantic istiophorid billfishes, which constitute a bycatch of the pelagic longline fishery, are severely depleted. Historically, the International Commission for the Conservation of Atlantic Tunas (ICCAT) has been reluctant to adopt management measures to protect stocks of Atlantic billfish, especially if such measures would impact fisheries for target species. Release of live billfish represents one means to reduce fishing mortality on overfished billfish stocks without impacting takes of target species, if released billfish survive. In general, more than 50% of istiophorid billfish are alive at the time of haulback; however, conventional tagging studies of billfish released from pelagic longline gear have reported very few tag recoveries, a result consistent with high post-release mortality. Over the past several years we have deployed pop-up satellite archival tags to estimate short term mortality of blue marlin, white marlin, and sailfish released from pelagic longline gear. Rates of post-release survival for all three species exceeded 80%, suggesting that live release represents an effective means of reducing fishing mortality. At its 2000 Commission meeting, ICCAT adopted a binding management measure requiring release of live blue marlin and white marlin from longline gear. Although many countries required a few years to implement this measure and compliance has not been perfect, the most recent assessments of blue marlin and white marlin stocks suggest that live release has had a positive impact.

TRADE-OFFS IN THE DESIGN OF FISHERY CLOSURES: MANAGEMENT OF SILKY SHARK BYCATCH IN THE EASTERN PACIFIC OCEAN TUNA FISHERY

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Bycatch—the incidental catch of non-target species—is a principal concern in marine conservation and fisheries management. In the eastern Pacific Ocean tuna fishery, a large fraction of non-mammal bycatch is captured by purse-seine gear when nets are deployed around floating objects. We examined the spatial distribution of a dominant species in this fishery's bycatch, the apex predator silky shark (*Carcharhinus falciformis*), from 1994 to 2005 to determine whether spatial closures, areas where fishing is prohibited, might effectively reduce the bycatch of this species. We then identified candidate locations for fishery closures that specifically considered the trade-off between bycatch reduction and the loss of tuna catch and evaluated ancillary conservation benefits to less commonly captured taxa. Smoothed spatial distributions of silky shark bycatch did not indicate persistent small areas of especially high bycatch for any size class of shark over the 12-year period. Nevertheless, bycatch of small silky sharks (<90 cm total length) was consistently higher north of the equator during all years. On the basis of this distribution, we evaluated nearly 100 candidate closure areas between 5◦N and 15◦ N that could have reduced, by as much as 33%, the total silky shark bycatch while compromising only 12% of the tuna catch. Although silky sharks are the predominant species of elasmobranchs caught as bycatch in this fishery, closures also suggested reductions in the bycatch of other vulnerable taxa, including other shark species and turtles. Our technique provides an effective method with which to balance the costs and benefits of conservation in fisheries management. Spatial closures are a viable management tool, but implementation should be preceded by careful consideration of the consequences of fishing reallocation.

THE COST OF JUVENILE FISHING: BY-CATCH IN THE WESTERN AND CENTRAL PACIFIC OCEAN TUNA PURSE SEINE FISHERY

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Tuna fisheries in the western and central Pacific Ocean are important for both food and economic security globally. Yellowfin and bigeye tuna stocks are declining, in part due to the juvenile by-catch of these species by the purse seine fishery, often fishing on fish aggregating devices (FADs). There appears to be a conflict of interest between the longline fishery for these species, which targets adult fish, and the purse seine fishery, targeting skipjack and adult yellowfin, but catching juvenile yellowfin and bigeye. This paper develops an equilibrium bioeconomic game-theoretic model to determine if the elimination of juvenile fishing might bring economic benefits to the region. Specifically, we model a two player game, purse seine and longline, for a multi-species fishery: skipjack, yellowfin and bigeye. The population dynamics model combines a yield per recruit approach, which considers growth and mortality, with a stock-recruitment model incorporating density dependent population effects. Costs of fishing and ex-vessel prices are then incorporated. Three management scenarios are run. Firstly, the status quo, which currently allows FAD fishing. Secondly, we model the potential profitability of a FAD regulation scheme, where the use of FADs is reduced. Thirdly, we totally eliminate the use of FAD fishing and juvenile by-catch. For all simulations, catch, effort and profitability of the fishery are estimated. Our results suggest that, at equilibrium, the elimination of FAD fishing could result in increased benefits to the region of about US $180 million per year. In the long run, both purse seine and longline fleets may benefit from such a management plan.

THE ECONOMIC VALUE OF BYCATCH REDUCTION

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Incidental take of vulnerable non-target species is an ongoing management challenge in commercial fisheries for tuna and other highly migratory species. Fisheries managed under the Magnuson-Stevens Act have addressed bycatch concerns through a range of conservation strategies, including the use of onboard observers to monitor bycatch, mandatory gear modifications, time-and-area closures, regulatory limits on the annual amount of bycatch, and permanent closures of fisheries which are deemed to pose an unacceptably high risk to protected species.

Bycatch reduction measures have both biological and economic impacts. The goal of this research is to compare the effect of alternative bycatch reduction strategies on the economic value of commercial fisheries. Key issues include the impact on the economic viability of fishing, and the incentive to further reduce bycatch through innovation of more selective gear and fishing techniques.

Examples of U.S. Pacific commercial swordfish fisheries employing alternative leatherback turtle bycatch reduction strategies will be considered, including the California/Oregon drift gillnet fishery and the Hawaii shallow set longline fishery. Bycatch species in these fisheries include non-target finfish such as blue shark, which are incidentally caught along with marketable species but discarded for economic reasons, and protected species such as critically endangered leatherback turtles, listed under the Endangered Species Act, and marine mammals, covered by the Marine Mammal Protection Act.

Another question of interest arises in the context of transboundary HMS stocks: What are the international trade, welfare and conservation impacts of bycatch reduction if both the target species and the bycatch species range outside the Exclusive Economic Zone where bycatch regulation applies? Leatherback turtle interactions in commercial swordfish fisheries may be regarded as a market failure, since external damage to the leatherback turtle population is not reflected in the market price of swordfish. While such an externality occurs in both U.S. and non-U.S. commercial fisheries which target swordfish in the Pacific Ocean, existing U.S. environmental regulations to limit leatherback turtle interactions apply unilaterally to effort in U.S. fisheries.

The Theory of the Second Best implies that regulating the externality in only one sector of a fishery with transboundary resource stocks and negative production externalities in two sectors may exacerbate the conservation problem the regulation was intended to mitigate. A version of the Theory of the Second Best will be used to show how unilateral leatherback turtle bycatch reduction measures inside the U.S. EEZ for a fishery with transboundary target and bycatch species creates incentives for a transfer of effort to the foreign sector. A possible undesirable consequence is to reduce the economic value of regulated U.S. Pacific commercial swordfish fisheries while increasing overall adverse conservation impacts on affected leatherback populations.

WALL STREET OR PACIFIC STOCKS? AN ANALYSIS OF THE HISTORICAL DRIVERS OF SPORTFISHING DEMAND

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Recent economic studies of recreational activities have primarily focused on the analysis of cross sectional and panel data to model recreator demand and choice. While these strategies may be advantageous for the estimation of welfare measures, they have left largely unexplored the relationship between recreation participation and general temporal economic trends. This research places focus on the impact that general economic trends have on recreation participation.

Through the estimation of an incomplete demand system time series model of consumer participation this research explores the impact that general economic conditions have on the consumer demand for saltwater angling from Commercial Passenger Fishing Vessels (CPFVs) off of the Southern California Coast. The modeling framework accounts for endogenous factors, such as measures of expected fishing success and ticket price, that are expected to impact the level of fishing effort through both quality and cost channels.

The model is applied to a unique recreational fishing effort and price time series within the Southern California tuna charter and party boat fleets between 1950 to 2008. While aggregate fisheries catch data was available for the estimation of the model, a CPFV pricing time series was unavailable. To overcome this obstacle, first, an incomplete price time series was collected through historical field research. Second, a hedonic time-series pricing model was estimated in order to build an estimated time series data set which accounted for price changes over time and the heterogeneity in CPFV trip characteristics. The demand for fishing effort is estimated utilizing an auto-regressive framework incorporating both economic and fishery characteristics. Empirical results illustrate that changes in relative recreator effort within the fishery are driven by both economic and fishery characteristics. Results support the calculation of cross elasticity estimates of income and fishery characteristics on fishing effort.

The research suggests that time series analysis may reveal long-term patterns undetectable in traditional cross-sectional or panel data analyses of recreational demand.

DESCRIPTION OF THE HISTORICAL AND CURRENT SOUTH FLORIDA RECREATIONAL TOURNAMENT FISHERY FOR SWORDFISH, *Xiphias gladius*

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Swordfish (*Xiphias gladius*) are increasingly sought after by recreational anglers around the world. The Florida Straits in particular are an important breeding and nursery area for North Atlantic swordfish, as well as being historical fishing grounds for both recreational and commercial swordfish fisheries. Despite the recreational fishing popularity of the species, there is no comprehensive description of the recreational fishery for swordfish. In the absence of a well monitored fishery, organized tournaments may provide a standardized set of fisheries-dependent data with which to generate a description of both the historic (1977-1983) and current (2000-present) fisheries. Data were obtained from tournament websites, magazine articles, and personal communications with tournament directors and local fisheries researchers. To date, information has been gathered from 88 swordfish (16 historic, 72 current) and 118 istiophorid billfish tournaments (all from the current period) that occurred on the east coast of Florida between Stuart and Key West, the region with the vast majority of U.S. swordfish tournaments. The current trend of boat participation shows a strong correlation with catches over time in both the historic and current periods. Although the participation correlates to the number of catches, catch per hour (CPH) remains on a slow although not significant decrease over time. This comes as a surprise as swordfish anglers state the species is an increasingly more difficult one to target, suggesting that this decrease should be occurring at a more rapid rate. The median entry fee for these current period swordfish tournaments is between 200 and 600 dollars while those for billfish tournaments are tenfold the swordfish entry costs. In conjunction with this, the awarded prize monies of billfish tournaments are tenfold of the awarded prize monies for swordfish tournaments, and are shown to be significantly different ($F = 18.75$, $p << 0.001$). Despite the steady recent decrease of catches in tournaments, swordfish remain a popular target for anglers in south Florida. With constant monitoring and evaluations, the south Florida recreational tournament fishery for swordfish may provide a pivotal baseline to compare swordfish recreational fisheries in other areas to increase management knowledge of the fishery as a whole.

CATCHING THE UNCATCHABLE: USE OF RESPONDENT-DRIVEN SAMPLING FOR OBTAINING REPRESENTATIVE CATCH ESTIMATES FOR TARGET AND BYCATCH SPECIES IN SPECIALISED SPORT FISHERIES

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Recreational fishing is a popular sport and social activity undertaken by an estimated 11.5% of the global population. In many countries, recreational catches have increased rapidly, contributing to an estimated global catch of around 47 billion fish. Increasing population size of coastal cities, availability, affordability and improvements of boats, searching technologies (e.g. GPS, sonar) and fishing tackle (e.g. electric reels), have resulted in increased efficiency and diversification of the recreational fishing sector. Specialized recreational gamefish fisheries have developed for many species worldwide, that target species such as swordfish, billfish, tunas, thresher and mako sharks, which can also have a large incidental bycatch component consisting of wahoo, dolphinfish, and a range of smaller tunas and tuna-like species. In some cases, this has led to conflict between commercial and recreational sectors. This is primarily due to recreational fishers claiming a greater share of shared stocks based on their perception that their activities generate superior economic and social benefits to the community than commercial fisheries. As a result, there is a critical need for fisheries scientists to obtain robust estimates of the recreational catch for inclusion in stock assessments to ensure resources are sustainable and shared equitably among stakeholders.

However, obtaining representative catch and effort data is problematic for specialized recreational fisheries that typically lack a complete sampling frame (e.g. a fishing license frame that contains no exemptions). Traditional probability-based sampling methods (e.g. creel or telephone surveys) are inadequate far too expensive for obtaining representative data from small hard-to-reach components within recreational fisheries (e.g. the gamefish fishery) that probably account for the majority of the total recreational catch for some species such as billfish, tunas and sharks.

Researchers in epidemiology and social sciences, routinely survey rare, 'hidden' or hard-to-reach populations within the general community (e.g. HIV carriers, sex workers, illicit drug users) by penetration of social networks rather than by interception of individuals. This paper introduces the idea of using Respondent-Driven Sampling (RDS), a form of chain-referral (or 'snowball') sampling, as a cost-effective means of obtaining representative catch rate estimates from elusive specialized recreational fisheries that lack a complete sampling frame using retrospective (e.g. recall) or prospective (e.g. angler diary) surveys. Unfortunately, the total recreational catch cannot be reliably estimated using a single RDS survey since the total population size of fishers is unknown, which is required to expand catch rate estimates. However, by undertaking a capture-recapture survey within multiple RDS surveys, we demonstrate how the population size can be estimated using heterogeneous mark-recapture models, and thus, allowing the total harvest of target and bycatch species to be estimated for specialized recreational fisheries.

THE EVOLUTION OF FADS IN THE TUNA PURSE-SEINE FISHERY OF THE EASTERN PACIFIC OCEAN

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Fish Aggregating Devices (FADs) are among the most important type of floating objects in the tuna purse-seine fishery. The majority of the tuna catch and bycatch occurs in sets associated with floating objects, and the activity of the floating object fishery has shifted noticeably from east to west in the eastern Pacific. The IATTC began collecting data on floating-object characteristics in 1987, with detailed information available from 2005. The spatial-temporal evolution of the floating-object fishery over the last 22 years is described. For the recent fishery, operational and structural characteristics of the FAD fishery are presented, with emphasis on strategies of FAD use and descriptions of FAD construction. The distribution of FAD and "encountered" floating object sets with respect to the time of sunrise is also described. Implications of the evolution in the FAD fishery with respect to shark bycatch are discussed.

BEHAVIOR OF THE PRIMARY SHARK BYCATCH SPECIES BY PURSE SEINERS, THE SILKY SHARK, AROUND DRIFTING FADS

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In the tuna purse seine fishery in the Western Indian Ocean, silky sharks (*Carcharhinus falciformis*) constitute the main elasmobranch species caught in sets made around drifting FADs. The objective of our study was to investigate the behavior of this species around FADs using acoustic telemetry. We tagged 10 juveniles with coded acoustic transmitters and monitored their presence at FADs through automated acoustic receivers (Vemco VR2 and ARGOS-VR3) attached to drifting FADs used by purse seiners in the Western Indian Ocean. Eight of the sharks were detected by the acoustic receivers.

Residence times of sharks at FADs ranged from 0.4 to 6.7 days (without departing the FAD for more than 24 hours). However, two sharks were observed for up to 10.7 days around the same FAD including a 3-day absence. Short (hours) and long (days) excursions from the FADs were observed. Some sharks displayed regular temporal patterns in their associative behavior while others did not. Synchronous behavior was observed where sharks left, or returned to, the FAD together, suggesting a social behavior. 99.8% of the swimming depths were above 85 m and 82% were in the top 35 m.

We discuss the significant role that FADs could play in the ecology of silky sharks as well as the vulnerability to purse seine nets that their vertical behavior induces.

WHERE'D THEY GO? THE BEHAVIOR OF TUNA AFTER THEY LEAVE FADS

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From a management perspective, it is important to know the geographic range of the population that supports a particular fishery. To better define the "catchment area" of the yellowfin tuna resource supporting the coastal Hawaii fishery, we double tagged FAD-associated yellowfin tuna with internally implanted acoustic transmitters and pressure sensitive, light-collecting archival tags. The former provided fine scale behavior of the fish when associated with FADs and the archival tags allowed light-based estimation of fish movements after they left the FADs. Fifty-two double tagged fish were released of which 16 (30%) were recovered after between 6 and 266 days at liberty. Significantly, all recaptures were made at FADs. Ten of the 15 recaptures occurred at the site of release. Analysis of the tracks of the 5 fish that left the FADs at which they were released shows that all off-FAD movements were constrained to within 150 km of the islands. Changes in depth preferences and dive patterns also occurred when the fish departed the FADs. Periodically, "nomadic" fish were detected at various FADs and this provided insight into the accuracy of the light-based geolocation estimates of their off-FAD movements. The behavior patterns of the "resident" versus "nomadic" fish are congruent with other analyses of the behavior of FAD-associated tuna that show two modes of length of absence from FADs.

STUDYING FISH AGGREGATIONS AROUND DRIFTING FADS USING FISHERS´ ECHO- SOUNDER BUOYS

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Drifting Fish Aggregating Devices (DFADs) are extensively used in purse seine fisheries. Regional fishery management organizations (RFMOs) have all called attention to the need for better understanding of the effects of thousands of DFADs on the spatial dynamics and behavior of tuna; and the need to conduct studies to reduce by-catch of sharks, turtles and juvenile tuna (mainly bigeye and yellowfin) around DFADs. However, few studies have monitored the dynamics of fish aggregations around DFADs mainly due to the fact that DFADs are difficult to access and monitor over time in offshore fishing grounds.

The present study shows the usage of a new tool to study fish dynamics around DFADs: Echo-sounder buoys used by fishers. Purse-seining for tropical tuna is one of the most technologically advanced fisheries in the world. These fishing vessels are equipped with sophisticated detection technology, such as long range sonars and scientific-grade echo-sounders. Likewise, the rapid improvement in buoy technology utilized to monitor and relocate DFADs, provide fishing masters with remotely monitored biomass estimates beneath their DFADs. During Selectun project (a research project funded by ANABAC (Spanish fleet owner association)), fishers' echo-sounder buoys were used with a double objective: to evaluate fishers´ buoys as a tool to remotely discriminate by-catch species around DFADs and to study fish aggregation's dynamics related to environmental variables in order to help understanding the impact of DFADs on fish habitat and behavior.

25 buoys were monitored in real time during 2009 and 2010 in the Western Indian Ocean. For each buoy position and date, remote sensing environmental data was extracted (Chlorophyll-*a*, Surface wind stress speed, Sea Level anomaly, Sea Surface Temperature and light intensity). Acoustic and environmental data were analyzed using GLMs. Satlink buoy equipped with a Simrad 190 kHz echo-sounder appeared to be the most promising instrument among the buoys used by fishers. Advances in sounder technology of these buoys show the potential of these tools to study such aggregations in large pelagic environments. Relationship of fish aggregation's biomass and environment are discussed.

IS THERE STOCK HETERGENIETY IN NORTH PACIFIC ALBACORE ENTERING THE NORTH AMERICAN WEST COAST FISHERY?

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Although there is a huge amount of information on albacore in the North Pacific, gaps in our knowledge limit the reliability of resource evaluations. Perhaps the most important factor confounding our knowledge of the status of the North Pacific resource involves stock structure. To date all of the population analyses of the North Pacific albacore have been based on the assumption of a single North Pacific stock. However, there is substantial circumstantial evidence which can be interpreted to indicate that there is stock heterogeneity in the North Pacific albacore resource and that two fishery stocks enter the surface fishery for North Pacific albacore conducted along the west coast of North America. This presentation will provide evidence that the latter is the case based on findings from a broad array of studies. In addition, a plea will be made that research using modern genetic methods must be undertaken to address the question of stock heterogeneity in the North Pacific albacore resource.

DISCRIMINATION OF AGE-0 PACIFIC BLUEFIN TUNA FROM TWO DIFFERENT SPAWNING GROUNDS IN LENGTH-FREQUENCY DISTRIBUTIONS

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There are two spawning grounds of Pacific bluefin tuna (*Thunnus orientalis*, PBF). One is the waters of northwestern Pacific Ocean off Taiwan and Nansei Islands from May to June and the other is Sea of Japan between July and August. Around Tsushima Islands, age-0 PBF originated from the two spawning grounds are believed to be mixed for the first time in its life history and caught by small-scale troll fishery. Catch per unit effort from the troll fishery is expected to be recruitment abundance index. According to results from the latest stock assessment on PBF, annual magnitude of recruitment of age-0 PBF, which might be different between the two spawning grounds, would affect fluctuation in spawning stock biomass. Hence, it is important to estimate the recruitment abundance index for each recruitment group. In this study, age-0 PBF from the two spawning grounds was discriminated using length-frequency distributions of the catch from the troll fishery. This study was based on the research project conducted by Fisheries Research Agency under commission of Fishery Agency, Ministry of Agriculture, Forestry and Fisheries.

Catch and length data of age-0 PBF in two fishing seasons (late 2007 – early 2008 and late 2008 – early 2009) used in this study were obtained at A-re port, one of the major fishing ports in Tsushima Islands. The length measurement data were derived from the stratified length measurement sampling program implemented by the market size category, which measures 50 fishes at a maximum for each size category. Length measurements were made by 1 cm and 0.1 kg intervals in fork length and weight, respectively. The length-frequency distributions of overall landings by ten-day interval were estimated by raising the length-frequency data in each size category with landing in number in the corresponding categories. Two modal mixed normal distributions were fitted to find mean length of each mode and its standard deviation of age-0 PBF originated from the two spawning grounds and proportions of them against whole landings in number. Von Bertalanffy growth functions of fork length at daily-age estimated by Itoh (2009) were used for inverse calculation of date of fertilization from the mean fork length.

In the length-frequency distributions, there were two modes at the length classes smaller than 60 cm in fork length. These modes might correspond to the early- and the late-hatched recruitment groups of age-0 PBF inferred as Pacific-Ocean-originated and Sea-of-Japan-originated cohorts, respectively. The periods of fertilization estimated from the mean fork length of two recruitment groups were roughly consistent with the previously known spawning seasons of them. Our results suggest that age-0 PBF originated from the two spawning grounds can be discriminated visually and statistically in the length-frequency distributions of catch due to distinct difference in the hatching period between the two spawning grounds. With regard to the differences between the fishing seasons (late 2007 – early 2008 and late 2008 – early 2009) analyzed in this study, there were remarkable variations in timing of recruitment to the troll fishery of the late hatched fish and its mean fork length when it recruited to the fishery. In late 2008 – early 2009, the late hatched fish recruited earlier than the previous year with larger fork length. Factors affecting annual variability in recruitment patterns or possible growth rate of each recruitment groups should be investigated in future.

GENETIC ANALYSIS OF POPULATION STRUCTURE OF STRIPED MARLIN IN THE PACIFIC OCEAN

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This study examines the spatial and temporal population structure of the Indo-Pacific striped marlin, *Tetrapturus audax*. Genetic variation was measured using both nuclear (microsatellite) and mitochondrial (control region sequences) DNA markers. A multi-year concurrent sampling scheme was employed to collect adult tissue from 7 locations representative of the striped marlin's range in the Pacific: Japan, Hawaii, Southern California, Mexico, Central America, New Zealand and Australia. Microsatellite and sequence results revealed small, but significant overall spatial subdivision among locations (F_{ST} =0.0145 and K_{ST} =0.06995, respectively). Pair-wise microsatellite analyses, using null-corrected data, revealed 4 striped marlin groups: 1) Japan, Immature Hawaii and Southern California 2) Mature Hawaii 3) Mexico and Central America and 4) Australia and New Zealand. Mitochondrial sequence analyses showed similar results as the microsatellites, although no significant differentiation was found between Mature Hawaii and the Japan, Immature Hawaii and Southern California groups. Despite detecting significant spatial structure, these patterns are of little use for management purposes until it can be determined that they are stable over time; therefore, temporal variation was also assessed in this study. To test for temporal stability, striped marlin samples were separated into 4 groups (based on the previously detected spatial patterns), and then divided into age-classes based on dorsal spine ageing techniques that were back-calculated to growth curves. Microsatellite data were used to calculate an unbiased estimate of temporal variance, Fs', and effective population size, N_e, which was corrected for overlapping generations. The magnitude of genetic drift ranged widely between consecutive age-classes, but did not alter the spatial patterns previously detected. Effective population sizes were very small for all groups (e.g. 16-76); however precision in these estimates was low. Even though this analysis could have been improved by more accurate ageing methods, additional life-history information, and larger sample sizes; this study represents the first attempt at applying the temporal method to assess levels of genetic drift among cohorts of striped marlin. Accounting for both spatial and temporal variation is crucial when interpreting genetic information for use in management strategies for striped marlin and other fisheries.

USE OF NUCLEAR GENETIC MARKERS AND BAYESIAN GENETIC CLUSTERING TO INFER POPULATION ADMIXTURE AND NEIGHBORING STOCK BYCATCH IN ATLANTIC SWORDFISH (*Xiphias gladius*)

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Previous genetic studies of North Atlantic, South Atlantic, and Mediterranean swordfish indicate genetic population partitioning and suggest areas of mixing at current management boundaries. In the absence of phenotypic differences between individuals from different stocks, the extent of incidental bycatch of swordfish from neighboring stocks is unknown. Here we analyze nuclear genetic data from single nucleotide polymorphisms (SNPs) in the genes *CaM, ARP, Mlc2, ActA2, ldhA, Oty1*, and intronic STRs in *Ald1 and VBC201* from NW Atlantic, South Atlantic and Mediterranean swordfish. Pairwise Fst between regions were significant and concordant with the inter-basin differentiation documented in previous studies. Individual assignment of swordfish from the three populations was implemented in *Structure 2.3*. The resulting Bayesian genetic clustering confirmed three distinct populations to which an average individual assignment of 95% or greater was found. Accordingly, nuclear markers and Bayesian genetic clustering appear to have sufficient power to resolve population admixture and estimate incidental bycatch of neighboring Atlantic swordfish stocks.

GENETIC STRUCTURE OF DOLPHINFISH, *Coryphaena hippurus*, IN THE GULF OF CALIFORNIA USING MICROSATELLITE LOCI

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We assayed genetic variations at five microsatellite loci of dolphinfish *Coryphaena hippurus* captured at 5 sites in 2005 and eight sites in 2006 to detect genetic population structure in the Gulf of California and surrounding waters. Results show high genetic variation, similar to other pelagic fishes with large populations. Pairwise F_{ST} values detected subtle, but significant heterogeneity in 2005, but not in 2006. Bayesian assignment analysis failed to detect genetic differentiation in either year, which was also supported by AMOVA and high gene flow estimates among the sampled sites. This suggest that despite the slight heterogeneity detected in the first series of samples, in this marine region, the dolphinfish forms a single panmictic population with high genetic variation and gene flow.

BACK TO BASICS FOR BYCATCH: USING PARASITES AND MORPHOMETRICS TO ASSESS STOCK STRUCTURE OF WAHOO, *Acanthocybium solandri*, IN AUSTRALIAN WATERS

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'Fishing down the food web' is now an increasingly apparent phenomena in fisheries whereby the depletion of large predatory target species results in a shift of fishing effort towards bycatch species in order for a fishery to remain economically viable. However, reliable information on long-term catch trends, basic biology and stock structure is often unavailable for bycatch species. Consequently, there is often insufficient data available for quantitative population assessments to inform management. One such species is the wahoo, *Acanthocybium solandri*, which is a large, tuna-like pelagic predator found in tropical and sub-tropical oceanic waters worldwide. Wahoo represents a significant bycatch species in most pelagic longline and troll fisheries throughout its distribution. In Australia, wahoo are caught in two Commonwealth and four state fisheries off both east and west coasts. Over recent years, annual catch of wahoo in these fisheries have steadily increased from less than 10t in 1996 to in excess of 45t in 2006, however little biological and ecological data exist for the region. Accurate representation of stock boundaries is essential prior to undertaking population assessments that can guide management. Therefore this study used geographic variation in parasite assemblages and morphometric characters to gain insight into the stock structure of wahoo off eastern Australia. Wahoo were collected from five areas along the east coast of Australia, and one additional outlying area off Australia's west coast. While some morphometric characters differed significantly between areas (e.g. pectoral fin length), multivariate analysis using all 14 characters displayed no significant difference between areas, or between ocean basins. Parasite analysis suggested that wahoo off eastern Australia comprised a single stock, although they were separated from fish in the Indian Ocean. This separation is likely to occur due to two bathymetric barriers: 1) the shallow, turbid waters of the Arafura Sea in northern Australia and 2) cold water off southern Australia. These results provide a better understanding of the population structure of a recreationally and commercially important species off Australia. Further research using genetics is envisaged to holistically assess the stock structure of wahoo in Australian waters and aid in verification of parasite and morphometric methodologies.

REVIEW OF JOINT RESEARCH ACTIVITIES AT THE IATTC'S ACHOTINES LABORATORY

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Achotines Laboratory is the only research facility in the world with captive broodstock tuna that have been spawning on a near daily basis for over a decade. Yellowfin tuna eggs, larvae and juveniles resulting from those spawns are used for a variety of studies including investigations of the effects of various environmental and biological factors on growth and survival.

To maximize tuna- and billfish-related investigations and utilization of the facilities at Achotines Laboratory the IATTC has entered into a number of research agreements with other institutions and entities around the world. Recent research partners include Hubbs Sea World Research Institute of San Diego, California, Texas A&M University, the University of Miami, and Georgia Aquarium of Atlanta, Georgia. There are also several projects being carried out at Achotines Laboratory that are funded by the Panamanian government organization Secretaría Nacional de Ciencia, Tecnología e Innovación (SENACYT) including one focusing on the feasibility of capturing, transporting, and culturing live Indo-Pacific sailfish, *Istiophorus platypterus* and wahoo *Acanthocybium solandri.*

A review of recent past, present, and planned future joint research projects will be presented as will preliminary results from some of these activities.

STAGE-SPECIFIC DENSITY EFFECTS ON GROWTH IN EARLY STAGES OF YELLOWFIN TUNA, *Thunnus albacares*

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A series of experiments have been conducted at the Inter-American Tropical Tuna Commission's (IATTC) Achotines Laboratory in the Republic of Panama from 1998 to 2009 to determine the effect of stocking densities on growth during larval and juvenile transformation stages of yellowfin tuna. Increases in larval densities may result in lower food conversion and growth deficits that could affect stage durations and subsequent pre-recruit survival.

Most of our experiments examined 2- to 4-fold differences in stocking densities at various developmental stages of yellowfin tuna larvae fed at higher and lower ranges of planktonic food levels. Growth rates in length and in dry weight of larvae were compared among density treatments. During the first week of feeding (from 3 to 9 days post hatching), growth is strongly affected by stocking densities regardless of food level. Larvae grew more slowly at the higher densities. In larvae older than 8-9 days post hatching, density dependent growth is present but is more variable and appears to be a decreasing function of larval age and size. Factors that may influence density effects on growth in older larvae and early-stage juveniles are larval development, food concentration, and food availability. These analyses of stage-specific differences in growth will be discussed.

RAM VENTILATION IN THE SHORTFIN MAKO, *Isurus oxyrinchus*: OXYGEN UTILIZATION AND THE BRANCHIAL PRESSURE GRADIENT

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This paper investigates aspects of ram ventilation in a lamnid shark, the shortfin mako, *Isurus oxyrinchus*, and examines the extent to which intrinsic structural differences in the gill design of elasmobranchs and teleosts may affect the lamnid-tuna convergence for high-performance swimming. The study of makos swimming in a water tunnel demonstrates that, despite differences in gill design, mouth gape, and basal swimming speeds, O2 utilization at the gills and the pressure head driving branchial flow for makos are similar to values reported for tunas. Also comparable to tunas are estimates of both the velocity and the residence time of water in the interlamellar channels of the mako. However, mako and tuna gills differ in the sites of primary branchial resistance. In the mako, much of the total branchial resistance resides with the septal channels, structures inherent to the elasmobranch gill and not present in tunas. The added resistance at this location is compensated by a correspondingly lower resistance at the gill lamellae, which is accomplished through wider interlamellar channels. Although greater interlamellar spacing minimizes branchial resistance, it also limits lamellar number and results in a lower total gill surface area for the mako relative to tunas. The elasmobranch gill design thus appears to constrain gill area and may potentially limit mako aerobic performance in comparison to tunas.

NEW TAGGING TECHNOLOGIES INCREASE POSITION ACCURACY, TAG CAPABILITIES, AND SAMPLE SIZE

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In 1994, Dr. A. Peter Klimley presented a paper at the **45th Annual Tuna Conference** titled "Optimizing positional accuracy of archival tags with irradiance and magnetic sensors." Recently Desert Star Systems developed and manufactured the first archival tag that uses magnetic sensing to determine latitude. This capability along with stored solar power has become a standard for the SeaTag product line.

This paper presentation will include initial field data results and a summary of how SeaTag's new capabilities can be used in tuna research. The presentation will also explain the capabilities and modularity of Desert Star Systems' energetic pop-up satellite tag, SeaTag-MOD.

SeaTag was funded under a NOAA Phase II SBIR contract (FY2007, Topic 8.1.3 F-E "Archival Tag for a Wide Range of Migratory Marine Animal Sizes"). The solicitation called out that current tags "are expensive and rather large, limited in the parameters they can collect, have restricted data storage, and pop-off attachment/release mechanisms currently limit time at liberty to less than one year." It was also important to NOAA that the tags become less expensive. Specifically they requested that a "target price should be less than $1,000 and preferably $600-$800" per tag. Desert Star Systems addressed these concerns with their SeaTag product line and introduced new methods of geo-positioning, innovative sensory capabilities, a more reliable pop-off mechanism and less expensive tags.

Using geo-magnetics for latitude estimation has proven to be significantly more accurate then length of day estimates. Initial tests reveal an average accuracy of 35 nautical miles which is in contrast to 100+ nautical miles for length of day estimations. Unlike length of day estimates, the Earth's magnetic field does not degrade with equinoxes, water turbidity, light attenuation with depth, or other weather issues.

The SeaTag product line uses new and unique capabilities such as the ability to harvest energy from the sun. The tags are equipped with a solar cell and an aerogel capacitor; the capacitor uses the stored solar power to run the tag. On a full charge the capacitor can collect data for a week of total darkness then it operates in clock management mode keeping the real-time clock accurate for another week. The animal does not need to be at the surface for energy harvesting to occur; instead it only needs to be in the euphotic zone.

The tags utilize an array of new sensors including a three-axis accelerometer and a light color sensor which has a potential use for chlorophyll measurements. Unique proxies for animal functions may become future capabilities, such as the use of a three-axis magnetometer not only for geo-positioning but also to measure animal activity (body or limb angular motion) or dive activity (vertical animal orientation).

In addition to archival tags, Desert Star Systems is developing a modular pop-up satellite tag with an energetic release. The design of this release allows it to be at liberty for significantly longer than one year. SeaTag-MOD, is programmed by the researcher to pop-off at a specific date. The tags energetic release section is screwed into the bottom portion of the main housing creating a very strong attachment point. Because the tag is solar powered, it will have the capability to transmit all of its raw data via ARGOS satellite rather than just processed or compressed data.

Finally, we will also address NOAA's requirement for less expensive tags. It has been brought to our attention through various conference talks and communication with researchers that tag prices are too expensive limiting the scope of the project and sample size. During this presentation we will discuss how we will manufacture and sell SeaTag inexpensively.

DETERMINING TRANSMITTER DRAG AND BEST-PRACTICE ATTACHMENT PROCEDURES FOR BIOTELEMETRY STUDIES ON SEA TURTLES

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Electronic transmitters attached to the carapace of marine turtles can increase the hydrodynamic drag and affect lift during locomotion. Electronic transmitters or biotelemetry (e.g., time-depth recorders, VHF radio and ultrasonic transmitters, satellite tags, and video cameras) are important tools, however, that are used to identify appropriate conservation management actions for recovering marine turtle populations. Currently, all sea turtles in U.S. waters are listed as threatened or endangered under the U.S. Endangered Species Act of 1973. This study was designed to quantify the drag force induced by the attachment of biotelemetry systems to marine turtles using the transmitters and methods of attachment demonstrated in the scientific literature. Casts were made of leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*) and olive ridley (*Lepidochelys olivacea*) turtles (40.5 to 84.0 cm straight carapace length) and tested in the Boundary Layer Wind Tunnel at the University of British Columbia. We found that drag coefficients ranged from 0.126 to 0.192 for the three casts. The various tags and attachment configurations caused increases in drag force of 1% to 110%.

Increases in drag force can cause a direct and proportional increase in power output if turtles are to maintain swimming speed. Alternatively, the turtles can reduce swimming speed. Therefore, the increased drag caused by the tags has many implications for the migratory energetics and welfare of the outfitted turtles. It is important that researchers using biotelemetry devices in their research strive to minimize the added drag caused by the devices, thus ensuring the applicability of the research data to tag-free turtles in the wild and lessening the adverse effects to the turtles. To lessen the drag effects, the frontal area of the tags should be reduced, the tags should have a teardrop shape and low profile, the antenna length and diameter minimized, and the tags should not be placed at the peak height of the carapace.

SPATIAL AND SEASONAL DISTRIBUTIONS OF 0-AGE PACIFIC BLUEFIN TUNA (*Thunnus orientalis*) BASED ON ANALYSIS OF JAPANESE TROLL FISHERY CATCHES

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Seasonal and regional migrating patterns of young-of-year Pacific bluefin tuna (*Thunnus orientalis*) are important to understand, especially in relation to changing environmental conditions. The coastal Japanese troll fisheries have the potential to provide useful information on recruitment patterns since there is an extensive database on catch levels from many different regions over a period of about 10 years. Monthly catch was analyzed using generalized linear models with year, season, port (as a random effect), and season-region interaction included as explanatory variables. The data show high seasonal and regional catch pattern variability but when standardized, a clear pattern is revealed. Catches from the main fishing ports along the Sea of Japan and East China Sea appeared from the north to the south part of Japan as autumn turns to winter. This seasonal pattern would be consistent with the migration route of this species toward south from autumn to winter. The catch patterns were associated with average sea surface temperature on the fishing ground: more than 90% of the standardized catch occurred when sea surface temperatures were between 15 and 22 ˚C in the Sea of Japan. These results show that these troll fisheries are affected by the migration patterns of young-of-year Pacific bluefin tuna. Year-to-year variability of the observed catch patterns may also reflect annual changing migration patterns.

AN EVALUATION OF SPATIAL STRUCTURE IN THE STOCK ASSESSMENT OF BIGEYE TUNA IN THE EASTERN PACIFIC OCEAN

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Tagging studies indicate restricted movements and regional fidelity of bigeye tuna in the eastern Pacific Ocean (EPO). Such restricted movements, combined with the spatial heterogeneity of the fleet distribution and the catch, suggest that localized depletion patterns of bigeye sub-stocks may exist in the EPO. A preliminary evaluation of spatial structure in the stock assessment of bigeye in the EPO was made. The EPO was divided into four major geographical regions - inshore, central, northern and southern – with no mixing of fish assumed between regions. An independent stock assessment was conducted for each region. The preliminary analyses show differences in the depletion levels of bigeye between geographical regions in the EPO. These results indicate that smaller spatial scales are important to consider. However, similar trends in recruitment indicate that bigeye sub-stocks may be connected through recruitment or similar recruitment processes.

DYNAMIC HABITAT MAPPING FOR LARGE PELAGIC SPECIES OF THE CALIFORNIA CURRENT

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We are developing a Pelagic Habitat Analysis Module (PHAM) to inform management on the spatial and temporal distributions of commercial and bycatch pelagic species. The project merges fishery-dependent (logbooks, observers, surveys, etc.) and fishery-independent (research surveys, tagging projects, etc.) data with satellite imagery and circulation models to analyze the habitat of each species. We use this information to predict the distribution of species of interest, determine areas of species overlap, and inform the population dynamics models used in stock management.

The PHAM resides within the EASy GIS system which provides a 4 dimensional (latitude, longitude, depth, and time) platform that integrates the various types of data. Data analysis tools include EOF analysis of satellite imagery, data matching between environmental data and species distribution data, and statistical regression techniques for examining relationships between environmental conditions and species habitat. PHAM utilizes the results from these tools to produce dynamic maps of predicted species density based on given environmental conditions. We have begun to apply the tools in a study that aims to assist management of target catch and bycatch of several species along the California coast, including blue shark (*Prionace glauca*), swordfish (*Xiphias gladius*), and common thresher sharks (*Alopias vulpinus*). The results of this study will indicate both temporally and spatially where a targeted species and a bycatch species have overlapping habitat, providing decision support for management. In addition to species distribution and interactions, PHAM integrates the remotely sensed data and NASA circulation models to provide further insight into the environmental drivers that affect recruitment variability and stock size.

In this talk we will present data and preliminary results from our analysis and demonstrate the utility of applying remotely sensed satellite data sets and circulation models to fishery management, which is often conducted with little or no environmental data.

HABITAT UTILIZATION AND TROPHIC ECOLOGY OF THREE CO-OCCURRING TUNA SPECIES IN THE EASTERN PACIFIC OCEAN

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Electronic archival tags have provided insight into the horizontal and vertical movements of Pacific bluefin, yellowfin, and albacore tunas in the Eastern Pacific Ocean (EPO). However, little work has been done comparing the behaviors of these three species where they overlap in space and time. While recent studies call for better species-specific trophic level assessment, little is known about the relative trophic positions of these tuna species in the Eastern Pacific Ocean. Electronic tag data, dietary analysis, and stable isotope analysis (SIA) are three complementary tools that are used here to explore overlap (or convergence) of diet and habitat utilization of these three tuna species when they co-occur.

Latitude and longitude position estimates from archivally tagged Pacific bluefin, yellowfin, and albacore tunas are analyzed to locate regions of high spatiotemporal overlap. Individuals of each species overlap in late summer in waters off Southern California and Northern Baja, Mexico. Species-specific differences in diurnal dive patterns are analyzed for yellowfin, Pacific bluefin, and albacore, and the possibility of niche partitioning is discussed. Preliminary dietary analysis lends insight into actual prey items that may cause differences in dive patterns and tissue stable isotope signatures. Results from stable ^{13}C and ^{15}N isotope analyses of white muscle and liver tissue suggest differences in feeding niche and ontogenetic shifts in feeding across these three species, as well as indications of recent migratory patterns. Use of broadscale habitats in the EPO is estimated using SIA of tunas and other EPO species (i.e. sharks, jacks, bonito). This multi-faceted approach to pelagic feeding ecology helps estimate similarities in diving behavior and diets of important EPO pelagic predators that can help inform and facilitate an ecosystems management approach.

CHARACTERISATION OF THE PHYSICAL ENVIRONMENT AT CROSS SEAMOUNT AND ITS EFFECTS ON MICRONEKTON

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In this study the author investigates the effects of Cross Seamount on the physical environment and the consequences of these effects on micronekton, thought to be the food source for economically important top predators. Mean currents impinging on the seamount topography result in a predominantly anticyclonic flow around the flanks and doming isopycnals over the plateau, consistent with the formation of trapped Taylor cones, while occasional depression of isopycnals over the plateau in combination with uplifting at the flanks indicate the presence of secondary circulation due to anticyclonic currents. Dominant semi-diurnal tides and frequent anticyclonic eddies result in a more prominent Taylor cone formation over the seamount. Bioacoustics data show that micronekton biomass is significantly higher and composed of relatively smaller organisms at the plateau and flanks of the seamount than in the nearby environment, with effects not extending to further than ~5 km away from the plateau's edge. Micronekton migrate between the shallow and the deep scattering layer at the downstream and upstream edge of the plateau, actively swimming against the currents. Differences in composition and active association with the seamount indicate the presence of resident species. Stronger anticyclonic circulation due to tidal flow and eddies result in a further increase in micronekton biomass. The increased micronekton biomass is presumably a response to increased presence of their forage, zooplankton, which are most likely swept into the seamount environment by the anticyclonic flow.

NURSERY HABITAT OF JUVENILE COMMON THRESHER SHARK (*Alopias vulpinus*) IN U.S. AND MEXICAN WATERS

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The largest commercial shark fishery in California waters is for the common thresher shark, *Alopias vulpinus*. Several recent and ongoing studies have begun to elucidate the biology of this species, including the relationship of movement patterns, habitat preferences and physiology to management. However, little information exists on the early life history of the common thresher. We used several methodologies to examine the juvenile habitat (nursery area) of the common thresher, both in the Southern California Bight and along the Pacific coast of Baja California, Mexico. These methodologies included acoustic and satellite telemetry, fisheries data analysis, and artisanal fishery surveys. Results of these studies indicate that juvenile common thresher primarily inhabit waters over the continental shelf until attaining a size of approximately 120 cm fork length, at which time they switch to primarily off-shelf habitat. Juveniles showed a strong preference for the upper 20 m of the water column, but often dove to depths of 50 to 100 m, with rare dives of up to 200 m. The geographic range of thresher nursery habitat appears to range from Punta Eugenia (Baja California, Mexico) to at least point Conception, CA. In the Mexican portion of this range, common threshers are harvested in the artisanal gillnet fishery, which takes juveniles almost exclusively.

POSTER ABSTRACTS

(In alphabetical order by author)

HOW DOES DELAYED HATCHING IN THE CALIFORNIA GRUNION, *Leuresthes tenuis*, AFFECT LARVAL LENGTH, ENERGY RESERVES, SWIMMING ACTIVITY AND SURVIVAL?

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The California grunion has the unique ability both to spawn terrestrially and to extend embryonic incubation in the sand beyond the initial hatching period of 9-14 days post-fertilization (dpf). Maternally supplied proteins and lipids provide energy for embryonic development and may play a role in larval survival. Previous studies have shown a linear decline in lipid droplet size with time up to 20 dpf in grunion embryos, but how total energy reserves change during extended incubation is not known. Metabolic rate increases during the first 9 days and thereafter remains steady during incubation of embryos at 18°C, but it is unknown whether further development occurs after this point. Additional development could lead to increased notochord length, swimming performance, or feeding ability post-hatching, resulting in greater larval survival. Therefore, we tested the hypotheses that delayed hatching in the California grunion results in larvae that are (1) longer (2) have less yolk, (3) have greater swimming activity, and (4) have decreased post-hatching survival without feeding.

We measured notochord length (NL) and yolk surface area and videotaped swimming of larvae hatched after initial incubation (10 dpf) and extended incubation (28 dpf) at 20°C from 9 batches of eggs, each from an individual female, fertilized by sperm from one male. Notochord length and yolk measurements were made using Image J software. Individual larvae swimming in an arena were videotaped at 30 Hz, and activity was quantified as the distance travelled in 60 s. We also measured the time to 50% mortality in 10-dpf and 28-dpf larvae that were starved in comparison to those that were fed.

NL was significantly longer in 28-dpf larvae than in 10-dpf larvae from 4 of 9 batches, significantly shorter in 2 of 9, and did not differ significantly in the other 3. Yolk content was significantly lower in the 28-dpf larvae from all batches studied. The effect of delayed hatching varied among batches for both NL and yolk size, suggesting parental effects, which we plan to investigate in future studies. Survival time was reduced in 28-dpf larvae than in 10-dpf larvae, corresponding with the decrease in yolk content. Swimming has been quantified for 1 batch of eggs thus far, and there is no difference in volitional swimming activity between 28-dpf larvae and 10-dpf larvae.

As a result of reduced energy reserves, increased mortality when starved, and no increase in swimming activity, larvae that must delay hatching are at a disadvantage when competing with those that do not. Future studies will examine whether adult lipid content explains the parental effects observed.

PATTERNS OF MOVEMENT AND BEHAVIOR OF COMMON THRESHER SHARKS (*Alopias vulpinus*) IN THE SOUTHERN CALIFORNIA BIGHT

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The common thresher shark (*Alopias vulpinus*) is the most landed shark in the Southern California Bight. Taken as both a target species and incidentally, it is a major component of the California drift gillnet fishery catch. Despite this high level of interaction, little is known about the patterns of movement or habitat preferences of these sharks, and fishery-independent data are very limited. From 2004 to 2008, NMFS conducted annual shark abundance surveys using longline gear in the Southern California Bight in an effort to examine the behavior and distribution of common threshers. During these cruises, 23 common thresher sharks (13 male, 10 female) were tagged with pop-up archival tags (PAT, Wildlife Computers). These sharks ranged in size from 89 – 230 cm fork length. Of the 23 tags deployed, 18 reported, four of which were recovered yielding archival data. A total of 2860 days including over 12,000 observations of depth and temperature were collected. Preliminary analysis has revealed vertical migrations as deep as 560 m and movement through a wide range of temperatures. Overall the sharks spent greater than 50% of their time above 16 m, with roughly 15% of their time spent at or near the surface. Average swimming depth was approximately 25 m. Temperatures recorded ranged from 6 – 25 ºC with a mean temperature of 14 ºC. Pop-off locations show a maximum net displacement of 668 km. Detailed horizontal tracking information from the light-based location estimates is currently being refined using composite SST data from satellite imagery and will be used to determine habitat preferences based on temporal and spatial environmental conditions. The Southern California Bight is a known nursery ground for the common threshers. Fishery-independent studies such as this one can reveal fine-scale vertical and horizontal behavior patterns beyond what we can learn from fishery-based studies of catch data alone and will aid in the development of appropriate management and conservation strategies.

SLUTH: SWORDFISH AND LEATHERBACK USE OF TEMPERATE HABITAT

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The management of commercial fisheries is often shaped by concerns over protected species bycatch. For example, U.S. swordfish fisheries in the North Pacific have been subjected to mandatory gear changes, substantial time and area restrictions and even complete closure in response to concerns about their impacts on turtles: loggerhead turtles in the high-seas shallow set longline fishery and leatherback sea turtles in the California/Oregon drift gillnet fishery. These restrictions can result in substantial loss of income and shore-side infrastructure for fishermen and local communities, and alone will not likely recover turtle populations. In 2008, researchers in the Fisheries Resources Division (FRD) teamed up with the Protected Resources Division (PRD) and the Southwest Region to launch a new initiative, Swordfish and Leatherback Utilization of Temperate Habitat (SLUTH). The overarching objective of SLUTH is to integrate studies of swordfish and leatherback sea turtles to identify management options that minimize and mitigate protected species bycatch concerns to allow for both healthy U.S. swordfish fisheries and also recover turtle populations in the North Pacific.

In addition to organizing stakeholder workshops, FRD and PRD at the center and region are moving forward on a number of SLUTH research objectives as identified in the first workshop held with representatives from the fishing industry. These research projects include 1) characterizing the environmental conditions associated with fishing activities, and the presence of swordfish and leatherbacks, 2) assessing the rates of blue shark bycatch in drift gillnet and longline fisheries and 3) exploring gear alternatives for catching swordfish.

While sea turtle bycatch has been a main driver behind fisheries regulations, there is also considerable concern about shark bycatch in swordfish fisheries. As a part of the NMFS Bycatch Reduction and Engineering Program we are currently comparing the catch rates of blue sharks in longline and drift gillnet fisheries using observer and logbook data. Preliminary results suggest that the number of blue sharks caught per swordfish is higher in the longline fishery than in the drift gillnet fishery. Multivariate analyses are underway to characterize how blue shark catch rates may be linked to environmental condition and fishing methods. Additional analyses are focused on using the drift gillnet data collected in the California Current to characterize the oceanography where fishermen set their gear, where swordfish are caught and where turtles are encountered. The goal is to combine this type of information with tracking data to develop predictive models that can serve as real-time tools to reduce likelihood of interaction between swordfish and fishermen and leatherbacks. This research is currently underway.

AN EVALUATION OF THE CONSERVATION BENEFIT OF CIRCLE HOOKS IN THE RECREATIONAL FISHERY FOR BLUE MARLIN *Makaira nigricans*

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We evaluated the conservation benefits of the use of circle hooks relative to standard J hooks in the recreational fishery for blue marlin *Makaira nigricans* by deploying 10 day pop-up satellite archival tags (PSATs) to follow the fate of 61 fish caught on natural baits or artificial lure/natural bait combinations rigged with either hook type. Furthermore, we recorded information on hook location and trauma (bleeding) for 123 blue marlin, 272 white marlin *Kajikia albida* and 132 sailfish *Istiphorus platypterus* caught on natural baits rigged with one of the two hook types. The frequencies of internal hooking locations and bleeding were significantly higher with J hooks than with circle hooks for each of the three species, although the incidences of internal hooking locations and bleeding resulting from J hooks for blue marlin were significantly lower than those observed for white marlin and sailfish. Analysis of the data received from 59 PSATs (two tags released prematurely) indicated there were no mortalities among the 29 blue marlin caught on circle hooks and released. For the 30 blue marlin caught on J hooks, two mortalities (6.7%) were inferred, a post-release mortality rate that was significantly lower than those of white marlin caught on the same hook type. Collectively, the hook location and PSAT data suggest that although blue marlin derive substantial conservation benefits from the use of circle hooks, the negative impacts of J hooks on this species are significantly reduced relative to those observed for white marlin and sailfish.

HABITAT UTILISATION AND MOVEMENTS OF LONGTAIL TUNA (*Thunnus tonggol*) AND INDO-PACIFIC SAILFISH (*Istiophorus platypterus*) IN NERITIC AUSTRALIAN WATERS AS DETERMINED BY POP-UP ARCHIVAL TAGS

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Longtail tuna (*Thunnus tonggol*) and Indo-Pacific sailfish (*Istiophorus platypterus*) are among the largest pelagic fishes in the neritic waters of northern Australia. Nine longtail tuna (86-115 cm FL; 12-27 kg) and five Indo-Pacific sailfish (171-191 cm LJFL; 20-35 kg) were tagged with minature pop-up archival tags (miniPAT) between August 2009-April 2010 over 4000km of coastline. Tags were deployed for 90, 115 or 180 days but all released prematurely after 3 to 82 days, producing 387 days of data. Both species showed a similar preference for depths of 0-40 m, with maximum dives to 90 m for longtail tuna and 57 m for sailfish. However, the two species had distinctly different water temperature preferences with longtail tuna preferring 25-28 °C (range 18.3-29.5 °C) while sailfish preferred a very restricted range of temperatures of 28-30 °C (range 27.4-31.5 °C). Light-based geolocation revealed fish exclusively utilised shallow waters within the Continental shelf. Longtail tuna often temporarily resided within embayments, presumably for feeding, during seasonal north-south movements of up to 650 km. Sailfish moved <300 km, although this probably reflects the short tag deployments. This study has shown that the behaviour and habitat preferences of these two species differ significantly to other species of large tunas and billfish common in the open ocean. The preference for shallow depths and restricted dives is likely to be related to physiology and may explain the evolutionary loss of a swim bladder in longtail tuna.

EASTERN PACIFIC SHARK CONSERVATION AND MANAGEMENT WORKSHOPS: REGIONAL PROGRESS ON IMPROVING SHARK IDENTIFICATION, DATA COLLECTION, AND REPORTING

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Achieving sustainable management of transboundary Eastern Pacific shark resources is being hindered by the lack of robust and accurate catch and landings data in the region's fisheries. Reliable, continuous monitoring of fisheries and species specific catch data are essential starting blocks for meeting conservation and management objectives, including accurate and timely stock assessment work. To achieve these objectives, two Eastern Pacific Shark Conservation and Management Workshops have been conducted with the sponsorship and assistance of NOAA Fisheries, the U.S. State Department, Ecuador's Ministry of Fisheries, Mexico's National Commission of Fisheries and Aquaculture, and a host of regional organizations including representatives of industry, government, academia, and key environmental groups operating in the region. The objectives of the workshops which were held in Manta, Ecuador in July of 2008 and Mazatlan, Mexico in December of 2008, were to: 1) assess the status of available shark fishery data and identify critical data gaps and regional capacity building and sampling needs, 2) determine a preliminary list of high priority shark species from which to focus efforts going forward, and 3) develop a Regional Spanish-language Shark Identification Guide and Data Collection Sheet and provide hands-on training in its use. The workshop participants identified five key shark species to focus on in order to develop stock assessment estimates: the silky shark *Carcharhinus falciformis*, scalloped hammerhead shark *Sphyrna lewini,* shortfin mako shark *Isurus oxyrinchus*, pelagic thresher shark *Alopias pelagicus*, and blue shark *Prionace glauca*. The workshop participants collaborated on the development of a Regional Shark Identification Guide which has been finalized and copies distributed. The Guide covers the most commonly encountered shark species in the Region's fisheries spanning from the United States to Chile and includes a standardized data collection sheet and format. A third workshop slated for early summer 2010 is being planned to provide a roll-out of the Shark Identification Guide and to conduct hands-on identification and data collection training at key artisanal shark landing sites in Ecuador along with introductory training in the use of DNA-based species identification techniques.

OPTIMAL AGE-SPECIFIC SUSTAINABLE HARVESTING POLICY FOR TUNA

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Highly migratory species like tunas are usually caught by a variety of fishing gears as well as by multiple countries. Simple management policy like a TAC and length limitation may not suitable for tuna because a fish from small to large size are caught at different places and life stages using different gears. Therefore, new harvesting policy applicable to tunas would be needed so as to consider them. The purpose of this study is to make a theory of optimal age specific sustainable harvesting policy for tuna and apply it to the management of tuna species. Simple dynamic pool model was used to examine the optimal age-specific sustainable harvesting policy. The policy can make sure sustainability of spawning biomass and efficient harvesting of each age simultaneously.

MAKING LEMONADE FROM LEMONS: USING PELAGIC LONGLINE GEAR BEHAVIOR TDR DATA FOR INSIGHTS INTO POST-HOOKING BEHAVIOR OF FISHES

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Determining the actual fishing depths of pelagic longline gear has long been a goal of fisheries science, largely for the standardization of fishing effort through the use of habitat-oriented modeling. Early efforts to record these depths used large temperature-depth recorders (TDRs) along the mainline, but more recent work with improved (smaller) technology has resulted in the deployment of hundreds of microTDRs on the gangions themselves to determine actual hook depths. The use of baited hooks on these gangions resulted in the occasional catch of a fish on a gangion equipped with a microTDR. These records are therefore useless from a gear behavior modeling perspective and have been previously disregarded.

The collection of several hundred new and old microTDR records of caught pelagic fishes now allows some insight into actual post-hooking fish behavior. A total of 490 records were examined from microTDR research by the senior author between 2003 and 2009, spanning 17 teleost and 13 elasmobranch species. Extracted data included time, temperature, and depth at hooking and death, and these were then matched with individual fish data, such as length. Analyses show a broad range of survival time on the hook, even within species. Hook location (internal versus external) and individual fish size were variable effects to the length of post-hooking survival. For individuals that survived for multiple hours on the hook, three general patterns of movement were seen: surface association, constant vertical movement, and repeated vertical movement. Post-hooking behavior patterns were consistent for some species (e.g., manta ray *Manta* sp.), but not others (e.g., swordfish *Xiphias gladius*).

Not surprisingly, the two most commonly used estimators of hook depths consistently overestimated the hooking depths for most species, suggesting that subsequent population analyses based on these estimated depths may be suspect. These data indicate that the present hook depth predictor equations may not provide sufficient information to extrapolate individual species' habitat utilization and, by extension, a strong rationale for their use in pelagic longline fishing gear standardization efforts.

MOLECULAR ASSAYS FOR GENDER DETERMINATION OF BILLFISH SPECIES

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Elucidating the mechanisms for gender determination in billfish could provide valuable information for stock assessment, particularly in those species with pronounced differential growth rates between males and females, and also for behavioral and ecological studies. The purpose of study is to identify gender-linked DNA polymorphism with aims to develop molecular assays for billfish sex determination. Mechanisms involved gender determinations in fishes are complex, and include among others chromosomally-based (XY and WZ) systems, multiple gene-interactions, environmental factors (e.g. temperature) and social interactions. In some fishes, several genes linked to gender determination have been identified, and molecular assays have been developed for gender identification using DNA isolated from tissue samples. While the mechanism of gender determination in billfish is unknown, the karyotype of white marlin suggests the presence an XY system. Accordingly, it may be possible to identify molecular markers linked sex chromosomes in billfish. In here, we present preliminary results that show sexually dimorphic specific banding patterns in blue marlin (*Makaira nigricans)* and sailfish (*Istiophorus platypterus*) obtained using Random Amplification of Polymorphic DNA (RAPD) assays. These results, however, still need to be validated using larger sample sizes, and in addition, the sequences of the distinct DNA fragments need to be determined. Parallel to the molecular work we conducted an external morphological inspection of the urogenital slit of sailfish. These observations revealed that it is possible to determine the gender of mature sailfish by visual inspection. In the further studies, we plan to enlarge the sample sizes of external inspection between females and males in others species of billfish, and expanded the molecular gender ID assays to swordfish and tunas.

INCIDENTAL CATCH OF DOLPHINFISH (C*oryphaena* spp.) REPORTED BY THE MEXICAN TUNA PURSE SEINERS IN THE EASTERN PACIFIC OCEAN

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In the eastern Pacific Ocean (EPO), dolphinfish (*Coryphaena* spp.) are caught incidentally by the tuna purse-seine fishery; therefore, the records of this fishery are a good source of information to analyze the distribution of dolphinfish. To determine the spatiotemporal distribution of dolphinfish and catch variability in the three types of tuna-fishing sets (on schools associated with dolphins or with floating objects, or on unassociated schools), statistical analyses were made of the 1998–2005 records taken by scientific observers on board tuna-fishing vessels. The incidental catch did not show a well-defined annual or seasonal distribution pattern. Two high catch areas were observed, the first located in Mexican offshore waters (15–25◦N), with 15% of the total catch, and the second located in offshore waters of the central EPO (0–10◦N), with almost 60% of the total catch. The incidental catch was significantly different among years and seasons ($H_{7,780}$ = 54.6, p < 0.05 for years, and $H_{3,780}$ = 42.7, p < 0.05 for seasons), the greatest catch being recorded during 1999 and the first two quarters, respectively. Sets on floating objects recorded most of the incidental catch of dolphinfish, followed by unassociated sets, while dolphin-associated sets recorded the lowest catch. Almost 80% of the total catch was fished in waters with sea-surface temperatures between 25 ◦C and 28 ◦C. The mean size of dolphinfish was significantly different ($H_{2,777}$ = 12.8, p < 0.05) by set type, but the smallest specimens caught were associated with floating objects. Among sets associated with floating objects, the incidental catch of dolphinfish was greatest in sets on logs, branches, etc. (PALO sets), though those on FADs (fish-aggregating devices) were the most numerous in the central EPO.

Keywords: Dolphinfish (*Coryphaena* spp.), Tuna purse-seine, Set types, Incidental catch, Floating objects.

FACTORS AND METHODS RELEVANT TO POST-RELEASE MORTALITY IN LARGE PELAGIC BILLFISHES AND SHARKS

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Without effective management, modern fishing fleets have the potential not only to reduce the effective population sizes of large pelagic species but to have dire implications for the health and sustainability of entire marine ecosystems. Although there is considerable disagreement and uncertainty about the current state of pelagic fish populations, the species groups at greatest risk are large apex predators, particularly sharks, scombrids (tunas), and istiophorids (billfishes). Shark populations, in particular, are susceptible to overfishing because of species' slow growth rates, low reproductive output, and late sexual maturity. Because commercial and recreational fishing activities generally remove the largest animals, substantial reductions in parental biomass of these long-lived, late-maturing predators could cause prolonged, population-genetic and ecosystem affects with possible evolutionary consequences (e.g. heritable changes in life-history traits such as body size, growth, age-at-maturity, and fecundity).

Uncertainty about long-term post-release mortality of pelagic bycatch species is a significant obstacle for the management of shark and billfish populations because discards may represent a significant portion of parental biomass. Quantification of post-release mortality caused by fishing is therefore vital to improve stock assessments. Moreover, if it can be determined that a particular bycatch species generally survives after release, then mitigation strategies could be optimized by concentrating on species with high rates of post-release mortality.

Conventional tagging, acoustic telemetry, listening stations, tank studies, reflex action mortality predictors, pop-up satellite archival tags (PSATs), and biochemical stress parameters can be used to estimate and predict, post-release mortality in pelagic species. Fisheries related factors (e.g., hook type, soak time, leader material), handling and discard practices, and fish size may influence the survival of large pelagic fish and shark species captured and released by fishing gear. Our results using PSATs and biochemical parameters show generally low rates of mortality in pelagic sharks released by longline gear and billfishes released by recreational fishers and suggest that catch-and-release can be a viable management tool. We also have found that hook type, soak time, and handling of catch during release all influence post-release mortality rates.

DOLPHINFISH (*Coryphaena* spp.) PURSE-SEINE BYCATCH IN THE EASTERN PACIFIC OCEAN: SPATIAL AND SEASONAL VARIABILITY

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The dolphinfish (Coryphaena spp.) is one of the main bycatch species recorded by the international tuna purse-seine fleet operating in the eastern Pacific Ocean (EPO). The variability of the spatial and temporal distribution of this species in the EPO was analyzed based on bycatch data of the tuna purse-seine fishery from 1997 to 2006. The environmental preferences of this species were characterized by the monthly composites of sea surface temperature (SST) measured from AVHRR images. The total bycatch and average bycatch/set were analyzed annually and seasonally using a one-degree latitude-longitude square resolution. Ninety-eight percent of the dolphinfish bycatch was recorded in tuna schools associated with floating objects. Large interannual variability of bycatch records was found, with 2001 the year with the highest bycatch (813 000 organisms) and 2006 the lowest (246 000). Zones along the equatorial upwelling from the coast to 130°W were important for bycatch and bycatch/set. A seasonal variability was found. The highest bycatch and bycatch/set were recorded during the third quarter, coinciding with the warmest temperatures.

TRENDS OF PELAGIC SHARK BIODIVERSITY AND ABUNDANCE INDEX IN THE WESTERN INDIAN OCEAN

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Increasing fishing pressure in the open ocean worldwide over recent decades has affected the abundance level of large pelagic fishes. Such impact concerns the target species such as tuna and swordfish as well as accessory species (bycatch). Among bycatch species suffering the effect of increasingly sophisticated open ocean fisheries (purse seine and longline) pelagic shark populations are probably most affected and their stocks have likely declined. The decline level is difficult to estimate due the quality of data for most data series and pessimistic values are published to increase concerns for shark conservation. Often sharks data reported in fishermen logbooks and observer reports are characterised by under-reporting or over-reporting of some species as result of misidentification or misuse of generic names.

In this study we analysed shark capture (by species or higher of taxa) data series collected in the western part of the Indian Ocean from 1961 to 2009 in the frame of both ocean-wide longline scientific cruises and the longline observer program based in La Réunion. Temporal trend in the pelagic elasmobranch (sharks and rays) diversity is analysed according to a spatial stratification with respect to biogeographic province, distance from the coast and vertical habitat. Our data demonstrate decreased species richness during recent decades; however probable misidentifications for some taxa during early years of research could introduce biases in the observed pattern. Decrease in nominal CPUE and mean weight of individuals are demonstrated for major pelagic shark taxa. The current status of the shark community in the studied region is discussed.

FORAGING ECOLOGY OF TUNAS IN THE SOUTHERN CALIFORNIA BIGHT: ONE COMPONENT OF A BROADER COOPERATIVE BIOLOGICAL SAMPLING PROGRAM

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Tunas in the Southern California Bight (SCB), including U.S. and Mexico waters, support substantial commercial and recreational fisheries and are an important component of the local food web. To better understand their basic biology and ecological role in the U.S. SCB, the NOAA Southwest Fisheries Science Center and the Sportfishing Association of California initiated a biological sampling program in 2007 to collect data on tuna and other highly migratory species. Utilizing the commercial passenger fishing vessels (CPFV) and recreational anglers based out of San Diego, biological samples were collected from albacore (*Thunnus alalunga*), bluefin (*T. orientalis*), yellowfin (*T. albacares*), and skipjack (*Katsuwonus pelamis)*. Approximately 200 samples from each tuna species (excluding skipjack; n=15). Changes in availability of the different tuna species across years complicated analysis of interspecific differences. Samples collected include a range of tissues including stomachs, otoliths and gonads. The initial focus has been on stomach content analysis.

Preliminary analysis of stomach contents shows that tuna forage almost exclusively on juvenile fish and squid; for fish consumed, the average standard length was 5.3 cm and for squid the average mantle length was 6.1 cm. In 2007, small teleosts comprised the dominant prey category by frequency of occurrence (89%), followed by cephalopods (18%) and crustaceans (16%). In 2008 there was a shift in prey composition with cephalopods [*Abraliopsis felis;* California market squid *(Loligo opalescens);* jumbo squid (*Dosidicus gigas*)] playing a more important role by frequency of occurrence (86%), followed by teleosts (84%) and crustaceans (56%). While teleosts were important in both years the species composition also changed. In 2007, 80% of the stomachs contained northern anchovy (*Engraulis mordax*), whereas in 2008 anchovy were present in only 2% of stomachs. Juvenile sebastes, myctophids, and jack mackerel (*Trachurus symmetricus*) made up the majority of teleost prey in 2008. The samples collected in 2009 have not yet been processed. The appearance of tuna and other HMS in the SCB during summer and fall likely coincides with the peak in abundance of a range of juvenile fish and squid species.

A lack of readily available northern anchovy in 2008 may explain the increase in frequency, diversity, and number of occurrence of the prey species present in 2008. In 2007 we identified 6 species of squid compared to 11 found in 2008. Likewise, in 2007 only 4 species of teleosts were identified compared to 13 found in 2008. The region of the water column exploited also seemed to change in 2008. The majority of prey species found in 2008 inhabit the deep scattering layer, whereas in 2007 the prey was comprised primarily of epipelagic fish. The moderate La Niña in the spring of 2008 may have increased the availability of squid as cooler temperatures favor the development of squid paralarvae. Additional efforts to link changes to environmental variability are ongoing.

USE OF SATELLITE TELEMETRY TO DETERMINE POST-RELEASE SURVIVORSHIP AND BEHAVIOR OF SEA TURTLES INCIDENTALLY CAUGHT IN LONGLINE FISHERIES

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Despite claims that fisheries are a driving force in the decline of sea turtle populations, we are still far from having reliable estimates of total mortality caused by fisheries, or any other factors. Many turtles caught in pelagic longline fisheries are alive when released from the gear but some may die soon after because of hook-induced injuries. Similar to such estimation for any pelagic species, the range of methods available to estimate sea turtle mortality is quite limited, due to costs and logistical constraints. In our research, we have used both pop-up satellite archival tag (PSAT) and platform terminal transmitters (PTTs) placed on sea turtles to estimate post-release survival of loggerhead turtles caught on longline fishing gear in the North Pacific Ocean, South Atlantic Ocean and Mediterranean Sea. Preliminary results of tracking studies indicate no differences in duration of transmissions as a function of how the turtles were hooked, either lightly (superficial), or deeply ingestion. Rather, with the exception of turtles tagged with PTTs in the Mediterranean, most sea turtles were tracked for the duration of the tag's battery life.

Tagging of loggerhead turtles in the Mediterranean was also accompanied by biochemical and hematological analyses to determine physiological impacts of hooking and potential impact on post-release mortality. Specifically, we made statistical comparisons (longline vs. control-caught turtles) of blood parameters indicative of injury (enzymes CPK & LDH, packed cell volume (PCV), white blood cell count (WBC), stress (corticosterone), and metabolic disruption (lactate). Results suggest that PCV (%) was significantly lower in longline turtles compared with controls (control = 38 vs. longline = 33), suggesting turtles captured in longline gear may experience blood loss due to injuries. Values of CPK, LDH and WBC were similar between turtle groups, however levels of corticosterone (ng/ml) was significantly higher in longline turtles compared with controls (control = 0.1 vs. longline = 4.3), suggesting that capture in longline gear induces systemic stress response in turtles. Results of tracking and biochemistry will be discussed in relation to turtles' post-release movements and potential for mortality.

TUNA FISHERIES AND FADS SYMPOSIUM, FRENCH POLYNESIA, NOVEMBER 2011
FIRST ANNOUNCEMENT

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Structures floating on ocean surface attract both juvenile and adult fish in great numbers and diversity. Fish aggregations have been recorded extensively around both natural drifting objects and artificial floating structures moored or drifting. Association with floating structures is also observed for sea turtles in open sea for resting reason or to avoid predators. FADs are widely used in tropical and semi-tropical waters by recreational, artisan and commercial fishermen, to concentrate pelagic fish for capture. While artisan fishermen have known and used such associations for hundreds to thousands of years, the use of FADs by large-scale industrial fishing fleets has developed on the latter part of the 20th century. Currently, more than half of the worldwide catch of the three main species of tuna that associate with FADs (Yellowfin, Skipjack and Bigeye) and over 100 000 tons of by-catch are caught each year in the Atlantic, Indian and Pacific oceans around FADs. The same aggregative phenomenon leads to very different impacts on marine resources depending on the type of FAD (moored or drifting) and level of the fisheries (small scale or industrial). Moored FAD appears to be a wonderful developing tool for small scale fisheries when drifting FAD represents an efficient but dangerous tool in the case of huge deployment by industrial purse seine fleets.

In 1999, a first international symposium on “Tuna fisheries and FADs”, held in Martinique (French West Indies), allowed many interesting exchanges between scientists, FAD managers and fishermen from more than 35 countries. This conference was also the beginning of several very interesting collaborative research projects using multidisciplinary approach on both drifting and moored FADs. Twelve years later, it is time for a new conference on the same topic in order to summarize and diffuse the main results of these projects developed in the last decade. Thanks to the collaboration between Ifremer, French Polynesian Ministry of marine resources, the South Pacific Community (SPC) and the French Research Institute for the development (IRD), this new “Tuna fisheries and FADs” will be held in French Polynesia, in November 2011. The success of this next symposium in French Polynesia depends on the large participation of the best scientists involved in tuna researches and in particular those who participate annually in this great Tuna Conference in Lake Arrowhead.

We are looking forward to welcoming you in Tahiti in 2011.

OCEANOGRAPHIC INFLUENCES ON ALBACORE TUNA CATCH IN THE NORTHEAST PACIFIC

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Albacore tuna, *Thunnus alalunga*, is a highly migratory species that ranges primarily between 10 to 50°N in the North Pacific, with juveniles spending most of their time in temperate waters before returning to subtropical waters as adults to spawn. Currently, fisheries in the North Pacific land about 50-100,000 t of albacore tuna annually. The U.S. troll fishery is the largest U.S. fishery targeting albacore tuna in the Northeast Pacific and an important component of albacore fisheries in the North Pacific as a whole. Previous research has associated increased catches of albacore tuna by this fishery with local environmental conditions like sea surface temperature (SST) and chlorophyll fronts, and shoaling of the mixed layer depth. However, previous studies did not provide quantitative models of how changing environmental conditions affect the catch of albacore tuna by the U.S. troll fishery. In this study, we take two approaches to understanding how changing oceanographic conditions influence albacore tuna catch. First, we model the albacore catch of the U.S. troll fishery with respect to environmental conditions using logbook data. Based on previous studies, the environmental parameters of interest include SST, chlorophyll a concentration, and sea surface height anomalies (SSHA). We fit the catch and effort data to a generalized linear model and/or a regression tree incorporating environmental conditions as explanatory variables. The model was cross-validated using 10-fold cross-validation. The model could then be used to map areas with lower or higher probability of catching albacore tuna. Our second approach examines the patterns of covariability of albacore catch per unit effort in the Northeast Pacific. We first construct normalized time-series of albacore CPUE within 1x1° squares and determine the spatial correlation scale of the time-series. Next, we identify the main modes of variability of albacore CPUE in the Northeast Pacific using an EOF analysis of the albacore CPUE time-series. We then plot the homogenous correlation maps of the first two EOFs to examine the patterns of CPUE covariability.

SPATIAL DISTRIBUTION OF BLUE SHARK (*Prionace glauca*) FROM THE PELAGIC LONGLINE FISHERY IN THE WIDER AZORES REGION

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Blue shark (*Prionace glauca*) has a broad geographic distribution, inhabiting tropical and temperate regions of the world's oceans and may be the most abundant of all pelagic sharks. Concurrently, trade records showed blue shark as one of the dominant shark species and analyses indicate that global exploitation of blue shark may have exceeded maximum sustainable yield. Blue shark is mainly caught as by-catch of pelagic longline fisheries targeting swordfish, although more recently a shift was observed with new fisheries targeting blue shark directly. In the North Atlantic (NA), evidence from conventional tagging data support the hypothesis of a single stock for management purposes and stock assessment. Furthermore, NA blue shark is characterized by its highly migratory behavior, including frequent trans-oceanic basin migrations, and a complex sexual and life-stage segregation. Mating areas are thought to be located in the north-western NA, while juveniles and pregnant females predominate in several regions of the eastern NA. Although stock status and stock assessment of NA blue shark remains controversial, demographic and risk analyses showed that overall population growth is strongly dependent on the survival of the juvenile segment. This is reason for concern since new fisheries targeting blue sharks have emerged in the eastern NA as a response to increased demand for shark meat in European markets. Little is known about the blue shark migratory patterns, particularly in relation to movements of juveniles in and out of the nursery grounds, although we can anticipate that this information is crucial for their management and conservation. The present study is a first step towards the evaluation of the spatio-temporal distribution of blue shark within the wider Azores region and the importance of the region as a nursery ground. Detailed capture and biological data from a surface longline fisheries experiment, spanning 5 consecutive years (2000-2004), are used to characterize the population segment present in the region and to investigate the spatial distribution of blue shark and its inter-annual variation.

NURSERY ORIGIN OF YELLOWFIN TUNA (*Thunnus albacares*) IN THE HAWAIIAN ISLANDS: AN OTOLITH CHEMISTRY APPROACH

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Stable isotopes of carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) in otoliths of yellowfin tuna were used to examine their utility as natural tracers for predicting natal origin of sub-adults (age-1) collected from the Hawaiian Islands. As a prerequisite to this approach, age-0 fish were collected from six nursery areas throughout the Western Central Pacific Ocean (WCPO) to determine whether sufficient differences existed in otolith cores (proxy for natal birth certificate) and to assess inter-annual variability among nurseries. Nursery areas included nearshore Hawaiian Islands, offshore Hawaiian Islands (Cross Seamount), Line Islands, Marshall Islands, Solomon Islands, and Philippines. Significant differences existed in otolith core $\delta^{13}C$ and $\delta^{18}O$ of age-0 fish collected among nursery areas within each year of the two-year study period with samples from the nearshore Hawaiian Islands most enriched in $\delta^{18}O$ while samples obtained from the Philippines were most depleted in both $\delta^{13}C$ and $\delta^{18}O$ relative to other nursery areas. Inter-annual variability in otolith core chemistry was significant for individuals from the Line Islands and Philippines demonstrating the importance of age-class matching when attempting to predict natal origin of older fish. Overall cross-validated classification success was highest for the Philippines (84 %) and nearshore Hawaiian Islands (80 %) the first year and Line Islands and nearshore Hawaiian Islands (100 %) the second year. Mixed-stock analysis indicated 91 % of sub-adult yellowfin tuna collected from the nearshore Hawaiian Islands originated from this nursery area. Results of this study highlight the importance of locally spawned fish to the nearshore Hawaiian Islands fishery.

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MOVEMENTS AND BEHAVIOR OF BLUE SHARKS (*Prionace glauca*) IN THE EASTERN NORTH PACIFIC

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The blue shark (*Prionace glauca*) is one of the most broadly distributed pelagic shark species. They are targeted and taken incidentally through much of their range in the Pacific Ocean. Despite blue sharks being a target species in Mexico and one of the highest bycatch species in U.S. West Coast drift gillnet and high-seas longline fisheries, few studies have focused on their movements and habitat use. Since 2002, we have deployed over 50 pop-off satellite archival (PSAT) tags and over 70 radio-linked position transmitting (SPOT) tags on 76 blue sharks throughout the California Current including Mexico, Canada, and the U.S. PSAT tags were used to examine movement patterns and vertical and thermal habitat use. Sea surface temperatures ranged from 9.8 – 29.8^{o}C; mean SST was 17.7 ^{o}C (0.06 ±SE). Individuals dove to depths as deep as 812 m encountering temperatures as low as 4.4^{o}C. Overall, sharks spent the majority of time in the surface mixed layer. The recovery of 7 PSAT tags and the archival datasets allowed for more detailed analysis of behavioral patterns. Archival records were separated into day and nighttime periods and revealed a distinct diel pattern with deepest dives occurring during the day. Timing and patterns of the individual dives are consistent with behavioral thermoregulation when the sharks returned to the surface mixed layer between foraging bouts. This diel pattern was also apparent in the transmitted data where light levels were used to differentiate between day and night using TAGBASE relational database software. The overall maximum depth recorded during the day was 776 m, compared to 480 m at night with some of the deeper nighttime dives occurring around the full moon. The average of the daily maximum daytime dives was 140 m (± 112 SD) compared to 63 m (± 58 SD) at night. SPOT tags were used to examine spatial movements from deployments of up to 347 days (average 109 days ± 79.5 SD). The tracks revealed a high degree of variability with some animals making directed movements away from the coast and others remaining in the California Current for protracted periods. In general, fish moved in a southerly direction regardless of initial tagging location. Patterns in movements, both vertical and geographic, will be used to examine fisheries vulnerability in the eastern North Pacific. Thus far similarities between swordfish and blue sharks provide some insight into the factors underlying the high catch rates of blue sharks in swordfish fisheries.

POPULATION DYNAMICS OF DOLPHINFISH (*Coryphaena hippurus*) CAPTURED OFF BAJA CALIFORNIA SUR, MÉXICO: MANAGEMENT IMPLICATIONS

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Although in Mexico dolphinfish (*Coryphaena hippurus*) are reserved for sportfishing within 50 miles of the coast, this species is taken illegally by artisanal fishing fleets in the coastal regions and it is the main bycatch species in the long-line and purse-seine fleets, which have increased their catch during the last decade. Although this species has been considered for potential development to be able to support a commercial fishery, the scarcity of its basic biology has been the limitation for the development of an adequate fishery-management plan. To achieve our main objective to study different aspects of its population dynamics; age, growth, mortality, reproduction, and fecundity, we analyzed 2839 dolphinfish caught by the sportfishing and commercial fleet off Baja California Sur. We sampled 1399 females and 1440 males with a size interval of 42- to 155-cm fork length (FL) during 2004 to 2006. A significant linear relation was found between the radius of the scales and the fork length. In 497 individuals with scales (246 females and 251 males) we determined that the formation of growth marks have an annual periodicity in October and November, which coincides with the species reproductive cycle and the annual variation of the sea surface temperature. The weight–fork length relationships indicated a significant negative allometric growth for both genders. The von Bertalanffy growth function parameters were K = 1.14, t_0 = -0.10, and L_∞ = 122.7 for males, and K = 1.68, t_0 = -0.09, and L_∞ = 102.8 for females, with K = 1.20, t_0 = -0.13, and L_∞=117.4 for the combined genders. Those parameters suggest that dolphinfish had a rapid growth of length and weight in their first 6 months. The estimate of total mortality (Z) using the catch curve was 2.6 per year and the alternative estimate using the Beverton and Holt method was 2.0 per year. The sexual maturity is reached at 80 cm at 0.8-years old. Using the quantity of lipids (lipid index) and the batch fecundity (number of eggs), the main reproductive potential was obtained in females >90 cm and 1.2-years old. The estimations of the partial fecundity were of 33 000 hydrated oocytes (Ho) for a female of 61-cm LF and 730 600 Ho (111-cm LF), with an average of 279 400 Ho. Based on the analysis of the population parameters, we propose two measures to be enforced for the dolphinfish in the BCS region; a minimum size of capture (80-cm FL) and a fishing ban during the months of peak reproductive activity, i.e. during the summer and autumn months.

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