Proceedings of the 64th annual Tuna Conference

Back to biology: the role of life history characteristics in tuna stock assessments

Proceedings of the 64th Annual Tuna Conference

Lake Arrowhead, California
May 20-23, 2013

Daniel W. Fuller – Chair
Joydelee Marrow - Coordinator

Southwest Fisheries Science Center
8901 La Jolla Shores Drive
La Jolla, CA 92037

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

PREFACE

Welcome to the 64th Annual Tuna Conference. The goal of the Tuna Conference is to provide an open and 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 tunas and 'tuna-like' species. The free and open exchange of ideas is the key to the Conference's success.

This year the theme of the conference is **"Back to Biology: The role of life history characteristics in tuna stock assessments."** As virtually everyone is are aware, continuous advances in computer technologies has made possible many advances in the complexities of techniques currently utilized in tuna stock assessments. However, the performance and reliability of these new assessment methods rely not only on catch, effort, and length-frequency information, but also on accurate life history information, and they can be sensitive to even slight variations in these parameters. It is essential that modern research techniques for evaluating stock structure, movements, natural mortality, age, growth, reproductive biology, and behavior be used. Studies have been conducted on these important life history characteristics of tunas and tuna-like species, but many of these have not been of applied value because they have not provided estimates of the biological parameters or other types of information that can be utilized in stock assessments.

Evaluations of the biology of commercially-important tunas and tuna-like species, taking into account possible changes in their biology over time, whether driven by fluctuations in population densities, fishing or environmental conditions, is necessary for the management of these fisheries. For these reasons it is essential to highlight the importance of these fundamental areas of biological research and how they are utilized by quantitative fisheries scientists in stock assessments. The importance of accurate life history information for inclusion in stock assessments, and the possible negative impacts the use of inaccurate information can have on management decisions cannot be overemphasized.

A total of 39 presentations and 12 posters touching on various aspects related to the theme of the 64th Tuna Conference will be presented over the course of four days.

Six student scholarships were awarded this year. The Tuna Conference Scholarship was awarded to Felipe Carvalho for his talk titled "Using pelagic fish movement data to estimate, predict and model CPUE". The Manuel Caboz Memorial Scholarship was awarded to Lela Schlenker for her talk titled "Evaluating post-release mortality of white marlin (*Kajikia albida*) caught in the recreational fishery: biochemical and physiological indicators of lethal stress". In addition, our industry partners graciously sponsored four scholarships. The DigitalGlobe Scholarship was awarded to Ben Galuardi for his talk titled "Tracking Sailfish from a Yucatan "hotspot"." The Desert Star Systems Scholarship was awarded to Maria Jose Juan-Jorda for her talk titled "Life history correlates of vulnerability in tuna and mackerels." The Wildlife Computers Scholarship was awarded to Frederic Vandeperre for his talk titled "Essential pelagic habitat of juvenile blue shark (*Prionace glauca*) in the North Atlantic." Lastly, the Advanced Model Builder Scholarship was awarded to Chi Hin (Tim) Lam for his work on "Movements and oceanographic associations of bigeye tuna (*Thunnus obesus*) in the NW Atlantic determined by popup satellite archival tags". All of these individuals presented impressive scientific work,

research goals, and progress. We wish them continued success in their graduate and post-graduate careers.

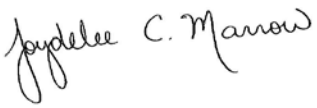
We wish to thank a suite of volunteers for assisting with the Tuna Conference. We thank Kim Holland, David Kerstetter, Kurt Schaefer, Owyn Snodgrass, Suzanne Kohin, Antonella Preti, John Hyde, Tim Lam, Shane Griffiths, and Felipe Carvalho for moderating the scientific sessions. We thank Cleridy Lennert-Cody, Robert Olson, James Hilger, John Hyde, and Owyn Snodgrass for reviewing the student scholarship applications. Christine Patnode updated the Tuna Conference web site and Millie De Los Reyes for handling all the bank transactions. We thank Rex Ito and Prime Time Seafood for donating the sashimi-grade tuna. Shane Griffiths kindly offered to pick up the tuna for the Tuna Barbecue and Sushi Social/Poster Session. A special thanks to the U.C.L.A. Conference Center personnel for accommodating our numerous requests. We are grateful to a whole team of SWFSC and IATTC staff members, too numerous to be named here, for general assistance with transporting supplies and people to this year's Conference. Last but not least we would also like to thank Rick Rosenthal for sending his movie titled "Hot Tuna" even though a scheduling conflict kept him from attending.

We gratefully acknowledge generous donations to the Tuna Conference to help support Student Scholarships, the Sushi Social/Poster Session, and the Tuna Barbecue. Donations this year were received from the Advanced Model Builder Project, American Fishermen's Research Foundation, American Tuna Boat Association, Ballast Point Brewing & Spirits, Desert Star Systems LLC, DigitalGlobe, International Seafood Sustainability Foundation, Lotek Wireless Inc., Monterey Bay Aquarium Foundation, Prime Time Seafood Inc., and Wildlife Computers Inc. Additionally, we thank Captains August Felando and Harold Medina for donating 60 autographed copies of their book titled" The Tuna/Porpoise controversy: How tuna fisherman were caught in the governments net and fought to survive" for attendees who may be interested

The abstracts contained in the Proceedings are considered reports of preliminary work. If readers are interested in the information presented in the abstracts, they should contact the author(s) directly, and no abstract should be cited without prior consent from the author(s).

In closing, we would like to thank you all for participating. We hope you have a productive and enjoyable time and look forward to seeing you back next year at the 65th Tuna Conference!

Daniel W. Fuller
64th Tuna Conference chair



Joydelee Marrow
64th Tuna Conference coordinator

64th TUNA CONFERENCE AGENDA

Monday, 20 May 2013

11:00 Registration opens in the Lakeview (continued throughout Monday and Tuesday morning)

13:30 Welcome and Introduction (Pineview)

SESSION 1: Tagging Studies (Moderator: Kim Holland)

13:40 Movements and Oceanographic Associations of Bigeye Tuna (*Thunnus obesus*) in the NW Atlantic determined by popup satellite archival tags - **Chi Hin (Tim) Lam***, Benjamin Galuardi and Molly Lutcavage
*Automatic Differentiation Model Builder (ADMB) Scholarship

14:00 Seasonal movements and habitat utilization of white marlin - **Emily Loose**

14:20 Movements of Dolphinfish (*Coryphaena hippurus*) along the U.S. East Coast as determined through conventional mark and recapture data - **Wessley Merten**, Richard Appeldoorn and Don Hammond

14:40 Tracking Sailfish from a Yucatan "hotspot" - **Benjamin Galuardi***, Chi Hin (Tim) Lam, Anthony Mendillo and Molly Lutcavage
*DigitalGlobe Student Scholarship / International Seafood Sustainability Foundation travel award winner

15:00 Coffee Break (30-minutes)

SESSION 2: Tagging Studies Part 2 (Moderator: David Kerstetter)

15:30 Evaluating post-release mortality of white marlin (*Kajikia albida*) caught in the recreational fishery: biochemical and physiological indicators of lethal stress - **Lela S. Schlenker***
*Manuel Caboz Student Scholarship / International Seafood Sustainability Foundation travel award winner

15:50 Post-release survival of school-size Atlantic bluefin tuna (*Thunnus thynnus*) caught in the recreational trolling fishery - **Benjamin Marcek**

16:10 Essential pelagic habitat of juvenile blue shark (*Prionace glauca*) in the North Atlantic - **Frederic Vandeperre***, Pedro Afonso, Alex Aires-da-Silva, Marco Santos, Alan Bolten and Ricardo Santos
*Wildlife Computers Student Scholarship / International Seafood Sustainability Foundation travel award winner

16:30 Leatherback turtle movements, dive behavior, and habitat characteristics in eco-regions of the Northwest Atlantic - **Kara Dodge**, Benjamin Galuardi, Timothy Miller and Molly Lutcavage

16:50 Movement Patterns of Blackfin Tuna (*Thunnus atlanticus)* in the Gulf of Mexico -Jenny Fenton, Jeffrey M. Ellis, Brett Falterman and **David Kerstetter**

18:30 Dinner

'Welcome Gathering' in the Tavern

Tuesday, 21 May 2013

8:00 Breakfast

SESSION 3: Modeling (Moderator: Owyn Snodgrass)

9:00 Environmental Influences on Albacore Tuna (*Thunnus alalunga*) distribution in the Coastal and Open Oceans of the Northeast Pacific: Preliminary results from boosted regression trees models - **Yi Xu**, Steven Teo and John Holmes

9:20 A Two-sector Model of the Transfer Effect - **Stephen Stohs** and Sarah Shoffler

9:40 Using pelagic fish movement data to estimate, predict and model CPUE - **Felipe Carvalho*** and Jose M. Ponciano
*Tuna Conference Student Scholarship / International Seafood Sustainability Foundation travel award winner

10:00 Demonstration of a Likelihood Framework for light based geolocation –M Basson, MV Bravington, T Patterson and **Jason Hartog**

10:20 Coffee Break (20-minutes)

SESSION 4: Life History (Moderator: Kurt Schaefer)

10:40 Ignorance of Stock Structure and Life History parameters contributes to uncertainty in tuna stock assessments - **Kurt Schaefer** and Daniel Fuller

11:00 Age and growth of three coastal pelagic tunas in the Florida Straits - **Jessica L. Adams** and David W. Kerstetter

11:20 Growth of Tropical Tunas in the Indian Ocean: What does the latest tagging and otolith data tell us! - **Paige Eveson**

11:40 Sexual Maturity in Western Atlantic Bluefin Tuna – Gilad Heinisch, Hillel Gordin, Hanna Rosenfeld and **Molly Lutcavage**

12:00 Lunch

SESSION 4: Life History – Continued (Moderator: Kurt Schaefer)

13:00 Comparative histological and stereological assessment of the reproductive status of female Atlantic bluefin tuna from the Gulf of Mexico and Mediterranean Sea - **Jessica Knapp**, Guillermo Aranda, Antonio Medina and Molly Lutcavage

13:20 Life history correlates of vulnerability in tuna and mackerels – **Maria Jose Juan-Jorda***, I. Mosqueira, J. Freire and N.K. Dulvy
*Desert Star Student Scholarship / International Seafood Sustainability Foundation travel award winner

13:40 Paradox of the Pelagics: Why Tuna Go Hungry in a Sea of Plenty - **Walter Golet**, Nicholas R. Record, Sigrid Lehuta, Molly Lutcavage, Ben Galuardi, Andrew Cooper and Andrew Pershing

SESSION 5: Assessment (Moderator: Tim Lam)

14:00 Can sport fishery catches impact the outcomes of stock assessments and management of tunas and billfish? - **Shane Griffiths**, Gavin Fay and Mitchell Zischke

14:20 Direct assessment of juvenile Atlantic bluefin tuna: integrating sonar and aerial results in support of fishery independent surveys - **Angelia Vanderlaan**, Thomas Weber, Yuri Rzhanov, J. Michael Jech, Benjamin Galuardi and Molly Lutcavage

14:40 Coffee Break (30 minutes)

SESSION 6: Gear Technology (Moderator: Shane Griffiths)

15:10 Testing Deep-set Buoy Gear for Swordfish in the Southern California Bight - **Chugey Sepulveda**, Craig Heberer and Scott Aalbers

15:30 Swordfish Buoy Gear as a Potential Alternative to Pelagic Driftnets in the Artisanal Fisheries of Morocco and Turkey - **Travis Moore** and David Kerstetter

15:50 Gulf of Mexico Alternative Gear Pilot Program - **David Kerstetter** and Max Appelman

16:30 Poster Session (Sushi Party)

Evaluating post-release survivorship in the Southern California recreational thresher shark fishery - **Craig Heberer**, S.A. Aalbers, S. Kohin, N. Spear and C.A Sepulveda

Wicked good tuna partnering with Bluefin fisherman leads to a wealth of new biological knowledge - **Emily Chandler**, Walter Golet, and Molly Lutcavage

Incorporating changes in target species in a fisheries stock assessment model: an illustration of alternative methods applied to the Blue Sharks (*Prionace glauca*) in the South Atlantic Ocean - **Felipe Carvalho**, Robert Ahrens, Debra Murie, Jose M. Ponciano, Alexandre Aires-da-Silva, Mark Maunder and Fabio Hazin

Stable isotope analysis elucidates migratory patterns of Pacific Bluefin tuna in the North Pacific Ocean - Daniel J. Madigan, **Heidi Dewar**, Owyn E. Snodgrass, Brian N. Popp, Zofia Baumann and Nicholas S. Fisher

Migration patterns of juvenile (AGE-0) Pacific Bluefin tuna (*Thunnus Orientalis*) in coastal nursery areas of Japan - **Ko Fujioka**, Hiromu Fukuda, Suguru Okamoto and Yukio Takeuchi

Comparative Economic Values for Alternative Pelagic Fishing Gears in the Gulf of Mexico - **Kristina A. Trotta**, Brad Gentner and David W. Kerstetter

Life history research in scombrid species: setting research priorities to inform management and conservation for the coming decades -
Maria Jose Juan-Jordá, I. Mosqueira, J. Freire and N.K. Dulvy

Using uv illumination to reduce bycatch in gillnet fisheries - John Wang, **Pedro Alvarez**, Joel Barkan, **Veronica Barragan, Gizelle Crisostomo, Khanh Chi Dam, Antonio Figueroa, Shara Fisler, Marcelo Santos** and Yonat Swimmer

Assessing movements and testing alternative deep-set fishing gear for swordfish above Point Conception, California - **Scott A. Aalbers**, C. Heberer, S. Kohin, H. Dewar and C.A. Sepulveda

Catching the uncatchable fishers with respondent-driven sampling: a new approach for surveying 'hard-to-reach' components of recreational fisheries - **Shane P. Griffiths**

How leading by example can exacerbate international conservation problems: a bioeconomic analysis - **Stephen M. Stohs** and Sarah M. Shoffler

Migratory movements, depth distribution and temperature preferences of dolphinfish (*Coryphaena hippurus*) in the northwestern Mexican Pacific - **Sofía Ortega-García**, John O´Sullivan, Rubén Rodríguez-Sánchez and Christopher Perle

Wednesday, 22 May 2013

8:00 Breakfast

SESSION 7: Shark Biology (Moderator: Suzanne Kohin)

9:00 Correlation of hook-time with post-release mortality and fishing induced stress response in sandbar (*Carcharhinus plumbeus*) and dusky (*Carcharhinus obscurus*) sharks - **Heather Marshall**, Richard Brill, Peter Bushnell, Gregory Skomal and Diego Bernal

9:20 Potential Impact of Spatial Fishery Closures on Silky Shark Populations in the Eastern Pacific Ocean - **Marlon H. Román** and Oscar Sosa-Nishizaki

9:40 Assessing post-release survival of purse seine captured silky sharks, *Carcharhinus falciformis* - **Melanie Hutchinson**, David Itano, Jeff Muir, Bruno Leroy and Kim Holland

10:00 Selective release of fish bycatch from purse seine gear: is it possible? - **David Itano**, Jeff Muir, Melanie Hutchinson and Kim Holland

10:20 Coffee Break (30-minutes)

SESSION 8: Fish Ecology (Moderator: John Hyde)

10:50 Foraging ecology of silky shark, *Carcharhinus falciformis*, in the eastern tropical Pacific Ocean - **Leanne M. Duffy**, Robert J. Olson, Felipe Galván-Magaña, Noemi Bocanegra-Castillo, Vanessa Alatorre-Ramírez, and Petra M. Kuhnert

11:10 Opah (*Lampris guttatus*) in the California current: Foraging and Movements - **Owyn Snodgrass**, Heidi Dewar, James Wraith, Suzy Kohin and Russ Vetter

11:30 Effects on length-weight relationship for blue shark in the North Pacific Ocean - **Yuko Hiraoka**, Yasuko Semba, Kotaro Yokawa and Minoru Kanaiwa

12:00 Lunch

SESSION 9: Fish Ecology - Continued (Moderator: John Hyde)

13:10 Transatlantic movements of juvenile Atlantic Bluefin tuna inferred from analyses of Organochlorine Tracers - **John Graves** and Andrew Wozniak

13:30 Autonomous Detection of Feeding Events in Tuna and Sharks - **Kim Holland** and Carl Meyer

SESSION 10: Physiology (Moderator: Felipe Carvalho)

13:50 Evidence for Pectoral endothermy in the Opah, *Lampris guttatus* - **Nick Wegner**, Owyn Snodgrass, Heidi Dewar and John Hyde

14:10 Investigations of thermal balance in free-swimming swordfish, *Xiphias gladius* - **Ashley Stoehr**, Alex Fowler, Chugey Sepulveda and Diego Bernal

14:30 Coffee Break (30-Minutes)

15:00 Improving Fitness and Survival in early life stages of reared California Yellowtail - *Seriola lalandi* - **Catherine Purcell** and John Hyde

SESSION 11: Early Life History (Moderator: Antonella Preti)

15:20 Studies of Tuna early life history conducted at the IATTC's Achotines Laboratory, 2012-2013 - **Daniel Margulies**, Vernon Scholey, Jeanne Wexler and Maria Stein

15:40 Comparative studies of feeding dynamics and growth of yellowfin tuna (*Thunnus albacores*) and Pacifc bluefin Tuna (*Thunnus orientalis*) larvae - **Maria Stein**, Dan Margulies, Jeanne Wexler and Vernon Scholey

18:30 Dinner – Tuna Barbeque sponsored by Tuna Barbeque sponsored by American Fishermen's Research Foundation, American Tuna Boat Association, Ballast Point Brewing & Spirits, DigitalGlobe, Lotek Wireless Inc., Prime Time Seafood Inc. and Wildlife Computers Inc.

The Campground – for gas campfire and social

Thursday, 23 May 2013

8:00 Breakfast

SESSION 12: Movie Time

9:30 "Hot Tuna" By Rick Rosenthal Narrated by David Attenborough 52 minutes air time

10:25 Tuna Conference Business Meeting

12:00 Lunch

Movements and oceanographic associations of bigeye tuna (*thunnus obesus*) in the nw atlantic determined by popup satellite archival tags

Chi Hin Lam (Tim), Benjamin Galuardi and Molly Lutcavage

Large Pelagic Research Center
Department of Environmental Conservation
University of Massachusetts, Amherst

timlam@eco.umass.edu
P.O Box 3188, Gloucester, MA 01931, U.S.A.

While bigeye tuna (BET) are among the most heavily exploited tunas in the Atlantic Ocean, our current understanding of their movements and behavior is based mostly on catch patterns, conventional tag releases and a few electronic tagging studies of short tracking durations (<1 month). To address the lack of fishery independent information on BET in the western North Atlantic, we conducted cooperative tagging with fishermen partners via a commercial longline vessel, releasing 21 adult BET (131 ± 12 cm CFL) between 2008 and 2010, mostly in the Sargasso Sea, and recovered data from nine individuals. To obtain position estimates, we applied a new variation of Trackit, the state-space Kalman filter geolocation model using sea-surface temperature (SST) and bathymetric correction. Our approach exploits the regularity of BET diel diving behavior and the correlation between depth and light in the water column to provide improved estimates of position. Detailed individual movement paths of up to 10 months were reconstructed.

PSAT tagging results revealed 1) pronounced north-south movements between areas including Gulf of Maine, Mid- and South Atlantic Bight, Caribbean Sea, and Brazilian shelf, 2) a lack of east-west exchange and 3) an activity "hotspot" centered at 25°N and 70°W (Hatteras Plain) for tagged individuals. Tag-derived movements in the western Atlantic were consistent with seasonal BET movements inferred from ICCAT's Atlantic longline catch data for the period 2000-2011. Tagged BET displayed deeper daytime depths with repeated surfacing dives over a range of oceanographic conditions and regions. BET heavily utilized depths of 300-400 m, irrespective of location or surface temperature. This suggests that an underlying behavioral driver, such as tracking a preferred forage base, characterizes BET depth associations, and our diet studies of BET from the central North Atlantic identified squid as a key component of their diet. Foraging conditions provided by the SEAPODYM model are being used to better identify factors driving Atlantic BET distributions, and more extensive studies of Atlantic BET are necessary in order to understand their population and ecosystem dynamics.

Seasonal movements and habitat utilization of white marlin

Emily Loose
Virginia Institute of Marine Science
College of William & Mary

P.O. Box 1346
Gloucester Point, VA 23062

Recent studies have demonstrated that the morphologically similar white marlin (*Kajikia albida*) and roundscale spearfish (*Tetrapturus georgii*) co-occur in the western North Atlantic, including the U.S. Mid-Atlantic Bight. Because the validity of the roundscale spearfish was not established until 2006, much of the biological information previously collected for "white marlin" in these waters may include data for both white marlin and roundscale spearfish. The objective of this study is to obtain a better understanding of the movements and habitat utilization ecology of positively identified white marlin that inhabit the U.S. Mid-Atlantic Bight during summer months. Twelve long-term (6 or 12 month) pop-up satellite archival tags were placed on white marlin that were caught and released in the recreational fishery. Three pairs of fish were caught at the same time allowing me to determine if these fish are more likely to have similar timing and patterns to their movements than fish that are observed independently. To date, 8 tags have popped up. Most fish moved out of the Mid-Atlantic Bight in September, but overwintering areas ranged from east of the Gulf Stream off the Carolinas, to the Caribbean and as far south as northern Brazil. As in previous studies, individuals spent the vast majority of their time in the top 10 m of the water column, and at temperatures within a few degrees of sea surface temperature, although definite shifts in habitat utilization were evident as fish moved from coastal offshore waters and crossed the Gulf Stream. These data demonstrate a large degree of connectivity among white marlin in the western North Atlantic.

Movements of dolphinfish (*Coryphaena hippurus*) along the U.S. East Coast as determined through conventional mark and recapture data

Wessley Merten[1,2], Richard Appeldoorn[1], Don Hammond[2]

[1]University of Puerto Rico - Department of Marine Sciences
[2]Dolphinfish Research Program
[1]University of Puerto Rico
Department of Marine Sciences
PO BOX 9000
Mayagüez, PR 00681

We used 10 years of conventional mark and recapture data (n=306) and satellite monitoring data (n=6 transmitters) to examine small and large scale dispersal and movement patterns of dolphinfish (*Coryphaena hippurus*) along the U.S. east coast. Movement speeds were dependent upon region, latitude, and distance from shore released. Movements from Florida to the South-Atlantic Bight (SAB)(44.67 ± 39.53 km/d) and Florida to northeastern North Carolina (MAB)(44.62 ± 15.31 km/d) had the highest observed speeds, while movements within the SAB were the slowest (11.80 ± 27.94 km/d). Regional movement headings varied with latitude, with dolphinfish released from Florida Keys to Central Florida displaying the most directional variability, with 2.4% conducting southerly movements. The majority of the southerly movements occurred during fall. The maximum straightline dispersal speed was 238.25 km/d and the greatest displacement distance was 1915 km observed in 51 days between the Florida Keys and Long Island, New York. Understanding the movements and migrations of dolphinfish along the U.S. east coast is the first step towards understanding larger scale basin-wide movements in the western North Atlantic and should facilitate state and regional stock assessments by better predicting seasonal and annual stock abundances by region and elucidating regional stock connectivity.

Tracking Sailfish from a Yucatan "hotspot"

Benjamin Galuardi[1], Chi Hin (Tim) Lam[1], Anthony Mendillo[2], and Molly Lutcavage[1]

[1] Large Pelagics Research Center (UMass Amherst)

[2]Keen M International
[2] 932 Washington St. Gloucester, MA 01930

Isla Mujeres, Mexico, is home to one of the most impressive winter aggregations of sailfish (*Istiophorus phatypterus*) in the world, attracting world class sportfishermen, divers and underwater photographers. Despite its prominence, little is known about the sailfish assemblage there. In January 2012, we applied pop-up satellite tags to sailfish (n= 8 Microwave Telemetry Inc. X-tags and n=4 Mini-PATS, Wildlife Computers Mini-PATs) in order to study population connectivity and biophysical interactions. Movement information for up to 6 months (January-July, 2012) was recovered and revealed 1) primarily shelf associated activity 2) occupancy of the Yucatan current (near Isla Mujeres) for up to 3 months and 3) additional activity hotspots west of the Yucatan peninsula and along the Mexican Gulf Coast. Tagged sailfish occupied a relatively narrow temperature ($\bar{x}$ = 26.4 $\pm$ 1.6^{o}C SD) and depth range ($\bar{x}$ = 11.4 $\pm$ 14.6 m SD, max=231m, median=4m). Differences in diel activity were present from March to July, corresponding to when the fish left the tagging area. Seasonal comparisons to World Ocean Atlas climatology showed that sailfish stayed almost exclusively above the thermocline regardless of location or season. Ocean color information and fronts, derived using the Belkin-O'Reilly algorithm, are being used to further classify and define productivity and water clarity characteristics of sailfish habitat. Previous studies show wide dispersion of conventionally tagged sailfish to the northern Gulf of Mexico, Florida east coast and southern Caribbean Sea. Our results show a primarily western dispersal, which may indicate bias in fishery dependent movement information. Spawning is reported to take place in June-August in the Gulf of Mexico inferring that spawning activity may have been occurred during the time at liberty of tagged fish.

Evaluating post-release mortality of white marlin (*Kajikia albida*) caught in the recreational fishery: biochemical and physiological indicators of lethal stress

Lela S. Schlenker
Virginian Institute of Marine Science
College of William and Mary
P.O. Box 1346 Gloucester Point, VA 23062

White marlin (*Kajikia albida*) are a highly migratory species that occur throughout temperate and tropical regions of the Atlantic and are the basis of a large sport fishery along the U.S. Atlantic coast. The single, Atlantic-wide stock is considered to be well below the target for maximum sustainable yield with less than half the spawning biomass that is estimated to be necessary. Billfish management measures adopted by the International Commission for the Conservation of Atlantic Tunas (ICCAT) and implemented in the United States by the National Marine Fisheries Service (NMFS), as well as increasing angler awareness of conservation, have resulted in the vast majority of white marlin being released after capture. In 2003 it was estimated that more than 99% of the 4,000-8,000 white marlin captured each year in the United States recreational fishery are released alive.

Not much information is available regarding the fate of released fishes; however, recent research aimed at estimating post-release mortality in marine and freshwater fishes suggests that mortality may vary with hook type, hook location, fight time, the amount of time the fish is exposed to air, relative temperature change, and the size of the animal. Stress resulting from an angling event may also have sublethal effects and stimulate physiological change at the organismal level, thereby impacting growth rates, reproductive output or investments, ability to evade predators, and disease resistance.

Circle hooks have been recognized by anglers as an important conservation tool and most U.S. Atlantic offshore anglers have adopted their use following research that showed that circle hooks have significantly lower post-release mortality, have a higher probability of catching in the corner of the jaw, and cause lower incidences of bleeding in white marlin than do J-hooks. This large-scale acceptance has allowed us to design a study that controls both for hook type and hooking location and examine the stress response due to angling.

We are examining post-release mortality and post-release physiological stress in recreationally angled white marlin with a two-part study collecting physiological data and deploying pop-up satellite archival tags (PSATs) on recreationally angled white marlin. In our first field season nine of twenty-one PSATs were deployed. These nine fish, plus an additional fifteen white marlin, were sampled for blood and tissue. Eight of the nine tags that were deployed reported sufficient data to determine survival; however, longer angling times remain to be evaluated in our second season. Physiological data analyzed to date suggests that ion concentrations, plasma lactate, plasma glucose, and hematocrit increased with angling time, indicating a marked physiological response with longer angling times. These data suggest that increased angling times lead to physiological stress, which will potentially lead to physiological change at the organismal level as well as immediate or delayed post release mortality for some members of the population.

Post-release mortality of school-size Atlantic bluefin tuna (*Thunnus thynnus)* caught in the recreational trolling fishery

Benjamin Marcek
Virginia Institute of Marine Science

1375 Greate Rd
Gloucester Point, VA 23062

Atlantic bluefin tuna (ABFT) support commercial and recreational fisheries in the United States. The abundance of these fish has decreased drastically since industrialized fishing began, leading to strict management measures to rebuild ABFT stocks. The current minimum size for ABFT set by the International Commission for the Conservation of Atlantic Tunas (ICCAT) is 30kg or approximately 47 inches curved lower jaw fork length (CLJFL). However, because of historically high catches of "undersized" (<30kg) bluefin in the U.S. recreational fishery, the United States is allowed to harvest up to 10% of its quota in undersized fish (27-47in CLJFL), commonly called "school" bluefin tuna. Large numbers of school-size ABFT are caught on trolled lures or lure/bait combinations in the recreational fishery along the U.S. east coast, from North Carolina to Massachusetts. The current bag limit for private boats in the United States is one fish between 27 and 73in CLJFL per boat per day while charter boats are allowed to retain one fish between 27 and 47in and one between 47 and 73in CLJFL per day. These strict bag limits have led to the release of the majority of ABFT caught in the recreational fishery. However, the fate of released ABFT is unknown. To investigate the fate of school-size ABFT released in the U.S. recreational fishery, I estimated the post-release mortality of fish caught on trolled lures or lure/bait combinations rigged with J hooks, the most common method of catching ABFT in the recreational fishery. Twenty fish were captured using 30 to 200lb test line and brought on board the vessel where they were measured and tagged with a 30 day pop-up satellite archival tag (PSAT), before being released. The first twenty ABFT encountered were tagged and all fish were handled in a manner that is typical of the recreational fishery. To avoid oversampling a single school, fish were tagged at a maximum rate of one fish every 30 minutes. Tagged fish ranged from 36 to 47in CLJFL (42.7+/-3.3in) and were caught between 19 June and 22 September, 2012 from Point Pleasant, NJ to Chatham, MA. Fight times ranged from 4 to 11 min (7.5+/-1.9 min) and total time (hooking to release) ranged from 5.5 to 12 min (9.1+/-2.1 min). None of the tagged fish were hooked internally though some variation in the hooking location was noted; upper jaw (55%), lower jaw (20%), orbit (15%), and the jaw hinge (10%). There was some variation in the amount of trauma induced by the capture event. Twenty percent of tagged fish had no bleeding, 70% had light bleeding around the hook site, and 10% were bleeding heavily when released. One tag failed to report and three tags reported prematurely yielding 7, 11, and 19 days of data, all other tags went to term. Tags reported 34-100% of the archived data yielding an average of 84.8% (+/-13.4%). The PSAT data indicate that none of the tagged fish died during the period the tags were attached, with the exception of one fish that exhibited normal behavior for 12 days before it (or the tag) was consumed by a shark. This was not considered to be directly related to the capture and tagging events. Based on the 19 survivals and one non-reporting tag (excluded from all analyses) the estimated mortality rate of ABFT caught in the recreational trolling fishery is 0% with 95% confidence intervals of 0% to 10.5%. This study indicates that the recreational trolling fishery for ABFT has a minimal impact on the stock.

Essential pelagic habitat of juvenile blue shark (*Prionace glauca*) in the North Atlantic

Frederic Vandeperre[1], Pedro Afonso[1], Alex Aires-da-Silva[2], Marco Santos[1], Alan Bolten[3] and Ricardo Serrao Santos[1]

[1] Department of Oceanography and Fisheries, University of the Azores, PT-9901-862 Horta, Portugal
[2] Inter-American Tropical Tuna Commission, 8604 La Jolla Shores Drive, La Jolla CA 92037-1508, USA
[3] Archie Carr Center for Sea Turtle Research, University of Florida, PO BOX 118525 Gainesville, Florida, USA

In the North Atlantic (NA), blue shark has become increasingly important as an accessory catch of the longline fisheries traditionally directed at swordfish. Nonetheless, the management and conservation of the species remains hampered by the poor knowledge of the complex life history of the species. In fact, like other pelagic sharks, the species is characterized by a dynamic and intricate segregation of sex and life stages in space and time. Insight in these dynamics is important as survival of particular life stages, in this case of juveniles, is essential for the sustainability of the population. The objective of this research is to define the essential pelagic habitat utilized by these juvenile life stages in terms of environmental variables (environmental space) in order to delineate sensitive areas for management purposes. This is achieved through the statistical modeling of both fisheries independent, i.e. satellite telemetry, and fisheries dependent data as both data sources provide complementary information, individual movement patterns vs. population abundance patterns respectively. The telemetry dataset consisted of tracks (up to 950 days) from 36 blue sharks of different sexes and life stages tagged with satellite transmitters (SPOT, PAT, mini-PAT) during successive cruises near the Azores archipelago. This area is located near the center of the blue shark distribution in the NA, i.e. where all life stages overlap, but the blue shark showed extensive movements, covering large parts of the NA. The fisheries data consist of data from different sources (research cruises, observers and logbooks) from the central NA. We will present a novel analysis framework based on generalized additive mixed models (GAMM) and developed for our particular case study. The first results will be discussed as well as their applicability for management.

Leatherback turtle movements, dive behavior, and habitat characteristics in ecoregions of the northwest atlantic

Kara L. Dodge[1,2], Benjamin Galuardi[2], Timothy J. Miller[3], Molly E. Lutcavage[2]

[1]Dept. of Biological Sciences, University of New Hampshire, Durham, NH 03824, U.S.A.
[2]Large Pelagics Research Center, UMass-Amherst, Gloucester, MA 01930, U.S.A.
[3]National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA 02543, U.S.A.

Leatherback sea turtles, *Dermochelys coriacea,* are highly migratory predators that feed exclusively on gelatinous zooplankton, thus playing a unique role in coastal and pelagic food webs. From 2007-2010, we used satellite telemetry to monitor the movements and dive behavior of nine adult (CCL ≥ 145 cm) and eleven subadult (CCL < 145 cm) leatherbacks captured on the NE USA shelf and tracked throughout the NW Atlantic. Leatherback movements and environmental associations varied by oceanographic region, with slow, sinuous, area-restricted search (ARS) behavior and shorter, shallower dives associated with productive (median chl *a* values: 0.49-0.89 mg m^{-3}), neritic (median bathymetries: 49-155 m) ecoregions and strong sea surface temperature fronts (median values: 0.16-0.25 °C km^{-1}) at temperate latitudes. We observed less ARS behavior in subtropical and tropical latitudes, but three individuals associated with areas of enhanced productivity near the convergence of the North Equatorial Current and North Equatorial Counter-Current, and North Brazil Current rings. Leatherbacks were highly aggregated in temperate shelf and slope waters during summer, early fall, and late spring, and more widely dispersed in subtropical and tropical oceanic and neritic habitat during late fall, winter and early spring. We applied generalized linear mixed-effects models to investigate the influence of ecoregion, satellite-derived surface chlorophyll (chl *a*), satellite-derived sea surface temperature (SST), SST front strength, chl *a* front strength, and bathymetry on leatherback search behavior, using path straightness as a proxy. The most well supported model included three factors, with differences in leatherback search behavior best explained by regional differences in chl *a*, SST, and bathymetry. Leatherbacks made the most sinuous, concentrated movements in productive, shallow, shelf habitats in both temperate and tropical regions of the NW Atlantic. Individuals favored colder water on the Canada shelf and in the Gulf Stream, and increased their search behavior in warmer water on US shelf. Coastal ecosystems are under intense pressure worldwide, with some of the highest predicted cumulative impact in the North American eastern seaboard and Caribbean. These regions were heavily exploited by leatherbacks, putting turtles at heightened risk from land and ocean-based human impacts.

Movement Patterns of Blackfin Tuna *Thunnus atlanticus* in the Gulf of Mexico

Jenny Fenton[1,3], Jeffrey M. Ellis[1], Brett Falterman[2], and **David W. Kerstetter[1]**

[1]Nova Southeastern University Oceanographic Center, 8000 North Ocean Drive, Dania Beach, FL 33004

Pop-up satellite archival tags (PSATs) were deployed on 10 blackfin tuna in the Gulf of Mexico in April 2012 from a recreational fishing vessel. Individual sizes ranged from 69.9-86.4 cm FL. Eight of the fish were jaw hooked, one was gut-hooked, and one was hooked in the nose; all hooks were removed except for the swallowed hook. The tag sensors collected individual data readings of temperature, pressure (converted to depth), and light levels of the surrounding environment every 90 seconds (n=2, total duration 9.5 days), 180 seconds (n=4, total duration 19 days), or 270 seconds (n=4, total duration 28.5 days) following capture and release.

Nine out of the 10 tagged blackfin tuna survived the full deployment period; the fish that died only survived approximately five hours. Straight-line distance traveled ranged from 7.3-97.5 km for the surviving fish. One fish moved in a northwest direction, traveling 38.0 km. Six of the fish stayed in approximately the same area, traveling between 7.3-16.9 km. Depths ranged from 0-216.5 m with a mean of 28.0 m (*SD* = 8.38 m) for all records; temperatures ranged from 13.9-32.9 °C with a mean of 23.8 °C (*SD* = 1.3 °C) for all records. The fish spent 90.3% of their time in depths from 0-56.5 m and 89.1% of their time in temperatures from 21.9-26.6 °C. Over 87 % of the movements in the water column, either ascending or descending, were less than 12 m in distance.

Environmental Influences on Albacore Tuna (*Thunnus alalunga*) Distribution in the Coastal and Open Oceans of the Northeast Pacific: Preliminary Results from Boosted Regression Trees Models

Yi Xu[1], Steven L.H. Teo[1] and John Holmes[2]
[1]NOAA Fisheries
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, CA 92037, USA

A boosted regression tree (BRT) model is used to study the distribution of albacore tuna (*Thunnus alalunga*) in the northeastern Pacific Ocean, based on logbook data from the US and Canadian troll and pole-and-line fisheries. The model domain covered the Northeast Pacific Ocean and was divided into two sub-regions to study the coastal ocean and the open ocean processes. The logbooks from US and Canada vessels provided time, location, catch and effort over two decades from 1992 to 2011. Satellite data including sea surface temperature, sea surface height (SSH) anomaly, meridional and zonal geostrophic currents and chlorophyll-a (chl-a) concentration were used as environmental predictors for the BRT model. We used data from 1998-2008 as the training dataset and 2009 as an independent testing dataset. The preliminary results showed that the open ocean and coastal ocean oceanographic dynamics affected albacore tuna distribution differently. In the open ocean, meridional geostrophic currents, SSH anomaly and zonal geostrophic currents were important influences on albacore CPUE (catch-per-unit-effort) changes. In the coastal ocean, chl-a concentration was the leading factor, followed by SSH anomaly. The predicted albacore CPUE showed a near 1:1 relationship to both training and testing data. In the future, if these relationships are found to be robust, these types of analyses may be integrated into population dynamic models to help improve fisheries management in the face of environmental changes.

A two-sector model of the transfer effect

Stephen M. Stohs and Sarah M. Shoffler
Southwest Fisheries Science Center

8901 La Jolla Shores Dr.
La Jolla, CA 92037-1509

We provide a theoretical analysis to explain the transfer of effort from one fishery to another which may arise due to unilateral domestic regulations to reduce bycatch in a fishery on a transboundary target stock; higher global protected species bycatch may result. A number of empirical studies have examined whether a *transfer effect* arose due to closing the Hawaii shallow-set longline fishery for swordfish in 2001-2004. One study provides evidence that leatherback sea turtle bycatch to swordfish catch ratios are higher in other Pacific longline fisheries than in the Hawaii swordfish fishery; several others analyze data to measure the effect of closing the Hawaii swordfish fishery on leatherback sea turtle bycatch elsewhere in the Pacific. While these studies provide evidence of a transfer effect due to the Hawaii swordfish fishery closure, questions remain about the causal mechanism which explains the phenomenon, or whether there is reason to suspect it might arise in other contexts due to weaker unilateral regulatory measures than an outright closure.

Our bioeconomic model assumes the existence of domestic (e.g. U.S.) and foreign sector fisheries that target the same transboundary stock. The target species catch is treated as a homogeneous commodity which supplies a world market subject to the Law of One Price. Protected species bycatch arises as an undesirable production externality in both the domestic and foreign sector fisheries. Five equilibrium equations describe production equilibrium in the domestic and foreign fishing sectors, market equilibrium between target species catch (supply) and world demand, and target and bycatch species population equilibria. We use comparative statics analysis to demonstrate how unilateral regulations to reduce bycatch in the domestic fishery may lead to a transfer effect which results in higher overall bycatch. This will occur if the increase in foreign sector bycatch, due to the transfer effect, exceeds the reduction in domestic sector bycatch due to both lower effort and a lower domestic bycatch rate under regulation. The results are interpreted as a textbook example of the Theory of the Second Best, which states that if two interdependent product markets are both subject to the same externality, the net effect of unilateral regulations to control the externality in only one of the markets may be to increase it globally.

Using pelagic fish movement data to estimate, predict and model cpue

Felipe Carvalho[1] and Jose M. Ponciano[2]

[1]Program of Fisheries and Aquatic Sciences, School of Forest Resources and Conservation, University of Florida
[2]Department of Biology, University of Florida

Fisheries and Aquatic Sciences, University of Florida, 7922 NW 71st, Gainesville, Florida, 32653 USA

In January 2008, a multinational initiative started tagging blue sharks (*Prionace glauca*) off the coast of Brazil and Africa using Pop-up Satellite Archival Tags (PSAT) aiming to collect movement information. A total of 28 blue sharks were tagged, with 7 sharks tagged in each of the four geographical regions of the southern Atlantic Ocean (NW, SW, SE, NE). The information collected by this project (i.e., the ecology of movement patterns and the associated habitat and behavioral studies) has improved the understanding on Atlantic blue shark ecology. The findings document trans-oceanic migration of blue sharks and include a case where an adult female traveled from its tagging site near the northeast coast of Brazil to the Gulf of Guinea off the west coast of Africa. Also, it was found that blue sharks movement is significantly influenced by climatic variables. In particular, in this study we show, using a data-driven stochastic modeling approach that the decision to leave or arrive to a particular location is strongly influenced by the depth of the thermocline. The stochastic model is a Discrete-Self-Decomposable Markov Chain. Furthermore, we illustrate how the estimated habitat suitability as a function of the environmental conditions from the movement data can be used to obtain process-based predictions of the inter-annual and spatial fluctuations in CPUEs. Finally, we illustrate how this approach can be extended to other pelagic fisheries.

Demonstration of a Likelihood Framework for light-based geolocation

Basson M[1], Bravington MV[2,] Patterson T[1] and **Hartog J[1]**

[1]CSIRO Marine & Atmospheric Research, GPO Box 1538, Hobart, Tasmania 7001, Australia.
[2]CSIRO Mathematics, Infomatics and Statistics

For many marine fish, light-based geolocation using twilight data from archival or pop-up tags is still the only way to estimate location. It is an inherently imprecise exercise because of short-term fluctuations in incident light, and the resulting uncertainty in location is big enough to need accounting for when reconstructing tracks and making inferences about habitat use. The key ingredient for any reliable geolocation-based statistical model of movement or habitat selection, whether Bayesian or "classical", is a valid likelihood function for each set of twilight data (i.e. a way to compute the relative probability of the observed data for any assumed location). However, the complex autocorrelations and non-Gaussian errors make it very difficult to devise and compute such a likelihood directly. Instead, we use data from moored tags to obtain an experimentally derived likelihood with correct confidence interval properties. This likelihood can then be computed directly from real tag data for use in state-space models which can construct a movement track with appropriate uncertainty. To demonstrate the general nature of the system, examples of geolocation using light data obtained from a variety of species, some with corresponding GPS tracks are presented.

Ignorance of stock structure and life history parameters contributes to uncertainty in tuna stock assessments

Kurt Schaefer and Daniel Fuller
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508

There are several assumptions, data limitations, and invalid estimates of biological parameters that contribute to the uncertainty in tuna stock assessments. Although stock assessment techniques have become more sophisticated, providing estimates of the annual levels of spawning stock biomass and recruitment, and other population metrics, the stock structure and life history characteristics are poorly known for most stocks of tunas. Because of these uncertainties it has been argued by some that there is no science-based justification for implementation of various tuna conservation measures.

Some of the assumptions and data requirements for the stock assessments are nearly impossible to resolve. But, our knowledge of the spatial dynamics and life history characteristics of tunas can be improved by focusing more research on tagging, age and growth, and reproductive biology, which would improve our stock assessments, leading to better management.

This presentation will include an overview of what we have learned about spatial dynamics and geographic variation in life history characteristics of tropical tunas in the eastern Pacific Ocean, and some of the current research being undertaken to improve upon the estimation of those biological parameters for potential inclusion in spatially-structured stock assessments.

Age and growth of three coastal pelagic tuna species in the Florida Straits

Jessica L. Adams and David W. Kerstetter

Nova Southeastern University Oceanographic Center
8000 North Ocean Drive
Dania Beach, FL 33004 USA

Understanding the life history of a species is essential for fully understanding its role within an ecosystem. However, many of the fish species of high ecological value have not been studied due to their less prominent roles in local recreational and commercial fisheries in comparison to other species. This study describes the age and growth patterns of three small tuna species inhabiting South Florida waters: blackfin tuna *Thunnus atlanticus*, skipjack tuna *Katsuwonus pelamis*, and little tunny *Euthynnus alletteratus*. Tuna specimens were collected via donations obtained from various fishing tournaments and charter captains in the areas of the Florida Straits as well as gillnetting and hook-and-line by the Nova Southeastern University Oceanographic Center. Specimen counts included 199 blackfin tuna, 200 little tunny, and 70 skipjack tuna. Age was described via sagittal otoliths. They were removed, dried, sectioned, and rings were counted as well as measured. Validation of the timing of ring deposits was done by marginal increment analysis. Growth parameters were determined by comparison of fish fork length to count measurements. This comparison via the Von Bertalanffy growth equation produced a growth rate for each species. The curves indicate an average size of an individual of a given species at a certain age and also give estimations of a maximum length (L_{∞}) for each species, in addition to specific growth rate, which is indicated by the slope. Parameters of each resulting Von Bertalanffy equation was compared among species. Results were also compared with growth rates calculated in other studies from various areas.

Growth of tropical tunas in the indian ocean: what does the latest tagging and otolith data tell us?

J. Paige Eveson[1], Julien Million[2], Fany Sardenne[3], and Gaël Le Croizier[2]

[1]CSIRO Marine and Atmospheric Research
GPO Box 1538, Hobart, Tasmania 7000, Australia

[2]Indian Ocean Tuna Commission

[3]Indian Ocean Tuna Commission/Institut de Recherche pour le Dévelopement

A growth model from which the expected age of a fish can be estimated based on its length is a key component to most stock assessments. For the three tropical tuna species in the Indian Ocean – yellowfin (*Thunnus albacores*), bigeye (*T. obesus*) and skipjack (*Katsuwonus pelamis*) – information about growth has been very limited until recently, when data from a large-scale Indian Ocean Tuna Tagging Programme initiated in 2005 became available. Parametric growth models were fit to tag-recapture data for all three species using a maximum likelihood method that models the joint density of release and recapture lengths as a function of age by treating age at tagging as a random variable. The method allows for individual variability in growth by modelling the asymptotic length parameter as a random effect. Direct age and length data from otolith readings were also included in the analysis for yellowfin and bigeye. The results support two-stanza growth models for all three species; however, the growth patterns for yellowfin (YFT) and bigeye (BET) differ from skipjack (SKJ). YFT and BET exhibit a transition in growth at ~65 cm fork length (2.5 years old), with faster growth in the second stanza than the first, whereas SKJ exhibit a transition in growth at ~45cm fork length (< 1 year old), with much faster growth in the first stanza than the second. Presumably, YFT and BET also experience a phase of rapid growth directly following birth, but lack of data for fish less than 50cm for these species precludes its estimation. Sex information exists for a small subsample of YFT and BET recaptures; these data show that males grow to a larger size than females for both species.

Sexual maturity in western atlantic bluefin tuna

Gilad Heinisch[1, 2], Hillel Gordin[3], Hanna Rosenfeld[3], **Molly Lutcavage[1]**

[1] Large Pelagics Research Center, University of Massachusetts Amherst, Gloucester, Massachusetts 01930, USA
[2] University of New Hampshire, Durham, New Hampshire, USA
[3] Israel Oceanographic and Limnological Research, National Center for Mariculture, Eilat Israel

The age at sexual maturity of the western Atlantic bluefin tuna (ABFT) population is unresolved despite intense debate about the status of the population. We used histological and endocrine analyses to investigate the sexual maturation status in 93 ABFT (134-292 cm curved fork length, CFL) sampled on NW Atlantic foraging grounds off New England and Nova Scotia and in seventeen young of the year (YOY) off Virginia. We demonstrate the lack of physiological differences among mature and sizes presumed to be immature ABFT. Partially spent testes and lipid stage oocytes were found in ABFT of all sizes >134 cm CFL, indicating that spawning during the previous or the next reproduction season was possible. Perigonadal fat body, an energy reserve for the maturing gonads, increased in size and weight (from 0.2 to 0.6, FSI) among all fish > 134 cm CFL as foraging season progressed. The ratio of follicle stimulating hormone (FSH) over luteinizing hormone (LH), a sexual maturity indicator, in YOYs was >2 and is consistent with that of eastern ABFT juveniles and other immature teleosts. The FSH/LH ratios detected in ABFT >134 cm CFL (<0.4), are similar to Mediterranean spawners, indicating that western ABFT considerably smaller than the current assumed size at first maturity (≥185 cm CFL), are likely mature. We have detected further evidence for asynchronous reproduction behavior in "giant" females ABFT (221–292 cm CFL) landed off Nova Scotia in September-October, where pituitary LH secretion could be the outcome of a recent spawning event.

Our approach enables the investigation of sexual maturity in fish sampled off spawning season and highlights the importance of physiological data in life history studies, especially in highly migratory species. Our results do not support the widely different maturity schedules assumed for western ABFT, and suggest that alternative spawning scenarios, such as early maturation and additional spawning grounds are likely.

Comparative histological and stereological assessment of the reproductive status of female atlantic bluefin tuna from the gulf of mexico and mediterranean sea

Jessica M. Knapp[1,3], Guillermo Aranda[2], Antonio Medina[2], Molly Lutcavage[3]

[1]Department of Biological Sciences, University of New Hampshire, Durham, New Hampshire, USA
[2]Department of Biology, Faculty of Marine and Environmental Sciences, University of Cádiz, Puerto Real, Cádiz, Spain
[3]Large Pelagics Research Center, University of Massachusetts Amherst, Gloucester, Massachusetts, USA

Despite attention focused on the population status and rebuilding trajectory of Atlantic bluefin tuna (*Thunnus thynnus*), the reproduction and spawning biology remains poorly understood, especially in the NW Atlantic. At present, the eastern and western spawning populations are believed to exhibit different reproductive characteristics and, consequently, stock productivity. Our study objective was to compare reproductive characteristics of the two putative stocks on their two known spawning grounds, the Gulf of Mexico and Mediterranean Sea. Between 2007 and 2009, we collected gonad samples from female Atlantic bluefin tuna in the northern Gulf of Mexico (n=147) and in the Mediterranean Sea (around the Balearic Islands; n=45). We used stereological analysis of ovarian tissue to identify similarities and differences in spawning frequency, fecundity, and spawning periodicity of the fish sampled from the two regions. Our data indicate that sampled eastern and western bluefin tuna exhibit the same spawning periodicity (three months) but different spawning frequencies (60% and <50%, respectively), and spawning in the northern US Gulf of Mexico occurs one month earlier than in most of the Mediterranean Sea. Eastern and western spawners showed similar realized fecundity (totally number of eggs); however, due to the larger size of western fish, the number of eggs per gram body mass was significantly higher in eastern fish (45.56 eggs g^{-1} vs. 28.14 eggs g^{-1} for western spawners).

Although our study is the first comparative histological analysis of eastern and western spawners, biological sampling of spawning fish remains incomplete. For example, reproductive samples were obtained from purse seine vessels operating around the Balearic Islands and, in the northern Gulf of Mexico, from bycatch of longline vessels targeting yellowfin tuna. Since electronic tagging results show bluefin tuna utilizing the entire Gulf of Mexico, more comprehensive spatial and temporal sampling of biological tissues is warranted. Combined with new determinations of size/age at maturity and the likelihood of additional spawning areas, our results suggest basic life history attributes warrant further scientific and management attention.

Life history correlates of vulnerability in tuna and mackerels

**Juan-Jordá[1,2], ** M.J., Mosqueira[3],I., Freire[4], J., and Dulvy[2], N.K.

[1]Grupo de Recursos Marinos y Pesquerías, Universidade da Coruña, Spain
[2]Earth to Ocean Research Group, Simon Fraser University, Canada
[3]EU-Joint Research Center, IPSC-Maritime Affairs Unit FISHREG, Ispra, Italy
[4]Barrabés Next, Madrid, Spain

The vulnerability of a species is a combination of its degree of exposure to extrinsic threats, such as fishing, and its intrinsic sensitivity to the threatening process. While there is broadening support for the idea that life histories and demography relate to measures of vulnerability including, decline, extinction risk and population collapse, the efficacy of different traits to predict vulnerability varies greatly. In this study, we first conducted a literature review to summarize current understanding of the life history traits that have been identified as useful biological correlates of vulnerability in marine fishes. Second, we identified potential life history correlates of vulnerability for scombrid species (tunas and mackerels). We found that age at maturity is the most consistent and reliable biological correlate of species intrinsic sensitivity, suggesting that age at maturity might be the most reliable predictor of species maximum per-capita growth rates (r_{max}). While maximum body size is the most reliable correlate of species vulnerability to fishing, suggesting that it might be the most reliable predictor of species declines, recoveries and threat status in marine fishes. The review also confirms, contrary to the widely-held perception, that fecundity is not a predictor of either species sensitivity or vulnerability to fishing, suggesting that the production of large number of eggs does not protect marine fishes from extinction risk. Moreover, we revealed longevity is the best predictor of population rates and extent of declines in adult biomass in scombrid populations. The longest-lived scombrid populations, rather than the largest, appear to have experienced the fastest rates of decline and the greatest extent of decline in adult biomass over the last 50 years. Identifying and quantifying the relative importance of biological and ecological correlates of vulnerability in fishes continues to be a challenge and is poorly understood. We believe understanding the intrinsic biology of species vulnerability and extinction risk is crucial to build tools to predict species responses to fishing and their risk of depletion or extinction.

Paradox of the Pelagics: Why Tuna Go Hungry in a Sea of Plenty

Walter Golet[1], Nicholas R. Record[2], Sigrid Lehuta[3], Molly Lutcavage[4], Benjamin Galuardi[4], Andrew B Cooper [5], and Andrew Pershing[1]

[1]School of Marine Sciences, University of Maine, and Gulf of Maine Research Institute
[2]Department of Earth and Oceanographic Science, Bowdoin College
[3]Gulf of Maine Research Institute
[4]Department of Environmental Conservation, UMass Amherst
[5]School of Resource and Environmental Management Simon Fraser University

The northwest Atlantic shelf is an important foraging ground for Atlantic bluefin tuna, yet, despite near record abundance of their primary prey (Atlantic herring), both the condition and availability of adult size classes declined substantially since the early 1990s. Low somatic condition led to substantial economic and reproductive losses when compared against the 1980 bluefin tuna baseline condition. Catch per unit effort in adjacent bluefin fisheries (Nova Scotia, Prince Edward Island) increased to historically high levels during the same time period that condition and distribution of bluefin was changing in the Gulf of Maine. We hypothesize that changes in condition and distribution of bluefin tuna result from a foraging strategy that relies on larger more energetically profitable herring. This hypothesis, captured in a simple optimal foraging model, suggests that bluefin foraging success is related to the relative abundance of large versus small herring. This hypothesis is supported by a significant correlation between bluefin weight anomalies and mean herring mass, and a very strong correlation between tuna weight anomalies and herring energetic profitability from the optimal foraging model. Spatial analysis between herring and bluefin tuna school suggests that bluefin tuna are located in areas of high herring density, but in order to forage efficiently, large herring must be present. A similar herring mass and energy time series from the Scotian Shelf and Gulf of St. Lawrence was significantly correlated with the shift in bluefin tuna distribution towards Canadian waters where the size spectrum of herring was much larger. Moving forward, fisheries managers will face an interesting challenge of how to manage for high abundance of small pelagic fish, which benefits fisheries and predators such as baleen whales, while at the same time maintaining a robust size structure beneficial to predators like tuna.

Can sport fishery catches impact the outcomes of stock assessments and management of tunas and billfish?

Shane P. Griffiths, Gavin Fay and Mitchell T. Zischke

CSIRO Division of Marine and Atmospheric Research, GPO Box 2583 Brisbane, QLD 4001, Australia

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. Specialised recreational gamefish fisheries have developed for many species worldwide, where the catches of large pelagic species such as swordfish, billfish, tunas, and pelagic sharks are similar to the commercial catch in some areas. There is now an increasing need for fisheries scientists to obtain robust estimates of the recreational catch for inclusion in stock assessments to assess the status of shared stocks and to equitably share a determined sustainable catch among all stakeholders.

Unfortunately, sport fisheries data are rarely integrated into stock assessments owing to the logistical difficulties and expense in sampling recreational fishers as well as the perception that a relatively small number of participants are unlikely to impact an entire stock.

In this paper, we address two important questions: i) how can unbiased representative catch and effort data be cost-effectively collected from relatively small and spatially dispersed populations of sport fishers? and ii) given the rarity of sport fishers within the recreational fishing population, do they really have the potential to have an impact upon large wide-ranging populations of pelagic predators to the extent that it will influence the outcomes of stock assessments and recommendations to management?

In dealing with this complex issue, we first highlight the inadequacies of traditional probability-based sampling methods (e.g. creel or telephone surveys) for collecting data from sport fisheries that typically lack a complete sampling frame (e.g. a fishing licence frame that contains no exemptions). As a potential cost-effective solution, we describe the results of recent surveys in Australia that trialled innovative sampling methods routinely in epidemiology and social sciences to survey 'hidden' populations (e.g. illicit drug users).

The consequences of ignoring recreational fisheries data in stock assessments were explored using an age-structured stock assessment for striped marlin (*Kajikia audax*) in the western Pacific Ocean. Model simulations indicated that estimates of stock status were biased when the recreational catch exceeded ~10% of the commercial catch, or when the recreational fishery caught different size-classes than the commercial fishery, and if these data are ignored in an assessment.

This paper shows that including data from recreational fishing can significantly change perceptions of stock status and impact recommendations for management action for some pelagic species. With developing survey strategies customised to capitalise on the behaviour of sport fishers, it is now possible for researchers to cost-effectively collect reliable and representative sport fisheries data that can be easily integrated into stock assessments.

Direct assessment of juvenile atlantic bluefin tuna: integrating sonar and aerial results in support of fishery-independent surveys

Angelia S.M. Vanderlaan[1,2], Thomas C. Weber[3], Yuri Rzhanov[3], J. Michael Jech[4], Benjamin Galuardi[1,5], and Molly E. Lutcavage[1]

[1]Large Pelagics Research Center, University of Massachusetts Amherst, P.O. Box 3188, Gloucester, MA, 01930, USA
[2]Department of Oceanography, Dalhousie University, Halifax, NS, Canada
[3]University of New Hampshire, Center for Coastal and Ocean Mapping, Durham, NH, USA
[4]National Oceanic and Atmospheric Administration, National Marine Fisheries Service, NEFSC, Woods Hole, MA, USA
[5]Department of Fisheries Oceanography, SMAST, University of Massachusetts Dartmouth, New Bedford, MA, USA

Fisheries management agencies typically formulate indices of past, present, and future states of populations based on catch-per-unit effort (CPUE). Of the twelve indices of abundance developed for the western population of Atlantic bluefin tuna (*Thunnus thynnus,* ABFT) by the International Commission for the Conservation of Atlantic Tunas (ICCAT), only one, a larval survey, is fishery independent. The value of a direct assessment approach has been recognized for ABFT, where spatial and temporal shifts in distribution routinely occur, as do management measures. ICCAT has called for development of experimental designs and pilot surveys for juvenile abundance estimation to include in ABFT stock assessments. Our goals are to design, implement, and analyze a formal, fisheries-independent survey of juvenile ABFT, and to assess the feasibility of biomass estimation in the Gulf of Maine. We determined in pilot studies that direct assessment of ABFT appears feasible using sonar in combination with aerial surveys of ABFT schools. During August 2012 we conducted sea trials on a commercial tuna vessel using a bow-mounted, split-beam sonar (Simrad EK-60) in conjunction with aerial support guiding the vessel to tuna schools and taking photographs. We used aerial imagery to determine the horizontal shape of the school and to identify and enumerate specific individuals in the upper few meters of the water column. The sonar data provided information on school height and the number of individuals not captured in the aerial photographs. We plan to integrate the sonar and aerial data to estimate the size of schools (biomass), number of individuals in schools, size of individuals within schools, and profiles of aggregation behavior. Challenges include variability in target strength, school height and width estimates for acoustic data, and geo-rectification and enumeration of individuals within a school in aerial imagery. Despite these difficulties, this survey approach is fishery-independent, delivers multi-dimensional information on ABFT schools and a less biased estimates of biomass.

Testing Deep-set Buoy Gear for Swordfish in the Southern California Bight

Chugey Sepulveda[1], Craig Heberer[2] and Scott A. Aalbers[1]

1. Pfleger Institute of Environmental Research (PIER), Oceanside, CA
2. National Marine Fisheries Service, Southwest Region, Sustainable Fisheries Division, Carlsbad, CA

Fishery interactions with species of concern (i.e., turtles and marine mammals) have severely impacted U.S. west coast swordfish fisheries, resulting in historic lows in effort, landings, and revenues. Fishery regulations have now constricted effort to the Southern California Bight, a relatively small portion of the historic fishery range off CA. The present study used swordfish depth distribution data to design a deep-set gear configuration to target swordfish within the California exclusive economic zone (EEZ). To minimize interactions with species of concern, the deep-set gear was designed to fish below the thermocline (270 to 350m) during the daylight hours. Gear specifications include the use of ten individual sets of deep-set gear which consist of two-8m gangions with 18/0 circle hooks. All ten sets were soaked for four consecutive hours and baited with both mackerel and squid. Gear trials were tested during the 2011 and 2012 swordfish seasons off the coast of southern California using both research and cooperative fisher vessels. A total of 54 sets (4,320 hook-hours) were completed resulting in the capture of 15 swordfish without any interactions with species of concern. Additional non-target catch included: bigeye thresher sharks, *Alopias superciliosus* (7), opah, *Lampris guttatus* (2), blue sharks, *Prionace glauca* (2) and common thresher shark, *Alopias vulpinus* (1). These data suggest that deep-set buoy gear can selectively be used to target swordfish deep during the day off southern California. Additional trials that investigate alternative configurations (i.e., gear modification, bait presentation) and reduce the probability of lost gear are currently underway.

Swordfish Buoy Gear as a Potential Alternative to Pelagic Driftnets in the Artisanal Fisheries of Morocco and Turkey

Travis A. Moore and David W. Kerstetter
Nova Southeastern University Oceanographic Center
8000 North Ocean Drive
Dania Beach, FL 33004 USA

Driftnet fisheries throughout the Mediterranean Sea and eastern Atlantic Ocean historically targeted swordfish during nighttime sets. However, recent management actions by organizations such as the International Commission for the Conservation of Atlantic Tunas (ICCAT) for purposes of fisheries bycatch reduction have resulted in a large-scale displacement of fishing effort within local fishing communities. The swordfish buoy gear developed in South Florida has shown consistently high catch rates when targeting swordfish, with low bycatch interactions, and has the additional utility of being fished from small vessels. Although preliminary, economic analyses suggest that such smaller vessels not only receive a higher ex-vessel price per pound for their product, but that overall per-vessel profitability is higher than the nearby pelagic longline fishery.

As part of recent efforts to reduce sea turtle and marine mammal bycatch in global fisheries, the NOAA Office of International Affairs has sponsored the evaluation of this buoy gear type aboard artisanal vessels in both Morocco (eastern Atlantic) and Turkey (eastern Mediterranean). The project with Turkey consisted of two phases during 2011. For phase one, three Turkish fishery scientists traveled to the United States in March to undergo first-hand training with swordfish buoy gear, as well as bycatch release training. Phase two consisted of fieldwork conducted in Turkey during May and June by two U.S. fishery scientists and a commercial swordfish captain from Florida to both train local Turkish captains on the gear type and to evaluate the gear in Turkish waters. Catch data, GPS, and vessel characteristics were recorded during the experimental testing of the gear. There was no sea turtle or marine mammal bycatch documented during a total of 15 observed sets in four locations. The catch rates for the swordfish buoy gear were low, although several environmental and regulatory factors potentially affected the effectiveness of the gear and consequently reducing the catch rates. The project with Morocco will occur in two phases as well during spring 2012 and spring 2013. Phase one occurred in 2012 and consisted of one U.S. fishery scientist and a commercial swordfish captain from Florida traveling to Morocco to introduce the gear type, evaluate potential local suppliers of gear components, and conduct one night of fishing operations. Phase two will occur in April with similar data collection protocols as the Turkish Project.

Gulf of Mexico Alternative Gear Pilot Program

David Kerstetter and Max Appelman

Nova Southeastern University Oceanographic Center
8000 North Ocean Drive
Dania Beach, FL 33004 USA

The pelagic longline (PLL) fishery for yellowfin tuna and swordfish in the U.S. Gulf of Mexico interacts with over 80 other incidental and bycatch species, including the overfished western Atlantic stock of Atlantic bluefin tuna during the December-May spawning season. Nova Southeastern University has conducted an Alternative Gear Pilot Program ("Program") to evaluate the catch and catch rates of two alternative gear types for these target species – greenstick gear (GSG) and swordfish buoy gear (SBG) – which are known to have much lower rates of bycatch and bycatch mortality than PLL gear.

Four commercial fishing vessels in the Gulf of Mexico have participated in this ongoing project, two from Louisiana and two from the west coast of Florida, totaling over 150 at-sea fishing days and landing over 20,000 of ex-vessel product. Trends in the data reveal catch rates have increased as captains and fishermen gain experience fishing the alternative gears and modify it for optimal performance in the Gulf of Mexico. The size of retained yellowfin and quality of fish product has also generally increased with each successive GSG fishing trip.

For GSG, 90% of the catch consisted of tuna species and 43% retained yellowfin tuna. Incidental catches of species such as wahoo, mahi, and bigeye tuna contributed nearly 4% of the total GSG catch, adding value to each trip. There were no observed interactions with Atlantic bluefin, marine mammals, sharks, sea turtles, or sea birds with GSG. Three billfish were caught with GSG, both released alive.

For SBG, 101 fish have been caught via SBG, 85% of which were swordfish (44% retained swordfish). The catch rate for SBG is 88.6 retained swordfish per 1000 hooks, which is nearly two orders of magnitude greater than PLL catch rates for swordfish. There were no observed interactions with Atlantic bluefin, marine mammals, sea turtles, or sea birds with SBG. Ten sharks (various species) were caught with SBG, all released alive.

The project will continue through June 2013, including comparisons of economic data for more complete experimental fishery evaluation, with results available later this summer.

Evaluating post-release survivorship in the Southern California recreational thresher shark fishery

C. Heberer[1], S.A. Aalbers[2], S. Kohin[3], N. Spear[3] and C.A Sepulveda[2]

1. National Marine Fisheries Service, Southwest Region, Sustainable Fisheries Division, Carlsbad, CA
2. Pfleger Institute of Environmental Research (PIER), Oceanside, CA
3. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, CA

Pfleger Institute of Environmental Research, 315 N. Clementine, Oceanside, CA 92054 USA

The common thresher shark (*Alopias vulpinus)* is the target of a popular recreational fishery in Southern California. This work assessed post-release survival in three different components of the recreational fishery: (1) threshers captured by the caudal fin, (2) threshers captured by the caudal fin and released with trailing gear, and (3) threshers captured by the mouth. Survivorship was determined using pop-off satellite archival tags (PSATs) deployed on common thresher sharks captured by replicating standard caudal and mouth hooking gear and methods used in the sport fishery. Sizes ranged from 111 cm to 221 cm FL. Tag deployments were scheduled for 10 days for both the caudal-based and mouth-based trials and 90 days for the sharks that were released with trailing gear. Tags were programmed to record depth, temperature, and light levels every minute and when possible the tags were re-acquired after release for subsequent deployment.

Collectively, PSATs have been deployed on 35 common thresher sharks for all three components assessed in the study. Nineteen PSATs were deployed on sharks captured by the caudal fin with five sharks dying shortly after release (74% survivorship). Nine PSATs were deployed on sharks captured by the caudal fin and released with trailing gear with six mortalities (33% survivorship). Lastly, all seven of the PSATs deployed on mouth-caught sharks survived (100% survivorship). Collectively, the results suggest that caudal-based angling techniques can negatively affect post-release survivorship whereas mouth-based angling techniques can result in high survivorship of released sharks.

Wicked good tuna: partnering with bluefin fishermen leads to a wealth of new biological knowledge

Emily Chandler[1], Walter Golet[2], and Molly Lutcavage[1]

[1]Large Pelagics Research Center, Department of Environmental Conservation, University of Massachusetts Amherst, Gloucester Marine Station, PO Box 3188, Gloucester, MA 01930

[2]University of Maine, School of Marine Sciences and Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME 04101

"Wicked Tuna", the reality show featuring New England bluefin fishermen is a world-wide hit, but the equally dramatic story of fishermen-scientist research partnerships remains unheralded. Beginning in 1993 the Large Pelagics Research Center (LPRC) developed long-term partnerships with commercial fishermen supporting biological and ecological research on Atlantic bluefin tuna (ABFT) and other large pelagic species. Initial cooperative projects (aerial surveys and acoustic tracking), "sea-truthed" fishery-dependent indices of abundance, established ABFT dispersal behavior and oceanographic associations, and developed a network of fishermen and dealers providing biological samples for ecological studies. Cooperative electronic tagging also produced a sixteen year time series of the spatial-temporal movements of "giants" (ABFT > 185 cm CFL) released off New England and Maritime Canada. Because information on juveniles is especially useful in stock assessments, LPRC expanded cooperative research in 2006 to include smaller size classes targeted by sport fishermen. LPRC's Tag A Tiny™ conventional tag and release program tested the feasibility of a conventional tagging program in the western Atlantic and created a broader network to access juveniles. The biological archive achieved through these partnerships includes samples from 2,620 ABFT, collected between 2004 and 2012, now being used in age and growth, sexual maturity, biomarkers, contaminants and genetics studies. To date, the Tag A Tiny™ program has enrolled 1,285 recreational anglers and captains, with >1,600 conventional tags deployed on ABFT. This cooperative network will be utilized to meet the US tagging goals under ICCAT's "Grande Bluefin Year Program," in collaboration with NOAA's Southeast Fisheries Science Center. Impact factors such as peer reviewed publications and valuable, fishery-independent data stemming from cooperative research provide the "wicked good" story: partnerships with knowledgeable stakeholders remain a cost-effective, innovative, and productive scientific path for fisheries scientists and managers.

Incorporating changes in target species in a fishieries stock assessment model: an illustration of alternative methods applied to the blue sharks (*prionace glauca*) in the south atlantic ocean

Felipe Carvalho[1*], Robert Ahrens[1], Debra Murie[1], Jose M. Ponciano[2], Alexandre Aires-da-Silva[3], Mark Maunder[3], and Fabio Hazin[4]

[1]Program of Fisheries and Aquatic Sciences, School of Forest Resources and Conservation, University of Florida
[2]Department of Biology, University of Florida
[3]Inter-American Tropical Tuna Commission
[4]Departamento de Pesca, Universidade Federal Rural de Pernambuco

Fisheries and Aquatic Sciences, University of Florida, 7922 NW 71st, Gainesville, Florida, 32653 USA

Catchability is an important parameter in many stock assessment models because it relates an index of abundance to stock size. Many biological and management factors may influence catchability in fisheries, among them are: spatial and temporal aggregation of fish, changes in fishing power, and gear selectivity. Furthermore, fishermen are constantly changing their target species to meet market demands. Trends in catchability overtime can cause biased estimates of stock size and fishing mortality rates in stock assessment models. In the present study a Bayesian state-space production model was used to assess the South Atlantic blue shark (*Prionace glauca*) stock under three alternative scenarios addressing the impact of changes in the targeting species (catchability) over time on biological reference points and harvest quotas for the stock. All three scenarios predicted that the stock is above B_{MSY} and that fishing mortality levels are below F_{MSY}. Varying catchability had no significant impact on the status of the population with respect to MSY-based reference points as a result of a high degree of certainty regarding the status of the stock. Despite differences in estimates among scenarios, it is unlikely that the population was being fished in excess of its optimal equilibrium harvest rate in 2006 regardless of the scenario used. The method developed can be implemented to model other stocks to allow catchability to vary as result of changing fisheries dynamics and to provide more robust predictions of stock status in the future.

Stable isotope analysis elucidates migratory patterns of pacific bluefin tuna in the north pacific ocean

Daniel J. Madigan[1], **Heidi Dewar[2]**, Owyn E. Snodgrass[2], Brian N. Popp[3], Zofia Baumann[4], Nicholas S. Fisher[4]

[1]Hopkins Marine Station of Stanford University, [2]NOAA Fisheries Southwest Fisheries Science Center, [3]Department of Geology and Geophysics University of Hawaii, [4]School of Marine and Atmospheric Sciences Stony Brook University

120 Oceanview Blvd
Pacific Grove, California 93950, USA

Understanding movement patterns of migratory marine animals is challenging but critical for effective management. Pacific bluefin tuna (PBFT) that inhabit the western and eastern Pacific Ocean (WPO and EPO) are fished by several nations in both regions and are in steep decline due to overfishing. Understanding the proportion of trans-Pacific migrants to long-term (>1 year) residents of the California Current Large Marine Ecosystem (CCLME) is essential for improving fisheries management, as the age-specific contributions of WPO PBFT to and from the CCLME fisheries remain largely unquantified. Here, we use bulk and amino acid stable isotope (δ^{15}N) analyses to distinguish recent WPO migrants from CCLME residents. The proportion of recent WPO migrants decreased in older year classes (YCs): 75% migrants for YC1-2, 33% for YC2-3, and 0% for YC3-4. Stable isotopic clock techniques were used to estimate the timing of migrations to the CCLME and the ages and sizes at which PBFT entered the CCLME. Most PBFT entered the CCLME in winter and early spring, and while most migrated in the latter half of their first year (0.7 – 0.9 years) or early in their second (1.0 – 1.5 years), some PBFT migrated at older ages (> 2 years old). The proportion of migrants in YC2-3 PBFT in the CCLME was higher than is generally assumed based on previous studies.

Published stable isotope data suggest that pelagic food webs near Japan are significantly shifted in δ^{13}C and δ^{15}N from base prey items (euphausiids) to upper trophic level predators (tunas and sharks) compared to the CCLME, where upwelling results in isotopic differences, particularly in higher δ^{15}N values. Stable isotope values of PBFT in Japan represent a wide range of δ^{15}N values, suggesting that PBFT sampled in Japan represent both long-term (> 1 year) residents of the WPO as well as recent migrants from the CCLME.

Stable isotope values provide quantitative information on the migratory dynamics of PBFT in the EPO. Our approach, combined with published data from the WPO, suggest that stable isotopes could be a valuable tool in discerning PBFT residents from migrants on both sides of the North Pacific Ocean. This approach can also be applied to other species that cross the North Pacific Ocean.

Migration patterns of juvenile (age-0) pacific bluefin tuna (*thunnus orientalis*) in coastal nursery areas of japan

Ko Fujioka, Hiromu Fukuda, Suguru Okamoto and Yukio Takeuchi

National Research Institute of Far Seas Fisheries, Fisheries Research Agency,
5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan

Pacific bluefin tuna (*Thunnus orientalis*, PBT) juveniles, hatched in the area around the Philippines and Nansei islands in the North Pacific Ocean, migrate to Kochi and Nagasaki coastal areas 2 to 3 months after hatch and are targeted by troll fishing for farming. During this period (August), the juveniles are still small (about 20cm in fork length (FL)) and so weak that even direct touch to the fish can cause fatal damage. Their vulnerability makes it difficult to collect vital data in the natural environment over the past years.

The habitat utilization of the juvenile PBT in coastal nursery areas was investigated using small archival tags (LAT2910; φ7.8mm × 26mm, Lotek, Inc.) implanted in a fish during August in 2012 for 75 individuals. Thirteen tags were recovered in total (recovery rate 17%) and we downloaded data successfully from four of them. One tagged juvenile, which recorded for 79 days from August (Summer) to October (Autumn) off Kochi (grew up from 24.5 to 50.0cm in FL), migrated both coastal areas and offshore into edge of the Kuroshio Current, according to a state-space Kalman filter statistical model estimating for their most probable tracks. The fish spent most of the time (70%) on the warmer side (28.3 °C) of the mixed surface layers (0-30m) in August at located away from the Kuroshio Current. When the fish moved into the edge of the Kuroshio Current in September, the vertical distribution of the fish markedly sifted from warm, upper water (27.3 °C) to the colder water under the thermocline (less than 25.4 °C) and stayed around 40-100m depth in day time (57%). In October, the fish moved from the edge of Kuroshio Current to coastal areas again. It stayed in the mixed surface layer (24.8 °C), which became thicker (0-80m) compared to summer. These results suggest that the tagged fish moved between coastal fishing grounds and offshore edge of the Kuroshio Current. Our results also indicate that juveniles could cross through the thermoclines. Their habitat utilization mechanism related to physiological thermoregulation ability with growth and fluctuations in prey availability requires further investigations to reveal their migration between areas.

Comparative Economic Values for Alternative Pelagic Fishing Gears in the Gulf of Mexico

Kristina A. Trotta[1], Brad Gentner[2] and David W. Kerstetter[1]

1. Nova Southeastern University Oceanographic Center, 8000 North Ocean Drive, Dania Beach, FL 33004 USA
2. Gentner Consulting Group, 9007 Eton Rd, Silver Spring, MD 20901

The commercial fisheries for pelagic fishes in the southeastern United States and Gulf of Mexico are important for the economic benefits they bring to their supporting communities. Pelagic longline gear has long been the primary method for targeting yellowfin tuna (*Thunnus albacares*) and swordfish (*Xiphias gladius*), but recent concerns have highlighted the Gulf of Mexico fishery due to its bycatch of Atlantic bluefin tuna (*T. thynnus*), which has been assessed for over ten years as severely overfished, with overfishing still occurring. As an alternative to pelagic longline gear, two fishing gears are now being scientifically evaluated for the first time in those waters, including greenstick gear for tuna and swordfish buoy gear. Despite the importance of the fishing industry in these geographic areas, little work has been done so far to describe the economic values associated with each of these fishing methods, and as a result, the economic impact of these fisheries is not known.

As a first step to closing this economic knowledge gap, these three modes of targeting HMS fishes – pelagic longline gear, swordfish buoy gear, and greenstick gear – in three different U.S. communities will be compared as a way of determining the financial efficiency of each fishery. We will be examining the pelagic longline fishery (PLL) in the U.S. southeast Atlantic versus the PLL in the Gulf of Mexico; the experimental swordfish buoy gear (SBG) fishery in the Gulf of Mexico versus the established fishery in the Florida Straits; and the experimental greenstick gear (GSG) fishery in the Gulf of Mexico versus the established greenstick gear fishery in North Carolina.

These economic data will be used to generate estimates of net differences in revenue per trip for each location when compared with the economic data currently being collected during the experimental alternative gear program with GSG and SBG in the Gulf of Mexico. Results will likely be used in on-going discussions regarding potential gear conversion programs for fisheries in the Gulf of Mexico associated with the federal legal settlement from the Deepwater Horizon oil spill event in 2010.

Life history research in scombrid species: setting research priorities to inform management and conservation for the coming decades

Juan-Jordá[1,2], M.J., Mosqueira[3],I., Freire[4], J., and Dulvy[2], N.K.

[1]Grupo de Recursos Marinos y Pesquerías, Universidade da Coruña, Spain
[2]Earth to Ocean Research Group, Simon Fraser University, Canada
8888 University Drive, Burnaby, BC V5A 1S6, Canada
[3]EU-Joint Research Center, IPSC-Maritime Affairs Unit FISHREG, Ispra, Italy
[4]Barrabés Next, Madrid, Spain

Scombrid species (tunas, bonitos, Spanish mackerels and mackerels) support important fisheries in tropical, subtropical and temperate waters around the world, being one of the most economically and socially important marine species globally. Their sustainable exploitation, management and conservation depend on accurate life history information, which is vital for the development of quantitative fisheries stock assessments and in the fishery data-poor situations. In this study, first we assemble life history traits (maximum size, growth, longevity, maturity, fecundity, spawning duration and interval) for the 51 species of scombrids. Second, we synthesize their current life history information on growth and reproductive biology, including a population-level review for the principal market tuna species, and identify major biological gaps in knowledge and priorities in life history research. Last, we prioritize life history research needs in scombrids based on their biological gaps in knowledge, the importance of their fisheries and their current conservation status according to the IUCN Red List. We find that the growth and reproductive biology of tunas and mackerel species have been more extensively-studied than for Spanish mackerels and bonitos, although there are notable exceptions in all groups. We also revealed that reproductive biology of species, particular fecundity, is the less-studied biological aspect in scombrid species. We identified two priority groups of species, including 32 species of scombrids, and several populations of principal market tunas, for which life history research should be prioritized following the species-specific life history gaps identified in this study in the coming decades. By highlighting the important gaps in biological knowledge and providing a priority setting for life history research in scombrid species we hope this study can provide guidance for management and conservation and serve as a guide for biologist and resource managers interested in the biology ecology and management of scombrid species.

Using uv illumination to reduce bycatch in gillnet fisheries

John Wang[1]*, **Pedro Alvarez[2], Joel Barkan[2], Veronica Barragan[2], Gizelle Crisostomo[2], Khanh Chi Dam[2], Antonio Figueroa[2], Shara Fisler[2], Marcelo Santos[2]**, Yonat Swimmer[3]

[1]Joint Institute for Marine and Atmospheric Research, Honolulu, HI
[2]Ocean Discovery Institute, San Diego, CA
[3]Pacific Islands Fisheries Science Center, Honolulu, HI

*Joint Institute for Marine and Atmospheric Research
University of Hawaii
1000 Pope Road
Honolulu, Hawaii USA 96822

Visual cues play important roles in sea turtle foraging behavior. As such, altering these cues can be a useful strategy to reduce the incidental catch of sea turtles in fisheries. We examined the effectiveness of illuminating gillnets with ultraviolet (UV) LEDs to reduce bycatch of green sea turtles (*Chelonia mydas)* in coastal fisheries. Net illumination was also tested in a commercial bottom gillnet fishery to quantify its effects on target fish catch rates and catch value. Our results indicate that nets illuminated by UV LEDs differed from control nets in the following ways: 1) significantly reduced mean sea turtle catch rates by 39%; 2) had similar rates of target fish catch and catch value; 3) increased the catch of California halibut (*Paralichthys californicus*), the fishery's most valuable species, by 32%; and 4) decreased the bycatch of elasmobranch species by 28%, including a 57% decrease in bycatch of scalloped hammerhead sharks (*Sphyrna lewini*). Taken together, our findings indicate UV illumination may have application in global fisheries to both reduce sea turtle and elasmobranch bycatch without negatively influencing profitability within the fishery.

Assessing movements and testing alternative deep-set fishing gear for swordfish above Point Conception, California.

S.A. Aalbers[1], C. Heberer[2], S. Kohin[3], H. Dewar[3] and C.A. Sepulveda[1]
[1]Pfleger Institute of Environmental Research (PIER), Oceanside, CA
315 Clementine, Oceanside, CA 92054 USA
[2]National Marine Fisheries Service, Southwest Region, Sustainable Fisheries Division, Carlsbad, CA
[3]National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, CA

Within the U.S. exclusive economic zone (EEZ) off of California, swordfish are primarily harvested using drift gillnet (DGN) gear as well as traditional harpoon techniques. DGN interactions with species of concern, particularly sea turtles and marine mammals, have spurred numerous restrictions that have directly impacted fishers through time-and-area closures and mandated gear modifications. Restricted fishing zones, including the 160,000 nautical mile^2 Pacific Leatherback Closure Area (PLCA), currently exclude DGN operations from the most productive waters off California during the season of peak swordfish abundance (August-November). As a consequence, the DGN fishery has reached historic low levels of catch, effort, and revenues during the 2012-13 season. Management strategies to reduce fishing gear interactions with bycatch species require spatial and temporal information on swordfish movements relative to other species of concern. To address the need for selective fishery options and support adaptive management efforts, a cooperative study was launched to (1) quantify the depth distribution and fine-scale movements of swordfish within the PLCA and (2) conduct experimental fishing trials using deep-set buoy gear. Three research cruises were conducted within the PLCA during the fall of 2012 to tag swordfish with pop-off satellite archival tags (PSATs). To date, six swordfish (80-150 kg) have been tagged with fine-scale archival records retrieved from three short duration PSAT deployments. Findings to date will be presented.

Catching the uncatchable fishers with respondent-driven sampling: a new approach for surveying 'hard-to-reach' components of recreational fisheries

Shane P. Griffiths

CSIRO Marine and Atmospheric Research, PO Box 120, Cleveland, Queensland 4163, Australia.

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. Specialised recreational gamefish fisheries have developed for many species worldwide, that target species such as swordfish, billfish, tunas, tuna-like species, thresher and mako sharks, which in some cases, has led to conflict between commercial and recreational sectors. As a result, there is a need for fisheries scientists to obtain reliable estimates of the recreational catch for inclusion in stock assessments to ensure resources are sustainable and shared equitably among stakeholders.

Unfortunately, obtaining representative catch and effort data is problematic for specialised recreational fisheries that typically lack a complete sampling frame (e.g. a fishing licence frame that contains no exemptions). Traditional probability-based sampling methods (e.g. creel or telephone surveys) are inadequate and 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 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, illicit drug users) by penetration of social networks. This paper introduces Respondent-Driven Sampling (RDS), a form of chain-referral (or 'snowball') sampling, as a potential cost-effective means of obtaining representative catch estimates from elusive specialised recreational fisheries that lack a complete sampling frame.

How leading by example can exacerbate international Conservation problems: a bioeconomic analysis

Stephen M. Stohs and Sarah M. Shoffler
Southwest Fisheries Science Center

8901 La Jolla Shores Dr.
La Jolla, CA 92037-1509

Leading by example through domestic regulations to protect endangered species from commercial fisheries impacts may exacerbate the conservation problem the regulations were intended to mitigate. The *transfer effect* describes how domestic regulations to conserve transboundary target or protected populations can lead to a transfer of effort from U.S. harvesters to foreign harvesters. Because of the *transfer effect*, also described as a "trade leakage" or "spillover effect," we cannot predict *a priori* whether unilateral domestic regulations will increase or decrease the global level of overfishing or protected species interactions on a transboundary stock. Regulating U.S. Pacific swordfish fisheries (*Xiphias gladius*) to limit interactions with endangered leatherback turtles (*Dermochelys coriacea*) provides an example.

Endangered leatherback sea turtles are sometimes caught as bycatch in commercial Pacific swordfish fisheries, including rare event bycatch in the Hawaii and California swordfish fisheries. The population ranges of leatherback sea turtles and swordfish extend outside the 200 mile Exclusive Economic Zone limits of the U.S. and other nations contiguous to the Pacific Ocean, with a high degree of overlap between the ranges of these species creating the risk of leatherback-swordfish fishery interactions. The U.S. has regulated the swordfish fisheries in Hawaii and California to address ESA requirements to protect the Western Pacific leatherback population; however, commensurate regulations have not been imposed on non-U.S. commercial Pacific swordfish fisheries which operate in areas where leatherback turtle bycatch may occur. The Theory of the Second Best suggests that it is impossible to predict *a priori* whether unilateral domestic regulations will increase or decrease the global level of protected species interactions.

A two-sector bioeconomic model of swordfish catch and endangered sea turtle interactions in the U.S. domestic and foreign Pacific swordfish fisheries describes the effects of unilateral domestic regulations to reduce endangered sea turtle interactions in the context of the Theory of the Second Best. The model assumes sea turtle interactions are an intrinsic production externality in both U.S. domestic and foreign sector fisheries. The analysis demonstrates that unilateral domestic regulation of the swordfish fishery intended to reduce interactions with endangered sea turtles may reduce U.S. swordfish fisheries' competitive advantage in production while increasing the global level of sea turtle interactions in Pacific swordfish fisheries.

Migratory movements, depth distribution and temperature preferences of dolphinfish (*Coryphaena hippurus*) in the northwestern Mexican Pacific

Sofía Ortega-García[1], John O´Sullivan[2], Rubén Rodríguez-Sánchez[1] and Christopher Perle[3]

[1]Instituto Politécnico Nacional-Centro Interdisciplinario de Ciencias Marinas
La Paz, B.C.S. México.
[2]Monterey Bay Aquarium
[3]California State University-Monterey Bay

Dolphinfish, *Coryphaena hippurus,* are epipelagic predators and have a cosmopolitan tropical to warm-temperate (>20 °C) distribution. This species is an important bycatch of the artisanal and commercial fisheries that operate in Mexican Pacific waters, however little information about their movements in this area is known. During two cruises made 28 September to 6 October 2010 and 25 September to 3 October 2011, we tagged 62 males (66- to 109-cm fork length) and 77 females (69- to 102-cm fork length) using 139 ¨spaghetti¨ type conventional tags and 10 miniPAT tags. Although the 10 pop-up tags were programmed to detach three months after their deployment, the maximum retention time recorded was 39 days. The transmitted summary of depth data for all tags combined shows that dolphinfish spent most of each day in waters shallower than 15 meters. The deeper depths generally occurred during short-term diving. The surface waters where they spent their time were warmer than 22 °C. The colder temperatures recorded were during the deep diving. Numerous deep dives to 100 meters or more were recorded. During the following two months after the fish were tagged with the conventional tags north off Bahia Magdalena (25.24, 112.78) in 2011, five tagged fish were recaptured, two off the Sinaloa coast (ca. 100-km south of released location), two off the Nayarit coast, and one off the Jalisco coast (ca. 300-km south of the released position), which suggests this species moves southward during Autumn. The movements of the dolphinfish seem to be related to the movement of the ocean currents present in the study area.

Correlation of hook-time with post-release mortality and fishing-induced stress response in sandbar (*Carcharhinus plumbeus*) and dusky (*Carcharhinus obscurus*) sharks

Heather Marshall[1], Richard Brill[2], Peter Bushnell[3], Gregory Skomal[4], Diego Bernal[1]

[1]University of Massachusetts Dartmouth; [2]National Oceanic and Atmospheric Administration/Virginia Institute of Marine Science; [3]Indiana University South Bend; [4]Massachusetts Division of Marine Fisheries

In recent years, exploitation of many shark species has incited management organizations to revise commercial fisheries management plans (FMPs) with the hopes of conserving shark populations. Specifically in the western Atlantic, amendments to the Consolidated Highly Migratory Species FMP demand the post-capture release of several coastal species, including the sandbar (*Carcharhinus plumbeus*) and dusky (*C. obscurus*) sharks (Family Carcharhinidae). Although these FMPs are designed to conserve populations, they result in an increased number of sandbar and dusky sharks being released after capture. Research on fishing-related stress indicates that the survival of released fish after capture is not well understood. This study investigates stress response in sandbar and dusky sharks after longline capture, and subsequent post-release mortality. Pop-up Satellite Archival Tags were used to determine post-release mortality of sandbar and dusky sharks after capture on longline gear, and blood stress parameters (electrolytes, metabolites, and *hsp*70) were collected from each fish. Post-release mortality appears to occur more often, after shorter capture times, in the dusky versus the sandbar shark. In addition, at-vessel mortality occurs on average ~3-5 hours after capture in the dusky shark, much earlier than the sandbar shark. Regression analysis reveals a significant ($p<0.05$) correlation of increasing levels of potassium and lactate within both species, with perhaps a greater exacerbation within the dusky shark. Blood potassium levels correlate with post-release mortality in the dusky sharks, at levels (>7 mmol/L) that may induce bradycardia and inhibit swimming-muscle relaxation. Combined at-vessel and post-release mortality levels reveal ~55% overall mortality of the dusky shark after capture times that are much shorter than standard commercial soak times. Overall, this research demonstrates how the physiology of the dusky shark seems greatly affected by capture, relative to sandbar sharks, resulting in higher rates of at-vessel and post-release mortality, therefore revealing additional considerations for the effective management of this species in the northwest Atlantic.

Potential Impact of Spatial Fishery Closures on Silky Shark Populations in the Eastern Pacific Ocean

Marlon H Román and Oscar Sosa-Nishizaki

Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California

Bycatch on fisheries targeting pelagic marine species has been the subject of discussion by various groups interested in conservation. One of the most important fisheries in the eastern Pacific Ocean (EPO) is the tuna purse-seine fishery, which incidentally catches several species of sharks, predominantly the silky shark (*Carcharhinus falciformis*). Shark species are very sensitive to overexploitation, due to their K-selected life-history strategy and high position in the food chain. The Inter-American Tropical Tuna Commission (IATTC), through resolutions, has encouraged research to identify areas and time periods during which silky sharks and other shark species are incidentally caught, with the goal of designing spatial-temporal closures to reduce bycatch. As such, efforts have been made to identify candidate fishery closure areas for silky shark conservation that minimize the economic impact of the loss of tuna catch. However, previous studies did not take into consideration the reallocation of fishing effort in areas outside the closure.

The impact on shark populations of a reallocation of fishing effort can be evaluated with population dynamic models. We assess the impact of several hypothetical spatial closure scenarios on the silky shark population in the EPO, taking into consideration the spatial differences in the size composition of catches of the silky shark occurring in the purse-seine fishery. The catch and effort data to be analyzed were collected by the IATTC and national observer programs onboard tuna purse-seine vessels. The fishing effort of hypothetical closed areas will be reallocated to other regions within the EPO, taking into consideration historical levels of fishing activity in the open areas. For each closure scenario, the amount and size composition of the silky shark catch resulting from the reallocated effort will be used as inputs to a standard age-structured model to assess demography and describe population growth. It is hypothesized that there would be a greater damage to the silky shark population in the EPO if the closure were to be implemented in the north and fishing effort redistributed south of the equator, a region with higher catch rates of adult females.

Assessing post-release survival of purse seine captured silky sharks, *Carcharhinus falciformis*

Melanie Hutchinson[1], David Itano[2], Jeff Muir[2], Bruno Leroy[3], and Kim Holland[1]

[1] University of Hawaii, Hawaii Institute of Marine Biology, 46-007 Lilipuna Rd. Kaneohe, Hawaii 96744

[2] Pelagic Fisheries Research Program, University of Hawaii

[3] Oceanic Fisheries Programme, Secretariat of the Pacific Community

Commercial tuna purse seine fishing operations have redirected most of their fishing effort from fishing on porpoise schools to fishing on drifting fish aggregating devices (FADs) due to the call for dolphin safe canned tuna from consumers. This increased fishing effort on FADs has increased the interaction rates of purse seiners with non-target and undersized species, such as juvenile silky sharks (*Carcharhinus falciformis*). Correspondingly a recent stock assessment of silky sharks in the western and central Pacific Ocean (WCPO) showed significant declines in spawning biomass, total biomass and recruitment. As a result, silky shark interactions with tuna purse seine gear have become a subject of concern amongst scientists, managers and fishers. To address this and other bycatch issues the International Seafood Sustainability Foundation (ISSF) has initiated the #BycatchProject that supports research cruises in the world's oceans on commercial tuna purse seine vessels to develop ways to reduce fishing mortality on non-target species. One of the research objectives during the #BycatchProject cruise in the WCPO was to identify the point in the fishing operations when post-release survival rates of silky sharks is compromised. To answer this question blood chemistry analysis was done on animals landed during the different stages of the fishing operation with their post-release condition and survival verified using survival pop-up archival tags (SPATs) and miniPAT satellite tags (Wildlife Computers, Redmond, Wa). Our results show a post release mortality rate of 84.3% in juvenile silky sharks caught in the purse seine gear. Animals that were landed and released early in the fishing operations (while still free swimming or entangled in the net during the net haul) however, had higher survival rates than animals landed during the brailing stages. Tag and blood chemistry data also show post-release survival to be significantly reduced once animals are confined in the sack. Thus efforts to promote the live release of sharks caught in the net need to be conducted during the early stages of the fishing operations, while sharks are still free swimming.

Selective release of fish bycatch from purse seine gear: is it possible?

David Itano[1], Jeff Muir[2], Melanie Hutchinson[2] and Kim Holland [2]

[1] NOAA Fisheries, Pacific Islands Regional Office
[2] Hawaii Institute of Marine Biology, University of Hawaii

NOAA/NMFS
1601 Kapiolani Boulevard, Suite 1110
Honolulu, HI 96814

Impacts, or perceived impacts, of tuna purse seine operations on target and non-target catch taken in association with floating objects have been driving T-RFMO management initiatives as well as E-NGO anti-fishing campaigns in recent years. The proliferation of large-scale purse seining on drifting FADs in all tropical oceans coupled with higher catch rates on FADs of bigeye tuna, target tuna species of undesirable size, oceanic sharks, marine turtles and miscellaneous finfish (mahi mahi, wahoo, marlins, etc.) is at the core of the problem. Bycatch mitigation efforts based on pre-set avoidance through acoustic methods, seeking vertical or horizontal behavioral patterns that segregate size or species, or the use of sorting grids after encirclement have not proved effective. Removal of unwanted catch from the work deck or well deck can be promoted but post-release condition has not been verified and is likely to be very poor.

A research cruise was conducted in the central equatorial Pacific during 2012 to develop and test methods to avoid undersize tuna and reduce the incidental mortality of non-target species that associate with drifting FADs. The cruise was conducted on a 1500 GRT tuna purse seine vessel operating in commercial mode with direction from a team of scientists in support of the *International Seafood Sustainability Foundation's* #BycatchProject; formed to investigate technical options to reduce bycatch in industrial tuna fisheries. Experimental results indicate that pre-set avoidance or selective release of non-target species from the net should be prioritized, as the condition and post-release survival of bycatch released during the loading stage of the fishing oeration is extremely low. Scuba dive surveys conducted during FAD sets documented a clear separation of tuna by size and species and between tuna and bycatch species, suggesting the possibility of selective bycatch release. Silky sharks (*Carcharhinus falciformis*), and to a lesser degree miscellaneous fish bycatch were observed to aggregate in a dynamic pocket of net that consistently formed during the latter stages of net retrieval where an experimental release panel was tested. A small number of sharks exited the panel during trials conducted during the cruise but groups of sharks and bycatch were observed very close to the opening, suggesting the concept may be useful if appropriate stimuli or technical issues were developed or different environmental conditions prevailed. The concept will be modified and tested during a second WCPO cruise during 2013.

Foraging ecology of silky sharks, *Carcharhinus falciformis*, in the eastern tropical Pacific Ocean

Leanne M. Duffy, Robert J. Olson, Felipe Galván-Magaña, Noemi Bocanegra-Castillo, Vanessa Alatorre-Ramírez, and Petra M. Kuhnert

Inter-American Tropical Tuna Commission, 8601 La Jolla Shores Drive, La Jolla CA 92037-1508, USA

The incidental catch of non-target species in large-scale industrial fisheries is a rapidly growing concern worldwide. Silky sharks are the most commonly-captured non-target shark species in the tuna purse-seine fishery of the eastern tropical Pacific Ocean (ETP). Ecosystem-based approaches to managing fisheries require a fundamental understanding of the ecological relationships in exploited ecosystems. To gain insight into the role of silky sharks in the ecosystem, their foraging ecology was characterized utilizing classification tree methodology. Stomach samples were collected from 786 silky sharks captured in 151 purse-seine sets during 2 sampling periods, 1992-1994 and 2003-2005. Most of the sharks were bycatch in sets on tuna schools associated with floating objects (86% of all sets). Relationships among predator-prey data and spatial, environmental, and biological covariates included in the model will be presented and discussed.

Opah (*lampris guttatus*) in the california current: foraging and movements

Owyn E. Snodgrass, Heidi Dewar, James Wraith, Suzanne Kohin, Russ Vetter
NOAA Fisheries, Southwest Fisheries Science Center

Fisheries Resources Division
8901 La Jolla Shores Drive
La Jolla, California 92037, USA

The opah (*Lampris guttatus*) is a large disk-shaped fish in the family Lampridae. Encountered in temperate and tropical oceans worldwide, opah is valuable bycatch in commercial fisheries that target tuna and swordfish. Known for their red coloration and popularity in seafood restaurants, opah are considered important pelagic predators in mesopelagic ecosystems. Despite their commercial and ecological value, very little is known about the role opah play in contemporary marine food webs.

Data from 68 stomachs and 8 Wildlife Computers MK-10 pop-up archival transmitting (PAT) tags were used to examine the foraging ecology and behavior of opah in the California Current from 2009 through 2012. Fish studied ranged from 72 cm to 126 cm fork length (FL) with a mean of 98 cm FL. Stomach contents included species of squid and fish typically associated with mesopelagic waters. Thirteen (13) species of cephalopods were identified with 3 (*Loligo opalescens, Gonatus spp, Dosidicus gigas)* making up the most important prey items based on the IRI (index of relative importance). Squid ranged from 30 mm (*Gonatus spp)* to over 266 mm mantle length (*Dosidicus gigas).* In addition, a few stomachs were dominated by epipelagic fish including Pacific saury (*Cololabis saira).* 30% of stomachs contained either small pieces of kelp or plastic. Regional diet differences comparing central and southern California are being examined and preliminary results will be reported.

From 2011-2012, 8 PAT tags were deployed on opah off California during annual longline research cruises. Four tags popped off prematurely and the remaining 4 tags stayed on for 240 days. Preliminary analyses reveal that opah show diel patterns moving between depths of ~ 250 m during the day to ~50 m at night. Unlike most diel vertical migrators, opah appear to remain below the mixed layer. Light and temperature data recorded from one tag indicated it was possibly predated upon by an endothermic shark. The four fish with 240 day deployments travelled distances ranging from 589 to 1,404 nautical miles. Of the full deployments, tags from 3 fish released off southern California popped up in March off Mexico. One tag deployed off central California in late October 2011 popped up northeast of Hawaii in June.

With fisheries managers focusing on ecosystem-based management, it is critical to understand how opah fit into pelagic food webs. For opah specifically, the apparent increase in their occurrence in California fisheries highlights the need to understand their movements, population dynamics and foraging ecology.

Effects on length-weight relationship for blue shark
In the north pacific ocean

Yuko Hiraoka[1], Yasuko Semba[1], Kotaro Yokawa[1] and Minoru Kanaiwa[2]

[1]*Bluefin Tuna Resources Division, National research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan*

[2]*Depertment of Aquatic Bioscience, Tokyo University of Agriculture, 196 Yasaka, Abashiri, Hokkaido099-2493, Japan*

Blue shark (*Prionace glauca*) is a large pelagic shark and distributed from tropical to temperate waters. In the North Pacific Ocean, the stock assessment of this species is ongoing as a cooperative work among WCPFC, ISC as well as IATTC. The length-weight relationship is one of the important biological information to estimate the stock biomass. For the large pelagic fishes, it is generally considered that this relationship is affected by sex, season and area which are associated with their lifecycles. Thus the effects of these factors on the length-weight relationship for this species were investigated by applying GLM analysis. The sexed size (PCL (pre caudal length); cm), whole or processed weight (kg) and the location of operation data were collected through variety of longline researches and training cruises conducted by the national and regional research organizations and by fisheries high schools in Japan during 1994-2012. The full model involve a response variable natural log transformed weight and explanatory variables four main effects (natural log transformed length, sex, season, area (north (≥30N) or south (<30N)) and their interactions. The step-wise method with BIC was applied for the full model to select the best fit model. The results of our analysis indicated that the length-weight relationship was largely affected by area where stratification was decided by parturition ground or not. Blue sharks caught in the south area were heavier than those in the north in the size range below approximately 170 cm PCL. The sexual and seasonal effects became large as they grow up in the north area whereas these effects were relatively small in the south area. To clarify the cause of seasonal and sexual differences, additional analysis with processed weight will be discussed.

Transatlantic movements of juvenile atlantic bluefin tuna inferred from analyses of organochlorine tracers

John E. Graves[1] and Andrew S. Wozniak[1,2]

[1]Virginia Institute of Marine Science, College of William & Mary, P.O. Box 1346
Gloucester Point, VA 23062 USA

[2] Department of Chemistry and Biochemistry, Old Dominion University, 4402 Elkhorn Ave., Norfolk, VA 23529 USA

Based on the presence of spatially discrete spawning grounds in the Gulf of Mexico and Mediterranean Sea, it was hypothesized that Atlantic bluefin tuna comprise distinct western and eastern stocks. Subsequent results of genetic, otolith stable isotope, and electronic tagging studies lend support for this hypothesis and indicate that there is considerable mixing of the two stocks throughout much of the North Atlantic Ocean. Recently, analyses of otolith stable isotopes and organochlorine tracers suggest that more than 50% of school size bluefin tuna (27 – 47 inch curved lower jaw fork length) in the western Atlantic represent migrants from the eastern Atlantic. In the current study we are using analysis of organochlorine tracers to better understand spatial and temporal variation of transatlantic movements of juvenile Atlantic bluefin tuna. Specifically, we are addressing the following three questions: (1) Do organochlorine pollutant ratios in baseline (young-of-the-year) bluefin spawned in the Gulf of Mexico and Mediterranean Sea vary annually? (2) What are the relative rates of mixing of school bluefin tuna in the Bay of Biscay? (3) Does the stock composition of school bluefin within the western Atlantic vary annually, by location, and/or within a season? Preliminary results indicate that there is limited interannual variation in the organochlorine pollutant ratios among western or eastern young-of-the-year bluefin tuna; however, the differences between western and eastern young-of-the-year fish are highly significant for any given year and for all years combined. To date, analysis of school size bluefin captured in the Bay of Biscay has not revealed the presence of recent migrants from the western Atlantic, although it is recognized that due to differences in stock sizes, large sample sizes of eastern fish would need to be screened to detect movements of western fish if western migration rates are small. Finally, migration of school bluefin from the east to the west has been high for the past several years, with approximately 30% of age-2 and age-3 being identified as recent migrants. These data clearly demonstrate that juvenile eastern fish make a substantial contribution to the western North Atlantic bluefin tuna fishery.

Autonomous Detection of Feeding Events in Tuna and Sharks

Kim Holland and Carl Meyer
Hawaii Institute of Marine Biology, University of Hawaii at Manoa
Coconut Island, Kaneohe, Hawaii

Electronic tracking has allowed unprecedented insights into both the vertical and horizontal movement patterns of top predators such as tuna, marlin and sharks. However, even though we now know what these behaviors look like, there is still uncertainty as to what is occurring during these behaviors - such as highly tortuous horizontal movements, prolonged association with floating objects, rapid deep dives, etc. Knowing whether feeding is occurring during these events would add greatly to our understanding of these behaviors and of energy flow through ecosystems. Here we report on the development of a tag that can directly detect ingestion and digestion events in top predators. We have successfully deployed prototype tags and, from the resultant data, we have characterized ingestion and digestion events in free swimming captive sharks and bluefin tuna. Here we present some of these data and discuss possible future directions for this evolving technology. The work to date has been supported in part by Monterey Bay Aquarium and Wildlife Computers.

Evidence for pectoral endothermy in the opah, *lampris guttatus*

Nicholas C. Wegner, Owyn Snodgrass, Heidi Dewar, and John R. Hyde

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

Unlike most pelagic fishes, the opah, *Lampris guttatus*, uses the pectoral fins for continuous swimming. The insulation of the large, red (aerobic) pectoral muscles by a thick layer of fat and connective tissue has led previous researchers to speculate concerning their possible function in heat production and retention. However, temperature measurements have been lacking and there has been no evidence of a countercurrent heat exchanger required to insulate muscle temperatures from convective blood heat loss at the gills. Here we report pectoral muscle temperatures that are significantly elevated above ambient for freshly decked opah and for fish outfitted with intramuscular temperature loggers swimming at depth. We also describe *retia mirabilia* in the gills of the opah that appear to function as countercurrent heat exchangers to conserve heat derived from the pectoral muscles. These *retia* (composed of extensions of the afferent and efferent filamental arteries embedded in adipose tissue within thick gill arches) allow for cold blood leaving the respiratory exchange surfaces to be rewarmed by blood entering the gill filaments. The unique placement of these countercurrent exchangers in the gills potentially allows for warm blood to be distributed throughout the body. In addition to the pectoral muscle, temperatures in the heart, gut, and cranial region are all significantly elevated above ambient.

Investigations of thermal balance in free-swimming swordfish, *Xiphias gladius*

Ashley Stoehr[1], Alex Fowler[1], Chugey Sepulveda[2], and Diego Bernal[1]

[1.] University of Massachusetts, Dartmouth; [2.] Pfleger Institute of Environmental Science

Swordfish, *Xiphias gladius*, are large, active pelagic predators that undergo extensive foraging dives characterized by rapid and large (>18°C) ambient temperature changes. This thermal tolerance allows swordfish to successfully hunt DSL-related organisms during the day, and experience diel vertical movements of greater depth and duration compared to most regionally endothermic and ecothermic species. Regionally endothermic fishes (i.e., tunas and lamnid sharks), not only maintain elevated locomotor muscle temperatures, but can decouple body temperature from fast changing ambient temperature. Despite the presence of several endothermic traits (i.e., medial red muscle position, rudimentary retia, and lateral vasculature) in swordfish, the abilities to defend elevated body core temperatures and control rates of heat transfer have not been documented. The objective of this study was to determine if swordfish are capable of activity-independent thermoregulation using a newly developed thermal balance model able to separate the effects conduction and convection on whole-body heat transfer. Simultaneous measurements of internal locomotor muscle temperature, ambient temperature, and depth of six free-swimming swordfish were acquired using modified PSAT tags programmed for short deployment (5-6 days) in the Southern California Bight. The application of Newtonian heat transfer models revealed substantial changes in whole body thermal conductivity, as indicated by changes in the thermal coefficient in response to ambient temperatures. The newly developed model permitted further investigations into the potential physiological control resulting in differential thermal balance. Simulated tissue temperature were based on relations between tissue, arterial, and venous temperatures, and influenced by potential heat exchanger efficiency, myogenic heat production, and blood flow. Internal conditions were time and ambient temperature dependent as indicated by higher rates of heat retention and slower blood flow during dive versus surface intervals, both of which affect heat transfer. In concert, the models suggest slow rates of cooling during dives coupled with faster rates of heating at the surface that together retard the effect of rapid ambient temperature change, and allow swordfish to move through disparate thermal regimes.

Improving fitness and survival in early-life stages of reared california yellowtail, *seriola lalandi.*

Catherine Purcell[1] and John Hyde[1]

[1]Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 8901 La Jolla Shores Dr., La Jolla, CA 92037 USA

A key challenge in aquaculture production is the occurrence of high percentages of fish with deformities. Malformations in the larval and juvenile stages directly impact commercial aquaculture by reducing the market value of fish, requiring additional labor for manual sorting to remove these individuals, and can lead to diminished growth rates and reduced survival in these fish. These deformities have been reported in the California yellowtail, *Seriola lalandi*, a species that is currently of interest for offshore aquaculture in southern California and Baja California, Mexico. Deformity rates for yellowtail at Hubbs SeaWorld Research Institute (HSWRI) have ranged from 25-40% depending on the cohort. In order to help identify, characterize and understand factors contributing to offspring deformities and growth rate variability, we are conducting pedigree analyses to evaluate the impact of parent-progeny relationships on this variability. Juvenile yellowtail (43 to 50 days post hatching) were collected from three production runs at HSWRI in the summer/fall of 2012. Sample collections included groups of small and large individuals (representing different growth rate categories), deformed and randomly sampled juveniles. Genetic samples from the 21 broodstock individuals were also collected. Juvenile offspring were photographed and deformities (when present) were recorded, including: cranial malformations (jaw deformities, incomplete or malformed opercula, and misshapen skulls), shortened (or perch-like) bodies, and skeletal abnormalities (such as lordosis, kyphosis). Currently, genetic markers (16 nuclear microsatellites) are being used to evaluate parent-progeny relationships to test whether observed fitness traits are associated with pedigree. Analyses are also being conducted to determine whether there is a genetic component of these deformities and, if relevant, the associated heritability of those deformities. Initial genetic analyses of juveniles sampled from HSWRI show significant differences in parental contribution between offspring with deformities and randomly sampled offspring. These results suggest a connection between certain brood individuals and deformed juveniles. Results of the pedigree analyses to date will be presented.

Studies of tuna early life history conducted at the iattc's achotines laboratory, 2012-2013

Daniel Margulies, Vernon Scholey, Jeanne Wexler, Maria Stein

Inter-American Tropical Tuna Commission
8604 La Jolla Shores Drive
La Jolla, CA 92037 U.S.A.

The Inter-American Tropical Tuna Commission (IATTC) conducts research on the reproductive biology and early life history of yellowfin tuna at the Achotines Laboratory, Republic of Panama. Yellowfin broodstock have been spawning at near-daily intervals since 1996, and the resulting eggs, larvae and early-juveniles are studied in experimental investigations.

During 2012-2013, several ongoing investigations of yellowfin early life history were continued or completed. Analyses continued on a collaborative study, funded by the Pelagic Fisheries Research Program (PFRP) and conducted with scientists of the Secretariat of the Pacific Community (SPC), Macquarie University, Australia and University of Gothenburg, Sweden, investigating the potential effects of ocean acidification on yellowfin early life stages. The experimental work for the project was conducted at the Achotines Laboratory. Preliminary results indicated some potential impacts of increased acidification on egg and larval stages over a broad range of acidification scenarios. Further studies, conducted under a more restricted "near future" acidification scenario, are strongly indicated. Preliminary results of the experimental trials conducted at Achotines will be presented.

In mid-2011, a 5-year joint study was initiated at the Achotines Laboratory and in Japan to conduct comparative studies of the early life histories of Pacific bluefin and yellowfin tuna. The project is a joint study conducted by the IATTC's Early Life History (ELH) Group, Kinki University and the Autoridad de los Recursos Acuáticos de Panama (ARAP). The project is being funded by the Japan International Cooperation Agency (JICA) and the Japan Science and Technology Agency (JST). Experimental results of comparative investigations of growth potential, responses to delayed feeding and starvation in larvae of both species are reported in this meeting by Stein et al. We present summaries here of additional ongoing studies of embryonic and larval development, density effects on larval growth and genetic monitoring, as well as a description of planned ocean cage culture of juvenile yellowfin in waters near Achotines.

During 2012, a 3-year study funded by California Sea Grant was initiated by the IATTC and the Hubbs Sea World Research Institute (HSWRI) to investigate the development of sustainable tuna aquaculture in the U.S. using yellowfin tuna as a model. The project includes feasibility studies of air shipment of yellowfin eggs and larvae from Panama to San Diego, as well as rearing studies of yellowfin larvae in both Panama and San Diego. During May of 2012, the first air shipment of yellowfin larvae, as well as some larval rearing studies, were completed. Results of these trials will be presented.

Other activities during 2012 included the 10th annual workshop at the Achotines Laboratory on "Physiology and Aquaculture of Pelagics, with Emphasis on Reproduction and Early Developmental Stages of Yellowfin Tuna," that was organized by the IATTC's ELH group and the University of Miami.

Comparative studies of feeding dynamics and growth of yellowfin tuna (*thunnus albacares*) and pacific bluefin tuna (*thunnus orientalis*) larvae

Maria Stein, Daniel Margulies, Jeanne Wexler, Vernon Scholey
Inter-American Tropical Tuna Commission

8901 La Jolla Shores Drive
La Jolla, CA 92037 U.S.A.

The Inter-American Tropical Tuna Commission (IATTC) conducts research on the reproductive biology and early life history of yellowfin tuna (*Thunnus albacares*) at the Achotines Laboratory, Republic of Panama. Larvae hatched from eggs spawned at the Achotines Laboratory are routinely used in a variety of laboratory designed to investigate the effects of key environmental and biological factors on pre-recruit survival.

The Fisheries Laboratory of Kinki University, located in Wakayama Prefecture, Japan, has been the world leader in studies of the spawning and rearing of Pacific bluefin tuna (*Thunnus orientalis*). In 2002, Kinki University successfully completed the life cycle of Pacific bluefin in captivity, and has continued to expand and refine its studies of the reproductive biology and aquaculture of Pacific bluefin.

In 2011, the IATTC, Kinki University, and the Autoridad de los Recursos Acuáticos de Panamá (ARAP) initiated a 5-year comparative study of the reproductive biology and early life history of Pacific bluefin and yellowfin. The joint project is being implemented under the Science and Technology Research Partnership for Sustainable Development (SATREPS). The joint research is being conducted mostly at the Fisheries Laboratory of Kinki University in Japan and the Achotines Laboratory in Panama.

As part of this collaboration, members of the IATTC's Early Life History Group (authors) have been conducting experiments at the Achotines Laboratory in Panama and the Kinki Fisheries Laboratory in Oshima, Japan with yellowfin and Pacific bluefin, respectively. Larvae are reared using the same experimental protocols when possible and under very similar experimental conditions. In this paper, we present preliminary results from experiments with larvae focused on three research areas. Comparisons of growth potential of larvae of both species were made at experimental food levels that correspond to a range of wild plankton levels, to determine if there are any species-specific differences in growth under varying food conditions. Species-specific abilities to recover from 1- to 2-day delays in optimal food levels, along with the growth rates attained once higher food concentrations are encountered, were also compared. Finally, a comparison of starvation rates of larvae of both species is ongoing and will be completed during July 2013.

LIST OF ATTENDEES

Scott Aalbers
Pfleger Institute of Environmental Research
315 N. Clementine St.
Oceanside, CA 92054
United States
+1 (760) 721-2531
Scott@pier.org

Jessica Adams
Nova Southeastern University
Oceanographic Center
8000 N. Ocean Drive
Dania Beach, FL 33004
United States
+1 (954) 262-3664
ja1082@nova.edu

Pedro Alvarez
Ocean Discovery Institute
2211 Pacific Beach Drive, Suite A
San Diego, CA 92109
United States
+1 (858) 488-3849
jbarkan@oceandi.org

Joel Barkan
Ocean Discovery Institute
2211 Pacific Beach Drive, Suite A
San Diego, CA 92109
United States
+1 (207) 232-0452
jbarkan@oceandi.org

Veronica Barragan
Ocean Discovery Institute
2211 Pacific Beach Drive, Suite A
San Diego, CA 92109
United States
+1 (858) 488-3849
jbarkan@oceandi.org

William Bayliff
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7025
wbayliff@iattc.org

Felipe Carvalho
University of Florida
2034 NW 7th Lane
Gainesville, FL 32603
United States
+1 (352) 359-8235
fcorreia@ufl.edu

Emily Chandler
University of Massachusetts – Amherst
Large Pelagics Research Center
P.O. Box 3188
Gloucester, MA 01931
United States
+1 (978) 283-0368
echandler@eco.umass.edu

John Childers
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7192
john.childers@noaa.gov

Gizelle Crisostomo
Ocean Discovery Institute
2211 Pacific Beach Drive, Suite A
San Diego, CA 92109
United States
+1 (858) 488-3849
jbarkan@oceandi.org

Khanh Chi Dam
Ocean Discovery Institute
2211 Pacific Beach Drive, Suite A
San Diego, CA 92109
United States
+1 (858) 488-3849
jbarkan@oceandi.org

Heidi Dewar
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7023
heidi.dewar@noaa.gov

Kara Dodge
University of New Hampshire
P.O. Box 38
Osterville, MA 02655
United States
+1 (978) 420-6096
kara.dodge@unh.edu

Leanne Duffy
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-5692
lduffy@iattc.org

Ethan Estes
Monterey Bay Aquarium
886 Cannery Row
Monterey, CA 93940-1085
United States
+1 (831) 655-6239
eestes@mbayaq.org

Paige Eveson
CSIRO Marine and Atmospheric Research
G.P.O. Box 1538
Castray Esplanede
Hobart, Tasmania 7001
+61 (3) 62325015
paige.eveson@csiro.au

Charles Farwell
Monterey Bay Aquarium
886 Cannery Row
Monterey, CA 93940-1085
United States
+1 (831) 648-4826
cfarwell@mbayaq.org

Antonio Figueroa
Ocean Discovery Institute
2211 Pacific Beach Drive, Suite A
San Diego, CA 92109
United States
+1 (858) 488-3849
jbarkan@oceandi.org

Francesca Forrestal
University of Miami / ISSF
4600 Rickenbacker Cswy
Miami, FL 33149
United States
+1 (305) 903-4535
fforrestal@rsmas.miami.edu

Ko Fujioka
National Research Institute of Far Seas Fisheries
5-7-1 Orido Shimizu
Shizuoka 424-8633
Japan
+81 (54) 3366035
fuji88@affrc.go.jp

Daniel Fuller
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7159
dfuller@iattc.org

Benjamin Galuardi
University of Massachusetts - Amherst
Large Pelagics Research Center
P.O. Box 3188
Gloucester, MA 01931
United States
+1 (978) 283-0368
galuardi@eco.umass.edu

Brad Gentner
Gentner Consulting Group, Inc.
9007 Eton Road
Silver Spring, MD 20901
United States
+1 (202) 455-4424
brad@gentnergroup.com

Walter J. Golet
University of Maine
Gulf of Main Research Institute
350 Commercial Street
Portland, ME 04101
United States
+1 (207) 228-1695
walter.golet@maine.edu

John Graves
Virginia Institute of Marine Science (VIMS)
College of William and Mary
1208 Greate Rd
P.O. Box 1346
Gloucester Point, VA 23062-1346
United States
+1 (804) 684-7352
graves@vims.edu

Thomas Gray
Desert Star Systems LLC
3261 Imjin Road
Marina, CA 93933
United States
+1 (831) 384-8000 x118
tgray@desertstar.com

Shane Griffiths
CSIRO Marine and Atmospheric Research
P.O. Box 2583
Dutton Park, QLD 4001
Australia
+61 (7) 38335927
Shane.griffiths@csiro.au

Jason Hartog
CSIRO Marine and Atmospheric Research
G.P.O. Box 1538
Castray Esplanede
Hobart, Tasmania 7000
Australia
+61 (3) 62325153
jason.hartog@csiro.au

Craig Heberer
NMFS Southwest Region
Sustainable Fisheries Division
501 West Ocean Boulevard, Suite 4200
Long Beach, CA 90802
United States
+1 (562) 980-4030
craig.heberer@noaa.gov

Roger Hill
Wildlife Computers, Inc.
8345 154th Avenue NE
Redmond, WA 98052
United States
+1 (425) 881-3048
tags@wildlifecomputers.com

Yuko Hiraoka
National Research Institute of Far Seas Fisheries
5-7-1 Orido Shimizu
Shizuoka 424-8633
Japan
+81 (54) 3366011
yhira415@affrc.go.jp

Kim Holland
Hawaii Institute of Marine Biology
University of Hawaii
P.O. Box 1346, Coconut Island
Kaneohe, HI 96744-1346
United States
+1 (808) 236-7410
kholland@hawaii.edu

Melinda J. Holland
Wildlife Computers, Inc.
8345 154th Avenue NE
Redmond, WA 98052
United States
+1 (425) 881-3048
tags@wildlifecomputers.com

Richard Holmquist
DigitalGlobe
2325 Dulles Corner Boulevard, Suite 1000
Herndon, VA 20171
United States
+1 (703) 480-7516
richard.holmquist@digitalglobe.com

Melanie Hutchinson
University of Hawaii at Manoa
Hawaii Institute of Marine Biology
46-007 Lilipuna Road
Kaneohe, HI 96744
United States
+1 (808) 927-3781
melanier@hawaii.edu

John Hyde
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7086
john.hyde@noaa.gov

David Itano
NOAA Fisheries Service
Pacific Islands Region Office
1601 Kapiolani Boulevard, Suite #1110
Honolulu, HI 96814
United States
+1 (808) 944-2201
david.itano@noaa.gov

Maria Juan Jorda
Universidad de La Coruña
Grupo de Recursos Marinos y Pesquerias
Facultad de Ciencias
Campus A Zapateira s/n C.P. 15071
A Coruna, Spain
+34 671072900
m.juan.jorda@udc.es

Mike Kelly
Sirtrack Limited
Private Bag 1403
Harelock North, Hawkes Bay 4157
New Zealand
+646 8728250
kellym@sirtrack.com

David Kerstetter
Nova Southeastern University
Oceanographic Center
8000 N. Ocean Drive
Dania Beach, FL 33004
United States
+1 (954) 262-3664
kerstett@nova.edu

Michael Kinney
NOAA Contractor with Ocean Associates, Inc.
8584 Villa La Jolla Drive
La Jolla, CA 92037
United States
+1 (951) 452-7988
michael.kinney@my.jcu.edu.au

Jessica Knapp
Large Pelagics Research Center
40 Averil Road
Newcastle, ME 04553
United States
+1 (207) 586-6098
jessieknapp@gmail.com

Suzanne Kohin
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7104
suzanne.kohin@noaa.gov

John LaGrange
American Fisherman's Research Foundation
533 N. Rios Avenue
Solana Beach, CA 92075
United States
+1 (858) 755-7215
john.lagrange@gmail.com

Chi Hin (Tim) Lam
University of Massachusetts - Amherst
Large Pelagics Research Center
P.O. Box 3188
Gloucester, MA 01931
United States
+1 (978) 283-0368
timlam@eco.umass.edu

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

Todd Lindstrom
Wildlife Computers, Inc.
8345 154th Avenue NE
Redmond, WA 98052
United States
+1 (425) 881-3048
tags@wildlifecomputers.com

Emily Loose
Virginia Institute of Marine Science (VIMS)
College of William and Mary
1208 Greate Rd
P.O. Box 1346
Gloucester Point, VA 23062
United States
+1 (804) 684-7434
eloose@vims.edu

Molly Lutcavage
University of Massachusetts - Amherst
Large Pelagics Research Center
P.O. Box 3188
Gloucester, MA 01931
United States
+1 (978) 283-0368
mlutcavage@eco.umass.edu

Benjamin Marcek
Virginia Institute of Marine Science (VIMS)
College of William and Mary
1208 Greate Rd
P.O. Box 1346
Gloucester Point, VA 23062
United States
+1 (804) 684-7434
bmarcek@vims.edu

Daniel Margulies
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7120
dmargulies@iattc.org

JoyDeLee C. Marrow
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7199
jmarrow@iattc.org

Heather Marshall
University of Massachusetts Dartmouth
516 Pleasant Street #207
New Bedford, MA 02740
United States
+1 (973) 820-5223
hmarshall@umassd.edu

Wessley Merten
University of Puerto Rico
701 Calle La Reseladora
Mayaguez, PR 00602
United States
+1 (787) 436-6300
wessley.merten@upr.edu

Shana Miller
Pew Environment Group
64 Meyhew Avenue
Babylon, NY 11702
United States
+1 (631) 671-1530
smiller-consultant@pewtrusts.org

Carolina Minte Vera
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7021
cminte@iattc.org

Travis A. Moore
Nova Southeastern University
Oceanographic Center
8000 N. Ocean Drive
Dania Beach, FL 33004
United States
+1 (954) 262-3686
tm810@nova.edu

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

Padraic O'Flaherty
Lotek Wireless, Inc.
Fish & Wildlife Monitoring Systems
114 Cabot Street
St. John's, Newfoundland A1C 1Z8
Canada
+1 (709) 726-3899
poflaherty@lotek.com

Sofía Ortega-García
CICIMAR - IPN
Avenida IPN S/N
Col. Playa Palo de Santa Rita
La Paz, B.C.S. 23090
México
+52 (612) 1225344
sortega@ipn.mx

Antonella Preti
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-5640
antonella.preti@noaa.gov

Catherine Purcell
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7189
catherine.purcell@noaa.gov

Marlon Roman
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-5694
mroman@iattc.org

Marcelo Santos
Ocean Discovery Institute
2211 Pacific Beach Drive, Suite A
San Diego, CA 92109
United States
+1 (858) 488-3849
jbarkan@oceandi.org

Kurt Schaefer
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7159
kschaefer@iattc.org

Lela Schlenker
Virginia Institute of Marine Science (VIMS)
College of William and Mary
1208 Greate Rd
P.O. Box 1346
Gloucester Point, VA 23062-1346
United States
+1 (804) 684-7434
lsschlenker@vims.edu

Chugey Sepulveda
Pfleger Institute for Environmental Research
315 N. Clementine Street
Oceanside, CA 92054
United States
+1 (760) 721-1404
chugey@pier.org

Sarah Shoffler
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-5678
Sarah.Shoffler@noaa.gov

Owyn Snodgrass
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 342-6372
owyn.snodgrass@noaa.gov

Oscar Sosa-Nishizaki
CICESE
Carretera Ensenada-Tijuana #3918
Fraccionamiento Playitas
Ensenada, BC 22860
México
+52 (646) 1745637
ososa@cicese.mx

Maria C. Stein
Inter-American Tropical Tuna Commission
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7026
mstein@iattc.org

Ashley Stoehr
University of Massachusetts Darmouth
516 Pleasant Street #207
New Bedford, MA 02740
United States
+1 (973) 820-5223
ashley.stoehr@gmail.com

Stephen Stohs
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7084
stephen.stohs@noaa.gov

Jenny Suter
OAI - Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
jennysuter@gmail.com

Kristina Trotta
Nova Southeastern University
Oceanographic Center
8000 N. Ocean Drive
Dania Beach, FL 33004
United States
+1 (305) 807-8818
kt326@nova.edu

Frederic Vandeperre
IMAR-University of Azores
VAT#: 502 776 463
Departamento de Oceanografia e Pescas
Horta, Azores PT-9901-862
Portugal
+351 292-200-400
vandeperre@uac.pt

Angelia Vanderlaan
University of Massachusetts, Amherst
Large Pelagics Research Center
P.O. Box 3188
Gloucester, MA 01930
United States
+1 (978) 283-0386
avanderl@eco.umass.edu

Russ Vetter
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7125
russ.vetter@noaa.gov

Rachael Wadsworth
NOAA Fisheries Service
Southwest Region
501 W. Ocean Blvd., Suite 4200
Long Beach, CA 90802
United States
Rachael.Wadsworth@noaa.gov

Nick Wegner
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7080
nick.wegner@noaa.gov

Yi Xu
Southwest Fisheries Science Center
NOAA Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
United States
+1 (858) 546-7074
yi.xu@noaa.gov

Notes

Notes

Notes

Notes