Proceedings of the 63rd Annual Tuna Conference

Natural and Anthropogenic Effects on Highly Migratory Fish Populations

PREFACE

Welcome to the 63rd 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 **"Natural and Anthropogenic Effects on Highly Migratory Fish Populations."** Our oceans are dynamic ecosystems that are constantly changing as a result of both natural and anthropogenic events. These events include, but are not limited to, natural large-scale oscillations such as ENSO, PDO, NAO, global warming, acidification, hypoxia, increased frequency of natural disasters (e.g. hurricanes, tsunamis), aquaculture expansion, oil spill contamination, and the addition or removal of natural and artificial structures as habitat. Effects of these events on ocean systems and natural mortality of individual stocks are poorly known or are beginning to be unraveled and will continue to be a major research focus in the coming years. We invite researchers to present on results and challenges of documenting the effects of these events on highly migratory species (HMS) populations. Given the valuable economic resource of these fisheries it is important for both scientists and fishery managers to understand the processes that effect HMS population dynamics.

A total of 40 papers and 12 posters touching on various aspects related to the theme of the 63rd Tuna Conference will be presented over the course of four days. In addition, a special session on marine mammal bycatch and a session on Kobe science recommendations and the integration of science into management decisions will both be held on Wednesday afternoon.

Six student scholarships were awarded this year. The Tuna Conference Scholarship was awarded to Maria Jose Juan Jorda for her research on "Life histories of tunas and their relatives: predicting species responses to fishing and ocean changes." The Manuel Caboz Memorial Scholarship was awarded to Iker Zudaire for his work on "Lipid class composition and energy allocation during reproduction of yellowfin tuna in the western Indian Ocean: comparison between FADs and free-swimming schools." In addition, our industry partners graciously sponsored four scholarships. The Desert Star Systems Scholarship was awarded to Mitchell Zischke for his work on "Age, growth, reproductive biology and assessment of wahoo, *Acanthocybium solandri*, off eastern Australia." The GeoEye Scholarship was awarded to Niriniony Rabehagasoa for her research on "Growth of two oceanic sharks, blue shark (*Prionace glauca*) and silky shark (*Carcharhinus falciformis*) assessed by back-calculation from vertebrae in the southwest Indian Ocean." The Wildlife Computers Scholarship was awarded to Stephanie Snyder for her studies of "Scratching the surface: Can water column characteristics explain albacore movements?" Lastly, the Advanced Model Builder Scholarship was awarded to Raul Martinez-Rincon for his work on "Comparative performance of generalized additive models and boosted regression trees for statistical modelling of incidental catch of wahoo (Acanthocybium solandri) in the Mexican purse-seine fishery". All of these students demonstrated impressive research goals and progress and we wish them continued success in their graduate careers.

We wish to thank a suite of volunteers for assisting with the Tuna Conference. Special thanks to JoyDeLee Marrow, past Tuna Conference Coordinator, who provided advice and detailed instructions on how to organize and coordinate the conference. We thank Bill Bayliff, Dan Fuller, Marty Golden, Kim Holland, Bob Olson, Kurt Schaefer, Owyn Snodgrass, and Kevin Weng for moderating the scientific sessions. We thank Cleridy Lennert-Cody, Heidi Dewar, and Tim Sippel for reviewing the student scholarship applications. Christine Patnode updated the Tuna Conference web site and Owyn Snodgrass designed this year's proceedings cover. Thanks to WikiTiki for offering our Conference Apparel and assisting with the shirt design. We thank Prime Time Seafood for donating sashimi-grade tuna. Marty Golden 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.

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 Albacore Fishing Association, American Fishermen's Research Foundation, American Tuna Boat Association, Ballast Point Brewing & Spirits, Desert Star Systems LLC, Floy Tag, GeoEye, International Seafood Sustainability Foundation, Lotek Wireless Inc., Monterey Bay Aquarium Foundation, Prime Time Seafood Inc., West Marine, and Wildlife Computers Inc.

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 had a productive and enjoyable time and look forward to seeing you back next year at the 64th Tuna Conference!

James Wraith and David Wells
63rd Tuna Conference Co-chairs

63rd TUNA CONFERENCE AGENDA

Monday, 21 May 2012

12:00 Registration opens in the Lakeview Tavern

SESSION 1: Movement & Behavior
(Moderator: Kevin Weng)

14:00 Welcome and Introduction (Pineview)

14:10 THE EFFECTS OF SHARK CAGE-DIVING ON THE LOCALISED AND BROADSCALE MOVEMENTS OF WHITE SHARKS IN AUSTRALIAN WATERS– **Barry Bruce** and Russell Bradford

14:30 MOVEMENTS OF MONCHONG AT A HEAVILY FISHED SEAMOUNT– Kevin Weng, **Andrew Gray**, Jeff Muir, Dave Itano, Kim Holland, and Mike Seki

14:50 SCRATCHING THE SURFACE: CAN WATER COLUMN CHARACTERISTICS EXPLAIN ALBACORE MOVEMENTS?– **Stephanie Snyder**, Suzanne Kohin, John Childers, and Peter Franks
*Wildlife Computers Student Scholarship / International Seafood Sustainability Foundation donation winner

15:10 POST-RELEASE SURVIVAL AND HABITAT UTILIZATION OF JUVENILE SWORDFISH IN THE FLORIDA STRAITS– **Jenny Fenton** and David Kerstetter

15:30 THE BEHAVIOR AND MOVEMENT OF SCALLOPED HAMMERHEAD SHARKS (*SPHYRNA LEWINI*) IN HAWAII AS REVEALED BY SATELLITE TELEMETRY TECHNOLOGY– Melanie Hutchinson, J. Anderson, John O'Sullivan, and **Kim Holland**

15:50 HABITAT UTILISATION AND POST-RELEASE MORTALITY OF BILLFISH CAUGHT BY SPORT FISHING METHODS OFF NORTHERN AUSTRALIA– **Shane Griffiths**

16:10 Coffee Break

SESSION 2: Population Modeling
(Moderator: Owyn Snodgrass)

16:30 SMALL-SCALE FISHERY OF SAILFISH *ISTIOPHORUS PLATYPTERUS* (SHAW & NODDER, 1792) AT GULF OF TEHUANTEPEC: A CATCH-AT-SIZE MODEL APPROACH– **Genoveva Cerdenares-Ladrón de Guevara**, Enrique Morales-Bojórquez, Samuel Ramos-Carrillo, and Gabriela González-Medina

16:50 COMPARATIVE PERFORMANCE OF GENERALIZED ADDITIVE MODELS AND BOOSTED REGRESSION TREES FOR STATISTICAL MODELING OF INCIDENTAL CATCH OF WAHOO (*ACANTHOCYBIUM SOLANDRI*) IN THE MEXICAN PURSE-SEINE FISHERY– **Raul O. Martínez-Rincón***, Sofía Ortega-García, and Juan G. Vaca-Rodriguez
*Advanced Model Builder (ADMB) Student Scholarship / International Seafood Sustainability Foundation donation winner

17:10 ANALYZING ANIMAL TRACKING DATA USING DISCRETE CHOICE MODELS IMPLEMENTED IN A HIDDEN MARKOV FRAMEWORK-A NEW APPROACH FOR ANALYZING SATELLITE TAG DATA– **Chris Wilcox**

17:30 Welcome Gathering Party in the Tavern (Continued after Dinner)

18:30 Dinner

Tuesday, 22 May 2012

8:00 Breakfast

SESSION 3: Life History
(Moderator: Kurt Schaefer)

9:00 SPATIAL AND SEX-SPECIFIC VARIATION IN GROWTH OF ALBACORE TUNA (*THUNNUS ALALUNGA*) ACROSS THE SOUTH PACIFIC OCEAN– **Ashley Williams**, Jessica Farley, Simon Hoyle, Campbell Davies, and Simon Nicol

9:20 REPRODUCTIVE BIOLOGY OF ALBACORE TUNA (*THUNNUS ALALUNGA*) IN THE SOUTH PACIFIC OCEAN– **Jessica Farley**, Ashley Williams, Campbell Davies, Paige Eveson, Simon Hoyle, and Simon Nicol

9:40 GROWTH OF TWO OCEANIC SHARKS, BLUE SHARK (*PRIONACE GLAUCA*) AND SILKY SHARK (*CARCHARHINUS FALCIFORMIS*) ASSESSED BY BACK-CALCULATION FROM VERTEBRAE IN THE SOUTHWEST INDIAN OCEAN– **Niriniony Rabehagasoa***, P. Bach, H. Bruggemann, and L. Vigliola
*GeoEye Student Scholarship / International Seafood Sustainability Foundation donation winner

10:00 COLLABORATIVE RESEARCH ACTIVITIES CONDUCTED BY THE IATTC'S EARLY LIFE HISTORY GROUP DURING 2011– **Jeanne Wexler**, Dan Margulies, Maria Santiago, Vern Scholey

10:20 Coffee Break

10:40 GENETIC CONNECTIVITY OF PELAGIC THRESHER SHARK (*ALOPIAS PELAGICUS*) POPULATIONS ACROSS THE PACIFIC– **John Hyde**, Wei-Chuan Chiang, Eric Lynn, and Carol Kimbrell

11:00 SKIPJACK REPRODUCTIVE CAPACITY IN RELATION TO ENERGY RESERVES: IS THERE AN INFLUENCE OF THE SCHOOL TYPE?– **Maitane Grande**, Hilario Murua, Nathalie Bodin, Iker Zudaire, and Nicolas Goni

SESSION 3 Continued: Life History
(Moderator: Dan Fuller)

11:20 AGE AND GROWTH OF ALBACORE (*THUNNUS ALALUNGA*) IN THE EASTERN NORTH PACIFIC– **Charlene Renck**, David Wells, Heidi Dewar, and Drew Talley

11:40 ENERGY CONTENTS OF JUVENILE PACIFIC BLUEFIN TUNA FOR THE BIOENERGETICS MODEL– **Osamu Sakai**, Ko Fujioka, Izumi Yamasaki, and Wataru Doi

12:00 Lunch

13:00 LIFE HISTORIES OF TUNAS AND THEIR RELATIVES: PREDICTING SPECIES RESPONSES TO FISHING AND OCEAN CHANGES– **M. J. Juan-Jorda***, I. Mosqueria, P.P. Molloy, J. Freire, and N.K. Dulvy
*Tuna Conference Student Scholarship / International Seafood Sustainability Foundation donation winner

13:20 AGE VALIDATION OF BLUE SHARKS IN THE NORTHEAST PACIFIC OCEAN– **Natalie Spear**, David Wells, and Suzanne Kohin

13:40 AGE, GROWTH, REPRODUCTIVE BIOLOGY AND ASSESSMENT OF WAHOO, *ACANTHOCYBIUM SOLANDRI*, OFF EASTERN AUSTRALIA– **Mitchell Zischke***, Shane Griffiths, Jessica Farley, and Ian Tibbetts
*Desert Star Student Scholarship / International Seafood Sustainability Foundation donation winner

SESSION 4: Fish Aggregating Devices (FADs)
(Moderator: Marty Golden)

14:00 THE INFLUENCE OF FADS ON SKIPJACK TUNA IN THE EQUATORIAL PACIFIC OCEAN– **Eunjung Kim** and John Sibert

14:20 FINE-SCALE BEHAVIOR OF BIGEYE, SKIPJACK, AND YELLOWFIN TUNAS WITHIN MIXED-SPECIES AGGREGATIONS ASSOCIATED WITH DRIFTING FISH-AGGREGATING DEVICES IN THE EQUATORIAL EASTERN PACIFIC OCEAN– **Kurt Schaefer** and Daniel Fuller

14:40 Coffee Break

15:00 CATCH PREDICTION: VALIDATING A PURSE-SEINE CAPTAIN'S ABILITY TO PREDICT SPECIES COMPOSITION, SIZES, AND QUANTITIES OF TUNAS PRIOR TO SETTING AROUND DRIFTING FISH-AGGREGATING DEVICES– **Daniel Fuller** and Kurt Schaefer

15:20 ARE FADS BAD? A REVIEW OF CURRENT KNOWLEDGE AND SUGGESTIONS FOR BETTER MANAGEMENT AND FUTURE RESEARCH– **Kim Holland**, Laurent Dagorn, Victor Restrepo, and Gala Moreno

15:40 LIPID CLASS COMPOSITION AND ENERGY ALLOCATION DURING REPRODUCTION OF YELLOWFIN TUNA IN THE WESTERN INDIAN OCEAN: COMPARISON BETWEEN FADS AND FREE-SWIMMING SCHOOLS– **Iker Zudaire***, Hilario Murua, Nathalie Bodin, Maitane Grande, and Nicolas Goni
*Manuel Caboz Student Scholarship / International Seafood Sustainability Foundation donation winner

16:00 TESTING DEEP-SET BUOY GEAR FOR SWORDFISH IN THE SOUTHERN CALIFORNIA BIGHT– **Chugey Sepulveda**, Scott Aalbers, and Craig Heberer

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

18:30 Dinner

POSTER SESSION IN THE TAVERN

EVALUATING POST-RELEASE SURVIVAL IN THE SOUTHERN CALIFORNIA RECREATIONAL THRESHER SHARK FISHERY– **Scott Aalbers**, Craig Heberer, Suzanne Kohin, Natalie Spear, and Chugey Sepulveda

NEW INSIGHTS INTO BASKING SHARK BIOLOGY IN THE EASTERN PACIFIC– **Heidi Dewar**

SOUTHERN BLUEFIN TUNA AERIAL SURVEY– **Jessica Farley**, Paige Eveson, Mark Bravington, and Marinelle Basson

CATCHING THE UNCATCHABLE FISHERS WITH RESPONDENT-DRIVEN SAMPLING: A NEW APPROACH FOR SURVEYING 'HARD-TO-REACH' COMPONENTS OF RECREATIONAL FISHERIES– **Shane Griffiths**

EVALUATING THE POTENTIAL OF SWORDFISH BUOY GEAR AS AN ALTERNATIVE TO PELAGIC DRIFTNETS IN THE ARTISANAL FISHERIES OF MOROCCO AND TURKEY– **David Kerstetter** and Travis Moore

STRIPED MARLIN (*KAJIKIA AUDAX*) DIET VARIABILITY OFF CABO SAN LUCAS, BAJA CALIFORNIA SUR, MEXICO DURING EL NINO-LA NINA EVENTS– **Sofia Ortega-Garcia**, Dana Arizmendi-Rodriguez, and Marcela Zuniga-Flores

ALGAL TOXINS AND APEX PREDATORS: DOMOIC ACID IN THE THRESHER SHARK, *ALOPIAS VULPINUS*, IN THE SOUTHERN CALIFORNIA BIGHT– Preston Kendrick, **Antonella Preti**, James Wraith, Elizabeth Frame, and Kathi Lefebvre

GENETIC VARIABILITY IN WILD AND BROODSTOCK POPULATIONS OF CALIFORNIA YELLOWTAIL, *SERIOLA LALANDI*– **Catherine Purcell** and John Hyde

STABLE ISOTOPE ANALYSIS CHALLENGES WASP-WAIST FOOD WEB ASSUMPTIONS IN AN UPWELLING PELAGIC ECOSYSTEM– Daniel Madigan, Aaron Carlisle, Heidi Dewar, **Owyn Snodgrass**, Steven Litvin, Fiorenza Micheli, and Barbara Block

U.S. CONSUMER DEMAND FOR CANNED TUNA WITH SCANNER DATA: EVALUATION OF MARKET BASED INCENTIVES FOR FISHERIES REFORM– **Jenny Sun**, Fu-Sung Chiang, Matt Owens, and Dale Squires

GILL MORPHOLOGY OF THE OPAH, *LAMPRIS GUTTATUS*– **Nicholas Wegner**, Owyn Snodgrass, Heidi Dewar, and John Hyde

STOCK DISCRIMINATION OF WAHOO IN THE PACIFIC AND INDIAN OCEANS USING MORPHOMETRICS AND PARASITES– **Mitchell Zischke**, Shane Griffiths, Ian Tibbetts, and Robert Lester

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Wednesday, 23 May 2012

8:00 Breakfast

SESSION 5: Environment & Trophic Studies

(Moderator: Bob Olson)

9:10 THE INFLUENCE OF CLIMATE-RELATED HYDRODYNAMICS ON ABUNDANCE AND DISTRIBUTION OF BLUEFIN TUNA LARVAE IN THE NORTHERN GULF OF MEXICO– **Guillermo Sanchez-Rubio** and James Franks

9:30 RELATIONSHIP BETWEEN THE PACIFIC DECADAL OSCILLATION AND SARDINE BIOMASS IN A CHANGING CLIMATE– **Sam McClatchie**

9:50 LEVELS OF ORGANIC CONTAMINANTS AND MERCURY IN FOUR SPECIES OF YOY LAMNID SHARKS– **Kady Lyons**, Aaron Carlisle, Mary Blasius, Christopher Mull, Chuck Winkler, John O'Sullivan, and Christopher Lowe

10:10 TROPHIC DYNAMICS OF THE SOUTHEAST FLORIDA, USA COASTAL PELAGIC FISH COMPLEX– **Travis Moore** and David Kerstetter

10:30 Coffee Break

11:00 STABLE ISOTOPIC COMPOSITIONS OF MERCURY INDICATE DEPTH OF FORAGE IN NORTH PACIFIC PELAGIC PREDATORY FISHES AND THEIR PREY FROM HAWAII– **Brian Popp**, Anela Choy, Jeffrey Drazen, and Joel Blum

11:20 FORAGING ECOLOGY OF TUNAS IN THE EASTERN PACIFIC OCEAN– **Helena Aryafar**, Owyn Snodgrass, and Heidi Dewar

11:40 SHARK FISHERIES IN NORTHWESTERN MEXICO– **Oscar Sosa-Nishizaki**

12:00 Lunch

SPECIAL SESSION: Marine Mammal Bycatch

13:10 Introduction: **Jeremy Rusin**

Panel I (What is known about marine mammal bycatch?)

13:20 PELAGIC PREDATOR ASSOCIATIONS: TUNA AND DOLPHINS IN THE EASTERN TROPICAL PACIFIC OCEAN– **Michael Scott**, Susan Chivers, Robert Olson, Paul Fiedler, and Kim Holland

13:35 MARINE MAMMAL BYCATCH IN PURSE SEINE AND LONGLINE FISHERIES OF THE WCPO– John Hampton, Peter Williams, and **Simon Nicol**

13:50 WHAT IS KNOWN ABOUT MARINE MAMMAL BYCATCH IN TUNA FISHERIES AND THE ROLE OF RFMO'S TO MITIGATE AND DEVELOP BEST PRACTICES– **Nina Young**

14:05 INTERACTIONS BETWEEN MARINE MAMMALS AND FISHERIES FOR TUNA AND TUNA-LIKE SPECIES IN THE INDIAN OCEAN– **David Wilson**

14:20 SOME PERSPECTIVES ON MARINE MAMMAL BYCATCH IN TUNA FISHERIES IN DEVELOPING ISLAND NATIONS– **Louella Dolar**

Panel II (Mitigation measures to reduce marine mammal bycatch within purse seine and longline tuna fisheries)

14:35 IMPROVING ASSESSMENT OF BYCATCH AMONG TUNA REGIONAL FISHERIES MANAGEMENT ORGANIZATIONS– **Simon Nicol**

14:50 MAINTAINING LOW DOLPHIN MORTALITY IN THE EASTERN PACIFIC OCEAN TUNA PURSE-SEINE FISHERY– **David Bratten**

15:05 MITIGATION AND DETERRENCE METHODS TO REDUCE MARINE MAMMAL INTERACTIONS IN LONGLINE FISHERIES FOR TUNA– **David Kerstetter**

15:10 **Discussion**

15:30 Coffee Break

SPECIAL SESSION: Kobe Science Recommendations and the Integration of Science into Management Decisions

***beverages provided during session**

15:50 Introduction: **Keith Chanon**

16:00 Management Expectations and Information Needs from the RFMO Science Committees– **Fabio Hazin** and **Russell Smith**

16:25 Scientific Challenges and Uncertainty– **Richard Deriso** and **Shannon Cass-Calay**

16:50 Discussion

17:20 Tuna Conference Business Meeting

18:30 Dinner – Tuna Barbeque sponsored by American Fishermen's Research Foundation, American Tunaboat Association, Floy Tag, GeoEye, Lotek Wireless Inc., and Monterey Bay Aquarium

Frontier Village – for gas campfire and social

Thursday, 24 May 2012

8:00 Breakfast

SESSION 6: Fisheries Management

(Moderator: Bill Bayliff)

9:10 EVALUATING EFFECTIVENESS OF HARVEST CONTROL RULES AND BIOLOGICAL REFERENCE POINTS FOR BIGEYE TUNA (*THUNNUS OBESUS*) AND YELLOWFIN TUNA (*THUNNUS ALBACARES*) FISHERIES IN THE INDIAN OCEAN– **Yuying Zhang** and Yong Chen

9:30 ECOSYSTEM-BASED PRECAUTIONARY ADAPTIVE MANAGEMENT– **Stephen Stohs**

9:50 THE EFFECT OF BIGEYE TUNA QUOTAS ON THE HAWAII-BASED LONGLINE FISHERY– **Russell Ito**, David Hamm, and Kimberley Lowe

10:10 A SCIENTIFICALLY TESTED REBUILDING STRATEGY FOR SOUTHERN BLUEFIN TUNA– **Campbell Davies**, Richard Hillary, Anne Preece, Marinella Basson, and Paige Eveson

10:30 Coffee Break

SESSION 7: Fishery & Program Overviews

(Moderator: Kim Holland)

11:00 THE PELAGIC FISHERIES RESEARCH PROGRAM-15 YEARS OF FISHERIES SCIENCE– **Kevin Weng** and John Sibert

11:20 OVERVIEW OF RESEARCH ON THE RECREATIONAL FISHERY FOR SOUTHERN BLUEFIN TUNA, IN TASMANIA– **Sean Tracey** and Jeremy Lyle

11:40 DYNAMICS OF TUNA PURSE SEINE FISHERY IN THE EPO: AN APPLICATION OF THE FISHSCAPE– **Jenny Sun** and D.G. Webster

12:00 Lunch

ABSTRACTS

(oral presentations and poster session, in alphabetical order by presenting author*)

EVALUATING POST-RELEASE SURVIVAL IN THE SOUTHERN CALIFORNIA RECREATIONAL THRESHER SHARK FISHERY

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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 components of the recreational fishery: (1) threshers hooked by the caudal fin (2) sharks with trailing gear left embedded in the caudal fin and (3) those captured by the mouth. Survivorship was determined for all three phases using pop-off satellite archival tags (PSATs) deployed on captured thresher sharks ranging in size from 125 to 221 cm FL. Tags were programmed to record fine-scale (30 sec) depth, temperature, and light level data over deployment schedules of 10-90 days. To date, observed post-release survival rates ranged from a high of 100% for mouth hooked individuals to a low of 28% for thresher sharks with trailing gear embedded in their caudal fin. Concurrent investigations on the effectiveness of degradable links and alternative fishing tackle and techniques were conducted to potentially enhance overall survivorship. Collectively, data on post-release mortality can be incorporated into future stock assessments for this species as well as in the development of best fishing practices for the catch-and-release fishery.

FORAGING ECOLOGY OF TUNAS IN THE EASTERN PACIFIC OCEAN

Helena Aryafar*, Owyn Snodgrass, Heidi Dewar

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Tunas in the California Current, including U.S., Canadian, and Mexican waters, support substantial commercial and recreational fisheries and are an important component of the local food web. To better understand the basic biology and ecology the Southwest Fisheries Science Center (SWFSC), Sportfishing Association of California (SAC), American Fisherman's Research Foundation (AFRF), and American Albacore Fisherman's Association (AAFA) are working together to collect biological samples. Utilizing the commercial passenger fishing vessels (CPFV) operating in the Southern California Bight (SCB), samples were collected from albacore (*Thunnus alalunga*), bluefin (*T. orientalis*), yellowfin (*T. albacares*) starting in 2007. In 2009 sample collections were expanded to include albacore caught commercially off Washington and Oregon (AFRF, AAFA). Samples collected include a range of tissues including stomachs, otoliths and gonads. The initial focus has been on stomach content analysis.

Stomach content analysis in the SCB is providing insight into the foraging ecology of tunas, including inter-annual and interspecific differences. Preliminary analysis shows that tuna forage almost exclusively on juvenile fish and squid; for fish consumed, the average standard length was 5.3 cm and for squid the average mantle length was 6.1 cm. Comparison across years show shifts in prey composition. In 2007 small teleosts comprised the dominant prey category by frequency of occurrence, %F (89%), followed by cephalopods (18%) and crustaceans (16%). In 2008 there was increase in prey diversity and a shift in prey composition with cephalopods [*Abraliopsis felis;* California market squid *(Loligo opalescens;* jumbo squid (*Dosidicus gigas*)] playing a more important role by %F (86%), followed by teleosts (84%) and crustaceans (56%). An increase in the %F of crustaceans (90%) was seen in 2009, with both teleosts and cephalopods at 82%. While teleosts were important in all years the species composition changed. In 2007, 80% of the stomachs contained northern anchovy (*Engraulis mordax*), whereas in 2008 anchovy were present in only 2% of stomachs, and in 2009 no anchovies were found. Juvenile sebastes, myctophids, jack mackerel (*Trachurus symmetricus*), and kelp pipefish (*Syngnathus californiensis*) made up the majority of teleost prey in both 2008 and 2009. The appearance of tuna and other HMS in the SCB during summer and fall likely coincides with the peak in abundance of a range of juvenile fish and squid species.

Albacore stomachs collected in 2010 were analyzed to explore foraging differences between WA/OR and the SCB. Comparing across regions, while some species were similar distinct differences in diet were apparent. *Engraulis mordax*, *Cololabis saira*, rockfishes, and Myctophids were found in stomachs from both areas. *Scomber japonicas* and *Trachurus symmetricus* were found only in the SCB while *Merluccius productus* was only found in stomachs collected off WA/OR. Comparing across all taxa cephalopods were more important in WA/OR.

Comparison of foraging ecology across species, years, and regions provides insight into the dynamics of forage base in the California Current. For example the apparent lack of readily available northern anchovy in 2008 and 2009 may have been responsible for the apparent increase in species diversity in comparison to 2007. Over the same period the moderate La Niña in the spring of 2008 may have increased the availability of cephalopods as cooler temperatures favor their recruitment. Additional efforts to link changes in forage base to natural and anthropogenic environmental variability are ongoing. Changes in availability of the different tuna species across years complicated analysis of interspecific differences.

MAINTAINING LOW DOLPHIN MORTALITY IN THE EASTERN PACIFIC OCEAN TUNA PURSE-SEINE FISHERY

David A. Bratten*

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At the 22nd Meeting of the Parties of the Agreement on The International Dolphin Conservation Program, held in La Jolla, CA on October 30, 2009, requirements for trial sets for vessels with Dolphin Mortality Limits were adopted. A trial set is when a vessel departs port, prior to the actual fishing trip, for the purpose of setting the net in local waters to align the dolphin safety panel in order to facilitate the safe release of encircled dolphins during the backdown procedure. Since 1998, IATTC staff have participated in 246 trial sets aboard vessels of 11 countries.

THE EFFECTS OF SHARK CAGE-DIVING ON THE LOCALISED AND BROADSCALE MOVEMENTS OF WHITE SHARKS IN AUSTRALIAN WATERS

Barry Bruce* and Russell Bradford

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The attraction or provisioning of sharks for the purpose of tourism viewing is a lucrative and popular industry that remains controversial in terms of its possible risks to target species or its impacts on local ecosystems. Benefits may also accrue through educational and research opportunities as well as economic returns to local communities via increased tourist inflow and associated expenditure. The long-term impacts of such activities on the behaviour and movement patterns of sharks have typically been difficult to establish as most studies investigate contemporary behaviour concurrent with existing operations and thus have no comparative base from which to establish effects. We examined the spatial and temporal patterns of residency and behaviour of white sharks at the Neptune Islands in South Australia over a 10-year period (2001 – 2011) via shark cage dive operator logbook data and the telemetry of acoustic-tagged sharks using receiver arrays deployed in the island system and throughout southern Australian waters. The 10-year period spanned a significant change in shark-cage diving effort where operator activity increased from an average of 128 days per year prior to 2007, to 270 days per year thereafter. This also corresponded with a change from irregular-timed, multi-day trips with irregular berleying periods, to a more regimented, near-daily operation with berleying occurring over a more regular timed daily schedule. Comparisons between periods before and after 2007 revealed significant changes in shark behaviour and residency at the North Neptune Islands since chumming effort and its regularity increased. Logbook data indicated a significant increase in the number of sharks sighted per day after 2007. Acoustic data confirmed that sharks were temporary visitors to the Neptunes Islands and that individuals undertake broad-scale movements across their Australian range. However, sharks have significant increased their periods of residency and the time periods spent within the areas where shark cage diving operations occur since 2007. Concurrent with these changes was a shift in diel behaviour with the presence of sharks at cage dive sites aligning with the overall daily timing of chumming operations. This shift in diel behaviour also propagated through to days when no cage diving operations occurred, suggesting a conditioned or anticipatory response by sharks to cage-diving activities as a result of chumming/provisioning. Although all parameters examined suggest behavioural changes have occurred in white sharks at the North Neptune Islands, this study was not designed to determine whether these represent long-term costs to white sharks visiting the area or the ecosystem of the area. However, given that white sharks are a listed threatened and migratory species under various jurisdictions (including all Australian waters) a process to minimise the impacts of shark cage-dive operations on shark behaviour at the Neptune Islands is warranted and further research is required to understand the implications of the observed changes in behaviour. The challenge for managing agencies and the shark cage-dive industry in South Australia, will be to find a balance between reducing these impacts on shark behaviour and the ecosystem within which they reside, while maintaining a successful, economically viable and world-class shark cage diving experience that fulfils client expectations, continues to contribute significantly to the local economy and provides a platform for education and research on white sharks and their conservation into the future.

SMALL-SCALE FISHERY OF SAILFISH *ISTIOPHORUS PLATYPTERUS* (SHAW & NODDER, 1792) AT GULF OF TEHUANTEPEC: A CATCH-AT-SIZE MODEL APPROACH

Genoveva Cerdenares-Ladrón de Guevara[1]*; Enrique Morales-Bojórquez[2]; Samuel Ramos-Carrillo[1], and Gabriela González-Medina[1]

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In the Pacific Ocean is located the Gulf of Tehuantepec, Mexico. The gulf is an area of high abundance of *Istiophorus platypterus* and the species is incidentally caught by the artisanal fleet. The objective in this study was to determine the current exploitation rate of sailfish *Istiophorus platypterus* in the Gulf of Tehuantepec by the artisanal fleet in Puerto Angel, Oaxaca. The data were analyzed from 2000 to 2008; catch per unit effort (CPUE), eye fork length (EFL), weight and sex were recorded.To estimate the current exploitation status of sailfish were used catch-at-size analysis model known as CASA. The EFL varied from 55 to 240 cm and weights from 1.6 to 69.7 kg were recorded. The size structure was unimodal, and the mean size showed a negative tendency. The CPUE showed a seasonal tendency during summer, with CPUE mean of 2.5 individuals per trip. Outputs of the CASA model showed high size selectivity, size class of 174.5 cm EFL was the most abundant in catch, and its harvest rate was almost 50%. The organisms fully recruited to the fishery have reached the asymptotic length. The harvest rate for all size classes was below 35% and maximum error evaluated was 5.4% during 2007. Finally, we consider that the sailfish *Istiophorus platypterus* stock of Puerto Angel, Oaxaca has low risk of overfishing.

A SCIENTIFICALLY TESTED REBUILDING STRATEGY FOR SOUTHERN BLUEFIN TUNA

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Southern bluefin tuna are a highly migratory, long-lived temperate tuna found over most of the eastern southern hemisphere below around 30 degrees south. They are both highly prized in the world sashimi market and, after decades of fishing, heavily depleted with a current estimate of spawning stock biomass at between 3-7% of the unfished level. The international fishery is managed by the Commission for the Conservation of Southern bluefin tuna (CCSBT) and there is rich variety of data available, including catch composition, CPUE, aerial survey and mark-recapture data, all of which are statistically integrated within the current operating model. This operating model had been used in an assessment context in the past, but the discovery of significant and sustained levels of unreported catch over two decades has made the process of providing a "best assessment" untenable. The disclosure of these unreported catches stalled the implementation of the previously adopted management procedure (MP). Hence, the Commission requested the development of a new MP designed specifically to rebuild the stock to 20% of the unfished level with high probability by 2035. Over the last two years member scientists have designed and tested an extensive set of candidate procedures in an MSE process which includes the process and observation uncertainty in the operating model, the unreported catch scenarios, and a set of plausible robustness tests to select and recommend and MP to the Commission that is likely to meet the rebuilding targets for the stock and be robust to major uncetainties in the state, dynamics and observation of the system. Communication of the process to industry and stakeholders has been undertaken at both at the national level and under the auspices of the CCSBT in their Scientific Committee and various Working Groups. Here we present the most recent work in a long line of MSE work done for southern bluefin tuna and the specification and performance of the MP that was adopted by the CCSBT Commission at their 2011 meeting as the scientific basis of setting the global catches at levels that should lead to a managed rebuilding of the stock and the fishery.

NEW INSIGHTS INTO BASKING SHARK BIOLOGY IN THE EASTERN PACIFIC

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The eastern North Pacific basking shark population appears to have declined dramatically in the last 50 years. Where hundreds to thousands of individuals were observed off our coast, sighting even a few individuals is now rare. The apparent reduced abundance in the eastern North Pacific is likely linked to targeted fisheries off California in the first half of the 1900s and the Canadian eradication program to keep basking sharks out of salmon nets. Due to concern about the basking shark population, the basking shark was listed as a Species of Concern in the U.S in 2010. Unfortunately, efforts to understand trends have been hampered by the lack of data on movements and essential habitat. To begin to fill data gaps, both Stanford University and the Southwest Fisheries Science Center (SWFSC) initiated electronic tagging programs in 2010.

In 2010 and 2011, the SWFSC deployed 3 MK10-GPS tags on basking sharks off San Diego in May and June. Scientists at Stanford deployed a fourth tag (MK10) in Monterey Bay in August, 2011. The tag from shark 1 released prematurely after 53 days off Morro Bay. The tag from shark 2 released early after 8 days and floated to a beach where the tag was recovered. The tag from shark 3 remained on the shark for 8 months and popped up northeast of Hawaii. The final tag (shark 4), released after 6 months off the tip of the Baja Peninsula, Mexico.

Using both the light-based and GPS locations (only 4 GPS locations were obtained), tracks were estimated for sharks 1, 3 and 4 using Trackit software with a bathymetric correction. Both sharks tagged in San Diego in the spring (sharks 1 and 3) moved towards Point Conception after tagging and remained in the area around Point Conception, including Morro Bay and the Channel Islands, for 5-6 weeks. Shark 1 was near Morro Bay when the tag came off in late July. Shark 3 left this same area in mid August and moved west southwest, ultimately finding an area northeast of Hawaii at ~150°W where it remained for three months until the tag popped off in February. Shark 4, remained in coastal waters off Central California from August until November. In November it proceeded south, offshore, making relatively directed movements until it reached the area around the tip of Baja where it remained for ~2-weeks before the tag popped off in late January.

Electronic tagging data is providing important information on the movements and habitat use of basking sharks in the North Pacific. All sharks showed retention to coastal areas remaining for periods from days to weeks near and over the continental shelf. The areas around Point Conception and Monterey Bay are also historic hotspots, and appear to still be important habitat for basking sharks. In contrast, the consistent occurrence off San Diego during the spring of 2010-2012 appears to be a new phenomenon. The diversity of movements over the longer tracks, highlights the need for additional data. Movement halfway across the Pacific indicates the potential for a continuous population across the North Pacific as suggested for the Atlantic. The large-scale movement also highlights the need for international cooperation beyond the eastern Pacific in developing a recovery plan.

SOME PERSPECTIVES ON MARINE MAMMAL BYCATCH IN TUNA FISHERIES IN DEVELOPING ISLAND NATIONS

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Efforts to address the issue of marine mammal by-catch have been made in developed countries, but very little attention has been given to developing island nations, some of which are major tuna producers. For example Indonesia and the Philippines ranked third and fourth in tuna production in 2004, producing 341,948 and 278,000 tonnes respectively. Together, they produced 14.4% of all tuna harvested that year. In 2009, Indonesia ranked first and the Philippines, second. Sri Lanka, although not belonging to the top ten tuna producing countries, has a rapidly developing tuna fishery.

Indonesia's industrial tuna fleet as of 2005 comprised 2,013 longliners, 3,872 tuna pole- and- line vessels and 1,474 purse seiners (in combination with fish aggregating devices or FADs) that operate in the Pacific and Indian Oceans. Almost 80% of the catches are from the western central Pacific Ocean; the remaining 20% are from the Indian Ocean. An estimate of the Philippine tuna fleet in 2005 was 1,000 hand liners, 164 purse seiners, 100 ring nets ("baby" purse seiners) and 39 long liners. As in Indonesia, most purse seine operations involved the use of FADs. Major fishing grounds include the Sulu Sea, Celebes and South China Sea. Outside the Philippines, tuna fishermen are known to also fish in Indonesia, Papua New Guinea and the Solomon Islands. In Sri Lanka over 3,000 boats engage in tuna fishing, more than half of which are fishing offshore, with the bigger boats venturing in international waters. Gillnets and longlines comprise 95% of the fishing effort.

Marine mammal by-catch in tuna fishing gears in these island nations has not been given much attention. In Indonesia annual by-catch rate of close to 19,000 loggerhead and leatherback turtles and various species of sharks and non-tuna fish was reported by WWF for longlines operating in the Pacific part of the country in 2005. The Indian Ocean Tuna Commission (IOTC) documented by-catch of purse seines and longline vessels operating in the eastern Indian Ocean from 2001 to 2005 to include 30 species of fish, some species of sharks and crocodiles. There was no mention in either report of marine mammal by-catch, which almost certainly occurs. Indonesia is home to about 30 species of marine mammals. In the Philippines, marine mammal by-catch was documented for a small group of domestic purse seiners in the Sulu Sea, long-ranging purse seiners using high intensity lights and driftnets for skipjack tuna. In Sri Lanka driftnets were reported to catch turtles and marine mammals. An estimate of annual marine mammal by-catch in Sri Lanka (in all fishing gears) is between 12,000 to 45,000 animals.

The lack of information on marine mammal by-catch in tuna fisheries in developing island nations can be attributed to various factors: 1) lack of resources and expertise to conduct studies, 2) extensive coastlines of the archipelagos (especially true for the Philippines and Indonesia), 3) fear of repercussions to the fishing industry, 4) danger involved in collecting information (e.g. piracy in remote areas, and 5) lack of information on fishing effort. In addition, estimating by-catch by small-scale and artisanal tuna fisheries, which collectively may be of similar or greater scale as the documented industrial tuna fleets, poses a great problem.

SOUTHERN BLUEFIN TUNA AERIAL SURVEY

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A scientific line-transect aerial survey of southern bluefin tuna (SBT) is conducted annually by CSIRO in the Great Australian Bight (GAB). Data gathered in the survey are used to estimate the relative abundance of juvenile (2-4 year-old) SBT that migrate through the region each summer. The data are analysed using statistical methods to produce annual estimates of relative abundance and corresponding estimates of precision. The annual abundance indices are one of two data sources used in the management procedure adopted by the Commission for the Conservation of Southern Bluefin (CCSBT) at the 2012 Commission meeting. They are also used in the population dynamics models of the stock and in management strategy evaluation models.

REPRODUCTIVE BIOLOGY OF ALBACORE TUNA (*THUNNUS ALALUNGA*) IN THE SOUTH PACIFIC OCEAN

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A comprehensive study of albacore tuna *Thunnus alalunga* population biology has just been completed in the South Pacific Ocean. In total, 3824 albacore (43-133 cm FL) caught between Australia and the Pitcairn Islands were measured and sampled. By processing the biological material collected and analysing the data, we estimated several key size- and age-specific biological parameters for albacore, including reproductive and maturity parameters.

Despite the long history of exploitation for albacore and general knowledge of its life-history, there are few quantitative estimates of reproductive parameters for South Pacific albacore. Many of the estimates currently integrated into the regional stock assessment model are derived from studies of other albacore stocks or other tuna species. In the current study, we significantly improved our understanding of the reproductive dynamics of South Pacific albacore through the analysis of 3,497 gonads, including the histological evaluation of 1,197 ovaries from females ≥ 70 cm FL. We confirmed that spawning is synchronised between 10 and 25^{0}S during the austral summer. The sex ratio of albacore differs from the expected 1:1 with males dominating in the larger length classes. We found that albacore spawn during the early hours of the morning, that reproductively active females spawn every 1.3 days on average during the peak spawning months, and that the mean number of eggs released per spawning was 64.4 oocytes per gram of body weight. Although we were not able to sample females monthly in the region east of 175˚E, we found no evidence of large variations in the reproduction or spawning dynamics of females across the southwest Pacific Ocean. We found, however, that the proportion of females mature-at-length and -age varied significantly with latitude in the Australian region, and that this variation was due to different geographic distributions of mature and immature fish during the year. A method proposed to account for the latitudinal variation in maturity showed that the predicted age at 50% maturity was 4.5 years. Overall, the suite of life-history traits examined will significantly improve the quality of biological inputs to the 2012 stock assessment for albacore.

POST-RELEASE SURVIVAL AND HABITAT UTILIZATION OF JUVENILE SWORDFISH IN THE FLORIDA STRAITS

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The use of pop-up satellite archival tags (PSATs) eliminates many of the limitations associated with acoustic and conventional tags by using fishery-independent data collection and retrieval. Previous research techniques have provided information on longer-term movements, migrations, and behavior patterns, but there is still a need for additional tagging studies with "second generation" tags with depth and light data and increased memory that will further define the short-duration activity patterns and habitat utilization of juvenile swordfish in the western North Atlantic. PSATs have been successfully used on other large pelagic fishes, but have yet to be used on juvenile swordfish.

This project investigates two topics: a) the post-release survival rates of juvenile swordfish after being released from the recreational rod-and-reel fishery and commercial swordfish buoy gear fishery in the Florida Straits, and b) the habitat utilization of juvenile swordfish following release. High-resolution PSAT technology is being used to estimate the post-release survival of 20 individual juvenile swordfish captured with standard recreational or buoy fishing gear and techniques in the southeast Florida swordfish fishery. To date, 16 of the 20 tags have been deployed. Analysis of release mortality estimates is being done using the "Release Mortality" Program. A deterministic, periodic model is being developed to fit to the data and describe the fishes' habitat utilization. This model has four amplitude parameters, two each for the daily and lunar cycle, and a mean depth value. This model will aid in identifying any diurnal and lunar signals in the data as well as any patterns in the residual data. Data gathered by the PSATs will also be used to analyze behavioral interactions with the fishing gear, such as habitat utilization patterns, and compared with other descriptions of swordfish behavior.

This study is a collaborative effort with the local recreational and buoy swordfish fisheries, utilizing local fishermen to conduct the field work. Data from this study will help to identify habitats most used by juvenile swordfish and their movement patterns. The data from the tags will also provide experimentally-generated estimates of fishing mortality. Data from this study will also aid in determining better management practices in terms of the efficacy of mandatory release of undersized fish.

CATCH PREDICTION: VALIDATING A PURSE-SEINE CAPTAIN'S ABILITY TO PREDICT SPECIES COMPOSITION, SIZES, AND QUANTITIES OF TUNAS PRIOR TO SETTING AROUND DRIFTING FISH-AGGREGATING DEVICES

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The catch of small, undesirable sizes of tunas by purse seine vessels targeting aggregations associated with fish-aggregating devices (FADs) has generated worldwide concern for the fishing industry, regional fisheries management organizations, and non-governmental organizations. There has been considerable debate as to the best methods for reducing the catch of these undesirable sizes of tunas; however, there should be little argument that identifying their presence at a FAD prior to setting is paramount to avoiding their capture and potentially reducing fishing mortality. Scientists from the Inter-American Tropical Tuna Commission (IATTC) in collaboration with the International Seafood Sustainability Foundation conducted a 73-day research cruise on board the Ecuadorian-flagged purse-seine vessel *Yolanda L.* during 11 May to 23 July, 2011. One of the objectives of the cruise was to evaluate the captain's accuracy in the pre-set estimation of species composition, sizes, and quantities of tunas present at drifting FADs.

During the cruise, experimental procedures included the captain providing estimates of the quantities (in tons) by species and size classes for skipjack, bigeye, and yellowfin tunas immediately prior to setting around a drifting FAD. The captain's estimates were made utilizing a Furuno CSH-5L multi-beam SONAR, Furuno FCV-291 Echo-sounder, visual observations from several crewmembers in the crow's nest, and radio communications with a crewman in a light boat while adjacent to the FAD, with a Furuno FCV-620 echo-sounder. Size classes were aggregated by species in three categories, small (< 2.5 kg), medium (2.5 to 15 kg), and large (> 15 kg). In addition to reporting confidence levels about the estimates, weight ranges around the total estimates for each of the three species were provided. Estimates of the amounts of tunas that escaped capture were also reported by the captain. Tunas loaded from each set for which catch predictions were conducted were partitioned in wells to facilitate tracking through the entire unloading, sorting, and weighing process, upon return to port. IATTC personnel were present during the unloading of the vessel and the sorting process at the StarKist® GALAPESCA Facility in Manta, Ecuador. Weights by species and size classes provided by StarKist® were compiled to match the three size classes utilized in the pre-set estimates. The measured quantities were compared to the captain's estimates and evaluated as to his accuracy in catch prediction. A total of eight purse-seine sets on drifting FADs were evaluated and the results presented.

SKIPJACK REPRODUCTIVE CAPACITY IN RELATION TO ENERGY RESERVES: IS THERE AN INFLUENCE OF THE SCHOOL TYPE?

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The skipjack tuna (*Katsuwonus pelamis*) is an epipelagic species distributed throughout the world's tropical and subtropical oceans and characterized by a higher productivity when compared to other tuna species. It is the main target species of the tuna fishery worldwide. In the last decade, it represents nearly half of the purse-seine catch in the Indian Ocean, with 87% by Fish Aggregation Device (FAD) sets and 13% by free-swimming school (FSC) sets. The increasing use of these drifting man-made FADs during last decades may have modified tuna habitat and raised questions about their potential effects on their population dynamics, which may affect their health status (or condition) and their reproductive potential. Therefore, this work aims to first investigate the skipjack tuna bioenergetics in relation to its maturation, and then to evaluate the potential effect of its associative behaviour (FADs *vs*. FSCs) on this energy allocation strategy, as well as on the tuna body condition. A total of 1208 skipjacks were caught under FAD-associated and un-associated schools. The selected fish covered the different reproductive developmental phases, and a large size spectrum. Morphometrics and total fat content measurements by using the Distell Fish Fatmeter were conducted directly in the field. The reproductive status of the females (n=673) was determined by histological analysis. Tissue sample collection (gonads, liver and white muscle) was done on 103 females for biochemical analysis. Tissue lipid class composition (i.e., SE-WE, KET, TAG, ST, AMPL and PL) was determined with an Iatroscan MK-6s (Iatron lab, Tokyo, Japan) after being extracted by the modified Folch method.

Total lipid concentrations were 14.2±8.0 µg/mg, 17.4±10.6 µg/mg and 5.3±4.7 µg/mg in gonads, liver and muscle of skipjacks, respectively. SE-WE and TAG results in gonads were highly variable in relation with the gonad maturation stages; indeed, they contributed to 32.4% of total lipids in immature females, and to 60.2% in individuals being in spawning capable phase. While tuna white muscle is known to represent the main energy (or lipid) reserves, our results didn't highlight any relationship between total lipids or lipid class distribution in muscle and the gonad maturation stages.

MOVEMENTS OF MONCHONG AT A HEAVILY FISHED SEAMOUNT

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Annual commercial landings of monchong in Hawaii have increased by 2730% from 23,000-628,000 lbs between 1987-2009, leading managers to request biological studies. One of the two monchong species, *Eumegistus illustris*, appears strongly associated with bathymetric features and is primarily caught at Cross Seamount, a single heavily fished guyot 290 km south of Honolulu. It may have distinct populations around seamounts, leading to concerns about the sustainability of harvests. Fifteen adult *E. illustris* were tagged with acoustic transmitters at Cross in 2010 to assess their movement, residence times and population vulnerability. Ten receivers on the seamount plateau at 356-414m depth detected position and depth of the fish. Eleven fish were detected for 1-182 days with 1-54,293 detections. Three of the eleven fish showed vertical and horizontal movement for 55-177 days and detections at 1-8 stations/day (mean=4.66). One fish remained at Cross for the duration of the tag life, one stopped being detected after 64 days, potentially leaving the seamount and the third was likely killed after 29 days at liberty. Two fish showed a preference for the seamount summit, while fish-184 showed a preference for the south and north slopes. Fish-184 was able to move 2km between the detection areas of the south and north stations in as little as 53 minutes (mean speed 2.26 km/hr), but showed high preference, possibly based on current direction, between the two stations for periods as long as 38 days. Two fish exhibited strong nightly vertical migration behavior comparable to the local micronekton with mean depths of 170-247m at night, 253-283m at twilight and below 310.9m during daylight hours. Present results demonstrate long residence times as well as the potential for migrations away from the seamount.

CATCHING THE UNCATCHABLE FISHERS WITH RESPONDENT-DRIVEN SAMPLING: A NEW APPROACH FOR SURVEYING 'HARD-TO-REACH' COMPONENTS OF RECREATIONAL FISHERIES

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

However, obtaining representative catch and effort data is problematic for 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 far too expensive for obtaining representative data from small hard-to-reach components within recreational fisheries (e.g. the gamefish fishery) that probably account for the majority of the total recreational catch for some species such as billfish, tunas and sharks.

Researchers in epidemiology and social sciences, routinely survey rare, 'hidden' or hard-to-reach populations within the general community (e.g. HIV carriers, sex workers, illicit drug users) by penetration of social networks rather than by interception of individuals. This poster introduces the idea of using Respondent-Driven Sampling (RDS), a form of chain-referral (or 'snowball') sampling, as a cost-effective means of obtaining representative data from specialised recreational fisheries that lack a complete sampling frame.

HABITAT UTILISATION AND POST-RELEASE MORTALITY OF BILLFISH CAUGHT BY SPORT FISHING METHODS OFF NORTHERN AUSTRALIA

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Ten billfish (9 Indo-Pacific sailfish, *Istiophorous platypterus*; 1 black marlin, *Makaira indica*) were tagged with miniature pop-up archival transmitting tags (miniPAT) in February 2010 and February 2012 within the neritic regime in northern Australia. Fish were captured using heavy game fishing tackle, brought onboard for tagging, and then released. Fish were tracked for between 1 and 180 days, providing a total of 420 days of data. All ten tags successfully reported to the ARGOS satellite. Archived depth and temperature profiles from the tags suggest that all fish survived capture and subsequent release, but seven fish (or at least the attached tags) were consumed by predators within 1-13 days of release. Closer analysis of temperature profiles revealed that the stomach temperatures of the predators were generally higher than ambient water temperatures, suggesting that it was likely the fish (and tag) were consumed by sharks. Three tagged sailfish avoided predation and were at liberty for 54, 90 and 180 days, where they utilised surface waters at depths of 0-40m with maximum recorded depth of 60 m, and occupied water temperatures of 28-31°C. Movement of the three sailfish ranged between 5-1500 km suggesting seasonal residency within the Gulf of Carpentaria before moving throughout the Arafura Sea and beyond into Indonesian waters.

ARE FADS BAD? A REVIEW OF CURRENT KNOWLEDGE AND SUGGESTIONS FOR BETTER MANAGEMENT AND FUTURE RESEARCH

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The use of fish aggregating devices (FADs) by purse seine fisheries has come under increasing criticism for its potential deleterious impacts on tuna stocks, for high levels of bycatch and threat to the biodiversity of tropical pelagic ecosystems. Here we review the current state of scientific knowledge of this technique and the management strategies of RFMOs. Our intent is to encourage objective discussion and identify areas worthy of future research. We show that catching juvenile tuna around FADs does not necessarily result in overfishing of stocks, although more selective fishing would help. Levels of non-tuna bycatch are comparable to or less than in other commercial tuna fisheries and are primarily comprised of species that are not considered threatened. Accordingly, to minimize impacts on ecosystem balance, there is merit in considering that all species captured in purse seine fisheries (excluding turtles and some shark species) should be retained (an approach already practiced in some other fisheries). The take of sharks and turtles could be further reduced by introduction of additional mitigation measures but these would be useless without parallel efforts with other gears such as longlines. Finally, there is no unequivocal empirical evidence that FADs represent an 'ecological trap' that inherently disrupts tuna biology although further research should focus on this issue. We encourage RFMOs to expand and improve their existing FAD management plans. Under appropriate management regimes, FAD fishing could be an ecologically and economically sensible fishing method.

THE BEHAVIOR AND MOVEMENT OF SCALLOPED HAMMERHEAD SHARKS (*SPHYRNA LEWINI*) IN HAWAII AS REVEALED BY SATELLITE TELEMETRY TECHNOLOGY

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The seasonal habitat use and ecology of the globally endangered scalloped hammerhead shark, *Sphyrna lewini* in Kaneohe Bay, Oahu, Hawaii has been well studied. Yet their offshore migration patterns after leaving the area have remained a mystery. To elucidate their behavior and monitor their vertical and horizontal movements outside of Kaneohe Bay, we fitted seven adult (248 cm Total Length ± 11) male hammerhead sharks with either pop-up archival tags (PAT) (n = 4), or satellite-linked transmitters (smart position only tags SPOT) (n = 4), where one shark was double tagged with both a PAT and a SPOT, and acoustically coded transmitters. Results from the PATs show vertical range expansions exceeding depths of at least 1250 m, which are previously un-documented for this species. Vertical profiles showed very clear diel dive activity. Some of the tagged hammerheads also exhibited previously unrecorded thermal tolerances to at least 3°C, spending an average 34.7% of their time in temperature ranges from 3° - 6° C. Suggesting this species may have some physiological adaptations to life at such temperatures. Horizontal movement and range data from the SPOT and acoustic transmitters are indicative of local (main Hawaiian Islands) residence with seasonal returns into and out of Kaneohe Bay. These results reveal that *S. lewini* exploit an expanded niche in the offshore waters of Hawaii, with scales of movement suggesting they may be pursuing deep water prey.

GENETIC CONNECTIVITY OF PELAGIC THRESHER SHARK (*ALOPIAS PELAGICUS*) POPULATIONS ACROSS THE PACIFIC

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Though heavily exploited by artisanal fisheries throughout the Indo- and Tropical Eastern Pacific, relatively little is known about the movement patterns and stock structure of pelagic thresher sharks. Curiously, of the three thresher shark species, the pelagic thresher is the most limited in global distribution, occurring only in the Indian and Pacific Oceans. A previous genetic study using mitochondrial control region data, suggested strong genetic differentiation of pelagic thresher populations on either side of the Pacific but lacked samples from the central Pacific and had a low overall sample-size. We present an improved analysis using samples (n=229) collected from the western, central, and eastern Pacific regions and data from the mitochondrial COI gene. Our data strongly support the existence of two remarkably distinct genetic stocks of pelagic thresher shark in the Pacific and suggest that the central Pacific may be a region of overlap between these stocks. These initial results highlight the need to gather additional data on this species for future management needs.

THE EFFECT OF BIGEYE TUNA QUOTAS ON THE HAWAII-BASED LONGLINE FISHERY

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The Hawaii-based pelagic longline fishery primarily targets bigeye tuna (*Thunnus obesus*), which is also a species of major interest to the two Regional Fishery Management Organizations (RFMOs) in the Pacific Ocean that deal with tunas, the Western-central Pacific Fisheries Commission and the Inter-American Tropical Tuna Commission. Both tuna RFMOs have passed and implemented Conservation and Management Measures (CCM's) and Resolutions intended to ensure that bigeye tuna catches are sustainable. The Hawaii-based longline fishery is affected by both of the RFMO's conservation measures because the fleet fishes in regions managed by both RFMOs. Although most of the Hawaii longline fishing effort and bigeye tuna catches occur in the western and central Pacific Ocean, with a limit of 3,763 mt, the eastern Pacific Ocean, with a 500 mt limit, is also a source for large, high quality fish. Fishery scientists use federal logbook data and State of Hawaii Marine Dealer data to estimate bigeye tuna catches in real-time and model a date when the limit is likely to be reached. The limit, close proximity of bigeye tuna to the Hawaiian Islands, and high demand for fish at the end of the year, are significant factors that increase the importance for fishery scientists to issue an accurate estimate of current bigeye tuna catch and to carefully forecast the date when the limit will be reached. Longline fishers adjusted their fishing patterns and worked within the RFMO's rules to stay within the two quotas while attempting to fill the local demand for high quality bigeye tuna through the end of the year.

LIFE HISTORIES OF TUNAS AND THEIR RELATIVES: PREDICTING SPECIES RESPONSES TO FISHING AND OCEAN CHANGES

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There are far more exploited fish species than there are stock assessments. The key challenge is to develop methods for predicting responses of data-poor species to fishing and oceanographic changes for informing management of stock status. Scombrids, commonly known as tunas, Spanish mackerels, mackerels and bonitos, comprise 51 species distributed throughout the tropical and temperate oceans supporting very important commercial and recreational fisheries. A few species are relatively well-known, but the fisheries and conservation status of most scombrids is poorly understood. On way we can start addressing this information shortfall is to characterize their life history strategies. The responses of populations to fishing impacts and oceanographic changes are narrowly bounded by life history tradeoffs. Here, we first assemble a dataset of life history traits (maximum size L_{max}, growth K, longevity T_{max}, length and age at maturity L_m *and* T_m, fecundity, spawning duration and frequency) for all scombrid species, globally. Second, we undertake a comparative analysis of life histories to examine patterns in trait diversity using two different approaches. The first consists in identifying major axes of life history variation across species using multivariate techniques and place scombrid life history strategies within the existing trilateral periodic-opportunistic-equilibrium life history continuum model described by Winemiller and Rose. The second approach consists in examining the variation in three Beverton and Holt dimensionless ratios (L_m/L_{max}, T_m/T_{max} *and* $K*T_{max}$) to describe patterns in growth, maturation and longevity. We show scombrid species are intermediate strategists. They span a large area in the trait ordination space between the endpoint strategies of periodic and opportunistic species, indicating a high life history diversity. Most of the variation in their life history traits can be explained along two axes: one influenced by size-related traits and the other by time-related traits. The first axis is mostly influenced by maximum size, size of maturity and fecundity, separating large species, such as Atlantic bluefin tuna and yellowfin tuna, from small body size species, such as the Indian mackerel and Atlantic mackerel, The second axis is mostly influenced by longevity, age at maturity and growth rates, which separates long-lived species, such as bluefin tuna and Atlantic mackerel versus relatively short-lived and fast growing species, such as yellowfin tuna and Indian mackerel (irrespective of their size). In addition, the dimensionless life history ratios have revealed broad constrains where the species exhibit constant ratios of size and time dimensions across populations and species, however we highlight that these constrains are not narrow suggesting considerably plasticity to adjust their life history strategy to local environments. Scenarios based on simple life history driven models such as these could be used as the basis for the assessment and management of data-poor species.

EVALUATING THE POTENTIAL OF SWORDFISH BUOY GEAR AS AN ALTERNATIVE TO PELAGIC DRIFTNETS IN THE ARTISANAL FISHERIES OF MOROCCO AND TURKEY

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Driftnet fisheries throughout the Mediterranean Sea 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 so-called swordfish buoy gear developed in South Florida has shown consistently high catch rates when targeting swordfish 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 (western Mediterranean) 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 2012. Phase one occurred in February, with 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 two parts: the first in April and the other in June or July, with similar data collection protocols as the Turkish project.

MITIGATION AND DETERRENCE METHODS TO REDUCE MARINE MAMMAL INTERACTIONS IN LONGLINE FISHERIES FOR TUNA

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The expansion of pelagic longline tuna fisheries, along with increasing fisheries observer coverage, has resulted in an increased documentation of interactions with small cetacean marine mammals. In particular, western North Atlantic fisheries interact with short- and long-finned pilot whale and Rosso's dolphins, while the central North Pacific fisheries interact with false killer whales. Other species infrequently also interact with this gear type, including bottlenose and common dolphins. Small cetacean interactions include depredation of caught fishes, hooking events, and entanglements.

Although some seasonality and area effects occur with small cetacean interaction rates, such effects are generally weak, and time-area closure discussions for these fisheries have met with strong opposition within U.S. constituent-based take reduction teams. A variety of alternative mitigation methods have instead been examined, including restrictions on the lengths of pelagic longline sets, limited soak times, and changes to baits. Another strategy involves requiring vessels to move a selected distance away from the location of any interaction. More recently, investigations into so-called “weak hook” technology, which exploit the weight difference between the target tunas and the bycatch small cetaceans, have been underway in the central North Pacific and the western North Atlantic. All of these strategies will be discussed within the context of reducing small cetacean interactions with pelagic longline fisheries.

THE INFLUENCE OF FADS ON SKIPJACK TUNA IN THE EQUATORIAL PACIFIC OCEAN

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The distributions of FADs are estimated in the Equatorial Pacific Ocean and its effect on skipjack tuna is analyzed in this study. Fisheries using FADs have been developed and have been using by industrial tuna purse seiners. It originated from sets on logs or branches that naturally had been flowed out to sea from the tropical rivers. This was based on fishermen's observation that pelagic fish are aggregating around floating objects. Currently, more than half of the world tuna catch is made from schools associated with FADs as a result of the widespread increase in FAD use. Despite the profound increase in FAD fisheries, little is known how FADs effect on tuna movement. This is because the difficulties on studying spatial dynamics of FADs in the open ocean, in particular drifting FADs. In this study, we approached the difficulties applying a streamline computational tool using ocean current velocity fields from Ocean General Circulation Models. To analyze the effect of FADs on skipjack movement, the Advection-Diffusion Reaction Model (ADRM), which has been using to study on tuna movement, was modified as a function of FAD density. In the model, the density of FADs control the movement of tuna by two ways; inhibit the movement by reducing diffusivity and attract toward the density gradient of FADs. The model is applied to the SPC Pacific Tuna Tagging Project (PTTP) skipjack tagging data.

LEVELS OF ORGANIC CONTAMINANTS AND MERCURY IN FOUR SPECIES OF YOY LAMNID SHARKS

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Maternal transfer of contaminants is a process by which females have the ability to transfer accumulated contaminants to their offspring during reproduction. Since organic contaminants are biomagnified through the food web, the magnitude and composition of contaminants passed to developing young will largely be function of the mother's trophic level. Liver contaminant concentrations were measured in four species of young of the year (YOY) lamnid sharks caught in southern and central California to compare the degree of maternal contaminant transfer from females with varying diets. YOY white sharks (n=19) had the highest levels of organochlorine contaminants among all four groups (∑PCBs 14 ± 10 µg/g ww [wet weight], ∑DDTs 75 ± 87 µg/g ww), followed by mako sharks (n=4; ∑PCBs 7 ± 7 µg/g ww, ∑DDTs 13 ± 75 µg/g ww), thresher (n=1; ∑PCBs 2.8 µg/g ww, ∑DDTs 5.7 µg/g ww) and salmon sharks (n=17; ∑PCBs 0.6 ± 0.5 µg/g ww, ∑DDTs 0.7 ± 0.6 µg/g ww). YOY white sharks also had the highest level of total mercury in their muscle (∑Hg 1.4 ± 1.1 µg/g ww) compared to salmon sharks (∑Hg 0.3 ± 0.1 µg/g ww). YOY white sharks were also the only species to show contaminant signatures indicative of foraging from the Palos Verdes Superfund site. While foraging location of sharks may play a role, the amount of contaminants accumulated by these young sharks is probably highly influenced by their mothers. Therefore, adult lamnids such as white and mako sharks that feed on highly contaminated marine mammals are more likely to pass higher loads of contaminants to their offspring. The elevated contaminant levels of these young animals are of concern since it may pose a greater health risk for humans that consume these sharks.

COMPARATIVE PERFORMANCE OF GENERALIZED ADDITIVE MODELS AND BOOSTED REGRESSION TREES FOR STATISTICAL MODELING OF INCIDENTAL CATCH OF WAHOO (*ACANTHOCYBIUM SOLANDRI*) IN THE MEXICAN PURSE-SEINE FISHERY

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Wahoo (*Acanthocybium solandri*) is distributed in all tropical and subtropical oceans and caught incidentally by the tuna purse-seine fishery in the Eastern Pacific Ocean (EPO). Generalized additive models (GAM) and boosted regression trees (BRT) were used to analyze relationships between presence of wahoo in logbook data from the Mexican tuna purse-seine fishery with environment, geographic area and set type (unassociated, associated with dolphins or floating objects set). Model performance was evaluated using changes in deviance in the fitted models and the area under the receiver operating characteristic curve (ROC). Results indicate little difference between the performance of GAM and BRT models. Both methods were consistent with predictions of presence of wahoo with respect to the variables used. Set type was the single most important predictor of variation in presence of wahoo, with highest probability of incidental catch in sets made on floating objects. With respect to environmental factors, chlorophyll-a concentration (<2 mg m^{-3}), sea surface temperature (20-25 °C) and sea surface height (downward tilt) determined the highest probability of incidental catch of wahoo. The coast of Baja California Sur, Mexico and south of the equator were predicted to have a high probability of incidental catch of wahoo.

RELATIONSHIP BETWEEN THE PACIFIC DECADAL OSCILLATION AND SARDINE BIOMASS IN A CHANGING CLIMATE

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Pacific sardines (*Sardinops sagax*) fluctuate widely in abundance over interannual to multidecadal time scales. For Pacific sardines, there have been repeated attempts to link fluctuations in biomass to indices of climatic variability, such as the Pacific Decadal Oscillation (PDO). Correlations between the PDO with periods of 40-76 years, and sardine biomass with periods of 40-70 years, have been inferred using 90-year time series (e.g. 1920-2010). The inferred correlations cannot be tested because the long-period fluctuations are outside the observation window that can be analysed statistically, i.e. the period (40-76 years) is greater than half the length of the series (45 years). To date, there has been no attempt to test the relationship between low-frequency fluctuations of sardine biomass and the PDO using longer paleontological time series proxies for sardine biomass and the PDO. Here we use a 370-year record of paleontological proxies to show that fluctuations in sardine biomass off California are not related to the PDO, despite the appearance of correlation in the 90-year record from 1920 to the present day.

TROPHIC DYNAMICS OF THE SOUTHEAST FLORIDA, USA COASTAL PELAGIC FISH COMPLEX

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The waters off the southeast coast of Florida are home to a rare coastal pelagic ecosystem where multiple top and mid-level teleosts are present. These teleosts, particularly scombrids such as tunas and wahoo, are primarily targeted by recreational anglers. However, there is a shortage of available trophic and diet composition data concerning fishes of the coastal pelagic ecosystem.

The objective of this research project is to investigate and achieve a greater understanding of coastal pelagic fishes, with an emphasis on the higher order species that inhabit the mid-range coastal pelagic to true pelagic waters, and the ecological role they play within the community ecology of the pelagic ecosystem. The selected fish species includes king mackerel (*Scomberomorus cavalla*), blackfin tuna (*Thunnus atlanticus*), skipjack tuna (*Katsuwonus pelamis*), Atlantic bonito (*Sarda sarda*), little tunny (*Euthynnus alletteratus*), wahoo (*Acanthocybium solandri*), and dolphinfish (*Coryphaena hippurus).* These species were selected based on their position as upper trophic level predators in the marine ecosystem food web and their general habitat distribution in the coastal pelagic zone.

In the two year period between March 2010 and March 2012, approximately 400 fish from the seven species have been sampled. The samples were collected opportunistically from recreational tournament anglers in the south Florida region between West Palm Beach and Key West. The stomach, gonads, muscle tissue, and liver tissue were collected from each specimen, as well as length (standard, fork, and total) data. Specimen sex was determined by gonad examination. Stable isotope analysis was performed with the muscle tissue samples using carbon $\delta^{13}C$ for dietary assimilation comparison and nitrogen $\delta^{15}N$ for trophic position. Stomach content analysis was performed with the frequency of occurrence, percent composition by number, percent composition by weight, and IRI indices used for a quantitative description of the diet. The stomach content analysis results are compared with the stable isotope values to evaluate the trophic interactions and trophic position among the coastal pelagic community.

The preliminary analysis of stomach contents shows that the fishes of this complex feed on a diverse diet of fish, squid, and crustaceans. However, the $\delta^{13}C$ data suggest that blackfin tuna (-16.5 to 20.5) has a greater spatial diet range compared to little tunny (-16.5 to -17.5) and skipjack tuna (-17.0 to -18.0). The king mackerel $\delta^{13}C$ data suggest a similar spatial diet range to the blackfin tuna. The wahoo stomach content analysis a diet exclusively of squid, which is supported by the $\delta^{13}C$ and $\delta^{15}N$ data. An examination of the $\delta^{13}C$ and $\delta^{15}N$ data together illustrates differences in trophic position and prey assimilation among the species in the coastal pelagic complex. Additional sampling and data analysis to evaluate the trophic dynamics of the coastal pelagic complex is ongoing.

MARINE MAMMAL BYCATCH IN PURSE SEINE AND LONGLINE FISHERIES THE WCPO

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A summary of available information on whale shark and other large animals (cetaceans) that form associations with tuna schools in the tropical purse seine fishery in the Western and Central Pacific Fisheries Commission Convention Area is presented. Sets are classified as "whale" or "whale shark" by the purse seine operator and by fisheries observers if the tuna aggregation being set upon is considered to have been associated with these animals at the time that the aggregation was located. The classification is not dependent on whether or not the associated animals are ultimately encircled by the set. The whale-associated set type is primarily associations with baleen whales, but not the other toothed cetaceans, which are smaller and faster (e.g. dolphins and porpoises). Interactions with the smaller toothed cetaceans do occur in the purse seine fishery, although they do not appear to maintain persistent associations with tuna in the WCPFC Convention Area in the same way that they do with yellowfin tuna in the eastern Pacific Ocean.

Observer data suggest that the numbers of whale- and whale shark-associated sets are severely under-reported on logsheets. According to logsheet and observer data, the frequency of tuna schools associated with "whales" (i.e. whale-associated sets) is clearly higher than the frequency of whale shark-associated sets. One of the reasons for this situation may be that vessels tend to report the presence of either whales or whale sharks in association with tuna schools as "whale-associated" instead of differentiating between the two distinct animal-association categories. The information on interactions by set type suggests that the proportion of whale-shark associated sets should be higher than that reported by observers. More than two-thirds (72%) of the sets where whale sharks were encountered in the net were not recorded as a "whale shark-associated" set type. The main reason for this is that the whale shark may be not visible at the time of setting and so the set is recorded as another set type (e.g. "unassociated). The mortality rate of interactions with whale sharks is estimated (based on observer data) at 12%. Whale-associated set types were recorded widely throughout the fishery, although observed interactions have occurred mainly in the western Pacific. Baleen whales are more frequently sighted at the time of setting and are therefore more likely to be assigned to the correct set type. Observers report that whales often escape before the net is completely closed and larger whales are also known to punch holes through the net when closed. Observers reported interactions with thirteen different species of toothed cetacean, with false killer whales and several dolphin species the most frequently encountered. Interactions occurred across all of the common purse seine set types, but were more common in the associated set types (drifting and anchored FADs and logs). Mortality rates were generally high (66% of interactions), with some reports indicating that they were not detected in the net early enough for release to be effected and had drowned.
Purse seine sets on whale sharks are a combination of both targeted sets and inadvertent capture. Interactions with toothed whales appear to be mainly incidental. Most sets on baleen whales do appear to be targeting a specific interaction, even if temporary, between the whales and tuna. Any mitigation measure prohibiting the setting in the vicinity of whale sharks and marine mammals will need to consider that the animal may not be detected until the setting operation is at an advanced stage, particularly for whale sharks.

IMPROVING ASSESSMENT OF BYCATCH AMONG TUNA REGIONAL FISHERIES MANAGEMENT ORGANIZATIONS

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The tuna Regional Fisheries Management Organisations recognise that many of the issues encountered are shared among tuna fisheries and solutions best achieved through collaboration and information exchange. Most of this collaboration occurs informally through the secretariats of each RFMO and through countries being members of several RFMOs. More formally collaboration is facilitated through joint meetings of the RFMOs. These meetings seek to harmonize the activities of the five tuna RFMOs. The first of these meetings was held in 2007 in Kobe, Japan and the meetings have subsequently been referred to as the "Kobe process".

The second Kobe meeting included harmonisation of bycatch and the workshop held on bycatch established a joint technical working group to provide advice to the RFMOs on harmonisation of bycatch related activities of the RFMO ecosystem/bycatch working groups. The "terms of reference" for the group include:

1) Identify, compare and review the data fields and collection protocols of logbook and observer bycatch data and provide guidance for improving data collection efforts and, to the extent possible, the harmonization of data collection protocols.
2) Identify species of concern that, based on their susceptibility to fisheries and their conservation status, require immediate action across Tuna RFMOs.
3) Review and identify appropriate qualitative and quantitative species population status determination methods for bycatch species.
4) Review data analyses to identify all fishery and non-fishery (e.g. oceanographic and physical) factors contributing to bycatch, taking into account the confidentiality rules of each RFMO.
5) Review existing bycatch mitigation measures including those adopted by each Tuna RFMO and consider new mitigation research findings to assess the potential utility of such measures in areas covered by other Tuna RFMOs taking into consideration differences among such areas.
6) Review and compile information on bycatch research that has been already conducted or is currently underway to delineate future research priorities and areas for future collaboration.

The first 12 month work-plan for this group was approved at the third Kobe meeting in July 2011 with a focus on data harmonisation, information sharing and risk assessment for shark species. The harmonisation of data collection has included the identification of the minimum data standards and data fields that should be collected across all RFMOs with a view to allowing interoperability and the harmonized identification guides and release protocols. Members of the working group has so far prepared information on appropriate standards for purse-seine observer data and review of seabird guides for consideration by the working group before submission to the RFMOs. Information sharing is being addressed through broadening of the Bycatch Mitigation Information System for application to all RFMOs. A concept plan has been prepared and submitted to WCPFC for approval prior to wider dissemination. Working group members have commenced discussion on collaborative efforts to undertake ecological risk assessments for sharks with CCSBT. The working group is expected to report to the secretariats of all RFMO in mid 2012.

STRIPED MARLIN (*KAJIKIA AUDAX*) DIET VARIABILITY OFF CABO SAN LUCAS, BAJA CALIFORNIA SUR, MEXICO DURING EL NIÑO-LA NIÑA EVENTS

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The adjacent waters off Cabo San Lucas, Baja California Sur due the great abundance have been called the core area for striped marlin, which is caught by sportfishing virtually year-round, generating important economic resources for the tourism sector. Despite the importance of this species, few studies have focused of the analysis of its feeding habits and in particular analyzing the interannual variability between years when El Niño and La Niña events occurred. Striped marlin stomach contents (1261 samples) collected during 2007-2010 were analyzed to determine if there was variability in the prey. During this period and in agreement with the ONI (Oceanic Niño Index), both of this events were recorded; La Niña (August 2007-June 2008) and El Niño (May 2009-May 2010). Thirty percent of the stomachs were empty. The trophic spectrum of this predator included 89 different items. The diet was dominated mainly by cephalopods (*Dosidicus gigas* and *Argonauta* spp.) and fish (*Scomber japonicus*, *Sellar crumenopthalmus,* and *Sardinops caeruleus*). Despite having a wide food spectrum in agreement with the Levin index (Bi = 0.03), this predator could be considered as a specialist. Based on the value of the amplitude of diet (index of relative importance (IRI)), *Dosidicus gigas* was present in greater amounts in periods characterized by cold sea surface temperature anomalies (IRI = 37% in 2007, 27% in 2008), whereas *Sardinops caeruleus* (IRI=36%) and *Scomber japonicus* (IRI=14%) were present with high values during the warm sea surface temperature anomalies prevalent during 2009. The differences in diet among years indicate the availability and abundance of prey, or suggest a migratory pattern of the prey. The results indicate that striped marlin could be considered a biological sampler of its prey.

STABLE ISOTOPIC COMPOSITIONS OF MERCURY INDICATE DEPTH OF FORAGE IN NORTH PACIFIC PELAGIC PREDATORY FISHES AND THEIR PREY FROM HAWAII

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Distinguishing between mercury (Hg) sources in marine fish remains a substantial challenge due in part to the open boundaries across which Hg can be transported and to its complex and active biogeochemical cycle, including reductive-oxidative, biological and phase transformations. Identifying Hg sources in pelagic fishes is especially complicated by fish mobility, which can move throughout ocean basins and through large vertical gradients. Mercury enters at the base of food webs and is transferred and bioaccumulated to higher trophic level organisms via diet. Therefore, examining Hg in fishes can aid substantially in reconstructing marine food webs.

In the ocean Hg can exist in the reduced form as $Hg(0)_{aq}$, or in the oxidized Hg(II) and methylmercury (MeHg(II)) forms. Under low oxygen conditions microbial reactions can methylate Hg(II) to MeHg, and microbial and photochemical processes can degrade MeHg back to Hg(II) or $Hg(0)_{aq}$. In the Pacific Ocean these processes result in a vertical distribution with methylated mercury species typically below limits of detection in open ocean surface waters, with higher concentrations in sub-thermocline low-oxygen deeper intermediate waters. In agreement with these vertical profiles, Hg levels in commercially important predatory pelagic fishes and their micronekton prey increase with median depth of occurrence.

Isotope ratios of Hg can be used to address a wide variety of environmental problems. Mercury has seven stable isotopes, and the isotopic compositions of Hg display mass-dependent fractionation (MDF) during most biotic and abiotic chemical reactions. Additionally, Hg displays unusual large mass-independent fractionation (MIF), during photochemical radical pair reactions, where isotope fractionation is greater for the odd (^{199}Hg, ^{201}Hg) than the even (^{198}Hg, ^{202}Hg) isotopes. The combination of mass-dependent and mass-independent fractionation provides a powerful new probe into the reaction pathways and history of Hg in the environment and can also provide a fingerprint of sources of Hg.

We measured Hg stable isotope ratios in a group of Hawaiian pelagic fish for which Hg concentration and median depth of occurrence are known. We hypothesized that the amount of MIF ($\Delta^{199}Hg$) in Hg from fish tissue would decline with depth of occurrence because MeHg at shallower depths would undergo more photochemical demethylation prior to introduction into the marine food web. Results show a strong correlation (r^2=0.73) consistent with our hypothesis and confirms that $\Delta^{199}Hg$ values provide a measure of the depth of forage where Hg was acquired. $\Delta^{199}Hg$ and $\delta^{202}Hg$ values also imply either that MeHg production occurs throughout water column with shallow MeHg entering shallow organisms and deep MeHg entering deeper organisms or that Hg(II) is methylated primarily at depth in the oxygen minimum zone and that MeHg is advected upwards where it is degraded primarily in near surface waters by photochemical demethylation (up to 80% loss). The food web and biogeochemical implications of these results will be discussed.

ALGAL TOXINS AND APEX PREDATORS: DOMOIC ACID IN THE THRESHER SHARK, *ALOPIAS VULPINUS*, IN THE SOUTHERN CALIFORNIA BIGHT

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Thresher sharks (*Alopias vulpinus*) forage near-shore and feed on small schooling fish such as sardine and anchovy, making them prime targets for exposure to the algal toxin, domoic acid. Domoic acid was detected in stomach content and blood samples collected from thresher sharks during the National Marine Fisheries Service (NMFS) Juvenile Thresher Abundance Survey along the Southern California Coast during September 2011. Of the 14 samples collected from 12 individuals, 9 (64%) were positive for domoic acid. Stomach contents were positive in 6 of 8 samples (75%) with values ranging from 4.5-44.6 ng/g. Stomach contents of sharks positive for domoic acid included market squid, Pacific mackerel, and Pacific sardine – a well know vector for domoic acid. Blood samples were positive in 3 of 6 cases (50%) with values ranging from 0.9 – 47.9 ng/g. The value of 47.9 ng/g is one of the highest reported concentrations of domoic acid measured in blood from a field-collected fish or animal. Our findings confirm that thresher sharks are indeed exposed to domoic acid through their prey, and measurable levels of this toxin can eventually make its way into their blood stream.

GENETIC VARIABILITY IN WILD AND BROODSTOCK POPULATIONS OF CALIFORNIA YELLOWTAIL, *SERIOLA LALANDI*

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On the west coast of the United States, the California yellowtail, *Seriola lalandi*, is considered a great candidate for mariculture due to its high market demand and value. While most yellowtail production relies on capture of wild juveniles and fattening in offshore pens, successful spawning and rearing techniques for *S. lalandi* have been developed at the Hubbs-SeaWorld Research Institute (HSWRI) with the intent to translocate reared individuals to offshore pens to raise to market size. The impact of unintentional releases on wild populations has become an increasingly important issue. As such, most future aquaculture projects will likely require a genetic analysis component for the permitting process. This study aims to examine the genetic diversity of yellowtail in the California-Mexico region, and to examine the genetic variability of broodstock and hatchery populations at HSWRI (San Diego, CA) using nuclear microsatellites. Parentage will be determined for broodstock populations, and the current broodstock will also be compared to local wild populations to ensure that genetic diversity is similar between groups. By creating the framework for a genetic diversity monitoring program, substantial progress can be made towards establishing *S. lalandi* as a commercially viable aquaculture species on the west coast. Results of the genetic assessment of wild and broodstock populations will be presented.

GROWTH OF TWO OCEANIC SHARKS, BLUE SHARK (*PRIONACE GLAUCA*) AND SILKY SHARK (*CARCHARHINUS FALCIFORMIS*) ASSESSED BY BACK-CALCULATION FROM VERTEBRAE IN THE SOUTHWEST INDIAN OCEAN

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Total recorded shark captures worldwide is around 722 thousand tons per year in which 192 thousand tons are taken from the Indian Ocean (FAO, 2009) but these catch values are certainly underestimated since non-reporting and underreporting of shark catches are common. The blue shark, *Prionace glauca* and the silky shark, *Carcharhinus falciformis* are the main species among elasmobranch bycatch in respectively longline and purse seine Indian Ocean fisheries which targeted tuna and swordfish. Because of the paucity of the basic biological knowledge of *P. glauca* and *C. falciformis* in this area, population trend remains unknown for the blue shark and decreases for the silky shark (IOTC, 2010). There is a genuine need for increased research. The objective of this study is to determine the age structure and growth parameters of the population of these two species by using back calculation and NLME fitted to VGBF. Knowledge on life history traits is necessary for prediction of population responses to fishing and for the management and the conservation of any species.

Between 2009 and 2010, 190 blue sharks, *P. glauca* (36cm - 275cm fork length, FL) and 208 silky sharks, *C. falciformis* (51cm - 264cm fork length, FL) were collected in the southwest Indian Ocean. Vertebrae of all these samples were aged and analyzed. Datasets generated from growth back-calculations are longitudinal and autocorrelated, and for both species the isometric model fitted very well the data, and explained 97% (*C. falciformis*) and 98% (*P. glauca*) of the variance, demonstrating a strong linear L-R relationship for the two species. The NLME fit of the von Bertallanffy equation revealed that the blue and the silky sharks' species had a relatively slow growth, attaining an average asymptotic size of about 250cm FL at an age of over 15 years. Models indicated that none of the von Bertallanffy growth parameters significantly differed among males and females. For the blue shark, a significant effect of sex could be detected by the NLME, males grow faster than females as commonly occurs in sharks worldwide. There was no significant effect of sex on growth for the silky shark. Final models indicated individual growth parameters ranging from -1.94 to -0.07 years for t0, 0.086 to 0.215 year^{-1} for k, 201 to 343 cm FL for L_∞ in *P. glauca*, and from -3.69 to -1.56 years for t0, 0.056 to 0.082 year^{-1} for k, 291 to 357 cm FL for L_∞ in *C. falciformis* . For both species, final NLME models fitted relatively well back-calculated size-at-age data at the individual level.

Infinite fork length and size at birth of the blue sharks in the Indian Ocean is the smallest one compared to all Oceans. Differences in life history may be, either genetically determined, or due to environmental factors. Blue sharks from Indian Ocean seem older than blue sharks from Atlantic Ocean at the same maximum length. This difference may suggest that growth rate of blue shark is faster in Atlantic than in western Indian Ocean. Combined sex of silky sharks from Indian Ocean has a slow growth rate with smallest size at birth despite the largest infinite fork length in this study. Back calculated growth rate of silky sharks in the Pacific and Atlantic oceans argues that they have more fast-growing rate and become faster and more efficient swimmers than silky shark populations from Indian Ocean.

AGE AND GROWTH OF ALBACORE (*THUNNUS ALALUNGA*) IN THE EASTERN NORTH PACIFIC

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North Pacific albacore (*Thunnus alalunga*) support the most lucrative fishery for highly migratory species on the U.S. West Coast and are currently assessed and managed as a single stock. The population structure of North Pacific albacore, however, may be more complex than the current single stock hypothesis given the apparent regional differences in growth rates and movement patterns in the eastern Pacific Ocean (EPO). While the data may support regional differences in life history characteristics, additional information is needed to effectively guide and manage this fishery. In this study, otolith-based techniques were used to analyze the age structure, growth rates and hatch dates of albacore in the EPO from two regions (northern: > 40 ^{o}N offshore Oregon and Washington; southern: < 40 ^{o}N offshore California) collected through recreational and commercial fishing vessels from July to October of 2010 and 2011. A total of 43 albacore was collected from the northern region ranging in size from 50.6 to 74.5 cm FL with corresponding daily ages ranging from 333 to 1105 days and mean daily growth rate of 0.0224 cm per day. From the southern region, 35 fish ranging from 71.0 to 79.5 cm FL had corresponding daily ages ranging from 669 to 1222 and mean daily growth rate of 0.0147 cm per day. Growth rates were significantly different between regions (analysis of covariance, ANCOVA, $P = 0.045$) with faster growth of albacore in the northern region. Back-calculated hatch dates suggest protracted spawning for fish from both regions ranging from January to July. Results from the first year of this two-year study period offer important life history information on albacore and will ultimately aid in managing this economically important species.

ENERGY CONTENTS OF JUVENILE PACIFIC BLUEFIN TUNA FOR THE BIOENERGETICS MODEL

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Pacific bluefin tuna *Thunnus orientalis* are one of the important predators of the Pacific Ocean. Their feeding has possibly impact for the marine environment, but the predation pressure of bluefin tuna has yet to be elucidated quantitatively. Bioenergetics models are widely used as a tool for estimating food consumption of animals. In order to adopt this model to bluefin tuna, it is necessary to parameterize their metabolism and energy contents based on the laboratory data and field study. In this study, the energy contents of juvenile bluefin tuna were estimated based of the analysis of biochemical composition of their muscle, and bioenergetics model was developed based on the recent studies of their respiration rate.

Juvenile bluefin tuna samples were collected between June and December in 2011 at the Japanese coast. For each sample, the muscle was mainly removed from the front half of fillet, homogenized, and used for the biochemical analysis. Water, lipid, protein, and carbohydrate contents were determined by the analysis, and energy contents were calculated by applying energy equivalents of 23.64, 17.15, and 39.54 kJ/g for protein, carbohydrate, and lipid, respectively. A bioenergetics model can be written as: C=(MR+REP+G)/AL, where C is consumption rate, MR is metabolic rate, REP is energy lost to reproduction, G is energy allocated to somatic tissue growth, and AL is assimilation losses. This study is focusing the juvenile stage, thus REP parameter was not used. AL was assumed 0.675 which was used commonly for the other tunas. MR was function of body size, temperature, and swimming speed. Sensitivity analysis was also conducted after the model development.

A total of 50 juveniles (237-587 mm FL) were analyzed for energy contents. Water contents were 63.7-76.0%, which was decrease in winter. In contrast, lipid contents increased in parallel. Reflecting these biochemical results, calculated values of energy contents were varied between 535 and 1023 kJ/g, and increased 1.6 times from September to December. Sensitivity analysis suggested that our bioenergetics model had lower robustness to the uncertainty of the parameters for the body size and temperature. Estimated values of energy requirement of bluefin tuna which is based on above results suggested the seasonal change of food consumption rate.

THE INFLUENCE OF CLIMATE-RELATED HYDRODYNAMICS ON ABUNDANCE AND DISTRIBUTION OF BLUEFIN TUNA LARVAE IN THE NORTHERN GULF OF MEXICO

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The objective of this study is to determine the link between worldwide climate-related meteorological and hydrological (hydrodynamics) regimes and distribution and abundance of bluefin tuna larvae in the northern Gulf of Mexico (GOM). Worldwide oceanic-atmospheric modes of variability are characterized by phases occurring on multidecadal (Atlantic Multidecadal Oscillation, AMO), decadal (North Atlantic Oscillation, NAO), and interannual (El Niño Southern Oscillation, ENSO) timescales. While AMO and ENSO phases are classified as warm (above average Sea Surface Temperature, SST) and cold (below average SST), NAO phases are classified as positive (above average Sea Level Pressure, SLP) and negative (below average SLP). Two opposite long-term hydrological regimes have been documented since plankton samples were first collected from the GOM in 1982 by NOAA Fisheries Southeast Area Monitoring and Assessment Program (SEAMAP). While the first regime (AMO cold/NAO positive phase: 1982-1994) was characterized by high atmospheric cyclonic activity creating wet conditions (high precipitation and river flow), the second regime (AMO warm/NAO negative phase: 1997-present) is characterized by low cyclonic activity producing dry conditions (low precipitation and river flow). Within the second long-term regime (AMO warm/NAO negative phase), annual fluctuations in cyclonic activities are clearly associated with ENSO along the northern GOM. Higher cyclonic activity associated with wetter conditions (high precipitation and river flow) was found during the ENSO warm phase than during the ENSO cold phase.

Because of clear associations between worldwide oceanic-atmospheric modes of variability and the hydrological and meteorological conditions along the northern GOM, the influence of ENSO phases within the AMO warm/NAO negative phase on the spatial and temporal abundance of eddies was analyzed using historical daily mesoscale altimetry data (Colorado Center for Astrodynamic Research) during April and May of years 1982-2010 when representative numbers of bluefin tuna larvae were collected in SEAMAP neuston samples. A higher number and broader distribution of eddies were found in the GOM during the ENSO warm phase than during the ENSO cold phase. Because of the well known association between oceanographic features and productivity, the influence of ENSO-related hydrodynamic regimes within the AMO warm/NAO negative phase on the spatial and temporal abundance of bluefin tuna larvae was examined. Higher numbers of bluefin tuna larvae per 10-minute neuston tow were found during the ENSO warm phase than during the ENSO cold phase.

Results of these studies provide an explanation for the physical association found between worldwide oceanic-atmospheric oscillations and northern GOM hydrodynamics and biological productivity. The time lags (months) among the components of this association constitute a great tool in the development of predictive models to explain the population dynamics of bluefin tuna larvae in the northern GOM.

FINE-SCALE BEHAVIOR OF BIGEYE, SKIPJACK, AND YELLOWFIN TUNAS WITHIN MIXED-SPECIES AGGREGATIONS ASSOCIATED WITH DRIFTING FISH-AGGREGATING DEVICES IN THE EQUATORIAL EASTERN PACIFIC OCEAN

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A 73-day research cruise was undertaken by scientists of the Inter-American Tropical Tuna Commission, during the period of 11 May to 23 July, 2011 to the equatorial eastern Pacific Ocean aboard the Ecuadorian-flag purse-seine vessel *Yolanda L.*, under a charter agreement between the vessel owner and the International Seafood Sustainability Foundation. The objectives of the cruise included attempting to reveal practical solutions for reducing the fishing mortality of undesirable sizes of bigeye and yellowfin, sharks, and other species of concern commonly captured during fishing operations by purse-seine vessels setting on mixed-species aggregations associated with drifting fish-aggregating devices (FADs). A focus of the scientific experiments conducted, and the overall research objective, was to elucidate whether the potential exists to modify purse-seine fishing methods to minimize the capture of such species, while optimizing the catches of skipjack tuna, associated with drifting FADs.

One of the research activities during the cruise was to elucidate fine-scale spatial and temporal differences in the behavior of bigeye, skipjack, and yellowfin tunas within mixed-species aggregations associated with drifting FADs. Ultrasonic telemetry experiments were undertaken at ten drifting FADs, with large mixed-species tuna aggregations present. Experimental methods included the capture and tagging with VEMCO V13P coded ultrasonic transmitters, of up to 3 each of bigeye, skipjack, and yellowfin tunas, and continuous ultrasonic transmitters, in up to 3 additional skipjack. VEMCO VR2 and VR28 acoustic receivers were utilized for the passive and active ultrasonic telemetry experiments. Each experiment was intended to be conducted for a minimum of 48 h.

Analyses of the ultrasonic telemetry data obtained from these experiments will be presented, along with evaluations and discussion of the simultaneous behavior of the three tuna species.

PELAGIC PREDATOR ASSOCIATIONS: TUNA AND DOLPHINS IN THE EASTERN TROPICAL PACIFIC OCEAN

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The association of yellowfin tuna and pantropical spotted dolphins in the eastern tropical Pacific Ocean (ETP) has been exploited by tuna fishermen and has intrigued scientists for decades, yet we still have questions about what the benefits of the association are, whether the association is obligatory or facultative, why the tuna are most often found with spotted dolphins, and why the species associate most strongly in the ETP. We review the hypotheses that have been proposed to explain the bond and present results from three studies conducted to address these hypotheses: a simultaneous tracking study of spotted dolphins and yellowfin tuna, a trophic interactions study comparing their prey and daily foraging patterns, and a spatial study of oceanographic features correlated with the tuna-dolphin association. These studies demonstrate that the association is neither permanent nor obligatory and that the benefits of the association are not based on feeding advantages. These studies do support the hypothesis that one or both species reduce the risk of predation by forming large, mixed-species groups. The association is most prevalent where the habitat of the tuna is compressed to the warm, shallow, surface waters of the mixed layer by the oxygen minimum zone, a thick layer of oxygen-poor waters underlying the mixed layer. The association has been observed in other oceans with similar oceanographic conditions, but it is most prevalent and consistent in the ETP where the oxygen minimum zone is the most hypoxic and extensive in the world.

TESTING DEEP-SET BUOY GEAR FOR SWORDFISH IN THE SOUTHERN CALIFORNIA BIGHT

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Within the U.S. West Coast exclusive economic zone (EEZ) off of California, swordfish are primarily landed using drift gillnet (DGN) gear as well as traditional harpoon techniques. West coast swordfish landings have dwindled to a historic low despite the latest assessments which suggest a healthy stock. DGN interactions with bycatch species of concern (e.g., marine mammals, sea turtles) have spurred numerous restrictions that have directly affected fisher participation primarily through time and areas closures [including a roughly 200,000 sq. mile Pacific Leatherback Closure Area (PLCA)] and mandated gear modifications. The DGN fleet is now at a historic low and is seasonally restricted to operate within the Southern California Bight (SBC), a relatively small portion of the CA coastline spanning Point Conception to the Mexican border. Similarly, the California harpoon fleet has declined in participation over the past two decades, most likely due to gear inefficiency, rising fuel costs and foreign imports. Given the concerns over bycatch in the DGN fishery, the present study used movement data from swordfish and bycatch species to develop and test a low-impact gear type that targets swordfish at depth (275 to 450 m) during the day. Initial tests revealed that swordfish can be successfully caught using deep-set buoy gear with minimal interactions with bycatch species of concern. Gear configuration, test trials and results to date will be discussed.

STABLE ISOTOPE ANALYSIS CHALLENGES WASP-WAIST FOOD WEB ASSUMPTIONS IN AN UPWELLING PELAGIC ECOSYSTEM

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Eastern boundary currents (EBCs) are typically nutrient-rich upwelling systems. They are often described as 'wasp-waist' ecosystems in which one or few mid-level forage species support a high diversity of larger, higher trophic level (HTL) predators with planktivorous forage fish playing the crucial link between upwelled nutrients and HTL predators. Ecosystems that exhibit wasp-waist dynamics have been shown to be highly susceptible to fluctuations in the biomass of mid-level prey. Although upwelling ecosystems are often assumed to be under wasp-waist control, this has not been vigorously tested. Stable isotope analysis was used (SIA) to test the hypothesis that a few forage species dominate the diets of HTL predators in the southern portion of the California Current large marine ecosystem (CCLME), one of five global EBCs. We analyzed plankton, prey, and predator tissue for $\delta^{13}C$ and $\delta^{15}N$ and used Bayesian mixing models to characterize foraging across trophic levels. Our results show high omnivory in the CCLME, planktivory by some large predators, and a high degree of trophic complexity including foraging on multiple trophic levels. This is the first study to make quantitative estimates of overall trophic dynamics in a pelagic ecosystem using mixing models of SIA. Results suggest that wasp-waist models may oversimplify trophic dynamics of the CCLME and possibly other EBCs**.** A consequence of the high-trophic complexity may be an increased resilience to fluctuations in populations at mid-trophic levels resulting from either human impact or environmental variability. This complexity would help to provide a predictable forage base for the large numbers of highly migratory species that migrate annually to the CCLME to forage.

SCRATCHING THE SURFACE: CAN WATER COLUMN CHARACTERISTICS EXPLAIN ALBACORE MOVEMENTS?

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In the Northeastern Pacific, juvenile albacore have been shown to make seasonal migrations to several offshore focal areas, including the Shared Offshore Foraging Area (SOFA). Five distinct migration patterns have been described, each with consistent migratory pathways, destinations, and seasonality: Baja – fish migrate seasonally along the Baja peninsula summering off southern California and wintering off southern Baja; South-Offshore-South – fish summer off southern California and migrate offshore to the SOFA over the winter; North-Offshore-North – fish summer off the Pacific Northwest and migrate to the central North Pacific over the winter; North-Offshore-South – fish tagged in summer off the Pacific Northwest migrate to the central North Pacific, but return to southern California waters the following summer; and Transpacific – fish tagged during summer off the Pacific Northwest migrate across the Pacific during the winter arriving off Japan in late spring. However, little is understood about the advantages of the migration paths, the reason behind migration, or the factors leading to the seasonality of the movements. Surface features such as sea surface temperature and chlorophyll demonstrate the diversity of the habitats that albacore encounter rather than elucidate the allure of migration pathways and benefits of focal areas. Albacore are known to associate with subsurface features, such as the thermocline, and their spawning grounds are characterized not only by sea surface temperature but also by the depth of the mixed layer. The objective of this study is to answer the question: Do water column characteristics, specifically turbidity and thermal profile, play a role in shaping albacore migration paths and diving patterns?

In this study, profiles from 16-tagged albacore were utilized to characterize the light attenuation, thermocline depth and stratification for both migration pathways and focal areas. The albacore were tagged between 2001 and 2006 in two regions of the Northeast Pacific: (i) off Northern Baja California, and (ii) off Washington and Oregon. Times at liberty ranged from 63 to 697 days. Diving behavior (specifically maximum diving depth, vertical speed and percent time spent in relation to the thermocline) was examined within the context of the temperature, light level, and stratification of the thermocline. Preliminary results show that all albacore dove deeper when the light attenuation coefficient decreased, and spent a greater percentage of time with slower diving speeds within the thermocline as light levels increased. In all cases, albacore spent less time in the thermocline while migrating than while residing, and diving speeds around the thermocline were faster while migrating than while residing. The results suggest that characteristics of the water column may influence the vertical and horizontal movement patterns of juvenile albacore. Further examinations that help identify feeding, spawning and transiting behaviors as well and factors associated with the distribution of albacore prey may help identify underlying mechanisms and motivations.

SHARK FISHERIES IN NORTHWESTERN MEXICO

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Mexico is among the 10th most important shark producer countries in the world. Between 2006 and 2010, Mexican total catches showed an increase tendency from 23,204 t to 29,775 t, with an average of 26,000 t during the period. Eighty three percent (24,727 t) of the 2010 national catches were produce in Mexico's Pacific coast, where the most important producing states were Sinaloa (5,596 t), Baja California Sur (5,159 t), Baja California (3,926 t) and Sonora (1,483 t), that are located in northwestern (NW) Mexico, and associated with the Gulf of California and the Baja California Peninsula. The 16,163 t produced by these four states represented 54% of the national production. Shark fishing in NW Mexico is based on several species, which are completed utilized as sources of low price protein.

The west coast of the Baja California Peninsula (WCBC) is influenced by the California current producing a temperate and semi-temperate habitat, while the Gulf of California (GC) has more complex oceanographic processes, and is characterized with a high fish endemism, including semi-tropical and tropical species. Because of these conditions, the fish fauna composition at these two regions has been described to belong to the San Diegan and Cortez biogeographic provinces. The principal shark species caught at the San Diegan province portion of WCBC (north Bahía Magdalena) are: Blue shark, Mako shark, Common Thresher, Tope shark, Salmon shark, and Pacific angelshark. South of Bahía Magdalena, where the Cortez province starts, other species of shark are also important, like the Pelagic Thresher shark, Scalloped Hammerhead, and Smooth Hammerhead. In the Gulf of California Silky shark, Blacktip shark, Brown Smooth-hound, Pacific Sharpnose shark, Pelagic Thresher, Bigeye Thresher, Scalloped Hammerhead, Smooth Hammerhead, Pacific Angelshark are important species. Nevertheless, in recent years the Blue shark has become an important species, mainly caught at the mouth of the gulf. Bull shark was an important species in the past, however, today is a difficult species to see in the landings.

In Mexico three types of fisheries that target sharks are recognized, depending on the size of the fishing vessels. 1) The small size vessel fishery is carried out on <10.5 m long vessels, with a capacity of 1.5-2 t, fishing with either a longline with 300 to 500 hooks or bottom gillnets with a mesh size = or > than 6 inches and up to 750 m long. 2) Middle size vessel fishery, which operates with vessels made of metal, wood or fiberglass, 10 to 27 m long, and a capacity of 14 to 75 t using longlines with up to 1000 hooks. 3) Ad the former large size vessel fishery (>27 m long), that was allowed to fish with longline with up to 1,500 that stop operating in 2009. In the presentation the general trend of the catches, the species composition, and further explanation of the fisheries structure and legal framework will be presented.

AGE VALIDATION OF BLUE SHARKS IN THE NORTHEAST PACIFIC OCEAN

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Accurate age and growth models are some of the most important biological parameters needed for stock assessment and fishery management. The blue shark (*Prionace glauca*) is subjected to the highest level of fishery bycatch in the world and supports the highest numbers of any species caught in the California/Oregon drift gillnet fishery where almost all are discarded at sea due to a lack of market value. Despite their numerical importance, the stock status of blue shark is uncertain and consequently a Pacific-wide assessment is planned for late 2012 by the International Scientific Committee (ISC) on Tuna and Tuna-like Species Shark Working Group. As such, the purpose of this study is to validate vertebral band counts of blue sharks in the Pacific. Oxytetracycline (OTC) labeled vertebrae of 44 blue sharks have been obtained from tag-recapture activities to determine timing of centrum growth band deposition. Tagging occurred off southern California from 2007 to 2009, with time at liberty ranging from 22 to 701 days (mean = 223 days). Further, a total of 10 returned vertebrae were at large for over one year to validate annual band periodicity. For vertebrae samples used for age validation, shark size at release ranged from 73 to 250 cm fork length (FL) (mean = 100 cm FL) with similar sex ratios of 48 and 52 % females and males, respectively. We plan to present results of the band deposition in addition to evaluating several methodologies to examine blue shark vertebrae including light microscopy, x-ray imaging, and histological techniques.

ECOSYSTEM-BASED PRECAUTIONARY ADAPTIVE MANAGEMENT

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Over the past century, anthropogenic influences have produced a range of impacts on finfish, marine mammal, marine turtle, and seabird populations of the Eastern Pacific Ocean. Some species, such as swordfish (*Xiphias gladius*) and albacore tuna (*Thunnus alalunga*) have experienced population declines from unfished biomass to present-day spawning stock biomass levels that support sustainable yields. Others, such as leatherback (*Dermochelys coriacea*) or loggerhead (*Carretta carretta*) sea turtles, have declined to severely depleted levels that led to listings under the Endangered Species Act.

The decline of some highly migratory marine vertebrate stocks to levels which warrant conservation concerns poses the following management challenge for commercial fisheries: How can regulation support sustainable fishing, while maintaining compliance with applicable conservation laws, such as the Reauthorized Magnuson-Stevens Fishery Conservation and Management Act (RMSA), the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA)? The challenge increases if fishing is proposed to occur in an area or season that lacks sufficient recent fishery-dependent data to gauge commercial fishing risks to various marine animal populations before the proposed effort begins.

Ecosystem-based precautionary adaptive management may offer a solution. Direct effects on ecologically significant species facing conservation concerns are taken into consideration, including market and bycatch species with a history of commercial fishery catch or interactions. Indirect effects are considered for non-target or bycatch species likely to face secondary impacts due to changes in fishing mortality.

The precautionary approach prioritizes regulatory measures which ensure compliance with RMSA, ESA, MMPA and other applicable conservation laws. In order to comply with legal requirements, managers determine biologically-based limits on fishery-induced mortality rates. Observer records are statistically analyzed to determine hard caps which serve as limit reference points to support mortality rate levels at or below Potential Biological Removal (PBR, as defined under the MMPA) for vulnerable marine mammal species or PBR-type levels for other species of conservation concern.

Precautionary adaptive management begins with stringent regulation to monitor and control protected species bycatch and features a mechanism to tighten regulation, if new fisheries-dependent data suggest a worse conservation problem than initially anticipated, or to relax regulation, if new data demonstrate benign conservation impacts. The management regime is incentive compatible with low-bycatch fishing, as future fishing opportunity implicitly depends on present utilization of best bycatch reduction practice. Potential application of the approach is explored for a proposed regulatory change to the Pacific Leatherback Conservation Area closure in the California drift gillnet fishery.

DYNAMICS OF TUNA PURSE-SEINER FISHERY IN THE EPO: AN APPLICATION OF THE FISHSCAPE

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In this study, we investigate economic and regulatory determinants of the spatial-temporal distribution of the fishing activity targeting tunas in the eastern Pacific Ocean (EPO). Specifically, we construct and parameterize a statistical model to explain monthly changes in the location and magnitude of fishing effort as measured by the number of sets deployed by three gear types (FOB=Floating Object, including fish aggregating devices, DEL=Dolphin Set and NOA=Non-associated free school) of the international purse-seine fleet targeting tropical tunas in the EPO. Monthly landings of skipjack, yellowfin and bigeye tuna landed by FOB, DEL and NOA sets were compiled based on the IATTC Public Domain dataset from Jan 1960 to Mar 2008. We also try to collect international market prices for cannery tuna and fuel, available fishing/vessel technologies, fisher strategies, and regulations. Using pooled time-series of cross-sectional data, we analyze the impact of these factors on the magnitude and distribution of purse seine effort targeting tropical tunas in the EPO.

This research is foundational for a larger project, Fishscape, which will generate a geo-spatial model of the fishery for tropical tunas in the EPO. To test our concepts and modeling, we apply Fishscape to the tuna fisheries of the EPO to identify the oceanographic, ecological, economic, and regulatory conditions. The study is sponsored by NSF/CNH and is developing means to understand and perhaps predict relationships and outcomes in complex coupled human and natural systems. Tuna fisheries provide examples of such systems. Complexity in these EPO fisheries arises from variation in environment, tuna populations, fisher behavior, capital and production markets, and from governmental policies. Fishscape may lead to a more complete understanding of the observed dynamics of resilience in the EPO fishery.

U.S. CONSUMER DEMAND FOR CANNED TUNA WITH SCANNER DATA: EVALUATION OF MARKET BASED INCENTIVES FOR FISHERIES REFORM

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This study estimates the US retail-level consumer demand elasticity of the canned tuna by using national level, syndicated, point-of purchase grocery store scanner data on a weekly basis for the period from 09/13/2008 through 09/03/2011 (156 weeks). The analysis helps determine the level of market-based incentives for environmental programs that may increase production costs and retail price of canned tuna. Based on the source and description of the canned tuna material, and the fishing practices indicated on the tuna can, products were classified by species (skipjack, albacore and yellowfin) as being either conventional or natural using their Universal Product Code. We found less than 0.2% of the total canned tuna sales in the Conventional Supermarkets Channel in the Nielsen scanner dataset to be identified as natural canned tuna, making it impossible to specify them as a substitute for the conventional tuna can. However, 14.81% of the canned tuna sales in the Natural Supermarkets Channel in the SPINS's scanner dataset are identified as a natural albacore tuna can, where consumers demonstrate a willingness to pay a $6.45/lb premium over the conventional albacore tuna can.

The SPINS's scanner dataset is used to specify a bundle consisting of conventional albacore, skipjack, and yellowfin tuna cans, and a natural albacore tuna can. As anticipated, the expenditure elasticity of conventional albacore, skipjack and yellowfin tuna cans are less than one (ηi = 0.85, 0.69, 0.97, respectively) and show that they are normal goods. However, the natural albacore can is estimated as a luxury good (ηi =1.88) for which demand increases more than proportionally as income rises. Except conventional albacore tuna (εii=0.72), all the other tuna cans demonstrated an elastic own-price elasticity (εii=3.11, 1.91, and 1.65, respectively); price increases would lead to a more than proportional decrease in quantity demanded and therefore a decrease in sales revenue. Natural tuna cans did not demonstrate less elastic own-price elasticities than conventional tuna cans.

Under current market conditions, these findings indicate that additional strategies beyond product labels, such as public awareness campaigns, may be necessary to drive more consumer willingness to pay a premium for natural tuna cans over conventional tuna cans. Importantly, this demand model could be coupled to the biomass model that would provide predictions on economic tradeoffs between catch methods. This could potentially build a business case for the reallocation of catch from purse seine with use of Fish Aggregating Devices (FAD) to FAD-free purse seine, pole and line, and longline catch methods, coinciding with consumer preference and/or market dynamics. Promoting FAD-free sustainable seafood sourcing policies that support environmental and economic best practices could result in a shift of surplus from the consumer to the producer that maintains industry profitability while increasing the quantitative existence value of biodiversity.

OVERVIEW OF RESEARCH ON THE RECREATIONAL FISHERY FOR SOUTHERN BLUEFIN TUNA, IN TASMANIA

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Following the major reduction of the southern bluefin tuna (SBT) stock due to overfishing by commercial fisheries, global efforts are underway to rebuild the population. Alongside the commercial sector, recreational fishing for SBT occurs across most southern Australian states. Currently there is no comprehensive harvest estimate for the recreational sector in Australia, nor an understanding of factors such as post-release survival. In this study we employ a suite of projects to address these knowledge gaps. By implementing an offsite telephone/diary survey targeting registered recreational boat owners in combination with an on-site creel survey at popular launching sites we are developing a picture of the recreational SBT fishery in Tasmania. The study will deliver, catch estimates, both harvest and release as well as characterising fishing practices and interactions of the fishery with marine wildlife. A second project utilises satellite tag technology and blood chemistry to assess post-release survival and stress of SBT from the recreational fishery. As a gamefish species, a catch and release ethic is associated with the fishery and in line with management strategies aimed to limit individual harvest (bag, possession or boat limits) there is also a legislative requirement to release fish. However, estimates of post-release survival (PRS) of SBT from the recreational sector are unknown. Ultimately these projects will provide a greater understanding of the direct and indirect sources of fishing mortality from the recreational SBT fishery in Tasmania, with the results having broader implications in regard to the management of the SBT fishery across Australia, the design of future research on the fishery, and promotion of fishery practices that maximise post-release survival.

GILL MORPHOLOGY OF THE OPAH, *LAMPRIS GUTTATUS*

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This study describes the gill structure and morphology of the opah, *Lampris guttatus*, in comparison to other pelagic fishes. Determination of gill surface area and associated dimensions allows for insights into opah metabolic requirements and the dissolved oxygen concentrations characteristic of its habitat. Opah gill morphometrics differ from those of more active pelagic teleosts by having a lower lamellar frequency (i.e., number of lamellae per length filament). However, opah show extensive fusion of the gill filaments, a characteristic previously documented only in high-performance teleosts (tunas of the genus *Thunnus*, the wahoo, *Acanthocybium solandri*, and billfishes). The occurrence of filament fusions in opah suggests a role other than that proposed for fast swimming fishes, which use gill fusions to maintain optimal gill orientation and slow and streamline branchial flow during ram ventilation.

THE PELAGIC FISHERIES RESEARCH PROGRAM - 15 YEARS OF FISHERIES SCIENCE

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At 65 million square miles, the Pacific Ocean is the largest single feature of planet Earth. It is six times as large as the Atlantic Ocean and covers one third of the Earth's surface. Fisheries for pelagic species in the Pacific land about 2.7 million metric tons of fish per year, valued at more than $2 billion. Since 1994, the Pelagic Fisheries Research Program (PFRP) has been funding new science to help improve management of fisheries in the Pacific Ocean. Based in Honolulu, Hawaii, the PFRP has distributed $27 million in competitive grants to scientists from around the world. This research has been crucial to understanding and managing fisheries for tunas, swordfish, and other large fish species that range far across the Pacific Ocean, crossing national boundaries and encountering fishhooks as they go. The PFRP also supports education of new fisheries scientists and encourages PFRP-funded scientists to get involved with agencies that regulate fisheries. Highlights of PFRP-funded research include stock structure of tunas, long term support for ecosystem modeling to support management (SEAPODYM), food web studies, geolocation algorithms, protected species bycatch mitigation, stock assessment models (MULTIFAN-CL, TUMAS), The ADMB Project, economic models for management decision support, and research into small scale and traditional fisheries. Under the present federal funding crisis, the PFRP is being considered for termination and requires the support of the community.

COLLABORATIVE RESEARCH ACTIVITIES CONDUCTED BY THE IATTC'S EARLY LIFE HISTORY GROUP DURING 2011

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Research activities associated with various collaborators were conducted by the IATTC's early life history group during 2011. These activities included three research projects: (1) a study, funded by the Saltonstall-Kennedy Program of NOAA, to investigate the feasibility of air shipping yellowfin eggs and larvae from the IATTC's Achotines Laboratory in Panama to Hubbs Sea World Research Institute (HSWRI) in San Diego, California; (2) experiments associated with a 5-year joint study at the Achotines Laboratory and Kinki University in Oshima, Japan to conduct comparative studies of the early life history of Pacific bluefin and yellowfin tuna; and (3) a collaborative experimental 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, to investigate the potential effects of ocean acidification on yellowfin early life stages. Other activities during the year included an 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. Preliminary results of some of the research conducted during the year will be presented.

ANALYZING ANIMAL TRACKING DATA USING DISCRETE CHOICE MODELS IMPLEMENTED IN A HIDDEN MARKOV FRAMEWORK – A NEW APPROACH FOR ANALYZING SATELLITE TAG DATA

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Although electronic tagging technologies have been around for some time, methodologies for analyzing the resulting data have lagged behind the technological development. Some types of data have been particularly difficult to handle due to uncertainty around position estimates and temporal gaps between observations. These difficulties have led to a number of ad hoc solutions for data analysis, including imputing positions between observations or smoothing distributions across locations and subsequently analyzing these statistical inferences as if they were data. The primary issue with these ad hoc approaches is they ignore the underlying uncertainty in the location estimates from which the patterns were produced.

We developed an alternative approach, which focuses on analyzing animal behavior only when observations are taken, and largely ignores the intervening period. When combined with explicit error models for location, this state space approach is able to overcome the limitations of positional uncertainty and large gaps between observations. The method was developed in order to analyze light and GPS tag data from broadbill swordfish, which suffer from both very high uncertainty in position estimates and long gaps between observations. In the analysis we compare the effects of spatial location, environmental characteristics, and memory in determine movement and site fidelity in swordfish. We found that contrary to conventional wisdom, swordfish show strong site fidelity, which may explain the pattern of serial depletion that has been observed in several contexts.

SPATIAL AND SEX-SPECIFIC VARIATION IN GROWTH OF ALBACORE TUNA (*THUNNUS ALALUNGA*) ACROSS THE SOUTH PACIFIC OCEAN

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Spatial variation in growth is a common feature of demersal fish populations which often exist as discrete adult sub-populations linked by a pelagic larval stage. However, it remains unclear whether variation in growth occurs at similar spatial scales for populations of highly migratory pelagic species, such as tuna. To examine this, we estimated the age of 1,969 albacore *Thunnus alalunga* sampled in the South Pacific Ocean based on counts of annual growth increments in otoliths. The periodicity of opaque growth increments was verified by a combination of direct and indirect methods, which indicated that increment formation occurred over the austral summer and was completed by autumn/winter. We then examined spatial variation in growth of albacore across the South Pacific from the east coast of Australia to the Pitcairn Islands. We use an information theoretic model selection procedure to determine the most appropriate growth model to fit to annual increment data from validated ageing techniques and to assess whether there are differences in growth between female and male albacore. We then fit growth models with longitudinal terms to estimate the level of longitudinal variation in length-at-age and growth parameters for both sexes. We found evidence for significant variation in length-at-age and growth parameters (L_∞ and k) between sexes and across longitudes. Growth trajectories were similar between sexes up until 4 years of age, after which the length-at-age for males was, on average, greater than that for females. Males reached an average maximum size more than 8 cm larger than females. Length-at-age and growth parameters were consistently greater at more easterly longitudes than at westerly longitudes for both females and males. Our results provide strong evidence that finer spatial structure exists within the South Pacific albacore stock and raises the question of whether the scale of their "highly migratory" nature should be re-assessed. Future stock assessment models for South Pacific albacore should consider sex-specific growth curves and spatial variation in growth within the stock.

INTERACTIONS BETWEEN MARINE MAMMALS AND FISHERIES FOR TUNA AND TUNA-LIKE SPECIES IN THE INDIAN OCEAN

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Marine mammal bycatch in fisheries for tuna and tuna-like species in the Indian Ocean is generally considered to be highly variable due largely to the use (or not) of driftnets/gillnets. In most instances, gillnets are associated with artisanal fisheries which play a significant role in fish production in the Indian Ocean. Catches of tuna and tuna-like species in the Indian Ocean are split almost equally between industrial and non-industrial (artisanal) fisheries. At present there is no mandatory requirement for artisanal fleets to record and report incidental catches or other forms of interactions with marine mammals. As such, the limited data held by the IOTC Secretariat are those which have been provided on a voluntary basis by Members of the Commission, usually collected through scientific observer programs which are for the most part, in the early stages of development. Industrial purse seine fisheries for tuna and tuna-like species are not considered to interact to any great extent with marine mammals in the Indian Ocean, due to the rare occurrence of associations between dolphins and tuna in this region. However, an issue which is receiving greater attention by researchers and managers in the Indian Ocean is that of depredation, in which marine mammals remove captured fish from nets or lines. Odontocete depredation and bycatch in longline fisheries is an extensive and widespread problem, affecting the economics of many longline fisheries, and potentially the status of depredating odontocete populations. Depredation has been reported to be very high in some areas of the Indian Ocean, as high as 19% in the Seychelles longline fishery, and reduces the value of catch and may lead to a greater risk of entanglement and the potential for retaliatory measures taken by fishers. To date, the IOTC have not adopted any mitigation measures.

WHAT IS KNOWN ABOUT MARINE MAMMAL BYCATCH IN TUNA FISHERIES AND THE ROLE OF RFMO'S TO MITIGATE AND DEVELOP BEST PRACTICES

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The bycatch of marine mammals in fisheries is a significant factor in long-term conservation and management of marine mammal stocks worldwide. It is estimated that tens to hundreds of thousands of these animals are killed each year through entanglement in fishing gear. Marine mammals interact with several gear types used in fisheries managed by tuna regional fisheries management organizations (RFMOs). They are most commonly caught in purse seine, longline, and gillnet gear. With the exception of the eastern Pacific Ocean, accurate abundance and bycatch estimates for marine mammals are lacking in areas where marine mammal distribution overlaps tuna fisheries, making quantitative analysis and mitigation of bycatch extremely difficult. Progress in quantifying tuna RFMO fishery impacts on marine mammal populations and related progress in mitigating or reducing the mortality has been slow, sporadic, and limited to a few specific fisheries or circumstances. With the exception of the Inter-American Tropical Tuna Commission, the remaining tuna RFMOs lack marine mammal population and bycatch data and, as a result, have not determined whether there is a need to adopt bycatch reduction measures for these species. In fact, much of what is known about marine mammal bycatch in fishing gear used by tuna fisheries has not been thoroughly reviewed and discussed by the RFMOs. Still, the data that exist within tuna RFMOs, their member nations, and other sources provide a suitable foundation for tuna RFMOs to begin discussions of how best to assess and address the conservation of those species of marine mammals that interact with high seas tuna fisheries. The combination of a lack of information in most tuna RFMOs and expertise to understand and reduce marine mammal interactions in purse seine and longline fisheries offer opportunities for tuna RFMOs to closely collaborate with one another and with some key inter-governmental organizations (IGOs) to design and implement data gathering programs. Working with these organizations, tuna RFMOs could also develop and adopt, if necessary, bycatch reduction measures; and monitor the effectiveness of and compliance with those measures.

EVALUATING EFFECTIVENESS OF HARVEST CONTROL RULES AND BIOLOGICAL REFERENCE POINTS FOR BIGEYE TUNA (*THUNNUS OBESUS*) AND YELLOWFIN TUNA (*THUNNUS ALBACARES*) FISHERIES IN THE INDIAN OCEAN

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Bigeye tuna (*Thunnus obesus*) and yellowfin tuna (*Thunnus albacares*) support two important fisheries in the Indian Ocean. The maximum sustainable yield-based biological reference points (BRP) are used as target BRPs for both bigeye and yellowfin tuna fisheries. However, the efficacy has never been evaluated. On the other hand, no explicit harvest control rule (HCR) had been developed and evaluated for the Indian tuna fisheries management. In this study, we evaluated four alternative HCRs for the tuna fisheries, which could adjust annual fishing mortality based on stock status. For each HCR, we further evaluate 1500 combinations of BRPs. Two age-structured operating models were developed to evaluate the performance of above HCRs and BRPs for long-term management periods. Monte Carlo simulation was used to evaluate the uncertainties quantified by observation errors, implementation errors and process errors. This project provides a systematic framework to identify suitable HCR with appropriate BRPs for Indian tuna fisheries based on a set of defined performance measures.

STOCK DISCRIMINATION OF WAHOO IN THE PACIFIC AND INDIAN OCEANS USING MORPHOMETRICS AND PARASITES

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The wahoo, Acanthocybium solandri, is large pelagic species distributed throughout tropical and sub-tropical waters worldwide. They are valuable to commercial purse seine and pelagic longline fisheries and are a prized catch in recreational fisheries. Global commercial catch has increased dramatically in recent years, and while recreational catch is largely unquantified, it may exceed that of commercial fisheries in some regions. Assessment and management in these fisheries is currently hindered by a lack of stock structure information, particularly the Pacific Ocean. This study investigated the stock structure of wahoo by examining their morphometric characters and parasite fauna from the western Pacific, eastern Pacific and eastern Indian Oceans. Multivariate analyses revealed that wahoo off eastern Australia are likely to consist of a single stock. Fish may move from the Coral Sea to more temperate waters in association with the seasonal expansion of the East-Australian Current. In contrast, wahoo were significantly different in both morphometrics and parasite fauna among other regions of the Pacific and eastern Indian Oceans. Wahoo appear similar to populations of other scombrid species, which exhibit stock boundaries in association with ocean currents and continental landmasses. This research indicates that wahoo may exist as multiple discrete stocks in the Pacific and Indian Oceans, which contradicts current genetic evidence that they exist as a single global population. To resolve these conflicts, additional complementary research is needed to provide comprehensive information suitable for fisheries management.

AGE, GROWTH, REPRODUCTIVE BIOLOGY AND ASSESSMENT OF WAHOO, *ACANTHOCYBIUM SOLANDRI*, OFF EASTERN AUSTRALIA

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The wahoo, Acanthocybium solandri, is a highly migratory fish species of importance to commercial and recreational fisheries worldwide. It is an important byproduct in purse seine and pelagic longline fisheries, where the global catch has increased dramatically over the past 20 years, including a ten-fold increase in Pacific Ocean. Catches from recreational and artisanal fisheries are poorly understood, but may be higher than the commercial catch in some regions. Despite their increasing importance to fisheries, little quantitative biological information exists for wahoo, particularly in the Pacific Ocean. This dearth of information currently hinders stock assessments and management. Therefore, this research aimed to quantify age, growth and reproductive dynamics and produce the first stock assessment for wahoo off eastern Australia. A total of 395 wahoo were collected from the extent of their range off eastern Australia. Sectioned sagittal otoliths were used to examine growth increments and histological examination of female and male gonads provided insight into their reproductive biology. Similar to wahoo in the Atlantic Ocean, wahoo off eastern Australia display a skewed female:male sex ratio of 3.2:1. Sexes also differed in their growth rates, with females generally growing faster and reaching a larger maximum size. Overall, wahoo display fast growth rates, reach sexual maturity early and have a maximum age of approximately 10 years. Both sexes have a protracted spawning season throughout the Austral summer (Oct-Feb) with peak activity in December and January. Females undergo asynchronous oocyte development and spawn approximately every four days during peak spawning season, resulting in an annual estimated fecundity of 10 to 100 million oocytes. A yield-per-recruit model suggested that the current fishing mortality of wahoo off eastern Australia appears sustainable. However, given the cosmopolitan distribution and potentially large stock boundaries of wahoo, and the variability in anthropogenic effects throughout these regions, stock assessment and management across multiple jurisdictional boundaries is likely to be required for the species.

LIPID CLASS COMPOSITION AND ENERGY ALLOCATION DURING REPRODUCTION OF YELLOWFIN TUNA IN THE WESTERN INDIAN OCEAN: COMPARISON BETWEEN FADS AND FREE-SWIMMING SCHOOLS

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One of the main challenges for marine science is to improve the understanding of factors affecting the relationship between adult population and recruitment (or productivity) as productivity is directly related to exploited population resilience. Since any natural or anthropogenic effect affecting this relationship may jeopardize the sustainability of the stocks, it is important to investigate the biological variables influencing productivity. In this sense, the increasing environmental release of drifting artificial floating objects (or fish aggregating devices, FADs) for tuna purse-seine fishery has been hypothesized to affect the tuna movements/migrations and leading them to low quality habitats, with potential detrimental effects on individual and/or population productivity. Therefore, the objective of this study was to investigate body condition and tissue lipid class dynamics of yellowfin tuna in relation to their reproduction cycle as well as to evaluate the potential effects of school types (FADs vs. free-swimming schools) on these parameters. Morphometrics, condition factor (Fulton's K) and total lipid content (Ditell Fish Fatmeter), as well as physiological indices (hepatosomatic, HSI, and gonadosomatic, GSI) were measured on 102 females during the sexual maturation in the Western Indian Ocean in 2009 and 2010. Biochemical analysis to determine lipid class composition in tuna muscle, liver and gonads was performed by using Iatroscan MK-6s (Iatron lab, Tokyo, Japon).

Preliminary results suggested that triacylglycerol (TAG), sterol- and wax-ester (SE/WE), phospholipids (PL) and ketones (KET) were related to the processes involved in yellowfin sexual maturation. Moreover, a positive relationship between WE-SE and TAG distribution in gonads with GSI was shown, highlighting the importance of those lipid classes in the allocation energy strategy during maturation for this tropical tuna species. In contrast, no significant contribution of white muscle as energy resource for reproduction was observed. Finally, the preliminary results did not show any significant influence of fish associative behavior (FADs vs. free-swimming schools) on either tissue lipid class composition or total lipid content (Fatmeter analysis), which could suggest that the reproductive capacity of yellowfin tuna was not influenced by school type.

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