Proceedings of the 59th Annual Tuna Conference

Lake Arrowhead, California
May 19-22, 2008

Heidi Dewar and John Hyde, Co-Chairs

NOAA Fisheries Service
Southwest Fisheries Science Center
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PREFACE

Welcome to the 59th Tuna Conference. The long-standing goal of the Tuna Conference has been to provide an informal forum for scientists, engineers, managers, fishermen and non-governmental organizations from around the world to exchange information and ideas including recent research findings on the biology of tuna and tuna-like species, the operation of associated fisheries, and the ecosystems that support them. The free and open exchange of ideas has been the key to the Conference's past success.

This year the theme of the conference is **"Challenges for HMS Management in the 21st Century."** Faced with an ever-growing demand for protein from the sea, climate change, and altered ecosystems, it becomes increasingly important to sustainably manage our fishery resources. This requires further advances in our understanding of the resources themselves and the role that international cooperation must play in the management and study of species that don't recognize international borders. Additional challenges are associated with ensuring that science is the cornerstone of policy decisions despite inevitable national and international conflicts with social, political, and economic factors. With continuing advances in technology (e.g. genetics, tags, and acoustic surveys) we have an increasingly rich set of tools available to aid in the study of pelagic organisms and their ecosystems. Many of these tools have already enriched our knowledge by aiding in the understanding of movement patterns, habitat utilization, spawning grounds, diet, and early life history. While there is still much to be learned, there is a desperate need to incorporate our current knowledge into both local and international management plans in a timely fashion.

The Conference is hosting a special session addressing the perceived needs and concerns of fishermen, management, and scientists as we look forward to the fisheries of tomorrow. We feel this session is timely given the move of international management bodies to consider fisheries in an ecosystem context. The session draws on representatives from NOAA Fisheries, IATTC, academia and the fishing community. We encourage all attendees to participate in the discussions. We are grateful to Christofer Boggs, Guillermo Compeán, John LaGrange, and John Sibert for agreeing to share their views on the challenges for HMS management in the 21st century.

Five student scholarships were awarded this year. The *Manuel Caboz Memorial Scholarship* was awarded to Ryan Schloesser for his research on the "Natal origin of Atlantic bluefin tuna (*Thunnus thynnus*) from the Gulf of St. Lawrence based on $\delta^{13}C$ and $\delta^{15}O$ in otoliths." Wildlife Computers, Inc. graciously sponsored a student scholarship this year, which was awarded to Tim Lam for his work "Using time series analysis techniques to analyze animal movement data from archival and pop-up archival tags." The three additional scholarships were awarded to Bridgett Ferriss for "Factors affecting the accumulation of mercury in four tuna species: Diet vs. Life History," Amber Michaud for "Population structure of shortfin mako (*Isurus oxyrinchus*) in the Pacific Ocean as inferred through mitochondrial DNA," and Tara Scott for "Adjusting economic productivity to account for undesirable harvest: Application to the CA/OR drift gillnet fishery." These students demonstrated impressive research goals and progress, and we wish them continued success in their graduate careers.

Hosting the Tuna Conference is an arcane and tradition bound process, and cannot be carried out without the assistance of a team of volunteers. The conveners extend a special thank you to Anne Allen, keeper of the flame and executive organizer of the 59th Tuna Conference. We also thank Bill Bayliff, Keith Bigelow, Suzy Kohin, Bob Olson, John Sibert, Jenny Suter, Bill Walsh, and Russ Vetter for moderating the scientific sessions. Bob Olson assisted on the student Scholarship Committee. Christine Patnode has done an excellent job maintaining the Tuna Conference web site. We thank Dan Fuller, Craig Heberer, Kim Holland, Russell Ito, and Kurt Schaefer for continuing the sashimi cutting tradition to help supply the Sushi Social/Poster Session. And we thank a whole team of IATTC and SWFSC staff members, too numerous to be named here, for general assistance with transporting supplies and people to this year's Conference.

We gratefully acknowledge generous donations to the Tuna Conference to help support student scholarships, the Welcome Gathering Party, Sushi Social/Poster Session and Tuna Barbecue. Donations this year were received from Lotek Wireless, Monterey Bay Aquarium, Prime Time Seafood, and Wildlife Computers, Inc.

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

In closing, we would like to thank you all for participating. Through all of your presentations, posters, and informal discussions around the poker table and jacuzzi, we hope you find the Conference fruitful and, most importantly, that you enjoy yourselves!

Heidi Dewar and John Hyde
59th Tuna Conference Co-chairs

AGENDA

Monday, 19 May 2008

13:00 Registration Opens in the Library

SESSION 1: Biology - Stable Isotopes (Moderator: Jenny Suter)

14:00 Welcome and Introduction

14:20 Food web inferences of stable isotope spatial patterns in copepods and yellowfin tuna in the pelagic Eastern Pacific Ocean
***Robert J. Olson**, Brittany S. Graham, Gladis A. López-Ibarra, Felipe Galván-Magaña, Cleridy E. Lennert-Cody, Brian N. Popp, Noemí Bocanegra-Castillo, Vanessa Alatorre-Ramírez, and Brian Fry*

14:40 Nursery origin of yellowfin tuna (*Thunnus albacares*) in the Hawaiian Islands
***R. J. David Wells**, Jay R. Rooker, and David G. Itano*

15:00 Natal origin of Atlantic bluefin tuna (*Thunnus thynnus*) from the Gulf of St. Lawrence based on $\delta^{13}C$ and $\delta^{18}O$ in otoliths
***Ryan W. Schloesser**, John Neilson, and Jay R. Rooker*

15:20 Contribution of western and eastern origin populations to U.S. bluefin tuna (*Thunnus thynnus*) fisheries: evidence from otolith stable isotope analysis
***David Secor**, Jay Rooker, Ryan Schloesser, and John Neilson*

15:40 Coffee Break

SESSION 2: Biology - Sharks (Moderator: Jenny Suter)

16:10 Interactions between fisheries and white sharks (*Carcharodon carcharias*) in the Southern California Bight
***Christopher G. Lowe**, Gwen D. Goodmanlowe, Mary E. Blasius, Erica T. Jarvis, Tom J. Mason and John B. O'Sullivan*

16:30 Population structure of shortfin mako (*Isurus oxyrinchus*) in the Pacific Ocean as inferred through mitochondrial DNA
***Amber Michaud**, John Hyde, Suzanne Kohin, Hugh Ellis, and Russ Vetter*

16:50 Occurrence of cookie cutter shark bites on pelagic fishes landed in the Hawaii longline fishery
Christopher G. Lowe*, Bradley M. Wetherbee, Yannis P. Papastamatiou, Gwen D. Goodmanlowe, Gerald Crow, and John. B. O'Sullivan*

17:10 Registration and Conference Center Check-in Continued

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

18:30 Dinner

Socializing in the Tavern

Tuesday, 20 May 2008

8:00 Breakfast

SESSION 3: Management (Moderator: Bill Bayliff)

9:00 IATTC shark species identification training - VIDEO
Marlon Roman

9:30 Stock Assessment Modeling 101: Transitioning from a backward- to a forward-estimation population model, using North Pacific albacore as a case study
Paul Crone

9:50 Shark catches in the Hawaii-based longline fishery as reported by fishery observers and in commercial logbooks
William A. Walsh *and Keith A. Bigelow*

10:10 Observer programs around the world: Why do we need them? How do existing programs collect data? Which model will work for your program?
Teresa Turk

10:30 Coffee Break

SESSION 4: Management (cont'd) (Moderator: John Sibert)

11:00 Measuring Taiwanese tuna longline fishing capacity in the Atlantic: Data envelopment analysis approaches
Yu-Min Yeh *and Wen-Da Lo*

11:20 Adjusting economic productivity to account for undesirable harvest: Application to the CA/OR drift gillnet fishery
Tara Scott

11:40 The best guess project: testing the accuracy of Hawaii recreational fishermen's estimates of fish weight
Nicole Bartlett

12:00 Lunch

SPECIAL SESSION: Challenges to Management in the 21st Century (Moderator: Russ Vetter)

13:30

An Industry View of International Fisheries Management
John LaGrange *– Fisherman and President, American Fishermen's Research Foundation*

Challenges to Developing International Consensus
Guillermo Compeán – *Director, Inter-American Tropical Tuna Commission*

Challenges to Tuna Fishery Management in the Twenty-First Century
John Sibert *– Manager, PFRP, University of Hawai'i at Manoa*

Data Collection and Stock Assessment for International Management
Christofer Boggs *– Fishery Biology and Stock Assessment Division Chief, NOAA Pacific Islands Fisheries Science Center*

15:10 Coffee Break

SESSION 5: Management (cont'd) (Moderator: Bill Walsh)

15:30 Why red list tunas and billfishes?
Bruce B. Collette *and Kent E. Carpenter*

15:50 Ecological risk assessment for Hawaii-based longline fisheries by productivity-susceptibility analysis
David S. Kirby, William A. Walsh, and ***Keith A. Bigelow***

16:10 Developments in experimental field trials on the use of modified fishing gear to reduce sea turtle bycatch in longline fishing gear
Yonat Swimmer *and Christofer Boggs*

16:30 Poster Session (See List of Posters) and 'Sushi Party' in the Tavern

18:30 Dinner

Socializing in the Tavern

Wednesday, 21 May 2008

8:00 Breakfast

SESSION 6: Biology – Habitat & Ecology (Moderator: Keith Bigelow)

9:00 Development of a pelagic fish habitat-based model from the Hawaii longline fishery data
Jeffrey J. Polovina and ***Melanie Abecassis***

9:20 A description of whale shark (*Rhincodon typus*) habitat in the northwestern North Pacific Ocean based on Japanese skipjack tuna fisheries data
Hidetada Kiyofuji*, Hirokazu Saito, Evan A. Howell, Hideki Nakano, and Jeffrey J. Polovina*

9:40 Simulated ecological effects of longlining and climate change on Eastern Australia's pelagic ecosystem
Shane P. Griffiths*, Jock Young, and Matt Lansdell*

10:00 Environmental effects on forage and longline fishery performance for albacore (*Thunnus alalunga*) in the American Samoa Exclusive Economic Zone
Réka Domokos

10:20 Coffee Break

SESSION 7: Biology – Tagging Studies (Moderator: Suzy Kohin)

10:50 Effects of deepwater petroleum platforms in the northern Gulf of México as fish aggregating devices for yellowfin tuna
Randy E. Edwards*, Michael Randall, and Kenneth J. Sulak*

11:10 Size dependent behavior of yellowfin tuna associated with anchored FADs
Kim Holland*, Laurent Dagorn, and David Itano*

11:30 Vertical movements and habitat utilization of bigeye tuna (*Thunnus obesus*) in the eastern Pacific Ocean, as determined from archival tag data
Daniel Fuller *and Kurt Schaefer*

12:00 Lunch

SESSION 8: Biology – Tagging Studies
(Moderator: Suzy Kohin)

13:30 Horizontal movements of yellowfin tuna (*Thunnus albacares*) in the eastern Pacific Ocean, ascertained from archival tags
***Kurt Schaefer**, Daniel Fuller, and Barbara Block*

13:50 Spatiotemporal variability in bigeye tuna (*Thunnus obesus*) dive behavior in the central North Pacific Ocean
***Evan A. Howell**, Donald R. Hawn, and Jeffrey J. Polovina*

14:10 Using time series analysis techniques to analyze animal movement data from archival and pop-up archival tags
***Chi H. Lam** and Vardis Tsontos*

14:30 Changing uses of tagging data in "management" of tuna fisheries the western and central Pacific Ocean
John Sibert

14:50 Coffee Break

SESSION 9: Biology
(Moderator: Bob Olson)

15:20 The intrinsic elasmobranch gill design potentially limits gas exchange and the aerobic performance of the shortfin mako, *Isurus oxyrinchus*, a lamnid shark
***Nicholas C. Wegner**, Chugey A. Sepulveda, and Jeffrey B. Graham*

15:40 Predatory interactions between mako shark, *Isurus oxyrinchus*, and jumbo squid, *Dosidicus gigas,* in the California Current
***Russ Vetter**, Suzanne Kohin, Antonella Preti, Sam McClatchie, and Heidi Dewar*

16:00 The influence of a Hawaiian seamount on a mesopelagic micronekton community
***Lisa De Forest** and Jeffrey Drazen*

16:20-18:20 Wildlife Computers Session: (or early end for the day)
Wildlife Computers, Inc. has been working on new algorithms that reduce archival data for transmission through Argos. They would like to discuss the algorithms, show examples, and solicit input from interested researchers.

18:30 Dinner – Tuna Barbeque

Socializing in the Tavern

Thursday, 22 May 2008

8:00 Breakfast

SESSION 10: Biology – Early Life History
(Moderator: Russ Vetter)

9:00 Early life history of sailfish, *Istiophorus platypterus*, in the northern Gulf of México
Jeffrey R. Simms *and Jay R. Rooker*

9:20 Preliminary investigation of age, growth, and spawning of albacore tuna in Australia's Eastern Tuna and Billfish Fishery
Jessica Farley

9:40 Effects of microturbulence and fish density on laboratory survival and growth of yellowfin larvae and juveniles
Maria Santiago*, Daniel Margulies, Jeanne Wexler, and Vernon Scholey*

10:00 Factors affecting the accumulation of mercury in four tuna species: Diet vs. life history
Bridget Ferriss *and Tim Essington*

10:20 Coffee Break

10:40 LOTEK Wireless Session: (or early end of the day)
Representatives from Lotek Wireless, Inc. will give an informative demonstration of how their latest products can be configured to meet the needs of an application.

11:40 Business Meeting

12:00 Lunch

13:00 End of Conference

Thanks for coming, hope to see you next year!

LIST OF POSTERS

Characterization of swordfish buoy gear catches in the Florida Straits
Shannon M. Bayse *and David W. Kerstetter*

Global phylogeography of dolphinfish (*Coryphaena hippurus*) reveals Indian origin of populations
Díaz-Jaimes, P.*, Durand, J.D., and Uribe-Alcocer, M.*

Population genetic structure of the Pacific mackerel (*Scomberomorus sierra*) from the Eastern Pacific
Domínguez L.M., Uribe A.M., and ***Díaz J.P.***

Are FADs ecological traps for tunas? Evidence from diet studies in the Eastern Pacific Ocean
Leanne M. Duffy *and Robert J. Olson*

Use of temperature-depth-recorders in the Hawaii-based longline fishery to characterize bigeye tuna (*Thunnus obesus*) fishing grounds
Donald Hawn*, Jeffrey Polovina, and Sean Martin*

Innovative bycatch reduction methods…why keeping U.S. fishermen fishing benefits living marine resources and the economy
Craig Heberer *and Heidi Hermsmeyer*

Age and growth of blue marlin (*Makaira nigricans*) caught around the southern tip of the Baja California peninsula, México
Ulianov Jakes-Cota, Rubén Rodríguez-Sánchez, ***Sofía Ortega-García****, and Michael L. Domeier*

Movements of Atlantic blue marlin in the Gulf of México
R. T. Kraus*, R. J. D. Wells, and J. R. Rooker*

Evidence of striped marlin (*Tetrapturus audax)* reproduction in Baja California Sur
Carmen Rodríguez-Jaramillo, ***Sofía Ortega García****, Michael Domeier, and Marcela S. Zúñiga Flores*

LIST OF POSTERS, CONTINUED

Studies of heat balance in free-swimming swordfish
Chugey A. Sepulveda, Scott A. Aalbers, *and Diego Bernal*

Combined shark tagging efforts of the California Department of Fish and Game, NMFS Southwest Fisheries Science Center, and cooperative anglers of southern California: 1968 – 2008
James Wraith*, Valerie Taylor, Darlene Ramon, Suzanne Kohin, Leeanne Laughlin, Rand Rasmussen, and Dave Holts*

Reproductive biology and spawning season of dolphinfish *Coryphaena hippurus* captured in Baja California Sur, México
Marcela S. Zúñiga-Flores*, Sofía Ortega-García, and Carmen Rodríguez-Jaramillo*

PAPER ABSTRACTS
(in alphabetical order)

THE BEST GUESS PROJECT: TESTING THE ACCURACY OF HAWAII RECREATIONAL FISHERMEN'S ESTIMATES OF FISH WEIGHT

Nicole Bartlett

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In the state of Hawaii, non-commercial fisheries data is currently collected through the Hawaii Marine Recreational Fishing Survey (HMRFS). The HMRFS samples catch through dockside interviews of fishermen when they return from a fishing trip. Review of the data from recent years suggested that it was difficult for interviewers to weigh or measure the length of larger yellowfin tuna (ahi) and other fish; weights have been obtained from only about 15 percent of the larger ahi landed. In some cases, the fish were simply too large to be weighed or measured by the surveyor's scale and measuring tape; in others, the fish were already in their ice slurry and fishermen did not want them handled. Measuring only the smaller ahi creates a bias in estimation of average weight of recreationally-landed ahi that is difficult to quantify.

One possible solution is obtaining weight estimates of larger ahi and other fish from the fishermen. A number of fishermen have indicated that Hawaii fishermen are very skilled in estimating weights fish they catch. To test this method of obtaining weight data, NOAA Fisheries teamed with organizers of a popular Hawaii recreational fishing tournament to conduct the Best Guess Project in June 2007. The Ahi Fever Tournament, hosted every Father's Day weekend by the Waianae Boat Fishing Club on the island of Oahu, is the largest small boat tournament in the state of Hawaii, with entries capped at 200 boats. In its 11^{th} year, the tournament draws both experienced and novice fishermen. Because all landed fish are weighed, the tournament provided an ideal setting for testing the accuracy of fishermen's estimates.

Over 50,000 lbs. of ahi were landed during the two-day tournament – a new record. Four NOAA volunteer surveyors collected 367 weight estimates of ahi and blue marlin from 226 fishermen. Over 50 percent of the estimates were within 10 lbs of the actual weight and over 80 percent were within 20 lbs. The most accurate estimates were within the 100-150 lb range. This paper describes the methods used, results of the analyses, and the planned future expansion of the project.

SOME DATA COLLECTION, STOCK ASSESSMENT AND BYCATCH MITIGATION ISSUES FOR INTERNATIONAL MANAGEMENT OF TUNA AND BILLFISH FISHERIES

Christofer H. Boggs

Pacific Islands Fisheries Science Center, NOAA Fisheries

Several important issues in international management of tunas and other highly migratory species concern data collection, stock assessment and bycatch mitigation. Some issues involve collection and submission of data to Regional Fisheries Organizations (RFOs). Membership in an RFO mandates submission of comprehensive statistics on fisheries participation (numbers of vessels and fishing effort), production (catches of fish in weight, and by size frequency), and performance (catch per unit of effort or CPUE) as a function of type of fishing, species, time, and area fished. However, adequate data are not submitted by all nations, or for all fisheries. Further, operational level data (e.g., from logbooks) indicating activities and results from individual operations are most comprehensively useful, yet these are generally withheld from RFO's as confidential. Instead, aggregated data are submitted so as to remove or shield identities of the economic entities producing the catch and data practices of multiple participants are merged into summary categories (i.e., latitude by longitude grid square totals).

Ancillary data on weight, size frequency, and species identities (IDs) of the landings are obtained by port sampling and from commercial landings statistics. Observer programs can provide more reliable details on operations, catch of non-target species, and discards than logbooks. RFOs may institute regional observer programs to collect such data. Port sampling programs, surveys, and commercial landings records may be the primary source of catch statistics for fisheries without logbooks, but often provide limited details on fishing type and effort needed to calculate CPUE. Systems to track commercial landings from fisheries and areas to distant markets and to track vessel locations at sea are becoming necessary to manage quotas, effort limitation schemes, and area restrictions.

Stock assessments seek to best interpret catch and CPUE in relation to many variables, to indicate the relative abundance of fish over time and in relation to the amount of fishing pressure applied (effort). Often there are issues in identifying and modeling effects of the environment and other factors to achieve a better measure of abundance. Abundance trends often seem affected by factors other than fishing pressure, most often interpreted as unexplained changes in recruitment of new fish into the stock.

Uncertainty regarding both abundance and effort trends creates difficulties for decision-makers, as does a lack of consensus regarding reference points. Reference points are generally agreed by RFOs as being the value of some measure of stock abundance in relation to the abundance that produces the maximum sustainable yield, or a similar value for fishing effort, but agreement on specific reference points is often lacking. A critical challenge has been to agree upon conservation measures to limit catch or effort, and reference point issues are often central to the debate. Uncertainty regarding whether or not a reference point is reached or approached requires some probabilistic consideration of risk, which often clouds consensus despite RFO conventions being specifically precautionary. To date some progress has been made, and some lost, in the struggle to limit the magnitude of fisheries for bigeye and yellowfin tuna.

Other management issues that are hotly contested involve bycatch and interactions with charismatic megafauna such as seabirds, sea turtles, and sharks. The RFO community in general is much less responsive on this topic than the U.S. The RFO's often hesitate to take concrete remedial actions based on principles, and demand evidence of demonstrable fisheries threats to such populations. Nevertheless, some important measures to reduce the frequency and/or severity of bycatch and protected species interactions have been successfully adopted in several fisheries.

WHY RED LIST TUNAS AND BILLFISHES?

Bruce B. Collette[1] and Kent E. Carpenter[2]

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[2] Department of Biological Sciences, Old Dominion University, Norfolk, VA, 23529 and Global Marine Species Assessment Coordinator, IUCN

The Red List Categories of the International Union for the Conservation of Nature have been widely used to provide an explicit, objective framework for the classification of a broad range of species according to their risk of extinction. This system has proved invaluable for the conservation of terrestrial and freshwater organisms but, until recently, it has not been widely used for marine organisms. There are nine clearly defined categories in the IUCN Red List system: extinct; extinct in the wild; critically endangered; endangered; vulnerable; near threatened; least concern; data deficient; and not evaluated. Several species such as the three species of bluefin tunas (*Thunnus thynnus, T. maccoyii*, *T. orientalis*), the Monterey Spanish mackerel (*Scomberomorus concolor*), and the white marlin (*Kajikia albida*), are under severe fishing pressure. Critical evaluation as to which category they belong may be helpful in persuading governments that some of these species need additional protection. A recent provisional Red List Assessment of the Mediterranean bluefin tuna categorized this population as vulnerable and a regional eastern Pacific assessment indicated that the Monterey Spanish mackerel is endangered based on its great reduction in geographic distribution. These listings are consistent with multi-national stock assessments and, therefore, indicate that Red List assessments will aid in making a case for conservation effort.

STOCK ASSESSMENT MODELING 101: TRANSITIONING FROM A BACKWARD- TO FORWARD-ESTIMATION POPULATION MODEL, USING NORTH PACIFIC ALBACORE AS A CASE STUDY

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North Pacific albacore (*Thunnus alalunga*) are a highly mobile species, generally distributed throughout the North Pacific Ocean (centered around 35° N latitude), and targeted by numerous fisheries for primarily commercial-, and to a lesser extent, recreational-related purposes. The status of this population is determined through efforts of an international forum (International Scientific Committee – Albacore Working Group, ISC-ALBWG), whereby fish stock assessments are developed jointly by researchers from multiple nations/institutions, including Canada, Chinese Taipei, Inter-American Tropical Tuna Commission, Japan, México, South Korea, and the United States. Since 2000, the ISC-ALBWG has relied on a classical, 'backward-computing' virtual population analysis (VPA) model (VPA-2BOX) for providing management advice concerning albacore in the North Pacific Ocean. Recently, an alternative, 'forward-computing' age-structured statistical model (Stock Synthesis 2, SS2) has been developed in parallel with the VPA model. In general, the SS2 model (and its underlying theory) allowed a more detailed evaluation of the sample data than possible using a generally-structured VPA, given its ability to estimate or fix subsets of relatively large numbers of parameters commonly incorporated in fish population assessments, e.g., stock-recruitment relationship, spatially-explicit fishery structure, and selectivity/catchability parameterization. Both estimation methods produced generally similar trends for management-based stock parameters of interest, including total stock abundance (in numbers and biomass), spawning stock biomass, and recruitment; however, differences in the two modeling approaches were observed for some model scenarios in terms of the scale (say magnitude) of the estimated time series. Finally, in this presentation, I will generally discuss model 'transition' issues related to: sample data, model theory and application, results from population analyses, diagnostics, and modeling plans for the future.

THE INFLUENCE OF A HAWAIIAN SEAMOUNT ON A MESOPELAGIC MICRONEKTON COMMUNITY

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Mesopelagic micronekton are important prey for many marine predators, several of which are commercially important species. Features which may act to change the abundance, biomass, diversity and/or taxonomic composition of the mesopelagic micronekton community could also influence the distribution of larger marine predators. Cross Seamount, located roughly 295 kilometers south of the island of Oahu, Hawaii, has been the site of known aggregations of juvenile bigeye (*Thunnus obesus*) and yellowfin tuna (*T. albacares*). Bigeye tuna in particular have been shown to feed heavily on mesopelagic micronekton over Cross Seamount. Using a large, modified Cobb trawl, samples were taken both directly over and away from the summit of Cross Seamount to sample the deep scattering layer during the day and the shallow scattering layer during the night. Trawls were conducted during two cruises in the spring of 2005 and 2007. All organisms collected were identified to the lowest taxonomic level possible resulting in a description of the local mesopelagic micronekton community over and around Cross Seamount.

Results from this study indicate that there is a significant decrease in total abundance of organisms and an absence of certain diel vertically migrating taxa directly over the summit as opposed to away. Reasons for the significant decrease in abundance could be due to increased predation directly over the summit or from active summit avoidance. The overall taxonomic composition of the community over the summit is dominated numerically by epipelagic juvenile fish and stomatopod larvae while away from the summit the community is dominated numerically by mesopelagic fish, with the epipelagic juvenile fish and stomatopod larvae contributing little to the overall taxonomic composition. The community over the summit also contains two species that appear to be found in higher abundance over the summit as opposed to away and may be considered as seamount associated species. These are a cranchiid squid, *Liocranchia reinhardti,* and a myctophid fish, *Benthosema fibulatum*. This seamount is known to impact the mesopelagic micronekton community and tuna community, but the mechanisms behind these impacts is largely unknown at this time. Currently there is little to no information on the currents above and around Cross Seamount or the structure and characteristics of the phytoplankton and zooplankton communities above Cross Seamount. Further studies at this seamount could aid in a better understanding of this unique ecosystem.

ENVIRONMENTAL EFFECTS ON FORAGE AND LONGLINE FISHERY PERFORMANCE FOR ALBACORE (*Thunnus alalunga*) IN THE AMERICAN SAMOA EXCLUSIVE ECONOMIC ZONE

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The South Equatorial Counter Current (SECC) strongly influences the American Samoa Exclusive Economic Zone (EEZ) and changes strength on a seasonal and ENSO cycle. Strong SECC is associated with a predominantly anticyclonic eddy field as well as increased micronekton biomass and catch-per-unit-effort (CPUE) for albacore tuna, the economically important target species of the local longline fishery. Strong SECC carries chlorophyll *a*-rich waters from upwelling regions at the north coast of New Guinea towards the EEZ; most likely resulting in the observed increase in micronekton biomass, forage for albacore. Relatively stable anticyclonic eddies show a further increase in micronekton biomass, apparently advected in from neighboring SECC waters. The presence of forage presumably concentrates albacore, thus resulting in the observed increase in CPUE. High shear regions of neither anticyclonic nor cyclonic eddies correlate with increased micronekton biomass. Areas characterized by South Equatorial Current (SEC) waters correspond to areas with the lowest micronekton biomass and the highest number of aggregative structures, which are most likely small pelagic fish shoals. Micronekton composition in SEC waters differs from that in the SECC. During El Niños, the seasonal signals at the north shore of New Guinea and in the SECC are exceptionally strong and correspond to higher albacore CPUE in the EEZ. Results suggest that the strength of upwelling and the resulting increase in chlorophyll *a* at New Guinea, as well as the Southern Oscillation Index, could be used to predict the performance of the local longline fishery for albacore tuna in the American Samoa EEZ.

EFFECTS OF DEEPWATER PETROLEUM PLATFORMS IN THE NORTHERN GULF OF MÉXICO AS FISH AGGREGATING DEVICES FOR YELLOWFIN TUNA

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We studied yellowfin tuna (YFT), *Thunnus albacares*, presence around and movements between deepwater (depth > 300 m) petroleum platforms (DPPs) in the northern Gulf of México. The primary purpose of the study was to evaluate the effects of the platforms as fish aggregating devices (FADs) for YFT. Six of 13 DPPs in the Mississippi Canyon area, offshore from the Mississippi delta, were instrumented with automatic ultrasonic receivers (Vemco VR2W). Three were closer to shore (25-41 km), close to at least two neighboring platforms (15-17 km), and close to numerous shallower platforms around which YFT are also frequently caught by anglers. Three instrumented DPPs were farther offshore (58-94 km) and more distant from nearest platforms (24–25 km). Seven DPPs in the area were not instrumented due to inability to obtain permission from two oil companies. We tagged 98 adult (68-135 cm CFL, mean = 110 cm CFL) YFT with internally-implanted, ultrasonic transmitters (Vemco V16) in summer of 2007. Nine of the 98 tags were depth indicating. Twelve adult YFT were previously tagged in July 2006 at one platform. Thirty-three YFT had been tagged in summer 2005 at one platform, but those tags' battery life would have been expired by 2007.

Eighty-five YFT (80 of 98 tagged in 2007, and five of 12 tagged in 2006) were detected on at least one day after the tagging date over a period from mid-May to late November 2007. Continuous residence time (CRT = number of days detected at a DPP without day-scale absences) ranged from 2 to 69 d. CRT at the offshore DPPs was significantly ($\alpha = 0.01$) greater (mean = 10.7 d) than at the nearshore DPPs (mean = 3.8 d). Residence time (from first detection to last, excluding five fish recaptured by anglers and five tagged a year earlier) ranged from 1 to 157 d (Mean = 43.4 d). Maximum and mean number of residence periods for individual fish were 13 and 2.7. Maximum and mean numbers of platforms visited by individual fish were 5 and 1.6.

Depth data from the nine tags exhibited a clear diurnal pattern, with fish near the surface frequently during the night, but mostly at depths around 30 to 100 m during the day. No extreme deep diving was recorded, with deepest dives (for individual fish) ranging from 124 to 228 m.

Five of 98 YFT tagged in 2007 were recaptured by anglers, after periods as short as 10 days after tagging. Two of 33 tagged in 2005 were recaptured by anglers over a year after tagging.

The latter recaptures, plus the detections of 5 fish tagged previously in 2006, suggest that YFT have a substantial degree of residency in, or inter-annual site fidelity to the area, with both long and short periods of residency at individual DPPs. Within the area, YFT move long distances between DPPs, including movement between inshore and offshore platforms. These findings suggest that it is possible, if not likely, that the installation of deepwater petroleum platforms in the northern Gulf of México, having inserted a large number of huge structures into a relatively bathymetrically featureless environment, has resulted in stronger FAD effects than those documented for other locations where YFT and FAD interactions have been studied.

PRELIMINARY INVESTIGATION OF AGE, GROWTH, AND SPAWNING OF ALBACORE TUNA IN AUSTRALIA'S EASTERN TUNA & BILLFISH FISHERY

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The catch of albacore by longliners in the Eastern Tuna and Billfish Fishery (ETBF) reached a record level of 2,583 tons in 2006. This was a significant increase from the preceding 5 years where 495-670 tons were caught annually, and made albacore an instant driver for management. To address the need for improved life-history parameters for the development of a harvest strategy, a 1-year project was initiated to begin to examine the age, growth and reproduction of albacore in the ETBF.

Age was estimated independently using both otoliths and fin spines for 100 albacore (48-106 cm FL). A direct comparison indicated very little bias in assumed ages 1-7 years, but otolith-based age estimates were generally higher than the spine-based estimates after age 7. Despite this, preliminary von Bertalanffy growth curves obtained from both structures were very similar, and both indicated that growth and L_∞ was greater in males than females. Substantially more (validated) direct age data are required to fully investigate sexual and regional differences in growth in South Pacific albacore.

Analysis of 145 gonads collected from the ETBF (15-20ºS) provided the first record of actively spawning albacore from the Coral Sea, and the high incidence of spawning fish during January/February suggests that this is an important spawning area/time. Histological analysis of ovaries confirmed that females are capable of spawning daily, although the average mature female spawned every 1.3 days (in Jan./Feb.). Mean relative batch fecundity estimated for 7 females was 65 oocytes per gram of body weight. We suggest that gonads collected from the temporal window of January to July will allow for a clear distinction between mature and immature females for size at 50% maturity estimation using the presence of atresia (alpha to delta) in histological sections to distinguish immature from post-spawning females.

A regional project is currently under development to build on this preliminary work, and will include tissue sampling for stable isotope and fatty acid work to examine the trophic ecology, biogeography and movement behaviour of albacore.

FACTORS AFFECTING THE ACCUMULATION OF MERCURY IN FOUR TUNA SPECIES: DIET VS. LIFE HISTORY

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Mercury concentrations in fish vary due to diet, life history parameters, and their environment. The influence of diet versus life history on the accumulation of Hg in tuna was examined by modeling the reactions of different species to different life history parameters and diet compositions. A mercury mass balance model allows for the manipulations of life history and diet parameters to determine the sensitivity of Hg bioaccumulation to these various parameters.

Four tuna species, yellowfin (*Thunnus albacares*), bigeye (*Thunnus obesus*), skipjack (*Katsuwonus pelamis*), and albacore (*Thunnus alalunga*) were compared, providing a range of life history and diet types. These species represent low (yellowfin) to high (albacore) standard metabolic rates, low (bigeye) to high (skipjack) fecundity, as well as ranges in size, depth, growth rate, and other life history parameters. They also differ in diet, proving to be good subjects for this modeling question. Bioenergetics and mercury mass balance models were created for each of the four selected species (yellowfin, bigeye, skipjack, and albacore). Manipulations of these models include: (1) feeding all species the same diet (with the same Hg) to determine how different life histories affect the accumulation of Hg; and (2) conducting a sensitivity analysis to determine which life history parameters are most influential in the control of Hg accumulation within these species. Results of this research will contribute to our understanding of the pathways that influence the mercury levels in these species of fish.

VERTICAL MOVEMENTS AND HABITAT UTILIZATION OF BIGEYE TUNA (*Thunnus obesus*) IN THE EASTERN PACIFIC OCEAN, AS DETERMINED FROM ARCHIVAL TAG DATA

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Preliminary results are presented on the vertical movements and habitat utilization of bigeye tuna tagged and released with archival (electronic data storage) tags in the equatorial eastern Pacific Ocean during 2000–2005. A total of 323 bigeye were tagged with archival tags and released, and 162 (50.2%) were recaptured and their tags returned. The results presented are based on data sets from 96 bigeye (54-126 cm length, mean = 90.1 cm) at liberty for 31.2 to 1,810.7 d (mean = 239.0) for a total of 18,867.8 days (51.7 years) of archival tag time series data.

Analyses presented include discrimination and classification of the proportions of days and frequency of events in which bigeye exhibited several unique behaviors, including association with floating objects and classical foraging in the deep-scattering layer, by size and quarterly time periods. The observed ontogenetic changes in those behaviors are analyzed. The occurrence and frequency of deep diving (>500 m) events are also presented. Vertical habitat utilization by size and quarterly time periods are presented, including a description of how ambient temperature and dissolved oxygen concentrations at depth appear to limit the foraging space and time of bigeye tuna.

SIMULATED ECOLOGICAL EFFECTS OF LONGLINING AND CLIMATE CHANGE ON EASTERN AUSTRALIA'S PELAGIC ECOSYSTEM

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Recent Australian fisheries legislation requires all Commonwealth and export fisheries to demonstrate ecologically sustainability. Australia's Eastern Tuna and Billfish Fishery (ETBF) is a large multi-species fishery targeting apex predators and, therefore, has the potential to disrupt functionality of the supporting ecosystem. A project was undertaken to describe the: 1) physical and biological oceanography of the ETBF; 2) trophic linkages using diets, stable isotopes and signature fatty acids; and 3) synthesizing these quantitative data in an ecosystem model to determine the ecological effects of longlining and climate change on the pelagic ecosystem. An Ecopath model was constructed and various perturbations (e.g. changes in fishing effort, altered targeting practices, and climate change) were forced upon the system in 2008 and the relative change in biomass of individual functional groups forecast to 2018. A 50% reduction in effort resulted in only 2-20% increases in the biomass of target species and their predators. Simulations involving doubling the fishing mortality on individual ETBF target species again resulted in <20% changes in the biomasses of any functional group. Simulated removal of sharks by illegal domestic and foreign finning practices resulted in large increases in the biomass of turtles and most target species, and small declines in wahoo, dolphinfish and striped marlin. Climate change scenarios involving a 20% decrease in micronekton fish biomass and a 50% increase in squid biomass both resulted in dramatic trophic cascades, highlighting their importance as key prey groups in the eastern Australian pelagic ecosystem. Our preliminary results indicate that there may ecological redundancy among high trophic level predators since they share a diverse suite of prey. Because they have relatively low biomasses the removal of biomass in a single group can be compensated by small changes in the biomass of several competing groups. However, when the biomass is altered in groups having high biomass and production rates that serve as both important prey and predators (e.g. 'keystone' species), more dramatic cascading effects in biomass changes can take place throughout the system.

SIZE DEPENDENT BEHAVIOR OF YELLOWFIN TUNA ASSOCIATED WITH ANCHORED FADS

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Sub-Adult and small juveniles usually comprise the major part of the assemblages of tuna found in association with FADs. The preponderance of these size classes at FADs results in large amounts of 'bycatch' in some large-scale fisheries that utilize FADs and the removal of very large numbers of sub-adults has become a significant concern of fishery managers. As a part of ongoing studies of the behavior of tuna around anchored FADs, the vertical distribution and horizontal movements (e.g., residence times) of sub-adult (60-80 cm FL,) and very small (approx. 30 cm FL) yellowfin tuna were observed using acoustic telemetry. Size dependent differences in distribution and behavior are emerging. Preliminary analyses of these results will be presented. This research was funded by the Pelagic Fisheries Research Program, University of Hawaii.

SPATIOTEMPORAL VARIABILITY IN BIGEYE TUNA (*Thunnus obesus*) DIVE BEHAVIOR IN THE CENTRAL NORTH PACIFIC OCEAN

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Data from 29 pop-up archival transmission (PAT) tags deployed on commercial size (122.2 +/- 7.8 cm F.L.) bigeye tuna (*Thunnus obesus*) in the central North Pacific Ocean from 4º-32ºN were used to describe variability in dive behavior across space and time. During the day bigeye generally spent time in the 0–50 m and 300–400 m depth ranges, with spatial and temporal variability in the deep mode. At night, bigeye tuna generally inhabited the 0–100 m depth range. Three daily dive types were defined based on the percentage of time spent in specific depth layers during the day. These three types were defined as shallow, intermediate and deep, and represented 24.4%, 18.8%, and 56.8% of the total number of days in the study, respectively. More shallow and intermediate dive type behavior was found in the first half of the year, as well as in the ranges from 14º–16ºN and north of 28ºN. A greater amount of deep dive behavior was found in the regions south of 10ºN and between 18º–28ºN during the third and fourth quarters of the year. Dive type behavior also varied with oceanographic conditions, with more shallow and intermediate behavior found in colder surface waters. Intermediate and deep dive types were pooled to reflect the depths where bigeye may have potential interactions with fishing gear. A Generalized Additive Model was used to quantify the effects of time, space, and sea surface temperature on this pooled dive type. Results from the model showed that while latitude and the quarter of the year were important parameters, sea surface temperature had the most significant effect on the pooled intermediate and deep dive behavior. Model predictions indicated that the largest percentage of potential interaction would be in the fourth quarter from 18º–20ºN, which corresponds to the time and place of the highest CPUE of bigeye tuna by the Hawaii-based longline fishery. These results suggest that a model framework using these three predictive variables may be useful in identifying areas of potentially high bigeye catch rates.

ECOLOGICAL RISK ASSESSMENT FOR HAWAII-BASED LONGLINE FISHERIES BY PRODUCTIVITY-SUSCEPTIBILITY ANALYSIS

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Ecological Risk Assessment (ERA) is a framework of processes and methods that was recently developed in Australia in order to achieve compliance with environmental legislation. As a process, it is designed to identify natural resource management objectives and to quantify the risks associated with not achieving them. As a suite of methods, it is designed to assess the impacts of human activities on ecosystems and their constituents. Productivity-Susceptibility Analysis (PSA) is a particular method developed for the analysis of fisheries that catch multiple species. It is designed to identify the vulnerability of species to mortality in fisheries and the consequence of that mortality for the species, as inferred from their biological productivity. PSAs have been used to assess >30 fisheries in Australia, and have recently been applied to the tuna longline fisheries of the western and central Pacific Ocean at both regional and national scales. In addition, NOAA Fisheries is exploring PSA as a possible means of informing choices regarding species at similar levels of risk that might be combined for purposes of determining annual catch limits in situations where data for the assessment of individual species is not available.

In this study, the PSA method is applied to analyses of fish species caught in two different Hawaii-based longline fisheries: deep gear targeting bigeye tuna and shallow gear targeting swordfish. The method has been enhanced through the analysis of hook depths and catch-at-depth by species for the fisheries concerned. The method illustrates the effectiveness of management measures (i.e. shark finning ban) in reducing risk. The method has the potential for application to other fisheries provided that the choice of productivity indicators accounts for correlation/coupling among them, and that the formulation of susceptibility of species to fishing gear is locally appropriate.

A DESCRIPTION OF WHALE SHARK (*Rhincodon typus*) HABITAT IN THE NORTHWESTERN NORTH PACIFIC OCEAN BASED ON JAPANESE SKIPJACK TUNA FISHERIES DATA

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Although the whale shark (*Rhincodon typus*) is the largest fish in the world, its habitat has not yet been fully documented. In this study, whale shark occurrences taken from the catch reports by two Japanese skipjack tuna fisheries (pole and line, and purse seine, respectively) were used to describe the apparent habitat of whale sharks in the northwestern North Pacific Ocean. Satellite-derived remote-sensing data were employed to investigate the relationships between whale shark occurrences and oceanographic characteristics. Overall, the number of whale shark occurrences was the highest in July and August for both fisheries. Whale sharks occurred primarily in the area to the south of approximately 40°N. Fishing activity associated with whale sharks for both fisheries shared common oceanographic characteristics based on satellite imagery. Sea surface temperature (SST) values for activity associated with whale sharks were constrained to warmer waters and ranged from 20°C to 26°C with the 24°C SST isotherm being a good indicator for whale shark occurrences in this area. Latitudinal position of fishing activity with whale sharks was correlated with the seasonal movement of the satellite-derived chlorophyll 0.2 mg/m^3 isopleth, which is defined as the transition zone chlorophyll front (TZCF) (pole and line, R^2 = 0.76; purse seine, R^2 = 0.65). This implies that their movement with the TZCF may be linked to whale shark foraging behavior in the frontal zone, an area which contains higher zooplankton and larval fish biomass. Comparisons of current and historical distributions of fishing activity with whale sharks suggest that whale shark habitat has not changed substantially over the last 50–70 years.

AN INDUSTRY VIEW OF INTERNATIONAL FISHERIES MANAGEMENT

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Over the course of the last forty years U.S. fishermen have come to accept the necessity of adequate fisheries management. This has lead to some notable success stories in the management of domestic fisheries. Unfortunately the record in international management of highly migratory species has been less positive. At a time when increasing fishing and political pressure make effective management mandatory, it seems that the regional fisheries management organizations are not able to pull together competing interests and implement meaningful management strategies. Several seemingly intractable problems facing the RFMO's make it unlikely that this situation will improve in the future. This leaves the industry vulnerable both to resource collapse and to charges of irresponsibility. The industry may respond with self-regulation through sustainability certification, either through existing programs such as MSC or through new industry-initiated programs. Management measures that could not be adopted through the RFMO's may be voluntarily adopted by industry or forced on industry by market conditions.

USING TIME SERIES ANALYSIS TECHNIQUES TO ANALYZE ANIMAL MOVEMENT DATA FROM ARCHIVAL AND POP-UP ARCHIVAL TAGS

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Archival tags and pop-up satellite archival tags (PSATs) are capable of recording light, depth and temperature data of tagged animals for an extended period of time. An archival tag or a recovered PSAT can return very high-resolution data that are sampled at every few seconds. This allows us to construct a detailed description of the tagged animals' underwater environment as the tagged individual transverses the ocean. The recorded data series are an integration of the many signals including environmental fluctuations, individual behavioral variability over a range of spatio-temporal scales. This can be especially true for large fishes that are capable of traveling long distances, and have complex behaviors and social structures. At the same time, specific movement behavior, such as diving associated with FADs (e.g. bigeye tuna), vertical foraging movements (e.g. basking shark), and life-history migrations (e.g. salmon) can provide characteristic patterns that are observable in the data.

Time-series analysis techniques, such as the Fast Fournier Transform have been demonstrated to be useful in identifying potential patterns in movement behavior, providing a means of statistically characterizing periodic behavior and a link to movement models. Another technique, autocorrelation analysis can also be informative, as it provides a way to hypothesize that behavior of an individual is dependent on, at least partially, on previous information or decisions. This set of techniques can be applied to both archival tags and PSATs, despite the lower data resolution of PSATs. Studies using PSATs often are able to retrieve data from many tags, and can allow us to investigate potential patterns from many individuals over multiple years. This talk will present preliminary results on time-series analysis of movement behavior from published tagging data of pelagic predators, including striped marlin. We aim to demonstrate the utility of these techniques via a systematic application to analysis and by providing the tools that are publicly available to carry out the analyses.

INTERACTIONS BETWEEN FISHERIES AND WHITE SHARKS (*Carcharodon carcharias*) IN THE SOUTHERN CALIFORNIA BIGHT

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The degree to which white sharks (*Carcharodon carcharias*) interact in southern California fisheries is unknown, despite their high public interest, economic value, and recent protection under state, federal, and international regulations. Data on white shark fishery interactions in southern California were mined from news reports, state and federal management agencies, fisher logbooks, and research institutions. Of the 219 records of reported white shark catch from 1936-2006, 70% were young of the year (YOY), followed by juveniles (11%) and adults (7%). YOY sharks were caught in nearshore waters (< 50 m depth) more often than adult sharks, which were mainly caught in offshore waters (> 50 m depth). In addition, the entangling net fisheries (drift gillnets and trammel nets) caught more white sharks (65%) than other fisheries (purse seines, trawls, hook and line; 13%), with a significant decline occurring after the closure of the nearshore gillnet fishery in 1994. Although a total of 247 sharks were caught during this time period, the total numbers of white sharks caught as bycatch in gillnet fisheries was three orders of magnitude lower than other bycatch species.

OCCURRENCE OF COOKIE CUTTER SHARK BITES ON PELAGIC FISHES LANDED IN THE HAWAII LONGLINE FISHERY

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Based on its unique dentition and bite mark, the cookie cutter shark (*Isistius brasiliensis*) is known to prey on a wide variety of pelagic organisms. Their bite mark is characterized as a slightly oval semi-circular gouge ranging in diameter from 3-8 cm. To examine feeding and distribution of cookie cutter sharks around the Hawaiian Islands, longline or hook & line caught pelagic fish landed at the Honolulu Fish Auction were sampled every week for one year. A total of 10 pelagic fish species comprising a total of 15,107 fish were sampled over the year. Seventy three percent (± 23.6 %) of the swordfish (*Xiphias gladius*) surveyed each week had cookie cutter shark bites, while none of the 430 blue marlins (*Makaira nigricans*) sampled were found to have bite marks. Forty three percent (± 16.7 %) of the opah (*Lampris regius*) surveyed had bite marks. Of the bigeye tuna (*Thunnus obesus*) surveyed 11.2 ± 6.5 % had bite marks. The percentage of all fish with bites was consistent from February – December (15.3 %), but was lowest during the month of January (6.7 %). Swordfish and opah also had the greatest numbers of bites per fish (range: 1-8); however, swordfish, yellowfin (*Thunnus albacares*), bigeye tuna, and opah had a higher occurrence of healed bites to fresh bites. Skipjack tuna (*Katsuwonus pelamis*) and pomfret (*Taratichthys sp.*) had a higher occurrence of fresh bites than healed bites. This suggests that cookie cutter sharks may take advantage of pelagic fish caught on long-lines or hook & line fishing, but more regularly prey on swordfish and opah based on the higher occurrence of healed bites on these two species. This also suggests that cookie cutter sharks may occur in higher abundance around the Hawaiian Islands than other locations.

POPULATION STRUCTURE OF SHORTFIN MAKO (*Isurus oxyrinchus*) IN THE PACIFIC OCEAN AS INFERRED THROUGH MITOCHONDRIAL DNA

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The shortfin mako is a wide ranging pelagic shark that occurs throughout temperate and tropical waters worldwide. Recent declines in shark populations worldwide have raised concerns of the ability of these organisms to sustain current levels of fishing pressure. Previous studies have demonstrated genetic subdivision of shortfin makos between ocean basins, as well as within the Atlantic Ocean. However, there has been no support of subdivision within the Pacific. In order to assess the genetic population structure of shortfin mako in the Pacific, mtDNA control region sequences were compared from seven sites (southern California, Hawaii, Japan, Australia, New Zealand, Chile, and South America). A 791-bp fragment revealed 56 unique haplotypes in 395 individuals with high haplotype (h = 0.866 ± 0.013) and nucleotide diversity (π = 0.00379± 0.002). Phylogenetic analyses reveal no geographic clustering of lineages and the most common haplotype occurred at all sample sites. Significant haplotype frequency differences (AMOVA, Φ_{ST} = 0.078, P = 0.000) were found when populations were grouped by region (North, Southwest, and Southeast). Additional haplotype frequency differences were discovered using pairwise comparisons of Φ_{ST} between all sample sites. Overall the patterns of mtDNA variation in shortfin mako sharks indicate significant structuring in the Pacific Ocean which allows us to reject the null hypothesis of a single panmictic population. This new information should be taken into account in order to design and implement effective management plans for this species.

FOOD WEB INFERENCES OF STABLE ISOTOPE SPATIAL PATTERNS IN COPEPODS AND YELLOWFIN TUNA IN THE PELAGIC EASTERN PACIFIC OCEAN

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Climate change and fisheries are key forces of ecological change. A changing climate is expected to affect biological production by forcing changes in the physical environment, and selective removal of large predatory fishes from food webs can impart changes in trophic structure and stability via trophic cascades. To appreciate future prospects of climate- and fishery-induced changes in marine populations requires an understanding of the extant variability in food webs. We report partial results of a project funded by the Pelagic Fisheries Research Program, University of Hawaii, designed to define the trophic structure and dynamics in the western, central, and eastern tropical Pacific using stable-isotope and diet data for diverse components of the pelagic food webs. We focus this presentation on copepods and yellowfin tuna in the eastern Pacific, important components at opposite ends of the food web.

Measurements of $\delta^{15}N$ (the ratio of $^{15}N/^{14}N$ standardized to atmospheric nitrogen) in a predator's tissues reflects its food and nutrient sources during a previous period of time, the length of which is determined by tissue turnover rates. The $\delta^{15}N$ values of the prey and the lower trophic levels depend on the $\delta^{15}N$ values of the dissolved nitrate consumed by phytoplankton at the base of the food web, which vary spatially. We measured the stable isotope values of omnivore copepods sampled on board two NOAA ships during the SWFSC *Stenella* Abundance Research Project of 2003, and of yellowfin tuna sampled on board tuna purse-seine vessels by IATTC observers during 2003-2005. We used generalized additive models to examine the spatial structure of the copepod $\delta^{15}N$ values, and to estimate the $\delta^{15}N$ values of the copepods at the sample positions of the yellowfin tuna. The similarity in the spatial patterns of both taxa was remarkable, suggesting limited movement behavior of yellowfin tuna. The difference between the yellowfin and copepod $\delta^{15}N$ values afforded us estimates of the relative trophic position of the tuna based on the assumption that omnivore copepods represent a proxy for the base of the food web. The spatial distributions of the yellowfin-copepod increment, defined as $\delta^{15}N_{yellowfin} - \delta^{15}N_{copepods}$, provided a means to examine mechanisms of $\delta^{15}N$ variability in the ecosystem. The yellowfin-copepod increments showed increasingly higher values moving from the coast to offshore.

We examined hypotheses that the inshore-offshore gradient owed to differences in yellowfin size, movement behavior, season or trophic structure. A linear model showed that copepod $\delta^{15}N$ was much more important ($p<<0.01$) than yellowfin size ($p=0.07$) is explaining the $\delta^{15}N$ variability in the yellowfin. We adjusted the yellowfin-copepod isotopic increment to account for the background variability, represented by the copepod $\delta^{15}N$ values, over a 95% probable ambit of yellowfin (archival tag data) during 154 days (>94% tissues turnover), and the spatial E-W pattern in the yellowfin increment was largely unaltered. An examination of stomach-contents data for 958 yellowfin tuna sampled during 2003-2005 by five-degree areas showed considerable trophic diversity, with diet TL estimates (based on a previous ecosystem model) on the same order of variability as the yellowfin-copepod increments. We conclude that trophic structure best explains the isotope spatial patterns, implying increasing trophic position of yellowfin from inshore to offshore.

DEVELOPMENT OF A PELAGIC FISH HABITAT-BASED MODEL FROM THE HAWAII LONGLINE FISHERY DATA

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Over the past decade, the most oligotrophic (least productive) regions within the subtropical gyres of the world's oceans have expanded (Polovina et al. 2008). To investigate the response of pelagic fishes around Hawaii due to this and future climate changes, a habitat-based model was developed using data from the Hawaii longline fishery. We use satellite remotely-sensed chlorophyll a concentration and sea surface temperature as indices of water masses and define habitats of fishes caught in the longline fishery based on these environmental variables following a methodology developed for loggerhead sea turtle habitat mapping (Kobayashi et al. 2008). We cluster species with similar habitats and produce quarterly maps of the spatial distributions of the species groups. Finally, we use the habitat model to examine the spatial dynamics of species groups in response to environmental changes.

EFFECTS OF MICROTURBULENCE AND FISH DENSITY ON LABORATORY SURVIVAL AND GROWTH OF YELLOWFIN LARVAE AND JUVENILES

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The Inter-American Tropical Tuna Commission's (IATTC) Achotines Laboratory is a research facility designed to study the ecology and biology of tropical tuna and tuna-like species. Achotines maintains an actively spawning yellowfin broodstock. A variety of experiments are conducted on the early life history of yellowfin, including studies of the effects of physical factors and fish density on vital rates during early life stages.

Previous studies, both theoretical and field-based, have indicated that microturbulence has a strong potential to influence encounter rates between marine fish larvae and their prey. Between 1997 and 2000, multiple laboratory experiments were conducted to investigate the effect of microturbulence on yellowfin larvae. Larvae were exposed to a gradient of microturbulence levels ranging from 3.0×10^{-9} to 3.7×10^{-8} m^{-2} s^{-3}, which correspond to approximate surface wind velocities of 1 to 6 m s^{-1}. Survival, final standardized biomass, gut contents, and growth after approximately one week of feeding were analyzed and compared among treatments for each of the experiments. Optimal levels of microturbulence for yellowfin larval survival were estimated. An area of the EPO within the yellowfin spawning range was selected and wind velocities taken from NASA's Jet Propulsion Laboratory database were compared to historical recruitment estimates for yellowfin calculated by the IATTC. The percentage occurrence of optimal wind velocities (based on the laboratory trials) was compared to estimates of yellowfin recruitment.

Experiments to determine the occurrence of density-dependent growth during the larval and juvenile phases of yellowfin have also been conducted at Achotines. Results from previous experiments have shown that density has a strong effect on the growth of yellowfin during the early and late larval stages (3 to 18 days after hatching). The most recent experiments conducted in 2007 were designed to further investigate the effect of fish density on the growth of late larval and early juvenile stages (14 to 24 days after hatching). The preliminary results will be presented.

HORIZONTAL MOVEMENTS OF YELLOWFIN TUNA (*Thunnus albacares*) IN THE EASTERN PACIFIC OCEAN, ASCERTAINED FROM ARCHIVAL TAGS

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Preliminary results are presented on the horizontal movements of yellowfin tuna tagged and released with LOTEK LTD_2310 geolocating archival tags in the eastern Pacific Ocean during 2002–2008.

Yellowfin tuna have been tagged with archival tags off Southern (n = 313) and Northern (n = 144) Baja California, México, aboard San Diego-based long-range sport-fishing vessels between 2002 and 2008. This yellowfin tuna archival tagging project is a component of the Tagging of Pacific Pelagics (TOPP) program, which is one of several programs supported by the Census of Marine Life (COML). TOPP is a program using electronic tagging to study the movements of several large open-ocean animals and the oceanographic factors influencing their behavior. TOPP also provided partial funding for the tagging of yellowfin in the equatorial eastern Pacific Ocean in 2006 (n = 45). Tagging yellowfin with archival tags was also conducted off the IATTC Achotines Laboratory, Panama, during January 2007 (n = 38) and 2008 (n = 11), and will continue in 2008.

The IATTC, in collaboration with the Instituto Nacional de la Pesca of México, has also tagged and released yellowfin with archival tags within the Revillagigedo Islands Marine Reserve, México, in February 2006 (n = 38), 2007 (n = 65), and 2008 (n = 44), utilizing a long-range sport-fishing vessel. A special permit was provided by the Comisión Nacional de Acuacultura y Pesca of México for the vessel, with a group of sport fishermen aboard, to conduct fishing and tagging activities within the reserve.

During these tagging cruises 698 yellowfin (51-161 cm in length, mean = 82.1 cm), were tagged and released with archival tags and 254 (36.4%), were recaptured and their tags returned.

NATAL ORIGIN OF ATLANTIC BLUEFIN TUNA (*Thunnus thynnus*) FROM THE GULF OF ST. LAWRENCE BASED ON $\delta^{13}C$ AND $\delta^{18}O$ IN OTOLITHS

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Increased knowledge of stock mixing and migration patterns of Atlantic bluefin tuna (*Thunnus thynnus*) is required to appropriately manage and conserve this diminishing species. Here we present a novel approach to identify the nursery origin of *T. thynnus* present in the Gulf of St. Lawrence using stable $\delta^{13}C$ and $\delta^{18}O$ isotopes in otoliths. Isotope signatures representative of eastern (Mediterranean Sea/Eastern Atlantic) and western (Gulf of México/Western Atlantic) origin were first determined by measuring $\delta^{13}C$ and $\delta^{18}O$ in whole otoliths of yearling *T. thynnus*. Due to cooler, more saline waters, *T. thynnus* otoliths from the eastern stock were enriched in $\delta^{18}O$, and were significantly different from the western stock; no difference in $\delta^{13}C$ was detected between regions. By comparing the isotopic composition of otolith cores (corresponding to the first year of life) from giant *T. thynnus* to yearling signatures, we determined 97.5% of *T. thynnus* caught in the Gulf of St. Lawrence fishery originated from the Gulf of México. This suggests little to no mixing from the eastern stock. Results from this study will aid management by providing contribution estimates from eastern and western spawning grounds to the Gulf of St. Lawrence fishery.

ADJUSTING ECONOMIC PRODUCTIVITY TO ACCOUNT FOR UNDESIRABLE HARVEST: APPLICATION TO THE CA/OR DRIFT GILLNET FISHERY

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Undesirable harvest such as juvenile fish, marine mammals, sea birds, and sea turtles are captured along with desirable species such as swordfish and thresher sharks in drift gillnets off the coasts of California and Oregon. Beginning in August of 2001, the take of endangered species (e.g. leatherback sea turtles) resulted in the annual closure of an area located between Point Conception and 45°N latitude, for the time period August 15 to November 15. This regulatory closure acts as a natural experiment for assessing the potential change in productivity for the California/Oregon Drift Gillnet Fishery.

The measurement of the change in productivity due to this closure is important, as it affects most of the production decision variables such as cost, employment, outputs, and prices within the fishery, and is subsequently reflected in measures of social welfare. Productivity change is also important as it may reflect changes in the scarcity or abundance of the resource stock. Fisheries managers need to understand the effects of regulations on the fishery in terms of economic losses. Many regulations currently facing the drift gillnet fishery used to protect the resource stock and other threatened or endangered species place constraints on productivity. This creates a potential for a reduction in productivity, which may lead to further misallocation of the resources, reduced profits, and increased costs. This increased cost also contributes to the inflation of food prices in the domestic markets.

Typical measures of productivity ignore the joint production of undesirable and desirable outputs since data on undesirable outputs are seldom available. The index models the joint production of undesirable and desirable outputs, crediting trips with reductions in undesirable harvest and increases in desirable. By incorporating undesirable harvest into the production process, more accurate measures of total factor productivity can be calculated and result in more effective policies designed to maintain or improve the fishery's economic performance.

This study uses a quadratic directional output distance function to measure total factor productivity of the fishery pre- and post-closure for the time period 1996-2006 to elucidate the effects of the closure on the fishery economic performance. Trip level data from the NOAA Drift Gillnet Fishery Logbooks and PacFIN database were used to estimate the productivity index. Shadow prices of undesirable outputs, which can be interpreted as the lower bound estimate of cost to society is calculated to show the impact of conservation regulations on the fishery. Results of this study will provide valuable information to the Pacific Fishery Management Council to help gauge the impact of protected species conservation measures on affected fisheries.

CONTRIBUTION OF WESTERN AND EASTERN ORIGIN POPULATIONS TO U.S. BLUEFIN TUNA (*Thunnus thynnus*) FISHERIES: EVIDENCE FROM OTOLITH STABLE ISOTOPE ANALYSIS

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It is generally accepted that there are two discrete populations of Atlantic bluefin tuna originating from the Gulf of México or Mediterranean Sea. We investigated how these two populations differentially contribute to U.S. fisheries. Stable oxygen isotopes in otoliths of yearling bluefin tuna from six year classes (1999-2004) were significantly different between collections from eastern (Mediterranean Sea/eastern Atlantic Ocean) and western (Gulf of México/western Atlantic Ocean) nurseries. Milled otolith cores were used to classify adolescent and adult samples to nursery of origin. Samples (n~200) from U.S. fisheries of mixed size classes showed strong contributions by the Mediterranean population at rates >50%. Smaller and younger bluefin tuna ("school" class) in particular were more likely to be of Mediterranean origin. The higher than expected rate of subsidy from the Mediterranean to U.S. fisheries requires re-examination of population benchmarks used in the current assessment and will likely lead to an altered view on the population productivity of western bluefin tuna.

CHALLENGES TO TUNA FISHERY MANAGEMENT IN THE TWENTY-FIRST CENTURY

John Sibert

Pelagic Fisheries Research Program
Joint Institute for Marine and Atmospheric Research
University of Hawaii

The abundance of tuna stocks has decreased to the point where most must be considered to be incapable of sustaining higher exploitation rates. In cases where increased exploitation might be considered, higher catches of target species will be accompanied by unsustainable catches of non-target species. Maximum sustainable yield is a problematical limit reference point for multi-stock management. It produces a low stock abundance which, if applied to a suite of top predators, may induce irreversible ecosystem effects. MSY is difficult to estimate, and it is equally difficult to determine when MSY is reached. Fisheries managers are often obsessed with uncertainty in stock assessment. Tuna assessments are hampered by the lack of "fishery-independent" which can help reduce uncertainty. Large scale tagging experiments are as close to a fisheries-independent data source and are a cost-effective means to reduce uncertainty in assessments of tuna stocks. Environmental variability on both interannual and interdecadal scales will complicate establishment of harvest targets. International management agencies may also face institutional problems making the budgetary and procedural changes required to prevent expansion of the fisheries and to reduce uncertainty in stock assessments.

The twenty-first century tuna fisheries managers must attempt to solve problems of:

- Catch or effort allocation
- Bycatch reduction
- Robust reference points
- Reducing uncertainty of stock assessments
- Environmental variability
- Data collection
- Higher (NOT lower) costs of management

In other words, the same general problems that were left unsolved in the twentieth century.

CHANGING USES OF TAGGING DATA IN "MANAGEMENT" OF TUNA FISHERIES IN THE WESTERN AND CENTRAL PACIFIC OCEAN

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Analytical models used to analyze conventional tagging data have evolved over the last 30 years from simple tag attrition models to age structured models with different degrees of spatial resolution. Tag analysis models and stock assessment models are converging in structure, and state-of-the-art stock assessment models often include tagging data. Further research is required to effectively utilize data from electronic tags in stock assessment, however. Costs of large scale tagging projects are comparable to the costs of scientific acoustic and trawl surveys that support stock assessment in demersal fisheries. Routine, large scale tagging projects should be considered an essential adjunct to responsible management of tuna fisheries, and members of tuna commissions need to accept the cost of tagging projects as necessary to promote the sustainability of the industry.

EARLY LIFE HISTORY OF SAILFISH, *Istiophorus platypterus*, IN THE NORTHERN GULF OF MÉXICO

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Sailfish, *Istiophorus platypterus*, are commonly taken by anglers in the Gulf of México (Gulf) and larvae are frequently reported in this region, indicating the Gulf's potential role as spawning and/or nursery ground. Ichthyoplankton surveys were conducted in northern Gulf waters off Texas and Louisiana (27–28°N, 88-94°W) from 2005–2007 to collect larvae for density, age and growth investigations. During the three year survey, over 2,500 sailfish larvae were collected, and sagittal otoliths were extracted from 748 larvae, ranging in size from 2.0-24.3 mm standard length (SL). Sailfish larvae were collected in 43% of samples with densities ranging from 0 to 51.0/1000m^2. Highest densities were found in association with the western edge of the Gulf Loop Current. Otolith microstructure analysis indicated sailfish ages ranged between 4 and 19 days, and hatch-date distributions suggest fish were from early May to mid-September spawning events. Instantaneous growth coefficients ranged from 0.121 to 0.158 with an overall rate of 0.144. Growth coefficients correlate to an approximately 12-15% increase in length per day. Growth rates varied by season and year, indicating temporal changes in environmental conditions, such as the Gulf Loop Current, may influence the survival and recruitment success of sailfish in this region.

DEVELOPMENTS IN EXPERIMENTAL FIELD TRIALS ON THE USE OF MODIFIED FISHING GEAR TO REDUCE SEA TURTLE BYCATCH IN LONGLINE FISHING GEAR

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The incidental capture of sea turtles, elasmobranchs, cetaceans, and seabirds in fisheries has been implicated in the rapid decline of several populations and is one of the most significant issues affecting fisheries management today. For the fishermen, bycatch can be a cause of inconvenience, loss of income due to time involved in handling non-target species, and can even pose potential danger. For the species involved, it can be the cause for serious population declines and eventual population extinctions. Fisheries bycatch is, by nature, a very complex biological, social, economic, and political issue, often times affecting an international scope. Due to these complexities, effective bycatch reduction strategies must also be comprehensive and integrative, often requiring creative collaborations.

This talk will summarize research comparing modified fishing gear to traditional methods in pelagic longline fisheries. The goal of the various projects is to identify method(s) to reduce the incidental capture of sea turtles while simultaneously maintaining the economic viability of the fishery. Summary of findings to date: 1) replacement of J and tuna hooks with circle hooks can effectively reduce the deep ingestion of hooks by sea turtle species that tend to bite baited hooks; 2) in fisheries with bycatch of relatively large loggerhead turtles (*C. caretta*) or leatherback turtles (*D. coriacea*), using large sizes of circle hooks (e.g. 18/0) can substantially reduce the bycatch of both species; 3) in fisheries with bycatch of smaller turtles, using smaller size circle hooks (e.g.16/0) can reduce capture rates of sea turtles when the circle hooks replace other hook styles with smaller widths; 4) using fish for bait instead if squid can reduce bycatch of sea turtles in fisheries and can also offset the potential loss of swordfish from use of circle hooks; and 5) using monofilament line in place of the more flexible multifilament cordage used in many artisanal fisheries can significantly reduce entanglement of sea turtles. This is not a comprehensive list of effective mitigation methods, and we encourage identification of more bycatch reduction methods to be used alone or in combination with other methods to further improve fisheries selectivity in longline and other coastal or pelagic fisheries.

OBSERVER PROGRAMS AROUND THE WORLD: WHY DO WE NEED THEM? HOW DO EXISTING PROGRAMS COLLECT DATA? WHICH MODEL WILL WORK FOR YOUR PROGRAM?

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Observer programs were first implemented in the early 1970s in the Eastern Tropical Pacific tuna purse seine fishery to record dolphin bycatch mortalities. Since that time, over 40 observer programs have been implemented throughout the world's oceans by 35 countries. Observer programs are widely recognized as the best method to obtain direct information on targeted catch, bycatch, and gear interactions with other marine species. They are also an effective means to assess regulatory compliance aboard fishing, processing, and transshipment vessels.

This presentation will provide a review of the different types of observer programs throughout the world, including the range of observer coverage levels in place and their justification, management and program drivers, funding structures and payment systems, and data collection, quality control and data harmonization. The presentation will also discuss ideas for improving existing observer programs and designing new programs that will be effective in the context of regional fisheries management organizations.

PREDATORY INTERACTIONS BETWEEN MAKO SHARK, *Isurus oxyrinchus*, AND JUMBO SQUID, *Dosidicus gigas,* IN THE CALIFORNIA CURRENT

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Within the California Current Large Marine Ecosystem (CCLME) mako shark, *Isurus oxyrinchus,* is an abundant species managed under the Pacific Fishery Management Council's Highly Migratory Species (HMS) Fisheries Management Plan. Data on the abundance, life history, and diet of makos are gathered from fishery-dependent sources (e.g. monitoring of the California Drift Gillnet Fishery) and fishery-independent sources (e.g. the annual NMFS Juvenile Shark Longline Abundance Survey). The recent expansion of the distribution of jumbo squid into the CCLME provides the potential for makos to exploit squid as a familiar prey source but in a more northern portion of their range. Information on the horizontal and vertical movements of makos within the CCLME is gathered by Pop-off Archival Tag (PAT) and Satellite Position Only Tag (SPOT) deployments conducted in cooperation with the Tracking of Pacific Predators (TOPP) program. Physical and biological oceanographic measurements within the CCLME are taken via CTD casts and shipboard instrumentation. The Juvenile Shark Longline Survey and the California Drift Gillnet fishery overlap the CalCOFI transects, and analysis of the ecology of mako sharks based on the survey and fishery data benefits from the biophysical oceanographic measurements collected through CalCOFI. In this paper we will summarize observations regarding the foraging niche of mako sharks and an apparent increase in interactions between mako sharks and jumbo squid. These data include: 1) the historical and present day location of the upper edge of the oxygen minimum zone (a preferred habitat of jumbo squid in the Gulf of California); 2) swimming-depth profiles (feeding excursions?) of mako sharks; 3) the pattern of occurrence of jumbo squid beaks in mako stomach contents; and 4) the incidence of jumbo squid scars on the bodies of mako sharks. Overharvest of tunas and billfishes and/or climatic changes are the two proposed reasons for the expansion of jumbo squid. The evidence for these claims will be discussed.

SHARK CATCHES IN THE HAWAII-BASED LONGLINE FISHERY AS REPORTED BY FISHERY OBSERVERS AND IN COMMERCIAL LOGBOOKS

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The bycatch of the Hawaii-based longline fishery includes substantial numbers of sharks, particularly blue shark, *Prionace glauca*, and a few other relatively common species, including shortfin mako, *Isurus oxyrinchus*, oceanic whitetip shark, *Carcharhinus falciformis*, and bigeye thresher shark, *Alopias superciliosus*. This presentation summarizes catch data for these species as reported by fishery observers and in commercial logbooks from 1994−2006. The observer data were used to assess catch rates and minimum mortality estimates in relation to changes in this fishery during this decade, including a closure of the sector that targeted swordfish, *Xiphias gladius*. The observer data were also used to depict the distributions of the catches of these species, and to fit statistical models, the coefficients of which were applied to the logbooks to identify sources of bias associated with self-reporting and to estimate catches.

THE INTRINSIC ELASMOBRANCH GILL DESIGN POTENTIALLY LIMITS GAS EXCHANGE AND THE AEROBIC PERFORMANCE OF THE SHORTFIN MAKO, *Isurus oxyrinchus*, A LAMNID SHARK

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The tunas (family Scombridae) and lamnid sharks (family Lamnidae) demonstrate a remarkable evolutionary convergence for high-performance swimming. Analysis of the gill structure of the shortfin mako, *Isurus oxyrinchus*, a lamnid shark, reveals similarities to tunas in the presence of specializations to maintain gill rigidity during ram ventilation and to permit the O_2 transfer required for fast, sustainable swimming. However, mako and tuna gill specializations have structurally different bases due to intrinsic differences in the gill design of elasmobranchs and teleosts. The elasmobranch gill has a more tortuous water pathway than that of teleosts, and *in vivo* measurements of mako gill resistance suggest that this design limits total gill surface area. Thus, while mako gill areas are larger than non-lamnid shark species, they are significantly less than those of tunas. The larger size of elasmobranch erythrocytes also increases mako respiratory lamellar thickness and gas diffusion distances in comparison to tunas. These intrinsic characters limit gas exchange and may prevent lamnid sharks from reaching the scope of sustainable aerobic performance achieved by tunas.

NURSERY ORIGIN OF YELLOWFIN TUNA (*Thunnus albacares*) IN THE HAWAIIAN ISLANDS

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Determining stock structure and defining the degree of stock heterogeneity or mixing is critical to the effective management of yellowfin tuna (*Thunnus albacares*) in the western and central Pacific Ocean (WCPO). Recent stock assessments indicate recruitment of yellowfin tuna has declined significantly over the past few decades, and thus an understanding of the source(s) of recruits to the Hawaii-based fisheries is needed to effectively manage this species. The purpose of this study is to determine whether chemical signatures in the otoliths of yellowfin tuna are distinct among putative nursery areas from the WCPO. Preliminary data suggests the stable isotopic composition of otolith cores from age-0 yellowfin tuna is different between nurseries in the Hawaiian Islands and the Equatorial Pacific, with enriched $\delta^{18}O$ and $\delta^{13}C$ values in fish collected from the Hawaiian Islands. After building our baseline data set to include all potential nurseries, otolith core material from age-1 and age-2 yellowfin tuna from the Hawaii-based fisheries will be compared to baseline data using mix-stock procedures. This will allow us to determine the origin of yellowfin tuna recruits and assess the contribution of distant nurseries to the Hawaii-based fisheries.

MEASURING TAIWANESE TUNA LONGLINE FISHING CAPACITY IN THE ATLANTIC: DATA ENVELOPMENT ANALYSIS APPROACHES

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This paper presents an analysis of fishing capacity and capacity utilization in the Taiwanese longline fleet participating in Atlantic tuna and tuna-like fisheries. One challenge for highly migratory species management nowadays is to harmonize the total capacity of the fleets to the resource stock conditions. The essential issues here involve the assessment of the current capacity in the fleets and the evaluation of the relationship between capacity levels and available fishing possibilities.

Before the issues are well resolved, the approximated fleet capacity limits have been usually imposed on the fishing entities, defined in terms of the number of fishing vessels. However, the rationality and the effectiveness of the management of fishing capacity by the limits in the size of a fleet depend on each vessel's efficiency and capacity utilization. Consider the availability of the data required, a national level research should carry out an evaluation of the fishing capacity of its fleet.

In this study, we tried to use data envelopment analysis (DEA) to estimate levels of capacity and capacity utilization in Taiwanese tuna longline fleet in the Atlantic during 2003 to 2005. DEA is commonly used to estimate capacity output for individual fishing vessels based on the level of inputs used and outputs produced. Based on the available national database, the vessel-level inputs are gross tonnage, overall length, width, hold capacity, days fished, and engine power. The vessel-level outputs produced are the landed catch of tuna and tuna-like species.

POSTER ABSTRACTS
(in alphabetical order)

CHARACTERIZATION OF SWORDFISH BUOY GEAR CATCHES IN THE FLORIDA STRAITS

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Swordfish buoy gear (SBG) is a relatively new commercial fishery located off the eastern and southern coasts of Florida that began in 2002. The area targeted by this fishery, part of the Florida East Coast statistical area (FEC), has been closed to commercial pelagic longline gear (PLL) since 2001. Swordfish buoy gear has largely taken the place of PLL as a commercial fishery for swordfish (*Xiphias gladius*) within the FEC. Conceptually, SBG is similar to a vertical longline, with free-floating individual buoys and "high-flyers" connected to approximately 100 meters of monofilament with one or two hooks constituting one "buoy." Most vessels currently using this gear are fishing approximately 10 "buoys" simultaneously. Due to the way each individual "buoy" drifts independently with the current, SBG is considered to fish more like PLL than the former NMFS classification of the "handgear" gear type. This study qualitatively compares swordfish catch rates, bycatch rates, and time on hook between contemporary SBG field data and historical PLL observer data from the FEC. Initial analysis shows higher CPUE for SBG vs. PLL (92.2 to 31.8 per 1000 hooks), lower bycatch rates (12.2 to 21.6 per 1000 hooks), and lower average time on hook (2:15 to 6:59). Initial conclusions show that SBG is a cleaner and more efficient commercial fishery for swordfish in this area when compared to PLL.

GLOBAL PHYLOGEOGRAPHY OF DOLPHINFISH (*Coryphaena hippurus*) REVEALS INDIAN ORIGIN OF POPULATIONS

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Dolphin fish *Coryphaena hippurus* is a large pelagic fish species distributed worldwide in tropical waters and the Mediterranean Sea. Main features of the dolphin fish include fast growing, high reproductive potential and significant dispersal capability. The study of phylogeographic patterns on worldwide-distributed fish species has become in the most representative example of the low or null divergence associated with the environment homogeneity and dispersal capability of marine species. Divergence patterns reported generally are coincident with low levels of genetic structure especially for large pelagic tropical fish species where a lack of differences between areas with obvious geographical barriers is being more frequently reported. We studied the global phylogeographic pattern of dolphin fish by analyzing the sequence variation in a 751 bp segment of the mtDNA-ND1 gene, in 12 locations from different basins; Pacific (5), Atlantic (3), Indian (2), and the Mediterranean Sea. Inter-oceanic genetic differentiation assessed by AMOVA analysis identified three main stocks: Atlantic, Indo-Pacific and Mediterranean (Φ_{CT} = 0.223; P = 0.015). Genetic variation at the intra-oceanic level showed genetic homogeneity for the Indian and Atlantic Oceans, whereas the Mediterranean population comprised a separate lineage. Genetic heterogeneity for the Pacific Ocean showed a more complex divergence pattern, with differences between the west-central Pacific for some locations and no differences between the west-east Pacific. Significant population sizes for dolphinfish and historical demography may play a relevant role on defining the phylogeography for tropical pelagic fish species.

POPULATION GENETIC STRUCTURE OF THE PACIFIC MACKEREL (*Scomberomorus sierra*) FROM THE EASTERN PACIFIC

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The Pacific mackerel (*Scomberomorus sierra*) is a pelagic fish species distributed in tropical and subtropical waters along North, Central and South America. Individuals have moderate dispersion capability associated with feeding and spawning activities (Collette and Nauen, 1983). Migratory movements may be influenced by sea surface temperatures, which can result in isolation of distant populations and hence promote the existence of discrete genetic populations. Pacific mackerel represent an important fishery in México; catch statistics have being estimated to reach 10,000 metric tons in 2005 with an increasing trend in fishing effort (FAO, 2000). No management strategies have been implemented for this species including the definition of their genetic stock structure. In order to test the genetic homogeneity hypothesis of Pacific mackerel in the eastern Pacific, we analyzed the spatial and temporal genetic variability of a 760 bp segment of the mtDNA-region control on samples from six locations collected during four consecutive years. Preliminary results showed significant levels of haplotype ($h = 0.999$) and nucleotide ($\pi = 0.042$) diversities in coincidence with stable demographic equilibrium of populations. Temporal genetic variability was homogeneous with no differences found between years and among locations. Likewise, no spatial heterogeneity was observed from AMOVA analysis ($\Phi_{CT} = 0.0012$; $P = 0.22$), however significant genetic differences were detected among the most north (Mazatlán) and south locations (Oaxaca) when testing pairwise sample divergence ($\Phi_{ST} = 0.075$; $P = 0.015$). Estimation of historical demographic parameters, neutrality tests and distribution of mismatches between haplotypes, showed evidence of demographic expansion occurred about 450,000 years ago, or spatial range expansion of populations to tropical waters, during the warming of waters in the inter-glacial periods followed by glacial episodes of the late Pleistocene.

ARE FADs ECOLOGICAL TRAPS FOR TUNAS? EVIDENCE FROM DIET STUDIES IN THE EASTERN PACIFIC OCEAN

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The increased use of artificial fish aggregation devices (FADs) for purse-seine fishing of tropical tunas has led to concern that numerous FADs in the environment could act as an ecological trap, to the detriment of tuna populations. An 'ecological trap' is defined as "a case in which organisms become 'trapped' by their evolutionary responses to formerly reliable cues that are no longer associated with adaptive outcomes, and experience reduced survival and reproduction as a result." Jean-Pierre Hallier and Daniel Gaertner, IRD, France, recently published an analysis of this hypothesis for yellowfin *Thunnus albacares* and skipjack tunas *Katsuwonus pelamis* in the Atlantic and Indian Oceans. They examined stomach fullness (empty *vs.* with food), fish "plumpness," growth rate, movement direction, and displacement rate to investigate evidence of maladaptive behavior.

We expanded on one aspect of Hallier and Gaertner's study using a diet database for 2,234 yellowfin and 1,754 skipjack tuna caught by purse-seine in the eastern Pacific Ocean (EPO) during 2003-2005. We computed stomach fullness as a percentage of the body weight of each fish (*i.e.* total stomach contents weight divided by body weight, estimated from weight-length relationships, times 100). The data pooled by species and set type showed significantly ($p<0.05$) lower average stomach fullness for both species caught on FADs compared to those caught in dolphin and unassociated sets (consistent with Hallier and Gaertner's findings); however, most FAD sets catch small individuals in the early morning. We, therefore, stratified the data by age class and time of day, and found that the stomach fullness was not significantly different ($p>0.05$) between yellowfin of age 1-2 years caught on FADs and in dolphin sets. Skipjack caught on FADs consistently had significantly ($p<0.05$) less food in the stomachs regardless of whether or not the data were stratified by time of day and age class. The yellowfin and skipjack that were caught on FADs in the eastern, more productive region showed no significant difference in stomach fullness compared to those caught in the far western, less-productive region.

We conclude that diet data for skipjack in the EPO showed evidence of reduced feeding intensity when associated with FADs in the daytime, a result consistent with nighttime feeding and fast gastric evacuation rates. The data for yellowfin were inconclusive because larger fish caught with dolphins had as much food in their stomachs as those at FADs. The data analyzed in this study were from sets performed during daylight hours; however, the occurrence of residual hard parts, archival tagging data, and visual observations indicate that tunas aggregating under floating objects may forage on organisms within the deep scattering layer at night. When examining foraging success, it is fundamental to analyze the total weight of food in each stomach and not just the presence or absence of food. While our analysis encompasses aspects of feeding, further information on other ancillary aspects of life history and behavior should be investigated before concluding that FADs are an ecological trap for tunas in the EPO.

USE OF TEMPERATURE-DEPTH-RECORDERS IN THE HAWAII-BASED LONGLINE FISHERY TO CHARACTERIZE BIGEYE TUNA (*Thunnus obesus*) FISHING GROUNDS

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Temperature-depth-recorders (TDRs) and catch data are used to describe bigeye tuna (*Thunnus obesus*) vertical movements and interactions with fishing gear in the Hawaii-based longline fishery. TDRs were deployed during commercial fishing operations throughout the fishing grounds, an area greater than 15,000,000 km^2 that is bounded by the equator to 40°N and 180°E-140°W. This vast dynamic area includes the well-defined subarctic-subtropical transition zone to the north and the seasonally warm pool/cold-tongue convergence zone of the equatorial waters to the south, and provides a variety of key habitat for bigeye tuna. From 1990 to 2006, 1,363,918 bigeye tuna were caught within this area, and in 2007 the fishery caught a record-high 159,000 bigeye tuna. It is noteworthy that medium- to large-sized bigeye tuna are often caught below the thermocline during the daylight hours. In order to quantify and improve the understanding of diurnal habitat preferences of bigeye tuna, we attached two TDRs on three consecutive baskets of gear, for a total of six TDRs for each fishing operation (n = 248 sets). One TDR was attached onto the mainline within 0.3 meters of the first branchline snap and another was attached to the deep (middle) section of the mainline. We present estimates of fishing depth and temperature distributions of longline gear that better characterize the physical oceanographic environment of bigeye tuna.

INNOVATIVE BYCATCH REDUCTION METHODS…WHY KEEPING U.S. FISHERMEN FISHING BENEFITS LIVING MARINE RESOURCES AND THE ECONOMY

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The reauthorized Magnuson-Stevens Fishery Conservation and Management Act includes several key provisions aimed at further reducing bycatch of living marine resources in U.S. commercial and recreational fisheries. As part of this effort, the National Marine Fisheries Service (NMFS) has designed and implemented a Bycatch Reduction Engineering Program (BREP). This poster will provide an overview of NMFS' bycatch reduction efforts including the BREP and highlight some innovative bycatch reduction methods that have been pioneered by U.S. fishermen in collaboration with resource managers, scientists, and academia partnerships. In several cases, these partnerships have resulted in the successful export of bycatch friendlier fishing methodologies to foreign fishing fleets which may lead to bycatch of savings on a larger scale.

AGE AND GROWTH OF BLUE MARLIN (*Makaira nigricans*) CAUGHT AROUND THE SOUTHERN TIP OF THE BAJA CALIFORNIA PENINSULA, MÉXICO

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Blue marlin, *Makaira nigricans***,** is the second most important recreational fishery species for the southern tip of the Baja California peninsula, Mexico. Despite its economic value, little is known about blue marlin age and growth. To study age and growth, we sampled 184 blue marlin landed by the sport fishing fleet at Cabo San Lucas, Baja California Sur, México, between January 2005 and December 2006. All sampled individuals were female. From each fish we recorded postorbital length and sectioned the fourth spine from the dorsal fin to estimation of age and growth rates. Samples ranged in length from 114 to 321 cm, with those of 170 to 210 cm predominating (65% of individuals sampled). The strong positive relationship between the diameter of the fourth spine from the dorsal fin (DS) and the postorbital fish length (R^2=0.84) suggest that this structure is reliable for being use in estimations of age and growth rates of blue marlin. We found that the appropriate place to obtain a thin section of the spine (thickness of 0.45 mm) is near the base. We counted the opaque-hyaline bands in each spine section and assumed that an opaque band followed by a hyaline band is an annual mark. Our results show that sport fishermen are catching seven age groups (1, 2, 3, 4, 5, 6 and 8 years old), with the age-groups 2 and 3 being the most abundant. Interestingly, we found no representatives of age groups 0 or 7. The estimated parameters that represent the individual growth for female blue marlin according to von Bertalanffy's equation (k=0.38, t_0=-0.16, and L_∞=299.66 cm) suggests that they have very fast growth in the early years of life, reaching 56 and 70% of their asymptotic length at age 2 and 3 respectively.

MOVEMENTS OF ATLANTIC BLUE MARLIN IN THE GULF OF MÉXICO

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For highly migratory fishes such as Atlantic blue marlin (*Makaira nigricans*), the distinction between genetic and demographic connectivity may be especially important for developing inter-jurisdictional spatial management strategies. Whereas homogeneity of genetic markers justifies a single blue marlin stock, limited conventional tagging data suggests at least two patterns of movement: 1) long-distance movements with a strong north-south seasonal component in western Atlantic; and 2) restricted movements in the Gulf of México (GOM) and Bahamas. Here we examined data from 26 pop-up archival transmitting (PAT) tags deployed on blue marlin in the GOM from 2003-2006. Only 5 individuals exhibited movement out of the Gulf of México, and our estimate of median residence time (using event analysis; Kaplan-Meier estimator) was 180 days. For deployments lasting into the fall and winter, the fish remained within or in close proximity to the GOM, and inter-annual differences in mean net movement were observed. Strong regional and seasonal differences in vertical habitat use were evident, and these results are being compared to 3-D ocean models to examine habitat selection. Our results support the hypothesis of residency in the GOM through the late fall and winter for a fraction of the blue marlin stock and suggest the productivity of this contingent may depend disproportionately on the GOM ecosystem.

EVIDENCE OF STRIPED MARLIN (*Tetrapturus audax)* REPRODUCTION IN BAJA CALIFORNIA SUR

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The striped marlin, *Tetrapturus audax,* is the most important billfish caught by the sport fishing fleet within waters of southern Baja California, México. Approximately 80% of the total striped marlin catch originates from the Los Cabos zone. Although previous studies have reported the presence of larvae and mature females (using gonadosomatic index) from waters off the Mexican Pacific, only one prior histological study of the gonads has been conducted. We evaluated the gonads of 102 adult striped marlin caught by the sport fishing fleet from 2005-2007. Striped marlin samples, caught in the waters of south of the Baja California Peninsula, ranged from 125-247 fork-length. The results demonstrate that this species presents a group-synchronous ovarian type, since at least two populations of oocytes can be distinguished at one time. Spawning females present only two oocytes categories in the ovaries: hydrated oocytes which will be soon be spawned and previtellogenic oocytes (immature). These observations allow us to infer that striped marlin reproduction is not continuous and the gonadal development takes a time interval greater than displayed in other large pelagics like dolphinfish.

STUDIES OF HEAT BALANCE IN FREE-SWIMMING SWORDFISH

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Swordfish *(Xiphias gladius)* are large pelagic predators known for their capacity to undergo extensive diurnal vertical movements (i.e., from the surface to more than 500m). These large fish, thus, appear to alternate thermal niches by spending much of the daylight hours in the cool water below the thermocline (except during brief surface basking events) and the night hours in the upper mixed surface layer. The aerobic, red locomotor muscle in swordfish is positioned more internally (i.e., in close proximity to the vertebrae) than in most other fishes and is consequently physically isolated from the skin. This derived red muscle morphology is also found in tunas, lamnid sharks, and the common thresher shark, all of which have the capacity to maintain an elevated temperature of this locomotor muscle (i.e., red muscle endothermy). However, unlike these other pelagic species, it is not known whether the swordfish also has the capacity to elevate the temperature of the medial RM. In this study we document the locomotor muscle temperature in a wild, free-swimming swordfish to document its capacity for red muscle heat balance. Swordfish were outfitted with a modified pop-off satellite archival transmitter (Wildlife Computers MK10 PSAT) with a Lotek, LAT 1410 archival tag affixed to its side. The archival tag was configured to record deep muscle temperature at the position of the tag anchor. The PSAT was deployed on a basking swordfish during daylight hours using traditional harpoon methods in the Southern California Bight. The preliminary results are based on the first deployment, a ~100 kg swordfish tagged on August 24th 2007. The transmitter was programmed for a short-term deployment (5 days) and, upon the release from the fish, was re-acquired using a signal direction finder. Fine-scale vertical movements and both ambient and deep muscle temperature data were collected every minute for the entire 600 hours of the deployment. The tagged swordfish exhibited diurnal movement patterns similar to those reported in previous studies, with the fish remaining predominantly below the thermocline during the day and in the upper mixed layer at night (< 700m) with two brief basking events during the daylight hours of days 2 and 3. Calculation of the thermal rate coefficients during 6 cooling (diving) and 5 heating (surfacing) events show that the rate of heating (k=0.03) was ~6.5 times faster than that of cooling (k=0.005). During the time the swordfish stayed at depth the red muscle always remained more than 1.5ºC above ambient and upon returning to the surface quickly warmed and remained at least 0.5ºC above ambient. Overall, the thermal rate coefficients during diving for swordfish appear to be within the range of values documented for some tunas but lower than those for mako sharks (i.e., swordfish cool slower than makos but similar to tunas) while the rates for heating are consistently lower in the swordfish than in both makos and tunas (i.e., swordfish warm slower). Future deployments will further investigate the swordfish's ability to withstand extended periods in the cool conditions below the mixed layer.

COMBINED SHARK TAGGING EFFORTS OF THE CALIFORNIA DEPARTMENT OF FISH AND GAME, NMFS SOUTHWEST FISHERIES SCIENCE CENTER, AND COOPERATIVE ANGLERS OF SOUTHERN CALIFORNIA: 1968 – 2008

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The National Marine Fisheries Service Southwest Fisheries Science Center (SWFSC) and California Department of Fish and Game (CDFG) have combined their shark tagging data representing nearly forty years of tagging information. Over 15,000 sharks of more than 25 species have been tagged during this period. The majority of this effort has been the result of a CDFG angler-based Shark Tagging Program, which was initiated in 1983. The program received wide support from sport fishermen with most tagging occurring along the southern California coast. Additional shark tagging has been done by both CDFG and SWFSC biologists during research cruises conducted along the North and Central American west coast. Net movements of nearly 500 sharks including 385 conventional tag recoveries and more than 100 satellite tagged sharks are reported. Over half of the sharks tags were deployed on three pelagic shark species - the blue (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*) and common thresher (*Alopias vulpinus*) sharks. Maximum time at liberty (days) and net movements (km) recorded for these species were: *I. oxyrinchus* – 1,938 d, 7,604 km; *P. glauca* – 1,378 d, 7,597 km; and *A. vulpinus* – 800 d, 695 km. The collaboration between State and Federal organizations and the combined Microsoft Access database that has resulted from this partnership can now be used to provide a comprehensive look at shark movements throughout the Pacific Ocean.

REPRODUCTIVE BIOLOGY AND SPAWNING SEASON OF DOLPHINFISH *Coryphaena hippurus* CAPTURED IN BAJA CALIFORNIA SUR, MÉXICO

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The dolphinfish *Coryphaena hippurus,* like other pelagic species (billfishes), presented important evidence of reproductive activity in the Mexican Pacific. The knowledge of biological information is essential to management of these resources in the region. The main goal of this study was to determine the reproductive biology and spawning season of dolphinfish in Baja California Sur, México. The results are based on 1,398 males and 1,435 females caught during 2004 to 2006. Only 231 female and 141 male gonads were histological analyzed. The gonado-somatic index (GSI) and the condition factor (CF) were calculated for both sexes. The monthly sex ratio was 1♂:1♀ in August, November and December. Fishes smaller than 90 cm fork length were predominantly females, while males were more abundant over that size. A low value GSI was obtained in the summer-autumn months due to the post-spawning conditions confirmed with the histological analysis. In conclusion, the dolphinfish spawned throughout the year with reproductive activity peaking in summer-autumn. This coincides with the sea surface temperature increase and when the resource is more abundant in the region.

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