Proceedings of the 60th Annual Tuna Conference

Lake Arrowhead, California
May 18-21, 2009

High-Tech Science For The Large Pelagics: What Have We Learned From It And How Should It Be Integrated Into Management And Conservation?

Alexandre Aires-da-Silva and JoyDeLee Marrow, Co-Chairs

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

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Inter-American Tropical Tuna Commission
8604 La Jolla Shores Drive
La Jolla, CA 92037

PREFACE

We warmly welcome you to the 60th Tuna Conference. The long-standing goal of the Tuna Conference has been to provide an open and informal forum for scientists, engineers, managers, fishermen and non governmental organizations from around the world to exchange information and ideas including recent research findings on tunas and 'tuna-like' species.

"High-Tech Science for the Large Pelagics: What Have We Learned From It And How Should It Be Integrated Into Management And Conservation?" is the theme of the 2009 Tuna Conference. Since the 1990s we have witnessed a rapid development of the technologies available to both fishers and fishery scientists. Tuna schools are more efficiently detected and caught from easier access to satellite-based environmental data, sonar, and other highly sophisticated technologies. At the science level, we can now rely on the fish themselves to collect extensive movement and environmental data, almost continuously over large periods of time. This is possible through the recent advances of archival and satellite tagging. Great improvements have also been made at the stock identification level as a consequence of the modern techniques of population genetics. Large volumes of data are rapidly accumulating as a result of this rapid expansion of the modern technologies. What have we learned from high-tech science for the large pelagics? How fast are we assimilating these large volumes of data and integrating it into management and conservation? How should we reconcile these new data with the historical data sets? Can improvements be made?

A total of 51 papers and 9 posters touching various aspects related to the modern science technologies applied to the large pelagics will be presented at the 60th Tuna Conference. In addition, a panel session focusing on the conference's theme questions will be held. The discussion panel will bring representatives from the IATTC, NOAA Fisheries, universities and the technology industry. We encourage all attendees to participate in the discussions. We are grateful to Alain Fonteneau, Roger Hill, Kim Holland, Molly Lutcavage and Mark Maunder to share their views on the challenges faced by high-tech science for the large pelagics and its integration into management and conservation at the discussion panel. Special thanks to Kim Holland for his availability to moderate the discussion panel.

Four student scholarships were awarded this year. The Manuel Caboz Memorial Scholarship was awarded to George Shillinger for his research on "Pop-up Satellite Tags Reveal Movements and Behaviors of Pacific Bluefin Tuna in the Southern Pacific Ocean". Wildlife Computers, Inc. graciously sponsored a student scholarship this year. The Wildlife Computers Scholarship was awarded to Daniel Dutton for his work "Habitat Utilization of Blue Marlin (*Makaira nigricans*) Inferred from Pop-up Satellite Archival Tags And Niche Partitioning with Other Istiophorids". Jason Phillips was awarded with the Tuna Conference Scholarship for his research "Linking U.S. Pacific Albacore CPUE to Fine Scale Satellite Environmental Data". The Automatic Differentiation Model Builder (ADMB) Foundation has kindly sponsored a new Scholarship to the Tuna Conference. Eunjung Kim was the recipient of the ADMB Award for her work "Simulating the Effect of FAD Density on Large Scale Movements". 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. We thank William Bayliff, Stephen Brouwer, Heidi Dewar, John Graves, Suzanne Kohin, Nathan Taylor, Nick Wegner and Kevin Weng for moderating the scientific sessions. We thank the anonymous reviewers who assisted on the student Scholarship Committee. Christine Patnode has done an excellent job maintaining the Tuna Conference web site and designing this year's T-Shirt and cover. Anne Allen past Tuna Conference Coordinator for her advice and assistance. Millie DeLosReyes for help with the banking and beverages, Ed Everett and Bob Olson assisting in the purchase of the beverages, Suzy Kohin, Marlon Ramon and Sam McClatchie in transportation. We thank Craig Heberer, Kim Holland, John Hyde, David Itano, Russell Ito and Suzy Kohin for continuing the sashimi cutting tradition to help supply the Sushi Social/Poster Session. A special thanks to the U.C.L.A. Conference Center personnel for accommodating our numerous requests. We are grateful to a whole team of 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, Sushi Social/Poster Session and Tuna Barbecue. Donations this year were received from American Fisherman's Research Foundation, American Tunaboat Association, Automatic Differentiation Model Builder (ADMB) Foundation, Monterey Bay Aquarium Foundation, Prime Time Seafood Inc., and Wildlife Computers, Inc.

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

In closing, we would like to thank you all for participating. We hope you had a productive and enjoyable time and look forward to seeing back next year at the 61st Tuna Conference!

Alexandre Aires-da-Silva and JoyDeLee Marrow

Alexandre Aires da Silva JoyDeLee C. Marrow

60th Tuna Conference Co-chairs

AGENDA

Monday, 18 May 2009

11:00 Registration Opens in the Library (continued throughout Monday and Tuesday morning)

SESSION 1: Environmental Studies (Moderator: Stephen Brouwer)

13:00 Welcome and Introduction

13:10 OCEANOGRAPHIC INFLUENCES IN REGIONAL DIFFERENCES OF MERCURY IN YELLOWFIN AND BIGEYE TUNA - Bridget Ferriss and Tim Essington

13:30 COMPARATIVE INFLUENCE OF OCEAN CONDITIONS ON YELLOWFIN AND ATLANTIC BLUEFIN TUNA CATCH FROM LONGLINES IN THE GULF OF MEXICO - Steven L. H. Teo and Barbara A. Block

13:50 THE INFLUENCE OF ENVIRONMENTAL VARIABILITY ON ATLANTIC BLUEFIN TUNA (*THUNNUS THYNNUS*) GROWTH, MIGRATION, AND REPRODUCTION - Erik W Chapman, Walter J Golet, and Molly Lutcavage

14:10 SPATIAL AND TEMPORAL DISTRIBUTIONS OF AGE-0 PACIFIC BLUEFIN TUNA CAUGHT IN JAPANESE TROLL FISHERIES - Momoko Ichinokawa

14:30 LINKING U.S. PACIFIC ALBACORE CPUE TO FINE SCALE SATELLITE ENVIRONMENTAL DATA - A. Jason Phillips and Lorenzo Ciannelli

14:50 Coffee Break

SESSION 2: Ecosystem and Bycatch Studies (Moderator: Nicholas Wegner)

15:10 QUANTIFYING PREDATION ON SKIPJACK AND YELLOWFIN TUNAS: RESULTS FROM A SYNTHESIS OF CONTEMPORARY AND HISTORICAL FOOD HABITS DATA - Mary Hunsicker, Timothy Essington, Robert Olson, Mark Maunder and Enric Cortes

15:30 TECHNOLOGICAL TOOLS FOR ECOLOGICAL RESEARCH ON PELAGIC FOOD WEBS - Robert J. Olson, Brian N. Popp, Jock W. Young, Brittany S. Graham, Gladis A. López-Ibarra, Felipe Galván-Magaña

15:50 TROPHIC CASCADES AMONG THE UPPER TROPHIC LEVELS IN THE CENTRAL NORTH PACIFIC SUBTROPICAL GYRE ECOSYSTEM, 1996 – 2006 - Jeffrey J. Polovina, Melanie Abecassis, Evan A. Howell, and Phoebe Woodworth (presenter)

16:10 SPECIES COMPOSITION OF TUNA SCHOOLS CAUGHT UNDER FADs AND ON FREE SCHOOLS DURING THE 1991-2007 PERIOD, IN THE ATLANTIC AND INDIAN OCEANS - Alain Fonteneau, Sofia Ortega-García and Alicia Delgado

16:30 SPATIAL DISTRIBUTION PATTERNS OF THE BYCATCH OF OCEANIC WHITETIP SHARK (*CARCHARHINUS LONGIMANUS*) IN THE TUNA PURSE-SEINE FISHERY OF THE EASTERN PACIFIC OCEAN - Marlon H. Roman, Alexandre Aires-da-Silva, Cleridy Lennert-Cody and Martín A. Hall

16:50 GILL DIMENSIONS IN FAST, CONTINUOUSLY SWIMMING TELEOSTS: SCOMBRIDS AND BILLFISHES - Nicholas C. Wegner, Chugey A. Sepulveda, Kristina B. Bull, and Jeffrey B. Graham

17:10

SHOWING OF DOCUMENTARY "SUPERFISH – FASTEST PREDATOR IN THE SEA" – Rick Rosenthal

18:30 Dinner
'Welcome Gathering' in the Tavern

Tuesday, 19 May 2009

8:00 Breakfast

SESSION 3: Population Genetics
(Moderator: John Graves)

9:10 GENETIC ANALYSIS OF ATLANTIC BLUEFIN TUNA POPULATION STRUCTURE - John E. Graves and Jan R. McDowell

9:30 BLUEFIN TUNA POPULATIONS IN THE NORTH ATLANTIC DELINEATED BY NOVEL ORGANOCHLORINE TRACERS - Rebecca M. Dickhut, Ashok D. Deshpande, Alessandra Cincinelli, Michele A. Cochran, Simonetta Corsolini, Richard W. Brill, David H. Secor and John E. Graves

9:50 RESOLVING POPULATION STRUCTURE AND ADMIXTURE IN ATLANTIC SWORDFISH (*XIPHIAS GLADIUS*) - Brad L. Smith, Ching-Ping Lu, Jaime R. Alvarado Bremer

10:10 POPULATION STRUCTURE ANALYSIS OF SWORDFISH (*XIPHIAS GLADIUS*) IN THE PACIFIC OCEAN - Ching-Ping Lu, Brad L. Smith, Michael G. Hinton, and Jaime R. Alvarado Bremer

10:30 Coffee Break

10:50 EXAMINATION OF POPULATION CONNECTIVITY OF THE SILKY SHARK (*CARCHARHINUS FALCIFORMIS*) IN THE PACIFIC OCEAN - John R. Hyde, Carol Kimbrell, Suzy Kohin, and Russ Vetter

11:10 THE ADVENT OF HIGH-RESOLUTION-MELTING ANALYSIS (HRMA) TO GENOTYPE HIGHLY MIGRATORY FISHES FOR POPULATION STUDIES AND SPECIES IDENTIFICATION - Jaime R. Alvarado Bremer, Brad L. Smith, and Ching-Ping Lu

11:30 SLOW RATE OF EVOLUTION IN TUNA MICROSATELLITES - Brandon L. Saxton, Jaime R. Alvarado-Bremer and Tiffany Talley-Farnham

12:00 Lunch

SESSION 4: Acoustic Telemetry
(Moderator: Suzanne Kohin)

13:10 MOVEMEMENTS AND SITE FIDELITY OF MANTA RAYS (*MANTA BIROSTRIS)* IN THE KOMODO MARINE PARK, INDONESIA - Heidi Dewar, Peter Mous, Michael Domeier, Andreas Muljadi, Jos Pet, and Jeff Whitty

13:30 BIGEYE TUNA AND ITS FORAGE BASE AT CROSS SEAMOUNT - Réka Domokos

13:50 BEHAVIOR OF SKIPJACK TUNA ASSOCIATED WITH DRIFTING FAD USING ULTRASONIC TELEMETRY IN THE CENTRAL PACIFIC OCEAN - Takayuki Matsumoto, Keisuke Satoh and Mikio Toyonaga

14:10 SUCCESFUL TESTING OF INTER-FISH TRANSMITTERS: THE 'BUSINESS CARD' TAG - Kim Holland, Carl Meyer and Laurent Dagorn

14:30 HAWAII TUNA TAGGING PROJECT 2 - David Itano, Kim Holland and Kevin Weng

14:50 Coffee Break

SESSION 5: Population Modeling and Fisheries
(Moderator: Nathan Taylor)

15:10 A SPATIALLY-STRUCTURED TAGGING MODEL TO ESTIMATE MOVEMENT AND FISHING MORTALITY RATES OF THE BLUE SHARK IN THE NORTH ATLANTIC OCEAN - Alexandre Aires-da-Silva, Mark N. Maunder, Vincent F. Gallucci, Nancy E. Kohler, John J. Hoey

15:30 THE EFFECTS OF TIME-VARYING MOVEMENT HYPOTHESES AND SPATIAL HARVEST POLICIES ON PROJECTED STOCK DYNAMICS OF ATLANTIC BLUEFIN TUNA - Nathan Taylor, Murdoch McAllister, John Neilson, Barbara Block and Gareth Lawson

15:50 SIMULATING THE EFFECT OF FAD DENSITY ON LARGE SCALE MOVEMENTS - Eunjung Kim

16:10 INFERRING THE BIG PICTURE FROM TAGGING SURVEYS: WHY AND HOW TO MERGE HETEROGENEOUS DATASETS - François Royer and Philippe Gaspar

16:30 A DEPLETION ESTIMATOR FOR WITHIN-SEASON MANAGEMENT OF YELLOWFIN TUNA - Mark N. Maunder

16:50 PRELIMINARY ANALYSIS ON LENGTH-FREQUENCY DISTRIBUTIONS OF AGE-0 PACIFIC BLUEFIN TUNA (*THUNNUS ORIENTALIS*) CAUGHT BY JAPANESE SMALL-SCALE TROLL FISHERY - Kazuhiro Oshima, Momoko Ichinokawa, Kotaro Yokawa and Yukio Takeuchi

17:10 UPDATE ON EXPERIMENTAL LONGLINE FISHING HOOKS: EFFECTS ON TARGET AND NON-TARGET SPECIES AND COMMENTS ABOUT POST-RELEASE SURVIVORSHIP - Yonat Swimmer and Jenny Suter

17:30 TEMPORAL AND SPATIAL CHANGES IN THE CONDITION FACTORS OF THE WESTERN PACIFIC BLUEFIN TUNA - Mikihiko Kai and Chien-Chung Hsu

18:30 Dinner
Sushi party in the Tavern – Sashimi donated by Prime Time Seafood, Inc.

POSTER SESSION IN THE TAVERN (see List of Posters)

Wednesday, 20 May 2006

8:00 Breakfast

SESSION 6: Archival and Satellite Tagging – Part 1 (Moderator: Heidi Dewar)

9:10 ELECTRONIC TAGGING IN THE SOUTHWESTERN PACIFIC AND ITS ROLE IN STOCK ASSESSMENT AND CONSERVATION MEASURES FOR BROADBILL SWORDFISH - Chris Wilcox and Karen Evans

9:30 FINE-SCALE MOVEMENTS OF THE WAHOO, *ACANTHOCYBIUM SOLANDRI,* IN THE EASTERN NORTH PACIFIC - C. A. Sepulveda, S.A. Aalbers, S. Ortega-Garcia, D. Bernal

9:50 USE OF SATELLITE TAGGING AND PHOTO IDENTIFICATION METHODS TO STUDY THE BEHAVIOR AND ECOLOGY OF WHITE SHARKS IN THE NORTHEASTERN PACIFIC - Nicole Nasby-Lucas and Michael Domeier

10:10 BIOLOGY OF JUVENILE WHITE SHARKS IN THE EASTERN PACIFIC - Kevin Weng, John O'Sullivan, Chris Lowe, Chuck Winkler, Oscar Sosa-Nishizaki, Barbara Block, Salvador Jorgensen and Christopher Perle

10:30 Coffee Break

10:50 INCORPORATING SEA-SURFACE TEMPERATURE TO THE LIGHT-BASED GEOLOCATION MODEL, TRACKIT - Anders Nielsen, John Sibert and Chi Hin Lam (presenter)

11:10 COLLABORATIVE RESEARCH ON REDUCING POST-RELEASE MORTALITY FOR COMMON THRESHER SHARKS CAPTURED IN THE SOUTHERN CALIFORNIA RECREATIONAL FISHERY - C. Heberer, C.A. Sepulveda, S.A. Aalbers, D. Bernal and S. Kohin

11:30 TAGBASE: A COMPREHENSIVE DATA MODEL AND MANAGEMENT SYSTEM FOR TAGGING APPLICATIONS - Vardis M. Tsontos and Chi Hin Lam

12:00 Lunch

SESSION 7: Archival and Satellite Tagging – Part 2
(Moderator: Kevin Weng)

13:10 ELECTRONIC TAGGING STUDIES OF SAILFISH (*ISTIOPHORUS PLATYPTERUS*) IN EASTERN TAIWAN TO EXAMINE MOVEMENT PATTERNS, HABITAT PREFERENCES AND FISHERIES INTERACTION - Wei-Chuan Chiang, Shin-Chin Fu, Tzu-Lun Huang, Chi-Lu Sun, Wen-Yie Chen, Don-Chung Liu, Wei-Cheng Su and Michael K. Musyl

13:30 HABITAT UTILIZATION OF BLUE MARLIN (*MAKAIRA NIGRICANS*) INFERRED FROM POP-UP SATELLITE ARCHIVAL TAGS AND NICHE PARTITIONING WITH OTHER ISTIOPHORIDS - Daniel J. Dutton and John E. Graves

13:50 MOVEMENTS AND BEHAVIORS OF LEATHERBACK TURTLES IN THE NORTHWEST ATLANTIC EXAMINED USING GPS-LINKED SATELLITE TAGS - Kara L. Dodge, Ben Galuardi, Andrew E. Myers, Molly E. Lutcavage

14:10 TRENDS IN BILLFISH ANGLER CATCH RATES AND BILLFISH TAGGING EFFORT -SUMMARY OF THE SWFSC COOPERATIVE BILLFISH ANGLER RESEARCH PROGRAMS - James Wraith, Suzanne Kohin, Dave Holts and Rand Rasmussen

14:30 Coffee Break

14:50 IS A METAPOPULATION STRUCTURE THE BEST EXPLANATION FOR INTEGRATED PSAT TAGGING RESULTS (1997-2009) FOR ATLANTIC BLUEFIN TUNA? - Molly Lutcavage

15:10 FIRST RESULTS FROM JUVENILE ATLANTIC BLUEFIN TUNA TRACKED WITH X-TAGS - Benjamin Galuardi, Jessica Knapp, John M. Logan and Molly Lutcavage

15:30 POP-UP SATELLITE TAGS REVEAL MOVEMENTS AND BEHAVIORS OF PACIFIC BLUEFIN TUNA IN THE SOUTHERN PACIFIC OCEAN - George Shillinger, Pete Saul, John Holdsworth, Tim Sippel, John Montgomery, Shelton Harley,Alan Swithenbank, Mike Castleton, and Barbara Block

15:50

DISCUSSION PANEL SESSION: High-Tech Science for the Large Pelagics: What Have We Learned From It And How Should It Be Integrated Into Management and Conservation?
(Moderator: Kim Holland)

Panel Members: Alain Fonteneau, Roger Hill, Molly Lutcavage and Mark Maunder

18:30 Dinner – Tuna Barbeque sponsored by American Fisherman's Research Foundation, American Tunaboat Association and Monterey Bay Aquarium
Frontier Village – for gas campfire and social

Thursday, 21 May 2006

8:00 Breakfast

SESSION 8: Life-history studies (Moderator: William Bayliff)

9:10 STUDIES OF YELLOWFIN TUNA EARLY LIFE HISTORY CONDUCTED AT THE IATTC's ACHOTINES LABORATORY, 2008-2009 - Daniel Margulies, Vernon Scholey, Jeanne Wexler, Maria Santiago

9:30 GROWING OLD CRUISING THE COASTS – AGE AND GROWTH OF LONGTAIL TUNA, *THUNNUS TONGGOL*, IN AUSTRALIAN WATERS - Shane P. Griffiths, Gary C. Fry, Fiona J. Manson, and Dong C. Lou

9:50 NURSERY ORIGIN OF YELLOWFIN (*THUNNUS ALBACARES*) AND BIGEYE TUNA (*THUNNUS OBESUS*) IN THE HAWAIIAN ISLANDS - R. J. David Wells, Jay R. Rooker, and David G. Itano

10:10 AGE, GROWTH, AND REPRODUCTIVE DYNAMICS OF STRIPED MARLIN (*KAJIKIA AUDAX)* IN THE SOUTHWEST PACIFIC OCEAN - R. Keller Kopf , Julian Pepperell, and Peter S. Davie

10:30 Coffee Break

10:50 DISTRIBUTION AND ABUNDANCE OF ISTIOPHORID AND XIPHIID LARVAE IN THE NORTHERN GULF OF MEXICO - Jeffrey R Simms and Jay R Rooker

11:10 USE OF ELECTROPOSITIVE METALS TO REDUCE SHARK-FEEDING BEHAVIOR AND SHARK CAPTURE RATES ON BOTTOM SET LONGLINES - John H. Wang, Melanie Hutchinson, Lianne McNaughton, Kim Holland, and Yonat Swimmer

11:30 Business meeting

12:00 Lunch

LIST OF POSTERS

THE ROLE OF THE CAUDAL FIN IN THE FEEDING ECOLOGY OF THE COMMON THRESHER SHARK (*ALOPIAS VULPINUS*) - S.A. Aalbers, J. Donley, J. Ness, T. Young, D. Syme, D. Bernal and C.A. Sepulveda

SUMMARY OF THE 2007 U.S. NORTH AND SOUTH PACIFIC ALBACORE TROLL FISHERIES - Amy Betcher and John Childers

FORAGING ECOLOGY OF TUNAS IN THE SOUTHERN CALIFORNIA BIGHT - Victoria Borchard, Owyn Snodgrass, Heidi Dewar and Robert Fletcher

THE MONTEREY BAY AQUARIUM SEAFOOD WATCH PROGRAM'S SUSTAINABILITY ASSESSMENTS OF TUNA FISHERIES WORLDWIDE - Stephanie Danner

WORLDWIDE HABITAT PREFERENCES OF TUNA AND TUNA-LIKE SPECIES BASED ON LONGLINE CPUE - Florence Dufour and Haritz Arrizabalaga

FEEDING HABITS OF THE BROADBILL SWORDFISH (*XIPHIAS GLADIUS*) SAMPLED FROM THE CALIFORNIA-BASED DRIFT GILLNET FISHERY, 2007-2008 - Antonella Preti, Heidi Dewar and Suzanne Kohin

FEEDING ECOLOGY OF THREE MYCTOPHID FISHES IN THE EASTERN TROPICAL PACIFIC. Joel Van Noord, Robert Olson, and Ron Kaufmann

TROPHIC STRUCTURE AND STABLE ISOTOPE ANALYSIS OF DIET COMPOSITION FOR ALBACORE (*THUNNUS ALALUNGA*), BLUEFIN (*THUNNUS ORIENTALIS)*, AND YELLOWFIN (*THUNNUS ALBACARES*) TUNA IN THE SOUTHERN CALIFORNIA BIGHT. Owyn Snodgrass, Heidi Dewar, Todd Miller, Robert Fletcher

MOONFISH RISING…BIG- OR SMALL-EYE? - Karen E. Underkoffler, Meagan A. Sundberg and John R. Hyde

ABSTRACTS

(in alphabetical order by first name of senior author)

THE ROLE OF THE CAUDAL FIN IN THE FEEDING ECOLOGY OF THE COMMON THRESHER SHARK (*ALOPIAS VULPINUS*) (POSTER)

S.A. Aalbers[1], J. Donley[2], J. Ness[2], T. Young[2], D. Syme[3], D. Bernal[4] and C.A. Sepulveda[1]

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The thresher sharks (Alopiidae) comprise a monophyletic group of pelagic sharks most commonly recognized by their elongate upper lobe of the caudal fin. It has been hypothesized that thresher sharks utilize the elongate fin to stun small-schooling prey during feeding. The bi-functional role of the caudal fin for both thrust production and predation represents a unique adaptation that has not been described for any elasmobranch. Field and laboratory studies were conducted to 1) document the use of the caudal fin during feeding using underwater video 2) examine the caudal fin morphology and 3) investigate the ocular morphology to assess vision in the posterior field. Underwater video records of 30 common thresher sharks revealed that all feeding events (n=25) were initiated with the upper lobe of the caudal fin. Morphological examination of the caudal fin revealed that the dorsal lobe is predominantly comprised of tendinous and cartilaginous support tissues. Both aerobic (red) and anaerobic (white) muscle fibers occurred throughout the entire length of the dorsal lobe. The large dorso-ventral cartilaginous support elements of the thresher shark caudal fin are similar to those described for lamnid sharks and provide a rigid framework for tissue attachment. Lateral ocular abduction was observed upon contact with the rostral ampullae, a protective reflex that may also enhance posterior vision. These findings document the unique role that the caudal fin plays in the feeding ecology of the common thresher shark.

A SPATIALLY-STRUCTURED TAGGING MODEL TO ESTIMATE MOVEMENT AND FISHING MORTALITY RATES OF THE BLUE SHARK IN THE NORTH ATLANTIC OCEAN

Alexandre M. Aires-da-Silva[1,*], Mark N. Maunder[1], Vincent F. Gallucci[2], Nancy E. Kohler[3], John J. Hoey[3]

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Large numbers of blue sharks are caught as bycatch, and have even become the target species in pelagic longline fisheries in the North Atlantic Ocean. The status of the stock is ambiguous due to the limitations of the available fishery-dependent data. Paradoxically, the North Atlantic blue shark is data-rich compared to most of other pelagic shark species worldwide in terms of availability of tagging data. This study presents a spatially-structured tagging model to estimate blue shark movement and fishing mortality rates in the North Atlantic. The model uses the blue shark tag-recovery data of the U.S.-N.M.F.S. Cooperative Shark Tagging Program (1965-2004). Four major geographical regions (two on each side of the ocean) are assumed and rates of annual mixing among regions are estimated. The blue shark fishing mortality rates (F) were found to be heterogeneous across the four regions. While the estimates of F obtained for the western North Atlantic were historically lower than 0.1 yr^{-1}, the F estimates over the most recent decade (1990s) in the eastern side of the ocean are rapidly approaching an estimated reference point for conservation (F_{max}=0.2 yr^{-1}). Because of the particular life-history of the blue shark, these results suggest careful monitoring of the exploitation since the juvenile and pregnant female segments of the stock are highly vulnerable to exploitation in the eastern North Atlantic.

THE ADVENT OF HIGH-RESOLUTION-MELTING ANALYSIS (HRMA) TO GENOTYPE HIGHLY MIGRATORY FISHES FOR POPULATION STUDIES AND SPECIES IDENTIFICATION

Jaime R. Alvarado Bremer[1,2], Brad L. Smith[2], and Ching-Ping Lu[2]

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During the last five decades, genetic studies on tunas, billfishes and swordfish have been aimed to provide information on species identification and phylogenetics, population differentiation and connectivity. This period has been characterized by the arrival of molecular genetics techniques to characterize variation at the DNA level, with the promise that by surveying variation at faster evolving loci it would reveal differences not found with allozymes. Despite these advances, certain aspects of the biology of tunas and billfish pose a unique challenge to population geneticists: high gene flow potential and presumably large effective population sizes could produce very small signals of differentiation, and thereby the challenge to "*separate the wheat from the shaft*". Nevertheless, substantial amounts of population differentiation have been uncovered in several species. Recognizably, most of these examples correspond to differences between basins, although for some species, differentiation within basins has also been reported. In general, however, population differentiation within the Pacific is substantially lower than that observed within the Atlantic or between the Atlantic and Mediterranean basins.

Using swordfish as an example, we find that most of the genetic differences have been revealed using data from mtDNA and nuclear exon-primed-intron-crossing (EPIC) loci. Microsatellite loci have failed to reveal differences within the Atlantic or within the Pacific. Thus, additional informative EPICs could help differentiate swordfish populations, as well as provide sufficient power to identify boundaries and levels of population admixture. There are many technical challenges to genotype variation in nuclear markers, and often several laboratory techniques are required increasing time and expense. In here, we introduce the use of high resolution melting analysis (HRMA) as a rapid (2 min), inexpensive, highly sensitive closed-tube post-PCR genotyping method that does not require labeled probes or a real-time PCR instruments. The entire genotyping process, from PCR to detection can be completed in less than 20 minutes. Using HRMA we efficiently and unambiguously genotyped several EPICs including ldhA, calmodulin, myosin light chain, Olb, and Oty, that are informative for population structure of swordfish. We also demonstrate the use of this technology for tuna species identification.

SUMMARY OF THE 2007 U.S. NORTH AND SOUTH PACIFIC ALBACORE TROLL FISHERIES (POSTER)

Amy Betcher and John Childers

Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
La Jolla, CA 92037

Cooperative surveys between National Marine Fisheries Service (NMFS) and the American Fishermen's Research Foundation (AFRF) began in 1971 which led to the expansion of the U.S. troll fishery to areas north of Hawaii and west of the International Dateline (Laurs, et al., 1975b). The North Pacific albacore troll season can begin as early as mid-April in areas northwest of Midway Atoll. In July and August, fishing effort expands to the east, towards the west coast of North America. Fishing areas along the west coast of North America extend from Vancouver Island, Canada to southern California. Fishing can continue into November if weather permits and albacore remain available to troll gear. From December to April, albacore are also harvested in the South Pacific. This fishery extends eastward from the International Dateline to approximately 120°W between 30°S and 50°S.

Total catch, catch and effort, and size composition data are collected by the Southwest Fisheries Science Center from the U.S. troll fisheries that harvest albacore in the Pacific. Total catch is obtained from landings data collected from the various ports where albacore troll vessels unload their catch. Daily catch and effort data are obtained from logbooks submitted by troll fishermen. The U.S. West Coast Highly Migratory Species Fisheries Management Plan (HMS FMP) was implemented in April 2005 which requires all U.S. fishing vessels targeting HMS (including albacore) in the Pacific to obtain a federal permit and submit copies of their fishing logbook to NMFS for each trip. Size composition data are obtained from port samplers who measure fish after they are unloaded from troll vessels and from length data collected by fishermen during the course of a trip.

A total of 622 vessels landed 11,436 t during the 2007 season compared to 601 vessels that landed 12,524 t in 2006. The most successful catch areas ranged from 43°N to 46°N, between 125°W and 126°W. Total effort increased slightly to 22,218 days in 2007. The average CPUE for the 2007 North Pacific season decreased from 87 fish per day in 2006 to 73 fish per day. Logbook sampling coverage for the North Pacific albacore fishery decreased from 70% in the 2006 season to 64% in 2007. The average fork length of albacore measured during the 2007 North Pacific season is 70 cm (15.6 lb or 7.1 kg). Length-frequency sampling coverage increased to 1.9% during 2007 compared to 1.4% in 2006.

Total catch from the 2006-2007 South Pacific season decreased from 601 t in the 2005-2006 season to 271 t. The annual catch decreased from 585 t in 2006 to 270 t in 2007. Six U.S. troll vessels fished 873 days in the 2006-2007 season compared to ten vessels that fished 1,310 days in the 2005-2006 season. The areas of highest catch for the 2006-2007 South Pacific season ranged between 130°W and 135°W, from 40°S to 45°S and between 155°W and 160°W, from 40°S to 45°S. The CPUE for the 2006-2007 season slightly decreased from 62 fish per day in the 2005-2006 season to 60 fish per day. Logbook sampling coverage for the 2006-2007 South Pacific albacore troll fishery decreased to 85% from 100% in the 2005-2006 season. The average fork length of albacore measured during the 2006-2007 season is 63 cm (11.5 lb or 5.2 kg). Length-frequency sampling coverage decreased from 0.5% in the 2005-2006 season to 0.2% in the 2006-2007 season.

FORAGING ECOLOGY OF TUNAS IN THE SOUTHERN CALIFORNIA BIGHT (POSTER)

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Eco-system management is dependent on establishing trophic links between species. To better understand the trophic ecology of highly migratory species in the Southern California Bight (SCC) the Sportfishing Association of California (SAC) and NOAA Fisheries initiated a biological sampling program in 2007 and 2008. Samples were taken from three tuna species, yellowfin (*Thunnus albacares)* (n=60), northern bluefin (*Thunnus orientalis)* (n=75), and albacore (*Thunnus alalunga)* (n=156*)* tuna, all caught aboard Commercial Passenger Fishing Vessels, as available. Stomach content analysis is ongoing with all prey items counted, length measured or estimated, and identified to species when possible. To date a total of 180 stomachs have been analyzed, most for albacore and yellowfin tuna caught in 2007.

In 2007 for albacore (n=116), fish comprised the dominant prey species by frequency of occurrence (89%), followed by cephalopods (18%) and crustaceans (16%). Teleost prey composition was dominated by anchovy (*Engraulis moradx)* and the frequency of occurrence was 76% in comparison to sardine (*Sardinops sagax)* (44%), and saury (*Cololabis saira)* (0.09%). These results are similar to other studies in the same area. Fish also dominated the stomach contents of yellowfin (n=15), with anchovies (86%) and sardine (80%) occurring in an almost equal percentage of stomachs. In comparison, saury were found in only two stomachs, crustaceans in four and cephalopods in only one. Interestingly, the yellowfin and albacore were caught in close proximity.

While analysis of stomach content for fish collected in 2008 are ongoing, some dramatic differences are apparent. For the three tuna species sampled, the dominant prey type appears to be cephalopods including market squid (*Loligo opalescens*) and the jumbo squid (*Dosidicus gigas*). This striking shift may be associated with the La Niña in 2008. Cold temperature is known to favor squid growth and recruitment. Results suggest that annual fluctuations in environmental conditions can dramatically impact forage available to tunas in the southern California Bight.

THE INFLUENCE OF ENVIRONMENTAL VARIABILITY ON ATLANTIC BLUEFIN TUNA (*THUNNUS THYNNUS*) GROWTH, MIGRATION, AND REPRODUCTION

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Improving our knowledge of migration and reproduction for Atlantic bluefin tuna (ABFT, *Thunnus thynnus*) is central to developing effective management for this heavily exploited, large pelagic species. Over a 20-30 year lifespan ABFT exhibit a broad range of food habits and migratory patterns, supported by an optimized "bauplan", fast growth rates, and a unique, warm bodied physiology. Energy acquisition and utilization is thus likely to be a key component of their complex life history. Recent analyses of electronic tagging and physiological data have provided insight into patterns of movement and somatic condition for juveniles and adults. However, critical elements of ABFT growth, maturation, migratory behavior, and spawning schedules remain unclear. In order to extend our current understanding of the Atlantic bluefin's life history strategy, it is necessary to place field observations into an energetic context, and modeling studies can be an integral part of this process. Results will be presented from simulations of a state-dependent energy allocation and behavior model for ABFT that uses an algorithm optimizing individual life-long fitness under different environmental conditions. Initial simulations investigate the influence of prey variability and the distribution and quality of forage habitat on ABFT growth, maturity, reproductive schedule and migration. Results highlight a range of potential explanations for observed movement and condition patterns while identifying gaps in current knowledge.

ELECTRONIC TAGGING STUDIES OF SAILFISH (*ISTIOPHORUS PLATYPTERUS*) IN EASTERN TAIWAN TO EXAMINE MOVEMENT PATTERNS, HABITAT PREFERENCES AND FISHERIES INTERACTION

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Sailfish (*Istiophorus platypterus*) are widely distributed in tropical and temperate surface waters of the world's oceans. Off Taiwan's eastern coast, sailfish are of substantial economic importance and are seasonally abundant from April to October (peaks from May to July). Sailfish are mainly caught by drift gill nets, although some are also caught by set nets, harpoons, and as incidental bycatch of inshore longline fisheries. There are virtually no discards of sailfish in Taiwan. Although the biology of sailfish has been investigated in eastern Taiwan, there is a paucity of movement studies to examine migration patterns and exchange rates between areas. Electronic tags have enhanced our understanding of the movement patterns and behavior of pelagic fishes. Pop-up satellite archival tags (PSATs) were used to study the movement patterns and habitat preference of 3 sailfish tagged in eastern Taiwan in summer 2008. The 3 sailfish tagged at a set net complex (near the coast of southeastern Taiwan), migrated to the East China Sea over the course of one month. One PSAT, programmed to release after 30 days, provided an aggregate total of 26 monitoring days of depth and temperature data. Two other PSATs released prematurely after periods ranging about 30 to 31 d. Pooled archival data downloaded from the PSATs showed that sailfish spent 64% of their time in the upper uniform mixed above 50 m. Diving depth ranged from 0 to 214 m and ambient water temperature from 18°C to 30°C. Linear displacements ranged from 370 to 1,150 km from deployment to pop-up locations and all were located in the East China Sea. Preference for near-surface depths suggests a greater vulnerability (or selectivity) to capture by gillnets prompting researchers to investigate optimal fishing gears that reduce incidental bycatch for sailfish in eastern Taiwan to meet regional management and conservation objectives.

THE MONTEREY BAY AQUARIUM SEAFOOD WATCH PROGRAM'S SUSTAINABILITY ASSESSMENTS OF TUNA FISHERIES WORLDWIDE (POSTER)

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The Monterey Bay Aquarium Seafood Watch® Program conducts sustainability assessments of wild and farmed seafood products to develop seafood recommendations for consumers and businesses. We define sustainable seafood as originating from sources that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch conducts scientifically rigorous analyses of capture fisheries using the best available data sources and based on five sustainability criteria: 1) inherent vulnerability; 2) stock status; 3) bycatch; 4) habitats and ecosystem impacts; and 5) management effectiveness. These assessments are regularly updated to include the most recent stock assessments and scientific literature, and form the basis for seafood recommendations for consumers, restaurants, chefs and major seafood buyers, including the two largest food service companies in the U.S. The recommendations are provided in various formats for each audience, including online resources, mobile applications (e.g., iPhone Application), buyer's guides, resources for chefs, training materials, scientific reports, and over 27 million regional pocket guides to date (including our new sushi pocket guide).

Tuna is among the top five most popular seafood items in the U.S. by volume. To date Seafood Watch has developed 46 distinct seafood recommendations for tuna fisheries broken down by region and species including albacore, bigeye, bluefin, skipjack, tongol, and yellowfin tuna, contained in 6 peer-reviewed, publicly available reports. The seafood recommendations vary from "Best Choice" to "Avoid" depending on species, region, and fishing method. For example, albacore caught in the South Pacific troll/pole fishery and skipjack caught in the Western and Central Pacific troll/pole fishery are both a "Best Choice" due to healthy stock status, low amounts of bycatch, and low impacts on habitats and ecosystems. Albacore caught in the Mediterranean longline fishery and skipjack caught in the Indian Ocean floating object purse seine fishery are "Avoid" due to critical bycatch concerns (such as bycatch of sharks and sea turtles) and ineffective management. Overall, Seafood Watch recommends that buyers source tuna from more environmentally friendly sources, such as those from moderate to healthy stocks caught with selective gears that cause the least amount of bycatch and ecological damage, and in regions with effective management enforcement.

MOVEMEMENTS AND SITE FIDELITY OF MANTA RAYS (*MANTA BIROSTRIS)* IN THE KOMODO MARINE PARK, INDONESIA

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The giant manta, *Manta birostris,* is globally distributed in tropical and subtropical waters. They are typically observed around near-shore reefs and over seamounts. Through much of their range mantas are taken incidentally in a range of fisheries and they are also targeted in some regions. The location with the largest targeted fishery for manta rays is Lamakera, Indonesia where around 1000 individuals are killed each year. Just to the west of Lamakera is the Komodo Marine Park where mantas are regularly observed by divers and park rangers. To determine whether this group of mantas was a resident population and examine their patterns of habitat use in the park, a study was initiated in 2000 in collaboration with The Nature Conservancy and Park Rangers.

To document the movements of manta rays in the Komodo Marine Park, an acoustic array was installed at up to seven sites in the Park between 2000 and 2003. A total of 41 acoustic tags were deployed in three separate deployments during 2000, 2001 and 2002. Mantas were recorded in the Park for up to 526 days with an average duration of 183 days $\pm$136 days (SD), when mantas made from 3 to 303 individual visits to different sites (median 58 visits)**.** There was a clear preference for three sites, which comprised over 90% of manta activity. The most popular site (German Flag) was off the southern tip of Komodo Island in an area with a high degree of bathymetric structure. Examination of the longest records suggests some site preference with 5 of 7 individuals spending greater than 90% of their time at the location where they were tagged. Using a general linear model it was possible to examine the effects of daytime, lunar phase, aggregation site, season and tidal phase on visitation patterns. The vast majority of visits were recorded during daylight hours at all sites. The strongest effects of both the lunar and tidal phase were apparent in the northern sites with the most visits occurring when tidal intensity was the greatest during full and new moons. The strongest seasonal pattern was observed in the south where no mantas were recorded during the first quarter in any year. This coincides with an increase in temperature and reduction of productivity in this region associated with monsoonal shifts.

For mantas in the Komodo Marine Park, both the direction and intensity of currents on large and small time scales appear to influence the suitability of habitat. The importance of flow patterns is not surprising given that manta rays are frequently observed filter feeding on surface slicks or in convergence zones set up by currents. On shorter time scales, tidal currents had the least impact on visitation patterns where there was the greatest bathymetric diversity. On larger time scales, the seasonal change in productivity and temperature associated with the monsoonal shift reduced the suitability of habitat in the southern regions. From a conservation perspective, the relatively long-term fidelity indicates that marine protected areas centered on aggregation sites could help protect this species from overexploitation. Additional information is needed on the extent of movements when mantas are outside the bounds of the acoustic array.

BLUEFIN TUNA POPULATIONS IN THE NORTH ATLANTIC DELINEATED BY NOVEL ORGANOCHLORINE TRACERS

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North Atlantic bluefin tuna (*Thunnus thynnus*) are highly valued and heavily exploited, and there is a critical need for improved methods to resolve key attributes of this highly migratory species. Low levels of nonachlors relative to polychlorinated biphenyls (PCBs) in fish from the Mediterranean Sea (MS) compared to the western North Atlantic (WNA), suggests that nonachlor/PCB ratios may be unique chemical tags for fish feeding in these geographically distinct ecosystems. PCBs and nonachlors persist in fish and the environment, and are steadily accumulated by bluefin tuna, making them useful tracers of tuna foraging regions over time scales of years. We measured significantly different (two-tailed t-test, $P \leq 0.000003$) ratios of *trans*nonachlor/PCB153 and *cis*nonachlor/PCB187 in young-of-the-year (YOY) bluefin tuna from the MS and WNA that have not undergone a transatlantic migration. Nonachlor/PCB ratios in medium to giant-sized bluefin tuna captured in the Gulf of Mexico overlapped those of WNA YOY reflective of fish that have foraged along the WNA coast with no evidence of biomass accumulation in the MS or mixing of eastern and western stocks in the Gulf of Mexico, a known spawning ground. Conversely, 70% of small school-sized bluefin tuna captured in the WNA had nonachlor/PCB ratios in between the range of values measured for MS and WNA YOY, indicative of fish that have accumulated biomass in both regions and confirming reports of extensive stock mixing in the WNA. Based on length-age relationships, all of these fish were age 2 at the time of collection, and mixing model calculations indicate that the putative fish of eastern origin acquired 31(±10)% (mean ± standard deviation) of their body weight in the MS prior to emigration. This implies that North Atlantic bluefin tuna migrate at age 1 from the Mediterranean to the WNA consistent with the migration patterns of Pacific bluefin tuna (*Thunnus orientalis*). Of 15 large school-size fish collected in the WNA, only one could be distinguished as originating in the MS. This apparently low extent of stock mixing is likely due to complete tissue turnover of the nonachlor/PCB ratios in bluefin tuna of eastern origin that migrated to the WNA at age 1 such that these fish can no longer be distinguished from those of western origin. Complete tissue turnover of the nonachlor/PCB ratios in bluefin tuna of eastern origin while foraging in the WNA suggests that individuals subsequently returning to the MS should be clearly recognizable. Indeed, five of the 38 bluefin tuna collected from the MS (13%) were identified as having recently returned from foraging in the WNA with nonachlor/PCB ratios overlapping those of WNA YOY. These migrants ranged in size from 35 to 178 kg (age 5 to 11 y) and were all captured during the summer fishery, which is suggested to be composed of both resident and migratory fish at a time when Mediterranean bluefin tuna are known to spawn. This novel tracer method exploits large differences in pesticide levels in food webs in geographically distant ecosystems to decipher migration patterns and stock mixing of North Atlantic bluefin tuna. This technique may likewise be useful for acquiring ecological information on other highly migratory species that periodically occupy regions with markedly different levels of long-lived chemical tracers in the food web.

MOVEMENTS AND BEHAVIORS OF LEATHERBACK TURTLES IN THE NORTHWEST ATLANTIC EXAMINED USING GPS-LINKED SATELLITE TAGS

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Similar to other highly migratory species such as tunas, sharks, and whales, leatherback turtles (*Dermochelys coriacea*) spend a significant portion of their lives on the high seas. This cryptic lifestyle has rendered leatherbacks difficult to study beyond nesting beaches. Most research on leatherbacks to date has focused on the inter-nesting period or post-nesting migrations of reproductive females, resulting in a paucity of in-water studies in high latitude foraging grounds. Leatherbacks are considered an endangered species worldwide, and critically endangered in the Pacific, where populations have undergone a precipitous decline over the last two decades. There is an urgent need to collect data on horizontal and vertical habitat use of males, subadults and female leatherbacks in order to address management needs, recovery objectives, and possible impacts of climate change for this species in all ocean basins.

Preliminary results are presented on the movements of nineteen leatherback turtles from two previously unstudied U.S. east coast foraging areas: off Cape Cod, Massachusetts (41°N 70°W, n=17) and off the northern Florida coast (30°N 81°W, n=2). We deployed two models of satellite linked time-depth recorders on leatherbacks during spring 2007 and summers of 2007-2008 (MK10-AF with Fastloc GPS (n=14) and MK10-A (n=5), Wildlife Computers, Inc.). Tags were deployed on adults and subadults of both sexes, of size 123 to 161.5 cm curved carapace length (CCL). Leatherbacks were captured at sea using a breakaway hoopnet (n=12) or accessed through the Massachusetts sea turtle disentanglement network (n=7), and tags were affixed directly to the carapace. Analyses of movement patterns are based on leatherbacks at liberty from 16 to 239 days* (142.1 d average), with distances traveled ranging from 400 to >10,000 km to date. Six of the nineteen turtles remained on the eastern U.S. continental shelf for the duration of the deployment. Of the thirteen turtles that left the shelf, ten undertook ESE migrations, widely dispersing from the northeast U.S. region to low latitude reproduction areas off South America and the Caribbean. Two turtles (the only subadults in our study to migrate off the shelf) took a different heading, migrating primarily in a southward direction. While the start of some individual's migration south varied (from 25 September to 1 January), most did so during October. One leatherback traveled north to the Canada maritime region after tagging and did not assume a southward migration, instead remaining in northern waters for the tracking period (174 d). Turtles traveling on the southeast U.S. shelf in spring 2007 encountered temperatures of 16 to >26°C and occupied depths to about 40-50 m. While on the northeast U.S. and eastern Canada shelf in summer and autumn (2007-2008), leatherbacks experienced ambient temperatures from 4 to >28°C and occupied depths to 200 m. Those migrating off the shelf experienced similar temperature ranges but made dives to > 500 m. Although turtles in our study chose divergent migratory paths, three of the five males that migrated south converged in a relatively small zone around the Windward Islands, likely an important breeding area where males can intercept and copulate with females. Conversely, the four females that migrated south of the Tropic of Cancer were widely dispersed, with two off nesting beaches in Central and South America and two occupying pelagic areas between 10° and 18° N.

BIGEYE TUNA AND ITS FORAGE BASE AT CROSS SEAMOUNT

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Cross seamount in the Hawaiian archipelago is known to aggregate juvenile and subadult bigeye tuna, a population which is heavily targeted by the local fishery. Results from shipboard acoustic surveys indicate that bigeye actively forages at the seamount and are at least partially drawn there by the presence of increased forage, micronekton. Micronekton biomass is consistently higher over the plateau and at the flanks of the seamount than in environments nearby. In addition to biomass, the seamount has an effect on the vertical distribution of micronekton, as several layers occupy the depths of 200-400 m, a layer that is devoid of organisms away from the plateau. Micronekton is observed to be actively swimming against the currents during their diel vertical migratory periods and their composition is different at the seamount than away from it. These facts indicate the presence of resident species. While the effects of the seamount on micronekton extend to slopes that are 800-1000 m deep, bigeye tuna are tightly associated with the 400 m deep plateau or slopes that are not deeper than about 500 m. Bigeye tuna appear at dawn at the upcurrent edge of the plateau to feed on specific micronekton layers which are migrating downward from the shallow scattering layer. At this time, bigeye occupy a very small area of the plateau, are highly mobile, and form very loose aggregations. During the morning hours, bigeye spread over a larger area of the plateau, still feeding. During the afternoon and early evening, bigeye occupy the entire area of the plateau and tend to form thicker aggregations. At around sunset, thick aggregations of bigeye start dispersing and seemingly leave the plateau, to appear next dawn again feeding at the upcurrent edge. It is likely that forming tight aggregations that are spread over the entire area of the plateau results in a decrease in their detectability as these types of aggregations would be easy to miss during acoustic transects.

WORLDWIDE HABITAT PREFERENCES OF TUNA AND TUNA-LIKE SPECIES BASED ON LONGLINE CPUE (POSTER)

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Information about tuna habitat preferences, such as oxygen or temperature, is not extensive in the literature. When it exists, it is based upon tagging data where, unfortunately, there are only a few individuals of interest and the area is limited. The aim of this study is to complete habitat preference knowledge, with information supplied by long-line fisheries. Further, habitat change with time is investigated as well as differences between oceans. With this objective, longline data from all the available fleets of the Atlantic, Indian, and East and West Pacific Oceans were collated. Monthly catch and effort data were available in 5ºx5º grid-boxes, from 1958 to 2006. Environmental data were obtained from coupled (physical and biogeochemical) and spatialized numeric models. Variables used to characterize habitat were temperature (at 5m, 100m and 200m), salinity (at 5m, 100m and 200m), oxygen (at 50m, 100m and 200m), chlorophyll (at 50m, 100m and 200m), the mixed layer depth and sea surface height anomaly. In order to associate spatial CPUE, to spatial environmental variables, quotient analyses were undertaken. Preliminary results indicate that: (i) some species have a different tolerance range, according to the ocean; and (ii) according to the decadal time period, habitat preference can shift, at least for some of the variables.

HABITAT UTILIZATION OF BLUE MARLIN (*MAKAIRA NIGRICANS*) INFERRED FROM POP-UP SATELLITE ARCHIVAL TAGS AND NICHE PARTITIONING WITH OTHER ISTIOPHORIDS

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Blue marlin *(Makaira nigricans*) are overfished in the Atlantic Ocean, with the vast majority of fishing mortality resulting from the pelagic longline fishery targeting tunas and swordfish. Population assessments of blue marlin have traditionally used standardized catch-per-unit-effort (CPUE) data, but these data have been affected by a shift in pelagic longline fishing practices to deeper water. One method for standardizing CPUE data for changes in fishing practices is a habitat-based standardization that models effort as a function of the vertical distribution of both the fishing gear and the target or bycatch species. For this model to be successfully applied to blue marlin population assesment, the vertical habitat and feeding preferences of blue marlin must be known. Pop-up satellite archival tags (PSATs) provide a means of collecting high resolution vertical habitat utilization data for released fish.

For this study, 45 Microwave Telemetry, Inc. PTT-100 HR model PSATs were deployed on blue marlin caught in the recreational fisheries off the U.S. East Coast, northern Caribbean, Venezuela, and Brazil. The tags were programmed to release after ten days and recorded depth, temperature, and light levels approximately every 90 seconds. All 45 tags successfully released from the fish, with one tag releasing prematurely after five days. Recovery of archived data has been very high (mean: 85.7%). Based on depth profiles, two mortalities have been identified. Dive characteristics from the 43 surviving fish including maximum depth, dive duration, change in temperature, and interdive interval are being used for analysis of habitat utilization and to investigate possible differences in habitat utilization across sampling locations and seasons within the western Atlantic.

White marlin (*Kajikia albida*) and sailfish (*Istiophorus platypterus*) also occur with blue marlin in the western Atlantic. To investigate behavioral differences and potential niche partitioning between these three istiophorids, habitat utilization of the blue marlin is being compared with 47 white marlin and 17 sailfish previously published, as well as an additional 39 unreported white marlin, all of which were tagged with similar ten day, high resolution tags in many of the same locations. The high resolution habitat utilization information from this study provides a better understanding of the behavior of istiophorids in the western Atlantic and their potential interactions with fishing gear, allowing for a more informed and accurate assessment of these stocks.

OCEANOGRAPHIC INFLUENCES IN REGIONAL DIFFERENCES OF MERCURY IN YELLOWFIN AND BIGEYE TUNA

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Tuna have unique ecological roles in pelagic ecosystems and support widespread fisheries that contribute significantly to food production and economies. As one of the principle predators in open ocean ecosystems, tuna can have among the highest mercury (Hg) levels of all marine fishes. Government agencies report their regulations and public health warnings at the species level, however a large range of concentrations has been found within the same tuna species. The objective of this study is to determine if Hg levels are related to oceanographic characteristics in their environment. The bioavailability of Hg in the marine water column has been tied to sulfide, dissolved oxygen, and dissolved organic matter. Given the evidence that tuna tend to reside within specific regions of the Pacific, their exposure to Hg may vary with location. Linear models will be used to determine if oceanographic characteristics relate to differences found in yellowfin and bigeye tuna Hg levels within the eastern and central tropical Pacific. Results of this pilot study will be presented.

SPECIES COMPOSITION OF TUNA SCHOOLS CAUGHT UNDER FADs AND ON FREE SCHOOLS DURING THE 1991-2007 PERIOD, IN THE ATLANTIC AND INDIAN OCEANS

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This conference analyzes species composition of tuna schools caught in the Atlantic and Indian oceans since 1991, based on the intensive species and size sampling that have been permanently conducted in these 2 oceans between 1991 and 2008. This study allows to show the pattern and variability of the time and area species composition and sizes taken on FAD and on free swimming tuna schools. This analysis has been done on a subset of selected samples, keeping only the perfectly well identified and homogeneous sets during the period. Each of the set has been classified within 12 categories as a function of its species composition. The paper analyses the importance and changes of each category of sets as a function of the environmental fishing zones of the purse seine fishery. This analysis shows great similarities between the 2 oceans, and major and permanent differences in the structure of FAD and free schools.

FIRST RESULTS FROM JUVENILE ATLANTIC BLUEFIN TUNA TRACKED WITH X-TAGS

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Conventional tagging studies reveal that some juvenile Atlantic bluefin tuna (*Thunnus thynnus*), ABFT, make trans-Atlantic crossings, but little else is known about their winter and springtime movements or behavior. Since 1996, PSAT tags applied to adult sized fish have produced a large body of information on ABFT habits, but until recently, these tags were too large to be applied to small individuals. In 2005, we began an electronic tagging program for juvenile ABFT (70 - 122 cm curved fork length, CFL) using implanted archival tags. None have been recovered to date, which precludes rapid advances in knowledge through fishery independent information. In 2007, with the new capabilities offered by the X-tag (Microwave Telemetry, Inc) we began a multi year study of year-long movements, depths, and temperature associations of juvenile ABFT.

In 2007 we deployed 32 X-tags on bluefin (105 to 178 cm CFL) tagged and released off Cape Cod in the Gulf of Maine, producing 21 tracks up to one year long. We corrected light based locations received from our tags using state space Kalman filtering and bathymetric correction. Data returned indicates that these fish stayed mainly on the continental shelf and in the Gulf Stream, with some individuals residing in the central Atlantic and South Atlantic Bight regions. Juvenile bluefin experienced a wide range of temperatures (5 - 25 ^{o}C) and ventured as deep as 600 m, although it appeared that some fish initially may have had shallow depth patterns that triggered extremely premature release of the tags (n = 5). Bluefin that retained their tags for the full year either returned to the Gulf of Maine (N = 5) or were off the coast of New Jersey (N = 2) when the tags popped off.

GENETIC ANALYSIS OF ATLANTIC BLUEFIN TUNA POPULATION STRUCTURE

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Atlantic bluefin tuna are thought to comprise two distinct stocks with spawning grounds in the Gulf of Mexico and Mediterranean Sea. Previous genetic studies employing analyses of both mitochondrial and nuclear gene regions have demonstrated significant heterogeneity between young-of the-year (YOY) bluefin taken from the western and eastern Atlantic, as well as adults taken from the Gulf of Mexico and Mediterranean Sea during the spawning season. Recent electronic tagging studies and investigations of otolith stable isotopes indicate that there is considerable mixing of the two stocks throughout the North Atlantic. In this study, we are attempting to use genetic signatures of YOY and spawning bluefin tuna from the Gulf of Mexico and Mediterranean Sea to estimate the contribution of eastern and western stocks to collections of school bluefin tuna (1 – 4 year old) and giant bluefin tuna (8+ years old) collected off the U.S. Atlantic coast in multiple years.

Samples are currently being screened for genetic variation at 8 nuclear microsatellite loci used in our previous genetic analyses of YOY bluefin tuna, as well as six loci that we recently developed from expressed sequence tags (ESTs). In addition, we are sequencing a subset of samples at the mitochondrial control region. To date, complete microsatellite genotypes have been obtained for more than 800 samples. All loci reveal variation, with 3 – 20 alleles per locus. Control region sequences have been generated for about 650 individuals. Using YOY bluefin tuna as well as adults taken from breeding grounds during spawning season as baseline samples, we are assessing the utility of various methods for assigning individuals to and excluding individuals from source populations based on their multilocus genotypes. We are also performing maximum likelihood estimates of mixture proportions in different age classes. Finally, we are using a cluster analyses to test the assumption of two stocks based on genetic data without prior information about location of capture. We will present the results of these analyses including preliminary estimates of mixture proportions within various age classes.

GROWING OLD CRUISING THE COASTS – AGE AND GROWTH OF LONGTAIL TUNA, *THUNNUS TONGGOL*, IN AUSTRALIAN WATERS

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Longtail tuna, *Thunnus tonggol* (Bleeker, 1851), is an economically important tuna that inhabits the tropical and subtropical waters of the Indo-Pacific region. Their distribution is unique compared to other wide-ranging oceanic *Thunnus* species in that they exclusively occupy the neritic regime surrounding landmasses. It is the second smallest of eight *Thunnus* species growing to a maximum size of 136 cm FL and 35.6 kg. This study investigated the age and growth of longtail tuna by examination of annual growth increments in sectioned sagittal otoliths from 461 fish (238-1250 mm FL) sampled from tropical and temperate waters in northern and eastern Australia between February 2003 and April 2005. Edge type analysis and daily ageing revealed that longtail tuna deposit a single annual growth increment peaking between August and October. Age was therefore determined for all fish by counting annual growth increments. Ages ranged from 154 days (238 mm) and 18.7 years (1117 mm), with the majority of fish aged being 3-9 years. Five growth models (specialised von Bertalanffy, generalised von Bertalanffy, Schnute-Richards, Gompertz and logistic) were fitted to length-at-age data, all of which indicated the species is relatively slow-growing and long-lived. Recaptures of two tagged fish at liberty for 6.2 and 10.5 years support this notion. The Schnute-Richards model provided the best fit to length-at-age data with the model parameter estimates (sexes combined): L_∞ = 135.4 cm FL, k = 0.223 yr^{-1} and t_0 = 0.120 yr^{-1}, δ = 150.0, v = 0.019, $\gamma = 2.7 \times 10^{-8}$. This is the first comprehensive study of longtail tuna growth using otoliths, which has revealed that longtail tuna grow substantially slower and live longer than other small tropical tunas. Coupled with their restricted neritic distribution, longtail tuna may be vulnerable to overexploitation by fisheries and caution needs to be exercised in managing the species until more reliable biological and catch data are collected to assess the status of the population.

COLLABORATIVE RESEARCH ON REDUCING POST-RELEASE MORTALITY FOR COMMON THRESHER SHARKS CAPTURED IN THE SOUTHERN CALIFORNIA RECREATIONAL FISHERY

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The common thresher shark (*Alopias vulpinus)*, is one of 13 economically important highly migratory species actively managed under the Fishery Management Plan for U.S. West Coast Highly Migratory Species (HMS) Fisheries. Thresher shark harvest is monitored under a conservative harvest guideline management strategy due to the species' vulnerability and low resiliency to overexploitation. In southern California there is a popular recreational fishery that targets the common thresher shark utilizing heavy troll gear with large J-hooks resulting in a high percentage of sharks being foul-hooked by the tail. Foul-hooked sharks have a reduced capacity for ram ventilation, which may result in reduced catch-and-release survivorship in this fishery. This is problematic as one of the continued conservation tools used by managers and marine conservation groups alike is to promote the practice of effective catch-and-release. The widespread use of tail-hooking techniques by recreational fishers and the unknown fate of released thresher sharks complicate the design of an effective management strategy for this valuable resource. Further complicating the management of this fishery is the presence of large gravid females in the Southern California Bight during the peak spring fishing months of this fishery. The increased fight times on these large, reproductively mature sharks may also be having an adverse impact on reproductive success.

A NOAA Fisheries Bycatch Reduction and Engineering grant was awarded in 2008 to: (1) assess the survivorship of rod-and-reel captured and released thresher sharks, (2) quantify the physiological indicators of capture stress (e.g., blood and tissue biochemistry, stress proteins) associated with both tail-hooked and mouth-hooked individuals, and (3) investigate potential gear and technique modifications that may enhance survivorship. The survivorship assessment is being conducted using pop-off satellite archival tags (PSATs) deployed on sharks hooked and fought using the same techniques that are employed in the southern California recreational thresher shark fishery.

A total of 28 thresher sharks were caught and released during the 2008 season. The large majority (93 percent) of thresher sharks captured during this work were tail-hooked. Twelve PSAT transmitters were deployed by the research team on adult and sub-adult thresher sharks caught using the tail-hooking technique. Preliminary findings from this study suggest a post-release mortality estimate of 17 percent for the sharks sampled thus far (155-230 cm FL). All adult tail-hooked thresher sharks (> 155 cm FL) captured during the study period were tagged and released. Once at the boat the sharks appeared exhausted and lethargic; however, all individuals with fight times less than 85 minutes survived the acute effects of capture as determined by the PSAT records. The two largest individuals with fight times in excess of 105 minutes did not survive. These preliminary data suggest that large tail-hooked thresher sharks exposed to prolonged fight times have increased mortality rates when compared to smaller individuals. Further NOAA Fisheries Bycatch Reduction and Engineering-funded work will be conducted in 2009 on larger individuals to more fully evaluate this work.

SUCCESFUL TESTING OF INTER-FISH TRANSMITTERS: THE 'BUSINESS CARD' TAG

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Four prototype "business card" tags produced by Vemco (Canada) were deployed on Galapagos sharks found in association with a shark ecotourism dive site on the north shore of Oahu, Hawaii. Approximately 30 other sharks had been previously tagged with coded acoustic transmitters at this site and the site was equipped with a standard VR3 acoustic data logger. The business card tag is capable of both transmitting and receiving (and storing) coded acoustic transmissions thereby potentially allowing free swimming animals to exchange codes when they come within range of each other. Two of the four business card tags were recovered and analysis of the stored data indicated that they performed qualitatively as well as the fixed VR3 unit in detecting transmitters carried by the other sharks (including the other 'business card' tags) and that the free ranging sharks equipped with business card tags detected other sharks that were not in the vicinity of the fixed monitor. Details will be presented and the potential applications of this system discussed.

QUANTIFYING PREDATION ON SKIPJACK AND YELLOWFIN TUNAS: RESULTS FROM A SYNTHESIS OF CONTEMPORARY AND HISTORICAL FOOD HABITS DATA

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The selective removal of marine life can cause profound restructuring of marine food webs. There is accumulating evidence that reductions of predator stocks through intense fishing pressure can induce a surge in productivity of low trophic level stocks. In the tropical Pacific Ocean, there have been fisheries-induced declines in the biomass of top trophic level predator populations, including large-bodied tunas, sharks, and marlins. The goal of our project is to evaluate the importance of intra-guild predation and cannibalism on Pacific tuna population dynamics and to determine whether it is biologically plausible for top predators to exert top-down control on juvenile skipjack (*Katsuwonus pelamis*) and yellowfin (*Thunnus albacares*) tunas. Here we present our first steps toward this goal. In this paper, we compile extensive historical and contemporary food habit studies to (1) identify the sources, magnitude, and variability in predation on skipjack and yellowfin tunas, (2) determine the life history stages targeted by top predators, and (3) estimate the reproductive potential of tunas vulnerable to these predators. Our results indicate that requiem sharks (*Carcharhinus* sp.) and hammerhead sharks (*Sphyrna* sp.) are important predators of yellowfin tuna while sailfish (*Istiophorus platypterus*) and amberjack (*Seriola rivoliana*) are main predators of skipjack tuna. We also found that a wide size range of tunas are vulnerable to top trophic level predators, including sub-adult and adult tunas life stages which hold reproductive value. This indicates that predation could potentially affect the recruitment of juvenile skipjack and yellowfin tunas as well as their population growth rates. The findings from this study will be used for simulation and mass-balance modeling to explore the implications of predation and predator removals on the productivity of tuna populations.

EXAMINATION OF POPULATION CONNECTIVITY OF THE SILKY SHARK (*CARCHARHINUS FALCIFORMIS*) IN THE PACIFIC OCEAN

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Despite the high occurrence of silky shark (*Carcharhinus falciformis*) as bycatch in pelagic tuna fisheries little is known about their migratory behavior, stock structure, and abundance trends. Available data suggest that silky shark abundance is declining worldwide, suggesting a need for management. In order to facilitate a proper management plan, the genetic stock structure for the species needs to be examined. Due to their ubiquitous nature the null hypothesis would be a single homogenous stock, at least within individual ocean basins. To test this hypothesis genetic information from specimens collected throughout the Pacific is being examined. Currently our analyses incorporate DNA sequence data from the mitochondrial control region and size polymorphisms from microsatellite and AFLP loci. Our preliminary results reject the null hypothesis of panmixia and support the existence of stock structure in the Eastern Pacific. However, additional samples are needed to properly assess the Western Pacific. In light of our findings we feel there is a need for further tagging studies and increased temporal sampling of silky sharks to better define migratory behavior and stock boundaries.

SPATIAL AND TEMPORAL DISTRIBUTIONS OF AGE-0 PACIFIC BLUEFIN TUNA CAUGHT IN JAPANESE TROLL FISHERIES

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The early life history stages of Pacific bluefin tuna (*Thunnus orientalis*, PBF) observed around Japanese Islands are age-0 fish which are initially caught in Japanese small-scale troll fisheries in the western and southern area of Japan. These young-of-the-year fish are known to migrate from two primary spawning grounds: one in the northwestern Pacific Ocean off Taiwan and Nansei Islands, and another in the Sea of Japan. The PBF spawning season occurs from April to June in the northwestern Pacific Ocean, while it occurs from end of June to August in the Sea of Japan. It is important to account for the existence of these two recruitment groups in estimating the magnitude of annual recruitment for stock assessment as well as for understanding their life history pattern and recruitment mechanisms.

However, little is known about the processes that determine the survival rates and migration patterns of PBF born in the two different spawning areas. Direct observations from research vessels are currently too limited to investigate their spatial and temporal distributions because juvenile PBF are very elusive and difficult to capture with survey gear. Although some ongoing research cruises in Japan target on juveniles and larvae of PBF, only qualitative information could be obtained due to the difficulty to survey. The information from troll fishery has been also limited because fishermen using troll gear have no obligation to submit their logbooks. There is little information on when and where the 0 age-old fish have been caught by the troll fisheries in fine temporal and spatial resolution. At present, the best available information about the distribution of age-0 PBF are the monthly catch in weight from troll fisheries by prefecture, some partial information on troll fishing effort and a few limited length measurements from port sampling conducted since 1994.

This presentation summarizes the rough spatial and temporal distributions of age-0 PBF catches from troll fisheries using the available fishery data. The fishery data in the resolution of prefecture and month would contain some good information that enable us to draw rough pictures of recruitment process of age-0 PBF form the two different spawning areas. The summaries suggest some alternative hypotheses about the migration routes of age-0 recruits from the two different spawning areas. The hypothesized migration routes are also compared to oceanographic parameters such as sea surface temperature to investigate whether these parameters influence the migratory pattern.

HAWAII TUNA TAGGING PROJECT 2

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The first *Hawaii Tuna Tagging Project* (HTTP) was funded by the PFRP to investigate movement, interaction, exploitation and aggregation influences relative to Hawaii-based yellowfin and bigeye fisheries as they existed during the 1990s. The project was highly effective in its use of conventional tag release and recapture data to estimate residence times and transfer rates at and between Hawaii pelagic fishing grounds and fisheries. Size and species-specific estimates of natural and fishing mortality were also generated from the tagging data. However, most of the tagging effort centered on the Cross Seamount and offshore areas to address interaction and movement related issues surrounding a controversial *offshore handline fishery* for juvenile bigeye tuna.

Since the conclusion of the HTTP several changes to Hawaii-based pelagic fisheries have occurred. Participation and landings in the offshore handline fishery have declined while portions of the fishery have evolved to target non-tuna species and larger, higher value tuna. Private "bigeye" *FADs* set close to the main islands have proliferated while conflict issues surrounding the near shore Hawaii state *FAD* system remain unresolved. Fishery competition and conflict issues will likely increase in the face of declining stock condition and the advent of restrictive management of WCPO tuna stocks.

The *Hawaii Tuna Tagging Project 2* (HTTP2) will use a combination of conventional and electronic tag types to address these issues while including skipjack tuna in the study. Conventional mark/recapture data will be used to update life history and movement parameters for bigeye and yellowfin while providing the first such estimates for skipjack tuna in Hawaii. Ongoing acoustic studies on the *FAD* associated vertical behavior of bigeye and yellowfin will also be expanded to include skipjack in mixed-species aggregations. Field operations will attempt to release tagged tuna from a variety of school types including free schools and focus on near shore areas where most of the small boat fisheries operate. However, a separate component of the project will examine the diurnal vertical behavior of bigeye tuna and lustrous pomfret (*Eumegistus illustris*) on the Cross Seamount where a seamount-associated fishery for pomfrets and deep-swimming tuna has developed in recent years. The HTTP2 was designed and is being implemented as a sub-regional component of the WCPO-wide *Pacific Tuna Tagging Program* endorsed by the WCPFC and implemented by the SPC Oceanic Fisheries Programme with arrangements for standardized protocols and data sharing.

The HTTP2 is supported by the PFRP. Supplementary funding to support collaborative research on the lustrous pomfret is being provided by the National Marine Fisheries Service, Pacific Islands Fisheries Science Center.

TEMPORAL AND SPATIAL CHANGES IN THE CONDITION FACTORS OF THE WESTERN PACIFIC BLUEFIN TUNA.

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Some condition factors (CFs) are used to be indicators of the fitness of a fish (e.g. Fulton's CF). Change in the CF is considered to be affected by food availability, physical factors and the physiology of fish, including its gonad maturity stage. The objective of this study is to make clear the reason for the seasonal migration around Japan and Taiwan of the western Pacific bluefin tuna (PBF) from perspectives on the feeding and spawning behaviors throughout the investigation of the temporal(monthly) and spatial changes in CF of PBF.

Weight-Length (W-L) datasets of Pacific bluefin tuna caught by Japanese fisheries from 1994 to 2007 and by Taiwanese fisheries in 1997 and 1998 were used, and sorted by a fish smaller and larger than 100cm as a mature and an immature fish, because PBF is known to start maturation at around 100cm. A W-L relationship was estimated by nonlinear least squares using a power function. The datasets were separated by months and 10 areas around Japan and Taiwan. An alternative of commonly used CF is defined as follows; CFr(relative CF)=observed body weight/expected body weight. The expected body weight was calculated by the W-L relationship obtained by the above. Significant differences of the CFr by months and areas in each datasets were tested based on the binomial test (the null hypothesis that the expected probability of occurrence of fatter individual is 0.5(50%)).

The CFr of mature fish was significantly higher from March to May and lower in June in the waters of the south western North Pacific Ocean, and was significantly higher from May to July and lower in August in the Sea of Japan. These findings supported that comparatively fatter individuals were gathered in the spawning area in the spawning season and those individuals were lost their weight in the water in the end of the season. This may be caused by the reduced feeding activities in the spawning season. In addition, the CFr of mature fish was increased from autumn to winter in the northern area of Japan (around Hokkaido) where the food of PBF is considered to be rich in the seasons. This finding supported that the mature fish moved to the northern area of Japan after spawning season and start feeding to prepare for spawning.

SIMULATING THE EFFECT OF FAD DENSITY ON LARGE SCALE MOVEMENTS

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The effect of fish aggregating device (FAD) density on large scale movements of skipjack tuna (*Katsuwonus pelamis*) in the western tropical Pacific Ocean is simulated in this study. Fisheries techniques using FADs have been developed by industrial tuna purse seiners to increase their catch since the 70's. In the three major oceans, tuna catches by purse seiners working around FADs account for around half of the total catches. Despite the profound increase of FAD fisheries utilizing aggregating behavior of tunas, little is known about how FADs modify movement behavior of tuna. In our study, we hypothesized that the high density of FADs inhibits skipjack movement by reducing the diffusive components of their behavior. Tag movement was simulated using an advection-diffusion reaction model (ADRM) in which diffusion is assumed to be a function of FAD density. The model is applied to the SPC Regional Tuna Tagging Project (RTTP) skipjack tagging data. The predicted tag recaptures from the simulation will be used to test the ability of a maximum likelihood estimation procedure to estimate a "FAD effect" from tag recapture data.

AGE, GROWTH, AND REPRODUCTIVE DYNAMICS OF STRIPED MARLIN (*KAJIKIA AUDAX)* IN THE SOUTHWEST PACIFIC OCEAN

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Striped marlin are the most commercially valuable species of billfish in the family Istiophoridae and are an important recreational resource throughout their distribution in the Indo-Pacific region. The sustainability of current fishing practices for this species is uncertain due to a lack of base line biological information required for stock assessment and ecological risk models. Age estimates and reproductive condition were examined from a sample of 489 striped marlin that were collected from five exclusive economic zones (EEZ's) in the southwest Pacific Ocean (0-45°S latitude, 145°E-145°W longitude). Ages were indirectly validated using otolith micro-increment counts, fin spine annuli counts, and a marginal increment analysis. Ages ranged from 130 estimated days in a 4kg whole weight (1120 mm, Lower Jaw – Fork Length, LJFL) male to eight estimated years in a 168kg (2871 mm, LJFL) female. Growth of young striped marlin was rapid, with both sexes attaining 70-75% of their maximum body length (~2749 mm, LJFL) during the first two years of life. Striped marlin showed significant sub-regional differences in age-structure and spawning condition with the oldest fish common at higher latitudes and increased relative abundance of juveniles in tropical and equatorial waters. Histological examination of ovaries and testis showed that spawning intensity peaked along a latitudinal band between 18-30°S extending from the east coast of Australia to Fiji during the fourth quarter of the year. Female striped marlin matured between the ages of one and three and released multiple batches of up to 4.8 million hydrated oocytes per spawning event. The present investigation represents the first indirectly validated growth model for striped marlin and revealed distinct age-specific distribution patterns that changed with reproductive condition.

POPULATION STRUCTURE ANALYSIS OF SWORDFISH (*XIPHIAS GLADIUS*) IN THE PACIFIC OCEAN

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There is substantial controversy about the population structure of Pacific swordfish, and different models have been proposed including two, three and four, subpopulations. Genetic differentiation of Pacific swordfish has been reported by using locus ldh-A (Alvarado Bremer et al. 2006), but not by an extensive survey using microsatellite data (Kasapidis et al. 2008). In this study, we compare samples from six regions: Northwest Pacific (Japan), Southwest Pacific (Australia), Central North Pacific (Hawaii), Northeast Pacific 1 (Mexico-Temperate), Northeast Pacific 2 (Mexico-Tropical), and Southeast Pacific (Chile). Seven Exon-Primed Intron-Crossing (EPICs) nuclear markers were characterized using High Resolution Melting Analysis (HRMA). In here we report genetic differences with locus OLB, consistent with results obtained previously with locus ldh-A. In addition, the comparison of Mexican tropical and temperate samples yields significant differentiation, in agreement with a recently proposed boundary for the NEPO derived from swordfish fisheries data (Ichinokawa and Brodziak 2008). Sample sizes and the coverage of the samples must be increased to resolve the mixing zones in the Pacific Ocean.

IS A METAPOPULATION STRUCTURE THE BEST EXPLANATION FOR INTEGRATED PSAT TAGGING RESULTS (1997-2009) FOR ATLANTIC BLUEFIN TUNA?

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Since 1997, large (185 $\pm$ 78 kg) Atlantic bluefin tuna (ABFT) released with PSATs (n= 356) on the NW Atlantic shelf displayed at least three to four dispersal patterns. In recent years, about a third of individuals tagged each season eventually entered the Gulf of Mexico, while none have entered the Mediterranean Sea while tracked. The other contingents travelled to the central north or east Atlantic, remained near the Gulf Stream system, or ventured to the Bahamas/Antilles region. The majority of fish with tags remaining on until the following summer and fall did not enter a known spawning area during their presumed reproductive period (April- June). These patterns have persisted for over 12 years of tagging. Of tag deployments meeting 11- 12 month missions, our tracks revealed that most fish return to their tagging location the following season, even after dispersing to different regions of the Atlantic.

The assumption that fish that don't visit known spawning areas are sexually immature is not supported by maturity evaluation of fish sampled over the same time period and geographic region as our PSAT tagging program. Our findings suggest either that non annual spawning is a predominant feature of a large number of ABFT, or more likely, that spawning occurs over a much broader range and time period than assumed in the prevailing biological and management paradigm. While micro-constituent and genetics data clearly distinguish at least two ABFT stocks, our integrated tagging data and biological sampling results support a more complex stock substructure for ABFT, as first suggested by Fromentin and Powers (2005). Evidence from historic fisheries, conventional tagging, behavioral patterns, and other electronic tagging studies also support a metapopulation structure.

STUDIES OF YELLOWFIN TUNA EARLY LIFE HISTORY CONDUCTED AT THE IATTC's ACHOTINES LABORATORY, 2008-2009

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

During 2008-2009, several ongoing investigations of yellowfin early life history were continued or completed. A multi-year study was completed on the tolerance of yellowfin eggs and larvae to limiting levels of water temperature and dissolved oxygen. The study was designed to gain a better understanding of the physical factors that control the spatial and temporal distribution of yellowfin eggs and larvae in oceanic habitats.

Ongoing analyses of the effects of microturbulence on yellowfin larval survival were also continued and expanded. Earlier analyses had estimated the optimal range of microturbulence for yellowfin larval survival during the first week of feeding in the laboratory. The analysis was expanded to estimate optimal wind speeds for yellowfin larval survival in mixed-layer habitats in the ocean. A 20-year period (1987-2007) of wind speeds in the eastern Pacific Ocean (EPO) was examined to investigate correlations between optimal wind speeds and yellowfin recruitment in the EPO. The analysis was conducted for selected 2º x 2º areas of the EPO. Generally, positive correlations were found for areas south of 10º N latitude and east of 100º W longitude. Correlations became negative in areas more westward and northward.

Additional studies supported by Panama's Secretaria Nacional de Ciencia y Tecnología e Innovación (SENACYT) were continued during the past year. These studies included an investigation of the feasibility of collecting and holding Pacific sailfish and wahoo (a collaborative study with the Aquaculture Program of the University of Miami), and a project to develop an algae reference collection at the Achotines Laboratory.

BEHAVIOR OF SKIPJACK TUNA ASSOCIATED WITH DRIFTING FAD USING ULTRASONIC TELEMETRY IN THE CENTRAL PACIFIC OCEAN

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Nowadays, many of purse seine sets are targeting tuna schools associated with floating objects including FADs (Fish Aggregating Devices), which causes of incidental catch of small bigeye and yellowfin tunas. Behavior of small tunas associated with drifting FADs, which is essential for considering gear effect, is not well known especially as for skipjack tuna probably because of difficulty in handling and monitoring the fish. Therefore, behavior of skipjack tuna was monitored using both continuous and coded transmitters (ultrasonic transmitter, pinger). Swimming depth and approximate location are recorded by continuous or coded transmitter and biotelemetry system.

This study was conducted in the equatorial area of central Pacific Ocean (around 5-7˚N, 177˚E-177˚W) by R/V *Shoyo-maru* (Fisheries Agency of Japan) in cooperation with chartered purse seine vessel No.18 *Taijin-maru* in August 2005. At first one skipjack tuna individual (65.2cm FL) was caught by jigging and released with a continuous transmitter (VEMCO V16P-1H, 62mm in length, 16mm in diameter, 9g in water) in the morning of August 7th. The vessel followed the fish and so the fish was tracked even when it left the FAD. The fish sometimes left the FAD temporarily (usually less than 2 hours). One time, the fish left the FAD for about 22.5 hours with maximum distance from the FAD about 9.7km, suggesting that skipjack tuna has ability of navigating. Clear difference of swimming depth was observed between day and night and by association with the FAD, that is, swimming depth during daytime was deeper than that during night especially when the fish was away from the FAD, and swimming depth during daytime was deeper when the fish was away from the FAD than when it was associated with the FAD. Swimming depth was mostly 100-150m during daytime when the fish was away form the FAD, and otherwise usually shallower than 100m. Swimming speed of the fish (substituted by ship speed) when it was away from the FAD was usually slower than 4.0 KT, and swimming speed during daytime (average 2.15 KT) was a bit faster than that during night (average 1.81 KT), although the mode of the speed was almost the same (around 2.0 KT).

Several skipjack tuna individuals were additionally caught around the same FAD by jigging or trolling and released with VEMCO coded transmitter, starting 3days after the beginning of monitoring the fish. After this, the vessel kept staying close to the FAD and so the fish were monitored only when they were associated with the FAD. The first fish monitored by continuous transmitter left the FAD in the evening of August 10th day and never returned during monitoring. Of 14 individuals released with coded transmitter (36.0-64.0cm FL), 6 individuals were monitored for more than two days. These fish ware usually associated with the FAD until the contact was lost, and occasionally left the FAD temporarily mainly during nighttime. Vertical movement of the fish monitored with coded transmitter was similar to that of the first fish monitored with continuous transmitter, that is, swimming depth of the fish was usually shallower than 100m and during night swimming depth was shallower than that during daytime. In this study, behavior of skipjack tuna of both FAD associated and free swimming was monitored. These results will be informative for both elucidating behavior of skipjack tuna and developing fishing technology for FADs and free swimming sets of purse seine fishery. Also, it will be useful information for effective catch of skipjack and avoiding incidental catch of small bigeye and yellowfin tunas.

A DEPLETION ESTIMATOR FOR WITHIN-SEASON MANAGEMENT OF YELLOWFIN TUNA

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A depletion estimator is developed to estimate annual abundance from annual time series of catch data and an index of abundance. The method is applied to weekly data for yellowfin tuna in the eastern Pacific Ocean. The estimates of abundance from the depletion estimator are similar to estimates derived from a full stock assessment. The method can be applied to estimate abundance when only partial data are available for a given year, and the estimates of abundance can be used for within-season management. Cross-validation tests show that the method performs well (less than about 15% error) even in a situation when only a quarter of a year's data are available. Information from the stock assessment about the fishing mortality levels corresponding to maximum sustainable yield suggest that the catch quota should be set at about 60% of the abundance estimate at the beginning of the year. The method is modified and applied to real-time weekly at sea data.

USE OF SATELLITE TAGGING AND PHOTO IDENTIFICATION METHODS TO STUDY THE BEHAVIOR AND ECOLOGY OF WHITE SHARKS IN THE NORTHEASTERN PACIFIC

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For the past decade, an adult white shark (*Carcharodon carcharias*) aggregation at Guadalupe Island, Mexico, has been studied via the use of popup archival satellite tags (PATs) and methodical photo-identification. Photo-ID records dating back to 2001 have indicated that white sharks exhibit strong philopatry for Guadalupe Island. To date 89 individual sharks have been identified, 78% of which have been sighted in more than one year and 43% that have been sighted at least 4 years. The use of PAT tags has shown that these sharks make annual migrations to a vast pelagic habitat that is also inhabited by white sharks from central California; thus it has been termed the Shared Offshore Foraging Area (SOFA). Seventy-five PAT tags were deployed providing 7,893 days of data, 5 roundtrip migrations and 9 tags that were physically recovered providing 2-min archival data. Using the photo identification data we have verified that two individual sharks were tagged in consecutive years, providing 2 years of round trip tracking data for each individual. Although males have been documented to return to Guadalupe Island each year, large females have been shown to return every other year and questions still remain regarding the destination and migration cycle of adult females.

INCORPORATING SEA-SURFACE TEMPERATURE TO THE LIGHT-BASED GEOLOCATION MODEL, TRACKIT

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Satellite tags (archival and pop-up archival) have been widely used to study movement dynamics of many marine pelagic species. Recent advances in light-based geolocation models have enabled better estimations of geographical positions of tagged animals.

In particular, TrackIt, a state-space model with Kalman filter uses only raw data streams from a tag for estimating positions, independent of manufacturer calculations. This approach is a complete break from the previous state-space models (e.g. KFSST, UKFSST), which rely on manufacturer-processed positions as an input to the model. Nielsen and Sibert (2007; 2008), using only light information, have demonstrated the utility of TrackIt with both simulated and real data from tagged animals. Our latest extension to the TrackIt model has incorporated sea-surface temperature (SST) data matching, an approach that is anticipated to improve position accuracy.

This talk will present the latest model, along with model runs using various sea-surface temperature products, and a comparison with similar state-space models. Through incorporating SST, we also hope to show the ease of extending the TrackIt model for new data streams that will be available in the next-generation archival tags, for instances geomagnetic data.

FEEDING ECOLOGY OF THREE MYCTOPHID FISHES IN THE EASTERN TROPICAL PACIFIC (POSTER)

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Myctophid fishes are abundant, cosmopolitan, mesopelagic fishes that are important components of the pelagic ecosystem in the eastern tropical Pacific Ocean (ETP). They conduct diel vertical migrations at night to feed on zooplankton in surface layers, and are important prey items for several upper-level predators. Understanding the trophic ecology of myctophids is important for assessing their role in transferring secondary production to the top trophic levels.

Nine species of myctophids were sampled one hour after sunset aboard two NOAA ships during the STAR 2006 mammal surveys in the ETP. The fish were caught by dipnet at 32 stations, and samples of the three most abundant species in the surveys (and sample sizes), *Myctophum nitidulum* (n=299), *Symbolophorus reversus* (n=199), and *Gonichthys tenuiculus* (n=82), were analyzed for diet composition. Each fish was measured and weighed, and a stomach fullness index (FI) was calculated as the weight of the stomach contents as a percentage of the weight of the entire fish. The stomach contents were identified to the lowest taxon possible, enumerated, and weighed by taxon.

Preliminary data show that *M. nitidulum* had the highest FI, 2.3 (±1.3)%, across all stations; followed by *S. reverses*, 1.6 (±1.0)%; and *G. tenuiculus*, 1.4 (±1.7)%. These three myctophid fishes fed predominately on ostracods, copepods, euphausiids, amphipods, and mollusks. Larval fishes, fish scales, and pieces of plastic were also found in the stomach contents. *M. nitidulum* was found to have a diet comprised mostly of ostracods, followed by copepods. *S. reverses* had a more diverse diet that favored euphausiids. *G. tenuiculus* had little food in the stomachs, mostly fish scales and copepods. The FI for all three fish was far lower than described in previous studies, indicating that these fish were captured before their peak feeding hours. The geographical distribution of prey species found in the stomachs changed according to distance from shore, for all three species. Euphausiids were found to be the dominate prey by number (more than 50% of the stomach contents of more than 50% of the individuals) in near-shore areas. Copepods were the dominant prey in number at the intermediate stations, while ostracods dominated at the furthest offshore stations for all three species.

Preliminary results appear to indicate that co-occurring myctophid species partition prey resources by prey selectivity and species-specific feeding chronology, which is consistent with other studies of myctophid fishes. This is on-going research, and future activities involve examining oceanographic variables at the sample locations and further prey taxonomy.

TECHNOLOGICAL TOOLS FOR ECOLOGICAL RESEARCH ON PELAGIC FOOD WEBS

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Chemical tracers, now common tools used by ecologists, can aid studies of the structure and variability of pelagic food webs that are required for improving our understanding of the role of climate and fishing on the dynamics and productivity of exploited ecosystems. We discuss the application of chemical tracers in research on pelagic food webs leading to tunas and billfishes. The techniques include bulk stable isotope analysis (SIA), compound-specific nitrogen isotope analysis (CSIA) of amino acids, and signature fatty acid (FA) analysis. Applications of the isotopic and fatty acid techniques are presented for the eastern Pacific Ocean and the Australian Eastern Tuna and Billfish Fishery, respectively. SIA and CSIA of yellowfin tuna white muscle tissue have uncovered a trophic gradient in the eastern Pacific, which stomach-contents analyses have not revealed. FA analysis of swordfish white muscle tissue showed that juveniles ate mainly small fishes and myctophids off eastern Australia, which was confirmed by stomach content analysis. FA analysis was also able to further separate myctophid prey to the species level. Another chemical tracer, mercury, is being applied by other researchers in the eastern and central pelagic Pacific Ocean (see presentation by Ferriss and Essington, this conference), and in the central Pacific by researchers at the University of Hawaii.

PRELIMINARY ANALYSIS ON LENGTH-FREQUENCY DISTRIBUTIONS OF AGE-0 PACIFIC BLUEFIN TUNA (*THUNNUS ORIENTALIS*) CAUGHT BY JAPANESE SMALL-SCALE TROLL FISHERY

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Japanese small-scale troll fishery operating around Japanese coastal waters targets small Pacific bluefin tuna (PBF), mainly age-0 and age-1 fishes. The troll fishery operated around Tsushima Islands of southwestern Sea of Japan yields approximately 25% of the total landings of small PBF caught by the troll fishery in Japan. There are two main spawning grounds of PBF. One is the waters of northwestern Pacific Ocean off Taiwan and Nansei Islands from April to June and the other is Sea of Japan between ends of June and August. Around Tsushima Islands, age-0 PBF originated from the two spawning grounds are believed to be mixed for the first time in its life history and caught by the troll fishery. An intensive length measurement program on them have been conducted at two major unloading ports in Tsushima Islands since the last fishing season (late 2007 − early 2008), in order to 1) analyze recruitment patterns of age-0 PBF from the two spawning grounds (Pacific-Ocean-origin and Sea-of-Japan-origin) to this fishery and 2) estimate relative magnitude of the recruitment of age-0 PBF from the two origins. This study presents results of preliminary analysis on length measurement data with landing data obtained in the last fishing season through this program at Are port, where the length measurement had been carried out almost every day.

At Are port, samplers employed for the intensive length measurement program conducted the measurement of PBF landings caught by the troll fishery almost every day from late November 2007 to early February 2008. Stratified length measurement was implemented by the market size category, taking measurement of 50 fishes at a maximum for each size category. Measurements were made by 1 cm and 0.1 kg intervals in fork length and weight, respectively. The length-frequency distributions of overall landings by a day or by ten-day interval were estimated by raising the length-frequency data in each size category with landing in number in the corresponding categories.

In the length-frequency distributions estimated by ten-day interval, there were two modes at the length classes smaller than 60 cm in fork length. These modes appear to correspond to the early- and the late-hatched recruitment groups of age-0 PBF inferred as Pacific-Ocean-originated and Sea-of-Japan-originated cohorts, respectively. The mode of the early-hatched fish was distinct and traceable with modal progression during the fishing season, whereas the modal distribution of the late-hatched fish became indistinct in January 2008 in spite of its remarkable appearance in December 2007. Daily length-frequency distributions showed large variations with frequent presence and absence of the mode of the late-spawned recruitment group. These results mentioned above indicate that the early-hatched fish had completely recruited to the troll fishery, although the late-hatched cohort might have not yet done. This difference in the recruitment patterns between the two cohorts appeared to be caused by differences in spatiotemporal distributions of fish school by growth stages. Factors regulating patterns of the spatiotemporal distributions of each recruitment group should be investigated in future. It is required that to examine effective frequency of the length measurement and number of fish for measurement per day considering temporal length variability by the size category of landings in order to maintain and promote the intensive length measurement program.

LINKING U.S. PACIFIC ALBACORE CPUE TO FINE SCALE SATELLITE ENVIRONMENTAL DATA

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Albacore tuna (*Thunnus alalunga*) occur through much of the temperate waters of the North Pacific and undergo zonal feeding migrations across the entire basin. Oceanic habitat preferences and timing of immigration and emigration into the Eastern North Pacific have not been studied in detail or on a fine scale (temporally and spatially). A hypothesis of interest is related to the role of the North Pacific frontal structure as a predictor of optimal albacore habitat. In this study we use albacore logbook CPUE data from 2000 through 2007 stratified by day, latitude, and longitude along with high resolution satellite-derived environmental variables to characterize albacore habitat. Our ultimate goal is to spatially identify the albacore habitat based on CPUE and related to environmental variables using GAM modeling for albacore captured east of 130°W during the main fishing season.

FEEDING HABITS OF THE BROADBILL SWORDFISH (*XIPHIAS GLADIUS*) SAMPLED FROM THE CALIFORNIA-BASED DRIFT GILLNET FISHERY, 2007-2008 (POSTER)

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Broadbill swordfish (*Xiphias gladius*) are widely distributed in all tropical and temperate oceans, from roughly 50ºN to 50ºS latitude. They are typically found in areas of high productivity near current boundaries and frontal zones of temperature and salinity. Along the West Coast of the U.S. and Baja California, Mexico swordfish are seasonally abundant in the highly productive eastern boundary ecosystem of the California Current. Limited tagging data demonstrate that within the California Current, swordfish typically remain close to the surface at night while spending daytime hours at depths of up to 400 m. Characterization of their diet from various regions, as well as tagging data and the presence of specialized tissues that warm the brain and eyes suggest that these predators forage at great depths in cold waters below the thermocline.

In Southern California, swordfish is an important commercial species taken in both a summer harpoon fishery and a fall-winter pelagic drift gillnet fishery. The Southern California Bight between Point Conception, California and Cape Colonet, Baja California, Mexico represents a diverse pelagic ecosystem at the limit of two biogeographic provinces with deep water punctuated by submarine seamounts and coastal islands. In addition to swordfish, the area is utilized by a number of other large pelagic fish including tunas, striped marlin, and pelagic sharks that all presumably come to feed in the highly productive waters. Despite the apparent importance of the region as a foraging ground, few quantitative studies have been conducted to examine the diets of swordfish along the U.S. West Coast.

To quantify the foraging ecology of swordfish within the Southern California Bight we examined stomachs collected from the California-based pelagic drift gillnet fishery over two fishing seasons. Sixty-four stomachs were collected by fishery observers from September through December in both 2007 and 2008 within the U.S. Exclusive Economic Zone between the U.S./Mexico border and Point Conception. Swordfish sampled ranged in size from around 120 to 200 cm eye to fork length (EFL). Stomach contents were examined and identified to the lowest possible taxa. For each prey item we calculated the weight, number, frequency of occurrence, geometric index of importance (GII) and the index of relative importance (IRI). Of the stomachs examined, 98% contained food representing at least 26 taxa. The most important prey overall was the jumbo squid (*Dosidicus gigas*), which was present in 82% of the stomachs and ranged in size from around 20 to 70 cm mantel length (ML). Preliminary data reveal that there is a direct relationship between swordfish EFL and squid ML. Larger swordfish are able to feed on larger jumbo squid. Other important prey included the boreopacific gonate squid (*Gonatopsis borealis*) and teleosts of the family Paralepididae (Barracudinas).

In comparing swordfish to other large pelagics foraging in the Southern California Bight (blue, mako, common thresher and bigeye thresher sharks) there are some distinct similarities. For swordfish, mako and blue sharks, cephalopods are the most important prey taxa, with jumbo squid being one of the dominant species. Similar to bigeye thresher sharks, swordfish target prey associated with the deep scattering layer in addition to small pelagics, indicating that they can forage broadly through the water column. Swordfish and bigeye thresher sharks also exhibit similar diel vertical migrations. Swordfish can feed on a variety of prey taxa but they tend to focus on jumbo squid that has been particularly abundant in Southern California during recent years.

TROPHIC CASCADES AMONG THE UPPER TROPHIC LEVELS IN THE CENTRAL NORTH PACIFIC SUBTROPICAL GYRE ECOSYSTEM, 1996 – 2006.

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Catch rates for the 13 most abundant species caught over the past decade in the deep-set Hawaii-based longline fishery provide evidence of trophic cascades in the subtropical ecosystem extending into the mesopelagic community. Catch rates for apex predators such as blue shark, bigeye and albacore tunas, shortbill spearfish, and striped marlin declined from three to ten percent per year while catch rates for four species lower on the food web, mahi mahi, sickle pomfret, escolar, and snake mackerel increased from ten to 18 percent per year. The mean trophic level of the top 13 species in the catch declined five percent from 3.85 to 3.66, and the mean production to biomass (P/B) value increased 21%, from 0.80 to 0.97. The increase in the mean P/B ratio suggests that the ecosystem may now be more responsive to climate variability.

SPATIAL DISTRIBUTION PATTERNS OF THE BYCATCH OF OCEANIC WHITETIP SHARK (CARCHARHINUS LONGIMANUS) IN THE TUNA PURSE-SEINE FISHERY OF THE EASTERN PACIFIC OCEAN

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The oceanic whitetip shark (*Carcharhinus longimanus*) is the second most abundant shark species in the bycatch of the purse-seine fishery for tunas in the eastern Pacific Ocean. Little is known about the life-cycle, migration patterns, parturition, nursery grounds and other biological parameters which are needed to understand the population structure of this species. In this study, the spatial distribution of the oceanic whitetip bycatches by size is analyzed. Higher occurrences of small-sized oceanic whitetip sharks (< 90 cm TL) were found in areas north the equator. This pattern is similar to other shark species found in the bycatch of this fishery, such as the silky shark (*Carcharhinus falciformis*). Areas with the highest bycatches per set of small sharks were also found in areas north of the equator. This could be an indication of the existence of nursery grounds in that region.

INFERRING THE BIG PICTURE FROM TAGGING SURVEYS: WHY AND HOW TO MERGE HETEROGENEOUS DATASETS

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Electronic tags have allowed the monitoring of pelagic species over a new range of space and time scales. The technology however has evolved rapidly, and there is now a healthy diversity of tag types and models, relying on internal storage or satellite transmission, or both. The accumulation of these large, heterogeneous datasets over the years has lead to several problems. Among these, one must address the need for data standardization, reliable storage, and consistent processing, analysis and interpretation.

In particular, the accumulation of these datasets now leads researchers to ask new questions, such as “are my dispersion patterns similar over all these years?”, or “Are these two years similar, despite the difference in sampling size and tag technology?”. We present in this paper some solutions available in the toolbox of today's modeler, the challenges of producing homogeneous datasets and results and how adequate post-processing can help us in this task.

SLOW RATE OF EVOLUTION IN TUNA MICROSATELLITES

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Microsatellites or Short Tandem Repeats (STRs) have gained wide acceptance in population studies because their typically high levels of polymorphism provide enough power to obtain robust estimates of migration, kinship, and effective population size (N_e). Mutation rates of microsatellite loci are generally unknown and are difficult to measure specially when dealing with wild populations. Instead, it has become common practice to adopt a 'universal' mutation when carrying population assessments. Because the choice of mutation rate could have dramatic effects on the magnitude of the parameters estimated, new methods that provide more realistic estimates of microsatellite mutation rate are needed.

Here we estimate a mutation rate using genetic and life history data from blackfin tuna and yellowfin tuna with an equation used to estimate time since divergence (T_D). The genetic distance $(\delta\mu)^2$ between these two tuna species was estimated with six microsatellite markers (1.08 gen/yr). The mutation rate was estimated to be between $4.3 \times 10^{-7} - 5.2 \times 10^{-7}$ Ma^{-1}. This rate is three orders of magnitude slower than the 'universally' accepted rate of 1×10^{-4}. A consequence of a slow rate of molecular evolution is that a large proportion of the observed similarity in allele frequencies is due to size identity by descent (plesiomorphy) as opposed to size identity resulting from convergent evolution (homoplasy). Comparisons with published allele frequency data for bigeye tuna and albacore tuna corroborate that microsatellites evolve extremely slowly in tunas, which would partially account for the extremely low levels of genetic differentiation among populations reported using these markers.

FINE-SCALE MOVEMENTS OF THE WAHOO, *ACANTHOCYBIUM SOLANDRI,* IN THE EASTERN NORTH PACIFIC

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The wahoo *Acanthocybium solandri* is a pelagic predator found throughout the sub-tropical and tropical ocean basins. Wahoo are targeted throughout their extensive range by recreational fisheries and comprise a valuable secondary target of many commercial operations. Despite its economic importance, few studies have focused on the distribution, movements, and ecology of this species in the Pacific. The objectives of this project were to evaluate the depth distribution and water temperature preferences of wahoo using archival tags. A total of 109 electronic data-loggers were deployed in wahoo from 2005 to 2008. Tagging operations were performed along the west coast of Baja California (25º 55'N/113º 21'W) and around two offshore sea mounts (Hurricane Bank; 16º 51'N/117º 29'W and Alijos Rocks; 25º 00'N/115º 45'W). To date 24 tagged wahoo have been recaptured resulting in an overall recapture rate of 22%. The highest site-specific recapture rate occurred in the Fall of 2008 (Hurricane bank) where 62% of the tagged wahoo were recaptured. All recaptured individuals were caught in close proximity to their release sites. Temperature and depth data from 499 days revealed that wahoo predominantly utilized the upper mixed layer, maintaining an average depth of 19 ± 12 m during the day and 17 ± 14 m at night. Recaptured wahoo spent 99.2% of the daylight hours and 97.9% of the night hours above the thermocline. While only brief excursions below the thermocline were recorded, the maximum depth recorded in this study was 253 m. Ambient water temperature ranged from 11.1 ºC to 27.9 ºC, with an average of 25.0 ºC ± 1.2 ºC. These data support the contention that wahoo lead a predominantly epipelagic existence and emphasize the importance of the upper mixed layer for this species. The recapture of tagged wahoo by both recreational and commercial interests off of Baja California validates the economic importance of this resource to the region.

POP-UP SATELLITE TAGS REVEAL MOVEMENTS AND BEHAVIORS OF PACIFIC BLUEFIN TUNA IN THE SOUTHERN PACIFIC OCEAN

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Pacific bluefin tuna (*Thunnus orientalis*) of large sizes (200-400 kg) congregate around commercial fishing trawlers targeting hoki (*Macruronus novaezelandiae)* in the south Tasman Sea off the west coast of New Zealand's South Island in winter months (August-September). The recently developed recreational fishery targeting these fish provided a rare opportunity to study the migratory movements and behaviors of mature Pacific bluefin tuna that visit the Southern Ocean. We present preliminary results from deployments of pop-up satellite archival tags (PAT4 and MK-10s, made by Wildlife Computers) on giant Pacific bluefin tuna in the southern hemisphere.

Tagging was conducted near the Hokitika Trench (approx: Lat: 41° 25', Lon: 170° 40) during August 2006, 2007, and 2008. The objectives of the research were to: 1) identify seasonal and inter-annual movement patterns, and residency times of bluefin tuna in the South Tasman Sea, 2) examine the migratory pathways of mature Pacific bluefin tuna, including travel to their putative spawning grounds, 3) examine the movements of Pacific bluefin tuna in relation to dynamic ocean processes to determine environmental preferences, and, 4) to provide data to assist with the management of Pacific bluefin tuna at local (e.g. New Zealand) and stock-wide levels.

A total of 46 tags were deployed during the 2006 (n=9), 2007 (n=15) and 2008 (n=22) seasons. During the first tracking season, nine tags were deployed to test feasibility, survivorship and procedure for tagging large bluefin in the region. The fish were captured with handlines (4 individuals) and gamefishing tackle (60 kg test). Fight times ranged from 15-145 minutes (mean: 87 min, sd: 55 min). Fish weights were estimated to range between 190-250 kg (mean: 233 kg, sd: 24 kg). All fish were tagged in the water alongside the vessel. Several individuals were also tagged with standard gamefish dart tags issued by the NZ Big Game Fishing Council. When possible, DNA samples were taken to confirm

species identity. Track durations ranged from 90-180 days, with a mean track duration of 128 days (sd: 40 days). All fifteen of the tags deployed during 2007 reported. Fight times ranged from 30-180 minutes (mean: 78 min, sd: 41 min) and fish weights were estimated to range between 200-425 kg (mean: 293 kg, sd: 60 kg). Track durations ranged from 30-180 days, with a mean track duration of 91 days (sd: 50 days). An additional 22 pop-up satellite tags were deployed on Pacific bluefin during the period of August 19, 2008 - September 7, 2008. Fight times for these fish ranged from 30-180 minutes (mean: 78 min, sd: 41 min). Fish weights were estimated to range between 200-425 kg (mean: 293 kg, sd: 60 kg). Track durations ranged from 30-180 days, with a mean track duration of 91 days (sd: 50 days).

Pacific bluefin tuna tagged during 2006 and 2007 tended to move north soon after tagging to latitudes between 30^{o} and 37^{o} S. This pattern was followed by eastward movements across the top of New Zealand or westward movements towards Australia. As warmer temperatures increased with the onset of summer, the bluefin moved south into waters with surface temperatures ranging from 13 ^{o}C to 19 ^{o}C. Three tags that popped up during March (180 day deployments) were south of latitude 42^{o} S. In general, tagged fish stayed within 1000 nautical miles of release, within an area encompassing New Zealand's North and South Islands, and spanning across the Tasman Sea from the southeastern coast of Australia (New South Wales) to southern Tasmania. Some fish appeared to exhibit short term residency within New Zealand's waters, but the dataset was constrained by tracking durations of six months or less. The presence of these tuna around both coasts of New Zealand during the six month tracking period is consistent with anecdotal reports of sightings of these fish and commercial catch records. The initial analysis of data from 2008 appears to repeat the pattern from the prior deployment providing temporal stability for the appearance of Pacific bluefin in these waters. The analysis of all data sets is underway and thus far preliminary results regarding tuna movements and behaviors are consistent with data from previous years.

Research was supported by TAG A Giant Foundation, Stanford University, Blue Water Marine Research (NZ), the New Zealand Ministry of Fisheries, the University of Auckland, and the NZ Marine Research Foundation. Our efforts were facilitated by the owners, skippers and their clients fishing out of Greymouth, New Zealand.

DISTRIBUTION AND ABUNDANCE OF ISTIOPHORID AND XIPHIID LARVAE IN THE NORTHERN GULF OF MEXICO

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Istiophorid and xiphiid billfish are commonly taken by recreational and commercial fisheries in the Gulf of Mexico (Gulf) and larvae are frequently reported in the region, indicating the Gulf's potential role as spawning and/or nursery ground of billfishes. Ichthyoplankton surveys were conducted during spring and summer months from 2005 to 2008 in shelf and slope waters off the Texas and Louisiana coasts between 27 – 28°N and 88 – 94°W. During the four year study, 4,404 istiophorid (sailfish, *Istiophorus platypterus*, white marlin, *Kajikia albida*, blue marlin, *Makaira nigricans*) and 451 xiphiid (swordfish, *Xiphias gladius*) larvae were collected. Sailfish were the dominant billfish collected, accounting for 63.3% of the total catch. The remainder of our collections was comprised of blue marlin (19.7%), swordfish (9.3%) and white marlin (3.0%), with a small fraction of the billfish larvae unidentified (4.7%). Istiophorid larvae were observed in 51% of collections while swordfish larvae were observed in only 22% of the collections. Maximum density of istiophorids and xiphiids was 51.5 and 3.1 individuals per 1000 m^{-2}, respectively. Catch rates and densities of sailfish and blue marlin larvae from the northern Gulf were comparable to or higher than value reported for other putative billfish spawning areas. Peak densities were observed within frontal features of the Loop Current and associated anti-cyclonic eddies, and multivariate analysis indicated that biotic (chlorophyll, prey abundance) and abiotic (temperature, water depth) factors were partly responsible for observed spatial variation. Results of this study indicate that billfish larvae are abundant in the northern Gulf and, based on comparisons of density to other presumed spawning areas, it appears that this region represents essential spawning/nursery habitat of certain species. Observed patterns of distribution and abundance appear linked to environmental and oceanographic conditions, and thus survival and recruitment success may be influenced by spatial and temporal variations in the pelagic environment.

RESOLVING POPULATION STRUCTURE AND ADMIXTURE IN ATLANTIC SWORDFISH (*XIPHIAS GLADIUS*)

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The population structure of Atlantic swordfish population has been the focus of numerous genetic studies, but has not been fully resolved. Based in part on genetic evidence, two stocks, a north and south, separated at the 5° N latitude are recognized. Catch data suggests a continuous distribution of swordfish in the Atlantic with possible zones of admixture between the Mediterranean and North Atlantic, North and South Atlantic, and South Atlantic and Indian Ocean. Previous studies of genetic differentiation of Atlantic stocks have used mitochondrial DNA (mtDNA), nuclear DNA genes (e.g. CaM, ldh-A, aldolase), and microsatellite loci. Though genetic differentiation was found, population stock structure remains elusive due to limitations in genetic markers or experimental design. While mtDNA is extremely useful for resolving the historical demography of the species, the maternal inheritance prevents admixture estimates from being derived. Estimates of F_{st} values using nuclear DNA (F_{st} = 0.3401) are one order of magnitude greater than mtDNA (F_{st} = 0.0344), and two orders of magnitude greater than microsatellites (F_{st} = 0.0012), making these markers an ideal candidate for resolving stock structure. To date studies have employed single markers (e.g. CaM) thus lacking the statistical power needed to resolve zones of mixing. Here we have genotyped swordfish from the North Atlantic, South Atlantic, and Mediterranean using seven developed exon-primed intron crossing (EPIC) nuclear DNA markers. High resolution melting analysis (HRMA) provided an effective, highly sensitive, and inexpensive closed tube approach for genotyping SNPs to differentiate stocks. F_{st} values obtained from the three sample pools were applied in POWSIM to access the statistical power and sample sizes needed to differentiate areas of mixing. We discuss the use of different statistical models (e.g. Bayesian) that can be employed for individual assignment in mixing zones.

TROPHIC STRUCTURE AND STABLE ISOTOPE ANALYSIS OF DIET COMPOSITION FOR ALBACORE (*THUNNUS ALALUNGA*), BLUEFIN (*THUNNUS ORIENTALIS),* AND YELLOWFIN (*THUNNUS ALBACARES*) TUNA IN THE SOUTHERN CALIFORNIA BIGHT (POSTER)

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Several species of tuna frequent the waters off San Diego each summer spending time foraging in the southern California Bight. Albacore (*Thunnus alalunga*), bluefin (*Thunnus orientalis*), and yellowfin (*Thunnus albacares*) tuna begin to appear in waters off Northern Baja California, Mexico and San Diego, CA in late June and July, remaining for several months. While in the Bight all species are targeted by recreational fisheries. Despite the importance of this region as a foraging ground, little information is available on the trophic ecology of these species off California. This limits the ability to take an ecosystems approach to management. To better understand the trophic ecology of highly migratory species in the southern California current (SCC) the Sportfishing Association of California (SAC) and NOAA Fisheries initiated a biological sampling program in 2007. To examine foraging ecology a combination of stomach content and tissue isotope analysis (nitrogen stable isotopes, $\delta^{15}N$) are being conducted over a range of trophic levels. The two methods provide a complimentary approach, stomach contents reveal a snap shot of foraging over a day or less while tissue isotope ratios provide an index of trophic level integrated over time.

Tissue and stomach content samples were collected in September and October of 2007 and 2008 from all species available. All tuna were caught by hook and line from Commercial Passenger Fishing Vessels. To date, measurements of the $\delta^{15}N$ for albacore samples (n=116) from 2007 have been analyzed and compared to albacore samples from the northern California Current (NCC). The ratio of $\delta^{15}N$ (14.3 0/00) in the albacore sampled in the SCC is higher than for more northern waters (13.8 0/00) suggesting a slightly higher tropic level. These findings may results from the apparent differences in foraging strategy noted for the two regions. Similar variations in trophic level have been observed when comparing yellowfin tuna from different regions within the eastern tropical pacific. Stomach content from albacore within the SCC was dominated (77% by composition) by northern anchovy (*Engraulis mordax)* in 2007. Past studies had similar results with anchovy being the most frequent prey species of albacore in the SCC. In comparison, in the NCC euphausids seem to be a larger component in the diet of albacore, which could explain the difference found in trophic level. Alternatively, isotope ratios of potential prey may vary between both regions and are being measured to account for differences in the base of the food web. Tissue samples from the bluefin and yellowfin tuna are currently being processed and will be compared to each other and the albacore from both years sampled.

Using diet analysis through identification of stomach content and stable isotope ratios we can begin to develop an idea for both the daily and long-term feeding habits of tuna in the SCC. By conducting studies over multiple years the impacts of short-term environmental variation on available forage can be determined with implications for assessing habitat quality. This should help explain migration timing and patterns observed in highly migratory species within the Southern California Bight and Northern Baja Ca, Mexico.

UPDATE ON EXPERIMENTAL LONGLINE FISHING HOOKS: EFFECTS ON TARGET AND NON-TARGET SPECIES AND COMMENTS ABOUT POST-RELEASE SURVIVORSHIP

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This talk will summarize research comparing modified fishing gear to traditional methods in experimental 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. Results indicate that replacement of J and tuna hooks with relatively large circle hooks can effectively reduce the CPUE of sea turtles caught in fishing gear in most shallow-set fisheries without adversely affecting overall profitability of the fishery. Additionally, use of fish for bait instead if squid can reduce capture rates of sea turtles and sharks. However, in some fisheries there is noted loss of swordfish capture rates (# individuals) and there are concerns with increased capture rate of sharks with large circle hooks. In deep-set tuna fisheries in the United States and Indonesia, use of circle hooks results in increased CPUE for tuna, and subsequently there is high demand for circle hooks in many parts of the world. 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.

Our work with satellite tagging of caught and released loggerhead turtles from longline fishing gear in the South Atlantic Ocean suggests no difference in predicted mortality between turtles caught "lightly" vs. those with more "severe" injuries.

We will also discuss our development of a relational database in MS Access to store the data from the various research projects in one place in order to compare and contrast aspects of the different studies and for meta-data analysis at a future date. A data template in MS Excel format for this database is located on the NOAA Fisheries Feature website (http://www.nmfs.noaa.gov/bycatch.htm), where it can be freely accessed by any researchers seeking guidance for data organization and storage.

THE EFFECTS OF TIME-VARYING MOVEMENT HYPOTHESES AND SPATIAL HARVEST POLICIES ON PROJECTED STOCK DYNAMICS OF ATLANTIC BLUEFIN TUNA

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Atlantic bluefin tuna stock assessments can be fit to as many as 31 catch-per-unit-effort time series as well as conventional and electronic tagging data. Since 2001, one catch-per-unit (CPUE) effort series in the Canada Gulf of St Lawrence waters has increased by a factor of ~9, while other indices in nearby areas have increased to a much lesser extent or actually decreased. The stock composition of fish in the Gulf of St Lawrence are thought to be fish largely of Western stock origin as a opposed to a mixture of Eastern and Western stocks throughout the Western Atlantic. Currently we know that there have been gear changes that have improved catch efficiency. Hypotheses about whether or not increased CPUE values represent Northward shifts in stock distribution, total stock biomass increases, improvements in catchability or some combination thereof. Here we fit a spatially-explicit model to available data and explore how alternative quota's allotted to Canadian waters affect Western stock rebuilding. We show ongoing work demonstrating stock-assessment sensitivity and policy outcomes to these hypotheses.

COMPARATIVE INFLUENCE OF OCEAN CONDITIONS ON YELLOWFIN AND ATLANTIC BLUEFIN TUNA CATCH FROM LONGLINES IN THE GULF OF MEXICO

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Directed fishing effort for Atlantic bluefin tuna in the Gulf of Mexico, their primary spawning grounds in the western Atlantic, has been prohibited since the 1980s due to the precipitous decline of the spawning stock biomass in this region. However, longlines targeted at other species, primarily yellowfin tuna and swordfish, continue to catch Atlantic bluefin tuna on their breeding grounds as bycatch. In order to alleviate this problem, it would be important to understand the processes that affect the catch of both the target species (yellowfin tuna) and the bycatch species (bluefin tuna). This study compares the ocean conditions that affect the catch of yellowfin versus bluefin tuna in the Gulf of Mexico during the breeding season of the bluefin tuna. Scientific observer logs from the Gulf of Mexico during 1993-2005 were obtained from the National Marine Fisheries Service. Ocean conditions at the time and location of each recorded longline set were subsequently extracted from several environmental databases. The environmental parameters of interest included sea surface temperature (SST), SST slope, sea surface height anomaly (SSHA), bathymetry, bathymetric slope, eddy kinetic energy, current speed, and wind speed. Bluefin catch per unit effort (CPUE) had more spatial and temporal variability as compared to yellowfin CPUE. Bluefin tuna CPUE increased substantially during the breeding months (March-June) and peaked in April, while yellowfin CPUE remained relatively high throughout the year. A marked interannual difference was apparent in the bluefin CPUE, with latter years being substantially higher than earlier years. Spatially, bluefin tuna tended to be caught in the western and central Gulf of Mexico while yellowfin tuna catch remained relatively high throughout most of the areas fished. Preliminary analyses indicated that zero inflation is likely a strong feature of the longline data. Therefore, zero-inflated Poisson (ZIP) and zero-inflated negative binomial (ZINB) models were used to relate variability in the bluefin and yellowfin catches to changes in ocean conditions and other parameters like hook depth and location. Our initial models indicate that SST and SSH played a major role in influencing bluefin tuna catch but they did not play a major role in influencing yellowfin tuna catch. Currently, we are performing model selection using Akaike's Information Criterion (AIC) to select the best model for these two species.

TAGBASE: A COMPREHENSIVE DATA MODEL AND MANAGEMENT SYSTEM FOR TAGGING APPLICATIONS

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Electronic tagging studies are providing fundamental new insights into the spatial ecology of pelagic species in support also of ecosystem-based fisheries assessment efforts. There is a proliferation of tagging programs, studies and tag deployments generating ever increasing volumes of data on the movement dynamics, physiology and habitat preferences of pelagics. Effective management of these data to ensure ease of access for synthesis and to ensure the legacy of these research programs longer-term is critical and currently an issue. With tools from manufacturers designed principally for the handling individual datasets and in the absence of readily available custom database solutions dealing with the complexities of tagging data in a generic fashion, the logistics of management and compilation of tag data resources is proving an impediment for researchers.

Here we report on our efforts to develop a complete data management solution for electronic tagging applications. Tagbase is a relational database application designed specifically for the handling of diverse electronic tagging datasets. Its comprehensive data model accommodates the full suite of manufacturer tag data formats in addition to providing support for tag deployment metadata and reprocessed geolocations. Tagbase includes an integrated set of tools for importing tag datasets into the system effortlessly. A series of stored queries and graph forms allow users to rapidly view data as diverse plots and in tabular form. Data within the system can be easily exported or seamlessly coupled to other packages. It provides integrated support for the ODV (Ocean Data View) software, and has been used as a dynamic data back-end for GIS applications. Developed initially in MS Access, Tagbase has now also been ported to an industrial strength database system (SQL-server) to fully address the data management needs of the tagging community, from individual investigators to large scale tagging programs.

MOONFISH RISING…BIG- OR SMALL-EYE? (POSTER)

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In Hawaii, the opah or moonfish, *Lampris guttatus,* has historically been an incidental catch of longline gear used in the pelagic fishery. Only recently has this species, which draws crowds at the United Fishing Agency (UFA) and around the dinner table, become commercially important. Opah, taken on longline gear year-round with landings peaking in April-August, are viewed as a lucky fish by old-time longline fishermen, who prefer to give it away as a gesture of goodwill rather than sell it. Now, moonfish incidentally captured by longline boats are placed on the UFA auction floor and put up for sale to restaurant, import and local buyers who bid the highest prices. The growing attention to the moonfish and its emergence as a commercially valuable species prompted scientists to investigate the sustainability of the fish in the marketplace and in the fishery. As stock assessment investigators expanded collection of biological data at the auction house, differences within the opah catch were brought to their attention. Curiosity led buyers to question why some opah had a smaller or larger eye with no other apparent morphological differences.

We responded by collecting approximately twenty fin clips, from opah of both eye types, for genetic analysis, we found that the sequence data from the mitochondrial cytochrome *c* oxidase, subunit I gene, produces two distinct clades that conform 100% to the morphotypes. This finding suggests that the big- and small-eye opah are separate species. This information, along with further investigations into the differentiation, leads us to believe there are two species of opah sold as one. We discuss the taxonomic implications, as no type specimens of these varieties of opah are known to exist.

USE OF ELECTROPOSITIVE METALS TO REDUCE SHARK-FEEDING BEHAVIOR AND SHARK CAPTURE RATES ON BOTTOM SET LONGLINES

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The sensory physiology and behavioral ecology of sharks are important components in the development of strategies to reduce shark incidental catch in fisheries. Elasmobranchs have an electroreceptive system (ampullae of Lorenzini) that is capable of detecting very small electric fields. This sensory modality allows them to detect prey in the absence of any other sensory stimuli. Very strong electric fields, however, have been shown to deter approaching sharks. Sharks are most likely perturbed by the large electric fields that may overload their electrosensory system. Unfortunately, the devices that generate large electric currents are not suitable for use in most fisheries due to their size and power requirements. A possible alternative to these electronic shark deterrent devices is to use highly electropositive metals (e.g. Lanthanide metals). Electropositive metals have a strong tendency to release electrons and generate large electric fields when placed in seawater. It is thought that these metals perturb the electrosensory system in sharks causing the animals to exhibit aversive behaviors.

We conducted two experiments to test the ability of electropositive metals to deter sharks from feeding. In one experiment we utilized a shark-viewing cage to film and observe choice experiments with Galapagos (*Carcharhinus galapagensis*) and sandbar sharks (*Carcharhinus plumbeus)*. Results indicate that bait associated with lead metal was eaten over bait associated with electropositive metal. In addition, sharks exhibited more aversion behaviors as they approached bait associated with the electropositive metal. In a second study, we conducted paired fishing experiments to determine the effects of Nd/Pr (Neodymiun/Praseodymium) alloy on the catch rates of sharks on bottom set longline gear. Preliminary results from longline field trials in Kaneohe Bay, Hawaii suggest that catch rates of juvenile scalloped hammerhead sharks (*Sphyrna lewini)* are reduced when a Nd/Pr weight is attached to the branchline. Taken together, these results suggest that electropositive metals do influence feeding behavior in sharks and could be potentially used to reduce the incidental capture of sharks in longline fisheries.

GILL DIMENSIONS IN FAST, CONTINUOUSLY SWIMMING TELEOSTS: SCOMBRIDS AND BILLFISHES

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This comparative study of the gill morphometrics in scombrids and billfishes was undertaken to determine optimal features of gill design related to high rates of gas transfer and the high-pressure branchial flow associated with fast, continuous swimming. Tunas have the largest relative gill surface areas of any fish group, and although the gill areas of non-tuna scombrids and billfishes are smaller than those of tunas, they are also disproportionally larger than those of most other teleosts. The structural features contributing to the large gill surface areas of these pelagic teleosts include: 1. a relatively large number of long gill filaments, 2. a high lamellar frequency (i.e., the number of lamellae per length of filament), and 3. lamellae that are long and low in profile (height), which allows a greater number of gill filaments to be tightly packed into the branchial cavity. These gill morphometrics utilized to augment gill surface area vary from that predicted and found in other teleost groups with relatively large gills, and these differences appear to be related to fast, continuous swimming. Both high lamellar frequencies and relatively long lamellae increase branchial resistance to water flow at the gills which consequently slows and streamlines the high-pressure branchial stream associated with ram ventilation. Among the high-energy demand teleosts examined, swordfish possess a previously undocumented branching of the gill filaments that appears to increase gill surface area above that of other billfishes and may allow swordfish to penetrate oxygen-poor waters at depth. Generally, however, pelagic teleost gill surface area appears to correlate with metabolic requirements and may help to predict the energetic demands of fish species where direct measurement is not possible.

NURSERY ORIGIN OF YELLOWFIN (*THUNNUS ALBACARES*) AND BIGEYE TUNA (*THUNNUS OBESUS*) IN THE HAWAIIAN ISLANDS

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Refining our understanding of population structure and varying degrees of stock mixing is critical to the effective management of Western Central Pacific Ocean (WCPO) tuna stocks. The purpose of this study is to determine whether chemical signatures in the otoliths of yellowfin and bigeye tuna in the WCPO are sufficiently distinct to be useful as "natural tags" indicating nursery origin. Chemical signatures (stable isotopes and trace elements) in the otolith cores of age-0 yellowfin and bigeye tuna from six areas in the WCPO were assessed in 2008. Significant differences (MANOVA $p < 0.01$) in otolith composition were found among all areas for both species. Otolith cores of yellowfin tuna from the Hawaiian Islands showed differing chemical signatures (i.e., enriched $\delta^{18}O$) relative to conspecifics from equatorial nursery areas with overall cross-validated classification success of 87%. In addition, otolith cores of bigeye tuna from the central Equatorial Pacific had different chemical signatures than fish collected from western Equatorial Pacific nursery areas with 82% classification success. Results indicate the approach has promise for distinguishing individuals of both species from different nurseries in the WCPO. Assessment of inter-annual variability in chemical tags is currently in progress using a second year (2009) of age-0 chemical signatures. Moreover, isolated otolith core material (~ comparable to age-0 period) of age-1 and age-2 yellowfin and bigeye tuna are underway to determine the nursery origin of these individuals.

BIOLOGY OF JUVENILE WHITE SHARKS IN THE EASTERN PACIFIC

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Juvenile white sharks have been studied using satellite telemetry in the eastern Pacific since 2002. Young-of-the-year to three-year-old white sharks appear to remain primarily in neritic waters, and undertake movements between US and Mexican waters. The home range of this age class of white sharks includes the California Current system off California and Baja California, as well as the Gulf of California. In contrast, adults and subadults do not appear to move between US and Mexican waters, instead making offshore movements from their respective nearshore aggregation sites into pelagic waters towards Hawaii. The neritic habitat of juveniles, combined with their smaller size, makes them more vulnerable to fishery interactions than adults. The primary management and conservation issue for white sharks in the Eastern Pacific appears to be capture in gillnets in the US and Mexico. Adults do not appear to be captured in commercial or recreational fisheries with any regularity. The most pressing conservation research needs for white sharks in the Eastern Pacific are the refinement of our understanding of juvenile habitat requirements and migrations, and means of reducing interaction with gillnets, or survivorship following interaction with gillnets.

ELECTRONIC TAGGING IN THE SOUTHWESTERN PACIFIC AND ITS ROLE IN STOCK ASSESSMENT AND CONSERVATION MEASURES FOR BROADBILL SWORDFISH.

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Catches of swordfish off the east coast of the Australian continent declined in the late 1990s and early 2000s, despite increasing effort. These declines appeared to be driven by local depletion of the fish on seamounts, and a general decrease in catches. This decline spawned the need for a stock assessment in order to understand the status of the stock and set sustainable catch levels. A fundamental uncertainty in developing the assessment was the stock structure and movement of the fish in the region. There was good evidence that both migrations and population structure were important for the species in this region; however, detailed data were lacking. This data gap resulted in the development of a regional tagging program designed to address some of the central information needs for developing the stock assessment. Three years down the line the tagging data is mostly in, the stock assessment has been updated, and conservation measures have been put in place in the Western Central Pacific Fisheries Commission. However, there are still some challenges in developing and incorporating electronic tagging data in stock assessments. We will provide an updated picture on swordfish movement and structure from our data, and discuss the process of incorporating that data into stock assessments and some of the challenges arising from the efforts.

TRENDS IN BILLFISH ANGLER CATCH RATES AND BILLFISH TAGGING EFFORT - SUMMARY OF THE SWFSC COOPERATIVE BILLFISH ANGLER RESEARCH PROGRAMS

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The Southwest Fisheries Science Center (SWFSC) conducts cooperative research with billfish anglers through the International Billfish Angling Survey and the Cooperative Marine Game Fish Tagging Program. The Billfish Newsletter is an annual publication written for the billfish angling community describing updated results from these research projects that have been ongoing for over 35 years. This research has only been possible because of the continued support of recreational billfish anglers, sportfishing clubs, commercial fishers, and agencies affiliated with SWFSC. We present a summary of the 2008 Billfish Newsletter.

The International Billfish Angling Survey is used to collect catch and effort data from recreational billfish anglers fishing in the Pacific and Indian Oceans. Anglers filling out the Survey are asked to indicate the number of days fished during the calendar year and the number of billfish caught by species and area, providing SWFSC researchers with a time series of relative abundance independent of commercial fisheries. In 2006, 792 survey responses were received, while 705 responses were received in 2007. Nominal catch-per-unit-effort (CPUE) was calculated as the number of billfish caught per angler day. In 2006, throughout all areas, anglers reported catching 5,164 billfish in 6,540 days (0.79 CPUE); in 2007, 3,913 billfish were reported caught during 5,654 fishing days (0.69 CPUE). In the Pacific, mean CPUE was 0.82 in 2006 and 0.68 in 2007, which were among the highest reported catch rates in over 20 years. The mean CPUE for striped marlin caught off Mexico during 2006 and 2007 were the highest on record. Similarly, striped marlin catch rates in Southern California were also up from previous years. Anglers in Costa Rica reported catching a total of 1,696 sailfish in 342 days during 2006 (4.96 CPUE), which was the second highest CPUE reported from this area in Survey history. Relative catch rates for Pacific blue marlin, black marlin, shortbill spearfish, and broadbill swordfish are also discussed.

Initiated in 1963, the Billfish Tagging Program has provided tagging supplies including applicator tips, nylon tipped dart tags, and release information cards to volunteer billfish anglers for over 44 years. Since inception of the Program, over 57,000 fish of 75 different species have been tagged and released. Most tags have been released on striped marlin (22,000), Pacific blue marlin (9,247), and sailfish (9,040). Throughout all areas, 1,964 billfish were tagged and released during 2006 and 2007 with nearly 1,500 of those tags deployed around the Hawaiian Islands. In total, 1,085 blue marlin, 208 striped marlin, 176 shortbill spearfish, and four black marlin were tagged and released off Hawaii during the two year period. In other areas, striped marlin made up the majority of tag releases; 185 striped marlin were tagged and released off Baja California, Mexico, and 78 off Southern California. From 1963 through 2007, 566 billfish tag returns have been reported (overall return rate of 1.11%). During 2006 and 2007: two striped marlin, three blue marlin, one shortbill spearfish, and one unidentified marlin were reported recaptured. Recapture reporting rates are down and efforts are being made to improve these numbers through enhanced outreach and web-based reporting mechanisms.

HISTORY OF THE TUNA CONFERENCE

HISTORY OF THE TUNA CONFERENCES

William H. Bayliff

Inter-American Tropical Tuna Commission

The Tuna Conferences were organized to provide a forum at which representatives of various organizations concerned with tunas, and later billfishes, would have the opportunity to exchange information and ideas. Except during the first few years, the conferences have been held at the University of California at Los Angeles Conference Center at Lake Arrowhead, California. Nearly all the attendees stay and eat at the Conference Center, which ensures that people from different organizations have ample time to talk with one another during breaks in the meetings. The conferences have always been dominated by biologists and oceanographers, but economists, fishermen, fish processors, representatives of sport-fishing interests, and legal experts have also attended, and some of these have given presentations. The Chairman of the 33rd Tuna Conference, Samuel F. Herrick, Jr., is an economist. Tunas associated with dolphins are taken by the purse-seine fishery of the eastern Pacific Ocean, and some dolphins are accidentally killed during fishing operations. As a result, several organizations doing research on tunas in the eastern Pacific Ocean began studies on dolphins, and some of the results of those studies have been presented at Tuna Conferences. Michael D. Scott, co-chairman of the 48th Tuna Conference, is a marine mammalogist.

The first Tuna Conference was held in 1950, and they have been held each year thereafter (Table 1). At first nearly all the attendees were from California, with a few from Washington, Oregon, Hawaii, the U.S. east coast, and countries other than the United States (Table 2). Many of the attendees from far-away places were probably visiting California for reasons other than attending the Tuna Conference. As time passed, more people from far-away places (and from northwestern Mexico) attended the Tuna Conferences. In 1994, for the first time, more than half the attendees at a conference held in California were from places other than California. Coincidentally, the caliber of the talks improved. Without doubt, the better talks lured more people from far-away places, and the inclusion of talks by people from far-away places resulted in programs which were of greater interest than would have been the case if nearly all the speakers had been from California. Unless travel funds are cut, the Tuna Conferences will probably continue to attract people from all over the world.

No information is available on the first Tuna Conference, and it is possible that proceedings of that conference were not prepared. Someone (I've forgotten who) told me that Dr. O. E. Sette of the U.S. Fish and Wildlife Service was probably primarily responsible for convening the first Tuna Conference.

The following persons participated in the second Tuna Conference:

American Tuna Boat Association – Wilbert M. Chapman;

California Department of Fish and Game – Clarkson E. Blunt, Jr., Frances N. Clark, Harry C. Godsil, Edward C. Greenhood;

Inter-American Tropical Tuna Commission – Franklin G. Alverson, Gerald V. Howard, Rolf Juhl, Milner B. Schaefer;

Oregon Fish Commission – Edwin K. Holmberg, Donald L. McKernan;

Pacific Marine Fisheries Commission – John Gharrett;

Scripps Institution of Oceanography – Carl L. Hubbs, John Isaacs, Roger R. Revelle, Warren S. Wooster;

U.S. Fish and Wildlife Service – Elbert H. Ahlstrom, Joseph E. King, William F. Royce, Edward A. Schaeffers, Oscar E. Sette;

University of Washington – Richard Van Cleve;

Washington Department of Fisheries – Donald R. Johnson.

The agenda for the second Tuna Conference is reproduced in Appendix 1. It is rigidly structured, and the full report appears as if it was written by a rapporteur, rather than assembled by one or more editors from reports written by the speakers, as is the case now. The same style prevailed for the next 10 to 15 years, although the reports on the various subjects became longer and the overall reports appear to have been assembled by one or more editors from abstracts written by the speakers. The reports for the various organizations appeared as appendices in the reports of the 16th, 17th, and 18th Tuna Conferences, rather that at the beginning of the reports, as had been be case previously. After that the reports for the various organizations were dropped, although the Director of the Southwest Fisheries Science Center of the U.S. NMFS still submits a separately-bound report to the Tuna Conference each year. The 14th, 15th, 17th, 18th, 22nd, 23rd, 24th, and 26th Tuna Conferences included reviews of the tuna fisheries in various areas. The abstracts of the papers presented at the 12th Tuna Conference were published in Special Scientific Report 415 of the U.S. Fish and Wildlife Service. The preface to the report of the 24th Tuna Conference begins with the statement, "The contents of these abstracts are of an informal nature, and therefore are not to be quoted or cited without permission of the author(s)," and most of the subsequent reports contain similar statements. Except during the first few years, there were usually sessions on various subjects, *e.g*., physiology and behavior, stock structure, *etc*. A panel discussion within the subject "Tuna Fisheries and Population Dynamics" was held at the 16th Tuna Conference, and panel discussions on various subjects were held at subsequent conferences. The 30th Tuna Conference was the first to have an overall theme, "Unit Stock Management of Highly Migratory Species: Is it an Imperative?" Previous to the 40th Tuna Conference the abstracts were submitted to the Chairman at the conference, and he subsequently put them together and mailed the reports to the attendees. For the 40th Tuna Conference, however, the Chairman received the abstracts before the conference and distributed the report at the conference, and this procedure has been followed for all subsequent conferences. This was a considerable improvement over the previous system. Posters were first exhibited at the 41st Tuna Conference.

The sexes of the attendees are listed in Table 3. During the early years nearly all the attendees were men. Dr. Frances N. Clark of the CDFG attended the second through the sixth conferences, and Ms. Yvonne M. M. Bishop of the IATTC attended the seventh and eighth conferences.

Eastern Pacific Ocean Council (EPOC) meetings were held in conjunction with the 8th through 10th and 12th through 26th Tuna Conferences. The Tuna Conferences extended from Monday morning until noon on Wednesday, and the EPOC meetings began after lunch on Wednesday and lasted until Friday afternoon. Many people attended all or parts of both

meetings. Tuna Conference presentations most likely to be of interest to oceanographers were given on Wednesday morning, and EPOC presentations mostly likely to be of interest to biologists were given on Wednesday afternoon. No information on the EPOC meetings subsequent to that for 1975 is available, but these meetings probably ceased to be held in conjunction with the Tuna Conferences at about the time that the dates of the latter were switched from October to May.

Four scholarships, the Tuna Conference scholarship, the Manuel Caboz Memorial scholarship, the Wildlife Computers scholarship, and the Automatic Differentiation Model Builder scholarship have been established to help defray the costs of attending the Tuna Conferences for students. The Tuna Conference scholarships are funded by registration fees, which were first collected at the 35th Tuna Conference, and the first scholarship was awarded at the 36th Tuna Conference. The Manuel Caboz Memorial scholarship was first awarded at the 41st Tuna Conference, the Wildlife Computers scholarship was first awarded at the 59th Tuna Conference, and the Automatic Differentiation Model Builder scholarship was first awarded at the 60th Tuna Conference. In addition, the Southern California chapter of the American Institute of Fishery Research Biologists gave an award for the best paper presented at the 48th Tuna Conference. Additional information on the scholarships is given on page 5 of the report for the 45th Tuna Conference.

Some information on Captain Manuel Caboz, which will be of interest to many of the people attending the Tuna Conferences, appears in Appendix 2.

The Tuna Conference has a web page, http://www.tunaconference.org, with up-to-date information on recent conferences.

TABLE 1. Locations, dates, chairpersons, and numbers of attendees for Tuna Conferences. The abbreviations are as follows: BCF, U.S. Bureau of Commercial Fisheries; CAS, California Academy of Sciences; CDFG, California Department of Fish and Game; FWS, U.S. Fish and Wildlife Service; IATTC, Inter-American Tropical Tuna Commission; n.a., not available; NMFS, U.S. National Marine Fisheries Service; SIO, Scripps Institution of Oceanography; STOR Scripps Tuna Oceanography Research. n.a. = not available

No.	Location	Dates	Chairperson(s)	Attendees
1				
2	Del Mar	Oct. 30-Nov. 1, 1951	Oscar E. Sette, FWS	23
3	CAS, San Francisco	Nov. 6-8, 1952	Milner B. Schaefer, IATTC	27
4	CDFG, San Pedro	Nov. 8-9, 1953	Robert C. Wilson, CDFG	31
5	SIO, La Jolla	Nov. 3-5, 1954	Bell M. Shimada, IATTC	38
6	CAS, San Francisco	Nov. 15-17, 1955	Garth I. Murphy, FWS	32
7	SIO, La Jolla	Oct. 22-24, 1956	Leo Pinkas, CDFG	43
8	Lake Arrowhead	Oct. 21-24, 1957	Gerald V. Howard, IATTC	42
9	Lake Arrowhead	Oct. 27-29, 1958	Maurice Blackburn, STOR	49
10	Lake Arrowhead	Dec. 7-9, 1959	Harold B. Clemens, CDFG	43
11	Lake Arrowhead	Sep. 30-Oct. 2, 1960	James H. Johnson, BCF	50
12	Lake Arrowhead	Sep. 25-27, 1961	Clifford L. Peterson, IATTC	48
13	Lake Wilderness, Wash.	Oct. 2-3, 1962	Robert W. Holmes, STOR	35
14	Lake Arrowhead	Sep. 30-Oct. 2, 1963	Robert R. Bell, CDFG	n.a.
15	Lake Arrowhead	Sep. 28-30, 1964	Richard R. Whitney, BCF	n.a.
16	Lake Arrowhead	Sep. 27-29, 1965	James Joseph, IATTC	n.a.
17	Lake Arrowhead	Oct. 17-19, 1966	Alan R. Longhurst, STOR	n.a.
18	Lake Arrowhead	Nov. 6-8, 1967	William L. Craig, CDFG	n.a.
19	Lake Arrowhead	Oct. 14-16, 1968	Frank J. Hester, BCF	n.a.
20	Lake Arrowhead	Oct. 13-15, 1969	Craig J. Orange, IATTC	87
21	Lake Arrowhead	Oct. 12-14, 1970	Albert C. Jones, NMFS	77
22	Lake Arrowhead	Oct. 11-13, 1971	Francis Williams, STOR	84
23	Lake Arrowhead	Oct. 16-18, 1972	Robson A. Collins, CDFG	n.a.
24	Lake Arrowhead	Oct. 1-3, 1973	R. Michael Laurs, NMFS	82
25	Lake Arrowhead	Sep. 30-Oct. 2, 1974	Robert C. Francis, IATTC	61
26	Lake Arrowhead	Sep. 29-Oct. 1, 1975	Charles W. Hooker, CDFG	71
27	Lake Arrowhead	Sep. 26-29, 1976	William W. Fox, Jr., NMFS	47
28	Lake Arrowhead	Oct. 3-4, 1977	Robin L. Allen, IATTC	39
29	Lake Arrowhead	May 22-24, 1978	Fred Hagerman, CDFG	42
30	Lake Arrowhead	May 13-16, 1979	Gary T. Sakagawa, NMFS	59
31	Lake Arrowhead	May 11-14, 1980	Alex Wild, IATTC	49

TABLE 1. (continued)

No.	Location	Dates	Chairperson(s)	Attendees
32	Lake Arrowhead	May 17-20, 1981	Doyle A. Hanan, CDFG	32
33	Lake Arrowhead	May 16-19, 1982	Samuel F. Herrick, Jr., NMFS	69
34	Lake Arrowhead	May 15-18, 1983	Robert J. Olson, IATTC	64
35	Lake Arrowhead	May 20-23, 1984	Andrew E. Dizon, NMFS	69
36	Lake Arrowhead	May 21-24, 1985	Kurt M. Schaefer, IATTC	74
37	Lake Arrowhead	May 18-21, 1986	Richard W. Brill, NMFS	65
38	Lake Arrowhead	May 17-20, 1987	Witold L. Klawe, IATTC	85
39	Lake Arrowhead	May 15-18, 1988	Norman W. Bartoo, NMFS	71
40	Lake Arrowhead	May 22-25, 1989	Michael G. Hinton, IATTC	72
41	Lake Arrowhead	May 21-24, 1990	Christopher H. Boggs, NMFS	93
42	Lake Arrowhead	May 20-23, 1991	Daniel Margulies and Jeanne B. Wexler, IATTC	77
43	Lake Arrowhead	May 8-21, 1992	Atilio L. Coan, Jr., and Alan R. Jackson, NMFS	69
44	Lake Arrowhead	May 17-20, 1993	Edward H. Everett and Richard G. Punsly, IATTC	84
45	Lake Arrowhead	May 23-26, 1994	Pierre Kleiber and Randall Rasmussen, NMFS	99
46	Lake Arrowhead	May 14-17, 1995	Ashley J. Mullen and Jenny M. Suter, IATTC	89
47	Lake Arrowhead	May 20-23, 1996	Norman W. Bartoo, Alan R. Jackson, and Randall Rasmussen, NMFS	92
48	Lake Arrowhead	May 19-22, 1997	Robert J. Olson and Michael D. Scott, IATTC	120
49	Lake Arrowhead	May 18-21, 1998	Christofer H. Boggs, NMFS	105
50	Lake Arrowhead	May 24-27, 1999	George M. Watters and JoyDeLee Marrow, IATTC	92
51	Lake Arrowhead	May 22-25, 2000	David Holts and Michelle DeLaFuente, NMFS	78
52	Lake Arrowhead	May 21-24, 2001	Mark Maunder and Sharon Hunt, IATTC	79
53	Lake Arrowhead	May 20-23, 2002	Keith Bigelow and Randy Chang, NMFS	59
54	Lake Arrowhead	May 13-16, 2003	Shelton Harley, IATTC	78
55	Lake Arrowhead	May 24-27, 2004	Paul Crone and Kevin Hill, NMFS	102
56	Lake Arrowhead	May 23-26, 2005	Simon Hoyle and Michael Hinton, IATTC	98
57	Lake Arrowhead	May 22-25, 2006	Russ Vetter and Suzy Kohin, NMFS	97
58	Lake Arrowhead	May 21-24, 2007	Jeanne Wexler and Daniel Margulies IATTC	95
59	Lake Arrowhead	May 19-22, 2008	Heidi Dewar and John Hyde, NMFS	85
60	Lake Arrowhead	May 18-21, 2009	Alexandre Aires-da-Silva and JoyDeLee Marrow, IATTC	94

TABLE 2. Numbers of attendees from organizations located in various areas. The data for 2009 are preliminary. The codes for the headings are given on the next page. n.a. = not available.

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1																
2	16	4	3													23
3	18	5	4													27
4	21	8	2													31
5	22	7	4	2			2	1								38
6	20	7	3				2									32
7	32	4	3	2			2									43
8	31	4	3				3	1								42
9	33	7	4	1			2	2								49
10	33	4	4	1			1									43
11	38	7	3	1			1									50
12	38	3	3	2			2									48
13	15	11	3	2			2	1				1				35
14																n.a.
15																n.a.
16																n.a.
17																n.a.
18																n.a.
19																n.a.
20	56	8	2	14	1		2	2			2					87
21	54	6	3	11		2	1									77
22	54	2	4	11	1	3	6		2		1					84
23																n.a.
24	59	8	2	4		3	1	2	2	1						82
25	47		3	2		1	1	2			2	1		2		61
26	55	4	3	3		2		1			1	1		1		71
27	32	1	3	7			1		1		1	1				47
28	32	1	3	1							1	1				39
29	34	1	3	3			1									42
30	40	4	2	11			1					1				59
31	38	4	3				3				1					49
32	58	3	1	2		3	1		1		4	1	1	1		76
33	47	4	3	5		5			1		2		2			69
34	46	2	6	1	2	2			1		1	1	1		1	64
35	50	4	6	4					2				2	1		69
36	50	4	8	3		1	2	1			3	1			1	74
37	37	1	8	4		5	4		2		2		1	1		65
38	48	3	5	6		8	1	1	4		3	1	1	2	2	85
39	42	3	4	2		10	2	1	2		1	2		1	1	71
40	38	4	8	5		4	2	1		3	3		1	2	1	72
41	48	4	8	9		5	3		3	1	5	5		1	1	93
42	40	2	2	10		7	2	1	5		3	2	2	1		77
43	35	4	4	8		7	1	1	3		2	1	1		2	69

TABLE 2. (continued)

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
44	47	1	3	6		14	1		3	1	3		1	2	2	84
45	35	10	11	9		14	1		5		7	5	1	1		99
46	41	3	19	5	2	7	1	1	1		3	2	1	1	2	89
47	40	6	15	11	1	2	1	2	1		6	2	1	4		92
48	50	8	18	16	1	7	1	1	4	1	5	4		4		120
49	40	2	16	21	1	7	3	1	5		2	2	1	4		105
50	44	6	10	12	-	3	-	2	4	-	4	3	2	-	2	92
51	31	6	11	11	0	1	-	1	5	1	5	3	-	3	-	78
52	38	2	15	5	2	3	2	-	3	-	5	3	-	1	-	79
53	21	3	17	4	1	1	2	1	2	-	1	4	-	1	1	59
54	27	3	12	13	-	4	2	-	6	-	4	4	2	-	1	78
55	50	6	16	6	1	5	3	1	2	-	5	5	2	-	-	102
56	42	4	13	11	2	3	5	1	8	-	2	5	-	2	-	98
57	54	4	16	9	-	6	3	-	1	-	-	2	1	1	-	97
58	41	8	18	9	-	3	3	1	1	-	4	4	2	-	1	95
59	37	7	16	16	1	3	3	-	-	-	1	2	-	-	-	85
60	44	8	12	17	-	-	1	-	3	-	5	4	-	-	-	94

1 California
2 Oregon, Washington, and Alaska
3 Hawaii
4 U.S. Atlantic and Gulf coasts (excluding Puerto Rico)
5 other U.S.
6 Mexico
7 Canada
8 Other western hemisphere (including Puerto Rico)
9 Europe (including USSR and former USSR)
10 Africa
11 Asia (excluding Pakistan and Sri Lanka)
12 Australia and New Zealand
13 New Caledonia
14 Pacific islands (excluding Hawaii and New Caledonia)
15 Indian Ocean (including Pakistan and Sri Lanka)

TABLE 3. Numbers of male and female attendees. The data for 2009 are preliminary. It was not always possible to determine a person's sex from his or her name, particularly when only initials were used for the first and second names.

Conference	Men	Women	Unknown	Total
1				
2	22	1		23
3	26	1		27
4	30	1		31
5	37	1		38
6	31	1		32
7	42	1		43
8	41	1		42
9	49	0		49
10	43	0		43
11	50	0		50
12	47	1		48
13	34	1		35
14				n.a.
15				n.a.
16				n.a.
17				n.a.
18				n.a.
19				n.a.
20	86	1		87
21	75	2		77
22	83	1		84
23				n.a.
24	78	4		82
25	58	3		61
26	66	5		71
27	43	4		47
28	37	2		39
29	39	3		42
30	54	4	1	59
31	48	1		49
32	62	2	12	76
33	51	2	16	69
34	61	3		64
35	61	7	1	69
36	66	8		74
37	56	8	1	65
38	73	11	1	85
39	61	9	1	71
40	62	9	1	72
41	84	9		93
42	65	12		77

TABLE 3. (continued)

Conference	Men	Women	Unknown	Total
43	59	9	1	69
44	75	8	1	84
45	90	9		99
46	78	11		89
47	73	18	1	92
48	94	23	3	120
49	86	18	1	105
50	67	20	5	92
51	59	15	4	78
52	63	12	4	79
53	44	11	4	59
54	56	17	5	78
55	78	20	4	102
56	70	24	4	98
57	65	27	5	97
58	62	28	5	95
59	56	26	3	85
60	63	31		94

TABLE 4. Recipients of Tuna Conference scholarships. The abbreviations are as follows: CICIMAR, Centro Interdisciplinario de Ciencias Marinas; IFREMER, Institut Français de Recherche pour l'Exploitation de la Mer; VIMS, Virginia Institute of Marine Science.

Conference	Name(s)	Affiliation(s)	Presentation(s)
36	José Goulart	Univ. of California at Davis	none
37	Barbara A. Block	Duke Univ.	Strategies for elevating brain and eye temperatures in tunas, sharks, and billfishes
37	Cheryl Watson	Astoria, Oregon	none
38	Miguel Ross	CICIMAR	none
38	Chi-Lu Sun	Univ. of Miami	none
39	Kae Lynne Nakamura	Univ. of British Columbia	Estimates of age, growth and spawning of yellowfin tuna, *Thunnus albacares*, in the Philippines, as determined from the examination of increments on sagittal otoliths
40	Nancy Chartier	VIMS	Catch-handling trends of Virginia's recreational tuna fishery: the effects of killing and storage methods on the quality of northern bluefin tuna, *Thunnus thynnus*
40	James N. Ianelli	Univ. of Washington	Preliminary results of microconstituent variability in yellowfin otoliths
41	Charles Barr	VIMS	Evaluation of food and feeding of northern bluefin tuna (*Thunnus thynnus*) and yellowfin tuna (*Thunnus albacares*) off the coast of Virginia
42	Troy Buckley	Dept. Mar. Wild. Res., American Samoa	Feeding habits of yellowfin tuna at fish aggregation devices in American Samoa
42	James Masuoka	Univ. of California at San Diego	A novel zinc-binding serum protein from albacore (*Thunnus alalunga*): is it species specific?
42	Gabriel Nuñez Marquez	CICIMAR	Length-frequency distribution of yellowfin tuna caught in Mexican waters, 1989
43	Agustin Hernandez-Herrera	CICIMAR	Some aspects of reproduction in sailfish (*Istiophorus platypterus*) from La Paz and Cabo San Lucas, B.C.S., Mexico
44	Paul R. Wade	U.S. NMFS	A Bayesian approach to the population dynamics and management of the eastern spinner dolphin, *Stenella longirostris orientalis*
45	Daniel R. Scoles	VIMS	Global phylogeny of mackerels of the genus *Scomber*
46	Yu-Min Yeh	National Taiwan Univ.	The relationship between CPUE and abundance of albacore in the South Pacific
47	Vincent P. Buonaccorsi	VIMS	A comparative approach to genetic stock identification in the blue marlin, *Makaira nigricans*

TABLE 4. (continued)

Confe-rence	Name(s)	Affiliation(s)	Presentation(s)
47	Jan Cordes	VIMS	Mitochondrial DNA analysis of white marlin, *Tetrapturus albidus*, population structure
48	Robert J. Allman	Florida State Univ.	Growth and mortality of little tunny (*Euthynnus alletteratus*) larvae off the Mississippi River plume and Panama City, Florida
48	Marta C. Gomez-Buckley	Univ. of Washington	Use of statistical bootstrapping for sample-size determination to estimate length-frequency distributions for Pacific albacore tuna, (*Thunnus alalunga*)
49	M. Shiham Adam	Imperial College	Estimates of skipjack tuna growth parameters from the Maldivian pole and line fishery using tag recapture data
49	Vincent Buonaccorsi	VIMS	Microsatellite evolution within and among species of the Istiophoridae
50	none		
51	Ralph Mana	Kagoshima Univ.	Structural features of the olfactory system of bigeye tuna, *Thunnus obesus*, and striped marlin, *Tetrapturus audax*, in connection with pelagic mode of life
51	Robyn Wingrove	Univ. of Charleston	Population structure of dolphin, *Coryphaena hippurus*, in the western central Atlantic, Caribbean Sea, and Gulf of Mexico, inferred from mitochondrial DNA variation
52	Nathaniel Newlands	Univ. of British Columbia	Aerial surveying of Atlantic bluefin tuna (*Thunnus thynnus*), Gulf of Maine: relative abundance estimates under alternative spatial sampling strategies
53	Chugey Sepulveda	Scripps Institution of Oceanography	The swimming energetics of the eastern Pacific bonito (*Sarda chiliensis*): one step closer to understanding the tuna-bonito relationship
54	none		
55	Juan Pedro Arias Aréchiga	CICIMAR	Fishing oceanography of the Gulf of Tehuantepec: the case of the yellowfin tuna, *Thunnus albacares*
55	Francois Royer	IFREMER	A modeling framework for studying bluefin tuna behavior in its environment
55	Chugey A. Sepulveda	Scripps Institution of Oceanography	The thermal biology of the slender tuna, *Allothunnus fallai*
55	Rebecca Shuford	Univ. of South Carolina	Otolith microchemical analysis of juvenile yellowfin tuna from nursery areas in the Atlantic Ocean
56	Walter Golet	Univ. of New Hampshire	Analysis of shape and fat content in the Gulf of Maine bluefin tunas (*Thunnus thynnus*)
56	John Logan	Univ. of New Hampshire	Analysis of forage preferences and movement patterns of Atlantic bluefin tuna (*Thunnus thynnus*) using carbon and nitrogen stable isotopes
56	Ramzi Mirshak	Dalhousie Univ.	Towards mapping thermocline depth in the equatorial Pacific with satellite altimetry

TABLE 4. (continued)

Conference	Name(s)	Affiliation(s)	Presentation(s)
56	John E. Richert	Univ. of California at Davis	Spatio-temporal variability in the trophic ecology of large pelagic fishes of the southern Gulf of California
57	Daniel Cartamil	Scripps Institution of Oceanography	Acoustic telemetry studies of common thresher shark (*Alopias vulpinus*) movement patterns in the Southern California Bight
57	Dámaris López Medina	CICIMAR	Spatio-temporal variability of yellowfin tuna catches in adjacent waters to the Isla Marias, Mexico
57	John E.Richert	Univ. of California at Davis	Spatio-temporal variability in the trophic ecology of large pelagic fishes of the southern Gulf of California
57	Luis Antonio Valdovinos-Jacobo	CICIMAR	Conceptual migratory model of Monterey Spanish mackerel (*Scomberomorus concolor*) in the Gulf of California
58	Fernando Arias Olaiz	CICIMAR	Spatial-temporal distributions of the relative abundance of the sailfish (*Istiophorus platypturus*) in the Mexican Pacific Ocean
58	Juleen Dickson	California State Univ. at Fullerton	Medial red muscle development in the yellowfin tuna, *Thunnus albacares*
58	Yoshiki Kato	Univ. of Tokyo	Effect of ocean turbulence on survival and ingestion of tuna, *Thunnus*, larvae
58	Catherine Purcell	Univ. of Southern California	Connectivity of striped marlin populations in the Pacific
58	Arturo Tripp Valdez	CICIMAR	Trophic ecology of the dolphinfish *Coryphaena hippurus* (Linnaeus, 1758) in two areas of the south of the Gulf of California
58	Nicholas C. Wegner	Scripps Institution of Oceanography	Specialization for gill rigidity in ram-ventilating teleosts
59	Bridgett Ferris	Univ. of Washington	Factors affecting the accumulation of mercury in four tuna species: diet vs. life history
59	Amber Michaud	Univ. of San Diego	Population structure of shortfin mako (*Isurus oxyrinchus*) in the Pacific Ocean as inferred through mitochondrial DNA
59	Tara Scott	VIMS	Adjusting economic productivity to account for undesirable harvest: application to the California/Oregon drift gillnet fishery
60	A. Jason Phillips	Oregon State Univ.	Linking U.S. Pacific albacore CPUE to fine scale satellite environmental data

TABLE 5. Recipients of Manuel Caboz Memorial scholarships. The abbreviations are as follows: CICESE, Centro de Investigación Cientifica y de Educación Superior de Ensenada; CICIMAR, Centro Interdisciplinario de Ciencias Marinas; IFREMER, Institut Français de Recherche pour l'Exploitation de la Mer; IRD, Institut de Recherche pour le Développement; ORSTOM, Office de la Recherche Scientifique et Technique d'Outre-Mer; UABC, Universidad Autónoma de Baja California; VIMS, Virginia Institute of Marine Science.

Confe-rence	Name	Affiliation	Presentation
41	Simon R. Thorold	Australian Inst. Mar. Sci.	A novel method for collection of larval and juvenile scombrids
42	Daniel Scoles	VIMS	Mitochondrial DNA restriction fragment analysis of Pacific yellowfin tuna
43	Lee Morgan	VIMS	Allozyme analysis of striped marlin population structure
44	José Manuel Grijalva-Chon	CICESE	Mitochondrial DNA analysis of north Pacific swordfish (*Xiphias gladius*)
45	Laurent Dagorn	ORSTOM	Studying tuna school movements, using an artificial neural network applied to remote-sensing data from SEAS station and concurrent data from fishing fleets
46	Margarita Margolles Sierra	CICESE	Age determination of north Pacific albacore*, Thunnus alalunga*, based on osseous structures
47	Anthony C. Chatwin	Inst. Ocean., Univ. São Paulo	Estimates of abundance of the little Atlantic tunny, *Euthynnus alletteratus*, and the frigate mackerels, *Auxis* spp., in southeastern Brazilian waters
48	Gisela Heckel	UABC	Evasive behavior of spotted and spinner dolphins (*Stenella attenuata* and *Stenella longirostris*) during fishing of yellowfin tuna (*Thunnus albacares*) in the eastern Pacific Ocean
49	Brian Hanrahan	Univ. of Massachusetts	Estimating bluefin tuna (*Thunnus thynnus thynnus*) school size from limited observational data
50	Brett Falterman	VIMS	Population structure of the black marlin, *Makaira indica*, inferred from analysis of nuclear and mitochondrial molecular markers
51	Arnaud Bertrand	IRD	Influence of prey distribution on tuna catchability with a longline: a question of scale
52	Christelle Ravier	IFREMER	Retrospective analysis of historical data to investigate eastern Atlantic bluefin tuna population dynamics
53	Charlotte Girard	Université de Strasbourg	FADS: fish aggregating devices or fish attracting devices?
54	Terrence Dammannagoda	Queensland Univ. of Technology	Genetic stock structure and inferred migratory patterns of skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*) stocks around Sri Lanka
55	Andrij. J. Horodysky	VIMS	Survival and habitat preferences of white marlin (*Tetrapturus albidus*) released from the western North Atlantic recreational fishery

TABLE 5. (continued)

Conference	Name	Affiliation	Presentation
56	Mathieu Doray	IFREMER	The distribution and the dynamics of large pelagic fish aggregations around moored FADS in Martinique (Lesser Antilles) and their contribution to local fisheries
57	Sarah Glaser	Scripps Institution of Oceanography	Predation by juvenile albacore in the California Current System and impacts on growth
58	Andreas Walli	Stanford Univ.	Estimating feeding from visceral warming in Pacific bluefin tuna: lab and field measurements
59	Ryan W. Schloesser	Texas A. and M. Univ.	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
60	George L. Shillinger	Stanford Univ.	Pop-up satellite tags reveal movements and behaviors of Pacific bluefin tuna in the southern Pacific Ocean

TABLE 6. Recipient of the American Institute of Fishery Research Biologists (Southern California chapter) award for the best paper presented at that conference.

Conference	Name	Affiliation	Presentation
48	Richard W. Brill	U.S. NMFS	How water temperature limits the vertical movements of pelagic fishes

TABLE 7. Recipients of the Wildlife Computers, Inc., student scholarship award.

Conference	Name	Affiliation	Presentation
59	Chi H. Lam	Univ. of Southern California	Using time series analysis techniques to analyze animal movement data from archival and pop-up archival tags
60	Daniel Dutton	VIMS	Habitat utilization of blue marlin (*Makaira nigricans*) inferred from pop-up satellite archival tags and niche partitioning with other istiophorids

TABLE 8. Recipient of the Automatic Differentiation Model Builder student scholarship award.

Conference	Name	Affiliation	Presentation
60	Eunjung Kim	Univ. of Hawaii	Simulating the effect of FAD density on large scale movements

APPENDIX 1

AGENDA FOR SECOND TUNA CONFERENCE

I. Consideration of agenda
II. Review of 1951 program and brief account of fishery of the region
    1. Oregon Fish Commission
    2. Washington Department of Fisheries
    3. Hawaii Division of Fish and Game
    4. South Pacific Fishery Investigations (U.S. FWS, Stanford?)
    5. Scripps Institution of Oceanography
    6. Inter-American Tropical Tuna Commission
    7. California Department of Fish and Game
    9. Tuna Boat Owners' Association
III. Methods and results of racial population studies
    1. California Department of Fish and Game
    2. Pacific Oceanic Fisheries Investigations (U.S. FWS, Hawaii)
    3. Oregon Fish Commission
IV. Methods and results of marking studies
    1. U.S. FWS (Seattle)
    2. Pacific Oceanic Fisheries Investigations
V. Methods and results of studies of the distribution in relation to the environment
    1. Pacific Oceanic Fisheries Investigations
VI. Methods and results of spawning studies
    1, Pacific Oceanic Fisheries Investigations
VII. Methods and results of age and growth studies
    1. Oregon Fish Commission
    2. Hawaii Division of Fish and Game
    3. Pacific Oceanic Fisheries Investigations
    4. California Department of Fish and Game
VIII. Methods and results of catch analysis studies
    1. Oregon Fish Commission
    2. California Department of Fish and Game
    3. Inter-American Tropical Tuna Commission
    4. Pacific Oceanic Fisheries Investigations (Japanese mothership expedition)
IX. Report of scouting trips
    1. South Pacific Fishery Investigations
    2. U.S. FWS (Seattle)
    3. California Department of Fish and Game
    4. Pacific Oceanic Fisheries Investigations
X. Tuna reaction studies
    1. Pacific Oceanic Fisheries Investigations
XI. Forecast of 1952 program, with recommendations for future research and outlining possible cooperative studies
    1. Washington Department of Fisheries
    2. Oregon Fish Commission

3. South Pacific Fishery Investigations
4. California Department of Fish and Game
5. Inter-American Tropical Tuna Commission
6. U.S. FWS (Seattle)
7. Pacific Oceanic Fisheries Investigations
8. Tuna Boat Owners' Association
9. Scripps Institution of Oceanography

XII. Standardization and exchange of albacore length-frequency data
XIII. Problems in sampling the commercial catch: how often? how to get random sample?
XIV. Consideration of block number assignment for use in recording areas of tuna catches
XV. Consideration of inviting Latin American representation at future Tuna Conferences
XVI. Consideration of inviting industry representatives to audit future meetings
XVII. Discussion of future Tuna Conference: when, where, chairman?

APPENDIX 2

Manuel Correia Caboz, 1929-1988

The information in this appendix comes from an obituary published in the San Diego Union on July 10, 1988, notes made by Dr. Michael G. Hinton when he spoke with Mrs. Názare Caboz in 1990, and data in the IATTC catch-and-effort statistics files.

Manuel Caboz was born in Madeira, Portugal, on May 14, 1929. His father moved his family to Venezuela after Manuel finished high school. Manuel then migrated from Venezuela to the United States in 1947 or 1948, married Názare Rodrigues, daughter of the captain of the *Sun Victoria*, a baitboat with a fish-carrying capacity of 335 metric tons (mt) built in 1937, and then went to work as a crew member on that vessel. He became a captain for the first time in 1956 aboard the *St. Matthews*, a 235-mt baitboat built in 1945. He subsequently became owner or part-owner of the *American Queen*, a 445-mt baitboat built in 1949 (converted to a 405-mt purse seiner in 1960); the *Jeanette C*., an 820-mt purse seiner built in 1967; another *American Queen*, a 1020-mt purse seiner built in 1972; the *Nazare Mary*, a 950-mt purse seiner built in 1974; and the *Carol Virginia*, a 905-mt purse seiner built in 1980. He died of cancer on July 6, 1988. He was managing owner of the *Carol Virginia* at that time.

In spite of his busy schedule, Captain Caboz was very active in community affairs. He was a member of the Board of Directors of the American Tunaboat Association, holding various offices in that organization since 1974. He was one of the founding directors of the U.S. Tuna Foundation, organized in 1977, which represents the interests of American canneries and of owners of American tuna vessels. He was also one of the founders of the Southern California Bank, which was established in 1979, and he was an active member of the St. Agnes Roman Catholic Church in San Diego.

He was survived by his wife, Názare R. Caboz, and four daughters, three of whom married captains of tuna boats.

Captain Caboz had often expressed his belief in the importance of a good education, so, in recognition of this, the Caboz family established the Caboz Memorial Scholarship Fund shortly after his death. Tuna biologists from all over the world have benefited from this generous gift. The first scholarship was awarded in 1990.

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