

JIMAR ANNUAL REPORT FOR FY 2010

P.I./SPONSOR NAME: Kevin Weng, Mike Musyl, Christina Larsen, Hans Malte and Rich Brill

NOAA OFFICE (Of the primary technical contract): NMFS/PIFSC

PROJECT PROPOSAL TITLE: Modeling the Eco-physiology of Pelagic Fishes and Sharks with Archival and Pop-up Satellite Archival Tags (PSATs)

FUNDING AGENCY: NOAA

NOAA GOAL (Check those that apply):

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management
- To understand climate variability and change to enhance society's ability to plan and respond
- To serve society's needs for weather and water information
- To support the nation's commerce with information for safe, efficient, and environmentally sound transportation

PURPOSE OF THE PROJECT (One paragraph): The project was designed to benefit by using available data from archival and PSAT tags to develop IBMs (individual based models) to describe the eco-physiology of different species of large pelagic fishes and sharks. This project will complement data already collected on a number of pelagic species and will be linked to existing PFRP projects by Musyl, Brill, and Moyes. Thus, the study will be a collaborative effort between many institutions and agencies including the University of Hawaii/JIMAR/PFRP, VIMS/National Marine Fisheries Service, and the Dept. of Zoophysiology, University of Aarhus, Denmark. Our ultimate goal is to develop model(s) which will be applicable to many different species of pelagic fish and shark. Using these models it was anticipated that researchers could evaluate the importance of specific oceanographic parameters in an unbiased fashion, which would allow for intra- and inter-species comparison. A second purpose of this study is to explore failure (or conversely success) scenarios in pop-up satellite archival tags (PSATs) attached to pelagic fish, sharks and turtles. Specifically, this aspect of the study is designed to look for explanatory variables in the context of PSAT retention rates, percentage retrieved satellite data (i.e. depth, temperature, geolocations), and tag failure. By examining several factors and information about PSATs attached to vastly different pelagic species, it is anticipated that certain patterns/commonalities may emerge to help improve our understanding of attachment methodologies, selection of target species and experimental design. Lastly, information derived from this study will

allow an unprecedented and critical appraisal of the overall efficacy of the technology.

PROGRESS DURING FY 2010 (One-two paragraphs, including a comparison of the actual accomplishments to the objectives established for the period, and the reasons for the slippage if established objectives were not met): Although the project was unavoidably delayed due to major knee surgery for PI Musyl in FY2007 and in FY2008 (and medical problems with other personnel), several manuscripts have been published and submitted by project personnel (outlined below) including a major review manuscript on PSAT performance and reliability (Musyl et al.), a major review on pelagic species in relation to physiology and movement (Bernal et al. 2009), an article on thermal biology in tuna (Boye et al. 2009) as well as a paper in 'NATURE' by Humphries et al. (2010) detailing search patterns of pelagic species which has important ramifications in learning how animals disperse. Project personnel have also completed major analyses to correlate movement patterns of PSAT tagged blue shark, silky shark, oceanic white-tip, bigeye thresher and short-fin mako shark with various oceanographic parameters. Another manuscript detailing the post-release survival of pelagic sharks from longline gear is to be submitted soon.

PLANS FOR THE NEXT FISCAL YEAR (One paragraph):

Project has been concluded but project personnel anticipate two additional manuscripts to be completed: 1) a manuscript detailing the post-release survival of marlin (blue, stripe and black) from sports fishing and longline gear, and 2) movements of marlin in relation to oceanographic conditions. It is also planned that project personnel will accession PSAT performance data into a public repository housed at the PFRP website (metadata is already available). Lastly, due to the success and inertia of the project, various researchers from many agencies (both domestic and foreign) have expressed an interest in collaboration and/or initiating new projects.

LIST OF PAPERS PUBLISHED IN REFERRED JOURNALS DURING FY 2009, in the following format: (Author or authors with last name and initials, publication year: Article title. *Journal name*, volume, page range.) For example: Charney, J.G., and A. Eliassen, 1964: On the growth of the hurricane depression. *J. Atmos. Sci.*, 21, 68-75.

Bernal D, Sepulveda C, **Musyl M**, Brill R (2009) The eco-physiology of swimming and movement patterns of tunas, billfishes and large pelagic sharks. In P Domenici and BG Kapoor, (eds) *Fish locomotion- An Etho-Ecological Approach*, Enfield Scientific Publishers.

Beverly S, Curran D, **Musyl M**, Molony B (2009) Effects of eliminating shallow hooks from tuna longline sets on target and non-target species in the Hawaii-based pelagic tuna fishery. *Fisheries Research* 96: 281–288

Sibert J, Nielsen A, **Musyl M**, Leroy B, Evans K (2009) Removing Bias in Latitude Estimated from Solar Irradiance Time Series. In JL Nielsen et al. (eds) *Tagging*

and Tracking of Marine Animals with Electronic Devices, Reviews: Methods and Technologies in Fish Biology and Fisheries 9, Springer.

Nielsen A, Sibert JR, Kohin S, **Musyl MK** (2009) State space model for light based tracking of marine animals: validation on swimming and diving creatures. In JL Nielsen et al. (eds) Tagging and Tracking of Marine Animals with Electronic Devices, Reviews: Methods and Technologies in Fish Biology and Fisheries 9, Springer.

Boye J, **Musyl M**, Brill R, Malte H (2009) Transactional heat transfer in thermoregulating bigeye tuna (*Thunnus obesus*) - a two-dimensional heat flux model. Journal of Experimental Biology 212:3708-3718

Musyl MK, Moyes CD, Brill RW, Fragoso N (2009) Factors influencing mortality estimates in post-release survival studies. Marine Ecology Progress Series 396:157–159

Swimmer Y, Arauz R, Wang J, Suter J, **Musyl M**, Bolanos A, Lopez A (2010) Comparing the effects of offset and non-offset circle hooks on catch rates of fish and sea turtles in a shallow longline fishery. Aquatic Conservation: Marine and Freshwater Ecosystems (DOI 10.1002/aqc.1108, published online 26 Mar 2010)

Humphries NE, Dyer JRM, Queiroz N, Pade NG, **Musyl MK**, Schaefer K, Brunnschweiler JM, Doyle TK, Houghton JDR, Hays GC, Jones CS, Noble LR, Wearmouth VJ, Southall EJ, Sims DW (2010) Environmental context explains Lévy and Brownian movement patterns of marine predators. Nature 465:1066-1069

Submitted/finished manuscripts

Musyl MK, Brill RW, McNaughton LM, Swimmer JY, Domeier M, Nasby-Lucas N, Lutcavage M, Wilson SG, Galuardi B, Royer F, Liddle JB (2010) Review and Meta-Analysis of Pop-up Satellite Archival Tag (PSAT) Performance and Reliability in Marine Fisheries Research. Marine Ecology Progress Series (*submitted*)

Musyl MK, Brill RW, Curran DS, McNaughton LM, Kikkawa B, Fragoso N, Moyes CD (2010) Post-release survival, vertical movements and thermal niche partitioning in five species pelagic sharks released from longline fishing gear in the Central Pacific Ocean. Fisheries Research (*in prep*)

Chiang W-C, **Musyl MK**, Fu S-C, Huang T-L, Sun C-L, Chen W-Y, Liu D-C, Su W-C, Yeh S-Z (2010) Electronic tagging studies of sailfish (*Istiophorus platypterus*) in eastern Taiwan to examine movement patterns, habitat preferences and fisheries interaction. Marine Ecology Progress Series (*submitted*)

Dewar H, Prince E, **Musyl MK**, Brill RW, Sepulveda C, Luo J, Foley D, Orbesen ES, Domeier ML, Nasby-Lucas N, Snodgrass D, Laurs RM, Block BA, McNaughton LM (2010) Movements and behaviors of swordfish in the Atlantic and Pacific Oceans examined using pop-up satellite archival tags. Fisheries Oceanography (*submitted*)

Hoolihan JP, Luo J, Abascal FJ, Campana SE, De Metro G, Dewar H, Domeier ML, Howey LA, Lutcavage ME, **Musyl MK**, Neilson JD, Orbesen ES, Prince ED, Rooker JR (2010) Evaluating irregular post-release behaviour of large pelagic fishes deployed with pop-up satellite archival tags. ICES J (*submitted*)

OTHER PAPERS, TECHNICAL REPORTS, ETC.:

Mike Musyl, Rich Brill, Chris Moyes, Nuno Fragoso, Lianne McNaughton, Dan Curran. 2009. Factors affecting post-release survival in large pelagic fish and sharks. PFRP Meeting, Honolulu, HI, November, 2009

Mike Musyl, Rich Brill, Chris Moyes, Nuno Fragoso, Lianne McNaughton, Dan Curran. 2010. Factors and methods relevant to post-release mortality in large pelagic billfishes and sharks. Pacific Grove Environmental Lab, NOAA, Monterey, CA, 22 April 2010

Michael K. Musyl, Richard W. Brill, Daniel S. Curran, Nuno M. Fragoso, Lianne M. McNaughton, Bert S. Kikkawa and Christopher D. Moyes. 2010. Factors and Methods Relevant to Post-release Mortality in Large Pelagic Billfishes and Sharks. 61st Tuna Conference, Lake Arrowhead, CA, May, 2010 (abstract).

GRADUATES (Names of students graduating with MS or PhD degrees during FY 2008; Titles of their Thesis or Dissertation): None.

AWARDS (List awards given to JIMAR employees or to the project itself during the period): None.

PUBLICATION COUNT (Total count of publications for the reporting period and categorized by NOAA lead author and Institute (or subgrantee) lead author and whether it was peer-reviewed or non peer-reviewed (not including presentations):

	JI Lead Author	NOAA Lead Author	Other Lead Author
Peer Reviewed	1	1	6
Non-Peer Reviewed	5	2	1

PERSONNEL:

For projects that awarded subcontracts in the fiscal year, please provide the number of supported postdocs and students from each subgrantee.

At present, no students or post-docs are paid by the project.

IMAGES AND CAPTIONS (We will also be including images for the annual report.

Please send two of your best high-resolution, color images (photo, graphic, schematic) as a **JPEG or TIFF (300 dpi)** with a caption for each image. If you do not have an electronic version of the image, a hardcopy version may be dropped off at the JIMAR office located in the Marine Sciences Building, Room 312):

Caption 1: Niche partitioning in the pelagic environment. Unweighted pair-group method using arithmetic averages (UPGMA) clustering using distributions of daytime temperature preference readings from pop-up satellite archival tags (PSATs). The greatest vertical distance between cumulative distribution functions among tags from two-sample Kolmogorov – Smirnov tests was formatted into a distance matrix as input for UPGMA clustering. Electronic tag data from other large pelagic species (bigeye tuna, swordfish, black marlin, blue marlin) were used as outgroups to help clarify and define relationships. B=blue shark (*Prionace glauca*), SF=shortfin mako (*Isurus oxyrinchus*), T=bigeye thresher (*Alopias superciliosus*), E=bigeye tuna (*Thunnus obsesus*), R=swordfish (*Xiphias gladius*), S=silky shark *Carcharhinus falciformes*, O=oceanic whitetip shark *C. longimanus*, K=black marlin (*Makaira mazara*), L=blue marlin (*M. nigricans*), M=male, and F=female. Total length (TL, in cm) and pop-up latitude are given for each tagged subject (na = not available). The cophenetic correlation (0.86) (measure of goodness-of-fit between the matrix and resultant clustering dendrogram) indicated “good” fit. For the most part, the topology of pelagic shark clusters did not appear to correlate with phylogeny, life history characteristics, neural anatomy, relative eye size, physiology or endothermy; indicating other factors (e.g. ontogeny, latitude, locomotion, diet, and dimensionality of the environment) probably influence the structure as well as the spatial and temporal stability of thermal niche partitions (Musyl et al., in prep).

Caption 2: Depth and temperature preferences of silky shark as identified by pop-up satellite archival tags (PSATs)[n = 10 PSATs, median days-at-liberty = 73 (733 total days-at-liberty, range: 12 – 194 days). Silky shark spend ~95% of the time within 2 degrees of sea surface temperature (SST) and are confined to the surface mixed-layer. (a) Representative vertical movement behaviors. (b) Temperature-depth profiles using the data from all sharks. The perpendicular nature of the profile indicates residency in the surface mixed-layer. (c) Exploded section from panel (a) with horizontal black bars representing nighttime. (d) Most Probable Tracks estimated from the Kalman Filter-SST model (Neilsen et al. 2006). (e) Average hourly depth (\pm SD) readings calculated for all samples. (f) Percentage time occupied in depth strata (\pm SD) for daytime and nighttime diving activities. Note that the population of silky shark (all immature, n = 4) south of ~10°N corresponds to the ‘Epipelagic C’ cluster in the above figure (samples tagged in 2005).

Figure 1

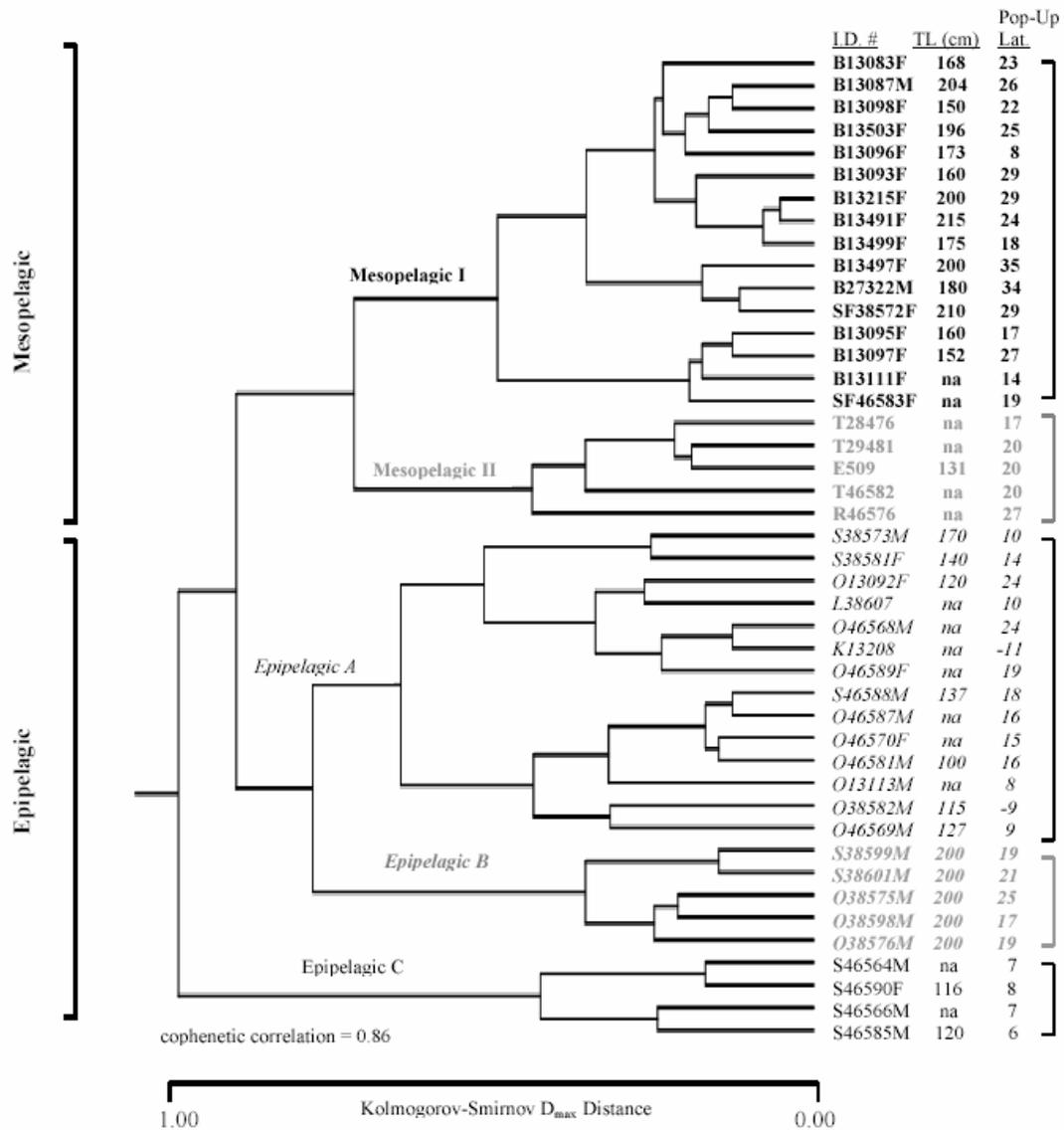


Figure 2

