

JIMAR – PFRP ANNUAL REPORT FOR FY 2007

P.I./Sponsor Name: Dr John R. Sibert (for Drs. Musyl, Larsen, Malte & Brill)/Dr. Tom Schroeder

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-base 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

1. Purpose of the Project (one paragraph)

We propose to use 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 collaboration between 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 pelagic fish and shark species. Using these models we can evaluate the possible importance of specific oceanographic parameters in an unbiased fashion, which will 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/commonalties 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.

2. Progress during FY 2007 (One-two paragraphs, including a comparison of the actual accomplishments to the objectives established for the period, and the reasons for slippage if established objectives were not met):

At present, the PI is adding final information to the PSAT Performance database. This database already contains information from >660 tags across 18 pelagic taxa (including 3 marine turtle species). Preliminary results indicate tags have an overall reporting rate of ca. 79% but PSATs attached to certain species (e.g. swordfish, bigeye thresher shark) have lower reporting rates ($\approx 30\%$). It is important to state that non-reporting tags (21%) are not synonymous with mortality. It is anticipated that this study will examine information from over ≈ 700 -750 PSATs. In discussion among members of the "PSAT Performance Group", consensus was reached to publish the manuscript detailing this work (see below) in the current fiscal year rather than adding additional data. Extra information can be added later when these data are publicly posted on the PFRP website. The PI has organized failure and survival analysis of the database using Weibull, log-normal, and Kaplan-Mier procedures with specialized engineering software and other procedures in the R statistical package. Tagheads developed by the project are providing long term retention in pelagic fishes (e.g. swordfish, 80 to 240 days).

The development of an oceanographic database (and associated tools) to examine/correlate movements patterns of PSAT tagged animals with various oceanographic parameters - on temporal and spatial scales (i.e. both horizontal and vertical vectors) is operational and PSAT information are now linked to this source ("IDENTIFICATION OF LARGE PELAGIC MARINE FISH HABITATS AND HABITAT UTILIZATION USING 'POP-UP' SATELLITE ARCHIVAL TAG AND OCEANIC SATELLITE REMOTE SENSING TECHNOLOGIES AND 'SODA' SIMPLE OCEAN DATA SIMULATION MODEL ANALYSES" BY R. Michael Laurs, David Foley, and Michael Musyl). The attached slides for #11 (below) provide results for blue shark, and white-tip. The PI is in discussions with Dr. David Sims (Marine Biological Association of the UK, School of Biological Sciences, Univ. Plymouth) and Dr. Diego Bernal (Univ. Massachusetts) to continue development of IBMs (Unfortunately Dr. Malte, Univ. Aarhus, could not continue on the project). Three manuscripts specifically examining PSAT tagged animals from the project have now been completed (see below #4; papers by Bernal et al., Malte et al. and Sims et al.). The person hired for "Research Associate" canceled with little prior notice thus leaving the senior PI to finish tasks slated for this position.

3. Plans for the next fiscal year (one paragraph):

Complete baseline research papers (outlined below) on horizontal and vertical movements of sharks, tunas, and billfish and performance of PSATs. Contract personnel to assist with the development of IBMs. Drs. Sims and Bernal have expressed interest in this aspect of the project. Funds requested for a Research Associate may be used for this purpose. Publicly post the PSAT Performance

Database on the PFRP website (after paper detailing this work is submitted). Trials using sandbar sharks at VIMS are underway to map the EMF produced by PSAT and other electronic tags to document sharks' ability to perceive this EMF. It is anticipated that results from this study will provide insight into why some PSAT tags fail to report. Continue to explore and develop new analytical methods to use on PSAT data, particularly oceanographic information comparing vertical depth variability.

Tentative PSAT papers currently coordinated by Musyl and slated to be drafted in 2007:

1). Post-release survivability and movements of blue shark (*Prionace glauca*) from longline fishing gear in the Central Pacific Ocean as Identified by Pop-up Satellite Archival Tags (PSATs) by Musyl, Brill, Laurs, Foley, Bigelow, & M^cNaughton

status: manuscript in preparation

2). Long Term Survivability of Pacific Blue Marlin (*Makaira mazara*) released from sportsfishing boats in Hawaii Determined from Pop-up Satellite Archival Tags (PSATs) by Musyl, Moyes, Brill, West, Bright, M^cNaughton

status: slated for late 2007/early 2008; data and tracks edited and collated, ran through kfsst

3). Movements and migration corridors of Pacific Blue Marlin (*Makaira mazara*) in relation to oceanographic conditions Determined from Pop-up Satellite Archival Tags (PSATs) by Bigelow, Musyl, Brill, Laurs, Foley & M^cNaughton

status: slated for late 2007/early 2008; data and tracks edited and collated, ran through kfsst

4). Temporal and Spatial Movement Patterns in Relation to Oceanographic Conditions for Epipelagic Sharks As Revealed by Pop-up Satellite Archival Tags (PSATs) in the Central Pacific Ocean: I. Oceanic White-tip shark (*Carcharhinus longimanus*) by Laurs, Foley, Nielsen, Bigelow, Musyl, Brill, M^cNaughton

status: slated for late 2007/early 2008; data and tracks edited and collated, ran through kfsst

5). Temporal and Spatial Movement Patterns in Relation to Oceanographic Conditions for Epipelagic Sharks As Revealed by Pop-up Satellite Archival Tags (PSATs) in the Central Pacific Ocean: II. Silky shark (*Carcharhinus falciformes*) by Laurs, Foley, Nielsen, Bigelow, Musyl, Brill, M^cNaughton

status: slated for late 2007/early 2008; data and tracks edited and collated, ran through kfsst

6). Behaviors and habitats of swordfish satellite tagged in the Atlantic and Pacific Oceans by Heidi Dewar, Eric Prince, Mike Musyl, Richard Brill, Chugey Sepulveda, Jiangang Lou, David Foley, Joe Serafy, Michael Domeier, Nicole Nasby-Lucas, Derk Snodgrass, Michael Laurs, Barbara Block and Lianne McNaughton

status: draft manuscript complete

7). PSAT Performance and Meta Data Analysis Project by Michael Musyl, Richard Brill, Michael Domeier, Ben Galuardi, Nicole Lucas, Molly Lutcavage, Lianne McNaughton, Francois Royer, Yonat Swimmer, and Steve Wilson

status: manuscript in preparation

4. List of papers published in refereed journals during FY 2007.

D.Bernal, C. Sepulveda, **M. Musyl**, and R. Brill. "The Eco-Physiology of Swimming and Movement Patterns of Tunas, Billfishes and Large Pelagic Sharks" in Fish locomotion- an Etho-Ecological Approach (P. Domenici and BG Kapoor, eds.)

Sims, D.W., E.J. Southall, N. J. Humphries, G. C. Hays, C.J.A. Bradshaw, J.W. Pitchford, A. James, M.Z. Ahmed, A. S. Brierley, M.A. Hindell, D. Morritt, **M. K. Musyl**, D. Righton, E.L.C. Shepard, V. J. Wearmouth, R. P. Wilson, M.J. Witt, J. D. Metcalfe. General scaling laws of marine predator search behaviour indicate adaptation to complex prey landscapes. *Nature* (revised and submitted)

Hyde, J.R. R. Humphreys, Jr., **M. Musyl**, E. Lynn, and R. Vetter. 2006. A central north Pacific spawning ground for striped marlin, *Tetrapturus audax* ***Bulletin Marine Science, 79: 683-690***

Malte, H., C. Larsen, **M. Musyl**, and R. Brill. 2007. Differential Heating and Cooling Rates in Bigeye Tuna (*Thunnus obesus*, LOWE): A Model of Non-Steady State Heat Exchange. *Journal of Exp. Biology* (*in press*)

Moyes, C.D., N. Fragoso, **M.K. Musyl**, R.W. Brill. 2006. Predicting post-release survival in large pelagic fish. ***Transactions American Fisheries Society 135:1389-1397.***

Swimmer, Y., R. Arauz, M. McCracken, L. McNaughton, J. Ballesterio, **M. Musyl**, K. Bigelow, R. Brill. 2006. Diving behavior and delayed mortality of olive ridley sea turtles *Lepidochelys olivacea* after their release from longline fishing gear. ***Marine Ecology Progress Series 323: 253-261.***

5. Other papers, technical reports, meeting presentations, etc.

PFRP Honolulu Talks 2006

Yonat Swimmer, Milani Chaloupka, Lianne McNaughton, **Michael Musyl**, & Chris Boggs. Bayesian semiparametric modelling of factors affecting post-release mortality of loggerheads in the North Pacific: Preliminary results. PFRP Principal Investigators Workshop GLOBEC-CLIOTOP WG3 Workshop. November 14 -17, 2006

Utilization Of Habitats by Large Pacific Sharks Using 'PSAT' Archival Tags, Oceanic Satellite Remote Sensing, and 'SODA' Ocean Assimilation Model Analyses
R. Michael Laurs, David G. Foley and **Michael Musyl**. PFRP Principal Investigators Workshop GLOBEC-CLIOTOP WG3 Workshop. November 14 -17, 2006

Talks at Lake Arrowhead Tuna Camp, 2007

IDENTIFICATION OF PACIFIC LARGE PELAGIC SHARK HABITATS USING 'PSAT' ARCHIVAL TAGS, OCEANIC SATELLITE REMOTE SENSING, AND 'SODA' OCEAN ASSIMILIATION MODEL ANALYSES – AN UPDATE ON CONTINUING RESEARCH by R. Michael Laurs, David G. Foley and **Michael Musyl**

REDUCING BYCATCH WITH A DEEP SET LONGLINE TECHNIQUE IN HAWAII'S TUNA FISHERY by Steve Beverly, Daniel Curran, and **Michael Musyl**

Movements and Behaviors of swordfish in the Atlantic and Pacific Oceans Examined using Pop-up Satellite Tags by Heidi Dewar, Eric Prince, **Mike Musyl**, Richard Brill, Chugey Sepulveda, Jiangang Lou, David Foley, Joe Seraphy, Michael Domeier, Nicole Nasby, Derk Snodgrass, Michael Laurs, Barbara Block and Lianne McNaughton.

Talks at the 2007 Pacific Billfish Symposium, 4-5 June, Institute of Oceanography, National Taiwan University, Taipei, Taiwan.

Attachment Techniques and Retention of Acoustic, Archival and PSATs on Turtles, Sharks, Tunas and Billfishes by **Michael Musyl** and Richard Brill

Movements of Pacific Blue Marlin Recorded Using PSATs by **Mike Musyl**, Chris Moyes, John Sibert, Anders Nielsen, Andrew West, Lianne McNaughton, and Richard Brill

Expeditionary

Chief Scientist, FBSAD Longline Cruise on the NOAA RV *Oscar Elton Sette* 11/01/06 to 11/28/06

PSAT tagging of sailfish in Chenkong, Taiwan 6-7 June 2007

Outreach

Representative for JIMAR/PFRP and NMFS at 2006 Hawaiian International Billfish Tournament (HIBT), invited to deliver talk to anglers and coordinated “Science Night”

6. Graduates (Names of students graduating with MS or PhD degrees during FY 2006. Provide titles of their thesis or dissertation):

None

7. Awards (List awards given to JIMAR employees or to the project itself during the period): Invited member of the IUCN Shark Specialist Committee

8. Publication Count (Total count of publications for the reporting period and previous periods categorized by NOAA lead author and Institute (or subgrantee) lead author and whether it was peer-reviewed or non peer-reviewed (not including presentations):

	JL Lead Author			NOAA Lead Author			Other Lead Author		
	FY05	FY06	FY07	FY05	FY06	FY07	FY05	FY06	FY07
Peer-reviewed			0			1			5
Non-peer reviewed			2			1			4

9. Students and Post-docs (Number of students and post-docs that were associated with NOAA funded research. Please indicate if they received any NOAA funding. For institutes that award subcontracts, please include information from your subgrantees):

At present, no students or post-docs are paid by the project. A \$13,000 services contract was written to Dr. R. Michael Laurs for FY 2006 to enable him to continue work on developing the oceanographic database with Dave Foley of PMEL. Laurs recently retired from NOAA, thus the impetus to contract him to provide continuous services/data specifically crafted for the project. To finish projects, the project requests the services contract for Laurs to be extended for another year and increased to \$24,000.

10. Personnel:

- (i) Number of employees by job title and terminal degree that received more than 50% support from NOAA, including visiting scientists (this information is not required from subgrantees):

Michael K. Musyl, Senior Research Scientist, (Ph.D.)

Research Associate, to start in Sept. 2006 – This person declined the position

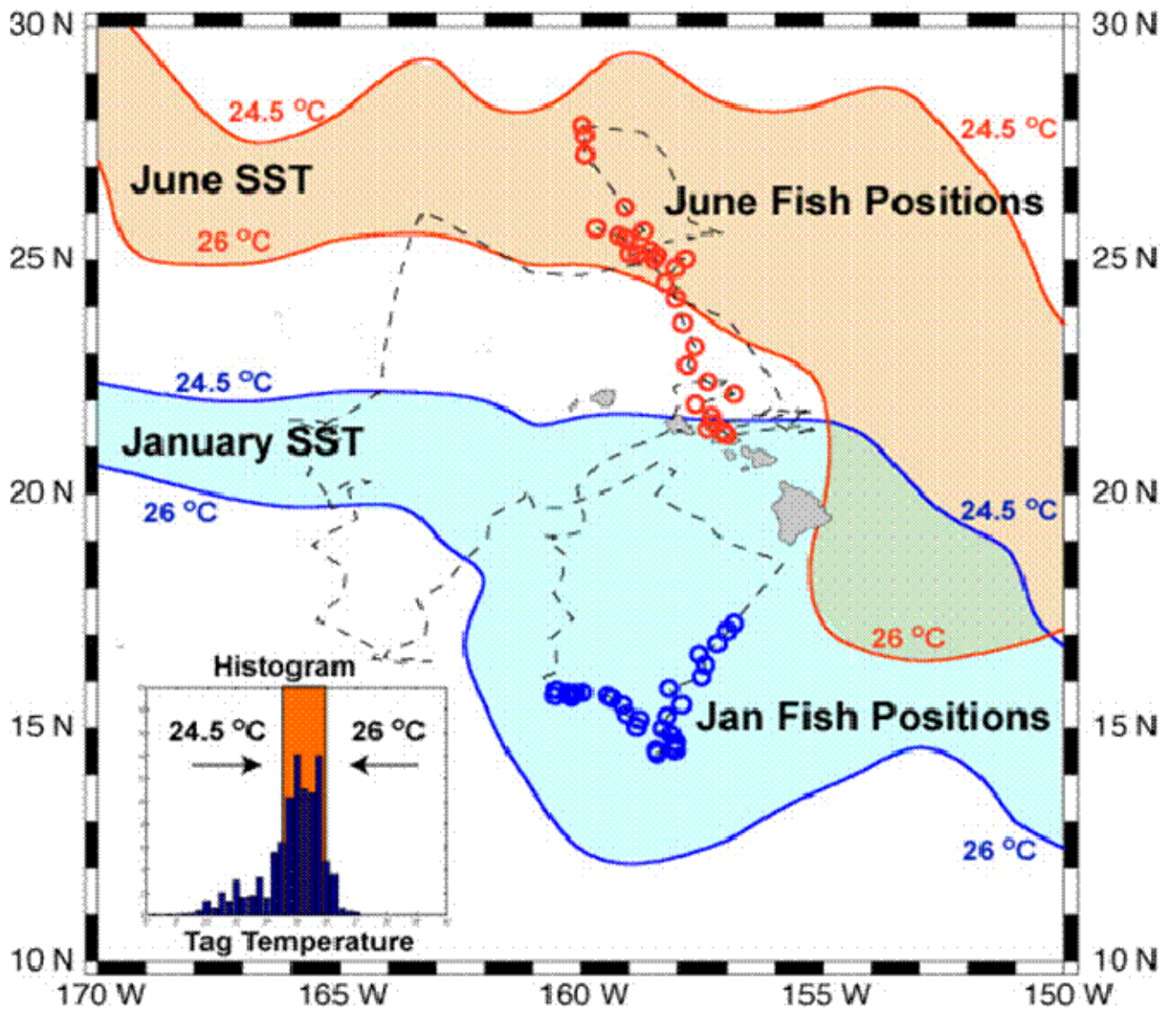
- (ii) Number of employees/students that received 100% of their funding from an OAR laboratory and/or are located within that laboratory.

None

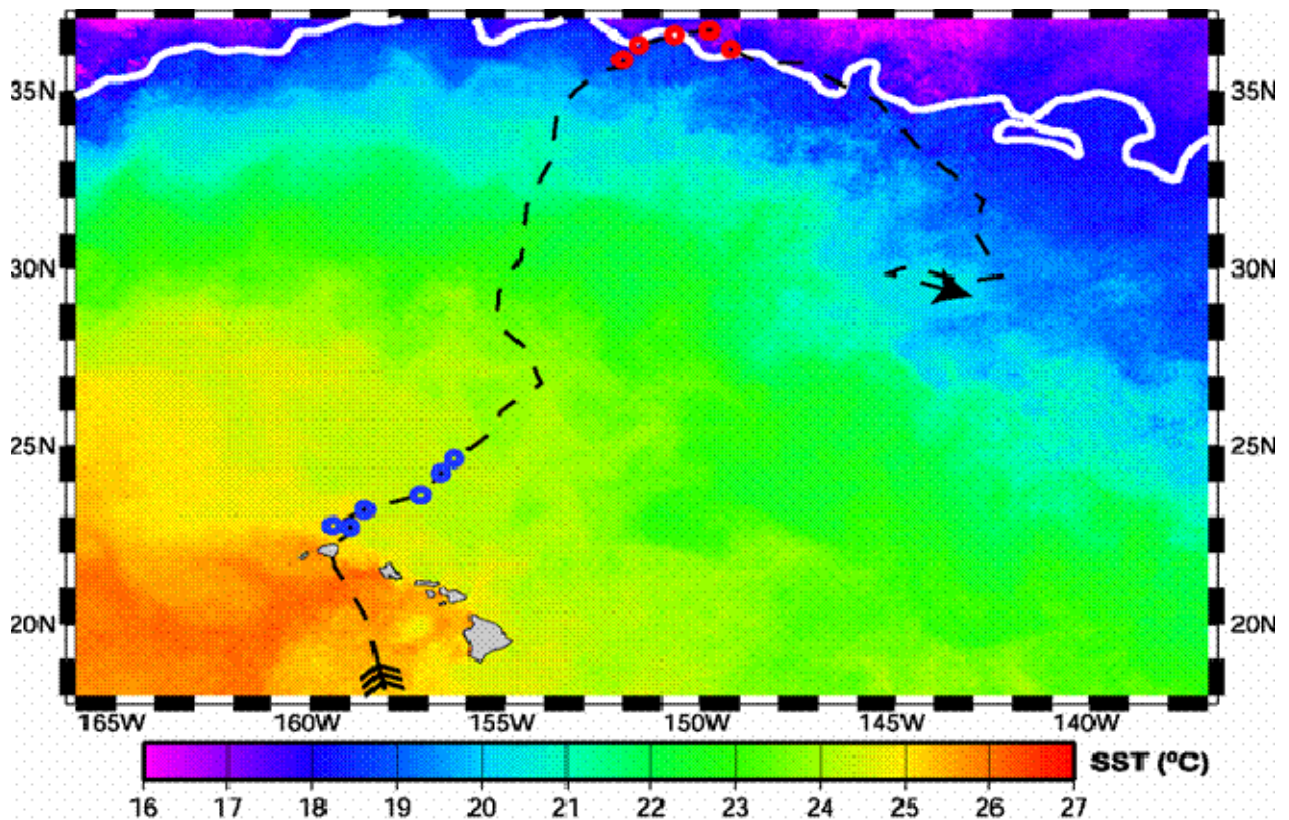
- (iii) Number of employees/students that were hired by NOAA during the past year:

None. *Research Associate, to start in Sept. 2006 – This person declined the position*

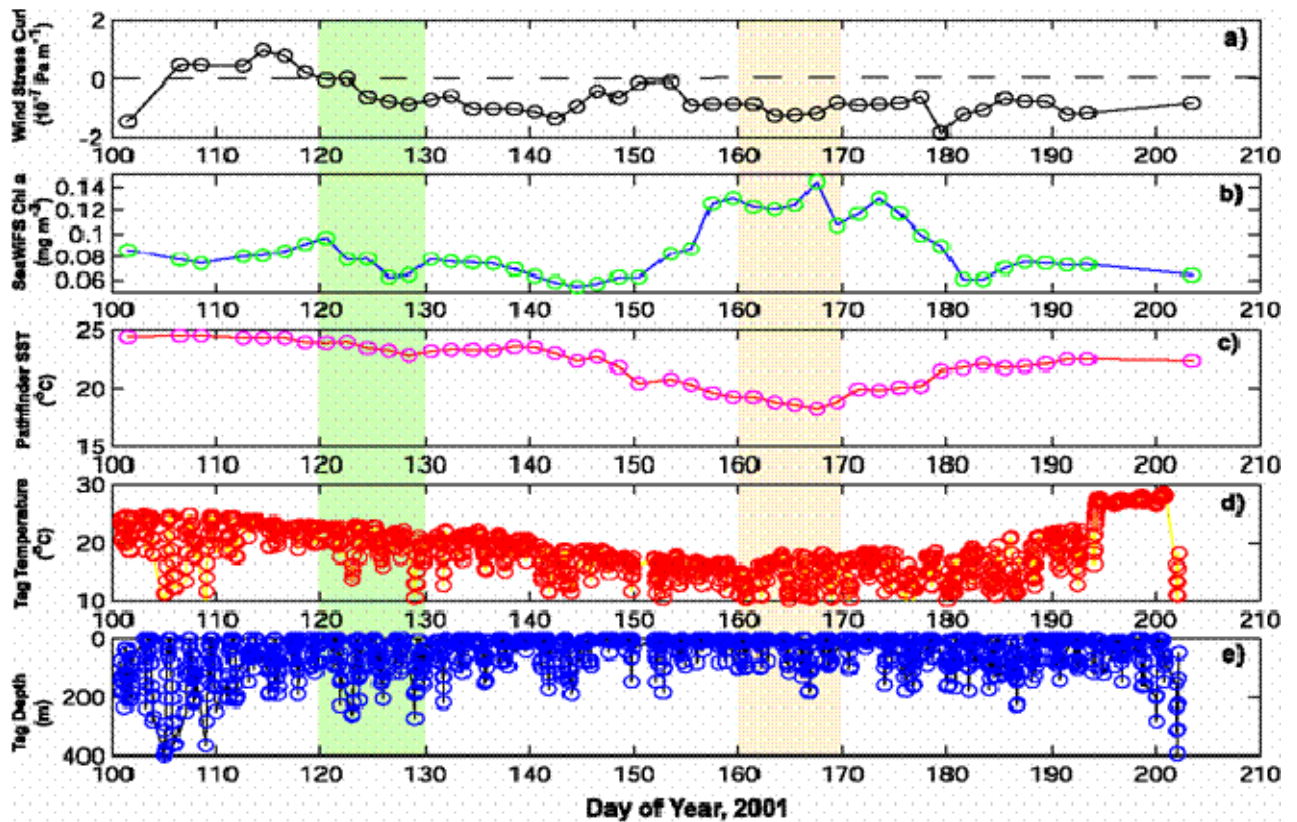
11. Images and Captions. (JIMAR will be including images in the annual report. Please send two of your best high-resolution, color images (photo, graphic, schematic) as a JPEG or TIFF with a caption for each image. Hardcopies of images can be dropped off at the JIMAR office if no electronic versions are available.



● Caption 1: Potential distribution of White-Tip Shark habitat during January and June. Based on satellite-derived SST from GOES, AVHRR, MODIS, AMSR-E Blend. Frequency distribution and temperature measured by PSAT on shark shown in histogram.



Blue shark (female ca. 2m FL) traveled 4210 km during 102 days at liberty at mean speed of 41 km/day. Locations in Tropical Waters and near STCZ shown in blue and red circles, respectively, superimposed on GOES SST averaged for 30 May through 9 June 2001. Heavy white line shows location of the STCZ.



Satellite-derived a) wind stress curl, b) Chlorophyll a, and c) SST mean values for the 1° lat./long. square surrounding estimated daily positions of the fish from PSAT, d) hourly temperature, and e) hourly tag depth recorded by PSAT.