JIMAR, PFRP ANNUAL PROGRESS REPORT
FY 2003

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Project Proposal Title: Survivorship, migrations, and diving patterns of sea turtles released from commercial longline fishing gear, determined with pop-up satellite archival transmitters.

Funding Agency: PFRP/NMFS

1. Purpose of the project and indicative results.

The objectives of this project are two-fold: 1) to provide reliable estimates of delayed mortality and morbidity in sea turtles following interactions with longline fishing gear, and 2) to compare the movements and behaviors of sea turtles caught and released from longline gear to free-swimming controls. To do this, we deployed pop-up satellite archival tags (PSATs) on longline-caught and free-swimming turtles. PSATs record hourly data on swimming depth, water temperatures, and provide daily estimates of light-based geolocations. Because tags can be programmed to release up to two years after deployment, their use provides an opportunity to determine long-term movement patterns and their associated ambient environments. Collection of long-term data will, in turn, allow for the design of time-area fishery closures that are effective at reducing rates of turtle-longline gear interactions.

2. Progress during FY 2003. Provide a thorough discussion of accomplishments <u>and</u> problems.

As documented previously, we maintained captive green turtles (*Chelonia mydas*) at the Kewalo Research Facility in order to identify a suitable technique for applying PSATs on hard-shelled turtles. Based on our initial findings, whereby PSATs stayed on turtles for up to one year in captivity, we selected a simple marine epoxy to attach a baseplate onto hardshelled turtles. Since March 2001, we have trained over 80 observers in Hawaii, California and Costa Rica on attachment techniques on hard-shelled turtles, and in that time, PSATs have been taken to sea on approximately 360 longline fishing trips, resulting in approximately 4,500 observed longline sets throughout the North Pacific Ocean.

Due to fishing restrictions in the Hawaii-based swordfish fishery, opportunities to tag turtles in and around the Hawaiian Islands have been severely limited. To date, two turtles (an olive ridley [*Lepidochelys olivacea*] and a loggerhead [*Caretta caretta*]) have been tagged, but we have only retrieved data for the olive ridley that was deeply hooked in the mouth. A PSAT remained on this turtle for 4 months and provided data on

horizontal and vertical movement patterns. Raw geolocation data were run through a state-space Kalman filter model (thanks to J. Sibert and A. Nielsen) in order to provide an estimate of the turtle's most probable track. We investigated the possibility that the turtle's movements were associated with oceanographic features. While no significant or strong correlations were found between turtle movements and sea surface temperature and chlorophyll fronts, the data suggest that the turtle's horizontal movements were correlated with the North Equatorial current (Figure 1). Regarding depth distribution, the turtle spent the majority of the time within the mixed layer (100m), with the majority of day time depths within the top 50m (Figure 2). The second PSAT deployed on a loggerhead (*Caretta caretta*) appears to have shed from the turtle nearly immediately after the turtles' release into the water. We are uncertain as to the reason for the early shedding of this tag. In both cases, the tags were shed early, apparently due to a deficiency in either the tag or the method of attachment.

In order to circumvent the problem of getting too few tags out with the Hawaiian longline fishery, we joined forces with the Sea Turtle Restoration Program and PRETOMA in Costa Rica, where incidence of turtle bycatch is high. Since December 2001, we have successfully applied PSATs on 10 sea turtles (9 olive ridleys, 1 green turtle) in the shallow- set (<100m) mahi mahi (*Coryphaena hippurus*) longline fishery in the EEZ of Costa Rica. Seven of the animals were caught by longline, and three were captured while free swimming. These later individuals served as controls (to estimate natural survivorship) to which the behaviors of longline-caught turtles could be compared. From the data obtained to date, turtles have remained at-liberty for approximately six to eight weeks, which is, however, considerably shorter than their programmed release date set at one year. We continue to investigate the problem of tag retention and have made both minor and major modifications to our attachment protocol in order to improve retention time.

The most probable horizontal movements of three longline-caught turtles (Figure 3) and three free-swimming turtles (Figure 4) suggest similar movements for a six to eight week period. Based on these observations (from a relatively small sample size), movements of both longline-caught and control turtles do not appear to be different. From the vertical movement data obtained so far, there have been no apparent mortalities. Depth data suggest that both longline-caught and control turtles spend approximately 85% of the time during the day within the top 40 m. During the night, both groups spent nearly 95% of their nighttime depths within the top 40 m, with control turtles spending 90% of that time within the top 20 m as compared to longline-caught turtles that remained slightly deeper. All olive ridley turtles around Costa Rica spent the majority of time in ambient water temperature at 26-28^{O}C. The one green turtle tagged also spent ~ 95% of it's day and night time depth within the top 40 m, and spent the majority of it's time in slightly warmer water at 29^{O}C. Once we collect more data of turtle movements, further analysis can be conducted to determine potential differences in turtle groups' directionality of movements, dive depth profiles and preferred water temperatures.

In September 2002, Y. Swimmer trained 12 observers assigned to the California-based longline fishery in PSAT attachment techniques. Since that time, observers have

deployed five PSATs on loggerhead turtles caught and released from longline fishing gear. Tags are set to release in October 2003. Because this fishery has opportunities for tagging, we have since sent six more PSATs on observed longline trips. We plan to continue this arrangement with the California observer program and train more observers in Fall 2003. We have approximately 15 PSATs dedicated to this work.

We have also been involved in several other related turtle tagging projects. In association with colleagues on the mainland (Drs. Molly Lutcavage, Anders Rodin, Sam Sadove, and Russ Andrews), a method for attaching PSATs to endangered leatherback turtles (*Dermochelys coriacea*) released from longline gear is also now being tested. The method involves a subdermal attachment of the PSAT's tether using a medical-grade titanium bone anchor (see Figure 5). During June 2002, Y. Swimmer joined colleagues on a leatherback nesting beach in Puerto Rico in order to test a direct carapace attachment method. During a one-week period, 5 females were successfully tagged. However, all 5 tags released to the surface within two months after deployment, approximately 6 months earlier than planned. Once again, we are investigating the possible failure mode and will modify our methods before another attempt at attaching PSATs on leatherbacks is made.

To date, none of the turtles appeared to have died during the first 6-8 weeks post release, the period of time for which the tags were attached to the turtles. All of the tags were shed earlier than planned. We will continue to investigate the reasons for the apparent early release of the PSATs.

3. Plans for the next fiscal year.

We plan to continue cooperative tagging efforts with collaborators in Costa Rica and in California. We will continue to tag both longline-caught turtles as well as controls. We have approximately 20 more PSATs for this purpose, and we forsee deploying these tags by December 2003. We may also continue efforts to establish a tagging program in Brazil.

We will also continue to conduct statistical analyses of depth data to investigate potential differences in the depth profiles of longline-caught vs. free-swimming control turtles. In addition to using statistical analyses to compare dive profiles between turtle groups (e.g., Kolmogorov Smirnov), we are also investigating various techniques to look at similarity of patterns (e.g. Principle Components Analysis) by way of resampling, bootstrapping techniques, and analyses of similarities (ANOSIM). If tags stay on for sufficient time periods, we will also be able to provide information on survivorship of sea turtles post-release from fishing gear.

4. List of papers published in refereed journals during FY 2003.

Swimmer, Y., Brill, R.W. & M. Musyl. 2002. Use of Pop-Up Satellite Archival Tags to Quantify Mortality of Marine Turtles Incidentally Captured in Longline Fishing Gear. Marine Turtle Newsletter 97:3-7.

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

Swimmer, Y., Brill, R.W. and M. Musyl. 2002. Quantifying sea turtle mortality with PSATs. PFRP Newsletter Volume 7, No. 2.

Swimmer, Y., Brill, R.W., Arauz, R., Mailloux, L., Musyl, M., Bigelow, K., Nielsen, A. and J. Sibert. 2002. Use of pop-up satellite archival tags to quantify mortality of marine turtles incidentally captured in longline fishing gear. Presented at: The Second International Fisher's Forum on seabird and sea turtle bycatch in the longline fishery Industry, Nov. 19 – 22, Honolulu, Hawaii.

Musyl, M., Swimmer, Y., Brill, R., Mailloux, L., Sibert, L., and A. Nielsen. 2002. Pop-up satellite archival tag (PSAT) studies of pelagic fishes and sea turtles in the Pacific Ocean. Presented at: The Second International Fisher's Forum on seabird and sea turtle bycatch in the longline fishery Industry, Nov. 19 – 22, Honolulu, Hawaii.

6. Names of students graduating with MS or Ph.D. degrees during FY 2003. Include title of thesis or dissertation.
N/A

7. For multi-year projects, provide budget for the next year on a separate page.

Figures

Figure 1. Horizontal movements of an olive ridley sea turtle (#13202) caught and released from a longline fishing vessel. This turtle was successfully tracked for 4.5. months, and the data suggest the turtle's movements were correlated with the North Equatorial current.

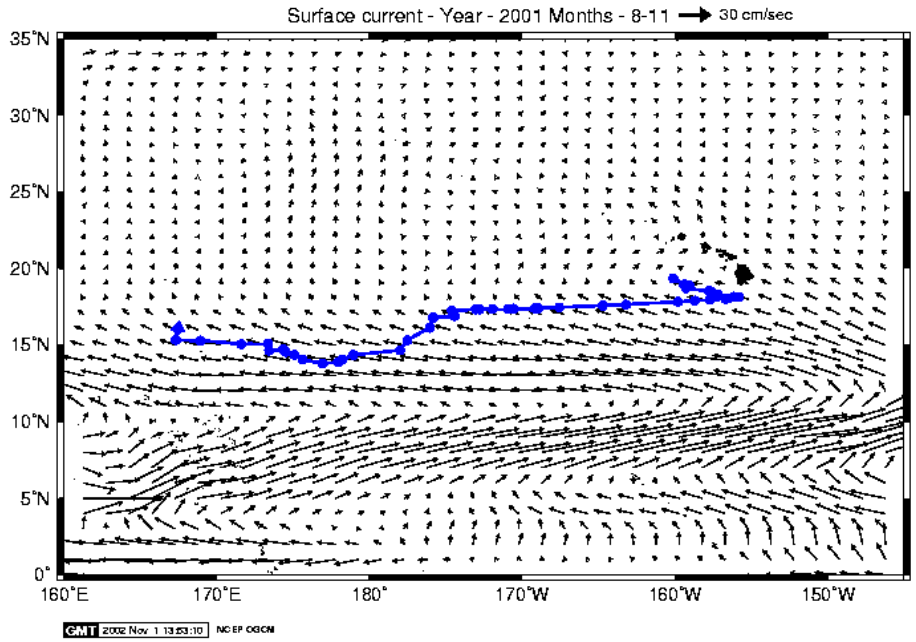

Figure 2. Vertical movements of an olive ridley sea turtle (#13202) caught and released from a longline fishing vessel.

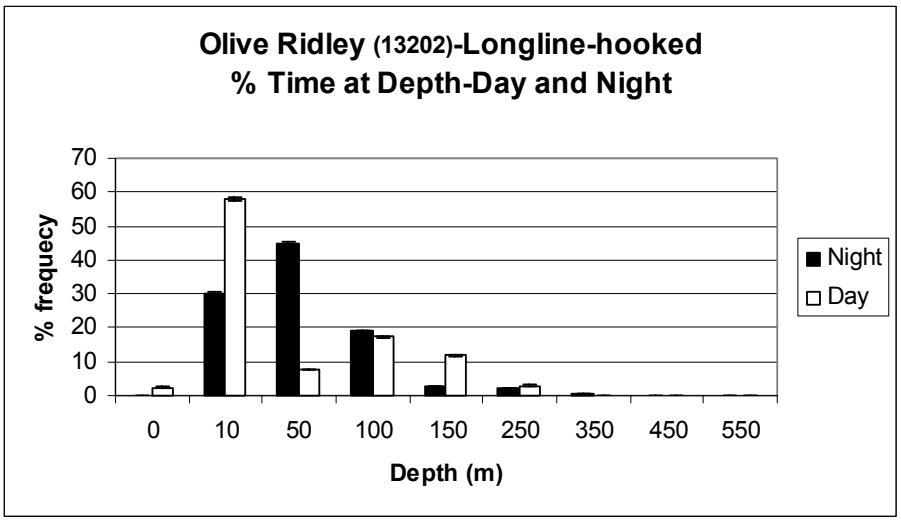

Figure 3. Horizontal movements of 3 longline-caught turtles tagged in Costa Rican waters. Numbers indicate number of days tag remained on turtle.

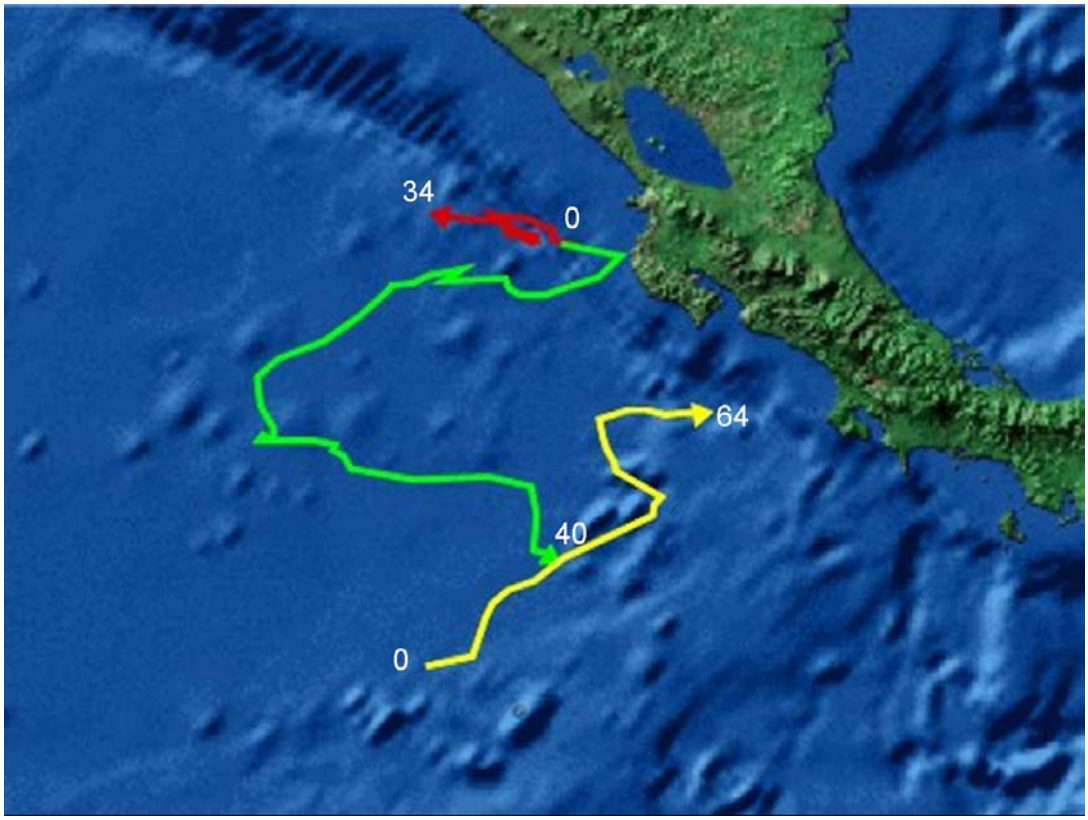

Figure 4. Horizontal movements of 3 free-swimming turtles tagged in Costa Rican waters. Numbers indicate number of days tag remained on turtle.

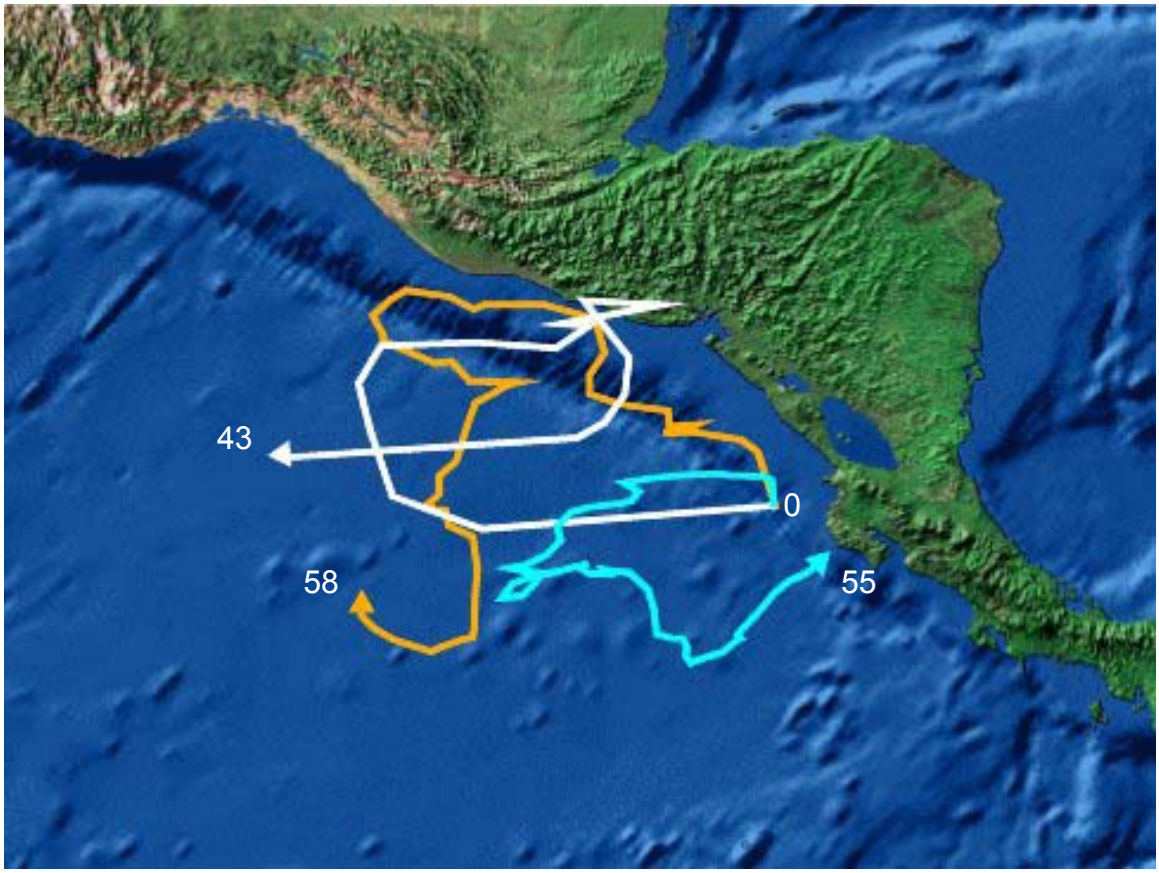

Figure 5. A subdermal attachment of the PSAT's tether using a medical-grade titanium bone anchor inserted into the carapace of a leatherback sea turtle.