Atlantic Tarpon Satellite PAT-Tagging: 2009 Summary Report

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with technical contributions from
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Introduction

Program Goals

To better understand Atlantic tarpon migratory patterns, spawning and feeding areas, and population connectivity in the southeastern U.S., Gulf of Mexico and Caribbean Sea, in collaboration with the Bonefish & Tarpon Trust (BTT), since 2001 we have been using "pop-up" archival transmitting (PAT) tags. These space-age tags deployed on tarpon can collect and archive second-by-second data on depth of the animal, water temperatures, light levels (specific for determining location of the tagged fish), and salinity (Luo et al. 2008a,b). Tags are preprogrammed to release from the tagged fish at a specified time and date, and then pop-up to the ocean surface where they will transmit their stored summary data to an ARGOS satellite network passing overhead. Data retrieved by the satellites is then forwarded to us here on earth for analysis. The goal of the UMiami-BTT satellite PAT-tagging research is to define the migratory range and timing of Atlantic tarpon appropriate for improved regional fishery management, and to evaluate essential coastal ocean habitat uses and spawning dynamics by tarpon during their annual migrations.

The 2009 PAT tagging program addressed this goal in several ways. First, the research built upon the understanding of regional migratory pathways identified in previous years, but it also greatly extended the verified northern range of tarpon migrations, suggesting that inter-annual variability in tarpon migratory behaviors could be coupled to seasonal variations in regional weather. Second, timing of migratory arrivals in Florida, Texas and elsewhere may be indicative of various stock components relevant for management. Genetic analyses concurrent with PAT tagging efforts is required to help identify potential differences in natal areas of these highly mobile fish. Third, continued evaluation of PAT technology reliability indicated that apparent "modest" migrations resulted from equipment malfunctions. As a result, design modifications to the attachment pin that dissolves in an electric field at "pop-up" are being explored, as well as employing a new breed of FastGPS PAT tagging technologies. Future research will employ a mixed use of PAT technologies to facilitate identification of the unit stock, ocean habitat uses, and potential spawning locations and timing. Finally, a vexing question remaining concerns the apparent inter-relationship between the over-wintering locations of tarpon (e.g., Mexico, Cuba, Nicaragua, Panama, etc.) and the proportions of the regional populations that migrate long distances. For example, what determines which fish moves up either Florida east or west coasts for those tarpon arriving in U.S. waters in spring via the Dry Tortugas or Florida Keys? Continued PAT research is critical to verify these hypotheses which are central to coordinating state, federal and international management efforts to ensure the US tarpon fishery is sustained and accessible to future generations.

Tarpon PAT Tagging Activities in 2009

In 2009, we PAT-tagged and released a total of 24 tarpon at a number of locations: 5 tagged in Whitewater Bay and the Florida Keys, Florida; 4 in St. Lucie, Florida; 1 in Boca Grande, Florida; 7 in Port O'Connor, Texas; 1 in Veracruz, Mexico; 3 in the San Juan River, Nicaragua; 1 in Trinidad, British West Indies; and 2 in Angola, Africa. Sizes of PAT-tagged tarpon ranged from 84 to 198 pounds. A summary of tag deployments, recaptures and migration routes are given in **Table 1** and **Figures 1 & 2**.

To date we have "heard" from 17 of these 24 PAT tags deployed on tarpon in 2009. Five of the 24 tags are still scheduled to pop-off in January and February of 2010. We physically recovered 10 of the 17 tags using an ARGOS hand-held receiver (**Figure 3**), which means that we were able to download the entire archived data series! Two tags were never heard from after their scheduled release dates. In general, the 2009 results mirror broad migration patterns we have seen in previous years.

During 2009 there was also great interest by the national and international TV and print media such as Florida Sportsman TV, *Familiar Waters*, *Hooked on the Fly*, Fly Fishing in Salt Waters, Saltwater Sportsman, Florida Sportsman, etc. A particularly nice piece that indicates the exceptional and growing media attention was represented by Voice of America TV piece on our tarpon migration research by Zuli Palacio entitled "Tarpon -- World's Best Fish" that aired for World Ocean Day in June 2009 in 46 languages around the world (http://www.youtube.com/watch?v=rDHQE1lA8Ro).

In the following sections, we first present some new information on our experimental trials with state-of-the-art tarpon tagging technology just available. Then we present some select highlights and detailed information on our PAT-tagging efforts at a number of regional locations such as: (1) Whitewater Bay, Everglades National Park; (2) San Juan River, Nicaragua; (3) Stuart, Florida; and the (4) Texas coastal waters.

Experimental PAT-Tag Trials Using FastGPS Technology

In 2009 we began trials of a new technology, FastGPS (**Figure 5B**), for continuously tracking tarpon movements as well as the 4 key environmental parameters (i.e., depth, temperature, salinity and light level) obtained by the PAT MK-10 tags currently in use. The FastGPS PAT-tag addresses the difficulties inherent in deploying traditional GPS receivers on free-ranging marine animals which spend very little time at the surface. It provides the ability to achieve highly accurate GPS locations, while requiring the tag antenna to be above the surface for less than one second, and represents a major step forward in the ability to track marine animals like the tarpon.

We conducted a series of tests of the FastGPS tag technology in St. Lucie, Florida, one because there were a lot of tarpon available in late summer 2009, and two because it was close to our laboratory in Miami and we could easily drive and recover the tag, if necessary.

Tarpon T136, a 143 pound fish, was tagged with our first FastGPS PAT tag on August 13, 2009. This experimental tag popped off on August 17, 2009, at St. Lucie, Florida and was recovered by Captains Bruce Ungar and George Santry based on accurate FastGPS locations provided by the ARGOS satellite network. After recovery, we were able to download the archived data along with eight (8) FastGPS locations for the 4 days of deployment (**Figure 5**). This provided an unprecedented and remarkable dataset that allowed us to combine location estimates with the archived depth, temperature, and wet/dry sensor values (**Figure 6**) that provided to us detailed information on the movements of the tarpon during the 4 days of tag deployment.

We also learned much from this test. First, as tarpon roll (or jump) FastGPS locations could be fixed and stored on the tag. Second, the FastGPS locations were accurate within 30 m, as compared to MK-10 PAT Argos location accuracy of 500 m and level light locations of ± 60 miles. Third, we also learned how to setup this type of tag and the types of environments were the tag should not be deployed (i.e., freshwater). The limitation of the FastGPS PAT tag is the relatively short deployment periods possible (maximum 30-45 days), due to high power consumption of the transmitter on the small lithium battery. More testing of this new generation tagging technology is required, but it holds much promise for refining tarpon migratory patterns, habitat use and spawning locations in 2010.

Table 1.- Summary of 2009 PAT-tagging in south Florida, Texas, Mexico, Trinidad, and Africa. A total of 24 tarpon were tagged in 2009. W is tarpon weight in pounds; Symbol * indicates that PAT-tag was physically recovered, ** indicates tag scheduled to pop-off on dates after publication of this preliminary report; and, NDR indicates no data was received.

Name	Tagging Date	Tag Location	W(lb)	Popoff date	Pop-off Location	Max depth m (ft)	Mean Temp °C (°F)	Distance km (mi)
T-81	05/27/09	Bahia Honda, FL Keys	108.4	08/25/09	NDR	NDR	NDR	NDR
T-87	01/22/09	San Juan River, Nicaragua	105.5	05/18/09	offshore of Panama	48 (158)	27.1 (80.8)	320 (200)
T-88	01/23/09	San Juan River, Nicaragua	142.5	03/02/09	Mouth of San Juan River	NDR	NDR	NDR
T-91	01/20/09	San Juan River, Nicaragua	134.0	02/24/09	Mouth of San Juan River	24 (79)	25.8 (78.4)	160 (100)
T-114	03/13/09	Whitewater Bay, FL	111.5	09/15/08	NDR	NDR	NDR	NDR
T-118	03/17/09	Whitewater Bay, FL	98.3	09/15/09	800 miles east of Cape Cod, MA	24 (79)	24.2 (75.6)	2500 (1555)
T-119	04/09/09	Luanda, West Angola	154.0	09/30/09	Luanda, West Angola	16 (52)	20.9 (70.0)	20 (12)
T-120	04/10/09	Luanda, West Angola	198.0	04/11/09*	found on beach	NDR	NDR	NDR
T-121	03/16/09	Whitewater Bay, FL	84.0	09/15/09*	Whitewater Bay, FL	2 (7)	30 (86)	1 (0.6)
T-122	06/15/09	Boca Grande, FL	130.0	06/24/09*	Boca Grande, FL	7.5 (25)	29.7 (85.5)	5 (3)
T-123	06/04/09	Veracruz, Mexico	121.2	06/26/09*	Veracruz, Mexico	24 (79)	28.8 (83.8)	10 (6)
T-124	08/20/09	St. Lucie Inlet, Florida	88.0	10/19/09*	North Miami Beach, Florida	20 (65)	28.5 (83)	179 (100)
T-125	09/20/09	Port O'Connor, TX	152.5	11/29/09	Tampico, Mexico	NDR	NDR	680 (420)
T-127	05/13/09	Bahia Honda, FL Keys	106.7	05/14/09*	Bahia Honda, FL	NDR	NDR	10 (6)
T-128	08/29/09	Port O'Connor, TX	163.0	**02/15/10**	**			
T-129	08/29/09	Port O'Connor, TX	145.4	**02/15/10**	**			
T-130	08/29/09	Port O'Connor, TX	90.0	11/07/09*	Padre Island, TX	25 (82)	27.5 (81.5)	210 (130)
T-131	09/20/09	Port O'Connor, TX	100.0	**02/15/10**	**			
T-132	09/20/09	Port O'Connor, TX	182.8	09/28/09*	Corpus Christi, TX	25 (82)	29.5 (85.1)	20 (12)
T-134	08/14/09	Trinidad, BWI	118.5	09/22/09	62 mile north of Trinidad, BWI	160 (528)	26.3 (79.5)	100 (62)
T-135	08/11/09	St. Lucie Inlet, Florida	134.1	**01/25/10**	Big Pine Key, FL			447 (250)
T-136	08/13/09	St. Lucie Inlet, Florida	142.5	08/19/09*	Stuart, Florida	10 (33)	30 (86.1)	20 (12)
T-137	08/20/09	St. Lucie Inlet, Florida	104	10/01/09*	Stuart, Florida	11 (36)	30 (86.1)	20 (12)
T-139	09/20/09	Port O'Connor, TX	170.0	**02/15/10**	**			

Figure 1.- Locations of deployments (pink) and pop-offs (white) of 24 PAT-tags in 2009 overlain on temperature and current vectors for September 15, 2009. Angola, Africa, tarpon are not shown.

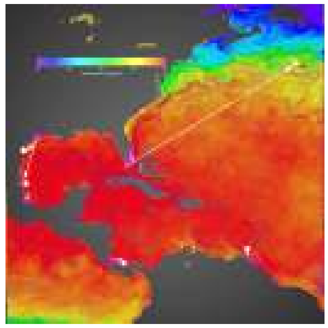


Figure 2.- Summary of PAT-tagged documented tarpon migrations in the Gulf of Mexico and southeastern United States in 2008. PAT-tag deployment locations (triangles) and pop-off locations (solid dots), and tarpon migratory paths are shown for: Florida (green); Texas (red); Veracruz, Mexico (light blue); and, Mobile, Alabama (white). Green and turquoise tracks are May-September; red and white tracks are September-late November. Trinidad tarpon are not shown.

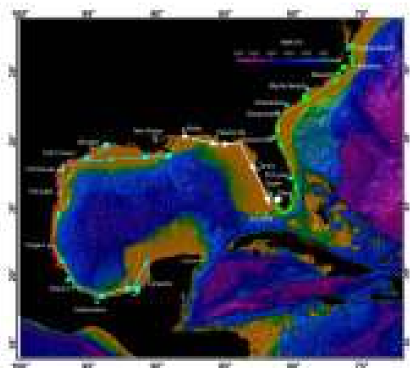


Figure 3.- Photos of tarpon PAT-tagging processes during 2009 showing tagging operations and placement of PAT-tag on tarpon.

Figure 4.- PAT tags recovered at variety of environments in 2009: (A) on beach in debris line; (B) on beach buried under debris; (C) on seawall covered with seagrass; (D) in mangrove prop roots with seagrass; (E) floating in mangrove-lined forest; and (F) up under mangrove prop roots.

Figure 5. - (A) Map of the St. Lucie River and Inlet showing T136 release and pop-off locations (red dots) and FastGPS locations (yellow tag with blue dot) received during tag deployment; (B) a FastGPS PAT tag. The attachment point on the tarpon is the same as with the MK-10 tag, but simply has a longer tether to facilitate tag contact with the surface. The data resolution in (B) is shown here strictly for diagrammatic purposes and demonstrating the feasibility of future use of this new tag technology by our research group.

Figure 6. - Archived data retrieved from FastGPS tag T136: (A) depth; (B) water temperature; (C) light attenuation coefficient; and (D) wet/dry sensor values; along with (E) tidal heights in St. Lucie River from August 13 to 17, 2009. Numbers (1 to 8) marked on the x-axis are the same location marks on Figure 5. The vertical red line indicates the interaction of the tarpon with coastal upwelled water near the St. Lucie Inlet seen in Figure 7, and the dive shows corresponding cold water, high water clarity, and seawater salinity conditions on the incoming tide as recorded by the FastGPS tag.

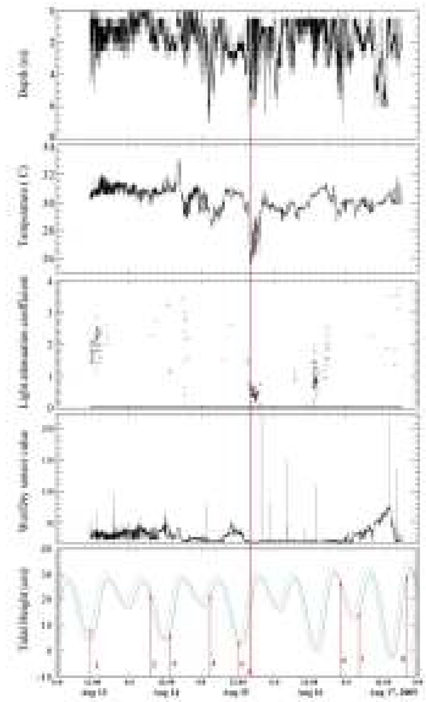
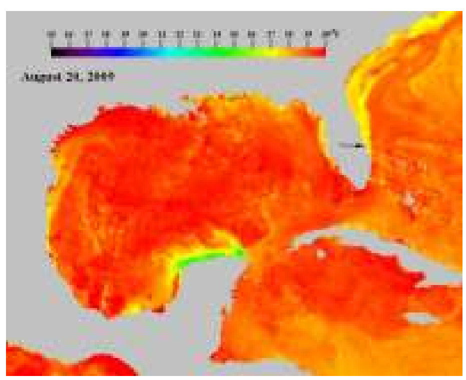


Figure 7- Advanced Very High Resolution Radiometer (AVHRR) sea surface temperature map of Gulf of Mexico and the Southeast coast of USA on August 20, 2009. A pocket of cold upwelled water is shown by the arrow just offshore of the St. Lucie Inlet, in east-central Florida.



Whitewater Bay, Everglades National Park, Florida

The year 2009 was a learning experience for us in Whitewater Bay, a location where tarpon seem to arrive "early" as the sentinels of the annual tarpon migration arrive with warming waters from foreign to U.S. waters. We began our process of group fishing for tarpon in early March 2009 with word from Capt. Tad Burke and others that tarpon were showing up. A several day expedition with the legendary Stu Apte and Capt, Dave Denkert proved futile as we saw some tarpon and droves of ladyfish and excellent tarpon prey, but the fish simply refused to bite. Subsequently, our group working with other fine anglers like Raymond Douglas of King Sailfish Mounts and the well-known outdoors writer Bob Stearns, we were able to catch, tag and release three tarpon in Whitewater Bay in 2009. Of these, one tag released ahead of schedule from the tarpon and washed up into the mangrove roots. We were able to later recover this tag and download all the data. One of these tags never uplinked data to the satellites.

However, the third tagged tarpon, T-118, made the most incredible journey that we have recorded since we began satellite-tagging tarpon in 2001, one of 139 silver kings. When satellite tag T-118 began transmitting data on Sept. 15, 2009, it had traveled more than 2,200 miles from where we originally attached it to a 98-pound tarpon caught on fly aboard Bob Stearns' boat six months earlier in Whitewater Bay, Florida. This was likely the greatest distance ever covered by a tagged tarpon. T-118 began transmitting data precisely on schedule, six months after the catch. At the time, it was located well into the North Atlantic (near 40.5 degrees north and 54.5 degrees west), some 800 miles east of Cape Cod and only 250 miles southwest of the location the Titanic sank almost 100 years ago (**Figure 8**). Now the question begs: How did it get there? And did it remain on the tarpon throughout the entire six months, or did it pop off at an earlier date and drift the remaining distance?

From the data we recovered by satellite — including temperature, depth, light levels and salinity — we are certain that the tag was attached to the tarpon in mid-August when the fish was some 1,200 miles north of its tagging location in the coastal waters of southern Virginia near the Chesapeake Bay, not an unusual destination for some of these coastal wanderers. Unfortunately, not enough information and data exist to explain exactly what happened after that.

Unfortunately, T-118 has not yet been physically recovered, and considering its location in the northern reaches of a huge ocean, it may never be found. If that's the case, much of the data permanently stored in memory will remain unavailable. T-118 transmitted for 10 days before its batteries ran out. That's usually enough time for recovery by a search party, had it washed up on a beach. That obviously did not happen in this case (although some tags are eventually recovered and returned by beachcombers long after battery failure).

After leaving Virginia, T-118 traveled at least another 1,000 miles eastward before it began uploading to the satellite. Perhaps not ironically, this is the same route followed by the warm current of the Gulf Stream — and its temperature in the mid-70s is well within a tarpon's comfort zone. Our experience shows that PATs have proven that tarpon are indeed incredible long-distance travelers, and it is entirely possible that this fish went the distance. It might well have been under way to some unknown destination when the PAT finally popped off. (After all, folks are still scratching their heads about how the 130-pound tarpon caught near Cork, Ireland, in the mid-1980s got there). PATs are tough, durable instruments, and we would not be surprised if T-118 does turn up on some European shore years from now. Until then, we'll just have to guess as to what exactly happened. Clearly, given these exciting results and their implications for assessment and management of a sustainable regional tarpon fishery, more PAT-tagging research is required in Whitewater Bay over the next several years.

Figure 8.- Tarpon T-118: (upper panel) capture of 98 pound tarpon on March 17, 2009, in Whitewater Bay, Florida; (lower panel) estimated migratory path from release in March 2009 to PAT-tag pop-up on September 15, 2009, some 800 miles east of Cape Cod, Massachusetts (Photos by Bob Stearns).

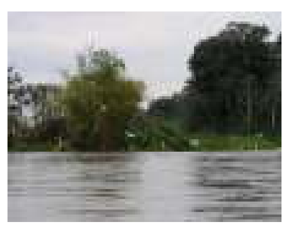
San Juan River, Nicaragua

To better understand tarpon (*Megalops atlanticus*) migratory patterns, spawning-feeding areas, and population connectivity in the Caribbean Sea, Gulf of Mexico and the southeastern US, in collaboration with *Tarpon Tomorrow* and *Bonefish-Tarpon Trust* (BTT), we travelled to the Rio San Juan, Nicaragua, in January 2009 to tag and track some of the regions "mysterious tarpon" that reside in the River. We found that many of the regional scientists, anglers and local population believed that these tarpon are unique to the Lake Nicaragua and San Juan River system, furthermore, that these tarpon spawn in Lake Nicaragua. Our goal was to determine if these anecdotal tales were true by physically tagging tarpon with space-age tags pop-up archival transmitting (PAT) tags.

Figure 9.- Expedition team (from left to right): Charles Parks, Dr. Jiangang Luo, Biol. Juan Bosco Mendoza Vallejos, Philippe Tisseaux, Alex Tisseaux, Dr. Jerry Ault, Biol. Juan Cabrone, Tommie Divine, and Scott Alford.

The 2009 expedition was organized by the *Tarpon Tomorrow* Treasurer and Tournament Committee Chairman Mr. Scott Alford, and led by Dr. Jerald Ault from the University of Miami. The team also included Mr. Charles Parks and Ms. Tommie Divine from Texas, Dr. Jiangang Luo from University of Miami, and Biol. Juan Bosco Mendosa from INPESCA of the Nicaraguan Ministry of Fisheries (**Figure 9**). The expedition was hosted by Mr. Philippe Tisseaux, owner of the San Carlos Sportfishing Lodge (La Esquina del Largo Lodge). From the International Airport in the capital city of Managua where we landed on January 19, 2009, we took a commuter plane ride south to the town of San Carlos, and then took a short boat ride to the Lodge at the edge of Lake Nicaragua where we were met by local and government authorities

from MARENA and INPESCA. After a delicious lunch of paella served with giant river shrimp, our research group was loaded into several small boats and headed to the *Hotel Sabalos*, and incredible on-river establishment some 30 miles down-river from San Carlos (**Figure 10**). Along the river route numerous colorful birds and monkeys lined the river banks. During the next four days we awoke about 3:00 a.m. each day and then fished until sunset extensively along a broad stretch of the river. Unfortunately, a strong cold front passage limited the action as the tarpon were not overly active and the strike-rate was very slow. However, in addition to catching an assortment of rocks, tree branches, power lines, and boats, we still managed to catch and PAT-tag three large tarpon up to 150 pounds among the rapids and headwaters in the pure freshwater river some 150 miles from the coast of the Caribbean Sea.

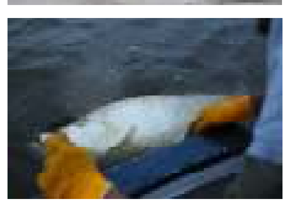


Figure 10.- Scenes from Nicaragua 2009: (a) river shrimp and paella lunch at Philippe Tisseaux's on the banks of Lake Nicaragua; (b) tropical birds on the bank of the Rio San Juan; (c) Hotel Sabalos, where the fishing occurred, and (d) a captured and PAT-tagged tarpon just before release.

All three PAT tags subsequently popped-off the tarpon in the Caribbean Sea within four months of tagging (**Figure 11**). Two PAT-tags popped off at the mouth of the San Juan River on February 25, and March 1, 2009, respectively. The third tag popped-off on May 18th, about 50 miles east of Puerto Limon, Costa Rica.

Figure 11.- Pop-off locations of three PAT tags placed on migrating tarpon in Rio San Juan, Nicaragua, in January 2009.

Of the three tags, we received good amounts of satellite-based messages back from two of them via Argos satellite network. We only received a few messages from the third tag. With the help of Philippe, we contacted a number of key local fishing lodge guides and to ask them to help search for our tags at the river mouth. Unfortunately, these efforts were not successful due to excessively rough terrain, extensive vegetation, and rough seas along the beaches. It is most likely that tags were buried by debris on the beach as we have seen repeatedly in our numerous tag recoveries throughout the region. The results obtained from the two tags that communicated with the satellites provided a relatively good number of clear messages and these data are presented below.

Tarpon91, a 134 pound fish, was tagged on our first full expedition day of fishing on January 20, 2009, near the Hotel Sabalos. The PAT-tag was scheduled for popoff on July 20, 2009, but the pin attaching the tag to the wire connecting the dart to the fish broke prematurely causing the tag to pop-off on February 26, 2009. The data transmitted by satellite showed that the tag had already washed up to the beach by February 19th as indicated by the warmer air temperatures on the beach (**Figure 12 upper**). It is not exactly clear when the tarpon actually arrived at the river mouth based on the water temperature data sensed by the tag, because both the river and the ocean had approximately the same temperature of about 26^{o} C (79 ^{o} F) at that

time (**Figure 12 lower**). However, based on the shallow depths recorded for the duration of time the tarpon carried that tag, we concluded that the tarpon arrived the river mouth on February 18th. According to the local guides, the river is mostly shallow with a few deep holes greater than 20 m.

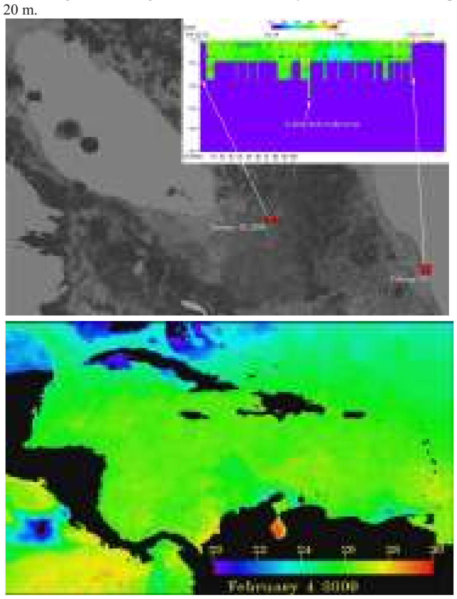


Figure 12.- (upper panel) Tagging and popoff location and vertical thermo-habitat use (inset) of Tarpon91 derived from Argos transmitted summary data; (lower panel) Advanced Very High Resolution Radiometer (AVHRR) sea surface temperature map of Caribbean Sea on Feb 4, 2009.

Tarpon87, a 106 pound tarpon, was tagged on January 22, 2009, also near the Hotel Sabalos. It was also scheduled for pop-off on July 20, 2009, but the pin broke early and it popped-off on May 18, 2009. These data showed that this tarpon entered the ocean waters on March 9th, as indicated by the sudden increase in recorded depths (**Figure 13, inset**). It is not clear to us exactly where about the tarpon was after it entered the ocean because of the relatively uniform distribution of sea surface temperature at that time (**Figure 14**). The deepest dive by this tarpon was about 50 m and occurred on May 7, two days before the full moon on May 9th (**Figure 14**). Previous data collected by us in the Gulf of Mexico have shown that tarpon seem to conduct deep dives two to three days before full and new moons, which may a possible indication of spawning behavior (Luo et al 2008b).

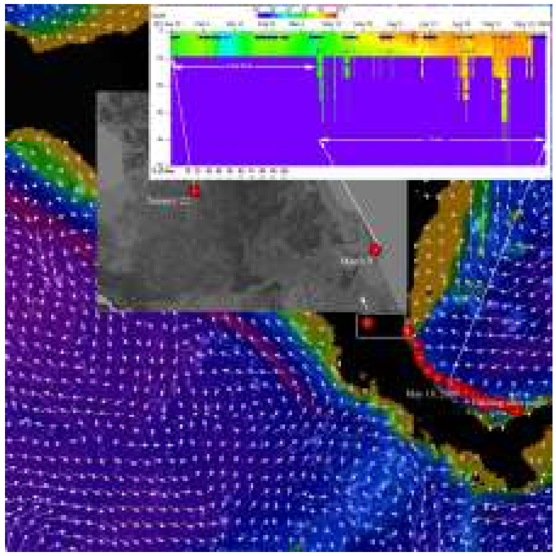


Figure 13.- Tagging and pop-off locations and vertical thermo-habitat use (inset) of Tarpon87 derived from Argos transmitted summary data; the current vectors are from HYCOM model on May 15, 2009.

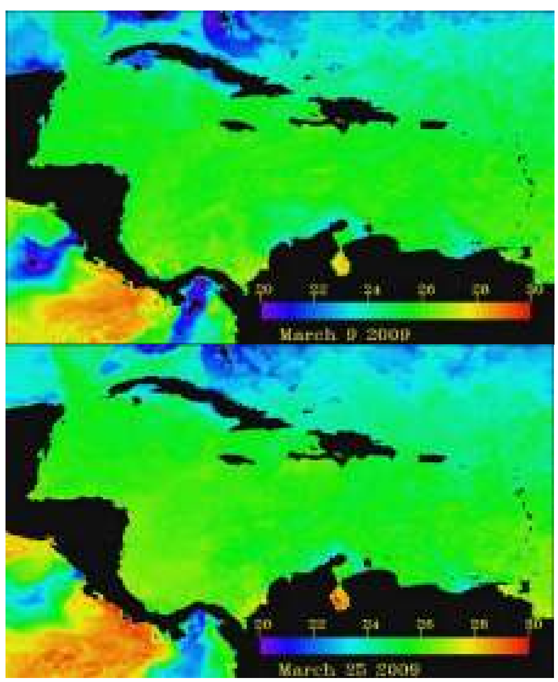


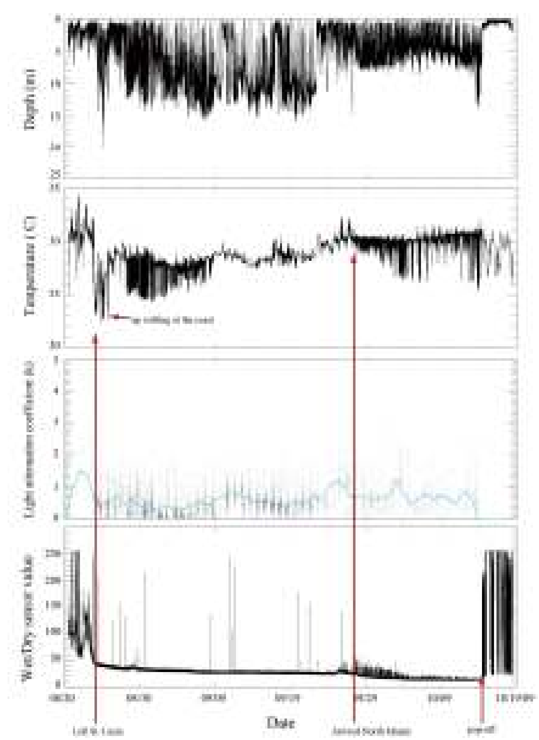
Figure 14.- Advanced Very High Resolution Radiometer (AVHRR) sea surface temperature map of Caribbean Sea on March 9 and March 25, 2009.

St. Lucie, Florida

Tarpon T124, an 88 pound tarpon, was tagged on August 20, 2009, at the St. Lucie Inlet, Florida. The PAT-tag popped off on Oct 19, 2009, at North Miami Beach, Florida (**Figure 15**). We were able to recover this tag using the hand-held Argos receiver, and download more than 60 days of archived data. The data indicated that the tarpon stayed in the St. Lucie Estuary for 4 days after the release as shown by the shallow depth and high wet/dry sensor values (**Figure 16a, d).** As the tarpon moved out the estuary, it encountered cold, upwelled water outside the mouth of the estuary (**Figure 16b, and Figure 7**). It is most likely that the tarpon reached the North Miami Beach at the end of September, indicated by the rapid variation of wet/dry sensor values associated with vertical salinity gradients in the lagoon as the tarpon moved up and down in the water column (**Figure 16d**).

Figure 15.- Tagging (red dot) and pop-off (yellow tag) locations of tarpon T124.

Figure 16.- Depth (A), water temperature (B), light attenuation coefficient (C), and wet/dry sensor values (D) from T124 for the deployment period of August 20 to October 19, 2009. The vertical red lines show the times at which: (left) the tarpon left St. Lucie inlet with presence of cool upwelled water along the coast (see Figure 7); (middle) arrival in the bay at north Miami; and, (right) tag T124 popped off the tarpon.



Port O'Connor, Texas

Tarpon T130, a 90 pound fish, was tagged on August 29, 2009, at offshore of Port O'Connor, Texas. The PAT-tag popped off on November 7, 2009, some 210 km south on the coast off Padre Island, Texas. The tag was subsequently recovered by our research partner Scott Holt with assistance from a Texas Park Ranger using a hand-held ARGOS receiver. We were then able to down load the archived depth, temperature, light level and wet/dry sensor data from the recovered tag. **Figure 17** summarizes the vertical and thermal habitat utilization of the tarpon during the deployment. We compared the water temperatures recorded by the tag with water temperatures recorded at two oceanographic stations located around these areas (**Figure 18**). One station was in Matagorda Bay (PCNT2), and the other was at the coast (Buoy 42048). It is clear that the tarpon spent most of time at the coast where water temperatures were similar to Buoy 42048, and except for a few occasions, the tarpon moved into or near Matagorda Bay (i.e., Sept 26, and Oct 12). The tarpon moved south to warmer water on November 1st as indicated by the warmer temperatures recorded by the tag as compared to those recorded by Buoy 42048.

Figure 17.- Vertical and thermo habitat utilization generated with archived depth and temperature data from Tarpon130. The temperatures are displayed in color scale from 20 to 30 °C. The size of open circle indicates the percentage of time the tarpon spent at each depth for each 4 hour interval.

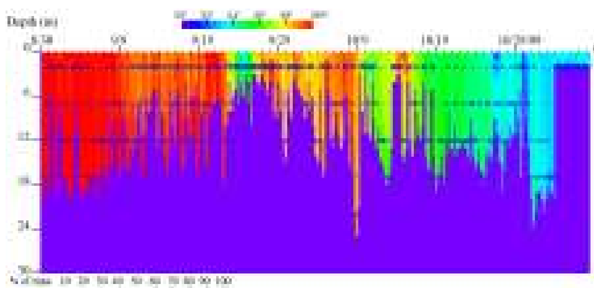
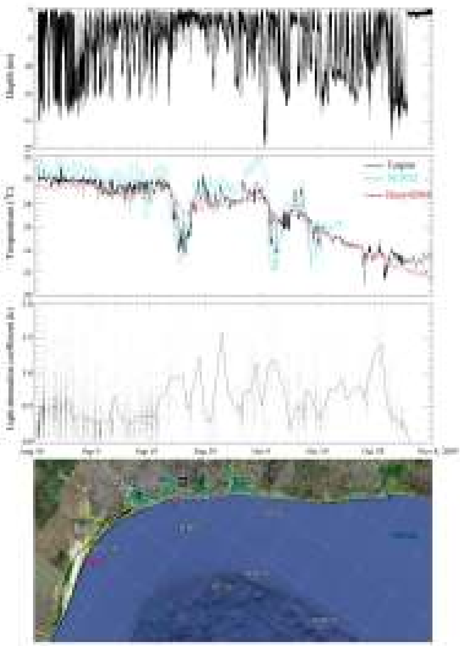


Figure 18.- Archived data retrieved from tag T130: (A) depth; (B) temperature; (C) light attenuation coefficient; and (D) release and pop-off locations. Two NOAA oceanographic buoy stations temperatures are also shown on (B), and buoy locations are indicated on (D).



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References

Ault, J.S. 2010. Silver King: A Most Perfect and Ancient Sportfish. The biology, ecology, management of *Megalops atlanticus* – and its precarious future. Chapter 15 in A Passion for Tarpon. Mill, A. P. Ford, J.S. Ault and S. Katner. Wild River Press. 481 p.

Ault, J.S. (Editor). 2008a. Biology and Management of the World Tarpon and Bonefish Fisheries. Taylor & Francis Group, CRC Series in Marine Science, Volume 9. Boca Raton, FL. 441 p.

Ault, J.S., R. Humston, M.F. Larkin, E. Perusquia, N.A. Farmer, J. Luo, N. Zurcher, S.G. Smith, L. Barbieri, and J. Posada. 2008b. Population dynamics and resource ecology of Atlantic tarpon and bonefish. Chapter 16 in Ault, J.S. (ed.) Biology and Management of the World Tarpon and Bonefish Fisheries. Taylor and Francis Group. CRC Series on Marine Biology, Volume 9. Boca Raton, Florida. 441 p.

Luo, J., Prince, E.D. Goodyear, C.P., Luckhurst, B.E., Serafy, J.E. 2006. Vertical habitat utilization by large pelagic animals: A quantitative framework and numerical method for use with pop-up satellite tag data. Fisheries Oceanography 15: 208-229.

Luo, J., J.S. Ault, M.F. Larkin, and L.R. Barbieri. 2008a Salinity measurements from pop-up archival transmitting (PAT) tags and application to geolocation estimation for Atlantic tarpon (Megalops atlanticus). Marine Ecology Progress Series 357: 101-109.

Luo, J., J.S. Ault, M.F. Larkin, R. Humston, and D.B. Olson. 2008b. Seasonal migratory patterns and vertical habitat utilization of Atlantic tarpon (*Megalops atlanticus*) from satellite PAT tags. Chapter 18 in Ault, J.S. (ed.) Biology and Management of the World Tarpon and Bonefish Fisheries. Taylor and Francis Group. CRC Series on Marine Biology, Volume 9. Boca Raton, Florida. 441 p.