Title page:

Field Testing of a novel application to examine habitat use and migration patterns of spiny dogfish (*Squalus acanthias)* in the Western Gulf of Maine

FINAL REPORT

Award number: 07-016
Date: September 30, 2009

Participants:

Project Leader- James Sulikowski, Marine Science Center
University of New England, 11 Hills Beach Rd., Biddeford, ME 04005, Office: 207-602-2730, Fax: 207-602-5945, Email: jsulikowski@une.edu; Paul Tsang, Department of Animal and Nutritional Sciences Durham, NH 03824, Phone: (603) 862 3479, Fax: (603) 862-3758, E-Mail: pct@cisunix.unh.edu

Project objectives and scientific hypotheses:

Central to any successful fishery management plan is the availability of accurate, detailed and updated life history information on the species. Several reports, including the current spiny dogfish FMP, outline an extensive list of research needs that would help build a successful management plan for this species. Two of the most important questions regionally, is whether or not spiny dogfish in the Gulf of Maine should be considered as part of the NW Atlantic stock and what areas of the Gulf of Maine are represent essential fish habitats for this species. Satellite tags offer a means to study the real time movement patterns and how an animal utilizes its environment. The success of this technique on several marine species, suggest that the use of this technology will provide insight into dogfish movements and habitat use in the Gulf of Maine. If the method in this pilot effort proves successful, the use of these techniques may be expanded to determine whether or not spiny dogfish should be considered a unit stock in Gulf of Maine and the determination of EFH for this species. Thus our goals are to test the feasibility of using satellite tag technology to track spiny dogfish movement in the Gulf of Maine.

Methods and work plan:

We have used the PTT-100 Archival popup x-tag Tag produced by Microwave Telemetry, (Columbia, MD) to track dogfish movements. Dummy tags were purchased in order to conduct pilots study in order to determine the appropriate tagging procedure. After several intensive studies, the appropriate method for attaching the satellite was to actually drill into the base of the dorsal fin (Figure 1). Here, a plastic screw is pushed through the drill hole, fastened with a nut and then bolted. Between the dorsal fin and screw there are plastic washers that that contain a soft rubber housing. This arrangement offers the least amount of friction between the dorsal fin and tethered satellite tag. Using this fastening technique, the satellite tag placed on the dogfish in the pilot study remained

on the animal for 3 months, before the animal mysteriously died. In the field, three dogfish were captured by hook and line and individually strapped to a wooden gurney and held underwater in a designated on-board live well. After attachment of the tags in the field, each individual dogfish was monitored for 30 minutes. No outward signs of stress were observed and all specimen's were released back to the Gulf of Maine.

Work completed to date:

Three tags were purchased and deployed on dogfish. One was deployed on October 31st, and the other two on November 7th. These tags all recorded and transmitted data.

Results to date:

Shark 78183

Forty-one out of a possible 82 days at liberty had geolocations available for analysis. Depth data indicated that the tag popped off on January 17, 2008 although it did not transmit until February 2, 2008. During the 82 days at liberty, the shark spent the majority of time in waters less than 50 m (Figure 1), and occupied a maximum depth of 70 m. The shark displayed an active vertical movement pattern and exhibited greater mean depth during the day (mean = 21 m; S.D. = 10) than during the night (mean = 20 m; SD= 11) (t-test = 3.15, $p < 0.01$) (Figure 2). Analysis of 4379 temperature readings indicated the shark remained within a relatively narrow range of 6.79 - 10.42 ^{o}C (mean = 9.18 ^{o}C; S.D. = 0.52 SD). The final estimated track revealed that the shark moved east after being tagged, stayed offshore during the months of November and December, and then moved in a southern direction in January (Figure 3). The estimated average horizontal speed of the shark was 1.36 km per hour.

Shark 78184

During its 189 days at liberty this shark occupied depths between 5 and 210 m (Figure 1). The mean day and night depths occupied by this shark were 79 m (S.D. = 47) and 73 m (S.D.=39), respectively. An f-test indicated that the variances of the mean day and night depths occupied were significantly different (f-value = 1.56 $p < 0.01$). A comparison of day and night distributions of the samples indicated that significantly deeper depths were occupied during the day (K-S statistic =1.42, $p = 0.04$). Analysis of the 1632 temperature readings indicated this shark occupied waters with temperatures ranging between 5.3-14.9 ^{o}C (mean = 8.6^{o}C; S.D.= 2.0). Because only 13 days worth of geolocation data were available out of 189 days at liberty the confidence intervals for the position estimates were as large as 8 degrees latitudinally. Given our data poor constraint, this was not unexpected. Since our first model achieved local minimization (general criteria for success, kftrack2008) using parameter defaults, we felt the large variance in the final position estimates were acceptable for large scale movements (Figure 3). On a large scale, it appears that the net movement of the shark was southward during its time at liberty. Horizontal speed of this shark was not calculated due to the limited amount of geolocation data.

Shark 78185

Shark 78185 occupied the deepest depths of the three tagged dogfish, diving to depths of over 600 m on several occasions (Figure 2). Shark 78185 displayed a highly active vertical movement pattern, similar to the other sharks (Figure 2), with a mean daytime depth of 176m (S.D.=108) and a mean nighttime depth of 129m (S.D. = 110)(Figure 1). Statistical comparison indicated a significant difference between the mean depth occupied during day and night (t-test = 12.50; $p < 0.01$). Analysis of 3310 temperature readings indicated this shark occupied waters between 5.2-14.9 ^{o}C (mean = 8.6^{o}C; S.D. = 2.0).

The fact that this shark was rarely in waters shallower than 11 meters likely played a significant role in the lack of light based geolocation measurements. This further confounded the track estimation since the use of sea surface temperature as an auxiliary correction was inhibited. The depth only approach employed here achieved reasonable results for large scale movement estimation. The final estimated track suggests that this shark displayed an offshore movement pattern during the months of November and December, before heading southwest in January (Figure 3). The mean horizontal speed of this shark over this time period was 2.49 km per hour.

Impacts and applications:

This study provided new information vertical and horizontal movement information for *S. acanthias* in the western North Atlantic and shows the feasibility of the x-tag for use on small elasmobranchs. We used three variations of state space Kalman filter and auxiliary depth data to produce the first estimates of dogfish at liberty in the northwest Atlantic Ocean. Although the data returned from the three dogfish presented several challenges, the generated tracks show enough information to present an interesting trend in the horizontal movement patterns of this species. All three sharks appeared to move east into offshore waters after tagging and then into southern waters off the coast of New Jersey, USA. This is in contrast to previous studies using conventional tags. Diel depth patterns were interesting in that each shark appeared to be equally active during both the day and night. In summary, based on the results of the current study, it would appear that the smaller x-tag can provide a useful information on the movement patterns of relatively small species of sharks.

Related projects:

This study acted as the catalyst for the funded proposal: “Dismissing Dogma: The Use of Satellite Tags to Examine the Behavior of Spiny Dogfish (*Squalus acanthias)* in Relation to Habitat Use, Depth Preferences and Movement Patterns in the Northwest Atlantic”. Funding source: NOAA S & K in the amount of $237,000

Partnerships: N/A

Presentations:
The seventh annual Northeast Consortium Participants Meeting; title-Skate’s, Dogs, and a big net; a cooperative research love story; date-12/11/07; location-Portsmouth NH.

Dismissing Dogma: New Insights into the movement, reproduction and feeding habits of the spiny dogfish. Cape Cod Commercial Hook Fishing Association. 2008. Hyannis MA.

The Potential Use of Pop-up Archival Transmitting (PAT) Tags to Examine Habitat Use and Migration Patterns of Spiny Dogfish (*Squalus acanthias)* in the Western Gulf of Maine. Ann. Mtg. Am. Soc. Ichty. and Herp. Montreal, CA.

An Introduction into the Life History and Ecology of the Spiny Dogfish in the Gulf of Maine:What do we really know about this voracious shark? Southern Maine Community College. March 2009. Portland ME.

The Spiny Dogfish. How This Voracious Predator Affects the Ecosystem Health and Fishery Resources Within the Gulf of Maine. New England Aquarium, June 2009. Boston, MA.

Student participation:

Undergraduate: Nathan Furey, Angela Cicia, Brittany Palm, Andy Wargo. Graduate: Walter Bubbley, University of New Hampshire.

Published reports and papers:

In prep: Use of satellite tags and novel geolocation filtering methods to elucidate the movements of spiny dogfish, *Squalus acanthias*, in the western North Atlantic Ocean.

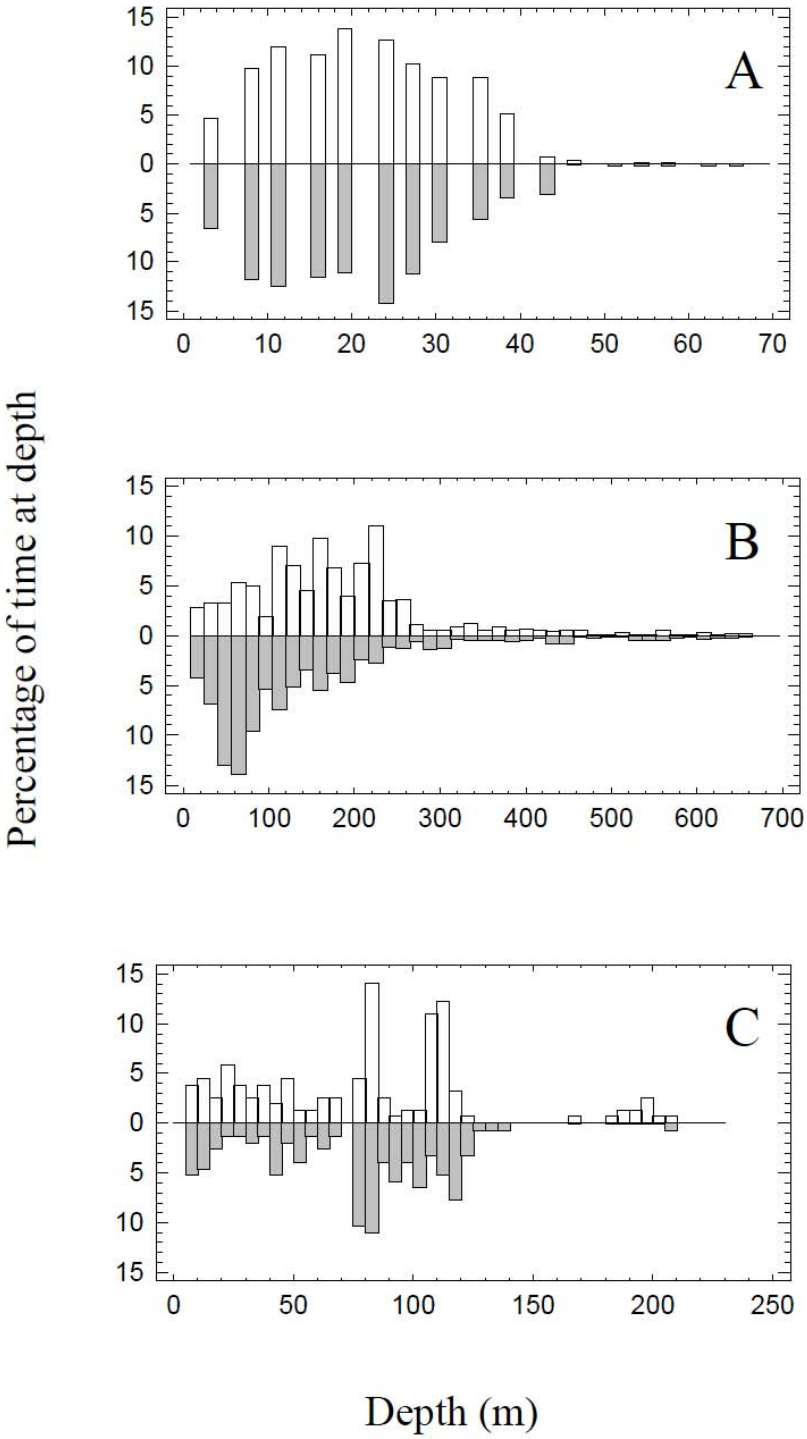

Figure 1. Diel depths (meters) for dogfish 78183 (panel A), 78184 (panel B) and 78185 (panel C) tagged with x-tag pop off satellite tags.

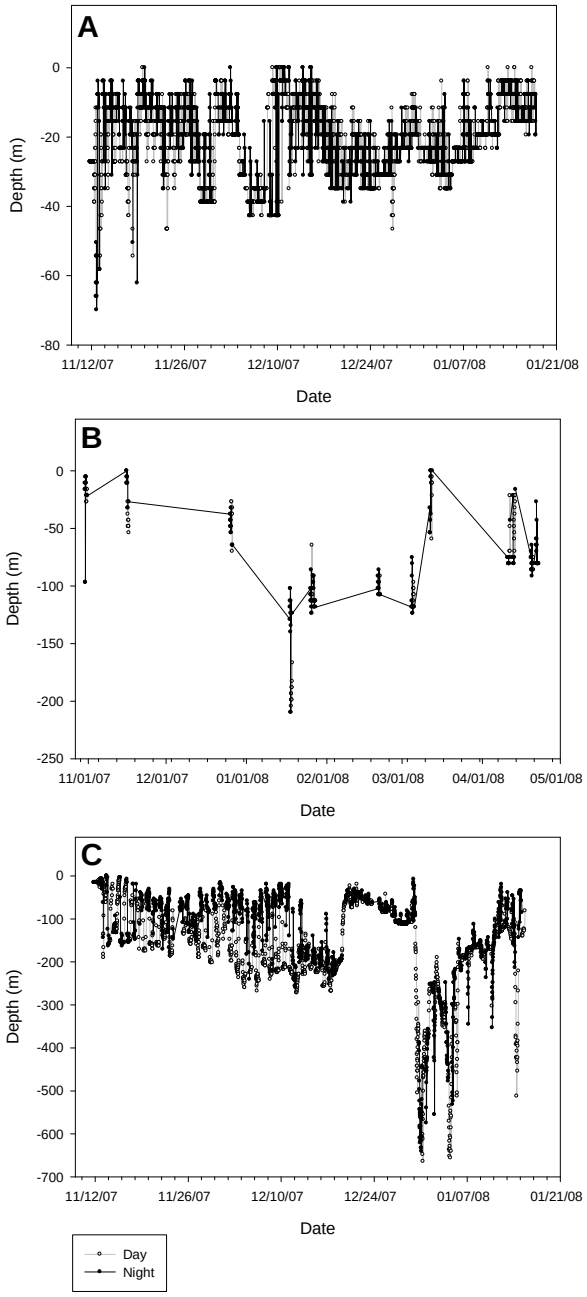

Figure 2. Differential time at depth patterns for dogfish 78183 (panel A), 78184 (panel B) and 78185 (panel C). Dogfish 78183 displayed a strong preference for depths less than 50 meters, while fish 78184 and 78185 displayed preferences of 80 to 130 m and over 200 m, respectively.

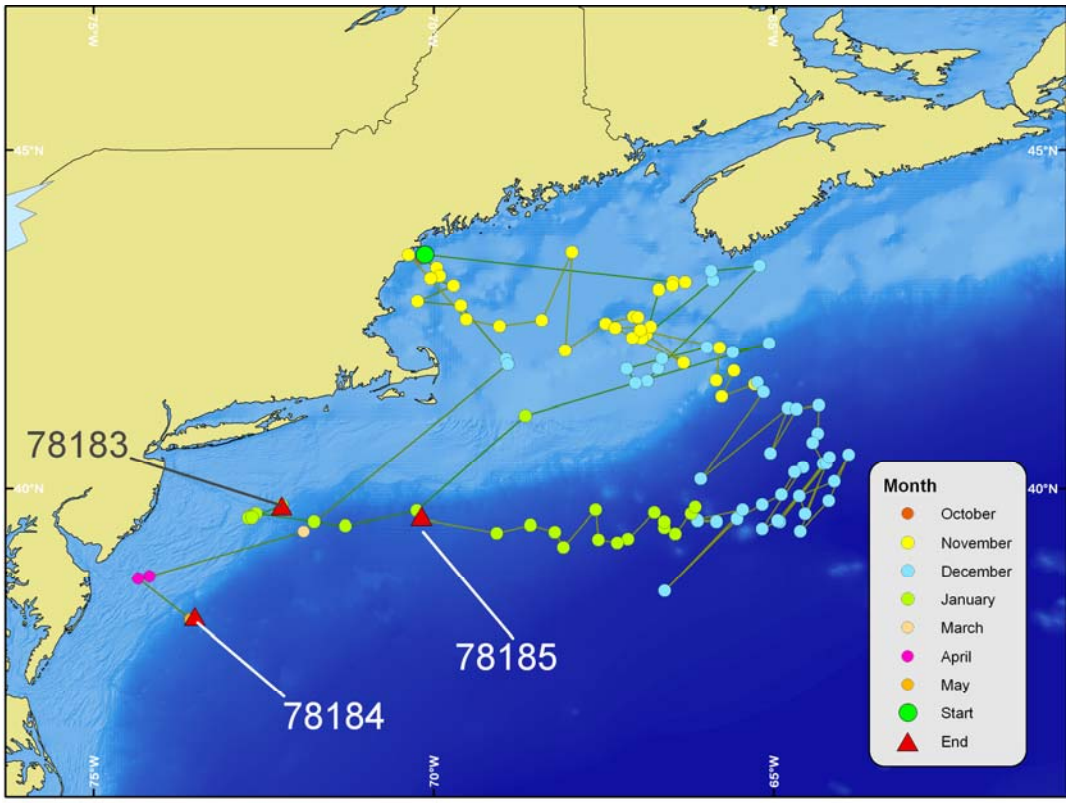

Figure 1. Filtered satellite tracks for three female spiny dogfish tagged in November of 2007. Numbers represent individual dogfish. Green circle represent tagging location, while triangles represent the "pop off" locations.