

**South Carolina Department of Natural Resources
Marine Resources Division**

COOPERATIVE FISHERIES RESEARCH PROGRAM COMPLETION REPORT

A. **Project Title:** Pilot Study to Assess the Usefulness of Pop-off Archival Satellite Tags to Monitor Temperature Preference, Vertical Water Column Use, and Migratory Behavior by Dolphin, *Corypheana hippurus*, Off the East Coast of the United States.

B. **Principle Investigator:** Donald L. Hammond, Marine Resources Division, SC Dept. Nat. Res., P. O. Box 12559, Charleston, SC 29412

C. **Project Duration:** From: 1 January 2005 To: 31 March 2006

D. **Project Objectives:** 1. Deploy seven archival pop-off satellite tags in dolphin captured off the South and Mid-Atlantic coasts of the US. 2. Generate a profile of daily water temperatures utilized by dolphin. 3. Record vertical movements in the water column along with water depth preference. 4. Attempt to document long distance movements.

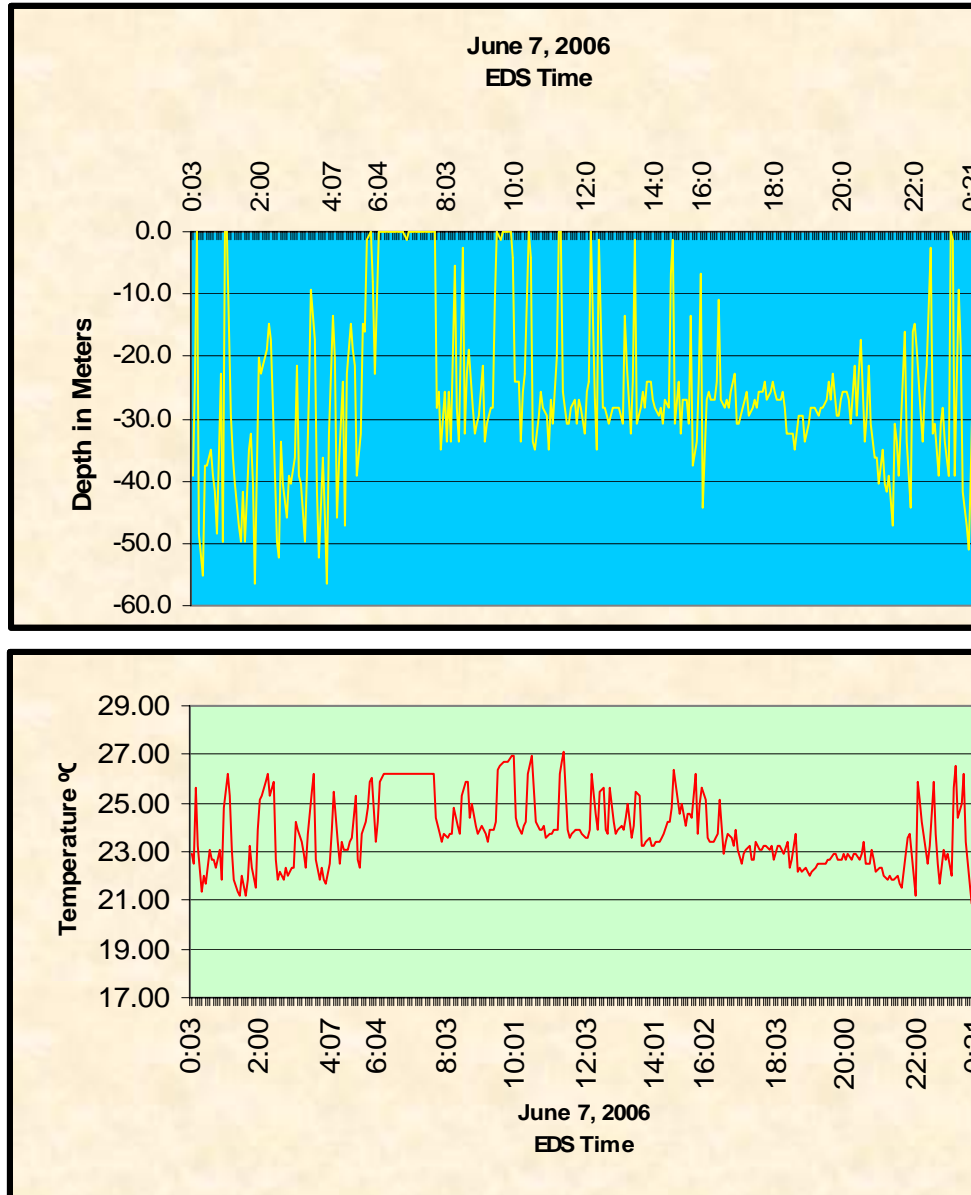
E. **Statement of Work:** The project arranged for private recreational fishermen who were experienced in the application of conventional streamer tags on dolphinfish, to volunteer to implant a satellite pop-off archival tag in a large dolphin. Tags were provided to two anglers fishing in the Florida Straits, three in South Carolina, and one in North Carolina. Another tag was provided to a biologist with the North Carolina Division of Marine Fisheries for deployment off Cape Hatteras. The Microwave Telemetry model PTT 100 HR archival tag with geolocation capabilities was utilized. This tag is 34cm long and weighs 68g. The sensing device records time specific temperature, pressure and light density every 3 to 4 minutes. It was programmed to release itself from the fish after a 30-day period.

Because of the large size of the tag, volunteers were asked to only tag fish of 13kg or larger. Subsequently, only one tag was deployed during the 2005 fishing season. The satellite tag was deployed off Charleston on June 4 by the charter boat *Tag Team* captained by Howard Mosley. The fish was released approximately 157km due east of Savannah, GA in waters 136m deep. The tag surfaced prematurely 10 days later, June 13th, roughly 167km due east of Isle of Palms, SC. Pressure data indicated that the fish was at 26.9m when the tag separated from the fish. The instrument was located 146.9km ENE of the release site in waters 274m deep at its initial contact with the satellite. It is unknown why or how the tag separated from the fish, but similar problems have been encountered by many other projects using this type tag. The tag initiated downloading data to the Argos Satellite system on June 17, 2005 at 19:44 EDST and continued transmitting until July 22, 2005.

F. **Results:** The deployed tag monitored the fish's water temperature and depth selection for a period of 213 hours. The tag transmitted data on 2,482 time-specific readings that documented the temperature and depth of the fish for 64 % of the tracking period. While most interruptions in the daily data tracks were less than 30 minutes in length, some gaps extended as long as two hours at a time. The data documented the depth, light intensity and temperature of the fish for 43.6 % to 78.1 % of each day during the track. Over this time period the fish made dives as deep as 74m and moved through waters that ranged from 19.6 °C to 27.1 °C. The fish exhibited extensive vertical

travel in the water column. Such was the case on June 5th when it traveled from the surface to 56.5m in 3 minutes.

Figure 1. Example of a 24-hour track of a dolphin's vertical movements and temperature selections off South Carolina.

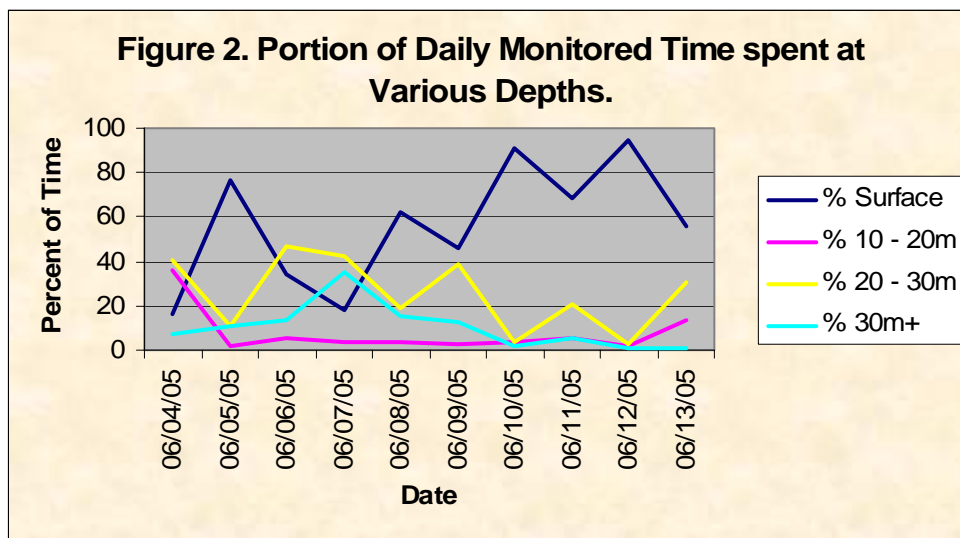


For the purpose of this report, the vertical movements are presented in a series of depth ranges, 0 to 10m, >10m to 20m, >20m to 30m and >30m. The proportion of time spent at a given depth is based on only that time when the fish's position was documented from the received data. Movements to deep water or the surface and the subsequent return automatically result in brief passage through mid-depth ranges. If the data did not report a recording during transit through the mid-depths, the use of that depth range during that movement was not counted towards time at that depth. An example would be the aforementioned June 5th dive where at one reading the fish was at the surface and the next reading, 3 minutes later, it was at 56m.

To evaluate if behavioral differences exist related to day light, each 24 hour day was divided into three photoperiods. The periods consisted of AM night (from midnight to first light), day (first light to last light) and PM night (last light to midnight). Determination of the time of first and last light was based on instrument readings of zero light intensity.

Water Column Utilization:

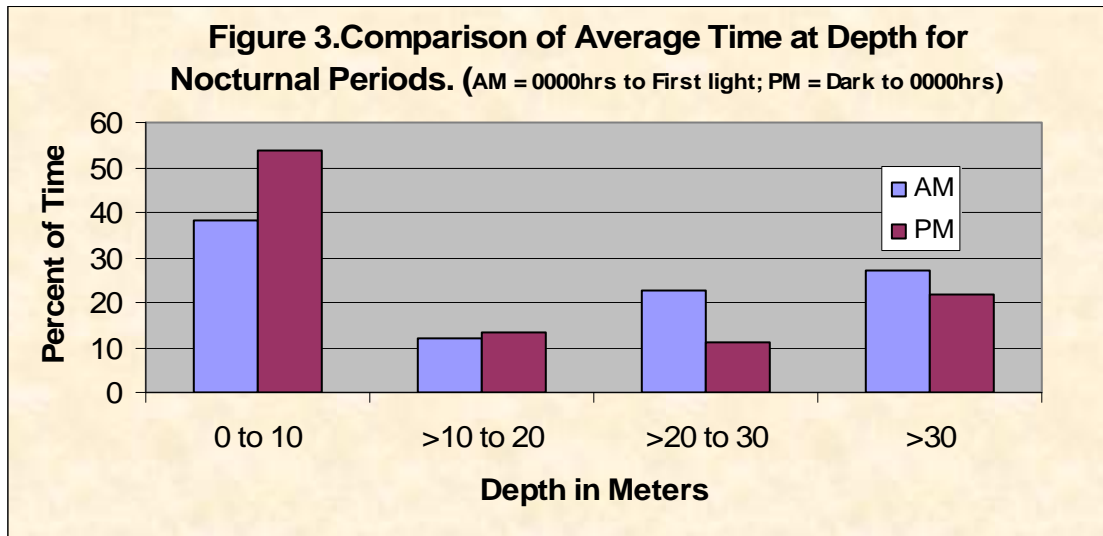
Data showed the fish to use a wide range of the water column and the portion of time spent within a depth range varied day to day. Overall, however, the majority of time was spent at or near the surface, 0 to 10m (Figure 1). The proportion of monitored time when the fish utilized the surface waters ranged from a low of 16.2% on the day it was tagged to 94.3% on June 12. The single longest period spent in the surface waters was 15.1 hours that began at first light on June 10th. Over the course of the track, the fish spent an average of 63.1 % of the time within 10m of the surface.



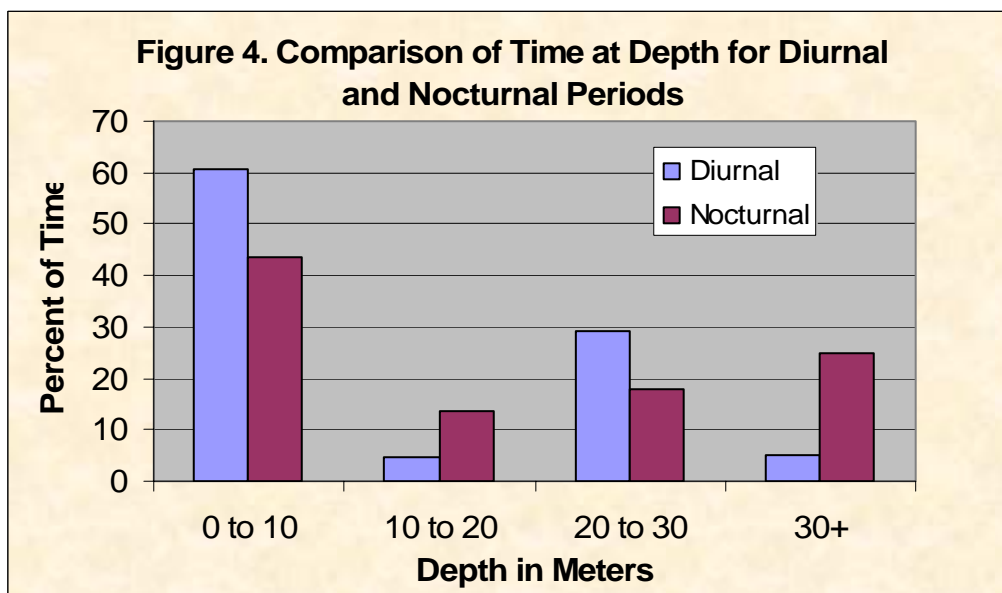
The amount of time spent below 10m each day ranged from 6% to 84% of the monitored time with an average of 37%. The fish utilized the deeper level more during the period of June 6th through 8th than any other time. It should be noted that the new moon occurred on June 6th and it is unknown if this may have affected the behavior. The longest continuous period, 6.4 hours, below 10m was on June 7th. During four days of the monitoring, the dolphin spent more time below 10m than it did above. On June 4 and 7 the fish spent more than 80% of its time below 10m. Depths of 20 to 30m were utilized more than any other range with an average of 22% of the time spent there and longest continual occupancy was for 2.6 hours on June 6th. The portion of the day spent at 20 to 30m depths ranged from 3% on June 12th to 46% on June 6th. It is interesting that the fish spent more time below 30m, an average of 11% of monitored time, than it did at the intermediate depths of 10 to 20m where it spent only 4% of the recorded time. Time spent each day below 30m ranged from 0.5% on June 12th to 35% on June 7th with the longest period lasting 47 minutes, June 6th. The longest continuous occupation of 10 to 20m lasted only 23 minutes.

Some variations were observed in the average depth occupied between the nocturnal hours and the diurnal hours. Minor differences were observed in depth selection between the night time periods (Figure 2). The fish tended to spend more time at the surface in the PM period

and more time at 20 to 30m in the AM period. Time spent at 10 to 20m and >30m was fairly equal between these periods.



Pressure data indicated that the fish utilized the surface waters more than any other depth throughout the day and night (Figure 3). However, there was a definite tendency for the fish to spend more time in the top 10m of water during daylight hours, 61% of monitored daylight hours, than at night when it spent 44 % of the monitored time in the top layer (Figure 3). Data showed the fish tended to utilize the deepest layers, 30m+, more at night spending more than 4 times the amount of time at these depths at night than during the daylight hours. Conversely, the intermediate depth of 20 to 30m was utilized over 60% more often during the daylight period than at night. The pressure track indicated that the fish made 13 descents to or below 50m. Nine of these dives, 69%, were made during night periods. However, the deepest dive, 74m, was made during daylight.



The bull dolphin did repeat one movement behavior every morning. At first light, the fish would always rise to the surface layer. This initial visit to the surface ranged from 4 minutes to

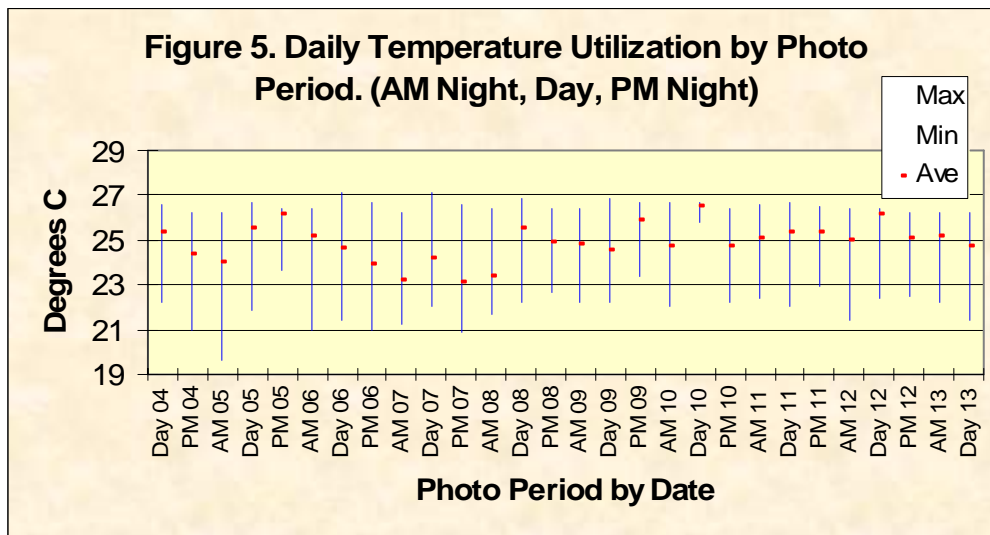
16 hours before making a sustained descent. The fish remained in the surface layer for an average of 2.3 hours each morning during this initial rise.

Temperature Selection

Temperatures utilized by the dolphin ranged 7.5 °C from 19.6 to 27.1 °C during the monitored period. The largest variation for a single day was 6.6 °C, 19.6 to 26.2 °C, on June 6th. During the period monitored, the average daily temperatures used by the fish ranged from 22.1 to 26.5 °C with an overall average of 24.9 °C. The lower temperature recordings were usually associated with the deeper depths while the highest temperatures were normally observed at the surface.

Comparing the temperatures occupied during the three daily photoperiods allows a look at how the fish's behavior may vary among the periods (Figure 4). While considerable variation was observed among the three periods each day, no significant pattern emerged. There was a tendency for the night time temperatures to be lower than the previous day's in most cases. Use of waters with temperatures below 24 °C were normally occupied for brief period usually lasting less than 30 minutes, but on June 7th the fish remained in these cooler waters for almost 6 hours continuously. Extended stays, those over 15 minutes, in to the cooler waters did not always follow long periods in the warmest waters.

The graphic plot of the average temperature noted for each photoperiod, Figure 4, indicates the 25 °C isotherm to be the focus of the thermal preference of dolphin. These data show less than a 2 °C variation, 23.1 °C to 26.5 °C, in the average temperature utilized by this fish during each photoperiod. It was usually during the day periods that the highest average temperatures were recorded. The overall average maximum and minimum temperatures noted for the three photoperiods varied little. The day period exhibited slightly higher average temperatures, 0.3 to 0.9 °C, than either nocturnal period.



A slightly different profile of temperature selection is seen when the frequency that a temperature was recorded is examined. Table 1 shows that almost 45% of all temperatures readings were in the 26°C range (26.0 to 26.99). Surprisingly, the 23°C range had the second most frequent occurrence of the temperatures, 18.5%. The 25°C range was the third most

frequently occupied thermal level, accounting for 13.7% of the readings. Over 87% of all temperature observations were between 23.0 and 26.7°C.

Table 1. Overall Temperature Selection and Depth Occurrence.

Temp °C	Depth (m)			Readings	
	Min	Max	Ave	No.	%
19+	41.7	55.1	50.2	3	0.1
20+	39	74	53.1	4	0.2
21+	16.1	57.8	41.5	54	2.2
22+	16.1	49.8	33	216	8.7
23+	1.3	53.8	27.5	459	18.5
24+	0	56.5	22.1	292	11.8
25+	0	47.1	11.5	339	13.7
26+	0	37.7	2.2	1113	44.8
27+	1.3	25.6	13.4	2	0.1

Temperature observations at depth indicated wide variations in the width of a temperature specific water masses. Lower temperature readings, below 23°C, were generally associated with the deeper levels below 30m. However, there were instances where these temperatures were encountered as shallow as 16m. Similarly, observations of 25°C were recorded as deep as 47m with readings of 24°C going as deep as 56m. These wide bands of temperature specific water allowed the fish to remain in its preferred temperature range while using more of the vertical water column.

While the dolphin definitely spent more time in waters of 25 to 26 °C, they would also utilize cooler waters. On June 7th, the fish remained in waters principally below 20m for 5.75 hours remaining in water that averaged 22.8 °C. However, the fish made limited use of waters below 22 °C. Most entries into these cool waters were brief, 3 to 6 minutes, with the longest period lasting only 17 minutes.

G. Discussion: Data acquired from this short-term monitoring of a male dolphin reaffirms it as an epipelagic species, spending the majority of its time in the surface waters. The vertical movement behavior provides the first insight into the daily water column usage by the species. It has shown the species to spend almost a third of its time below 20m depths and to visit waters as deep as 74m. There was no evidence that the fish actually descended to the bottom since the release as well as the recovery site were more than 60m deeper than the deepest dive. Slight behavioral differences were exhibited between diurnal and nocturnal periods. The fish spent a larger portion of daylight hours in the surface layer than at night while during the nocturnal periods it utilized depths below 30m to a greater extent than during the diurnal period.

Temperature observations support the dolphin as a warm-water subtropical species. While it spent the majority of time in 25 to 26 °C water, it would commonly use waters with temperatures as low as 22°C. While the fish showed that it would enter waters below 20°C, it limited time spent in waters below 22°C to brief periods of 3 to 15 minutes.

The vertical movement behavior as well as temperature utilization pattern is likely region-specific. It is probably a direct function of the hydrography of the area's major ocean current, the Gulf Stream in our case. Its speed, width and presence of ephemeral or permanent gyres have major impacts on dolphinfish and their behavior. Behavior of dolphinfish in the Florida Straits and in the Mid-Atlantic Bight could be very different from what was observed off South Carolina.

H. Conclusions: This is the track of one fish for a short period off South Carolina made during June 2005. It cannot be assumed that data collected from this fish is representative for the species as a whole. However, it does provide the first information on vertical water column movements and temperature selection by a dolphin over a multi-day period off the South Carolina coast. Due to the short distance traveled, no data on geolocation was available to assess this system's usefulness. This tag deployment showed that while the archival pop-off satellite tag is not perfect, it clearly demonstrated potential to provide valuable data never before acquired on the life history the dolphinfish.

I. Recommendations: Additional tagging studies use archival pop-off satellite tags should be conducted to fully evaluate dolphin behavior as it relates to their environment. The tag attachment system needs to be adjusted to be more compatible to the species and to aid in preventing premature separation from the fish due to anchoring failure. The remaining tags should be used to continue this study especially after the outstanding results that the first tag provided.

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