South Carolina Sea Grant Consortium
Cooperative Fisheries Research Grant Progress Report
Progress Report for Grant R60A

Title: Use of pop-off archival satellite tags to study cobia in Port Royal Sound, South Carolina and dolphinfish present off the East Coast.

Report Period: July 1, 2006 to May 24, 2007

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Introduction:

Cobia and dolphinfish are two important species supporting major recreational fisheries not only in South Carolina but also in all coastal states from Texas to Massachusetts. Science has little information about the movements, migrations and essential habitat for these species. The South Atlantic Fisheries Management Council which is responsible for managing both species has identified collection of this information as a priority for research. The use of pop-off archival satellite tags (PAST) on bluefin tuna, marlins and sailfish has shown the instrument effective in collecting long term information on water temperatures, movement through the vertical water column and temporal/spatial movements of individual fish. However, these instruments have never been used to study dolphin any where and only four cobias in the Gulf of Mexico have been monitored with these devices.

The first big hurdle this study had to cross was what size the fish needed to before tagging and how to attach the device to the fish. The Microwave Telemetry, Inc. PTT-100 instrument utilized in this study weighs 68 gr with a module measuring 13.3 cm by 4.1 cm. Study animals in all previous studies using this device were significantly larger than this study's target animals, even the Gulf cobia were reported as 32 kg plus in weight. These previous studies relied upon an internal anchor system that utilized large metal dart heads roughly 2cm by 5cm to secure the tag. A fork length of 112 cm was set as the minimum size for tagging which translated to an 18 kg cobia and a 14 kg dolphin. After using this system to attach four tags, the method was determined to cause excessive tissue trauma in these smaller animals. A new anchoring system was adopted in 2007 to reduce the tissue damage. The system involves passing a heavy monofilament line from the instrument laterally through the dorsal musculature below the dorsal fin and being secured on the opposite by a stainless steel plate that is held in place by a double barrel crimp placed on the monofilament. Because this system requires the fish to be removed from the water, a special mouthpiece was developed to facilitate ventilation of the gills with saltwater using a pump and hose system while the fish is out of water. This anchoring system should remove the potential for the tether to be dislodged from the fish.

Preliminary Results:

Cobia

The project called for the deployment of four pop-off archival satellite tags on cobia captured in or adjacent to Port Royal Sound. This has been achieved. One was attached to a fish in 2006 but the instrument never contacted a satellite. Other studies have noted a 25% failure rate in these tags to transmit data. Such failures could be due to any number of reasons from damage to the device by

a predator to instrument malfunction. The other three telemetry platforms were deployed May 12, 2007, Table 1. All cobia tagged were provided by different charter boats operating in Port Royal Sound. The first of these tags should begin transmitting data around the middle of June 2007 with the other two devices initiating data transfer in mid-August 2007.

Table 1. Pop-off archival satellite tag deployment.

Tag NO.	Date Deployed	Species	Tag Program	Start Lat.	Start Lon.	Geographic Area
37066	06/09/06	Dolphin	30 days	25.655	79.394	Southeast Florida
55487	06/21/06	Dolphin	30 days	32.453	78.926	South Carolina
55548	05/10/06	Dolphin	30 days	24.578	80.736	Southeast Florida
55551	06/07/06	Cobia	90 days	32.056	80.415	Off Port Royal Sound
55504	05/12/07	Cobia	30 days	32.291	80.708	Port Royal Sound
55552	05/12/07	Cobia	90 days	32.351	80.762	Port Royal Sound
55550	05/12/07	Cobia	90 days	32.353	80.762	Port Royal Sound

A 132 cm FL cobia is prepared for release in Port Royal Sound following attachment of a PAST monitor.

Dolphinfish

This study proposed to deploy six PAST devices on dolphinfish captured in the South Atlantic Bight. Three instruments were deployed on dolphin in 2006, Table 1. Two were deployed in the Florida Straits, one off Islamorada and the other off the Western side of Bimini Island, Bahamas. The third tag was deployed off South Carolina. The study fish were provided by private recreational fishermen. All of the instruments reported data via satellite, however, none remained with a fish for the full 30 days. All instruments reported releasing due to constant pressure, Table 2. This could be due to the death of the fish, the tag attachment to the fish being dislodged, or the monofilament tether being severed.

Table 2. Platform performance for those instruments having reached transmission date.

Tag #	Species	Pop-off Date	First Contact	End Latitude	End Longitude	% Data Transmitted	Pop-off Reason	Number Days Tracked	Data Collection Points
37066	Dolphin	02-Jul-06	03-Jul-06	26.317	78.679	63%	Constant Pressure	23.3	6,335
55487	Dolphin	27-Jun-06	01-Jul-06	32.358	77.197	76%	Constant Pressure	6.9	1,907
55548	Dolphin	20-May-06	24-May-06	29.176	78.817	73%	Constant Pressure	10	3,092
55551	Cobia	No Contact	NA	NA	NA	NA	NA	NA	NA

The 30 day high resolution tags used on dolphin record time sensitive temperature, pressure and light intensity every 3 to 4 minutes but the instrument does not provide geo-location information. The data does allow the fish to be followed each day as it moves vertically in the water column showing the water's temperature at each point, Figures 1 and 2. The initial examination of the dolphin data showed distinct differences in behavioral patterns between light and dark periods. For this reason, the data was separated by photoperiod and examined separately.

Figure 1. Vertical movement by a bull dolphin off South Carolina as monitored by a PAST on June 22, 2006.

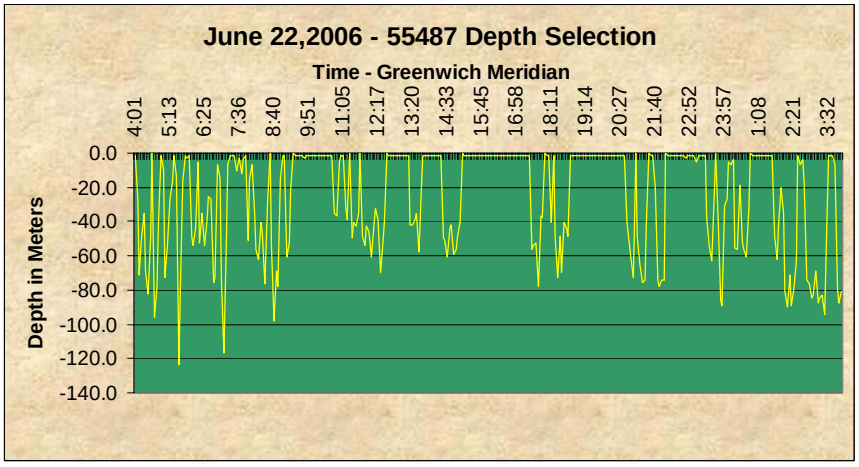
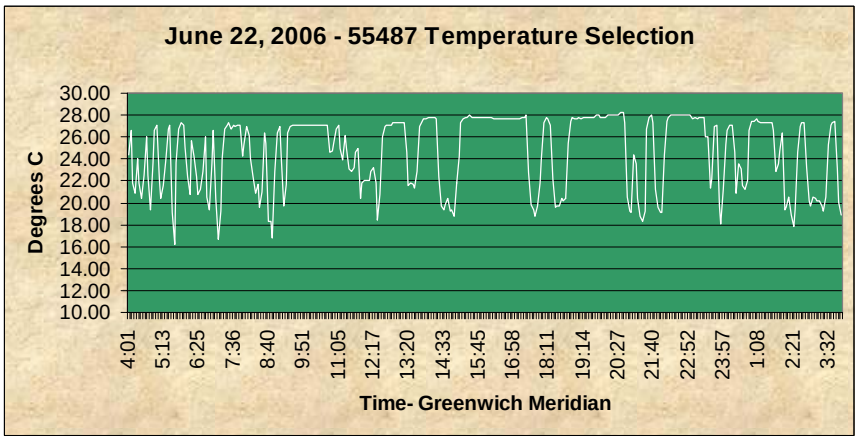
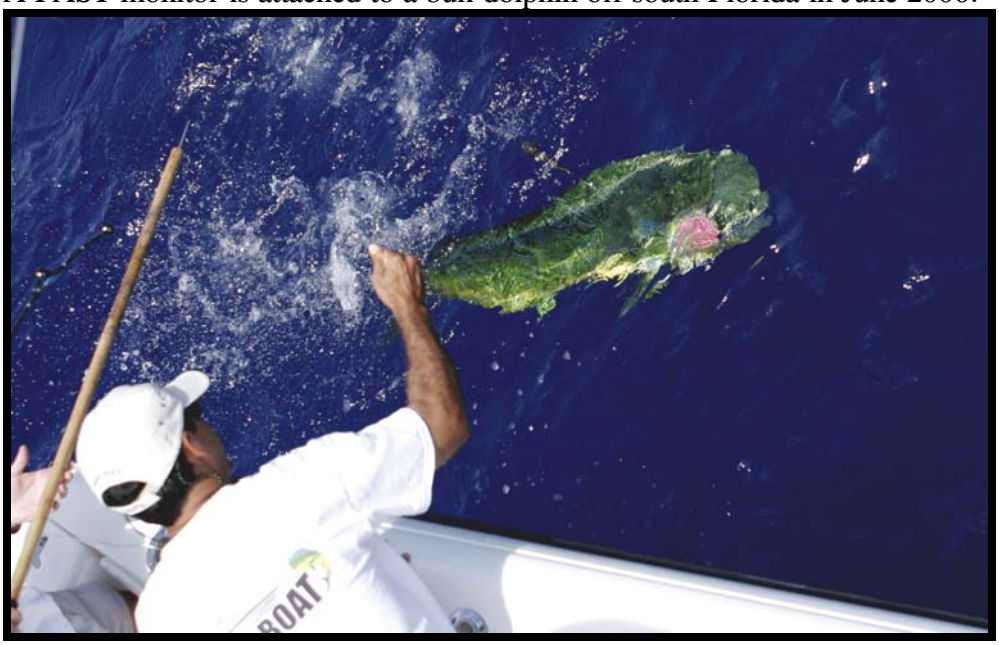


Figure 2. Water temperatures associated with movement a bull dolphin off South Carolina on June 22, 2006.

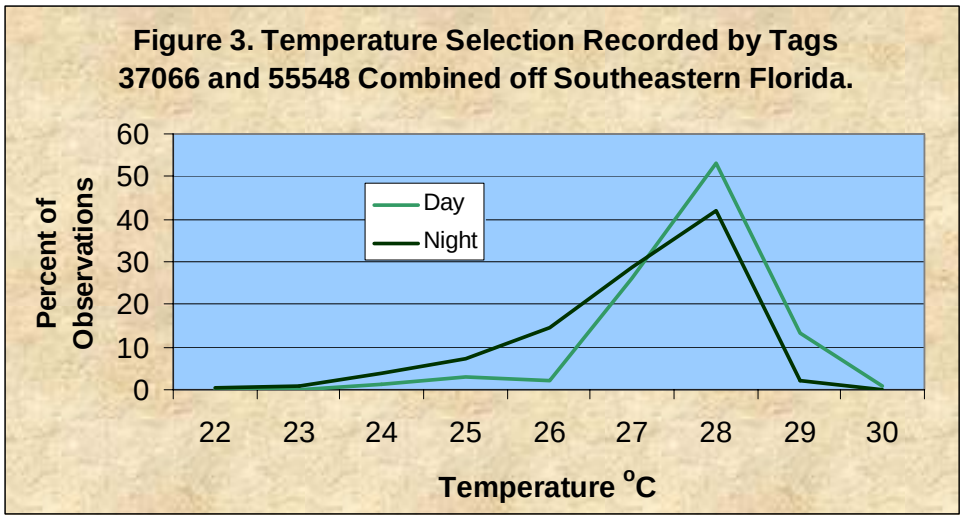


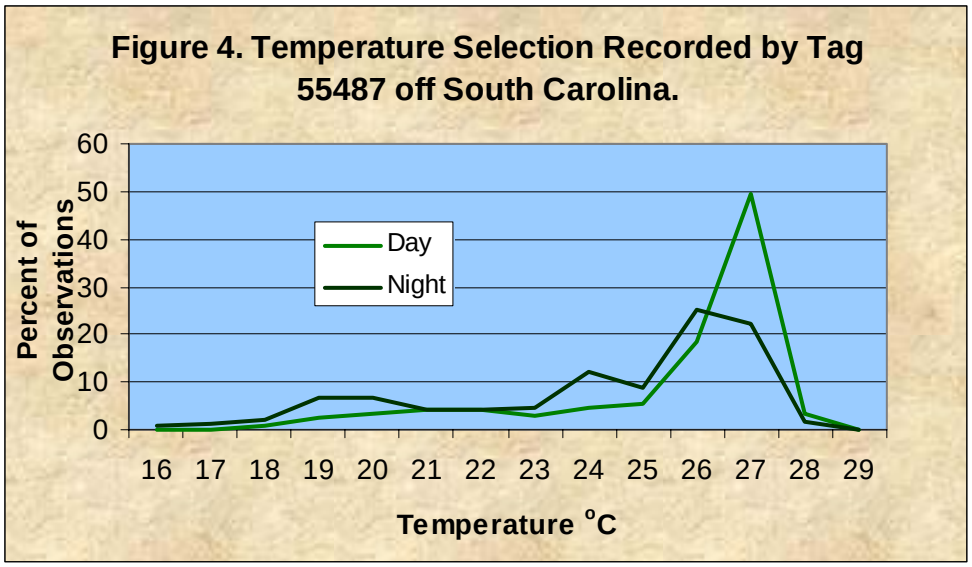
A PAST monitor is attached to a bull dolphin off south Florida in June 2006.



Thermal Observations:

Over 12,000 time specific observations on temperature and depth were received from the three tags. These data showed that fish off south Florida used warmer and a narrower range of temperatures, Figure 3, than the dolphin off South Carolina, Figure 4. However, there was noticeable differences between the two Florida fish with the one tagged in May using cooler waters (22 to 29ºC) than the June fish which used waters from 24 to 30ºC. This coupled with the fact that the fish tagged off South Carolina in late June entered much colder waters, down to 16.1ºC, indicates that dolphin will use a broader range of temperatures than previously thought.



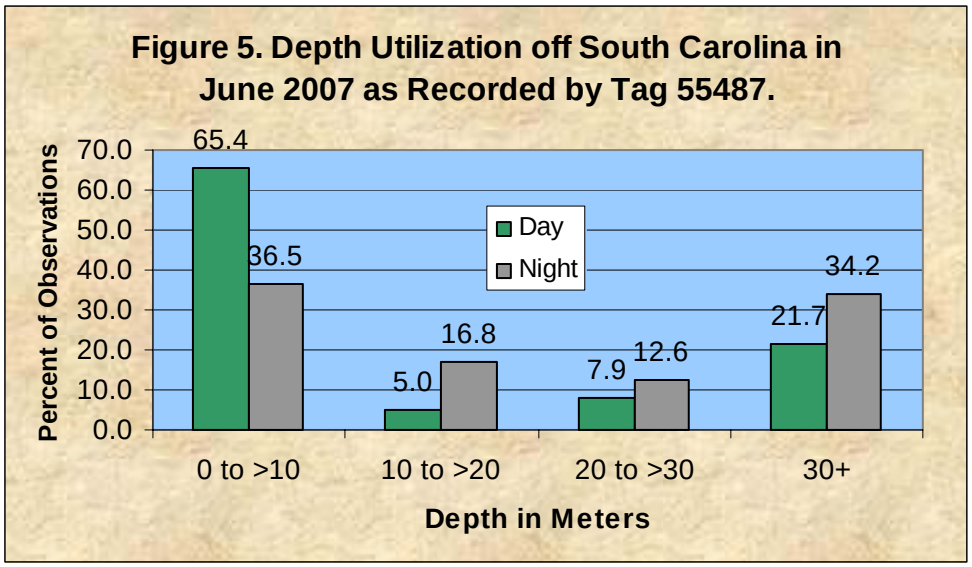


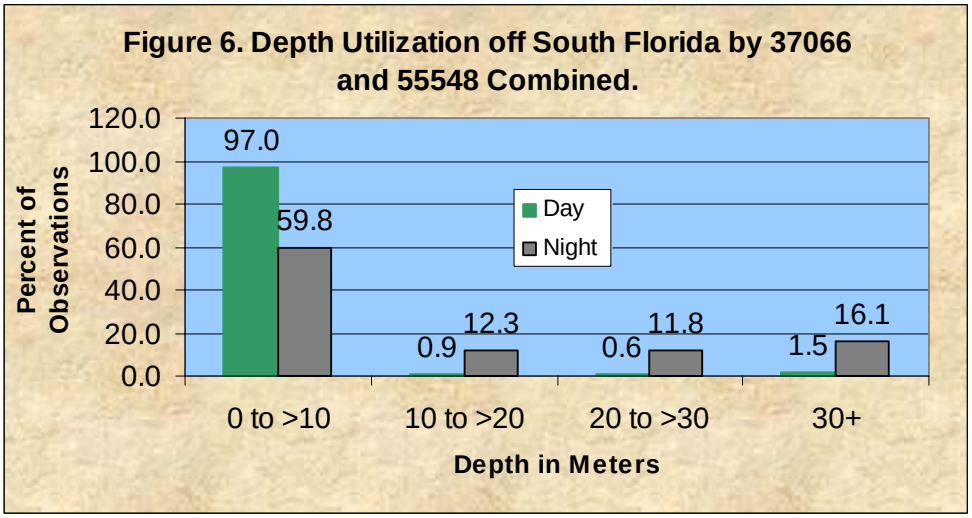
Dolphinfish have historically been perceived as a surface dwelling species likely stemming from it's pursuit of warmer waters which typically occur at the ocean's surface. Data showed that 92% of the temperature observations for the two fish off south Florida were at or above 26°C. The fish off South Carolina had 63% of its temperature recordings fall within this range. These higher temperatures, however, were not restricted to just the surface layer. Off south Florida, waters of 26°C or higher were recorded as deep as 69.9 m while off South Carolina they were encountered as deep as 53.8 m. These odd temperature readings were likely the result of a down-welling or other hydrodynamic events. Temperatures used by dolphin are likely influenced by the region's thermal structure of its water column and any hydrodynamic phenomenon that might occur.

Sea surface temperature preference by these fish was also examined since it is the sea surface temperature maps produced from satellite imagery that fishermen use to determine where to fish. Also fishermen are only able to monitor surface temperatures. Examining the records for the South Carolina fish indicated that it occupied temperatures from 23.91°C to 28.57°C while at the surface with 68% of the readings falling into the bracket of 27.0°C to 27.99°C. Collectively, the two Florida fish showed a surface temperature range of 24.78°C to 30.87°C. Records for the fish tagged in May showed that 84% of the observations were between 27.0°C to 27.99°C but the fish tagged in June had 76% of it surface readings in the bracket of 28.0°C to 28.99°C. These observations indicate that surface waters of 27.0°C to 28.99°C were most frequently utilized by these three fish.

Water Column Usage:
While dolphin have historically been considered a fish that lives at the surface, data from the three monitoring devices clearly show that they use a large portion of the water column down to depths of at least 123 m. The data showed that dolphin spend more of their time, both day and night in the surface layer than in any other layer, Figures 5 and 6, based on number of observations. One unexpected behavior found to be common to all fish was that they would to rise to the surface just before or at first light each day.

Comparing the number of observations recorded for each layer provides us with a relative index of usage. For the purposes of this study, the vertical water column was divided into four layers; 0 to 10 m (surface layer), 10+ to 20 m, 20+ to 30 m and more than 30 m. Differences in depth usage were observed not only between daylight and dark periods but also between fish off south Florida and off South Carolina. The most noticeable difference in diving behavior between fish in the two areas was the amount of time spent in the surface layer. Fish off south Florida spent roughly 50% more time in the surface layer than the dolphin off South Carolina, Figure 5 and 6. The South Carolina dolphin utilized the lower water layers, especially waters below 30 m, 10 times more frequently during the daylight and 60% more often at night than the fish off Florida. However, fish in both areas clearly showed higher usage of the deeper waters during the night than in daylight. The fact that dolphin off South Carolina spent 35% of the daylight period below the surface layer could suggest that they may be less vulnerable to harvest by recreational anglers who traditionally fish their baits at the surface than the fish off Florida which left the surface layer only during 3% of the daytime.





The deep diving phenomenon, below 30 m, recorded by these instruments is the first-look at this behavior in dolphinfish. Each fish exhibited this behavior to varying degrees. Tables 3, 4 and 5 give a daily account of the fish's deep diving activity broken down by photo period. These tables show that all fish utilized the ocean depths more frequently at night but not uniformly from one day to the next. Table 3 shows a pattern of heavier usage of deep water by the South Carolina fish which made deep dives on 71% of the daylight periods and 83% of the night periods monitored than Florida fish. The south Florida dolphin made deep dives only on 26% of the days and 85% of the nights during their tracks, Tables 4 and 5. Another behavior that was observed in all fish was the tendency to descend to a specific depth on consecutive dives, especially at night.

Table 3. Deep diving behavior off South Carolina by fish 55487. (Depth in meters and time in minutes)

Date	Daytime				Night			
	Number Dives	Maximum Duration	Total Time	Maximum Depth	Number Dives	Maximum Duration	Total Time	Maximum Depth
21-Jun	1	1	1	33.6	23	26	140	123.7
22-Jun	16	43	245	88.8	11	70	219	121
23-Jun	14	107	484	88.8	8	71	282	115.7
24-Jun	17	43	212	82	3	10	18	33.6
25-Jun	0	0	0	0	0	0	0	0
26-Jun	0	0	0	0	15	23	77	53.8
27-Jun	2	1	2	35	0	0	0	0
Average*	10	39.0	18.9	65.6	12	12.3	12.26	89.6

* Based only on dates when dives were made to or below 30m.

Table 4. Deep diving behavior off south Florida by fish 55548. (Depth in meters and time in minutes)

Date	Daytime				Night			
	Number Dives	Maximum Duration	Total Time	Maximum Depth	Number Dives	Maximum Duration	Total Time	Maximum Depth
10-May	1	1	1	36.3	21	4	31	43
11-May	11	29	109	53.8	16	79	226	94.1
12-May	1	1	1	36.3	22	36	180	87.4
13-May	0	0	0	0	14	19	78	60.5
14-May	1	22	22	64.6	6	16	38	71.3
15-May	4	1	4	44.4	19	26	156	69.9
16-May	0	0	0	0	3	12	14	48.4
17-May	0	0	0	0	16	22	89	61.9
18-May	0	0	0	0	0	0	0	0
19-May	1	1	1	49.8	1	10	10	49.8
20-May	0	0	0	0				
Average*.	3.17	9.17	7.26	47.5	13.11	24.89	6.97	65.14

* Based only on dates when dives were made to or below 30m.

Table 5. Deep diving behavior off south Florida by fish 37066. (Depth in meters and time in minutes)

Date	Daytime				Night			
	Number Dives	Maximum Duration	Total Time	Maximum Depth	Number Dives	Maximum Duration	Total Time	Maximum Depth
9-Jun	6	1	6	39	11	13	29	53.8
10-Jun	10	13	112	55.1	3	1	3	37.7
11-Jun	0	0	0	0	9	17	59	53.8
12-Jun	0	0	0	0	0	0	0	0
13-Jun	0	0	0	0	9	3	11	40.3
14-Jun	0	0	0	0	6	1	6	40.3
15-Jun	0	0	0	0	9	7	23	45.7
16-Jun	0	0	0	0	8	1	8	36.3
17-Jun	0	0	0	0	10	10	37	44.4
18-Jun	0	0	0	0	8	10	19	51.1
19-Jun	0	0	0	0	0	0	0	0
20-Jun	0	0	0	0	23	13	118	71.3
21-Jun	0	0	0	0	17	24	129	79.3
22-Jun	1	3	3	37.7	5	4	10	47.1
23-Jun	0	0	0	0	4	3	6	52.4
24-Jun	0	0	0	0	0	0	0	0
25-Jun	0	0	0	0	8	14	29	40.3
26-Jun	0	0	0	0	9	4	16	43
27-Jun	0	0	0	0	10	14	25	44.4
28-Jun	0	0	0	0	4	6	9	53.8
29-Jun	0	0	0	0	5	1	5	32.3
30-Jun	0	0	0	0	1	1	1	33.6
1-Jul	0	0	0	0	0	0	0	0
2-Jul	0	0	0	0	0	0	0	0
Average*	5.67	5.67	7.12	43.93	8.37	7.74	3.42	47.42

* Based only on dates when dives were made to or below 30m.

The deep diving behavior exhibited by these dolphinfish naturally leads to the question of why they do it. But when you begin to add together other information about the fish, a plausible explanation for the behavior emerges. The most amazing fact about dolphin is their rapid growth rate, reportedly growing as much as 4 cm per week in the Caribbean. Animals having such rapid growth have been shown to have a high food demand and a fast digestion process which means that dolphin are eating machines. This is supported by laboratory observations of dolphin consuming as much as 20% of their body weight per day in captivity. Add to these facts observations of rock shrimp, squid and paper nautilus being found in their stomachs by biologists and recreational fishermen and a picture begins to emerge.

Squid and paper nautilus are known to hide in the dark depths of the ocean by day along with the many other animals that form the ocean's deep sea scattering layers. At night these animals rise toward the surface where they become vulnerable to many predators. The rock shrimp takes its effort to hide during daylight one step farther by burrowing into the deep ocean floor sediment but it also rises up in the water column at night where it is exposed to possible predation.

Combining these pieces of information, a picture of dolphin diving down to intercept these animals rising from the ocean depths begins to emerge. The fact that dolphin make multiple dives to the same depth on a given night could indicate that food had been discovered at that level and the fish returned for additional foraging. This theory provides a realistic explanation of how the various animals that hide during the day at great depths of the ocean are found in dolphin stomachs. Because of the dolphin's fast rate of digestion, these fish would likely become hungry during the night even if they had captured food just before dark.

Among the five published food studies on dolphin, only one study done in North Carolina in 1959 reported a member of the deep sea community, squid, to be a primary food source of dolphin composing 61% of their diet. Other studies report squid making up from 9 to 24% of the dolphin's diet. Squid along with most members of the deep scattering layer are soft-bodied and likely digest quickly. The food habit studies have collected their samples in the evenings from recreational vessels. Such vessels typically start fishing an hour or more after sun rise and continue into the afternoon or evening. This would provide ample time for dolphin to digest food consumed during the night and return to active feeding during the day. This could lead to a bias in the evaluation of prey importance, skewing the results to favor food items consumed during the daylight period.

Discussion:

While no data has been acquired from the single satellite tag deployed on a cobia in 2006. Much has been learn about acquiring assistance from charter captains and recreational anglers. Also methods for safely handling large fish to minimizing potential injury to the fish while the tag is attached has been worked out. Subsequently, there is high optimism for the pending data files to be received from the three instruments deployed in 2007.

This project has acquired life history data never before obtained on dolphinfish. Unfortunately, the applicability of the findings to the species as a whole is uncertain, since the monitoring has been limited to only the larger and older specimens whose behavior may not be identically to smaller/younger fish. It has shown that dolphin will enter waters as cool as 16.1°C. This is a lower temperature than has been reported for the species. Data shows that dolphin will utilize waters below 21°C only for short periods before returning to warmer waters. Preliminary results also indicate that dolphin will utilize different temperatures depending on the area and time of year. This data will serve to better define their thermal requirements.

For the very first time, dolphin have been documented to use at least the top 123 m of the water column. This is important information that helps define their essential habitat that management agencies have never had. The data has shown that deep diving below 30 m to be common behavior for at least the large bull dolphin. It has also provided the first evidence of a nighttime feeding behavior which will likely alter the list of major forage animals for the species.

This project, while collecting some amazing data never before seen, has had its challenges. Both species of fish are highly prized food and game fish within the recreational fishery. It is hard to convince anglers to give up their trophy fish for $200 or $300. They would rather have the fish. But with time, specific anglers have been identified that are willing to donate their fish while other

anglers have come to realize the importance of the study and now willingly support it. A major part of the success in educating the public to the importance of this study has come from the outstanding media coverage that has been provided by instate and out-of-state newspapers as well as regional and national sports fishing magazines.

No other researcher is known to have used these large instruments to study fish as small as 14 kg. The minimum size of fish to be tagged was based on what was the largest size that would be reasonably available. Then, calling on past tagging experience and consulting with Dr. Jim Franks (University of Southern Mississippi) who is the only other researcher to put PAST on cobia, an alternative system to the harpoon anchor was developed that would minimized tissue trauma and prevented dislodgement of the anchoring tether. With this new system it is hoped that the instruments deployed in 2007 will actively monitor the fish's behavior for their full programmed period.

Even though none of the instruments have operated for their entire programmed period, the data that has been received has been worth the effort and has been cost-effective. The only other option to acquire this information would be with the use of archival tags that require the recovery of the instrument to obtain the data. These tags are less expensive costing $1,200 each. However, in the case of dolphin, it would require the deployment of 100 instruments to possibly get 2 or 3 instruments returned.

Microwave Telemetry, Inc has introduced a new, miniaturized PAST that is 40% lighter in weigh with a smaller module. This smaller tag will allow the use of smaller specimens of cobia and dolphin which will be significantly easier to acquire and more representative of the typical fish caught in the fisheries. This will make future projects using this device much easier to secure study animals and will allow a smaller size/age class to be monitored.

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