Shark Research Institute – Operation Whale Shark
Mafia Island, Tanzania, Nov. 2006 – March 2007
Preliminary Tagging Report – Field Season 1 Data

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SRI Mafia Island, Tanzania Expeditions Nov. 2006-Mar.2007

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Abstract

Whale sharks have been observed in many locations across the Indian Ocean from the East coast of Africa to Australia. An area with consistent aggregations of whale sharks during the last few years has been Mafia Island, off the coast of Tanzania. The community of Mafia Island wishes to capitalize on the congregations of whale sharks for ecotourism purposes. A research project was set up by the Shark Research Institute, with support provided by The Kairos Company, Ltd., WWF-Tanzania, and The WAVE Foundation. A full research proposal was submitted to COSTECH and approved. The principal investigator, Matthew Potenski, conducted field surveys and tagged whale sharks for the period of Dec. 2006-March 2007. The tagging program was successful, as twenty-five ID tags were deployed. Additionally, eight PAT satellite tags were attached to whale sharks. This is a preliminary report of the data collected from the tagging and survey efforts during the above mentioned interval.

Introduction

Mafia Island is the southernmost island of the Zanzibar Archipelago off the coast of Tanzania. Over the past few years, whale sharks (*Rhincodon typus*) have been observed aggregating off the western side of the island, particularly in Kilindoni bay (Fig. 1- whale shark photographed off Mafia Island).

Figure 1 – Whale shark (*R. typus*) photographed in Mafia Island waters

The status of the whale shark worldwide is not concretely known but there is some evidence that its numbers are very low. Whale sharks were added to the Appendix II list of CITES and are on the ICUN red list for threatened species. Whale shark ecotourism has also become a major attraction in many areas where the sharks can be found. Despite the high profile that whale sharks have in the media, we still know very little about them and need to understand many things about them to effectively manage and protect their populations. Research projects are beginning to illuminate

the world of the whale shark, but years of effort are still ahead. Mafia Island presents us with a unique opportunity, as it has a reliable population of whale sharks with a light ecotourism impact. To determine parameters of whale shark population structure, behaviors and movements, a research projct on the whale shark population off Mafia Island was initiated.

A proposal was submitted to COSTECH in November 2006 and a Research Permit was granted by COSTECH on December 10, 2006. The author of this proposal was a shark biologist from the Shark Research Institute (USA). Other partners in the development, funding and implementation of the project are The Kairos Company, Ltd., WWF-Tanzania office, The Mafia Island Whale Shark Conservation Society, and the WAVE Foundation of the Newport Aquarium.

The proposal outlined a program of ID tagging, PAT satellite tagging, direct observation, and photographic records. The methodologies were employed during a study period from December 2006 -- March 2007. This report explains what was accomplished via field work during this period.

Maps

Figure 2- Mafia Island, Tanzania

Figure 3 – Whale shark sampling area – Kilindoni Bay

Fieldwork/Research

The primary goals of this research project were to a) deploy visual ID tags on as many whale sharks as possible, b) to deploy eight PAT satellite tags onto sharks in this population, and c) to take photos of as many sharks as possible for photo-identification analysis and database records. During the time period from November 2006-March 2007, a total of 24 days in the field was recorded. Whale sharks were observed on 15 of those days, while no sharks were observed on 9 of those days (see Table 1).

Table 1: Dates of field work with observance of whale sharks

Month	Whale Sharks Observed	No Sharks Observed
November	17	
December 2006	12, 13, 14, 26	
January 2007	04, 05, 18, 23	19, 30, 31
February	03, 04	24, 25
March	07, 11, 12, 13	02, 08, 09,10

From November through the end of February, the research was hosted by the M/V Kairos and its support RIB zodiac boats. In March, the project became land-based in Mafia Island with support of WWF, utilizing the local Bushmen II Seamen boats as support vessels. The research was carried out as per the methodologies and parameters set forth in the project proposal submitted to and approved by COSTECH (see Potenski 2006). The weather seemed to play a major role in the abundance of whalesharks. During the end of January and throughout February into early March there was an abnormally high amount of rainfall. This time is traditionally the dry season in this region. The large amount of rainfall, coupled with the close proximity of the Rufiji River delta and subsequent fresh water inundation, caused an unmeasured but visible drop in plankton levels. Sharks were not observed during most of this time, and could either have potentially moved out of the area to more plankton-rich waters or simply spent more time completely submerged below the fresh water cap, and thus avoided detection by the surveyors. There was also a small amount of equipment failure. Twenty-five tags were attached while twenty-seven shots were taken. In two events, the tag was damaged on attempted application, resulting in the ID placard being severed from the tag tether. The main cause of this failure was the accidental catching of the tag tether on the applicator tip, usually due to the actual bending of metal caused by repeated impact with a shark. A simple solution was to replace the tagging head with a backup unit. Two types of tag anchors and respective applicators were used, both with success. The tag applicators both worked the same way, with only a slight variation in actual design. All fieldwork was done in-situ on snorkel from several small boats, including the RIB tenders for the M/V Kairos, and a fiberglass v-hulled vessel with outboard engine. All sharks were approached from the left side (off the starboard side of the vessels). The water visibility was sometimes less than two meters, and required the observer to get fairly close to the sharks for tagging and photography purposes. Sharks were found on the surface and were encountered in the water from 0-5m depth. Typically, three separate encounters were needed to get data on an individual shark. The first dive was to observe the sharks, denote and markings, determine sex, and get ID pictures. The second dive was to place a tag in the shark. Finally, a third dive was taken to verify and inspect the tag attachment and take additional pictures.

Preliminary Results

TAGGING

A total of twenty-five whale sharks were marked with visual ID tags during the course of this study (Refer to Appendix 1 – Field tagging data summary). There was a significant bias in the population as male sharks outnumbered female sharks in a ratio of roughly 3:1. Of the twenty-five sharks tagged, eighteen were observed to be males, with six females, and one shark whose sex was undetermined due to poor water visibility. Eight of those twenty five sharks also received a PAT satellite tag. The satellite tags were divided among six males and two female sharks, which conforms to the sex ratio determined in the population. Eleven sharks were tagged in December 2006, five in January 2007, two in February 2007, and seven in March 2007. One PAT satellite tag was deployed in January 2007 with the final seven being deployed in March 2007. See Figure 4 for an illustration of the two types of tags attached to a whale shark.

Figure 4 – Whale shark with both ID tag and PAT tag attached

The most tags put out in a single day were nine (March 12, 2007), comprising four ID tags and five PAT tags. Eighteen of the twenty-five tags total tags were deployed in the first and last weeks of the study. The abundance of whale sharks seemed to severely wane during late January into February and contributed to a dearth of taggings during this period. There was also some minor equipment failure with two tagging attempts resulting in the damage of the tag and non-attachment to the shark. Some small modifications to the general tagging methodology included the following; 1) all sharks were tagged ONLY on their left sides – to standardize where to look for tags and make it easier to determine if a shark had been previously tagged 2) no shark <4m will be tagged, as their small body size and softer skin/muscle may contribute to equipment damage and/or injury to the shark, 3) two anchor head designs were employed, both successfully with the caveat that the tag attachment head had a wide stopper ring on it – this stopper ring limited the penetration of the spear and in most cases allowed the spear shaft to bounce out and clear of the sharks body for a clean

tag insertion, 4) the large 3-band speargun was very powerful, and had no problem penetrating the skin of the sharks – in fact it was deemed almost too powerful and one band was removed with 100% success of penetration using two bands. The whale sharks were observed feeding on the surface, and many did shallow dives when approached or tagged. However, the sharks would almost invariably resurface somewhere between 50-100m away and resume normal feeding behaviors. This was observed even after repeated tagging (ID tag and PAT tag attachments on the same shark during a short time period). The general lack of reaction to the tagging event coupled with the quick resumption of normal feeding behaviors tend to point to the success of this methodology to effectively mark individuals in the population with little to no effects on their behavioral patterns.

PAT Satellite Tagging

Among the eight satellite tags deployed there were four 8-month tags, three 12-month tags, and one 2-month tag. A summary of the satellite tagging data can be seen in Table 2.

Table 2 – PAT satellite tagging data from Mafia Island, Tanzania 2007

Date	Time	Lat	Long	ID Num	Length	Sex	Sat Tag Num	Duration mon	Est Popoff date
18-Jan-07	14:45	07° 53.90 S	039° 38.04 E	0149	6.5m	M	67452	8	Aug-07
11-Mar-07	10:10	07° 54.86 S	039° 37.99 E	0661	5m	M	67453	2	May-07
12-Mar-07	9:30	07° 54.18 S	039° 38.34 E	0801	5m	F	73241	8	Nov-07
12-Mar-07	14:15	07° 53.50 S	039° 39.23 E	0598	7m	M	73242	8	Nov-07
12-Mar-07	15:20	07° 54.44 S	039° 37.53 E	0842	6m	F	73244	12	Mar-08
12-Mar-07	15:40	07° 54.29 S	039° 37.47 E	0841	7m	M	73245	12	Mar-08
12-Mar-07	16:15	07° 54.31 S	039° 38.12 E	0809	6m	M	73243	8	Nov-07
13-Mar-07	10:10	07° 54.31 S	039° 37.28 E	0846	5.5m	M	73246	12	Mar-08

One of the eight satellite tags has already transmitted data. Tag number 67452 was set for an eight-month deployment. The tag was placed on a shark on January 18, 2007 and popped-off on February 4. This tag popped-up prematurely and the tag data stated the reason for pop-off as constant pressure. The shallow depths the whale sharks encounter off of Mafia Island may not allow for the depth variance preferred by the tag. A consideration for additional tags will be to discuss with Microwave Telemetry to have a finer scale for constant pressure pop-off, ie. a range of only 2-3m. The data transmission and recovery from the tag was 100% and the data was processed to make the following figures. Figure 5 shows a map with the calculated shark movements for the interval of tag retention. The map clearly shows that for this interval the shark remained in the same relative area. The tag release point is very close to the point of tagging and the averaged movements (dark blue color on the graphic) indicates a strong core area of usage.

Figure 5: Telemetry map of shark movements, Tag 67452 on Jan.18-Feb. 04, 2007

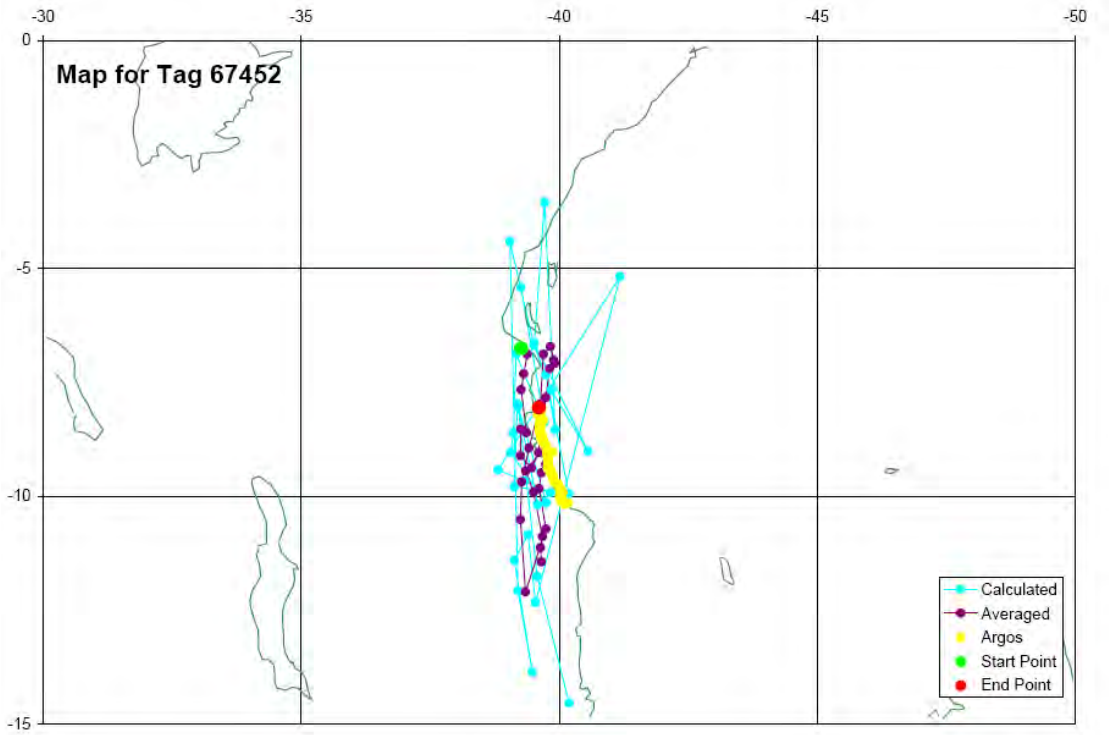


Figure 6 shows the temperature profile data from the tag retention interval. The water temperatures encountered by the whale shark appears to be fairly consistent, staying within a narrow range from 25-30ºC. This supports the tracking data, as a consistent range of water temperatures would be expected in a shark that remains in the same area and presumably the same water mass

Figure 6 – Temperature profile from tag 67452 on Jan.18-Feb.04, 2007 (yellow)

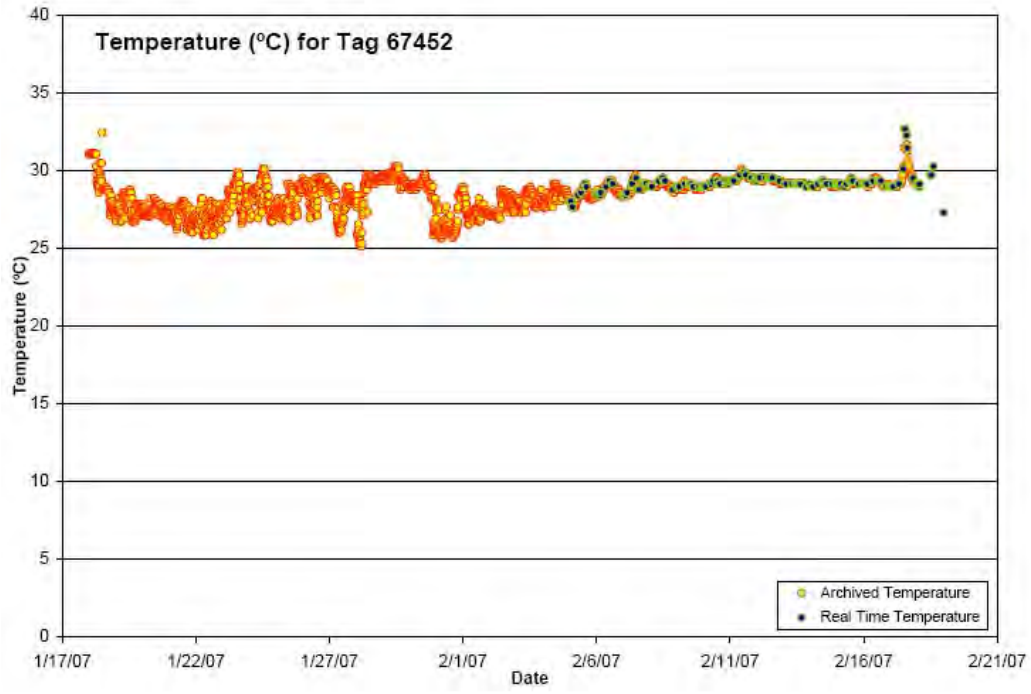


Figure 7 shows a plot of the depth measurements recorded by the tag and gives insight into the vertical swimming behaviors of the whale shark. The graph shows a distinct affinity of this particular individual to the upper levels of the water column, with the majority of the measurements coming from the surface (0m) to 10 m in depth. The plot also shows fairly regular diving behavior, with periodic data points over 20m in depth and a maximum dive to over 40m. This data will have to be looked at more in depth to determine specific nuances or patterns in the dive behavior.

Figure 7 – Depth plot for tag 67452 on Jan.18-Feb.04, 2007

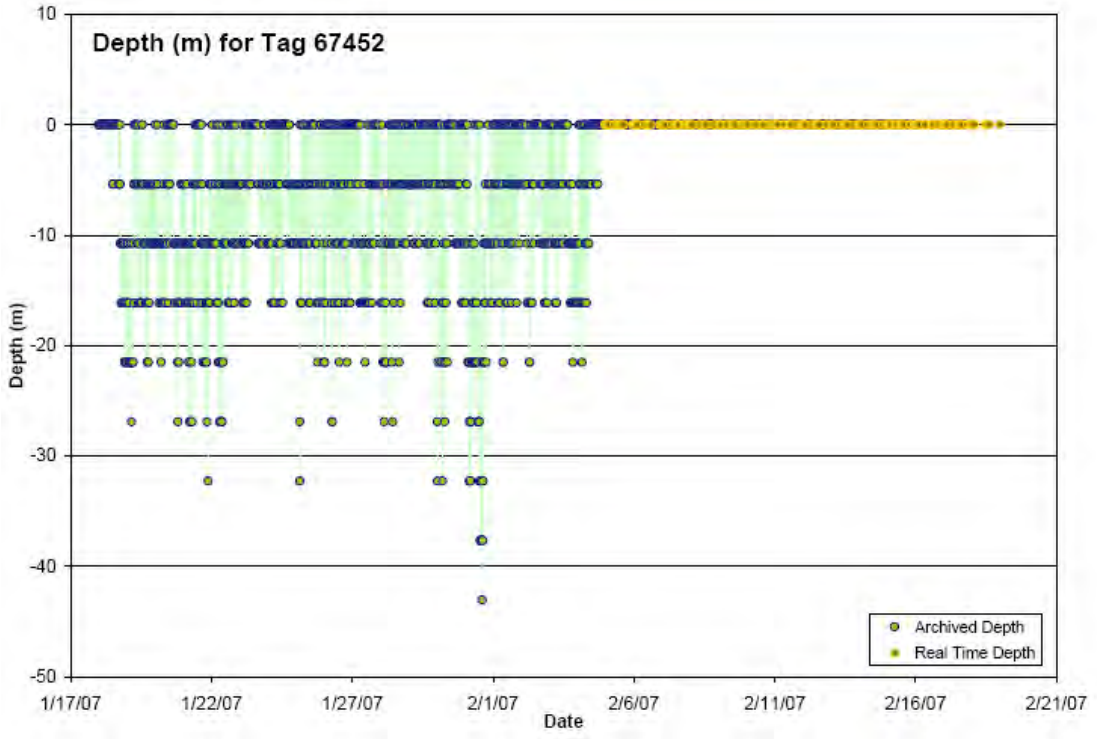
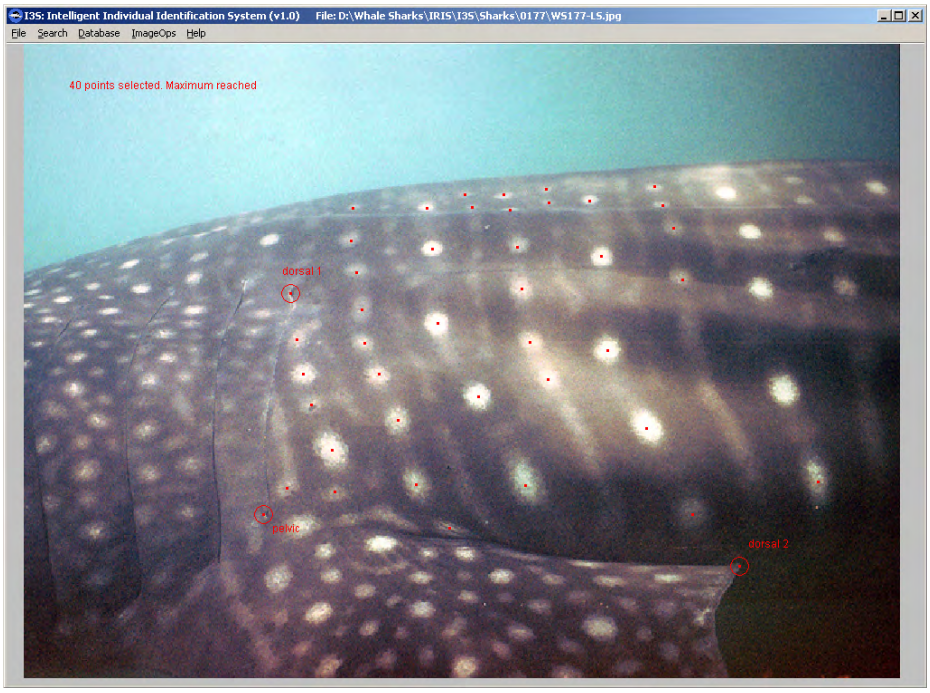


Photo-Identification Database

The author took over 500 images of whale sharks during the course of the research in Tanzania. The images of the whale sharks were taken via a Canon 20D digital SLR Camera utilizing a Canon 10-22mm lens. The camera and lens were put in an Aquatica A20 housing with 8 inch acrylic dome port. All images were taken using ambient light and shot in the RAW format, for maximum image quality and ability to extract contrast. The images are currently being edited from their original RAW format to jpegs for processing in a photo-identification database. Once converted to jpegs, the photos must be cropped, straightened, and the contrast boosted. The image is then "mapped". In order to accomplish this you have to set static or comparable anchor points in all the photos, to provided scale and spatial reference to a two dimensional matrix. For whale sharks, the area that is mapped is directly behind the gill slits. The last gill slit is used as the first two points – as the top and bottom edges serve as anchors. Lastly, the trailing margin of the pectoral fin serves as a third anchor point. Once the anchors are in place the spots are marked out in a distinctive "map" (see figure 8). At this point, spot maps can be compared via algorithms that look for overlap. You will get the most probable matches from a database with a ranked score for fit. The operator will always have to visually recheck the matches, but the software packages have a high accuracy rate. The algorithms for this software

were originally developed for star-recognition and were applied to the spot patterns of whale sharks (see Arzoumanian et al 2005).

Figure 8 – Spot pattern map in I3S software (from Pierce 2007)



Conclusions

The tagging efforts were very successful when conditions were favorable. The whale sharks in this area were easy to work with and the methodologies employed gathered the data as desired. The sub-optimal conditions that were caused by the weather during the middle period of the study were indicated to be an anomaly. All results point to continued application and resultant success for year 2 of the project. Additional data analysis will be necessary for two facets of this project. More data will be input as the PAT tags pop-off and transmit their archived data. The data will need to be compared between all individuals and any patterns discerned. Reassessment of tag programming parameters may be looked at and adjustments for subsequent tags made (such as a finer scale constant depth pop-off mechanism or similar revisions). Additional, fine-scale movements may be looked at via acoustic telemetry in the area to determine diurnal activity patterns around Mafia. The photo-identification database will continually grow as all images can be digitally processed, formatted for the libraries, subjected to spot-mapping and algorithm conversion, and submitted for addition to the overall database. The author will be using both I3S software and working with the Ecocean online photo-ID library so that the whale sharks from Tanzania can be compared to sharks across the entire Indian Ocean basin.

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Appendix – Tagging Data Summary

ID TAG #	SAT TAG	SEX	SIZE	Date Tagged
0149	SAT-8	M	6.5m	12-Dec-06
0159		M	5m	13-Dec-06
0174		F	6.5m	13-Dec-06
0194		F	4.5m	12-Dec-06
0195		M	5m	13-Dec-06
0598	SAT-8	M	7m	12-Dec-06
0650		F	4.5m	4-Jan-07
0651		M	6m	14-Dec-06
0655		**Und**	5m	14-Dec-06
0657		M	5.5m	4-Jan-07
0659		M	5m	13-Dec-06
0660		F	6m	13-Dec-06
0661	SAT-2	M	5m	12-Dec-06
0669		M	6.5m	18-Jan-07
0800		M	5m	18-Jan-07
0801	SAT-8	F	5m	23-Jan-07
0809	SAT-8	M	6m	4-Feb-07
0811		M	5m	4-Feb-07
0840		M	5.5m	12-Mar-07
0841	SAT-12	M	7m	12-Mar-07
0842	SAT-12	F	6m	12-Mar-07
0843		M	6m	11-Mar-07
0846	SAT-12	M	5.5	13-Mar-07
0847		M	6m	11-Mar-07
0848		M	4.5m	12-Mar-07