Whale sharks (*Rhincodon typus*) at Ningaloo Reef, Western Australia: Pop-up archival tag deployments (3-9 May 2004)*

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* The intent of this report is to briefly inform the institutions and agencies that supported the research of our activities in 2004, and the Western Australia Department of Conservation and Management as required by Permit No. SF004543.

We initiated this study in May 2003 to document the movements and behavior of whale sharks that aggregate seasonally at Ningaloo Reef, Western Australia (Stewart *et al.* 2003). It is a collaborative effort involving Dr. Steven G. Wilson (University of New Hampshire), Dr. Brent S. Stewart (Hubbs-SeaWorld Research Institute), Dr. Jeffrey J. Polovina (U.S. NOAA Fisheries) and Dr. Mark G. Meekan (Australian Institute of Marine Science). In May 2003, we attached pop-up archival tags (PAT tags) to four whale sharks at Ningaloo Reef using several different anchor designs and implantation techniques (Stewart *et al.* 2003). Our results included three-short term records (several days to three weeks) and one longer-term record (6+ months) showing geographic movements, dive patterns, and oceanographic data (water temperature) (see Appendix I).

We attached another 15 PAT tags to whale sharks at Ningaloo Reef between 3 and 9 May in 2004 (Table 1). The sharks were located with the assistance of a dedicated spotter plane. Once a shark was spotted, the aircraft directed a shore-based charter vessel (*Hook Up*) to position divers ahead of the approaching shark for tag deployment. Flat titanium sub-dermal anchors (Wildlife Computers Inc.) were attached to the PAT tags with short tethers (ca 15-20 cm) made of either nylon monofilament (n=7) or stainless steel leader (n=8). After the first seven tag deployments, we switched from using monofilament tethers to using stainless steel tethers because it appeared that the titanium anchor might cut the monofilament tether during implantation (i.e. on two occasions the monofilament was severed and the tags recovered and subsequently redeployed). We implanted (ca 10-12 cm deep) the anchors in the sub-dermal adipose tissue using a

Table 1. Summary of PAT tags deployed at Ningaloo Reef, Western Australia (3-9 May 2004).

Shark #	Tag #	Tag date	Tag time	Sex	TL (m)	Height of 1st dorsal (cm)	Latitude	Longitude	SST (°C)	Pop-up date (months)	Tether[1]
1[2]	61	3 May	1042	M	4.5	-	22°38.2'	113°36.7'	27.5	6	Mono
2[3]	66	3 May	1250	F	8.5	-	22°40.1'	113°37.3'	27.5	6	Mono
3[4]	62	3 May	1330	F	7.5	50	22°38.2'	113°36.7'	27.5	9	Mono
4	70	4 May	1020	F	4.7	45	22°38.2'	113°38.7'	27.5	6	Mono
5[5]	72	4 May	1047	F	4.5	-	22°30.0'	113°40.3'	27.5	9	Mono
6[5]	63	4 May	1058	F	11	100	22°30.0'	113°40.3'	-	9	Mono
7	65	4 May	1230	F	7.3	-	22°37.6'	113°36.3'	-	6	Mono
8[6]	67	5 May	1109	-	4.7	38	22°37.5'	113°41.8'	-	9	Wire
9	71	5 May	1352	F	7.6	-	22°38.7'	113°38.5'	28.3	6	Wire
10	68	7 May	1329	F	5.6	53	22°31.8'	113°38.9'	-	6	Wire
11[7]	69	7 May	1450	F	7.6	49	22°41.7'	113°38.2'	-	6	Wire
12	74	8 May	1247	F	6.2	60	22°29.7'	113°39.5'	-	4	Wire
13	73	8 May	1315	M	7	60	22°25.9'	113°47.7'	-	2	Wire
14	60	8 May	1335	F	7	-	22°24.7'	113°43.1'	-	6	Wire
15	64	9 May	1045	F	5.3	42	22°40.5'	113°37.6'	-	9	Wire

[1] Mono = monofilament line; Wire = nylon coated braided wire.
[2] Attachment pin failed. Tag detached on the same day it was deployed and found floating in Ningaloo Reef lagoon the following day.
[3] Tag detached on the same day it was deployed for an unknown reason. This may be the same shark that a long-term archival record was obtained from in 2003.
[4] Anchor was shallow. Tag detached 3 days after deployment.
[5] These two individuals were swimming in close proximity to one another for approximately 1 hour prior to being tagged. The smaller shark (TL=4.5 m) was approximately 10-20m ahead of the larger one (TL=11 m) when it was tagged (but both females?).
[6] Anchor went all the way through dorsal fin.
[7] Tag detached 3 days after deployment for an unknown reason.

hand-held pole-spear (i.e., Hawaiian-sling or gidgy). We were able to implant the anchors deeply for all but one tag. They were inserted on the dorsal surface just distal to where the first dorsal fin meets the body (Fig. 1) to reduce the chance of dislodging when when sharks rub against the sea-floor. We did not encounter any problems during the deployments.

Figure 1. Photograph showing a PAT tag attached to shark #10 (taken on day of deployment). Note photograph of the same tag approximately 1 month later in Figure 2.

The deployed tags will record ambient light, depth and seawater temperature measurements continuously for periods ranging from two to nine months. An electronic circuit will then activate, causing the tag to detach from the animal and float to the surface and begin transmitting all archive data to several earth-orbiting satellites of the Argos Data Collection and Location Service. Migratory routes will be determined by daily geographic locations of the sharks from archived daily ambient light profiles to estimate latitude and longitude from algorithm determinations of sunrise, sunset and local apparent noon. Depth and temperature data will be used to construct vertical thermal structure profiles and sea-surface temperature patterns for comparisons with remotely sensed data along migratory routes to correlate shark habitat use with physical and

biological characteristics of habitats of varying biological productivity.

By 15 June 2004, four tags had detached prematurely and were transmitting archived data (Table 1). We recovered one of those tags on 4 May 2004. The pin where the tether attaches was severed. Inadequate anchor insertion may account for the premature detachment of another tag, though we have not been able to determine the cause of detachment of the other two. We are very encouraged that 11 of the 15 tags (73%) are still attached. Several of the sharks have been seen again since early May by the tourism industry (based in Exmouth and Coral Bay), allowing us to judge the integrity of the attachment and the state of healing around the small insertion wound (Figure 2). The nominal timing for release of the tags is expected to be between 8 July 2004 (a high resolution data record) and 9 February 2005 (lower resolution data record).

Figure 2. Photograph showing a PAT tag attached to shark #10 approximately 1 month after deployment (Photo courtesy of Alli Richards).

Some members of the tagging team at Ningaloo Station in May 2004 (L-R: Jeffrey Polovina, Steven Wilson, Cary McClean and Mark Meekan).

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Appendix I

Tag 39796 was attached to a 6-8 m whale shark (unknown sex) on May 5, 2003. The tag reported on November 12, 2003 at a location approximately 300 km NW of Rowley Shoals.

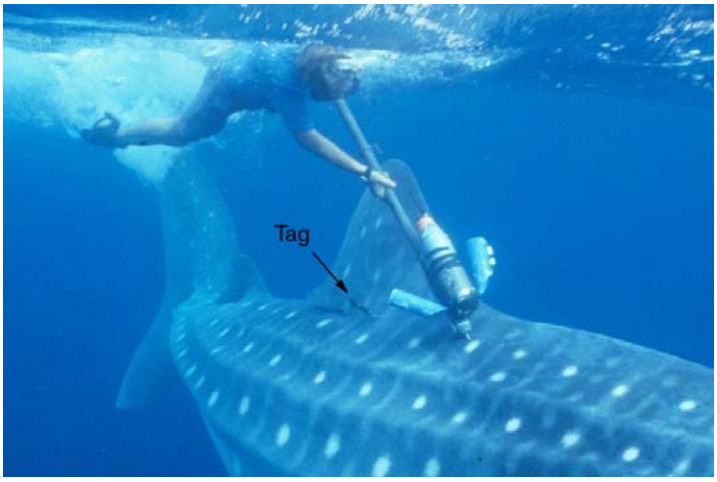

Figure A-1. Photograph showing deployment of the Crittercam system – tag 39796 is visible at the point where the first dorsal fin meets the body.

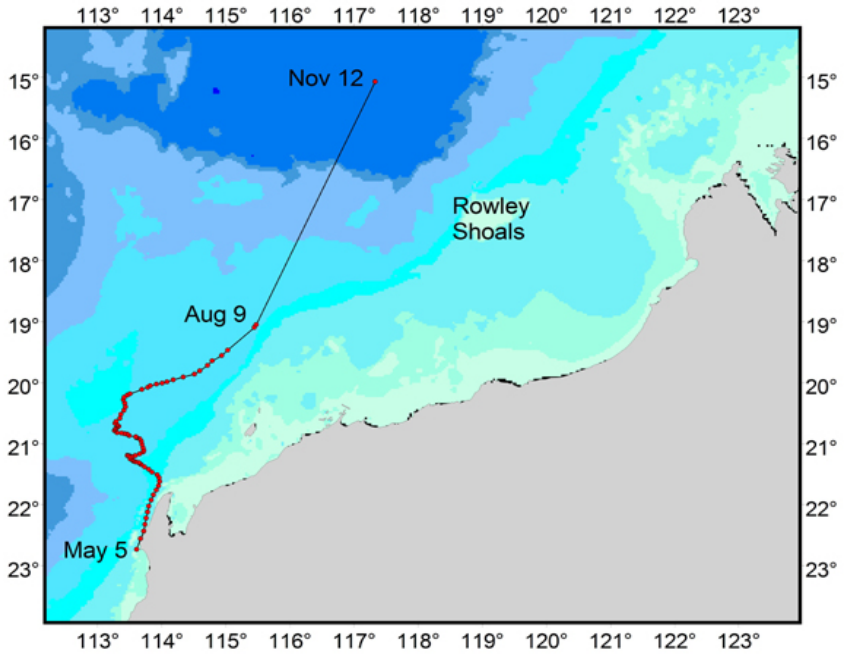

Figure A-2. Kalman filtered trackline of the horizontal movements of tag 39796. Note that no geolocation estimates were calculated between 10 August 2003 and reporting date (likely related to equinox and change in vertical behavior associated with offshore movement).

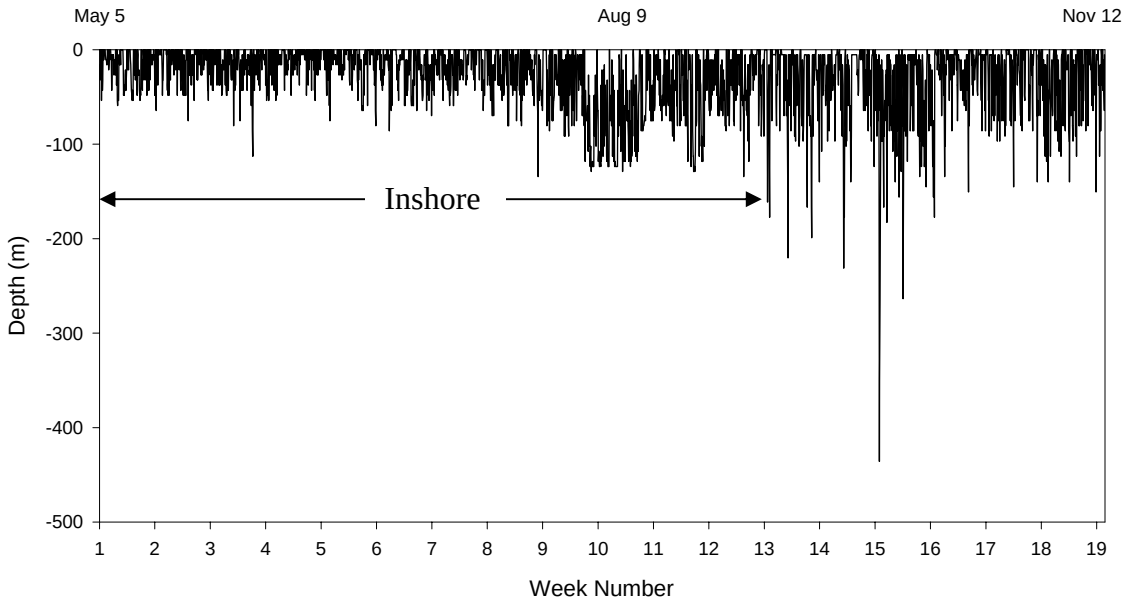

Figure A-3. Depth record for tag 39796. Maximum depth recorded was 435 m.

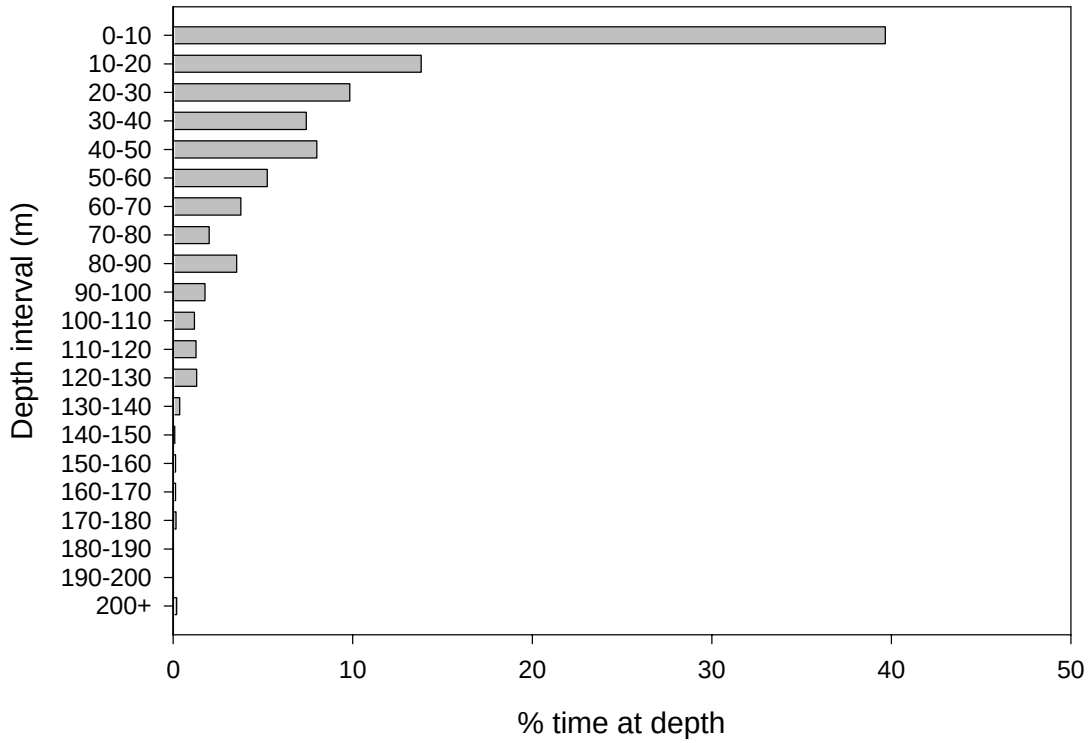

Figure A-4. Histogram showing percent time at depth.

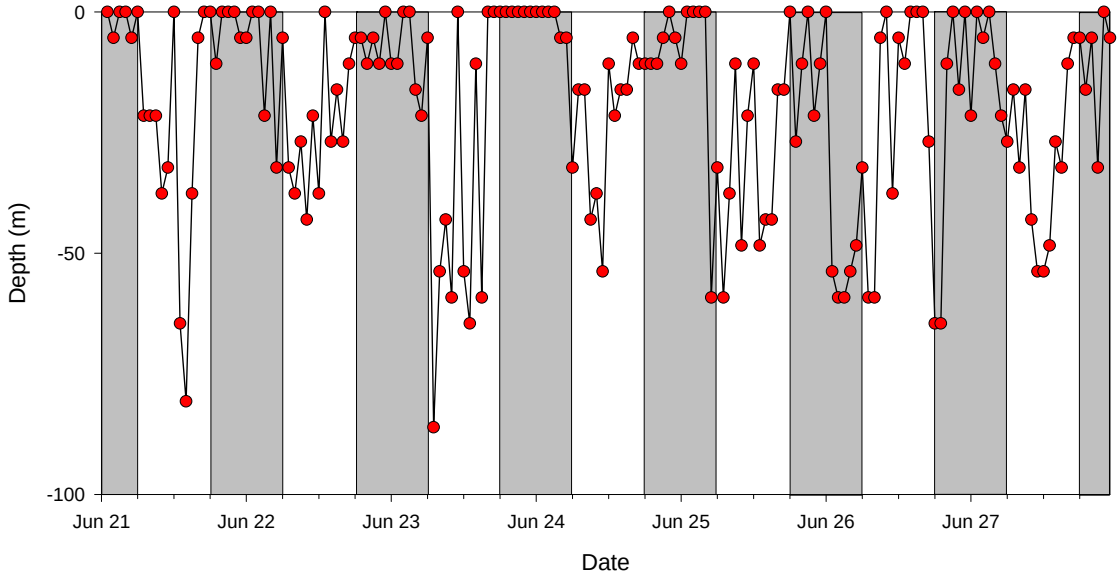

Figure A-5. Depth record for 1-week period when in inshore waters (bathymetrically constrained). Note shallower night-time depth distribution (shaded areas indicate night).

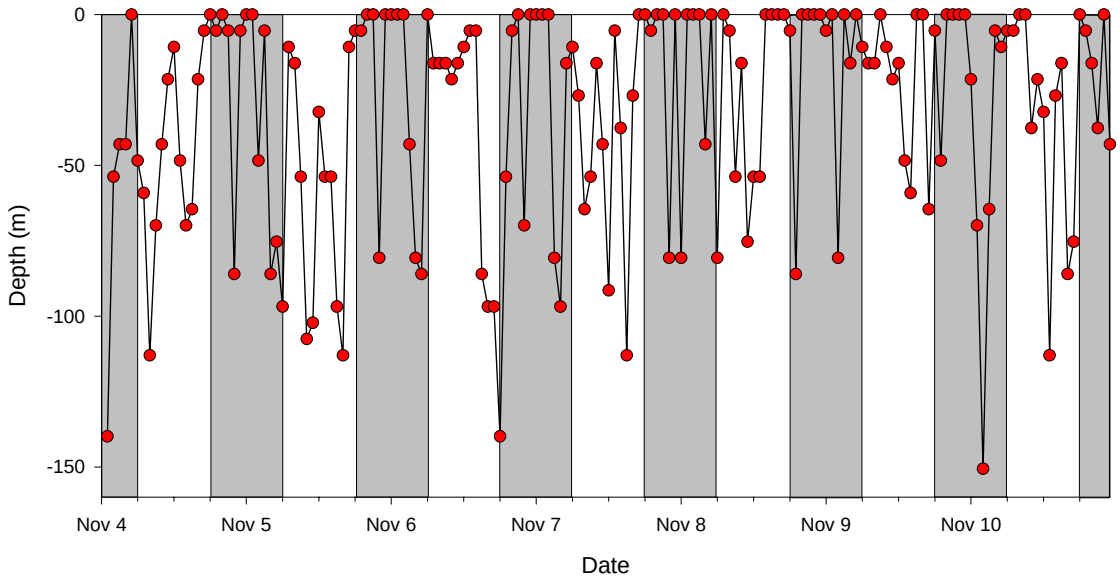

Figure A-6. Depth record for 1-week period when the shark was in offshore waters. Note the shallower night-time (shaded) depth distribution.

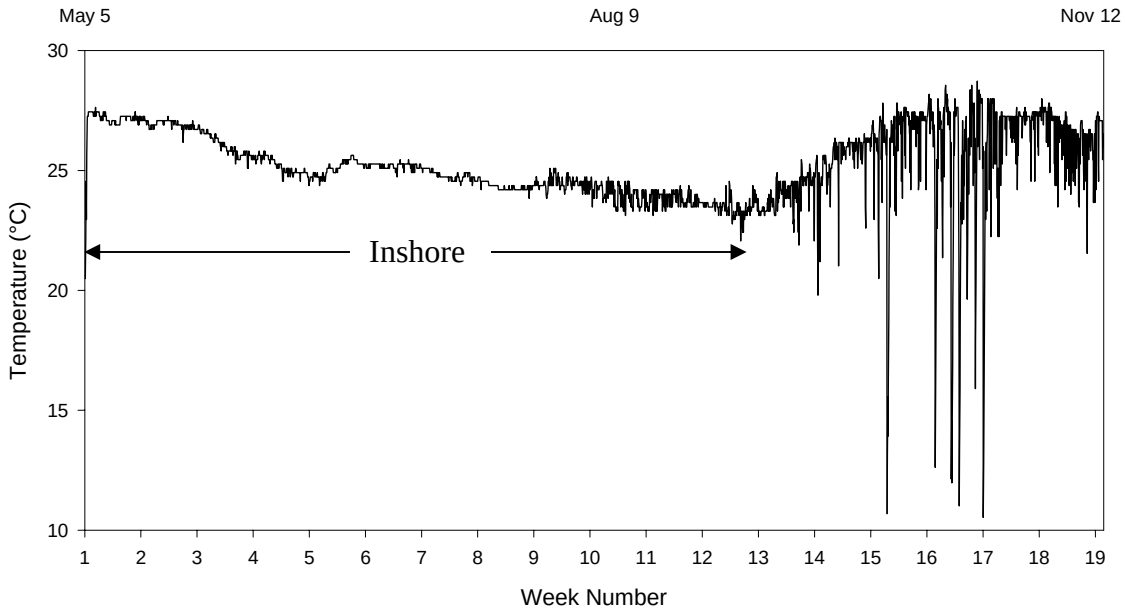

Figure A-7. Temperature record for tag 39796. Temperatures experienced ranged from 10.5-28.7 °C.

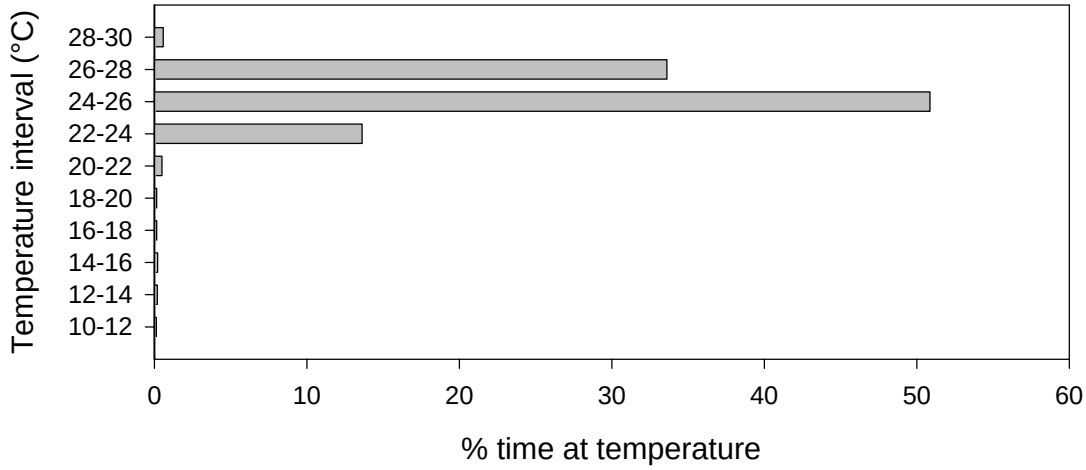

Figure A-8. Histogram showing percent time at temperature.