IMOS Integrated Marine Observing System

IMOS is an initiative of the Australian Government being conducted as part of the National Collaborative Research Infrastructure Strategy

Australian Acoustic Tagging and Monitoring System (AATAMS)

Final Report following the use of AATAMS VR2W receivers

1. Project title

Habitat use and migration patterns of silvertip and grey reef sharks at the Rowley Shoals, Western Australia

2. Authors

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3. Project summary

(as stated in your application form)

There is increasing concern worldwide that populations of sharks are declining and yet we have little more than a very basic understanding of most aspects of their biology including home ranges, stock sizes and migration patterns. This information is essential if management strategies such as Marine Protected Areas (MPAs) are to be implemented at scales appropriate to ensure the survival of sharks in reef systems.

The abundant populations of reefs sharks at the Rowley Shoals, primarily silvertip (*Carcharhinus albimarginatus*) and grey reef sharks (*C. amblyrhynchos*) provide a unique opportunity to gather baseline biological information on habitat use and migration over time that can be used in the design and implementation of MPAs.

Using an array of acoustic listening stations and sonar tags we propose to monitor and describe the spatial and temporal patterns of reef use by 2 common shark species at this locality. We will:

1. deploy acoustic transmitter tags on 20 sharks of each species,

2. track the movement of the sharks across the reef atolls,

3. determine patterns of reef attendance and habitat use, and migration rates among reefs.

4. Project aims

(as stated in your application form)

The abundant populations of reefs sharks at the Rowley Shoals, primarily silvertip (*Carcharhinus albimarginatus*) and grey reef sharks (*C. amblyrhynchos*) provide a unique opportunity to gather baseline biological information on habitat use and migration over time that can be used in the design and implementation of MPAs.

Using acoustic telemetry we propose to:

1. Deploy tracking devices on 20 sharks of each species,

2. to track the movement of the sharks across the reef atolls, and

3. to determine patterns of reef attendance and habitat use, and migration rates among reefs.

5. Level of achievement

(for each aim, provide information on the level of achievement justifying why some aims might have not been reached)

Aim 1. - Deploy tracking devices on 20 sharks of each species

In total, 37 tracking devices were deployed at the Rowley Shoals. The majority (*n*=35) of these units were attached to grey reef sharks. Silvertip sharks were rarely (*n*=2) caught and the project was focused on the movement and habitat use of grey reef sharks.

Aim 2. - Track the movement of the sharks across the reef atolls

Capture-mark-reacapture (CMR) data was collected using tracking devices (Vemco V13 transmitters) and an array of acoustic receiver stations (Vemco VR2w receivers) over 10 months before the receivers were recovered. The receivers were deployed to provide some movement data around individual reefs and between reefs. Twelve of the original fifteen receivers have been retrieved and data downloaded. All 37 sharks were recaptured at least once during the monitoring period by the receivers. From preliminary analysis this data has shown local movement and habitat use patterns and some limited movement of individuals between reefs.

Aim 3. - Determine patterns of reef attendance and habitat use, and migration rates among reefs

This data has yet to be analysed in detail, but will be checked and processed in early to mid-2009 and a manuscript of the results prepared before the end of 2009.

6. Methods

(including the timeline, provide information about your methods used - moorings, deployments, range testing, analysing the data)

In December 2007 researchers on the AIMS R.V. Solander visited the Rowley Shoals, spending five days at each of Clerke, Imperieuse and Mermaid Reefs. Although the original

deployment plan was to deploy the bulk of receiver stations and transmitters at Imperieuse Reef, due to time restrictions and the distribution of shark catches, the receiver deployments were principally split between Imperieuse and Clerke Reefs. At Imperieuse Reef, seven Vemco VR2w receiver stations (VEMCO, Halifax, Nova Scotia, Canada) were deployed and 15 sharks fitted with Vemco V13 transmitters (13 grey reef sharks and 2 silvertip sharks). At Clerke Reefs six receivers were deployed and 16 sharks fitted with transmitters. At both reefs the receivers were moored at various locations within the lagoons and around the reef's outside slope (Appendices 1 and 2). This allows for both within and between reef comparisons of a long-term movement, migration and habitat use data. We also deployed two receiver stations and tagged six sharks at Mermaid Reef.

To determine changes in the range of the receivers a number of sentinel transmitters were also deployed. These transmitters were placed at known distances from the receivers and will continue to transmit over the course of the deployment.

Receiver and sentinel transmitter deployments

Before deployment, the receivers were wrapped in woven duct tape and painted in two coats of anti-fouling paint.

All receivers were deployed by divers in water depths between 10 and 17 m. The receivers were moored to the reef using two star pickets, cable ties and stainless steel wire (Figure 1). For each unit 2.4 m star pickets were used. One star picket was driven in vertically and then the second was driven in at an angle to provide a brace support. Where possible each star picket was driven in to approximately 1 m. When it was not possible to drive the star pickets in to the preferred depth, then additional support was provided by binding the star pickets to a coral outcrop using cable ties (12 mm in width). The receivers were then mounted on the vertical star picket with three 12 mm cable ties, a metre long stainless steel trace to the base of the star picket and stainless steel wire directly to the star picket. The receiver head was place at least 1 m above the substrate.

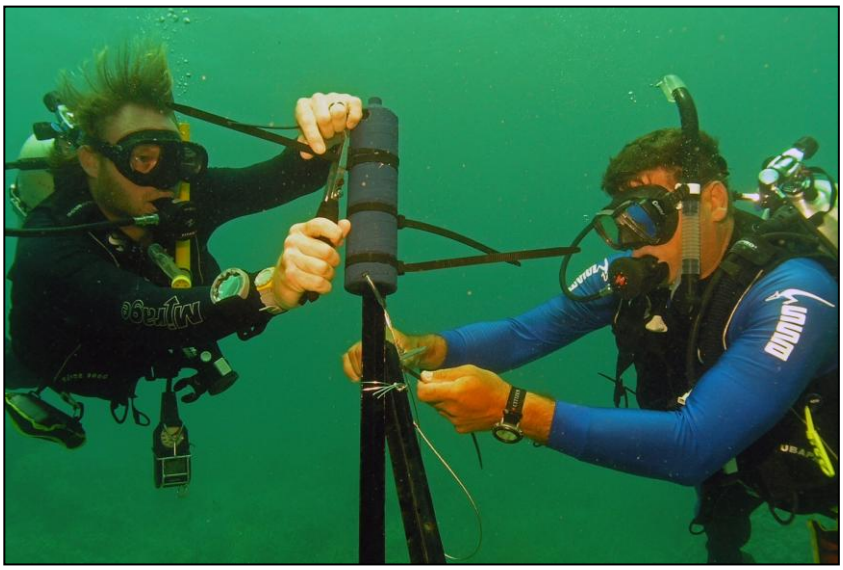

Figure 1. The attachment of the VR2w receiver station to the star picket mooring.

For each receiver, after deployment, we tested range of the reception by placing three v13 transmitters over the side of a zodiac on a piece of rope at a depth of approximately 5 m and drifting over the site of each receiver station. Each drift was from approximately 400 m either side of the receiver location.

Each sentinel transmitter was deployed using a similar technique as for the receivers but using a single star picket. The transmitters were placed in a moulded mount of marine epoxy putty that fitted against the angled side of the star pickets and was held in place using two cable ties.

At three sites sentinel tags were placed at 100 m from a receiver and at two of these sites an additional sentinel tag was placed 300 m away.

Shark capture and transmitter deployments

We equipped 37 sharks with Vemco v13 transmitters (VEMCO, Halifax, Nova Scotia, Canada). 35 transmitters were attached to grey reef sharks and two on silvertip sharks. All of the sharks, except one, were large enough to support a fin mounted transmitter on a dorsal fin tag. The smallest individual (less than 1 m in total length), whose dorsal fin was not strong enough to support a tag mounted transmitter, had a transmitter surgically implanted in to the inter-peritoneal cavity.

Sharks were caught using handlines with baited barbless hooks for tagging. Hooks were set either on the bottom, in mid-water or at the surface depending on the tides and depth sounder images of the individual location. Once hooked the sharks were brought to the surface. The sharks were then brought alongside the research vessel and a tail rope attached.

For external attachment, due to the working deck height of the research vessel, the sharks were then manoeuvred alongside an inflatable rubber boat moored alongside the RV Solander and into the canvas stretcher that restrained and supported sharks without removing them from the water. This gave access to the sharks for measurement, determination of sex and attachment of the tag mounted transmitter to the dorsal fin.

Each v13 transmitters was mounted (glued and cable tied) on a jumbo rototag (Fig 3) that was then pinned to the dorsal fin, using a pre-cut hole made by a hole punch.

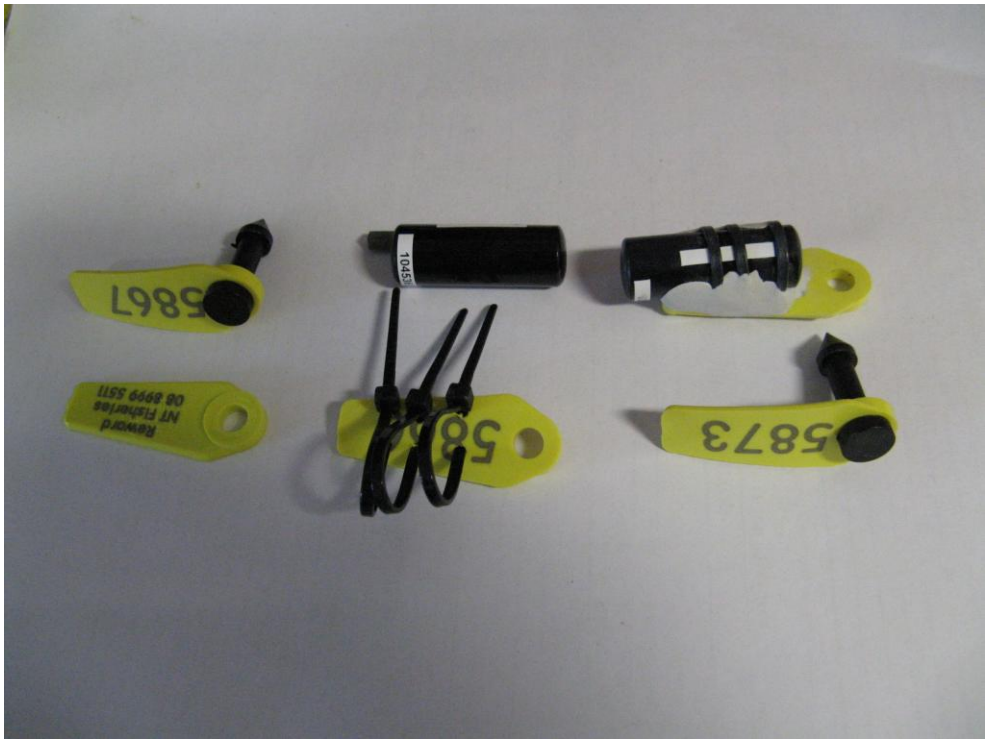

Figure 3. (from left to right) The base male (top) and female (bottom) rototag, a Vemco v13 transmitter and female tag below with cable ties to clamp the transmitter to the tag, and the transmitter mounted on the female tag with male tag beneath.

For implantation of the transmitter, the small shark was placed upside down in a custom cradle that allowed fresh seawater to flow into the shark's mouth and around the shark while the tag was inserted. The shark was held gently during the operation to prevent any movement. A small incision (~25 mm) was made in sharks abdomen just forward of the anus. The transmitter, coated in beeswax, was then inserted into the body cavity and the incision was then sutured closed.

While the sharks were held a small tissue biopsy was collected for a genetic sample and later analyses. Before release all sharks were allowed to recover from the handling by holding them in open water, with water flowing over their gills until they actively showed signs of swimming and were then released. No sharks were killed or harvested during the study.

Proposed downloads and receiver retrieval

Mid –year downloads and retrievals were planned for May-September 2008 by the joint Western Australian Government patrols by the Department of Conservation (DEC) or WA Fisheries. These patrols were unable to retrieve any of the receivers due to weather and logistical limitations. The receivers were retrieved by one local tour charter operators, True North' in September-October 2008 and by an AIMS cruise in October. One of the retrievers was missing in actions with the mooring still in good condition but no evidence of the receiver and two units remain on Imperieuse Reef that have been inaccessible for retrieval to date. Further attempts will be made to retrieve the receivers next year by tour operators and WA DEC.

Analysis

Each receiver's data was downloaded using the Vemco VUE software. This data was then exported to a Mircosoft Access database. Preliminary analysis and visualisation of the data has been done using R (R Core Package) and Eon Fusion Software (Myriax Pty, Hobart, Australia). Detailed analysis of the data will use time series analyses and quantify habitat use using the 'temptrak' package in R. These analyses will be completed in 2009.

7. Results

Preliminary analyses of the data collected has been summarized below, however detailed analyses will not be completed until mid to late 2009.

In December 2007, 37 reefs shark were tagged, which included 35 grey reefs sharks and 2 silvertip sharks. Of these sharks 30 grey reef sharks and one silvertip shark were detected by the receivers over the 11 month study period at each of the reefs (Table 1).

Table 1. The number of sharks tagged and released at each reef and detected during the course of the study.

	Grey reef sharks		Silvertip sharks		
Reef	Tagged	Detected	Tagged	Detected	Total
Imperieuse	13	11	2	1	15
Clerke	16	15			16
Mermaid	6	4			6
Grand Total	35	30	2	1	37

The mean total length of grey reef sharks in this study was 134 cm (range 79-169cm). The two silvertips sharks were 97 cm and 121 cm in length. The total length distribtions for grey ref sharks at each of the reefs can be seen below (Fig 4)

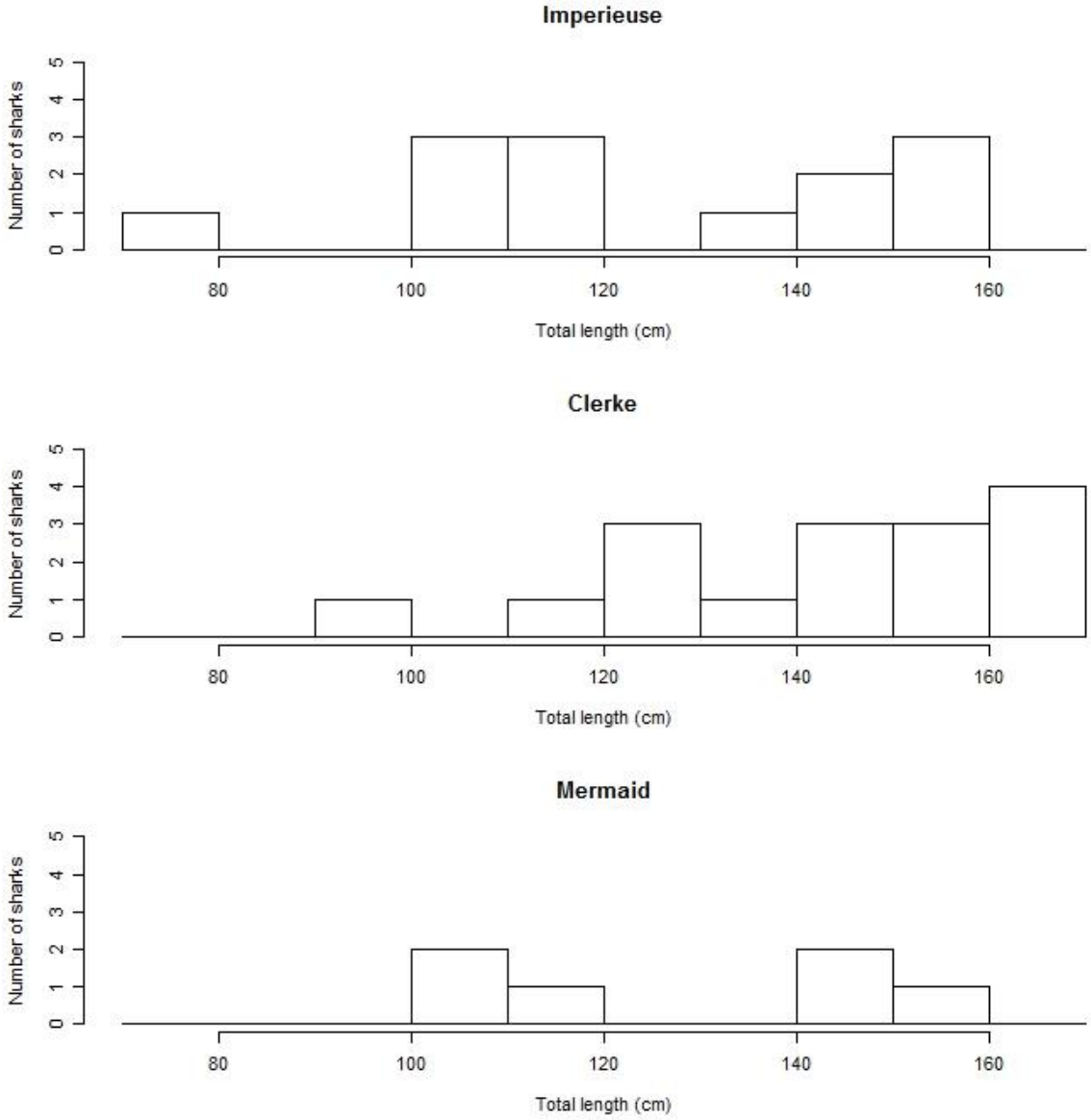

Figure 4. The total length distributions of grey reef sharks that had transmitters attached at Imperieuse, Clerke and Mermaid reefs, in December 2007.

The length of time over which the sharks were detected varied for each shark (Fig 5). The median number of days that a shark remained within the receiver array was 222 days and ranged from 51 to 323 days (323 days was the total length of the study). For grey reef sharks, this was found to be related to the size of the individuals using a general linear model, with larger individuals have longer residence times (one-way ANOVA $F_{2,28}$=6.1, p=0.019) and no sex effect.

Most grey reef sharks, around were two thirds, were only detected on the outside of the reefs. Overall, the proportion of the total number of days each shark was detected, the sharks spent 4 % of their time inside the reef and 97 % outside.

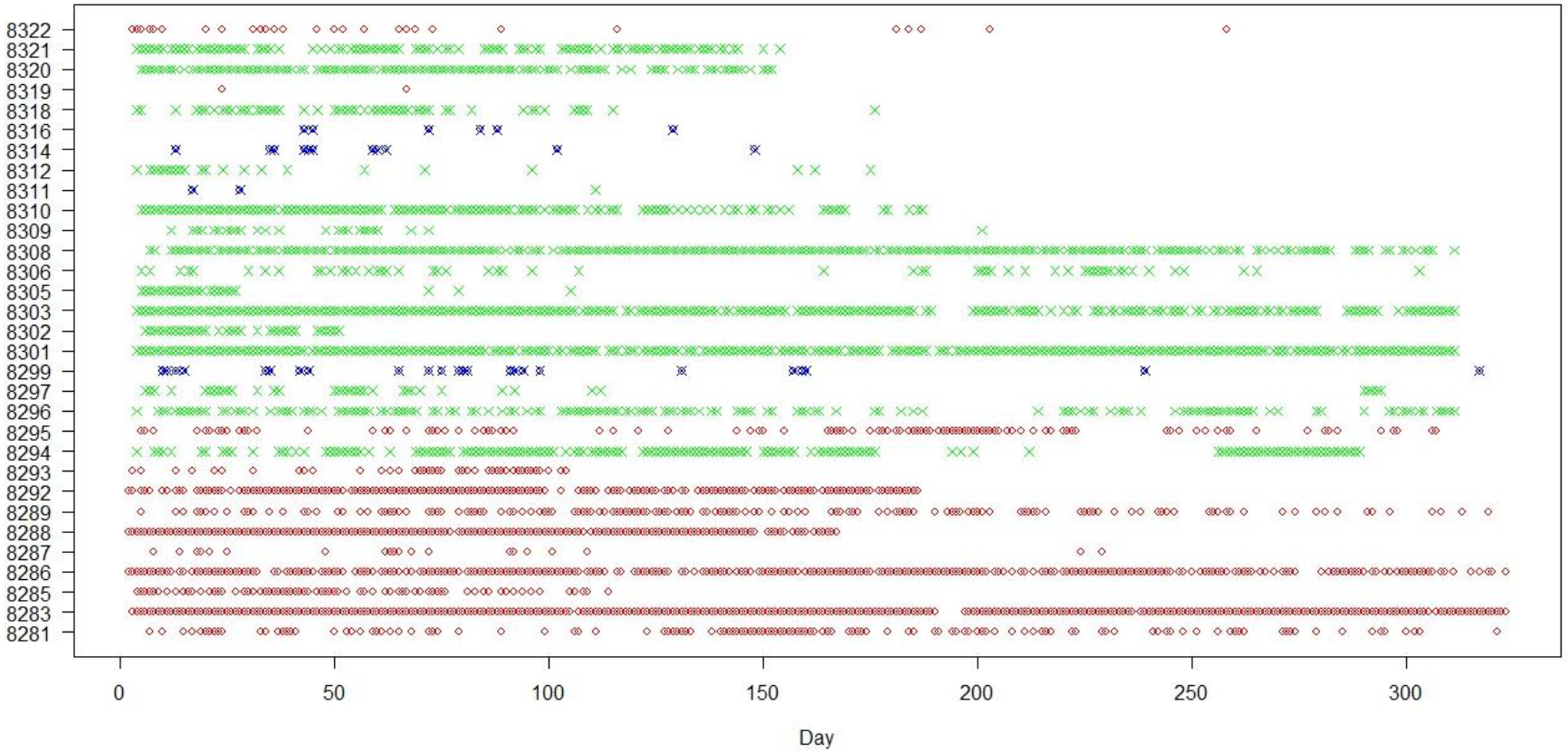

Figure 5. The daily detection of each tagged shark over the duration of the study from 6th December 2007 onwards. The individual shark ID is shown on the y-axis, with 8319 being the only silvertip shark that was detected. The colour of the symbols indicates the reefs at which the sharks were recorded by a receiver (red=Imperieuse, green=Clerke, blue=Mermaid).

The relative amount of are used by grey reef sharks, determine by the maximum number of receiver stations visited any day, range from 2 to 4 receiver stations. Nine sharks were detected inside and outside the reef in one day indicating that some of the sharks are at least moving using in and outside the reef. However this behaviour was limited and only two sharks displayed this behaviour for over 10 days in total.

Migration between the refs was also extremely rare, with only one Grey reef shark moving from Mermaid Reef to Clerke Reef, where it was only detected once. Therefore we urge some caution over this possible migration between reefs.

The single silvertip shark was only detected at a receiver station on the outside of the reef.

Detailed temporal and fine scale analyses will be completed later in 2009.

8. Discussion

Our preliminary results indicate that there is little movement of grey reef sharks between the reefs of the Rowley Shoals. The grey reefs sharks that were deployed with transmitters showed that most sharks used the outside areas of the reefs with some movement between receiver stations. The inside areas of the reefs were visited occasionally by these sharks. Most sharks used a limited area of the reefs only being detected at a maximum of 2 receiver stations during any day.

These preliminary findings have provided new insights into the movement patters and habitat use of a common reef shark species. Further analyses, result and discussion will be presented later in 2009.

9. Outputs

(conference presentation, public talks, scientific papers, media coverage, etc)

After the deployment cruise the project was feathers on the Western Australian ABC news and Stateline programs. The project has also generated six lay publications to date, including two articles in the Ocean Geographic magazine, and one article in each of the following publications; the Australian Society for Fish Biology magazine, the Australian Marine Science Association Bulletin, the WAVES newsletter and AIMS Waypoint newsletter.

One scientific publication is in preparation from this study and should be completed toward the end of 2009. The results of this study will also be presented at either the higher order predator symposium at the 2009 annual AMSA conference in Adelaide or the 2009 OCS conference in Perth.

10. Acknowledgements

We wish to thank the crew of the AIMS RV Solander, and other expeditioners to the Rowley Shoals in December 2007. We also wish to thank True North Expeditions and J. Gilmour for assisting in the recovery of the VR2 receviers. The project was approved by the Charles Darwin University Animal Ethics Committee and funding was provided by Grants from Western Australian Department of the Environement and Conservation and the Natural Heritage Trust.

Appendix 1 - Deployment summary

Unit ID	unit type	reef	loc	Date	Latitude	Longitude	Depth
101803	VR2w	Imperieuse	I5(mid out)	2/12/2007	17 32.912	118 58.468	15
101802	VR2w	Imperieuse	I3(chan)	3/12/2007	17 32.051	118 58.392	14
101804	VR2w	Imperieuse	I2(nne)	3/12/2007	17 29.997	118 57.669	14
101807	VR2w	Imperieuse	I1(nw)	3/12/2007	17 30.010	118 56.529	14
101899	VR2w	Imperieuse	I4(chan in)	3/12/2007	17 32.168	118 57.843	11
101806	VR2w	Imperieuse	I6(mid in)	4/12/2007	17 33.949	118 57.856	12
101906	VR2w	Imperieuse	I7(s in)	4/12/2007	17 36.046	118 58.054	10
101903	VR2w	Clerke	C2	8/12/2007	17 16.263	119 22.448	16
101905	VR2w	Clerke	C3	8/12/2007	17 16.626	119 22.579	14
101900	VR2w	Clerke	C1	9/12/2007	17 14.737	119 21.069	14
101902	VR2w	Clerke	C4	9/12/2007	17 16.659	119 21.994	12
101907	VR2w	Clerke	C6	9/12/2007	17 17.613	119 21.771	13
101904	VR2w	Clerke	C5	10/12/2007	17 17.653	119 22.724	15
101805	VR2w	Mermaid	M2	12/12/2007	17 03.615	119 38.857	14
101901	VR2w	Mermaid	M1	12/12/2007	17 01.646	119 37.042	13

Appendix 2. - Rowley Shoals deployment maps

Figure A1. The location of acoustic receiver stations and shark tagging locations at Imperieuse Reef, Rowley Shoals, Western Australia

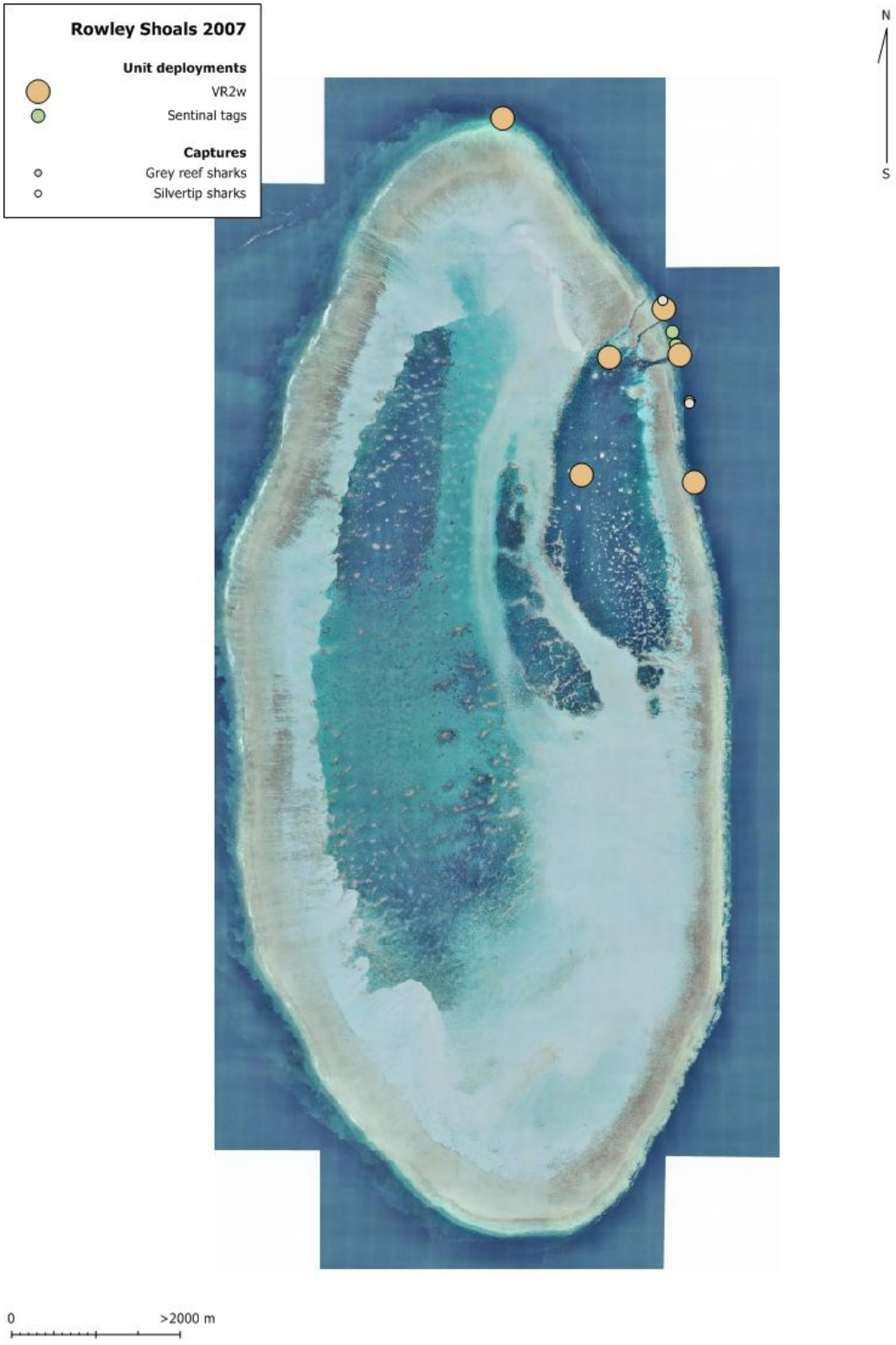

Figure A2. The location of acoustic receiver stations and shark tagging locations at Clerke Reef, Rowley Shoals, Western Australia

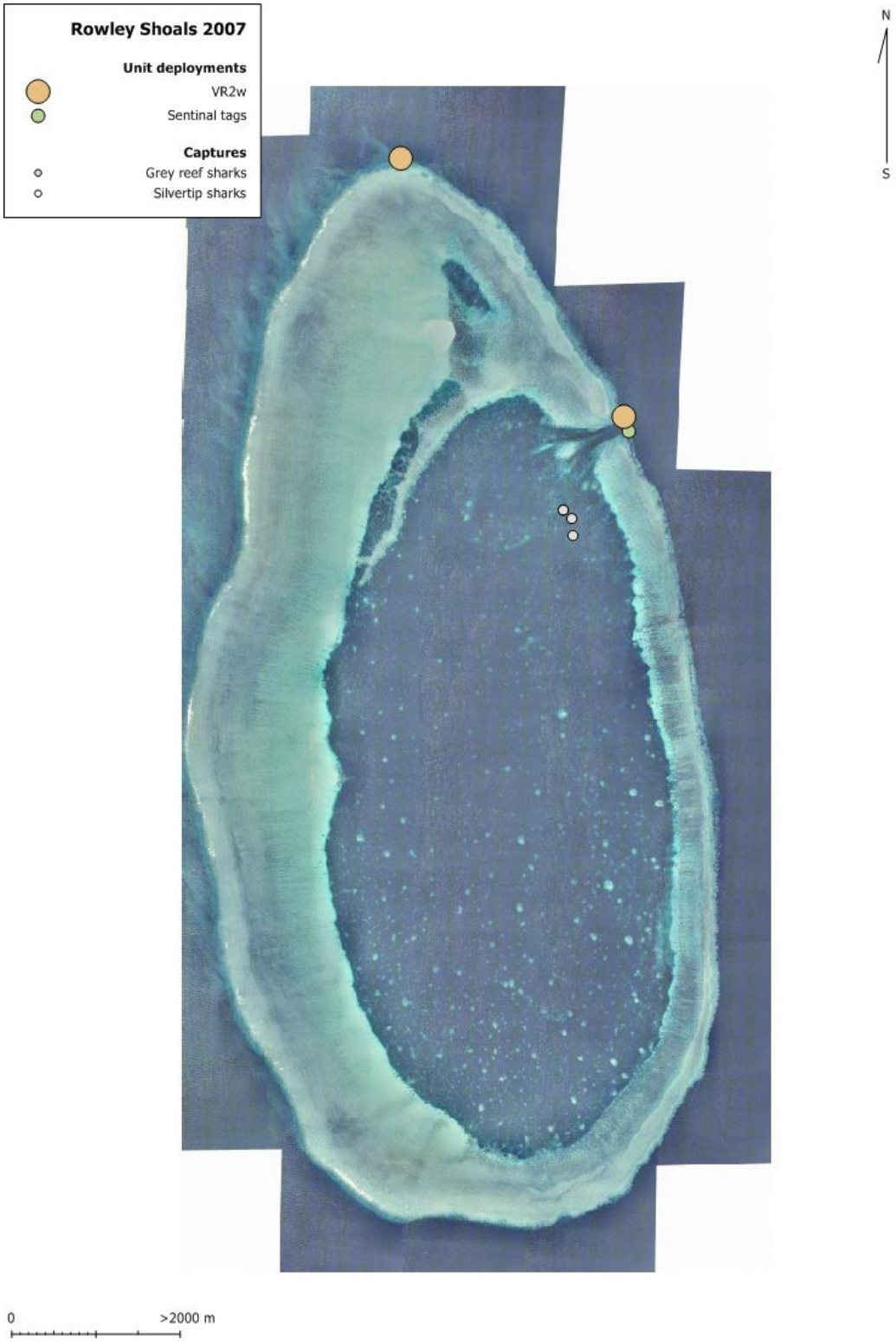

Figure A3. The location of acoustic receiver stations and shark tagging locations at Mermaid Reef, Rowley Shoals, Western Australia