NORTHERN AUSTRALIAN SHARKS & RAYS:

Determining feasibility of acoustic tag attachment and documenting short-term movements in *Pristis zijsron* Bleeker, 1851.

Compiled by: Stirling Peverell (QLD DPI & F)

&

Richard Pillans (CSIRO Marine Research)

First Published 2004

Disclaimer

Information contained in this publication is provided as general advice only. For application to specific circumstances, professional advice should be sought.

The Department of Primary Industries have taken all reasonable steps to ensure the information contained in this publication is accurate at the time of the survey. Readers should ensure that they make appropriate enquires to determine whether new information is available on the particular subject matter.

The correct citation of this document is

Stirling Peverell and Richard Pillans. (2004). Determining feasibility of acoustic tag attachment and documenting short-term movements in Pristis zijsron Bleeker, 1851. – Report for the National Oceans Office

Coordinated by the Marine Fisheries Group, QDPI,

Northern Fisheries Centre, Cairns, 2004.

Enquires should be directed to:

Stirling Peverell	or	**Richard Pillans**
Northern Fisheries Centre,		CSIRO Cleveland
PO Box 5396 CAIRNS		PO Box 12 BRISBANE

Cover photo**: Tag and release of *P.zijsron* specimen acoustically tracked in this study.**

Acknowledgments

The authors would like to thank the owner (Mr Peter Tonon) and skipper (Tim Dudgeon) for their goodwill and assistance with the data collection. The commitment and support given by Andrew Taylor is also acknowledged and greatly appreciated. The project team would also like to thank QBFP Weipa, Peter McCulkin (DPI Project Officer) and the Mapoon Aboriginal Council for their logistical support and assistance. We thank Geoff McPherson and Dr Neil Gribble of the Department of Primary Industries Northern Fisheries Centre for their time in critiquing this document. This project would not have been made possible if wasn't for the funding support of the National Oceans Office administered by Steve Jackson.

Executive summary

A female *Pristis zijsron* was tracked for 27 h in the Port Musgrave estuary using an ultrasonic tracking tag and depth recorder, both of which were recovered after 27 hours, leaving the animal unharmed. This represents the first track of a sawfish in Australia and provides important data on habitat usage for the management and conservation of sawfish within Australia. Overall, the sawfish moved 28 714 m at an average speed of 28.4 $m.min^{-1}$ and was at all times within 200 m of the shoreline in very shallow water. Average water depth was 0.69 m. During the day, the sawfish was in slightly deeper water (0.84 m) compared to the night (0.48 m). These observations were most likely attributed to the tidal cycle during the time of the study or a combination of tidal cycle and diurnal preferences. The conservation and management implication of these data as well as the use of these data for future research into the movement and habitat requirements of sawfish are discussed.

Table of contents

List of Figures

List of Tables

Introduction

In Australia the family Pristidae is represented by four species, *Pristis microdon*, *P. zijsron*, *P. clavata* and *Anoxypristis cuspidata*, all of which are recognized by the IUCN Red List of Species as endangered or critically endangered (Cavanagh et al., 2003). Within Australia, the freshwater sawfish (*P. microdon*) is listed as threatened under the EPBC Act and a nomination to list the green sawfish *Pristis zijsron* as threatened under the EPBC has recently been submitted.

Our knowledge of the biology, ecology and behaviour of sawfish is very limited with only two publications on their distribution and biology in Australia (Thorburn et al 2003, and Peverell *in press*). Of the four species identified inhabiting the Queensland Gulf of Carpentaria, Peverell (*in press*) documented that *P. zijsron* posses the lowest catch per unit of effort (max 0.21 sawfish/500m net /day). The abundance of this species was documented to be greatest in the northern region of the GoC, Weipa.

There is an almost complete lack of data on habitat usage and movement patterns of sawfish both in the Australia and worldwide. Information on habitat utilization by sawfish, mainly through direct observation, suggests that mud/sand flats adjacent to major river and tributary channels is one of this families preferred habitats.

Stobutzki et al (2002) identified sawfish as being at high risk of population decline in northern Australia based on limited data on their life history and biology. Concerns have been expressed by scientists, resource managers, industry and conservation groups worldwide over the observed decline in sawfish populations throughout their range. This is primarily due to sawfish being long-lived, slow to mature and having low fecundity. Sawfish's association with the inshore coastal regions of tropical and sub-tropical waters makes them vulnerable to commercial/recreational net and line fisheries and habitat degradation. This combined with their heavily toothed rostrum, which is easily tangled in nets, results in sawfish being extremely prone to capture in any form of net fishing practice.

Failure to understand the life-history and habitat requirements of sawfish could result in some fishing practices, such as gillnetting, becoming ‘key threatening processes’. If this occurs, it will be necessary for fisheries to produce “threat mitigation plans” to reduce their impact. This can only be done with better knowledge of the species behaviour, habitat requirements and life history patterns.

The interaction of gill net fisheries with sawfish is an unknown but critically important issue that can only be addressed by developing methods of studying these behaviours. Knowledge of habitat usage of sawfish over a range of spatio-temporal scales is extremely important because habitat usage influences population distribution and abundance. Spatial distribution will in turn dictate the availability of a species to target or bycatch fisheries, which in the case of sawfish will have important conservation and fisheries management implications. A better understanding of the habitat utilization of sawfish will assist in the management of specific habitat requirements and the better management of activities threatening sawfish sustainability.

The specific aims of this project are:

1) To attach acoustic tags and time depth recorders to two sub-adult (2 – 3 m TL) sawfish (either *P. microdon, P. clavata* or *P. zijsron*) and track the animals over a 48 hour period.
2) Acoustic tags will determine short-term activity patterns, swimming speed, movement and diurnal activity within shallow coastal marine environments.
3) Time depth recorders will record swimming depth and temperature. These data will be then be analysed with a track of water depth to determine which area of the water column is utilized by the animals.
4) This study will also provide additional data on the feasibility of a potentially larger sawfish project addressing similar objectives on a national scale. Data from daily movement patterns (tidal and diurnal patterns) will also assist in determining the feasibility of using listening station arrays to monitor sawfish movement patterns over long periods (months to years) in future research.
5) Data from this research will contribute to the baseline information on sawfish biology and ecology already collected under the FRDC funded Northern

Australian sharks and rays: the sustainability of target and bycatch species, phase 2 FRDC 2002/064.

Methods

Study site

Four species of sawfish inhabit the northern Gulf of Carpentaria (GoC) and this area most likely supports the largest population of sawfishes in Queensland.
Mapoon Aboriginal Community is situated on the southern side of Port Musgrave located approximately 80km north of Weipa, latitude 12° 00’ S longitude 141° 53’ E (Figure 1). Port Musgrave was chosen as the site for this study because of the logistical support provided by Mappon Fishing Enterprises and the known abundance of sawfish inhabiting the waters. Commercial fisher contacts obtained through the FRDC Project 99/125 - Tropical Resource Assessment Program Phase 2 observer program provided the project staff with accurate historical records of sawfish abundance in the region, including Weipa.

Port Musgrave is a relatively shallow embayment made up of vast soft mud flats and rocky headlands with mangroves dominating the shoreline. The Wenlock and the Ducie Rivers drain into Port Musgrave before flowing into the GoC. Water salinity levels in Port Musgrave are heavily influenced by the freshwater flows of both these river systems during the monsoonal wet season. The area is part of the operational area of the GoC barramundi commercial net fishery. Mapoon Aboriginal community operates two commercial fishing licences in the area and also fish traditionally. Recreational line fishers also frequent the area during the dry season months from May through to October.

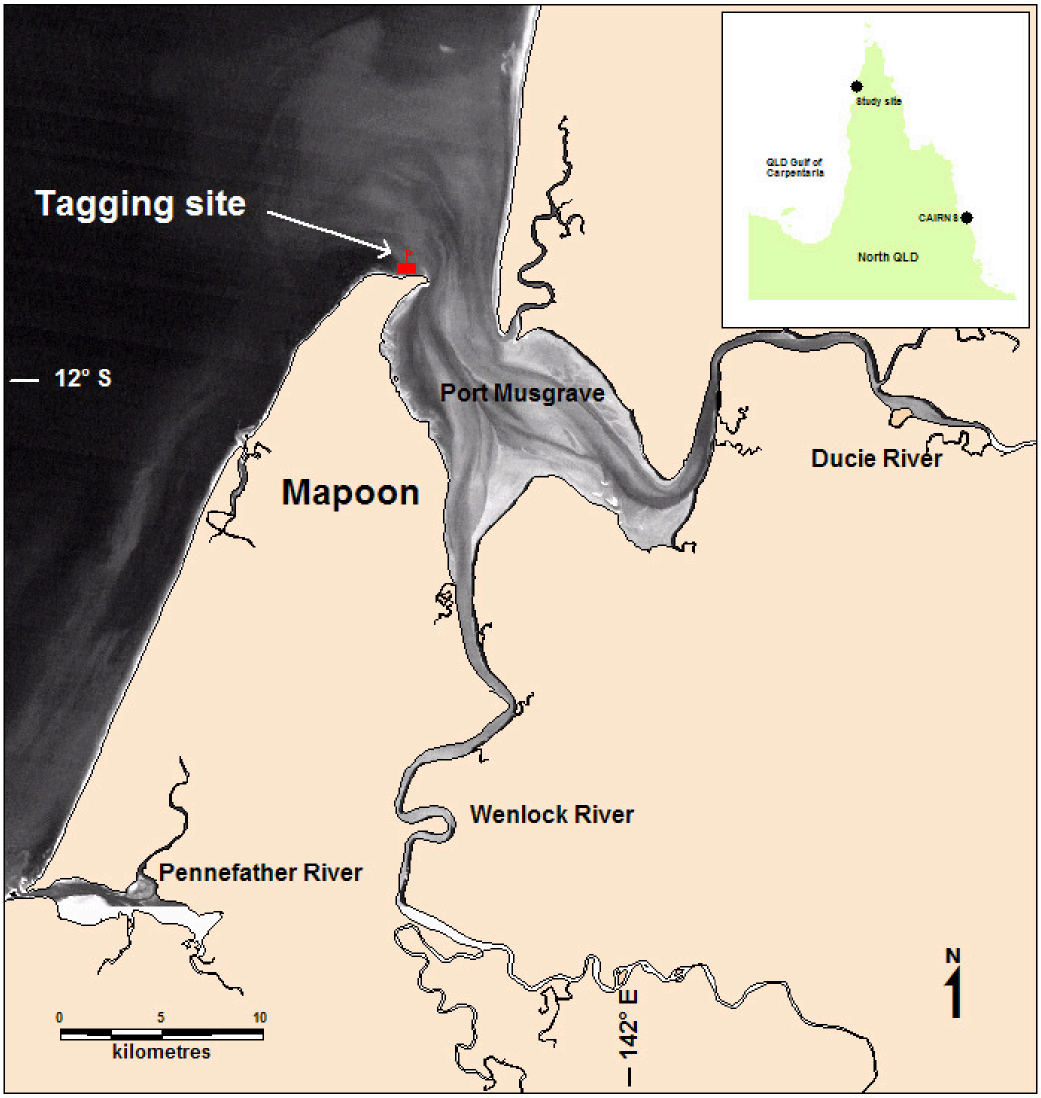

Figure 1. Sawfish acoustic tracking site location map for the Mapoon region north western Cape York Peninsula, Queensland. The water layer is presented as an aerial photograph with the darker patches indicative of deeper water.

Acoustic tracking and depth recording equipment

The equipment used to track the sawfish included a Sonotronics CHP-87S tag and Sonotronics ultrasonic receiver (model USR-91) and hydrophone mounted on the side of a 3.5m punt. This equipment was chosen because it has been used successfully to track *Carcharhinus leucas* in freshwater and estuarine waters of the Brisbane River. The signal transmitted from the acoustic tag can be detected from a distance of 600 to 1000 m. Salinity, water depth, substrate profile and underwater obstacles and surface chop can interfere with the strength of the signal. The position of the sawfish was established by using a directional hydrophone which was kept in the water with the acoustic signal monitored on a continuous basis.

A Lotek LTD_10 TDR (time depth recorder) was programmed to record depth and temperature every 10 seconds. The TDR was attached to the acoustic tag, which was then attached to the animal via a corroding tag. A galvanic time release corroding swivel was designed to release the tag after approximately 38 hours. This was dependent on salinity levels and a time release trial was performed under marine conditions prior to attaching the tag to check the systems reliability. This tag corroded after 41 hours. Salinity levels in Port Musgrave however were a lot lower (average 24ppt) than those used during the time trial. For this reason a 24 hour swivel was used in replace of the 38 hour galvanic time release corroding swivel.

A small high-density float was attached to the TDR and acoustic tag to aid in the recovery of the tag (Figure 2). Water depth (m) was recorded as the distance from the water surface to the origin of the first dorsal fin (Figure 2).

Figure 2: Position and size of acoustic tag and floats. A = LTD_10, B = acoustic tag, and C = galvanic time release. Horizontal line and arrows indicate where water depth was measured.

Tagging protocol

A sawfish (*P. zijsron*) was captured by gill net on the foreshore at Port Musgrave; latitude 11 57' 192", longitude 141 54' 168". It was originally planned that two sawfish were to be acoustically tracked over the week, however only one animal was caught during the study. The sawfish was removed from the net using a net hook and the procedures set out by Peverell (2002). Following removal from the net a fin clip was taken for future genetic analysis and total length (T_L) and lower jaw total length (L_{JTL}) were recorded. The ultrasonic tag and time depth recorder were attached via the galvanic time release swivel attached to the first dorsal fin. The hole for the time-release swivel was made using a leather hole punch. A wet towel was placed over the head of the sawfish to reduce stress.

Tracking protocol

Following tagging the animal was released and the tag signal checked. Throughout the course of the tracking period, we tried to maintain our position so that the sawfish was between the shoreline and the vessel. The position of the tagged sawfish was recorded using a Garmin 12 portable global positioning system. Waypoints were recorded on an opportunistic basis (but never more than 20 minutes apart) when the animal demonstrated periods of movement. Waypoints (latitude and longitude) were taken as close as possible to the animal (as determined by the strength of the signal) and in all instances were within 50 m of the actual position. Distance of the observing dinghy from the sawfish had no apparent influence on the animal's behaviour. Salinity and water temperature was recorded hourly using a WTW LF340 salinity/conductivity meter. The sawfish was monitored on a continuous basis until the time-release swivel dissolved freeing the acoustic and time depth recorder tag. Water temperature (°C) and salinity (ppt) was recorded a meter below the surface at the beginning and end of the tracking study and at 6 hourly intervals.

Analysis and presentation of tracking data

Sawfish tracking waypoints were imported into MapInfo® Software where they were overlayed on a geographic vector layer of Mapoon and Port Musgrave. The direction of the acoustic track was presented in the form of a route created by joining each successive waypoint with a directional arrow. A blue coloured directional arrow represents times and distances of rapid movement.

Distance (Dist) was calculated by summing the distance (m) between successive waypoints. Average rate (Av Rate) of foraging movement was calculated as the "Dist" divided by the "duration" of tracking; ie, total distance travelled divided by the total elapsed time. Maximum rate (Max Rate) was the maximum rate of displacement calculated between any two successive waypoints. Rate of movement was recorded in metres per minute. Foraging area (km^2) was calculated using a modified version of the convex polygon method whereby, the foraging polygon was created by joining the waypoints on the outer most margins of the route and the area calculated in MapInfo®.

Activity budget

An activity time budget was calculated using Ms Excel and presented graphically as a line chart and histogram where the x-axis represents elapsed time standardised for each plot; ie tidal cycle, distance moved and rate of movement. The data used to calculate and interpret the sawfish activity budget included diurnal tide (m), route - distance travelled (m) and activity data ($m.s^{-1}$).

Depth data

Data from the TDR tag was downloaded using TAGTALK software provided by Lotek. Pressure data was then converted into depth (m). The distance from the origin of the first dorsal fin to the TDR was subtracted from the depth recorded by the TDR to give depth at first dorsal fin origin (Figure 2).

Results

A female *P. zijsron* (355mm TL) was captured in a 165.5mm monofilment gillnet in approximately 1.5 m of water and over a firm sandy substrate. The animal was tagged with an acoustic and time depth recorder tag (Figure 2) and released on the southern foreshore of Port Musgrave at 14:43 on the 1/5/04 and tracked continuously for a 27 hour period at which time the galvanic dissolving swivel broke and released the tag.

Following release the sawfish travelled in a north easterly direction along the sandy foreshore before rounding the sand spit on the southern bank of the entrance to Port Musgrave. Once in the embayment the animal travelled in a southerly direction parallel to and close to the shoreline in shallow water. In Port Musgrave the average water temperature was 31°C and 24ppt salinity.

Depth

Throughout the track the sawfish was in very shallow water (mean water depth = 0.69 m) as shown by Figure 3. Water depth was recorded from the vessel and corresponded to depth of the animal. The sawfish being was in contact with or slightly above the substrate throughout the track. The maximum depth of the sawfish was 1.84 m while the minimum depth was 0.4 m. The minimum water depth recorded was limited by the length of line attaching the tag to the dorsal fin with a depth of 0.4 m being the depth at which the tag was on the surface. There was a significant difference between sawfish depth during day and night, with the sawfish in deeper water (mean = 0.84 m) during the day compared to night (mean = 0.48 m).

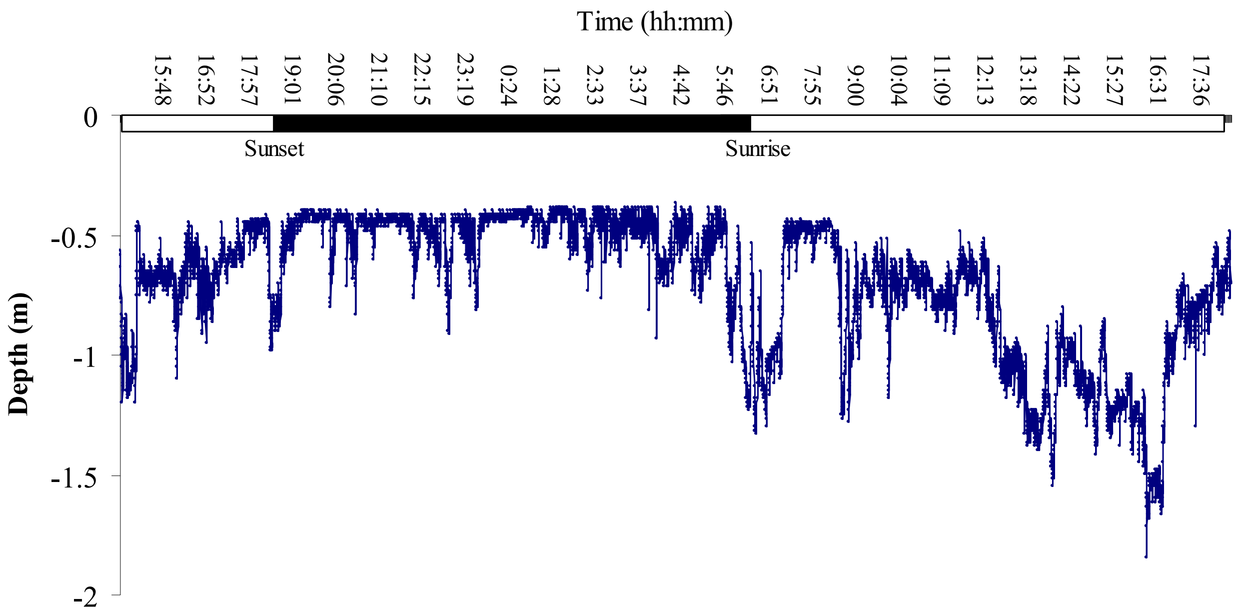

Figure 3: Data from the TDR recorded over 27 h, showing the depth profile over time.

Activity budget

The direction and position of the foraging pathway are presented in Figure 4. In total the sawfish travelled 28 714 m with an overall speed (distance/length of track) of 18.6 m/min (Rate of movement = 0.31 $m.s^{-1}$). The average speed (mean of distance travelled between waypoints) was 28.4 (± 4.8 $m.min^{-1}$). The minimum and maximum speed recorded between 2 waypoints were 0.15 and 289 $m.min^{-1}$, respectively.
The foraging area calculated over the 27 hours of continuous tracking was 8.032km^2 (Figure 5)

The tagged sawfish demonstrated rapid movement on two occasions, and both were in the early morning corresponding with the ebbing tide. During these two events the sawfish travelled a distance of 1921 and 868 metres respectively (Figure 6). This rapid movement took place along the channel edge between waypoints 58 – 59 and 63 – 64 (Figure 4).

Observations

Sightings of the tag breaking the surface were observed on 6 separate occasions totalling approximately 3.5 hours. During this time the water depth was less than 0.5 m. The sawfish was observed on five separate occasions and its behaviour was interpreted to be that of feeding with the rostrum breaching the surface in a thrashing movement. This behaviour was usually associated with baitfish breaking the surface followed by a sudden burst of movement creating large swirls and water displacement.

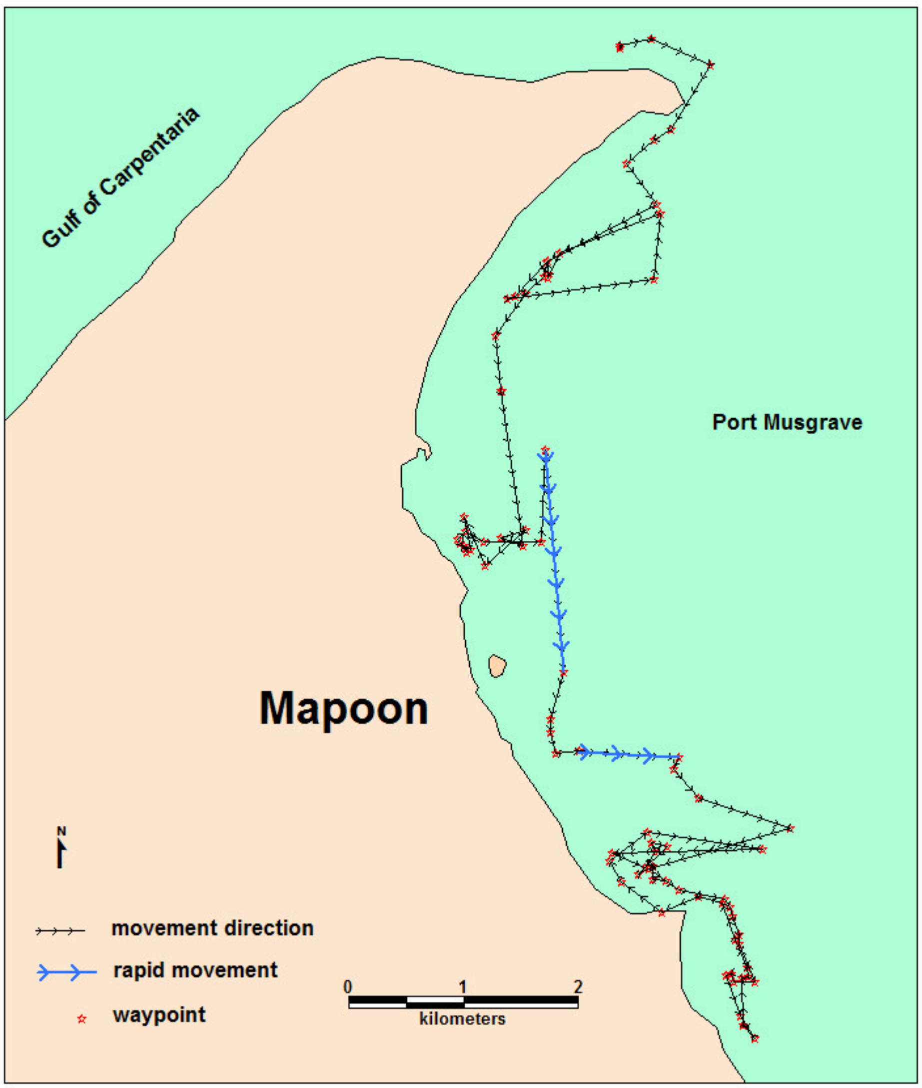

Figure 4: Map of the track of a *P. zijsron* acoustically tagged on the 1/5/04. Tag released and recovered after 27 hours

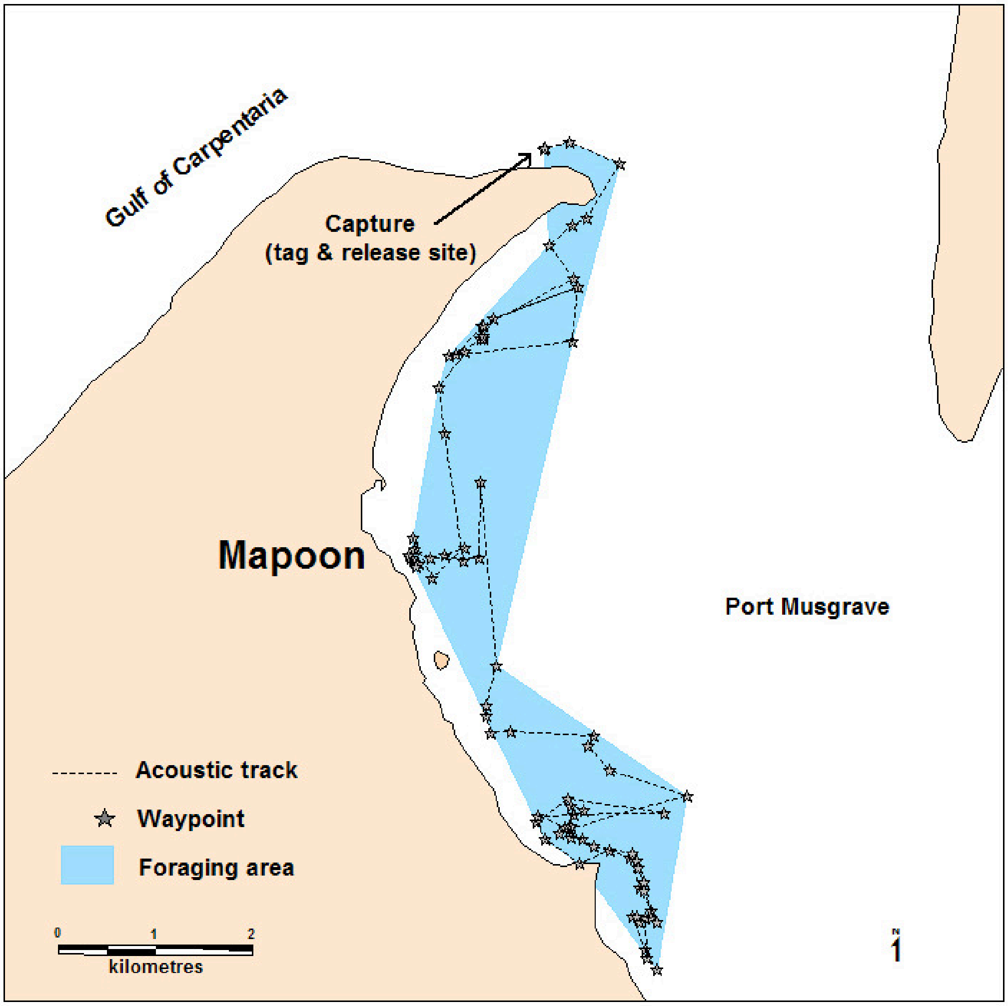

Figure 5: Foraging area calculated from the tracking route of *P. zijsron* monitored over a period of 27 hours

Table 1: Summary of tracking data (acoustic tag) of *P. zijsron* at Port Musgrave

				Rate of movement (m.min^{-1})			
Sex	T_L (mm)	Distance travelled (m)	Duration of track (hh:mm)	Overall	Average (± SEM)	Minimum	Maximum
F	**355**	**28714**	**27**	**18.6**	**28.4 (4.8)**	**0.15**	**289**

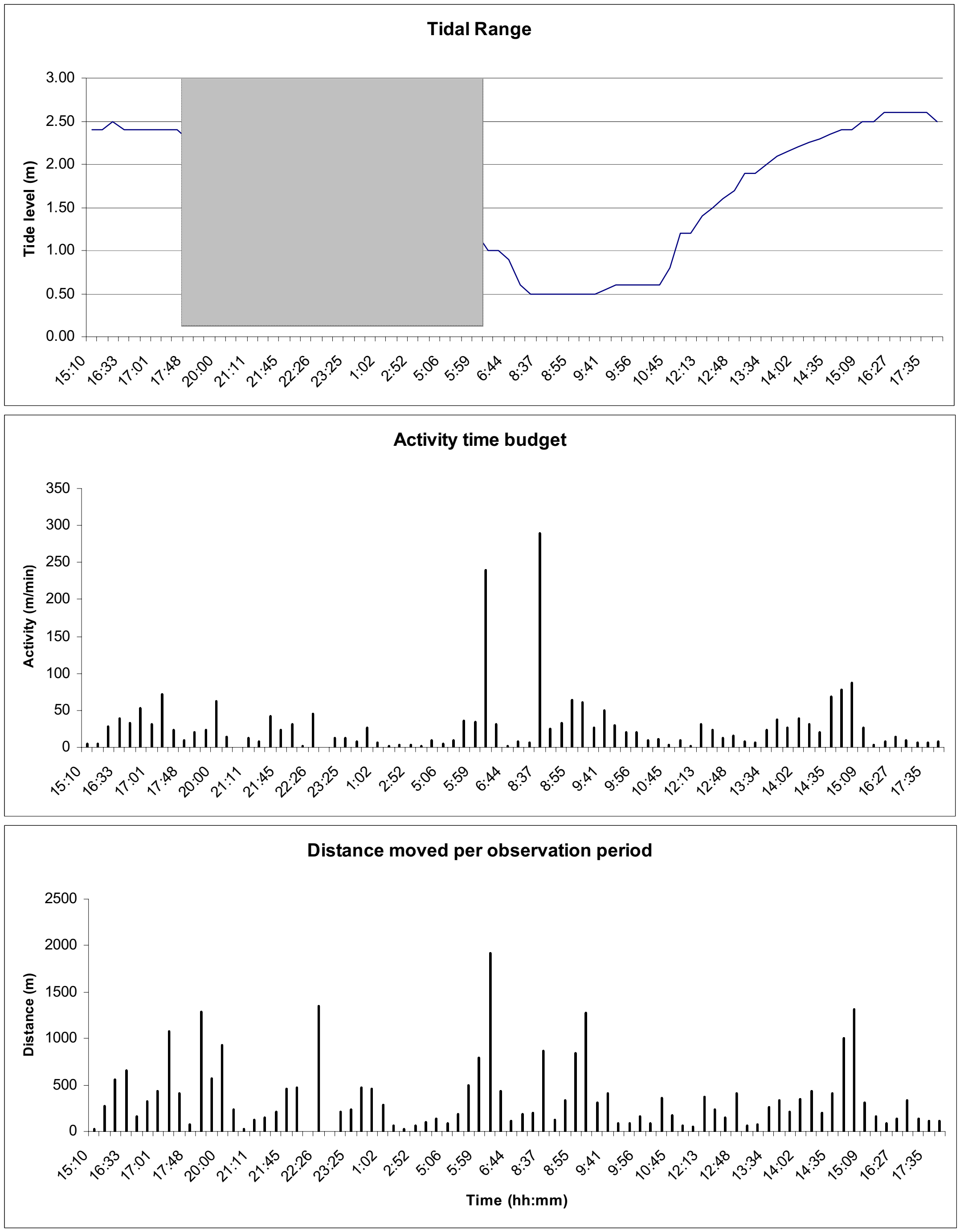

Figure 6: Time activity budget for acoustically tagged *P. zijsron*; top – tidal cycle and day night; middle – activity measured in metres travel per minute; and bottom – activity measured as distance in meres travelled between successive waypoints.

Discussion

Movement

A female *P. zijsron* (355 mm T_L) was successfully tracked for 27 h in a tropical estuary in Northern Australia and represents the first continuous track of this species ever recorded. This is also the first time any sawfish has been tracked in Australia. Our data show a pattern of slow near-shore movement along the southern foreshore of Port Musgrave. The position of the track and corresponding depth data gathered from the TDR indicate that the animal was in very shallow water (< 2.0 m) throughout the track (Figure 3).

Despite being captured in a commercial gill net and having spent over 6 hours in the net, the sawfish displayed a fast recovery. The animal did not move to deeper water adjacent to release site after being released. In addition, the animal was observed feeding within an hour of being released.

Following release the animal moved parallel to the coast and into the Port Musgrave estuary. Once inside Port Musgrave, the animal spent approximately 5 h in a small bay. During this time it was moving in an apparently random pattern within the bay and was observed feeding on several species of baitfish species

During feeding the high density foam floats were observed on the surface for long periods. A similar pattern of slow, short (< 1 km) and deliberate movements in a southerly direction and parallel to shore punctuated by periods of apparently random movement in a relatively small area were observed over the entire duration. The periods of random omnidirectional movement are interpreted as foraging in search of schools of baitfish located in the shallow water.

Throughout the track the animal moved progressively further south and by 13:00 on the 2^{nd} day had reached the most southerly point. Between 13:10 and 16:50, the sawfish moved approximately 2 km in a northerly direction along the coast. Between 16:50 and the end of the track (18:19), the animal moved back and forth within a small embayment.

Depth

A small diurnal shift in preferred water depth was apparent. On average, during the day the sawfish was in water twice as deep as during the night. This is most likely attributed to the lack of water on the flats at low tide and the sawfish being forced into the channel adjacent to the flats during the day. The tidal cycle would influence the foraging area made available to the sawfish for feeding.

Comparing the tidal cycle data against the data from TDR tag it appears that there might be a diurnal influence on the sawfish's preference for water depth. The relationship was significant for the sawfish's preference for deeper water during the day and shallower water during the night. Further investigations are required to test these preliminary findings. Despite these observations it appears that this sawfish displayed no inhibitions in moving into shallow water despite its large size (355 mm T_L).

Management issues

The preference for shallow water shown by the sawfish in this study and the fact that it moved parallel to the shoreline suggests that sawfish may occupy a relatively small area of available habitat that is concentrated in a narrow strip of water adjacent to the shoreline, at least during feeding. These data are supported by studies on the small tooth sawfish (*P. perotetti*) in North America (Simpfendorfer 2000; Simpfendorfer Pers. Comm 2003) where sawfish have been recorded along the shallow inshore regions of the coastline. However, *P zijsron* have also been recorded in water depth greater than 30 metres (Peverell & Gribble 2003) along the east coast of Queensland.

Pristis zijsron have been identified as a bycatch species of concern in the GoC inshore gill net fishery (Roelofs 2003 and Peverell *in press*). The reason for concern is that sawfish are extremely vulnerable to capture because their toothed rostrum is easily entangled in fishing net.

Commercial inshore gillnet fishers in the GoC target species such as barramundi, queenfish, blue salmon, king salmon and sharks and use up to 600 m of 165.5 to

200mm net. Generally the nets are set from the high water mark perpendicular to the shoreline in shallow water (Roelofs, 2003). Although the commercial fishers are not targeting sawfish, given the behaviour of the sawfish we observed and the position of the nets, and it is likely that this activity would have an increased probability of capturing sawfish.

This report further support the published literature on sawfish, which suggests *P. zijsron* have a preference at certain times for inshore shallow marine and estuarine waters. The tagged animal in this study was tagged and released in a marine environment and was tracked in estuarine waters (salinity 24ppt).

Future research

There is clearly a need for more intensive research into the movement and habitat requirements of sawfish as this study only provides a snapshot of movement and habitat preference for a single specimen of one species of sawfish. Due to the nature of the environment and the acoustic equipment, the animal must be constantly followed to gather data on movement. A major drawback of acoustic telemetry studies is the manpower and resources needed to continuously follow an individual for long periods of time. While intensive experiments can be employed to obtain data over short periods, there is a drastic need to obtain long term data on the movement patterns and critical habitat requirements of sawfish populations.

Data gathered from this present study suggest that sawfish spend a proportion of time in shallow water close to shore, which makes them an ideal candidate for satellite tag attachment as well as acoustic tag and listening stations. Swimming behaviour and depth play a major role in the success of satellite tags which transmit a radio signal to satellites fitted with ARGOS receivers. The tags can only transmit a position when the tag antenna is clear of the water where there is an uninterrupted radio signal. Satellite fixes are accurate to within 150 m and position can be tracked anywhere in the world. Satellite tags have been used to successfully track white sharks (*Carcharodon carcharias*) and whale sharks (*Rhychodon typus*) within Australia.

The use of arrays of listening stations to monitor sawfish movements in tropical estuaries would also be feasible given the narrow track of the sawfish. Listening stations (automated acoustic tag identification sites) record the presence of individual acoustic tags and can be anchored on the sea bottom in several locations to determine rates of movement and movement patterns within an estuary. Listening station arrays have been used to obtain critical information concerning the early life history and the importance of nursery areas to the survival of young sharks in Florida (Heupel and Simpfendorfer 2002) as well as to gather information on the movement and migration patterns of critically endangered grey nurse sharks (*Carcharias taurus*) within Australia (J. D. Stevens Pers. Comm 2004)

References

Cavanagh, R.D., Kyne, P.M., Fowler, S.L., Musick, J.A., and Bennett, M.B. (Ed) 2003. The Conservation Status of Australasian Chondrichthans. Report of the IUCN Shark Specialist Group Australia and Oceania Regional Red List workshop March 2003. The University of Queensland, School of Biomedical Sciences, Brisbane, Australia. 170 pp

Heupel, MR, Simpfendorfer, CAE. 2002. Estimation of mortality of juvenile blacktip sharks, Carcharhinus limbatus, within a nursery area using telemetry data. Can. J. Fish. Aquat. Sci. 59 (4): 624 – 632.

Peverell, SC. 2002 Queensland Sawfish Identification Guide. Department of Primary Industries Queensland, QI03038

Peverell SC, Gribble NA. 2003. Sawfish (F. Pristidae) in the Northern Planning Area – Description of key species groups for the National Oceans Office

Roelofs, A. 2003. Ecological assessment of the Gulf of Carpentaria inshore finfish fishery - A report to Environment Australia on the sustainable management of a multi species tropical gillnet fishery. Department of Primary Industries, Queensland.

Simpfendorfer, CA. 2000. Predicting population recovery rates for endangered western Atlantic sawfishes using demographic analysis. Env. Biol. Fish. 58 (4): 371-377.

Stobutzki, IC, Miller, JM, Heales, DS, and Brewer, DT. (2002). Sustainability of elasmobranchs caught as bycatch in a tropical prawn (shrimp) trawl fishery. Fishery Bulletin. 100: 800-821.

Thorburn, DC, Peverell, SC, Stevens, JD, Last, PR, and Rowland, AJ. (2003). Status of freshwater and estuarine elasmobranchs in Northern Australia. Report to Natural Heritage Trust, Canberra.