Catching and tracking the world’s largest Zambezi (bull) shark *Carcharhinus leucas* in the Breede Estuary, South Africa: the first 43 hours

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The Zambezi or bull shark *Carcharhinus leucas* is a large, predatory shark that occurs in warm-temperate, tropical and subtropical coastal and estuarine systems worldwide. To confirm reports of Zambezi sharks in the Breede Estuary on the south-west coast of South Africa, a survey was undertaken during 20–26 January 2009. On 24 January, a large female Zambezi shark was caught on rod and reel. Measuring 400 cm total length and 320 cm precaudal length, it is the largest recorded Zambezi shark. Furthermore, its occurrence in the Breede Estuary is the southernmost record of the species, extending its previously documented range by 366 km. The shark was tagged with a continuous acoustic tag and tracked for 43 consecutive hours. During that period, it swam as far as 20 km upstream, but it also briefly exited the estuary and travelled 2 km out to sea. Most of the time (24%) was spent 11–13 km upstream, where it actively inspected boats and shore-anglers, a behaviour considered to be an opportunistic foraging strategy. Estuaries appear to represent critical habitats in the life history of Zambezi sharks.

Keywords: acoustic tracking, *Carcharhinus leucas*, estuary, freshwater, largest size recorded, nursery

Introduction

Zambezi (bull) sharks *Carcharhinus leucas* are large carcharhinid sharks that commonly occur in the turbid waters of lagoons, river mouths and shallow coastal waters in tropical and subtropical seas (Sadowsky 1971, Snelson et al. 1984, Compagno et al. 2005, Simpfendorfer et al. 2005). Spending much of their time in estuaries, it is the only shark species that readily occurs in both salt- and freshwater. Zambezi sharks can breed in freshwater, although most breeding likely occurs in the high reaches of warm-water estuaries and rivers (Montoya and Thorson 1982, Cliff and Dudley 1991, Compagno et al. 2005, Pillans 2006).

In South Africa, distribution records indicate that the species occurs from the Moçambican border to Cape St Francis in the Eastern Cape (Compagno et al. 1989). Recently, however, increased anecdotal reports of Zambezi sharks in both the southern Eastern Cape and the Western Cape provinces, particularly in the Breede Estuary, suggest a possible southward shift in their distribution and/or a re-establishment of populations that existed beyond collective memory.

According to Whitfield (1996, 1998), the Zambezi shark is partially estuarine-dependent, using estuaries as pupping and nursery grounds. As such, they would be particularly susceptible to habitat degradation, alteration and environmental change, and that ever-increasing human utilisation and concurrent degradation of estuaries will likely result in population declines. Zambezi sharks are currently targeted or taken as bycatch in several South African fisheries, including the drum-line fisheries, pelagic and demersal longline fisheries, the recreational shark fishery and the handline fishery, and they are commonly caught in shark-protection nets off KwaZulu-Natal (Dudley 2000).

Listed as Near-Threatened on the IUCN Red List (IUCN 2008), Zambezi sharks are considered a species of global conservation concern. The systematic removal of these predators from either a coastal or estuarine system will undoubtedly have negative cascade effects on the health and integrity of these systems (Baum et al. 2003, Myers and Worm 2003). Thus, it is imperative that further research into the ecology and life history of this species, and the role of estuaries in sustaining populations, be conducted.
To determine whether reports of Zambezi sharks in the Breede Estuary could be confirmed, a research expedition was undertaken, with a secondary objective of acoustically tagging an individual to examine its movement patterns in the estuary.

**Materials and methods**

**Study area**

The Breede River is 322 km long with a draining catchment area of 12 600 km². It enters the Indian Ocean in Sebastian Bay and falls within the warm-temperate Agulhas biogeographical region (Figure 1) (Emmanuel et al. 1992). The total surface area of the estuary is approximately 455 ha and extends 50 km upstream to a series of rocky sills where tidal influence ceases (Taljaard et al. 2001). The estuary falls within the winter/bimodal rainfall transition zone, but most of the catchment falls in the winter rainfall area and flows are strongly seasonal with high flows and floods during winter. However, the combination of the two rainfall zones adds to physical variability, ultimately accounting for multiple behavioural signals and the high diversity of the ichthyofauna in the estuary (Harrison 1999, Lamberth et al. 2008). The Breede Estuary is permanently open, has a mean depth of 4.6 m, and high flows and strong currents are able to completely flush and reset the system within a single tidal cycle (Taljaard et al. 2001).

**Shark capture and tracking**

Attempts to capture a Zambezi shark in the Breede Estuary were conducted during 20–26 January 2009. Fishing methods included handline and rod-and-reel using live spotted grunter Pomadasys commersonnii and dusky kob Argyrosomus japonicus as bait. Post-capture stress was minimised by using tow straps around the torso and caudal areas to reduce pressure on the spinal column and body cavities. Body measurements taken were total length (TL, cm), precaudal length (PCL, cm) and interdorsal length (IDL, cm). Genetic samples were taken and stored in alcohol for later processing. Sex and stage of maturity were also recorded. The shark was injected with oxytetracycline for age validation purposes.

Three types of tags were used: a conventional plastic dart tag of 14 cm long, which was inserted with a 4 mm outside diameter applicator needle (Hallprint), a VEMCO-coded acoustic transmitter (69 kHz R69K), and a VEMCO continuous acoustic transmitter (V16 54 kHz), anchored with umbrella darts (VEMCO — Division of AMIRIX Systems Inc., Halifax, Nova Scotia). All tags were inserted into the dorsal muscle of the first dorsal fin. An antibiotic (propolis) was used to wash each tag insertion to prevent possible infection.

Three tracking teams working in 4 h shifts continuously tracked the Zambezi shark using a VEMCO VR100 acoustic receiver, beginning at 15:30 on 24 January and ending at 10:00 on 26 January. Positions at the start and end of each tracking shift were marked on a Garmin handheld GPS. To ensure integrity of the track, GPS positions were manually logged every 5–10 min on the VR100. Changes in shark behaviour near boats, around fishing activities and at tidal changes were noted throughout the 43 h tracking period.

**Results**

**The catch**

The Zambezi shark (Figure 2) was hooked 5.2 km upriver at 13:30 on 24 January using rod and reel with live spotted grunter as bait. It was landed 7.7 km upriver at around 14:50. The shark measured 400 cm TL and 320 cm PCL with an IDL of 85 cm. The weight was estimated to be in excess of 600 kg, using a length–weight relationship provided by Wintner et al. (2002). However, given the large size of the shark, this derived weight fell well outside the upper range of the curve and thus is considered a rough estimate. The shark was female and appeared pregnant due to the distension of its abdomen.

The capture of a Zambezi shark in the Breede Estuary represents a range extension south-westwards of 366 km from Cape St Francis in the Eastern Cape, where it was previously documented (Compagno et al. 2005). However, anecdotal and photographic evidence shows that the presence of this species in the Breede Estuary dates back to at least the 1960s.

**Tracking**

A total of 205 GPS positions were manually logged on the VR100 receiver when signal strength indicated the presence of the shark close to the observation boat. During the first five hours of tracking (15:00–20:00), the shark appeared to be resting against the edge of a mudbank drop-off, spending most of its time within 500 m of where it was released (Figure 3). From 22:00, it started to move
Figure 2: The Zambezi shark that was caught, tagged and released with acoustic tags in the Breede Estuary on 24 January 2009 (photo: Alison Towner)

Figure 3: Google Earth image of the Breede River showing the track of the tagged Zambezi shark over a 43 h period during 24–26 January 2009. The positions shown (white dots) are those logged at 15 min intervals. Date, time and direction of major movements are indicated by grey arrows. The hooked and landed positions are shown.
slowly downstream, inspecting some fishing boats on the way. At 3:00 the following morning (25 January), it exited the mouth and swam approximately 2 km out to sea — it was then 15 km from its release position. At 06:00, the shark returned to the estuary and spent the next 4 h resting just inside the surf-zone adjacent to the entrance channel. From 09:00 to 10:00, it inspected a group of shore-anglers and cast-netters at the mouth of the estuary, after which it made a 5 km burst upstream. From there, it swam slowly farther upstream and spent most of the next 24 h moving among boats and shore-anglers, possibly in anticipation of easy prey. The shark spent 24% of its time between 11 km and 13 km upstream (Figure 3).

The estuary was well mixed at the time of the study, with barely discernible vertical stratification. Saltwater intrusion extended 35 km upstream at high tide, but throughout the tracking period the shark remained within the 15–35 salinity ranges in the lower 20 km of the estuary. Water temperatures were fairly high, ranging from 20 °C at the mouth to 24 °C upstream. Turbidity at the mouth was low at 5 NTU but increased to >20 NTU in the upper reaches. The shark remained within the 10–15 NTU range throughout most of the daylight hours and forays into the clearer, lower reaches of the estuary were almost exclusively confined to the night and early morning. The water column was well oxygenated throughout the estuary. All physico-chemical parameters measured were typical of the Breede system at the time of sampling (Lamberth et al. 2008).

**Behavioural notes**

Although the shark’s behaviour was not quantified during this exploratory survey, descriptive notes on its behaviour near boats and around fishing activities were recorded during the night when such activities peaked.

On 24 January, boat-based night fishing was concentrated between 11 km and 13 km upstream, where the shark appeared to spend the majority of its time. From 19:40 to 21:00, the shark swam between three boats that were fishing for grunter and kob. It explored an area beneath each vessel for several minutes before moving to another boat.

During the final tracking shift (06:00–10:00 on 26 January), the shark moved from 11 km to 15 km upriver, following boat-based fishing activities. It moved between seven boats, all with fishing lines in the water, spending several minutes near each one before moving away. At 07:23, the shark moved toward a boat while it pulled anchor and began following the boat when it trolled downstream with four rapalla fishing lures in the water. The shark spent approximately 35 min following the trolling boat.

At 08:00 on 26 January, as tidal flow slackened (low tide was at 09:20) and the majority of fishing boats returned to shore, the shark moved into the shallower bank waters of the river and appeared to drift downhill (at a rate of approx. 3.5 km h⁻¹), during which time it inspected shore- and boat-anglers for a few minutes at a time, and frequently entering shallow waters <1.5 m deep.

**Discussion**

Zambezi sharks commonly occur in shallow coastal waters and estuaries of tropical and subtropical seas throughout the world (Compagno et al. 2005, Pillans 2006). In South Africa, they are found in several estuaries and coastal waters from KwaZulu-Natal to Cape St Francis in the Eastern Cape (Compagno et al. 1989). This study is the first confirmed record of Zambezi sharks in the Breede Estuary and represents the southernmost occurrence for the species, extending its previously known range by 366 km.

Anecdotal reports and photographs indicate that Zambezi sharks inhabited the Breede Estuary in the 1960s and 1970s. A notable reduction in anecdotal reports from the late 1970s to early 2000s suggests that direct hunting of these sharks during earlier years (as documented in the photographs) may have decimated the population of these sharks in that estuary. Increased reports of Zambezi sharks in the Breede Estuary since 2003 may mark their local reappearance. Possible reasons for this could be the degradation and closure of other estuaries — and possible nursery and breeding grounds — along the South African coastline (Cliff and Dudley 1991, Turpie et al. 2002).

Previously thought to reach a maximum total length of 340–350 cm (Bass et al. 1973, Cliff and Dudley 1991, Dudley 2000, Compagno et al. 2005), the Zambezi shark under study represents a 50–60 cm increase in the maximum known size of the species.

The shark spent most of its time between 5 km and 11 km upstream, where boat-based fishing activities were most concentrated. This may represent conditioning to these activities, which could result in lower levels of energy expenditure while foraging. The shark appeared to move with the tidal flow, swimming down the estuary on slack and low tide and up the estuary during high tide. Similar movements have been shown for estuarine fish, whereby they follow the tidal cycle to minimise energetic output (Ackerman et al. 2000, Heupel et al. 2006, Collins et al. 2007, Childs et al. 2008). Alternatively, the shark may have been following prey such as grunter and kob, which exhibit synchronised tidal movements (Cowley et al. 2008). This behavioural adaptation may also allow the shark to opportunistically prey on fish by either moving on or off the shallow intertidal areas during the flood and ebb tides. Further tracking studies on this Zambezi shark will examine its fine-scale movement patterns and behaviour in the estuary.

As a partially estuarine-dependent elasmobranch species, Zambezi sharks use estuaries as pupping and nursery grounds (Whitfield 1998, Pillans 2006). The shark under study appeared to be pregnant at the time of capture, suggesting that the Breede Estuary may serve as a nursery ground for this species. The species was previously thought to pup only farther north, in the St Lucia Estuary in KwaZulu-Natal (Bass et al. 1973, Cliff and Dudley 1991). Exploratory surveys similarly to this study indicate that the Umzimvubu Estuary, some 800 km north of the Breede Estuary (Figure 1), may also be a (previously undocumented) nursery ground for Zambezi sharks; juveniles bearing distinct umbilical scars were captured in that estuary in February 2008 (S Wintner, Natal Sharks Board, pers. comm.).

It is uncertain whether this record of a Zambezi shark in the Breede Estuary represents a single or a population range extension for the species. The Breede River has ideal nursery conditions for Zambezi sharks: a permanently open warm-temperate estuarine system, is highly productive, has

Although the residency and abundance of these sharks in the Breede Estuary is yet to be determined, the discovery of the largest recorded Zambezi shark there indicates that the estuary provides favourable habitat for a species listed globally as Near Threatened (IUCN 2008). Future studies should focus on the role of these vulnerable predators in the Breede Estuary, including abundance, residency, population dynamics and habitat utilisation.

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