

An integrated approach to study bull shark behaviour and ecology in the South Pacific: The *Bull Shark Tagging Programme*

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Bull sharks (*Carcharhinus leucas*) are widespread along the continental coasts of all tropical and subtropical seas but also occur around remote island states far away from continental waters. They are often found close inshore in shallow water which makes them readily accessible for scientific study. The *Bull Shark Tagging Programme* started in 2003 with a pilot study in the Bahamas to test the feasibility of studying movement patterns and habitat use of bull sharks with state-of-the-art pop-up satellite archival tags. Since 2004 the project's main field site is located in Fiji where the behaviour and ecology of bull sharks is investigated using direct and indirect observational and monitoring techniques and tools.



The study site

Shark Reef is a small reef patch off the southern coast of Viti Levu, Fiji. It is separated from Beqa Lagoon by the 300+ m deep Beqa Channel (Fig. 1). Shark Reef is easily accessible year-round and is home to the *Bull Shark Tagging Programme*.



Shark Reef Marine Reserve (SRMR)

This privately initiated community-based marine conservation and ecotourism project was officially established in 2004. The basic concept of the project has been to "buy" the fishing rights from the local villages that traditionally own the fishing rights on Shark Reef and designate it as a no-take zone.



Direct observation

Underwater videography and still photography are powerful tools that provide scientists the opportunity not only to observe, directly, phenomena of interest, but also to collect data over sufficient periods of time so that quantitative analyses are possible. Since 2004, free-ranging bull sharks have been observed in SRMR on more than 550 days. To date, more than 30 individual bull sharks have been identified based on external markings. Some of these individuals return to Shark Reef often and on a regular basis while others only visit SRMR rarely at certain times of the year (Fig. 2a). Both, the total number of observed sharks and the number of individually known sharks decrease over the course of a calendar year (Fig. 2b).



Telemetry

Acoustic and satellite telemetry are used to study residency patterns, daily and seasonal small- and large-scale movements, and habitat use of bull sharks off the southern coast of Viti Levu. To date, more than 50 bull sharks have been equipped with acoustic transmitters. Various VR2 listening stations are placed on Shark Reef and surrounding reefs to monitor small-scale movement patterns and daily presence/absence (Fig. 3). In addition, a total of 12 bull sharks were equipped with pop-up satellite archival tags between 2004 and 2008 to study their horizontal and vertical movements (Fig. 4). Preliminary analysis of satellite data confirm results from direct observation and acoustic tagging that show bull sharks leaving SRMR for longer time periods moving along the Viti Levu coast.

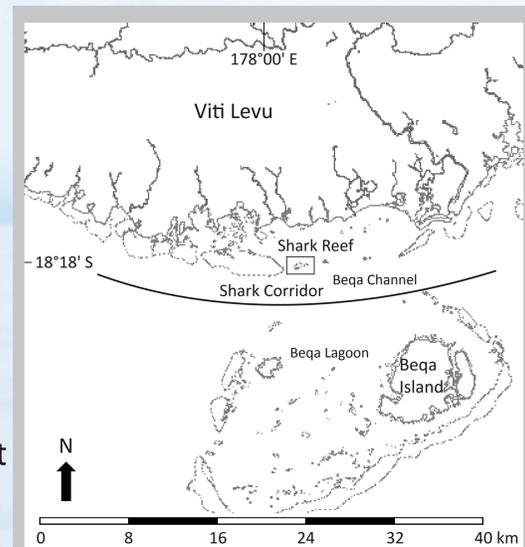


Figure 1 Shark Reef, Beqa Channel and the Shark Corridor (in which shark fishing is banned) off the southern coast of Viti Levu. The western part of Shark Reef is the designated no-take zone Shark Reef Marine Reserve.

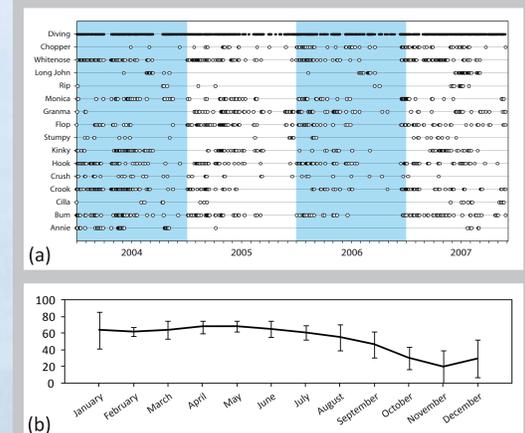


Figure 2 (a) Presence of 15 selected bull sharks in SRMR, and (b) overall percentage (\pm S.D.) of individually known bull sharks present in SRMR between 2004 and 2007.

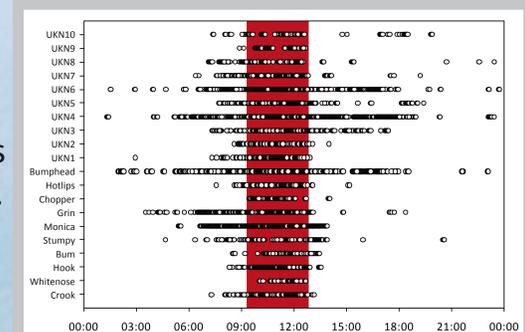


Figure 3 Presence of 20 bull sharks in SRMR monitored with acoustic transmitters over multiple days in SRMR between 2006 and 2008. The red marked area indicates the time of the day when recreational divers are present at the site.

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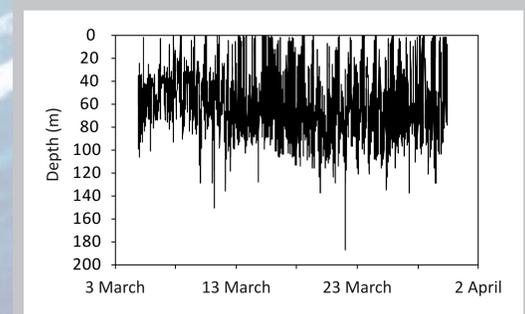


Figure 4 Depth profile of a female bull shark tagged with a high-rate pop-up satellite archival tag for 25 days in March 2008. Overall, bull sharks spent the majority of time between 30 and 50 m and some individuals showed diel patterns (deeper during the day, shallower during the night).

Acknowledgements

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