# Habitat features associated with newborn Giant Shovelnose Rays (*Glaucostegus typus*)

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## Abstract

Understanding patterns of habitat use by newborn-sized animals is critical to conserving threatened species and their potential nursery grounds. Giant Shovelnose Rays (*Glaucostegus typus*) are Critically Endangered but at least locally abundant in the Australian portion of their range, providing an opportunity in Australia to understand what types of habitat features are associated with newborn and young-of-the-year individuals in the absence of intense fishing pressure. To investigate this, we used replicated belt transects to study Giant Shovelnose habitat use and abundance in shallow (< 0.5 m), shoreline waters. 28 whole-island surveys were conducted at low tide over 2 years on Heron Island, Australia. In total, we counted 552 Giant Shovelnose Rays, 79% of which were newborn class (< 40 cm in length), in both sand flats and shallow areas with rock rubble. These habitat characteristics are consistent with other studies of Giant Shovelnose Rays in Australia, adding to the existing knowledge that these juvenile animals commonly use shallow waters. Studying newborn Giant Shovelnose habitat characteristics in a portion of their range where they are still locally abundant can offer a roadmap for managers to locate key regions to protect within imperiled portions of their range.



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## Introduction

Effectively maintaining and growing populations of threatened species is a major goal in conservation sciences. However, certain ecological and life history traits make some species highly vulnerable to extinction. In marine ecosystems, factors such as low fecundity, slow sexual maturity, relying on easily accessible shallow water habitats, and living in regions with exceptional fishing pressure increase vulnerability to extinction (Powles *et al*. 2000; Dulvy *et al.* 2014). Because life history data in particular can contribute to population projections, population recovery rate, and identifying important areas for protection and management, these data can also help influence which strategies are used to improve population success (Carrier & Pratt 1998; Simpfendorfer 2000; McAllister *et al*. 2018). Among elasmobranchs (sharks, rays and skates), conservation strategies have sometimes included targeting specific life stages (i.e. minimum length requirements and bag limits) (NMFS 2006), park closures during mating season (Carrier & Pratt 1998), establishing Shark Refuge Areas to protect nursery areas (McAllister *et al*. 2018), and prohibiting gill and trammel nets near shore to protect young-of-the-year (YOY) (Teo *et al.* 2018).

Protecting nursery grounds along with breeding aggregation sites has been a priority in elasmobranch and large-fish conservation research. It is important to note, however, that focusing only on nursery-centric management in the absence of plans for other life stages is not likely to provide population growth benefits (Kinney & Simpfendorfer 2009). When coupled with appropriate management for other life stages, however, managing nursery grounds can be beneficial to population recovery (Kinney & Simpfendorfer 2009). There are typically three types of evidence needed to designate a nursery area for elasmobranchs: (1) the species is more commonly found in the nursery area than in other areas, (2) animals remain in the nursery area for weeks to months, and (3) the area is repeatedly used over multiple years while other areas are not used (Heupel *et al.* 2007; Martins *et al.* 2018).

Giant Shovelnose Rays (*Glaucostegus typus*) (also known as Giant Guitarfish), an elasmobranch found throughout the Indo-Pacific, face threats from overfishing, the fin trade, climate change, and coastal development in portions of their range (Kyne *et al.* 2020). *G. typus* is listed as Critically Endangered by IUCN Redlist due to its low biological productivity and the high value of its fins, which leads to extreme fishing pressure (D'Alberto *et al*. 2019; Jabado 2019; Kyne *et al.* 2020). However, populations in the Australian portion of its range are not so threatened, there being no extreme fishing pressure (Kyne *et al.* 2019) and the species being at least locally abundant (e.g. Vaudo & Heithaus 2009). The relative abundance of these animals in this portion of their range may provide an opportunity to see how their populations function in the absence of intense anthropogenic disturbance. Two nursery grounds have recently been identified in Australia (Cerutti-Pereyra *et al.* 2014; Freeman 2019) and there are likely more unidentified nursery grounds in northern Australia.

Here, we present data from nearshore surveys conducted on Heron Island that suggest this coral cay likely serves as another nursery ground for Giant Shovelnose Rays. We present habitat characteristics commonly used by newborn and YOY rays and propose the use of these data to determine foci for future conservation efforts in regions where this species is imperiled.

## Methods

Heron Island (23º27'S, 151º55'E) is a small coral cay (0.29 $km^2$) situated in the southern Great Barrier Reef in Queensland, Australia, in the Capricorn-Bunker group. The site is characterized by a semidiurnal tidal cycle with a tidal range of 3 m and encompassed by a 27 $km^2$ reef platform with lagoons. The shoreline habitat around the entire island is mainly sand flats with some rock rubble, rock outcrops, and an occasional small coral head. In preliminary surveys of the island, we observed both adult and juvenile Giant Shovelnose Rays (*Glaucostegus typus*) in the shallows around Heron Island (Fig. 1). Adults and medium-sized individuals were observed congregating near the jetties, and juveniles were concentrated in ankle-deep water.

**Figure 1. Newborn Giant Shovelnose Ray (*Glaucostegus typus*) in shallow water (scale in cm).** Photo by Leo Gaskins.

To quantify newborn Giant Shovelnose Rays' use of shoreline habitat on Heron Island, we conducted replicate shoreline surveys around the entire perimeter of the island in shallow water (< 0.5 m depth) (Fig. 2). Each survey consisted of a 4 m wide belt transect encircling the island, a distance of 2.29 km. Our survey did not include the reef flat itself. Whole-island shoreline transects were conducted during both the day (n = 14) and night (n = 14), beginning within 90 minutes of the low tide. Surveys were conducted over two years, from March 29 to April 2, 2019, and from January 26 to March 2, 2020. A total of 4 day and 5 night surveys were conducted in 2019, and 10 day and 9 night surveys conducted in 2020. We surveyed the entire island perimeter because juvenile ray distribution was highly patchy. The starting point of each transect varied to avoid sampling bias. In each transect, we counted and measured all Giant Shovelnose Rays observed, carefully hovering a ruler overtop of the body of the ray to determine body length. If an individual was not stationary, we waited until it moved in-between two visual markers (e.g. rocks, dead coral), which we used as a reference to measure ray length. Shovelnose rays that stayed within the transect were visually tracked as the observers walked to avoid double-counting animals. However, most shovelnose rays either swam behind observers or out of the transect area after being counted. No animals were caught or directly handled. For each animal, we recorded the time of observation as well as the depth of the water where the animal was observed. As the newborn length for this species is 38–40cm (Last *et al.* 2016), anything under 40 cm was considered to be a newborn. The size range for YOY is not yet officially designated by the literature. Transects were only completed under fair weather conditions when visibility was not compromised by wind or rain. At night, observers used headlamps to increase visibility of shovelnose rays.

Data were analyzed in R (R Development Core Team 2019). Differences in the number of individuals observed per survey by time of day (day/night), year (2019/2020), and the interaction of these factors, were tested using a two-way ANOVA followed by a Tukey HSD test for pairwise comparisons. Data were square-root transformed to meet the requirements for normality and homogeneity of variance of these statistical tests.

**Figure 2. Shallow water habitat around Heron Island, Australia, where Giant Shovelnose Rays (*Glaucostegus typus*) were found.** Photo by Leo Gaskins.

## Results

In 2019, a total of 55 Giant Shovelnose Rays were encountered in nine whole-island surveys. The average total length (TL) of rays was 38 cm (n = 55, standard error (SE) = 0.8) with a range of 27–59 cm. There was not a statistically significant difference between animals overserved day and night in 2019, likely because of the low sample size for day surveys in 2019 ($p = 0.184$). On average, two shovelnose rays (n = 8, SE = 0.7) were observed on daytime transects, with a range of 0–5 individuals and a density of two individuals per ha. At night, we encountered an average of nine shovelnose rays (n = 47, SE = 0.4) with a range of 5–13 individuals and a density of ten individuals per ha. The average depth at which these shovelnose rays were encountered was 14 cm (n = 55, SE = 1).

In 2020, we encountered a total of 497 Giant Shovelnose Rays in 19 whole-island surveys. The average TL of rays was 38 cm (n = 497, SE = 0.1) with a range of 29–47 cm. Giant Shovelnose Rays were more commonly seen during night surveys than during day surveys in the second year ($p < 0.0001$). On average, nine shovelnose rays (n = 94, SE = 1) were observed on daytime transects, with a range of 0–25 individuals and a density of ten individuals per ha. At night, we encountered an average of 45 shovelnose rays (n = 403, SE = 0.8) with a range of 23–71 individuals and a density of 49 individuals per ha. The average depth at which these shovelnose rays were encountered was 16 cm (n = 497, SE = 0.3).

Abundances of shovelnose rays were not significantly different between years during the day ($p = 0.30$) but were significantly more abundant at night in 2020 ($p < 0.001$). This could be related to the difference in months in which the surveys were conducted as the 2019 data were taken in late March and April and the 2020 data were taken from January to early March. The interaction term between year and time of day was not significant ($p = 0.058$).

Across both years, we observed a total of 552 Giant Shovelnose Rays in 28 whole-island surveys. The average length of rays was 38 cm (n = 28, SE = 0.8) with a range of 27–59 cm (Fig. 3). Giant Shovelnose Rays were more commonly seen at night ($p < 0.0001$) (Fig. 4). On average, seven shovelnose rays (n = 102, SE = 0.9) were observed on daytime transects, with a range of 0–25 individuals, a density of eight individuals per ha. At night, on average 32 shovelnose rays (n = 450, SE = 1) were encountered with a range of 5–71 individuals, a density of 35 individuals per ha. The average depth at which these shovelnose rays were encountered was 16 cm (n = 552, SE = 0.3).

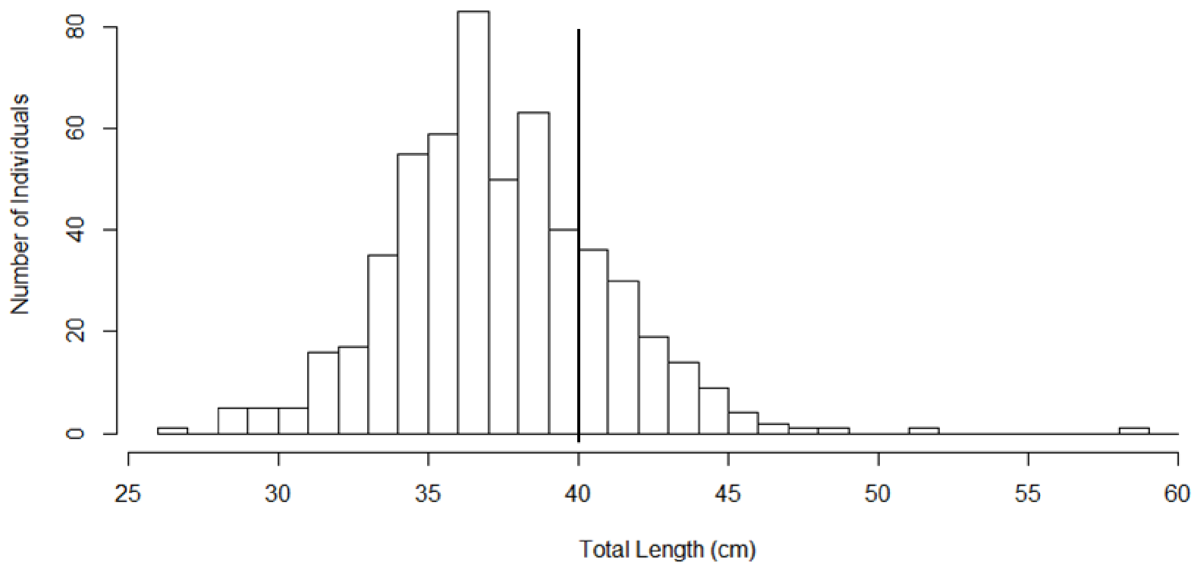


**Figure 3. The range and frequency of Giant Shovelnose Ray total lengths (TL) of all individuals encountered in transect surveys of shallow water on Heron Island (n = 552) in 2019 and 2020.** The vertical black line represents the cutoff size for Giant Shovelnose Rays that are considered newborns at 40 cm (Last *et al.* 2016). Thus, 79% of individuals measured are considered newborns.

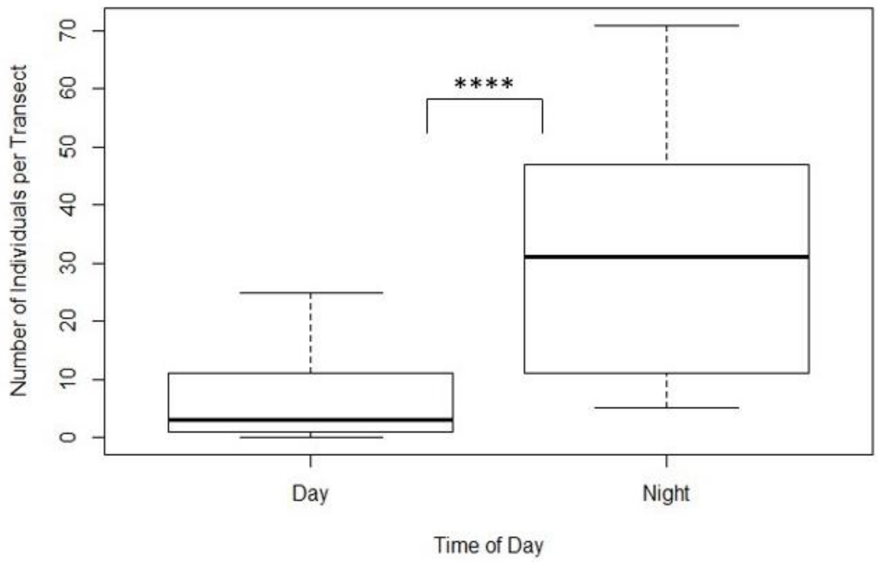


**Figure 4**. **The number of giant shovelnose rays observed during night and day transects for the two survey years combined.** The four stars indicate that shallow water use was significantly higher at night ($p < 0.0001$).

## Discussion

Our replicated nearshore surveys indicate that Giant Shovelnose Rays (*Glaucostegus typus*) newborns use sandy and rock rubble habitats adjacent to tidal reef flats at extremely shallow depths, averaging only 16 cm. Since shovelnose rays are dorsoventrally compressed, they may use these extremely shallow waters as refugia, as other ray species commonly do (Davy *et al.* 2015; Last *et al*. 2016). This behaviour likely provides safety from natant predators such as Lemon Sharks (*Negaprion acutidens*) (White *et al*. 2004), Blacktip Reef Sharks (*Carcharhinus melanopterus*), Grey Reef Sharks (*Carcharhinus amblyrhynchos*), and Tiger Sharks (*Galeocerdo cuvier*) (Heupel *et al*. 2018) at a young age, especially at night when they were more commonly observed in shallow shoreline waters (Fig. 4). This finding is consistent with other elasmobranch studies, which show YOY use shallow waters throughout the day, presumably to avoid predation (Davy *et al.* 2015; George *et al.* 2019).

In previous studies of habitat features used by juvenile Giant Shovelnose Rays in Australia, rays were found most commonly in shallow waters in mangroves, the unvegetated regions directly adjacent to mangroves (White & Potter 2004; H.M. Penrose unpublished data in Nagelkerkin *et al*. 2008; Cerutti-Pereyra *et al*. 2014; White *et al.* 2014), or sandflats (Vaudo & Heithaus 2009; White *et al.* 2014; Freeman 2019). Our findings are consistent with these studies of young Giant Shovelnose Ray habitat preferences and highlight the importance of shallow water habitats for the conservation of these critically endangered animals.

These findings also underscore the value Heron Island has as a protected region within the southern Great Barrier Reef, and suggests that its nearshore shallow water habitats are a previously unknown nursery ground for Giant Shovelnose Rays. This study provides evidence of multi-year use by YOY individuals, fulfilling one of the criteria (Heupel *et al.* 2007; Martins *et al*. 2018) for designation as a nursery ground. While we did not explicitly survey other habitats around the island, in the cumulative 2 months we spent on Heron Island across two years, we never saw newborn-sized individuals in any other regions of the island. Comparative surveys of multiple island-adjacent habitats are needed to test the efficacy of this observation. Although this study did not examine the residence time of young shovelnose rays in the nearshore habitats we surveyed, the abundance of predators (Heupel *et al.* 2018) in deeper waters suggests that these newborn rays may stay in shallow shoreline waters for long periods of time. Tracking young animals via acoustic tagging would help to determine if they remain in shallow regions exclusively or venture into deeper water habitats.

We encountered 552 shovelnose rays in our surveys with an average size of 38 cm, with 79% of individuals less than 40cm. Since shovelnose rays of 38-40cm have been identified as newborn individuals (Last *et al.* 2016), most of the individuals in our surveys were likely YOY, or fish under one year of age. These survey data suggest that the definition of newborn-sized giant shovelnose rays needs to be expanded to include smaller sizes, as we measured individuals as small as 27 cm in length. Currently, there is no size range defined for YOY individuals. Because nursery designation criteria refer to YOY elasmobranchs, further studies need to be done to define YOY size for Giant Shovelnose Rays, which would also help standardize life history data reporting across *G. typus* research.

The pupping season of this species is also not currently well-defined, but pups were consistently found across all our survey months on Heron Island. We found a higher concentration of *G. typus* in 2020 when our surveys were conducted between late January and early March, than in 2019 when surveys were done in late March to early April. Though we cannot make sweeping conclusions based on our limited data, the difference in timing could account for the abundance differences observed between these years. Given the strong policies already in place on Heron Island, these newborn Giant Shovelnose Rays are well-protected in this location. Places like Heron Island can act as a conservation guide for Giant Shovelnose Rays in those regions where they are dwindling.

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