

## BRIEFING NOTE SERIES

New insights into ray movement and conservation

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*Objective – A briefing note aims to provide a concise outcome based synopsis of recent research or expert opinion that may inform decision making and activities by authorities, NGOs and NPOs. The briefing note series complements the academic peer reviewed literature published by SAIAB.*

## 1) Rays in a global context

Rays are a cartilaginous group of fishes closely related to sharks. Indeed, the term ‘flat sharks’ has often been applied to this group given that they share many characteristics with sharks. However, rays are more diverse than sharks, comprising 26 families and at least 630 species. They range greatly in size, from 25 cm to over 6 m disc width, and shape, from completely circular bodies of some stingrays to elongated ‘shark-like’ bodies of the guitarfishes. Despite this variability, the defining characteristics of this group are that they are dorsoventrally flattened (i.e. compressed on the top to bottom axis). Their bodies are modified into a disc by the complete or partial fusion of the pectoral fins with the head and trunk, and they have gill slits underneath their bodies and eyes on top of their bodies (see Figure 1).

Rays also occupy a wide variety of habitats, from shallow freshwater rivers to deep ocean basins, and are distributed throughout the world’s oceans, barring the polar regions. Their flattened bodies are perfectly suited for life on the seafloor where they often rest and feed. However, some species have enlarged and muscular pectoral fins which they use to actively swim in the pelagic (i.e. open water) environment above the seafloor. Consequently, species may either be fully benthic (living on the seafloor) or semi-pelagic (swimming in the water column and not resting on the seafloor).

Rays can be relatively abundant and make up a significant portion of a community’s biomass in certain ecosystems, thereby playing critical ecological roles. One of their major ecological roles is often that of ‘ecosystem engineer’. Most ray species feed on the invertebrate community living in the sandy benthos and when they hunt for these invertebrates, they excavate and turn over large volumes of sediment, oxygenating and keeping the physical benthos healthy. Their second major ecological role is that of ‘mesopredator’. Rays hunt for prey and in turn are also hunted by larger marine animals, such as sharks, thus sitting in the middle of, and providing crucial links in, many ocean food webs.

Rays are also of economic and social importance around the world, caught in many different commercial, subsistence and recreational fisheries (either intentionally or as by-catch). This heavy exploitation, in combination with their biology of low reproductive potential, has resulted in many species being listed in one of threatened categories on the IUCN Red List of Threatened Species. In fact, a recent global assessment found 36% of all ray species to be threatened with extinction, making them one of the most imperiled animal groups across both ocean and land systems. Unfortunately, despite their high ecological and fishery importance and highly threatened conservation status, they remain one of the most under-researched animal groups, with many aspects related to their biology and ecology unknown, severely hampering management and conservation strategies.



**Figure 1:** The diversity of rays with the top images showing traditional benthic stingrays and the bottom images showing muscular semi-pelagic rays. Image credit: Rainer von Brandis

## 2) Rays in a local context

Many of these global themes are relevant and amplified in a local southern African context. This region is home to a relatively large portion of the global ray diversity, having 17 families and 72 species (more than 10% of the global number), making it a global hotspot. Many of these rays are impacted by local fisheries. They are either taken as by-catch in commercial fisheries or targeted by recreational beach anglers, especially during fishing competitions. Whilst the latter is generally catch-and-release, the levels of post-release mortality remain unknown. In terms of the conservation status of South African rays, a high percentage are listed as Data Deficient (38.7%) or threatened (26.7%) by the IUCN Red List of Threatened Species. Finally, local research efforts are even more limited than on the global scale, with only one dedicated study historically existing on one species, the blue stingray *Dasyatis chrysonata*. This lack of research effort means we do not have answers to even the most basic biological and ecological questions for all of the ray species that occur along our coastline.

### 3) The importance of movement and habitat use information in conservation

It cannot be argued that there is a need for directed and appropriate management and conservation efforts for South Africa's ray species. At present, the only management and conservation measures that South Africa employs for rays is that of spatial protection measures (i.e. Marine Protected Areas, MPAs). However, the success of this approach hinges on correctly matching the spatial scale of individual movements to the scale of MPA's, and ensuring that important habitats, critical to the persistence of a species, falls within these MPAs. The integration of movement and habitat use information into management and conservation planning has proven successful in multiple locations around the world. For rays, these important habitats either function as feeding, resting, breeding or nursery grounds and the delineation of these important habitats is necessary in order to protect them. However, given the lack of research on rays in South Africa, none of this information has historically been available. For no species was there information on how far individuals can travel, whether they are resident to specific areas, whether they make migrations, or what areas could be considered as important habitats. This has dire consequences as it rendered the only management and conservation measures in South Africa (spatial protection) somewhat redundant.

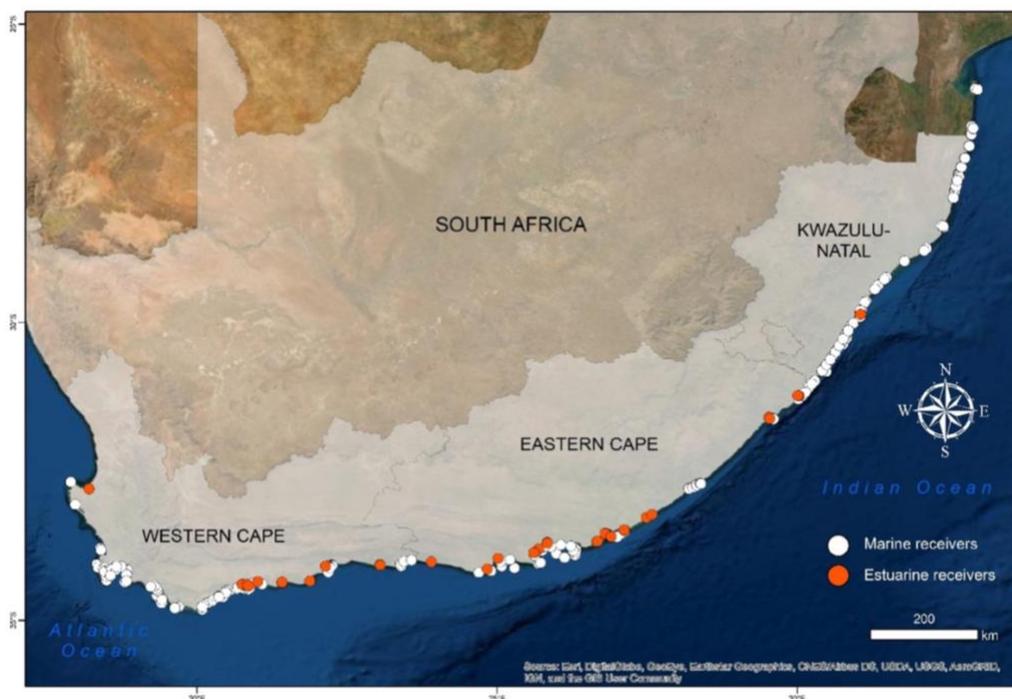
There are multiple ways to study the movement behaviour of marine animals, however, passive acoustic telemetry has become one of the most common approach in recent decades. This technology consists of two parts – an acoustic transmitter that is either attached externally to an animal or surgically implanted within the animal and an acoustic receiver. The transmitters emit uniquely coded pulses of noise that are picked up by acoustic receivers, which are stationed at pre-determined locations in the ocean, moored to the ocean floor, and passively listen for the acoustic signals emitted by the transmitters. In this way, when a tagged individual swims within range of an acoustic receivers (usually within 300m), we know when and where that individual was.



**Figure 2:** An acoustic receiver being moored in the marine environment, and a tagged stingray swimming next to a receiver, allowing us to determine when and where that individual was. © Ryan Daly and Rainer von Brandis

#### 4) Tracking rays in South Africa

To start addressing these dire knowledge gaps, the Acoustic Tracking Array Platform (ATAP – a national collaborative network of passive acoustic receivers) has been tagging and tracking the movements of rays since 2016. Tagged animals have been monitored by a network of ~ 179 moored acoustic receivers spanning ~ 2 200 km of the South African coastline, from St Helena Bay in the Western Cape Province to Ponta do Ouro at the South Africa/Mozambique border. Receivers are located in coastal bays, along coastal shelves and in estuaries, allowing us to understand 1) coastal habitats that are important to rays, 2) fine-scale movements in specific habitat types, 3) large-scale annual migrations, 4) movements in relation to MPA boundaries, and 5) the influence of the environment on movement and habitat use.



**Figure 3:** The Acoustic Tracking Array Platform (ATAP), with acoustic receivers in marine and estuarine habitats from the west coast of South Africa up into Mozambique, that was used to track the movements of rays. © Taryn Murray, ATAP

Among many other species, one hundred individual rays, spanning three endemic or threatened species, have been tagged by ATAP and have had their movements interrogated:

- 42 blue stingrays *Dasyatis chrysonota*, regionally endemic, IUCN status of Near Threatened,
- 33 diamond rays *Gymnura natalensis*, regionally endemic, IUCN status of Least Concern,
- 25 duckbill rays *Aetomylaeus bovinus*, IUCN status of Critically Endangered.

This has allowed us to gain numerous insights into the ecology of these animals, and various implications for management have been uncovered. This is illustrated below in three different case studies.

### Case study 1: Population delineation and MPA use

Blue stingrays are endemic to southern Africa, occurring from Angola through to the KwaZulu-Natal coastline. They are listed as Near Threatened on the IUCN Red List of Threatened Species with a declining population trend. They are considered to be a medium-sized (up to 75 cm disc-width) benthic species that are known to occur in shallow inshore habitats (bays, estuaries and sheltered sandy beaches) during the summer. However, their winter habitat use and potential migration and habitat connectivity pathways remained unknown. Consequently, blue stingrays were tagged in the south-east and south-west regions of the South African coastline and monitored for up to 4.5 years. Individuals displayed attachment to defined areas of the coastline, with the majority of detections occurring in the shallow habitat they were tagged in. However, individuals left these areas and travelled significant distances (up to ~500 km) during winter months, and important movement corridors between inshore and offshore habitats, and between coastal bay and shelf habitats were identified. This represented the first example internationally of a benthic stingray species being tracked on a large spatial scale, and it challenged pre-conceived notions that these types of stingrays cannot travel far distances. It also highlighted for the first time that these species may be important in linking different habitats. Furthermore, the individuals tagged in the western and eastern regions of the south coast did not overlap in their space use, suggesting there may be spatially isolated sub-populations along our coastline, an important consideration for management. Finally, individuals tagged in Algoa Bay were most often detected just outside of the borders of the MPA in the bay, suggesting the current MPA zonation in this bay may be insufficient to protect blue stingrays from further population declines.



**Figure 4:** The blue stingray *Dasyatis chrysonota*, and surgically implanting an acoustic transmitter into the abdomen of a blue stingray restrained on a PVC sheet. © Helen Walne

### Case study 2: Estuaries as important habitat types

Estuaries are known to be important habitat types to rays throughout the world, for example in Australia, New Zealand, and the United States of America. In South Africa, while rays have been anecdotally reported to occur in estuaries, their reliance on this habitat type had not yet been investigated. This is a dire oversight as estuaries and their inhabitants are often the most negatively impacted by human activities, given their close proximity to human populations. Habitat loss through infrastructure development, changes in water dynamics, pollution and intense fishing pressure are all common threats faced by estuarine sharks and rays. Furthermore, although some estuaries are included in MPAs, specific attention on their protection has been lacking. Therefore, if these are important habitats to elasmobranchs, it represents a significant oversight in conservation efforts.

Diamond and duckbill rays were two of the species anecdotally recorded to occur in estuaries, and as such, 58 of these rays were tagged in coastal and estuarine habitats. Only six of these tagged rays (4 diamond and 2 duckbills) were recorded using estuaries, representing a small portion of tagged individuals, but estuaries were found to be very important to these individuals. They were resident to estuaries from spring – autumn, and returned to one specific estuary (Breede Estuary) every year for up to 6 years after making a winter migration out of the estuary. Furthermore, 15 blue stingrays were tagged in Knysna Estuary and were resident to this estuary during spring – autumn. Most tagged individuals were pregnant females, suggesting this is a critical habitat for reproductive purposes. A separate study which did not use acoustic telemetry, but used a combination of survey techniques to sample the Keurbooms Estuary weekly over a period of two years, found juvenile common eagle rays *Myliobatis aquila* (IUCN status: Critically Endangered) were present in the estuary every month. This suggests the estuary may be functioning as a nursery habitat, which is critical to the survival and growth of juveniles into sexual maturity. All of these examples illustrate that while not all individuals in a species may rely on estuaries, these are very important, and historically overlooked, habitats to sub-populations of at least four stingray species in South Africa. This highlights that estuaries need to be taken into account when spatial planning is underway, and that certain estuaries should be granted protection.



**Figure 5:** A juvenile common eagle ray *Myliobatis aquila* in the Keurbooms Estuary and a pregnant blue stingray female *Dasyatis chrysonota* in the Knysna Estuary, highlighting estuaries are critical habitats to a number of different ray species in South Africa. © Melissa Nel and Helen Walne

### Case study 3: Seasonal migration routes

While the 58 tagged diamond and duckbill rays mentioned in the previous case study were seasonally resident to estuaries and coastal bays, individuals left these areas and were found to make winter migrations. Individuals travelled significant distances, up to ~1200 km away from their tagging locations in winter months. Individuals tagged on the western portion of the south coast travelled to the border of the south and east coast, while those tagged on the eastern portion of the south coast travelled all the way to the east coast. This is the first evidence showing that rays migrate along the South African coastline, and highlights important eastward winter migratory routes. The reason behind these migrations remain unclear, but it might be related to reproduction, where individuals travel east to mate and pup. It also highlights that individuals are vulnerable to capture along these migrations, as they travel outside the boundaries of MPAs.



**Figure 6:** Tagging diamond rays *Gymnura natalensis* and duckbill rays *Aetomylaeus bovinus* with acoustic transmitters so their movements along the South African coastline can be determined.

## 5) Conclusions and implications for management and conservation

All three of these case studies reveal new insights into the movement ecology of rays: 1) all species tagged show site fidelity, returning to the same, very specific, areas on the coastline after winter absences, 2) estuaries are an important habitat type to sub-populations of a number of different ray species, 3) the blue stingray, a benthic species, appears to be more spatially constrained than its semi-pelagic counterparts (diamond and duckbill rays) and so may be constituted of spatially isolated sub-populations, and 4) more mobile rays (diamond and duckbill rays) travelled significant distances on winter migrations, thus being important agents in linking different ecosystems.

Finally, given all of these insights, it is unlikely that the current spatial zonation of MPAs is sufficient to protect these rays from further population declines. Despite the importance of estuaries, very few are provided any spatial protection, blue stingrays spend most of their time outside the boundary of the MPA in Algoa Bay, and individuals are vulnerable to capture whilst on their migration routes. Either MPAs need to be redesigned taking these factors into account, or the management and conservation of rays needs to be part of a broader assessment-based fisheries management strategy. Finally, given the emerging evidence for both inter- and intra-specific variability in the movement patterns of rays, it is necessary to continue research on a broad number of species across different locations, especially in data-deficient areas like South Africa.

## 6) Recent papers for noting

Elston, C., Murray, T.S., Parkinson, M.C., Filmlalter, J.D., Cowley, P.D. (2023). Female diamond rays *Gymnura natalensis* and bull rays *Aetomylaeus bovinus* display seasonal philopatry to South African estuaries. *Estuaries and Coasts*.

Murray, T.S., Elston, C., Bennett, R.H., Childs, A-R., Cowley, P.D. (2023). Movement patterns and underestimation of the maximum age of a Vulnerable endemic guitarfish species inferred from mark-recapture studies. *African Journal of Marine Science* 45(2).

Faure-Beaulieu, N., Lombard, A.T., Olbers, J., Goodall, V., da Silva, C., et. al (2023). A systematic conservation plan identifying critical areas for improved chondrichthyan protection in South Africa. *Biological Conservation* (284).

Elston, C., Cowley, P.D., Murray, T.S., Parkinson, M.C. (2022). Novel insights into the coastal site affinity and habitat connectivity of a benthic stingray with implications for management. *Biodiversity and Conservation* (Nov 2022).

Murray, T.S., Elston, C., Parkinson, M.C., Filmlalter, J.D., Cowley, P.D. (2022). A decade of South Africa's Acoustic Tracking Array Platform: An example of a successful ocean stewardship program. *Frontiers in Marine Science* (May 2022, Vol 9).

Elston, C., Murray, T.S., Parkinson, M.C., Cowley, P.D. (in prep). Diamond *Gymnura natalensis* and duckbill rays *Aetomylaeus bovinus* seasonally migrate along the South African coastline.

Elston, C., Murray, T.S. (in prep). Multi-method approach reveals South African estuary to be an important elasmobranch habitat and potential nursery.

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