



# MARINE MEGAFUNA FOUNDATION

## AN OVERVIEW OF ANTHROPOGENIC THREATS & RECOMENDATIONS IN THE GREATER VILANCULOS AREA

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Herein we provide an assessment of the anthropogenic threats present within the Greater Vilanculos Area, with special emphasis on the Bazaruto Archipelago National Park (BANP). The threats were identified through a combination of direct observations and reports of detrimental activities occurring within the region. They can be summarised as the overexploitation of fish stocks, cryptic anthropogenic threats, and habitat degradation.

### ***Overexploitation of fish stocks***

Coastal communities across Mozambique heavily rely on marine resources as their primary source of protein and income. Local communities within the BANP and it's surrounding areas are particularly reliant on the ocean and are largely composed of fishermen and marine harvesters. As early as 2000 it was suggested that fish stocks in Southern Mozambique, including those within the BANP, were nearing overexploitation (Pereira, 2000). This is reflected in the recent shift towards non-selective fishing methods such as longlines, gillnets, and purse-seine nets. Such indiscriminate methods threaten not only the local food supply and the general health of regional ecosystems, but economically important marine megafauna species. A study on artisanal fishing on Mayotte Island, Mozambique Channel, found that nets were primarily responsible for reported catches of marine mammals (dolphins and dugongs). Furthermore, sea turtles caught in nets had 33% higher mortality in comparison to those caught in handlines (Pusineri & Quillard, 2008).

Non-selective fishing methods have been widely demonstrated to be the most destructive, depleting the marine resources upon which communities are heavily reliant. Gill and seine netting are common fishing methods within the Greater Vilanculos Area and are often used

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within the BANP boundaries. It is not uncommon to hear of entire reefs being depleted of fish after intensive net fishing bouts. Continuous pressure on certain sites can prevent the proper recovery of stocks as well as serially depleting resources and shifting entire ecosystems out of equilibrium.

Fishing gear, such as longlines and gill nets, are also employed to unsustainably remove large quantities of marine megafauna including several species of shark, sea turtle and ray. Targeted shark fishing utilising these methods is increasingly common in southern Mozambique causing catastrophic effects to local reefs due to reductions in predator abundance. Large schooling rays, such as devil and cownose rays, are also frequent targets of this equipment. Due to the devastating effectiveness of this precision-catching, hundreds of animals are removed from the BANP and it's surrounding areas in a single fishing bout.

Seine nets are regularly and intensively utilised in the region to harvest small fish and benthic species (e.g. crustaceans, molluscs, echinoderms etc.) from intertidal mudflats and estuaries. The level and impact of unregulated harvesting of these animals remains largely unquantified. These species represent a significant portion of coastal marine food webs and so their overexploitation results in trophic cascades that alter the composition and structure of a habitat's community. For example, bivalve molluscs often lend structural integrity to the benthos through the formation of thick shellfish beds and mats (Bruno & Bertness, 2001; Crooks, 1998), decreasing the physical reefs' susceptibility to damage during extreme conditions (Crooks, 1998). Motile, burrowing benthic organisms also play an important role by creating complexity in the physical structure of the seafloor. Through bioturbation, they aerate the sediment, forming ecologically valuable nutrient gradients within the water column. As nutrients diffuse into the pelagic system, they are consumed by primary producers, which are an important food source for zooplankton (Coleman & Williams, 2002). Due to this, over-harvesting of benthic animals can limit the food available for filter feeding megafauna such as manta rays (*Manta* sp.) and whale sharks (*R. typus*). As well as causing indirect impacts, many of these intertidal species are important prey items for several species of ray and teleost fish.

The regional collapse of fish stocks may be driving the poaching of species that are becoming increasingly difficult to catch with traditional methods (e.g. rods and reels). Expansions of coastal communities, coupled with the rise in demand for red meat protein, place continued

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pressure on a suite of threatened species from sea turtles to dugongs. Concurrently, resources that are becoming increasingly scarce due to over-exploitation in areas where fishing is permitted has led to poaching in protected areas, e.g. sea cucumber and lobster harvesting of the BANP. Equally, species deemed undesirable in the past, like sharks and manta rays, are now being unsustainably targeted due to rapidly increasing demands from foreign nationals seeking to export their products abroad.

The implementation of elementary fisheries management can potentially increase fish catch by 40% (Costello et al., 2012). Education should be the primary mechanism utilised to counteract the pervasive use of non-selective methods. The establishment of management, when combined with recruitment from no-take zones, should increase fish stocks to pre-exploitation levels allowing for continuous sustainable harvests. The establishment of no-take zones has been shown to enhance fish stocks by up to 446% (Lester et al., 2009). To replicate this for BANP reefs systems, current levels of protection can be made more comprehensive by extending no-take zones to include additional reefs, developing science-based seasonal fisheries closures, and having stricter enforcement. We also recommend substantial fines for any individuals removing any of the species described within the BANP threatened species list. Marine megafauna are particularly susceptible to population declines and local extirpations can occur swiftly. Whilst they exhibit a range of life history strategies, they tend to have a long life span, late maturity and low reproductive output (Lewison et al., 2004). Typically, the high rates of survival of sub-adult and juvenile individuals offset this low fecundity, although this makes their populations particularly susceptible to population declines when targeted (Frisk et al., 2001). As top predators in the ecosystem, serious top-down trophic cascades can occur as a result of overharvesting.

Community fisheries management should be supported through the establishment of exclusive-access areas for community fishers. Adjacent no-take zones should actively feed these areas, allowing fish stocks to be continually replenished via recruitment from within the protected areas. Workshops should be conducted with the C.C.P. members to increase their capacity for management. Methods of management presented to communities should include a rotation of fishing grounds, the identification and protection of nursery habitat, and catch regulations preventing the removal of juveniles or gravid females. Upon completing a workshop, individuals then receive permits to operate within their area. This should be

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continually checked by park officials to discourage fishing by non-local communities. The intertidal areas that communities presently exploit should be identified and sectioned into quadrants. The quadrants should be rotated every six months, with two made available for simultaneous exploitation. Additionally, a no-take zone should border the quadrants allowing consistent stock replenishment.

The types of fishing gear employed within the park require regulation and enforcement. Indiscriminate methods such as gill nets, longlines with long soak times, and seine nets are not appropriate or sustainable due to their extensive detrimental impacts on the ecosystem and incidental capture of non-intended or desired items. A shift toward more traditional fishing methods should be encouraged, within at least the park boundaries, with increased numbers of hand line fishermen, marine gathering of specific food items, crab and lobster pots, and small marine farming projects.

Sport fishing is one of the largest drivers of marine tourism in the region, however it is inadequately controlled. Currently anyone can purchase a daily fishing permit meaning that the pressure on pelagic fish such as marlin, sailfish, tuna, trevally, kingfish, queenfish, king mackerel, and cobia can be intense as they are heavily targeted. Currently there are no sustainable guidelines or restrictions for visiting fishermen such as daily catch limits. Often sport fishermen compete with their artisanal counterparts to supply local restaurants, or export large quantities of fish for sale in their home country. Again, similar to their artisanal counterparts, sport fishermen are often observed bottom fishing though it is prohibited within the park. While a small portion of the fishermen use more sustainable gear and practice catch and release, many others do not. Sport fishing tournaments are particularly destructive as they target fish in their prime season, within their critical habitats, due to the regularity of landings in these locations. Both artisanal and sport fishing frequently result in lines, nets, and anchors being discarded on reef systems. We have observed the resultant ghost fishing to be highly prevalent within the park. Such discarded items present a significant risk of entanglement to megafauna species, which often leads to drowning or suffocation. At best they are left with a series of wounds that seriously impair their fitness.

Sport fishing requires additional regulation. Bag and catch size limits should be implemented following recommendations from targeted scientific studies. Such limits should vary between

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species, seasons, areas of the park, and boat size. The types of fishing gear permitted within the park should also be strictly controlled (e.g. circle versus treble hooks). Additionally, every fishing boat operating within the park should have a Mozambican onboard with a guiding license. In order to obtain such a license, individuals will have to pass a course focusing on sustainable practices. Whilst this may appear heavy handed, we believe it would create sustainable jobs, benefit local communities, and decrease the prevalence of foreign nationals leading fishing expeditions. Further, it would decrease the numerous accounts of tourists claiming ignorance to the parks regulations.

Whilst we note the logistical difficulty of the task, efforts need to be made towards the quantification of landings. Ten mandatory landing sites could be created within the park allowing catch composition to be checked and monitored. This would reduce the number of rare marine fauna being removed from the park, and provide information critical to the modeling of the park's marine populations and subsequent exploitation limits. To estimate the levels at which intertidal areas are being exploited, several landings assessments should be conducted annually, providing invaluable feedback on the success of the proposed management strategies.

Whilst the problems associated with unsustainable artisanal and sport fishing cannot be underestimated, a more pressing concern is the regular sightings of commercial fishing vessels around the BANP park boundaries, with increasing sightings within the park itself. The primary method used by these boats are midwater or benthic trawls, and longlines. Whilst they may not always be targeting marine megafauna, bycatch from both small and large scale commercial fisheries has been identified as a significant driver of megafauna population declines both globally (Lewison et al., 2004; Read et al., 2006) and in the southwest Indian Ocean (Amir et al., 2002). In addition to the direct impact of indiscriminate fishing methods on megafauna, it has been found that overexploitation of smaller prey fish can impact the abundance of larger predators (Bearzi et al., 2006). Vessels in the BANP have been sighted at Bazaruto Point, Lighthouse Reef, Dolphin Bay, Sailfish Bay, Two Mile Reef, and the San Sebastian Peninsula. Even if they are only operating periodically in these areas, they are likely causing significantly detrimental impacts to the ecosystem.

The presence of commercial fishing vessels within the park boundaries should be immediately terminated and subsequent breaches strictly punished. Vessels should be informed that their presence within the park is not tolerated. To further enforce this, we recommend that a social

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media group be created for the park as a means for local stakeholders to report observations of inimical activities directly to rangers. The continued operation of these vessels within the BANP would most likely counteract any aforementioned community fisheries management projects and therefore must be addressed as a priority.

### **Cryptic Anthropogenic Threats**

Following on from 2D & 3D seismic surveys in 2006, Sasol Petroleum began well testing as part of their gas exploration project in 2008. They operated a shallow water site off the northwest border of the BANP, and a deepwater site east of Bazaruto Island. The project was deemed unviable after 5 years, as gas reserves were found to be unsuitable for commercial exploitation. Now, new exploration is occurring, reopening the discussions of the potential impacts on the Greater Vilanculos Area's marine ecosystems. The risks associated with such a project include gaseous emissions, noxious fluid discharges, noise disturbance through increased boat traffic, boat strikes and disturbance of the physical structure of the seafloor (Heather-Clark & de Jong, 2009). During the Sasol project, gas leaks were deemed to be unlikely however, the biological and financial consequences of such an event would be damaging enough on both a temporal and spatial scale for this risk to be seriously considered as a potential threat to the area.

Over the last decade, the Inhambane Province has experienced the highest growth of marine tourism in the country. As a National Park, and a mooted world heritage site, the BANP and it's surrounding areas experience high traffic from tourism and local investors as the area increasingly develops. As a result the high volume of boat traffic is a prevalent issue both within the BANP as well as the Greater Vilanculos Area. The most obvious repercussion of boat traffic is an increase in collisions and propeller injuries. Marine megafauna species (sea turtles, dugongs, whale sharks, manta rays etc) are often observed with scars evidently attributable to boat strikes. Whilst recovery from minor strikes is possible, major injuries received from a collision can seriously inhibit an individual's fitness, result in mortality, increase stress levels of individuals, and alter the behaviour of individuals and populations over time (Speed et al., 2008). Boat traffic also increases marine pollution in a region by orders of magnitude. Boats frequently suffer small oil and fuel leaks which, in regions with high volumes of traffic, leads to a sizable deposit residing within the marine environment.

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Another problematic issue associated with high volumes of boat traffic is noise pollution. This is an emerging field of study, the results of which have demonstrated significant detrimental effects on marine animal behaviour (Radford et al., 2012). The most obvious effect is masking the signals of species, primarily marine mammals (e.g. whales, dolphins, dugong), that heavily rely on acoustic communication (Miller et al., 2000; Radford et al., 2014). In response to chronic exposure to anthropogenic sound, they may exhibit two behaviours. One is to respond as if threatened by a predator, leading to increased production of cortisol (i.e. stress hormone), which results in allostatic physiological responses. The other is to avoid areas of high boat traffic, leading to possible displacements of populations from important habitats (Tyack, 2008). Noise pollution is also proposed as a major factor leading to mass strandings, such as the one that occurred within the BANP in 2006. Species that use high frequency sounds in prey or predator detection will be similarly affected. Sharks have been found to approach high frequency and irregular sounds that mimic struggling prey, this would lead to them unnecessarily expending energy and potentially exposing themselves to predation from humans or an increased risk of entanglement (Myrberg, 2001).

In order to mitigate the threat of high volumes of boat traffic within the BANP we propose several recommendations. To limit and control the threat of boat strikes to vulnerable marine megafauna, small modifications should be made to locally registered and permitted boats. Items such as propeller cages can be fitted, reducing the likelihood of serious injury to animals. Slow go and no go zones should be defined and enforced in areas where conflicts between boats and marine animals (e.g. dugongs, turtles) are at their highest. This will avoid altering the short and long-term behaviour of animals as well as their access to critical habitats.

Another cryptic anthropogenic threat to marine life and ecosystems in the Greater Vilanculos Area is recreational marine tourism (e.g. jets skiers, kite surfers, water skiers). Increased numbers of tourists entering the park's waters leads to large deposits of chemicals such as sunscreen that are toxic to marine life. To mitigate these effects within the park, tourism areas should be properly zoned to reduce degradation of critical habitats. Permits for certain recreational activities should be introduced with codes of conduct explained and enforced for all activities conducted within the boundaries of the National Park (e.g. wake boarding, skiing, jetskiing, hover crafts, etc.).

A problem that is present in popular S.C.U.B.A. diving destination around the world is diver damage. At high-use sites, such as Two Mile Reef, the occasional striking of the reef by

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inexperienced divers can lead to a significant depletion of the slow growing coral substrate that forms the basis of many reef ecosystems. A reduction in coral cover is often mirrored with a decline of the abundance and diversity of the reef fish community, particularly those with close coral association (Jones et al., 2004; Komyakova et al., 2013). Coupled with top-down effects of the removal of reef megafauna, this reduces ecosystem stability, which negatively affects the associated community (Hughes, 2009). The presence of divers can also disturb ritualised behaviours of marine life. We have observed the disturbance of animals that are being cleaned, an important behaviour that positively influences health. Evidence has also been found for the long term foraging strategies of fish to be altered at popular dive sites (di Franco et al., 2013). It was observed that when divers disturbed the substrate benthic animals suffered higher levels of predation. As a result, certain species of fish learned to shadow divers with the expectation of higher food intake. Courtship may also be disrupted by diver observation, however this has not yet been extensively studied.

SCUBA diving and snorkeling operators should be required to have operating licensing which mandate staff complete annual training focusing upon sustainable practices. Tourists should be presented with official code of conducts for the sport as well as for reef health and megafauna encounters. Code of conduct briefings fit easily within current pre-tour briefing procedures and have been successfully implemented in Tofo, Inhambane. To minimise disturbances, and increase the ability of dive leaders to control diver behaviour, no more than ten divers should be present on a dive site at one time. Further, dive operators should rotate between dive sites and cease simultaneous tours to the same site. As part of permit obligations, dive centres, can also be responsible for annual reef clean-ups to remove discarded lines and nets from reefs.

### ***Habitat Degradation***

Due to increased terrestrial development along the coast of southern Mozambique, beach areas are suffering a reduction in vegetative cover. Coastal sand vegetation traps and stabilizes sand and so vegetative removal increases the beaches susceptibility to rapid erosion (Purvis et al., 2015). The increased volume of sand being fed into the neighbouring marine habitat can increase turbidity and smother the benthic community, reducing the abundance of a number of species that are important prey items, and more critically it reduces the photosynthetic ability of coral symbionts due to smothering (Manning et al., 2014). Over large

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time scales it also leads to a substrate shift to rock, decreasing the number of suitable nesting sites for the five turtle species native to the BANP (Maison et al., 2010; Spanier, 2010). In order to cease the high levels of beach erosion occurring within the park, coastal development should be prevented on beaches or primary dune systems. Environmental impact studies should be a prerequisite to construction in sensitive habitats (e.g. estuarine or mangrove). Many of these habitats are nurseries for a diverse range of animals and so anthropogenic development within these areas should be limited. Operating a vehicle on a beach should result in strict fines due to the practices high level of habitat destruction.

Coastal development and urbanisation also leads to unnatural levels of light, which has been extensively shown to disrupt turtle nesting behaviour. It also causes females to avoid specific areas of the beach, choosing less ideal (e.g. high predator density) locations in which to nest (Verutes et al., 2014). Additionally, light pollution reduces the sea-finding ability of turtle hatchlings (Witherington & Martin, 2000; Berry et al., 2013). We suggest requirements mandate that all stakeholders on beaches use turtle friendly lights to offset their the impacts on turtle nesting and hatching. Lights should not be directed seaward and those currently existing should be fitted with a shade box limiting the light projected directly onto the beach.

Due to the exceptional variation in building styles and quality there can be many other effects of urbanisation of the waterfront including improper waste disposal. The resultant pollution of waterways eventually transports waste into the ocean. Of particular concern is raw sewage and plastics. Plastics can have serious repercussions on marine life, ensnaring organisms, and leaching toxic chemicals. As they degrade they form microplastics, which can be ingested by all orders of sea life including sea birds, turtles and planktivorous filter feeders (Andrady, 2011).

Few animals can egest microplastics following consumption, and so they accumulate in their stomachs, causing damage to internal organs due to the plastics' associated toxicity (Andrady, 2011; Wright et al., 2013). This reduces their fitness due to the effort expended combating the toxic effects. Regular and rotated beach clean ups can be conducted in partnership with NGO's and children from local communities. These can form a part of larger events designed to educate children on the fragility, and uniqueness, of their surrounding marine ecosystems.

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