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TEN YEARS (2006-2016) OF MONITORING THE EFFECTIVENESS OF THE PONDOLAND MPA IN PROTECTINGOFFSHORE REEF-FISH

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1. INTRODUCTION

Marine protected areas (MPAs) are commonly proclaimed to conserve biodiversity and assist in managing fisheries. MPAs have become increasingly popular, worldwide, to achieve these two primary objectives. Biodiversity conservation has been well entrenched in MPA objectives for many years and is expected to result in localised changes within the boundaries of an MPA. In more recent years, there has been increasing focus on the benefits that MPAs have on adjacent fisheries through spill-over of adult fish and through seeding of eggs and larvae (Roberts et al. 2001).

During 2002-03, the Oceanographic Research Institute (ORI) undertook a sub-tidal marine biodiversity survey of the Pondoland region in the northern reaches of the Eastern Cape, South Africa. This was commissioned by Marine and Coastal Management (MCM) prior to the establishment of the proposed Pondoland MPA. The Pondoland MPA was subsequently proclaimed in June 2004 (Government Notice 694) with the following objectives: 1) "*Protect and conserve marine ecosystems and populations of marine species*"; 2) "*Protect the reproductive capacity of commercially important species of fish, including shellfish, rock lobster and traditional linefish and to allow their populations to recover*"; 3) "*Promote eco-tourism within the Marine Protected Area*". The MPA is broadly divided into an inshore zone and an offshore zone, each having designated no-take zones and controlled use zones. This report is concerned specifically with the offshore zone, which consists of a single large no-take zone and two smaller controlled exploitation zones (Fig 1.).

Management[1] responsibilities for the MPA were not clearly allocated at the outset, and much deliberation took place between national and provincial authorities. In 2008, the national agencyinitially delegated management authority to the provincial agency for a portion of the MPA (between Mtentu and Lupatana) but later in 2011 the provincial agency was delegated responsibility for management of the entire Pondoland MPA.

Following proclamation of the MPA, ORI was contracted by MCM through the provincial MCM/NRF funding route, to assist with the development of a monitoring programme, which commenced in April 2006. Monitoring programmes in MPAs are necessarily a long-term commitment and should ultimately be the responsibility of the MPA management authority concerned. However, in the case of the Pondoland MPA, because initial responsibilities were not clearly allocated between national and provincial management agencies, ORI designed this monitoring programme to provide the initial framework for monitoring MPA effectiveness and to assist with the implementation of the management plan for this MPA. This included the provision of appropriate staff training and aimed to build linkages with other MPA training initiatives such as the WWF-SA MPA training programme.

In early 2007, a three-year contract was signed between ORI and MCM to continue this project in terms of direct transfer payments. In March 2009, the contract with MCM ended and it was indicated that no further funding would be made available. As a result, a new one-year renewable contract was established between ORI and the Eastern Cape Parks and Tourism Agency (ECPTA) with funding initially provided by the Wild Coast Project and later by DEA for ongoing monitoring of the Pondoland MPA. After 10 productive years, during which 40 research fishing field trips and various other diving trips were conducted, no further funding was available to continue this project. The Pondoland MPA monitoring project was therefore terminated in February 2016.
In order to monitor the effectiveness of the MPA, ORI developed a long-term monitoring project in line with one of the stated objectives of the Pondoland MPA, which is, "*To protect the reproductive capacity of commercially important species of fish, including shellfish, rock lobster and traditional line-fish and to allow their populations to recover*". As such,ORI's monitoring of the Pondoland MPA has focused specifically on its contribution to the rebuilding of commercially important line-fish resources and conservation of ichthyofaunal biodiversity. Additionally, ORI also undertook to investigate the potential of the MPA to enhance adjacent fisheries.Specifically, this project monitored the relative abundance, size composition, movement patterns and

[1]Marine and Coastal Management (MCM) was the national management authority until 2008. MCM then split into the Department of Agriculture, Forestry and Fisheries (DAFF) and the Department of Environmental Affairs (DEA). Eastern Cape Parks Board (ECPB) was the delegated provincial management authority for the Eastern Cape until 2008, when it was renamed as the Eastern Cape Parks and Tourism Agency (ECPTA).

ecological interactions of offshore reef fish populations inside the Pondoland MPA no-take area and in the adjacent fished area.

2. METHODS

Offshore reef fishes, many of which are important in the east coast line-fishery,were monitored on selected sub-tidal reefs (15-30 m deep) in the Pondoland MPA from April 2006 to February 2016.

2.1 Study area

The Pondoland MPA, on the Eastern Cape coast of South Africa, covers ~1380 km^2 of scattered reef and sand habitat, from the shoreline to the 1 000 m isobath beyond the shelf edge (Fig. 1).The central region of the MPA, 643 km^2 is designated as a restricted no-take zone, which is closed to all forms of vessel-based exploitation. Controlled use zones are situated to the north-east and to the south-west of the no-take zone, together accounting for 661 km^2.In the controlled use zones, vessel-based linefishing and vessel-based spearfishing are permitted (Fig. 1). No industrial fishing, such as trawling or longlining, is permitted anywhere within the MPA. These areas are very large, and for logistical reasons, sampling was limited to four selected 2-km^2 study sites (hereafter referred to as blocks) with similar depth and habitat type. Each 2-km^{2}block contained large areas of scattered reef in a water depth of 10-30 m. Two blocks were situated within the Pondoland MPA no-take zone, (Mtentu and Mkhambati), hereafter referred to as the no-take area. Two moreblocks were located in the adjacent fished area (Mnyameni and Mzamba)(Fig. 1). Mnyameni lies within the MPA's northern exploited zone and Mzamba lies entirely outside the MPA, but both sites are similarly open to linefishing and are hereafter referred to as the exploited area. In 2011, detailed bathymetric maps were produced by Environmental Mapping and Surveying for each of the four study blocks. These maps provided knowledge of the extent and exact location of reef habitat within each of the study blocks, enabling improved randomised sampling. A Garmin™ 76c, with an accuracy of ≤ 15 m,was used for all navigation tasks and for recording the position of captured fish.

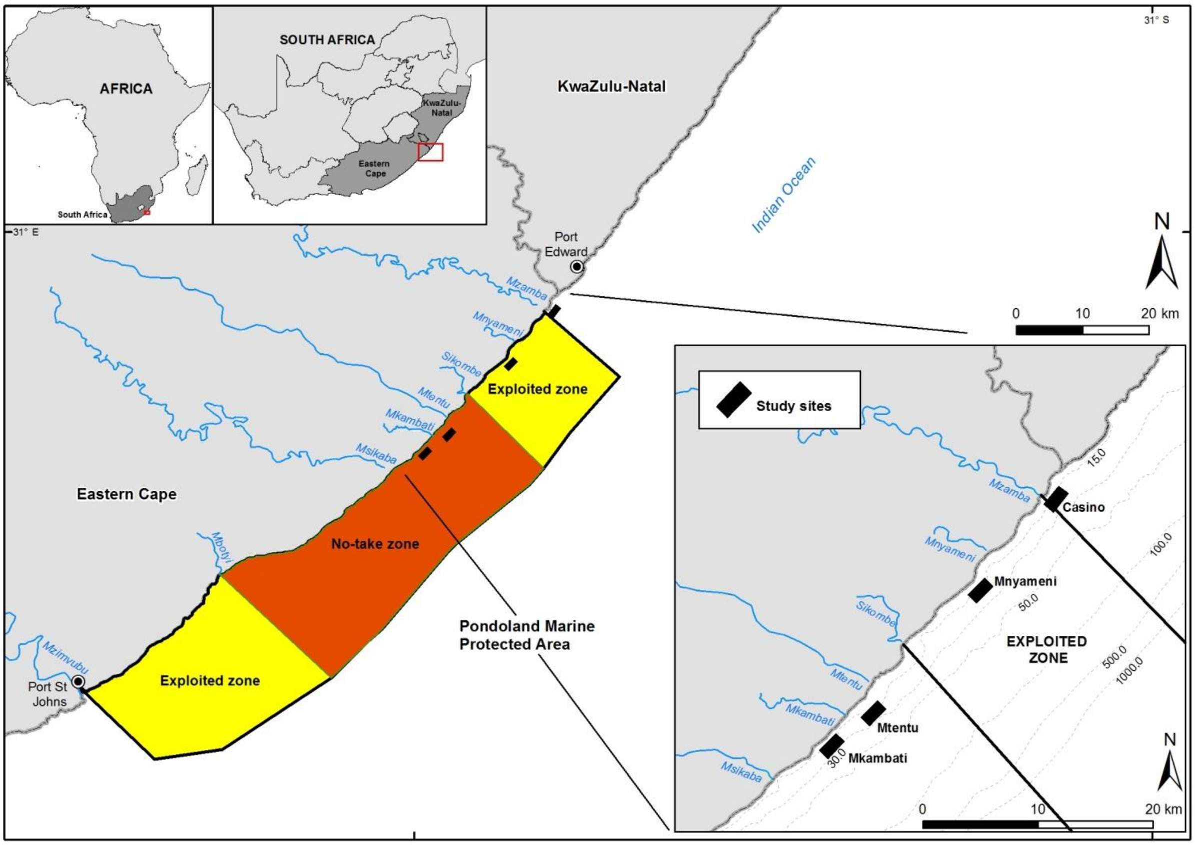

Figure 1. Map of the Pondoland MPA showing offshore zonation. Red shading represents the restricted no-take zone for all vessel-based exploitation. Yellow shading represents the exploited (controlled use) zone where certain types of exploitation are permitted (e.g. boat-based line-fishing and spearfishing). No industrial fishing such as trawling or long-lining is permitted anywhere in the MPA.

2.2 Controlled Angling Survey (CAS)

Standardised research fishing methodology was used to collect catch-per-unit-effort (CPUE) and length frequency data from April 2006 to February 2016. This was to investigate the role of the MPA in the recovery of depleted, commercially important, line-fish species. Each field trip consisted of sampling over two days. One day was spent anglingat randomly selected reef coordinates inside the two study blocks in the no-take area, south of the Sikombe River, and the other day was spent in the two study blocks in the exploited area, north of the Sikombe River. Angling was conducted for ~2-3 hours in each block, per field trip. Three trained anglers fished on a least three randomly selected GPS marks per block and each fishing session was timed. A rule was imposed whereby a minimum of 15 minutes and a maximum of 60 minutes was spent fishing at each mark to avoid bias. Standard bottom fishing rods and Scarborough type reels were used,and these were fitted with 30-40 kg nylon or braided line. Standardised bottom traces were used consisting of two circle hooks (6/0 above and 8/0 below), two three-way swivels and a 300-500 g sinker. All fish caught were carefully handled, identified, measured and returned to the water as quickly as possible. Fishing was limited to depths shallower than 30 m toreduce the effects of barotrauma. If barotrauma was evident,the swimbladder was deflated by insertion of a 12-gaugehypodermic needle through the body wall into the swimbladder(known as venting) or, in the case of larger fish, individuals were returned to theseabed using a weighted down-rigger system (Sumpton etal. 2010). Barbless circle hooks were used to reduce theincidence of gut hooking (Cooke and Suski 2004), to allow for rapid hook removal andto reduce injury (Schaeffer andHoffman 2002). On the rare occasionwhen a fish was deep-hooked, the line wascut close to the hook and this was recorded against the tagnumber. Attempting to remove the hook in such instancesincreases the chances of mortality (Butcher et al. 2010). One person processed the catch and another recorded data. One of the three anglers on each field trip was usually an invited guest angler from the local ski-boat angling fraternity.

2.3 Underwater Visual Census (UVC)

Line-fishing, as used in the controlled angling survey, is selective in that mostly large carnivorous species are sampled. To gain a wider perspective of the fish community in the MPA, including small species not caught on hook and line, an annual underwater visual census (UVC) using scuba was conducted from 2007 to 2012. This was particularly to investigate the indirect effects that predator removal by the fishery has on the wider fish community. The number of rock lobster *Panulirushomarus* occurring in close proximity of the divers was also noted from 2007 to 2010. An annual UVCwas conducted in May/June of each year when the probability of good weather and clean water is higher.

Point count methodology was initially used from 2007 to 2010 and is explained in detail by Maggs (2011). However, this sampling method featured certain problematic elements. For example, a single diving station (fixed geographic coordinate) within each of the four study blocks was revisited each year.This resulted in poor representation of the wider study area. Similarly, divers conducting point counts remained in relatively close proximity for safety and logistical reasons, resulting in pseudo-replication of samples.

Strip transects were found to be superior to point-counts in terms of efficiency, variability and bias (Bennett et al. 2009). Therefore, point-counts were abandoned in favour of strip transects, which were used from 2011 to 2012. Similar to point-counts, transects were conducted once per year in each of the four 2-km^2 study blocks. Three transects were conducted at randomly selected geographic coordinates (on reef-habitat)within each block. Two scuba divers descended to the seafloor at the selected location. A transect, 50 m long and 5 m wide, was then conducted along the seafloor into the current. One diver, the observer, swam along the weighted transect lineand recorded the density and total length(5 cm size classes) of all fish species encountered within the transect area (2.5 m on either side of the line). The second diver, assisted by rolling out and rolling up the transect line.

Water visibility in the Pondoland area is frequently poor, which caused postponement of the annual UVC on numerous occasions. From the start of the project, ORI undertook the UVC in winter (May/June) when there is more chance of good weather and clean water. However, after a lengthy period of adverse weather in the winter of 2013, and a failed sampling trip due to poor water visibility, the UVC was discontinued in favour of a new method known as Baited Remote Underwater Video (BRUV) surveys, which are also used for collecting fish community data.

2.4 Underwater VideoSurvey (UVS)

After termination of the annual UVC in 2013, fish community data was collected by means of an Underwater Video Survey (UVS) using Baited Remote Underwater Video (BRUV) systems. This relatively new method of sampling sub-tidal fish populations uses an underwater camera mounted on a steel frame in front of a plastic canister, which is filled with bait. The system, which is tethered to a surface marker buoy, is lowered down to the seafloor,where it records marine animals that are attracted to the bait canister for a set period of time. Besides carnivorous fishes, which are attracted to the bait, other non-carnivorous species are also attracted by the activity which takes place around the BRUV. In this way, data can be collected on the wider fish community.

Sampling with BRUV systemsoffers an alternative sampling strategy to UVCin certain circumstances where constraints makeUVC difficult. BRUV systems can be deployed in relatively low visibility as little as 1-3 m. Multiple BRUV units can be deployed simultaneously, which increases the number of samples possible.ORI experimented with BRUVs in the Pondoland MPA from November 2012 to July 2013. With input from other scientists at the University of Cape Town and the South African Environmental Observation Network, ORI developed a suitable BRUV system and sampling protocol, which was suitable for the Pondoland environment. Because the BRUV technology does not suffer from the same constraints as diving, it was possible to collect substantially more data on the fish community. However, a caveat is that with the current BRUV systems, having only one camera, fish length could not be recorded.

BRUV sampling commenced officially in October 2013 and was terminated in February 2016. BRUV surveys were conducted quarterly in tandem with the CAS. As such, BRUV sampling was conducted over one day in the no-take area and over another day in the exploited area. During each survey, three BRUV systems were deployed per study block. Within each study block, BRUV units were deployed in quick succession, each at randomly chosen geographic coordinates. Bait canisters were filled with approximately one kg of chopped pilchard *Sardinopssagax*. The duration of deployments lasted for a minimum of one hour. These units were left to record while data was collected for the CAS.

Raw BRUV data were stored as MP4 video files. Community data was extracted from the video file by recording the relative abundance of each species, defined as the maximum number of individuals (Max*N*) in the field of view at one time (Cappo et al. 2003, Priede et al. 1994). During analysis of the video files, the observer waited for the BRUV system to settle on the seafloor for at least five seconds and then analysed 60 minutes of footage.

2.5 Tag-recapture

Fish movement within the four study blocks was investigated by means of a tag-recapture experiment. Selected species were tagged during the CAS from April 2006 to February 2016. Fish were tagged with plastic dart tags (Hallprint Pty Ltd, Australia), each marked with a unique alpha-numeric code and contact details (ORI Cooperative Fish Tagging Project) (Dunlop et al 2013). Small D-type tags (85 mm long and 1.6 mm diameter) were used for small fish (300–599 mm) and larger A-type tags (114 mm long and 1.6 mm diameter) were used for larger fish (600 mm or longer). No fish <300 mm were tagged. Using a hollow stainless steel applicator, a tag was inserted into the dorsal musculature of the fish, and anchored behind a pterygiophore with the barb pointing posteriorly (Fig. 2). Each time a fish was captured or recaptured, the species, length (mm fork or total length), date, time, condition of the fish and geographical coordinates were recorded against the tag number. Besides fish recaptured by the research team within the four study sites, members of the angling public also reported recaptures from areas outside the no-take area. Localised movement data within study blocks was used to investigate residency and the MPA's contribution to the protection of depleted line-fish stocks. Long-range movements, reported by the angling public gave an indication of the MPA's ability to enhance adjacent fisheries.

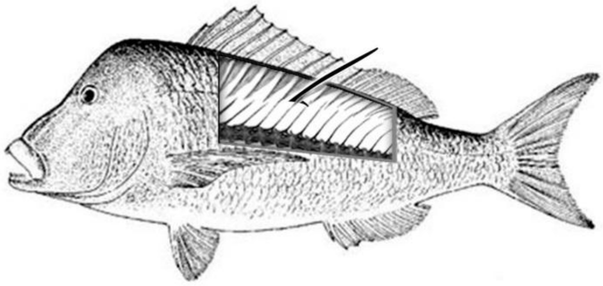

Figure 2. Tag placement with*Polysteganuspraeorbitalis* as an example (image copyright belongs to the Oceanographic Research Institute with editing by AdéleMaggs).

2.6 Biotelemetry

In collaboration with Dr Paul Cowley of the South African Institute for Aquatic Biodiversity (SAIAB), ORI installed two VR2 acoustic receivers on the seafloor off Mkhambati. The first instrument was deployed at a depth of 18 m in July 2012. A 170 kg concrete block was used as the bottom mooring, to which a 2 m long rope and buoy were attached. The acoustic receiver was attached midway along the rope. A second receiver was installed directly offshore of the shallow receiver at a depth of 30 m in July 2014. For this receiver, a 1 m length of railway track (70 kg) was used as the mooring, to which a 2 m long rope and buoy were attached. The receiver was similarly attached midway along the rope. The receivers at Mkhambati detect any fish tagged with acoustic transmitters, which are moving past within a radius of approximately 300 m. Although no fish have been fitted with acoustic transmitters as part of the Pondoland MPA monitoring project, the receivers off Mkhambati listen for teleosts and elasmobranchs, which have been fitted with acoustic transmitters by other researchers around South Africa. This data is submitted to the Acoustic Tracking Array Platform (ATAP), which has a network of receivers deployed in coastal waters around South Africa. ATAP is the regional node of the Canadian-based global Ocean Tracking Network (OTN) and is aimed at investigating the movement and migrations of inshore marine animals (http://www.saiab.ac.za/atap.htm). Within the Pondoland MPA, detection of tagged animals indicates movement through the no-take zone and the importance of this area as a corridor for more migratory species.

2.7 Underwater Temperature Recorder (UTR)

In collaboration with Dr Mike Roberts and the Department of Environmental Affairs (DEA), ORI installed an Underwater Temperature Recorder (UTR) off Mkhambati. The UTR instrument was installed on the seafloor at a depth of 18 m on the same concrete block as the shallow VR2 acoustic receiver. The UTR records water temperature every hour throughout the year and is serviced annually in July. Servicing consists of replacing the UTRwith a new instrument and sending the data-laden instrument to DEA, where the data is retrieved and stored. Besides providing valuable environmental data for interpretation of results from this study, the maintenance of this recorder contributes to a nationwide system of environmental monitoring being undertaken by DEA.

3. RESULTS

3.1 Controlled angling Survey (CAS)

Forty research fishing field trips were undertaken over a period of ten years from the start of the monitoring project in April 2006 until February 2016. Overall, CPUE in the no-take areaaveraged 8.4 fish/angler/hour, whereas in the exploited area the CPUE averaged only 5.1 fish/angler/hour (Fig. 3). During this period, 8328 fish from 68 species and 27 families were caught and released.Sparidaeand Serranidae dominated catches (Fig 4).

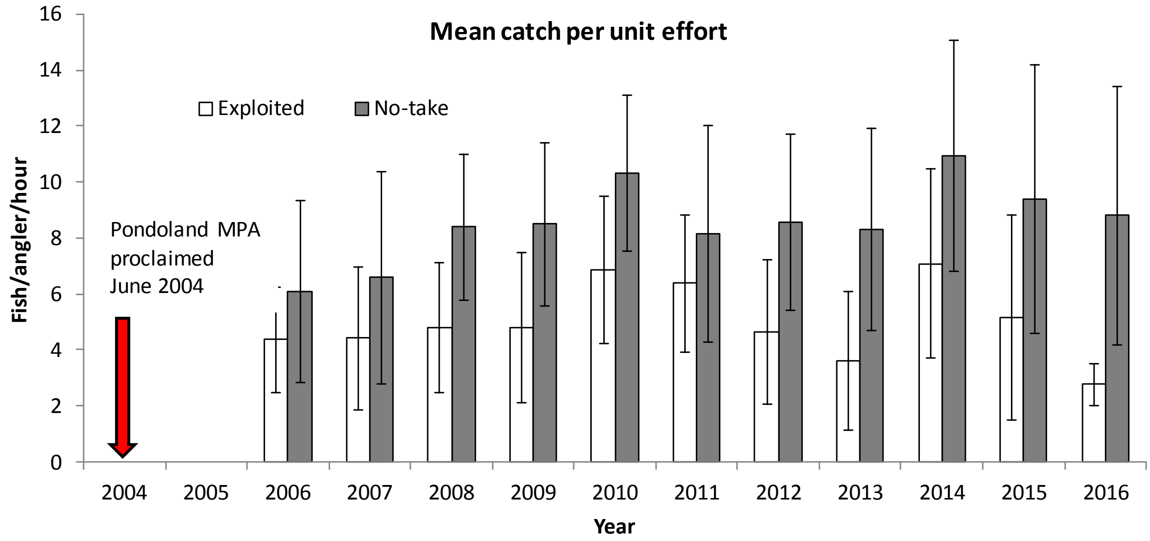

Figure 3. Catch per unit effort data recorded during the Controlled Angling Survey from April 2006 to February 2016. For all species combined, a comparison is made between the no-take area (both blocks combined) and the exploited area (both blocks combined) of the Pondoland MPA. Error bars indicate standard deviation.

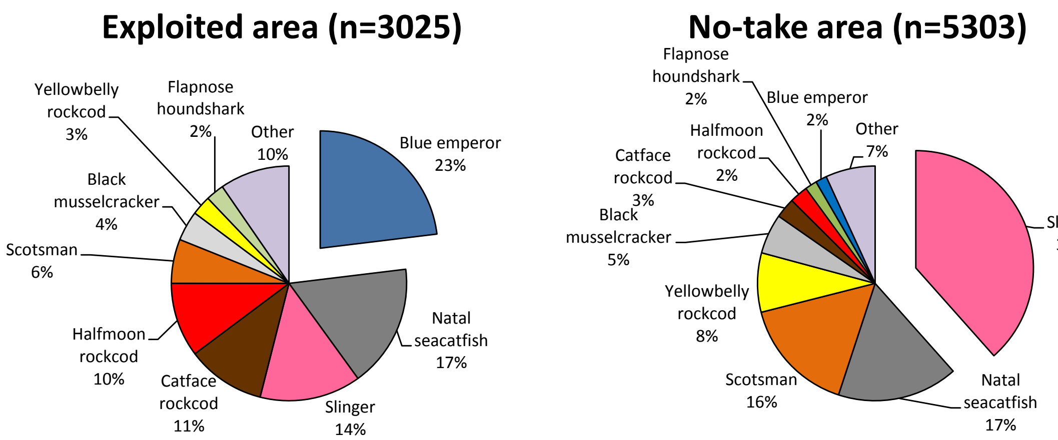

Figure4. Catch composition recorded during the Controlled Angling Survey from April 2006 to February 2016. A comparison is made between theno-take area (both blocks combined) and the exploited area (both blocks combined) of the PondolandMPA. Category "Other" includes all other species not displayed on the pie graph.

Eight species accounted for 90% of the overall catch on the project and were selected for further analysis. Of these eight species, Slinger*Chrysoblephuspuniceus*, Scotsman*Polysteganuspraeorbitalis*, black musselcracker*Cymatocepsnasutus*, yellowbellyrockcod*Epinephelusmarginatus*and Natal seacatfish*Galeichthystrowi*were consistently more abundant in the no-take area of the MPA (Fig 5.).

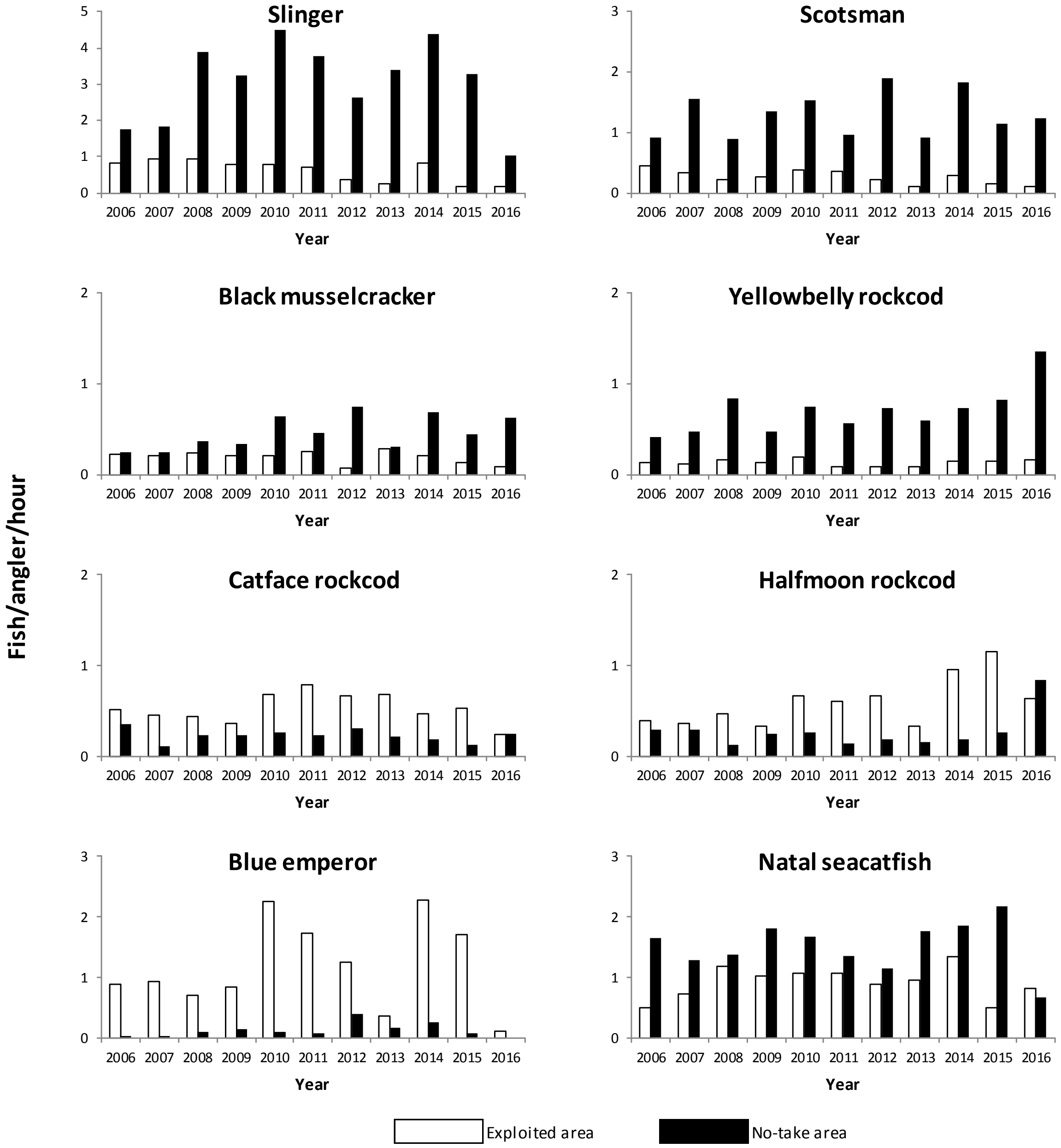

Figure 5. Catch per unit effort (fish/angler/hour) recorded during the Controlled Angling Survey from April 2006 to February 2016. For the eight most abundant species, a comparison is made between the no-take area and the exploited area of the PondolandMPA.

In all of the top eight species, there was a higher frequency of large individuals in the no-take area compared with the adjacent exploited area (Fig. 6), which is again strongly indicative of the effect of protection in the no-take area. Larger individuals of most species are also noticeably less abundant in the exploited area (with catfacerockcod*Epinephelusandersoni*being the only exception).

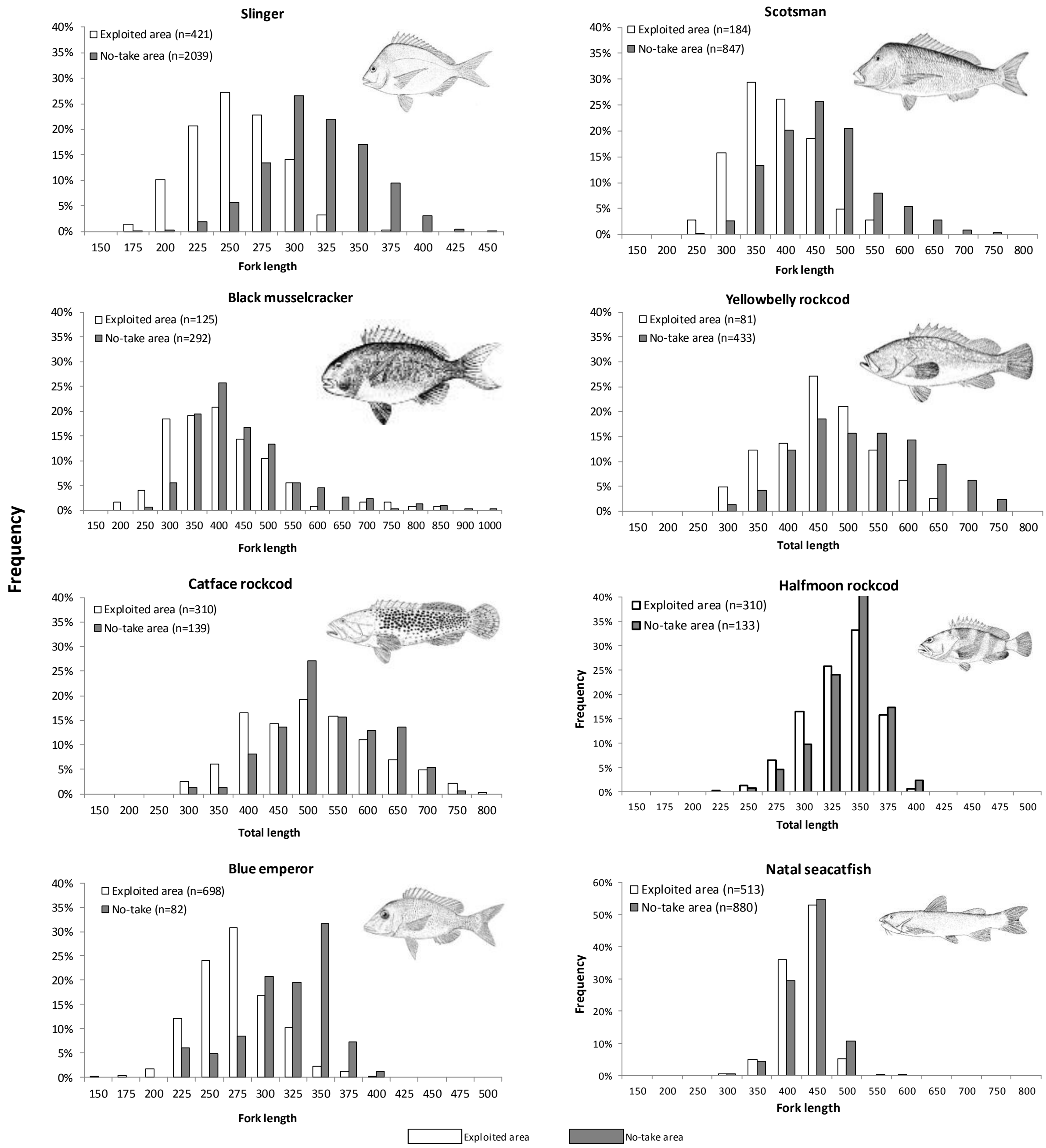

Figure 6. Length frequency distributions recorded during the Controlled Angling Survey from April 2006 to February 2016. For the eight most abundant species, a comparison is made between the no-take area (both blocks combined) and the exploited area (both blocks combined) of the Pondoland MPA.

3.2 Underwater Visual Census (UVC)

<u>*Point counts (2007-2010)*</u>

From May 2007 to June 2010, ORI undertookfour Underwater Visual Census field trips to the Pondoland MPA and completed 96 point counts in the four study blocks. Depth of point counts ranged from 12 to 24 m. Overall, 4616 fish from 93 species and 29 families were recorded (Appendix 1). There was also 42 lobster *Panulirus spp*. counted.

In the exploited area, 2625 fish from 83 species were recorded belonging to 28 families, with the Labridae being the most speciose family (16 species) followed by the Sparidae (12 species). Five families accounted for 77% of the abundance in the exploited area. These were the Sparidae (33%), Haemulidae (16%), Serranidae (14%), Pomacentridae (8%) and the Lethrinidae (7%) (Fig.7a). The top five species, accounting for 51% of the fishes in the exploited area, were slinger (16%), sea goldie*Pseudanthiassquamipinnis*(13%), dusky rubberlip*Plectorhinchuschubbi*(8%), blue emperor *Lethrinus nebulosus*(7%) and striped grunter *Pomadasys striatum*(7%).

In the no-take area, 1991 fish from 56 species were recorded belonging to 17 families with the Sparidae being the most speciose family (15 species) followed by the Labridae (eight species). Five families accounted for 88% of the fishes in the no-take area. These were the Sparidae (47%), Haemulidae (30%), Serranidae (5%), Sciaenidae (4%) and the Pomacanthidae (3%) (Fig.7b). The top five species, accounting for 55% of the fishes in the no-take area, were slinger (17%), dusky rubberlip (15%), pinky*Pomadasysolivaceum*(13%), Cape stumpnose*Rhabdosargusholubi*(5%) and Scotsman (4%).

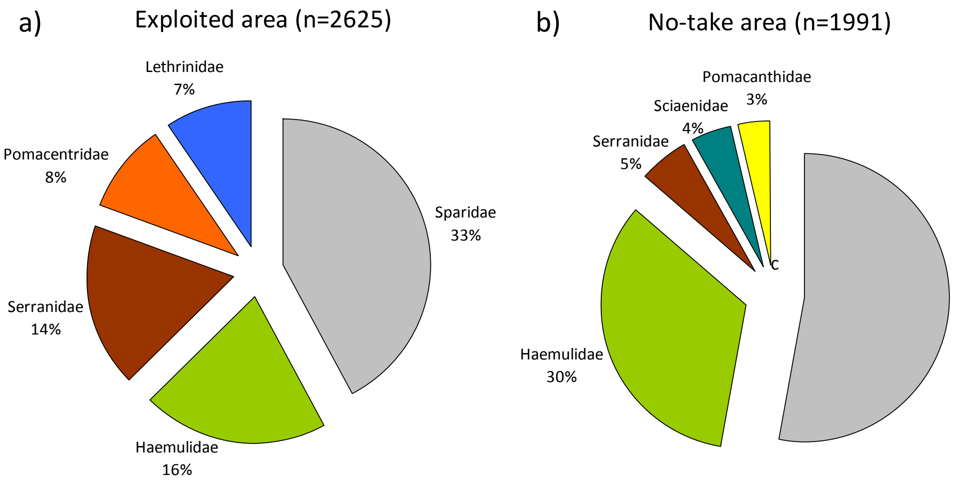

Figure 7. The top five fish families by number recorded by Underwater Visual Census (point counts) from May 2007 to June 2010 in the a) exploited area and b) no-take area of the Pondoland MPA.

Similar to the CAS, Mann-Whitney Rank Sum Tests showed that the median size of slinger and Scotsman in the exploited area was significantly (P<0.001) smaller than in the no-take area (Fig 8).

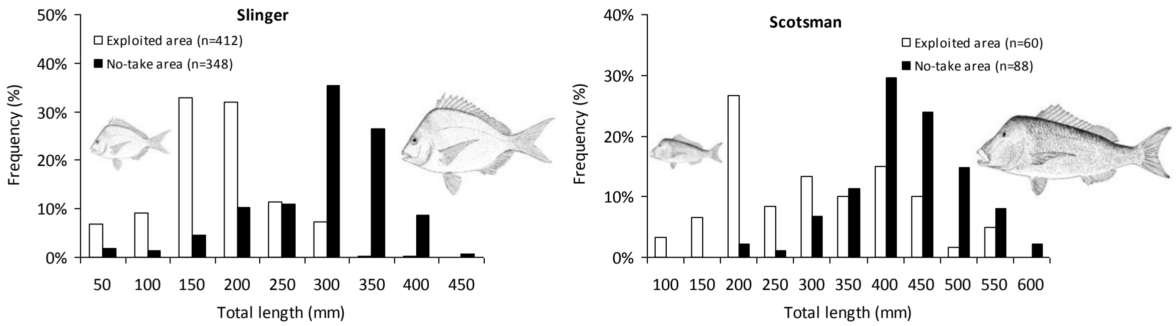

Figure 8. Length frequency distribution of slinger *Chrysoblephuspuniceus*and Scotsman *Polysteganuspraeorbitalis*in the Pondoland exploited area (open bars) and no-take area(black bars) according to Underwater Visual Census point-counts conducted between 2007 and 2010.

The trophic structure of the fish community in the exploited area differed from that found in the no-take area primarily by the relative contribution of planktivores and piscivores (Fig.9). Small planktivores, mostly the sea goldieand the blue-spotted damsel *Chromisdasygenys*, contributed 25% to the fish assemblage in the exploited area, whereas planktivorous fishes, the majority of which were sea goldies contributed only 2% in the no-take area. There was also a marked difference in the contributions made by omnivores to the two areas. Omnivorous fishes, mostly Cape stumpnose and Fransmadam*Boopsoideainornata*, accounted for 15% of the community in the no-take area, whereas omnivores, mostly blacktail*Diploduscapensis* and Fransmadam, contributed only 7% in the exploited area.

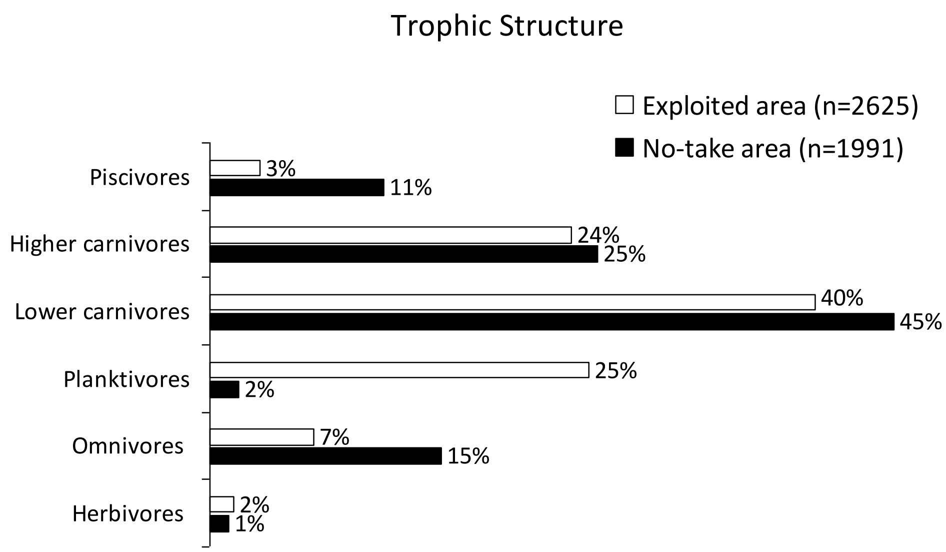

Figure 9.A comparison of the trophic structure of the fish community sampled by Underwater Visual Census from May 2007 to June 2010 in the Pondoland exploited (open bars) and no-take areas (black bars).

Transects (2011-2012)

From July 2011 to May 2012, ORI undertook two UVC field trips to the Pondoland MPA and completed 24 strip transect counts in the four study blocks. Depth of transect counts ranged from 18 to 26 m. Overall, 1262 fish from 59 species and 22 families were recorded (Appendix 1). No lobster *Panulirus spp*. were counted during transect counts.

In the exploited area, 733 fish from 51 species were recorded belonging to 19 families, with the Sparidae being the most speciose family (14 species) followed by the Labridae (9 species). Five families accounted for 84% of the abundance in the exploited area. These were the Sparidae (37%), Lethrinidae (22%), Haemulidae (11%), Serranidae (7%) and the Pomacentridae (6%). The top five species, accounting for 57% of the fishes in the exploited area, were blue emperor (22%), slinger (13%), striped grunter (11%), bluespottedchromis (6%) and blacktail (5%).

In the no-take area, 529 fish from 41 species were recorded belonging to 19 families with the Sparidae being the most speciose family (13 species) followed by the Labridae and Serranidae(each having four species). Five families accounted for 87% of the fishes in the no-take area. These were the Sparidae (61%), Caesionidae (11%), Haemulidae (5%), Pomacanthidae (5%) and the Cheilodactylidae (4%). The top five species, accounting for 58% of the fishes in the no-take area, were slinger (19%), Scotsman (14%), yellow sash fusilier *Caesioxanthalytos* (11%), German *Polyamblyodongermanum* (8%) and striped grunter (5%).

3.3 Underwater Video Survey (UVS)

From October 2013 to February 2016, ORI undertook 10 Underwater Video Surveys (UVS) in the Pondoland MPA and successfully completed 100 Baited Remote Underwater Video (BRUV) deployments in the four study blocks. Deployment depths ranged from 15 m to 30 m. Overall, 6015 fish from 130 species and 46 families were recorded (Appendix 1).

In the exploited area, 3114 fish from 98 species were recorded belonging to 37families, with the Sparidae being the most speciose family (16 species) followed by the Labridae (10 species). Five families accounted for 76% of the abundance in the exploited area. These were the Sparidae (48%), Lethrinidae (13%), Haemulidae (6%), Serranidae (5%) and the Mullidae (4%) (Fig.10a). The top five species, accounting for 49% of the fishes in the exploited area, were slinger (17%), blue emperor (13%), and blacktail (9%), striped grunter (6%) and steentjie*Spondyliosomaemarginatum* (4%).

In the no-take area, 2901 fish from 94 species were recorded belonging to 36 families with the Sparidae being the most speciose family (19 species) followed by the Serranidae (seven species). Five families accounted for 81% of the fishes in the no-take area. These were the Sparidae (61%), Serranidae (6%), Pomacanthidae (6%),Haemulidae (5%) and Ariidae (3%) (Fig.10b). The top five species, accounting for 49% of the fishes in the no-take area, were slinger (31%), old woman *Pomacanthusrhomboides* (5%), Scotsman (5%), Cape stumpnose (4%) and Dane *Porcostomadentata* (4%).

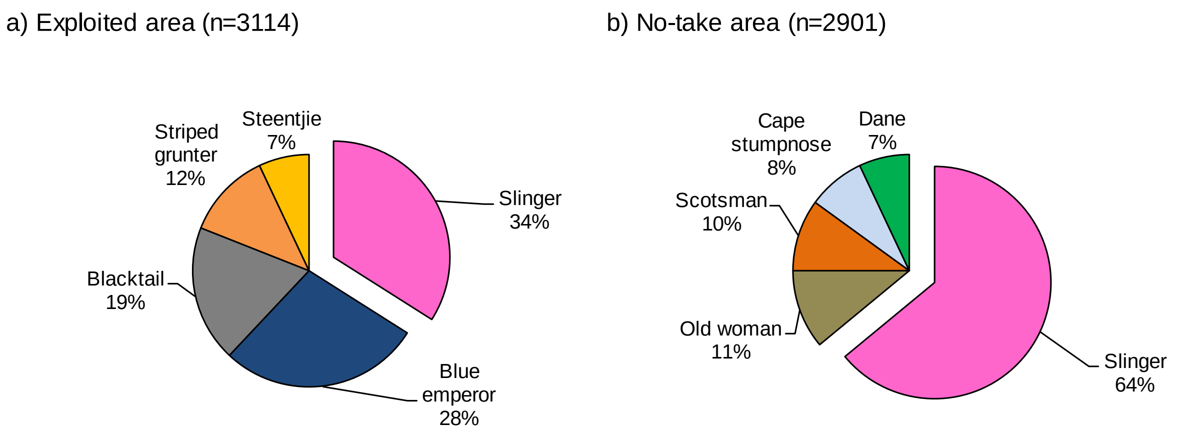

Figure 10. Species composition recorded during the Baited Remote Underwater Video Survey conducted in the PondolandMPA from October 2013 to February 2016 with a comparison made between the no-take area (both blocks combined) and the exploited area (both blocks combined).

3.4 Tag-recapture

From April 2006 to February 2013, 4159 fishes were tagged, of which 770 (19%) individual fish have been recaptured (Appendix 1). If multiple recaptures are included, the overall recapture rate is 27%. Recapture rates (including multiple recaptures) for yellowbellyrockcod(51%), Natal seacatfish(45%), catfacerockcod(44%), Scotsman (38%), black musselcracker(29%) and halfmoonrockcod(23%) were exceptionally high, indicating a high degree of residency among these heavily targeted species. Alternatively, the recapture rate for slinger (9%) and blue emperor (9%) was relatively low. From 33-85% of the recaptures of the top eight species were recorded within 100 m of where they were originally tagged (Table 1, Fig. 11).

Besides resident behaviour within individual home ranges, which is typical of these reef-associated species, it was found that five of the eight speciesalso undertook longer-distance movements of more than 1000 m (6% of all recaptures). These movements ranged from 1-1211 km, often taking the fish well beyond the borders of the no-take area into adjacent fished areas. Interestingly, all these long-distance movements were in a north-easterly direction. Of fish tagged in the no-take area of the MPA, four slinger were recaptured between Warner Beach

(163 km) and Quissico in Mozambique (1059 km). Sixteen Scotsman were recaptured between the Mpahlane River (21 km) and Pont da Barra in Mozambique (1211 km). A black musselcracker moved 334 km to Port Durnford. Eight yellowbellyrockcod were recaptured between Umgababa (149 km) and Richards Bay (335 km). Three catfacerockcod were recaptured between Port Shepstone (76 km) and Mapelane (411 km).

Considering that all of the above species are normally highly resident, these recaptures are quite remarkable and have greatly added to our knowledge on the movement behaviour of these fishes. All of these species are important to the line-fishery, and are currently considered to be overexploited. These movements of fish from the MPA no-take area northward to become available to the fishery indicate some measure of the potential of the Pondoland MPA to enhance adjacent fisheries.

Table 1. Percentage of recaptures recorded within 100 m of the original tagging locality. Tag-recapture data collected in the no-take area of the PondolandMPA during the Controlled Angling Survey from April 2006 to February 2016.

Species	Percentage of recaptures within 100 m of tag-release (No-take area only)	Number of individuals
Slinger *Chrysoblephuspuniceus*	40	33
Scotsman *Polysteganuspraeorbitalis*	36	84
Black musselcracker *Cymatocepsnasutus*	42	25
Yellowbellyrockcod *Epinephelusmarginatus*	70	107
Catfacerockcod *Epinephelusandersoni*	78	32
Halfmoonrockcod *Epinephelusrivulatus*	85	11
Blue emperor *Lethrinus nebulosus*	33	1
Natal seacatfish *Galeichthystrowi*	50	66

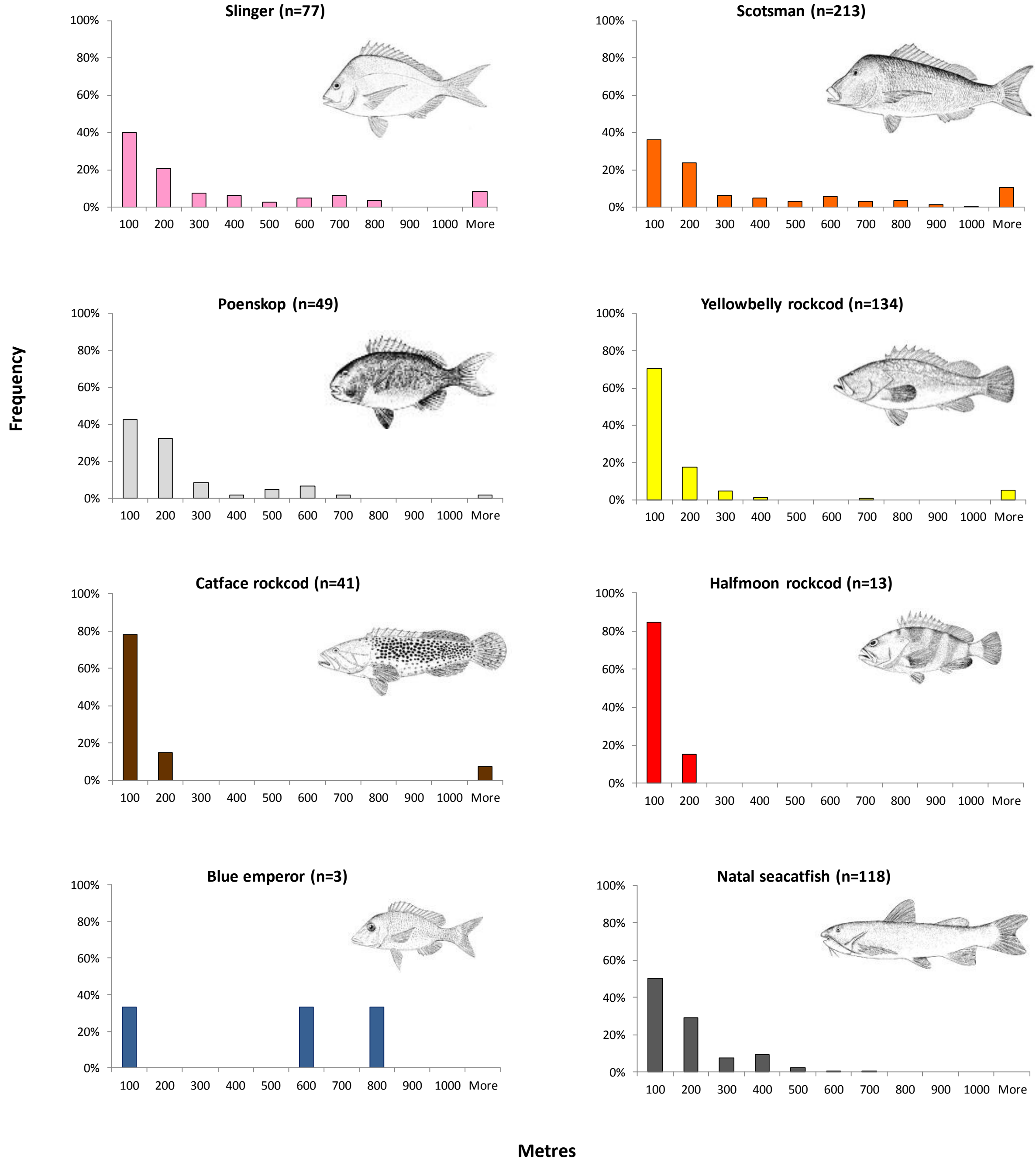

Figure 11. Tag-recapture data collected during the Controlled Angling Survey from April 2006 to February 2016.Displacement in metres shown by tagged and recaptured individuals of the top eight species in the no-take area of the PondolandMPA. Note: some recapture data supplied by members of the angling public.

3.5 Biotelemetry

The shallow receiver (-18 m) was first deployed off Gwegwe, Mkhambati on 20 July 2012 and replaced on the 25 July 2013 and 2 July 2014. Unfortunately, this instrument was lost at sea along with the seafloor mooring and underwater temperature recorder sometime between 2 July 2014 and 25 July 2015. Two lengthy underwater searches, using scuba divers, on the 25 July 2015 were unsuccessful in recovering these instruments. During the successful deployments, from 20 July 2012 to 2 July 2014, this receiver recorded 418 detections across 33 individuals from five species(Table 2). The deep receiver (-30 m) was first deployed off Gwegwe, Mkhambati on 20 November 2014. This receiver was successfully replaced on 25 July 2015. During this limited deployment time, the deep receiver recorded232 detections across 12 individuals from five species (Table 2).

Table 2. Fish species tagged with acoustic tags in other monitoring projects and detected on the Pondoland MPA Gwegwe receivers from 20 July 2012 – 2 July 2014.

	Shallow receiver		Deep receiver	
Common name	**No. of individuals detected**	**No. of detections**	**No. of individuals detected**	**No. of detections**
Blacktip shark *Carcharhinuslimbatus*	1	33	2	89
Dusky kob *Argyrosmusjaponicus*	1	2		
Garrick / Leervis *Lichiaamia*	2	8		
Great white shark *Carcharodoncarcharias*	19	76	6	104
Spotted ragged-tooth shark *Carchariastaurus*			1	19
Tiger shark *Galeocerdocuvier*			1	2
Zambezi shark *Carcharhinusleucas*	10	299	2	18
Total	33	418	12	232

3.6 Underwater Temperature Recorder (UTR)

An underwater temperature recorder (UTR) was installed on the seafloor (-18 m) off Mkhambati onthe 25 July 2013. This instrument was retrieved on the 2 July 2014 and sent back to Dr Mike Roberts at the Department of Environmental Affairs, where the data was downloaded and stored on a long-term database. A new instrument was installed on 2 July 2014 to replace the old instrument. Unfortunately, this instrument was lost at sea along with the seafloor mooring and shallow acoustic receiver. Nevertheless, the 2013/2014 deployment yielded interesting data. Daily averages of the temperature data show relatively little variation during winter and early spring, whereas fluctuations of up to seven degrees Celsius over the period of a few days were observed during the summer and autumn months (Fig 12).

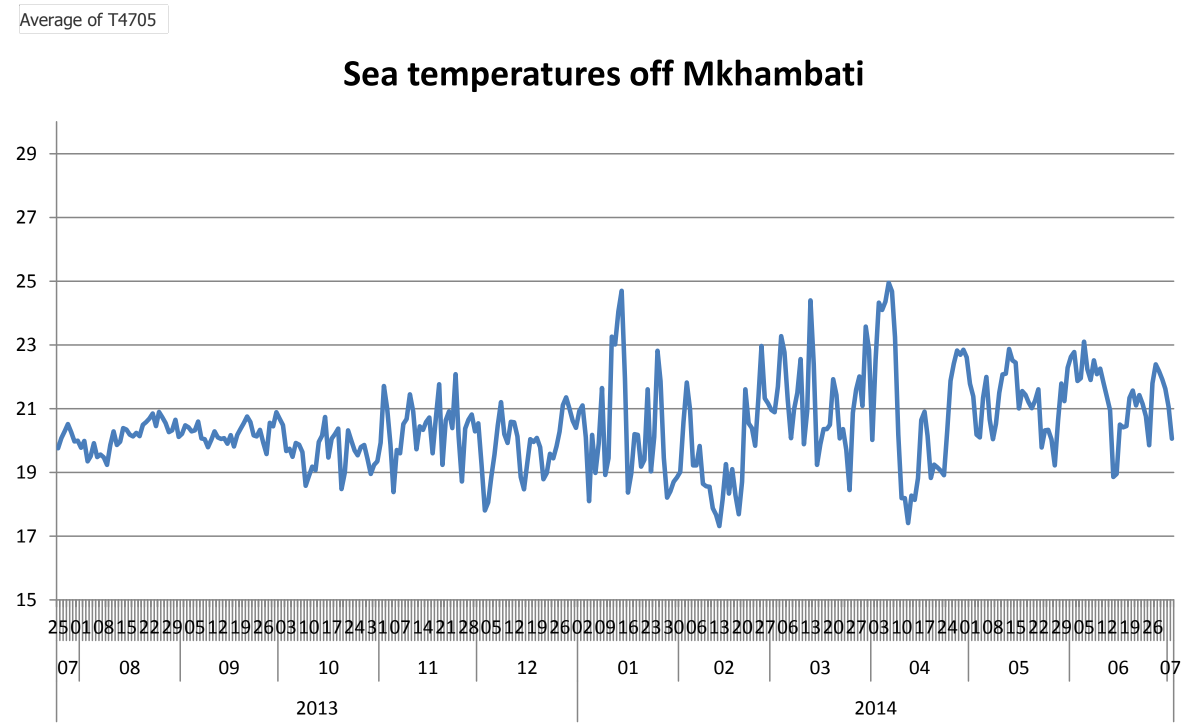

Figure 12. Daily average of sea temperatures recorded at -18 m off Mkhambati in the no-take area of the PondolandMPA as recorded by underwater temperature recorder T4705 from 25 July 2013 to 2 July 2014.

4 DISCUSSION

4.1 Biodiversity conservation (localised effects)

Fishing typically directly reduces the abundance of target species and selects larger individuals (Pauly et al. 2002), causing a reduction in mean size and age of fished species (Pauly and Watson 2005). The Controlled Angling Survey (CAS) yielded evidencethat the no-take zone is providing an important refuge for commercially important line-fish species (Maggs et al. 2013a). Of the eight study species, slinger, Scotsman, black musselcracker, yellowbellyrockcod and Natal seacatfishhad a consistently higher CPUE in the no-take area than in the adjacent exploited area. Length frequencies for all eight species also indicated a larger body size in the no-take area.By prohibiting fishing, the Pondoland MPA no-take area is thus contributing to the protection of the reproductive capacity of at least five commercially important line-fish species (Maggs et al. 2013a). The commercial importance of Natal seacatfish may be questioned; however, this species is becoming increasingly popular, especially among the crew on commercial boats. The lower abundance and smaller body size in the exploited area suggests that fishing is already having an impact on this species.

Samples collected in the Underwater Visual Census (UVC) and the Underwater Video Survey (UVS) were not biased towards line-fish species. In contrast to the CAS, UVC and UVS samples indicated that the relative abundance of fishes (all species combined) was higher in the adjacent exploited area. This was mostly due to the high abundance in the exploited area of species, which are generally reluctant to take bait, for example dusky rubberlip as well as small ornamental species such as sea-goldies. Nevertheless, point-counts, strip transects and BRUV deployments allshowed that heavily exploited species, such as slinger and Scotsman contributed more to the species composition in the no-take area than in the adjacent exploited area.The results of the UVC and UVS support the results of the CAS by providing evidence of higher abundance of targeted line-fish species in the no-take area.Point-counts conducted from 2007 to 2010, also showed that slinger and Scotsman were significantly larger in the no-take area compared with the adjacent exploited area further supporting the results of the CAS. One shortfall of our single-camera BRUV method is that fish size cannot be measured. As with the point-counts and strip transects, BRUV footage has consistently shown more fish in the exploited area than in the no-take area but it does not show the larger size of fish in the no-take area as we see in the UVC and CAS methods.

It is well established that in most cases, fishing can directly alter a fish community by the removal of piscivores and higher carnivores (Russ & Alcala 1989, Jennings & Polunin 1997, Pauly et al. 1998, Myers & Worm 2003). However, predator removal may indirectly affect other non-target species, disrupting the trophic structure (Stallings 2008). Analysis of point-count data showed a prevalence of high trophic level species, especially piscivores, in the no-take area. Piscivorous fishes are reported to be the most significant consumers of fish biomass (Grigg et al. 1984) even surpassing biomass removed by fishing (Jennings & Lock 1996) in some cases. Investigation of the fish community suggests that fishing in the exploited area has directly altered the community by the removal of larger, higher trophic level individuals. Evidence is also provided of differences in the fish community at lower trophic levels.

An anecdotal observation was made during the UVS, where it was seen that when all predatory fish had left the field of view, small bodied prey fishspecies emerged from the reef. These were mostlyplanktivorouspomacentrids and lower carnivores, such as labrids. These species rapidly disappeared once the predators returned. This suggests that numbers of prey species, typically observed in the UVC and UVS, are likely to be under-counted, especially in the no-take area.

Due to the limitations of the experimental design, it was not possible to conclusively attribute the observed patterns of fish abundance and diversity exclusively to the proclamation of the Pondoland MPA because the cessation of fishing was confounded with biogeography. The exploited area was located north-east of the no-take area and there are known latitudinal differences in fish (Mann et al. 2006) and invertebrate (Celliers et al. 2007) species distribution due to the transitional nature of the Pondoland ecosystem. Although desirable, it was not logistically possible to implement a rigorous before-after-control-impact (BACI) design or a stratified configuration of study sites. Nonetheless, the no-take area is protecting a unique fish community dominated by piscivorous predators and it is likely that this community is at least in part a result of the cessation of fishing.

4.2 Enhancement of adjacent fisheries (regional effects)

The success of MPAs in conserving biodiversity has led to their rapid increase on a global scale (Gell& Roberts 2003). However, their localised conservation benefits have little immediate benefit to adjacent fishing communities and opposition from these communities remains the principal barrier to area closure (Gell& Roberts 2003; T. McClanahan, Wildlife Conservation Services, 2010, pers. comm.). A community in opposition to a no-take area may hinder conservation efforts by poaching (Gell& Roberts 2003). Reasons for opposition include loss of fishing grounds, removal of livelihood, lack of involvement of local people and dissatisfaction with past failures (Gell& Roberts 2003). Enhancement of adjacent fisheries may be accepted as compensation for loss of fishing ground and may even provide incentive for the fishing community to assist with monitoring of illegal fishing (Johannes 1978, 1982, Alcala & Russ 2006). With the proclamation of more MPAs comes the increasing demand for proof of benefits to fisheries (Kramer & Chapman 1999, Gell& Roberts 2003).

No-take MPAs can benefit adjacent fisheries through spill-over – the net export of post-larval fishes(Palumbi 2001). Tag-recapture data has indicated a high degree of residency among the eight study species, which supports their recovery in the no-take area (Maggs et al. 2013b). However, some fish tagged in the no-take area have moved out and been recaptured by members of the public fishing in exploitable areas along the KZN coast and even entering into neighbouring Mozambique. It is difficult to say whether these movements are representative of true spill-over. For example, it is unknown whether the movement out of the no-take area outweighs the movement into the no-take zone. It is also unknown if these are density-dependent movements or are associated with individual spawning migrations.This movement behaviour may be size or age related. For example, juvenile fish may be highly resident but once reaching maturity, adults become more mobile and move both offshore onto deeper reefs and up the coast in a north-easterly direction. This certainly appeared to be the case with both slinger and Scotsman.

When certain areas exploited by a fishery are closed to fishing, as with the declaration of a no-take area, an overall reduction of yield is expected, but fishes moving out of a closed area are expected to contribute to the yield in adjacent areas (Botsford et al. 2004). This begs the question of whether the volume of fishes moving north from the Pondoland no-take area would be sufficient to compensate for the loss of fishing ground (and therefore yield) enclosed in the no-take area (Hilborn et al. 2004). However, there is more to consider. Most MPAs nowadays are proclaimed in response to declining fish stocks caused by over-fishing. It is unrealistic to expect an MPA to improve the yield in the adjacent area to a level achieved while over-fishing was taking place (Gell& Roberts 2003). If the Pondoland no-take area is able to contribute towardsimproved yield in the adjacent fished areas through the constant supply of adult fishes moving northward, this would in itself be an importantcontribution. Furthermore, if fish species such as Scotsman and slinger are receiving protection in the Pondoland MPA as resident juveniles and then moving northwards as adults to spawning areas in the northern parts of their distribution, such as within the iSimangaliso MPA and the proposed Thukela MPA, such an MPA network would bode well for the future sustainable use of such species as both juveniles and adults would receive some spatial protection.

A build-up of large reproductively active individuals in an MPA can also lead to seeding of adjacent fished areas with eggs and larvae (Palumbi 2001). Anecdotal reports by anglers fishing in areas adjacent to the no-take areasuggest an increasing abundance of juvenile black musselcracker. Although this is very difficult to prove empirically, seeding of adjacent fished areas with fish eggs and larvae from adult fish which have spawned in the no-take area is an expected outcome of aneffective MPA. It is hoped that this important biological process will continue to take place with black musselcracker and other over-exploited species known to spawn in the no-take area, such as red steenbras*Petrus rupestris*and seventy-four *Polysteganusundulosus*. (Garratt 1988).

While spatial protection, such as no-take MPAs,is known to be less effective in the protection of highly migratory species, data obtained from the acoustic receivers is showing that the Pondoland no-take areacontains an important corridor for the movement of large predators such as sharks and migratory fish species. Considering the importance of the annual sardine run and recent oceanographic information (Roberts et al. 2010), which suggests the formation of a temporary “gate” off Waterfall Bluff (located within the Pondoland no-take area), spatial protection of such dynamic ecological processes adds considerable value to the Pondoland MPA.

4.3 Environmental

The large temperature fluctuations observed on the UTR off Gwegwein summer and autumn may be caused by a strong thermocline that is established during summer. The Pondoland coast is prone to strong north-easterly winds during the summer months, which forces the thermocline to become shallower and move inshore. South-westerly winds result in a reversal of this trend resulting in the observed temperature fluctuation. During the winter months strong cold fronts from the south-west result in mixing of the water column and a breaking down of the thermocline resulting in more stable temperatures. This pattern is likely to also be influenced by the cyclonic eddy that periodically sheers off the Agulhas Current and moves northward up the coast. This seasonal variation in environmental conditions was accounted for in the CAS and the UVS by conducting quarterly field trips.However, the UVC was only conducted in the winter months, when underwater conditions were suitable for scuba diving.

5 MANAGEMENT CONSIDERATIONS

5.1 Future scientific monitoring

Over the 10 years of sampling, ORI’s monitoring strategy expanded with the implementation of underwater video surveys (UVS), deployment of acoustic telemetry receivers and the maintenance of an underwater temperature recorder (UTR). Shallower water UVS sampling replaced the underwater visual census (UVC)conducted by scuba diving in the 15-30 m depth range. However, the UVS was prone to two obstacles. No length data could be collected using the single-camera BRUV units, and sampling in deep water was logistically very difficult due to the strong currents encountered. Our initial intention was to deploy BRUV units in the deep reef areas of the Pondoland MPA, but exceptionally strong currents are frequently present in the 50-100 m depth range, especially in the Mkhambati area. Unfortunately two BRUV units have already been lost while attempting to sample in this depth range off Mkhambati.

Fortunately, the deep reef areas were successfully sampled in January 2014 and May 2015 by Dr Anthony Bernard from the South African Institute for Aquatic Biodiversity (SAIAB) and ORI staffusing stereo-BRUVs. These are large robust systems capable of being deployed in deep water. Each unit also has two cameras,and specialised software enables the measurement of fish lengths. During some of the deep water deployments in the no-take area, red steenbras, seventy-four and dageraad*Chrysoblephuscristiceps* were recorded. These are all heavily over-exploited species with populations reduced to critically low levels. Protection of these species was one of the prime motivations for the original establishment of the Pondoland MPA.

5.2 Compliance and enforcement

Poaching of line-fish in the no-take area of the Pondoland MPA by both commercial and recreational ski-boat operators continues to threaten the value of this MPA. Studies elsewhere have shown that even minor amounts of poaching in a no-take area can have substantial negative impacts on the conservation role of an MPA. There are two ways to address this problem: (1) maintain a regular presence of compliance personnel in the no-take area, and (2) apprehend and convict individuals who break the law.

It has proven exceptionally difficult to successfully convict ski-boat fishermen who have previously been caught poaching in the no-take area of the Pondoland MPA. Court cases are lengthy, time-consuming processes and cases against certain individuals have been dismissed from court based on technicalities. Failed convictions are counter-productive as compliance staff are drawn away from their regular duties and may become disillusioned with repeated failures. Failed convictions are also likely to encourage further poaching.

A regular presence of compliance personnel would probably prove more effective at deterring poaching before it takes place, which would also then negate the need for compliance staff to follow laborious court proceedings. It is therefore very encouraging that ECPTA staff have periodically been launching their patrol boat from Mkhambati in the no-take area. It is imperative that this vessel maintains a regular presence in the MPA, specifically on days when the weather and sea conditions are good. It is on these days that ski-boats launching at Port Edward or Port St Johns are most likely to take a chance and make the long trip into the no-take area. If potential poachers are aware that there is a regular presence of compliance personnel on a vessel within the MPA, they would be less inclined to poach.

In recent years, the Marlin Ski-boat Club at Port Edward has shown increased support for the Pondoland MPA and has emphasised their stance of non-tolerance towards poaching by their members. This type of support and self-policing is of critical importance to the success of any MPA and should be encouraged wherever possible. Club members are periodically invited to participate as guest anglers on field trips to assist in raising the level of awareness. Numerous reports have been received from ski-boat anglers and cottage owners from Msikaba and Port Grosvenor who have observed large fishing vessels entering the MPA at night and fishing relatively close inshore. There is little hard evidence for these sightings but it appears to be happening with increased regularity and, from descriptions of the vessels and gear, is believed to be illegal longlining. Better surveillance is urgently required and improved cooperation between marine law enforcement agencies such as DAFF and the SA Navy is needed to put a stop to this illegal activity.

6 ACKNOWLEDGEMENTS

Eastern Cape Parks and Tourism Agency, Department of Environmental Affairs (DEA), Wild Coast Project, South African Association for Marine Biological Research and the KwaZulu-Natal Sharks Board are thanked for providing funding and logistic support for this project. We are grateful to all who provided us with accommodation during field trips, especially Ezemvelo KZN Wildlife and Peter and Theresa Breton from Ashton Manor. Thanks to the Marlin Ski-Boat Club at Port Edward for their ongoing support and to the many guest anglers who participated in field trips. We hope that you were inspired to support MPAs by what you witnessed first-hand on field trips with us. We are grateful to the uShaka Sea World Curatorial Department for the use of their boat, fishing equipment, vehicles and skippers on many occasions. Thanks also to Adcan Marine for supplying the bait for this project at reduced cost over the past 10 years. Staff at the South African Institute for Aquatic Biodiversity (SAIAB) are thanked for their collaboration with regard to providing the equipment and data recorded on the acoustic receivers off Mkhambatithrough the Acoustic Tracking Array Platform (ATAP) and for involving us in the stereo-BRUV project. Thanks also to the technical staff at DEA for supplying us with temperature data collected on the UTRs.

7 ASSOCIATED PUBLICATIONS

In addition to the publications listed below, the project leader (Bruce Mann) and co-workers have presented a number of talks and lectures to ski-boat clubs, university students, conservancies and other interest groups regarding the results of the Pondoland MPA monitoring project.

7.1 Peer-reviewed Journal Articles

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7.2 Theses

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Mann BQ. 2000. Pondoland Marine Park – Dream or Reality?KwaZulu-Natal Nature Conservation Service Annual Research Symposium, Queen Elizabeth Park, 19-21 September 2000.Paper.

Mann BQ. 2001. Establishment of a large marine protected area along the Pondoland coast – an essential prerequisite to the conservation of overexploited South African reef fish species. Sixth Indo-Pacific Fish Conference, 21-25 May 2001, Durban, South Africa.Paper.

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7.8 YouTube

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Maggs JQ. 2015. Spotted ragged-tooth shark. YouTube.Published 25 November 2015.https://youtu.be/8Jw1TPehBuY

Maggs JQ. 2015. Tiger shark visits the bait box. YouTube.Published 7 August 2015.https://youtu.be/gGaIfLj-dk0

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9 APPENDICES

Appendix 1. List of species recorded in each survey from 2006 to 2016. CAS – controlled angling survey conducted from April 2006 to February 2016. UVC – underwater visual census conducted from May 2007 to May 2012. UVS – underwater video survey conducted from October 2013 to February 2016. “Tagged” indicates those species tagged with plastic dart tags. “Recaptured” indicates those species for which recapture data exists.

Family	Scientific name	Common name	CAS	UVC	UVS	Tagged	Recaptured
Acanthuridae	*Acanthurusblochii*	Tailring surgeon		●	●		
	Acanthurusdussumieri	Pencilled surgeon		●	●		
	Acanthurusnigrofuscus	Brown surgeon		●			
	Zebrasomagemmatum	Spotted tang		●	●		
Alopiidae	*Alopias*	Thresher sharks			●		
Apogonidae	*Apogontaeniophorus*	Ninestripe cardinal		●			
Ariidae	*Galeichthystrowi*	Natal seacatfish	●	●	●	●	●
Balistidae	*Sufflamenfraenatus*	Bridle triggerfish	●	●	●		
Blenniidae	*Parablenniuspilicornis*	Ringneck blenny		●			
	Plagiotremusrhinorhynchos	Twostripe blenny		●	●		
	Plagiotremustapeinosoma	Piano blenny		●	●		
Bothidae	*Pseudorhombusnatalensis*	Smalltooth flounder			●		
Caesionidae	*Caesio sp.*	Yellow striped fusilier		●			
	Caesioteres	Beautiful fusilier		●			
	Caesioxanthalytos	Yellow sash fusilier			●		
Carangidae	*Caranx*	Kingfish			●		
	Caranxignobilis	Giant kingfish			●		
	Caranxsexfasciatus	Bigeye kingfish	●			●	
	Serioladumerili	Greater yellowtail			●		
	Seriolalalandi	Giant yellowtail	●			●	
	Seriolarivoliana	Longfin yellowtail			●		
Carcharhinidae	*Carcharhinusbrevipinna*	Spinner shark	●		●	●	
	Carcharhinuslimbatus	Blacktip shark	●				
	Carcharhinus obscurus	Dusky shark	●			●	●
	Galeocerdocuvier	Tiger shark			●		
	Musteluspalumbes	Whitespotted smooth-hound	●			●	
	Scylliogaleusquecketti	Flapnosehoundshark	●	●	●	●	●
Chaetodontidae	*Chaetodonblackburnii*	Brownburnie		●	●		
	Chaetodondolosus	Blackedged butterflyfish			●		
	Chaetodonkleinii	Whitespotted butterflyfish		●	●		
	Chaetodonmadagaskariensis	Pearly butterflyfish		●			
	Chaetodonmarleyi	Doublesash butterflyfish		●	●		
Cheilodactylidae	*Cheilodactyluspixi*	Barred fingerfin		●			
	Chirodactylusbrachydactylus	Twotonefingerfin		●	●		
	Chirodactylusjessicalenorum	Natal fingerfin		●	●		
Cirrhitidae	*Cirrhitichthysoxycephalus*	Spotted hawkfish			●		
	Cyprinocirrhitespolyactis	Swallowtail hawkfish		●			
Coryphaenidae	*Coryphaenahippurus*	Dolphinfish	●				
Dasyatidae	*Dasyatischrysonota*	Blue stingray	●	●	●	●	
	Dasyatisthetidis	Thorntail stingray	●				
	Gymnuranatalensis	Backwater butterflyray	●		●		
	Himanturauarnak	Honeycomb stingray			●		
	Taeniuramelanospilos	Round ribbontailray	●		●		
Dichistiidae	*Dichistiuscapensis*	Galjoen			●		
Dinopercidae	*Dinopercapetersi*	Cavebass	●	●	●	●	●

Family	Scientific name	Common name	CAS	UVC	UVS	Tagged	Recaptured
Echeneidae	*Echeneisnaucrates*	Shark remora			●		
Ephippidae	*Plataxteira*	Longfin batfish		●			
Gobiidae	*Ptereleotrisheteroptera*	Blacktail goby		●			
Haemulidae	*Plectorhinchuschubbi*	Dusky rubberlip	●	●	●	●	●
	Plectorhinchusflavomaculatus	Lemonfish		●			
	Plectorhinchusschotaf	Minstrel	●			●	●
	Pomadasyscommersonnii	Spotted grunter		●			
	Pomadasysolivaceum	Pinky / Olive grunt	●	●	●		
	Pomadasys striatum	Striped grunter	●	●	●		
Kyphosidae	*Kyphosusvaigiensis*	Brassy chub			●		
Labridae	*Anampsescaeruleopunctatus*	Bluespotted tamarin		●			
	Anampseslineatus	Lined tamarin		●			
	Anchichoeropsnatalensis	Natal wrasse		●	●		
	Bodianusatrolumbus	Palebar hogfish	●		●	●	
	Bodianusbilunulatus	Saddleback hogfish	●	●	●		
	Bodianusperditio	Goldsaddle hogfish		●			
	Cheilioinermis	Cigar wrasse		●	●		
	Coriscaudimacula	Spottailcoris		●	●		
	Corisformosa	Queen coris		●			
	Halichoerescosmetus	Adorned wrasse		●			
	Halichoeres lapillus	Jewelled wrasse		●			
	Labroidesdimidiatus	Bluestreak cleaner wrasse		●	●		
	Macropharyngodonvivienae	Madagascar wrasse		●			
	Oxycheilinusbimaculatus	Twospot wrasse			●		
	Stethojulisinterrupta	Cutribbon wrasse		●	●		
	Thalassomaamblycephalum	Twotone wrasse		●	●		
	Thalassomagenivittatum	Redcheek wrasse		●			
	Thalassomaherbraicum	Goldbar wrasse		●			
	Thalassomalunare	Crescent-tail wrasse		●	●		
Lethrinidae	*Lethrinuscrocineus*	Yellowfin emperor	●		●	●	●
	Lethrinus nebulosus	Blue emperor	●	●	●	●	●
Lutjanidae	*Aprionvirescens*	Green jobfish			●		
	Lutjanusargentimaculatus	River snapper	●	●	●	●	
	Lutjanuskasmira	Bluebanded snapper		●			
Malacanthidae	*Malacanthusbrevirostris*	Stripetail tilefish			●		
Monacanthidae	*Stephanolepisauratus*	Porky			●		
Mullidae	*Parupeneus*	Goatfish			●		
	Parupeneuscinnabarinus	Redspot goatfish		●	●		
	Parupeneusfraserorum	Fraser's goatfish			●		
	Parupeneusindicus	Indian goatfish		●	●		
	Parupeneusmacronema	Band-dot goatfish		●	●		
	Parupeneusrubescens	Blacksaddle goatfish	●	●	●		
Muraenidae	*Gymnothorax cf. undulatus*	Marbled leopard moray	●		●		
	Gymnothoraxchilospilus	Lipspot moray	●		●		
	Gymnothoraxfavagineus	Honeycomb moray	●		●		
	Gymnothoraxflavimarginatus	Yellow-edge moray			●		
Myliobatidae	*Myliobatisaquila*	Eagleray	●		●	●	
	Pteromylaeusbovinus	Duckbill ray			●		
Narkidae	*Electrolux addisoni*	Ornate sleeper ray			●		
Odontaspididae	*Carchariastaurus*	Raggedtooth shark	●		●		
Oplegnathidae	*Oplegnathusconwayi*	Cape knifejaw		●	●		
	Oplegnathusrobinsoni	Natal knifejaw		●	●		
Pinguipedidae	*Parapercisrobinsoni*	Smallscalesandsmelt	●		●		

Family	**Scientific name**	**Common name**	**CAS**	**UVC**	**UVS**	**Tagged**	**Recaptured**
Plotosidae	*Plotosusnkunga*	Eel-catfish	●				
Pomacanthidae	*Apolemichthyskingi*	Tiger angelfish		●	●		
	Centropygeacanthops	Jumping bean		●	●		
	Centropygemultispinis	Dusky cherub		●			
	Pomacanthusrhomboides	Old woman		●	●		
Pomacentridae	*Chromisdasygenys*	Bluespottedchromis		●	●		
	Chromisdimidiata	Chocolate dip		●			
	Chromisfieldi	Chocolate dip			●		
	Chromisnigrura	Blacktailchromis		●	●		
	Chromisweberi	Darkbarchromis			●		
	Pomacentruscaeruleus	Blue pete		●			
Pomatomidae	*Pomatomussaltatrix*	Elf	●				
Priacanthidae	*Priacanthushamrur*	Cresent-tail bigeye		●			
Pseudochromidae	*Pseudochromisdutoiti*	Dutoiti		●			
	Pseudochromisnatalensis	Natal dottyback		●	●		
Rachycentridae	*Rachycentroncanadum*	Prodigal son			●		
Rhinobatidae	*Rhinobatosholcorhynchus*	Slender guitarfish	●			●	
	Rhinobatosleucospilus	Greyspot guitarfish	●		●	●	
	Rhynchobatusdjiddensis	Giant guitarfish			●		
Scaridae	*Scarus sp.*	Parrotfish			●		
	Scarusghobban	Bluebarred parrotfish		●			
Sciaenidae	*Argyrosomusjaponicus*	Dusky kob	●	●		●	
	Argyrosomusthorpei	Squaretail kob	●	●	●	●	●
	Atractoscionaequidens	Geelbek	●		●	●	●
	Umbrinacanariensis	Tasselfish / Baardman		●			
	Umbrinarobinsoni	Slender baardman	●		●	●	
	Umbrinaronchus	Slender baardman		●			
Scombridae	*Euthynnusaffinis*	Eastern little tuna			●		
	Scomberomoruscommerson	King mackerel	●		●	●	●
Scorpaenidae	*Pterois miles*	Devil firefish			●		
Scyliorhinidae	*Haploblepharusedwardsii*	Puffaddershyshark	●				
	Porodermamarleyi	Blackspotted catshark	●			●	
	Porodermapantherinum	Leopard catshark	●			●	
Serranidae	*Acanthistiussebastoides*	Koester	●				
	Anthiascooperi	Silver-streak goldie		●			
	Anthiassquamipinnis	Sea goldie		●			
	Cephalopholissonnerati	Tomato rockcod	●		●		
	Epinephelus	Rockcods and seabass			●		
	Epinephelusalbomarginatus	Captain fine rockcod	●				
	Epinephelusandersoni	Catfacerockcod	●	●	●	●	●
	Epinephelusmalabaricus	Malabar rockcod	●			●	
	Epinephelusmarginatus	Yellowbellyrockcod	●	●	●	●	●
	Epinephelusrivulatus	Halfmoonrockcod	●	●	●	●	●
	Pseudanthiascooperi	Silver-streak goldie			●		
	Pseudanthiassquamipinnis	Sea goldie			●		
	Serranuscabrilla	Comber		●			
	Serranusknysnaensis	Comber			●		
Siganidae	*Siganusluridus*	Dusky rabbitfish		●	●		
	Siganussutor	Whitespotted rabbitfish			●		
Sparidae	*Boopsoideainornata*	Fransmadam	●	●	●		
	Cheimeriusnufar	Santer		●			
	Chrysoblephusanglicus	Englishman	●	●	●	●	●
	Chrysoblephuscristiceps	Dageraad	●			●	●

Family	Scientific name	Common name	CAS	UVC	UVS	Tagged	Recaptured
	Chrysoblephuslophus	False englishman			●		
	Chrysoblephuspuniceus	Slinger	●	●	●	●	●
	Cymatocepsnasutus	Black musselcracker	●	●	●	●	●
	Dentexnufar	Santer	●		●	●	●
	Diploduscervinushottentotus	Zebra	●	●	●	●	●
	Diplodussarguscapensis	Blacktail	●	●	●		
	Pachymetoponaeneum	Blue hottentot	●	●	●	●	
	Pachymetopongrande	Bronze bream	●	●	●	●	●
	Pagellusbellottiinatalensis	Sand soldier	●				
	Polyamblyodongermanum	German	●	●	●	●	
	Polysteganuspraeorbitalis	Scotsman	●	●	●	●	●
	Porcostomadentata	Dane	●	●	●	●	
	Rhabdosargus	Stumpnose			●		
	Rhabdosargusholubi	Cape stumpnose		●	●		
	Rhabdosargusthorpei	Bigeye stumpnose			●		
	Sarpasalpa	Strepie		●	●		
	Sparodondurbanensis	White musselcracker		●	●		
	Spondyliosomaemarginatum	Steentjie		●	●		
Sphyraenidae	*Sphyraena*	Barracudas	●		●		
Sphyrnidae	*Sphyrna*	Hammerhead sharks			●		
	Sphyrna lewini	Scalloped hammerhead	●		●	●	
	Sphyrna zygaena	Smooth hammerhead	●			●	
Tetraodontidae	*Amblyrhynchoteshonckenii*	Evileyeblaasop			●		
	Arothronhispidus	Whitespottedblaasop			●		
	Arothronimmaculatus	Blackedgedblaasop		●			
	Arothronmappa	Map blaasop		●			
	Canthigasterrivulata	Doubleline toby		●			
	Tetraodontidae	Blaasops			●		
Triakidae	*Mustelusmustelus*	Smoothhound	●		●	●	
Zanclidae	*Zancluscanescens*	Moorish idol		●			
		Number of species	68	99	122	43	22