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THE HABITATS AND BIODIVERSITY OF WATAMU MARINE NATIONAL PARK: EVALUATING OUR KNOWLEDGE OF ONE OF EAST AFRICA'S OLDEST MARINE PROTECTED AREAS

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THE HABITATS AND BIODIVERSITY OF WATAMU MARINE NATIONAL PARK: EVALUATING OUR KNOWLEDGE OF ONE OF EAST AFRICA'S OLDEST MARINE PROTECTED AREAS

B. COWBURN[1,2], P. M. MUSEMBI[1], V. SINDORF[1], D. KOHLMEIER[1], C. RAKER[1], A. NUSSBAUMER[1], H. F. R. HEREWARD[1], B. VAN BAELENBERGHE[1], D. GOEBBELS[1], J. KAMIRE[1], M. HORIONS[1], R. D. SLUKA[1*], M. L. TAYLOR[3*], and A. D. ROGERS[2*]

ABSTRACT

Watamu Marine National Park (WMNP) is one of the oldest no-take Marine Protected Areas (MPAs) in the world. Since its establishment in 1968, it has been the subject of a number of scientific studies as well as being exposed to range of modern anthropogenic threats to coastal marine habitats. The current state and conservation value of WMNP is documented in terms of habitat, biodiversity, and available scientific literature. Most of the 101 published references relating to WMNP focus on coral reef ecology, with less attention to biodiversity, socio-economics, or the ecology of non-coral reef habitats. The habitat map produced of WMNP is the first to show this level of detail and the only habitat map of a Kenyan MPA. Nine habitat categories were mapped, revealing that the most dominant habitat type by area is seagrass and the least is coral reef. Species lists were collected for fish, echinoderms, molluscs, crustaceans, corals, and seagrass, and species abundances were used to estimate total species richness, species diversity and sampling completeness. There were 18 species across all groups that fall into a category of conservation concern (other than Least Concern or Not Evaluated) on the IUCN Red List and 8 species found which are currently undescribed. This detailed case-study of marine biodiversity conservation in a less economically developed tropical nation emphasises the importance of non-coral habitats in the WMNP, such as seagrass beds, and the need for more research into the ecology and conservation importance of these habitats.

1 INTRODUCTION

Marine protected areas (MPAs) have increased threefold in the past decade, largely in response to Aichi Target 11[4]; to conserve 10% of marine areas through the use of protected areas and other spatial management measures by 2020 (Juffe-Bignoli *et al.* 2014). The purpose of MPAs varies from location to location, although broadly they are established for the protection of biodiversity and habitats, managing fisheries, promoting sustainable use of marine resources, and promoting tourism (Salm and Clark 2000). Various attempts have been made to assess how effective MPAs are as a conservation strategy (Wood *et al.* 2008, Lester *et al.* 2009, Fox *et al.* 2014). These assessments have shown broadly positive successes, such as maintenance of higher biomass of fish (Lester *et al.* 2009) and preventing coral loss (Selig and Bruno 2010). However, there is concern that many MPAs are too small (Mora *et al.* 2006), have ineffective management (Sale 2008), and do not share the benefits of MPAs equitably within local communities (Juffe-Bignoli *et al.* 2014). A common theme in these studies is the difficulty of assessing

[1] A Rocha Kenya, Plot 28, Beach Road, Watamu 80202, Kenya
[2] Department of Zoology, Tinbergen Building, South Parks Road, Oxford, OX1 3PS
[3] School of Biological Sciences, University of Essex, Wivenhoe Park, Colchester, CO4 3SQ
[*] These authors were joint supervisers of this project
[4] https://www.cbd.int/doc/strategic-plan/targets/T11-quick-guide-en.pdf

MPA effectiveness, because of a paucity of information available for assessments (Wood *et al.* 2008, Juffe-Bignoli *et al.* 2014).

The Western Indian Ocean (WIO) is a biogeographically distinct region of the wider tropical Indo-Pacific realm (Richmond 2002, Obura 2012), which includes the tropical East African coastline from the Red Sea to South Africa, and islands such as the Seychelles, Mauritius and Madagascar. It has moderately high biodiversity with over 60 genera of corals (Obura 2012) and 2000 species of fish (Richmond 2002), but compared to other shallow tropical marine areas it has received much less scientific attention (Sheppard 2000). The WIO has a long history of marine conservation, with many countries establishing their first MPAs in the 1960s (Wells *et al.* 2007). In Kenya there are four no-take marine 'parks' (total area – 55km^2) where fishing and all forms of extraction are forbidden, and six 'reserves' (735km^2) where fishing and other activities are regulated for sustainability (Figure 1), meaning that Kenya currently protects 8.7% of its continental shelf (Wells *et al.* 2007). Continuous fringing coral reef is present along the southern coastline of the country, but because of local geology and currents it is more patchily distributed in the north (McClanahan 1988; Figure 1). The MPA network in Kenya protects coral reefs, seagrass beds, mangrove areas and a range of intertidal habitats including mudflats, beaches, and rocky shorelines (Semesi 1998, Gullström et al. 2002, Nordlund 2012, McClanahan 2014).

Watamu Marine National Park (WMNP) covers a 10km^2 section of the lagoon and back-reef south of Watamu village (Figure 2), and includes all habitats between the dune vegetation to the reef crest. At its southern end a tidal inlet formed by Mida Creek creates a deeper channel and break in the reef-crest. Mida Creek contains 32km^2 of mangrove forests and rich tidal mudflats, a crucial habitat for wading birds. Both Mida Creek and the fore-reef slope are outside of the park, but are part of the Watamu-Malindi Marine National Reserve (164km^2), which extends 20km to the north and also encompasses Malindi Marine National Park (Figure 1). WMNP was created in 1968 and the Watamu-Malindi Marine National Reserve was declared a UNESCO biosphere reserve in 1979. The park is officially managed by Kenya Wildlife Service (KWS), who are responsible for the management and conservation of both marine and terrestrial parks in Kenya, with some cross over in responsibility with the Ministry of Fisheries (Muthiga 2009). The park saw a steady increase in tourists from the 1970s to present (Muthiga 2009) and now tourism is the major component of the local economy (Carter 2012). There are three NGOs carrying out marine conservation in WMNP, through data collection, community relationships and links with tourism. Watamu Turtle Watch works with turtles and has a rehabilitation centre near the beach, while Watamu Marine Association plays an important role in connecting local marine stakeholders, tourist organisations and government bodies to discuss conservation issues. A Rocha Kenya's marine programme was established in 2010, focussing on biodiversity and ecological research in MPA habitats, with a major component of its data collection on the being presented in this paper.

Although WMNP has been protected for 50 years, there has never been a comprehensive inventory of species or a map documenting the range of habitats found in its boundaries. Without this information it is difficult to identify conservation priorities or develop management actions and risks a 'sliding baseline' in our understanding of the biodiversity and habitats found there (Knowlton and Jackson 2008). The aim of this paper is to collate all the historical information available for WMNP and construct a contemporary baseline for the park. Specifically, we aim to:

- Compile all the existing literature available for the park to identify where historical data are available and highlight gaps in our understanding of WMNP.
- Produce a habitat map for the park to demonstrate the range and extent of the habitats being protected.
- Assess the biodiversity of major taxa in the different habitats of the park as a first step towards understanding the biota of WMNP as an integrated system.

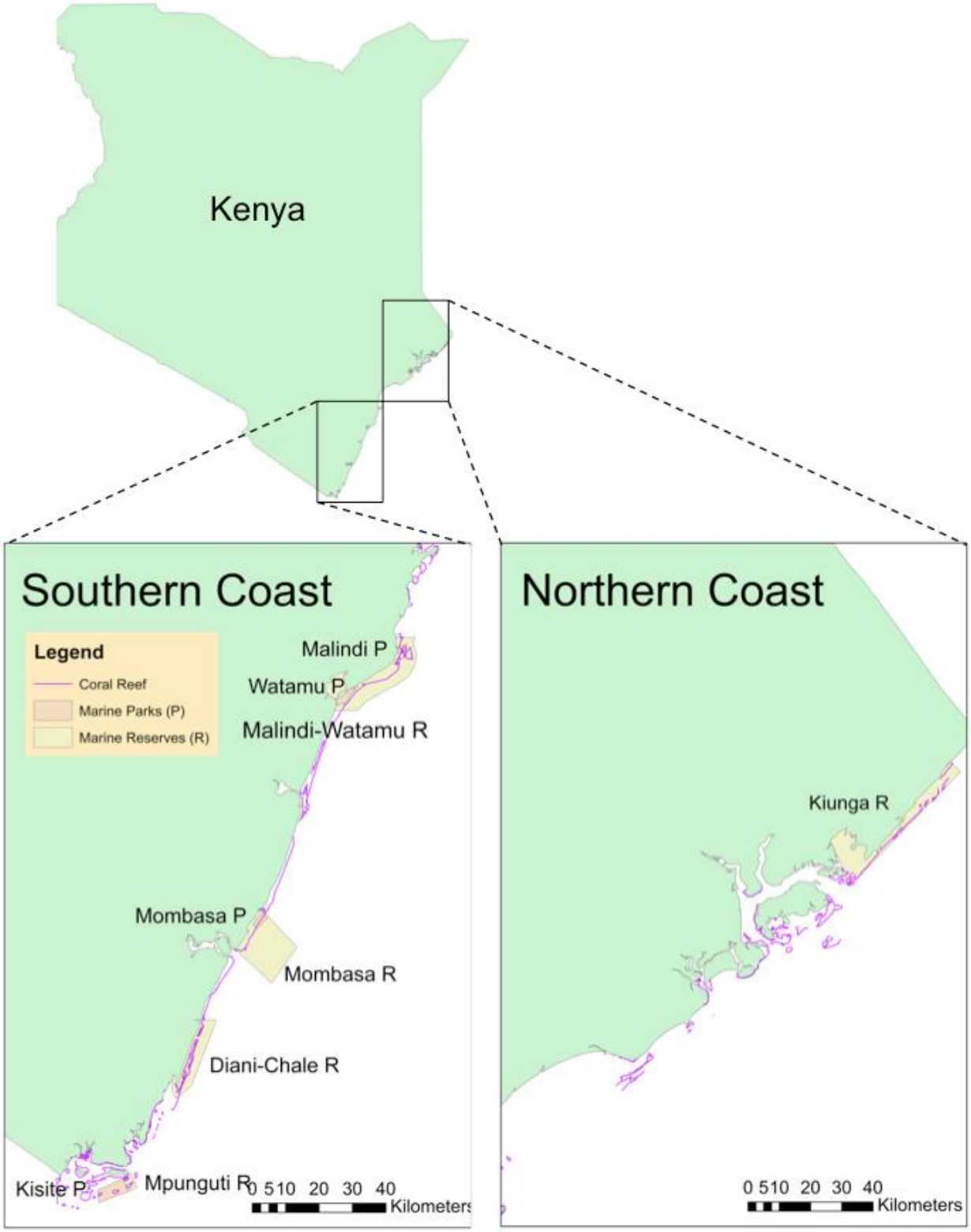

Figure 1. A map of Kenya's coastline and coral reefs, showing the locations of MPAs.

Figure 2. Satellite image of WMNP used in habitat mapping, showing the locations of Kenya Wildlife Services, conservation groups and main villages surrounding the MPA. Image date: 20.1.11. Image accessed from Google Earth.

2 METHODS

2.1 Literature review

A detailed bibliography of all published papers, grey literature, and reports was compiled by Muthiga and Kawaka (2010) for all marine protected areas in Kenya. An initial bibliography for WMNP was compiled from this, augmented with more recent records,and annotated (Appendix 1). The geographical scope of each reference was defined as 'Watamu' if WMNP was the only study site, 'Kenya' if WMNP was one of several sites in the country or 'International' for any study including data from outside of Kenya.

2.2 Habitat mapping

Habitat classifications were chosen *a priori* based on similar habitats defined in Jones (1969). These were based on dominant benthic component and divided among the littoral zone as follows:

- *Subtidal*
    - Coral reef: Holocene carbonate formations with >5% coral cover
    - Subtidal rock: Pleistocene carbonate formation with <5% coral cover
    - Subtidal sand: Mobile carbonate sand deposits
    - Subtidal seagrass: Benthos with >50% covering of seagrass
    - Mixed: Benthos with <50% seagrass mixed with rubble, macroalgae and bare substrate
- *Intertidal – Between Mean Low Water Spring (MLWS) and Mean High Water Spring (MHWS)*
    - Tidepool: Eroded pleistocene carbonate platforms containing pools
    - Beach: Intertidal sand
    - Intertidal seagrass: Intetidal areas with >50% seagrass cover
- *Supralittoral fringe*
    - Islands, dunes and cliffs: Any area above MHWS

Ground-truthing surveys of subtidal habitats were conducted by dividing the park into zones (2-3km^2 each) and systematically traversing from the low tide mark to the reef crest in roughly parallel lines, with an observer in the water and a second person on a boat recording GPS positions. Notes were made on the dominant benthic substratum and particular attention was paid to the presence of patch reefs. Subtidal ground-truthed waypoints were plotted onto a satellite image of WMNP (Figure 2) and overlain on the map. Habitat polygons were created through 'heads up digitising' (ESRI 2017) whereby the mapper uses visible colour patches, the ground-truthed points and knowledge of the area to manually draw habitat patches. Intertidal habitats were mapped by recording tracks on a GPS by walking around habitat patches at the lowest tide of each tidal cycle (i.e. MLWS). Intertidal polygons were converted from these GPS tracks. Habitat layers and maps were produced using ArcMap 10.0 (ESRI 2010).

2.3 Biodiversity

Species lists were collected for fish, echinoderms, molluscs, crustaceans, and seagrass, but corals were identified to genus level. These lists are based on both quantitative sampling and chance incidental observations from 2011-2014 when the lead author was based at A Rocha Kenya's marine programme. Twelve affiliates of the marine programme contributed to data

collection (Table 1). The eight intertidal and subtidal habitats defined for habitat mapping were condensed into three 'zones' to structure data collection: 'coral reef', 'intertidal' (beach, tidepool and intertidal seagrass), and non-reef 'subtidal' (rocky reef, sand, seagrass and mixed). The supralittoral zone, composed of dunes, rocky cliffs and islands in the park was not surveyed for biodiversity.

Table 1. Data collection for fish, echinoderm, mollusc, crustacean, seagrass, and coral diversity by zone. Incidental and quantitative data collection (blue) and incidental records only (yellow) are indicated. Data collectors include Benjamin Cowburn (BC), Robert Sluka (RS), Dawn Goebbels (DG), Victoria Sindorf (VS), Cassie Raker (CR), Peter Musembi (PM), Hannah Hereward (HH), Aline Nussbaumer (AN), Mattias Horions (MH), Jack Kamire (JK), Benjamin van Baelenberghe (BB) and Dorothea Kohlmeier (DK). All collectors are affiliated with A Rocha Kenya's marine programme.

Taxon	***Zone***		
	Coral Reef	**Intertidal**	**Subtidal**
Fish	BC, RS, DG	VS, BC	CR, BC
Coral	BC	BC, VS, PM, BB	*Not sampled*
Echinoderms	PM, AN, BC	CR, PM	BC
Molluscs	PM, HH, AN, BC	MH, JK, PM	BC
Crustacea	HH	HH	*Not sampled*
Seagrass	*Not sampled*	DK	DK

All of the sampling was done visually; cryptic and infaunal (burrowing) species were not included. For some taxa (e.g. Molluscs and Echinoderms) this will have missed a significant number of species actually found in the park. Quantitative data were collected for all fish and non-cryptic echinoderms and molluscs (>1cm) in coral reef and intertidal areas. In subtidal areas only fish were assessed quantitatively (Table 1). Data were collected at the six lagoonal patch reefs between 1 to 8m below mean low water (MLW) using randomly placed belt transects. Fish transects were 40x5m (200m^2) and for echinoderms and molluscs, 20x2m (40m^2). Biodiversity data from intertidal areas were collected on rocky platforms (~1m above MLW) at regular intervals along the beach. Intertidal areas were sampled with 1m^2 quadrats placed randomly on the platforms, for all taxa sampled (Sindorf *et al.* 2015). Subtidal fish data were collected in 5m-wide belt transects running in 4 lines that traverse the park at regular intervals (~2km apart) from the beach to the reef crest.

Incidental records for various taxa were collected based on chance observations reported by A Rocha affiliates (Table 1). New species were added to the relevant species list and, where possible, a location and date. Incidental records were made for fish, corals, molluscs, echinoderms, seagrass and crustaceans. Intertidal incidental records also include beach and intertidal seagrass habitats, which were not surveyed during quantitative intertidal sampling. All species lists were annotated with IUCN Red List status of species classed as 'Near Threatened' or greater (http://www.iucnredlist.org/) and the fish list was annotated with species' biogeographical affinity (Froese and Pauly 2015). Quantitative data were analysed to produce estimates of species abundance, total species richness, species diversity and community similarity between zones, using 'R' packages BiodiversityR and Vegan (Kindt and Coe 2005). The sampling completeness of quantitatively surveyed taxa in each zone (coral reef, intertidal and subtidal) was determined using individual-based rarefaction curves and by calculating total richness estimates. Four common total richness estimates were used: Chao, Jackknife 1, Jackknife 2 and Bootstrap (Kindt and Coe 2005) to give a range of estimated values.

3 RESULTS

3.1 Literature review

A total of 101 unique references were found (Figure 3 and Appendix 1), with topics varying from subsistence economics (Versleijin 2001) to turtle endogeny (Watson 2006). Of the references that present biological information gathered in WMNP, 14 include data from the intertidal zone, 14 from the subtidal zone and the majority, from coral reefs. There were 43 references focussed on Watamu alone, 51 where information from WMNP was included with other sites in Kenya, and seven with sites internationally (Appendix 1).

The first publication to include data from Watamu (Isaac and Isaac 1968) reviewed marine botany for the entire Kenyan coast. Shortly afterward the Bangor University expedition in 1969 collected specific information about the newly created park and produced 8 publications, largely around lead editor David Jones' interest in isopods (Crustacea: Isopoda e.g. Jones 1971), but also including the first comprehensive baseline data available for the park's biodiversity and ecology (Jones 1969). A research expedition from the University of Nijmegen, in the Netherlands, carried out a second review of the park in 1982, focussing on coral health and sedimentation from terrestrial erosion (Blom *et al*. 1985, van Katwijk *et al.* 1993). In 1987 the Kenyan Wildlife Conservation Society (WCS) group, headed by Dr. Timothy McClanahan, began regular ecological monitoring of Kenya's MPAs. To date, with nearly 30 years of annual data collection, WCS have published 45 pieces of work using data from Watamu, including some of the most widely cited coral reef ecology and conservation references in current scientific literature (e.g. McClanahan *et al.* 2001, McClanahan *et al.* 2007). This is especially true post-1998, when the devastating mass bleaching and mortality of corals in Watamu and across the world, spurred the study of coral reef ecology and conservation in the face of human-driven climate change.

More recently the government bodies Kenya Wildlife Services (KWS) and Kenya Marine and Fisheries Research Institute (KMFRI) began monitoring and conducting marine research. In partnership with KWS, A Rocha Kenya began its marine programme in 2010. There have been 14 papers and reports from this group (available online at http://kenya.arocha.org/work/scientific-research/reports/) relating to various aspects of marine biodiversity and ecology.

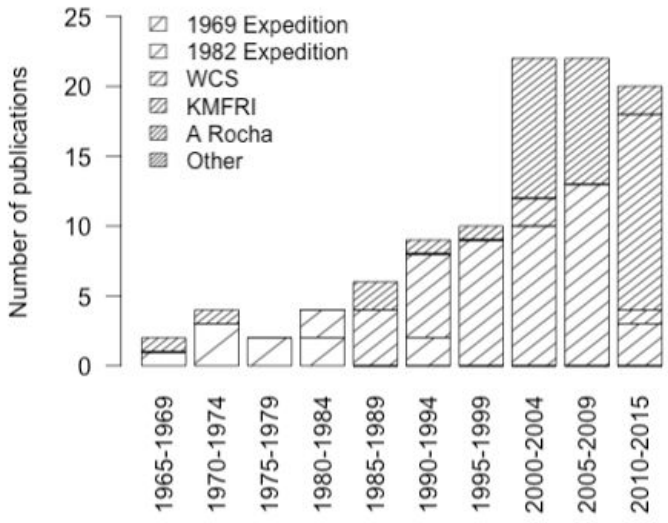

Figure 3. Publication by research group in WMNP from 1968-2015, including records from the

1969 University of Bangor expedition, 1982 University of Nijmegen expedition, Wildlife Conservation Society, Kenya Marine and Fisheries Research Institute (KMFRI) and A Rocha Kenya

3.2 Distribution of habitats in WMNP

Habitats were mapped in 8.35km^2 (83.5% of 10km^2) of the park's area. Areas of the MPA beyond the reef crest were not surveyed because of difficulty in accessing these rougher waters and in the reliability of detection of habitat patches on satellite imagery. An estimated 82% of the mapped area is subtidal, 13% is intertidal and 5% is the supralittoral fringe (Table 2). Subtidal seagrass is the most dominant component of the park covering nearly 40% of the benthos found in calm sheltered waters <3m deep. On shallow reef crest higher wave energy has created a mixed habitat of seagrass, rubble and occasional coral colonies (14% of area) and in deeper channels (3-10m) sandy carbonate deposits dominant the benthos (26%). Coral reef was the smallest habitat covering an estimated 1%. Hard substrata (either rock or coral) cover just 5.3% of intertidal and subtidal areas. Lines of exposed Pleistocene limestone run parallel to the shore, along the beach edge forming the numerous tide-pool patches and also along the reef crest and through the lagoon forming subtidal rocky reefs (Figure 4). Other areas were characterised by sandy and rubble substrata with extensive seagrass growth in shallower (<4m) depths.

Table 2. Area covered by different habitat in WMNP in km^2 and percentage of the mapped area

Habitat	Area in km^2	% of mapped area
Littoral	0.418	5.0
Coral	0.085	1.0
Tidepool	0.216	2.6
Subtidal rock	0.144	1.7
Beach	0.495	5.9
Subtidal sand	2.185	26.2
Intertidal seagrass	0.359	4.3
Subtidal seagrass	3.292	39.4
Mixed subtidal	1.154	13.8

Most coral reef habitat is also found in a line parallel to shore on the seaward slope of a channel (3-6m deep) that stretches along the central section of the park, including Coral Gardens, the most popular tourist spot (Figure 4). This habitat consists of a chain of small (10-50m long) lagoonal patch reefs, featuring large (>2m) *Porites* colonies. At the landward edge of these patch reefs, the reef rises above the ~1m deep sandy/seagrass habitat to the MLW. Other reefs are found at Turtle Reef and Uyombo, where smaller channels near the reef crest support reef growth on slopes (~30°) extending to 8-10m deep (Figure 4). These areas are similar to the main reef chain, but have greater water circulation and wave exposure from the ocean, encouraging some fore-reef species (e.g. *Manta* sp.) to foray into these habitats. Much of the intertidal area is beach (43%), with significant areas of intertidal seagrass found near Uyombo village. Rocky tidepool habitats are most common near the northern edge of Mida Creek channel and on the northern shoreline near Turtle Bay. Limestone platforms (0.5-1m above mean low water) are eroded in complex honeycomb patterns, which has created a network of pools and underground tunnels, some of which are large enough to snorkel in.

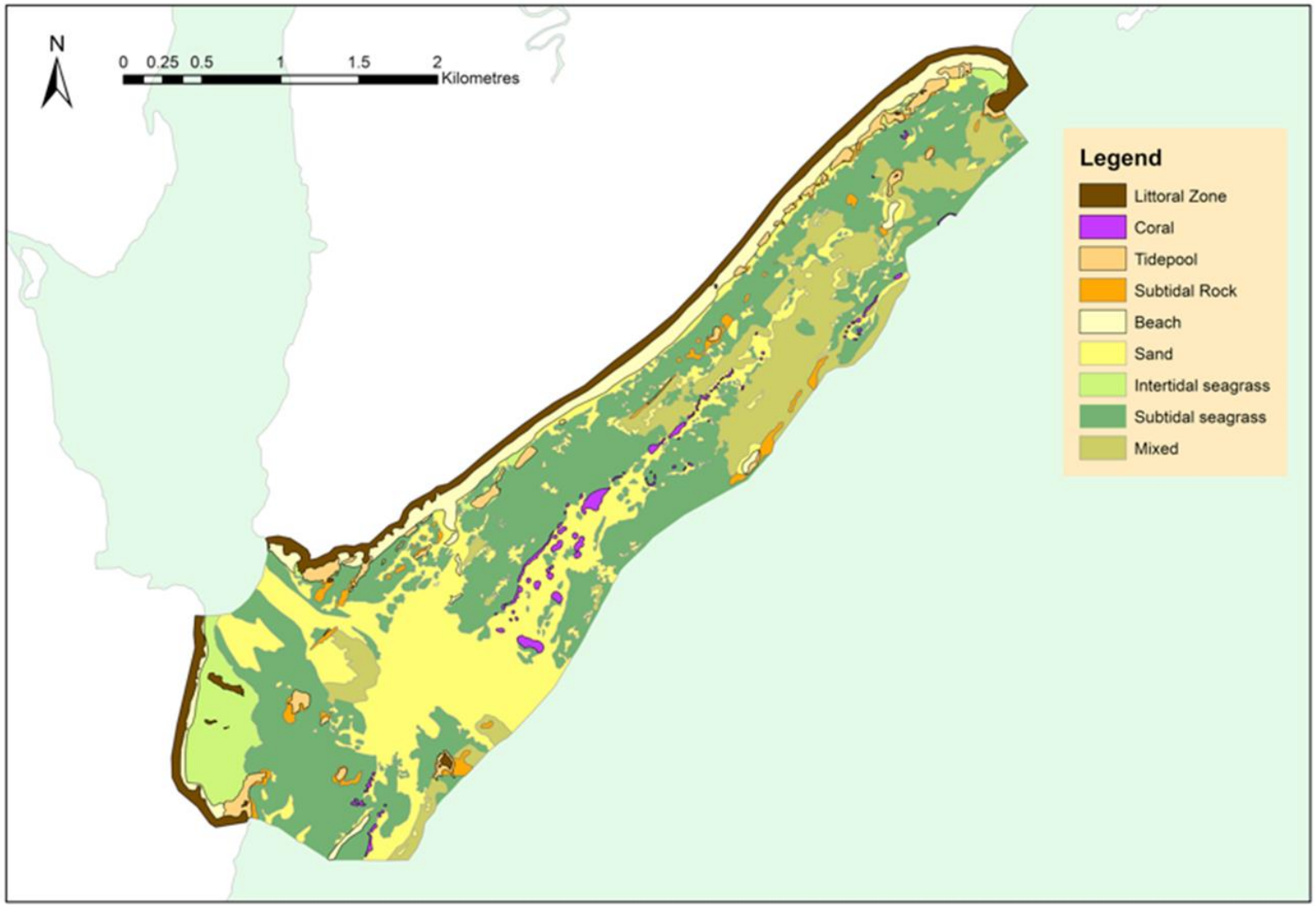

Figure 4. Map of habitats found between the reef crest and terrestrial boundary of WMNP.

3.3 The biodiversity of WMNP

Table 3. Species richness of fish, echinoderms, molluscs, crustacean and seagrass, and genus richness for corals from quantitative and *incidental* data collection in different zones.

Taxon		***Zone***			***Total Richness***
		Reef	**Intertidal**	**Subtidal**	
Fish	Quantitative	146	38	71	**407**
	Incidental	*266*	*89*	*157*	
Echinoderms	Quantitative	13	11	n.d.	**34**
	Incidental	*22*	*23*	*9*	
Molluscs	Quantitative	17	32	n.d.	**60**
	Incidental	*26*	*39*	*8*	
Crustacea	*Incidental*	*10*	*15*	*1*	**23**
Seagrass	*Incidental*	*n.d.*	*n.d.*	*11*	**11**
Coral (genus)	*Incidental*	*41*	*13*	*n.d.*	**43**

Fish were the richest taxon in the park with 407 species observed from 62 families and 178 genera overall. The most speciose family were the wrasses (Labridae) with 45 species, followed by damselfish (Pomacentridae – 36 species) and groupers (Serranidae – 24 species). Ten of the fish species were elasmobranchs, six of which are considered threatened (Appendix 2). Most fish had a range extending beyond the Indian Ocean with 323 (81%) being Indo-Pacific, six species (2%) with a circumtropical range, with 44 species (11%) endemic to the WIO region. Coral reefs had the highest richness for fish observed of all the habitats (Table 3). Most coral genera were also found on the reef, but 13 genera were observed in the rocky intertidal (tidepool) zone, with 2 of these (*Anomastrea* and *Alveopora*) only seen in this habitat. Molluscs were the most speciose invertebrate taxon assessed, with incidental records of 60 species. A total of 55 mollusc species were gastropods, including 12 nudibranchs. The 34 echinoderms were comprised of nine starfish (Asteroidea), ten urchins (Echinoidea), ten sea cucumbers (Holothuroidea) and five brittlestars (Ophiuroidea). The 43 genera of corals observed came from 11 families.

There were 18 species found which have an IUCN Red List status other than least concern (LC) or data deficient (DD), with five near threatened (NT) species, 11 vulnerable (VU) species and two endangered (EN) species. Six of these species were elasmobranchs, six were bony fish (Teleosts), four sea cucumbers (Holothuroidea), one seagrass and one coral species. During species identification of fish seven potentially undescribed sweepers were observed *(Pempheris spp.*, J. Randall, Bishop Museum, pers. comm.).

Black-tip reef shark - *Carcharhinus melanopterus* (NT)
White-tip reef shark - *Triaenodon obesus* (NT)
Blue-spotted stingray - *Taeniura lymma* (NT)
Brown-marbled grouper - *Epinephelus fuscoguttatus* (NT)
Malabar grouper - *Epinephelus malabaricus* (NT)

Sharp-nose stingray - *Himantura gerrardi* (VU)
Honeycomb stingray – *Himantura uarnak* (VU)
Alfred's manta ray - *Manta alfredi* (VU)
Giant grouper - *Epinephelus lanceolatus* (VU)
Saddle-back coral grouper - *Plectropomus laevis* (VU)
Thorny seahorse - *Hippocampus hystrix* (VU)
Hedgehog sea cucumber - *Actinopyga echinites* (VU)

White-belly sea cucumber - *Actinopyga mauritiana* (VU)
Military sea cucumber - *Actinopyga miliaris* (VU)
South African eelgrass - *Zostera capensis* (VU)
Crisp pillow coral - *Anomastraea irregularis* (VU)

Humphead wrasse - *Cheilinus undulatus* (EN)
Edible sea cucumber - *Holothuria scabra* (EN)

3.4 Completeness of biodiversity records

Table 4. Sampling effort of quantitative data collection by taxon and habitat

Taxon	Habitat	Area surveyed (m^2)	% Area of mapped habitats	Number of individuals recorded
Fish	Coral reef	4000	4.7%	2409
	Intertidal	131	0.1%	220
	Subtidal	14,500	0.2%	1400
Echinoderms	Coral reef	800	0.9%	565
	Intertidal	153	0.1%	772
Molluscs	Coral reef	1440	1.7%	95
	Intertidal	1510	0.7%	622

The area surveyed and number of individuals recorded is presented to demonstrate the sampling effort for each taxon (Table 4). The largest area covered in quantitative surveys was for fish in the subtidal zone covering 14,500m^2 (Table 4). However, as a percentage of this habitat's total area this only represents sampling of 0.2%. By contrast, the smaller area covered for fish on coral reef of 4000m^2 was technically a greater sampling effort as this accounted for 4.7% of its area. Intertidal fish had the lowest sampling effort with just 220 individuals recorded from 0.1% of the total habitat in WMNP (Table 4). Species rarefaction and richness estimate curves for reef fish and subtidal fish (Figure 5a, Table 5) suggest these habitats were adequately sampled for fish, whereas intertidal fish appeared to have been under sampled. Sampling for echinoderm species lists appeared to be largely complete with the rarefaction curves for both intertidal and reef species nearing the asymptote (Figure 5b). Intertidal molluscs appeared well sampled (Figure 5c), but the small number of reef molluscs observed (95) means this group is probably under sampled. It is interesting to note that in all habitats the incidental richness of fish and echinoderms (Table 3) was higher than most of the richness estimates (Table 5).

Table 5. Observed species richness and total richness estimates from quanitative data. Estimates using Jackknife1 (JK1), Jackknife2 (JK2), Chao (CH) and Bootstrap (BS).

Taxon	Habitat	Observed Quantitative Richness	JK1	JK2	CH	BS
Fish	Reef	146	183	197	175	164
	Intertidal	38	58	76	137	46
	Subtidal	71	99	116	108	83
Echinoderms	Reef	13	15	12	13	14
	Intertidal	11	15	19	17	13
Molluscs	Reef	17	24	26	22	20
	Intertidal	32	42	42	37	37

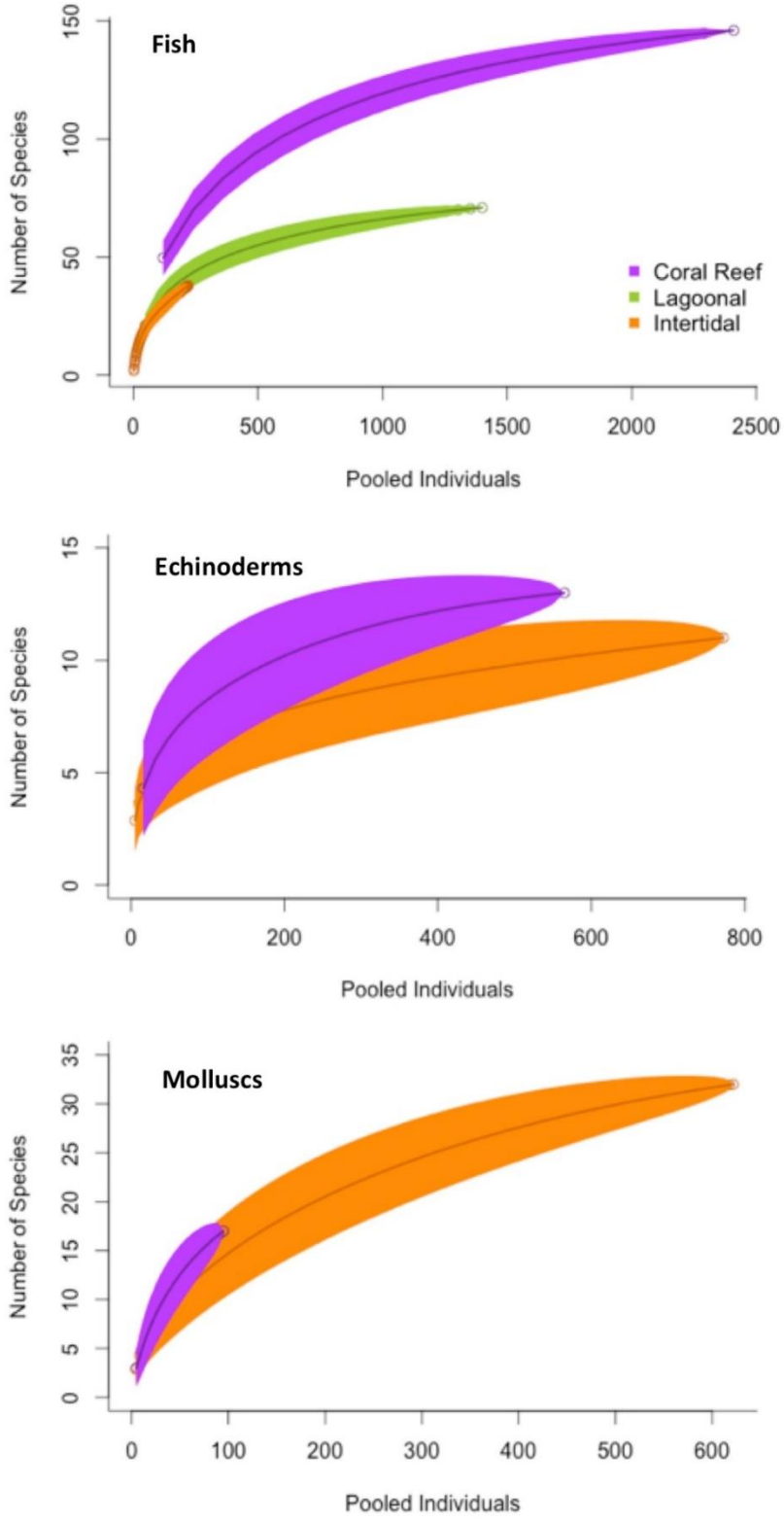

Figure 5. Rarefaction curves of species richness based on individual sampling by zones

4 DISCUSSION

4.1 Historical biodiversity records from WMNP

During the past 50 years there have been several key studies documenting the biodiversity found in the park, all of which were published over 20 years ago. Isaac and Isaac's (1968) monograph on the ecology and biodiversity of mangroves, seagrass and seaweeds found in Kenya unfortunately doesn't present data by site, i.e., there is no information specific to Watamu. In this survey, 11 of the 12 seagrass species listed in Kenya were recorded in the park (Table 3, Appendix 2). The Bangor Expedition in 1969 collected a great deal of information on the non-coral invertebrate fauna of the park, published over the following 12 years (Appendix 1: Research Group = 'Bangor Expedition'). Humphreys (1981) lists 107 species of Echinodermata in the park, organised by habitat, niche, and relative abundance, and includes all of the 34 species recorded in this survey. The Bangor Expedition work is much more comprehensive than this survey (34 species), including infaunal (burrowing) echinoderms and more attention to the taxonomically difficult brittle stars (Ophiuroidea). The Bangor expedition also collected data on the crustaceans and polychaetes found in the park (e.g., Jones 1971, 1972, 1976 and 1982). Brander (1971) found 50 unidentfied species of polychaetes and 30 crustaceans in reef areas. A Rocha's work surveyed crustaceans incidentally and polychaetes not at all, thus these groups remain poorly known.

In 1982 Nijmegen University compiled a species list of corals (Scleractinia) found in the wider Watamu-Malindi Marine Reserve, including 113 species from 45 genera (Lemmens, 1993). This list includes 7 genera not found in A Rocha's surveys (*Seriatopora, Stylophora, Pachyseris, Cynarina, Diploastrea, Physogyra* and *Gyrosmilia*). The wider range of habitats surveyed by Nijmegen University may explain why some of these genera were not included in A Rocha's list (Appendix 2), with genera such as *Pachyseris* and *Diploastrea* being present and common outside the park, in the reserve on the fore-reef slope (B. Cowburn, pers. obs.). A Rocha's surveys found 43 genera (Table 3, Appendix 2), including three coral genera not listed in Lemmens (1993) - *Ctenactis, Anomastrea* and *Symphyllia* - and also 'gained' two genera because of recent changes to coral taxonomy; *Isopora* which was formerly included within *Acropora,* and *Coelastrea* which was previously named *Goniastrea aspera*. McClanahan (1990) surveyed the sea snail fauna (Prosobranchia) of Kenya and presented quantitative records of abundance. Information about the 10 most common species is presented at the site level, meaning a complete list for WMNP is not available. A fish list was compiled for the park by local enthusiast and tour guide Mr. Richard Bennett, who has recorded nearly 500 species during his ~20 years of residence in Watamu since the 1990s.

4.2 Research gaps and future work

The majority of the literature related to coral reef ecology and biodiversity, despite this habitat only covering 1% of the mapped area (Table 2, Figure 4). The most understudied habitats are the seagrass beds, subtidal rocky reefs, and sandy channels in the non-reef subtidal zone, which cover 82% of the mapped park area. A heavy focus on coral reefs is not unusual in tropical marine ecology because of their considerable importance in terms of biodiversity (Plaisance et al. 2011), ecosystems services (Constanza et al. 1997) and aesthetic appeal. However, key ecological processes and biodiversity are found within other tropical marine habitats. This study found the intertidal zone had the most biodiverse echinoderm and mollusc communities (Figure 6) and recorded 10 of the 18 IUCN red-listed species of conservation concern in non-reef habitats. Sindorf et al. (2015) noted that rocky intertidal areas (~2% of WMNP) contained a high proportion juvenile reef fish species, which are presumably using the pools as nursery grounds. The extensive seagrass beds in WMNP provide various ecological roles and ecosystem services, such as carbon storage, feeding grounds for coral reef organisms, and helping to prevent erosion

(Gullström et al. 2002, Green and Short 2003). However, based on the current literature available for WMNP there is little known about the biodiversity or ecosystem functioning locally.

The sampling completeness for many taxa and habitats appeared complete based on quantitative results, but incidental observations recorded higher richness values than the richness estimations. This may be because there is greater habitat diversity within zones than captured from the areas covered in quantitative surveys, meaning some species ranges were not included. Species records were limited to well-documented and conspicuous groups that could be easily identified in the field. Identification of other taxa, such as soft corals (Octocorallia) and sponges (Porifera), which require a higher degree of taxonomic specialisation and the collection of specimens, was not attempted. Sampling of cryptic and infaunal invertebrate taxa require taking sediment cores and dead coral rock, which was beyond the scope of the current study, but contribute greatly to biodiversity of these taxa (Plaisance et al. 2011). Many of the taxa not assessed contribute significantly to total biodiversity of shallow marine habitats (Taylor 1971, Richmond 2002) and play a crucial role in coral-reef ecology and functioning (Diaz and Rutzler 1999). Future biodiversity assessments should prioritise infaunal species of mollusc, echinoderm and crustaceans and all species of soft corals, sponges, macroalgae, polychaetes and tunicates. This study provides the most detailed and accurate information to date of habitat distribution within the lagoon. However, the area mapped only extends to the reef crest and the remaining 1.65km2 within the boundaries of WMNP is un-surveyed, without any information on the species found there. An additional gap in the mapping is for the supra-littoral habitats, recognising the differences in the dunes, coastal scrub, cliffs and islands found above the tideline, which are protected as part of the MPA.

4.3 Conservation challenges and the conservation value of WMNP

When WMNP was initially created, there were concerns of overexploitation in the lagoon, particularly of shells for the tourist trade (Jones 1969). In the past 50 years human population has increased dramatically in Watamu (>500%), triggered by tourism and migration into the area (Muthiga 2009). The presence of a large human population has had several impacts, the most obvious of which is the encroachment of the dune and beach areas of the park by hotels and other developments. Another potential impact of tourist development, which has never been formally assessed, is the increase in polluting substances entering the lagoon. Large numbers of pleasure vessels and tourist boats are moored in the northern part of the park, which could be releasing hydrocarbons and antifouling paint into the water. Inadequate sewage systems in the growing residential areas of Watamu may mean elevated levels of nutrients are entering the park. These pollutants have damaging impacts on coral and seagrass communities (Fabricius 2005, Green and Short 2003), and should be assessed and managed if necessary.

Increasing human populations on the Kenyan coast has also impacted reef fisheries, with a significant reduction in fish yields over the past 20 years (Kaunda-Arara et al. 2003, Samoilys et al. 2017). While WMNP has been moderately successful at enforcing its no-take status (McClanahan et al. 2010), there exists a degree of poaching of fish and other natural resources from the park (B. Cowburn pers. obs.), the extent and impacts of which are unclear. The increasingly degraded areas around the park may be causing a ‘spill-in’ of negative environmental conditions (Eklof et al. 2009), through reduced larval supply, or reduced populations of fish that range both inside and out of the park. The most significant impact to the park to date was the mass bleaching and mortality of coral in 1998 (Muthiga 2009). This extreme mass-bleaching event that caused the loss of approximately 16% of reefs globally (Wilkinson 2008), saw 70% mortality of corals in WMNP (McClanahan et al. 2001). Since 1998 there have been four minor bleaching events and, with further increases in ocean temperatures predicted, the future of corals in WMNP is under threat (van Hooidonk et al. 2016).

Despite these threats the park maintains high habitat and species diversity (Figure 4, Appendix 2) with 18 species with an IUCN red list designation of ‘conservation concern’.

Many more are listed as data deficient, including several of the grouper (Serranidae) and elasmobranches, demonstrating the need for more research into the conservation importance of thes habitats. WMNP has been effective at protecting a healthier fish community than surrounding areas (McClanahan 2014), and possesses important keystone species including the orange-lined triggerfish (Balistoides undulates) and red knobbed starfish (Protoeaster linckii). On unprotected reefs in Kenya the loss of these species through overfishing has been associated with the rapid increase of sea urchin populations Diadema spp. and Tripneustes gratillia, which has resulted in urchin overgrazing on reefs and seagrass meadows respectively (McClanahan 2000, Eklof et al. 2009). In addition to the conservation value of the park for habitats and species, protecting WMNP is also important for the local tourist economy, which attracts approximately 25,000 visitors per year, generating €200,000 per year in park entrance fees (Cowburn et al. 2013). (Appendix 2). Despite being a small MPA in a less economically developed tropical nation, WMNP is far from being a 'paper-park' and contributes to local and regional conservation efforts. It is one of the oldest MPAs in the world and has a remarkable amount of historical data collection for a Western Indian Ocean site. However, with increasing pressure from human development and climate change, the future of its habitats and biodiversity relies on effective management of threats and maintaining public support for its existence.

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APPENDIX 1:
ANNOTATED LIST OF REFERENCES CONTAINING INFORMATION FROM WATAMU MARINE NATIONAL PARK

Alati, V M (2011). **Estimating the value of goods and services in a marine protected area, the case of Watamu Marine National Park and Reserve, Kenya.** *Vrije Universiteit Brussel*
Type: Master's thesis
Keywords: MPA, Ecosystem services
Research Group: Other

Blom, J., Van der Hagen, H., & van Hove, E. (1985). **Decline of the Malindi-Watamu Reef complex: quantitative and qualitative survey of the coral growth.** *Kenya-Belgium project in marine ecology.*
Type: Report
Keywords: Coral, sedimentation, resilience
Research Group: 1982 University of Njimegen expedition

Brander, K. M., McLeod, A., & Humphreys, W. F. (1971). **Comparison of species diversity and ecology of reef-living invertebrates on Aldabra Atoll and at Watamu, Kenya**. *Symp Zool Soc London 28,* 397-431
Type: Published article
Keywords: Biodiversity, invertebrates, polychaetes, crustaceans, echinoderms
Research Group: 1969 University of Bangor expedition

Bush, E. R. 2013. **What's the catch? Mosquito net fishing in coastal East African.** *Imperial College London.*
Type: Master's thesis
Keywords: Fisheries, livelihoods, health
Research Group: A Rocha

Cahill, R (1992). **Birds of Watamu**. *Majestic printing works, Nairobi*.
Type: Book
Keywords: Biodiversity, birds
Research Group: Other

Calnan, JM (2006). **Changes in benthic communities in Kenyan marine protected areas**. *Columbia University, USA.*
Type: Master's thesis
Keywords: Resilience, post-bleaching, fish, algae, MPA
Research Group: Wildlife Conservation Society

Carreiro-Silva, M. (1999). **Echinoid bioerosion and herbivory on Kenyan coral reefs: the role of Marine Protected Areas.** *University of Wales*
Type: Master's thesis (published in Carreiro-Silva and McClanahan (2001))
Keywords: Resilience, bioerosion urchins, coral, MPA
Research Group: Wildlife Conservation Society

Carreiro-Silva, M., & McClanahan, T. R. (2001). **Echinoid bioerosion and herbivory on Kenyan coral reefs: the role of protection from fishing.** *Journal of Experimental Marine Biology and Ecology*, *262*(2), 133–153.
Type: Published article
Keywords: Resilience, bioerosion urchins, coral, MPA

Research Group: Wildlife Conservation Society

Cowburn, B., Sluka, R. (2012). **Impact of snorkeling tourism on marine habitats of Watamu Marine National Park.** *A Rocha Kenya occasional research report #26.*
Type: Report (Published in Cowburn et al. 2013)
Keywords: Tourism, MPA
Research Group: A Rocha

Cowburn, B., Sluka, R., Smith, J., & Mohamed, M. O. S. (2013). **Tourism, Reef Health, and Visitor Enjoyment in Watamu Marine National Park, Kenya.** *Western Indian Ocean Journal of Marine Science*, *12*(1), 57–70.
Type: Published article
Keywords: Tourism, MPA
Research Group: A Rocha

Cowburn, B., Sluka, R., Smith, J. (2013). **Coral reef ecology and biodiversity in Watamu Marine National Park, Kenya.** *A Rocha Kenya occasional research report #27.*
Type: Report
Keywords: Biodiversity
Research Group: A Rocha

Darling, E. S., McClanahan, T. R., & Côté, I. M. (2010). **Combined effects of two stressors on Kenyan coral reefs are additive or antagonistic, not synergistic.** *Conservation Letters*, *3*(2), 122–130.
Type: Published article
Keywords: Resilience, post-bleaching, fisheries, MPA
Research Group: Wildlife Conservation Society

Darling, E. S., McClanahan, T. R., & Côté, I. M. (2013). **Life histories predict coral community disassembly under multiple stressors.** *Global Change Biology 19,* 1930-1940
Type: Published article
Keywords: Post-bleaching, reef ecology, coral

Davies, J. G. (2002). **The attitudes of fishermen and management staff towards three marine protected areas.** *University of Newcastle, UK.*
Type: Master's thesis (Published in McClanahan et al. 2005)
Keywords: Fisheries, MPA
Research Group: Wildlife Conservation Society

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Type: Published article
Keywords: MPA, urchins
Research Group: Wildlife Conservation Society

Giesen, W., Kerkhof, K. (1984). **The impact of river discharge on a Kenyan coral reef ecosystem – the physical processes.** *Kenya-Belgium project in marine ecology.*
Type: Report
Keywords: Coral, sedimentation, resilience
Research Group: 1982 University of Njimegen expedition

Glaesen, H. (1997). **Fishers, parks and power: The socio-environmental dimensions of marine resource decline and protection on the Kenyan coast**. *University of Winsconsin-Madison, USA*
Type: PhD thesis
Keywords: Fisheries, livelihoods, MPAs
Research Group: Wildlife Conservation Society

Gordon, T. (2015). **Defended territories of an aggressive damselfish contain lower juvenile coral density than adjacent non-defended areas on Kenyan lagoon patch reefs.** *University of Cambridge, UK*.
Type: Undergraduate thesis (Published in Gordon et al. 2015)
Keywords: Resilience, coral recruitment, damselfish
Research Group: A Rocha

Gordon, T., Cowburn, B., & Sluka, R. D. (2015). **Defended territories of an aggressive damselfish contain lower juvenile coral density than adjacent non-defended areas on Kenyan lagoon patch reefs.** *Coral Reefs, 32*, 13-16.
Type: Published article
Keywords: Resilience, coral recruitment, damselfish
Research Group: A Rocha

Hemery, G., & McClanahan, T. (2005). **Effect of recreational fish feeding on reef fish community composition and behaviour.** *Western Indian Ocean Journal of Marine Science*, *4*(2), 123–133.
Type: Published article
Keywords: Tourism, fish
Research Group: Wildlife conservation society

Hendrick, J. V. (1997). **A survey of fish populations and feeding patterns in a Kenyan coral reef: Short-term impact of macroalgal removal and its potential in reef rehabilitation.** *University of Newcastle, UK.*
Type: Master's thesis (Published in McClanahan et al. 1999 and McClanahan et al. 2002)
Keywords: Resilience, macroalgae, coral, fish
Research Group: Wildlife conservation society

Hereward, H., Sluka, B. (2014). **Testing ghost crab density as a useful indicator of human impacts on exposed sandy beaches.** *A Rocha Kenya occasional research report #29.*
Type: Report
Keywords: Crab, beach ecology
Research Group: A Rocha

Holdich, D. M., & Jones, D. A. (1973). **The systematics and ecology of a new genus of sand beach isopod (Sphaeromatidae) from Kenya.** *Journal of the Zoological Society London*, *171*, 385–395.
Type: Published article
Keywords: Biodiversity, isopods
Research Group: 1969 University of Bangor expedition

Humphreys, W. F. (1981). **The echinoderms of Kenya's marine parks and adjacent regions.** *Musee royal de l'Afrique Centrale.*
Type: Book
Keywords: Biodiversity, echinoderms

Research Group: 1969 University of Bangor expedition

Icely, J. D., & Jones, D. A. (1978). **Factors affecting the distribution of the genus Uca (Crustacea: Ocypodidae) on an East African shore.** *Estuarine and Coastal Marine Science*, *6*(3), 315–325.
Type: Published article
Keywords: Crab, beach ecology
Research Group: 1969 University of Bangor expedition

Isaac, E. W., & Issac, F. M. (1968). **Marine Botany of the Kenya Coast** *Journal of East Africa Natural History Society and National Museum 27*(116), 7-27.
Type: Published article
Keywords: Biodiversity, algae, seagrass
Research Group: Other

Jones, D. A. (1969). **Bangor-Watamu Expedition: Preliminary report**. *University of Bangor, UK*
Type: Report
Keywords: Biodiversity, habitat maps, reef ecology
Research Group: 1969 University of Bangor expedition

Jones, D. A. (1971). **The systematics and ecology of some sand beach isopods (Crustacea: Eurydicidae) from the coast of Kenya.** *Journal of Zoology*, *165*(2), 201–227.
Type: Published article
Keywords: Biodiversity, ecology, isopods
Research Group: 1969 University of Bangor expedition

Jones, D. A. (1972). **Aspects of the ecology and behaviour of Ocypode ceratophthalmus (Pallas) and O. kuhlii de Haan (Crustacea: Ocypodidae).** *Journal of Experimental Marine Biology and Ecology*, *8*(1), 31–43.
Type: Published article
Keywords: Ecology, crabs
Research Group: 1969 University of Bangor expedition

Jones, D. A. (1976). **The systematics and ecology of some isopods of the genus Cirolana (Cirolanidae) from the Indian Ocean region.** *Journal of Zoology*, *178*(2), 209–222.
Type: Published article
Keywords: Biodiversity, isopods
Research Group: 1969 University of Bangor expedition

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Research group: Other

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Keywords: MPA
Research group: Other

APPENDIX 2: SPECIES LISTS

'x' - Incidental record
'34' - Abundance from quantitative surveys

Appendix 2a: Fish

Family	Genus	Species	Common Name	Reef	Intertidal	Subtidal
Acanthuridae	*Acanthurus*	*dussemieri*	Eyestripe surgeonfish	x		2
Acanthuridae	*Acanthurus*	*leucosternon*	Powderblue surgeonfish	279		1
Acanthuridae	*Acanthurus*	*lineatus*	Lined surgeonfish			x
Acanthuridae	*Acanthurus*	*nigricauda*	Blackstreak surgeonfish	38		8
Acanthuridae	*Acanthurus*	*nigrofuscus*	Dusky surgeonfish	34	x	65
Acanthuridae	*Acanthurus*	*tennentii*	Lieutenant surgeonfish	8		x
Acanthuridae	*Acanthurus*	*triostegus*	Convict surgeonfish	2	2	28
Acanthuridae	*Acanthurus*	*xanthopterus*	Yellowfin surgeonfish	10	x	x
Acanthuridae	*Ctenochaetus*	*binotatus*	Twospot Bristletooth	x		
Acanthuridae	*Ctenochaetus*	*striatus*	Striped Bristletooth	253		
Acanthuridae	*Ctenochaetus*	*truncatus*	Goldring Bristletooth	18		
Acanthuridae	*Naso*	*annulatus*	Whitemargin unicornfish	x		
Acanthuridae	*Naso*	*brachycentron*	Humpback unicornfish	1		
Acanthuridae	*Naso*	*brevirostris*	Spotted unicornfish	17		
Acanthuridae	*Naso*	*elegans*	Orangespine unicornfish	7		
Acanthuridae	*Naso*	*fageni*	Horse-face unicornfish	x		
Acanthuridae	*Naso*	*unicornis*	Bluespine unicornfish	26		
Acanthuridae	*Naso*	*vlamingi*	Bignose unicornfish	x		
Acanthuridae	*Zebrasoma*	*desjardinii*	Desjardin's sailfin tang	2		
Acanthuridae	*Zebrasoma*	*scopas*	Brown tang	24		
Antennariidae	*Histrio*	*histrio*	Sargassumfish			
Apogonidae	*Apogon*	*nigripes*	Blackfoot cardinalfish			102
Apogonidae	*Apogon*	*semiornatus*	Obliquebanded cardinalfish			
Apogonidae	*Apogonichthyoides*	*taeniatus*	Twobelt cardinalfish		x	
Apogonidae	*Archamia*	*fucata*	Orange-lined cardinalfish	x		
Apogonidae	*Cheilodipterus*	*arabicus*	Tiger cardinalfish	x		7
Apogonidae	*Cheilodipterus*	*artus*	Wolf cardinalfish	x		
Apogonidae	*Cheilodipterus*	*macrodon*	Large-tooth cardinalfish	x		
Apogonidae	*Cheilodipterus*	*quinquelineatus*	Five-lined cardinalfish	x	x	
Apogonidae	*Ostorhinchus*	*angustatus*	Broad-striped cardinalfish	x		
Apogonidae	*Ostorhinchus*	*aureus*	Ring-tailed cardinalfish	x		
Apogonidae	*Ostorhinchus*	*cookii*	Cook's cardinalfish	x	17	6
Apogonidae	*Ostorhinchus*	*cyanosoma*	Yellow-striped cardinalfish	x		2
Apogonidae	*Ostorhinchus*	*flagellifera*	Coachwhip cardinalfish	x		
Apogonidae	*Ostorhinchus*	*nigrofasciatus*	Black-stripe cardinalfish	x		

Apogonidae	*Ostorhinchus*	*taeniophorus*	Reef-flat cardinalfish		5	104
Apogonidae	*Pristapogon*	*kallopterus*	Iridescent cardinalfish	x	1	
Atherinidae	*Atherinomorus*	*lacunosus*	Hardy silverhead		x	x
Aulostomidae	*Aulostomus*	*chinensus*	Trumpetfish	5		
Balistidae	*Balistoides*	*undulatus*	Orange-strip triggerfish	4		
Balistidae	*Balistoides*	*viridescens*	Giant triggerfish	x		
Balistidae	*Pseudobalistes*	*flavimarginatus*	Yellowmargin triggerfish		x	
Balistidae	*Pseudobalistes*	*fuscus*	Blue triggerfish	x		
Balistidae	*Rhinecanthus*	*assasi*	Picassofish	1	x	20
Balistidae	*Rhinecanthus*	*rectangulus*	Wedge picassofish		x	1
Balistidae	*Sufflamen*	*chrysopterus*	Halfmoon triggerfish	10		1
Balistidae	*Sufflamen*	*fraenatus*	Bridled triggerfish	3		1
Blenniidae	*Antennablennius*	*variopunctatus*	Orange-spot blenny		21	
Blennidae	*Aspidontus*	*taeniatus*	Cleanerfish mimic			
Blenniidae	*Blenniella*	*chrysospilos*	Red-spotted blenny		x	
Blenniidae	*Blenniella*	*cyanostigma*	Striped rockskipper		19	
Blenniidae	*Cirripectes*	*castaneus*	Chestnut blenny	3		
Blenniidae	*Cirripectes*	*stigmaticus*	Redstreaked blenny	x		
Blenniidae	*Entomacrodus*	*striatus*	Blackspotted rockskipper		x	
Blenniidae	*Exallias*	*brevis*	Leopard blenny	1		
Blenniidae	*Hirculops*	*cornifer*	Highbrow rockskipper		1	
Blenniidae	*Istiblennius*	*lineatus*	Lined rockskipper		x	
Blenniidae	*Istiblennius*	*unicolor*	Pallid rockskipper		1	
Blenniidae	*Meiacanthus*	*mossambicus*	Mocambique fangblenny	3		
Blenniidae	*Plagiotremus*	*rhinorhynchos*	Bluestriped fangblenny	1	x	
Blenniidae	*Plagiotremus*	*tapeinosoma*	Scale-eating fangblenny	1		x
Blenniidae	*Salarias*	*fasciatus*	Jeweled blenny		1	
Caesionidae	*Caesio*	*caerulaurea*	Scissor-tailed fusilier	x		
Caesionidae	*Caesio*	*lunaris*	Lunar fusilier	6		
Caesionidae	*Caesio*	*teres*	Yellowback fusilier	x		
Caesionidae	*Caesio*	*xanthonota*	Yellowtop fusilier	x		
Caesionidae	*Dipterygonotus*	*balteatus*	Mottled fusilier	x		
Caesionidae	*Pterocaesio*	*chrysozona*	Goldband fusilier	30		
Callionymidae	*Synichiropus*	*stellatus*	Starry dragonet	x		
Caracanthidae	*Caracanthus*	*madagascariensis*	Spotted coral croucher	x		
Caracanthidae	*Caracanthus*	*unipinna*	Pygmy coral croucher	x		
Carangidae	*Alectis*	*inidicus*	Indian threadfin			x
Carangidae	*Carangoides*	*ferdau*	Bar jack	x		
Carangidae	*Carangoides*	*fulvoguttatus*	Yellow-dotted trevally	x		
Carangidae	*Caranx*	*herberi*	Black-tip trevally	x		
Carangidae	*Caranx*	*ignobilis*	Giant trevally			x
Carangidae	*Caranx*	*melampygus*	Bluefin trevally	1		

Carangidae	*Caranx*	*papuensis*	Brassy trevally	x		
Carangidae	*Caranx*	*sexfasciatus*	Bigeye trevally	x		
Carangidae	*Gnathanodon*	*speciosus*	Golden trevally			x
Carangidae	*Scomberoides*	*lysan*	Doublespot queenfish	x		
Carangidae	*Trachinostus*	*blochii*	Silver pompano			x
Carcharhinidae	*Carcharhinus*	*melanopterus*	Reef blacktip shark			x
Carcharhinidae	*Triaenodon*	*obesus*	Reef whitetip shark	x		
Centriscidae	*Aeoliscus*	*punctulatus*	Speckled shrimpfish			x
Chaetodontidae	*Chaetodon*	*auriga*	Threadfin butterflyfish	13	x	4
Chaetodontidae	*Chaetodon*	*falcula*	Saddleback butterflyfish	x		
Chaetodontidae	*Chaetodon*	*guttatissimus*	Spotted butterflyfish	2		
Chaetodontidae	*Chaetodon*	*kleinii*	Klein's butterflyfish	x		1
Chaetodontidae	*Chaetodon*	*lineolatus*	Lined butterflyfish	x		
Chaetodontidae	*Chaetodon*	*leucopleura*	Somali butterflyfish			x
Chaetodontidae	*Chaetodon*	*lunula*	Raccoon butterflyfish	14	x	5
Chaetodontidae	*Chaetodon*	*meyeri*	Meyer's butterflyfish	4		
Chaetodontidae	*Chaetodon*	*trifascialis*	Chevroned butterflyfish	4		
Chaetodontidae	*Chaetodon*	*trifasciatus*	Redfin butterflyfish	7		
Chaetodontidae	*Chaetodon*	*vagabundus*	Vagabond butterflyfish			x
Chaetodontidae	*Chaetodon*	*xanthocephalus*	Yellowhead butterflyfish	1		
Chaetodontidae	*Forcipiger*	*flavissimus*	Long-nose butterflyfish	x		
Chaetodontidae	*Heniochus*	*acuminatus*	Longfin bannerfish	x		
Chaetodontidae	*Heniochus*	*monoceros*	Masked bannerfish	2		
Cirrihitidae	*Amblycirrihitus*	*bimacula*	Two-spotted hawkfish	x		
Cirrihitidae	*Paracirrhites*	*arcatus*	Monocle hawkfish	2		
Cirrihitidae	*Paracirrhites*	*forsteri*	Freckled hawkfish	7		
Cirrihitidae	*Cirrhitichthys*	*oxycephalus*	Pixy hawkfish	x		
Cirrihitidae	*Cirrhitus*	*pinnulatus*	Stocky hawkfish			x
Clupeidae	*Herklotsichthys*	*quadrimaculatus*	Gold spot herring		x	x
Clupeidae	*Spratelloides*	*gracilis*	Blue lateral sprat			x
Congridae	*Conger*	*cinereus*	Moustache conger			
Dasyatidae	*Himantura*	*gerrardi*	Sharpnose stingray			x
Dasyatidae	*Himantura*	*uarnak*	Honeycomb stingray			x
Dasyatidae	*Neotrygon*	*kuhlii*	Bluespotted stingray (grey)			x
Dasyatidae	*Taeniura*	*lymma*	Bluespotted Stingray	1		x
Diodontidae	*Diodon*	*hystrix*	Porcupinefish	x	x	1
Diodontidae	*Diodon*	*liturosus*	Black-blotched porcupinefish	x	x	x
Echeneidae	*Echeneis*	*naucrates*	Sharksucker	x		
Ephippidae	*Platax*	*orbicularis*	Batfish	7		
Ephippidae	*Platax*	*teira*	Longfin spadefish		x	
Ephippidae	*Tripterodon*	*orbis*	African spadefish			
Fistulariidae	*Fistularia*	*commersonii*	Cornetfish	6		

Gerreidae	*Gerres*	*longirostris*	Smallscale mojarra		x	
Gerreidae	*Gerres*	*oyena*	Blacktip mojarra		x	x
Gobiidae	*Amblyeleotris*	*wheeleri*	Gorgeous prawn-goby			x
Gobiidae	*Cryptocentrus*	*fasciastus*	Barred prawn-goby			x
Gobiidae	*Cryptocentrus*	*lutheri*	Luther's prawn-goby			x
Gobiidae	*Cryptocentrus*	*strigilliceps*	Target prawn-goby			x
Gobiidae	*Ctenogobiops*	*feroculus*	Sandy prawn-goby			x
Gobiidae	*Gnatholepis*	*cauerensis*	Eye-bar goby		7	
Gobiidae	*Gnatholepis*	*scapulostigma*	Shoulder-spot goby		x	
Gobiidae	*Istigobius*	*ornatus*	Ornate goby		4	
Gobiidae	*Paragobiodon*	*modestus*	Modest goby	x		
Gobiidae	*Pleurosicya*	*micheli*	Michels ghost goby	x		
Gobiidae	*Valenciennea*	*strigata*	Blue-streak goby	x		x
Haemulidae	*Plectorhinchus*	*albovittatus*	Giant sweetlips			x
Haemulidae	*Plectorhinchus*	*chubbi*	Dusky sweetlips	x		
Haemulidae	*Plectorhinchus*	*flavomaculatus*	Gold-spotted sweetlips	38		20
Haemulidae	*Plectorhinchus*	*gaterinus*	Black-spotted sweetlips	29		
Haemulidae	*Plectorhinchus*	*gibbosus*	Gibbus sweetlips			x
Haemulidae	*Plectorhinchus*	*paulayi*	Diagonal-lined sweetlips			x
Haemulidae	*Plectorhinchus*	*plagiodesmus*	Red-lined sweetlips			x
Haemulidae	*Plectorhinchus*	*playfairi*	Whitebarred sweetlips	6		
Haemulidae	*Plectorhinchus*	*schotaf*	Somber sweetlips	1		x
Haemulidae	*Plectorhinchus*	*sordidus*	Black sweetlips			x
Haemulidae	*Plectorhinchus*	*vittatus*	Oriental sweetlips	x		
Hemiramphidae	*Hyporhamphus*	*affinis*	Insular halfbeak			x
Hemiramphidae	*Hemiramphus*	*far*	Spotted halfbeak			5
Holocentridae	*Myripristis*	*adusta*	Bronze soldierfish			
Holocentridae	*Myripristis*	*hexagona*	Doubletoothed soldierfish	4		
Holocentridae	*Myripristis*	*murdjan*	Red soldierfish			x
Holocentridae	*Myripristis*	*pralinia*	Scarlet soldierfish			x
Holocentridae	*Myripristis*	*violacea*	Violet soldierfish	3		
Holocentridae	*Neoniphon*	*argenteus*	Clearfin soldierfish			
Holocentridae	*Neoniphon*	*sammara*	Bloodspot soldierfish	x		
Holocentridae	*Plectrypops*	*lima*	Cardinal soldierfish		x	
Holocentridae	*Sargocentron*	*caudimaculatum*	Tailspot squirrelfish	x		
Holocentridae	*Sargocentron*	*diadema*	Crown squirrelfish	2		7
Kuhliidae	*Kuhlia*	*mugil*	Barred flagtail		x	
Kyphosidae	*Kyphosus*	*cinerascens*	Highfin rudderfish	x		
Kyphosidae	*Kyphosus*	*vaigiensis*	Brassy rudderfish	65		
Labridae	*Anampses*	*caeruleopunctatus*	Blue-spotted wrasse	3		
Labridae	*Anampses*	*melanurus*	White-spotted wrasse	x		
Labridae	*Anampses*	*meleagrides*	Yellowtail wrasse	1		

Labridae	*Anampses*	*twistii*	Yellow-breasted wrasse	5		
Labridae	*Bodianus*	*axillaris*	Axilspot hogfish	9		
Labridae	*Bodianus*	*diana*	Diana's hogfish	x		
Labridae	*Cheilinus*	*chlorourus*	Floral wrasse	x		x
Labridae	*Cheilinus*	*oxycephalus*	Snooty wrasse	4		
Labridae	*Cheilinus*	*trilobatus*	Tripletail wrasse	23		14
Labridae	*Cheilio*	*inermis*	Cigar wrasse	2	x	27
Labridae	*Coris*	*aygula*	Clown Coris	2		
Labridae	*Coris*	*caudimacula*	Spottail Coris	3	1	24
Labridae	*Coris*	*cuvieri*	African Coris	1		2
Labridae	*Coris*	*formosa*	Queen Coris	1	x	9
Labridae	*Epibulus*	*insidiator*	Slingjaw wrasse	2		
Labridae	*Gomphosus*	*caeruleus*	Indian bird wrasse	15		
Labridae	*Halichoeres*	*hortulanus*	Checkerboard wrasse	26	2	3
Labridae	*Halichoeres*	*marginatus*	Dusky wrasse	6		
Labridae	*Halichoeres*	*nebulosus*	Nebulous wrasse			45
Labridae	*Halichoeres*	*scapularis*	Zigzag wrasse	2	1	3
Labridae	*Hemigymnus*	*fasciastus*	Barred thicklip wrasse	6		
Labridae	*Hemigymnus*	*melapterus*	Blackedge thicklip wrasse	x		
Labridae	*Hologymnosus*	*annulatus*	Ring wrasse	2		2
Labridae	*Iniistius*	*pavo*	Blue razorfish			x
Labridae	*Iniistius*	*pentadactylus*	Fivefinger razorfish			x
Labridae	*Labrichthys*	*unilineatus*	Tubelip wrasse	5		
Labridae	*Labroides*	*bicolor*	Bicolour cleaner wrasse	3		
Labridae	*Labroides*	*dimidiatus*	Bluestreak cleaner wrasse	32	6	17
Labridae	*Macropharyngodon*	*bipartitus*	Vermiculate wrasse	x		5
Labridae	*Novaculichthys*	*macrolepidotus*	Seagrass wrasse			19
Labridae	*Novaculichthys*	*taeniourus*	Dragon wrasse	2		
Labridae	*Oxycheilinus*	*bimaculatus*	Twospot wrasse	x		
Labridae	*Oxycheilinus*	*digrammus*	Bandcheek wrasse	6		
Labridae	*Pseudocheilinus*	*evanidus*	Disappearing wrasse	x		
Labridae	*Pseudocheilinus*	*hexataenia*	Six-line wrasse	17		
Labridae	*Pteragogus*	*flagellifera*	Flagfin wrasse	x		
Labridae	*Stethojulis*	*albovittata*	Bluelined wrasse	x	x	28
Labridae	*Stethojulis*	*strigiventer*	Three-line wrasse	x	x	
Labridae	*Thalassoma*	*amblycephalum*	Two tone wrasse	58	1	x
Labridae	*Thalassoma*	*hardwicke*	Six-bar wrasse	19		2
Labridae	*Thalassoma*	*hebraicum*	Goldbar wrasse	62	11	5
Labridae	*Thalassoma*	*lunare*	Crescent wrasse	5		3
Labridae	*Thalassoma*	*purpureum*	Surge wrasse			x
Labridae	*Thalassoma*	*quinquevittatum*	Five-stripe wrasse			x
Labridae	*Thalassoma*	*trilobatum*	Christmas wrasse	x		

Lethrinidae	*Gnathodentex*	*aurolineatus*	Yellowspot emperor	x		
Lethrinidae	*Lethrinus*	*harak*	Blackspot emperor	1	x	45
Lethrinidae	*Lethrinus*	*lentjan*	Pink-ear emperor			x
Lethrinidae	*Lethrinus*	*mehsena*	Sky emperor	7		x
Lethrinidae	*Lethrinus*	*microdon*	Smalltooth emperor	1		
Lethrinidae	*Lethrinus*	*obsoletus*	Orange-stripe emperor	x		
Lethrinidae	*Monotaxis*	*grandoculis*	Big-eye emperor	4		
Lutjanidae	*Lutjanus*	*argentimaculatus*	River snapper	11		x
Lutjanidae	*Lutjanus*	*bohar*	Red snapper	17		
Lutjanidae	*Lutjanus*	*coeruleolineatus*	Blueline snapper			
Lutjanidae	*Lutjanus*	*ehrenbergi*	Ehrenberg's snapper			x
Lutjanidae	*Lutjanus*	*fluvus*	Flametail snapper	x		
Lutjanidae	*Lutjanus*	*fulviflamma*	Blackspot snapper	42	1	2
Lutjanidae	*Lutjanus*	*gibbus*	Humpback snapper	3		
Lutjanidae	*Lutjanus*	*kasmira*	Blue-lined snapper	1	1	
Lutjanidae	*Lutjanus*	*monostigma*	One-spot snapper	x		
Lutjanidae	*Lutjanus*	*rivulatus*	Scribbled snapper	x		
Lutjanidae	*Macolor*	*niger*	Black and white snapper	4		
Microdesmidae	*Ptereleotris*	*evides*	Blackfin dartfish	50		
Microdesmidae	*Ptereleotris*	*microlepis*	Pearly dartfish			x
Mobulidae	*Manta*	*alfredi*	Alfred manta			x
Monacanthidae	*Acreichthys*	*tomentosus*	Seagrass filefish			
Monacanthidae	*Aluterus*	*scriptus*	Scribbled filefish	1		
Monacanthidae	*Cantherhines*	*fronticinctus*	Spectacled filefish	x	x	
Monacanthidae	*Cantherhines*	*pardalis*	Wire-net filefish	4		x
Monacanthidae	*Oxymonacanthus*	*longirostris*	Longnose filefish	2		
Monacanthidae	*Paraluteres*	*prionurus*	Saddleback mimic			
Monacanthidae	*Pervagor*	*janthinosoma*	Blackbar filefish	2		
Monodactylidae	*Monodactylus*	*argenteus*	Silver batfish			10
Mugilidae	*Oedalechilus*	*labiosus*	Foldlip mullet		x	
Mugilidae	*Valamugil*	*seheli*	Bluespot mullet			x
Mullidae	*Mulloidichthys*	*flavolineatus*	Yellowstripe goatfish	2		
Mullidae	*Mulloidichthys*	*vanicolensis*	Yellowfin goatfish	x		
Mullidae	*Parupeneus*	*bifasciatus*	Two-barred goatfish			x
Mullidae	*Parupeneus*	*barberinus*	Dash and dot goatfish	55	x	11
Mullidae	*Parupeneus*	*ciliatus*	Whitesaddle goatfish	x		
Mullidae	*Parupeneus*	*cyclostomus*	Yellow-saddle goatfish	1		
Mullidae	*Parupeneus*	*indicus*	Indian goatfish	2		10
Mullidae	*Parupeneus*	*macronema*	Longbarbel goatfish	x		2
Mullidae	*Parupeneus*	*rubescens*	Rosy goatfish	x		x
Mullidae	*Upeneus*	*tragula*	Blackstriped goatfish			x
Muraenidae	*Echidna*	*leucotaenia*	Whiteface moray	x	1	

Muraenidae	*Echidna*	*nebulosa*	Snowflake moray	x	1	
Muraenidae	*Gymnomuraena*	*zebra*	Zebra moray		x	
Muraenidae	*Gymnothorax*	*chilospilos*	Lipspot moray			
Muraenidae	*Gymnothorax*	*favagineus*	Honeycomb moray			x
Muraenidae	*Gymnothorax*	*flavimarginatus*	Yellow-margined moray	x		
Muraenidae	*Gymnothorax*	*grisea*	Geometric moray	x		
Muraenidae	*Gymnothorax*	*pictus*	Peppered moray		x	
Muraenidae	*Gymnothorax*	*undulatus*	Undulated moray			
Muraenidae	*Scuticaria*	*tigrinus*	Tiger snake moray	x		
Muraenidae	*Uropterygius*	*marmoratus*	Marbled snake moray			
Myliobatidae	*Aetobatus*	*ocellatus*	Spotted eagle ray			x
Nemipteridae	*Scolopsis*	*ghanam*	Arabian spinecheek	2	x	
Ophichthidae	*Callechelys*	*marmorata*	Marbled snake eel			x
Ophichthidae	*Myrichthys*	*colubrinus*	Harlequin snake eel	x		
Ophichthidae	*Myrichthys*	*maculosus*	Spotted snake eel	x		
Ostraciidae	*Lactoria*	*cornuta*	Longhorn cowfish		x	
Ostraciidae	*Lactoria*	*fornasini*	Thornback cowfish		x	
Ostraciidae	*Ostracion*	*cubicus*	Yellow boxfish	x		
Ostraciidae	*Ostracion*	*meleagris*	Whitespotted boxfish	x		1
Pegasidae	*Eurypegasus*	*draconis*	Short dragonfish			
Pempheridae	*Pempheris*	*bexillion*		x		
Pempheridae	*Pempheris*	*flavicycla*		76	20	
Pempheridae	*Pempheris*	*spp.*				
Pempheridae	*Pempheris*	*spp.*				
Pempheridae	*Pempheris*	*spp.*				
Pempheridae	*Pempheris*	*spp.*				
Pempheridae	*Pempheris*	*spp.*				
Pempheridae	*Pempheris*	*spp.*				
Pempheridae	*Pempheris*	*spp.*				
Pinguipedidae	*Parapercis*	*hexophthalma*	Speckled sandperch	2		
Platycephalidae	*Papilloculiceps*	*longiceps*	Indian Ocean crocodilefish			x
Platycephalidae	*Sunagocia*	*arenicola*	Broadhead flathead			x
Platycephalidae	*Thysanophrys*	*chiltonae*	Longsnout flathead			x
Plotosidae	*Plotosus*	*limbatus*	Darkfin catfish			x
Plotosidae	*Plotosus*	*lineatus*	Striped catfish		x	x
Pomacanthidae	*Centropyge*	*multipinis*	Brown dwarf-angelfish	10		
Pomacanthidae	*Pomacanthus*	*chrysurus*	African angelfish	1	x	x
Pomacanthidae	*Pomacanthus*	*imperator*	Emperor angelfish	x		x
Pomacanthidae	*Pomacanthus*	*semicirculatus*	Semicircle angelfish	5	x	5
Pomacanthidae	*Pygoplites*	*diacanthus*	Regal angelfish	x		
Pomacentridae	*Abudefduf*	*notatus*	Yellow-tail sergeant		x	
Pomacentridae	*Abudefduf*	*septemfasciastus*	Banded sergeant			x

Pomacentridae	*Abudefduf*	*sexfasciatus*	Scissor sergeant	77	x	x
Pomacentridae	*Abudefduf*	*sordidus*	Black-spot sergeant		x	5
Pomacentridae	*Abudefduf*	*sparoides*	False-eye sergeant	23	x	2
Pomacentridae	*Abudefduf*	*vaigiensis*	Indo-Pacific sergeant	4	21	29
Pomacentridae	*Amphiprion*	*akallopisos*	Skunk anemonefish	1		
Pomacentridae	*Amphiprion*	*allardi*	Allard's anemonefish	x		3
Pomacentridae	*Chromis*	*dimidiata*	Half and half chromis	100		30
Pomacentridae	*Chromis*	*nigura*	Blacktail chromis	6		
Pomacentridae	*Chromis*	*ternatensis*	Ternate chromis	x		
Pomacentridae	*Chromis*	*viridis*	Blue-green chromis	40		
Pomacentridae	*Chromis*	*weberi*	Weber's chromis	15		
Pomacentridae	*Chrysiptera*	*annulata*	Blackbarred demoiselle		x	15
Pomacentridae	*Chrysiptera*	*biocellata*	Twospot damsel		1	
Pomacentridae	*Chrysiptera*	*brownriggi*	Surge demoiselle		7	36
Pomacentridae	*Chrysiptera*	*glauca*	Grey demoiselle		1	
Pomacentridae	*Chrysiptera*	*unimaculata*	One spot demoiselle		x	
Pomacentridae	*Dascyllus*	*aruanus*	Humbug dascyllus	2		
Pomacentridae	*Dascyllus*	*carneus*	Indian dascyllus	5		
Pomacentridae	*Dascyllus*	*trimaculatus*	Three-spot dascyllus	8	x	48
Pomacentridae	*Neoglyphidodon*	*melas*	Black damsel	x		
Pomacentridae	*Neopomacentrus*	*azysron*	Yellowtail demoiselle	33		
Pomacentridae	*Neopomacentrus*	*cyanomos*	Regal demoiselle	x		
Pomacentridae	*Plectroglyphidodon*	*dickii*	Dick's damsel	6		
Pomacentridae	*Plectroglyphidodon*	*imparipennis*	Brighteye damsel		x	
Pomacentridae	*Plectroglyphidodon*	*johnstonianus*	Johnston damsel	7		
Pomacentridae	*Plectroglyphidodon*	*lacrymatus*	Jewel damsel	103		
Pomacentridae	*Pomacentrus*	*aquilus*	Dark damsel	3	5	58
Pomacentridae	*Pomacentrus*	*baenschi*	Baensch's damsel	4		1
Pomacentridae	*Pomacentrus*	*caeruleus*	Blue-yellow damsel	2	x	3
Pomacentridae	*Pomacentrus*	*pavo*	Blue damsel	x	x	
Pomacentridae	*Pomacentrus*	*sulfureus*	Sulphur damsel	15		
Pomacentridae	*Pomacentrus*	*trichrous*	Pailtail damsel	x		
Pomacentridae	*Pomacentrus*	*trilineatus*	Three-line damsel		x	x
Pomacentridae	*Stegastes*	*fasciolatus*	Pacific gregory	2		
Priacanthidae	*Heteropriacanthus*	*cruentatus*	Glasseye	x		
Priacanthidae	*Priacanthus*	*hamrur*	Goggle-eye	2		
Pseudochromidae	*Pseudochromis*	*leucorhynchus*	White-nose dottyback			x
Rhinobatidae	*Glaucostegus*	*halaci*	Halavi ray			x
Scaridae	*Calotomus*	*carolinus*	Stareye parrotfish	39		
Scaridae	*Cetoscarus*	*bicolor*	Bicolour parrotfish	x		
Scaridae	*Chlorurus*	*atrilunula*	Black crescent parrotfish	7		
Scaridae	*Chlorurus*	*capistratoides*	Pale bullethead parrotfish	1		

Scaridae	*Chlorurus*	*sordidus*	Bullethead parrotfish	67		12
Scaridae	*Chlorurus*	*strongylocephalus*	Indian Ocean steephead parrotfish	x		
Scaridae	*Hipposcarus*	*harid*	Indian Ocean longnose parrotfish	1		
Scaridae	*Leptoscarus*	*vaigiensis*	Seagrass parrotfish	2	x	47
Scaridae	*Scarus*	*frenatus*	Bridled parrotfish	16		
Scaridae	*Scarus*	*ghobban*	Bluebarred parrotfish	11		1
Scaridae	*Scarus*	*niger*	Swarthy parrotfish	8		
Scaridae	*Scarus*	*psittacus*	Palenose parrotfish	6		
Scaridae	*Scarus*	*rubroviolaceus*	Redlip parrotfish	12		
Scaridae	*Scarus*	*scaber*	Dusky-capped parrotfish	x		
Scombridae	*Rastrelliger*	*kanagurta*	Striped mackerel			
Scorpaenidae	*Dendochirus*	*zebra*	Zebra lionfish			
Scorpaenidae	*Parascorpaena*	*mossambica*	Mozambique scorpionfish			x
Scorpaenidae	*Pterois*	*antennata*	Spotfin lionfish	x		
Scorpaenidae	*Pterois*	*miles*	Common lionfish	1	x	
Scorpaenidae	*Pterois*	*mombasae*	Mombasa lionfish	x		
Scorpaenidae	*Pterois*	*radiata*	Clearfin lionfish	x	x	
Scorpaenidae	*Scorpaenopsis*	*oxycephala*	Tassled scorpionfish	x	6	
Scorpaenidae	*Scorpaenopsis*	*venosa*	Raggy scorpionfish	x		
Scorpaenidae	*Sebastapistes*	*cyanostigma*	Yellowspotted scorpionfish	12		
Scorpaenidae	*Sebastapistes*	*strongia*	Barchin scorpionfish			x
Scorpaenidae	*Synanceia*	*verrucosa*	Stonefish			
Scorpaenidae	*Taenianotus*	*triacanthus*	Leaf scorpionfish	x		
Serranidae	*Aethaloperca*	*rogaa*	Redmouth grouper	x		
Serranidae	*Cephalopholis*	*argus*	Peacock grouper	2		x
Serranidae	*Cephalopholis*	*leopardus*	Leopard hind	x		
Serranidae	*Cephalopholis*	*miniata*	Coral hind	x		
Serranidae	*Cephalopholis*	*sonnerati*	Tomato grouper	x		
Serranidae	*Dermatolepis*	*striolata*	Smooth grouper	x		
Serranidae	*Epinephelus*	*areolatus*	Areolate grouper	x		
Serranidae	*Epinephelus*	*caeruleopunctatus*	Whitespotted grouper			
Serranidae	*Epinephelus*	*fasciatus*	Blacktip grouper	1		
Serranidae	*Epinephelus*	*fuscoguttatus*	Brown-marbled grouper	x		
Serranidae	*Epinephelus*	*lanceolatus*	Giant grouper			x
Serranidae	*Epinephelus*	*longispinis*	Longspine grouper			
Serranidae	*Epinephelus*	*macrospilos*	Snubnose grouper			x
Serranidae	*Epinephelus*	*malabaricus*	Malabar grouper	x		
Serranidae	*Epinephelus*	*merra*	Honeycomb grouper	x		2
Serranidae	*Epinephelus*	*ongus*	Specklefin grouper	x		
Serranidae	*Epinephelus*	*spilotoceps*	Foursaddle grouper	x		
Serranidae	*Epinephelus*	*tauvina*	Greasy grouper			x
Serranidae	*Epinephelus*	*tukula*	Potato grouper			x

Serranidae	*Grammistes*	*sexlineatus*	Six-striped soapfish		1	x
Serranidae	*Plectropomus*	*laevis*	Saddleback coralgrouper	x		
Serranidae	*Plectropomus*	*punctatus*	Marbled coralgrouper	1		
Serranidae	*Pseudanthias*	*squamipinnis*	Lyretail anthias	x		
Serranidae	*Variola*	*louti*	Lyretail grouper	x		
Signidae	*Siganus*	*argenteus*	Forktail rabbitfish	x		x
Signidae	*Siganus*	*luridus*	Squaretail rabbitfish			
Signidae	*Siganus*	*stellatus*	Stellate rabbitfish	3		2
Signidae	*Siganus*	*sutor*	African whitespotted rabbitfish	75	x	379
Soleidae	*Pardachirus*	*marmoratus*	Moses sole			2
Solenostomidae	*Solenostomus*	*cyanopterus*	Ghost pipefish			
Sphyraenidae	*Sphyraena*	*barracuda*	Great barracuda			x
Sphyraenidae	*Sphyraena*	*flavicauda*	Yellowtail barracuda			x
Sphyraenidae	*Sphyraena*	*forsteri*	Blackspot barracuda			10
Sphyraenidae	*Sphyraena*	*jello*	Pickhandle barracuda			x
Sphyraenidae	*Sphyraena*	*putnamiae*	Sawtooth barracuda			x
Sphyraenidae	*Sphyraena*	*qenie*	Blackfin barracuda			x
Sygnathidae	*Corythoichthys*	*schultzi*	Guilded pipefish	x		
Sygnathidae	*Doryhamphus*	*excisus*	Bluestripe pipefish			
Sygnathidae	*Hippocampus*	*hystrix*	Thorny seahorse			
Sygnathidae	*Micrognathus*	*andersonii*	Short-nose pipefish		x	
Synodontidae	*Synodus*	*dermatogenys*	Sand lizardfish	x		1
Synodontidae	*Saurida*	*gracilis*	Graceful lizardfish	x	1	
Tetraodontidae	*Arothron*	*hispidus*	Whitespotted puffer			2
Tetraodontidae	*Arothron*	*immaculatus*	Immaculate puffer			x
Tetraodontidae	*Arothron*	*mappa*	Globe puffer			x
Tetraodontidae	*Arothron*	*meleagris*	Guineafowl puffer			x
Tetraodontidae	*Arothron*	*nigropunctatus*	Blackspotted puffer	4		
Tetraodontidae	*Arothron*	*stellatus*	Star puffer			1
Tetraodontidae	*Canthigaster*	*amboinensis*	Ambon toby			x
Tetraodontidae	*Canthigaster*	*bennetti*	Bennett's toby	6	x	20
Tetraodontidae	*Canthigaster*	*janthinopera*	Honeycomb toby	x		
Tetraodontidae	*Canthigaster*	*petersii*	Peters toby	5	1	
Tetraodontidae	*Canthigaster*	*valentini*	Blacksaddle toby	9	x	1
Theraponidae	*Terapon*	*jarbua*	Crescent-banded grunter		x	
Torpedinidae	*Torpedo*	*sinuspersici*	Marbled electric ray	x		
Zanclidae	*Zanclus*	*cornutus*	Moorish idol	19		1

Appendix 2b – Species lists for Echinoderms, Molluscs and Crustacea

Phylum	Class	Genus	Species	English	Reef	Intertidal	Subtidal
Echinodermata	Asteroidea	*Culcita*	*schmideliana*	Cake star	x	x	x
Echinodermata	Asteroidea	*Dactylosaster*	*cylindricus*		1		
Echinodermata	Asteroidea	*Euretaster*	*cribrosus*	Dimple star			x
Echinodermata	Asteroidea	*Leiaster*	*coriaceus*	Mottled star		x	x
Echinodermata	Asteroidea	*Linckia*	*laevigata*	Blue star	3	x	
Echinodermata	Asteroidea	*Linckia*	*multifora*	Irregular arm star		x	
Echinodermata	Asteroidea	*Monachaster*	*sanderi*	Pygmy plate star	x	1	
Echinodermata	Asteroidea	*Nardoa*	*variolata*	Red dot star	x	x	
Echinodermata	Asteroidea	*Protoeaster*	*lincki*	Red crown star	x	x	
Echinodermata	Echinoidea	*Astropyga*	*radiata*	Radiant urchin	x	x	x
Echinodermata	Echinoidea	*Diadema*	*savingyi*	Blue star urchin	23	1	
Echinodermata	Echinoidea	*Diadema*	*setosum*	Anal spot urchin	5	x	
Echinodermata	Echinoidea	*Echinometra*	*matthaei*	Rockpool urchin	44	275	
Echinodermata	Echinoidea	*Echinostrephus*	*molaris*	Burrowing urchin	198		
Echinodermata	Echinoidea	*Echinothrix*	*calamaris*	Black and white urchin	18	x	
Echinodermata	Echinoidea	*Echinothrix*	*diadema*	Reef urchin	257	161	
Echinodermata	Echinoidea	*Eucidaris*	*metularia*	Rough pencil urchin			x
Echinodermata	Echinoidea	*Toxopneustes*	*pileolus*	Flower urchin	2	x	x
Echinodermata	Echinoidea	*Tripneustes*	*gratillia*	Seagrass urchin	x	11	x
Echinodermata	Holothurioidea	*Actinopyga*	*echinites*	Hedgehog cucumber		x	
Echinodermata	Holothurioidea	*Actinopyga*	*mauritiana*	White belly cucumber	x	1	
Echinodermata	Holothuroidea	*Actinopyga*	*miliaris*	Military cucumber		x	
Echinodermata	Holothuroidea	*Bohadschia*	*sp.*	Red dot cucumber		x	
Echinodermata	Holothuroidea	*Bohadschia*	*subrubra*	Patch cucumber	x		
Echinodermata	Holothuroidea	*Holothuria*	*atra*	Common black cucumber	1		
Echinodermata	Holothuroidea	*Holothuria*	*scabra*	Tasty cucumber			x
Echinodermata	Holothuroidea	*Patinapta*	*crosslandi*	Worm cucumber		x	
Echinodermata	Holothuroidea	*Pearsonothuria*	*graeffei*	Black palp cucumber	x		
Echinodermata	Holothuroidea	*Synapta*	*maculata*	Seagrass cucumber			x
Echinodermata	Ophiuroidea	*Amphiura*	*dejectoides*	Brittlestar		41	
Echinodermata	Ophiuroidea	*Ophiocentrus*	*dilalatus*	Brittlestar	x		
Echinodermata	Ophiuroidea	*Ophiocoma*	*erinaceus*	Brittlestar	2		
Echinodermata	Ophiuroidea	*Ophiocoma*	*scolopendrina*	Brittlestar	8	268	
Echinodermata	Ophiuroidea	*Ophiomastix*	*venosa*	Brittlestar		7	
Mollusca	Bivalvia	*Chione*	*toreuma*			1	
Mollusca	Bivalvia	*Tridacna*	*maxima*	Burrowing giant clam	2	1	
Mollusca	Bivalvia	*Tridacna*	*sqaumosa*	Fluted giant clam	53	x	
Mollusca	Cephalopoda	*Octopus*	*cyanea*	Common reef octopus	1	x	x

Mollusca	Gastropoda	*Asteronotus*	*cespitosus*			x	
Mollusca	Gastropoda	*Ceritium*	*nodulosum*			3	
Mollusca	Gastropoda	*Charonia*	*tritonis*	Giant triton	x		
Mollusca	Gastropoda	*Conus*	*arenatus*	Sand dusted coneshell		10	
Mollusca	Gastropoda	*Conus*	*catus*	Cat coneshell	1	2	
Mollusca	Gastropoda	*Conus*	*coronatus*	Crowned coneshell		1	
Mollusca	Gastropoda	*Conus*	*ebraeus*	Black and white coneshell		88	
Mollusca	Gastropoda	*Conus*	*litteratus*	Lettered coneshell		4	
Mollusca	Gastropoda	*Conus*	*lividis*	Livid coneshell	2	18	
Mollusca	Gastropoda	*Conus*	*rattus*	Rat coneshell		3	
Mollusca	Gastropoda	*Conus*	*striatellus*	Coneshell		2	
Mollusca	Gastropoda	*Chromodoris*	*spp.*	Nudibranch	x		
Mollusca	Gastropoda	*Clypeomorus*	*bifasciatus*			3	
Mollusca	Gastropoda	*Cypraea*	*tigris*	Leopard cowrie		x	x
Mollusca	Gastropoda	*Cypraecassis*	*rufa*	Bullmouth helmetshell		x	x
Mollusca	Gastropoda	*Dolabella*	*auricularia*	Wedge seahare		x	
Mollusca	Gastropoda	*Drupa*	*fusconigra*			x	
Mollusca	Gastropoda	*Drupella*	*rugosa*	Rugose drupe		58	
Mollusca	Gastropoda	*Engina*	*mendicaria*	Bumblebee shell	1	261	
Mollusca	Gastropoda	*Flabellina*	*exoptata*	Desirable flabellina	2		
Mollusca	Gastropoda	*Giberellus*	*giberellus*	Humpback conch		2	
Mollusca	Gastropoda	*Glossodoris*	*hikuerensis*	Nudibranch	x		
Mollusca	Gastropoda	*Halgerda*	*formosa*	Nudibranch	9		
Mollusca	Gastropoda	*Halgerda*	*tessellata*	Nudibranch	x		
Mollusca	Gastropoda	*Halgerda*	*wasinensis*	Nudibranch	x		
Mollusca	Gastropoda	*Hastula*	*lanceata*			2	
Mollusca	Gastropoda	*Hypselodoris*	*regina*	Nudibranch			x
Mollusca	Gastropoda	*Jorunna*	*rubsecens*	Nudibranch	x		
Mollusca	Gastropoda	*Lambis*	*chiragra (arthritica)*	Arthritic spider conch	5		
Mollusca	Gastropoda	*Lambis*	*lambis*	Spider conch	1		
Mollusca	Gastropoda	*Lambis*	*truncata*	Giant spider conch	x		
Mollusca	Gastropoda	*Littoraria*	*scabra*	Mangrove periwinkle		2	
Mollusca	Gastropoda	*Littoraria*	*undulata*	Periwinkle	1	1	
Mollusca	Gastropoda	*Mauritia*	*histrio*	Harlequin cowrie		2	
Mollusca	Gastropoda	*Mirta*	*paupercula*	Miter shell			
Mollusca	Gastropoda	*Monetaria*	*annulus*	Goldring cowrie		5	
Mollusca	Gastropoda	*Morula*	*granulata*	Mulberry shell	2		
Mollusca	Gastropoda	*Nerita*	*albicilla*	Blotched nerite		111	
Mollusca	Gastropoda	*Ovula*	*ovum*	Common egg cowrie	x		
Mollusca	Gastropoda	*Phyllidia*	*varicosa*	Nudibranch	3	x	
Mollusca	Gastropoda	*Phyllidiella*	*meandrina*	Nudibranch	x	x	

Mollusca	Gastropoda	*Phyllidiella*	*zeylonica*	Nudibranch	7	x	
Mollusca	Gastropoda	*Phyllidiopsis*	*striata*	Nudibranch	x		x
Mollusca	Gastropoda	*Pleuroploca*	*trapezium*	Tulip shell			x
Mollusca	Gastropoda	*Pollia*	*fumosus*	Smoky goblet		9	
Mollusca	Gastropoda	*Pollia*	*undodsus*	Waved goblet		1	
Mollusca	Gastropoda	*Pteraeolidea*	*ianthina*	Blue dragon school	x		
Mollusca	Gastropoda	*Rhinoclaris*	*sinensis*	Chinese cerith	1		
Mollusca	Gastropoda	*Terebra*	*dimidiata*	Giraffe screwshell			x
Mollusca	Gastropoda	*Thuridilla*	*indopacifica*	Nudibranch	x		
Mollusca	Gastropoda	*Vasum*	*ceramicum*	Ceramic vaseshell		1	
Mollusca	Gastropoda	*Vasum*	*rhinocerus*	Rhinocerus vaseshell		2	
Mollusca	Gastropoda	*Vasum*	*turbinellus*	Black and white vaseshell	3	4	
Mollusca	Gastropoda	*Vexillium*	*rugosum*	Ribbed miter		2	
Mollusca	Gastropoda	*Volema*	*paradisiaca*	Pear melongena		1	
Mollusca	Polyplacophora	*Acanthopleura*	*gemmata*	Splashzone chiton		5	
Crustacea	Anomura	*Dardanus*	*deformis*	Anemone hermit crab		x	
Crustacea	Anomura	*Dardanus*	*lagopodes*	Hairy hermit crab	x		
Crustacea	Anomura	*Dardanus*	*megistos*	Bluespot hermit crab	x	x	
Crustacea	Anomura	*Neopetrolisthes*	*maculatus*	Anemone crab		x	
Crustacea	Brachyura	*Calappa*	*hepatica*	Box crab			x
Crustacea	Brachyura	*Cardisoma*	*carnifex*	Red land crab		x	
Crustacea	Brachyura	*Eriphia*	*smithi*	Redeye rockpool crab		x	
Crustacea	Brachyura	*Estisus*	*slendidus*	Red crab	x		
Crustacea	Brachyura	*Graspus*	*tenuicrustatus*	Surge crab		x	
Crustacea	Brachyura	*Lydia*	*annulipes*	Striped stone crab		x	
Crustacea	Brachyura	*Ocypode*	*ceratophthalmus*	Horny eyed ghostcrab		x	
Crustacea	Brachyura	*Ocypode*	*cordimanus*	Smooth handed ghostcrab		x	
Crustacea	Brachyura	*Ocypode*	*ryderi*	Pink ghostcrab		x	
Crustacea	Brachyura	*Percnon*	*planissium*	Flat coral crab	x		
Crustacea	Brachyura	*Tetralia*	*glaberrima*	Acropora coral crab	x		
Crustacea	Brachyura	*Trapezia*	*rufopunctata*	Spotted coral crab	x		
Crustacea	Caridea	*Hymenocera*	*picta*	Harlequin shrimp		x	
Crustacea	Caridea	*Rhynchocinetes*	*durbanensis*	Jagged shrimp	x		
Crustacea	Caridea	*Stenopus*	*hispidus*	Banded cleaner shrimp	x	x	
Crustacea	Palinura	*Panulirus*	*versicolor*	Painted spiny lobster	x	x	
Crustacea	Stomatopoda	*Gonodactylus*	*chiragar*	Sandy mantis shrimp		x	
Crustacea	Stomatopoda	*Gonodactylus*	*platysoma*	Spotted mantis shrimp		x	
Crustacea	Stomatopoda	*Odontodactylus*	*scyllarus*	Peacock mantis shrimp	x		

Appendix 2c – Genus list for Scleractinian corals

Family	Genus	Reef	Intertidal
Acroporidae	*Acropora*	x	x
	Alveopora		x
	Astreopora	x	x
	Montipora	x	
Agarciidae	*Gardineroseris*	x	
	Leptoseris	x	
	Pavona	x	x
Coscinaraeaidae	*Anomastrea*		x
	Coscinaraea	x	x
Dendrophyllidae	*Turbinaria*	x	
Euphyllidae	*Plerogyra*	x	
Faviidae	*Cyphastrea*	x	
	Echinopora	x	
	Favia	x	x
	Favites	x	x
	Goniastrea	x	x
	Leptastrea	x	x
	Leptoria	x	
	Montastrea	x	
	Oulophyllia	x	
	Platygyra	x	x
	Plesiastrea	x	
Fungiidae	*Ctenactis*	x	
	Fungia	x	
	Herpolitha	x	
	Podabacia	x	
Merulinidae	*Hydnophora*	x	x
	Merulina	x	
Mussidae	*Acanthastrea*	x	
	Blastomussa	x	
	Lobophyllia	x	
	Symphyllia	x	
Oculinidae	*Galaxea*	x	
Pectiniidae	*Echinophyllia*	x	
	Mycedium	x	
	Pectinia	x	
Pocilloporidae	*Pocillopora*	x	
Poritidae	*Goniopora*	x	
	Porites	x	x
Siderastreidae	*Psammocora*	x	