

# **CEPA - JICA**

---

## **Biodiversity Project**

### **MARINE BIODIVERSITY SURVEY**

#### **FINAL REPORT**

---

**A CEPA-JICA PROJECT ON BIODIVERSITY CONSERVATION THROUGH  
IMPLEMENTATION OF  
THE PNG POLICY ON PROTECTED AREAS**

**APRIL 2018**



*Prepared by the Centre for Biodiversity and Natural Products,  
University of Papua New Guinea*

**Contents**

EXECUTIVE SUMMARY..... 1

CHAPTER 1. MARINE BIODIVERSITY SURVEY OVERVIEW ..... 5

    Introduction..... 5

    Sites description ..... 6

        Geographical Location..... 6

        Geology..... 7

        Marine Environment ..... 8

        Climate..... 8

        Vegetation ..... 8

CHAPTER 2. BIODIVERSITY INVENTORY ..... 12

INVENTORY OF BOGORO AND MOTUPORE ..... 12

    Introduction..... 12

    Objectives..... 12

    Methods and Material..... 12

    Results and Discussion ..... 13

    Floristic Composition and Diversity..... 14

        Mangrove species..... 15

        Seagrass Species ..... 17

    Faunal Composition and Diversity..... 18

        Mammals..... 18

        Birds..... 19

    Marine Biodiversity ..... 20

        Cnidarians..... 20

        Ascidians..... 25

        Marine Worms ..... 26

        Crustaceans ..... 28

        Molluscs..... 32

        Echinoderms..... 36

        Sponges ..... 39

        Marine Macro-Algae..... 41

        Fishes ..... 42

        Marine Mammals ..... 42

Marine Reptiles .....	42
Conclusion .....	43
References.....	43
Appendix 2-1. Plant species list for Bogoro Inlet and Motupore Island.....	47
Appendix 2-2. Fish species recorded at Bootless Bay. ....	56
CHAPTER 3. FLORA SURVEY .....	71
Introduction.....	71
Objectives.....	72
Material and Methods.....	72
Results .....	74
Floral diversity .....	74
Lifeforms.....	74
Vegetation structure .....	76
Discussion.....	76
Conclusion .....	78
References.....	79
Appendix 3-1. List of Plant species recorded in survey.....	80
CHAPTER 4. TERRESTRIAL FAUNA SURVEY (BIRDS, INSECT, REPTILES).....	81
Introduction.....	81
Material and Methods.....	81
Point Counts .....	81
Mist nets for birds and bats .....	82
Results .....	82
Discussion.....	84
References.....	84
Appendix 4-1. MacKinnon List of birds observed at Motupore Island.....	86
Appendix 4-2. MacKinnon List of birds observed at Bogoro Inlet.....	87
CHAPTER 5. MARINE HABITAT AND DIVERSITY .....	88
Introduction.....	88
Objectives.....	88
Material and Methods.....	88
Results .....	91
Cover types.....	91
Marine Diversity .....	93

Species Composition .....	94
Macroalgae.....	94
Seagrass.....	94
Cnidarians.....	95
Echinoderms.....	96
Discussion.....	98
Conclusion .....	99
References.....	99
CHAPTER 6. THE FISH DIVERSITY SURVEY.....	101
Introduction.....	101
Objectives.....	101
Material and Methods.....	101
Study Sites .....	101
Survey Design .....	102
Data Analysis .....	103
Results .....	104
Species Richness and Density Levels .....	104
Trophic Structure.....	105
Catch Composition and Efforts.....	106
Discussion.....	107
Conclusions.....	113
References.....	115
Appendix 6-1: List of fish species observed at Bogoro Inlet and Motupore Island proposed MPAs..	116
CHAPTER 7. ANTHROPOGENIC IMPACT - A PRELIMINARY SURVEY .....	121
Introduction.....	121
Objectives.....	121
Material and Methods.....	121
Results .....	122
Fishing Activity.....	122
Mangrove Forest .....	125
Discussion.....	125
References.....	127
CHAPTER 8. BIODIVERSITY ASSESSMENT .....	128
Introduction.....	128

Biodiversity Assessment.....	128
Objectives.....	129
Methods and Material.....	129
Biodiversity Conservation Values Analysis.....	129
Results and Discussion.....	130
Bootless Bay Ecosystems.....	130
Biodiversity of Bogoro Inlet and Motupore Island.....	131
High Conservation Values.....	133
Mangrove Forest (Criteria HCV 2-5).....	133
Bogoro Marine Environment (HCV 3-5).....	134
Motupore Island (HCV 1 – 5).....	134
Conclusion.....	135
Recommendations.....	136
Reference.....	136
BIODIVERSITY PICTURES.....	137

### List of Figures

Figure 1. Close-up of Bootless Bay, this marine biodiversity suvey area with study sites indicated in the white circle (Bogoro Inlet Mangroves and Motupore Island Marine Habitats).....	7
Figure 2. Google earth satellite image showing patches of degraded and clearings in mangrove forest at Bogoro Inlet.....	10
Figure 3. Publications recorded for Motupore and surrounding areas, Bootless Bay.....	13
Figure 4. Location of sampling stations at Bogoro Inlet and Motupore Island. Stations 1 and 2 at Bogoro Inlet and stations 3, 4, 5 and 6 on Motupore Island. ....	73
Figure 5. Schematic diagram of flora survey at each station. Sampling transects (TR) indicated by shaded orange rectangular. ....	73
Figure 6. Lifeform cover of Site 1(Bogoro Inlet) and Site 2 (Motupore Island).....	75
Figure 7. Diameter class distributions for Bogoro Inlet (Site 1) and Motupore Island (Site 2). Diameter class: 1 = <5cm; 2 = 5-10cm; 3 = 10.1-15cm; 4 = 15.1-20cm and 5 = >20cm. ....	76
Figure 8. Observational sites (Bogoro Inlet and Motupore Island) and stations within sites. Yellow dots indicate observation stations. ....	81
Figure 9. Schematic diagram of a 10-minute Point count described in the text above.....	82
Figure 10. The two study sites (enclosed in white oval shape) and the six sampling stations. ....	89

Figure 11. Schematic layout of sampling method of reef environment. Sampling transects established at every 50m interval. Transect layout with 1m x 1m quadrat also indicated to the right. ....	90
Figure 12. Lay out of stations 3, 4, 5, and 6 at Motupore Island. The green dots represent sampling transects that are 50m apart from each other. ....	91
Figure 13. Percentage cover types for for stations 1 to 6. Cover data from all transects in each station were pooled and mean percent coverage calculated. ....	92
Figure 14. Percentage frequency of major groups of organisms recorded at Bogoro Inlet and Motupore Island. ....	93
Figure 15. Predicted species diversity if sampling effort is increased. ....	98
Figure 16. The two study sites (enclosed in white oval-shape) and the six stations. ....	102
Figure 17. Illustration of the survey design showing the arrangements of sites, stations, and replicated transects. Source: modified from Pakoa et al., 2014. ....	103
Figure 18: Percent fish trophic structure on Bogoro Inlet and Motupore Island. ....	106
Figure 19. Mean number of fish species per station.....	107
Figure 20. Cover types of stations 2, 3, 4, 5 and 6. ....	108
Figure 21. Mean density (Ind.Ha <sup>-1</sup> ) per stations.....	109
Figure 22. Seinenet catch compositions by family.....	110
Figure 23. Mean number of fishes in each trophic level per hectare of reef in Bogoro Inlet and Motupore Island. ....	111
Figure 24. IUCN Category of the recorded fish species.....	113
Figure 25. Fishing sightings observed during the duration of the survey .....	123
Figure 26. Percent frequency of methods employed by locals when fishing around Motupore Island and the surroung island.....	123
Figure 27. Fishing methods employed by local fishermen. From local informants, dynamite is commonly used. During the survey, only one explosion was heard near Lion Island, SW of Motupore Island.....	124
Figure 28. Temporal patterns of fishing activities as observed and recorded around Motupore Island. The percentages are derived from counting the total number of fishermen fishing over a 24 hour period. ...	124
Figure 29. Image of mangrove forest indicating clearance (light green shade. Inserted picture was taken from where the arrow is pointing to the larger image. ....	125
Figure 30. National Capital District(NCD) Development plan of 2011. ....	126
Figure 31. Mangrove zones of Bogoro Inlet. ....	133

Figure 32. Bogoro Inlet marine environment.....	134
Figure 33. Two sampling stations (3 and 5) of HCV status.....	135

**List of Tables**

Table 1. Mangrove species recorded at Bogoro Inlet and Motupore Island. ....	15
Table 2. Seagrass species of Motupore Island and Bogoro Inlet. ....	17
Table 3. List of mammals known to occur in the area and surrounding areas. Information sourced from Bonaccorso [35], and Flannery [36]. ....	18
Table 4. List of common birds known to occur in the proposed development area. ....	20
Table 5. Checklist of Cnidarians recorded or observed so far at Bogoro Inlet and Motupore Island. Almost all cnidarians have not been evaluated by IUCN Redlist criteria. ....	21
Table 6. Checklist of Ascidians recorded at Bogoro and Motupore Island. ....	26
Table 7. Marine worms recorded within Bootless Bay. ....	26
Table 8. Checklist of Crustaceans recorded at Bogoro and Motupore Island.....	28
Table 9. Checklist of Molluscs recorded at Bogoro Inlet and Motupore Island.....	32
Table 10. Checklist of Echinoderms recorded at Bogoro Inlet and Motupore Island.....	37
Table 11. Checklist of Sponges recorded at Bogoro Inlet and Motupore Island.....	39
Table 12. Common Algae recorded at Bogoro Inlet and Motupore Island.....	41
Table 13. Marine mammals recorded within Bootless Bay.....	42
Table 14. Reptile species observed within Bootless Bay.....	42
Table 15. Summary of the two sites and their stations (see text in material and methods above). ....	74
Table 16. Mangrove species occurring with Bogoro Inlet and Motupore Island.....	77
Table 17. Check list of birds recorded at Bogoro Inlet (Site 1) and on Motupore Island (Site 2). [CODE, * = Residents; ***= new record for Motupore Island (red)]. ....	83
Table 18. Summary of species recorded in each station.....	93
Table 19. Macroalgae species recorded during the rapid biodiversity survey. ....	94
Table 20. List of seagrass species recorded from sampling transects. ....	95
Table 21. List of Cnidarians recorded from all transects at Bogoro Inlet and Motupore Island.....	95
Table 22. Mean number of species and density per hectare of reef and dominant taxa for each station.	104

Table 23. CPUE for Stations 3-6.....	106
Table 24. IUCN Redlist categories and definitions. Source: adapted from IUCN, 2001.....	111
Table 25. Species diversity of significant taxonomic groups with comparison to PNG (ND = not determine) .....	132

**List of Plates**

Plate 1. <i>Scaevola taccada</i> was recorded in the 1970s but was not present in the 1990s. Reappeared again on Motupore Island.....	74
Plate 2. The mangrove <i>Aegialites annulata</i> becoming rare in Bootless Bay. Occuring on Motupore Island. Photo by Pius Piskaut, 2018. ....	78
Plate 3. Eclectus Parrot, <i>Eclectus roratus</i> , a new resident on Motupore Island. ....	84
Plate 4. Examples of seagrass cover percentages relative to a 1m x 1m quadrat (adopted from <a href="http://www.seagrasswatch.org">www.seagrasswatch.org</a> ).....	89



## EXECUTIVE SUMMARY

### Introduction

This report presents the results of a rapid biodiversity inventory of the Bogoro Inlet and Motupore Island within the Bootless Bay (a large embayment bordering the South-eastern side of the expanding Port Moresby City), Central Province, Papua New Guinea. The biodiversity survey was conducted at Tahira on the eastern coast of Bogoro Inlet and Motupore Island which is a small island about 1km from the coastline of Tahira (see maps in the main report). Both Tahira and Motupore Island are state lands leased to the University of Papua New Guinea and are proposed marine protected areas as part of the Conservation and Environment Protection Authority (CEPA) pilot initiative for establishing protected areas in line with the PNG policy on protected areas.

This rapid biodiversity inventory was commissioned by the CEPA-JICA Project on biodiversity conservation in PNG with an aim to rapidly generate and disseminate baseline data, which is a requirement for establishing biodiversity protected areas, as well as providing protocols for conducting biodiversity inventory, assessment, and monitoring.

### Overview

Of the many publications written about different aspects of Bootless Bay, very few (examples Hopkins & Menzies (1995), Baine & Harasti (2007), and Coleman (1989) have actually documented the full range of species of plants and animals inhabiting the Bogoro Inlet and Motupore Island.

The Bogoro Inlet and Motupore Island are part of the Bootless Bay and are composed of Eocene deposits comprising mainly of tightly folded calcareous shale and chert on Motupore Island and calcarenite limestones along Tahira shores. These areas are covered mainly by different habitat types typical of the climatic and oceanic conditions of the Southeast Papuan Coastline of New Guinea. The Bootless Bay is a semi-enclosed and shallow (30m) embayment comprising of reefs, channels, seagrass meadows, and mangroves which receive rainfall during northwest monsoon from November to April but generally dry year round.

Typical of many areas in the Coral Triangle region, Bootless Bay is home to an array of marine life that has supported the local people for many years and one that is worth millions in monetary values. Unfortunately, this diverse marine life is undergoing rapid changes due to the different development pathways pursued by the local people as well as the government and its development partners in Port Moresby City.

The University of Papua New Guinea has been using the Tahira and Motupore Island for conducting educational programs while restricting active use of marine biodiversity there.

The CEPA-JICA project team has selected the Bogoro Inlet and Motupore Island as proposed Marine Protected Areas (MPAs) by promoting Biodiversity Conservation through the implementation of the PNG Policy on Protected areas.

## **Summary of Methods**

Focusing mainly on sampling the marine biodiversity, the Bogoro Inlet and Motupore Island biodiversity inventory was conducted using literature searches, visual censuses, transect samplings and various fishing methods while the biodiversity status assessment (using the results) was analysed using High Conservation Value (HCV) methods. This biodiversity inventory focuses mainly on sampling the marine ecosystems which included coastline shore, mangrove, seagrass bed, coral reef, and channel ecosystems in the proposed MPAs. The biodiversity inventory was conducted using visual censuses aided by photographic, quadrat, and belt transect sampling techniques which were used within six sampling stations covering an area of 2.00km<sup>2</sup> of marine ecosystems. For each station the sampling transects started at the terrestrial-marine interface usually at the high water mark of the intertidal zones. Within a sampling station the survey transects were placed at 50m intervals, and perpendicular to the coastline, and parallel to each other. For the seagrass beds and coral reefs, the surveys were conducted starting from the land-sea or mangrove-sea interfaces.

For the inventory of the birds, the transects were extended into the forests and modified into a 50m radius circular plot having a marked center where an observer is positioned and conducts a 10 minute count and identification of birds.

The high conservation value (HCV) method was applied on the results of the inventory to assess the conservation status of the biodiversity in the proposed MPAs. The HCV method has six categories that encompassed both the ecological and socio-economic systems of Bogoro Inlet and Motupore Island.

## **Summary of Results**

The marine ecosystems of the Bootless Bay (including Bogoro Inlet and Motupore Island) included coastline shores, saltmarshes, mangroves, seagrass beds, sand and rubble beds, coral reefs, and channel ecosystems.

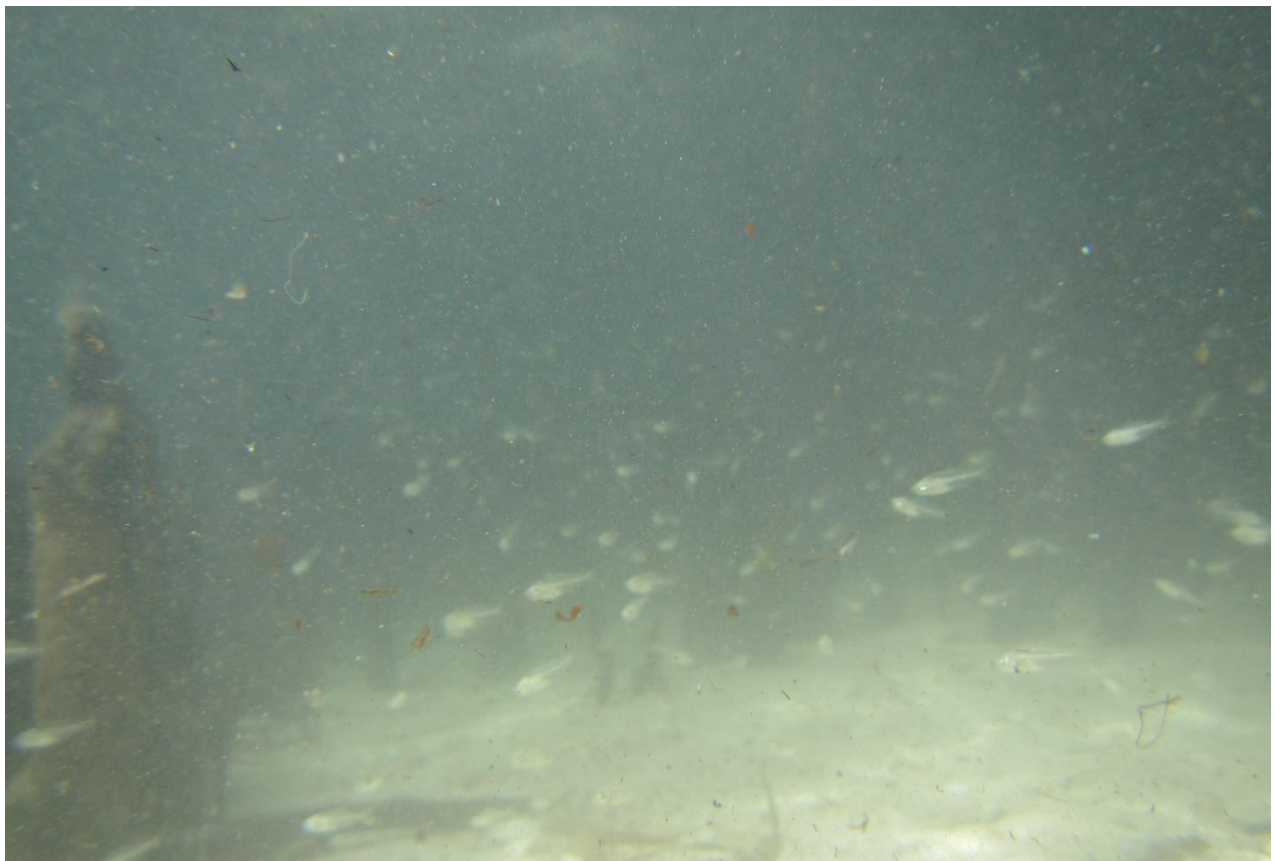
The Bogoro Inlet and Motupore Island comprise ecosystems and species rich marine environment, comparable with many areas in PNG and the region. The species of plants and animals reported in the previous publications and this inventory included 283 terrestrial plants, 23 mangrove species, 10 seagrass species, 81 bird species, 4 species of marine mammals, 1 species of saltwater crocodile, 2 species of sea snakes, 3 species of turtles, 512 species of fishes, 284 species of reef corals, and many macroalgae, crustaceans, echinoderms, and molluscs.

However, the entire marine ecosystems of Bogoro Inlet and Motupore Island are undergoing rapid changes from intact ecosystems to those having features of degraded ecosystems. Mangrove ecosystems for example, were being cleared resulting in loss of species locally and release of mud into the surrounding reefs; coral reefs were losing corals and reef habitat structures as a result of burial by sediments released from the cleared mangroves; and fish stocks decreasing as indicated by small size fishes and low catch rates.

The Bogoro Inlet and Motupore Island constitute high conservation values which are being threatened by the rapid changes taking place in the area. The two proposed MPA sites features a number of important ecosystem values; both have specific nursery grounds for many fish species. Motupore harbours the most expensive sea cucumber, the threaten Maori Wrasse, nesting site for green turtle, mating site for shark species, home to the Banded sea snake, host to 7 endemic plant species, nome to the locally rare mangrove species, *Aegialites annulata*, support up to 54 residential bird species and harbours a wide array of coral species.



Maori Wrasse (*Thalassoma* sp.) caught by handline on Motupore Island.



Picture of fries (baby fish) foraging in mangrove edge near the sandspit on Motupore Island, Bootless Bay. Photo by Pius Piskaut, 2018.

### Summary of Conclusions

Using the high conservation value concept, the two proposed MPAs meet the requirements to be declared Marine Protected Areas. Establishing the MPAs will set in some form of management needed to protect and sustainably manage the ecosystems and resources.

Biodiversity summary of Bogoro Inlet and Motupore Island.

Significant Taxonomic Groups	Sub groups	Bogoro/Motupore (Area = 200ha)	PNG [4,5]
Plants	Fern	2	2414
	Gymnosperm	1	10
	Terrestrial angiosperms	280	~20,000
	Mangroves	23	36
	Seagrasses	10	14
Birds		81	863
Fish		512	2719
Cnidarian	Corals (soft and hard)	90	560
	Hydrozoans	5	Unknown
	Sea Jellies	2	Unknown
	Sea Fens	4	Unknown
Echinoderm	Sea cucumber	28	Unknown

### Recommendations

The proposed MPAs are established to protect the existing biodiversity as well as prevent further degradation of the marine ecosystems and losses of marine resources.

## CHAPTER 1. MARINE BIODIVERSITY SURVEY OVERVIEW

*“We declare our fourth Goal.....that the environment is utilized wisely and preserved for the collective benefit of all and our future generations”.*

PNG Constitution...1975.

### **Introduction**

The Papua New Guinea Conservation and Environment Protection Authority (CEPA) in partnership with Japan International Cooperation Agency (JICA), through the Technical Cooperation Scheme, are proposing to declare Bootless Bay as a Marine Protected Area (MPA) as output 3 of the project. The targeted Bootless Bay area is about 15km southeast of the city of Port Moresby within the National Capital District, sharing its eastern-most boundary with Central Province. The CEPA-JICA Biodiversity Conservation Project, herein known as the CEPA-JICA Project, is an initiative of the Japanese and PNG Governments and was initiated purposely to implement the PNG policy on Protected Areas. This CEPA-JICA Project serves marine biodiversity survey in potential protected area in Bootless Bay of Papua New Guinea (PNG).

Based on a series of surveys conducted by the CEPA-JICA Project team on the general Bootless Bay area (Figure 1), it was decided that the marine biodiversity survey will be carried out in State Lease Areas of Bogoro Inlet, Tahira and Motupore Island to serve as an impetus for marine conservation efforts within the entire Bootless Bay and the overall East Hiri Coastline. The title holders of these areas have agreed in principle, to partner with CEPA-JICA’s endeavor to declare their areas as part of the proposed MPAs.

As part of the CEPA-JICA Project’s Conservation efforts, a rapid biodiversity inventory and assessment study was commissioned to assess the marine ecosystems of Bogoro/Tahira and Motupore Island (Figure 1). The study’s aim is to provide baseline data needed to validate the proposed MPAs establishment. Furthermore, protocols utilized in carrying out this study are documented to serve as guides for the establishment of any potential MPAs in PNG.

This report documents the biodiversity inventory and assessment results of the Bogoro Inlet and Motupore Island MPAs. The report presented herein meets the requirements of Article 1 of the “Contract” signed between UPNG and JICA on the 12th January 2018 and implemented from the 26<sup>th</sup> day of the same month.

Overall, the study will provide landscape/seascape, ecosystem and biodiversity information, particularly, on coral reefs, fishes, seagrasses, mangroves and birds (including endemic and exotic species). Such information gathered will fill gaps on the biodiversity and the overall conservation values of the area for the management of Bogoro Inlet Mangrove and Motupore Island, components of the MPA under the Bootless Bay Marine Conservation Initiative (BBMCI).

The report is divided into eight chapters. Chapter 1 (this section) provides an overall introductory note on the purpose of the study and the general descriptions of the proposed MPAs. Chapter 2 looks at the biodiversity inventory of the marine flora and fauna already recorded in published and unpublished

studies within the Bootless Bay. Chapters 3 to 7 present results from individual surveys conducted in the area. It also presents an executive summary.

### ***Sites description***

#### ***Geographical Location***

Bootless Bay is a body of water in south-eastern Papua New Guinea, within the NCD with centroid coordinates of 9.504444°S and 147.262778°E. The coastline of the Bay is very peculiar, comprising small coves to large embayments. The outstanding embayments are Tuna Bay, Bogoro Inlet, and Tubuserea Inlet (Figure 1). There are four islands in the Bay: Motupore Island, Loloata Island, Manunouha Island, and Bunamotu Island. A barrier reef across the mouth of the inlet protects it from rough seas. Several small creeks empty into the Bay, but with no large rivers.

Bogoro Inlet and Motupore Island are owned by different entities. The University of Papua New Guinea is the title holder for Motupore Island and Tahira Boating Centre (within Bogoro Inlet). The adjacent land areas, outside the UPNG jurisdiction, are owned by different entities, who have agreed to preserve their mangrove forests and marine habitats (Figure 1).

Bogoro Inlet and Motupore Island are adjacent to each other with similar land and seascapes and are generally subjected to similar conditions.



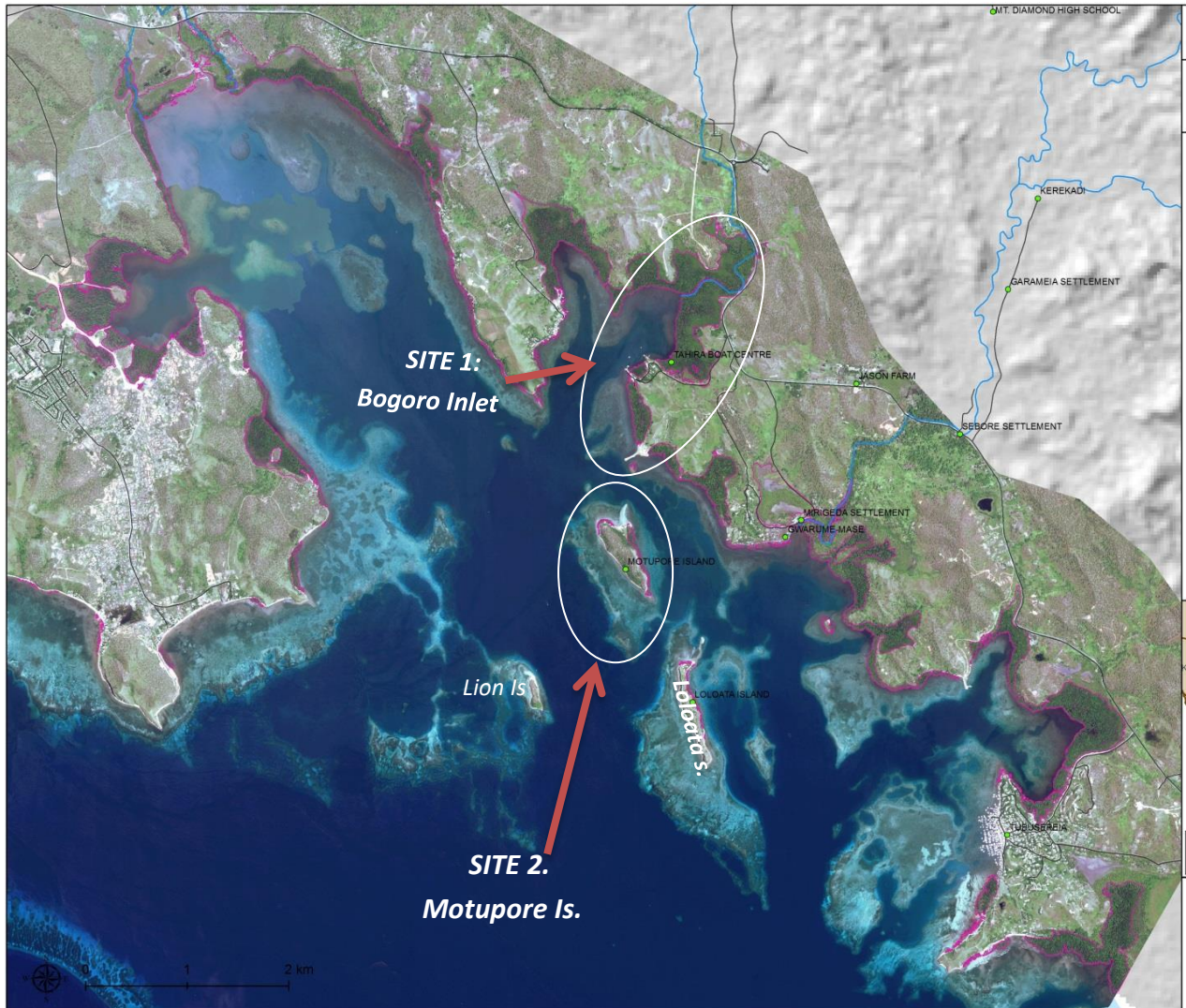


Figure 1. Close-up of Bootless Bay, this marine biodiversity survey area with study sites indicated in the white circle (Bogoro Inlet Mangroves and Motupore Island Marine Habitats).

## Geology

The Bogoro Inlet and Motupore Island are part of the Eocene deposits, known as the Port Moresby Beds (Yates and Ferranti, 1967; Hopkins and Menzies, 1995). The deposits are variable in structure and composition but generally composed of bands of calcareous shale and chert laid down as deep marine sediments, and now tightly folded and faulted. At Bogoro Inlet the deposits largely comprise rock type of grey calcarenite or detrital limestones which are only confined to this area (Glaessner, 1952) in Yates and Ferranti (1967).

The island of Motupore is formed from a ridge crest when the area subsided and then covered by the sea.

## Marine Environment

---

Bootless Bay is a semi-enclosed Bay on the southwest coast of Papua New Guinea. The bay is bordered by the great Papuan Barrier Reef, 3-5km offshore and coastline of southeastern New Guinea. The Bay is approximately 9.5 km along its longest axis (northwest-southeast) and 2 km wide. The Bay is shallow with a maximum depth of approximately 30 m (Drew et al., 2012).

The marine environment of Bogoro Inlet and Motupore Island comprises variety of micro and macrohabitats. There appeared to be some zoning of habitats but the zonations are not too distinct within Bogoro Inlet. From the edges of mangrove forest, is the intertidal zone, comprising large coarse gravels, mixed with muddy sand. In Bogoro Inlet, this zone extends out of the cove to the sea. There is a reef patch that is not often exposed during normal low tides (*pers. obser.*). The environment is subjected to sedimentation and siltation from developments farther inland which enter the inlet through the Bogoro Creek.

A reef proper occurs at the mouth of the inlet and is similar to the fringing reefs occurring at Motupore Island. There are distinct zonations and include;

- Intertidal – rocky shoreline or patches of sandy beaches.
- Seagrass meadow – narrow and very sparse in density at some locations.
- Reef flat
- Reef Crest
- Reef shelves – to a maximum depth of 30m (Drew et al. 2012)

## Climate

---

The annual rainfall for the focus areas of this study is between 1000-2000mm but is highly variable from year to year. The climate is strongly seasonal with most rain usually falling between November and April, and very little during the rest of the year. The SE Trade Winds (Laurabada) blow almost daily from May to October, though they may start early in March and continue till the end of November or even to December, with little or no rain. After a period of doldrums, the NW Mosoon Winds (Lahara) then brings intermittent rain, being heaviest during January to March.

## Vegetation

---

Several vegetation types are prominent in this general area ranging from beach forests to savanna grassland. A brief description of each type is given below.



## 1. Mangrove forest

Mangrove community is the most prominent and important vegetation within the Bootless Bay area. It serves as a nursery grounds for fisheries and buffers both marine and terrestrial environment from severe erosion and natural catastrophe.

A good stand of mangrove forests occurs within the Bogoro Inlet and a small fringe occupy the northeastern part of Motupore Island. The forest around Bogoro Inlet has an average canopy height of 10m, rarely 15m. The larger diameter trees include *Avicennia marina*, *Rhizophora apiculata*, *Bruguiera gymnorhiza* and *B. sexangula*. Average tree girth in the area is around 30cm diameter. Forest zonation is distinguishable with *Heritiera*, *Avicennia* and *Ceriops* occupying the landward end, *Bruguiera* and *Rhizophora apiculata* in the middle, and *R. stylosa* at the seaward end. Regeneration is prolific in some areas, but seedling mortality is high due to the relatively closed canopy under the mature stand. The understory is therefore fairly open with very little growth of common ferns like *Acrosticum* nor that of *Acanthus* species (student's data, unpub.).

There appeared to be a lot of encroachment into the mangrove forests recently. Satellite imagery indicates mosaic patches of clearance at Bogoro and Tahira mangrove forest (Figure 2).

On Motupore Island, mangroves form mosaic fringes at the northern and eastern portion of the island. The eastern mangrove is more extensive. Compare to Bogoro Inlet, the mangrove forest is more stunted in its structure. Some species present at Bogoro Inlets are absent on the island. Common species include, *Rhizophora stylosa*, *Bruguiera gymnorhiza*, *Osbornia octodonta*, *Sonneratia alba* and *Avicennia eucalyptifolia* (Hopkins and Menzies, 1995).

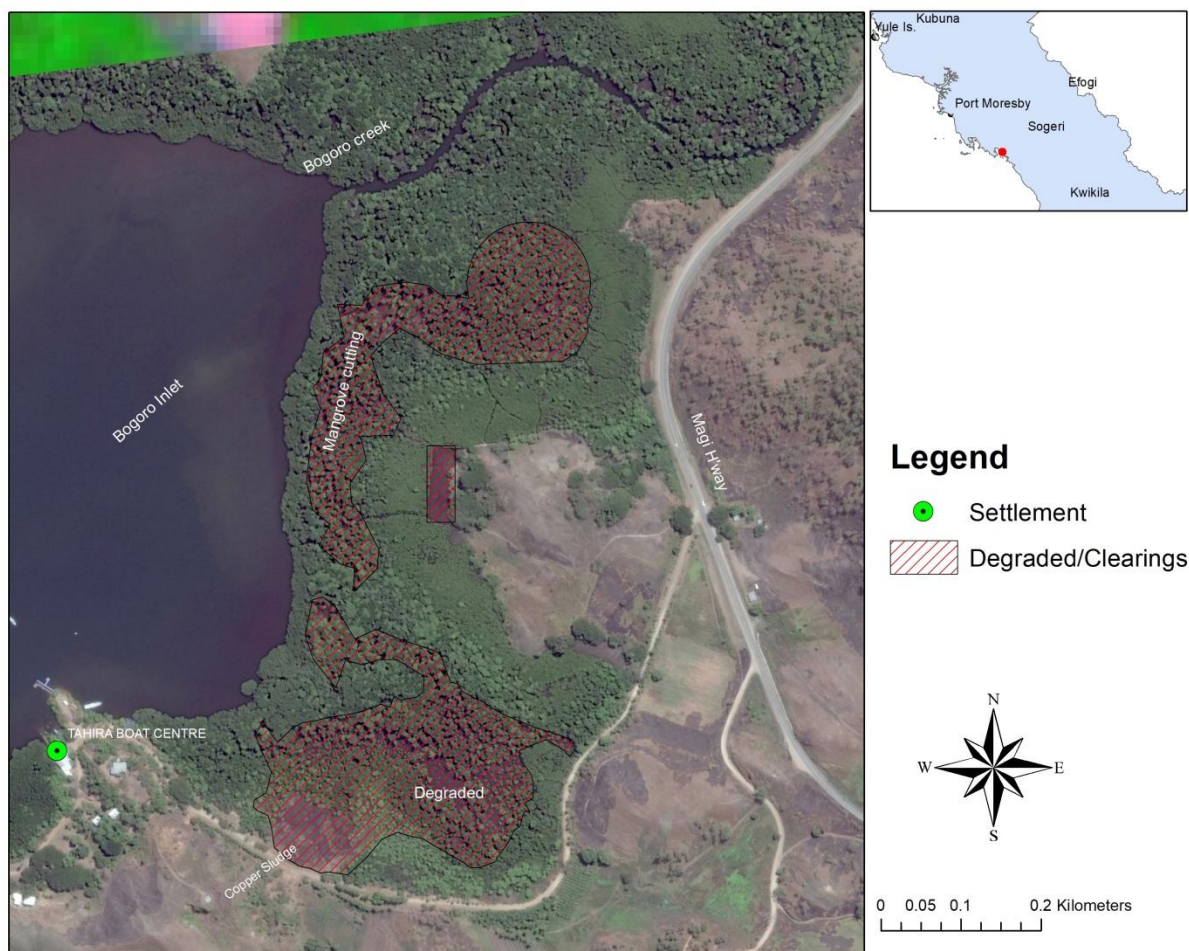


Figure 2. Google earth satellite image showing patches of degraded and clearings in mangrove forest at Bogoro Inlet

### Beach Strand Vegetation

This vegetation forms a narrow fringe of plants growing just above the high water-mark. Where mangrove fringe occurs along the coastline, there is usually a bare rocky or sandy strip separating it from the strand vegetation at the back.

The beach strand vegetation includes a number of distinctive species which are semi-deciduous and are relatively tolerant to salt. It is a specialized community but geographically widespread due largely to dispersal of fruits and seeds by ocean currents (Hopkins and Menzies, 1995).

The community is characterized by the presence of *Pongamia pinnata*, *Cordia subcordata*, *Guettarda speciosa*, and *Thespesia populnea*. Less common trees include *Excoecaria agallocha* and *Xylocarpus rumphii*, while such as *Clerodendron inerme*, *Premna serratifolia*, *Maytenus emarginata*, *Colubrina asiatica* and *Vitex trifoliata* may be locally common.

### Eucalyptus savanna

Almost 70% of the area is covered by savanna grassland which extends at the back of the beach strand vegetation. This is an open woodland dominated by Eucalyptus trees over a dense grass layer of *Themeda*

*novaeguineensis* and *Imperata cylindrica* and other grass species. The vegetation is very open reaching approximately 6m (rarely 10m) in height. The density of trees varies so that in some places there is broken canopy, and elsewhere there is open patches of grasses particularly on hills (Hopkins and Menzies, 1995).

Common Eucalypts in this community are *Eucalyptus confertiflora*, *E. tereticornis*, *E. alba*, and *E. papuana*. Other associates include *Acacia auriculiformis*, *Timonius timon*, and the shrubs *Ficus opposita*, *Canthium suborbiculare*, *Allophylus cobbe*, *Alectryon repando-dentata* and *Flueggea virosa*.

### **Riverine Forest**

This forest type forms a narrow band along the upper Bogoro creeks towards Bautama. Hammermaster, and Saunders, (1995) classified this forest type as open forest. The canopy of this forest can reach 30m in height. The canopy is very open and has many, often large, gaps revealing a lower tree stratum.

Floristically, the community is dominated by *Alstonia scholaris*, *Garuga floribunda*, *Intsia bijuga*, *Planchonia papuana*, *Vitex cofasus* and *Maniltoa*.

### **Monsoonal Scrub and Forest**

This vegetation once dominates the hills and valleys but are now reduced to patches. The vegetation is strongly affected by the climate. It occurs as degraded patches in gullies on hill sides and minor valleys. This vegetation occurs on Motupore and remnants can be observed at Gereka, a village on the opposite side of Tahira.

## CHAPTER 2. BIODIVERSITY INVENTORY

To conserve marine biodiversity, marine protected areas must have a solid foundation in biology and include representative and unique marine habitats [1]. In addition, the success of marine protected areas at protecting biodiversity depends on user compliance [2, 3] which highlights the importance of explicitly addressing the needs of stakeholders in the planning process [4]. This is the theme of this rapid biodiversity study for the proposed Bogoro Inlet and Motupore Island MPAs. The study aims at determining the biodiversity values composite to the proposed MPAs.

This chapter reports the biodiversity inventory and individual survey studies of Bogoro Inlet and Motupore Island. The chapter is divided into two parts. The first part presents the biodiversity inventory information extracted from literature. The second part presents the results of individual biodiversity survey studies.

### INVENTORY OF BOGORO AND MOTUPORE

#### *Introduction*

Understanding the magnitude and direction of ecosystem change requires careful documentation of the biodiversity present within that ecosystem. Without quantitative data, large-scale changes in one generation can be overlooked, resulting in a gradual shift towards increasingly degraded natural states being accepted as the baseline for future comparisons [5].

A starting point prior to collecting quantitative data is to examine the body of information already available for the area or the region. But acquiring information is, in itself, a very daunting task, since information on biodiversity are not readily available and must be extracted from the many taxonomic or biological studies on different taxa from the focused area or in the general vicinity of the area.

Despite this formidable task, this chapter compiles biodiversity information already known from the proposed MPAs and are presented in the result section.

#### *Objectives*

The main objective of the biodiversity inventory is to collate and consolidate biodiversity information already known in the area. The checklists of species will provide the basis whereby additional species will be added to the list. The second objective is to verify the species status against the IUCN Red List and PNG Red List (if any).

#### *Methods and Material*

A literature search was conducted to retrieve published papers. Most of the academic staff at the University of Papua New Guinea published their research papers in the local Journal “*Science in New Guinea*” (now inactive). We visited the archive and physically checked the journal for papers related to the Bootless Bay area. We then accessed the on-line museum collections through [www.fishnet2.net](http://www.fishnet2.net) with the “Search Polygon” feature centered around Bootless Bay.

Other data were also extracted from unpublished researches within and around the project area including data compiled from UPNG students’ field exercises to Bogoro Inlet and Motupore Island. For verification purposes, information on floral and faunal compositions were sourced from the National Herbarium (PNG Forest Research Institute, Lae), UPNG Natural Science Resource Centre (NSRC) and the PNG National Museum. Other site specific information were extracted from landsat satellite images [6].

## Results and Discussion

The marine environment around Motupore Island and Bogoro Inlet within the Bootless Bay is one of the most studied sites in Papua New Guinea, largely because of the facilities provided by Motupore Island Research Station. There are 350 publications of Motupore Island and the surrounding areas that deal specifically with or include the terrestrial and marine flora and fauna, the physical environment, or archaeology [7, 8]. Over half of these publications and reports relate to the marine environment, demonstrating the considerable volume of scientific research that has been conducted in this area (Figure 3).

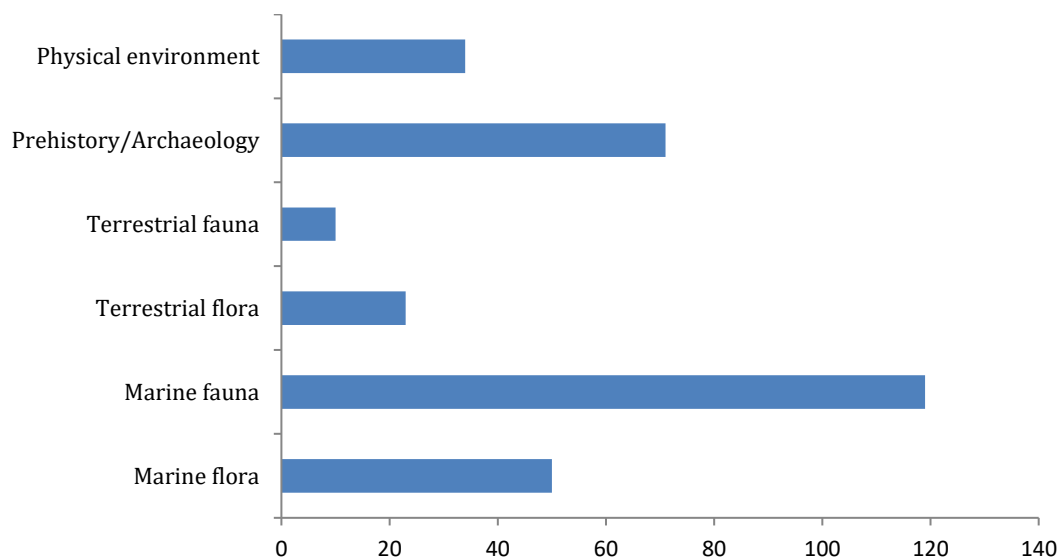


Figure 3. Publications recorded for Motupore and surrounding areas, Bootless Bay.

However, closer scrutiny of the articles on marine fauna showed that most studies only looked at the biology of single taxons. This is an artifact of the researchers' specialities. The diversity of countless marine fauna within Bootless Bay was never attempted until the beginning of the 21<sup>st</sup> century when two books comprising pictorial images were published. The first book, *“Discover Loloata Island”* by N. Coleman, published in 1998 [9] is designed as a simple introductory photo-guide to some of the flora and fauna living within the Bootless Bay. The book comprises 501 coloured photographs. The second book, *“The Marine Life of Bootless Bay”* by M. Baine and D. Harasti was published in 2007 [8] with brief narratives on the biology and ecology of all major taxonomic groups, from algae and sponges to fish and reptiles. The book comprises 900 coloured photographs.

At the terrestrial end, the book, *The Flora of Motupore Island* by H. F. Hopkins and J. I. Menzies [10], gives detailed botanical descriptions and distributions of the 230 plant species (including mangroves) occurring on Motupore Island and nearby Loloata and Lion islands. Of particular interest in the flora are seven species which are endemic or nearly so to the Port Moresby region (see section below).

Overall, the marine life of the Bootless Bay area is very colourful, as portrayed by the books indicating the quality and a variety of habitat types that range from coral reef, seagrass meadows, mangrove forests to patches of calcareous sandy beaches.

Excluding most fish species, a very conservative estimate of 1,500 marine species (flora and fauna) are known to occur in the Bootless Bay. A brief account of the biodiversity already known in the area is presented below.

**Floristic Composition and Diversity**

An estimated 300 plant species have been recorded within the Bogoro Inlet and Motupore Island [10, 11, 12]. On Motupore alone, a total of 230 plant species have been described and published in the book *“The Flora of Motupore Island”* by Hopkins and Menzies [10]. Appendix 1 list the species recorded so far in the area. Figure 3 gives a general floristic distribution of the species relative to the global distribution.

The MPA areas share 18% of the flora with Southeast Asia, 10% with Australia, 13% with Indo-Malesia (India, SE Asia, Philippines) and 22% of the species are pantropical. The other 21% are species

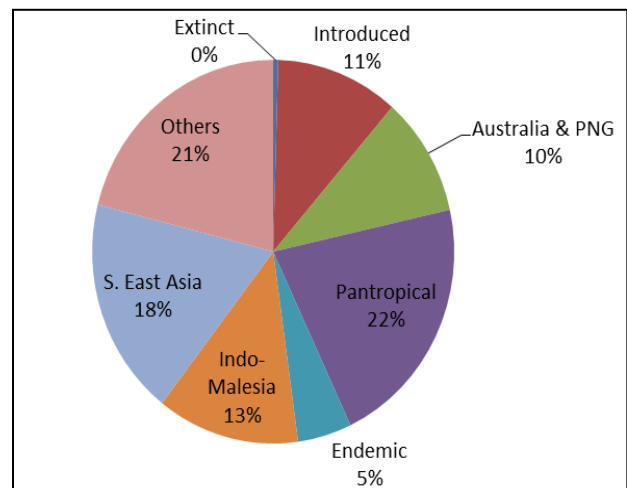


Figure 3. Phytogeography of plant species. Others included plants genus only or species that are far and wide (Africa and New Guinea). Data generated from Hopkins and Menzies [10].

which occur elsewhere. Additionally, 11% are introduced while 5% (11 species) are endemic to the Port Moresby region. The endemic species include *Cycas campestris*, *Bridelia oligantha*, *Albizia carri*, *Canthium suborbiculare*, *Jossinia desmantha*, and *Harpullia leptococca*. In addition *Alectryon repando-dentatus* is only known from the Port Moresby area and the Murray Island in the Torres Strait.

In savanna grassland *Eucalyptus spp.* and *Grevillea foetida* represent the Australian affinity and their occurrences are correlated with low rainfall, fire and the geology of the area.

### **Mangrove species**

Species of mangrove plants occurring within the Bogoro Inlet and Motupore Island are included in Appendix 1. Maniwavie [13] recorded 31 species within the entire Bootless Bay. There are at least 16 species of mangroves; 11 confirmed on Motupore and about 5 additional species at Bogoro Inlet (Table 1). This number is likely to go up to 18 (20) at most.

Table 1. Mangrove species recorded at Bogoro Inlet and Motupore Island.

Family	Scientific name	Common name	IUCN Status	PNG Status	Reference
Combretaceae	<i>Lumnitzera racemosa</i>	White-flowered Black Mangrove	Least Concern	Unavailable	14
Meliaceae	<i>Xylocarpus granatum</i>	Cannonball Mangrove	Least concern	Unavailable	15
Myrsinaceae	<i>Aegiceras corniculatum</i>	River Mangrove	Least concern	Unavailable	15, 42
Myrtaceae	<i>Osbornia octodonta</i>	Myrtle Mangrove	Least concern	Unavailable	15, 42
Plumbaginaceae	<i>Aegialitis annulata</i> **	Club Mangrove	Not evaluated	Unavailable	15, 43
Rhizophoraceae	<i>Bruguiera gymnorhiza</i>	Large-leaf Orange Mangrove	Not evaluated	Unavailable	15, 42
	<i>Ceripos tagal</i>	Rib-fruited Yellow Mangrove	Not evaluated	Unavailable	15, 42
	<i>Rhizophora apiculata</i>	Corky Stilt Mangrove	Least concern	Unavailable	15, 42
	<i>Rhizophora lamarckii</i>	Southern Hybrid Stilt Mangrove	Not evaluated	Unavailable	42, 43
	<i>Rhizophora mucronata</i>	Upstream Stilt Mangrove	Least concern	Unavailable	15, 42
	<i>Bruguiera sexangula</i>	Upriver Orange	Not evaluated	Unavailable	15, 42

		Mangrove			
	<i>Rhizophora stylosa</i>	Long-styled Stilt Mangrove	Least concern	Unavailable	15, 42
Sonneratiaceae	<i>Sonneratia alba</i>	White-flowered Apple Mangrove	Least concern	Unavailable	15, 42
Sterculiaceae	<i>Heritiera littoralis</i>	Looking-glass Mangrove	Least concern	Unavailable	15, 42
Acanthaceae	<i>Avicennia marina</i>	Grey/White Mangrove	Least concern	Unavailable	15, 42
	<i>Avicennia eucalyptifolia</i>	Grey/White Mangrove	Not evaluated	Unavailable	42

\*\*locally becoming rare and threatened.



## Seagrass Species

Seagrass meadows occur within the intertidal zones. Their cover varies from 80% cover to as low as 5%. Ten species had been recorded at Motupore Island and Bogoro Inlet are listed in Table 2.

Table 2. Seagrass species of Motupore Island and Bogoro Inlet.

Family	Scientific name	Common name	IUCN Status	PNG Status	Reference
Cymodoceaceae	<i>Halodule uninervis</i>	Needle seagrass	Least concern	Unavailable	15, 42
Cymodoceaceae	<i>Halodule pinifolia</i>		Least concern	Unavailable	15, 42, 43
Cymodoceaceae	<i>Cymodocea rotundata</i>	Ribbon seagrass	Least concern	Unavailable	15
Cymodoceaceae	<i>Cymodocea serrulata</i>		Least concern	Unavailable	15
Cymodoceaceae	<i>Syringodium isoetifolium</i>		Least concern	Unavailable	15
Cymodoceaceae	<i>Thalassodendron ciliatum</i>		Least concern	Unavailable	15
Hydrocharitaceae	<i>Halophila ovalis</i>	Paddle grass	Least concern	Unavailable	15, 42, 43
Hydrocharitaceae	<i>Halophila minor</i>		Least concern	Unavailable	15, 42, 43
Hydrocharitaceae	<i>Enhalus acoroides</i>	Tape seagrass	Least concern	Unavailable	15
Hydrocharitaceae	<i>Thalassia hemprichii</i>	Turtle seagrass	Least concern	Unavailable	15

**Mammals**

The mammal diversity of the Bootless Bay area is very low compared to adjacent Central Province. So far only 25 species are known to occur in the general area including Bautama and nearby inland areas. This may be an artifact of sampling efforts since only few or no sample at all, had been recorded in the area. A list of mammal species known to occur in area is provided in Table 3.

Table 3. List of mammals known to occur in the area and surrounding areas. Information sourced from Bonaccorso [35], and Flannery [36].

Family	Scientific names	Common names	IUCN Status	PNG Status	Reference
Dasyuridae	<i>Myoictis melas</i>	Three-Striped Dasyure	Least concern	Unavailable	36
Hipposideridae	<i>Hipposideros maggietylorae</i>	Maggie-Taylor's Horseshoe Bat	Least concern	Unavailable	15
Macroipodidae	<i>Thylogale stigmatica</i>	Red-legged Pademelon	Least concern	Unavailable	15
Macropodidae	<i>Dorcopsis leutuosa</i>	Grey Forest Wallaby (lowland)	Not Evaluated	Unavailable	15
Macropodidae	<i>Macropus agilis</i>	Agile Grass Wallaby	Least concern	Unavailable	15, 36
Macropodidae	<i>Thylogale brunii</i>	Dusky Pademelon	Vulnerable	Unavailable	15, 36
Muridae	<i>Coniurus penicillatus</i>	Brush-Tailed Rabbit Rat	Not evaluated	Unavailable	36
Muridae	<i>Hydromys chrysogaster</i>	Common Water Rat	Least concern	Unavailable	15, 36
Muridae	<i>Melomys lutillus</i>	Grassland Melomys	Least concern	Unavailable	15, 36
Muridae	<i>Melomys refescens</i>	Black Tailed Melomys	Not evaluated	Unavailable	36
Muridae	<i>Pseudomys delicatulus</i>	Delicate Mouse	Not evaluated	Unavailable	36
Muridae	<i>Rattus rattus</i>	Common House Rat	Not evaluated	Unavailable	36
Muridae	<i>Rattus praetor</i>	Large spiny Rat	Least concern	Unavailable	15, 36
Peroryctidae	<i>Echymipera rufescens</i>	Long-nosed Echymipera	Least concern	Unavailable	15
Peroryotidae	<i>Echymipera kalabu</i>	Common Echymipera	Least concern	Unavailable	15, 36
Phalangeridae	<i>Phalanger intercastellanus</i>	Southern Common Cuscus	Not assessed	Unavailable	36
Phalangeridae	<i>Spilocus maculates</i>	Common Spotted Cuscus	Not assessed	Unavailable	36
Pseudocheeriidae	<i>Pseudochirulus forbesi</i>	Painted Ringtail	Least concern	Unavailable	15

Pteropodidae	<i>Macroglossus minimus</i>	Northern Blossom-Bat	Least concern	Unavailable	15, 36
Pteropodidae	<i>Nyctimene albiventer</i>	Common Tube-Nosed Bat	Least concern	Unavailable	15, 36
Pteropodidae	<i>Pteropus neohibernicus</i>	Greater Flying Fox	Not assessed	Unavailable	36
Pteropodidae	<i>Syconycteris australis</i>		Not assessed	Unavailable	36
Tachyglossidae	<i>Tachyglossus acculeatus</i>	Short beaked Echidna	Not assessed	Unavailable	36
Vespertilionidae	<i>Phoniscus papuensis</i>	Trumpet-eared Bat	Least concern	Unavailable	15

## **Birds**

The diversity of birds is slightly higher in the Papuan region. A total of 72 bird species had been recorded on Motupore Island (Tarburton, unpubl). The full species list is attached as Appendix 4-1 and 4-2. List of more common birds observed regularly in the area are presented in Table 4.

Table 4. List of common birds known to occur in the proposed development area.

Family	Scientific names	Common names	IUCN Status	PNG Status	Reference
Accipitridae	<i>Haliastur indus</i>	Brahminy kite	Least concern	unavailable	15
Alcedinidae	<i>Syma torotoro</i>	Yellow billed kingfisher	Least concern	Unavailable	15, 44
Columbidae	<i>Macropygia amboinensis</i>	Slender-billed Cuckoo-dove	Least concern	Unavailable	15
	<i>Ptilinopus</i> sp.	Fruit dove		Unavailable	44
	<i>Reinwardtoena reinwardti</i>	Great cuckoo-dove	Least concern	Unavailable	15
Corvidae	<i>Corvus tristis</i>	Black crow	Least concern	Unavailable	15
Meliphagidae	<i>Philemon buceroides</i>	New Guinea (Helmeted) Friar bird	Least concern	Unavailable	15
Psittaculidae	<i>Lorius</i> sp.	Western black lory		Unavailable	44
	<i>Trichoglossus haematodus</i>	Rainbow lorikeet	Least concern	Unavailable	15, 44
Sturnidae	<i>Myna dumontii</i>	Yellow faced myna	Not assessed	Unavailable	15, 44

## Marine Biodiversity

Bootless Bay has one of the richest marine macro-faunas in the Western Pacific region but comparatively lower diversity than other coastal areas of PNG [8, 9].

### Cnidarians

Cnidarians are a large group of marine animals characterized by having nematocysts or stinging darts. Recorded representatives from Bootless Bay [8, 9] are listed in Table 5 and include;

- ❖ Hydroids or Sea Fens (Class Hydrozoan) – 4 species
- ❖ Hydrocorals (Class Hydrozoan) – 5 species
- ❖ Sea Jellies (Class Scyphozoa) – 2 species
- ❖ Sea Wasps (Class Cubozoa) – 0 species
- ❖ Soft Corals (Class Anthozoa) – 32 species

- ❖ Sea Whips, Sea Pens, and Sea Fans (Class Anthozoa) – 16 species
- ❖ Hard Corals (Class Anthozoa) – 60 species
- ❖ Sea Anemones (Class Anthozoa) – 14 species

Cnidarians have two main body forms: those having medusa with tentacles facing downwards (example Sea Jellies) and those having polyp with tentacles facing upwards (example corals).

Maniwavie. [16] reported the number of corals in Bootless Bay to be 284. Baine & Harasti [8] and Coleman [9] photographed about 92 soft and hard coral species which is about a third of that reported by Maniwavie [16]. Live coral cover recorded from the fringing reefs of Bootless Bay has been fluctuating overtime. Prachett et al. (2009) reported the percentage live coral cover to be 42.4 in 2005 and 19.1 in 2006 following an outbreak of crown-of-thorns star fish in Bootless Bay. Maniwavie [17] recorded a range of percentage live coral cover values from 10-42% on four sites between Bogoro Inlet and Motupore Island.

Table 5. Checklist of Cnidarians recorded or observed so far at Bogoro Inlet and Motupore Island. Almost all cnidarians have not been evaluated by IUCN Redlist criteria.

Family	Species	Common Name	IUCN Status	PNG Status	Reference
Plumaridae	<i>Macrorhynchia philippina</i>	Philippine hydroid	Not assessed	Unavailable	16, 38
Sertuariidae	<i>Idiellana pristis</i>		Not evaluated	Unavailable	16, 38
Milleporidae	<i>Millepora</i> sp.	Fire coral		Unavailable	8, 9
Stylasteridae	<i>Distichopora</i> sp.	Lace coral	Not evaluated	Unavailable	16, 38
Stylasteridae	<i>Distichopora violacea</i>	Violet hydrocoral	Not evaluated	Unavailable	8, 16, 38
Stylasteridae	<i>Stylaster cf. papuensis</i>		Not evaluated	Unavailable	8, 16, 38
Physaliidae	<i>Physalia physalis</i>	Portugese man of war	Not evaluated	Unavailable	8, 16, 38
Cassiopeidae	<i>Cassiopea</i> sp.	Upside down sea jelly	Not assessed	Unavailable	8, 16, 38
Mastigiidae	<i>Mastigias papua</i>	Papuan sea jelly	Not evaluated	Unavailable	8, 9, 16, 38, 46
Alcyoniidae	<i>Sarcophyton</i> sp.	Leather coral	Not evaluated	Unavailable	8, 16
Alcyoniidae	<i>Lobophytum</i> sp.	Lobed leather coral	Not evaluated	Unavailable	8, 9, 16
Alcyoniidae	<i>Sinularia flexibilis</i>	Flexible leather coral	Not evaluated	Unavailable	8, 16, 38
Alcyoniidae	<i>Sinularia</i> sp.	Finger leather coral	Not evaluated	Unavailable	8, 16, 38

Briareidae	<i>Briareum</i> sp.	Green star polys	Not evaluated	Unavailable	8, 38
Nephtheidae	<i>Dendronephthya</i> sp.	Tree coral	Not evaluated	Unavailable	8, 9, 38
Nephtheidae	<i>Dendronephthya</i> sp.	Carnation coral	Not evaluated	Unavailable	8, 38
Nephtheidae	<i>Stereonephthea</i> sp.		Not evaluated	Unavailable	8, 38
Nidaliidae	<i>Chironophthya</i> sp.		Not evaluated	Unavailable	8, 38
Nidaliidae	<i>Siphonogorgia</i> sp.		Not evaluated	Unavailable	8, 38
Xeniidae	<i>Anthelia</i> sp.		Not evaluated	Unavailable	8, 38
Ellisellidae	<i>Junceela fragilis</i>	Delicate sea whip	Not assessed	Unavailable	8, 16
Ellisellidae	<i>Ellisella</i> sp.	Sea whip	Not evaluated	Unavailable	8, 38
Anthothelidae	<i>Alertigorgia orientalis</i>	Bushy gorgonian fan	Not evaluated	Unavailable	16, 38
Gorgoniidae	<i>Rumphella</i> sp.	Gorgonian fan	Not evaluated	Unavailable	8, 9, 16, 38
Plexauridae	<i>Astrogorgia</i> sp.		Not evaluated	Unavailable	8, 9, 38
Pteroeididae	<i>Pteroeides</i> sp.	Sea pen	Not evaluated	Unavailable	8
Virgularidae	Unidentified sp.	Sea pen	Not evaluated	Unavailable	8
Veretillidae	<i>Cavernularia</i> sp.	Sea pen	Not evaluated	Unavailable	8
Acroporidae	<i>Acropora c.f. caroliniana</i>		Not assessed	Unavailable	8, 9, 16, 38
Acroporidae	<i>Acropora elseyi</i>	Christmas coral	Not assessed	Unavailable	8, 9, 16, 38
Acroporidae	<i>Acropora grandis</i>	Staghorn coral	Not assessed	Unavailable	8, 9, 16, 38
Acroporidae	<i>Acropora intermedia</i>	Staghorn coral	Not assessed	Unavailable	8, 9, 16, 38
Acroporidae	<i>Acropora loripes</i>		Not assessed	Unavailable	8, 9, 16, 38
Acroporidae	<i>Acropora millepora</i>	Bushy staghorn	Not assessed	Unavailable	8, 9, 16, 38
Acroporidae	<i>Acropora muricata</i>	Staghorn coral	Not assessed	Unavailable	8, 9, 16, 38
Acroporidae	<i>Acropora tennalis</i>	Purple-tip acropora	Not assessed	Unavailable	8, 9, 16, 38
Acroporidae	<i>Acropora valenciennesi</i>	Branching coral	Not assessed	Unavailable	8, 9, 16, 38
Acroporidae	<i>Acropora</i> sp.	Bottlebrush coral	Not assessed	Unavailable	8, 16, 38

Acroporidae	<i>Acropora</i> sp.	Table coral		Unavailable	8
Acroporidae	<i>Astreopora</i> sp.	moon coral		Unavailable	8
Agariciidae	<i>Pachyseris speciosa</i>	phonograph coral	Not assessed	Unavailable	8, 38
Agariciidae	<i>leptoseris explanata</i>		Not assessed	Unavailable	8, 38
Agariciidae	Unidentified sp.				8
Dendronphylliidae	<i>Tubastrea faukneri</i>	Sun coral	Not assessed	Unavailable	8, 16, 38
Dendronphylliidae	<i>Tubastrea micranthus</i>	Black sun coral	Not assessed	Unavailable	8, 16, 38
Dendronphylliidae	<i>Turbinaria frondens</i>	Cup coral	Not assessed	Unavailable	8, 16
Dendronphylliidae	<i>Turbinaria reniformis</i>	Scroll coral	Not assessed	Unavailable	8
Dendronphylliidae	<i>Turbinaria</i> sp.	Vase coral		Unavailable	8
Euphyllidae	<i>Euphyllia cristata</i>	Whire grape coral	Not assessed	Unavailable	8, 16
Euphyllidae	<i>Physogyra lichtensteini</i>	Pearl coral	Not assessed	Unavailable	8, 16
Faviidae	<i>Diploastrea heliopora</i>		Not assessed	Unavailable	8, 14
Faviidae	<i>Echinopora horrida</i>		Not assessed	Unavailable	8, 9, 16, 38
Faviidae	<i>Echinopora lamellosa</i>		Not assessed	Unavailable	8, 16, 38
Faviidae	<i>Favia</i> sp.	Moon coral	Not assessed	Unavailable	8
Faviidae	<i>Platygyra lamellina</i>	Maze coral	Not assessed	Unavailable	8
Fungiidae	<i>Ctenactis echinata</i>		Not assessed	Unavailable	8, 38
Fungiidae	<i>Fungia</i> sp.			Unavailable	8
Fungiidae	<i>Heliofungia actiniformis</i>		Not assessed	Unavailable	8, 38
Fungiidae	<i>Herpolitha limax</i>	Tongue coral	Not assessed	Unavailable	8, 38
Fungiidae	<i>Herpolitha</i> sp.	Mole coral		Unavailable	8
Fungiidae	<i>Polyphyllia talpina</i>	Slipper coral	Not assessed	Unavailable	8, 38
Merulinidae	<i>Merulina ampliata</i>	Ruffled coral	Not assessed	Unavailable	8, 38
Mussidae	<i>Lobophyllia</i>		Not assessed	Unavailable	8, 38

	<i>hemprichii</i>				
Mussidae	<i>Scolymia</i> sp.	Disc coral	Not evaluated	Unavailable	8
Mussidae	<i>Symphyllia agaricea</i>	Brian coral	Not assessed	Unavailable	8, 38
Mussidae	<i>Symphyllia c.f recta</i>	Brian coral	Not evaluated	Unavailable	8, 38
Oculinidae	<i>Galaxea fascicularis</i>	Crystal coral	Not evaluated	Unavailable	8, 38
Pectiniidae	<i>Pectinia paeonia</i>	Palm lettuce coral	Not evaluated	Unavailable	8, 38
Pocilloporidae	<i>Pocillopora damicornis</i>	Cauliflower coral	Not evaluated	Unavailable	8, 38
Pocilloporidae	<i>Pocillopora</i> sp.		Not evaluated	Unavailable	8, 38
Pocilloporidae	<i>Seriotopora</i> sp.	Brush coral	Not evaluated	Unavailable	8, 38
Pocilloporidae	<i>Stylophora pistillata</i>	Cluster coral	Not evaluated	Unavailable	8, 38
Poritidae	<i>Alveopora</i> sp.	Daisy coral	Not evaluated	Unavailable	8, 38
Poritidae	<i>Goniopora</i> sp.	Daisy coral	Not evaluated	Unavailable	8, 38
Poritidae	<i>Porites cylindrica</i>	Cylinder coral	Not evaluated	Unavailable	8, 38
Poritidae	<i>Porites</i> sp.	Boulder coral	Not evaluated	Unavailable	8, 38
Trachyphylliidae	<i>Trachyphyllia geoffroyi</i>	Crater coral	Not evaluated	Unavailable	8, 38
Order Corallimorphia	<i>Corallimorph</i> sp. 1		Not evaluated	Unavailable	8, 38
Discosomatidae	<i>Corallimorph</i> sp. 2		Not evaluated	Unavailable	8, 38
Actiniidae	<i>Entacmea quadricolor</i>	Bubble - tip coral	Not evaluated	Unavailable	8, 38
Actinodendriidae	<i>Actinodendron arboreum</i>	Abominate sea anemone	Not evaluated	Unavailable	8, 38
Edwardsiidae	<i>Edwardsiantus pudica</i>		Not evaluated	Unavailable	8, 38
Stichodactylidae	<i>Heteractis magnifica</i>	Magnificent sea anemone	Not evaluated	Unavailable	8, 38
Stichodactylidae	<i>Heteractis aurora</i>	Beaded sea anemone	Not evaluated	Unavailable	8, 38
Stichodactylidae	<i>Stichodactyla giganteum</i>	Gigantic sea anemone	Not evaluated	Unavailable	8, 38



Stichodactylidae	<i>Stichodactyla mertensii</i>	Merten's carpet anemone	Not evaluated	Unavailable	8, 38
Thelassianthidae	<i>Cryptodendrum adhaesivum</i>	Pizza anemone	Not evaluated	Unavailable	8, 38
Thelassianthidae	<i>Unidentified sp.</i>		Not evaluated	Unavailable	8, 38
Cerianthidae	<i>Cerianthus sp.</i>	Tube anemone	Not evaluated	Unavailable	8, 38
Epizoanthidae	<i>Epizoanthus sp.</i>	Branching zoanthid	Not evaluated	Unavailable	8, 38
Zoanthidae	<i>Palythoa ceasia</i>		Not evaluated	Unavailable	8, 38
Antipathidae	<i>Cirripathes c.f. contorta</i>	Corkscrew black coral	Not evaluated	Unavailable	8, 38
Antipathidae	<i>Antipathes sp. 1</i>		Not evaluated	Unavailable	8, 38
Antipathidae	<i>Antipathes sp. 2</i>		Not evaluated	Unavailable	8, 38
Antipathidae	<i>Unidentified sp.</i>		Not evaluated	Unavailable	8, 38
Myriopathidae	<i>Myriopathes sp.</i>		Not evaluated	Unavailable	8, 38

## Ascidians

Ascidians are commonly known as sea squits and their body consists mainly of a hollow sac with two siphons for inhaling and exhaling water while filtering food [8]). Coleman [9] listed 8 different species while Baine & Harasti [8] listed another 11 species of Ascidians in Bootless Bay. Of the 19 total species photographed from Bootless Bay waters [8, 9], 4 were unidentified, 2 identified to genera level, and 13 were identified to species level (Table 6).

Table 6. Checklist of Ascidians recorded at Bogoro and Motupore Island.

Family	Scientific name	Common Name	IUCN list	PNG Status	Reference
Clavelinidae	<i>Clavelina moluccensis</i>	-	Not assessed	Unavailable	8, 38
Clavelinidae	<i>Nephtheis fascicularis</i>	-	Not assessed	Unavailable	8, 38
Diazonidae	<i>Rhopalaea crassa</i>	-	Not assessed	Unavailable	8, 38
Didemnidae	<i>Didemnum membranaceum</i>	-	Not assessed	Unavailable	8, 38
Didemnidae	<i>Didemnum molle</i>	-	Not assessed	Unavailable	8, 38
Didemnidae	<i>Lissoclinum patella</i>	-	Not assessed	Unavailable	8, 38
Didemnidae	<i>Unidentified sp.1</i>	-	Not assessed	Unavailable	8, 38
Didemnidae	<i>Unidentified sp.2</i>	-	Not assessed	Unavailable	8, 38
Didemnidae	<i>Unidentified sp.3</i>	-	Not assessed	Unavailable	8, 38
Didemnidae	<i>Unidentified sp.4</i>	-	Not assessed	Unavailable	8, 38
Perophoridae	<i>Perophora modificata</i>	-	Not assessed	Unavailable	8, 38
Perophoridae	<i>Perophora namei</i>	-	Not assessed	Unavailable	8, 38
Pycnoclavellidae	<i>Pycnoclavella diminuta</i>	-	Not assessed	Unavailable	8, 38
Styelidae	<i>Polycarpa aurata</i>	-	Not assessed	Unavailable	8, 38

### Marine Worms

Marine worms are categorized into two distinct groups: Flatworms and Segmented worms. About 30 different species of Flatworms and Segmented worms have been photographed from Bootless Bay waters with many unidentified or identified to genera level [8, 9]. Baine & Harasti [8] suggested that about 130 Flatworm species occur in PNG waters. Species occurring within the Bootless are given below.

Table 7. Marine worms recorded within Bootless Bay.

Family	Scientific name	Common name	IUCN Status	PNG Status	Reference
Euryleptidae	<i>Prostheceraeus sp.</i>		Not evaluated	Unavailable	8, 16
Pseudocerotidae	<i>Acanthozoon sp.</i>		Not evaluated	Unavailable	8, 16

Pseudocerotidae	<i>Pseudobiceros bedfordi</i>	Bedford's Flatworm	Not evaluated	Unavailable	8, 18
Pseudocerotidae	<i>Pseudobiceros hancockanus</i>	Hancock Flatworm	Not evaluated	Unavailable	8, 16, 18
Pseudocerotidae	<i>Pseudobiceros strigosus</i>	Favoured Flatworm	Not evaluated	Unavailable	8, 16, 18
Pseudocerotidae	<i>Pseudoceros bifurcus</i>	Racing stripe Flatworm	Not evaluated	Unavailable	8, 16, 18
Pseudocerotidae	<i>Pseudoceros dimidiatus</i>	Dimidiate Flatworm	Not evaluated	Unavailable	8, 9, 18, 19
Pseudocerotidae	<i>Pseudoceros prudhoei</i>	Prudhoe's Flatworm	Not evaluated	Unavailable	18
Pseudocerotidae	<i>Pseudoceros sapphirinus</i>	Sapphire Flatworm	Not evaluated	Unavailable	8, 18
Pseudocerotidae	<i>Pseudoceros sp.</i>		Not evaluated	Unavailable	8, 15
Polynoidae	<i>Asterophilia carlae</i>	Seastar worm	Not evaluated	Unavailable	8, 20
Sabellidae	<i>Megalomma sp.</i>		Not evaluated	Unavailable	8, 16
Sabellidae	<i>Sabellastarte sp. 1</i>	Fan worm	Not evaluated	Unavailable	8, 16
Sabellidae	<i>Sabellastarte sp. 2</i>	Paper Tube worm	Not evaluated	Unavailable	8
Sabellidae	Unidentified sp. 1				8
Sabellidae	Unidentified sp. 2				8
Serpulidae	<i>Serpula c.f. vasifera</i>		Not evaluated	Unavailable	8, 38
Serpulidae	<i>Spirobranchus c.f. gaymardi</i>	Christmas tree worm	Not evaluated	Unavailable	8, 38
Serpulidae	<i>Spirobranchus giganteus</i>	Christmas tree worm	Not evaluated	Unavailable	8, 38
Serpulidae	<i>Spirobranchus sp.</i>	Christmas tree worm	Not evaluated	Unavailable	8, 38
Serpulidae	<i>Protula bispiralis</i>		Not evaluated	Unavailable	21
Amphinomidae	<i>Pherecardia sp.</i>		Not evaluated	Unavailable	38
Syllidae	<i>Opisthosyllis sp.</i>		Not evaluated	Unavailable	38
Polynoidae	<i>Gastrolepidia clavigera</i>		Not evaluated	Unavailable	38

## Crustaceans

Crustaceans are a large group of marine animals with a soft body that is protected by an exoskeleton or hard-shell cover. The main subgroups of Crustaceans include Barnacles, Stomatopods (Mantis Shrimps), and Decapods (Shrimps, Prawns, Lobsters, and Crabs). Three different species of Barnacles and Mantis Shrimps each have been photographed in Bootless Bay ([8,9]). Decapods recorded included 30 species of shrimps, 3 species of lobsters, and 30 species of crabs ([8,9]). Checklist of species is provided (Table 7).

Table 8. Checklist of Crustaceans recorded at Bogoro and Motupore Island.

Family	Scientific name	Common name	IUCN Status	PNG Status	Reference
Lepadidae	<i>Lepas anserifera</i>	Goose barnacle	Not evaluated	Unavailable	8, 22,23
Tetraclitidae	<i>Tetraclita squamosa</i>	Common barnacle	Not evaluated	Unavailable	8, 24
Odontodactylidae	<i>Odontodactylus scyllarus</i>	Peacock mantis shrimp	Not evaluated	Unavailable	8, 25
Penaeidae	<i>Penaeus japonicus</i>	Kuruma prawn	Not evaluated	Unavailable	8, 23, 26
Penaeidae	Unidentified sp.		Not evaluated	Unavailable	8
Callinassidae	<i>Neocallichirus</i> sp.	Ghost shrimp	Not evaluated	Unavailable	8
Alpheidae	<i>Alpheus ochrostriatus</i>	Snapping shrimp	Not evaluated	Unavailable	8, 27
Alpheidae	<i>Synalpheus</i> sp.	Snapping shrimp	Not evaluated	Unavailable	8
Hippolytidae	<i>Lysmata amboinensis</i>	White banded cleaner shrimp	Not evaluated	Unavailable	8, 28
Hippolytidae	<i>Thor amboinensis</i>	Squat anemone shrimp	Not evaluated	Unavailable	8, 29
Hymenoceridae	<i>Hymenocera picta</i>	Harlequin shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Dasycaris zanzibarica</i>	Bumblebee shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Laomenes</i> sp.	Crinoid shrimp	Not evaluated	Unavailable	8

Palaemonidae	<i>Manipontonia psamathe</i>	Commensal shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Periclimenes emboinensis</i>	Crinoid shrimp	Not evaluated	Unavailable	8
Palaemonidae	<i>Periclimenes brevicarpalis</i>	Snow-capped shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Periclimenes holthuisi</i>	Holthuis's shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Periclimenes imperator</i>	Imperial shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Periclimenes inornatus</i>	Mirror shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Periclimenes magnificus</i>	Magnificent shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Periclimenes soror</i>	Sea star shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Periclimenes tosaensis</i>	Red-eyed shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Periclimenes tenuipes</i>	Glass shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Periclimenes</i> sp.1		Not evaluated	Unavailable	8
Palaemonidae	<i>Periclimenes</i> sp.2		Not evaluated	Unavailable	8
Palaemonidae	<i>Stegopontonia commensalis</i>	Sea urchin shrimp	Not evaluated	Unavailable	8, 29
Palaemonidae	<i>Vir philippinensis</i>	Philippine shrimp	Not evaluated	Unavailable	8, 29
Rhynchocinetidae	<i>Rhynchocinetes durbanensis</i>	Durban shrimp	Not evaluated	Unavailable	8, 29
Stenopodidae	<i>Stenopus hispidus</i>	Banded coral shrimp	Not evaluated	Unavailable	8, 29
Palinuridae	<i>Panulirus ornatus</i>	Ornate spiny lobster	Least Concern	Unavailable	8, 16
Palinuridae	<i>Panulirus versicolor</i>	Painted lobster	Least concern	Unavailable	8, 16
Diogenidae	<i>Calcinus minutus</i>	Minute hermit	Not evaluated	Unavailable	8,29

		crab			
Diogenidae	<i>Clibanarius</i> sp.	Green hermit crab	Not evaluated	Unavailable	8
Diogenidae	<i>Dardanus lagopodes</i>	Red hairy hermit crab	Not evaluated	Unavailable	8, 29
Diogenidae	<i>Dardanus megistos</i>	White spotted hermit crab	Not evaluated	Unavailable	8, 29
Diogenidae	<i>Dardanus pedunculatus</i>	Anemone hermit crab	Not evaluated	Unavailable	8, 29
Diogenidae	<i>Dardanus</i> sp.	Hermit crab	Not evaluated	Unavailable	8
Diogenidae	<i>Diogenes</i> sp.	Hermit crab	Not evaluated	Unavailable	8
Galatheididae	<i>Allogalatea elegans</i>	Elegant squat lobster	Not evaluated	Unavailable	8, 30
Galatheididae	<i>Galathea</i> sp.	Squat lobster	Not evaluated	Unavailable	8
Porcellanidae	<i>Neopetrolisthes oshimai</i>	Oshima's porcellanid crab	Not evaluated	Unavailable	8
Calappidae	<i>Calappa hepatica</i>	Livid box crab	Not evaluated	Unavailable	8
Calappidae	<i>Calappa</i> sp.1	Box crab	Not evaluated	Unavailable	8
Calappidae	<i>Calappa</i> sp.2	Box crab	Not evaluated	Unavailable	8
Majidae	<i>Achaeus</i> sp.	Delicate decorator crab	Not evaluated	Unavailable	8
Majidae	<i>Hoplophrys oatesii</i>	Oate's soft coral crab	Not evaluated	Unavailable	8
Majidae	<i>Hyastenus</i> sp.	Decorator crab	Not evaluated	Unavailable	8
Majidae	<i>Oncinopus</i> sp.	Orangutan crab	Not evaluated	Unavailable	8
Majidae	<i>Xenocarcinus tuberculatus</i>	Black coral crab	Not evaluated	Unavailable	8
Matutidae	<i>Ashtoret lunaris</i>	Speckled surf crab	Not evaluated	Unavailable	8

Ocypodidae	<i>Uca perplexa</i>	Fiddler crab	Not evaluated	Unavailable	8
Ocypodidae	<i>Uca</i> sp.	Fiddler crab	Not evaluated	Unavailable	8
Portunidae	<i>Lissocarcinus laevis</i>	Sea anemone crab	Not evaluated	Unavailable	8
Portunidae	<i>Lissocarcinus polyboides</i>	Sea star crab	Not evaluated	Unavailable	8
Portunidae	<i>Portunus pelagicus</i>	Blue swimmer crab	Not evaluated	Unavailable	8
Trapexiidae	<i>Quadrella boopsis</i>	Red trapeze crab	Not evaluated	Unavailable	8
Xanthidae	<i>Actaeodes tomentosus</i>	Velvet reef crab	Not evaluated	Unavailable	8

## Molluscs

Molluscs (Phylum Mollusca) is a diverse group of marine animals comprising of Chitons, Gastropods (Shells), Bivalves (Clams), Nudibranchs, Sea Hares, Sea Slugs, and Cephalopods (Octopuses, Squids, Cuttlefishes, and Nautilus). From the Bootless Bay waters Coleman [9] and Baine & Harasti [8] photographed 116 Molluscs species (Table 8) and consist of these major groups:

- ❖ Chitons (1 species),
- ❖ Gastropods (64 species)
- ❖ Bivalves (32 species)
- ❖ Nudibranchs (44 species)
- ❖ Sea Hares (2 species)
- ❖ Sea Slugs (9 species)
- ❖ Cephalopods (8 species)

Table 9. Checklist of Molluscs recorded at Bogoro Inlet and Motupore Island

Family	Scientific name	Common name	IUCN Status	PNG Status	Reference
Chitonidae	<i>Acanthopleura gemmata</i>	Gemmate chiton	Not evaluated	Unavailable	8, 16, 38
Haliotidae	<i>Haliotis ovina</i>	Ovate abalone	Not evaluated	Unavailable	8, 16, 38
Buccinidae	<i>Phos senticosus</i>	Common Pacific phos	Not evaluated	Unavailable	8, 16, 38
Cerithiidae	<i>Pseudovertagus aluco</i>	Aluco creeper	Not evaluated	Unavailable	8, 16, 38
Columbellidae	<i>Euplica turturina</i>	Crouching dove snail	Not evaluated	Unavailable	8, 16, 38
Conidae	<i>Conus eburneus</i>	Spotted cone snail	Least concern	Unavailable	8, 16
Conidae	<i>Conus marmoreus</i>	Marbled cone snail	Least concern	Unavailable	8, 16
Conidae	<i>Conus virgo</i>	Virgin cone snail	Least concern	Unavailable	8, 16
Costellariidae	<i>Vexillum castum</i>	Ribbed mitre snail	Not assessed	Unavailable	8, 38
Costellariidae	<i>Vexillum exasperatum</i>	Exasperating mitre snail	Not assessed	Unavailable	38, 8
Costellariidae	<i>Vexillum luculentum</i>	Banded mitre snail	Not assessed	Unavailable	38
Cypraeidae	<i>Cypraea annulus</i>	Gold-ringed money cowry	Not evaluated	Unavailable	8, 16
Cypraeidae	<i>Cypraea arabica</i>	Arabian cowry	Not evaluated	Unavailable	18, 6
Cypraeidae	<i>Cypraea argus</i>	Eyed cowry	Not assessed	Unavailable	38
Cypraeidae	<i>Cypraea carneola</i>	Carnelian cowry	Not evaluated	Unavailable	16, 38
Cypraeidae	<i>Cypraea humphreysii</i>	Humphrey's cowry	Not assessed	Unavailable	38



Cypraeidae	<i>Cypraea moneta</i>	Money cowry	Not evaluated	Unavailable	16, 38
Cypraeidae	<i>Cypraea tigris</i>	Tiger cowry	Not evaluated	Unavailable	16
Cypraeidae	<i>Cypraea erosa</i>	Eroded cowry	Not evaluated	Unavailable	8, 16, 38
Harpidae	<i>Harpa harpa</i>	Articulate harp	Not evaluated	Unavailable	8, 16, 38
Littorinidae	<i>Littoraria articulata</i>	Tessellated periwinkle	Not evaluated	Unavailable	8, 16, 38
Mitridae	<i>Mitra mitra</i>	Giant mitra	Not evaluated	Unavailable	8, 16, 38
Mitridae	<i>Subcancilla flammea</i>	Flamed mitre snail	Not evaluated	Unavailable	8, 16, 38
Muricidae	<i>Chicoreus microphyllus</i>	Short-froned murex snail	Not evaluated	Unavailable	8, 16, 38
Muricidae	<i>Mancinella echinata</i>	White rock snail	Not evaluated	Unavailable	8, 16, 38
Muricidae	<i>Morula granulata</i>	Oyster borer	Not evaluated	Unavailable	8, 16, 38
Muricidae	<i>Thais tuberosa</i>	Tuber-like rock shell	Not evaluated	Unavailable	8, 16, 38
Nassariidae	<i>Nassarius arcularia</i>	Box-like dog whelk	Not evaluated	Unavailable	8, 16, 38
Naticidae	<i>Naticarius onca</i>	Spotted moon snail	Not evaluated	Unavailable	8, 16, 38
Naticidae	<i>Naticarius orientalis</i>	Oriental moon snail	Not evaluated	Unavailable	8, 16, 38
Naticidae	<i>Sinum</i> sp.	Internal-shelled moon snail		Unavailable	8, 16, 38
Naticidae	<i>Tanea undulata</i>	Wavy moon snail	Not evaluated	Unavailable	8, 16, 38
Turbinidae	<i>Lunella cinerea</i>	Smooth moon turban snail	Not evaluated	Unavailable	8, 16, 38
Neritidae	<i>Nerita chamaeleon</i>	Variable nerite	Not evaluated	Unavailable	8, 16, 38
Neritidae	<i>Nerita polita</i>	Polished nerita	Not evaluated	Unavailable	8, 16, 38
Olividae	<i>Oliva miniacea</i>	Orange-mouthed olive snail	Not evaluated	Unavailable	8, 16, 38
Olividae	<i>Oliva reticulata</i>	Reticulate olive snail	Not evaluated	Unavailable	8, 16, 38
Ovulidae	<i>Cymbovula deflexa</i>	Canoe spindle cowry	Not assessed	Unavailable	8, 16, 38
Ovulidae	<i>Phenacovolva coarctata</i>	Compressed spindle cowry	Not assessed	Unavailable	8, 16
Ovulidae	<i>Phenacovolva tokioi</i>	Tokio's spindle cowry	Not assessed	Unavailable	8, 16
Ovulidae	<i>Phenacovolva</i> sp.	Spindle cowry	Not assessed	Unavailable	8, 16
Ovulidae	<i>Prionovolva</i> sp.	Soft coral egg cowry	Not assessed	Unavailable	8, 16
Ovulidae	<i>Prosimnia</i> sp.	Gorgonian cowry	Not assessed	Unavailable	8, 16
Ovulidae	<i>Pseudosimnia culmen</i>	Gold spotted egg cowry	Not assessed	Unavailable	8, 16
Ovulidae	<i>Pseudosimnia</i> sp.	Egg cowry	Not assessed	Unavailable	8, 16
Planaxidae	<i>Planaxis sulcatus</i>	Sulcate periwinkle	Not assessed	Unavailable	8, 16
Ranellidae	<i>Charonia tritonis</i>	Triton's trumpet shell	Not assessed	Unavailable	8, 16

Strombidae	<i>Conomurex luhanus</i>	Red-mouthed stromb	Not assessed	Unavailable	8, 16
Strombidae	<i>Lambis lambis</i>	Common spider snail	Not assessed	Unavailable	8, 16
Strombidae	<i>Lambis scorpius</i>	Scorpion spider snail	Not evaluated	Unavailable	8, 16
Strombidae	<i>Strombus aratrum</i>	Black mouthed stromb	Not evaluated	Unavailable	8, 16
Strombidae	<i>Strombus gibberulus gibbosus</i>	Hump-back conch	Not evaluated	Unavailable	8, 16
Strombidae	<i>Strombus gibbosus</i>	Hump-back conch	Not evaluated	Unavailable	8, 16, 38
Strombidae	<i>Strombus vomer</i>	Vomer stromb	Not evaluator	Unavailable	8, 16, 38
Terebridae	<i>Hastula albula</i>	White auger snail	Not evaluatee	Unavailable	8, 16, 38
Terebridae	<i>Terebra areolata</i>	Subulate auger	Not evaluated	Unavailable	8, 16, 38
Terebridae	<i>Terebra cingulifera</i>	Girdled auger snail	Not evaluatr	Unavailable	8, 16, 38
Terebridae	<i>Terebra crenulata</i>	Crinkled auger snail	Not evaluated	Unavailable	8, 16, 38
Terebridae	<i>Terebra dimidiata</i>	Dimidiate auger snail	Not evaluated	Unavailable	8, 16, 38
Terebridae	<i>Terebra subulata</i>	Spotted auger snail	Not evaluated	Unavailable	8, 16, 38
Terebridae	<i>Terebra undulata</i>	Wavy auger snail	Not evaluated	Unavailable	8, 16, 38
Hexabranthidae	<i>Hexabranthus sanguineus</i>	Spanish dancer	Not evaluated	Unavailable	8, 16, 38
Polyceridae	<i>Nembrotha lineolata</i>	Lined nembrotha	Not evaluated	Unavailable	8, 16, 38
Aegridae	<i>Notodoris minor</i>	Minor notodoris	Not evaluated	Unavailable	8, 16
Discodorididae	<i>Discodoris fragilis</i>	Fragile nudibranch	Not evaluated	Unavailable	8, 16
Discodorididae	<i>Halgerda aurantiomaculata</i>	Gold spotted halgerda	Not evaluated	Unavailable	8, 16
Discodorididae	<i>Jorunna funebris</i>	Funeral jorunna	Not evaluated	Unavailable	8, 16
Discodorididae	<i>Kentrodon rubescens</i>	Reddish nudibranch	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Ceratosoma sinuatum</i>	Sinuate ceratosoma	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Ceratosoma trilobatum</i>	Three horned ceratosoma	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Chromodoris annae</i>	Anna's chromodoris	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Chromodoris fidelis</i>	Faithful chromodoris	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Chromodoris geometrica</i>	Geometric chromodoris	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Chromodoris kuniei</i>	Kunie's chromodoris	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Chromodoris lochi</i>	Loch's chromodoris	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Chromodoris magnifica</i>	Magnificent chromodoris	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Chromodoris strigata</i>	Strigate chromodoris	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Glossodoris atromarginata</i>	Black-margined glossodoris	Not evaluated	Unavailable	8, 16

Chromodorididae	<i>Hypselodoris bullockii</i>	Bullock's hypselodoris	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Hypselodoris maculosa</i>	Spotted hypselodoris	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Hypselodoris nigrostriata</i>	Black-striped hypselodoris	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Hypselodoris infucata</i>	Inky hypselodoris	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Mexichromis multituberculata</i>	Pustuled mexichromis	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Risbecia godeffroyana</i>	Godeffroy's nudibranch	Not evaluated	Unavailable	8, 16
Chromodorididae	<i>Risbecia tryoni</i>	Tryon's nudibranch	Not evaluated	Unavailable	8, 16
Bornellidae	<i>Bornella anguilla</i>	Eel-like Bornella	Not evaluated	Unavailable	8, 16
Facelinidae	<i>Phidiana indica</i>	Indian phidiana	Not evaluated	Unavailable	8, 16
Facelinidae	<i>Phyllodesmium longicirrum</i>	Long cirri phyllodesmium	Not evaluated	Unavailable	8, 16
Facelinidae	<i>Pteraeolidia ianthina</i>	Blue dragon	Not Evaluated	Unavailable	8, 16
Flabellinidae	<i>Flabellina bilas</i>	Spear-point flabellina	Not evaluated	Unavailable	8, 16
Flabellinidae	<i>Flabellina exoptata</i>	White-tipped flabellina	Not evaluated	Unavailable	8, 16
Flabellinidae	<i>Flabellina rubrolineata</i>	Red-lined flabellina	Not evaluated	Unavailable	8, 16
Phyllidiidae	<i>Phyllidia coelestis</i>	Celestial phyllidia	Not evaluated	Unavailable	8, 16
Phyllidiidae	<i>Phyllidia elegans</i>	Elegant phyllidia	Not evaluated	Unavailable	8, 16
Phyllidiidae	<i>Phyllidia ocellata</i>	Ocellate phyllidia	Not evaluated	Unavailable	8, 16
Phyllidiidae	<i>Phyllidia varicosa</i>	Varicose phyllidia	Not evaluated	Unavailable	8, 16
Phyllidiidae	<i>Phyllidiella lizae</i>	Liz's phyllidiella	Not evaluated	Unavailable	8, 16
Phyllidiidae	<i>Phyllidiella nigra</i>	Black phyllidiella	Not evaluated	Unavailable	8, 16
Phyllidiidae	<i>Phyllidiella pustulosa</i>	Warty phyllidiella	Not evaluated	Unavailable	8, 16
Phyllidiidae	<i>Phyllidiella rudmani</i>	Rudman's phyllidiella	Not evaluated	Unavailable	8, 16
Phyllidiidae	<i>Phyllidiopsis pipeki</i>	Pipek's phyllidiopsis	Not evaluated	Unavailable	8, 16
Phyllidiidae	<i>Phyllidiopsis shireenae</i>	Shireen's phyllidiopsis	Not evaluated	Unavailable	8, 16
Phyllidiidae	<i>Reticulidia fugia</i>	Mushroom coral phyllidia	Not assessed	Unavailable	8, 16
Phyllidiidae	<i>Reticulidia halgerda</i>	Halgerda-like phyllidia	Not evaluated	Unavailable	8, 16
Aplysiidae	<i>Aplysia occulifera</i>	Eyed sea hare	Not assessed	Unavailable	8, 16
Aplysiidae	<i>Dolabella auricularia</i>	Eared sea hare	Not evaluated	Unavailable	8, 16
Aglajidae	<i>Chelidonura electra</i>	Electric tailed slug	Not evaluated	Unavailable	8, 16
Aglajidae	<i>Chelidonura inornata</i>	Ornate tailed slug	Not evaluated	Unavailable	8, 16
Aplustridae	<i>Micromelo undata</i>	Wavy lined bubble shell	Not evaluated	Unavailable	8, 16

Plakobranchidae	<i>Thuridilla bayeri</i>	Bayer's sap-sucker	Not evaluated	Unavailable	8, 16
Plakobranchidae	<i>Thuridilla splendens</i>	Splendid sap-sucker	Not evaluated	Unavailable	8, 16
Polybranchidae	<i>Cyerce nigricans</i>	Black and gold cyerce	Not evaluated	Unavailable	8, 16
Pleurobranchidae	<i>Berthella martensi</i>	Martens' berthella	Not evaluated	Unavailable	8, 16
Pleurobranchidae	<i>Pleurobranchus forskalii</i>	Forskals' side-gilled slug	Not evaluated	Unavailable	8, 16
Onchidiidae	<i>Onchidium</i> sp.	Mangrove slug		Unavailable	8, 16
Arcidae	<i>Barbatia foliata</i>	Leafy ark clam	Not evaluated	Unavailable	8, 16
Chamidae	<i>Chama</i> sp.	Jewel-box clam		Unavailable	8, 16
Gryphaeidae	<i>Hyotissa hyotis</i>	Giant coxcomb oyster	Not evaluated	Unavailable	8, 16
Ostreidae	<i>Lopha cristagalli</i>	Cock's comb oyster	Not evaluated	Unavailable	8, 16
Ostreidae	<i>Saccostrea mordax</i>	Rock oyster	Not evaluated	Unavailable	8, 16
Pectinidae	<i>Pedum spondyloideum</i>	Coral scallop	Not evaluated	Unavailable	8, 16
Pinnidae	<i>Atrina vexillum</i>	Black razor clam	Not evaluated	Unavailable	8, 16
Pinnidae	<i>Pinna muricata</i>	Razor clam	Not evaluated	Unavailable	8, 16
Spondyliidae	<i>Spondylus sinensis</i>	Asian thorny oyster	Not assessed	Unavailable	8, 16
Spondyliidae	<i>Spondylus</i> sp.	Thorny oyster		Unavailable	8, 16
Pteriidae	<i>Pteria cypsellus</i>	Winged oyster	Not evaluated	Unavailable	8, 16
Tridacnidae	<i>Tridacna crocea</i>	Crocus giant clam	Least concern	Unavailable	8, 16
Tridacnidae	<i>Tridacna maxima</i>	Elongate giant clam	Least concern	Unavailable	8, 16
Tridacnidae	<i>Tridacna squamosa</i>	Fluted giant clam	Least concern	Unavailable	8, 16
Loliginidae	<i>Sepioteuthis lessoniana</i>	Common reef squid	Not evaluated	Unavailable	8, 16
Octopodidae	<i>Octopus</i> sp.	Octopus		Unavailable	8, 16
Sepiidae	<i>Sepia latimanus</i>	Broadclub cuttlefish	Data deficient	Unavailable	8, 16
Sepiidae	<i>Sepia</i> sp.	Cuttlefish		Unavailable	8, 16
Sepiidae	<i>Metasepia pfefferi</i>	Flamboyant Cuttlefish	Data deficient	Unavailable	8, 16

## Echinoderms

Echinoderms are divided into three main groups that include Starfishes (Sea Stars, Feather Stars, and Brittle Stars), Sea Urchins, and Sea Cucumbers. Baine and Harasti [8] recorded 22 species of Sea Stars, 16 Feather Stars, 9 Brittle Stars and 10 species of sea urchins. Ko'ou [39] and Kinch [40] reported a total of 31 commercial sea cucumber species while Baine & Harasti [8] listed two non-commercial species from the reef-flats of Bootless Bay. Table 9 lists the species recorded at Bogoro Inlect and Motupore Island.

Table 10. Checklist of Echinoderms recorded at Bogoro Inlet and Motupore Island.

Family	Scientific name	Common Name	IUCN list	PNG Status	Reference
Acanthasteridae	<i>Acanthaster planci</i>	Crown of thorns starfish	Not evaluated	Unavailable	16
Archasteridae	<i>Archaster typicus</i>	Typical sand star	Not evaluated	Unavailable	16
Echinasteridae	<i>Echinaster callosus</i>	Thick skinned sea star	Not evaluated	Unavailable	16
Echinasteridae	<i>Echinaster luzonicus</i>	Luzon sea star	Not evaluated	Unavailable	16
Luidiidae	<i>Luidia c.f. savignyi</i>	Savigny's sea star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Celerina heffernani</i>	Heffernan's sea star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Fromia hadracatha</i>	Hadra star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Fromia indica</i>	Indian sea star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Fromia milleporella</i>	Thousand-pores star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Fromia monilis</i>	Necklace sea star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Gomophia egeriae</i>	Egeri's sea star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Gomophia watsoni</i>	Watson's sea star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Linckia guildingi</i>	Yellow sea star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Linckia laevigata</i>	Blue sea star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Linckia multifora</i>	Multi-pore sea star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Nardoa novaecaledonia</i>	Yellow mesh sea star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Nardoa tuberculata</i>	Tuberculate star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Neoferdina cumingi</i>	Cumming's sea star	Not evaluated	Unavailable	16
Ophidiasteridae	<i>Ophidiaster granifer</i>	Grainy star	Not evaluated	Unavailable	16
Oreasteridae	<i>Bothriaster primigenius</i>	Pentagonal sea star	Not evaluated	Unavailable	16
Oreasteridae	<i>Choriaster granulatus</i>	Pillow sea star	Not evaluated	Unavailable	16
Oreasteridae	<i>Culcita novaeguinea</i>	Pin-cushion sea star	Not evaluated	Unavailable	16
Oreasteridae	<i>Protoreaster nodosus</i>	Nodose sea star	Not evaluated	Unavailable	16
Ophiocomidae	<i>Ophiarthrum pictum</i>	Painted brittle star	Not evaluated	Unavailable	16
Ophiocomidae	<i>Ophiarthrum sp.</i>		Not evaluated	Unavailable	16
Ophiocomidae	<i>Ophiocoma erinaceus</i>	Spiny brittle star	Not evaluated	Unavailable	16
Ophiothrichidae	<i>Macrophiothrix sp.</i>		Not evaluated	Unavailable	16
Ophiothrichidae	<i>Ophiothrix purpurea</i>	Purple brittle star	Not evaluated	Unavailable	16
Ophiothrichidae	<i>Ophiothrix sp. 1</i>		Not evaluated	Unavailable	16
Ophiothrichidae	<i>Ophiothrix sp. 2</i>		Not evaluated	Unavailable	16

Class Ophiuroidea	<i>Unidentified sp.</i>		Not evaluated	Unavailable	16
Colobometridae	<i>Cenometra bella</i>	Pretty feather star	Not evaluated	Unavailable	16
Colobometridae	<i>Colobometra perspinosa</i>	Spinose feather star	Not evaluated	Unavailable	16
Colobometridae	<i>Oligometra carpenteri</i>	Carpenter's feather star	Not evaluated	Unavailable	16
Colobometridae	<i>Oligometra serripinna</i>	Winged feather star	Not evaluated	Unavailable	16
Comasteridae	<i>Comanthus alternans</i>		Not evaluated	Unavailable	16
Comasteridae	<i>Comanthus suavia</i>		Not evaluated	Unavailable	16
Comasteridae	<i>Comaster sp.</i>		Not evaluated	Unavailable	16
Comasteridae	<i>Oxycomanthus bennetti</i>	Bennett's feather star	Not evaluated	Unavailable	16
Himerometridae	<i>Himerometra rubustipinna</i>	Robust feather star	Not evaluated	Unavailable	16
Himerometridae	<i>Himerometra sp.</i>		Not evaluated	Unavailable	16
Class Crinoidea	<i>Unidentified sp. 1</i>		Not evaluated	Unavailable	16
Class Crinoidea	<i>Unidentified sp. 2</i>		Not evaluated	Unavailable	16
Class Crinoidea	<i>Unidentified sp. 3</i>			Unavailable	16
Arachnoididae	<i>Arachnoides placenta</i>	Cake sand dollar	not yet assessed	Unavailable	16
Astriclypeidae	<i>Echinodiscus auritus</i>	Pancake urchin	not yet assessed	Unavailable	16
Laganidae	<i>Peronella lesueurii</i>	Lesueur's sand dollar	not yet assessed	Unavailable	16
Diadematidae	<i>Astropyga radiata</i>	Radiant sea urchin	not yet assessed	Unavailable	16
Diadematidae	<i>Diadema savignyi</i>	Savigny's sea urchin	not yet assessed	Unavailable	16
Diadematidae	<i>Echinothrix calamaris</i>	Stinging sea urchin	not yet assessed	Unavailable	16
Diadematidae	<i>Echinothrix diadema</i>	Crowned sea urchin	not yet assessed	Unavailable	16
Echinometridae	<i>Echinometra mathaei</i>	Mathae's sea urchin	not yet assessed	Unavailable	16
Echinometridae	<i>Echinostrephus aciculatus</i>	Needle spined sea urchin	not yet assessed	Unavailable	16
Parasaleniiidae	<i>Parasalenia pohlii</i>	Pohli's sea urchin	not yet assessed	Unavailable	16
Temnopleuridae	<i>Salmacis sphaeroides</i>	Bicolor urchin	not yet assessed	Unavailable	16
Toxopneustidae	<i>Toxopneustes pileolus</i>	Flower urchin	not yet assessed	Unavailable	16
Toxopneustidae	<i>Toxopneustes gratilla</i>	Cake urchin	not yet assessed	Unavailable	16
Holothuriidae	<i>Actinopyga sp.</i>		not yet assessed	Unavailable	16
Holothuriidae	<i>Bohadschia argus</i>	Eyed sea cucumber	least concern	Unavailable	31
Holothuriidae	<i>Bohadschia similis</i>	Chalkfish	data deficient	Unavailable	32
Holothuriidae	<i>Bohadschia vitiensis</i>	Brown sandfish	data deficient	Unavailable	32
Holothuriidae	<i>Holothuria atra</i>	Lolly fish	least concern	Unavailable	31
Holothuriidae	<i>Holothuria coluber</i>	Snakefish	least concern	Unavailable	31

Holothuriidae	<i>Holothuria edulis</i>	Pinkfish	least concern	Unavailable	31
Holothuriidae	<i>Holothuria fuscogilva</i>	White teatfish	vulnerable	Unavailable	16
Holothuriidae	<i>Holothuria hilla</i>	Papillate sea cucumber	least concern	Unavailable	16
Holothuriidae	<i>Holothuria leucospilota</i>	Black fringed cucumber	least concern	Unavailable	16
Holothuriidae	<i>Holothuria scabra</i>	Sandfish	endangered	Unavailable	8, 16
Holothuriidae	<i>Holothuria (Selenkothuria) erinacea</i>	not yet assessed	not yet assessed	Unavailable	8, 16, 40
Holothuriidae	<i>Holothuria</i> sp.1	not yet assessed	not yet assessed	Unavailable	8, 16, 40
Holothuriidae	<i>Holothuria</i> sp.2		not yet assessed	Unavailable	8, 16
Holothuriidae	<i>Pearsonothuria graeffei</i>	Flower fish	least concern	Unavailable	8, 16
Stichopodidae	<i>Stichopus chloronotus</i>	Green fish	least concern	Unavailable	16, 38
Stichopodidae	<i>Stichopus herrmanni</i>	Curry fish	vulnerable	Unavailable	16, 38, 40
Stichopodidae	<i>Stichopus horrens</i>	Dragon fish	data deficient	Unavailable	16, 38, 40
Stichopodidae	<i>Thelenota ananas</i>	Prickly red fish	endangered	Unavailable	16, 38, 40
Stichopodidae	<i>Thelenota anax</i>	Amber fish	data deficient	Unavailable	16, 38, 40
Stichopodidae	<i>Thelenota rubralineata</i>	Red-lined sea cucumber	data deficient	Unavailable	16, 38, 40
Synaptidae	<i>Euapta godeffroyi</i>	Godeffroy's sea cucumber	not yet assessed	Unavailable	16
Synaptidae	<i>Synapta maculata</i>	Spotted sea cucumber	not yet assessed	Unavailable	16

## Sponges

Baine and Harasti [8] recorded 33 sponge species with 17 identified to species level while the other 16 species identified to genus level (Table 11).

Table 11. Checklist of Sponges recorded at Bogoro Inlet and Motupore Island.

Family	Scientific name	Common name	IUCN Status	PNG Status	Reference
Agelasidae	<i>Agelas</i> sp.	None	Not evaluated	Not available	8, 38
Ancorinidae	<i>Rhabdastrella globostellata</i>	None	Not evaluated	Not available	8, 38
Callyspongiidae	<i>Callyspongia aerizusa</i>	None	Not evaluated	Not available	8, 38
Callyspongiidae.	<i>Callyspongia</i> sp.	None	Not assessed	Not available	8, 38
Chalinidae	<i>Haliclona nematifera</i>	None	Not assessed	Not available	8, 38
Chalinidae	<i>Haliclona velina</i>	None	Not assessed	Not available	8, 38, 41
Chalinidae	<i>Heliclona</i> sp.	None		Not available	8
Clionaidae	<i>Spheciospongia vagabunda</i>	None	Not evaluated	Not available	8, 38
Clionaidae	<i>Spheciospongia</i> sp.	None		Not available	8-
Crambidae	<i>Monanchora unguiculata</i>	None	Not assessed	Not available	8
Crellidae	<i>Crella</i> sp.	None		Not available	8
Darwinellidae	<i>Chelonaplysilla violacea</i>	None	Not evaluated	Not available	41
Dictyonellidae	<i>Liosina granularis</i>	None	Not evaluated	Not available	41
Dysideidae	<i>Dysidea</i> sp.	None		Not available	8
Leucettidae	<i>Leucetta chagosensis</i>	None	Not evaluated	Not available	8, 38
Leucettidae	<i>Leucetta</i> sp.	None		Not available	8

Leucettidae	<i>Pericharax heteroraphis</i>	None	Not evaluated	Not available	8, 38
Microcionidae	<i>Clathria mima</i>	None	Not evaluated	Not available	8, 38
Microcionidae	<i>Clathria (Thalysias) reinwardti</i>	None	Not evaluated	Not available	8, 38
Niphatidae	<i>Geliodes fibulata</i>	None	Not evaluated	Not available	8, 38, 41
Mycalidae	<i>Mycale (Arenochalina) humilis</i>	None		Not available	38
Niphatidae	<i>Geliodes</i> sp. 1	None		Not available	41
Niphatidae	<i>Geliodes</i> sp.2	None		Not available	41
Petrosiidae	<i>Petrosia</i> sp.	None		Not available	8
Petrosiidae	<i>Strongylophora sphaeroidea</i>	None	Not evaluated	Not available	38
Petrosiidae	<i>Xestospongia testudinaria</i>	None	Not evaluated	Not available	38
Petrosiidae	unidentified sp.1	None		Not available	8
Phloeodictyidae	<i>Aka</i> sp.1	None		Not available	8
Phloeodictyidae	<i>Aka</i> sp.2	None		Not available	8
Phloeodictyidae	<i>Aka</i> sp.3	None		Not available	8
Soleneiscidae	<i>Dendya</i> sp.	None		Not available	8
Suberitidae	<i>Terpios</i> sp.	None		Not available	8
Tetillidae	<i>Cinachyrella schulzei</i>	None		Not available	8



## Marine Macro-Algae

Marine macro-algae, commonly known as seaweeds, are categorized into three colour groups; the blue-green algae, green algae, and brown algae. Of the many species from the three color groups, 29 marine species have been recorded within Bootless Bay [8; 9]. These are listed in Table 12.

Table 12. Common Algae recorded at Bogoro Inlet and Motupore Island.

Family	Scientific name	Common name	IUCN Status	PNG Status	Reference
Caulerpaceae	<i>Caulerpa racemosa</i>	Sea grapes	Not evaluated	Not available	16
Caulerpaceae	<i>Caulerpa taxifolia</i>	Feather algae	Not evaluated	Not available	16
Halimedaceae	<i>Halimeda</i> sp.	Cactus algae	Not evaluated	Not available	16
Halimedaceae	<i>Halimeda</i> sp.	Cactus algae	Not evaluated	Not available	16
Halimedaceae	<i>Halimeda</i> sp.	Cactus algae	Not evaluated	Not available	16
Siphonocladaceae	<i>Boergesenia forbesii</i>	Green algae	Not evaluated	Not available	16
Siphonocladaceae	<i>Dictyosphaeria versluysii</i>	Buttonweed	Not evaluated	Not available	16
Udoteaceae	<i>Avrainvillea</i> sp.	Mermaid's fan	Not evaluated	Not available	16
Udoteaceae	<i>Chlorodesmis fastigiata</i>	Turtle weed	Not evaluated	Not available	16
Valoniaceae	<i>Valonia ventricosa</i>	Sailor's eyeball	Not evaluated	Not available	16
Galaxauraceae	<i>Actinotrichia fragilis</i>	Fragile algae	Not evaluated	Not available	16
Gracilariaceae	<i>Gracilaria salicornia</i>		Not evaluated	Not available	16
Hypneaceae	<i>Hypnea pannosa</i>	Tattered sea moss	Not evaluated	Not available	16
Rhodomelaceae	<i>Acanthophora spicifera</i>	Spiny seaweed	Not evaluated	Not available	16
Rhodomelaceae	<i>Dasya</i> sp.	Red algae	Not evaluated	Not available	16
Peyssonneliaceae	<i>Peyssonnelia</i> sp.	Red algae	Not evaluated	Not available	16
Phylloporaceae	<i>Ahnfeltiopsis</i> sp.	Ahnfelt's seaweed	Not evaluated	Not available	16
Dictyotaceae	<i>Dictyota magneana</i>	Branched algae	Not evaluated	Not available	16
Dictyotaceae	<i>Dictyota</i> sp. 1	Branched algae	Not evaluated	Not available	8
Dictyotaceae	<i>Dictyota</i> sp. 2	Branched algae	Not evaluated	Not available	8
Dictyotaceae	<i>Padina</i> sp.	Funnelweed	Not evaluated	Not available	8
Sargassaceae	<i>Sargassum</i> sp.	Sargassum weed	Not evaluated	Not available	8
Sargassaceae	<i>Sargassum</i> sp.	Sargassum weed	Not evaluated	Not available	8
Sargassaceae	<i>Turbinaria decurrens</i>	Triangular sea bell	Not evaluated	Not available	8, 16
Scytosiphonaceae	<i>Hydroclathrus clathratus</i>	Netweed	Not evaluated	Not available	8, 16
Boodleaceae	<i>Boodlea</i> sp.		Not evaluated	Not available	8, 16
Phormidiaceae	<i>Microcoleus lyngbyaceus</i>	Mermaid's hair	Not evaluated	Not available	8, 16
(cyanophyta)	Unidentified sp. 1		Not evaluated	Not available	8
(cyanophyta)	Unidentified sp. 2		Not evaluated	Not available	8

## Fishes

In their fish diversity assessment, Drew et al. [5] generated a checklist of 488 fish species from 72 families for Bootless Bay while further postulated that up to 940 fish species could be found in the Bay. Drew et al. [5] contained most or all of the fish species recorded in previous publications before 2012. Checklist of the fish species is attached as appendix 2-2.

## Marine Mammals

Records from Baine & Harasti [8] and Coleman [9] showed that Bootless Bay has a few marine mammal species which include three species of dolphins and a dugong species (Table 13). The dolphin species (Family Delphinidae) include the Common dolphin (*Delphinus delphis*), Spinner dolphin (*Stenella longirostris*), and Bottle-nosed dolphin (*Tursiops truncatus*) have been recorded in several publications [8, 9] but their status is unclear. Contrastingly, the Dugong (*Dugong dugon*) has been missing from the accounts of recent publications and is rarely seen in Bootless Bay.

Table 13. Marine mammals recorded within Bootless Bay.

Family	Scientific name	Common	IUCN Status	PNG Status	Reference
Delphinidae	<i>Delphinus delphis</i>	Common dolphin	Not evaluated	Protected	16, 34
	<i>Stenella longirostris</i>	Spinner dolphin	Not evaluated	Protected	16, 34
	<i>Tursiops truncatus</i>	Bottle-nosed dolphin	Not evaluated	Protected	16, 34
Dugongidae	<i>Dugong dugon</i>	Dugong *	Not evaluated	Protected	34

\*- not observed in recent years.

## Marine Reptiles

Reptiles occurring in Bootless Bay include crocodiles, several species of turtles, and a few sea snakes. Reports and sightings by staff of Motupore Island Research Centre indicated that Bogoro Inlet is home to a couple of saltwater crocodile of the species *Crocodylus porosus*. Of the six extant species of marine turtles found in PNG waters, four were mentioned as occurring in Bootless Bay but records from Baine & Harasti [8] and Coleman [9] indicated only three are actively inhabiting the Bay. The three turtle species (Family Cheloniidae) include the Green Turtle (*Chelonia mydas*), Hawksbill Turtle (*Eretmochelys imbricatus*), and Loggerhead Turtle (*Caretta caretta*). Baine & Harasti [8] and Coleman [9] also recorded two sea snakes including the Olive sea snake (*Aipysurus leavis*, Family Hydrophidae) and Banded sea snake (*Laticauda sp.*, Family Laticaudidae) as occurring in the Bay.

Table 14. Reptile species observed within Bootless Bay.

Family	Scientific name	Common name	IUCN Status	PNG Status	Reference
	<i>Crocodylus porosus</i>	Saltwater crocodile	Least concern	Protected	33, 34
Cheloniidae	<i>Chelonia mydas</i>	Green Turtle	Endangered	Protected	8, 16, 33, 34
	<i>Eretmochelys imbricatus</i>	Hawksbill Turtle	Critically endangered	Protected	8, 16, 33, 34
	<i>Caretta caretta</i>	Loggerhead Turtle	Endangered	Protected	8, 16, 33, 34,

Hydrophidae	<i>Aipysurus leavis</i>	Olive Sea Snake	Data deficient	Not evaluated	8, 16
Laticaudidae	<i>Laticauda</i> sp	Banded Sea Snake	Not assessed		8, 16

## Conclusion

The biodiversity inventory of Bogoro Inlet and Motupore Island shows a wide range of lifeforms. There are differences in the number of species amongst different taxonomic groups – some taxa are poorly represented while others show great diversity. Of significance are seagrasses, mangroves, and invertebrates. Of the 12 species of seagrasses recorded in the waters of Papua New Guinea, 10 species occur on Motupore and nearby islands. At a global scale, the 10 species represent almost 50% of the total seagrass species found worldwide.

Similarly, of the 35 mangrove species found in Papua New Guinea, 20 species are recorded within Bootless Bay, and representing about 50% of the total mangroves recorded globally.

Almost the entire species of sea cucumber (Holothrians) are represented on Motupore and Loloata islands. Sponges on the other hand, represent a gold mine to new discoveries in Science.

Bootless Bay is within NCD, and offers a very luxuriant marine life, for sea lovers.

## References

1. Roberts, C. M., et al. 2003a. Ecological criteria for evaluating candidate sites for marine reserves. *Ecological Applications* **13**:S199–S214.
2. Sumaila, U. R., and A. T. Charles. 2002. Economic models of marine protected area: an introduction. *Natural Resource Modeling* **15**:261–272.
3. Moore, J., A. Balmford, T. Allnutt, and N. Burgess. 2004. Integrating costs into conservation planning across Africa. *Biological Conservation* **117**:343–350.
4. Richardson, E. A., M. J. Kaiser, G. Edwards-Jones, and H. P. Possingham. 2006. Sensitivity of marine-reserve design to the spatial resolution of socioeconomic data. *Conservation Biology* **20**:1191–1202.
5. Drew J A, Amatangelo K L, Hufbauer R A. 2015. Quantifying the Human Impacts on Papua New Guinea Reef Fish Communities across Space and Time. *PLoS ONE* 10(10): e0140682. doi:10.1371/journal.pone.0140682.
6. Google Earth Pro. <http://www.earth.google.com>
7. McGregor R K and Hubber E M. 1993. A bibliography of research relating to Motupore Island, Papua New Guinea. *Science in New Guinea* 19(2): 59-76
8. Baine M and Harasti D. 2007. *The marine life of Bootless Bay Papua New Guinea*. Motupore Island Research Centre, School of Natural and Physical Sciences, University of Papua New Guinea.
9. Coleman Neville. 1998. Discover Loloata Island – Marine life guide to Papua New Guinea. Neville Coleman’s Underwater Geographic Pty Ltd, Australia.

10. Hopkins F H and Menzies I. 1995. The flora of Motupore Island, Papua New Guinea. University of Papua New Guinea Press, Unisearch PTY Ltd, Papua New Guinea.
11. Frodin D G. 1983. Vegetation of Motupore Island. 1 MIRD workshop, University of Papua New Guinea.
12. Frodin D G and Johnstone I M. (nd). A self guiding tour of the plants of Motupore Island. Unpub. Manuscript.
13. Frodin D G and Leach G J. 1982. Mangroves of the Port Moresby Region. Department of Biology, University of Papua New Guinea.
14. Maniwavie T. 2007. Pictorial guide to mangrove species of Papua New Guinea. Unpub. Manuscript.
15. Ellison, J., Koedam, N.E., Wang, Y., Primavera, J., Jin Eong, O., Wan-Hong Yong, J. & Ngoc Nam, V. 2010. *Lumnitzera racemosa*. The IUCN Red List of Threatened Species 2010: e.T178846A7625290. <http://dx.doi.org/10.2305/IUCN.UK.2010-2.RLTS.T178846A7625290.en>. Downloaded on 01 April 2018.
16. The IUCN Red List of Threatened Species. Version 2017-3. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 01 April 2018.
17. Maniwavie T. 2000. Corals of Motupore Island. Unpub. Manuscript.
18. Maniwavie, M. 2010. Sediment levels and its impacts on live coral cover in Bootless Bay, Port Moresby. Research techniques and skills course work report. University of Papua New Guinea.
19. Tyler, S., Artois, T.; Schilling, S.; Hooge, M.; Bush, L.F. (eds) (2006-2018). World List of turbellarian worms: Acoelomorpha, Catenulida, Rhabditophora. *Pseudoceros dimidiatus* Graff, 1893. Accessed through: World Register of Marine Species at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=483959> on 2018-04-01
20. Graff, L. von. (1893). In: W. Saville-Kent. *The Great Barrier Reef of Australia; its products and potentialities*. W. H. Allen, London. page 362.
21. Hanley, J. Russell 1989. Revision of the scaleworm genera *Arctonoe* Chamberlin and *Gastolepidia* Schmarda (Polychaeta: Polynoidae) with the erection of a new subfamily Arctonoinae. The Beagle, Records of the Northern Territory Museum of Arts and Sciences, 6(1): 1-34.
22. Read, G.; Fauchald, K. (Ed.) (2018). World Polychaeta database. *Protula bispiralis* (Savigny, 1822). Accessed through: World Register of Marine Species at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=209958> on 2018-04-01
23. WoRMS (2018). *Lepas (Anatifa) anserifera* Linnaeus, 1767. Accessed at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=733347> on 2018-04-01

24. Spence Bate, C. (1888). Report on the Crustacea Macrura collected by the Challenger during the years 1873-76. *Report on the Scientific Results of the Voyage of H.M.S. "Challenger" during the years 1873-76*. 24: i-xc, 1-942, Plates 1-157.
25. WoRMS (2018). *Tetraclita squamosa* (Bruguère, 1789). Accessed at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=208890> on 2018-04-01
26. WoRMS (2018). *Odontodactylus scyllarus* (Linnaeus, 1758). Accessed at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=>
27. WoRMS (2018). *Penaeus canaliculatus japonicus* Spence Bate, 1888. Accessed at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=377717> on 2018-04-01
28. WoRMS (2018). *Alpheus ochrostriatus* Karplus, Szlep & Tournamal, 1981. Accessed at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=549781> on 2018-04-01
29. WoRMS (2018). *Lysmata amboinensis* (de Man, 1888). Accessed at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=241289> on 2018-04-01
30. Lemaitre, R.; McLaughlin, P. (2018). World Paguroidea & Lomisoidea database. *Calcinus minutus* Buitendijk, 1937. Accessed through: World Register of Marine Species at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=367448> on 2018-04-01
31. WoRMS (2018). *Allogalatea elegans* (Adams & White, 1848). Accessed at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=246208> on 2018-04-01
32. Conand, C., Gamboa, R. & Purcell, S. 2013. *Bohadschia argus*. The IUCN Red List of Threatened Species 2013: e.T180541A1645352. <http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T180541A1645352.en>. Downloaded on 26 February 2018.
33. Samyn, Y. 2013. *Bohadschia similis*. *The IUCN Red List of Threatened Species* 2013: e.T180386A1623976. <http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T180386A1623976.en>. Downloaded on 26 February 2018.
34. PNG Constitution. *The "Crocodile Trade Act, 1982"*. Sovereign State of PNG, Papua New Guinea
35. PNG Constitution. *The "Fauna Act, 1982"*, PNG Government. Papua New Guinea
36. Bonaccorso F J. (1998). Bats of Papua New Guinea. Conservation International Field Guide Series. Conservation International, Washington, D. C. 489pp.
37. Flannery T. 1995. Mammals of New Guinea. Cornell University Press. Ithaca. USA. 568pp.
38. Leary, T., Seri, L., Wright, D., Hamilton, S., Helgen, K., Singadan, R., Menzies, J., Allison, A., James, R., Dickman, C., Lunde, D., Aplin, K., Flannery, T. & Woolley, P. 2016. *Myoictis melas*. The IUCN Red List of Threatened Species 2016: e.T14086A21945102. <http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T14086A21945102.en>. Downloaded on **01 April 2018**.

39. WoRMS 2018. <http://www.marinespecies.org/aphia.php?>
40. Ko'ou, A. Y. 2014. Habitats influence on the variations in the recruitment of overfished sea cucumbers on the fringing reefs of Bootless Bay, Papua New Guinea - MSc Thesis. Diponegoro University, Semarang, Indonesia.
41. Kinch, Jeff. 2007. Socio-economic Assessment of the Beche-de-mer Fisheries in the Western, Central and Manus Provinces, Papua New Guinea. National Fisheries Authority, Port Moresby, Papua New Guinea.
42. Kelly-Borges, M.; Bergquist, P.R. 1988. Sponges from Motupore Island, Papua New Guinea. *Indo-Malayan Zoology* 5: 121-159. page(s): 137.
43. *The Plant List (2013)*. Version 1.1. Published on the Internet; <http://www.theplantlist.org/> (accessed 1st January).
44. Tropicos.org. Missouri Botanical Garden. Accessed 16 April 2018 at <http://www.tropicos.org>.
45. BirdLife International. Published on the Internet; [www.datazone.birdlife.org/species/factsheet/](http://www.datazone.birdlife.org/species/factsheet/) (accessed April 16, 2018).
46. Chang, Y. 2011. "*Mastigias papua*" (On-line), Animal Diversity Web. Accessed April 16, 2018 at [http://animaldiversity.org/accounts/Mastigias\\_papua/](http://animaldiversity.org/accounts/Mastigias_papua/)

## Appendix 2-1. Plant species list for Bogoro Inlet and Motupore Island

Family	Scientific name	Common name	IUCN Status	PNG Status	Reference
Sterculiaceae	<i>Abroma angusta</i>		Not assessed		10, 16
Fabaceae	<i>Abrus precatorius</i>		Not assessed		10, 16
Malvaceae	<i>Abutilon auritum</i>		Not assessed		10, 16
Malvaceae	<i>Abutilon indicum</i>		Not assessed		10, 16
Fabaceae	<i>Acacia auriculiformis</i>		Least concern		10, 16
Amaranthaceae	<i>Achrysanthes aspera</i>		Not assessed		10, 16
Fabaceae	<i>Adenanthera pavonina</i>		Not assessed		10, 16
Plumbaginaceae	<i>Aegialitis annulata</i>		Not assessed		10, 16
Myrsinaceae	<i>Aegiceras corniculatum</i>		Least concern		10, 16
Rubiaceae	<i>Aidia cochinchinensis</i>		Not assessed		10, 16
Fabaceae	<i>Albizia carrii</i>		Not assessed		10, 16
Sapindaceae	<i>Alectryon repandodentatus</i>		Not assessed		10, 16
Sapindaceae	<i>Allophylus cobbe</i>		Not assessed		10, 16
Apocynaceae	<i>Alstonia spectabilis</i>		Not assessed		10, 16
Amaranthaceae	<i>Alternanthera pungens</i>		Not assessed		10, 16
Amaranthaceae	<i>Alternanthera sessilis</i>		Not assessed		10, 16
Fabaceae	<i>Alysicarpus bupleurifolius</i>		Not assessed		10, 16
Fabaceae	<i>Alysicarpus vaginalis</i>		Not assessed		10, 16
Vitaceae	<i>Ampelocissus acetosa</i>		Not assessed		10, 16
Lamiaceae	<i>Anisomeles malabarica</i>		Not assessed		10, 16
Annonaceae	<i>Annona squamosa</i>		Not assessed		10, 16
Fabaceae	<i>Atylosia scarabaeoides</i>		Not assessed		10, 16
Avicenniaceae	<i>Avicennia eucalyptifolia</i>		Not assessed		10, 16
Avicenniaceae	<i>Avicennia marina</i>		Not assessed		10, 16
Avicenniaceae	<i>Avicennia officinalis</i>		Not assessed		10, 16
Avicenniaceae	<i>Avicennia resinifera</i>		Not assessed		10, 16
Acanthaceae	<i>Barleria lupulina</i>		Not assessed		10, 16
	<i>Barringtonia asiatica</i>		Not assessed		10, 16

Fabaceae	<i>Bauhinia binata</i>		Not assessed		10, 16
Fabaceae	<i>Bauhinia variegata</i>		Not assessed		10, 16
Asteraceae	<i>Bidens Sp.</i>		Not assessed		10, 16
Nyctaginaceae	<i>Boerhavia diffusa</i>		Not assessed		10, 16
Nyctaginaceae	<i>Boerhavia erecta</i>		Not assessed		10, 16
Nyctaginaceae	<i>Boerhavia repens</i>		Not assessed		10, 16
Bambacaceae	<i>Bombax ceiba</i>		Not assessed		10, 16
Euphorbiaceae	<i>Breynia cernua</i>		Not assessed		10, 16
Eupphorbiaceae	<i>Bridelia oligantha</i>		Not assessed		10, 16
Rhizophoraceae	<i>Bruguiera gymnorrhiza</i>		Not assessed		10, 16
Orchidaceae	<i>Bulbostylis barbata</i>		Not assessed		10, 16
Fabaceae	<i>Caesalpinia bonduc</i>		Not assessed		10, 16
Clusiaceae	<i>Calophyllum inophyllum</i>		Not assessed		10, 16
Fabaceae	<i>Canavalia papuana</i>		Not assessed		10, 16
Rubiaceae	<i>Canthium suborbiculare</i>		Not assessed		10, 16
Capparaceae	<i>Capparis lucida</i>		Not assessed		10, 16
Capparaceae	<i>Capparis quiniflora</i>		Not assessed		10, 16
Capparaceae	<i>Capparis sepiaria</i>		Not assessed		10, 16
Fabaceae	<i>Cassia lechenaultiana</i>		Not assessed		10, 16
Fabaceae	<i>Cassia tora</i>		Not assessed		10, 16
Lauraceae	<i>Cassytha filiformis</i>		Not assessed		10, 16
Cassuarinaceae	<i>Cassuarina equisetifolia</i>		Not assessed		10, 16
Acanthaceae	<i>Catharanthus roseus</i>		Not assessed		10, 16
Vitaceae	<i>Cayratia acris</i>		Not assessed		10, 16
Vitaceae	<i>Cayratia cardiophylla</i>		Not assessed		10, 16
Vitaceae	<i>Cayratia schumanniana</i>		Not assessed		10, 16
Vitaceae	<i>Cayratia trifolia</i>		Not assessed		10, 16
Amaranthaceae	<i>Celosia argentea</i>		Not assessed		10, 16
Ulmaceae	<i>Celtis philippinensis</i>		Not assessed		10, 16
Rhizophoraceae	<i>Ceriops tagal</i>		Not assessed		10, 16
Fabaceae	<i>Chamaecrista absus</i>		Not assessed		10, 16



Fabaceae	<i>Chamaecrista nictitans</i>		Not assessed		10, 16
Oleaceae	<i>Chionanthus ramiflorus</i>		Not assessed		10, 16
Poaceae	<i>Chloris barbata</i>		Not assessed		10, 16
Fabaceae	<i>Christia obcordata</i>		Not assessed		10, 16
Vitaceae	<i>Cissus hastata</i>		Not assessed		10, 16
Vitaceae	<i>Cissus repens</i>		Not assessed		10, 16
Capparaceae	<i>Cleome viscosa</i>		Not assessed		10, 16
Verbenaceae	<i>Clerodendrum floribundum</i>		Not assessed		10, 16
Verbenaceae	<i>Clerodendrum inerme</i>		Not assessed		10, 16
Fabaceae	<i>Clitoria ternatea</i>		Not assessed		10, 16
Arecaceae	<i>Cocos nucifera</i>		Not assessed		10, 16
Rhamnaceae	<i>Colubrina asiatica</i>		Not assessed		10, 16
Commelinaceae	<i>Commelina ensifolia</i>		Not assessed		10, 16
Tiliaceae	<i>Corchorus aestuans</i>		Not assessed		10, 16
Boraginaceae	<i>Cordia dichotoma</i>		Not assessed		10, 16
Boraginaceae	<i>Cordia subcordata</i>		Not assessed		10, 16
Fabaceae	<i>Crotalaria chinensis</i>		Not assessed		10, 16
Fabaceae	<i>Crotalaria montana</i>		Not assessed		10, 16
	<i>Cudrania javanensis</i>		Not assessed		10, 16
Fabaceae	<i>Cupaniopsis curvidens</i>		Not assessed		10, 16
Sapindaceae	<i>Cupaniopsis napaensis</i>		Not assessed		10, 16
Cycadaceae	<i>Cycas campestris</i>		Near Threaten		10, 16
Amaranthaceae	<i>Cyathula prostrata</i>		Not assessed		10, 16
Poaceae	<i>Cymbopogon</i>		Not assessed		10, 16
Asclepiadaceae	<i>Cynachum carnosum</i>		Not assessed		10, 16
Poaceae	<i>Cynodon dactylon</i>		Not assessed		10, 16
Cyperaceae	<i>Cyperus javanicus</i>		Not assessed		10, 16
Cyperaceae	<i>Cyperus rotundus</i>		Not assessed		10, 16
Poaceae	<i>Dactyloctenium aegyptium</i>		Not assessed		10, 16
Fabaceae	<i>Derris trifoliata</i>		Not assessed		10, 16
Orchidaceae	<i>Dendrobium discolor</i>		Not assessed		10, 16

Fabaceae	<i>Desmodium umbellatum</i>		Not assessed		10, 16
Fabaceae	<i>Desmodium velutinum</i>		Not assessed		10, 16
Poaceae	<i>Digitaria longifolia</i>		Not assessed		10, 16
Dioscoreaceae	<i>Dioscorea bulbifera</i>		Not assessed		10, 16
Dioscoreaceae	<i>Dioscorea esculenta</i>		Not assessed		10, 16
Ebenaceae	<i>Diospyros littorea</i>		Not assessed		10, 16
Cucurbitaceae	<i>Diplocyclos palmatus</i>		Not assessed		10, 16
Ochidaceae	<i>Dipodium punctatum</i>		Not assessed		10, 16
Acanthaceae	<i>Dipteracanthus bracteatus</i>		Not assessed		10, 16
Asclepiadaceae	<i>Dischidia ovata</i>		Not assessed		10, 16
Polypodiaceae	<i>Drynaria quercifolia</i>		Not assessed		10, 16
Euphorbiaceae	<i>Drypetes australasica</i>		Not assessed		10, 16
Asteraceae	<i>Eclipta prostrata</i>		Not assessed		10, 16
Asteraceae	<i>Ehretia dichotoma</i>		Not assessed		10, 16
Elaeocarpaceae	<i>Elaeocarpus arnhemicus</i>		Not assessed		10, 16
Sapindaceae	<i>Ellatostachys tetraporandra</i>		Not assessed		10, 16
Poaceae	<i>Eleusine indica</i>		Not assessed		10, 16
Asteraceae	<i>Emilia sonchifolia</i>		Not assessed		10, 16
Fabaceae	<i>Entada sp</i>		Not assessed		10, 16
Asteraceae	<i>Eragrostis tenella</i>		Not assessed		10, 16
Fabaceae	<i>Erythrina variegata</i>		Not assessed		10, 16
Myrtaceae	<i>Eucalyptus confertiflora</i>		Not assessed		10, 16
Myrtaceae	<i>Eucalyptus papuana</i>		Not assessed		10, 16
Myrtaceae	<i>Eugenia sp</i>		Not assessed		10, 16
Euphorbiaceae	<i>Euphorbia heterophylla</i>		Not assessed		10, 16
Euphorbiaceae	<i>Euphorbia hirta</i>		Not assessed		10, 16
Euphorbiaceae	<i>Euphorbia plumeroides</i>		Not assessed		10, 16
Euphorbiaceae	<i>Euphorbia prostrata</i>		Not assessed		10, 16
Euphorbiaceae	<i>Euphorbia vachellii</i>		Not assessed		10, 16
Convolvulaceae	<i>Evolvulus alsinoides</i>		Not assessed		10, 16
Euphorbiaceae	<i>Excoecaria agallocha</i>		Not assessed		10, 16

Santalaceae	<i>Exocarpus latifolius</i>		Not assessed		10, 16
Moraceae	<i>Fatoua pilosa</i>		Not assessed		10, 16
Moraceae	<i>Ficus microcarpa</i>		Not assessed		10, 16
Moraceae	<i>Ficus opposita</i>		Not assessed		10, 16
Flagellariaceae	<i>Flagellaria indica</i>		Not assessed		10, 16
Fabaceae	<i>Flemingia strobilifera</i>		Not assessed		10, 16
Euphorbiaceae	<i>Flueggea virosa</i>		Not assessed		10, 16
Fabaceae	<i>Galactia tenuiflora</i>		Not assessed		10, 16
Sapindaceae	<i>Garuga floribunda</i>		Not assessed		10, 16
Euphorbiaceae	<i>Glochidion disparipes</i>		Not assessed		10, 16
Fabaceae	<i>Glycine tomentella</i>		Not assessed		10, 16
Rutaceae	<i>Glycosmis cyanocarpa</i>		Not assessed		10, 16
Tiliaceae	<i>Grewia acuminata</i>		Not assessed		10, 16
Tiliaceae	<i>Grewia breviflora</i>		Not assessed		10, 16
Tiliaceae	<i>Grewia species A</i>		Not assessed		10, 16
Tiliaceae	<i>Grewia xanthopetala</i>		Not assessed		10, 16
Rubiaceae	<i>Guettarda speciosa</i>		Not assessed		10, 16
Asclepiadaceae	<i>Gymnanthera oblonga</i>		Not assessed		10, 16
Asclepiadaceae	<i>Gymnema geminatum</i>		Not assessed		10, 16
Sapindaceae	<i>Harpullia leptococca</i>		Not assessed		10, 16
Simaroubaceae	<i>Harrisonia brownii</i>		Not assessed		10, 16
Rubiaceae	<i>Hedyotis corymbosa</i>		Not assessed		10, 16
Sterculiaceae	<i>Heritiera littoralis</i>		Not assessed		10, 16
Poaceae	<i>Heteropogon contortus</i>		Not assessed		10, 16
Malvaceae	<i>Hibiscus schizopetalus</i>		Not assessed		10, 16
Malvaceae	<i>Hibiscus tiliaceus</i>		Not assessed		10, 16
Lamiaceae	<i>Hyptis suaveolens</i>		Not assessed		10, 16
Asclepiadaceae	<i>Ichnocarpus frutescens</i>		Not assessed		10, 16
Fabaceae	<i>Indigofera colutea</i>		Not assessed		10, 16
Fabaceae	<i>Indigofera hirsuta</i>		Not assessed		10, 16
Fabaceae	<i>Indigofera linifolia</i>		Not assessed		10, 16

Fabaceae	<i>Indigofera linnaei</i>		Not assessed		10, 16
Fabaceae	<i>Intsia bijuga</i>		Not assessed		10, 16
Convolvulaceae	<i>Ipomoea carnea</i>		Not assessed		10, 16
Convolvulaceae	<i>Ipomoea macrantha</i>		Not assessed		10, 16
Convolvulaceae	<i>Ipomoea nil</i>		Not assessed		10, 16
Convolvulaceae	<i>Ipomoea pes-capri</i>		Not assessed		10, 16
Convolvulaceae	<i>Jaquemontia paniculate</i>		Not assessed		10, 16
Oleaceae	<i>Jasminum aemulum</i>		Not assessed		10, 16
Oleaceae	<i>Jasminum didymum</i>		Not assessed		10, 16
Myrtaceae	<i>Jossinia desmantha</i>		Not assessed		10, 16
Myrtaceae	<i>Jossinia reinwardtiana</i>		Not assessed		10, 16
Poaceae	<i>Lepturus repens</i>		Not assessed		10, 16
Fabaceae	<i>Leucaena leucocephala</i>		Not assessed		10, 16
Lamiaceae	<i>Leucas flaccida</i>		Not assessed		10, 16
Lauraceae	<i>Litsea glutinosa</i>		Not assessed		10, 16
Combretaceae	<i>Lumnitzera racemosa</i>		Not assessed		10, 15
Euphorbiaceae	<i>Macaranga tanarius</i>		Not assessed		10, 16
Moraceae	<i>Maclura cochinchinensis</i>		Not assessed		10, 16
Fabaceae	<i>Macroptilium atropurpureum</i>		Not assessed		10, 16
Euphorbiaceae	<i>Mallotus philippensis</i>		Not assessed		10, 16
Malvaceae	<i>Malvastrum coromandelianum</i>		Not assessed		10, 16
Euphorbiaceae	<i>Manihot esculenta</i>		Not assessed		10, 16
Asclepiadaceae	<i>Marsdenia velutina</i>		Not assessed		10, 16
Verbenaceae	<i>Maytenus emarginata</i>		Not assessed		10, 16
Convolvulaceae	<i>Merremia tridentata</i>		Not assessed		10, 16
Rutaceae	<i>Micromelum minutum</i>		Not assessed		10, 16
	<i>Millettia</i>		Not assessed		10, 16
Sapotaceae	<i>Mimusops elengi</i>		Not assessed		10, 16
Curcubitaceae	<i>Momordica charantia</i>		Not assessed		10, 16
Rubiaceae	<i>Morinda citrifolia</i>		Not assessed		10, 16

Fabaceae	<i>Mucuna gigantea</i>		Not assessed		10, 16
Curcubitaceae	<i>Mukia maderaspatana</i>		Not assessed		10, 16
Rutaceae	<i>Murraya paniculata</i>		Not assessed		10, 16
Myristicaceae	<i>Myristica sp</i>		Not assessed		10, 16
Areaceae	<i>Nypa fruticans</i>		Not assessed		10, 16
Lamiaceae	<i>Ocimum tenuiflorum</i>		Not assessed		10, 16
Opiliaceae	<i>Opilia amentacea</i>		Not assessed		10, 16
Poaceae	<i>Opismenus undulatifolius</i>		Not assessed		10, 16
Cactaceae	<i>Opuntia stricta</i>		Not assessed		10, 16
Fabaceae	<i>Ormocarpum orientale</i>		Not assessed		10, 16
Myrtaceae	<i>Osbornia octodonta</i>		Not assessed		10, 16
Pandanaceae	<i>Pandanus tectorius</i>		Not assessed		10, 16
Poaceae	<i>Panicum sp</i>		Not assessed		10, 16
Asclepiadaceae	<i>Parsonia quinquebullata</i>		Not assessed		10, 16
Passifloraceae	<i>Passiflora foetida</i>		Not assessed		10, 16
Euphorbiaceae	<i>Pedilanthus tithymaloides</i>		Not assessed		10, 16
Fabaceae	<i>Peltophorum ptercarpum</i>		Not assessed		10, 16
Thelypteridaceae	<i>Phaleria sp</i>		Not assessed		10, 16
Euphorbiaceae	<i>Phyllanthus amarus</i>		Not assessed		10, 16
Euphorbiaceae	<i>Phyllanthus niruri</i>		Not assessed		10, 16
Fabaceae	<i>Pithecellobium dulce</i>		Not assessed		10, 16
Plumbaginaceae	<i>Plumbago zeylanica</i>		Not assessed		10, 16
Apocynaceae	<i>Plumeria sp</i>		Not assessed		10, 16
Capparaceae	<i>Polycarpaea sp</i>		Not assessed		10, 16
Meliaceae	<i>Pongamia pinnata</i>		Not assessed		10, 16
Portulacaceae	<i>Portulaca pilosa</i>		Not assessed		10, 16
Verbenaceae	<i>Premna dallachyana</i>		Not assessed		10, 16
Verbenaceae	<i>Premna serratifolia</i>		Not assessed		10, 16
Fabaceae	<i>Psoralea badocana</i>		Not assessed		10, 16
Rubiaceae	<i>Psychotria bracteosa</i>		Not assessed		10, 16
Fabaceae	<i>Pycnospora lutescens</i>		Not assessed		10, 16

Polypodiaceae	<i>Pyrrisia longifolia</i>		Not assessed		10, 16
Rubiaceae	<i>Randia cochinchinensis</i>		Not assessed		10, 16
Rhizophoraceae	<i>Rhizophora apiculata</i>		Not assessed		10, 16
Rhizophoraceae	<i>Rhizophora lamarckii</i>		Not assessed		10, 16
Rhizophoraceae	<i>Rhizophora stylosa</i>		Not assessed		10, 16
Poaceae	<i>Rhynchelytrum repens</i>		Not assessed		10, 16
Fabaceae	<i>Rhynchosia minima</i>		Not assessed		10, 16
Malpigiaceae	<i>Rhyssopteris timoriensis</i>		Not assessed		10, 16
Fabaceae	<i>Samanea saman</i>		Not assessed		10, 16
Goodeniaceae	<i>Scaevola sericea</i>		Not assessed		10, 16
Cyperaceae	<i>Sclerica brownii</i>		Not assessed		10, 16
Flacourtiaceae	<i>Scolopia novoguineensis</i>		Not assessed		10, 16
Rubiaceae	<i>Scyphiphora hydrophyllacea</i>		Not assessed		10, 16
Asclepiadaceae	<i>Secamone elliptica</i>		Not assessed		10, 16
	<i>Securinega melanthesoides</i>		Not assessed		10, 16
Fabaceae	<i>Senna siamea</i>		Not assessed		10, 16
Fabaceae	<i>Sesbania cannabina</i>		Not assessed		10, 16
Aizoaceae	<i>Sesuvium portulacastrum</i>		Not assessed		10, 16
Malvaceae	<i>Sida cordifolia</i>		Not assessed		10, 16
Smilacaceae	<i>Smilax zeylanica</i>		Not assessed		10, 16
Asteraceae	<i>Sonchus oleraceus</i>		Not assessed		10, 16
Sonneratiaceae	<i>Sonneratia alba</i>		Least concern		10, 16
Fabaceae	<i>Sophora tomentosa</i>		Not assessed		10, 16
Poaceae	<i>Sorghum nitidum</i>		Not assessed		10, 16
Rubiaceae	<i>Spermacoce assurgens</i>		Not assessed		10, 16
	<i>Spondias cytherea</i>		Not assessed		10, 16
Poaceae	<i>Sporobolus diander</i>		Not assessed		10, 16
	<i>Sporobolus virginicus</i>		Not assessed		10, 16
Verbenaceae	<i>Stachytarpheta jamaicensis</i>		Not assessed		10, 16
Asteraceae	<i>Synedrella nodiflora</i>		Not assessed		10, 16
Fabaceae	<i>Tephrosia astragaloides</i>		Not assessed		10, 16

Fabaceae	<i>Tephrosia filipes</i>		Not assessed		10, 16
Combretaceae	<i>Terminalia catappa</i>		Not assessed		10, 16
Combretaceae	<i>Terminalia microcarpa</i>		Not assessed		10, 16
Poaceae	<i>Themeda novoguineensis</i>		Not assessed		10, 16
Poaceae	<i>Themeda triandra</i>		Not assessed		10, 16
Malvaceae	<i>Thespesia populnea</i>		Not assessed		10, 16
Rubiaceae	<i>Timonius timon</i>		Not assessed		10, 16
Boraginaceae	<i>Tournefortia muelleri</i>		Not assessed		10, 16
Tiliaceae	<i>Trema cannabina</i>		Not assessed		10, 16
Aizoaceae	<i>Trianthema portulacastrum</i>		Not assessed		10, 16
Zygophyllaceae	<i>Tribulus cistoides</i>		Not assessed		10, 16
Asteraceae	<i>Tridax procumbens</i>		Not assessed		10, 16
Moraceae	<i>Trophis scandens</i>		Not assessed		10, 16
Meliaceae	<i>Turraea virens</i>		Not assessed		10, 16
Fabaceae	<i>Uraria lagopodoides</i>		Not assessed		10, 16
Asteraceae	<i>Vernonia cinerea</i>		Not assessed		10, 16
Fabaceae	<i>Vigna radiata</i>		Not assessed		10, 16
Verbenaceae	<i>Vitex trifolia</i>		Not assessed		10, 16
Meliaceae	<i>Xylocarpus granatum</i>		Not assessed		10, 16
Meliaceae	<i>Xylocarpus rumphii</i>		Not assessed		10, 16
Cucurbitaceae	<i>Zehneria japonica</i>		Not assessed		10, 16

**Appendix 2-2. Fish species recorded at Bootless Bay.**

Family	Scientific Name	Common Name	IUCN Status	PNG Status	Reference
Acanthuridae	<i>Acanthurus auranticavus</i> (Randall, 1956)		Least Concerned		15
Acanthuridae	<i>Acanthurus fowleri</i> (de Beaufort, 1951)		Least Concerned		15
Acanthuridae	<i>Acanthurus grammoptilus</i> (Richardson, 1843)		Least Concerned		15
Acanthuridae	<i>Acanthurus lineatus</i> (Linnaeus, 1758)	Striped surgeonfish	Least Concerned		8, 15
Acanthuridae	<i>Acanthurus nigrofuscus</i> (Forsskål, 1775)		Least Concerned		15
Acanthuridae	<i>Acanthurus nigroris</i> (Valenciennes, 1835)		Least Concerned		15
Acanthuridae	<i>Acanthurus olivaceus</i> (Bloch and Schneider, 1801)		Least Concerned		15
Acanthuridae	<i>Acanthurus pyroferus</i> (Kittlitz, 1834)	Mimic surgeonfish	Least Concerned		8, 15
Acanthuridae	<i>Acanthurus triostegus</i> (Linnaeus, 1758)		Least Concerned		15
Acanthuridae	<i>Ctenochaetus binotatus</i> (Randall, 1955)		Least Concerned		15
Acanthuridae	<i>Ctenochaetus striatus</i> (Quoy and Baimard, 1825)	Striated surgeonfish	Least Concerned		15
Acanthuridae	<i>Naso brevirostris</i> (Cuvier, 1829)	Spotted unicornfish	Least Concerned		8, 15
Acanthuridae	<i>Naso lituratus</i> (Forster, 1801)	Orange-spine unicornfish	Least Concerned		8, 15
Acanthuridae	<i>Naso vlamingii</i> (Valenciennes, 1835)		Least Concerned		15
Anguillidae	<i>Anguilla obscura</i> (Günther, 1872)		Data Deficient		15
Antennariidae	<i>Antennarius pictus</i> (Shaw, 1794)	Painted Angler Fish	Least Concerned		15
Antennariidae	<i>Histrio histrio</i> (Linnaeus, 1758)	Sargassum Frogfish	Least Concerned		15
Apogonidae	<i>Apogon aureus</i> (Lacépède, 1802)	Ringtailed cardinalfish	Least Concerned		15
Apogonidae	<i>Apogon crassiceps</i> (Garman, 1903)		Not evaluated		15
Apogonidae	<i>Apogon cyanosoma</i> (Bleeker 1853)	Yellowstriped cardinalfish	Least Concerned		15
Apogonidae	<i>Apogon exostigma</i> (Jordan and Starks, 1906)		Not evaluated		15
Apogonidae	<i>Apogon fraenatus</i> (Valenciennes, 1832)	Bridled cardinalfish	Not evaluated		15
Apogonidae	<i>Apogon fucata</i> (Cantor, 1849)	Orange lined cardinalfish	Not evaluated		15
Apogonidae	<i>Apogon kallopterus</i> (Bleeker, 1856)	Iridescent cardinalfish	Not evaluated		15
Apogonidae	<i>Apogon nigrofasciatus</i> (Lachner, 1953)	Blackstriped cardinalfish	Not evaluated		15
Apogonidae	<i>Apogon perlitus</i> (Fraser and Lachner, 1985)	Pearly cardinalfish	Not evaluated		15
Apogonidae	<i>Apogon rhodopterus</i> (Bleeker, 1852)		Not evaluated		15
Apogonidae	<i>Apogon</i> sp. 1				8, 15



Apogonidae	<i>Apogon sp. 2</i>				8, 15
Apogonidae	<i>Apogon sp. 3</i>				8, 15
Apogonidae	<i>Archamia zosterophora</i> (Bleeker, 1856)	Blackbelted cardinalfish	Not evaluated		15
Apogonidae	<i>Cheilodipterus alleni</i> (Gon, 1993)	Allen's cardinalfish	Not evaluated		8, 15
Apogonidae	<i>Cheilodipterus isostigmus</i> (Schultz, 1940)		Not evaluated		8, 15
Apogonidae	<i>Cheilodipterus macrodon</i> (Lacépède, 1802)	Large-toothed cardinalfish	Not evaluated		8, 15
Apogonidae	<i>Cheilodipterus parazonatus</i> (Gon, 1993)	Mimic cardinalfish	Not evaluated		8, 15
Apogonidae	<i>Cheilodipterus quinquelineatus</i> (Cuvier, 1828)	Five-lined cardinalfish	Not evaluated		8, 15
Apogonidae	<i>Cheilodipterus sp.</i>				8, 15
Apogonidae	<i>Fowleria marmorata</i> (Alleyne and MacLeay, 1877)		Not evaluated		15
Apogonidae	<i>Fowleria variegata</i> (Valenciennes, 1832)		Not evaluated		15
Apogonidae	<i>Pseudamia hayashii</i> (Lachner & Fraser, 1985)		Not evaluated		15
Apogonidae	<i>Rhabdamia cypselurus</i> (Weber, 1909)	Swallowtail cardinalfish	Not evaluated		15
Apogonidae	<i>Siphamia elongata</i> (Lachner, 1953)		Not evaluated		15
Apogonidae	<i>Siphamia versicolor</i> (Smith & Radcliffe, 1911)	Urchin cardinalfish	Not evaluated		8, 15
Apogonidae	<i>Sphaeramia nematoptera</i> (Bleeker, 1856)	Pyjama cardinalfish	Not evaluated		8, 15
Apogonidae	<i>Sphaeramia orbicularis</i> (Cuvier, 1828)	Orbiculate cardinalfish	Not evaluated		15
Aulostomidae	<i>Aulostomus chinensis</i> (Linnaeus, 1766)	Trumpetfish	Least Concerned		15
Balistidae	<i>Abalistes stellatus</i> ([Lacépède, 1798])	Starry triggerfish	Least Concerned		15
Balistidae	<i>Balistapus undulatus</i> (Park, 1797)	Orange-lined triggerfish	Not evaluated		15
Balistidae	<i>Balistooides conspicillum</i> (Bloch and Schneider, 1801)	Clown triggerfish	Not evaluated		15
Balistidae	<i>Balistooides viridescens</i> (Bloch and Schneider, 1801)	Titan triggerfish	Not evaluated		15
Balistidae	<i>Melichthys vidua</i> (Richardson, 1845)		Not evaluated		15
Balistidae	<i>Pseudobalistes flavimarginatus</i> (Rüppell, 1829)		Not evaluated		15
Balistidae	<i>Rhinecanthus aculeatus</i> (Linnaeus, 1758)	Blackbar triggerfish	Not evaluated		15
Balistidae	<i>Rhinecanthus verrucosus</i> (Linnaeus, 1758)		Not evaluated		15
Balistidae	<i>Sufflamen bursa</i> (Bloch and Schneider, 1801)	Boomerang triggerfish	Not evaluated		15
Balistidae	<i>Sufflamen chrysopterus</i> (Bloch and Schneider, 1801)	Flagtail triggerfish	Not evaluated		15
Belonidae	<i>Tylosurus crocodilus</i> (Péron & Lesueur, 1821)		Least Concerned		15
Belonidae	<i>Zenarchopterus gilli</i> (Smith 1945)		Least Concerned		15
Blenniidae	<i>Aspidontus taeniatus</i> (Quoy and Gaimard, 1834)		Least Concerned		15

Blenniidae	<i>Blenniella cf. gibbifrons</i> (Quoy and Baimard, 1824)		Least Concerned		15
Blenniidae	<i>Crossosalarias macrospilus</i> (Smith-Vaniz and Springer, 1971)		Least Concerned		8, 15
Blenniidae	<i>Ctenogobiops</i> sp.				15
Blenniidae	<i>Ecsenius namiyei</i> (Jordan and Evermann, 1902)	Black comb-tooth blenny	Least Concerned		8, 15
Blenniidae	<i>Ecsenius yaeyamaensis</i> (Ayoagi, 1954)	Yaeyama blenny	Least Concerned		8, 15
Blenniidae	<i>Meiacanthus grammistes</i> (Valenciennes, 1836)	Striped fangblenny	Least Concerned		8, 15
Blenniidae	<i>Meiacanthus vittatus</i> (Smith-Vaniz, 1976)	One-striped fangblenny	Least Concerned		8, 15
Blenniidae	<i>Plagiotremus laudandus</i> (Whitley, 1961)	Bicolor fangblenny	Least Concerned		8, 15
Blenniidae	<i>Plagiotremus rhinorhynchos</i> (Bleeker, 1852)	Bluestriped fangblenny	Least Concerned		8, 15
Bothidae	<i>Bothus mancus</i> (Broussonet, 1782)		Least Concerned		15
Caesionidae	<i>Caesio caerulea</i> (Lacépède, 1801)	Blue and gold fusilier	Least Concerned		15
Caesionidae	<i>Caesio cuning</i> (Bloch, 1791)	Yellowtail fusilier	Least Concerned		15
Caesionidae	<i>Caesio teres</i> (Seale, 1906)		Least Concerned		15
Caesionidae	<i>Pterocaesio digamma</i> (Bleeker, 1864)		Least Concerned		15
Caesionidae	<i>Pterocaesio pisang</i> (Bleeker, 1853)		Least Concerned		15
Callionymidae	<i>Callionymus enneactis</i> (Bleeker, 1879)		Not evaluated		15
Callionymidae	<i>Dactylopus dactylopus</i> (Valenciennes, 1837)	Fingered dragonet	Not evaluated		8, 15
Callionymidae	<i>Synchiropus stellatus</i> (Smith, 1963)	Starry dragonet	Not evaluated		15
Carangidae	<i>Carangoides plagiotaenia</i> (Bleeker, 1857)	Barcheek trevally	Not evaluated		15
Carangidae	<i>Caranx melampygus</i> (Cuvier, 1833)	Bluefin trevally	Not evaluated		8,15
Carangidae	<i>Caranx sexfasciatus</i> (Quoy and Gaimard, 1825)		Least Concerned		15
Carcharhinidae	<i>Carcharinus melanopterus</i> (Quoy and Baimard, 1824)	Black-tip reef shark	Near Threatened		15
Carcharhinidae	<i>Triaenodon obesus</i> (Rüppell 1837)	White-tip reef shark	Near Threatened		15
Chaetodontidae	<i>Chaetodon auriga</i> (Forsskål, 1775)		Least Concerned		15
Chaetodontidae	<i>Chaetodon baronessa</i> (Cuvier, 1829)		Least Concerned		15
Chaetodontidae	<i>Chaetodon bennetti</i> (Cuvier, 1831)	Bluelashed butterflyfish	Data Deficient		15
Chaetodontidae	<i>Chaetodon citrinellus</i> (Cuvier, 1831)		Least Concerned		15
Chaetodontidae	<i>Chaetodon ephippium</i> (Cuvier, 1831)	Saddle butterflyfish	Least Concerned		15
Chaetodontidae	<i>Chaetodon kleinii</i> (Bloch, 1790)	Brown butterflyfish	Least Concerned		15
Chaetodontidae	<i>Chaetodon lunulatus</i> (Quoy and Gaimard, 1825)		Least Concerned		15
Chaetodontidae	<i>Chaetodon melannotus</i> (Bloch and Schneider, 1801)		Least Concerned		15

Chaetodontidae	<i>Chaetodon ornatissimus</i> (Cuvier, 1831)	Ornate butterflyfish	Least Concerned		15
Chaetodontidae	<i>Chaetodon pelewensis</i> (Kner, 1868)	Sunset butterflyfish	Least Concerned		15
Chaetodontidae	<i>Chaetodon plebeius</i> (Cuvier, 1831)	Blue-dash butterflyfish	Least Concerned		15
Chaetodontidae	<i>Chaetodon rafflesii</i> (Bennett, 1830)	Latticed butterflyfish	Least Concerned		15
Chaetodontidae	<i>Chaetodon speculum</i> (Cuvier, 1831)		Least Concerned		15
Chaetodontidae	<i>Chaetodon trifascialis</i> (Quoy and Gaimard, 1825)	Melon butterflyfish	Near Threatened		15
Chaetodontidae	<i>Chaetodon ulietensis</i> (Cuvier, 1831)	Double-saddled butterflyfish	Least Concerned		15
Chaetodontidae	<i>Chaetodon unimaculatus</i> (Bloch, 1787)		Least Concerned		15
Chaetodontidae	<i>Chaetodon vagabundus</i> (Linnaeus, 1758)	Vagabond butterflyfish	Least Concerned		15
Chaetodontidae	<i>Chelmon rostratus</i> (Linnaeus, 1758)	Copperband butterflyfish	Least Concerned		15
Chaetodontidae	<i>Forcipiger flavissimus</i> (Jordan and McGregor, 1898)	Longnosed butterflyfish	Least Concerned		15
Chaetodontidae	<i>Forcipiger longirostris</i> (Broussonet, 1782)	Big longnosed butterflyfish	Least Concerned		15
Chaetodontidae	<i>Hemitaurichthys polylepis</i> (Bleeker, 1857)	Pyramid butterflyfish	Least Concerned		15
Chaetodontidae	<i>Heniochus acuminatus</i> (Linnaeus, 1758)	Reef bannerfish	Least Concerned		15
Chaetodontidae	<i>Heniochus chrysostomus</i> (Cuvier, 1831)	Pennant bannerfish	Least Concerned		15
Chaetodontidae	<i>Heniochus singularis</i> (Smith and Radcliffe, 1911)		Least Concerned		15
Chaetodontidae	<i>Heniochus varius</i> (Cuvier, 1829)	Humphead bannerfish	Least Concerned		15
Cirrhitidae	<i>Cirrhitichthys aprinus</i> (Cuvier, 1829)	Spotted hawkfish	Least Concerned		15
Cirrhitidae	<i>Cirrhitichthys falco</i> (Randall, 1963)	Dwarf hawkfish	Least Concerned		15
Cirrhitidae	<i>Cirrhitichthys oxycephalus</i> (Bleeker, 1855)	Coral hawkfish	Least Concerned		15
Cirrhitidae	<i>Oxycirrhites typus</i> (Bleeker, 1857)	Longnose hawkfish	Least Concerned		15
Cirrhitidae	<i>Paracirrhites arcatus</i> (Cuvier, 1829)	Ring-eyed hawkfish	Least Concerned		15
Cirrhitidae	<i>Paracirrhites forsteri</i> (Schneider, 1801)	Forster hawkfish	Least Concerned		15
Congridae	<i>Heteroconger hassi</i> (Klausewitz & Eibl-Eibesfeldt, 1959)	Spotted Garden Eel	Not evaluated		15
Congridae	<i>Congridae sp.</i>				15
Dasyatidae	<i>Dasyatis kuhlii</i> (Muller and Henle, 1841)	Blue-Spotted Stingray	Data Deficient		15
Dasyatidae	<i>Taeniura lymma</i> (Bennett, 1830)	Blue-spotted Fantail Stingray	Near Threatened		15
Diodontidae	<i>Diodon hystrix</i> (Linnaeus, 1758)		Least Concerned		15
Ephippidae	<i>Platax orbicularis</i> (Forsskål, 1775)	Orbicular batfish	Not evaluated		15
Ephippidae	<i>Platax pinnatus</i> (Linnaeus, 1758)	Dusky batfish	Not evaluated		15
Ephippidae	<i>Platax teira</i> (Forsskål, 1775)	Tail-fin batfish	Not evaluated		15

Fistulariidae	<i>Fistularia commersonii</i> (Rüppell, 1838)		Least Concerned		15
Gobiesocidae	<i>Diademichthys lineatus</i> (Sauvage, 1883)	Urchin Clingfish	Least Concerned		15
Gobiesocidae	<i>Discotrema crinophila</i> (Briggs, 1976)	Crinoid Clingfish	Least Concerned		15
Gobiidae	<i>Amblyeleotris arcupinna</i> (Mohlmann and Munday, 1999)	Red-banded shrimpgoby	Not evaluated		15
Gobiidae	<i>Amblyeleotris guttata</i> (Fowler, 1938)	Spotted shrimpgoby	Not evaluated		15
Gobiidae	<i>Amblyeleotris randalli</i> (Hoese and Steene, 1978)	Randall's shrimpgoby	Not evaluated		15
Gobiidae	<i>Amblygobius decussatus</i> (Bleeker, 1855)	Orange-striped goby	Not evaluated		8, 15
Gobiidae	<i>Amblygobius phaelena</i> (Valenciennes, 1837)	Banded goby	Not evaluated		8, 15
Gobiidae	<i>Amblygobius rainfordi</i> (Whitley, 1940)	Old glory	Least Concerned		8, 15
Gobiidae	<i>Bryaninops amplus</i> (Larson, 1985)	Large whip goby	Least Concerned		15
Gobiidae	<i>Bryaninops loki</i> (Larson, 1985)	Loki whip goby	Least Concerned		8, 15
Gobiidae	<i>Calumia</i> sp. 1				8, 15
Gobiidae	<i>Calumia</i> sp. 2				8, 15
Gobiidae	<i>Cryptocerus</i> sp.				8, 15
Gobiidae	<i>Eviota</i> sp.				8, 15
Gobiidae	<i>Exyrias belissimus</i> (Smith, 1959)	Beautiful goby	Least Concerned		8, 15
Gobiidae	<i>Fusigobius inframaculatus</i> (Randall, 1994)	Blotched goby	Least Concerned		8, 15
Gobiidae	<i>Fusigobius signipinnis</i> (Hoese & Obika 1988)		Not evaluated		8, 15
Gobiidae	<i>Fusigobius</i> sp.				8, 15
Gobiidae	Gobidae sp. 1				8, 15
Gobiidae	Gobidae sp. 2				8, 15
Gobiidae	Gobidae sp. 3				8, 15
Gobiidae	<i>Gobiodon okinawae</i> (Sawada, Arai & Abe, 1972)	Yellow coralgoby	Not evaluated		8, 15
Gobiidae	<i>Istigobius goldmanni</i> (Bleeker, 1852)		Not evaluated		15
Gobiidae	<i>Istigobius ornatus</i> (Rüppell, 1830)	Ornate goby	Least Concerned		8, 15
Gobiidae	<i>Istigobius rigilius</i> (Herre, 1953)		Least Concerned		15
Gobiidae	<i>Oplopomus oplopomus</i> (Valenciennes, 1837)		Not evaluated		8, 15
Gobiidae	<i>Paragobiodon xanthosomus</i> (Bleeker, 1852)		Least Concerned		15
Gobiidae	<i>Periophthalmus argentilineatus</i> (Valenciennes, 1837)		Not evaluated		15
Gobiidae	<i>Pleurosicya bilobata</i> (Koumans, 1941)		Least Concerned		15

Gobiidae	<i>Pleurosicya micheli</i> (Fourmanoir, 1971)	Stiny coral ghostgoby	Least Concerned		8, 15
Gobiidae	<i>Pleurosicya mossambica</i> (Smith, 1959)	Common ghostgoby	Least Concerned		8, 15
Gobiidae	<i>Priolepis</i> sp.				15
Gobiidae	<i>Signigobius biocellatus</i> (Hoese & Allen 1977)	Signal gobyfish	Not evaluated		8, 15
Gobiidae	<i>Trimma</i> sp. 1				15
Gobiidae	<i>Trimma</i> sp. 2				15
Gobiidae	<i>Trimma</i> sp. 3				15
Gobiidae	<i>Trimma caesiura</i> (Jordan & Seale 1906)	Dwarf goby	Least Concerned		15
Gobiidae	<i>Trimma macrophthalma</i> (Tomiyama, 1936)		Least Concerned		15
Gobiidae	<i>Trimma okinawae</i> (Aoyagi, 1949)		Least Concerned		15
Gobiidae	<i>Trimma striatum</i> (Herre 1945)		Least Concerned		15
Gobiidae	<i>Valenciennea helsdingenii</i> (Bleeker 1858)	Two stripe goby	Least Concerned		8, 15
Gobiidae	<i>Valenciennea puellaris</i> (Tomiyama 1956)	Maiden goby	Least Concerned		8, 15
Gobiidae	<i>Valenciennea strigata</i> (Broussonet, 1782)	Bluestreak goby	Least Concerned		8, 15
Haemulidae	<i>Plectorhinchus chaetodontoides</i> (Lacépède 1801)	Harlequin sweetlips	Not evaluated		15
Haemulidae	<i>Plectorhinchus chrysotaenia</i> (Bleeker, 1855)	Yellow-striped sweetlips	Not evaluated		15
Haemulidae	<i>Plectorhinchus lineatus</i> (Linnaeus, 1758)	Yellow-banded sweetlips	Not evaluated		15
Haemulidae	<i>Plectorhinchus vittatus</i> (Linnaeus, 1758)	Oriental sweetlips	Not evaluated		15
Hemiramphidae	<i>Hemiramphus archipelagicus</i> (Collette & Parin 1978)		Not evaluated		15
Hemiramphidae	<i>Hemiramphus far</i> (Forsskål, 1775)		Not evaluated		15
Hemiramphidae	<i>Hyporhamphus quoyi</i> (Valenciennes, 1847)		Not evaluated		15
Hemiscyllidae	<i>Hemiscyllium hallstromi</i> (Whitley, 1967)	Epaulette shark	Vulnerable		15
Holocentridae	<i>Myripristis berndti</i> (Jordan and Evermann, 1903)	Blotcheye soldierfish	Least Concerned		15
Holocentridae	<i>Myripristis kuntzei</i> (Valenciennes, 1831)		Least Concerned		15
Holocentridae	<i>Myripristis murdjan</i> (Forsskål, 1775)	Pinecone soldierfish	Least Concerned		15
Holocentridae	<i>Myripristis violacea</i> (Bleeker, 1851)	Violet Soldierfish	Least Concerned		15
Holocentridae	<i>Myripristis vittata</i> (Valenciennes, 1831)	Whitetip Soldierfish	Least Concerned		15
Holocentridae	<i>Neoniphon argenteus</i> (Valenciennes, 1831)		Least Concerned		15
Holocentridae	<i>Neoniphon sammara</i> (Forsskål, 1775)	Sammara Squirrelfish	Least Concerned		15
Holocentridae	<i>Plectrypops lima</i> (Valenciennes, 1831)		Least Concerned		15
Holocentridae	<i>Sargocentron caudimaculatum</i> (Rüppell 1838)	Silver spot squirrelfish	Least Concerned		15

Holocentridae	<i>Sargocentron cf. iota</i> (Randall 1998)		Least Concerned		15
Holocentridae	<i>Sargocentron cornutum</i> (Bleeker 1853)		Least Concerned		15
Holocentridae	<i>Sargocentron ensifer</i> (Jordan & Evermann 1903)	Yellow-striped soldierfish	Least Concerned		15
Holocentridae	<i>Sargocentron rubrum</i> (Forsskål, 1775)		Least Concerned		15
Holocentridae	<i>Sargocentron spiniferum</i> (Forsskål 1775)	Sabre suirrelfish	Least Concerned		15
Holocentridae	<i>Sargocentron tiereoides</i> (Bleeker, 1853)		Least Concerned		15
Holocentridae	<i>Sargocentron violaceum</i> (Bleeker, 1853)		Least Concerned		15
Kyphosidae	<i>Kyphosus cinerascens</i> (Forsskål 1775)		Least Concerned		15
Labridae	<i>Anampses neoguinaicus</i> (Bleeker, 1878)	New Guinea wrasse	Least Concerned		8, 15
Labridae	<i>Bodianus anthioides</i> (Bennet, 1832)	Lyretail hogfish	Least Concerned		8, 15
Labridae	<i>Bodianus axillaris</i> (Bennet, 1832)		Least Concerned		15
Labridae	<i>Bodianus bimaculatus</i> (Allen, 1973)	Two-spot slender hogfish	Least Concerned		8, 15
Labridae	<i>Bodianus diana</i> (Lacépède, 1801)	Diana's hogfish	Least Concerned		8, 15
Labridae	<i>Bodianus mesothorax</i> (Bloch and Schneider, 1801)		Least Concerned		15
Labridae	<i>Cheilinus chlorourus</i> (Bloch, 1791)		Least Concerned		15
Labridae	<i>Cheilinus digrammus</i> (Lacépède, 1801)	Cheeklined wrasse	Least Concerned		8, 15
Labridae	<i>Cheilinus fasciatus</i> (Bloch, 1791)	Redbreast wrasse	Least Concerned		8, 15
Labridae	<i>Cheilinus oxycephalus</i> (Bleeker 1853)		Least Concerned		15
Labridae	<i>Cheilinus trilobatus</i> (Lacépède, 1801)		Least Concerned		15
Labridae	<i>Cheilinus undulatus</i> (Rüppell, 1835)	Napoleon wrasse	Endangered		8, 15
Labridae	<i>Choerodon anchorago</i> (Bloch, 1791)		Least Concerned		15
Labridae	<i>Cirrhilabrus punctatus</i> (Randall and Kuitert, 1989)	Dotted wrasse	Least Concerned		15
Labridae	<i>Coris batuensis</i> (Bleeker, 1856–57)		Least Concerned		15
Labridae	<i>Coris gaimard</i> (Quoy and Baimard, 1824)	Yellowtail coris	Least Concerned		8, 15
Labridae	<i>Epibulus insidiator</i> (Pallas, 1770)	Slingjaw wrasse	Least Concerned		8, 15
Labridae	<i>Gomphosus varius</i> (Lacépède, 1801)	Bird wrasse	Least Concerned		8, 15
Labridae	<i>Halichoeres argus</i> (Bloch and Schneider, 1801)		Least Concerned		15
Labridae	<i>Halichoeres biocellatus</i> (Schultz, 1960)	Red-lined wrasse	Least Concerned		8, 15
Labridae	<i>Halichoeres chloropterus</i> (Bloch, 1791)		Least Concerned		15
Labridae	<i>Halichoeres hortulanus</i> (Lacépède, 1801)	Checkerboard wrasse	Least Concerned		15
Labridae	<i>Halichoeres leucurus</i> (Walbaum, 1792)	Greyhead wrasse	Least Concerned		15

Labridae	<i>Halichoeres melanurus</i> (Bleeker, 1851)		Least Concerned		15
Labridae	<i>Halichoeres prosopeion</i> (Bleeker, 1853)		Least Concerned		15
Labridae	<i>Halichoeres richmondi</i> (Fowler and Bean, 1928)		Least Concerned		15
Labridae	<i>Halichoeres trimaculatus</i> (Quoy and Gaimard, 1834)	Threespot wrasse	Least Concerned		15
Labridae	<i>Hemigymnus fasciatus</i> (Bloch, 1792)	Barred thicklip wrasse	Least Concerned		15
Labridae	<i>Hemigymnus melapterus</i> (Bloch, 1791)		Least Concerned		15
Labridae	<i>Hologymmnosus annulatus</i> (Lacépède, 1801)	Ring wrasse	Least Concerned		15
Labridae	<i>Labrichthys unilineatus</i> (Guichenot, 1847)		Least Concerned		15
Labridae	<i>Labroides dimidiatus</i> (Valenciennes, 1839)	Blue streak cleaner wrasse	Least Concerned		15
Labridae	<i>Labropsis micronesica</i> (Randall, 1981)		Least Concerned		15
Labridae	<i>Macropharyngodon meleagris</i> (Valenciennes, 1839)	Leopard wrasse	Least Concerned		15
Labridae	<i>Novaculichthys taeniourus</i> (Lacépède, 1801)	Rockmover wrasse	Least Concerned		15
Labridae	<i>Oxycheilinus bimaculatus</i> (Valenciennes 1840)		Least Concerned		15
Labridae	<i>Oxycheilinus digramma</i> (Lacépède, 1801)		Least Concerned		15
Labridae	<i>Pseudocheilinus evanidus</i> (Jordan and Evermann, 1903)		Least Concerned		15
Labridae	<i>Pseudocheilinus octotaenia</i> (Jenkins, 1901)		Least Concerned		15
Labridae	<i>Pseudocheilinus</i> sp.				15
Labridae	<i>Stethojulis bandanensis</i> (Bleeker, 1851)		Least Concerned		15
Labridae	<i>Thalassoma hardwicke</i> (Bennett, 1830)	Six bar wrasse	Least Concerned		15
Labridae	<i>Thalassoma lunare</i> (Linnaeus, 1758)	Moon wrasse	Least Concerned		15
Labridae	<i>Thalassoma lutescens</i> (Lay and Bennett, 1839)	Sunset wrasse	Least Concerned		15
Labridae	<i>Wetmorella nigropinnata</i> (Seale, 1901)		Least Concerned		15
Lethrinidae	<i>Lethrinus erythracanthus</i> (Valenciennes, 1830)	Longfin emperor	Least Concerned		15
Lethrinidae	<i>Lethrinus harak</i> (Forsskål, 1775)		Least Concerned		15
Lethrinidae	<i>Lethrinus variegatus</i> (Valeciennes, 1830)		Least Concerned		15
Lethrinidae	<i>Monotaxis grandoculis</i> (Forsskål, 1775)	Humpnose bigeye bream	Least Concerned		15
Lutjanidae	<i>Lutjanus argentimaculatus</i> (Forsskål, 1775)	Mangrove jack	Least Concerned		15
Lutjanidae	<i>Lutjanus biguttatus</i> (Valenciennes, 1830)	Two-spot banded snapper	Least Concerned		15
Lutjanidae	<i>Lutjanus gibbus</i> (Forsskål, 1775)		Least Concerned		15
Lutjanidae	<i>Lutjanus semicinctus</i> (Quoy and Gaimard, 1824)		Least Concerned		15
Lutjanidae	<i>Macolor macularis</i> (Fowler, 1931)	Midnight snapper	Least Concerned		15

Lutjanidae	<i>Symphoricthys spilurus</i> (Günther, 1874)	Sailfin snapper	Least Concerned		15
Megalopidae	<i>Anguilliformes Megalops cyprinoides</i> (Broussonet, 1782)		Data Deficient		15
Mobulidae	<i>Manta birostris</i> (Walbaum, 1792)	Manta Ray	Vulnerable		15
Monacanthidae	<i>Aluterus scriptus</i> (Osbeck 1765)	Srawled filefish	Least Concerned		15
Monacanthidae	<i>Cantherhines dumerilii</i> (Hollard 1854)		Least Concerned		15
Monacanthidae	<i>Cantherhines pardalis</i> (Rüppell 1837)		Least Concerned		15
Monacanthidae	<i>Monacanthus chinensis</i> (Osbeck, 1765)		Least Concerned		15
Monacanthidae	<i>Oxymonacanthus longirostris</i> (Bloch & Schneider, 1801)	Harlequin filefish	Vulnerable		15
Monacanthidae	<i>Pervagor cf. melanocephalus</i> (Bleeker, 1853)		Least Concerned		15
Monacanthidae	<i>Pervagor janthinosoma</i> (Bleeker, 1854)		Least Concerned		15
Monacanthidae	<i>Rudarius minutus</i> (Tyler, 1970)		Least Concerned		15
Mugilidae	<i>Moolgarda seheli</i> (Forsskål, 1775)		Not evaluated		15
Mullidae	<i>Parupeneus barberinoides</i> (Bleeker, 1852)		Least Concerned		15
Mullidae	<i>Parupeneus crassilabris</i> (Valenciennes, 1831)		Least Concerned		15
Mullidae	<i>Parupeneus indicus</i> (Shaw, 1803)		Least Concerned		15
Mullidae	<i>Parupeneus multifasciatus</i> (Quoy and Gaimard, 1852)	Manybar goatfish	Least Concerned		15
Mullidae	<i>Upeneus tragula</i> (Richardson, 1846)	Freckled goatfish	Least Concerned		15
Muraenidae	<i>Echidna nebulosa</i> (Ahl, 1789)	Snowflake moray	Not evaluated		15
Muraenidae	<i>Gymnothorax cf. chilospilus</i> (Bleeker, 1864)		Least Concerned		15
Muraenidae	<i>Gymnothorax elegans</i> (Bliss, 1883)		Not evaluated		15
Muraenidae	<i>Gymnothorax favagineus</i> (Bloch & Schneider, 1801)	Blackspotted Moray	Not evaluated		15
Muraenidae	<i>Gymnothorax fimbriatus</i> (Bennett, 1832)		Not evaluated		15
Muraenidae	<i>Gymnothorax flavimarginatus</i> (Rüppell, 1830)	Yellow edged Moray	Not evaluated		15
Muraenidae	<i>Gymnothorax herrei</i> (Beebe & Tee-Van, 1933)		Not evaluated		15
Muraenidae	<i>Gymnothorax javanicus</i> (Bleeker, 1859)	Giant Moray Eel	Not evaluated		15
Muraenidae	<i>Gymnothorax richardsoni</i> (Bleeker, 1852)		Not evaluated		15
Muraenidae	<i>Gymnothorax thyrsoidea</i> (Richardson, 1845)		Not evaluated		15
Muraenidae	<i>Gymnothorax undulatus</i> (Lacépède, 1803)		Not evaluated		15
Muraenidae	<i>Gymnothorax zonipectis</i> (Seale, 1906)		Not evaluated		15
Muraenidae	<i>Moringua</i> sp.				15
Muraenidae	<i>Pseudoechidna brummeri</i> (Bleeker, 1859)		Not evaluated		15



Muraenidae	<i>Rhinomuraena quaesita</i> (Garman, 1888)	Ribbon Moray	Least Concerned		15
Myliobatidae	<i>Aetobatis narinari</i> (Euphrasen 1790)		Near Threatened		15
Nemipteridae	<i>Pentapodus trivittatus</i> (Bloch, 1791)	Three-striped whiptail	Least Concerned		15
Nemipteridae	<i>Scolopsis bilineata</i> (Bloch 1793)	Two-lined monocle bream	Least Concerned		15
Nemipteridae	<i>Scolopsis ciliatus</i> (Lacépède, 1802)	Whitestreak monocle bream	Least Concerned		15
Nemipteridae	<i>Scolopsis lineata</i> (Quoy & Gaimard 1824)		Least Concerned		15
Nemipteridae	<i>Scolopsis margaritifera</i> (Cuvier 1830)	Pearly monocle bream	Least Concerned		15
Nemipteridae	<i>Scolopsis monogramma</i> (Cuvier, 1830)	Monocle bream	Least Concerned		15
Ophichthidae	<i>Callochelys marmorata</i> (Bleeker, 1853)	Marbled Snake Eel	Not evaluated		15
Ophichthidae	<i>Kaupichthys</i> sp.				15
Ophichthidae	<i>Ophichthus bonaparti</i> (Kaup, 1856)	Napolean Snake Eel	Not evaluated		15
Orectolobidae	<i>Eucrossorhinus dasypogon</i> (Bleeker 1867)	Tasselled Wobbegong	Least Concerned		15
Ostraciidae	<i>Lactoria cornuta</i> (Linnaeus, 1758)	Longhorned cowfish	Not evaluated		15
Ostraciidae	<i>Ostracion cf. cubicus</i> (Linnaeus, 1758)		Not evaluated		15
Ostraciidae	<i>Ostracion meleagris</i> (Shaw, 1796)	white-spotted boxfish	Not evaluated		15
Ostraciidae	<i>Ostracion solorensis</i> (Bleeker, 1853)	Reticulate boxfish	Not evaluated		15
Pegasidae	<i>Eurypegasus draconis</i> (Linnaeus 1766)	Short dragonfish	Least Concerned		15
Pempheridae	<i>Parapriacanthus ransonneti</i> (Steindachner, 1870)	Yellow sweeper	Not evaluated		15
Pinguipedidae	<i>Parapercis clathrata</i> (Ogilby, 1910)	Latticed grubfish	Not evaluated		15
Pinguipedidae	<i>Parapercis hexophthalma</i> (Cuvier 1829)		Not evaluated		15
Pinguipedidae	<i>Parapercis lineopunctata</i> (Randall, 2003)	Nose stripe grubfish	Not evaluated		15
Pinguipedidae	<i>Parapercis millepunctata</i> (Günther, 1860)	Blackdotted grubfish	Not evaluated		15
Pinguipedidae	<i>Parapercis xanthozona</i> (Bleeker, 1849)	Java grubfish	Least Concerned		15
Platycephalidae	<i>Cymbacephalus beauforti</i> (Knapp 1973)	Crocodile Fish	Least Concerned		15
Plesiopidae	<i>Calloplesiops altivelis</i> (Steindachner 1903)	Comet	Not evaluated		15
Plesiopidae	<i>Plesiops caeruleolineatus</i> (Rüppell, 1835)		Not evaluated		15
Plotosidae	<i>Plotosus lineatus</i> (Thunberg, 1787)	Striped Catfish	Not evaluated		15
Pomacanthidae	<i>Apolemichthys trimaculatus</i> (Cuvier 1831)	Three spot angelfish	Least Concerned		15
Pomacanthidae	<i>Centropyge bicolor</i> (Cuvier 1831)	Bicolor angelfish	Least Concerned		15
Pomacanthidae	<i>Centropyge bispinosa</i> (Günther 1860)	Twospined angelfish	Least Concerned		15
Pomacanthidae	<i>Centropyge vrolikii</i> (Bleeker 1853)		Least Concerned		15

Pomacanthidae	<i>Genicanthus melanospilos</i> (Bleeker 1857)	Blackspot angelfish	Least Concerned		15
Pomacanthidae	<i>Pomacanthus imperator</i> (Bloch 1787)	Emperor angelfish	Least Concerned		15
Pomacanthidae	<i>Pomacanthus sexstriatus</i> (Cuvier 1831)	Sixbar angelfish	Least Concerned		15
Pomacanthidae	<i>Pomacanthus xanthurus</i> (Bleeker 1853)	Yellowface angelfish	Least Concerned		15
Pomacanthidae	<i>Pygoplites diacanthus</i> (Boddaert 1772)	Royal angelfish	Least Concerned		15
Pomacentridae	<i>Abudefduf lorenzi</i> (Hensley & Allen 1977)		Least Concerned		15
Pomacentridae	<i>Abudefduf sexfasciatus</i> (Lacépède 1801)		Least Concerned		15
Pomacentridae	<i>Abudefduf vaigiensis</i> (Quoy & Gaimard 1825)		Least Concerned		15
Pomacentridae	<i>Amblyglyphidodon aureus</i> (Cuvier 1830)	Golden damselfish	Least Concerned		8, 15
Pomacentridae	<i>Amblyglyphidodon curacao</i> (Bloch 1787)	Staghorn damselfish	Least Concerned		8, 15
Pomacentridae	<i>Amblyglyphidodon leucogaster</i> (Bleeker 1847)	Yellowbelly damselfish	Least Concerned		8, 15
Pomacentridae	<i>Amphiprion clarkii</i> (Bennett 1830)	Clark's anemonefish	Not evaluated		8, 15
Pomacentridae	<i>Amphiprion melanopus</i> (Bleeker 1852)	Fire anemonefish	Least Concerned		8, 15
Pomacentridae	<i>Amphiprion percula</i> (Lacépède 1802)	Clown anemonefish	Least Concerned		8, 15
Pomacentridae	<i>Amphiprion perideraion</i> (Bleeker 1855)	Pink anemonefish	Least Concerned		8, 15
Pomacentridae	<i>Amphiprion polymnus</i> (Linnaeus 1758)	Saddleback anemonefish	Least Concerned		8, 15
Pomacentridae	<i>Chromis amboinensis</i> (Bleeker 1871)	Ambon chromis	Not evaluated		8, 15
Pomacentridae	<i>Chromis atripectoralis</i> (Welander & Schultz 1951)		Not evaluated		15
Pomacentridae	<i>Chromis atripes</i> (Fowler & Bean 1928)	Darkfin chromis	Least Concerned		8, 15
Pomacentridae	<i>Chromis margaritifer</i> (Fowler 1946)		Not evaluated		15
Pomacentridae	<i>Chromis retrofasciata</i> (Weber 1913)	Blackbar chromis	Not evaluated		8, 15
Pomacentridae	<i>Chromis ternatensis</i> (Bleeker 1856)		Not evaluated		15
Pomacentridae	<i>Chromis viridis</i> (Cuvier 1830)	Blue green damselfish	Not evaluated		8, 15
Pomacentridae	<i>Chromis weberi</i> (Fowler & Bean 1928)		Not evaluated		15
Pomacentridae	<i>Chrysiptera rollandi</i> (Whitley 1961)	Rolland's demoiselle	Not evaluated		8, 15
Pomacentridae	<i>Chrysiptera talboti</i> (Allen 1975)	Talbot's demoiselle	Not evaluated		8, 15
Pomacentridae	<i>Dascyllus aruanus</i> (Linnaeus 1758)	Humbbug dascyllus	Not evaluated		8, 15
Pomacentridae	<i>Dascyllus melanurus</i> (Bleeker 1854)		Not evaluated		15
Pomacentridae	<i>Dascyllus reticulatus</i> (Richardson 1846)		Not evaluated		8, 15
Pomacentridae	<i>Dascyllus trimaculatus</i> (Rüppell 1829)		Not evaluated		8, 15
Pomacentridae	<i>Dischistodus chrysopoecilus</i> (Schlegel & Müller 1839)		Not evaluated		15

Pomacentridae	<i>Dischistodus prosopotaenia</i> (Bleeker 1852)	Honey-head damsel	Not evaluated		8, 15
Pomacentridae	<i>Neoglyphidodon melas</i> (Cuvier 1830)		Not evaluated		15
Pomacentridae	<i>Neoglyphidodon nigroris</i> (Cuvier 1830)	Black and gold chromis	Not evaluated		8, 15
Pomacentridae	<i>Neoglyphidodon oxyodon</i> (Bleeker 1858)		Not evaluated		15
Pomacentridae	<i>Neopomacentrus azysron</i> (Bleeker 1877)	Yellowtail demoiselle	Not evaluated		8, 15
Pomacentridae	<i>Neopomacentrus taeniurus</i> (Bleeker 1856)		Data Deficient		15
Pomacentridae	<i>Plectroglyphidodon lacrymatus</i> (Quoy & Gaimard 1825)	Jewel damsel	Not evaluated		8, 15
Pomacentridae	<i>Pomacentrus amboinensis</i> (Bleeker 1868)	Ambon damsel	Not evaluated		8, 15
Pomacentridae	<i>Pomacentrus armillatus</i> (Allen 1993)		Not evaluated		15
Pomacentridae	<i>Pomacentrus bankanensis</i> (Bleeker 1854)	Speckled damselfish	Not evaluated		8, 15
Pomacentridae	<i>Pomacentrus cf. amboinensis</i> (Bleeker, 1868)		Not evaluated		15
Pomacentridae	<i>Pomacentrus cf. wardi</i> (Whitley 1927)		Not evaluated		15
Pomacentridae	<i>Pomacentrus colini</i> (Allen 1991)	Colin's damselfish	Not evaluated		8, 15
Pomacentridae	<i>Pomacentrus grammorhynchus</i> (Fowler 1918)	Bluespot damsel	Not evaluated		8, 15
Pomacentridae	<i>Pomacentrus moluccensis</i> (Bleeker 1853)		Not evaluated		15
Pomacentridae	<i>Pomacentrus nagasakiensis</i> (Tanaka 1917)	Nagasaki damsel	Not evaluated		8, 15
Pomacentridae	<i>Pomacentrus nigromanus</i> (Weber 1913)	Goldback damsel	Not evaluated		8, 15
Pomacentridae	<i>Pomacentrus pavo</i> (Bloch 1787)		Not evaluated		15
Pomacentridae	<i>Pomacentrus reidi</i> (Fowler & Bean 1928)		Not evaluated		15
Pomacentridae	<i>Premnas biaculeatus</i> (Bloch 1790)	Spinecheek anemonefish	Not evaluated		15
Pomacentridae	<i>Stegastes albifasciatus</i> (Schlegel & Müller 1839)		Not evaluated		15
Pomacentridae	<i>Stegastes fasciolatus</i> (Ogilby 1889)		Not evaluated		15
Pomacentridae	<i>Stegastes nigricans</i> (Lacépède 1802)	Dusky gregory	Not evaluated		15
Priacanthidae	<i>Priacanthus hamrur</i> (Forsskål 1775)	Crescent tail bigeye	Least Concerned		15
Pseudogrammidae	<i>Pseudogramma polyacantha</i> (Bleeker 1856)		Least Concerned		15
Pseudogrammidae	<i>Suttonia lineata</i> (Gosline 1960)		Least Concerned		15
Psuedochromidae	<i>Pictichromis aurifrons</i> (Lubbock 1980)	Yellow-headed dottyback	Not evaluated		15
Psuedochromidae	<i>Pseudochromis fuscus</i> (Müller & Troschel 1849)		Least Concerned		15
Psuedochromidae	<i>Pseudochromis marshallensis</i> (Schultz 1953)		Least Concerned		15
Psuedochromidae	<i>Pseudochromis sp.</i>				15
Pterelotridae	<i>Nemateleotris decora</i> (Randall & Allen 1973)	Purple fire goby	Least Concerned		15

Pterelotridae	<i>Nemateleotris magnifica</i> (Fowler 1938)	Fire goby	Least Concerned		15
Pterelotridae	<i>Ptereleotris evides</i> (Jordan & Hubbs 1925)	Arrow goby	Least Concerned		15
Scaridae	<i>Calotomus carolinus</i> (Valenciennes 1840)		Least Concerned		15
Scaridae	<i>Calotomus spinidens</i> (Quoy & Gaimard 1824)		Least Concerned		15
Scaridae	<i>Cetoscarus bicolor</i> (Rüppell 1829)	Bicolor parrotfish	Least Concerned		15
Scaridae	<i>Chlorurus bleekeri</i> (de Beaufort 1940)	Bleeker's parrotfish	Least Concerned		15
Scaridae	<i>Chlorurus microrhinos</i> (Bleeker 1854)		Least Concerned		15
Scaridae	<i>Chlorurus sordidus</i> (Forsskål 1775)	Bullethead parrotfish	Least Concerned		15
Scaridae	<i>Hipposcarus longiceps</i> (Valenciennes 1840)		Least Concerned		15
Scaridae	<i>Leptoscarus vaigiensis</i> (Quoy & Gaimard 1824)		Least Concerned		15
Scaridae	<i>Scarus chameleon</i> (Choat & Randall 1986)		Least Concerned		15
Scaridae	<i>Scarus flavipectoralis</i> (Schultz 1958)		Least Concerned		15
Scaridae	<i>Scarus frenatus</i> (Lacépède 1802)		Least Concerned		15
Scaridae	<i>Scarus ghobban</i> (Forsskål 1775)		Least Concerned		15
Scaridae	<i>Scarus niger</i> (Forsskål 1775)	Swarthy parrotfish	Least Concerned		15
Scaridae	<i>Scarus quoyi</i> (Valenciennes 1840)		Least Concerned		15
Scaridae	<i>Scarus rivulatus</i> (Valenciennes 1840)		Least Concerned		15
Scaridae	<i>Scarus schlegeli</i> (Bleeker 1861)		Least Concerned		15
Scaridae	<i>Scarus spinus</i> (Kner 1868)		Least Concerned		15
Sciaenidae	<i>Sciaenops</i> sp.				15
Scombridae	<i>Euthynnus affinis</i> (Cantor 1849)		Least Concerned		15
Scombridae	<i>Katsuwonus pelamis</i> (Linnaeus 1758)		Least Concerned		15
Scombridae	<i>Rastrelliger kanagurta</i> (Cuvier 1816)		Data Deficient		15
Scombridae	<i>Scomberoides lysan</i> (Forsskål 1775)		Least Concerned		15
Scombridae	<i>Scomberoides tol</i> (Cuvier 1832)		Least Concerned		15
Scorpaenidae	<i>Ablabys taenianotus</i> (Cuvier 1829)		Not evaluated		15
Scorpaenidae	<i>Dendrochirus brachypterus</i> (Cuvier 1829)	Shortfin Lionfish	Least Concerned		15
Scorpaenidae	<i>Dendrochirus zebra</i> (Cuvier 1829)	Zebra lionfish	Least Concerned		15
Scorpaenidae	<i>Pterois antennata</i> (Bloch 1787)	Spotfin lionfish	Least Concerned		15
Scorpaenidae	<i>Pterois volitans</i> (Linnaeus 1758)	Common Lionfish	Least Concerned		15
Scorpaenidae	<i>Rhinopias aphanes</i> (Eschmeyer 1973)	Lacy Scorpionfish	Least Concerned		15

Scorpaenidae	<i>Scorpaenodes albaiensis</i> (Evermann & Seale 1907)		Least Concerned		15
Scorpaenidae	<i>Scorpaenodes guamensis</i> (Quoy and Gaimard 1824)		Least Concerned		15
Scorpaenidae	<i>Scorpaenodes hirsutus</i> (Smith 1957)		Least Concerned		15
Scorpaenidae	<i>Scorpaenodes parvipinnis</i> (Garrett 1864)		Least Concerned		15
Scorpaenidae	<i>Scorpaenodes</i> sp. 1				15
Scorpaenidae	<i>Scorpaenodes</i> sp. 2				15
Scorpaenidae	<i>Scorpaenopsis diabolus</i> (Cuvier 1829)	Devil scorpionfish	Least Concerned		8, 15
Scorpaenidae	<i>Scorpaenopsis macrochir</i> (Ogilby 1910)	Flasher scorpionfish	Least Concerned		8, 15
Scorpaenidae	<i>Scorpaenopsis oxycephala</i> (Bleeker 1849)	Tasselled scorpionfish	Least Concerned		8, 15
Scorpaenidae	<i>Scorpaenopsis possi</i> (Randall & Eschmeyer 2001)	Poss's scorpionfish	Least Concerned		8, 15
Scorpaenidae	<i>Scorpaenopsis venosa</i> (Cuvier 1829)	Raggy scorpionfish	Least Concerned		8, 15
Scorpaenidae	<i>Sebastapistes</i> sp.				15
Scorpaenidae	<i>Sunagocia</i> sp.	Fringe lip flathead			15
Scorpaenidae	<i>Taenianotus triacanthus</i> (Lacépède 1802)	Leaf Scorpionfish	Least Concerned		15
Serranidae	<i>Anyperodon leucogrammicus</i> (Valenciennes 1828)	White-lined rockcod	Least Concerned		15
Serranidae	<i>Cephalopholis argus</i> (Schneider 1801)		Least Concerned		8, 15
Serranidae	<i>Cephalopholis boenak</i> (Bloch 1790)		Least Concerned		15
Serranidae	<i>Cephalopholis leopardus</i> (Lacépède 1801)		Least Concerned		15
Serranidae	<i>Cephalopholis miniata</i> (Forsskål 1775)	Coral rockcod	Least Concerned		8, 15
Serranidae	<i>Cephalopholis urodeta</i> (Forster 1801)	Flagtail rockcod	Least Concerned		8, 15
Serranidae	<i>Cromileptes altivelis</i> (Valenciennes 1828)	Barramundi cod	Vulnerable		15
Serranidae	<i>Diploprion bifasciatum</i> (Cuvier 1828)	Barred soapfish	Least Concerned		15
Serranidae	<i>Epinephelus fasciatus</i> (Forsskål 1775)	Black-tip rockcod	Least Concerned		8, 15
Serranidae	<i>Epinephelus fuscoguttatus</i> (Forsskål 1775)	Flowery cod	Near Threatened		8, 15
Serranidae	<i>Epinephelus maculatus</i> (Bloch 1790)	Marbled rockcod	Least Concerned		8, 15
Serranidae	<i>Epinephelus merra</i> (Bloch 1793)	Honeycomb cod	Least Concerned		8, 15
Serranidae	<i>Epinephelus polyphkadion</i> (Bleeker 1849)	Camouflage cod	Near Threatened		8, 15
Serranidae	<i>Grammistes sexlineatus</i> (Thunberg 1792)	Lined soapfish	Least Concerned		15
Serranidae	<i>Plectropomus laevis</i> (Lacépède 1801)	Blacksaddle coral trout	Vulnerable		15
Serranidae	<i>Plectropomus leopardus</i> (Lacépède 1802)		Near Threatened		15
Serranidae	<i>Pseudanthias fasciatus</i> (Kamohara 1954)	One-stripe anthias	Not evaluated		8, 15

Serranidae	<i>Pseudanthias hypselosoma</i> (Bleeker 1878)	Stocky anthias	Least Concerned		8, 15
Serranidae	<i>Pseudanthias luzonensis</i> (Katayama & Masuda 1983)		Least Concerned		8, 15
Serranidae	<i>Pseudanthias pleurotaenia</i> (Bleeker 1857)	Square-spot anthias	Least Concerned		8, 15
Serranidae	<i>Pseudanthias squamipinnis</i> (Peters 1855)	Scalefin anthias	Least Concerned		8, 15
Serranidae	<i>Pseudanthias tuka</i> (Herre & Montalban 1927)	Purple anthias	Least Concerned		8, 15
Siganidae	<i>Siganus argenteus</i> (Quoy & Gaimard 1825)		Least Concerned		15
Siganidae	<i>Siganus javus</i> (Linnaeus 1766)	Java rabbitfish	Least Concerned		15
Siganidae	<i>Siganus puellus</i> (Schlegel 1852)		Least Concerned		15
Siganidae	<i>Siganus spinus</i> (Linnaeus 1758)		Least Concerned		15
Siganidae	<i>Siganus vulpinus</i> (Schlegel & Müller 1845)		Least Concerned		15
Soleidae	<i>Pardachirus pavoninus</i> (Lacépède 1802)		Least Concerned		15
Soleidae	<i>Pardachirus</i> sp.				15
Solenostomidae	<i>Solenostomus cyanopterus</i> (Bleeker 1854)	Robust ghost pipefish	Least Concerned		15
Solenostomidae	<i>Solenostomus halimeda</i> (Orr, Fritzsche & Randall 2002)	Halimeda ghost pipefish	Data Deficient		15
Solenostomidae	<i>Solenostomus paegnius</i> (Jordan & Thompson 1914)	Rough snout ghost pipefish	Not evaluated		15
Solenostomidae	<i>Solenostomus paradoxus</i> (Pallas 1770)	Ornate ghost pipefish	Least Concerned		15
Sphyraenidae	<i>Sphyraena flavicauda</i> (Rüppell 1838)	Yellowtail barracuda	Not evaluated		15
Sphyraenidae	<i>Sphyraena qenie</i> (Klunzinger 1870)	Blackfin barracuda	Not evaluated		15
Stegostomatidae	<i>Stegostoma fasciatum</i> (Hermann 1783)	Leopard Shark	Endangered		15
Synanceia	<i>Synanceia verrucosa</i> (Bloch & Schneider 1801)		Not evaluated		15
Syngnathidae	<i>Corythoichthys amplexus</i> (Dawson & Randall 1975)	Brown-banded pipefish	Least Concerned		15
Syngnathidae	<i>Corythoichthys haematopterus</i> (Bleeker 1851)	Messmate pipefish	Least Concerned		15
Syngnathidae	<i>Corythoichthys intestinalis</i> (Ramsay 1881)	Scribbled pipefish	Least Concerned		15
Syngnathidae	<i>Corythoichthys ocellatus</i> (Herald 1953)	Ocellated pipefish	Least Concerned		15
Syngnathidae	<i>Corythoichthys polynotatus</i> (Dawson 1977)	Many spotted pipefish	Least Concerned		15
Syngnathidae	<i>Corythoichthys schultzi</i> (Herald 1953)	Schultz's pipefish	Least Concerned		15
Syngnathidae	<i>Doryrhamphus dactylophorus</i> (Bleeker 1853)	Ringed pipefish	Data Deficient		15
Syngnathidae	<i>Hippocampus</i> sp.	Seahorse			8
Syngnathidae	<i>Syngnathoides biaculeatus</i> (Bloch 1785)	Alligator pipehorse	Least Concerned		15
Syngnathidae	<i>Trachyrhamphus bicoarctatus</i> (Bleeker 1857)	Bend stick pipefish	Least Concerned		15
Synodontidae	<i>Saurida gracilis</i> (Quoy & Gaimard 1824)	Gracile Lizardfish	Least Concerned		15

Synodontidae	<i>Synodus dermatogenys</i> (Fowler 1912)		Least Concerned		15
Synodontidae	<i>Synodus rubromarmoratus</i> (Russell & Cressey 1979)	Redmarbled lizardfish	Least Concerned		15
Synodontidae	<i>Synodus variegatus</i> (Lacépède 1803)	Variiegated lizardfish	Least Concerned		15
Tetradontidae	<i>Arothron caeruleopunctatus</i> (Matsuura 1994)		Least Concerned		15
Tetradontidae	<i>Arothron hispidus</i> (Linnaeus 1758)	White spotted pufferfish	Least Concerned		15
Tetradontidae	<i>Arothron manilensis</i> (Marion de Procé 1822)	Narrow-lined pufferfish	Least Concerned		15
Tetradontidae	<i>Arothron mappa</i> (Lesson 1831)	Map pufferfish	Least Concerned		15
Tetradontidae	<i>Arothron nigropunctatus</i> (Bloch & Schneider 1801)	Blaack-spotted pufferfish	Least Concerned		15
Tetradontidae	<i>Arothron stellatus</i> (Anonymous 1798)	Starry pufferfish	Least Concerned		15
Tetradontidae	<i>Canthigaster compressa</i> (Marion de Procé 1822)	Compressed Toby	Least Concerned		15
Tetradontidae	<i>Canthigaster janthinoptera</i> (Bleeker 1855)	Honeycomb toby	Least Concerned		15
Tetradontidae	<i>Canthigaster papua</i> (Bleeker 1848)	Papuan toby	Least Concerned		15
Tetradontidae	<i>Canthigaster valentini</i> (Bleeker 1853)	Valentini's sharpnose toby	Least Concerned		15
Tetradontidae	<i>Tetradontidae</i> sp.				15
Trichonotidae	<i>Trichonotus setiger</i> (Bloch & Schneider 1801)	Spotted sand diver	Least Concerned		15
Tripterygiidae	<i>Enneapterygius</i> sp.				15
Tripterygiidae	<i>Helcogramma</i> sp. 1				15
Tripterygiidae	<i>Helcogramma</i> sp. 2				15
Tripterygiidae	<i>Helcogramma striatum</i> (Hansen 1986)	Striped triplefin	Least Concerned		15
Xenisthmidae	<i>Xenisthmus cf. polyzonatus</i> (Klunzinger 1871)		Least Concerned		15
Zanclidae	<i>Zanclus cornutus</i> (Linnaeus 1758)	Moorish idol	Least Concerned		15

## CHAPTER 3. FLORA SURVEY

### Introduction

The floral compositions along the margin of the seashores play very significant roles in protecting the marine diversity. It is now known that the coral reef, seagrass meadow and the mangrove-beach forests play complimentary roles in protecting the marine and coastal ecosystems. The mangrove forest protect the marine ecosystems from land based pollution while coral reefs and seagrass meadows protect the coastline communities from catastrophic events such as tsunami and king tides.

This section reports the floral surveys conducted on the mangrove forests at Bogoro Inlet and on Motupore Island.

### **Objectives**

The objective of the survey is two-fold;

- i. to determine the species composition of the mangrove forest
- ii. to determine the distribution patterns of plant species.

### **Material and Methods**

Two sites were pre-selected; the Bogoro Inlet and Motupore Island (Figure 1). In both sites, 6 sampling stations were randomly selected from satellite images; 2 at Bogoro Inlet and 4 at Motupore Island (Figure 4). In each station a straight line of travel was established, traversing perpendicular to the coastline with the starting point (0m) at the mangrove–seaward edge or the intertidal zone. The mangrove-sea interphase forms the reference point for marine and terrestrial biodiversity surveys (see Figure 5). Along the line of travel, transects of dimension 2 x 40m, were established at every 50m interval towards the back of the mangrove forest (eg. 0, 50, 100, 150m etc.). In each transect all plants were identified, enumerated and categorized into the following lifeform categories;

- Seedling – plants less than 1m tall.
- Sapling – plants greater than 1m tall but less than 5m, diameter generally less than 5cm.
- Shrub – plant branching at almost ground level, very bushy reaching heights of 3m to 5m.
- Climber – Creeping or crawling or climbing plant.
- Treelet or tree. – plant general with sympodial branching and greater than 5 m tall.

Stem diameters of shrub, treelets and trees were measured using calibrated diameter tape while saplings and seedlings were all categorized under the  $\leq 5$ cm diameter dbh.





Figure 4. Location of sampling stations at Bogoro Inlet and Motupore Island. Stations 1 and 2 at Bogoro Inlet and stations 3, 4, 5 and 6 on Motupore Island.

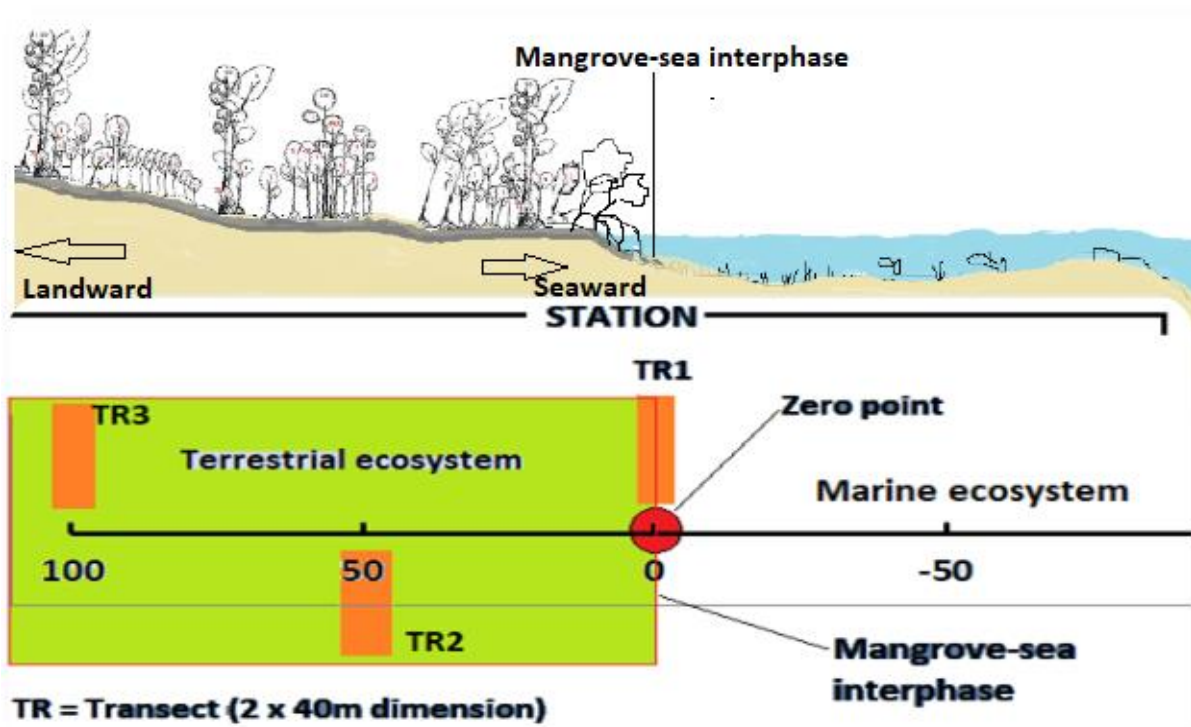


Figure 5. Schematic diagram of flora survey at each station. Sampling transects (TR) indicated by shaded orange rectangular.

## Results

### Floral diversity

A total of 443 individuals, representing 54 species were recorded in both sites. Within Bogoro Inlet, only 9 species were recorded while 49 species were recorded on Motupore Island. Of the 54 species, 16 were mangrove species. A summary of the sites and stations is presented in Table 15 below. A list of the species recorded is attached as appendix to this section.

The species enumerated in all transects effectively represent only 20% of the total foral diversity. This is an artifact of sampling intensity. Our samplings were concentrated more at the mangrove edges. Nonetheless, opportunistic survey of the flora confirms the 300+ species recorded in the area. On Motupore Island, two additional species, *Scaevola taccada*, and *Intsia bijuga*, were included to the list.



Plate 1. *Scaevola taccada* was recorded in the 1970s but was not present in the 1990s. Reappeared again on Motupore Island

Table 15. Summary of the two sites and their stations (see text in material and methods above).

Characteristics	Site 1- Bogoro Inlet		Site 2 – Motupore Island			
	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Forest type	Mangrove	Mangrove	Mangrove/ Strand	Mangrove	Mangrove	Strand
No. of transects	10	3	3	1	1	1
Total area sampled (m <sup>2</sup> )	800	120	120	40	40	40
No. Species recorded (no. stems)	6(103)	7 (123)	25 (67)	9 (51)	25 (66)	5 (31)
Mean Diameter (cm)	7.48 ± 0.72	3.70 ± 0.47	6.56± 0.83	7.60± 0.70	4.83 ± 0.69	6.63 ± 1.23
Common species	<i>C. tagal</i> , <i>R. apiculata</i> <i>R. stylosa</i>	<i>R. stylosa</i> , <i>Bruguera</i> <i>gymnorhyza</i>	<i>R. apiculata</i> <i>R. stylosa</i>	<i>R. stylosa</i>	<i>R. stylosa</i>	Mix species

### Lifeforms

A diversity of lifeforms was recorded on Motupore Island due to some transects traversing through different habitats. At Bogoro Inlet only trees and their seedlings or saplings were recorded. No other plant

lifeforms were recorded. Note the abundance of seedlings/saplings at the Bogoro Inlet (Stations 1 and 2 of Site 1) signifying wanton clearance of mangroves taking place.

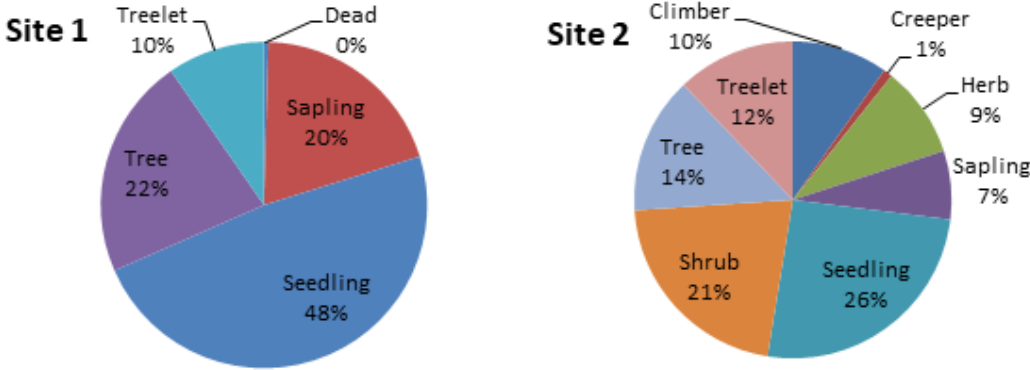


Figure 6. Lifeform cover of Site 1(Bogoro Inlet) and Site 2 (Motupore Island).

## Vegetation structure

The structure of the vegetation, particularly the mangrove follows a typical J-shape curve typical of natural forest. Under close canopy, mangrove forests tended to have less sapplings, let alone seedling establishment. Overall analysis of the diameter indicates a higher seedling and sapling counts at Bogoro Inlet (45%) indicating a highly disturbed vegetation.

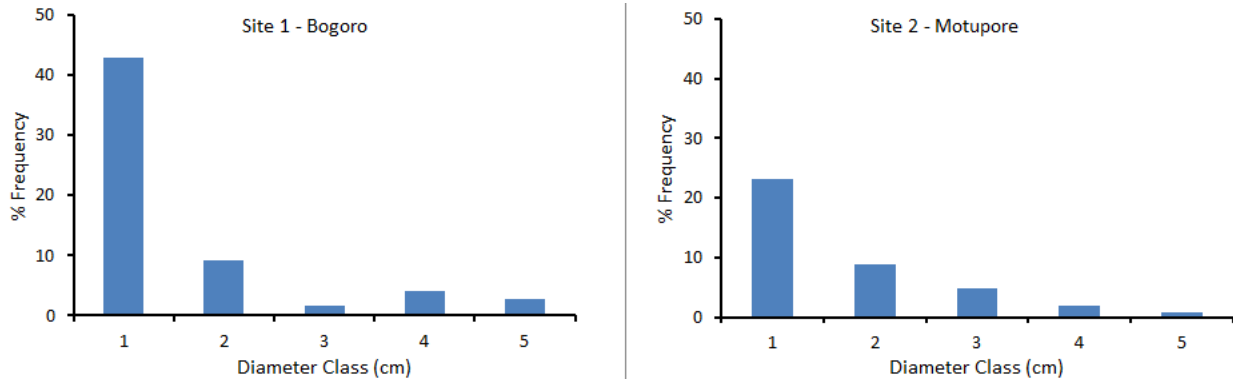


Figure 7. Diameter class distributions for Bogoro Inlet (Site 1) and Motupore Island (Site 2). Diameter class: 1 = <5cm; 2 = 5-10cm; 3 = 10.1-15cm; 4 = 15.1-20cm and 5 = >20cm.

## Discussion

An estimated 300 plant species have been recorded within the Bogoro Inlet and Motupore Island [2, 3, 4]. On Motupore alone, a total of 231 plant species have been recorded, described and published in the book “*The Flora of Motupore Island*” by Hopkins and Menzies [4]. Appendix 3-1 list the species recorded so far in the area.

According to the Papua New Guinea Conservation Needs Assessment published in 1993 [9], the Bogoro Inlet and Motupore Island area lies within the ‘Central Province Dry Zone’, an area of important terrestrial biodiversity comprising savanna and monsoon forest complex with wetlands. Thus the floral diversity of Bogoro Inlet and Motupore Island is typical of the coastal lowlands of Port Moresby.

Heyligers in 1972 reported 292 correctly identified plant species in the coastal lowland of Port Moresby [8]. This figure has not changed thus placing Bogoro Inlet and Motupore Island as very speciose, representing almost all the floral elements occurring in the Port Moresby area. Moreover, all the endemic species recorded in the coastal lowland of Port Moresby are all present on Motupore Island. These include *Cycas campestris*, *Bridelia oligantha*, *Albizia carri*, *Canthium suborbiculare*, and *Jossinia desmantha*. Given the looming pressure on plant resources and land areas for settlement within NCD (eg. expanding settlement at Gereka), Bogoro Inlet and Motupore Island become ideal refugia and heritage area for NCD and Central Province.

For the mangroves, Maniwavie [5] recorded 31 species within the entire Bootless Bay. There were 17 species of mangroves, previously recorded in Bogoro and Motupore Island; 11 confirmed on Motupore and 6 additional species at Bogoro Inlet (Table 2). *Bruguiera cylindrica* and *Avicennia officinalis* were recorded in this survey. All mangrove species are listed under the IUCN Redlist as “least concern”. However, the mangrove ecosystem itself is under threat as advocated throughout the world [6] and as such all organisms present should be included as vulnerable to anthropogenic interference.

Table 16. Mangrove species occurring with Bogoro Inlet and Motupore Island

Family	Scientific name	Common name	IUCN Redlist
Combretaceae	<i>Lumnitzera racemosa</i>	White-flowered Black Mangrove	Least Concern
Meliaceae	<i>Xylocarpus granatum</i>	Cannonball Mangrove	Least Concern
Myrsinaceae	<i>Aegiceras corniculatum</i>	River Mangrove	Least Concern
Myrtaceae	<i>Osbornia octodonta</i>	Myrtle Mangrove	Least Concern
Plumbaginaceae	<i>Aegialitis annulata**</i>	Club Mangrove	Least Concern
Rhizophoraceae	<i>Bruguiera gymnorhiza</i>	Large-leaf Orange Mangrove	Least Concern
	<i>Bruguiera cylindrica*</i>	Orange Mangrove	Least Concern
	<i>Ceripos taga var. tagal</i>	Rib-fruited Yellow Mangrove	Least Concern
	<i>Rhizophora apiculata</i>	Corky Stilt Mangrove	Least Concern
	<i>Rhizophora lamarckii</i>	Southern Hybrid Stilt Mangrove	Least Concern
	<i>Rhizophora mucronata</i>	Upstream Stilt Mangrove	Least Concern
	<i>Bruguiera sexangula</i>	Upriver Orange Mangrove	Least Concern
	<i>Rhizophora stylosa</i>	Long-styled Stilt Mangrove	Least Concern
Sonneratiaceae	<i>Sonneratia alba</i>	White-flowered Apple Mangrove	Least Concern
Sterculiaceae	<i>Heritiera littoralis</i>	Looking-glass Mangrove	Least Concern
Verbenaceae	<i>Avicennia marina</i>	Grey/White Mangrove	Least Concern
	<i>Avicennia eucalyptifolia</i>	Grey/White Mangrove	Least Concern
	<i>Avicennia officinalis*</i>	Grey mangrove	Least Concern

\*Recorded this survey \*\*Becoming rare locally



Plate 2. The mangrove *Aegialites annulata* becoming rare in Bootless Bay. Occuring on Motupore Island. Photo by Pius Piskaut, 2018.

### **Conclusion**

The floral diversity of Bogoro Inlet and Motupore Island represent the dry coastal lowlands of the Port Moresby area. Most of the native, naturalized and endemic plant species occur in the area, particularly on Motupore Island. Motupore Island is a research sanctuary and the whole island is under protection.

Distraction of mangrove forests appeared uncontrolled at Bogoro Inlet as indicated by the seedling abundance. The Inlet mangrove forest is important to fisheries and the entire marine ecosystem thus requires some management to regulate the clearance of trees.

Nevertheless, Bogoro Inlet and Motupore Island are very speciose thus are ideal for conservation as refugia of significant heritage to NCD and Central Provinve.



## References

1. SAS. 2012. JMP Statistical Package. California, USA.
2. Frodin D G. 1983. The vegetation of Motupore Island. 1. MIRD workshop.
3. Frodin & Johnstone unpubl. manuscript
4. Hopkins F, H and I. Menzies, 1995. Flora of Motupore Island. UPNG Press. University of Papua New Guinea Press, NCD, Papua New Guinea.
5. Maniwavie T. 2009. Pictorial guide to mangrove of Papua New Guinea. Unpublished manuscript. University of Papua New Guinea
6. Piskaut P and R. Samuel, 2007. Mangroves of the Madang Lagoon. Technical Report. WWF, Papua New Guinea.
7. Frodin D. & Leach G. 1982. The mangrove of the Port Moresby Region. Occasional Paper No. 3, Biology Department.
8. Heyligers P C. 1972. Analysis of the Plant Geography of the Semideciduous Scrub and Forest and the Eucalypt Savannah near Port Moresby. *Pacific Science* **26**: 229-241.
9. Swartzendruber J. F. (1993) Papua New Guinea Conservation Needs Assessment Synopsis Report. Government of Papua New Guinea Department of Conservation and Environment. Boroko, Papua New Guinea.

### Appendix 3-1. List of Plant species recorded in survey.

Species	Frequency of Occurrence	Species	Frequency of Occurrence
<i>Aegialitis annulata</i>	6	<i>Flagellaria indica</i>	1
<i>Aegiceras corniculatum</i>	1	<i>Garuga floribunda</i>	1
<i>Albizia carii</i>	1	<i>Grewia</i> sp.	2
<i>Alectryon repandodentatus</i>	3	<i>Gymnanthera oblonga</i>	1
<i>Alstonia spectabilis</i>	1	<i>Harrisonia brownii</i>	1
<i>Asclepiadaceae</i>	1	<i>Ichnocarpus frutescens</i>	1
<i>Avicennia eucalyptifolia</i>	2	<i>Jacquemontia paniculata</i>	2
<i>Avicennia officinalis</i>	4	<i>Jasminum didymum</i>	6
<i>Bombax ceiba</i>	1	<i>Jossinia desmantha</i>	1
<i>Bridelia oligantha</i>	2	<i>Maclura cochinchinensis</i>	1
<i>Bruguiera cylindrica</i>	2	<i>Maytenus emarginata</i>	4
<i>Bruguiera gymnorhiza</i>	37	<i>Micromelum minutum</i>	16
<i>Bruguiera sexangula</i>	1	<i>Mimusops elengii</i>	3
<i>Canthium suborbiculare</i>	1	<i>Nypa fruticans</i>	2
<i>Celtis philippinensis</i>	2	<i>Osbornia octodonta</i>	27
<i>Ceriops tagal</i>	144	<i>Premna serratifolia</i>	1
<i>Clerodendrum inerme</i>	3	<i>Psychotria bracteosa</i>	1
<i>Commelina ensifolia</i>	2	<i>Rhizophora apiculata</i>	33
<i>Cordia subcordata</i>	1	<i>Rhizophora lamarckii</i>	1
<i>Cupaniopsis curvidens</i>	1	<i>Rhizophora mucronata</i>	21
<i>Cycas campestris</i>	7	<i>Rhizophora stylosa</i>	39
<i>Cyperus rotundus</i>	4	<i>Secamone elliptica</i>	2
<i>Dioscorea esculenta</i>	2	<i>Sonneratia alba</i>	3
<i>Drypetes australasica</i>	14	<i>Themeda australis</i>	12
<i>Elaeocarpus arnhemicus</i>	5	<i>Trophis scandens</i>	5
<i>Exocarpus latifolius</i>	1	<i>Turraea virens</i>	2
<i>Fatoua pilosa</i>	4	<i>Xylocarpus granatum</i>	1



## CHAPTER 4. TERRESTRIAL FAUNA SURVEY (BIRDS, INSECT, REPTILES)

### Introduction

Avian assessment was conducted at two sites within the Bootless Bay; site 1 at Bogoro Inlet and site 2 at Motupore Island (see Figure 8 below). The sites are adjacent to each other therefore the birds forage between the sites. The survey covered the whole island with observations conducted at stations 3, 4 and 6. At Bogoro Inlet, observations were conducted is stations 1 and 2.

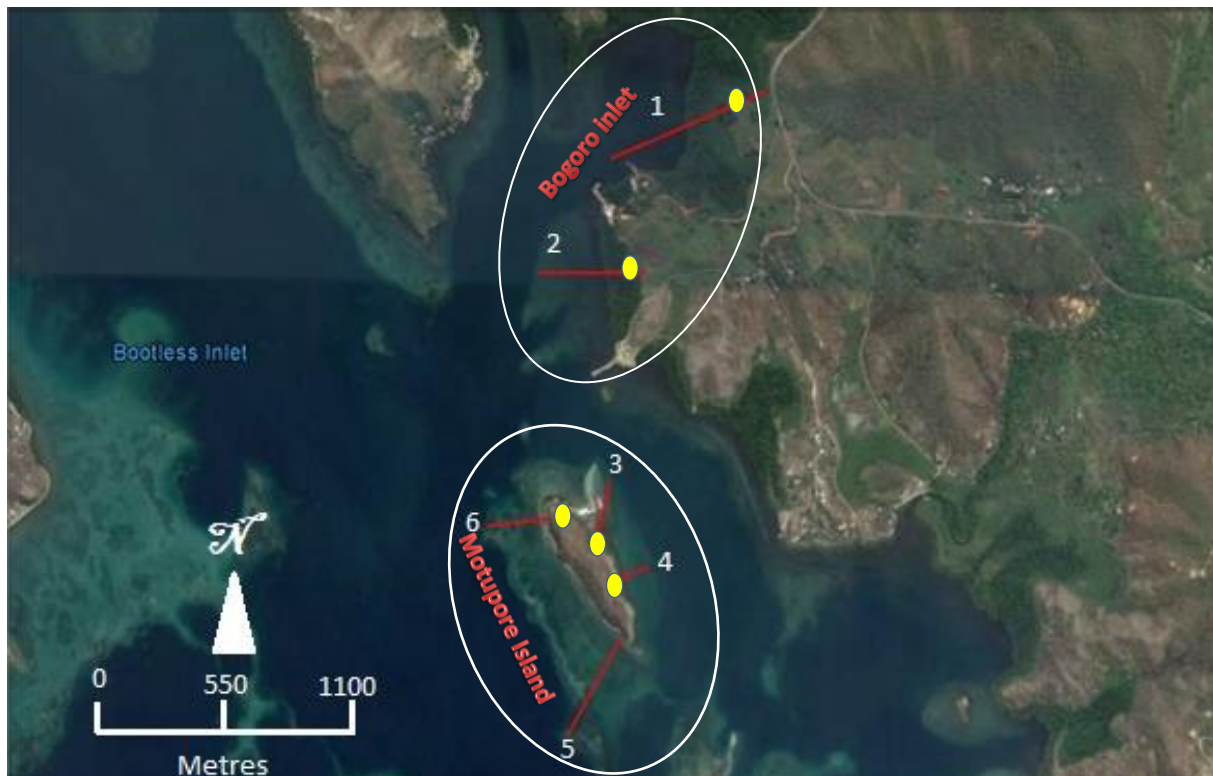


Figure 8. Observational sites (Bogoro Inlet and Motupore Island) and stations within sites. Yellow dots indicate observation stations.

### Material and Methods

Two (2) methods or techniques of data collection were employed during this survey; 1. Point counts (bird species) and 2. Mist Nets for flying mammals and bird species.

#### Point Counts

A 10 minutes point count method was deployed to record the bird species within a 50m radius. This technique involved pre-determining observation points or stations usually on a straight line, approximately 50m apart. Using the “Distance App” for android phone (Potatotree Soft), a 50m radius station was determined using natural pegs or markers such as trees, and boulders. Within the larger 50m radius, distance proxies of 10m, 20m, 30m, 40m and >50m were quickly established.

At each station, a 10 minutes observation of birds was conducted. Birds sighted or identified from unique calls were categorized into distance proxies of 10m radius, 20m, 30m, 50m and >50m radius. This technique was used to determine the population size of bird species within a defined area (Figure 9).

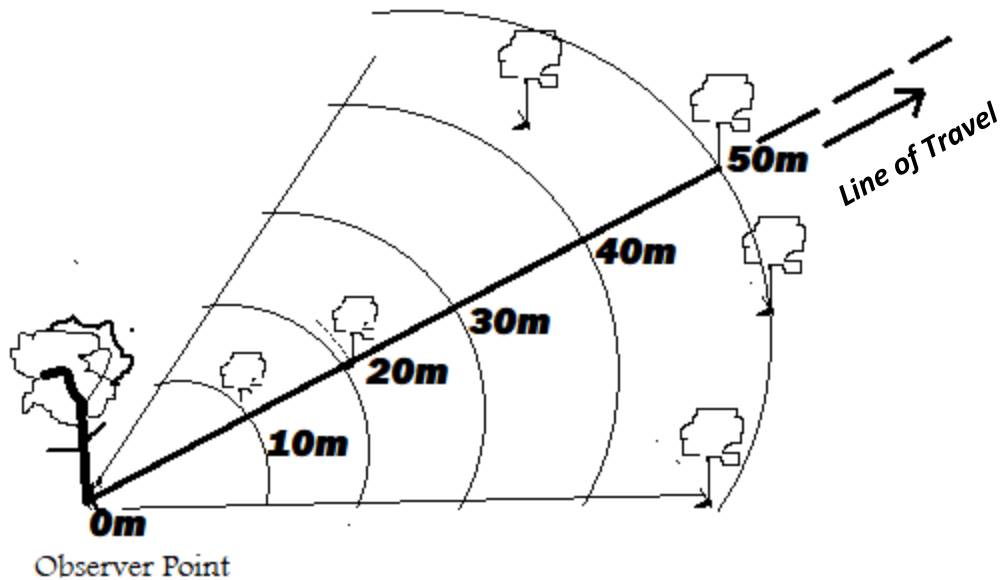


Figure 9. Schematic diagram of a 10-minute Point count described in the text above.

### **Mist nets for birds and bats**

Mist nets were used for capturing flying vertebrates such as bats, flying foxes and birds. A narrow lane of approximately 20 - 30 meters was minimally cleared of vegetation and mist nets were erected on poles of 2.5 – 3.0m high. Nets were left open all through each day of the survey for birds and left open all through the nights for bats. The nets were set up randomly in beach strand forest and at mangrove edges. The setup were checked every day in the mornings from 6:00am to 8:30am and again in the afternoons starting at 4:30pm to 7:30pm for two days.

### **Results**

A total of 52 species of birds were recorded at Bogoro Inlet and Motupore Island over an eight day period. These are listed below (Table 17). On Motupore Island, a 10-minutes point counts covering 6 sites and starting at 6.30am and ending at 8.15am recorded 99 individuals, representing 33 species. Of this total, 44 individuals were recorded from calls while 54 were sighted.

Table 17. Check list of birds recorded at Bogoro Inlet (Site 1) and on Motupore Island (Site 2). [CODE, \* = Residents; \*\*\*= new record for Motupore Island (red)].

Scientific Name	Common Name	IUCN Status	References
<i>Geopelia humeralis</i> *	Bar-shouldered Dove	Least Concern	1, 2, 3
<i>Cracticus mentalis</i> *	Black-backed Butcherbird	Least Concern	1, 2, 3.
<i>Coracina novaehollandiae</i> *	Black-faced Cuckoo-shrike	Least Concern	2, 3, 4.
<i>Dacelo leachii</i> *	Blue-winged Kookaburra	Least Concern	1, 2, 3.
<i>Haliastur indus</i> *	Brahminy Kite	Least Concern	1, 2, 3.
<i>Onychoprion anaethetus</i> *	Bridled Tern	Least Concern	5, 2, 3.
<i>Accipiter fasciatus</i> *	Brown Goshawk	Least Concern	6, 2, 3.
<i>Ardea ibis</i>	Cattle Egret	Least Concern	5, 2, 3.
<i>Scythrops novaehollandiae</i> *	Channel-billed Cuckoo	Least Concern	4, 2, 3.
<i>Todirhamphus chloris</i> * ( <i>collaris</i> )	Collared Kingfisher	Least Concern	1, 2, 3.
<i>Actitis hypoleucos</i>	Common Sandpiper	Least Concern	5, 2, 3.
<i>Sterna hirundo</i>	Common Tern	Least Concern	5, 2, 3.
<i>Egretta sacra</i> *	Eastern Reef-Egret	Least Concern	4, 2, 3.
<i>Eclectus roratus</i> ***	Eclectus Parrot	Least Concern	1, 2, 3.
<i>Passer montanus</i> ***	Eurasian Tree Sparrow	Least Concern	5, 2, 3.
<i>Chlamydera cerviniventris</i> *	Fawn-breasted Bowerbird	Least Concern	1, 2, 3.
<i>Meliphaga gracilis</i> *	Graceful Meliphaga	Least Concern	8, 2, 3.
<i>Lonchura caniceps</i>	Grey-headed Mannikin	Least Concern	7, 2, 3.
<i>Colluricincla harmonica</i> ***	Grey Shrikethrush	Least Concern	1, 2, 3.
<i>Philemon buceroides</i> *	Helmeted Friarbird	Least Concern	1, 2, 3.
<i>Passer domesticus</i> ***	House Sparrow	Least Concern	7, 2, 3.
<i>Fregata ariel</i> *	Lesser Frigatebird	Least Concern	4, 2, 3.
<i>Ceyx pusillus</i>	Little Kingfisher	Least Concern	1, 2, 3.
<i>Colluricincla megarhyncha</i> ***	Little shrikethrush	Least Concern	9, 2, 3.
<i>Microcarbo melanoleucos</i>	Little Pied Cormorant	Least Concern	4, 2, 3.
<i>Gerygone levigaster</i> *	Mangrove Gerygone	Least Concern	1, 2, 3.
<i>Pachycephala melanura</i> *	Mangrove Golden Whistler	Least Concern	1, 2, 3.
<i>Meliphaga analoga</i>	Mimic Meliphaga	Least Concern	7, 2, 3.
<i>Cinnyris jugularis</i> ***	Olive-backed Sunbird	Least Concern	7, 2, 3.
<i>Megapodius reinwardt</i> *	Orange-footed Scrubfowl	Least Concern	10, 3, 2.
<i>Ptilinopus aurantiifrons</i> *	Orange-fronted Fruit-Dove	Least Concern	6, 2, 3.
<i>Cuculus optatus</i> ***	Oriental Cuckoo	Least Concern	6, 2, 3.
<i>Anas superciliosa</i>	Pacific Black Duck	Least Concern	4, 2, 3.
<i>Chalcophaps longirostris</i> *	Pacific Emerald Dove	Least Concern	6, 2, 3.

<i>Hirundo tahitica</i> *	Pacific Swallow	Least Concern	7, 2, 3.
<i>Podargus papuensis</i>	Papuan Frogmouth	Least Concern	1, 2, 3.
<i>Geopelia placida</i> ***	Peaceful Dove	Least Concern	6, 2, 3.
<i>Meliphaga aruensis</i> *	Puff-backed Meliphaga	Least Concern	7, 2, 3.
<i>Trichoglossus haematodus</i>	Rainbow Lorikeet	Least Concern	6, 2, 3.
<i>Conopophila albogularis</i> *	Rufous-banded Honeyeater	Least Concern	1, 2, 3
<i>Myiagra alecto</i> *	Shining Flycatcher	Least Concern	1, 2, 3.
<i>Xanthotis flaviventer</i>	Tawny-breasted Honeyeater	Least Concern	1, 2, 3..
<i>Corvus orru</i> *	Torresian Crow	Least Concern	7, 2, 3.
<i>Ducula spilorrhoe</i> ***	Torresian Imperial Pigeon	Least Concern	6, 2, 3
<i>Numenius phaeopus (sum mig)</i>	Whimbrel	Least Concern	5, 2, 3.
<i>Haliastur sphenurus</i> *	Whistling Kite	Least Concern	1, 2, 3.
<i>Coracina papuensis</i> *	White-bellied Cuckoo-shrike	Least Concern	1, 2, 3.
<i>Haliaeetus leucogaster</i> *	White-bellied Sea-eagle	Least Concern	1, 2, 3
<i>Artamus leucorhynchus</i> *	White-breasted Woodswallow	Least Concern	1, 2, 3
<i>Rhipidura leucophrys</i> *	Willie Wagtail	Least Concern	1, 2, 3.
<i>Mino dumontii</i> **	Yellow-faced Myna	Least Concern	7, 2, 3.
<i>Ptilotula flavescens</i> **	Yellow-tinted honeyeater	Least Concern	1, 2, 3

## Discussion

Bell [13] in his 1982 bird survey of the Port Moresby area, reported on average, 55 bird species per 10ha. Piskaut and Kei [14] recorded 29 species per 3 ha at the Port Moresby International Airport during the El Nino period of 2016. On Motupore Island, 72 bird species have been recorded [12] over a long period since the late 70s. This study recorded 54 species of which 9 species are new records. Most of the birds recorded were residents. Migratory birds were absent, indicating that they moved out just before the onset of the study.

Amongst the 9 new records, the sparrows were well established, inhabiting the building within the station area.



Plate 3. Eclectus Parrot, *Eclectus roratus*, a new resident on Motupore Island.

Overall, 81 bird species are now known to inhabit Bogoro and Motupore Island. Most are residence and common.

## References

1. Christidis, L. and Boles, W.E. 2008. *Systematics and Taxonomy of Australian Birds*. CSIRO Publishing, Collingwood, Australia.
2. Pratt, Thane K. & Beehler, Bruce M. 2015. *Birds of New Guinea*, 2<sup>nd</sup> edn, Princeton, New Jersey.

3. Coates, Brian J., and William S. Peckover. 2001. *Birds of New Guinea and the Bismarck Archipelago*. Dove Publications, Alderley, Australia.
4. Turbott, E.G. 1990. *Checklist of the Birds of New Zealand*. Ornithological Society of New Zealand, Wellington.
5. Cramp, S. and Simmons, K.E.L. (eds). 1977-1994. *Handbook of the birds of Europe, the Middle East and Africa. The birds of the western Palearctic*. Oxford University Press, Oxford.
6. del Hoyo, J., Collar, N.J., Christie, D.A., Elliott, A. and Fishpool, L.D.C. 2014. *HBW and BirdLife International Illustrated Checklist of the Birds of the World. Volume 1: Non-passerines*. Lynx Edicions BirdLife International, Barcelona, Spain and Cambridge, UK.
7. del Hoyo, J., Collar, N.J., Christie, D.A., Elliott, A., Fishpool, L.D.C., Boesman, P. and Kirwan, G.M. 2016. *HBW and BirdLife International Illustrated Checklist of the Birds of the World. Volume 2: Passerines*. Lynx Edicions and BirdLife International, Barcelona, Spain and Cambridge, UK.
8. Pratt, T.K. & Beehler, B.M. 2015. *Birds of New Guinea*, 2nd edn, Princeton, New Jersey.
9. Norman, J. A.; Rheindt, F. E.; Rowe, D. L.; Christidis, L. 2007. Speciation dynamics in the Australo-Papuan Meliphaga honeyeaters. *Molecular Phylogenetics and Evolution* **42**: 80-91.
10. Rozendaal, F. G., and Lambert, F. R. 1999. The taxonomic and conservation status of *Pinarolestes sanghirensis* Oustalet 1881. *Forktail* **15**: 1-13.
11. Jones, D.N., Dekker, R.W.RJ. and Roselaar, C.S. 1995. *The Megapodes*. Oxford University Press, Oxford, U.K.
12. Tarburton, M., nd. Checklist of birds of Motupore Island. Pacific Adventist University, Papua New Guinea.
13. Bell, H. L., 1982. Abundance and seasonality of the savanna avifauna at Port Moresby, Papua New Guinea. *Ibis*, 124: 252–274. Doi:10.1111/j.1474-919x.1982.tb03772.x
14. Piskaut P and Kei P. 2016. Biological assessment of the Port Moresby International Airport. Technical report submitted to National Airport Commission (NAC).

**Appendix 4-1. MacKinnon List of birds observed at Motupore Island.**

<b>Site ID</b>	Around Mot. Is.	<b>Date</b>	1-02-18
<b>Surveyor</b>	E. Sohun	<b>Start Time</b>	10:20 am
<b>Weather</b>	After rain, windy on west side.		
<b>Comments</b>	<b>Started at east side mangrove and went around island 3 hours</b>		
<b>Time</b>	<b>10:20am</b>	<b>Time</b>	<b>1:30pm</b>
<b>No</b>	<b>Species</b>		<b>Species</b>
1	Papuan Frogmouth	1	Shining Flycatcher
2	Olive-backed Sunbird	2	Helmeted Friarbird
3	Willy Wagtail	3	Yellow-faced Myna
4	Orange-footed Scrubfowl	4	Eurasian Tree Sparrow
5	Helmeted Friarbird	5	Torresian Crow
6	Blue-winged Kookaburra	6	Blue-winged Kookaburra
7	Eclectus Parrot	7	Lesser Frigatebird
8	Yellow-faced Myna	8	Little Shrikethrush
9	Torresian imperial Pigeon	9	Olive-backed Sunbird
10	Orange-fronted Fruit-Dove	10	Pacific Swallow
<b>Time</b>	<b>11:13am</b>	<b>Time</b>	<b>2:15pm</b>
<b>No</b>	<b>Species</b>		<b>Species</b>
1	Torresian Crow	1	Brahminy Kite
2	Whimbrel	2	Whistling Kite
3	Peaceful Dove	3	White-bellied Sea Eagle
4	Whistling Kite	4	Black-faced Cuckooshrike
5	Shinning flycatcher	5	Eastern Reef Egret
6	Olive-backed Sunbird	6	Bar-shouldered Dove
7	Torresian Imperial Pigeon	7	Eclectus Parrot
8	Orange-fronted Fruit-Dove	8	Common Tern
9	Graceful Meliphaga	9	Pacific Emerald Dove
10	Oriental Cuckoo	10	Bridled Tern
<b>Time</b>	<b>12:22 pm</b>	<b>Time</b>	
<b>No</b>	<b>Species</b>		<b>Species</b>
1	Common Sandpiper	1	
2	White-breasted Woodswallow	2	
3	Lesser Frigatebird	3	
4	Torresian Imperial Pigeon	4	
5	Graceful Meliphaga	5	
6	Rufous-banded Honeyeater	6	
7	Eastern Osprey	7	
8	Willy Wagtail	8	
9	Common Sandpiper	9	
10	Olive-backed Sunbird	10	

**Appendix 4-2. MacKinnon List of birds observed at Bogoro Inlet.**

<b>Site ID</b>	<i>Tahira Area</i>	<b>Date</b>	7 Feb 2018
<b>Surveyor</b>	<i>E. Sohun</i>	<b>Start Time</b>	
<b>Weather</b>	<i>Windy</i>		
<b>Comments</b>			
<b>Time</b>	<b>9:50 am</b>	<b>Time</b>	<b>12:48 pm</b>
<b>No</b>	<b>Species</b>		<b>Species</b>
1	<i>Graceful Meliphaga</i>	1	<i>Pacific Emerald Dove</i>
2	<i>Brown Goshawk</i>	2	<i>Helmetted Friarbird</i>
3	<i>White-bellied Cuckooshrike</i>	3	<i>White-bellied Cuckooshrike</i>
4	<i>Whimbrel</i>	4	<i>Yellow-faced Myna</i>
5	<i>Torresian Crow</i>	5	<i>Cattle Egret</i>
6	<i>Black-backed Butcherbird</i>	6	<i>Mimic Meliphaga</i>
7	<i>Helmetted Friarbird</i>	7	<i>Bar-shouldered Dove</i>
8	<i>Blue-winged Kookaburra</i>	8	<i>Shinning Flycatcher</i>
9	<i>Mimic Meliphaga</i>	9	<i>Brahminy Kite</i>
10	<i>Black-faced Cuckooshrike</i>	10	<i>Grey Shrikethrush</i>
<b>Time</b>	<b>10:40am</b>	<b>Time</b>	<b>1:00 pm (Finished)</b>
<b>No</b>	<b>Species</b>		<b>Species</b>
1	<i>Little Kingfisher</i>	1	
2	<i>Mimic Meliphaga</i>	2	
3	<i>Helmetted Friarbird</i>	3	
4	<i>Fawn-breasted Bowerbird</i>	4	
5	<i>Mangrove Gerygone</i>	5	
6	<i>Yellow-tinted Honeyeater</i>	6	
7	<i>Shinning Flycatcher</i>	7	
8	<i>Channel-billed Cuckoo</i>	8	
9	<i>Olive-backed Sunbird</i>	9	
10	<i>Grey-headed Mannikin</i>	10	
<b>Time</b>	<b>11:44</b>		
<b>No</b>	<b>Species</b>		
1	<i>Mimic Meliphaga</i>		
2	<i>Rainbow Lorikeet</i>		
3	<i>Brown Goshawk</i>		
4	<i>Bar-shouldered Dove</i>		
5	<i>Toressian Crow</i>		
6	<i>Shining Flycatcher</i>		
7	<i>Willy Wagtail</i>		
8	<i>Mangrove Golden Whistler</i>		
9	<i>Tawny-breasted Honeyeater</i>		
10	<i>Pacific Swallow</i>		

## CHAPTER 5. MARINE HABITAT AND DIVERSITY

*“The sea, once it casts its spell, holds one in its net of wonder forever”*

-Jacques Cousteau-

### **Introduction**

Coral reefs are regarded as oligotrophic marine ecosystems, with very low concentrations of dissolved inorganic nutrients [1]. Yet they are considered to be highly productive ecosystems. This is partly because of their efficiency to recycle nutrients. The benthic organisms that make up the coral reefs, all play pivotal roles in nutrient recycling and energy flow, making coral reefs no different from tropical rainforests. Maintaining the biodiversity is very critical to sustaining this marine ecosystem [2]. Understanding the relative contribution of the many factors influencing the distribution of biodiversity in coral reefs is one of the major goals of ecology [3].

The coral reef of Bootless Bay faces a suite of stressors resulting from increased human population along the coast. To sustain the health of the coral reef, such that it continually provides goods and services, CEPA is proposing to declare the Bootless Bay a Marine Protected Area under the PA Bill.

This section reports the biodiversity survey results on the macrohabitat cover of Bogoro Inlet and Motupore Island within the Bootless Bay.

### **Objectives**

The objectives of this section include:

- determine the cover types of reefs at two sites
- determine the overall diversity compositions of the sites

### **Material and Methods**

Cover types were assessed from 6 stations representing the two pre-selected sites; Bogoro Inlet and Motupore Island (Figure 10).



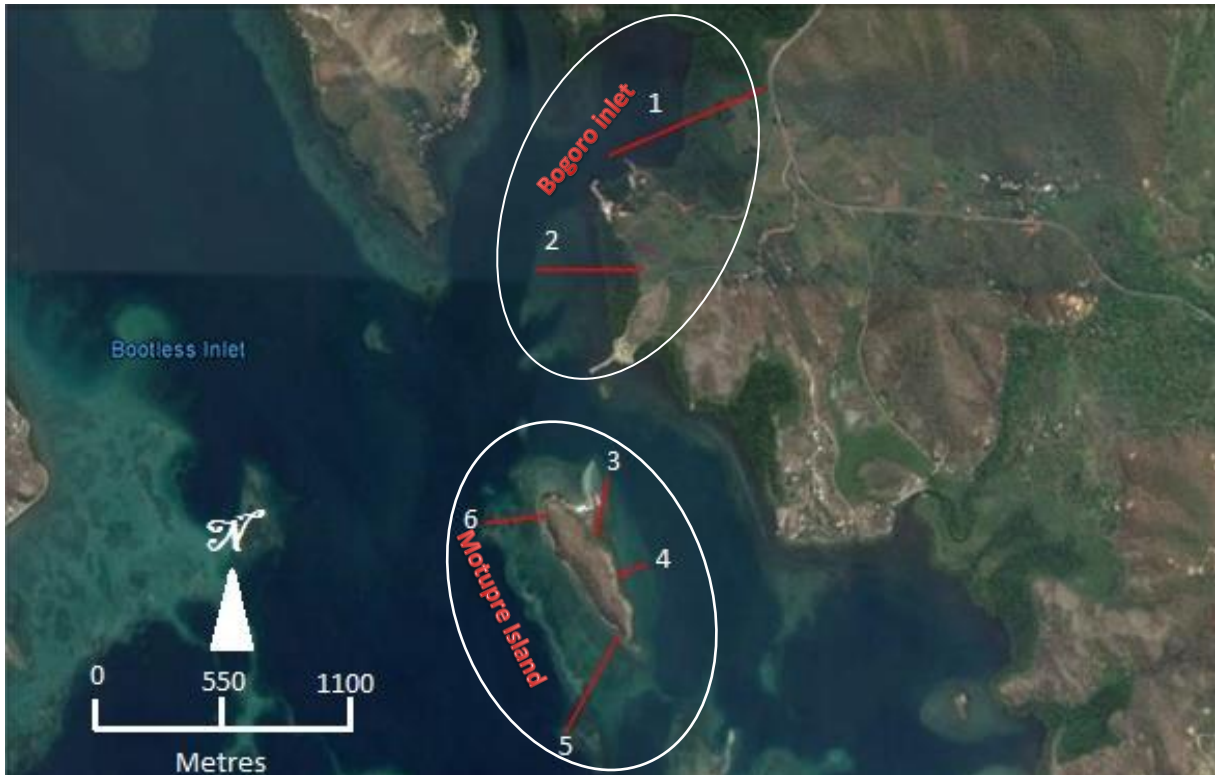


Figure 10. The two study sites (enclosed in white oval shape) and the six sampling stations.

The method deployed is as described under the Terrestrial Biodiversity Survey, however, with slight modification to accommodate cover assessment. Figure 11 below shows a schematic layout of each stations and sampling plots (green dots). Figure 12 presents the actual stations and sampling points on a straight line out to the sea.

Cover types were assessed in 1m x 1m quadrats. Forty (40) such quadrats were placed along the entire length (40m) of each transect. In each quadrat the percentage cover, relative to the quadrat, was scored for the following cover categories; seagrass, coral, macroalgae, sand, mud, rubble, and rocks. The cover categories

present the microhabitats common within the two sites.

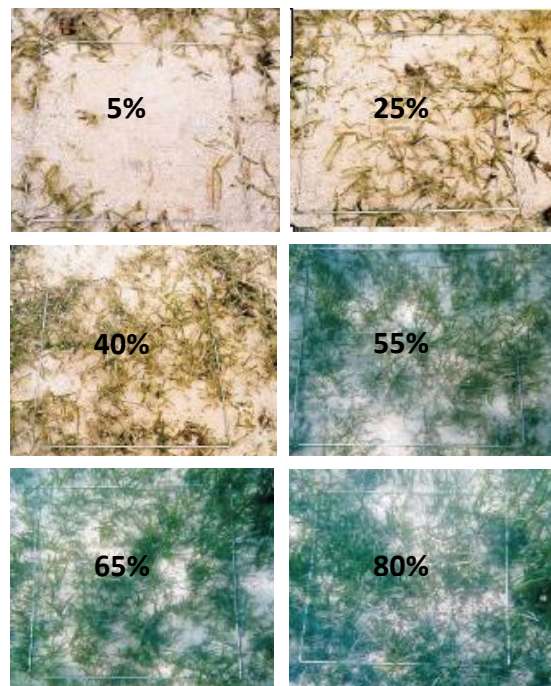


Plate 4. Examples of seagrass cover percentages relative to a 1m x 1m quadrat (adopted from

The rest of the organisms (sea cucumbers, sea stars, molluscs etc.) were enumerated in the 2m x 40m transect.

All cover data were entered into excel spreadsheet [4] and average cover calculated for each station. Similarly, records of other organisms were inputted into excel spreadsheet. In excel spreadsheet all data were subjected to quality check to verify correct identification, spelling and correct site of collection.

Descriptive statistics of mean cover types and species frequency/occurrence were performed in JMP Statistical package [5].

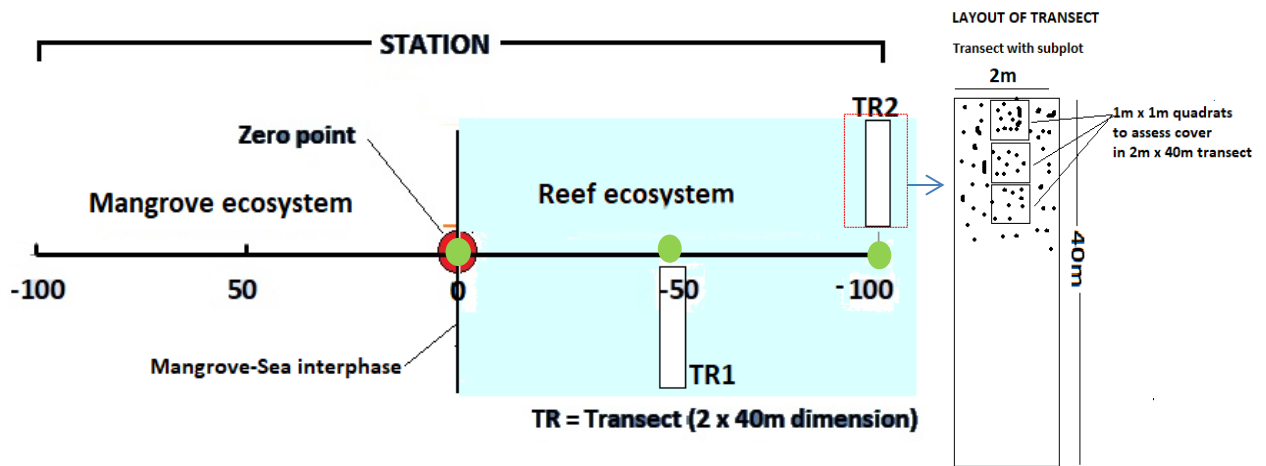


Figure 11. Schematic layout of sampling method of reef environment. Sampling transects established at every 50m interval. Transect layout with 1m x 1m quadrat also indicated to the right.

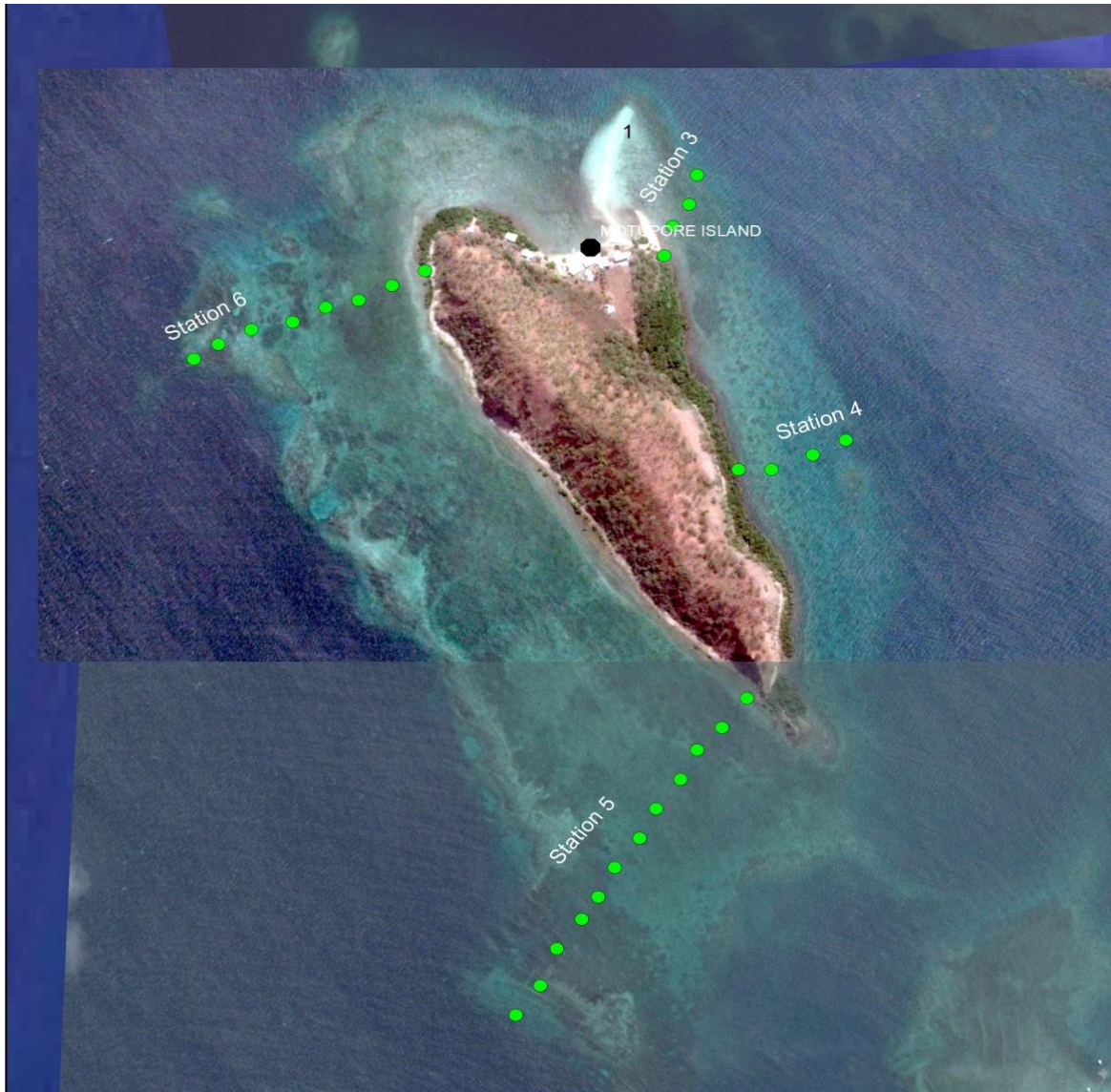


Figure 12. Lay out of stations 3, 4, 5, and 6 at Motupore Island. The green dots represent sampling transects that are 50m apart from each other.

## Results

### Cover types

Seagrass cover appeared common in all stations indicating its significance as a microhabitat within the study area (Figure 13). Seagrasses grow well on sandy substrate therefore, sand is also a common microhabitat in the area. Mud is dominant at Bogoro Inlet and is a result of sedimentation from overland flow through the mangrove and into the inlet. Macroalgae, are scattered but appeared to be colonizing rubbles. Corals on the other hand, are well established at stations 5 and 6 on Motupore Island.

Other cover types are site specific and reflect the site location relative to current and wave actions and to landuse. For example, mud scored higher percentages at Bogoro Inlet than at Motupore Island, due to human activities upstream.



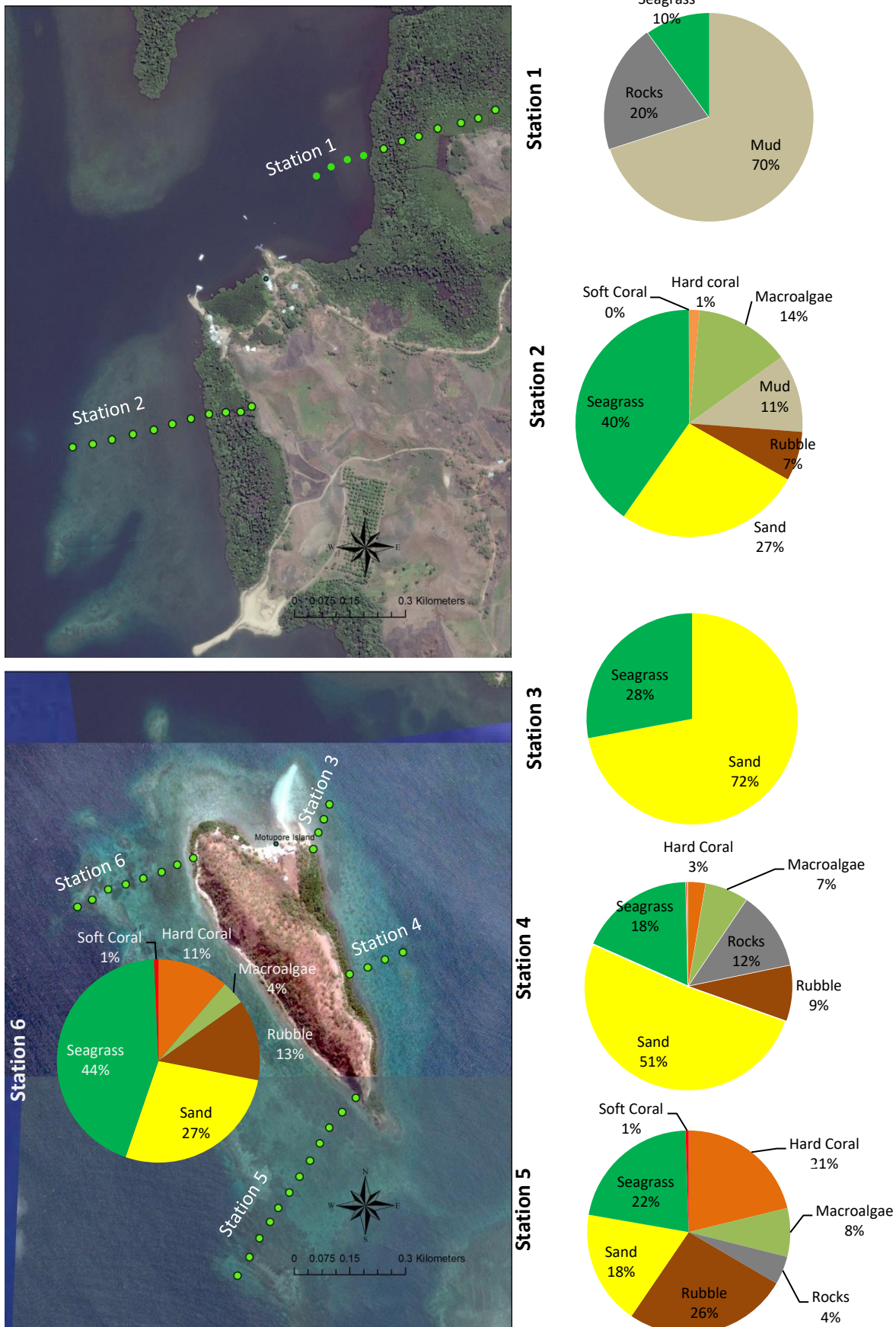


Figure 13. Percentage cover types for for stations 1 to 6. Cover data from all transects in each station were pooled and mean percent coverage calculated.

## Marine Diversity

A total of 1681 organisms representing 212 species in 11 major groups were observed and recorded in all stations. Station 1 at Bogoro Inlet is species poor, while Motupore Island is species rich (Table 18). While station 5 on Motupore scored the highest species number, species density appeared similar around the island.

Table 18. Summary of species recorded in each station.

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
No. Individuals	10	83	88	197	1090	228
No. Species	1	19	53	55	136	39
Area sampled (m <sup>2</sup> )	Visual	400	240	240	720	560
Species density	-	0.05	0.22	0.23	0.19	0.07
Dominant cover	Mud	Mud Sand Seagrass	Sand Seagrass	Sand rocks	Sand Seagrass Coral	Sand Seagrass Coral

In terms of species assemblages, cnidarians (corals, sea anemones, hydrozoans, zoanthids) were the dominant group attributing up to 75% of all organisms encountered. While macroalgae (seaweed, green algae, red algae) were present throughout all stations, their abundance are patchy hence contributing only 18% of the total organisms observed and recorded (Figure 14). Other organisms such as the echinoderms (sea cucumbers, sea urchins), molluscs (bivalves, nudibranchs) and sponges were present in low numbers.

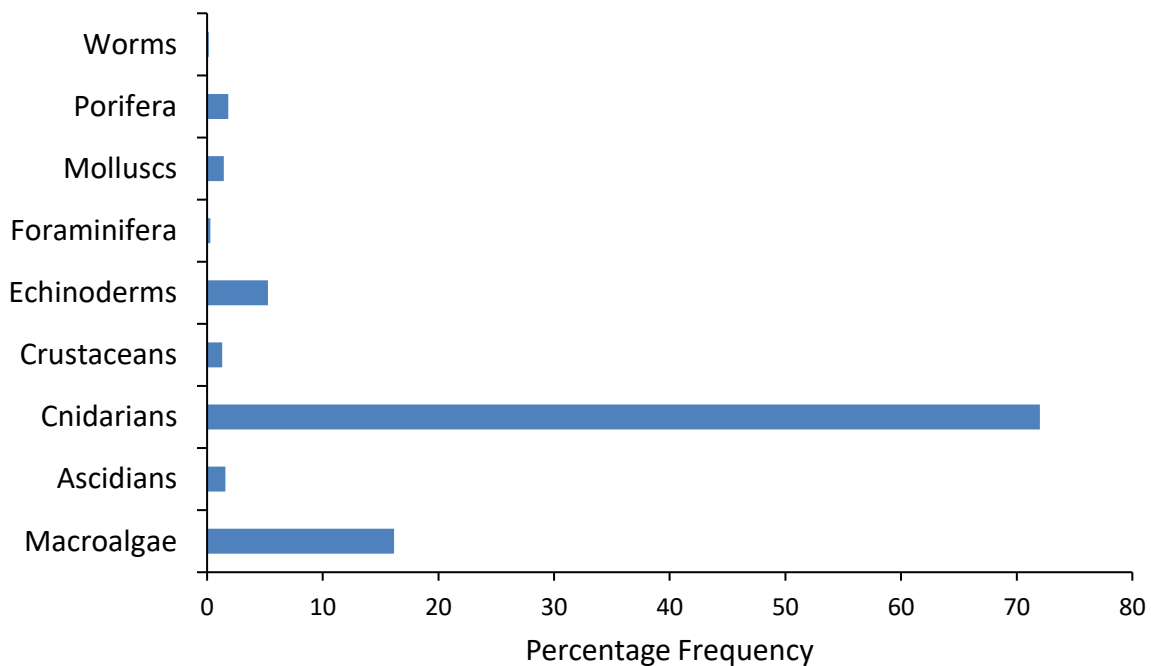


Figure 14. Percentage frequency of major groups of organisms recorded at Bogoro Inlet and Motupore Island.

## Species Composition

Pooled list of common organisms are tabulated below. These are organisms recorded from the transects in all stations.

### Macroalgae

Twenty species of macroalgae were recorded from all transects (Table 19). *Halimeda*, the cactus algae, and the seaweeds (*Padina*, *Sargassum* and *Turbinaria*) were common throughout the Bogoro Inlet and Motupore Island.

**Table 19. Macroalgae species recorded during the rapid biodiversity survey.**

Scientific name	Common name	IUCN Status	Reference
<i>Boergesenia forbesii</i>	Green algae	Not yet assessed	5
<i>Boodlea</i> sp.		Not yet assessed	5
<i>Chlorodesmis fastigiata</i>	Turtle weed	Not yet assessed	5
<i>Dictyota</i> sp.	Branched algae	Not yet assessed	5
<i>Gracilaria Salicornia</i>	Green algae	Not yet assessed	5
<i>Gracilaria</i> sp.	Green algae	Not yet assessed	5
<i>Halimeda cf. macroloba</i>	Cactus algae	Not yet assessed	5
<i>Halimeda</i> sp.	Cactus algae	Not yet assessed	5
<i>Halymenia</i> sp.		Not yet assessed	5
<i>Hydroclathrus clathratus</i>	Netweed	Not yet assessed	5
<i>Neomeris anulata</i>		Not evaluated	5, 7
<i>Padina</i> sp.	Funnelweed	Not yet assessed	5
<i>Peyssonnelia</i> sp.	Red algae	Not yet assessed	5
<i>Sargassum</i> sp. ( <i>broad</i> )	Sargassum weed	Not yet assessed	5
<i>Sargassum</i> sp. ( <i>linear</i> )	Sargassum weed	Not yet assessed	-
<i>Turbinaria decurrens</i>	Triangular sea bell	Not yet assessed	5
<i>Turbinaria</i> sp.	Triangular sea bell	Not yet assessed	5
<i>Valonia ventricosa</i>	Sailor's eyeballs	Not yet assessed	5, 6

### Seagrass

Seven species of seagrasses were recorded in sampling transects out of the 10 species known to occur in the area (Table 20). However, not all 7 are present in any one station. *Thalassia hemprichii* and *Cymodocea rotundata* are widely distributed from Bogoro inlet to Motupore Island. Note, all seagrass species are not included in the IUCN RedList due to their pantropical distribution.

Table 20. List of seagrass species recorded from sampling transects.

Family	Scientific name	Common name	IUCN	Reference
Cymodoceaceae	<i>Halodule uninervis</i>	Needle seagrass	Not evaluated	13
Cymodoceaceae	<i>Cymodocea rotundata</i>	Ribbon seagrass	Not evaluated	13
Cymodoceaceae	<i>Cymodocea serrulata</i>		Not evaluated	13
Cymodoceaceae	<i>Syringodium isoetifolium</i>		Not evaluated	13
Hydrocharitaceae	<i>Halophila minor</i>		Not evaluated	13
Hydrocharitaceae	<i>Enhalus acoroides</i>	Tape seagrass	Not evaluated	13
Hydrocharitaceae	<i>Thalassia hemprichii</i>	Turtle seagrass	Not evaluated	13

## Cnidarians

Cnidarians were the most common organisms recorded during the rapid biodiversity survey. Juvenile jelly fish (*Mastigias*) were particularly common during high seas. Up to 90 species were identified and 44 most dominant forms are listed below (Table 21).

Table 21. List of Cnidarians recorded from all transects at Bogoro Inlet and Motupore Island.

Family	Species	Common Name	IUCN Status	Reference
Acroporidae	<i>Acropora cf digitifera</i>		Not evaluated	9, 10, 5
Acroporidae	<i>Acropora elseyi</i>	Christmas coral	Not evaluated	10, 11,5
Acroporidae	<i>Acropora grandis</i>	Staghorn coral	Not evaluated	10
Acroporidae	<i>Acropora intermedia</i>	Staghorn coral	Not evaluated	10
Acroporidae	<i>Acropora loripes</i>		Not evaluated	10
Acroporidae	<i>Acropora millepora</i>	Bushy staghorn	Not evaluated	10
Acroporidae	<i>Acropora muricata</i>	Staghorn coral	Not evaluated	10
Acroporidae	<i>Acropora</i> sp.	Bottlebrush coral	Not evaluated	10
Acroporidae	<i>Acropora</i> sp.	Table coral	Not evaluated	10
Acroporidae	<i>Acropora tennalis</i>	Purple-tip acropora	Not evaluated	10
Poritidae	<i>Alveopora</i> sp.	Daisy coral	Not evaluated	10
Acroporidae	<i>Astreopora</i> sp.	moon coral	Not evaluated	10
Fungiidae	<i>Ctenactis echinata</i>		Not evaluated	10
Nephtheidae	<i>Dendronephthya</i> sp.	Tree coral	Not evaluated	10
Nephtheidae	<i>Dendronephthya</i> sp.	Carnation coral	Not evaluated	10
Faviidae	<i>Diploastrea heliopora</i>		Not evaluated	12,10
Stylasteridae	<i>Distichopora</i> sp.	Lace coral	Not evaluated	10
Stylasteridae	<i>Distichopora violacea</i>	Violet hydrocoral	Not evaluated	10
Faviidae	<i>Echinopora horrida</i>		Not evaluated	10
Faviidae	<i>Echinopora lamellosa</i>		Not evaluated	10
Faviidae	<i>Favia</i> sp.	Moon coral	Not evaluated	
Fungiidae	<i>Fungia</i> sp.		Not evaluated	

Mussidae	<i>Lobophyllia hemprichii</i>		<i>Not evaluated</i>	10
Mastigiidae	<i>Mastigias papua</i>	Papuan sea jelly	<i>Not evaluated</i>	8, 5
Milleporidae	<i>Millepora</i> sp.	Fire coral	<i>Not evaluated</i>	
Pectiniidae	<i>Pectinia paeonia</i>	Palm lettuce coral	<i>Not evaluated</i>	10
Pocilloporidae	<i>Pocillopora damicornis</i>	Cauliflower coral	<i>Not evaluated</i>	10
Pocilloporidae	<i>Pocillopora</i> sp.		<i>Not evaluated</i>	10
Poritidae	<i>Porites cylindrica</i>	Cylinder coral	<i>Not evaluated</i>	10
Poritidae	<i>Porites</i> sp.	Boulder coral	<i>Not evaluated</i>	10
Alcyoniidae	<i>Sarcophyton</i> sp.	Leather coral	<i>Not evaluated</i>	10
Mussidae	<i>Scolymia</i> sp.	Disc coral	<i>Not evaluated</i>	
Pocilloporidae	<i>Seriotopora</i> sp.	Brush coral	<i>Not evaluated</i>	
Alcyoniidae	<i>Sinularia flexibilis</i>	Flexible leather coral	<i>Not evaluated</i>	10
Alcyoniidae	<i>Sinularia</i> sp.	Finger leather coral	<i>Not evaluated</i>	10
Nephtheidae	<i>Stereonephthea</i> sp.		<i>Not evaluated</i>	10
Stichodactylidae	<i>Stichodactyla giganteum</i>	Gigantic sea anemone	<i>Not evaluated</i>	10
Stichodactylidae	<i>Stichodactyla mertensii</i>	Merten's carpet anemone	<i>Not evaluated</i>	10
Pocilloporidae	<i>Stylophora pistillata</i>	Cluster coral	<i>Not evaluated</i>	10
Mussidae	<i>Symphylia agaricea</i>	Brian coral	<i>Not evaluated</i>	10
Mussidae	<i>Symphylia cf recta</i>	Brian coral	<i>Not evaluated</i>	10
Dendronphylliidae	<i>Turbinaria frondens</i>	Cup coral	<i>Not evaluated</i>	10
Dendronphylliidae	<i>Turbinaria reniformis</i>	Scroll coral	<i>Not evaluated</i>	10
Dendronphylliidae	<i>Turbinaria</i> sp.	Vase coral	<i>Not evaluated</i>	10
Melithaeidae	Unidentified sp.			
Plexauridae	Unidentified sp.			
Subergorgiidae	Unidentified sp.			
Subergorgiidae	Unidentified sp.			
Subergorgiidae	Unidentified sp.			
Virgularidae	Unidentified sp.	Sea pen		
Agariciidae	Unidentified sp.			
Thelassianthidae	Unidentified sp.			
Antipathidae	Unidentified sp.			

## Echinoderms

Species list of the echinoderms recorded (this survey) is provided in Table 8. Assemblages of echinoderms appear patchy in distribution. A total of 28 species were recorded. Most members were recorded as singleton. The lollyfish (*Holothuria atra*) is a frequent singleton in all stations, except in station 1.



Table 8. Species composition of Echinoderms recorded at Bogoro Inlet and Motupore Island.

Family	Scientific name	Common Name	IUCN list	Reference
Ophiasteridae	<i>Linckia laevigata</i>	Blue sea star	Not evaluated	13
Oreasteridae	<i>Choriaster granulatus</i>	Pillow sea star	Not evaluated	13
Oreasteridae	<i>Culcita novaeguineae</i>	Pin-cushion sea star	Not evaluated	13
Oreasteridae	<i>Protoreaster nodosus</i>	Nodose sea star	Not evaluated	13
Ophiothrichidae	<i>Ophiothrix purpurea</i>	Purple brittle star	Not evaluated	13
Ophiothrichidae	<i>Ophiothrix</i> sp. 1			
Ophiothrichidae	<i>Ophiothrix</i> sp. 2			
Colobometridae	<i>Cenometra bella</i>	Pretty feather star	Not evaluated	13
Comasteridae	<i>Comanthus alternans</i>			
Comasteridae	<i>Comanthus suavia</i>			
Comasteridae	<i>Oxycomanthus bennetti</i>	Bennett's feather star	Not evaluated	13
Himerometridae	<i>Himerometra rubustipinna</i>	Robust feather star	Not evaluated	13
Himerometridae	<i>Himerometra</i> sp.		Not evaluated	13
Class Crinoidea	<i>Unidentified</i> sp. 1			
Class Crinoidea	<i>Unidentified</i> sp. 2			
Class Crinoidea	<i>Unidentified</i> sp. 3			
Diadematidae	<i>Astropyga radiata</i>	Radiant sea urchin	Not evaluated	13
Diadematidae	<i>Diadema savignyi</i>	Savigny's sea urchin	Not evaluated	13
Diadematidae	<i>Echinothrix calamaris</i>	Stinging sea urchin	Not evaluated	13
Diadematidae	<i>Echinothrix diadema</i>	Crowned sea urchin	Not evaluated	13
Echinometridae	<i>Echinostrephus aciculatus</i>	Needle spined sea urchin	Not evaluated	13
Toxopneustidae	<i>Toxopneustes gratilla</i>	Cake urchin	Not evaluated	13
Holothuriidae	<i>Actinopyga</i> sp.			
Holothuriidae	<i>Holothuria atra</i>	Lolly fish	Least concern	13, 14
Holothuriidae	<i>Holothuria coluber</i>	Snakefish	Least concern	13, 14
Holothuriidae	<i>Holothuria edulis</i>	Pinkfish	Least concern	13, 14
Holothuriidae	<i>Holothuria hilla</i>	Papillate sea cucumber	Least concern	13, 15
Holothuriidae	<i>Holothuria leucospilota</i>	Black fringed cucumber	Least concern	13, 15
Holothuriidae	<i>Holothuria scabra</i>	Sandfish	Endangered	16
Holothuriidae	<i>Holothuria</i> sp.1		Not evaluated	
Holothuriidae	<i>Holothuria</i> sp.2		Not evaluated	
Stichopodidae	<i>Stichopus herrmanni</i>	Curry fish	Vulnerable	17, 18
Stichopodidae	<i>Stichopus horrens</i>	Dragon fish	Data deficient	15
Synaptidae	<i>Synapta maculata</i>	Spotted sea cucumber	Not evaluated	

## Discussion

There are some distinct differences between the Bogoro Inlet and Motupore Island. However, this could be an artifact of our sampling efforts. Generally, the physical location of Bogoro Inlet did have some influences on the biodiversity. The siltation that proliferate at the edge of the mangrove and extending some 100 to 200m out into the sea were derived from land-used activities. The mangrove ecosystem is partially deteriorated and do not have the full capacity to retain sediment input into the inlet. Consequently, the macrohabitats are fewer compare to Motupore Island (see Figure 13).

In terms of the overall diversity, the cnidarian assemblages comprise almost 70% of the total species recorded at all stations. While most members tended to concentrate toward the reef crest and shelves, they were present in all microhabitats as singletons or doubletons and free swimming as well.

From the five sampling stations (stations 2 – 6) 200 species of marine organism were recorded excluding fish species. Increasing the sampling stations to 20 would reach an asymptote at 600 species (Figure 14).

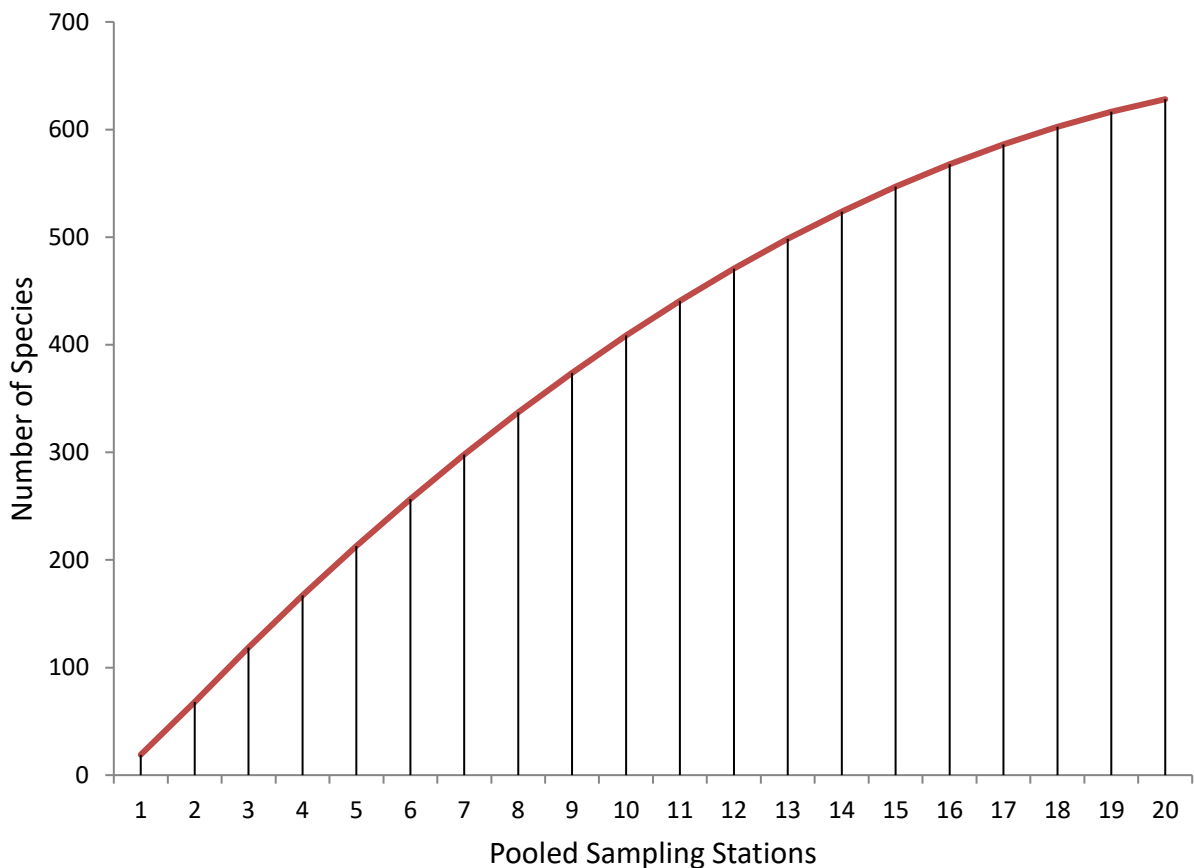


Figure 15. Predicted species diversity if sampling effort is increased.

## Conclusion

The marine environment of Bogoro Inlet and Motupore Island is very speciose. For example, of the 10 species of seagrass known in the Port Moresby area, 7 species occur at Motupore Island. Similarly, of the 33 species of sea cucumbers occurring in the PNG waters (Alfred Ko'ou, *per. com.*), 28 species occur at the Bogoro Inlet and Motupore Island. The area is therefore rich in marine life, therefore making it an ideal refugia location for marine life in the the waters of Bootless Bay and surrounding seas.

## References

1. Gottschalk S., Uthicke S and Heiman K. 2007. Benthic diatom community composition inn three regions of the Great Barrier Reef, Australia. *Coral Reefs* 26: 345-357. Doi 10.1007/s00338-007-0204-3.
2. Berzunza-Sanchez M. M., del Carmen Gomez Cabrera M and Pandolfi J. M. 2013. Historical patterns of resource exploitation and status of Papua New Guinea coral reefs. *Pacific Science* 67(3): 425-440.
3. Drew J A, Amatangelo K L, Hufbauer R A. (2015) Quantifying the Human Impacts on Papua New Guinea Reef Fish Communities across Space and Time. *PLoS ONE* 10(10): e0140682. doi:10.1371/journal.pone.0140682
4. Microsoft Office Excel 10. Microft Soft Office.
5. Baine M and Haresti D. (2007). Marine life of Bootless Bay. Motupore Island Reseach Centre, University of Papua New Guinea.
6. "[Valonia ventricosa J.Agardh](#)", Algaebase.
7. Guiry, M.D. and G.M. Guiry (2009). AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. <http://www.algaebase.org>; searched on 25 March 2018.
8. Jarms G. and Morandini A.C. (2018). World List of Scyphozoa. Aurelia coerulea von Lendenfeld, 1884. Accessed through: World Register of Marine Species at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=292506> on 2018-03-25.
9. Dana, J.D. (1846). *United States Exploring Expedition during the years 1838-1842. Zoophytes 7: 1-740. Lea and Blanchard, Philadelphia.*, available online at [http://www.sil.si.edu/digitalcollections/usexex/navigation/ScientificText/USExEx19\\_08select.cfm](http://www.sil.si.edu/digitalcollections/usexex/navigation/ScientificText/USExEx19_08select.cfm)
10. WoRMS (2018). Acropora digitifera (Dana, 1846). Accessed at: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=207045> on 2018-03-25
11. Brook G (1892) Preliminary descriptions of new species of Madrepora in the collections of the British Museum. Part II. *Annals and Magazine of Natural History* 10: 451-465.
12. Lamarck, J.-B. M. de. (1816). Histoire naturelle des animaux sans vertèbres. Tome second. Paris: Verdière, 568 pp., available online at <http://www.biodiversitylibrary.org/item/47698>
13. [The IUCN Red List of Threatened Species. Version 2017-3. <www.iucnredlist.org>](http://www.iucnredlist.org)
14. Conand, C., Gamboa, R. & Purcell, S. 2013. Holothuria atra. The IUCN Red List of Threatened Species 2013: e.T180421A1628832. <http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T180421A1628832.en>. Downloaded on 26 February 2018.
15. Conand, C., Purcell, S. & Gamboa, R. 2013. *Holothuria fuscogilva*. The IUCN Red List of Threatened Species 2013: e.T200715A2681354. <http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T200715A2681354.en>. Downloaded on 26 February 2018.

16. Hamel, J.-F.; Mercier, A.; Conand, C.; Purcell, S.; Toral-Granda, T.-G. & Gamboa, R. (2013). "[Holothuria scabra](#)". [The IUCN Red List of Threatened Species](#). IUCN. 2013: e.T180257A1606648. [doi:10.2305/IUCN.UK.2013-1.RLTS.T180257A1606648.en](#). Retrieved 14 January 2018.
17. Ismail, H., et al. (2004). The structure of calcareous rings in *Stichopus hermanni* Semper and *Holothuria atra* Jaeger. *Jurnal Sains Kesihatan Malaysia* 2(2) 47-52.
18. Poh-Sze, C. (2004). Fisheries, trade and utilization of sea cucumbers in Malaysia. In: Lovatelli, A., et al. *Advances in Sea Cucumber Aquaculture and Management*. FAO. Rome.

## CHAPTER 6. THE FISH DIVERSITY SURVEY

### *Introduction*

Fishes are a very important and integrated living component of any aquatic ecosystem in which they provide services that maintain ecological integrity as well as sustain human livelihood. Protecting fishes and sustainably managing the services they provide has become a major task for the increased human population in many coastal areas of the world and Papua New Guinea is no exception. Papua New Guinea is within a region of the highest marine biological diversity called “Coral Triangle” and has more than a thousand fish species in many of its regional seas. For Bootless Bay, previous records showed that 488 fishes inhabit the marine ecosystems of Bootless Bay (Drew et al., 2012). However, estimates from Drew et al. (2012) indicated that at least a thousand fish species could be expected to inhabit Bootless Bay.

Threats, such as overexploitation and sedimentation, to fish and other marine resources in Bootless Bay are obvious and increasing but not investigated and documented. There are limited fisheries assessment (e.g Kinch, 2007) and monitoring done to advice on appropriate management of these marine resources within Bootless Bay. The fishing activities by fishermen in Bootless Bay are a recipe for the “Tragedy of the Common” where everyone is fishing their share and no one is responsible for sustainably managing the marine resources.

The results of the fish surveys conducted at Bogoro Inlet and on Motupore Island are reported herein this section.

### *Objectives*

The objectives of the fish survey are to determine;

- i. the species composition, and
- ii. the distribution patterns of fish species.
- iii. Assess the fishing efforts

### *Material and Methods*

#### *Study Sites*

The proposed MPAs included Bogoro Inlet area and Motupore Island. These two areas became the two survey sites for this biodiversity inventory project (Figure 16). Six (6) stations (Figure 16) were selected based on aerial observations during the scouting before actual surveys. The criteria for selecting survey stations within the two sites are (1) to maximize encounter of the different microhabitats and therefore species and (2) survey as many stations as practically possible. Complex reef systems with many microhabitats contained more or higher assemblages of marine organisms which the current project is targeting to achieve. As such, potential stations containing heterogeneous microhabitats were favorable and homogeneous microhabitats such as mudflats or sand areas were assumed to contain less diversity and were to be sampled if given the time.



Figure 16. The two study sites (enclosed in white oval-shape) and the six stations.

### **Survey Design**

The biodiversity inventory for this project was designed to sample species within different habitat strata, from dry land through mangroves and coral reefs, using visual census, underwater visual census (UVC), and capture by netting and handline fishing techniques. The survey areas were nested into sites, stations (within each site), and replicated transects (within each station) as shown in Figure 17. Within each site, stations were demarcated which run perpendicular to the coastline, starting from the land-sea or mangrove-sea interface depending on the location of the station. Along the station, sampling transects were established at every 50m interval. The number of stations and transects is dependant on the length or size of the survey site. A transect covers an area of 80m<sup>2</sup> and sampling was conducted using a 40m X 2m Belt Transect. The survey transects were placed parallel to the coastline. The substrates and life forms within each transect were recorded and enumerated. To measure the substrate cover; a 1m<sup>2</sup> Quadrat was used to quantify percent cover within each transect. Forty (40) Quadrats were placed side-by-side within each transect and photographs of substrates and life forms (Figure 17) were taken and analysed soon after the surveys were completed. Fish survey transects were placed in the opposite direction to the invertebrates survey transects.



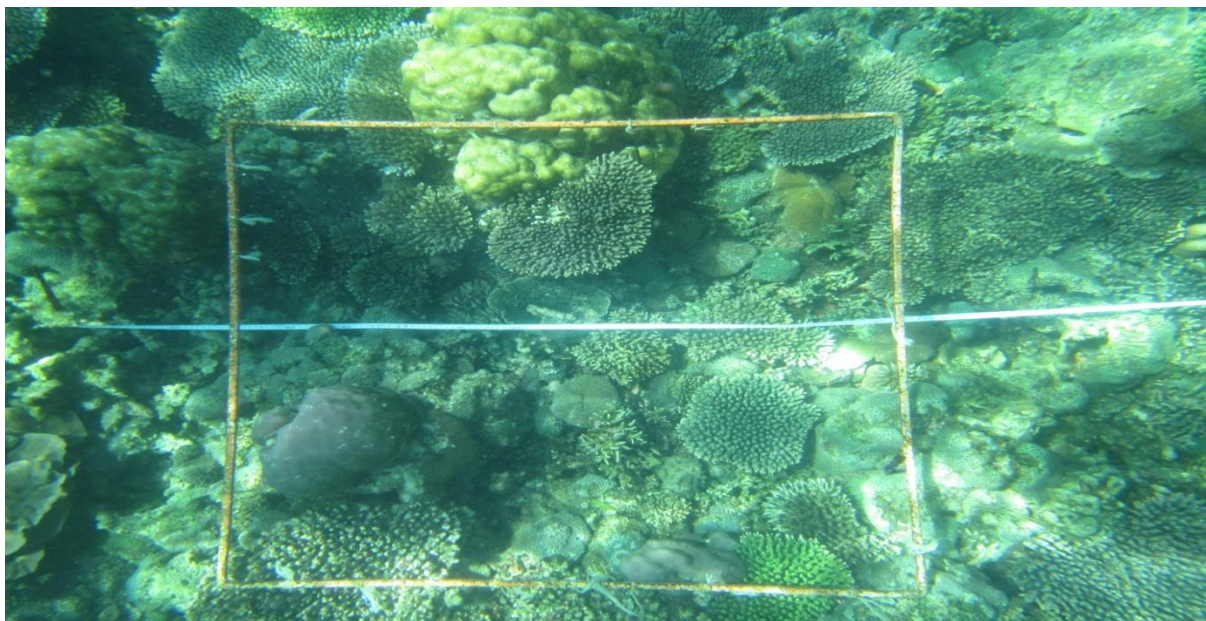
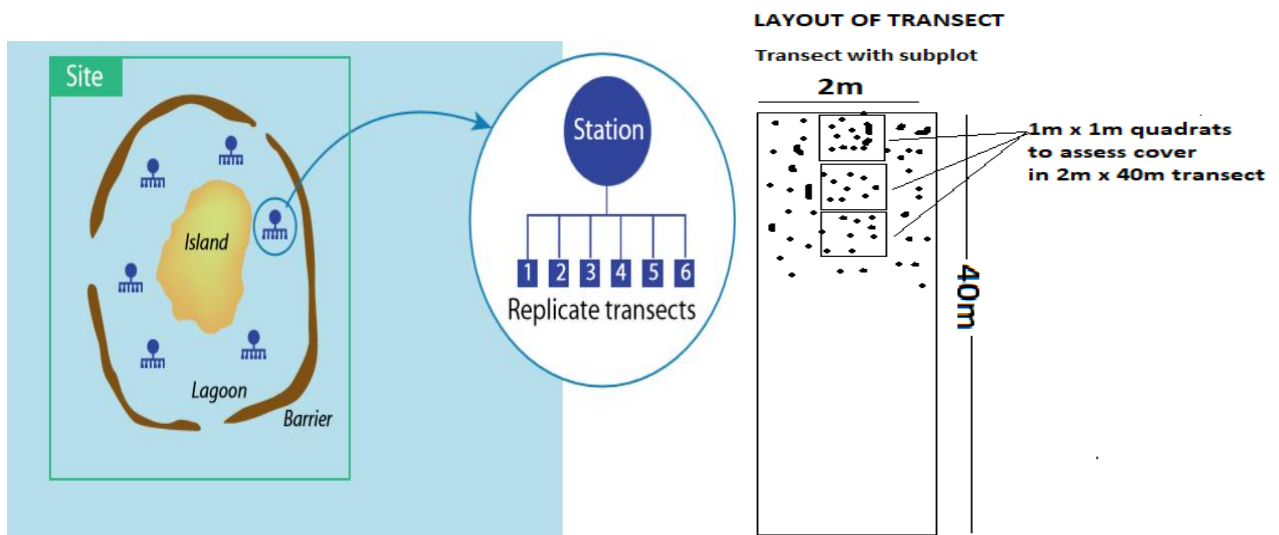


Figure 17. Illustration of the survey design showing the arrangements of sites, stations, and replicated transects. Source: modified from Pakoa et al., 2014.

Additionally, fishes were captured using fish nets and handline fishing techniques. Fishing efforts (man-hour of seine and gill netting in station 3 and handline fishing on all stations) were conducted in each station on Motupore Island. A 4inch 5m x 50m Gillnet was set at the edge of Station 3 for 12 hours per night for three nights. A 50m Seinenet was dragged three times over the seagrass bed on Station 3 between transects 3, 2, and 1. Handline fishing was conducted on all the four stations on Motupore Island.

### **Data Analysis**

Fishes caught and photographed from each transect or station were identified to species level and assessed in terms of species composition, density level, trophic structure, and catch composition and catch-per-unit-effort (CPUE). Fish species abundance for each transect were standardized to density levels by conversion to individual per hectare (Ind.Ha<sup>-1</sup>) of reef.

For the catch composition and CPUE; total length (TL) of fishes caught were converted to weights in grams using the formula  $W = a \times L^b$ ; where, W = Fish Weight in grams; L = Fish Length i.e. Total Length in centimeters; and 'a' and 'b' are constants (King, 1995). Specific species constants were obtained from FishBase ([www.Fishbase.org](http://www.Fishbase.org)).

Microsoft Excel 2010 was utilized to conduct basic descriptive statistics and graphical analyses of the data.

## Results

### Species Richness and Density Levels

A total of 1635 individual fishes representing 127 fish species and 36 families were recorded from the six stations in Bogoro Inlet and Motupore Island (Appendix 6-1). This inventory has recorded additional two families and 20 species to the list (488 fish species in 73 families) provided by Drew et al. (2012). Thus, 75 fish families and 512 fish species are now known to inhabit Bootless Bay.

**Table 22. Mean number of species and density per hectare of reef and dominant taxa for each station.**

Characteristic	Site 1- Bogoro Inlet		Site 2 – Motupore Island			
	St 1	Station 2	Station 3	Station 4	Station 5	Station 6
Mean Species Richness (Ind.Ha <sup>-1</sup> of reef )		11 ± 2.96	8 ± 1.86	9 ± 1.44	35 ± 5.51	22 ± 9.92
Mean Density (Ind.Ha <sup>-1</sup> of reef)		451.7 ± 185.76	1387.4 ± 531.96	277.78 ± 18.80	588.41 ± 77.74	710.72 ± 190.42
Dominant Family		Siganidae	Siganidae	-	Pomacentridae	Pomacentridae
Dominant Species		<i>Siganus canaliculatus</i>	<i>Siganus canaliculatus</i>	-	<i>Chromis viridis</i>	<i>Amblyglyphidodon curacao</i>

Station 1 was not surveyed thoroughly due to high turbidity, which increases the level of risk from crocodile attack, during the time of survey. However, while conducting mangrove survey, about 6 individuals of *Mugil cephalus* (Mullet - Mugilidae) and a *Tylosurus* sp. (Longtom - Belonidae) were observed on station 1.



Other fish species observed outside of the six stations include one individual each of several individuals of *Hemiscyllium hallstromi* (Epaulette shark – Hemiscyllidae) around Station 3, one *Triaenodon obesus* (Whitetip reef shark – Carcharhinidae) on Station 5, *Pterois volitans* (Lionfish – Scorpanidae), *Scorpaenopsis diabolis* (Scorpionfish – Scorpaenidae).

## **Trophic Structure**

---

Ecosystems are better described using the energy and nutrients pathways in which different species can be grouped using the food chains and web concepts. In an ecosystem, such as a coral reef, the different species have a feeding relationship that connects all of them in the ecosystem. This feeding relationship enables the flow of energy and nutrients from one species to another and thereby forming a structure with many levels. This feeding relationship structure is referred to as “trophic structure” and many species can be grouped into its different feeding levels.

The sun is the source of energy for most life forms and can enter the trophic structure through a process called photosynthesis which is mainly performed by plants. Thus, the plants are referred to as primary producers of energy and form the first level in the trophic structure.

Those animals that feed on plants are known as herbivores and those feeding on herbivores are known as carnivores. The omnivores are both herbivores and carnivores and all are Predators. The top predators are those animals at the end of a food chain or web. The predators feed on different food items and thereby have names reflecting such relationship. For examples fishes that feed on planktons are referred to as Planktivores and those feeding on invertebrates, Invertivores. The carnivores can form many levels which are separated into groups and the first group which feed on herbivores is called primary consumers, those feeding on primary consumers are secondary consumers and so on.

The feeding relationship that showed only one path linking several species is known as food chain and one that showed many paths linking together many different species is known as food web. Disruption of the food chains or webs will lead to collapse of the trophic structure and consequently ecosystem together with its ecosystem goods and services. Thus, it is important to maintain a balance ecosystem that has well established trophic structures. Also a balance ecosystem is one that can support many or a high proportion of top predators.

The fishes on the reefs play an important role (mainly as predators) in maintaining a balance ecosystem and their removal has potential consequences on the reef trophic structure. The parrot and Sergeant fishes are key herbivores keeping macro-algae underchecks on the reefs such that macro-algae do not out-compete corals for settlement spaces.

From the six stations this survey recorded 10 top predators, 200 carnivores, 45 planktivores, 40 omnivores, and 89 herbivores. Carnivore is the dominant trophic structure in all the stations (Figure 18).

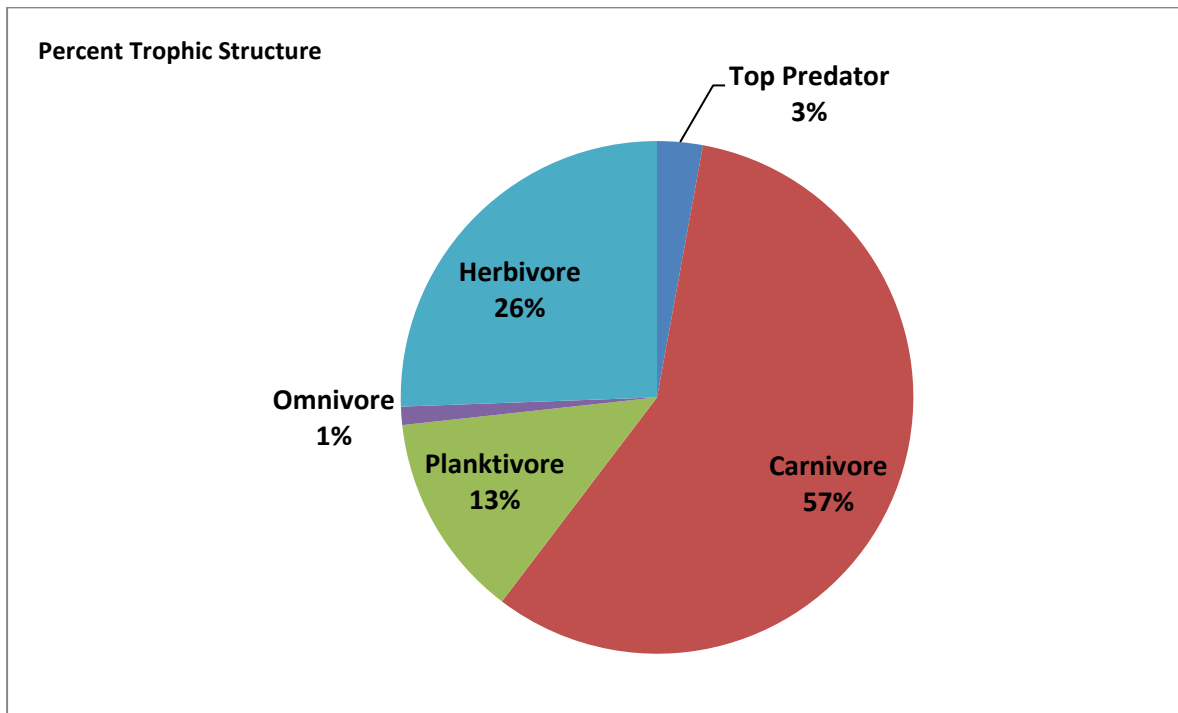


Figure 18: Percent fish trophic structure on Bogoro Inlet and Motupore Island.

The top predators such as sharks, snappers, and groupers consisted of a small portion (3%) of the survey and catch data; an indication of an unbalanced ecosystem and reflective of fishing pressure in the area.

### Catch Composition and Efforts

A total of 10.12kg of fish was caught using a 4-inch Gillnet over three nights. The CPUE for Gillnet-night was 0.28kg of fish per man-hour of fishing.

A total of 0.87kg of fish was caught during three Seinenet-hauls using a 50m Seinenet. The CPUE for Seinenet-haul was 0.29kg of fish per haul.

A total of 5.17kg of fishes was caught for Stations 3-6 on Motupore Island using handline fishing technique (Table 23).

Table 23. CPUE for Stations 3-6.

Station	Total Biomass (g)	CPUE (Handline/Person/Hour)	Dominant Family
3	1931.91g	643.97g/Man-hour	Nemipteridae
4	399.24 g	299.62g/Man-hour	Nemipteridae
5	1365.17 g	682.59g/Man-hour	Nemipteridae
6	1471.09 g	735.55g/Man-hour	Lethrinidae

## Discussion

The sampling stations 5 and 6 have higher mean number of fish species than stations 2, 3, and 4 which are species poor (Figure 19). Station 6 has higher within station (differences in the number of species from the transects) variation due to differences in the number of species for each transects. Transects 2 – 4 of station 6 were within the seagrass bed and contained fewer species than transects 5 and 6 which were on the coral reef crests. Interestingly, station 6 appeared to be an intermediate zone that showed affinities (cover types) of stations 2 – 4 on one hand and station 5 on the other (Figure 20). This can be explained by continuum of seagrass cover from stations 4 and 3 reaching 44% cover at station 6 (Figure 20) and peak coral cover (22%) at station 5, declining to 11% at station 6 and <2% in the other stations. Thus, fish species variation is indicative of habitat type and complexity.

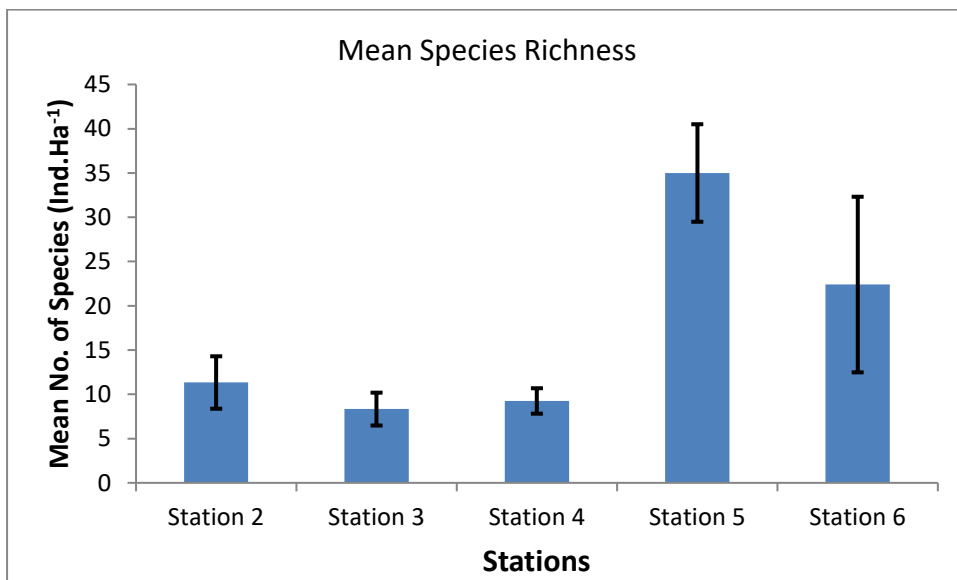


Figure 19. Mean number of fish species per station.

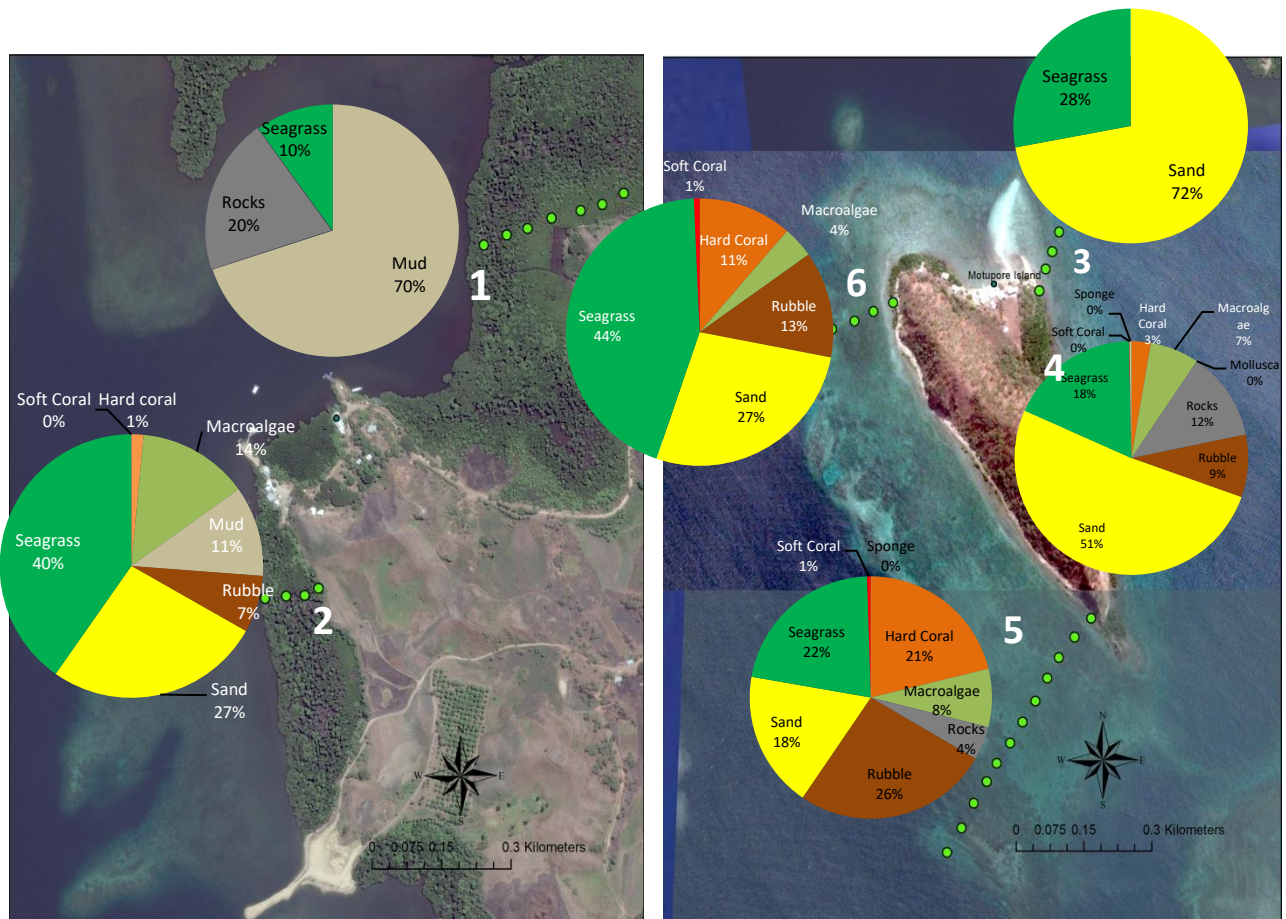


Figure 20. Cover types of stations 2, 3, 4, 5 and 6.

Species richness generally increases as distance away from Bogoro Inlet increases toward the Papuan Barrier Reef (Table 22; Figure 19). Given this trend, it is assumed that current species list will increase ocean-ward and probably higher diversity expected along the Papuan Barrier Reef.

Based on the species richness and abundance data, an average (calculated from the means in Table 22) of 17 different fish species with a mean density of 683.20 (Ind.Ha<sup>-1</sup>) inhabit a one hectare of reef on Bogoro Inlet (Station 2) and Motupore Island (Figures 19 and 21). The wave-exposed reefs (Stations 5 and 6) generally exhibit higher number of species than wave-sheltered channel reefs (Stations 2, 3, and 4) closer to the main land coast. Stations 5 and 6 also exhibit more microhabitats with higher live coral cover (Figure 20).

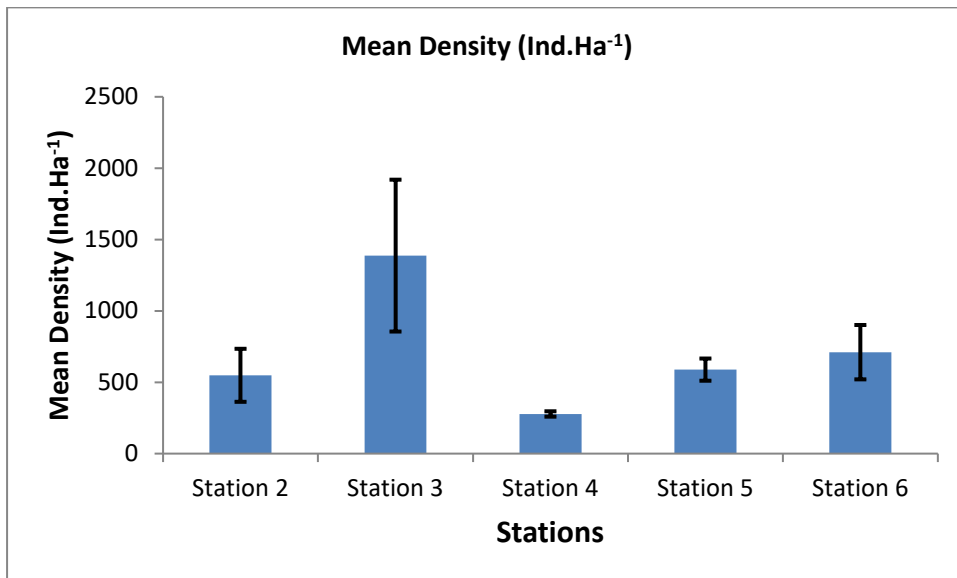


Figure 21. Mean density (Ind.Ha<sup>-1</sup>) per stations.

Station 3 has higher number of individuals (Figure 21) but is species poor (Figure 19) compared to other stations. Examination of the data revealed that high mean density in Station 3 is a result of large schools of new recruits or juvenile fishes. Station 3 comprised of 28% seagrass cover (Figure 20) and this large seagrass bed plays a significant role as nursery and feeding ground for many young fishes.

Generally, the more complex a reef system is, the higher its fish diversity. A complex reef system has many microhabitats and high percentage live covers (corals, seagrass, macroalgae) as indicated by the survey data. This observation is supported by commercial seacucumber recruitment patterns in Bootless Bay where more complex reef systems exhibit higher abundance of newly recruited seacucumbers (Ko'ou, 2014). Hence in conservation and management of these marine diversity and resources, more complex reef systems should be targeted and given high priority.

The CPUE for gillnet-night and seinenet-haul are very low for Station 3 on Motupore Island. Only one fish species (*Caranx ignobilis* - Carangidae) contributed to the CPUE for gillnet-night. Fish species from the fish families Monacanthidae and Nemipteridae dominated the Seinenet-haul catch composition (Figure 22) probably due to their larger sizes. Despite their low biomass, Siganidae and Mullidae were the dominant families in terms of abundance. As indicated by Figure 21, juveniles of Siganidae and Mullidae contributed a lot to the high mean density observed on Station 3.

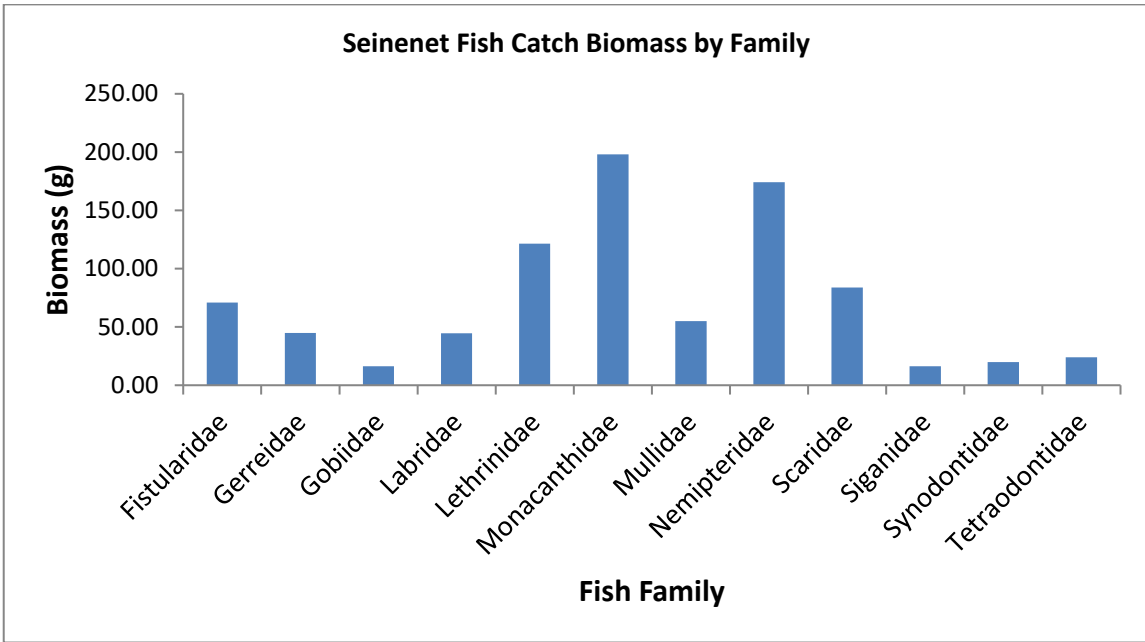


Figure 22. Seine net catch compositions by family.

A higher biomass and CPUE for handline fishing was observed for Stations 6 and 5 on the wave-exposed side of Motupore Island (Table 23). However, most of the fishes caught were of small sizes relative to known maximum size for those fishes.

The mean for carnivore is significantly higher than all the other trophic levels (Figure 23). Given the mean of 17 fish species per hectare of reef recorded above, carnivores would be represented by about 10 of the 17 species, herbivore 4 of the 17 species, planktivore 2 species, and at least a species of top predators or Omnivores (Figure 23). Large numbers of top predators (sharks and snappers) foraging on a reef system reflects abundance of prey species. Although the current survey sites can provide a mean of about 600 individual fishes (potential preys) per hectare of reef, the low mean number (Figure 23) of top predators indicate their absence from the reefs surveyed. This observation may require further investigations to determine the cause of lack of predatory fishes in Bogoro Inlet and Motupore Island reefs. This observation also applies to large herbivores. It is advisable to monitor fishing pressure on the reefs in the two sites as soon as is practically possible because of unregulated intensive night-dive fishing at least 3 times a week (as observed during survey period) on these reefs.

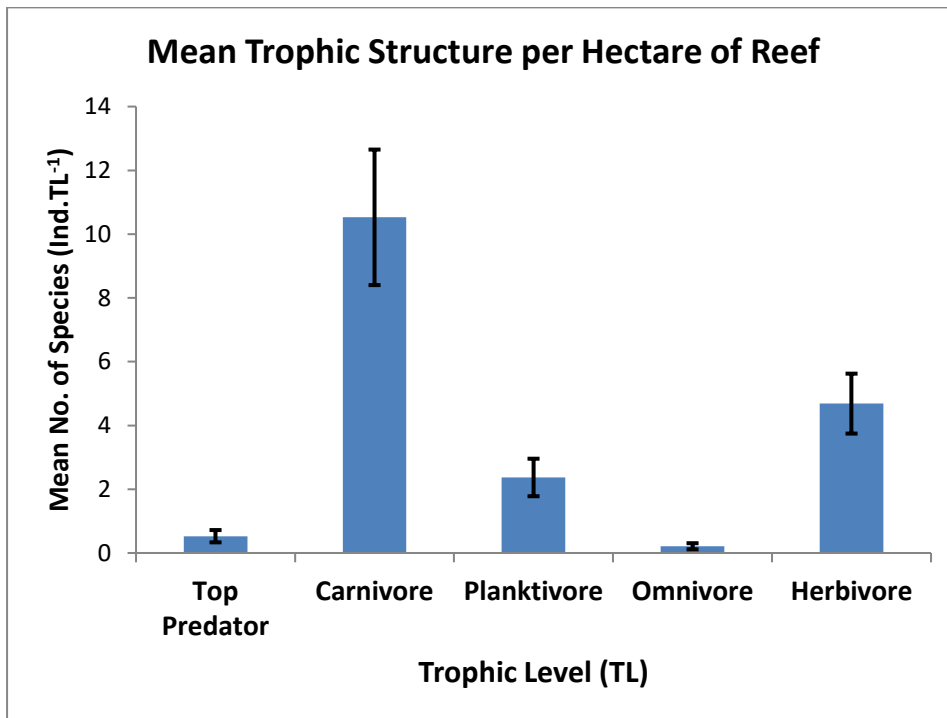


Figure 23. Mean number of fishes in each trophic level per hectare of reef in Bogoro Inlet and Motupore Island.

Observations of fishermen (during the survey period) fishing at least 3-4 nights per week are intensive and pose greater risk of overharvesting of fish and other marine resources. It is therefore important to assess the current fishes' status in terms of their risk of extinction, especially local extinction. The International Union for Conservation of Nature (IUCN) has established criteria for assessing the risk of extinction for many species whereby they are categorised based on their status as shown in Table 24.

Table 24. IUCN Redlist categories and definitions. Source: adapted from IUCN, 2001.

IUCN Category	Definition
EXTINCT (EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
EXTINCT IN THE WILD (EW)	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
CRITICALLY ENDANGERED (CR)	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.

ENDANGERED (EN)	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.
VULNERABLE (VU)	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.
NEAR THREATENED (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
LEAST CONCERN (LC)	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
DATA DEFICIENT (DD)	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.
NOT EVALUATED (NE)	A taxon is Not Evaluated when it has not yet been evaluated against the criteria.



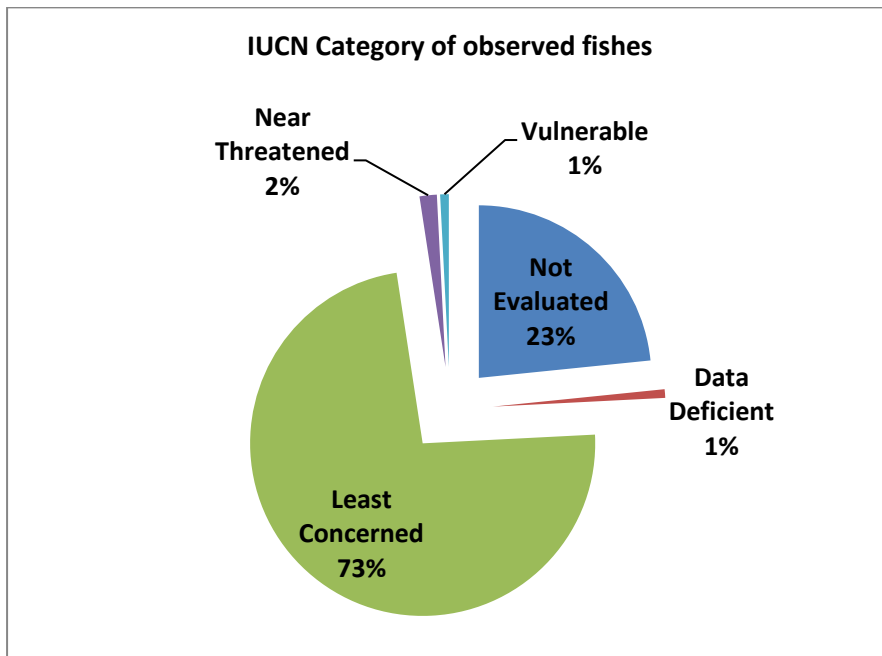


Figure 24. IUCN Category of the recorded fish species.

IUCN Redlist of the fishes observed at Bogoro Inlet and Motupore Island (Figure 24) showed that the majority of the fish species are either of least concerned (73%) or not evaluated (23%). However, sporadic occurrence of top predatory fishes (example sharks, snappers, and groupers) and lack of large size fishes observed in all the stations during the survey period (2 weeks) indicated a significant fishing pressure (3-4 night-dives per week observed) on the fish resources of Bogoro Inlet and Motupore Island. Given this trend, and if it goes on unchecked, the fish diversity in Bootless Bay may suffer recruitment as overfishing diminished fishes' population and may not have the ability to replenish their populations. This would also mean a disaster for the people who are dependent on fishing to support their livelihoods. Unfortunately, the vulnerable and near threatened fish species (3%) also face the same threats. It is advisable to monitor their populations and mitigate any threats they are subjected to.

### Conclusions

An updated fish species checklist for Bootless Bay includes 512 species from 77 families. Bogoro Inlet and Motupore Island are fish species rich marine ecosystems and more species are yet to be documented. Increase and repeated sampling will determine the full range of species and their distribution in Bootless Bay.

More fish species inhabit complex reef systems with high live cover types (corals, seagrass, and algae) than homogeneous or simple reef systems. However, large homogeneous seagrass, mangrove, and coral beds provide important nursery and feeding grounds for many juvenile fishes.

The dominant fish trophic structure of the Bogoro Inlet and Motupore Island are carnivores and herbivores. The lack of top Predators from the surveyed reefs is probably an indication of the current fishing pressure which is not being monitored.

The majority of the fish species in Bogoro Inlet and Motupore Island are of least concerned or not evaluated in regards to their IUCN risk of extinction status. However, the excessive harvesting of these species can lead to local extinction and pose a threat to coastal livelihoods that depends on these fish and other marine resources in Bootless Bay.

Addressing marine resources sustainability issues is paramount to conserving marine biodiversity in Bootless Bay. The causes and impacts of current fishing pressure must be understood and necessary steps taken to prevent potential overfishing trend and its consequences.

The dominant fish trophic structure of the Bogoro Inlet and Motupore Island are Carnivores and Herbivores. The lack of Top Predators from the surveyed reefs is probably an indication of the current fishing pressure which is not being monitored.

The majority of the fish species in Bogoro Inlet and Motupore Island are of least concerned or not evaluated in regards to their IUCN risk of extinction status. However, the excessive exploitation of the resource(s) (see chapter 7) can lead to local extinction and pose threats to coastal livelihoods that depend on these fish and other marine resources within Bootless Bay.

Addressing marine resources sustainability issues is paramount to conserving marine biodiversity in Bootless Bay. The causes and impacts of current fishing pressure must be understood and necessary steps taken to prevent potential overfishing trend and its consequences.

## References

---

- 1) Mark Baine & David Harasti. 2007. The marine life of Bootless Bay Papua New Guinea. Motupore Island Research Centre, School of Natural and Physical Sciences, University of Papua New Guinea.
- 2) Neville Coleman. 1998. Discover Loloata Island – Marine life guide to Papua New Guinea. Neville Coleman’s Underwater Geographic Pty Ltd, Australia.
- 3) Drew, J. A., Buxman, C. L., Holmes, D. D., Mandrecki, J. L., Mungkaje, A. J., Richardson, A. C. and Westneat, M. W. 2012. Biodiversity inventories and conservation of the marine fishes of Bootless Bay, Papua New Guinea. *BMC Ecology*, 12:15. Doi: 10.1186/1472-6785-12-15.
- 4) Allen, Gerry. 1991. Reef fishes of New Guinea.
- 5) Allen, Gerry. 1999. Marine fishes of South-east Asia. Periplus Editions (HK) Ltd. Singapore.
- 6) King, Michael. 1995. Fisheries biology, assessment and management. Fishing News Books Ltd, London, UK.
- 7) Kuitert, Rudie H & Debelius, Helmut. 2006. World atlas of marine fishes.
- 8) Ko’ou, A. Y. 2014. Habitats influence on the variations in the recruitment of overfished sea cucumbers on the fringing reefs of Bootless Bay, Papua New Guinea - MSc Thesis. Diponegoro University, Semarang, Indonesia.
- 9) Maniwavie, M. 2010. Sediment levels and its impacts on live coral cover in Bootless Bay, Port Moresby. Research techniques and skills course-work report. University of Papua New Guinea.

## Appendix 6-1: List of fish species observed at Bogoro Inlet and Motupore Island proposed MPAs.

Family	Scientific Name	Common Name	IUCN Redlist	Reference
Acanthuridae	<i>Acanthurus lineatus</i>		Least Concerned	4, 5
Acanthuridae	<i>Ctenochaetus striatus</i>		Least Concerned	4, 5
Acanthuridae	<i>Naso lituratus</i>		Least Concerned	4, 5
Acanthuridae	<b><i>Naso unicornis</i></b>		Least Concerned	4, 5
Acanthuridae	<b><i>Zebrasoma scopas</i></b>		Least Concerned	4, 5
Acanthuridae	<b><i>Zebrasoma veliferum</i></b>		Least Concerned	4, 5
Apogonidae	<i>Apogon kallopterus</i>		Least Concerned	4, 5
Apogonidae	<i>Sphaeramia orbicularis</i>		Not evaluated	4, 5
Apogonidae	<i>Apogon cyanosoma</i>		Least Concerned	4, 5
Balistidae	<i>Balistapus undulatus</i>		Not evaluated	4, 5
Balistidae	<i>Rhinecanthus aculeatus</i>		Not evaluated	4, 5
Balistidae	<i>Rhinecanthus verrucosus</i>		Not evaluated	4, 5
Balistidae	<i>Sufflamen chrysopterus</i>		Not evaluated	4, 5
Belonidae	<i>Tylosurus crocodylus</i>		Least Concerned	4, 5
Blenniidae	<i>Meiacanthus grammistes</i>		Least Concerned	4, 5
Caesionidae	<i>Caesio caeruleaurea</i>		Least Concerned	1,4, 5
Carangidae	<i>Caranx ignobilis</i>	Giant Trevally	Least Concerned	4, 5
Carcharhinidae	<b><i>Triaenodon obesus</i></b>	Whitetip reef shark	Least Concerned	1
Chaetodontidae	<i>Chaetodon baronessa</i>		Least Concerned	4, 5
Chaetodontidae	<i>Chaetodon citrinellus</i>		Least Concerned	4, 5
Chaetodontidae	<i>Chaetodon ephippium</i>		Least Concerned	4, 5
Chaetodontidae	<i>Chaetodon kleinii</i>		Least Concerned	4, 5
Chaetodontidae	<i>Chaetodon plebeius</i>		Least Concerned	4, 5
Chaetodontidae	<i>Chaetodon rafflesi</i>		Least Concerned	4, 5
Chaetodontidae	<i>Chaetodon speculum</i>		Least Concerned	4, 5
Chaetodontidae	<i>Chaetodon trifascialis</i>		Near Threatened	4, 5
Chaetodontidae	<i>Chaetodon trifasciatus</i>		Least Concerned	4, 5
Chaetodontidae	<i>Chaetodon vagabundus</i>		Least Concerned	4, 5
Chaetodontidae	<i>Chelmon rostratus</i>		Least Concerned	4, 5

Chaetodontidae	<i>Heniochus chrysostomus</i>		Least Concerned	4, 5
Chaetodontidae	<i>Heniochus singularis</i>		Least Concerned	4, 5
Chaetodontidae	<i>Heniochus varius</i>		Least Concerned	4, 5
Dasyatidae	<i>Dasyatis kuhlii</i>	Blue-spotted Stingray	Data Deficient	4, 5
Dasyatidae	<i>Taeniura lymma</i>	Fantail Stingray	Near Threatened	4, 5
Fistulariidae	<i>Fistularia commersoni</i>		Least Concerned	4, 5
Gobiidae	<i>Amblygobius cf phalaena</i>	Gobifish	Not evaluated	4, 5
Haemulidae	<i>Plectorhinchus chrysotaenia</i>		Not evaluated	1, 4, 5
Haemulidae	<i>Plectorhinchus orientalis</i>	Oriental Sweetlips	Least Concerned	4, 5
Harpodontidae	<i>Saurida gracilis</i>	Gracile lizardfish	Least Concerned	4, 5
Hemirhamphidae	<i>Hemirhamphus dussumieri</i>	Dussumier's Garfish	Least Concerned	4, 5
Hemirhamphidae	<i>Hemirhamphus far</i>		Not evaluated	4, 5
Hemiscyllidae	<b><i>Hemiscyllium hallstromi</i></b>	Epaulette shark	Vulnerable	1, 7
Holocentridae	<i>Sargocentron caudimaculatum</i>		Least Concerned	1
Labridae	<i>Cheilinus chlorurus</i>		Least Concerned	4, 5
Labridae	<b><i>Cheilinus undulatus</i></b>		Least Concerned	4, 5
Labridae	<i>Cheilio inermis</i>		Least Concerned	4, 5
Labridae	<i>Choerodon anchorago</i>		Least Concerned	4, 5
Labridae	<i>Halichoeres argus</i>		Least Concerned	4, 5
Labridae	<i>Halichoeres chloropterus</i>		Least Concerned	4, 5
Labridae	<i>Halichoeres hortulanus</i>		Least Concerned	4, 5
Labridae	<i>Hemigymnus melapterus</i>		Least Concerned	4, 5
Labridae	<i>Labroides dimidiatus</i>		Least Concerned	4, 5
Labridae	<i>Macropharyngodon meleagris</i>		Least Concerned	4, 5
Labridae	<i>Stethojulis bandanensis</i>		Least Concerned	4, 5
Labridae	<i>Thalassoma hardwickei</i>		Least Concerned	4, 5
Labridae	<i>Thalassoma janseni</i>		Least Concerned	4, 5
Labridae	<i>Thalassoma lunare</i>		Least Concerned	4, 5
Lethrinidae	<i>Monotaxis grandoculis</i>		Least Concerned	4, 5
Lethrinidae	<i>Lethrinus lentjan</i>		Least Concerned	4, 5
Lethrinidae	<i>Lethrinus nebulosus</i>		Least Concerned	4, 5

Lethrinidae	<i>Lethrinus harak</i>		Least Concerned	4, 5
Lethrinidae	<i>Lethrinus ornatus</i>		Least Concerned	4, 5
Lethrinidae	<i>Lethrinus variegatus</i>		Least Concerned	4, 5
Lutjanidae	<i>Lutjanus bohar</i>		Least Concerned	4, 5
Lutjanidae	<i>Lutjanus carponotatus</i>		Least Concerned	4, 5
Lutjanidae	<i>Lutjanus semicinctus</i>		Least Concerned	4, 5
Lutjanidae	<i>Macolor niger</i>		Least Concerned	1, 4, 5
Monacanthidae	<i>Oxymonacanthus longirostris</i>		Least Concerned	1
Monacanthidae	<i>Pervagor nigrolineatus</i>		Least Concerned	4, 5
Mugilidae	<i>Mugil cephalus</i>		Least Concerned	4, 5
Mullidae	<i>Parupeneus barberinoides</i>	Goatfish	Least Concerned	4, 5
Mullidae	<i>Parupeneus barberinus</i>	Goatfish	Least Concerned	4, 5
Mullidae	<i>Parupeneus bifasciatus</i>		Least Concerned	4, 5
Mullidae	<i>Parupeneus indicus</i>	Goatfish	Least Concerned	4, 5
Mullidae	<i>Parupeneus multifasciatus</i>		Least Concerned	4, 5
Nemipteridae	<i>Pentapodus trivittatus</i>		Least Concerned	4, 5
Nemipteridae	<i>Scolopsis bilineatus</i>	Bridled Monocole-bream	Least Concerned	4, 5
Nemipteridae	<i>Scolopsis ciliatus</i>		Least Concerned	4, 5
Pinguipedidae	<i>Parapercis diplospila</i>		Least Concerned	7
Pomacanthidae	<i>Centropyge bicolor</i>		Least Concerned	4, 5
Pomacanthidae	<i>Centropyge vrolikii</i>		Least Concerned	4, 5
Pomacentridae	<i>Abudefduf sexfasciatus</i>		Least Concerned	4, 5
Pomacentridae	<i>Abudefduf whitleyi</i>	Whitley's sergeant	Not evaluated	4, 5
Pomacentridae	<i>Amblyglyphidodon curacao</i>	Staghorn damsel	Not evaluated	4, 5
Pomacentridae	<i>Amphiprion clarkii</i>		Not evaluated	4, 5
Pomacentridae	<i>Amphiprion melanopus</i>		Not evaluated	4, 5
Pomacentridae	<i>Amphiprion polymnus</i>	Anemone fish	Least Concerned	4, 5
Pomacentridae	<i>Chromis amboinensis</i>		Not evaluated	4, 5
Pomacentridae	<i>Chromis cinerascens</i>	Green Chromis	Not evaluated	4, 5
Pomacentridae	<i>Chromis margaritifer</i>		Not evaluated	4, 5
Pomacentridae	<i>Chromis viridis</i>	Blue-green Chromis	Not evaluated	4, 5

Pomacentridae	<i>Dascyllus aruanus</i>		Not evaluated	4, 5
Pomacentridae	<i>Dascyllus melanurus</i>	Black-tailed dacyllus	Not evaluated	4, 5
Pomacentridae	<i>Dascyllus reticulatus</i>	Reticulated dascyllus	Not evaluated	4, 5
Pomacentridae	<i>Dascyllus trimaculatus</i>	Three-spot dacyllus	Not evaluated	4, 5
Pomacentridae	<i>Dischistodus chrysopoecilus</i>		Not evaluated	4, 5
Pomacentridae	<i>Dischistodus prosopotaenia</i>		Not evaluated	4, 5
Pomacentridae	<i>Neoglyphidodon melas</i>	Black Damsel	Not evaluated	4, 5
Pomacentridae	<i>Neoglyphidodon nigroris</i>		Not evaluated	4, 5
Pomacentridae	<i>Neopomacentrus azysron</i>		Not evaluated	4, 5
Pomacentridae	<i>Plectroglyphidodon lacrymatus</i>	Jewel Damsel	Not evaluated	4, 5
Pomacentridae	<i>Pomacentrus grammorhynchus</i>		Not evaluated	4, 5
Pomacentridae	<i>Pomacentrus nagasakiensis</i>		Not evaluated	4, 5
Pomacentridae	<i>Pomacentrus reidi</i>		Not evaluated	4, 5
Pomacentridae	<i>Stegastes nigricans</i>		Not evaluated	4, 5
Scaridae	<i>Chlorurus sordidus</i>		Least Concerned	4, 5
Scaridae	<i>Leptoscarus vaigiensis</i>		Least Concerned	4, 5
Scaridae	<i>Scarus bleekeri</i>		Least Concerned	4, 5
Scaridae	<i>Scarus dimidiatus</i>		Least Concerned	4, 5
Scaridae	<i>Scarus oviceps</i>	Blue Parrotfish	Least Concerned	4, 5
Scaridae	<i>Scarus rivulatus</i>		Least Concerned	4, 5
Scaridae	<i>Scarus schlegeli</i>		Least Concerned	4, 5
Scorpaenidae	<i>Pterois volitans</i>	Lionfish	Least Concerned	1
Scorpaenidae	<i>Scorpaenopsis diabolis</i>	Scorpionfish	Least Concerned	1
Serranidae	<i>Epinephelus merra</i>	Honeycomb Cod	Least Concerned	4, 5
Serranidae	<i>Cephalopholis boenak</i>		Least Concerned	4, 5
Siganidae	<i>Siganus canaliculatus</i>		Least Concerned	4, 5
Siganidae	<i>Siganus doliatus</i>		Least Concerned	4, 5
Siganidae	<i>Siganus spinus</i>		Least Concerned	4, 5
Siganidae	<i>Siganus vulpinus</i>		Least Concerned	4, 5
Sphyraenidae	<i>Sphyraena barracuda</i>	Great Barracuda	Least Concerned	4, 5
Syngnathidae	<i>Corythoichthys haematopterus</i>	Messmate pipefish	Least Concerned	4, 5

Synodontidae	<i>Synodus variegatus</i>		Least Concerned	1, 4, 5
Tetraodontidae	<i>Arothron hispidus</i>	Pufferfish (juv)	Least Concerned	4, 5
Tetraodontidae	<i>Arothron stellatus</i>	Pufferfish (juv)	Least Concerned	4, 5
Tetraodontidae	<i>Canthigaster compressa</i>		Least Concerned	4, 5
Tetraodontidae	<i>Canthigaster valentini</i>		Least Concerned	4, 5
Zanclidae	<i>Zanclus cornutus</i>		Least Concerned	4, 5



## CHAPTER 7. ANTHROPOGENIC IMPACT - A PRELIMINARY SURVEY

### *Introduction*

The tropical coastal and marine zones are important marine ecosystems for human that provide a variety of goods and services, highly beneficial to humans in terms of food supplies, amenities and protection from land erosion [1, 2, 3]. Yet, the tropical seascape suffers from different types of severe threats due to abiotic and anthropogenic disturbances, where important ecosystem functions might be lost [4, 5, 6]. Of any significance are the flow of energy and nutrients within an ecosystem and the export of the energy to the surrounding ecosystems.

Coastal people in many developing countries are dependent on fisheries as their main income and food security. Empirical evidence indicates that they are already affected by the declining fish catches and other seafood sources [6, 8]. The loss of ecosystem functions from overfishing also affects habitat resilience, making these habitats more vulnerable to other stressors such as global warming [6, 9, 10]. Overexploitation might lead to a regime shift in an ecosystem [11]. Overfishing of herbivorous fish (e.g. parrotfishes, sweetlips) on coral reefs, for instance, has shown to alter the ecosystem to a more algae-dominated system, where corals are overgrown by algae in absence of herbivores which in turn may lead to an ecosystem collapse [12, 13]. Since connectivity between different habitats within ecosystems is high in the tropical seascape, such threats might not only affect individual habitats but also the whole coastal seascapes [6].

Mangrove forests on the other hand, are repeatedly being stressed as one of the world's most threatened tropical ecosystems [14]. The mangrove forests harbour a multitude of organisms, some serve as income sources, including mud crabs, mussels, oysters, etc. for many coastal communities. Mangrove trees are used for firewood, construction wood, wood chip and pulp production, and animal fodder [14]. Clearance, overharvesting, and overfishing threatens mangrove forests and in turn, the entire marine ecosystems.

A common way to preserve and manage ecosystem functions is to establish marine protected areas (MPAs) in areas where mangroves are found. However, to develop an important management strategy for the protection of such ecosystems will require a strong understanding of the background issues relating to the anthropogenic activities happening within and around such an ecosystem.

This report outlines a preliminary survey of the anthropogenic activities and their impacts on the coastal zone and marine ecosystems of Bogoro and Motupore Island within the Bootless Bay area.

### *Objectives*

This survey is part of the biodiversity study conducted for Bogoro Inlet and Motupore Island. The objectives were to conduct preliminary surveys of any activities and utilization pertaining to the marine ecosystem. The results will be used as a guide for drawing recommendations for the establishment of MPAs in Bootless Bay area.

### *Material and Methods*

Anthropogenic impacts were purely based on sightings and mapping. Fishing activities by locals were monitored during the duration of this study both at Motupore Island and Borogo Inlet. The monitoring includes recordings of number of fishermen, their canoes and outboard motors catching fish by various fishing methods (e.g., diving, using nets, trawling and/or doing bottom fishing) around Motupore Island and Borogo Inlet. Much of the recordings involved observations focused on fishing. It includes the time of fishing (morning, afternoon or night) and the location of fishing activities around the Motupore Island and at Borogo Inlet. Locations were plotted on a paper map and later translated to GPS coordinates. All records were kept in a log sheet in Microsoft Office Excel 2010 Spread sheet. All sightings were mapped and shown in Figure 25.

Impacts on mangroves were assessed during the transect surveys of mangrove forests at Borogo Inlet and confirmed from satellite imageries @googleearth.com and ground truthing. Maps were produced using ArcMap 10.1.

## Results

### Fishing Activity

The frequency of fishing activities by the local villages was observed to be very high as indicated by the number of fishermen and their canoes and boats doing fishing by day and night. Over the duration of the biodiversity survey, 22 fishing sightings of locals were recorded in our log book (Figure 22).

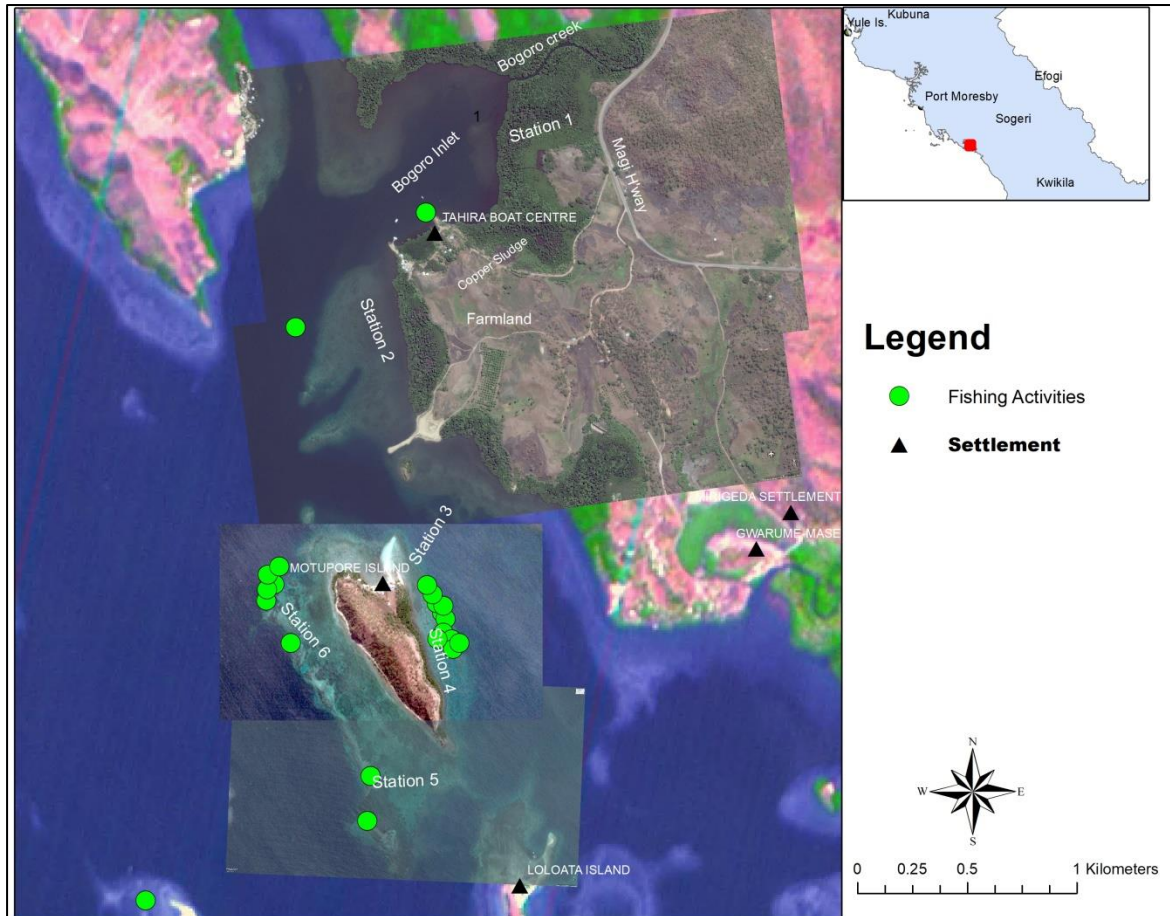


Figure 25. Fishing sightings observed during the duration of the survey

Fishing at Bogoro Inlet were infrequent than on the island. On Motupore Island, line fishing and night diving were common methods employed by the locals (Figures 26 and 27).

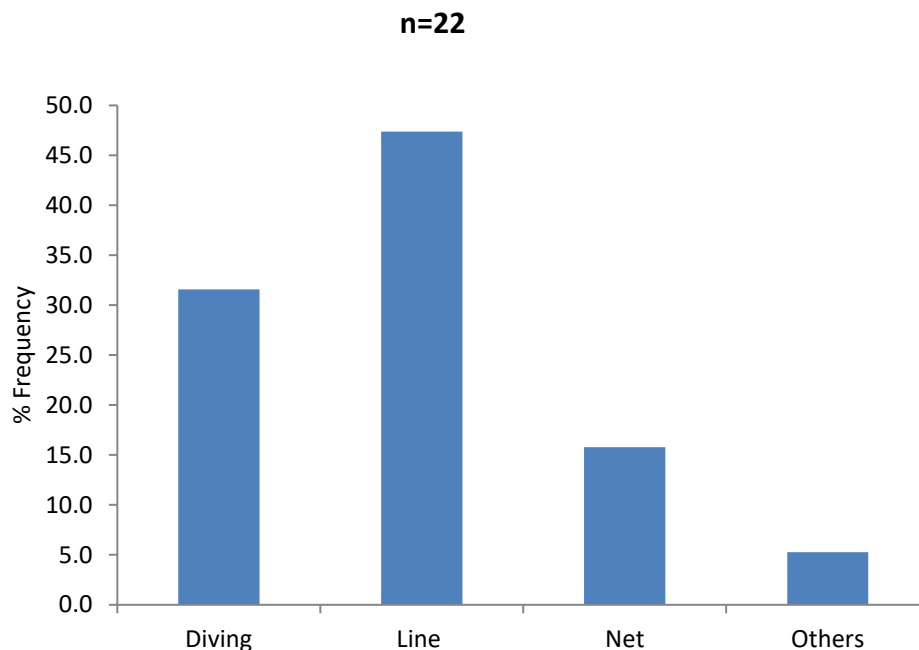


Figure 26. Percent frequency of methods employed by locals when fishing around Motupore Island and the surrounding island.

At Motupore Island the locals conduct their fishing activities mostly on reef edges at the western and eastern parts of the island as indicated in Figure 27. Most of the catch comprises reef fishes (e.g., rock cods, halfbeaks, snappers, mullets, damselfish) and some pelagic fishes (e.g., long toms, tunas, skipjacks, trevallies). Apart from fishing at the eastern section of the island, locals also dive to harvest edible bivalves and univalves. Most of what they caught and harvest are for sale at the markets in the urban markets and whatever is not sold are consumed.

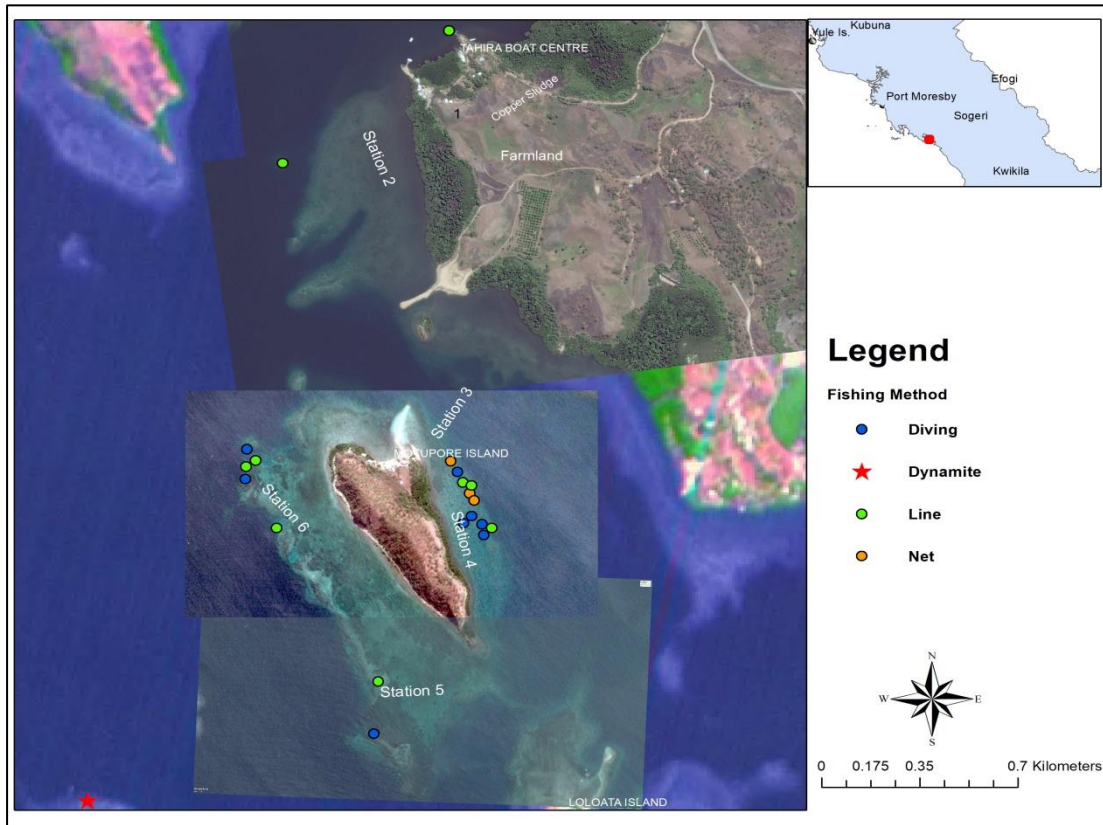


Figure 27. Fishing methods employed by local fishermen. From local informants, dynamite is commonly used. During the survey, only one explosion was heard near Lion Island, SW of Motupore Island.

More line fishing and diving were performed during afternoons and nights (Figure 27). While at the Bogoro Inlet, the only site of fishing was observed at the Tahira jetty, especially in the afternoons where the fishermen usually do their fishing.

### Time of fishing

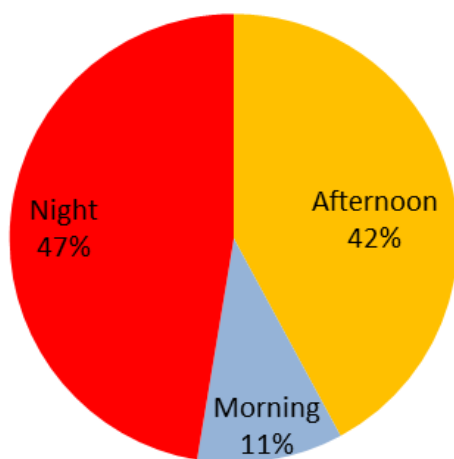


Figure 28. Temporal patterns of fishing activities as observed and recorded around Motupore Island. The percentages are derived from counting the total number of fishermen fishing over a 24 hour period.



The line of survey established for biodiversity assessments at site 1 and site 2, intercepted large clearance in the middle zone of the forest at Bogoro (Figure 22).

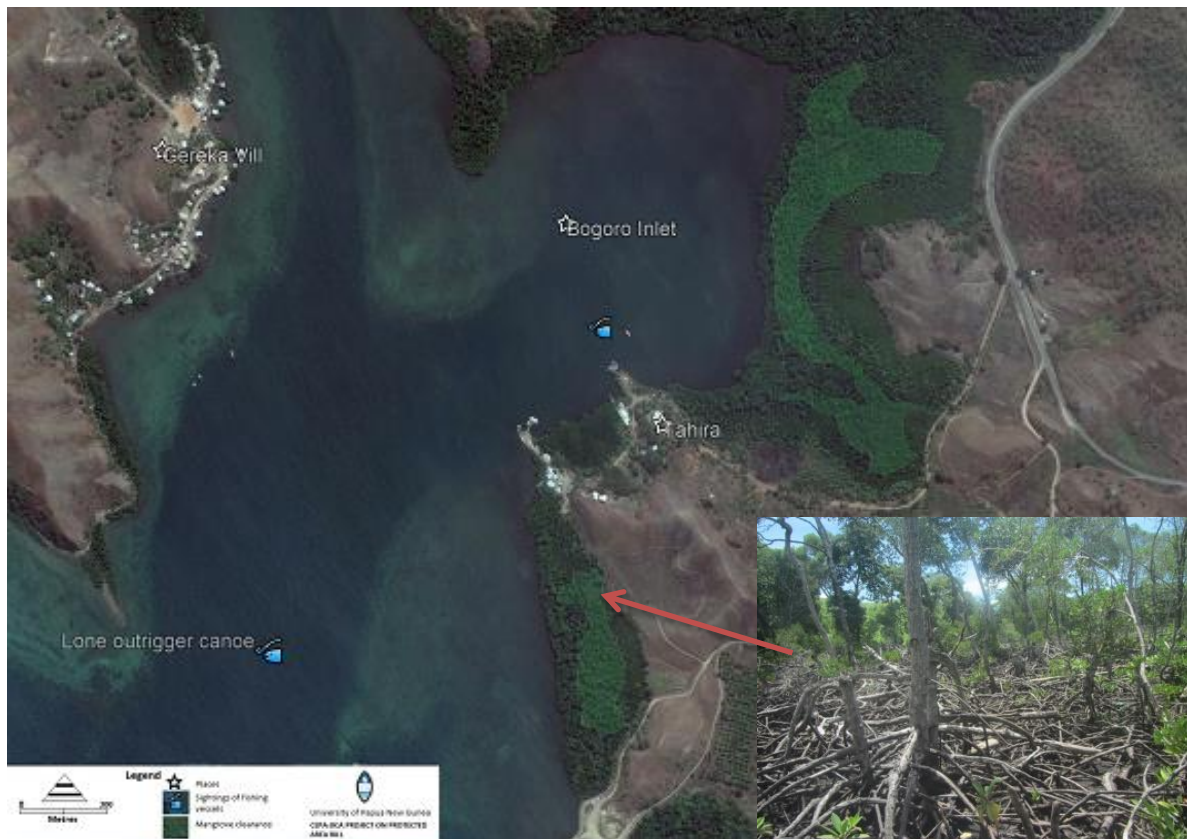


Figure 29. Image of mangrove forest indicating clearance (light green shade. Inserted picture was taken from where the arrow is pointing to the larger image.

## Discussion

Overexploitation in terms of overfishing or mangrove harvesting is one of the major anthropogenic threats to marine ecosystems. Overfishing for example, have adversely affects biodiversity, not only directly from overfishing and harvesting of target species, but also indirectly through the use of destructive fishing methods, where important habitats are destroyed [6, 7].

Our preliminary results indicate that there is an increasing pressure on the marine resources, especially by overfishing and harvesting by the local fishermen and villagers. Such a pressure will further increase as the population around the Bootless Bay area as well as from the city increase. Note that already, the settlements around the Bay area, especially around Taurama, Gereka and Tuna Bay area are increasing, apart from Tubusera and other coastal Motu villages to the east of the study area. Increased population within the areas surround the proposed MPA will inevitably require more land clearances for roads, housing and gardening for food crops. Further, such increase in population will also result in high production of additional domestic wastes which will eventually enter the the MPA and its environment.

Further, land-based disturbances around the Bootless Bay area, as noted, are also exerting additional impacts into the marine ecosystem. This is particularly obvious from the increasing infrastructural developments, such as land clearance for roads, aviation fuel pipeline and houses. Farming activities inland of the Bogoro Inlet as well as the surrounding areas, couples with continual burning of savanna shrub-grassland will add more pressure on to the mangroves and the marine systems in the area.

Such activities will continue to increase as the city continues to expand into the surrounding areas, including the Bootless Bay area. In fact, the urban development plan by the National Capital District (NCD) has included the land surrounding the Bootless Bay in its overall plan (Figure 30). With all these planned development activities, it can be predicted that there will be an increase in sedimentation loads from eroding inland cleared surfaces going into the Bay. In fact, there is already ample evidence on this matter, especially around the Bogoro Inlet as shown in Figure 29.

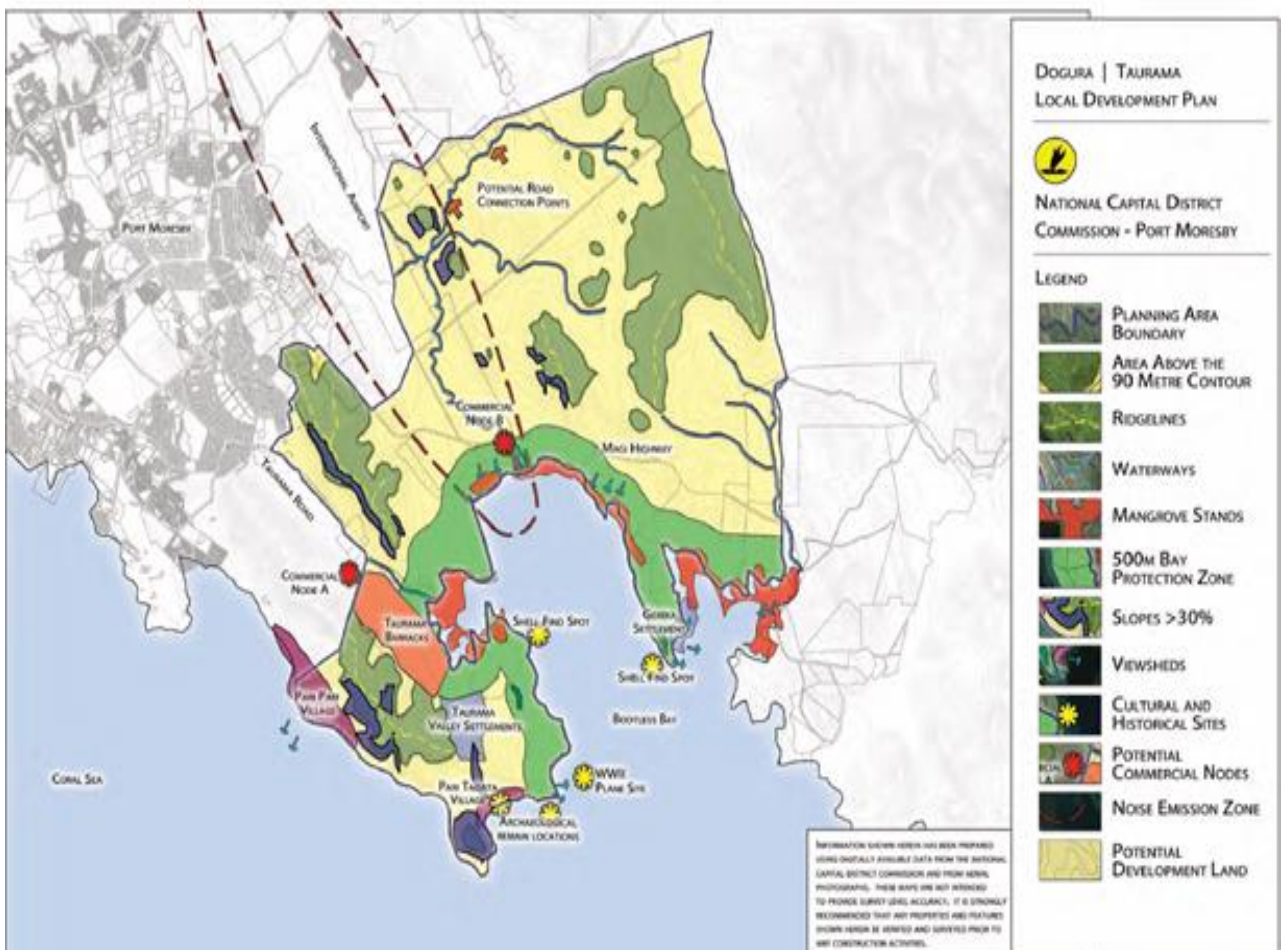


Figure 30. National Capital District(NCD) Development plan of 2011.

Thus, there is an urgent call for action to protect the whole of the Bootless Bay area and its surroundings and the current proposal for the establishment of an MPA for the Bay is timely, but this needs an urgent action to be implemented now rather than later.

In addition, appropriate management strategies are now required to be put in place to better manage the proposed MPA and all other developments that have been planned for the area.

## References

1. Moberg, F. and Folke, C. (1999) Ecological goods and services of coral reef ecosystems. *Ecological Economics*, **29**, 215-233.
2. Department of the Environment, Water, Heritage and the Arts (2009). *Ecosystem Services: Key Concepts and Applications*, Occasional Paper No 1, Department of the Environment, Water, Heritage and the Arts, Canberra.
3. Donato, D. C., Kauffman J. B., Murdiyarsa, D., Kurnianto, S., Stidham, M. and Kanninen M. (2011) Mangroves among the most carbon-rich forests in the tropics. *Nature*, **4**, 293-297.
4. Halpern, B. S., Selkoe, K. A., Micheli, F. and Kappel, C. V. (2007) Evaluating and ranking the vulnerability of global marine ecosystems to anthropogenic threats. *Conservation Biology*, **21**, 1301-1315.
5. Cheung, W. W. L., Watson, R. and Pauly, D. (2013) Signature of ocean warming in global fisheries catch. *Nature*, **497**, 365
6. Skoglund, S. (2014) *Effects of different marine protection levels on fish communities in tropical seagrass beds and coral reefs*. MSc Thesis, Master's programme in Biology, Department of Ecology, Environment and Botany, Stockholms universitet.
7. Dayton, P. K., Thrush, S. F., Agardy, M. T. and Hofman, R. J. (1995) Environmental-effects of 24 marine fishing. *Aquatic Conservation-Marine and Freshwater Ecosystems*, **5**, 205-232.
8. Cruz-Trinidad, A., Alino, P. M., Geronimo, R. C. and Cabral, R. B. (2014) Linking Food Security with Coral Reefs and Fisheries in the Coral Triangle. *Coastal Management*, **42**, 160-182.
9. Drew, J. A., Buxman, C. L., Holmes, D. D., Mandrecki, J. L., Mungkaje, A. J., Richardson, A. C. and Westneat, M. W. 2012. Biodiversity inventories and conservation of the marine fishes of Bootless Bay, Papua New Guinea. *BMC Ecology*, **12**:15. Doi: 10.1186/1472-6785-12-15.
10. Johansen, J. L., Messmer, V., Coker, D. J., Hoey, A. S. and Pratchett, M. S. (2014) Increasing ocean temperatures reduce activity patterns of a large commercially important coral reef fish. *Global Change Biology*, **20**, 1067-1074.
11. Ko'ou, A. Y. 2014. Habitats influence on the variations in the recruitment of overfished sea cucumbers on the fringing reefs of Bootless Bay, Papua New Guinea - MSc Thesis. Diponegoro University, Semarang, Indonesia.
12. Elmhirst, T., Connolly, S. R. and Hughes, T. P. (2009) Connectivity, regime shifts and the resilience of coral reefs. *Coral Reefs*, **28**, 949-957.
13. Fox, R. J. and Bellwood, D. R. (2014) Herbivores in a small world: network theory highlights vulnerability in function of herbivory on coral reefs. *Functional Ecology*, **28**, 642-651.
14. [http://wwf.panda.org/about\\_our\\_earth/blue\\_planet/coasts/mangroves/mangrove\\_threats/](http://wwf.panda.org/about_our_earth/blue_planet/coasts/mangroves/mangrove_threats/)
15. Cardno 2015. Study into the Port Moresby urban development plan. Port Moresby.

## CHAPTER 8. BIODIVERSITY ASSESSMENT

### *Introduction*

### *Biodiversity Assessment*

The assessment of biodiversity of Bogoro Inlet and Motupore Island in light of their conservation values is presented in this section. The assessment includes presentation of data on the proposed Boot Bay MPA (BBMPA) biodiversity and ecological processes. The term 'conservation value' is defined as an element of environment identified as a key ecological feature. The key ecological feature is identified in this assessment using systems approach whereby each system identified is examined in the context of its biodiversity (species, habitats, functional groups), ecological processes (energy and biogeochemical cycle), and changes to the feature due to impacts from natural and anthropogenic induced stressors.

A key ecological feature is further defined as a feature of biodiversity (species or ecosystems) that meet one or more of the following assessment criteria:

1. A species, group of species, or community with important ecological role (for example as a predator (parrotfishes i.e. remove algae) or a prey species that affects a large biomass or number of other species); or
2. A species, group of species, or community that is locally or regionally important for maintaining high concentration of biodiversity (example mangroves or keystone species); or
3. An area or habitat that is locally or regionally important for:
  - a. maintaining high concentration of biodiversity values (endemism, rare, endangered or threatened species; refugia);
  - b. maintaining large aggregations of life forms (such as feeding, breeding or nursery areas),
  - c. maintaining high biological productivity (for example upwelling), or
4. A unique feature (for example barrier reef) with known or presumed ecological properties of local or regional significance.

Local scale importance includes significance at ecosystems, and landscapes or seascapes while regional scale importance includes significance at seas and oceans. For examples Bootless Bay ecosystem is within the Papuan Basin Seascape which is within Coral Sea in the Western Pacific Ocean.

These assessment criteria determine the biodiversity and conservation values of a proposed protected area and also add values to the design of the management plans.



Therefore, as a conclusion of this report, this chapter will dwell on the identification of sites within the two study sites which appear to have high conservation values (HCVs) as defined above. Such values include sites that have high species occurrence, endemics, and uniqueness in terms of cultural and/or aesthetic values. Additionally, and supplementary to this report is the collation and distribution of the Mangrove and Bird guides and a Monitoring manual to monitor the MPAs.

## **Objectives**

The objective of this assessment is to provide a summary of the available and relevant information, including maps, about the Bogoro Inlet and Motupore Island biodiversity (species and habitats) status, ecological processes and physical environments (i.e. oceanography, geomorphology, substrate type, geological history), threats to the biodiversity status, and threats to management approaches. It also highlights the diversity localities and high conservation values as determined by the findings of this study.

## **Methods and Material**

### **Biodiversity Conservation Values Analysis**

Prioritizing and designating protected areas will be based on the principles of comprehensiveness, adequacy, representation, and resilience [1] where key areas and values are identified and prioritized.

The high conservation values (HCV) method is employed to assess the proposed Bootless Bay MPA, and its habitats and species of significance in terms of their conservation values. The HCV method involved assessing biodiversity for their conservation values using six (6) criteria [2, 3]. The six criteria are;

1. HCV 1. Areas containing globally, regionally or nationally significant concentrations of biodiversity values (e.g. endemism, rare, endangered or threatened species, refugia).
2. HCV 2. Globally, regionally or nationally significant large landscape/seascape-level areas where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance.
3. HCV 3. Areas that are in or contain rare, threatened or endangered ecosystems.
4. HCV 4. Areas that provide basic ecosystem services in critical situations (e.g. watershed, erosive coast or hilly slopes).
5. HCV 5. Areas fundamental to meeting basic needs of Barakau, Tubusereia, Gereka, and Pari communities (e.g. subsistence, health).
6. HCV 6. Areas critical to Barakau, Tubusereia, Gereka, and Pari communities traditional cultural identity (areas of cultural, ecological, economic or religious significance identified in cooperation with such local communities).

Additionally, the biodiversity and habitat aspects will be evaluated under the following sub-criteria under HCV 1-4;

- ✓ HCV 1.1 Protected Areas as per UPNG research category
- ✓ HCV 1.2 Threatened and endangered species

- ✓ HCV 1.3 Endemic and rare species
- ✓ HCV 1.4 Critical temporal use sites by migratory animals (e.g. birds and turtles)
- ✓ HCV 2.0 Nationally significant large landscape level mangrove forests or large seascape level coral reefs
- ✓ HCV 3.0 Forest or marine areas that are threatened as well as whether the species contain in them are rare, threatened or endangered
- ✓ HCV 4.0 Forest or marine areas that provide basic services of nature in critical situations
- ✓ HCV 4.1 Forests critical to water catchments
- ✓ HCV 4.2 Mangrove forests critical to coastal erosion control
- ✓ HCV 4.3 Mangrove forests providing barriers to destructive wave action (e.g. king tide)

## **Results and Discussion**

### **Bootless Bay Ecosystems**

The Bootless Bay ecosystem, as represented by Bogoro Inlet and Motupore Island, generally comprised of three distinctive zones which include mud, sand, and rocks. The land-sea interface can be any of the three zones or all in existence concurrently. These three zones have influences over the distributions of different life forms as observed during the inventory. For examples, the crocodile was associated with mud and mangroves, seagrass with sand, and corals with rocks.

The mud zone exists along the land-sea interface areas which are relatively sheltered from sea currents and waves. This zone is mainly covered by mangroves except where it becomes too deep or where human settlements or saltmarshes exist. In the study area the mud zone extent from Bautama through Tahira and most probably overlaying the channel seafloor throughout Bogoro Inlet especially between Tahira and Gereka. This area is also covered mainly by mangroves.

The sand zone is extensive and occurs mainly in open and wave-exposed areas. The zone is covered mainly by the seagrass beds especially close to shores and to a depth of about 10m. The bottom of channels between the islands, patch reefs, and mainland of Bootless Bay is mainly sand.

The rocks and rubbles along the coastline and also of the coral reefs form the third zone. The rocks and rubbles along the coastlines of Bogoro Inlet and Motupore Island composed mainly of limestone.

Table 1: Representation of habitat types in Bogoro Inlet and Motupore Island.

Habitat	% Total Area	Critical for	Comments
Mangrove	26	Crocodile	
		Mangrove birds	

		Fish nursery	
		Fish avoidance of predators	
Sand	23	Seagrass meadows	
		Fish nursery	
		Algal species	
		Several species of sea cucumbers	
Coral, rocks/rubble	51	Foraging by fishes	
		Coral species	
		Seaweeds (macroalgae)	

The coral reef zone can be further divided into different types of reefs (Fringing and Barrier) and according to different depths as well. The fringing reefs extent from the land and terminate at about 30m depth which is the distribution depth of most reef corals that derived their food through the relationship with photosynthetic zooxanthalle algae.

### ***Biodiversity of Bogoro Inlet and Motupore Island***

The biodiversity of Bogoro Inlet and Motupore Island proposed MPAs is very diverse, considering that the sites only cover 200 ha (both mangroves and fringing reefs). Some taxa are highly diverse while others are poorly represented. For example, the number of mangrove species and seagrasses are exceptionally high. Out of the 36 true mangrove species recorded so far in Papua New Guinea, this study recorded 20 species (56%) of all true mangroves. Similarly, of the 14 species of seagrasses recorded in the waters of PNG, 11 species (79%) occur in the two sites within the proposed MPAs (Table 24).

In regard to fish diversity about 3000 species are known to dwell in the waters of PNG. Within Bogoro Inlet and Motupore Island, Drew and colleagues recorded 488 fish species in 2012 [4]. This study recorded an extra 20 species, increasing the total to 512 species thus representing 17% of the known PNG fishes within such a small area.

The coral reef of Motupore Island and Bogoro Inlet covers a total area of 64 ha (excluding seagrass meadows) and include a total of 90 species of corals (soft and hard) which were recorded or known to occur within these sites. While corals are major components of the reef ecosystem, their identification is problematic due to variations in morphology and coloration [5]. This figure of 90 species will eventually increase once the corals are properly identified to species level. Nonetheless, 90 species represent 17% of the 600 species known in PNG. This is about half the species found at the Red Sea (200 spp.) and 50% more species than that found in the entire Carribeans (90 spp.) [6, 7].

Within these sites of the proposed MPAs it was observed that they have high diversity of sea cucumbers. A total of 28 holothurian species out of the 31 species were observed and recorded [8]. Most members were recorded as singleton indicating very low populations (Table 24)

Table 25. Species diversity of significant taxonomic groups with comparison to PNG (ND = not determine)

Significant Taxonomic Groups	Sub groups	Number of species recorded or estimated	
		Bogoro/Motupore (Area = 200ha)	PNG [4,5]
Plants	Fern	2	2414
	Gymnosperm	1	10
	Terrestrial angiosperms	283	~20,000
	Mangroves	23	36
	Seagrasses	10	14
Birds		81	864
Fish		512	2719
Cnidarian	Corals (soft and hard)	90	560
	Hydrozoans	5	Unknown
	Sea Jellies	2	Unknown
	Sea Fens	4	Unknown
Echinoderm	Sea cucumber	28	Unknown

On the whole, although the Bogoro Inlet and Motupore Island sites of the proposed MPAs only represent a small portion of the entire Bootless Bay area, they appeared to represent the marine ecosystem of the Bay and the east Hiri Coastline. The high species diversity observed is reflective of Motupore Island being a sanctuary/refuge for marine life since its ownership was transferred to the University in 1967. Note, Motupore Island is a University Property, devoted to research and as such, has been under protection since.

## High Conservation Values

### Mangrove Forest (Criteria HCV 2-5)

The mangrove forest of Bogoro Inlet is categorized as a high conservation valued ecosystem. The forest ecosystem fulfills HCV assessment criteria 2, 3, 4, and 5. The different communities present within the proposed MPAs are influenced by the connectiveness of various ecosystems in terms of energy and nutrient flow as well as its diversity. Mangrove forest forms the transition between terrestrial and marine ecosystems. On one extreme, it buffers the marine environment from natural land based events such as flood, and storm water runoffs including soil erosion. On the other extreme, mangrove forests also protect terrestrial system from sea-based events such as king tide and even tsunamis.

Generally, mangrove forests are well-known for the countless goods and services that they provide to coastal communities.

The largest stand of mangrove forest found on these two sites was at Bogoro Inlet which showed three very distinct zones as indicated in Figure 31. However, the results from this study revealed that the mangrove forest here is a very degraded one. The *Rhizophora-Bruguiera* zone has been targeted for clearance due to good pole-sized trees occurring in this zone.

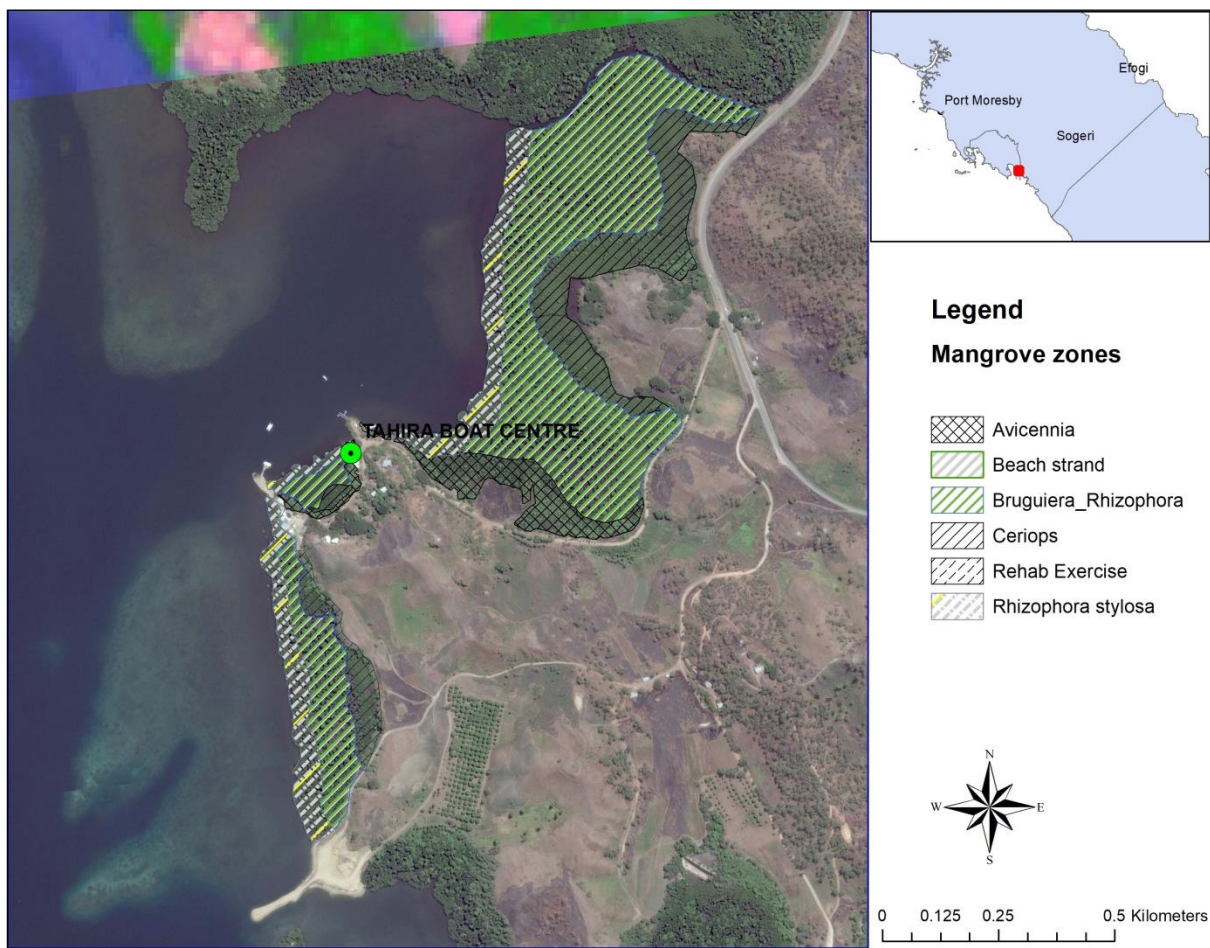


Figure 31. Mangrove zones of Bogoro Inlet.



### **Bogoro Marine Environment (HCV 3-5)**

The reef ecosystem of Bogoro Inlet is very degraded due to accretion of sediment over time. The entire reef from Tahira to Gereka settlement is buried under mud (Figure 32). Nonetheless, the area is categorized as HCV in criteria 3, 4, and 5, because the area supports a small population of saltwater crocodile - a protected species, under the PNG Fauna Act and Crocodile Trade Act. The reptile is locally under threat from hunting and habitat destruction due to harvesting and sedimentation resulting from mangrove clearance. The locals also forage and gather bivalves for consumption.

However, the sampling station two features some important HCVs which include high density of fish juveniles indicating that the area is an important nursery ground for many fish species (see Figure 32). In addition, a very rare scene of sea cucumber with feeding tentacles was observed within this station (Figure 32).

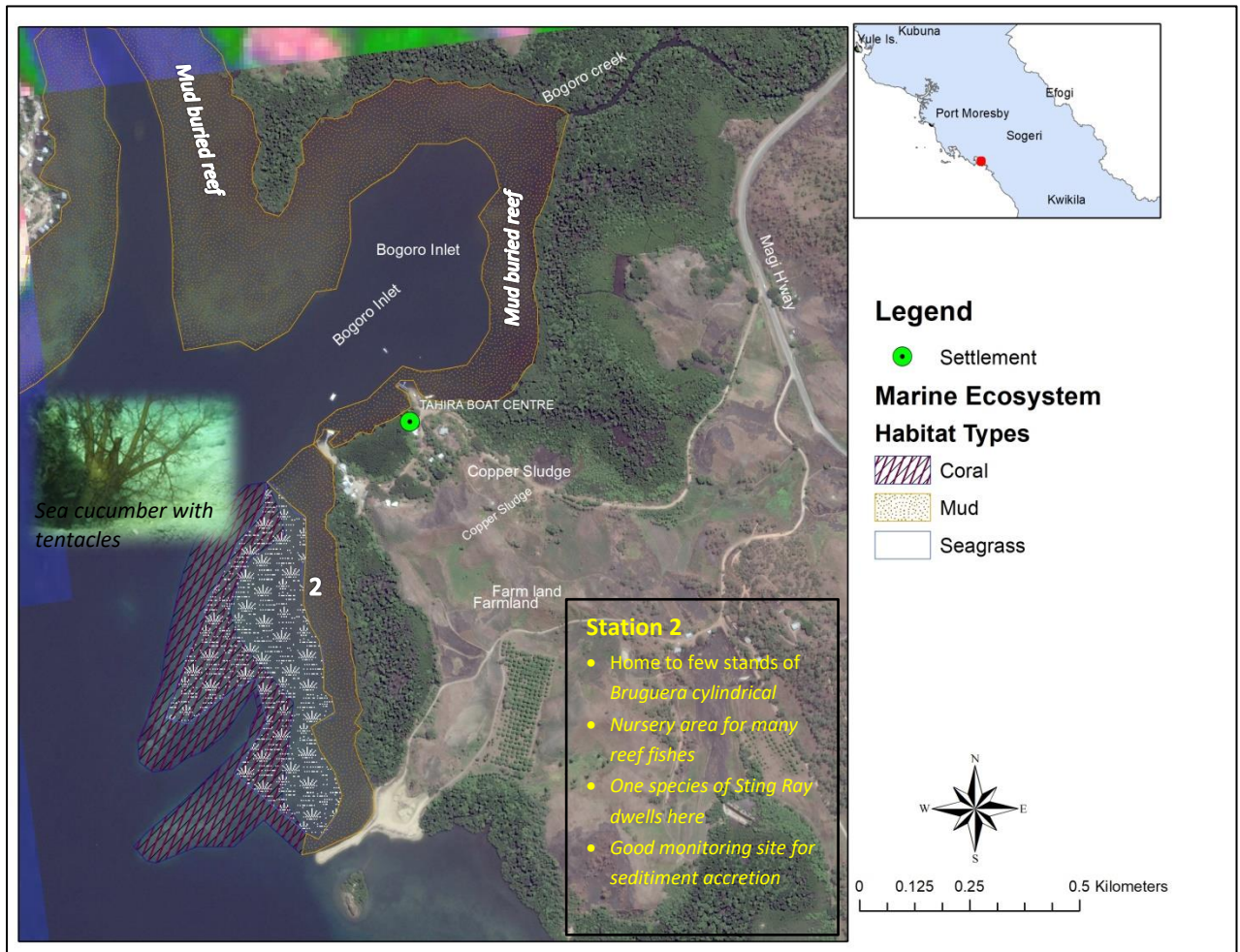


Figure 32. Bogoro Inlet marine environment.

There were other interesting features found in this station including a home of a few *Bruguiera cylindrical*, one species of sting ray and a site where sediment accretion was obvious.

### **Motupore Island (HCV 1 - 5)**

The whole Motupore Island is classified as an area of high conservation values, fulfilling HCV assessment criteria 1, 2, 3, 4, 5, and 6. The island has always acted as a sanctuary and refugia for marine organisms. The diverse habitats support several plant endemics and several highly threatened fish species including a turtle and a sea banded snake. From observation and site specific results, stations 3 and 5 on Motupore Island are very significant (see Figure 33).

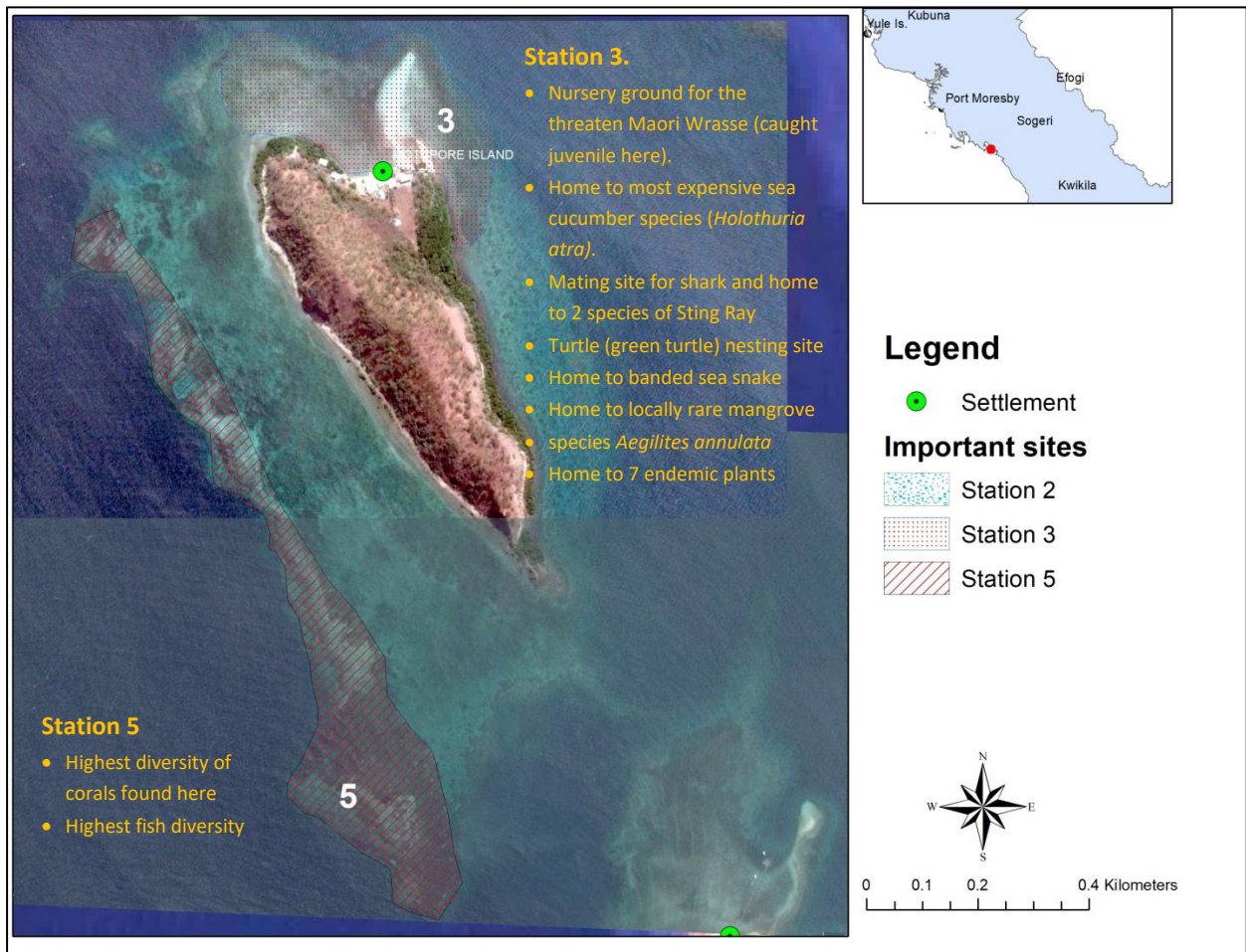


Figure 33. Two sampling stations (3 and 5) of HCV status.

### Conclusion

The biodiversity status of the proposed MPA sites is overwhelming for such a small area. However, there are evidences of extensive fishing that posed a potential threat to the marine lives of the proposed MPA areas.

The percentage coral cover was reduced from 42% to 19% between 2005 and 2006 (Pratchett et al., 2009). It has remained low and reduced further to 10% as recorded by this survey. Unfortunately, the algal cover has not increased as a result of the decreased in coral cover. This indicated that the coral reefs in the proposed MPA areas have lost their ability (resilience) to recover after the crown-of-thorn starfish (*Acanthaster planci*) infestation of corals in 2005 [10].

## Recommendations

Based on the inventory results and discussions the study strongly recommends the **MPA establishment** for Bogoro Inlet and Motupore Island. Given the expansion of the city (see chapter 7), Bootless Bay must be managed such that the provision goods and services from ecosystems are maintained into the future.

## References

1. Swartzendruber, J. F. 1993. Papua New Guinea conservation needs assessment, synopsis report. Department of Environment and Conservation, Government of Papua New Guinea.
2. Neugarten, R., and C.E. Savy. 2012. A global review of national guidance for High Conservation Value. Washington, DC: Conservation International & Africa Biodiversity Collaborative Group (ABCG).
3. ProForest, 2008. Good practice guidelines for High Conservation Value assessments. A practical guide for practitioners and auditors. Oxford OX1 3HZ, United Kingdom.
4. Drew, J. A., Buxman, C. L., Holmes, D. D., Mandecki, J. L., Mungkaje, A. J., Richardson, A. C. and Westneat, M. W. 2012. Biodiversity inventories and conservation of the marine fishes of Bootless Bay, Papua New Guinea. *BMC Ecology*, 12:15. Doi: 10.1186/1472-6785-12-15.  
<http://indopacificimages.com/papua-new-guinea/papua-new-guinea/biodiversity>
5. IUCN (2012). Guidelines for Application of IUCN Red List Criteria at Regional and National levels: Ver 4.0. Gland, Switzerland and Cambridge, UK: IUCN. Iii +41pp.
6. Miloslavich P, Klein E, Di'az JM, Herna'ndez CE, Bigatti G, et al. 2011. Marine Biodiversity in the Atlantic and Pacific Coasts of South America: Knowledge and Gaps. *PLoS ONE* 6(1): e14631. doi:10.1371/journal.pone.0014631.
7. [indopacificimages.com/papua-new-guinea](http://indopacificimages.com/papua-new-guinea).
8. Ko'ou, A. Y. 2014. Habitats influence on the variations in the recruitment of overfished sea cucumbers on the fringing reefs of Bootless Bay, Papua New Guinea - MSc Thesis. Diponegoro University, Semarang, Indonesia.
9. <http://www.birdsofmelanesia.net/pau8.pdf>. Accessed 04/06/2018
10. Pratchett MS, Schenk TJ, Baine M, Syms C, Baird AH (2009) Selective coral mortality associated with outbreaks of *Acanthaster planci* L. in Bootless Bay, Papua New Guinea. *Mar Environ Res* 67: 230–236



## BIODIVERSITY PICTURES

Graceful Maliphaga (*Meliphaga igracillis*)

Eastern Osprey (*Pandion cristatus*)

Grey Shrikethrush (*Colluricincla harmonica*)

New Guinea Helmeted Friarbird (*Philemon sp.*)

Torresian Imperial Pigeon (*Ducula spilorrhoe*)

Shinning Flycatcher (*Myiagra alecto*, male)

Sabellidae *Ophiothrix sp.*

*Didemnum molle* (Ascidian)

Gracilaria salicornia (Green algae)

Tripneustes gratilla (sea urchin)

Sabellidae, *Ophiothrix sp.*

Coral diversity (*Acropora*, *Sinularia* etc.)

Coral diversity

Coral diversity

Coral diversity

Soft coral, *Sinularia sp.*

Scorpaenidae - Scorpion fish

*Leuceana leucophylla*

*Tridax procumbens*

*Aegialites annulata* (Mangrove)

*Guttarda speciosa* (beach plant)

*Osbornia octodonta* (Mangrove)

*Sonneratia alba* (Mangrove)

*Alectryon repando-dentata* (Strand vegetation)

Papilionid species of butterfly

Papillionid species